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

Partially incorporating January 22, 2001 Biological Assessment
submitted to the National Marine Fisheries Service and
February 13, 2001 Biological Assessment
submitted to the U.S. Fish and Wildlife Service

Prepared By:

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Klamath Basin Area Office

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CHAPTER 1.0 - INTRODUCTION

1.1 INTRODUCTION

This biological assessment (BA) describes the Bureau of Reclamation=s (Reclamation) proposed operation of the Klamath Project (Project) from April 1, 2002 through March 31, 2012. Reclamation is submitting this BA pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) to both the Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) to ensure that the proposed action is not likely to jeopardize the continued existence of listed species and to ensure that there is coordination between what may otherwise be conflicting needs between multiple listed species.

Under the relevant regulations, the Acontents of a biological assessment are at the discretion of the Federal agency and will depend on the nature of the Federal action.@ 50 CFR ' 402.12(f). In the event that the FWS or NMFS determines that the proposed action is likely to jeopardize the continued existence of listed species, Reclamation has identified in Appendix A to this BA actions that could be implemented as reasonable and prudent alternatives to the proposed action, as reasonable and prudent measures to reduce any incidental take associated with the proposed action, or to promote conservation and recovery of listed species pursuant to Section 7(a)(1) of the ESA.

1.2 PURPOSE OF BIOLOGICAL ASSESSMENT

Reclamation=s objective is to work with the Services toward developing an operations plan that meets Reclamation=s legal commitments with respect to the Project in a manner that is consistent with the requirements of the ESA. Reclamation prepared this BA to describe and analyze the effects of its proposed actions related to operation of the Project on listed species. The BA describes proposed discretionary actions for 10 years, from April 1, 2002-March 31, 2012. This BA incorporates by reference and summarizes applicable and relevant portions of the BAs submitted to the FWS and NMFS in early 2001. Reclamation has also added new information to this BA, including:

- Proposed actions different from those described in previous BAs;
- A description of the environmental baseline condition that is consistent with ESA implementing regulations at 50 CFR ' 402.02 and the FWS Section 7 Consultation Handbook;
- Additional analyses of the effects of the proposed action relative to the baseline such that the incremental effects on the listed species associated with proposed actions can be distinguished from the effects of non-Federal and non-Project actions.

1.3 SUMMARY OF 2001 CONSULTATION ACTIVITIES

On January 22, 2001 (Reclamation 2001a) and February 13, 2001 (Reclamation 2001b), Reclamation submitted BAs for proposed operation of the Project to NMFS and the FWS, respectively. NMFS issued a final biological opinion on April 6, 2001 (NMFS 2001) and FWS issued its final opinion on April 5, 2001 (FWS 2001). Reclamation issued an Annual Operations Plan for the Project on April 6, 2001. The NMFS BO was effective through September 30, 2001, and the FWS BO was effective through March 31, 2002. Reclamation notified NMFS and FWS on August 17, 2001 that further consultation would be needed before April 1, 2002 for continuing operation of the Project. NMFS issued an amendment to its

BO on September 28, 2001. On December 17, 2001, Reclamation requested an additional amendment to the NMFS BO. On December 28, 2001, NMFS issued an additional amendment that is effective through February 2002.

In an August 17, 2001 memorandum, Reclamation informed FWS of a number of concerns that need to be addressed in future Klamath Project ESA consultations, including:

1. Independent Science Peer Review. On October 2, 2001, the Department of the Interior announced that it had signed an agreement with the National Academy of Sciences (NAS) to review scientific and technical information regarding aquatic endangered species in the Klamath Basin. The Departments of the Interior and Commerce are jointly funding this review. Through this review, NAS is evaluating existing scientific information and how it was applied in Reclamation's 2001 BAs and the Services' 2001BOs. On February 6, 2002, NAS published an interim report. NAS's preliminary findings are discussed in Chapter 5 of this BA, and the Interim Report is attached as Appendix B. A final report is expected by March 30, 2003.

2. Involvement of Contracting Districts, Tribes, and Other Parties. Contracting districts, Tribes, and other parties need to be involved in consultations and in developing long-term strategies for Project operation, given the basin-wide issues that need to be addressed. This is consistent with the Secretary of the Interior's "four Cs" policy, which commits all Interior agencies to communication, consultation, cooperation, and conservation when undertaking Departmental efforts.

3. Addressing the Impacts of Non-Project Actions. Reclamation believes that the Project should not be responsible for effects of all of the water development and land management activities throughout the Basin, both federal and non-federal, on endangered suckers and threatened coho salmon. For example, the diversion and use of water by federal and non-federal parties upstream from Upper Klamath Lake under water rights that are junior in priority to those claimed by the United States for the Project may significantly deplete inflows to the lake, adversely affecting lake levels in, and flows downstream from, the lake. In particular, the Project should not be held responsible for impacts associated with upstream water uses permitted by the State of Oregon based on appropriation dates subsequent to those for the Project. Likewise, the Project is not responsible for depletions that may result from the operation of FWS's upstream national wildlife refuge. Those effects, if any, should be addressed in an intra-service consultation by FWS with respect to species listed by it and in a consultation between NMFS and FWS with respect to species listed by NMFS.

4. Concerns Regarding a Potential Reasonable and Prudent Alternative (RPA) for Long-term Project Operations. Project operations during the 2001 irrigation season were based on assumptions that were valid only for the 2001 operations year. Accordingly, Reclamation incorporated the 2001 BOs' RPAs for that year only. RPAs for future Project operations must provide for the long-term operation of the Project in a way that can be applied in all types of water years.

5. Reasonable and Prudent Measures (RPMs). In separate discussions, Reclamation also notified the FWS last year with concerns over the scope of the RPMs FWS recommended to minimize incidental take of bald eagles. While Reclamation was able to obtain water through cooperative means from water users in the Basin to provide the protections sought by FWS, this remains another area where Reclamation and the Services need to ensure that any RPMs are consistent with applicable regulations.

CHAPTER 2.0 - DESCRIPTION OF THE ACTION

2.1 INTRODUCTION

Reclamation proposes, through consultation and development of a subsequent operations plan, to operate the Project to divert, store, and deliver (from storage) Project water consistent with applicable law. For purposes of this BA, the proposed operations begin April 1, 2002, and continue through March 31, 2012. This BA is only the first step in the consultation process. After completion of consultation with both the FWS and NMFS, Reclamation will develop an operations plan that provides for the continued operation of the Project in a way that meets its legal obligations.

2.2 SUMMARY OF LEGAL AND STATUTORY AUTHORITIES, WATER RIGHTS, AND CONTRACTUAL OBLIGATIONS RELEVANT TO THE ACTION

2.2.1 Introduction

Legal and statutory authorities and obligations, water rights, and contractual obligations guide Reclamation's proposed action. This section of the BA elaborates on those authorities, responsibilities, and obligations.

2.2.2 Legal and Statutory Authorities

The Klamath Project is one of the earliest federal Reclamation projects. The Act of February 9, 1905, 33 Stat. 714, authorized the Secretary of the Interior (Secretary) to change the level of several lakes and to dispose of certain lands that were later included in the Project. The Oregon and California legislatures, on January 20 and February 3, 1905, respectively, passed legislation ceding certain lands to the United States for use as Project lands. The Oregon statute expressly authorized the use of Upper Klamath Lake in any irrigation and reclamation undertaking by the United States. The Project was authorized by the Secretary on or about May 15, 1905, in accordance with the Reclamation Act of 1902 (43 U.S.C. § 372 et seq, Act of June 17, 1902, 32 Stat. 388) and approved by the President on January 5, 1911, in accordance with the Act of June 25, 1910, 36 Stat. 835.[1] This authorization included construction of Project works to drain and reclaim lakebed lands of the Lower Klamath and Tule Lakes, to store waters of the Klamath and Lost Rivers, including storage of water in Lower Klamath and Tule Lakes, to divert irrigation supplies, and to control flooding of reclaimed lands. Under provisions of the Reclamation Act and contractual obligations, Project costs were to be repaid by the beneficiaries on the reclaimed project lands. These costs have been repaid except for the costs of reserved works facilities.

[1]The Act of February 9, 1905 was based on the Reclamation Act of 1902, 32 Stat. 388, which provided for the construction and maintenance of irrigation works for the storage, diversion, and development of waters for reclamation of arid and semiarid lands. Section 1. The acts by the Oregon and California legislatures stated as their purpose to aid in the operations of irrigation and reclamation and for the storage of water in connection with the irrigation and reclamation operations.

2.2.3 WATER RIGHTS

2.2.3.1 General

Federal law provides that Reclamation obtain water rights for its projects and administer its projects pursuant to state law relating to the control, appropriation, use or distribution of water used in irrigation, unless the state laws are inconsistent with express or clearly implied congressional directives. 43 U.S.C. ' 383; California v. United States, 438 U.S. 645, 678 (1978); appeal on remand, 694 F.2d 117 (1982). Water can only be stored and delivered by the Project for authorized purposes for which Reclamation has asserted or obtained a water right in accordance with Section 8 of the Reclamation Act of 1902 and applicable federal law. Reclamation must operate the Project in a manner that does not impair senior or prior water rights. Reclamation has an obligation to deliver water to the Project water users in accordance with the Project water rights and contracts between Reclamation and the water users (which may be through a water district). Water lawfully stored in the Project's reservoirs can be used for Project purposes to the extent the water is applied to beneficial use within the Project.

The beneficial interest in the Project water right is in the water users who put the water to beneficial use. Nevada v. United States, 463 U.S. 110 (1983). In Oregon, as in most western states, a water right is obtained through appropriation followed by application within a reasonable time to beneficial use. See ORS 539.010. Likewise, Oregon law (as well as California law) is similar to the laws of most other western states in that actual application of the water to the land is required to perfect a water right for agricultural use.[2] Federal law concerning Reclamation projects, which is consistent with Oregon law, also provides that the use of water acquired under the Act "shall be appurtenant to the land irrigated, and beneficial use shall be the basis, measure, and the limit of the right." 43 U.S.C. ' 372. Beneficial use is determined in accordance with state law to the extent it is not inconsistent with Congressional directives. See Alpine Land & Reservoir Co., 697 F.2d at 853-854; see also California v. United States, 438 U.S. at 678. Reclamation has no general authority to reallocate Project water. As to the Klamath Project, Reclamation, in certain circumstances, may be unable to deliver water for Project purposes. See sections 2.2.8, 2.2.9 below. See also, for example, Klamath Water Users Association v. Patterson, 204 F. 3d 1206 (9th Cir. 2000) and Kandra v. United States, 145 F. Supp. 2d 1192 (D. Or. 2001). Further, Reclamation may exercise its discretion with respect to the protection of tribal trust resources. These authorities and the contracts with the United States create and define the extent of the water users' rights.

2.2.3.2 Appropriation by the United States

The United States filed its notice of intent to appropriate waters for the Project with the State of Oregon on May 19, 1905, "to completely utilize all the waters of the Klamath and Lost River Basins in Oregon." It is recorded in AWater Filings@ on page 1. This notice was also published in the *Klamath Falls Express* of Klamath Falls, Oregon on June 15, 22, 29, and July 6, 1905. Similar filings were also made in California.[3] The May 19, 1905, notice provided that the water was to be used "in the operation of works

[2] See ORS '' 539.010 et seq.; State ex rel. v. Hibbard, 570 P.2d 1190, 1194 (Or. Ct. App. 1977); Alexander v. Central Oregon Irrigation District, 528 P.2d 582 (Or. Ct. App. 1974), and Cal. Water Code ' 1240; Joerger v. Pacific Gas & Elec. Co., 276 P. 1017 (Cal. 1929); Madera Irr. Dist. v. All Persons, 306 P.2d 886 (Cal. 1957).

[3] Oregon statutes concerning the appropriation of water before February 24, 1909, the effective date of the Oregon Water Rights Act of 1909, provided that the extent of the appropriation was determined by the actual capacity of the completed diversion structure, assuming that the requirement to post a notice of intent to appropriate together with application of water to beneficial use within a reasonable time had occurred. See In re Waters of the Tualatin River and its Tributaries, 366 P.2d 174 (Or. 1961). The laws for appropriation of water in California that were in effect in 1905 were similar to those in Oregon. Cal.

for the utilization of water in the State of Oregon under the provisions of the act of Congress approved June 17, 1902 (32 Stat. 388) known as the Reclamation Act." This appropriation of water for Project purposes was made as directed by Section 8 of the Reclamation Act of 1902 and in conformance with state law as it existed in 1905. 43 U.S.C. ' 383.

To facilitate the filing on the water rights by the U.S. for Project purposes, the Oregon legislature passed a statute that stated in part as follows:

Whenever the proper officers of the United States, authorized by law to construct works for the utilization of water within this state, shall file in the office of the state engineer a written notice that the United States intends to utilize certain specified waters, the waters described in such notice and unappropriated at the date of the filing thereof shall not be subject to further appropriation under the laws of this state, but shall be deemed to have been appropriated by the United States.

Act of February 22, 1905, Ch. 5, title 43, L. O. L., section 2 (section 6588, L. O. L.). The Oregon Supreme Court held that when the United States complied with the procedure as established by the legislature of the State of Oregon in the above act the United States thereby obtained "title to all the then unappropriated water" of the river with priority dating from the date the notice was filed.[4] See In Re Umatilla River, 168 Pac. 922 (OR. 1917) (concerning rights to the waters of the Umatilla River). The Reclamation Service of the United States filed detailed plans and specifications covering the construction of the Klamath Project with the State Engineer of Oregon on May 6, 1908, and on May 8, 1909, filed with the State Engineer proof of authorization of the construction of the works therein set forth. The United States met the requirements of this statute when it filed for the water rights of the Project in 1905. The U.S. has also claimed water rights for the refuges and for the Klamath Tribes, as well as for other federal agencies within the Basin.

2.2.3.3 Acquired Water Rights

In addition to initiating the appropriative rights procedure in the States of Oregon and California, the United States acquired certain rights from entities and landowners who had initiated the appropriation of water in the Project area before 1905. The fact that a considerable number of these rights were purchased by the United States indicates that early private development of the basin was already well under way at the advent of Reclamation. It was necessary to acquire these rights from the entities involved to facilitate Project operation. Reclamation has filed claims in the pending adjudication for water rights with a priority date of 1905 (and some earlier) for Project storage and use, including domestic and irrigation as well as incidental fish and wildlife, recreation, and flood control purposes.

Civil Code of 1872, '' 1410-22 (Deering 1977). The effective date of the California Water Commission Act, which established California's current appropriation scheme, is December 19, 1914.

[4] In addition, the Klamath River Basin Compact (Compact) provides the following concerning rights of the Klamath Project and rights of the United States in general.

> There are hereby recognized vested rights to the use of waters originating in the Upper Klamath River Basin validly established and subsisting as of the effective date of this Compact under the laws of the State in which the use or diversion is made, including rights to the use of waters for domestic and irrigation uses within the Klamath Project.

Congress consented to the negotiation of the Klamath River Basin Compact (between the States of Oregon and California) by the Act of August 9, 1955, 69 Stat. 613 and to the Compact itself by the Act of August 30, 1957, Public Law 85-222, 71 Stat. 497.

2.2.3.4 Adjudication Proceedings

A formal adjudication of a river system establishes in a competent court the relative rights to the use of water within the area that is being adjudicated. Testimony is received from all persons claiming a right and the State makes determinations based on the testimony of the relative priority dates. The Klamath River Basin is undergoing such a process.

The State of Oregon is adjudicating all of the pre-1909 water rights in the Klamath River Basin. This includes water rights for the Project, Klamath Tribes (claims were also filed by the United States on behalf of the Tribes because those rights are held in trust for the Tribes by the United States), and four Klamath Basin national wildlife refuges, among other federal and private rights. Various irrigation districts and individuals that receive water from the Project also filed claims in the adjudication for the Project water rights. These claims are similar, but not identical, to the claims filed by the United States for the Project water rights. As the Klamath Basin adjudication is still pending, no water rights have been quantified for those parties who filed claims, including those listed above. There is currently no process underway for the adjudication or quantification of downstream (California) water rights. However, certain of the tributaries, such as the Scott and Shasta Rivers, were adjudicated in the early 1900s. Although decreed, these rights have not been effectively administered.

Concurrent with the Klamath adjudication, the State of Oregon initiated an Alternative Dispute Resolution (ADR) process in an attempt to resolve as many water rights issues in the adjudication as possible to avoid litigation by various claimants. The U.S. and other water users and parties with interests in the Basin participated in the ADR process.

The State of Oregon began the adjudication of the Lost River system in the early 1900s. Certificates were issued to individuals who had rights predating the Project's filings. Since the U.S. was not a party to the adjudication, certificates were not issued for the Project. The State did, however, recognize an inchoate right in the U.S. for Project purposes in the decree.

A number of water users above Gerber Dam claimed to have not been notified of the adjudication. As a result, the State reopened the adjudication process and completed it in 1989. This portion of the adjudication set forth the relative priorities of water use above Gerber Dam. The Klamath County Circuit Court affirmed last year that the United States was never a party to the Lost River Adjudication. Thus, the water rights of the United States, including those of the Project, remain unadjudicated. Currently, no proceeding is scheduled to complete this adjudication.

2.2.4 Perpetual Contracts

Project water, which is water stored or diverted for Project purposes, is delivered to project beneficiaries pursuant to various contracts with Reclamation. Reclamation entered into numerous perpetual contracts pursuant to the Reclamation Act of 1902 with various irrigation districts and individuals to provide for the repayment of project costs in return for the delivery of Project water to specified lands. In most cases, the contracts do not specify a particular amount of water, but rather create a perpetual obligation of Reclamation to deliver available Project water for beneficial use on the specified lands. The majority of the contracts contain "shortage" provisions that limit the United States' liability for water shortages related to causes specified in the contracts.

In all, over 250 perpetual contracts are administered either directly or through irrigation districts on the Project. The United States also entered into contracts with Project irrigation districts for the operation and maintenance of certain Project facilities. Irrigation Districts that fall into this category are Klamath Irrigation District, Tulelake Irrigation District, and the Langell Valley Irrigation District.

In addition to the above, Reclamation entered into numerous perpetual contracts that were written pursuant to the Warren Act of 1911. These contracts provide that Project water will be delivered at a certain point, and from there it is the responsibility of the contractor to construct, operate and maintain all the necessary conveyance facilities (i.e., pumps, laterals, and turnouts) to distribute that water to the lands identified in the contract.

2.2.5 Lease Lands

There are approximately 22,000 acres of agricultural lands within either the Lower Klamath or Tule Lake National Wildlife Refuges leased on an annual basis. As such, the U.S. Fish and Wildlife Service administers these lands; however, the irrigation water supplied to these lands is provided by Reclamation through contracts it has with Project irrigation districts. Leasing of these lands dates back to the 1930s. Reclamation has discretion regarding the delivery of Project water to these lands.

2.2.6 Temporary Water Contracts

Reclamation has discretion to determine whether surplus water is available to certain Project lands that are not covered by perpetual contracts. In many cases, these lands have been receiving surplus irrigation water from the Project for over 50 years. For numerous reasons, these lands were never given a perpetual contract. Concurrently, the Project irrigation districts also make a determination whether or not to sell surplus water. The irrigable acreage covered by surplus water contracts in 2000 was approximately 5,248 acres

The irrigable acreage represented by these temporary contracts is less than two percent of the total acreage irrigated on the Project. Water is delivered to these lands through the existing irrigation systems. In many cases, the water is delivered and controlled by the irrigation districts.

2.2.7 Power Contracts

In 1917, the United States entered into a contract with the predecessor to PacifiCorp, under which the power company constructed and conveyed to the United States Link River Dam at the outlet of Upper Klamath Lake. The power company also obtained the right to regulate the level of the Lake for power purposes subject to the needs of the Project for irrigation and reclamation requirements. The contract was renewed in 1956, as a result of FERC Project 2082 concerning the construction and operation of downstream Klamath dams operated by the power company. The present contract, which will expire in 2006, allows PacifiCorp to operate the dam within certain guidelines.

2.2.8 Endangered Species Act (ESA)

Each federal agency has an obligation to insure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify its critical habitat unless that activity is exempt pursuant to the ESA. 16 U.S.C ' 1536(a)(2); 50 CFR ' 402.03. It is under this authority that Reclamation has prepared this BA.

Under section 7(a)(2), a discretionary agency action jeopardizes the continued existence of a species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species." 50 CFR 402.02. If a discretionary agency action is jeopardizing a species, the agency must stop the action or adapt it through reasonable and prudent alternatives (RPAs), which must be within the scope of the agency's legal authority. 50 CFR § 402.02.

Through this consultation and subsequent development of an operations plan, Reclamation will comply with its obligations under the ESA, namely, to: (1) avoid any discretionary action that is likely to jeopardize the continued existence of listed species; (2) take listed species only as permitted by the relevant Service; (3) and use Reclamation's authorities to conserve listed species. For the purposes of this BA, impacts to listed species are assessed with respect to the separate actions of diversion, storage, and release or delivery of water.

Reclamation also is proposing actions to benefit the species under its existing authorities and consistent with its 7(a)(1) obligation to conserve and protect listed species. Section 7(a)(1) alone does not give Reclamation additional authority to undertake any particular action, regardless of its potential benefit for endangered species. Whether undertaken as section 7(a)(1) conservation activities or as RPAs subsequent to 7(a)(2) compliance, any Reclamation action for endangered species purposes must be within the agency's existing authority. Where there is no 7(a)(2) question (i.e., no indication that a proposed discretionary action is likely to jeopardize species), Reclamation's failure to take an action that is conceivably within its authorities cannot be determined to be a cause of "jeopardy."

2.2.9 Tribal Water Rights and Trust Resources

There are four federally recognized Indian Tribes in the Klamath Basin for which the Project operation is an important issue. These Tribes are the Klamath Tribes in Oregon, and the Yurok, Hoopa and Karuk tribes in California. The Klamath Tribes' water rights are currently included in the pending Klamath Basin adjudication in Oregon. There is currently no proceeding pending to determine the other tribes' water rights.

The Klamath Indian Tribes have treaty-based rights. The treaty reserves to the Tribes a federal Indian reserved water right to support their hunting, fishing, and gathering rights. United States v. Adair, 723 F.2d 1394 (9th Cir. 1983), cert. denied, 464 U.S. 1252 (1984). Although the Klamath Tribes' water rights have not yet been quantified in the pending Oregon adjudication, the existence of the Klamath Tribes' rights to the water needed to protect their treaty-reserved hunting and fishing rights (with a priority date of time immemorial) and for agricultural uses has been confirmed by the Ninth Circuit Court of Appeals. Id.

The Yurok and Hoopa Valley Tribes have federal Indian reserved fishing rights to take anadromous fish within their reservations in California. These rights were secured to the Yurok and Hoopa Indians by a series of nineteenth century executive orders. The Yurok and Hoopa Valley Tribes in California hold unadjudicated water rights to support their fishing rights. These rights vested at the latest in 1891 and perhaps as early as 1855. See, e.g., United States v. Adair, supra; Arizona v. California, 373 U.S. 546, 600 (1963); United States v. Winans, 198 U.S. 371 (1905).

2.2.10 National Wildlife Refuges

The Upper Klamath, Lower Klamath, Tule Lake, and Clear Lake National Wildlife Refuges are adjacent to or within the Project. These refuges were established by Executive Orders dating as early as 1908. The U.S. Fish and Wildlife Service under the Migratory Bird Treaty Act, the Refuges Administration Act, the National Wildlife Refuge System Improvement Act, and other laws pertaining to the National

Wildlife Refuge System manage the refuges. These refuges support many fish and wildlife species and provide suitable habitat and resources for migratory birds of the Pacific Flyway. Portions of the refuges are also used for agricultural purposes. See the discussion above regarding leaselands. The refuges either receive water from or are associated with Project facilities.

The refuges have federally reserved water rights for the water necessary to satisfy the refuges= primary purposes. In addition, the Lower Klamath and Tule Lake refuges have water rights for irrigation of waterfowl habitat, based on a portion of the Project water right. In addition, and subject to the assumption by FWS of responsibility for the proportionate impacts to listed species, Reclamation also can continue to provide available Project water for beneficial reuse by the refuges to the extent of past and current usage and consistent with Project purposes.

2.3 THE PROPOSED ACTION

Reclamation's proposal includes operating the Project in a manner that not only seeks to avoid jeopardizing listed species but also to conserve and protect the species (7a1) and in furtherance of Reclamation's tribal trust obligations. Consistent with these goals, Reclamation proposes to continue operation of the features and facilities of the Klamath Project consistent with the historic operation of the Project from water year 1990 through water year 1999 ("10-year period"). As discussed in more detail below, all water year types are represented during this 10-year period. The "below average" water year type and "dry" water year type are represented by only one year each. The remainder of the years in the 10-year period include six "above average" years and two "critical dry" years.

In addition to the actions proposed in this section, Appendix A describes actions for consideration by the FWS and NMFS that may be used as elements of a reasonable and prudent alternative to the proposed action if needed to avoid jeopardy to listed species. These actions could also be used as elements of appropriate recovery plans for the listed species or as voluntary conservation measures/actions to benefit the listed species. Reclamation anticipates that the United States would adopt and implement these cooperative measures in a manner consistent with Reclamation's contractual obligations. Consultation with the States of Oregon and California may also be required to assure that any necessary approvals are obtained. **These measures are not included in Reclamation=s proposed action described in this BA.**

2.3.1 Project Facilities

The three primary Project reservoirs used for diversion, storage, and delivery of water for Project purposes are Upper Klamath Lake and Clear Lake and Gerber Reservoirs. Project operations were described in detail in Reclamation's 1992 BA (Reclamation 1992a). The November 2000 *Klamath Project Historic Operation* report (Reclamation 2000) also described Project features and their operation in more detail. This BA incorporates by reference the description of facilities found on pages 11-30 of that report.

A brief description of the major Project features follows:

- Link River Dam on the Link River at the head of the Klamath River regulates flow from Upper Klamath Lake into the Klamath River, and water diverted from Upper Klamath Lake provides the majority of irrigation supplies for the Project lands. Reclamation contracted with PacifiCorp for construction of the Dam, which is owned by the United States. Construction was completed in 1921.

- Clear Lake Dam and Reservoir located on the Lost River in California. Reclamation is proceeding with a Safety of Dams (SOD) project at Clear Lake to correct known safety deficiencies of the dam. This project will be completed in 2002. The effects of the SOD project were described in an October 2000 environmental assessment, and it was the subject of a separate Section 7(a)(2) consultation completed in September 2001.

- Gerber Dam and Reservoir located on Miller Creek, a tributary of the Lost River in Oregon. The dam was constructed in 1925 and has a maximum surface area of 3,800 acres and capacity of 94,000 acre-feet. As authorized by Pub. Law 106-498, Reclamation is proceeding with a feasibility study and NEPA process to raise Gerber Dam to provide additional storage for Project purposes.

- Malone Diversion Dam on the Lost River downstream from Clear Lake Dam in Oregon. Constructed in 1923, this small dam diverts water released from Clear Lake into two canals in the Langell Valley Irrigation District.

- Lost River Diversion Dam on the Lost River in Oregon that diverts excess water to the Klamath River through the Lost River Diversion Channel (LRDC). This dam, constructed in 1912, has a primary purpose of flood control for the Project lands in the Tule Lake area. In addition, the LRDC carries water from the Klamath River for irrigation at certain times when not operating for flood control purposes.

- Anderson-Rose Dam on the Lost River diverts water for irrigation of California lands. This supply includes water from both the Klamath River and the Lost River. Klamath River water is diverted through the LRDC to the Lost River and then to Anderson-Rose Dam.

- Tule Lake Tunnel was constructed in 1941 to convey natural flow and Project return flows from Tule Lake to Lower Klamath Lake. The Tunnel and associated Pumping Plant D were built in 1941. It also serves as a flood control and water delivery facility.

- Agency Lake Ranch. Reclamation acquired Agency Lake Ranch in 1998 to store additional water for Project uses that would otherwise be spilled to the Klamath River during periods of high runoff. Reclamation diverts water onto the ranch when it is available and subsequently pumps that stored water into Agency Lake for Project purposes. In 2000, approximately 15,000 acre-feet of additional water was stored on the ranch.

2.3.2 Description of the Proposed Action

2.3.2.1 Proposed Action's Foundation

The National Academy of Science's Committee on Endangered and Threatened Fishes in the Klamath River Basin published its interim report in February 2002. The key conclusions regarding project operations were as follows:

<u>Regarding Upper Klamath Lake elevations:</u> "The present scientific record is consistent with use of operational principles in effect between 1990 and 2000."

<u>Regarding Klamath River flows:</u> "On the whole, there is no convincing scientific justification at present for deviating from flows derived from operational practices in place between 1990 and 2000."

Reclamation's proposed action is described in this chapter. The proposed action provides a Project water supply while staying within the operating regime observed from water year 1990 through water year 1999 (ten-year period). Observed values for lake levels and river flows that occurred during the ten-year period were used to develop operating criteria.

2.3.2.2 "Rainbow" Concept

In general, the upper Klamath River Basin hydrology can be characterized by river flows that build during the fall and winter and subsequently decline as spring moves through summer. Lake levels follow this "rainbow" trend.

Through the years, the basin experiences a variety of annual hydrologic conditions ranging from drought to flood. Single season sets of observed lake levels and river flows can be grouped together and defined as a water year "type." Like bands within a rainbow, distinctive groupings of observed lake levels and river flows develop that are representative of the respective water year type.

2.3.2.3 Developing Operating Criteria

The NAS report finds no substantial scientific data to support changing the Project operations regime of the 1990's. Project operations resulted, by water year type, in minimum and maximum lake level and river flow values. Proposed operations must stay within that range, and will not go lower than the minimum. Reclamation must also be careful not to let the average creep down.

Pursuant to its trust responsibilities and section 7(a)(1) of the ESA, Reclamation proposes to exercise its authorities to provide additional benefits to listed species, beyond the requirements of Section 7(a)(2) of the ESA. Reclamation proposes to do more than strictly adhere to the minimum operational regime of the ten-year period. Reclamation also proposes to establish a "water bank" through which willing buyers and sellers will provide additional water supplies for fish and wildlife purposes and to enhance tribal trust resources. At this time, the size of the water bank is anticipated to be up to 100,000 acre feet with "deposits" coming from a variety of sources including off-stream storage, irrigation demand reduction, and groundwater. Implementation of the water bank is consistent with Reclamation's goal of retaining Project viability in a manner that not only seeks to avoid jeopardizing listed species but also to conserve and protect the species and to address Reclamation's tribal trust obligations.

The proposed Project operation is a four-step process.

Step 1 Determination of Water Year Type: Reclamation will determine the water year type (above average, below average, dry, or critical dry) using a 70 percent exceedance factor and NRCS's April 1 runoff forecast.

Step 2 Preliminary Calculation of Project Water Supply: Reclamation will estimate the annual water supply that would be available for irrigation and refuge deliveries under the following criteria:

> Upper Klamath Lake, Gerber Reservoir, and Clear Lake levels: Reclamation will estimate the available supply based on lake levels no lower than the minimum end-of-month elevations for the ten-year period.
>
> Klamath River flows below Iron Gate Dam: Reclamation will estimate the available supply based on operations that differ, depending on year type as follows:

For above average and below average years, Reclamation will estimate available supply based on daily average river flows no lower than the respective ten-year minimums or FERC flows, whichever are greater.
For dry and critical dry years, Reclamation will estimate available supply based on daily average river flows no lower than the observed ten -year minimums.

Step 3 Second Calculation of Project Water Supply (Proposed Action): Reclamation will estimate annual water supply available for proposed irrigation and refuge deliveries using the following criteria:

Upper Klamath Lake, Gerber Reservoir, and Clear Lake: Regardless of water year type, lake levels no lower than the average end-of-month elevations for the ten- year period.

Klamath River flows below Iron Gate Dam differ based on water year type.
For above average and below average years – daily average river flows no lower than their respective ten-year minimums or FERC flows, whichever is greater (as proposed in step 2 above).
For dry and critical dry years – daily average river flows no lower than their actual, observed ten- year averages plus a pulse of water to facilitate smolt downstream migration (10,000 acre feet in April).

Reclamation proposes operating to the 10-year averages rather than the 10-year minimums pursuant to its 7(a)(1) duty to conserve species and in furtherance of its tribal trust obligations. Maintenance of precise lake levels and river flows are not the actions upon which Reclamation is consulting under this Biological Assessment; rather, the above criteria provide boundaries for the proposed action based on observed values for lake levels and river flows that occurred during the 10-year period. Experience has shown that hydrologic conditions can and do occur that will result in lake levels and/or river flows exceeding the operating criteria.

Step 4 Determine Water Bank Requirements. Implementation of the proposed action will require the use of a Project water bank. The size of the water bank will be determined by calculating the difference in Project water supply between the proposed operations (Step 3, above) and preliminary calculations (step 2, above). Reclamation anticipates annual water bank requirements of up to 100,000 acre feet, depending on year type.

At this time, Reclamation believes several sources, including offstream storage, irrigation demand reduction, and groundwater, hold promise and may aid in establishing the water bank. Offstream storage opportunities may include Agency Lake Ranch, Lower Klamath area lands, and winter storage in the Tule Lake area. Irrigation demand reduction would involve compensating farmers to idle their lands in any given year. Groundwater or conjunctive use will involve use of wells to supplement surface supplies.

2.3.2.4 Coordination

Reclamation will meet with the USFWS, NMFS, Klamath Basin Tribes, PacifiCorp, and irrigation districts on a periodic basis, as needed, to coordinate activities and discuss water supply conditions, species status, and available options for Project operation. Reclamation will work with the USFWS and NMFS to jointly prepare an annual report documenting the preceding year’s activities and accomplishments.

2.3.2.5 Reduce Fish Entrainment into the A-Canal from Upper Klamath Lake and Provide Fish Passage at Link River Dam

a. Entrainment Reduction

Entrainment of endangered suckers and lack of connectivity between sucker populations have been identified as some of the major effects of Project operations. Reclamation defers to the judgment of USFWS with respect to the benefits of the screens. Based on prior recommendations by USFWS that screens be installed, Reclamation proposes to prepare for Service approval a multi-year plan to design and install screens and ladders at other diversions in the Project service area by January 1, 2003. Reclamation has already begun a process to screen the A-Canal. Reclamation will prepare final designs for a permanent fish screen at the A-Canal headworks by September 1, 2002. Construction is proposed to begin by December 1, 2002, and to be completed and operational by the beginning of the irrigation season on April 1, 2004.

Reclamation shall continue to conduct annual salvage of suckers stranded below outlet structures of dams and in the canal systems. Salvage operations shall be conducted in a manner consistent with efforts during previous years. Annual reports describing salvage operations shall be prepared by Reclamation and sent to the USFWS, California Department of Fish and Game, Oregon Department of Fish and Wildlife, and Klamath Tribes by January 1 of each year.

b. Fish Passage at Link River Dam

Reclamation proposes to study and implement specific measures to provide fish passage at Link River Dam. Reclamation completed a draft conceptual Link River fish passage plan in May 2001 for Service review and comment. Final fish passage designs will be prepared by January 2004. Final design will be coordinated with the results of a two-year study starting in 2002. Reclamation anticipates that installation of fish passage will be completed within two years after approval of the final designs. The estimated completion date is January 2006.

2.3.2.6 Implement Klamath Basin Water Supply Enhancement Act (Public Law 106-498)

Reclamation proposes to undertake feasibility studies authorized by the Klamath Basin Water Supply Enhancement Act to study enhancing the water supply available for Project use. Such studies will include, but will not necessarily be limited to: (1) increasing the water storage capacity of Gerber Reservoir and Upper Klamath Lake; (2) developing off-stream water storage in the Lower Klamath Lake area; and (3) a water storage leasing program. Implementation of actual projects and/or programs would be contingent upon the results of the feasibility studies, Congressional approval, authorization, and appropriation, and completion of appropriate environmental compliance activities.

2.3.2.7 Operation of Klamath Basin National Wildlife Refuge Complex

This complex of national wildlife refuges includes Tule Lake, Lower Klamath Lake, Upper Klamath Lake and Clear Lake National Wildlife Refuges. These refuges are under the jurisdiction of the USFWS and their operation is subject to the USFWS management and control. This assessment describes only those effects upon the refuge complex that result from operation of the Klamath Project and not the effects of refuge operation. For the purposes of this BA only, Reclamation has included the effects of water use on these refuges within the effects of the Klamath Project as interrelated and interdependent activities.

CHAPTER 3.0 - LISTED SPECIES POTENTIALLY AFFECTED BY THE PROPOSED ACTION

3.1 LISTED SPECIES FOUND IN ACTION AREA

The Southern Oregon/Northern California Coast coho salmon (SONCC) Evolutionary Significant Unit (ESU) (*Oncorhynchus kisutch*) was listed as threatened under the ESA on May 6, 1997. The listing of these stocks was NMFS's response to abrupt declines in their abundance, particularly during the last decade. The designation of critical habitat for the stocks within the above-mentioned ESU followed in May 1999. The Lost River sucker (LRS) (*Deltistes luxatus*) and shortnose sucker (SNS) (*Chasmistes brevirostris*) were listed as endangered on July 18, 1988. Critical habitat for the endangered suckers was proposed December 1, 1994. A final designation has not been made.

The bald eagle (*Haliaeetus leucocephalus*) was listed as endangered in most states and as threatened in Oregon on February 14, 1978. Due to range-wide trend of increasing populations, the bald eagle was proposed for delisting in 1999. No final status has been determined. There is no critical habitat designated for bald eagles.

3.2 BALD EAGLE

3.2.1 Background

The bald eagle is a generalized predator/scavenger primarily adapted to edges of aquatic habitats (USFWS 2001). It weighs up to 12 pounds and has a wingspan of 6-7 feet. Its primary foods are fish, waterfowl, carrion, and small mammals. 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 about 4 feet wide and 3 feet deep. Often eagles have an additional alternate nest in their territory. They can occupy nesting territories and nests for twenty or more years. Eagles generally mate for life but will replace lost mates readily. Eagles lay an average of 1-3 eggs. If adequate prey is not available during brooding, only the largest nestling may survive. Young fledge (first fly) in approximately 10-12 weeks by may take another 4 weeks to become proficient at flight. Within several weeks of flight proficiency the young are generally self-sufficient and can find food on their own, though they often remain near their parents nesting territory.

Bald eagles require year-round access to food (USFWS 2001). Bald eagles that occupy nesting areas without winter access to food migrate from nesting areas to wintering areas with accessible food and night-roosting shelter for thermo-regulation and protection from disturbance. Immature or non-breeding adults often spend a longer period at wintering areas than do breeding adults.

During the late fall and winter, as many as 1,000 bald eagles from throughout the Pacific Northwest, western states and Canada migrate into the Upper Klamath Basin. The Klamath Basin contains approximately 25% of the nesting bald eagles in Oregon. Nests are widespread in the basin and are found at most of the Project reservoirs. Upper Klamath Lake has more than 20 nesting pairs of bald eagles.

More detailed information on description, life history, historic abundance, and distribution of the bald eagle were described in the February 13, 2001 biological assessment (Reclamation 2001) and April 5 biological opinion (USFWS 2001).

3.3 LOST RIVER AND SHORTNOSE SUCKERS

3.3.1 Background

Historically, Lost River and shortnose suckers were abundant in Upper Klamath Lake and were utilized as a subsistence fishery by the Klamath Tribes. In the 1900's, the suckers were subjected to a snag fishery on spawning adults. Over the period from 1966 to 1986, the annual harvest of fish declined 95 percent from about 12,500 to 687 fish and several spawning groups went extinct (USFWS 1993). In 1988, when the species were listed as endangered the Williamson River/Sprague runs were estimated at less than 12,000 Lost River suckers and less than 3,000 shortnose suckers. Little information was known about the status of suckers in other Upper Klamath Basin lakes (USFWS 1993).

Both suckers are long-lived, up to 43 yr (LRS) and 33 yr (SNS), with a reproductive lifespan for females beginning at 6-9 yrs (LRS) and 4-7 yrs (SNS) (Perkins et al. 2000a). Females produce 20,000 to 200,000+ eggs per spawning season (Buettner and Scoppettone 1990). Spawning may not occur every year particularly for females (Perkins et al. 2000a).

Both species of suckers are lake dwelling but spawn in tributary streams or shoreline springs (Buettner and Scoppettone 1990). Sucker spawning can begin as early as February and continue through May. Tributary spawning generally occurs in riffle areas with moderate current and gravel/cobble substrate. In Upper Klamath Lake sucker spawn in shallow water at shoreline spring areas with coarse substrate.

The small eggs hatch in about 1-2 weeks and then remain in the substrate for another week. After absorbing most of their yolk, the larvae swim out of the gravel and migrate downstream (Buettner and Scoppettone 1990).

Larval suckers produced at lake shoreline and tributary stream spawning areas may be present from March through July (USFWS 2001). The larvae produced in tributaries usually spend relatively little time there and migrate back to the lake shortly after they hatch. Larval sucker migration from the spawning areas can begin as early as March but mostly occurs during May and June for Upper Klamath Lake. Larvae appear to be dependent on shallow shoreline areas; particularly those vegetated with emergent wetland plants (Cooperman and Markle 2000).

Larvae grow into juveniles (age 0) during the summer (usually by July) where they continue to occupy shoreline habitats in UKL including emergent vegetation, and un-vegetated areas particularly those with clean gravel and cobble substrates but not fine silty bottoms (Simon et al 2000). In late summer and early fall age 0 juveniles continue to occupy shoreline areas but also utilize open water habitat where all substrates are fine silts. Emergent vegetation is absent from some lakes supporting suckers including Clear Lake and Gerber Reservoir where juveniles occupy shoreline and open water habitats (Scoppettone et al. 1995, Reclamation 2001).

Older juveniles and adult suckers are found in open water areas typically at depths of greater than 3 feet (Peck 2000, USFWS 2001). In Upper Klamath Lake, they are mostly concentrated in the upper portion of the lake. During periods of poor water quality (low dissolved oxygen and high temperature, pH, and unionized ammonia) in UKL, many adult suckers occupy areas of better water quality adjacent to inflowing tributary streams and groundwater springs particularly near Pelican Bay (Peck 2000).

Poor water quality has been implicated as a cause of fish kills in 1995, 1996, and 1997 in UKL (Perkins et al. 2000b). The ultimate cause of the UKL water quality problem is excessive nutrients, especially nitrogen and phosphorus, due to natural inputs, external sources and internal loading. Sediment cores show increases in the sediment accumulation rate, nitrogen and phosphorus concentrations, and a shift toward the nuisance algae responsible for existing poor water quality over the last 50-100 years (Eilers et al. 2001).

Recent sucker information on biology, distribution and abundance, age and growth, habitat, water quality, entrainment, and genetics was described in the February 13, 2001 BA. Most of the pertinent habitat, fish population and water quality monitoring data collected in 2001 has not been reported yet.

3.3.2 New Information Related to Current Status

In 2001, adult population monitoring was conducted at the Chiloquin Dam fish ladder, lower Williamson River, shoreline spawning locations, and stations around UKL by USGS-Biological Resources Division (R. Shively, BRD, per. com.). Although sampling effort increased from 33 days in 2000 to 40 days in 2001, the total number of suckers captured in the ladder decreased from 1,576 to 697. The majority of the suckers captured were Klamath large-scale (48%) and Lost River suckers (42.5%), followed by shortnose suckers (3.5%) and undetermined species (6.0%). Large portions of suckers captured in the ladder in 2001 were untagged. Sixty-three suckers were recaptured mostly from prior years' sampling efforts at the ladder.

The longest and most consistent adult monitoring program has occurred in the lower Williamson River from 1995 through 2001 (U.S. Geological Survey 2001). In 2001, sampling occurred from February 13 to June 1 at four fixed locations. A total of 1,329 suckers were captured including 922 shortnose suckers, 281 Lost River suckers, 73 Klamath large-scale suckers and 49 fish with intermediate characteristics. Abundance index values were computed using catch rate data for the entire season allowing for comparison between years. The Lost River sucker index value was 16.5, the highest value since 1995 (35.5). The shortnose sucker index value was 37.4 which is higher than 1997-2000 (8.7-26.8) but lower than 1995 (258.8) and 1996 (119.2). One important consideration of these data is the relatively high percentage of spent fish captured in 2001. Approximately 50% of the shortnose and 25% of Lost River suckers were classified as spawned out. However, there appears to be a general increasing trend in abundance index values for both species since 1998 following the three fish kill years (1995-1997). This trend may be related to more complete recruitment of the 1991 and 1993 year-classes.

Shoreline spawning areas in UKL were sampled from mid-February through May 2001. A total of 1,553 Lost River and 30 shortnose suckers were captured. The overall catch of Lost River suckers was higher than in 2000 (1,258) but lower for shortnose suckers (68). A total of 201 Lost River and 10 shortnose suckers were captured that had been originally tagged in previous years' sampling. Most tagged fish were originally tagged and recaptured at shoreline spawning locations. Length frequency of male and female Lost River suckers sampled from shoreline areas had a similar pattern as the previous two years with a slight shift to the right. This suggests that the age class distribution may have not changed much for shoreline spawning groups. There does not appear to be major recruitment of younger age classes into the spawning population.

Additional sampling of adults occurred at 27 different locations in UKL from mid-February to June. A total of 1,237 suckers were collected with over half being captured in the Modoc/Goose Bay area. Most fish were identified as shortnose suckers (626) or Lost River suckers (422). There were also 81 Klamath large-scale suckers and 65 fish with intermediate characteristics between those species. The majority of the male Lost River and shortnose suckers were captured in “ripe” (ready to spawn) condition, while most females were either in a “pre-spawn” state or spawning condition was not apparent. After April 30, the majority of all suckers were found to be in a “spent” (spawned out) condition.

Oregon State University (OSU) monitored relative abundance of age 0 suckers in 2001. Annual year class strength indices for age 0 shortnose suckers were the lowest for 2001 in August and September. Annual year class strength was 2nd lowest in the month of October for the period 1995-2001 (D. Simon, OSU, per. com.). For age 0 Lost River suckers, 2001 ranked fourth out of 5 years, fourth out of 7 years in September and October. The low apparent recruitment in 2001 appears to be related in part to relatively poor spawning success since larval and early juvenile catch rates in spring and early summer were low.

Over the last decade, juvenile sucker abundance has been monitored in late summer. Since 1995, the effort has used a stratified random design to calculate a September index of year-class strength (Simon et al. 2000). Despite using different methodologies in 1991-1994, a September year-class strength index can be estimated for 1991 to 1994 based on the number of individuals caught adjusted by the effort used to catch them. When September year-class strength indices are arranged by July 15 elevation, it appears there is a relationship with lake level (Cooperman and Markle 2001). When lake elevation exceeds 4141.7 on July 15, the average Lost River sucker index is about two times higher than at lower elevations, and four times higher for shortnose sucker. The result is a probability distribution—higher lake elevations are more likely to produce higher indices but are not guaranteed to do so. For example, there are low water years (1991) when year-class strength was strong and high water years (1998) when year-class strength was poor. Those observations suggest that factors other than lake elevation are important.

Reclamation monitored water quality at several fixed sites in UKL from April through November 2001 using Hydrolab datasondes. Water temperature, dissolved oxygen, and pH was similar to that monitored during previous years (1992-2000). Dissolved oxygen and pH varied consistently with the state of blue-green algae growth in UKL. During June and July,2001, large amounts of *Aphanizomenon* were present leading to photosynthetically elevated pH (>9). During August and September algal decay cycles dominated resulting in lower pH (7-8) and dissolved oxygen values (3-5 mg/l). Stressful levels of pH (>9) and dissolved oxygen (<5 mg/l) occurred throughout most of the summer consistent with data from prior years. Extremely low dissolved oxygen concentrations (<3 mg/l) were measured at individual stations for short periods of time (< 1 week). Extended periods of windless or low wind days associated with previous fish die-off events did not occur in 2001. Only localized fish kills of sculpins and small chubs were documented by BRD and OSU field crews during the summer. No sucker die-offs occurred.

No sucker monitoring was conducted in Gerber Reservoir, Clear Lake, Tule Lake and the Lost River in 2001. OSU collected sucker larvae at a few locations in Lake Ewauna in 2001 but were unsuccessful in capturing juvenile suckers later in the summer.

National Research Council Peer Review

The National Research Council (NRC) completed a preliminary scientific and technical assessment of the 2001 biological assessments of the Bureau of Reclamation and biological opinions of the U.S. Fish and Wildlife Service and National Marine Fisheries Service regarding the effects of operations of the Bureau of Reclamation’s Klamath Project on endangered and threatened fishes of the Klamath River Basin. A draft interim report was released February 6, 2002 and is attached to this BA as Appendix B.

The NRC committee concluded:

"**All components of the biological opinion issued by the USFWS on the endangered suckers have substantial scientific support except for the recommendations concerning minimum water levels for Upper Klamath Lake. A substantial data-collection and analytical effort by multiple agencies, tribes, and other parties has not shown a clear connection between water level in Upper Klamath Lake and conditions that are adverse to the welfare of the suckers. Incidents of adult mortality (fish kills), for example, have not been associated with years of low water level. Also, extremes in chemical conditions considered threatening to the welfare of the fish have not coincided with years of low water level, and the highest recorded recruitment of new individuals into the adult populations occurred through reproduction in a year of low water level. Thus, the committee concludes that there is no scientific basis for recommending an operating regime for the Klamath Project that seeks to ensure lake levels higher on average than those occurring between 1990 and 2000. At the same time, the committee concludes that there is no scientific basis for operating the lake at mean minimum levels below the recent historical ones (1990-2000), as would be allowed under the USBR proposal. Operations leading to lower lake levels would require acceptance of undocumented risk to the suckers**."

3.4 COHO SALMON

3.4.1 Background

During the twentieth century, naturally produced populations of coho salmon have declined or have been extirpated in California, Oregon, and Washington. Limited information is available on historical coho salmon abundance in the Klamath River Basin. In 1983, the estimated spawning escapement was 15,000-20,000 which included hatchery stocks and were less than six percent of their estimated abundance in the 1940's. Klamath and Trinity Basin coho salmon runs are now composed largely of hatchery fish, although there may be wild runs remaining in some tributaries.

Coho salmon are anadromous salmonids that typically exhibit a 3-year life cycle almost equally divided between the freshwater and the sea phase. In the Klamath system coho normally spawn in tributary streams from November through February peaking in January. Some spawning occurs in the mainstem Klamath River in gravel/cobble riffle areas with moderate current.

Once spawning is complete, eggs incubate in the gravel for about 7 weeks before hatching. The time for egg incubation in the Klamath system is from November through March. Fish remain in the gravel as fry for about 2-3 weeks until the yolk is absorbed, then emerge as free-swimming actively feeding fry. Emergence typically occurs from February to mid-May.

Most coho salmon young remain in freshwater for at least one year before migrating to the ocean. Juvenile coho will initially take up residence in shallow, gravel areas near the streambank. Later in the summer fish will move into deeper pools seeking slow moving water and structure for cover. Coho fry are present in the mainstem Klamath River from at least April through late July and coho yearlings from mid-March through August. Coho salmon juveniles likely rear year-round in the mainstem.

Klamath River basin coho out-migrate from February through June with a peak usually in May. Peak numbers of coho smolts generally arrive in the Klamath River estuary in April and May. The number of fish declines to lower levels after May and remain low until October or November. Coho captured in the spring were smolts while fish captured in the fall were juveniles.

The major factors identified as responsible for the decline of coho salmon in the Klamath River Basin include logging, road building, grazing, dams, water withdrawals and unscreened diversions for irrigation. Other factors include mining, harvest, predation by seals and sea lions, hatchery practices, and mining.

More detailed information on description, life history, historical abundance and distribution for SONCC coho salmon addressed in this BA were described in the January 22, 2001 BA.

3.4.2. New Information Related to Current Status

Reclamation participated on a technical committee for the Hardy Phase II study to develop flow recommendations necessary to aid restoration efforts of aquatic resources within the mainstem Klamath River. This effort included the development of habitat versus flow relationships for various anadromous salmonids in the Klamath River, including coho salmon. Presently, the draft Phase II report is available for public review. Reclamation recognizes that there is a level of uncertainty with these relationships. For example, much of the recently developed site-specific habitat suitability criteria used data obtained during 1998 and 1999, which were "average" to "above average" water years with relatively high springtime river releases. However, in the absence of other available data, Chapter 5 (Effects Analysis for Coho Salmon) uses the Hardy II habitat-flow relationship data but does not use the Hardy II study's analyses or interpretation of that data.

New information related to the current status of coho salmon is also found at the end of Chapter 4.0 (section 4.5.2).

CHAPTER 4.0 - ENVIRONMENTAL BASELINE

4.1 INTRODUCTION

This chapter on the environmental baseline describes the impacts of past and ongoing human and natural factors leading to the present status of the species and its habitat within the action area. The environmental baseline provides, in effect, a "snapshot" of the relevant species' health at a specified point in time (i.e. the present). It does not include the effects of the discretionary action proposed in the current consultation, but it does include past and present impacts of all federal, state, or private actions and other human activities in the action area. 50 CFR § 402.02. For purposes of this BA, the current effects of all past activities include those associated with construction of the Project, historic operation of the Project, and the associated natural environment. The baseline also includes State, tribal, local, and private actions affecting the species or habitat and actions that will occur contemporaneously with the consultation in progress. The environmental baseline assists both the action agency and the Services in determining the effects of the proposed action on the listed species.

4.2 PAST AND PRESENT IMPACTS OF ALL FEDERAL, STATE OR PRIVATE ACTIONS AND OTHER HUMAN ACTIVITIES IN THE ACTION AREA

4.2.1 Impacts to Suckers

4.2.1.1 Impacts of Lake Modifications

Historically, Lost River and shortnose suckers occupied four lakes--Clear Lake, Tule Lake, Upper Klamath Lake, and Lower Klamath Lake--and their associated tributaries in the Upper Klamath Basin. Watershed development, including construction of the Klamath Project, associated agriculture and refuge development, and construction of dams on the Klamath River for hydroelectric power, substantially changed sucker habitat. New sucker habitat was created as a result of construction of Gerber, J.C. Boyle, Copco, and Iron Gate dams and reservoirs and sucker habitat at Clear Lake has expanded over time as a result of watershed development. In contrast, major reductions in habitat occurred at Tule Lake (75-90 percent reduction from pre-development levels) and Lower Klamath Lake (97 percent reduction). Moderate reductions (20-30 percent) in sucker habitat have occurred in Upper Klamath Lake.

Table 4.1 illustrates the changes in lake size in the Klamath Basin related to watershed development. Changes in lake size result in changes in available sucker habitat. In the late 1800s, prior to most watershed development, approximately 223,000-330,000 acres (276,000 average) of shallow lake and associated wetland habitat existed compared to 76,000-122,000 acres (99,000 average) now. Overall, suckers' lake habitat has decreased approximately 64 percent (177,000 acres) over the last century. 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, but was also attributable to suckers' blocked access to spawning and rearing areas and entrainment losses resulting from diversions. The following section discusses changes in habitat and impacts on suckers at each of the lakes.

Table 4.1 - Changes in lake size in the Klamath Basin related to watershed development.		
Water Body	Historic size (acres)	Present size (acres)
Upper Klamath Lake	78,000-111,000	55,000-77,593
Lower Klamath Lake	85,000-94,000	4,700
Clear Lake	15,000	8,500-25,760
Tule Lake	55,000-110,000	9,450-13,000
Gerber Reservoir	--	1,076-3,870
J.C. Boyle Reservoir	--	420
Copco No. 1 Reservoir	--	1,000
Copco No. 2 Reservoir	--	40
Iron Gate Reservoir	--	944
TOTAL	233,000-330,000	81,130-127,327

Upper Klamath Lake

Upper Klamath Lake was modified when the predecessor to PacifiCorp constructed Link River Dam in 1921 and cut a channel through the rock reef at the lake outlet as part of the Project. Water levels before Project development ranged from about 4140 feet to 4143 feet, but fluctuated between 4137 feet and 4143 feet after the Project was developed. In general, during years when lake levels dropped below 4140, less habitat was available for shoreline spawning, larval and juvenile rearing, juvenile and adult open water, and water quality refuge than historically available.

Historically, approximately 111,000 acres of lake and marsh habitat existed at pre-development maximum elevation, compared to 78,000 acres now (30 percent reduction). Private, non-Project agricultural development by landowners around Upper Klamath Lake accounted for all of this reduction in available sucker habitat. The reduction in marsh habitat may have resulted in lower survival of larval and juvenile suckers and smaller sized year classes which could then lower overall sucker populations.

Refer to Section 4.2.1.2 for a more detailed discussion of impacts of UKL modifications.

Clear Lake

Historically, Clear Lake was approximately 15,000 acres with about 5,000 acres of wetlands at elevation 4523. Clear Lake Dam was constructed as part of the Project in 1910 increasing the storage capacity, depth and area of this lake. At maximum elevation (4543), the lake covers 25,760 acres, an increase of approximately 10,000 acres (66%). At a minimum elevation of 4519, the surface area of the lake is 8,500 acres. At an elevation of 4528 (average post-project elevation), there are 21,200 acres of lake habitat, representing a 41% increase in area over the pre-Project area. Wetlands are currently absent from Clear Lake due to substantial fluctuations in water levels associated with Project operation. It is estimated that with more lake habitat and better access to spawning tributaries, sucker populations likely increased substantially as a result of Clear Lake Dam construction.

Tule Lake

Pre-development, Tule Lake varied substantially in size due largely to its connection with the Klamath River (55,000-110,000 acres). During high runoff periods, water from the Klamath River flowed into the Lost River Slough and down the Lost River to Tule Lake. Much of the historic Tule Lake lakebed was reclaimed for Project agriculture development during the first 60 years of the twentieth century. Present shallow lake and marsh habitat in two sumps (1A and 1B) range from 9,450-13,000 acres.

In 2000, Sump 1B (3,550 acres) was drained as part of a wetland restoration project by the USFWS (Tule Lake National Wildlife Refuge). Plans are to reconnect it to Sump 1A in a few years, after the emergent marsh has become well established. The USFWS also manages another 640 acres of demonstration and experimental marshes and 17,500 acres of agricultural lease lands that were lake habitat before most of Tule Lake was drained. Large sucker populations (Howe 1968) declined to very low numbers as a result of draining most of Tule Lake for agricultural development (Scoppettone et al. 1995). Not only was the lake habitat reduced to a fraction of its former size, but access to spawning areas in the Lost River was blocked by Project diversion dams.

Lower Klamath Lake

Lower Klamath Lake once covered 85,000-94,000 acres but included only about 30,000 acres of open water habitat. Development associated with the Project eliminated most of this habitat. Currently, there are only 4,700 acres of permanently flooded open water and wetland habitat. This includes about 2,475 acres in Keno Reservoir (Lake Ewauna and Klamath River to Keno Dam), with the remainder in Lower Klamath National Wildlife Refuge (2,225 acres). The USFWS also manages 21,105 acres of wetlands and 14,400 acres of agricultural lease and cooperative farmland that were part of pre-Project Lower Klamath Lake. Draining and reclaiming Lower Klamath Lake areas resulted in the extirpation of sucker populations in Lower Klamath Lake. The remaining open water habitat is too shallow to support suckers.

Gerber Reservoir

Gerber Reservoir was constructed in 1926 as a storage reservoir for the Project. Prior to its construction, there were approximately 3,500 acres of seasonal wetlands but no permanent lake habitat. At maximum elevation of 4836, there are 3,870 acres. Historic wetland habitat was transformed to deep open water habitat. No shoreline wetlands are present due to large fluctuations in water level. Construction of this reservoir resulted in the expansion of shortnose sucker populations in the Lost River watershed. A relatively large population of suckers has become established where none existed before the reservoir was built.

Other Areas

Additional lake habitats that support sucker populations were developed along the Klamath River as part of the PacifiCorp Hydroelectric Project. Four reservoirs were constructed, including J.C. Boyle, Copco 1 and 2, and Iron Gate, which are 420, 1000, 40, and 944 acres respectively. No lake habitat existed in the Klamath River below Keno historically. Sucker populations have expanded into these lake habitats although it appears that only those in J.C. Boyle are successfully reproducing. Fish in the other reservoirs likely moved from upstream areas. Populations are generally small compared to those in Upper Klamath Lake, Gerber Reservoir, and Clear Lake. Resident sucker populations have also become established in impounded areas of the Lost River including Wilson Reservoir (1912; Project dam) and Harpold Reservoir (1924; Horsefly Irrigation District).

4.2.1.2 Impacts of Upper Klamath Lake Modifications

Extensive conversion of Upper Klamath Lake peripheral wetlands has occurred over the last century due to mostly private non-Project agricultural development (Table 4.2). The littoral wetland area of the lake once comprised 51,510 acres (46 percent) of the total lake area of 111,510 acres at maximum elevation (Geiger 2001). The historical records of lake fluctuation prior to construction of the Link River Dam in 1921 document the lake fluctuating between a maximum of 4143.0 and a minimum of 4140.0. Following dam construction and after the last diking and draining of wetlands in 1968 (Snyder and Morace 1997), the lake area at maximum elevation of 4143.3 had decreased to 77,590 acres, and littoral marsh area decreased to 17,370 acres (22% of the total lake area). The lake lost 30% of its area and the associated lake volume through diking and draining. The in-lake wetland area was reduced by 66% (34,000 acres). In addition, there was a reduction of littoral lake volume from 82,000 a-f to 28,000 a-f; a 66% reduction.

Historic operation of the Project (1961-1997) has resulted in occasional lowering of Upper Klamath Lake levels to 4137.0 compared to 4140.0 before Link River Dam was constructed. The wetland area inundated at the pre-dam minimum of 4140.0 was 20,300 or 40% of the wetland area inundated at maximum elevation. Post-project wetland area inundated at maximum elevation is 17,370 acres versus approximately 500 acres at minimum elevation of 4137.0 or 3%. Open water area was nearly the same at maximum elevation before and after Project construction (60,000 acres, 4143.3). At the pre-dam minimum elevation of 4140.0 there were 47,400 acres of open water area compared to 55,800 acres after diking and dam construction (4137.0). This change represents a 7% increase in open water area at minimum lake elevation.

Table 4.2 - Wetlands adjacent to Upper Klamath Lake converted to agricultural land[1].

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

[1] Approximately 8,000 acres, primarily in the Wood River watershed, were converted but are not accounted for in this table.

Not only has non-Project development resulted in a loss of lake surface and wetland area, the most important wetland areas providing sucker habitat in the lower reaches of the Williamson River and in UKL near the Williamson River mouth are now thin bands of vegetation perched at relatively high elevations adjacent to dikes. While approximately 100% of the marsh habitat is available in undisturbed marsh areas at 4142, the marsh habitat in the lower Williamson River and in the lake near the mouth of the Williamson River diminished by about 50%. This difference in habitat inundation is essentially due to the difference in width and elevation gradient between the northern marshes and the narrow shoreline marshes near the Williamson. As a result of wetland habitat loss and the remaining habitat's high elevation, any lowering of the lake has reduced the amount of larval rearing habitat. This loss is considered to be one factor that has affected survival of larval suckers and resulted in smaller year classes.

Major modifications were made to several UKL stream/river deltas (Williamson River, Wood River, Seven Mile Creek, Four Mile Creek) through mostly private, non-Project agricultural development during the twentieth century. Wetland areas near the mouth of these tributaries were diked and drained, and approximately 20 miles of narrow meandering river channels were straightened, rerouted, widened and disconnected from adjacent wetlands. Riparian corridors lined with willows and cottonwood trees were cleared. The delta areas performed several important ecosystem functions including providing passage corridors for migrating fish, nursery habitat for larvae and juvenile suckers, rearing and feeding areas for juveniles, refuge habitat for juvenile and adult suckers during periods of poor water quality in UKL and water quality improvement by nutrient and sediment removal in the wetlands.

A large tributary delta restoration project has been completed by the Bureau of Land Management (Wood River) and a pilot river restoration project has been initiated by the Nature Conservancy on the Williamson River. This will improve emergent vegetation habitat in these rivers.

Historically, there were many shoreline springs that were important spawning areas for Lost River and shortnose suckers including Barkley Springs, Odessa Springs, Harriman Springs, Sucker Springs and several others along the east side of UKL. Sucker spawning currently occurs at only a few areas including Sucker Springs, Silver Building Springs, Ouxy Springs, Cinder Flat and Boulder Springs. Spawning substrate was added to Sucker Springs and Silver Building Springs in the 1980s by several entities to improve spawning success. These additions were made at relatively high elevations along the shoreline. Harriman Springs on the west side of Upper Klamath Lake was degraded by increased sedimentation resulting from watershed activities including logging, grazing, residential development and channelization of Four Mile Creek. Barkley Springs were extensively modified by Klamath County for park development. Harvest of suckers prior to closure of the fishery (1987) reduced population levels at several of these springs. Shoreline spawning success also may have been reduced by this habitat degradation.

Shoreline spawning habitat at springs along the eastern shoreline of UKL was negatively impacted by construction of the Southern Pacific railroad about 1912 along the shoreline between Modoc Point and Algoma (about 5 miles). Natural cobble and gravel shoreline substrate was covered with large boulder riprap. Substrate recruitment from the steep escarpment has been eliminated.

UKL tributaries, important spawning habitat for suckers, have been dramatically altered over the last century by non-Project land use practices in the watershed. Agriculture, grazing, logging, road construction, flood control projects and residential development have resulted in degradation of over 100 miles of historic sucker spawning and rearing habitat along the Williamson River, Sprague River, Wood River, Seven Mile Creek and Four Mile Creek (USFWS 2001). Sucker spawning and rearing habitat alterations in these locations include increased sedimentation and nutrient loading, increased temperatures, channel modifications (diking, straightening, widening, deepening), loss of riparian vegetation, flow reductions and changes in the hydrograph (steeper with higher peak flows and lower minimum flows). Increased nutrient loading led to larger algae blooms and associated poor water quality.

4.2.1.3 Impacts of Water Diversions and Diversion Structures

Irrigation, recreation, fish and wildlife, and power production are the major uses of surface water in the Upper Klamath Basin. Domestic, municipal, and industrial uses are small in relation to Basin yield. Over 95% of the consumptive use of water in the Klamath Basin is for agricultural purposes (Oregon State Water Resources Board 1971). However, depletion by consumptive use in irrigation and reservoir evaporation is estimated to be only 9% of the total annual Klamath River runoff into the Pacific Ocean (Klamath River Compact Commission 1956).

Approximately 240,000 acres of irrigable agricultural lands are within the Project service area. An average of about 200,000 acres of Project lands are currently being irrigated. Irrigable lands above the Project include about 25,000 acres in the Lost River watershed (Reclamation 1970a, 1970b, 1970c) and 150,000 acres in the Upper Klamath Lake watershed (Risley and Leanen 1999; Geiger et al. 2000). Of that, over 100,000 acres of irrigable lands are located in the Sprague River and Williamson River watersheds above Upper Klamath Lake (Table 4.3). The diversion of water from areas of sucker habitat, for consumptive uses has affected habitat for endangered suckers. Impacts include reductions in and degradation of spawning and rearing habitat, water quality degradation, entrainment, isolation of populations, and increased risk of hybridization. All of these factors have contributed to the present condition of sucker populations (FWS 2001).

Table 4.3 - Annual non-project irrigated land acreage permitted by the Oregon Dept. of Water Resources in the Williamson/Sprague River basin, Oregon (Risely and Leanen 1999)

YEAR	ACRES
1880	5,000
1890	7,000
1900	10,000
1910	15,000
1920	17,000
1930	30,000
1940	32,000
1950	33,000
1960	50,000
1970	75,000
1980	100,000
1990	110,000

4.2.1.4 Barriers to Upstream Passage

Dams block sucker migration corridors, isolate population segments, concentrate suckers in limited spawning areas increasing the likelihood of hybridization between species, may result in stream channel changes, and alter water quality and provide habitat for exotic fish that prey on suckers or compete with them for food and habitat. 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. However, not all sucker populations move upstream or downstream, choosing instead to hold and use existing areas.

Only Link River Dam has a fish ladder and, although suckers have been observed in the ladder, it has been deemed inadequate for sucker passage. There are at least 16 non-Project dams that block or restrict upstream access for suckers within the range of the endangered suckers.

The most significant non-Project dam with inadequate upstream passage facilities within historic sucker habitat is the Sprague River Dam (Chiloquin Dam), located 12 miles upstream of UKL. This dam has a partially effective fish ladder that is negotiated by some endangered suckers. Approximately 60 miles of proposed critical habitat in the Sprague River lie above the dam.

In the Gerber Reservoir watershed, fish passage is 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.

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.

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, 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.

PacifiCorp owns and 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 the ladders, they were not designed for sucker passage and generally are inadequate for sucker passage. Access to about 54 miles of river habitat is blocked or restricted by these dams.

Several removable fish ladders have been installed at irrigation diversion dams in the Wood River Valley along the Wood River and Seven Mile Creek. It is not known if these ladders are passable by endangered suckers.

Overall, non-Project dams block or restrict upstream passage and connectivity to approximately 175 miles of stream spawning and rearing habitat. Project dams block access to approximately 100 miles of stream habitat. These dams have prevented fish from migrating to historic spawning and rearing areas, likely leading to lower spawning success and survival of all life stages.

4.2.1.5 Unscreened Diversions

Reclamation identified 221 diversions within the Project service area including Upper Klamath Lake that are directly connected to endangered sucker habitat (Reclamation 2001; Table 4.4).

Table 4.4 - Diversions within the upper Klamath River basin that potentially entrain endangered suckers (not including the Sprague or Wood Rivers).

Owner	Number	% (no.)
Private	165	75
Irrigation districts	26	12
Reclamation	16	7
State	8	4
USFWS	5	2
BLM	2	1
TOTAL	221	100

Reclamation has only 16 diversions (7%) but has the highest potential entrainment because most diversions are large gravity and pump diversions delivering water to approximately 200,000 acres of agricultural lands (Reclamation 2001). There are about 165 private diversions or 75% of the total number of diversions. Most are small pump diversions delivering water to relatively small parcels of land along the Lost River and Klamath River to Keno. Irrigation district diversions within the project make up 12% of the total number.

Diversions around Upper Klamath Lake have the highest potential to entrain suckers because they are adjacent to river and lake shoreline habitats that have relatively high densities of suckers. There are about 25 diversions around UKL including the lower reaches of the Wood River, Seven Mile Canal, and the Williamson River under lake level influence. Reclamation has the largest diversion serving 7,200 acres

(Agency Lake Ranch). This 100 cfs diversion was screened in 2001. The remaining diversions (non-Project) diverting water to approximately 23,000 acres of agricultural lands and managed wetlands are unscreened.

The largest source of sucker entrainment is at the A-Canal at the lower end of UKL. This Project facility, constructed in 1906, diverts 400-1,000 cfs during the April through October irrigation period. In 1996 and 1997, entrainment estimates were 3 million and 1.7 million sucker larvae, respectively (Gutermuth et al. 2000). Juvenile and adult sucker entrainment estimates were 47,000 in 1997 and 250,000 in 1998. Entrainment is a function of total lake outflow. The higher entrainment rates of suckers in 1998 correspond to a period of higher total lake outflow than in 1997. High entrainment may also be related to fish seeking to escape poor water quality conditions in UKL. Reclamation is currently developing designs for a fish screen facility to be installed by April 2004.

Entrainment itself accounts for a substantial component of the age 0 juvenile mortality in UKL (USFWS 2001). Large numbers of suckers are entrained at the Eastside and Westside diversions at Link River Dam each year. Fish entrainment at the two diversions on Link River Dam (PacifiCorp) was 21,000 (1997), 82,000 (1998), and 41,000 (1999) with most suckers age 0. However, dependent on size of fish and flow through the powerhouse, not all fish will perish. The total entrainment estimates for A-Canal and the two Link River canals approach the total population estimate of age 0 suckers derived from lake sampling by Oregon State University (Simon and Markle 2001). The OSU age 0 sucker population estimates from August 1997 and 1998 were 82,000 and 665,000 respectively. The combined A-Canal and Link River entrainment indices for age 0 suckers in 1997 and 1998 were 64,000 and 328,000 with most suckers caught in August and September.

4.2.1.6 Impacts of Water Quality

Upper Klamath Lake Watershed

Upper Klamath Lake is the primary water supply reservoir for the Project. It also supports the largest populations of endangered Lost River and shortnose suckers. However, 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 (USFWS 2001). Previous investigations have shown that the lake has been productive for thousands of years (Sanville et al. 1974). This view of the lake as a naturally eutrophic (rich in nutrients and supporting high abundances of suspended algae) system is consistent with its shallow morphology, deep organic-rich sediments, and its large watershed with phosphorus-enriched soils. Watershed development, beginning in the late-1800s and accelerating though the 1900s is strongly implicated as the cause of the lake's current hypereutrophic (exaggerated state of eutrophication) character (Bortleson and Fretwell 1993). The poor water quality associated with massive algae blooms has led to major declines in Upper Klamath Lake sucker populations over the last several decades.

Recent sediment core studies indicated a substantial increase in sediment accumulation rates and nutrient concentration over the last 150 years corresponding with increases in erosion input from the watershed (Eilers et al. 2001). Sediment accumulation rates have increased from about 18 g/m2/year in 1880 to a high of 120 g/m2/year in 1995 (Table 4.5). The changes in sediment composition 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. Blue-green algae (*Aphanizomenon flos-aquae)*--absent from the lake a century ago--showed major increases during the twentieth century and is now the dominant bloom-forming species.

Table 4.5 - Sediment accumulation rate from Upper Klamath Lake sediment core analysis (grams/m^2/year; Eilers et al 2001).	
Year	Sediment Accumulation Rate
1880	18
1900	20
1920	20
1940	30
1960	40
1980	60
1995	120

In the upstream basin, livestock, particularly cattle, have heavily grazed flood plains, wetlands, forest, rangelands, and riparian corridors, resulting in the degradation of these areas. Grazing by cattle has contributed to accelerated erosion (sediment accumulation) and nutrient loading in the upper Klamath River basin, and especially to Upper Klamath Lake. 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 4.6). Cattle production is currently near 120,000 head (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. In the Sprague River Valley approximately 20,000 head graze on pastures in summer and approximately 1,500 head graze during winter.

Table 4.6 - Cattle production in Klamath County, Oregon derived from U.S. Department of Commerce (Eilers et al. 2001)	
YEAR	# 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	120,000

Throughout the Klamath River 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. Logging and road building practices in the past did not often provide for adequate soil stabilization and erosion control. Approximately 80 percent of the upper basin is forested, and intensive, even-aged timber harvesting methods (such as clear cutting) have been used. Timber harvest activities were most active from 1925 to 1945, reaching a maximum production in excess of 800 million board feet (mmbf) annually (Risley and Leanen 1999). Timber harvest production declined to about 200 mmbf in 1960 and has stabilized near 400 mmbf annually since 1970. Timber harvest in Klamath County, which represents about double the area of the Williamson River watershed, increased dramatically from about 120 mmbf in 1920 to 800 mmbf in 1940 (Table 4.7). Timber harvest and associated roads have contributed to the high sediment and nutrient inputs to UKL from tributary watersheds.

Table 4.7- Approximate annual timber harvest in Klamath County, Oregon in million board feet (mmbf) (Risley and Leanen 1999).

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

Accelerated phosphorus loading is a key factor driving the massive blue-green algae blooms that now dominate UKL nearly continuously from June through October. Although nitrogen is also important in structuring algae communities and determining biomass, in UKL *Aphanizomenon* is able to satisfy its nitrogen needs through nitrogen fixation in what may otherwise be a nitrogen-limiting situation.

Despite high background phosphorus levels in Upper Klamath Basin tributaries, data exists from several studies to indicate that phosphorus loading and concentrations are elevated substantially above these background levels (Miller and Tash 1967; USACE 1982; Reclamation 1993; Kann and Walker 1999). Walker estimated that an increase in Agency Lake inflow concentration from 81 to 144 ppb total phosphorus is the estimate of the anthropogenic impact (Walker 1995). Kann and Walker (1999) estimated that approximately 40% of the phosphorus load to UKL can be attributed to man-caused sources.

Nutrient loading studies indicate that despite contributing only 3% of the water inflow (43,000 af/year), direct agricultural input from pumps 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). The Sprague and Williamson rivers accounted for 51% of the average annual inflow (743,000 af/year) and 48% of the phosphorus load (86 metric tons/year). Seven Mile Creek and Wood River contributed 9% and 19% respectively of the average total phosphorus load. The disproportionate loadings from the smaller Seven Mile Creek and Wood River drainages illustrate the management importance of these areas. For example, phosphorus unit area loads for the Wood River and Seven Mile Creek were 237 and 156 kg/km2 respectively, which are an order of magnitude higher than those for the Williamson River watershed. Agricultural pump loading around UKL were also very high (188 kg/km2).

Over 34,000 acres of wetlands (66% reduction) were isolated from UKL through diking and draining for non-Project agricultural development. Approximately 15,000 acres of this total are in the process of being reclaimed to wetland but remain unconnected to UKL. The disassociation of the wetlands from the lake has meant a substantial loss of nitrogen and phosphorus 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 because of wetland plant senescence and decomposition. Wetlands remove nutrients during the summer growing season. The timing of nutrient release and uptake is an important factor in the lake’s water quality dynamics.

Wetlands also may affect water quality through production and release of decomposition products, particularly dissolved humic substances that appear to inhibit *Aphanizomenon* growth. The absence or reduction of this algae species just downstream, at or within marsh environments has been noted at Hanks Marsh (Forbes 1997) and Upper Klamath National Wildlife Refuge (Sartoris et al. 1993). Perdue et al. (1981) noted the absence of *Aphanizomenon* in UKL at a location heavily influenced by the Williamson River. Both wetlands in the lake, reclaimed wetlands behind the dikes, and 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, would have resulted in lower lake concentrations of dissolved humic substances.

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). There is a large net internal loading occurring during late spring and early summer of each year. These large net internal loading events are generally followed by a substantial decline, indicating a large sedimentation event. Such events coincide with algal bloom crashes (Kann 1998). On average, internal loading was 60%, while external loading was 40%. Although there is a high contribution of internal phosphorus concentration during the algae growing season, it has been noted that the mobilization of phosphorus from iron has the potential to respond rapidly when primary productivity and pH maxima are reduced (Marsden 1989). The rapid response may be due to the reversal of the positive feedback mechanism associated with photosynthetically elevated pH. Elevated pH increases phosphorus release from the sediments to the water column by solubilizing iron-bound phosphorus in both bottom and re-suspended sediments as high pH causes increased competition between hydroxyl ions and phosphate ions decreasing the sorption of phosphate on iron. It appears that at a pH of about 9.3 the probability of internal loading sharply increases (Kann 1998). 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.

Accelerated sediment and nutrient loading to UKL resulting from land use practices 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 dissolved oxygen, and high ammonia) that increase fish stress, negatively impact fish health and increase the size and frequency of fish kills. Overall, sucker populations have declined largely due to this impact.

Oregon Department of Environmental Quality has identified nearly 25 stream segments flowing into UKL as being temperature limited (ODEQ 1998). Increased temperatures are symptomatic of degraded stream conditions resulting from loss of riparian vegetation and channel modifications associated with intensive grazing, flow reductions, and agricultural activities.

Lost River Watershed

The Clear Lake watershed is mostly publicly owned under the jurisdiction of the U.S. Forest Service (Modoc National Forest) and the USFWS (Clear Lake National Wildlife Refuge). Grazing is the primary land use. 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 over the past 10 years, improving stream habitat and water quality.

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 Bureau of Land Management (Klamath Resource Area). Section 7 consultations on the effects of grazing management and forestry on suckers and bald eagles have been completed by the two federal agencies. The condition of the watershed is relatively good because management focuses on the agencies to protect water quality and riparian areas. A few creeks, e.g. Barnes Valley and Lapham creeks, are listed for exceeding temperature criteria (ODEQ 1998). The impaired temperature regimes are a symptom of degraded riparian and floodplain conditions generally resulting from overgrazing.

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 above Malone Reservoir and generally poor downstream to Tule Lake. Water quality is seasonally poor owing to nutrients and sediment input. Most of the Lost River is listed on the ODEQs 303(d) list for water-quality limited streams for the following criteria: chlorophyll-a, dissolved oxygen, temperature, and fecal coliform.

4.2.1.7 Impacts of Introduced Species

Introduced fishes including fathead minnows, yellow perch, and brown bullhead have become established in UKL. Scoppettone and Vinyard (1991) reported 84.5 percent of the fish biomass in UKL is introduced species, and Logan and Markle (1993) reported the 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 Upper Klamath Lake 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 fishes. Since 1995, patterns have been more complex. In 1998, the year following the 1995-1997 fish kills, 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). Concern about the potential impacts of the fathead minnow on sucker larvae prompted studies to assess the predatory capabilities (Klamath Tribes 1995). The studies indicated that fathead minnows were effective predators on sucker larvae, particularly in shallow water and in other areas where hiding cover was not available. When water depth increased to about 2 feet, the surface orientation of the sucker larvae and the bottom orientation of the fathead minnows result in enough separation nearly to eliminate predation. Competition and predation by introduced fishes undoubtedly affect the current status of suckers in UKL.

There is evidence that at least Lost River suckers may have a resident population in the Sprague River (L. Dunsmoor, Klamath Tribes per. com.). Introduced fish in that area include largemouth bass, yellow perch, pumpkinseed, brown trout, and brook trout that may compete with and/or prey on these fish.

Introduced 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 and Gerber Reservoir watersheds (Buettner and Scoppettone 1991; Scoppettone et al. 1995; Reclamation 2000). Because relatively stable sucker populations co-exist with abundant non-native fish populations in Clear Lake and Gerber Reservoir, Reclamation does not consider exotic fish to be a major threat.

These same introduced fishes occur in the Lost River (Reclamation 2001; BRD 1999), Tule Lake (Scoppettone et al. 1995), and Klamath River (Desjardins and Markle 2000). 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 2001). Many of the introduced 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.

4.2.1.8 Impacts of Fish Harvest

Historically, the Klamath Tribes on UKL, UKL 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/Williamson and UKL springs (Andreasen 1975, Bienz and Ziller 1987). Over this period, the annual harvest of fish on the Sprague/Williamson 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 East Side of UKL were extirpated.

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). The Klamath Tribes stopped subsistence harvest of suckers in 1987, and the recreational snag fishery was closed about the same time.

Harvest of adult suckers was very detrimental to the Upper Klamath Lake sucker populations, which were already negatively affected by loss of spawning and rearing habitat and poor water quality. Several shoreline spawning groups likely were extirpated by removal of reproducing adults from the population.

4.2.1.9 Other Impacts

The effects of urban land use and chemical contamination, have been addressed in previous consultations and are included here by reference (USFWS 2001, Section III, Part 2, page 94).

4.2.2 Impacts on Salmon

4.2.2.1 Impacts of Actions Affecting Salmon Habitat

Historic salmon habitat in the Upper Klamath River Basin was blocked as early as 1889 at Klamathon near Iron Gate (KRBFTF 1991). Beginning in 1910, the Federal Bureau of Fisheries installed a fish rack to capture salmon eggs, leaving little chance for passage of upstream migrants after that time. In 1917, the construction of Copco Dam formed a complete block to upstream migration and the loss of over 75 miles of habitat in the Klamath River plus tributaries as far upstream as above Upper Klamath Lake.

Mining activities within the Klamath Basin began before 1900 (KRBFTF 1991). Water was diverted and pumped for use in sluicing and hydraulic mining operations. This resulted in dramatic increases in silt levels altering stream morphology and degrading spawning and rearing areas. The mining activities may have had a greater negative impact to the salmon fishery than the large fish canneries of the era. Since the 1970s, mining operation have been curtailed due to stricter environmental regulations. However, mining operations in some of the Klamath River tributaries continue, including suction dredging, placer mining, gravel mining, and lode mining. These operations can adversely affect spawning gravels, decrease survival of eggs and juvenile fish, decrease the abundance of bottom food organisms, adversely affect water quality, and impact stream banks and channels.

Roads associated with timber harvesting and timber management activities have contributed to erosion and increases in sedimentation in streams causing degradation of spawning gravels, pool filling, reduced aquatic insect abundance, and changes in channel structure and habitat diversity.

4.2.2.2 Impacts of Water Diversions and Diversion Structures

a. Klamath River Mainstem

Beginning in the late 1800s, construction and operation of the numerous non-Project facilities and, beginning in 1906, Project facilities have changed the natural hydrographs of the mainstem Klamath River (Reclamation 2001b). Major Project diversion facilities include the A-Canal, Link River Dam, Lost River Diversion Dam, and the Lost River Diversion Channel. Non-Project facilities include Copco Nos. 1 and 2 Dams, J.C. Boyle Hydroelectric Dam, Iron Gate Dam and Keno Dam. Changes in the flow regime at Keno, Oregon, after the construction of the A-Canal, Link River Dam, and the Lost River Diversion Dam, can be seen in the 1930-to-present flow records. These changes have reduced average flows in summer months and altered the natural seasonal variation of flows to meet peak power and diversion demands (Hecht and Kamman 1996). Flows downstream from Iron Gate Dam affect the quantity and quality of aquatic habitat for coho salmon in the mainstem Klamath River in California.

Iron Gate Dam, located approximately at River Mile 190 on the mainstem Klamath River, was completed in 1962 and is owned and operated by PacifiCorp. Iron Gate Dam was constructed to re-regulate flow releases from the Copco facilities, but it did not restore the pre-project hydrograph. Minimum stream flows and ramping rate regimes were established in the FERC license covering operation of Iron Gate Dam. A fish hatchery was constructed by PacifiCorp as a mitigation measure for the loss of fish habitat between Iron Gate and Copco No. 2 Dams.

b. Klamath River Tributaries

Klamath River tributaries downstream of Iron Gate Dam provide habitat critical for coho salmon. Most coho spawning occurs in the tributary streams rather than in the mainstem of Klamath River. The mainstem serves primarily as a migratory pathway. Coho move into the tributaries with the onset of fall rains and increased flows. Suitable tributary flows are important to provide coho access to spawning habitat during their upstream migrations. Many coho attempt to migrate as far upstream as possible and then hold in deep pools near good spawning sites until they are ready to spawn a month or more after freshwater entry. Redds (spawning sites) must remain watered throughout the incubation period. After they emerge from the gravel in the spring the young fish disperse into the available habitat. During the year that juvenile coho spend in freshwater they utilize pools with good cover and cool water, which are predominantly in the tributaries. Cool water is critical for survival during the warm summer period. Many coho likely move downstream from the spawning location because coho generally spawn near the upstream extent of good rearing habitat. It is unlikely that significant numbers of coho enter the mainstem Klamath for summer rearing because tributary water temperatures are cooler. During winter when water temperature is below about 10 ^{o}C and high flows are more frequent, juvenile coho seek denser cover and lower water velocity than used during the summer. These conditions are often found in off-channel areas of the tributaries.

Outside of the Klamath Project, many Klamath River tributaries have been modified significantly, which affected coho populations. The natural hydrograph has been modified by water diversions in major tributaries such as the Shasta River, Scott River, Trinity River, Cottonwood Creek, and Bogus Creek. Many of the steeper watersheds have experienced substantial road building and timber harvest. Mining occurred historically and continues within active channels mostly in the form of small one or two person operations using portable dredges in areas such as the Scott River.

Agricultural diversions from major Klamath tributaries downstream of the project have resulted in summer flow conditions that eliminate a significant amount of juvenile rearing habitat. Agricultural diversions typically start during the spring and continue into the fall. During most years, spring flows are sufficient to maintain fish habitat and support the diversions. Coho generally rear near the area that they were spawned. When diversions begin in the spring of dry years, stream flow drops substantially and can strand fry or outmigrating smolts. As the summer progresses, and natural flows decrease, the diversions take a majority of the impaired flow. The coho downstream of diversions get forced into smaller habitat areas, water temperature increases with the lower water volume, and predation by other fish and terrestrial predators increases. The result is a much lowered survival of juvenile coho through the summer and fall period. While many diversions have been screened in recent years, there remain many unscreened diversions. Some coho rearing near the diversion points get diverted into agricultural fields or may get drawn into pumps and killed. During many years, the flows required to maintain fishery values and support heavy agricultural diversions simply are not in the system during the latter part of July, August, and September. Many streams would have critically low flow levels during this time even if no water were diverted.

During the fall when adult coho salmon begin their upstream migrations, flows from the tributaries are critical for providing access to the spawning areas in the tributaries. During dry years, such as occurred in 2001, flows in tributaries can be too low for adults to enter the rivers. They are then forced to hold in the mainstem Klamath River until flows increase enough to allow for upstream migration. Some tributaries contain difficult passage areas where low flows cause partial or total barriers to upstream migration. If coho are held back by low flows until ready to spawn they can spawn in areas lower in the watershed, but the amount of habitat available to the juveniles is then restricted to the lower reaches of the rivers. Diversion dams exist in some tributaries and impede upstream access by juveniles and adults.

4.2.2.3 Impacts of Water Quality

In addition to hydrologic changes caused by the activities discussed above, human activities have resulted in degraded water quality in the Klamath River basin. The main water quality problem for coho is high water temperature. 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 (SWRCB) proposed that the Klamath River be listed under the CWA as impaired for both temperature and nutrients, requiring the development of Total Maximum Daily Load (TMDL) limits and implementation plans. The United States Environmental Protection Agency (USEPA) and the 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 summer water temperatures and algae blooms associated with high nutrient loads, water impoundments, and agricultural water diversions (USEPA 1993). However, the Klamath River has probably always been a relatively warm river (Hecht and Kamman 1996).

Tributary influences to the Klamath River mainstem temperatures are seasonally important (Deas and Orlob 1999). During the spring, certain tributaries contribute significant inflow to the mainstem. By mid- to late spring, the tributary flow drops in response to irrigation demand, and tributary contributions to the mainstem are minor. In the summer and early fall, tributary flows are small relative to the mainstem flow. Locally, these tributaries may have an impact, but generally, they provide minor contribution to the water temperature of the system (Deas and Orlob 1999). Generally tributary water is cooler than the mainstem, and the tributary flows are much lower than the mainstem such that the higher mainstem flows mask the temperature benefits from the tributaries. The termination of irrigation in late fall results in increased inflow from major tributaries. These tributaries have small thermal mass relative to the Klamath River (and Iron Gate Reservoir), and thus cool quickly as the weather cools, providing thermal relief to the mainstem.

Dissolved oxygen sometimes falls to harmful levels below Iron Gate Dam at night during warm periods of the summer. This is caused by the high nutrient load from upstream sources causing increased algal growth in the warm water. The generally well-oxygenated tributary inflows can provide water quality refuge areas for coho salmon as they enter the mainstem Klamath River.

4.2.2.4 Incubation and rearing habitat for juveniles

Since developing eggs are very dependent on an adequate exchange of fresh water to provide oxygen and to remove metabolic wastes, inadequate flows can reduce egg survival (CDFG 1980). Flow reductions after spawning may even dewater some eggs. Coho salmon juveniles are very susceptible to habitat and flow conditions because they need to spend at least one full summer in the stream. Rearing habitat requires sufficient shelter, food, and water temperature. Reduced flows shrink the amount of shelter in pools as well as the quantity of streambed invertebrates available for food from the riffle areas. Lack of shelter also exposes the fish more to potential predators, such as heron and otter. All of these factors lower the number of fish the river can support (CDFG 1980). The large numbers of young steelhead and coho rescued by CDFG from drying tributaries and the main rivers (over 300,000 per year from the Scott Basin alone) indicates the significant loss of population occurring from this deprivation of habitat (Puckett 1982).

4.2.2.5 Impacts of Fish Harvest

Commercial fishing for salmon in the Klamath River had major impacts on populations as early as 1900. Commercial and recreational ocean troll fisheries, tribal subsistence fisheries, and in-river recreational fisheries have impacted salmon including coho throughout the 20th Century. Over-fishing was considered one of the greatest threats facing the Klamath River coho salmon populations in the past. However, these harvest rates probably would not have been as serious if spawning and rearing habitat was not so extensively reduced and degraded. Sport and commercial fishing restrictions ranging from severe curtailment to complete closure in recent years may be providing an increase in adult coho survival. The tribal harvest in the Klamath has been relatively small in the last five years and likely has not had a measurable effect on coho populations (NMFS 2001).

4.2.2.6 Impacts of Hatchery Programs

The Klamath and Trinity Basin coho salmon runs are now composed largely of hatchery fish, although there may still be wild fish remaining in some tributaries. Because of the predominance of hatchery stocks in the Klamath River Basin, stock transfers (use of spawn from coho salmon outside the Klamath River Basin) in the Trinity and Iron Gate Hatcheries may have had a substantial impact on natural populations in the basin. Artificial propagation can substantially affect the genetic integrity of natural salmon populations in several ways. First, stock transfers that result in interbreeding of hatchery and natural fish can lead to loss of fitness (survivability) in local populations and loss of diversity among populations (Weitkamp et al. 1995). Second, the hatchery salmon may change the mortality profile of the populations, leading to genetic change relative to wild populations that is not beneficial to the naturally reproducing fish. Third, hatchery fish may interfere with natural spawning and production by competing with natural fish for territory or mates. The presence of large numbers of hatchery juveniles or adults may also alter the selective regime faced by natural fish.

4.2.3 Impacts on Bald Eagles

This BA incorporates by reference the description of environmental baseline conditions for bald eagles in Reclamations February 13, 2001 biological assessment.

4.3 ANTICIPATED IMPACTS OF ALL PROPOSED FEDERAL ACTIONS IN THE ACTION AREA THAT HAVE ALREADY UNDERGONE EARLY OR FORMAL SECTION 7 CONSULTATION

All proposed Federal projects in the action area that have already undergone consultation are included in the baseline. In addition, for this consultation only, Reclamation has included in the environmental baseline depletion-related effects resulting from discretionary actions by other federal agencies that may not yet have been the subject of consultation. As more information is gathered about the status of these consultations, it may be appropriate to exclude any such effects from the environmental baseline in any future BA.

4.3.1. Operation of PacifiCorp's Klamath Hydroelectric Project FERC No. 2082

PacifiCorp operates its hydroelectric facilities at the Westside and Eastside power plants at Link River Dam, Keno Dam, J. C. Boyle Dam, Copco No. 1 and Copco No. 2, and Iron Gate Dam as described in the 1996 BA (Reclamation 1996). These facilities are operating pursuant to a license issued by the Federal Energy Regulatory Commission (FERC) that expires in 2006 and a biological opinion dated July 15, 1996 (USFWS 1996). PacifiCorp's operations are covered under the 1996 BO and are only included in the environmental baseline in this BA.

4.3.2. Operation of New Earth /Cell Tech Facilities

New Earth operates and maintains an algae harvesting and processing facility at the head end of the C-Canal under permit from Reclamation. A detailed description of these privately owned facilities is provided in the 1996 BA (Reclamation 1996a) and BO (USFWS 1996). New Earth's operations are only included in the environmental baseline in this BA.

4.4 IMPACT OF STATE OR PRIVATE ACTIONS THAT ARE CONTEMPORANEOUS WITH THE CONSULTATION

State or private actions that are contemporaneous with this consultation are also included in the environmental baseline. For purposes of this BA only, the effects of contemporaneous private actions of upstream depletions associated with water rights that may be junior or senior to those of the Project are included in the environmental baseline. All upstream depletions are occurring and have affected Upper Klamath Lake elevations, thus affecting the current status of listed species.

4.4.1 Beneficial State or Private Actions

In addition to the state and private actions discussed above, the following beneficial state or private action are also occurring contemporaneous with the consultation:

- The Nature Conservancy acquired approximately 8,000 acres of former wetlands around UKL (Tulana Farms and Goose Bay Farms) in the last five years. They have initiated wetland restoration projects on these properties. These projects are located adjacent to the Williamson River Delta.

- The Running Y Ranch Resort has initiated a wetland restoration project on former Caledonia Marsh adjacent to UKL (up to 500 acres).

- Fish screening and fish passage projects in the Wood River Valley, Sprague River, and Miller Island Wildlife Refuge by private landowners and the State of Oregon.

- Sycan Marsh Preserve wetland restoration oi the Sprague River watershed by The Nature Conservancy.

- Riparian and floodplain restoration in the Wood River Valley, Williamson River, Sprague River, and Clear Lake watersheds by private landowners and the agricultural community.

- Riparian and floodplain restoration in the Shasta River and Scott River areas by private landowners.

- Numerous fish screening and fish passage projects in the Shasta and Scott River valleys by private landowners and the State of California.

4.5 ENVIRONMENTAL BASELINE CONDITION

4.5.1 Baseline Condition of Lost River and Shortnose Suckers

4.5.1.1 Adult Sucker Data

There have been attempts to estimate the size and age structure of sucker populations in UKL (Bienz and Ziller 1987; USFWS 2001). However, confidence intervals are large, methodologies differ, and interpretation of these numbers should be cautious. At an order-of-magnitude scale, all of the estimates suggest adult populations between 1984 and 1997 are measured in the low thousands to low 100 thousands. Since 1997, no population estimates have been made but adult populations are probably at least in the low 10 thousands based on the numbers of fish captured in spawning run monitoring and relatively low tag recapture rates (M. Buettner, Reclamation ,per. com.). Because there are no reliable long-term adult population estimate data, abundance indices have been relied upon. For example, a Williamson River spawning abundance index was downward from 1995 to 1998 (Shively et al. 2001) consistent with three consecutive adult sucker kills during 1995, 1996, and 1997. In 2000 and 2001 abundance indices were higher than those in 1998 and 1999 but were lower than those in 1995 and 1996 (R. Shively, BRD, per. com.).

In the 1980's at the time of listing, the sucker populations in Upper Klamath Lake appeared limited by lack of juvenile recruitment and were heavily skewed to older fish, 18-28 years (Buettner and Scoppettone 1990). In the late 1990s, successful recruitment from 1991 and 1993 year classes brought in some younger fish (Cunningham and Shively 2000; USFWS 2001), but many older fish appear to have died prematurely, probably because of the fish kills in 1995, 1996, and 1997. Based on lengths of suckers entering the Williamson River in 2000 and 2001 (Cunningham and Shively 2001; R. Shively, BRD, per. com. 2002) and age frequency information from the fish kills, most adult Lost River and shortnose suckers are from the 1991 and 1993 year classes. Coupled with the apparent declining adult abundance, the shift in age structure to younger fish means the reproductive potential declined. For example, the loss of large old fish during the fish kills means that even if the adult populations in the late 1980s and 2001 were the same size, the reproductive potential would have been lower in 2001.

Sucker population monitoring has been less intensive in other areas including Clear Lake, Gerber Reservoir, Lost River, Tule Lake, and the Klamath River (Reclamation 2001). In 2000, BRD sampled sucker populations on 10-20 occasions during the summer at Clear Lake and Gerber Reservoir. At Clear Lake a wide range of size groups of both Lost River and shortnose suckers were captured including juveniles (R. Shively, BRD, per. com). This information along with relatively high catch per unit effort data suggests that sucker populations remain at levels similar to the last intensive survey in 1995 (Scoppettone et al. 1995). Shortnose sucker catch rates were also relatively high for Gerber Reservoir with a wide range of sizes (R. Shively, BRD, per. com.). Biologists from the Bureau of Land Management have documented successful reproduction in tributaries to Gerber Reservoir almost every year since 1995 (A. Hamilton, BLM, per. com.). Overall, sucker populations in Gerber Reservoir and Clear Lake are relatively large and represented by multiple year classes.

In 1999, Reclamation and BRD conducted intensive fish sampling in the Lost River. Adult shortnose suckers were captured throughout the river with higher densities around Harpold Dam and Wilson Dam. Juvenile suckers were also commonly sampled (Shively et al. 2000). Low sucker catch rates occurred in the Lost River below Wilson Dam and above Miller Creek. Sucker populations appear to be relatively small but stable in the Lost River above Wilson Dam.

Reclamation has infrequently monitored spawning runs from Tule Lake on the Lost River below Anderson-Rose Dam. Small numbers of adult Lost River and shortnose suckers were observed every year between 1995-2000 (Reclamation 2001). Adults of both species were also captured from Tule Lake Sump as part of a radio tracking study in 1999 and 2000. Based on spawning run and lake monitoring over the last couple of years, the adult population of shortnose and Lost River suckers is probably less than 1,000 fish.

PacifiCorp and Oregon State University monitored relative abundance of fish in Keno Reservoir during 2000. Few suckers were captured which is consistent with earlier surveys indicating low numbers of fish probably inhabit this area (D. Simon, OSU, per. com.).

4.5.1.2 Juvenile Sucker Data

Oregon State University researchers have been monitoring seasonal abundance and distribution and habitat use yearly since 1991 (Simon et al. 2001). Very low juvenile abundance was monitored in 1992 and 1994. Juvenile abundance since 1995 has been variable. During the period 1995-1998, juvenile sucker abundance generally declined for both Lost River and shortnose suckers (Simon et al. 2000). However, in 1999 relatively large numbers of juvenile Lost River and shortnose suckers were sampled. Juvenile suckers abundance in 2000 was lower than 1999 and in 2001 juvenile sucker abundance was very low. Since 1991, relatively good juvenile survival has occurred in 1991and 1993 and recruitment into the adult population. However, it is too soon to know if the juvenile suckers from 1995-2000 will survive until adults.

4.5.1.3 Sucker Habitat

Historically, suckers spawned in several tributaries (Williamson River/Sprague River, Wood River, Crooked Creek, Sevenmile Creek) and springs in UKL. Today, the Williamson River and Sprague River are the only tributaries supporting substantial spawning (USFWS 2001). The spawning habitat in these streams is degraded due to sedimentation and high plant nutrients that lead to dense algae and aquatic plant growth that adversely affects spawning success. In the lake, spawning currently occurs at only a few springs (Sucker, Silver Building, Ouxy, Cinder Flat, and Boulder). Others like Harriman Springs, Odessa Springs, and Barkley Springs no longer support sucker spawning.

Sucker habitat is degraded in Upper Klamath Lake and its tributaries because of poor water quality and habitat loss. Access is restricted to historic spawning areas in the Sprague River by a poorly designed fish ladder at Chiloquin Dam. Alteration of floodplains and riparian areas along the tributaries including Sprague River by flood control projects and non-Project agricultural uses had degraded historic spawning and juvenile rearing habitat. Grazing of tens of thousands of livestock in forest, rangeland, and agricultural lands, and intensive timber harvest and road construction in forested areas has accelerated erosion and sedimentation, and nutrient loading in the tributaries and UKL.

Diking and draining of wetlands around UKL by mostly private non-Project interests for agricultural development have reduced wetland habitat by approximately 35,000 acres. These wetlands provided important rearing habitat for larval and juvenile suckers. They also functioned to remove plant nutrients and sediment from the inflows and lake water. Marsh vegetation decomposition substances released from the wetlands may have inhibited blue-green algae growth in the lake. Although approximately 15,000 acres of agricultural lands around the lake have been acquired by the federal government and The Nature Conservancy and are in various stages of restoration, they are not completely functional and reconnected to UKL.

Age 0 juvenile sucker refers to fish after hatching and before completion of their first winter. Age 0 suckers typically range from 10-75 mm. They are subdivided into larval (10-25 mm) and juvenile stages (>25 mm). Larval suckers typically are found in the Williamson River-UKL system from March through June and juveniles after April. The mouth of the Williamson River and Goose Bay are two areas known to have high concentrations of larval and juvenile suckers and are considered important rearing grounds (Klamath Tribes 1996). Larval suckers are associated with emergent vegetation around the periphery of the lake and the edges of the lower Williamson River. Channelization and diking of the lower Williamson River by non-Project interests has shortened and widened the river channel. Habitat complexity related to the previously highly sinuous river channel has been lost. Extensive willow and cottonwood riparian areas were eliminated. Floodplain habitat has been drastically reduced, and floodplain functions, such as nutrient removal, invertebrate production, and water storage are minimal in the lower river section. Over the last century, non-project agriculture interests reclaimed large tracts of marshes by diking and dredging around the perimeter of UKL. Emergent vegetation habitat at Goose Bay has been greatly reduced as a result. Complex shoreline habitat in the lower Williamson and along the shoreline at Goose Bay is confined to narrow strips perched at relatively high elevations (Dunsmoor et al. 2000).

Grazing in both the Clear Lake and Gerber watersheds has previously destabilized streambank vegetation resulting in erosion, sedimentation, reduced quality of spawning gravel/cobble, increased water temperatures, and lower water tables. However, stream habitat although still degraded is in pretty good condition and appears to support viable sucker populations.

River habitat in the Lost River and Klamath River (Keno Reservoir) has been substantially altered by Project and non-project channelization, construction of diversion dams, and loss of riparian habitat. Sucker spawning and rearing habitat is generally in poor condition.

Tule Lake habitat is marginal for suckers because of its shallow depth (mostly less than 3 feet). In addition, spawning habitat in the Lost River is limited to a small gravel area below Anderson-Rose Dam.

4.5.1.4 Water Quality

The high algae productivity of UKL and associated poor water quality has been implicated as a major factor affecting the status of the suckers. Excessive blooms of the blue-green algae *Aphanizomenon flos-aquae* cause significant water quality deterioration due to photosynthetically elevated pH and to both supersaturated and low dissolved oxygen. Dissolved oxygen, pH, and ammonia achieve harmful and lethal levels in UKL, and as such are important variables affecting survival and the viability of sucker populations. The ultimate cause of the UKL water quality problem is excessive nutrients, especially nitrogen and phosphorus, due to natural inputs, external sources, and internal loading. However, sediment cores of the lake bottom show the nutrient budget has changed dramatically in the past 50-100 years (Eilers et al. 2001). Sediment cores show increase in the sediment accumulation rate, nitrogen and phosphorus concentrations, and a shift toward the nuisance alga responsible for existing poor water quality.

Upper Klamath Basin has extensive upwelling of groundwater containing nitrogen and phosphorus that enter UKL or contribute to tributary inflows. Multiple anthropogenic activities contribute nutrients to UKL, including livestock grazing, agriculture, fertilizer, logging and road construction, and drainage of wetlands (Bortleson and Fretwell 1993; Snyder and Morace 1997; Risely and Leanen 1999). Wetland soils of the Klamath Basin have a high percentage of organic matter, normally maintained in the soil as refractory material (undecomposed remains of plants) and not biologically available. Wetland drainage dries the soil, allows oxygenation, promotes aerobic bacteria that decompose refractory material and produce bio-available nutrients, which can enter UKL either via groundwater discharge or during seasonal pumping of drainage water. The production and export of external nutrient loads to UKL is exacerbated by loss of the filtering effects of wetlands and streamside riparian vegetation. These habitats filter and immobilize nutrients by capturing particulate matter suspended in surface run-off and by uptake of nutrients transported in groundwater (Gregory et al. 1991).

Internal loading is the liberation of nutrients from the lakebed into the water column. Nutrients bound to sediment are not biologically available until liberated into the water column. It is estimated that up to 60 percent of the annual phosphorus budget of UKL comes from internal loading (Kann and Walker 1999). Internal loading is particularly troublesome in UKL because it happens in summer when water quality already may be stressful to fish. The high pH, which can cause stress to fish, also initiates internal loading, triggering or maintaining algal blooms and further exacerbating the situation. A primary contributor to the annual budget of internally loaded nutrients is the decayed remains of previous years' algae.

Summer water quality in the Klamath River (Lake Ewauna to Keno) is generally poor, with large blue-green algae growth, high pH and ammonia levels, and low dissolved oxygen concentrations (CH2M HILL 1995). Poor water quality in the Klamath River is associated with poor quality of water entering from UKL, a high sediment oxygen demand, and a number of significant discharges with high biological oxygen demand. In addition, irrigation return flows entering this reach from the Klamath Straits Drain that frequently have poor water quality during the summer.

Water quality conditions in Clear Lake Reservoir and Gerber Reservoir are generally good. Algae growth is low to moderate, pH and dissolved oxygen levels generally remain within a range acceptable for suckers (Reclamation 2001). Summer water temperatures are occasionally stressful for fish in the shallower Clear Lake. Low dissolved oxygen conditions may occur during ice-cover conditions at extremely low lake levels in both reservoirs and during the summer in Gerber Reservoir.

In the Lost River, water quality conditions (temperature, pH, dissolved oxygen) are generally within acceptable levels for suckers (Reclamation 2001). However, high nutrient loading from natural and anthropogenic sources including agriculture, grazing, septic tanks, dairy operations, municipal sewage treatment facilities, and other sources occurs leading to large algae and aquatic plant growth during the summer. This excessive plant growth impacts the Lost River water quality. Dissolved oxygen and pH levels are high during the day as a result of photosynthetic activity and low at night when the plants respire. The low dissolved oxygen condition may be stressful to fish.

4.5.2 Baseline Condition of Coho Salmon

Limited information exists regarding present coho salmon abundance in the Klamath River Basin. Adult counts in a few Klamath River tributaries and juvenile trapping on the Klamath River mainstem and tributaries provide valuable information on presence of coho salmon in specific areas during key time periods, but less valuable for determining population status or trends (NMFS 2001). However, they do provide some indication of low abundance and the status of coho salmon populations in the Klamath River Basin.

4.5.2.1 Adult Data

During the period 1991 and 2000, adult coho salmon counts using weir and video observations in the Shasta River ranged from 0 to 24 fish, with 1 or 0 fish counted during four of these years. Counting weirs in the Scott River indicated an average of 4 fish (range 0-24) during the period 1991 and 2000. One of those years accounted for approximately 65 percent of the total number of coho observed and zero coho were observed in four years. Coho salmon were observed in the Scott River during this period as early as September 21. In Bogus Creek, an average of 4 coho adults (range 0-10 were counted at the weir. These data emphasize the importance that one year’s spawning success can have on the survival of these coho salmon stocks.

Coho salmon counts in the Trinity River are mostly of hatchery origin, and 100 percent marking of hatchery coho salmon has only recently occurred so estimates of naturally-produced coho are only available since the 1997 return year. The results of counting from these three years yielded an estimated 198, 1,001, and 491 naturally produced adult coho salmon for the 1997-1998, 1998-1999, and 1999-2000 seasons, respectively (CDFG 2000). Coho salmon were first observed at the Trinity River weir during the week of September 10 during the 1999-2000 trapping season (CDFG 2000).

4.5.2.2 Juvenile Data

Recent smolt data suggests that Klamath Basin coho salmon recruitment is very low. Juvenile traps, operated by USFWS on the Klamath River mainstem at Big Bar (River Mile 48), were used to estimate indices of smolt production. Based on counts from these traps between 1991 and 2000, the annual average number of wild coho salmon smolts was estimated at only 548 individuals (range 137-1,268)(USFWS 2000). For the same period, an average output of 2,975 wild coho salmon smolts (range 565-5,084) was estimated for the Trinity River at Willow Creek, within the Trinity sub-basin (USFWS 2000). The incomplete trapping record provides limited information in terms of temporal trends, but it still is a useful indicator of the extremely small size of coho salmon populations in the Klamath Basin.

The FWS operates downstream juvenile migrant traps on the mainstem Klamath River at Big Bar (River Mile 48). The incomplete trapping record provides limited information in terms of abundance or trends, but does indicate the presence of coho at different life stages during certain times of the year (NMFS 2001). Indices of abundance are calculated from actual numbers trapped. In 2001, coho salmon smolts from trapping at Big Bar resulted in an actual total count of 23 fish between April 9 and July 22; 14 which were considered wild (FWS 2001). Trapping was discontinued after July 22 because of heavy algal loading in the traps. This data is preliminary (Bill Pinnix, personal communication, 2002).

A 1997 FWS report and 2001 mainstem trap data (CDFG unpublished) show that young-of-the-year coho salmon are emerging from the Shasta and Scott rivers, where they probably were spawned, into the mainstem of the lower Klamath River between March and August. Considering the low numbers of coho salmon fry that have been reported from these sub-basins, it is unlikely that these fish were displaced downstream because of competitive interactions with other juveniles of their own species. Instead, the most likely explanation for their summer movement is that declining water quality and quantity in the lower-order tributaries force these young fish to seek refuge elsewhere. Thus, they end up in the river's mainstem earlier than in other river systems. This exploratory behavior and movement in search for adequate nursery habitat has been well documented, especially before the onset of winter (Sandercock 1991).

Relationship of Klamath River Flows to Fall Chinook Escapement, and Juvenile Abundance

Given the lack of coho-specific information on relationships between abundance and habitat, general trends in fall-run chinook salmon populations and their response to changes in mainstem macrohabitat and microhabitat conditions may provide a good approximation of the expected coho salmon responses to these changing conditions in the mainstem Klamath River. Both species, when considering the YOY and juvenile life stages, depend on edge habitat for velocity shelters, protection from predators, and food sources. Klamath fall-run chinook adult returns typically consist of five age classes but are dominated by 3 and 4-year old fish.

The relatively high escapement observed in 1995 and 1996 may reflect freshwater conditions in 1992 and 1994 (Table 4.8). The relative strength of adult returns in both years may be attributed to very good ocean conditions and excellent microhabitat rearing conditions in the Klamath River in 1993. Despite drought conditions in 1992 and 1994, it appears high flow conditions in the mainstem and tributaries in 1993 compensated somewhat for poor microhabitat and macrohabitat conditions in the watershed below Iron Gate Dam in 1992 and 1994. However, there is no empirical evidence demonstrating a clear association between changes in Klamath River flow and the status of the salmon.

The relationship between Klamath River fall-run chinook escapement, juvenile chinook abundance, and Klamath River flows was evaluated by Craig (1998). Data from 1988 to 1998 (Table 4.8) showed a weak positive correlation ($r = 0.194$) between average daily river flow and natural juvenile chinook abundance. Data from 1989/1990 (escapement year/juvenile index year) were not included because unseasonable late spring rains in 1990 severely reduced the ability to conduct monitoring during a period of significant hatchery and natural stock emigrations (Craig 1998). There was also a weak positive correlation ($r = 0.261$) between spawning escapement and juvenile chinook abundance. These correlations improved when the 1993/1994 (escapement year/juvenile index year) data point was omitted. Craig (1998) speculated that the high juvenile abundance in 1994 was due to several related factors: 1) relatively low escapement in the fall of 1993 (reduced density-dependant factors); 2) low and consistent (absent significant flow peaks) late fall-spring tributary flows and; 3) the inherent productivity of Klamath Basin waters. Craig (1998) stated that "... it is a difficult, if not impossible, task to clearly ascertain which factor or combination of factors most affected a particular adult run-size or influenced the magnitude and/or health condition of the Basin's annual juvenile salmonid production."

The National Research Council (1996) also recognized the complexity involved with attempting to quantify these relations: "The salmon production cycle has three principal components that determine abundance: reproductive potential of adults returning from the sea to spawn, which is affected by their growth at sea; production of offspring from natural reproduction in streams and artificial propagation in hatcheries; and sources of mortality (including natural mortality, fishing mortality, dam-caused mortality, mortality from habitat alterations and changes in environmental conditions, and so on). All three components are affected by changes in environmental conditions as well as by human activities. Variations in the three components and their interactions ultimately determine the ability to sustain salmon populations and their production."

Total 1999 fall-run chinook salmon spawning escapement into the Klamath River system was estimated at 52,538 fish (CDFG 2000). This included 19,719 natural adults, 14,915 hatchery returns, and 17,904 in-river fishing harvest (CDFG 2000). Natural juvenile chinook abundance indices for 1999 and 2000 were 367,036 and 287,000, respectively, at Big Bar (FWS 2001). Mean flows (May-July) in 1999 and 2000 were 9,978 and 5,173 cfs, respectively (FWS 2001). For comparison, indices for natural juvenile coho abundance in 1999 and 2000 at Big Bar totaled 6,033 and 4,256, respectively (FWS 2001).

Given the complexity involved with attempting to quantify these relationships, effects of Klamath River flows resulting from the proposed action on coho salmon escapement and juvenile abundance are difficult to assess.

Table 4.8 - Natural adult fall chinook spawning escapement (1988-1997, 1989 omitted), natural juvenile chinook abundance index (1989-1998, 1990 omitted) and average daily Klamath River flow during May-July (1989-1998, 1990 omitted), with corresponding ranks (1=highest, 9=lowest) (Craig 1998)

Year	Spawning Escapement [1]	Rank	Year	Juvenile index [2]	Rank	River flow [3]	Rank
1988	29,783	3	1989	135,200	7	5628	5
1990	7,102	7	1991	55,169	9	3461	7
1991	5,905	8	1992	165,227	6	1975	9
1992	4,135	9	1993	220,439	5	11,519	2
1993	9,453	6	1994	1,334,078	1	2476	8
1994	20,960	5	1995	302,581	4	9856	3
1995	79,851	1	1996	826,188	3	8684	4
1996	31,755	2	1997	128,465	8	5182	6
1997	28,415	4	1998	1,038,520	2	13,900	1
Average	24,151			467,319		6965	

[1] Spawning escapement = natural adult fall chinook spawners in the Scott, Shasta, and Salmon Rivers, Bogus Creek and mainstem Klamath River.
[2] Juvenile abundance index = Sum of daily catch of natural juvenile chinook x (mean daily river flow (cfs)/volume of river flow sampled (cfs)).
[3] Flow = average mean daily Klamath River flow at Orleans USGS gage during May - July.

4.5.2.3 Habitat

Anadromous salmonids in the Klamath River are restricted to the mainstem Klamath River and tributaries below Iron Gate Dam. No passage facilities exist at Iron Gate or Copco dams, which are owned and operated by PacifiCorp.

Coho salmon still occur in the Klamath River and its tributaries (CH2M Hill 1985; Hassler et al. 1991). Between Seiad Valley and IGD, coho salmon populations are believed to occur in Bogus Creek, Shasta

River, Humbug Creek, Empire Creek, Beaver Creek, Horse Creek, and Scott River (NMFS 1999b). Between Orleans and Seiad Valley, coho salmon populations are believed to occur in Seiad Creek, Grider Creek, Thompson Creek, Indian Creek, Elk Creek, Clear Creek, Dillon Creek (suspected), and Salmon River (NMFS 1999b). Finally, between Orleans and Klamath (mouth of the river), coho salmon populations are believed to occur in Camp Creek, Red Cap Creek, Trinity River, Turwar Creek, Blue Creek, Tectah Creek, and Pine Creek (NMFS 1999b). It is estimated that Shasta River presently maintains approximately 38 miles of coho habitat, which is below pre-development levels (INSE 1999). Available data suggests that existing coho salmon habitat in the Scott River now constitutes approximately 88 miles (INSE 1999).

Unscreened or ineffectively screened diversions are common in the Shasta and Scott Rivers resulting in substantial entrainment and fish stranding. Downstream migrants are also trapped in pools or side channels when stream flows drop sharply during early summer and soon die from high temperatures, lack of food, or predation. Some portions of streams often become entirely dewatered due to diversion. A recent inventory of diversion ditches possibly affecting salmonids in the Scott River indicates an estimated 125 unscreened ditches (Sommarstrom 1994). To date, CDFG has screened 30 diversions throughout the Scott River. Coho salmon juveniles are very susceptible to diversions because they need to spend at least one full summer in the stream.

4.5.2.4 Water Quality

The combined effects of high temperatures, high nutrient concentrations, and low dissolved oxygen levels during the summer months can create extremely stressful conditions for coho salmon and other salmonids in the Lower Klamath River. High nutrient concentrations and associated increase in the abundance of algae and aquatic plants tend to lead to increased sedimentation and water temperatures, slower velocities, and lower dissolved oxygen. In June of 2000, temperatures and dissolved oxygen levels reached critical levels in the Klamath River and resulted in a large fish kill of juvenile salmonids (CDFG 2000). No major fish kills were reported in the mainstem Klamath River during summer 2001.

High nutrient concentrations in the Klamath River in large part come from the Upper Klamath Basin where anthropogenic sources contribute significantly. Widespread grazing, agriculture, logging and conversion of wetland to agricultural land have increased nutrient loading. Most lakes in the Upper Klamath Basin are shallow and water temperatures closely track air temperatures. Thus, flows originating from the headwater areas are naturally warm during the summer.

4.5.2.5 Critical Dry Water Year Water Quality Analysis (Applicable to summer of 2001)

a. Water Temperature

Temperature dynamics in the Klamath River below Iron Gate Dam are affected by upstream reservoirs, local meteorological conditions, regulation flows in the Klamath River, quantity of release to the Klamath River and tributary contributions (Deas 2001). Water quality model simulations using the RMA-11 model by Deas (2001) resulted in the following conclusions:

- Under drought conditions, tributary contributions are typically small.
- Under typical summer flows, operation of the Klamath River dams produces predictable “nodes” of minimum temperature variation separated by a one-day travel time in the river (at mean

velocity). These phenomenon, apparent in sub-daily data and simulations, are critical in interpreting sub-daily water temperature information.

- Seasonal changes are apparent in the system as well as short-term climatic meteorological conditions.

- Iron Gate Reservoir (and possibly Copco Reservoir) affect the thermal regime of the downstream river in three principal ways (under current operating conditions):

    1. In mid-to late spring Iron Gate flows are often well below equilibrium temperature, maintaining a “cool” water release to the Klamath River.

    2. In summer, there is minimal cool water benefit to the Iron Gate flows (with respect to anadromous fishes). The flows at Iron Gate Dam are still below equilibrium temperature, but only by a modest amount. However, the flow does moderate the daily maximum and minimum temperature.

    3. In fall, as air temperatures decline, the Iron Gate flows can be warmer than equilibrium levels for a week or so until the large mass of water cools down. Under such conditions, the flows are a heat source for the river.

b. Dissolved Oxygen

Dissolved oxygen (DO) dynamics in the Klamath River below Iron Gate Dam are complex. DO concentration of releases, nutrient availability, and primary production directly affects DO concentration in space and time. A few notable remarks include:

- Simulated mean Klamath River DO (as depicted in longitudinal profiles) illustrates that throughout most of the summer daily mean DO concentrations are fairly constant throughout the river reach. However, in the fall, DO at Iron Gate Dam begin to decrease.

- Further examination of the daily mean DO profiles illustrates that there is potentially appreciable primary production immediately below Iron Gate Dam, shown by a slightly increased daily mean DO.

- Examination of the simulated time series suggests that seasonally (and spatially) primary production directly and appreciably impacts sub-daily dissolved oxygen levels.

- The various flow regimes had a modest impact on daily mean DO concentration. The lower flows did produce a slightly higher mean daily DO, possibly due to increased aeration at shallower depths. Sub-daily data were more highly variable between alternatives, but these data have not been critically assessed at this time to provide an explanation for this response.

c. Tributary Contributions: Flow (non-Project)

Flows during the 2001 period (those used to determine accretions as well as assign to the Shasta and Scott Rivers) were representative of a drought year. Thus, during much of the simulation period they were small and often negligible. There was even a simulation period when accretions were negative, suggesting that the river flow at Seiad Valley was less than the release at Iron Gate Dam. Thus, the impacts of tributary flow on water quality were modest. This is not always the case. Often early June contributions from the Scott River are appreciable and can have an appreciable impact on water quality downstream of River Mile 143 (mouth of the Scott River). Likewise, summer period flows in the Shasta River are sometimes on the order of 100 cfs. For example, if Klamath River flows were reduced to 600 cfs then the Shasta River contribution can have larger effect on water quality.

Shasta River

Shasta River flow experienced a daily averaged flow of 25.6 cfs from June 1 through September 30, 2001. Although maximum flow was just less than 100 cfs, the standard deviation over the period was just under 9 cfs. For most of the period, the Shasta River experienced flows on the order of 25 cfs. There was no remnant of the spring hydrograph in the Shasta River flow record, but it was apparent that irrigation dropped off after about September 26.

Scott River

Scott River flow experienced a daily averaged flow of about 15 cfs from June 1 through September 30, 2001. Although maximum flow was just over 100 cfs, the standard deviation over the period was just about 6 cfs. For most of the period, the Scott River experienced flows on the order of 15 cfs. Scott River flows differed from Shasta River in that there was a remnant of the spring hydrograph present. However, these flows diminished by June 16. Scott River flows did not recover in late September as they did in the Shasta River.

Accretions

Accretions were updated for 2001 conditions as well because tributary inflow between Iron Gate Dam and Seiad Valley is appreciably less in critically dry years. To estimate accretions the flow at tributary inflow from the Shasta and Scott Rivers was subtracted from flows below Iron Gate Dam. This value was compared to Klamath River flow at Seiad Valley.

Through about the third week in June, accretions were positive, i.e., there was net inflow from ungaged tributaries between Iron Gate Dam and Seiad Valley. However, from Late June through early August (with the exception of a few days) accretions were negative (depletions). That is, flow at Seiad Valley was less than flow at Iron Gate, including the additions of the Shasta and Scott Rivers. From mid-August to mid-September, accretions were essentially negligible, and after mid-September accretions once again began to pick up, but remained small. The spring period response is expected for a dry year in the Klamath basin when snowpack is small and exhausted early. Likewise, the fall period increases in baseflow are consistent with water resources development and meteorological and hydrological conditions.

It is apparent that the drought condition in the basin during 2001 markedly affected tributary contribution to the Klamath River between Iron Gate Dam and Seiad Valley, as illustrated by the depletion or lack of appreciable accretion within this reach during much of the summer. For modeling purposes, accretion was set as outlined below (Table 4.9). Accretions were added to the model at River Mile 180, River Mile 161, and River Mile 131. A portion of the accretion is also assigned to the Scott River between Ft. Jones and the confluence with the Klamath River. For further details on the assignment of accretions to the individual locations, refer to Deas and Orlob, (1999).

Table 4.9 – Monthly accretions used in all simulations	
Date	**Accretion (cfs)**
June 1 - June 16	100
June 16 - August 10	-20
August 10 - September 15	0
September 15 – September 30	25

Real-time data (15 minute interval or less) were downloaded from the California Data Exchange Center (CDEC) and are presented as preliminary by USGS. Daily average data were used as model input. The stations used in this analysis are discussed below.

Klamath River below Iron Gate Dam flows (2001): Data are from USGS Klamath River below Iron Gate Dam (KIG). Data quality summary: data difficult to process, because on varied interval. Processed period when flow changes occurred, e.g., June. Other months set to steady state flow of 1020-1040 cfs based on review of data. Missing periods from a few days

Shasta River flows (2001): Data are from USGS Shasta River near Yreka (SRY). Data quality summary: missing parts of a few days

Scott River flows (2001): Data are from USGS Scott River near Ft Jones (SFJ). Data quality summary: missing several days and parts of several days

Klamath River near Seiad Valley flows (2001): Data are from USGS Klamath River near Seiad Valley (KSV). Data quality summary: missing portions of many days in June, few days in other months. One erroneous point on 9/2/01 (sudden increase from 1030 cfs to roughly 1750 cfs) – corrected

4.5.2.6 Water Quality Data

Water quality data form boundary conditions at three locations within the study reach: Iron Gate Dam, Shasta River, and Scott River. Accretions being uncertain in space and time throughout the river each are not assigned any inflow quality (in addition, accretions are almost negligible for the period of this analysis).

Due to time limitations, 1996 data were used. However, water quality data from 1996 was compared with the data from the comprehensive monitoring program completed in 2000 and found to be roughly comparable.

4.5.2.7 Meteorological Data

Available air temperature from the California Department of Forestry station at Brazie Ranch compared for the May 1 through October 31 period for 1996, 1997, 2000 and 2001 (Table 4.10). The warmest year was found to be 1996. 1996 meteorological data was used in this analysis. It should be noted that although air temperature is often viewed as an indicator of general climate response (e.g., warm, average, cold), it is only one of several meteorological parameters that may affect water temperature. Further, water resources development, operations, and hydrology play fundamental roles in thermal response of aquatic systems.

Table 4.10 – Comparison of air temperatures			
Year (May 1-October 31)	**# hours>100ºF**	**# hours>90ºF**	**# hours>80ºF**
1996	122	356	840
1997	101	236	687
2000	0	179	685
2001 [1]	0	227	719
[1] - Data available only through 09/09/01.			

4.5.2.8 Summary

All actions described as part of the environmental baseline have led to the current status of coho salmon in the Klamath River Basin. Coho are restricted to the mainstem Klamath River and tributaries below Iron Gate Dam. No passage facilities exist at Iron Gate or Copco dams, which are owned and operated by PacifiCorp. Available recent information suggests adult populations are small to nonexistent in some years. Existing information also indicates that adult coho salmon are present in the Klamath River as early as September and juvenile coho salmon are present in the mainstem Klamath River year round.

4.5.3 Baseline Condition of Bald Eagle

This BA incorporates by reference the description of environmental baseline conditions for bald eagles in Reclamations February 13, 2001 BA.

4.5.4 Baseline Hydrology

Reclamation developed a hydrologic baseline for the BA that reflects the effects of non-Project activities and, in accordance with ESA implementing regulations, excludes the effects of the proposed action from the baseline. This approach is taken to provide quantitative information to both Reclamation and the Services to assist in analyzing the effects of the proposed action on the species and to more readily model the effects of the proposed action compared to the baseline condition.

The hydrologic component of the environmental baseline includes the seasonal analysis of several data sets representing multi-year dry, normal, and wet weather conditions. The baseline hydrological figures incorporate minimum and average Upper Klamath Lake elevations and Klamath River flows at Iron Gate Dam that would result if the Klamath Project was not operated. This simulates only non-Project flow depletions occurring upstream from Upper Klamath Lake. KPOPSIM used net (i.e. "impaired") inflows using a hydrologic time series data set of flows at Iron Gate Dam with time steps from 1961-1997 developed by Philip Williams and Associates (PWA 2001). Tables 4.11 and 4.12 summarize baseline flows at Iron Gate Dam and Upper Klamath Lake elevations by water year type. These flows and elevations were generated by PWA (2001) with "no Klamath Project operation" but with physical facilities in place.

Table 4.11- Baseline flows at Iron Gate Dam (values in cfs) by water year type

Time step	Above Average (19)		Below Average (11)		Dry (5)		Critical Dry (2)	
	Min	Ave	Min.	Ave.	Min.	Ave.	Min.	Ave.
April 1-15	3215	4793	2605	2978	1877	2251	1590	1627
April 16-30	3357	4783	2491	2919	1717	2088	1572	1584
May 1-15	3409	4295	2156	2582	1794	1939	1362	1515
May 16-31	3115	4049	1901	2366	1713	1811	1175	1369
June 1-15	2420	3317	1552	1956	1369	1485	994	1045

June 16-30	1985	2834	1246	1692	1148	1313	847	897
July 1-15	1613	2180	1133	1398	838	1002	711	746
July 16-31	1222	1723	961	1183	651	827	645	668
August	1078	1373	753	1064	689	805	577	600
September	912	1331	861	1097	723	892	650	651
October	1038	1565	1120	1368	972	1084	795	811
November	1384	2050	1447	1986	1374	1762	1126	1136
December	1639	2676	1384	2832	1643	2636	1445	1516
January	1819	3243	1772	3240	1730	2950	1953	2097
February	2105	4315	2403	3133	2001	2521	1630	1774
March 1-15	3176	4760	2750	3270	2213	2749	1745	1791
March 15-31	3129	5010	2802	3283	2246	2739	1726	1783

Table 4.12- Baseline Upper Klamath Lake elevations by water year type

Time step	Above Average (19)		Below Average (11)		Dry (5)		Critical Dry (2)	
	Min	Ave	Min.	Ave.	Min.	Ave.	Min.	Ave.
April 1-15	4141.7	4142.4	4141.2	4141.5	4140.9	4141.1	4140.6	4140.6
April 16-30	4141.8	4142.4	4141.1	4141.5	4140.8	4141.0	4140.6	4140.6
May 1-15	4141.8	4142.2	4141.0	4141.3	4140.7	4140.8	4140.3	4140.4
May 16-31	4141.6	4142.1	4140.8	4141.1	4140.7	4140.7	4140.2	4140.3
June 1-15	4141.2	4141.7	4140.6	4140.9	4140.4	4140.5	4139.9	4140.1
June 16-30	4141.0	4141.4	4140.4	4140.7	4140.3	4140.4	4139.7	4139.9
July 1-15	4140.6	4141.0	4140.2	4140.4	4140.1	4140.2	4139.7	4139.8
July 16-31	4140.2	4140.6	4140.0	4140.2	4139.9	4140.0	4139.7	4139.7
August	4140.0	4140.3	4139.9	4140.1	4139.8	4139.9	4139.6	4139.6
September	4140.1	4140.4	4140.1	4140.2	4139.9	4140.0	4139.7	4139.7
October	4140.3	4140.7	4140.3	4140.6	4140.1	4140.3	4140.0	4140.0
November	4140.5	4141.1	4140.5	4141.0	4140.5	4140.9	4140.4	4140.5
December	4140.8	4141.4	4140.7	4141.4	4140.6	4141.3	4140.6	4140.7
January	4140.8	4141.6	4140.9	4141.6	4140.7	4141.4	4140.9	4141.0
February	4140.9	4142.1	4141.1	4142.1	4140.9	4141.2	4140.7	4140.7
March 1-15	4141.4	4142.3	4141.2	4142.3	4140.9	4141.2	4140.6	4140.7
March 16-31	4141.4	4142.4	4141.3	4142.4	4141.0	4141.2	4140.6	4140.6

"Without Project Operation" figures in the following analyses refer to a hydrologic baseline with no agriculture or refuge deliveries and only net inflow into Upper Klamath Lake (PWA 2001), but with all physical facilities in place. Minimum and average flows for each time step and water year type were calculated from this data set. The KPOPSIM model run assumed that outflows from Upper Klamath Lake are controlled by the original reef elevation at the outlet of Upper Klamath Lake to the Link River. Flows at Iron Gate Dam were computed by adding the following to Link River flows: (1) accretions to Lake Ewauna; (2) Area A2 winter runoff; (3) Lower Klamath Lake runoff to Klamath Straits Drain and; (4) flow accretions between Keno Dam and Iron Gate Dam. The total effect on the listed species will be comprised of the specific effects of the proposed action combined with the baseline condition and other identified effects.

CHAPTER 5.0 - EFFECTS OF THE PROPOSED ACTION

5.1 INTRODUCTION

"Effects of the action" refers to the direct and indirect effects of a proposed action on listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered along with the environmental baseline and the predicted cumulative effects (Chapter 6) to determine the overall effects on the species. 50 CFR § 402.02.

For the purposes of this BA, effects on listed species and critical habitat are analyzed individually with respect to the proposed action. In accordance with the provisions of the ESA implementing regulations and the FWS 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.

Reclamation has provided this BA to help analyze the effects of the proposed action and to assist FWS and NMFS in developing coordinated BOs. Maintenance of precise lake levels and river flows are not the actions upon which Reclamation is consulting in this BA; rather, the criteria defined in Chapter 2 provide boundaries for the proposed action based on observed values for lake levels and river flows that occurred during the 10-year period from water year 1990 through water year 1999.

5.1.1 National Academy of Sciences Interim Report

In furtherance of its commitment to independent peer review of the science concerning the suckers and the coho salmon, the Department of the Interior and the Department of Commerce entered an agreement with the National Academy of Sciences (NAS) to form a Committee on Endangered and Threatened Fishes in the Klamath River Basin. Through this agreement, NAS was tasked with reviewing the underlying scientific information used in preparing the 2001 BAs and BOs on the Klamath Project.

Following the release of the draft Klamath BA on January 29, 2002, and while preparing the final BA, Reclamation received NAS's Interim Report, "Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes in the Klamath River Basin" (NAS Interim Report). Released on February 6, 2002, this report reflected the NAS's preliminary assessment of the data supporting the biological opinions. Although the interim report specifically deals with the two biological opinions, the Committee also offered conclusions about the two biological assessments prepared by Reclamation for use by the Services in preparing the BOs.

Among the NAS's preliminary findings are the following:

While information of a sporadic or anecdotal nature is available over as much as 100 years, routinely-collected data on environmental characteristics and fish are available only since 1990 or later. Thus, while the long-term lake level record seems to invite statistical analysis of the welfare of fish in relation to lake level, the information suitable for analysis is actually limited to the most recent period of ten years or less, since 1990. (NAS Interim Report at 12.)

The NAS committee concluded that there is no substantial scientific support for the FWS BO's recommendations concerning minimum water levels for Upper Klamath Lake. The Committee concluded that there is presently no sound scientific basis for recommending an operating regime for the Klamath Project that seeks to ensure lake levels higher on average than those occurring between 1990 and 2000. **At the same time, the Committee concluded that there is no scientific basis for operating the lake at mean minimum levels below the 1990-2000 levels, as Reclamation proposed in its 2001 BA because such operations would require acceptance of undocumented risk to the suckers**. (NAS Interim Report at 2.)

Although the recommendations regarding Upper Klamath Lake level control in the BOs were based on concerns related to habitat (shoreline spawning areas, emergent vegetation) and water quality (low oxygen in summer, need for deep water refugia in summer and fall, possibility of adverse conditions under ice cover), an essential premise of the lake level recommendations is that adverse water quality conditions known to stress or kill the endangered suckers are associated with the lowest lake level within the recent historical range since 1990. **Presumption of this connection, which is essential to the arguments for specific lake levels that are proposed in the RPA, is inconsistent with present information on Upper Klamath Lake.**

Overall, the presumed connections between lake levels and recruitment of the sucker populations in Upper Klamath Lake do not have strong scientific support at present. While the use of emergent vegetation by fry is cited as a reason for maintaining high water levels, the combination of high recruitment in 1991 and low recruitment in other years (as inferred from year class data) casts doubt on the importance of this factor, at least within the operating range of the 1990s. (Interim Report at 15.)

The Committee did not find clear scientific or technical support for the NMFS BO recommendations concerning increased minimum flows in the Klamath River mainstem for the coho salmon, noting, in part, that water added to sustain higher flows in the mainstem during dry years would need to come from reservoirs and this water could equal or exceed the lethal temperatures for coho salmon during the warmest months. (NAS Interim Report at 3). **The Committee also found that Reclamation's proposed action in its 2001 BA could lead to more suppression of flows than has been seen in the past and also cannot be justified.**

Reclamation had prepared the January 29, 2002 Draft BA before the NAS Interim Report was available. In the absence of other available data, Reclamation had used the same type of analytic approach in the draft BA as it had used in previous biological assessments. The NAS criticized conclusions drawn from sporadic or anecdotal information as unfounded. After reviewing the 2002 draft BA in light of the NAS Interim Report's conclusions, Reclamation has revised the BA to reflect the NAS report and has attempted to note where conclusions made from the effects analyses in this BA related to Upper Klamath Lake levels and Klamath River mainstem flows were based on clear scientific and technical data. The NAS study is attached as Appendix B to this BA.

5.2 EFFECTS ON ENDANGERED LOST RIVER AND SHORTNOSE SUCKERS

5.2.1 Analysis Approach

To determine the effects of the proposed action on endangered Lost River and shortnose suckers in Upper Klamath Lake (UKL), Reclamation compared lake elevations and habitat quantity for the proposed action to the environmental baseline (Table 5.1). For each time step, the average elevations observed from 1990-1999 were compared to baseline elevations computed using the MIKE 11 hydrodynamic model (PWA 2001). Differences in elevation were evaluated qualitatively for effects on water quality. Maximum lake levels are not addressed because they are subject to PacifiCorp's flood release criteria outlined in its *Klamath Project Guide for High Runoff Season Operation*. These criteria are incorporated into Reclamation's Standing Operating Procedures for Link River Dam and Upper Klamath Lake and are part of the environmental baseline. The action proposed in this BA does not vary those criteria.

Reclamation's proposed operations will typically achieve or exceed the average end of month elevations for the 1990-1999 period by using a conservative estimate of projected inflow (70 percent exceedance) and use of a water bank. In rare instances, lake levels may drop as low as the minimum for each time step for the 1990-1999 period.

Data to assess the habitat quantity vs. lake elevations was available for shoreline spawning habitat (Table 5.2), emergent vegetation habitat for larval and juvenile suckers (Table 5.3), and open water habitat for adult suckers (Table 5.4). Maximum habitat values are at a full pool elevation of 4143.3. The change in habitat with the proposed action compared to baseline is assessed for each water year type and time step (Table 5.5).

Table 5.1. Comparison of elevations resulting from the proposed action with the environmental baseline by water year type and time step.

Time Step	Above Average			Dry Year		
	Baseline elevation average	1990-1999 elevation average	Difference (feet)	Baseline elevation average	1990-1999 elevation average	Difference (feet)
October	4140.7	4139.7	-1.0	4140.3	4138.2	-2.1
November	4141.1	4140.3	-0.8	4140.9	4139.0	-1.9
December	4141.4	4141.0	-0.4	4141.3	4139.7	-1.6
January	4141.6	4141.5	-0.1	4141.4	4140.3	-1.1
February	4142.1	4141.9	-0.2	4141.2	4140.4	-0.8
March 1-15	4142.3			4141.2		
Mar. 16-31	4142.4	4142.5	+0.1	4141.2	4141.7	+0.5
April 1-15	4142.4			4141.1		
April 16-30	4142.4	4142.9	+0.5	4141.0	4142.2	+1.2
May 1-15	4142.2			4140.8		
May 16-31	4142.1	4143.1	+1.0	4140.7	4142.4	+1.2
June 1-15	4141.7			4140.5		
June 16-30	4141.4	4142.6	+1.2	4140.4	4141.5	+1.1
July 1-15	4141.0			4140.2		
July 16-31	4140.6	4141.5	+0.9	4140.0	4140.3	+0.3
August	4140.3	4140.5	+0.2	4139.9	4139.0	-0.9
September	4140.4	4139.8	-0.6	4140.0	4138.2	-1.8

Time Step	Below Average			Critical Dry		
	Baseline elevation average	1990-1999 elevation average	Difference (feet)	Baseline elevation average	1990-1999 elevation average	Difference (feet)
October	4140.6	4138.8	-1.8	4140.0	4137.3	-2.7
November	4141.0	4139.0	-2.0	4140.5	4138.1	-2.4
December	4141.5	4138.8	-2.7	4140.7	4138.9	-1.8
January	4141.6	4139.5	-2.1	4141.0	4140.1	-0.9
February	4141.5	4141.7	+0.2	4140.7	4141.1	+0.4
March 1-15	4141.6			4140.7		
March 16-31	4141.6	4142.7	+1.1	4140.7	4142.0	+1..3
April 1-15	4141.5			4140.6		
April 16-30	4141.5	4142.8	+1.3	4140.6	4141.9	+1..3
May 1-15	4141.3			4140.4		
May 16-31	4141.1	4142.7	+1.6	4140.3	4141.4	+1.1
June 1-15	4140.9			4140.1		
June 16-30	4140.7	4142.1	+1.4	4139.9	4140.1	+0.2
July 1-15	4140.4			4139.8		
July 16-31	4140.2	4140.7	+0.5	4139.7	4138.9	-0.8
August	4140.1	4139.6	-0.5	4139.6	4137.6	-2.0
September	4140.2	4138.9	-1.3	4139.7	4137.1	-2.6

Table 5.2 - Spawning habitat-lake level relationship for endangered suckers at known shoreline spawning areas (average of Cinder Flat, Ouxy Springs, Silver Building Springs and Sucker Springs; BRD 2001).

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
4137.0	0.0

Table 5.3 - Emergent vegetation habitat-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 (Dunsmoor et al. 20009).		
Lake elevation (feet)	Lower Williamson (percent inundated)	Tulane and Goose Bay (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
4137.0	0.0	0.0

Table 5.4 - Adult rearing habitat-lake elevation relationships for endangered adult suckers in the northern portion of UKL where most radio-tagged fish were located (Peck 2000).	
Upper Klamath Lake elevation (feet)	Northern portion of Upper Klamath Lake (percent area > 3 feet deep).
4143.3	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	48.1
4137.0	43.1

Table 5.5 - Percent of maximum adult rearing, shoreline spawning, and emergent vegetation habitat in Upper Klamath Lake resulting from the proposed action (average elevations) compared to environmental baseline. (Maximum habitat is available at "full pool" elevation 4143.3).

Water Year	Time Step	Adult Habitat Baseline	Adult Habitat 1990-1999 ave.	Percent Change	Shore Spawn Habitat BL	Shore Spawn 1990-1999 ave.	Percent Change	Emergent Habitat UKL Baseline	Emergent Habitat UKL 1990-1999 ave.	Percent Change	Williamson Baseline Habitat	Williamson 1990-1999 ave.	Percent Change
AA	Oct.	95.6	83.0	-12.6				13.7	2.0	-11.7			
	Nov.	98.3	92.2	-6.1				23.0	7.7	-15.3			
	Dec.	98.7	98.1	-0.7				31.2	20.4	-10.8			
	Jan.	99.1	98.9	-0.2				37.4	34.4	-3.0			
	Feb.	99.7	99.5	-0.2	76.9	71.3	-5.6	53.7	46.9	-6.8			
	Mar 1-15	99.7						60.9					
	Mar 16-31	99.7	99.8	+0.1	86.9	90.2	+3.3	64.4	68.0	+3.6			
	April 1-15	99.7						64.4					
	April 16-30	99.7	99.8	+0.1	86.9	94.0	+7.1	64.4	83.1	+19.7	51.5	78.1	+26.6
	May 1-15	99.7						57.2					
	May 16-31	99.7	99.9	+0.2	76.9	96.6	+19.7	53.7	91.2	+37.5	37.4	89.0	+51.6
	June 1-15	99.2						40.5					
	June 16-30	98.3	99.8	+1.5				31.2	71.7	+40.5	12.6	61.8	+49.2
	July 1-15	98.1						20.4					
	July 16-31	94.7	98.9	+4.2				11.8	34.4	+22.6	0.8	15.4	+14.6
	August	92.2	93.9	+1.7				7.7	10.1	+2.4			
	September	93.1	85.2	-7.9				8.9	2.4	-7.5			
BA	October	94.7	64.5	-30.2				11.8	0.0	-11.8			
	November	98.1	67.4	-30.7				20.4	0.1	-20.3			
	December	98.9	64.5	-34.4				34.4	0.0	-34.4			
	January	99.1	78.6	-20.5				37.4	1.3	-36.1			
	February	98.9	99.2	+0.3	61.9	66.6	+4.7	34.4	40.5	+6.1			
	Mar 1-15	99.1						37.4					
	Mar 16-31	99.1	99.8	+0.7	64.3	92.1	+27.8	37.4	75.4	+38.0			
	April 1-15	98.9						34.4					
	April 16-30	98.9	99.8	+0.9	64.3	93.1	+28.8	34.4	79.2	+44.8	15.4	72.6	+57.2
	May 1-15	98.6						28.2					
	May 16-31	98.3	99.8	+1.5	52.1	92.1	+40.0	23.0	75.4	+52.4	6.0	67.1	+61.1
	June 1-15	97.3						18.0					
	June 16-30	95.6	99.7	+4.1				13.7	53.7	+40.0	1.4	37.4	+36.0
	July 1-15	93.1						8.9					
	July 16-31	91.4	95.6	+4.2				6.3	13.7	+7.4	0.2	1.4	+1.2
	August	90.5	80.8	-9.7				5.1	1.6	-3.5			
	September	91.4	65.9	-25.5				6.3	0.0	-6.3			
Dry	October	92.2	55.9	-36.3				7.7	0.0	-7.7			
	November	97.3	67.4	-29.9				18.0	0.1	-17.9			
	December	98.6	83.0	-15.6				28.2	2.0	-26.2			
	January	98.7	92.2	-6.5				31.2	7.7	-23.5			
	February	98.4	93.1	-5.3	54.6	34.9	-19.7	25.6	8.9	-16.7			
	Mar 1-15	98.4						25.6					
	Mar 16-31	98.4	99.2	+0.8	54.6	66.6	+12.0	25.6	40.5	+14.9			
	April 1-15	98.3						23.0					
	April 16-30	98.1	99.7	+1.6	49.7	86.9	+37.2	20.4	64.4	+44.0	4.4	51.5	+47.1
	May 1-15	96.4						15.8					
	May 16-31	95.6	99.7	+4.1	43.2	86.9	+43.7	13.7	64.4	+50.7	1.4	51.5	+50.1
	June 1-15	93.9						10.1					
	June 16-30	93.1	98.9	+5.8				8.9	34.4	+25.5	0.2	15.4	+15.2
	July 1-15	91.4						6.3					
	July 16-31	89.7	92.2	+2.5				4.0	8.9	+4.9	0.0	0.0	0.0
	August	87.5	67.4	-20.1				3.0	0.1	-2.9			
	September	89.7	55.9	-33.8				4.0	0.0	-4.0			

CD	October	89.7	46.1	-43.6				4.0	0.0	-4.0			
	November	93.9	54.5	-39.4				10.1	0.0	-10.1			
	December	95.6	65.9	-29.7				13.7	0.0	-13.7			
	January	98.1	90.5	-7.6				20.4	5.1	-15.3			
	February	95.6	98.3	+2.7	43.2	52.1	+8.9	10.1	23.0	+12.9			
	Mar 1-15	95.6						13.7					
	Mar 16-31	95.6	98.1	+2.6	43.2	73.6	+30.4	13.7	50.2	+36.5			
	April 1-15	94.7						11.8					
	April 16-30	94.7	99.5	+4.8	41.0	71.3	+30.3	11.8	46.9	+35.1	0.8	29.2	+28.4
	May 1-15	93.1						8.9					
	May 16-31	92.2	98.7	+6.5	33.6	59.9	+26.3	7.7	31.2	+23.5	0.0	12.6	+12.6
	June 1-15	85.2						5.1					
	June 16-30	87.5	90.5	+3.0				3.0	5.1	+2.1	0.0	0.0	0.0
	July 1-15	85.2						2.4					
	July 16-31	83.0	65.9	-17.1				2.0	0.0	-2.0	0.0	0.0	0.0
	August	80.8	49.1	-30.9				1.6	0.0	-1.6			
	September	83.0	44.1	-38.9				2.0	0.0	-2.0			

5.2.2 Effects of Diverting Flows

Diversions of flows to storage at Agency Lake Ranch are not likely to negatively affect endangered suckers in UKL because flow diversion occurs during the winter and spring when inflows generally exceed the flood control levels, and water would be spilled at Link River Dam.

Diversions of flows from the Klamath River (Lake Ewauna to Keno Dam) are not likely to have a negative effect on suckers because water levels and resulting habitat remain fairly constant year round regardless of Project operation.

Flow diversion from Clear Lake and Gerber Reservoir are likely to have a detrimental effect 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. Baseline flows, although unquantified, would be higher than those resulting from the proposed action. 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. However, there is a lack of fish population data to demonstrate a clear association between lake levels, river flows, and the health of the species.

During the spring and summer, Miller Creek below Miller Creek Diversion Dam is reduced to very low flows resulting in poor habitat conditions for suckers. Agricultural return flows generally provide some accretions below East Langell Valley Road. However, these flows are not consistent or stable.

In the Lost River below Bonanza to Wilson Dam, flow diversions at Clear Lake and Gerber Reservoir 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 kills.

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.

5.2.3 Effects of Storing Water in Lakes/Reservoirs

5.2.3.1 Upper Klamath Lake

Reclamation proposes to store water in Upper Klamath Lake year round with a significant portion of the water stored during October through March. In some water years, storage is significant in April, May, and June. During water storage, UKL levels increase resulting in more shoreline spawning habitat and larval, juvenile, and adult rearing habitat, increased depth in and access to water quality refuge areas (Tables 5.1, 5.2, 5.3, 5.4, 5.5). Therefore, these conditions potentially could be beneficial for the survival of all sucker life stages. However, there is a lack of empirical data that indicates that sucker recruitment and fish survival is associated with any particular lake levels.

5.2.3.2 Clear Lake and Gerber Reservoir

Reclamation proposes to store water in Clear Lake and Gerber Reservoir generally from October though April and deliver from storage from April through September. Lake levels resulting from the proposed action are included in Tables 5.6 and 5.7.

Table 5.6. Gerber Reservoir elevations resulting from the proposed action by water year type and time step.

Time Step	Above average	Below average	Dry	Critical dry
October	4822.6	4804.4	4798.0	4801.6
November	4822.7	4804.3	4798.0	4801.7
December	4824.8	4804.4	4798.0	4802.1
January	4826.7	4804.5	4798.2	4807.7
February	4825.4	4817.5	4804.8	4811.8
Mar 1-15	--	--	--	--
Mar 16-31	4833.6	4821.3	4804.2	4812.3
April 1-15	--	--	--	-
April 16-30	4835.0	4821.2	4808.3	4811.8
May 1-15	--	--	--	--
May 16-31	4834.2	4818.9	4808.1	4809.8
June 1-15	--	--	--	--
June 16-30	4832.8	4816.1	4803.6	4808.1
July 1-15	--	--	--	--
July 16-31	4830.1	4812.3	4799.2	4805.9
August	4827.6	4808.7	4798.6	4803.6
September	4825.3	4804.6	4798.1	4801.7

Table 5.7. Clear Lake elevations resulting from the proposed action by water year type and time step.				
Time Step	Above average	Below average	Dry	Critical dry
October	4531.2	4526.8	4522.5	4520.4
November	4531.0	4526.8	4522.5	4520.5
December	4531.5	4526.7	4522.8	4520.7
January	4532.4	4527.0	4522.9	4522.6
February	4531.9	4531.1	4527.0	4524.6
Mar 1-15	--	--	--	--
Mar 16-31	4534.6	4531.5	4527.1	4524.6
April 1-15	--	--	--	--
April 16-30	4535.3	4531.2	4526.9	4524.6
May 1-15	--	--	--	--
May 16-31	4535.3	4530.6	4526.4	4523.6
June 1-15	--	--	--	--
June 16-30	4534.7	4529.9	4525.7	4522.8
July 1-15	--	--	--	--
July 16-31	4533.8	4528.8	4524.5	4521.8
August	4532.8	4527.7	4523.5	4520.6
September	4532.1	4527.1	4522.8	4520.6

The proposed storage action results in increased volume and surface area in Clear Lake and Gerber Reservoir. This action potentially is beneficial for the lake dwelling suckers because it increases habitat for all life stages and reduces the potential risk of winterkill during ice cover periods. Increased habitat potentially decreases competition with other fish for food and space, fish and bird predation, and disease potentially resulting in better health and survival of endangered suckers. However, there is a lack of fish population data that demonstrates a clear relationship between lake levels and sucker survival.

5.2.4 Effects of Water Delivery

5.2.4.1 Upper Klamath Lake

Water delivery for Project purposes includes both 1) delivery of water from Upper Klamath Lake storage; and 2) diversion of water from impaired inflows.

Water delivered from Agency Lake Ranch to Upper Klamath Lake may be warmer with lower dissolved oxygen concentrations and may contain higher levels of nitrogen and phosphorus compounds than the receiving water. This may degrade water quality and contribute to conditions favorable for large blue-green algae blooms. However, water delivery operations are generally targeted for late spring before water quality becomes poor in UKL.

UKL elevations generally begin to increase during October, November, and December but are still less than baseline elevations, which go as low as 4139-4140, during those corresponding months. Storage may be occurring during those months, but elevations are less than baseline because of the low lake levels at the end of September resulting from the proposed action.

October elevations are 4139.7 (above average), 4138.8 (below average), 4138.2 (dry) and 4137.3 (critical dry). The difference between the proposed action and baseline elevations are –1.0, -1.8, -2.1, and –2.7 feet for “above average,” “below average,” “dry,” and “critical dry” years respectively. Overall, the October elevations resulting from the action are substantially lower than those for the baseline resulting in an un-quantified increased risk of achieving harmfully low dissolved oxygen and high ammonia conditions because of lower dilution, higher re-suspension of sediments, and lower volume to sediment surface area.

Adult sucker habitat (open water areas) resulting from the proposed water delivery ranges from 46.1 percent for “critical dry” years to 83.0 percent for “above average” years in October (Table 5.5). The difference between the proposed action and baseline adult habitat is –12.6, -30.2, -36.3, and -43.6 percent for “above average”, “below average”, “dry” and “critical dry” years respectively. There is substantially less adult habitat as a result of proposed water delivery in “below average”, “dry” and “critical dry” years than the baseline. Adult suckers may be crowded during these year types, potentially increasing the risk stress and disease.

The area of shoreline emergent vegetation habitat resulting from the proposed water delivery is small during all year types ranging from 0 to 2.0 percent. The difference between the “proposed action” and baseline shoreline emergent habitat is –11.7, -11.8, -7.7, and –4.0 percent for “above average”, “below average”, “dry”, and “critical dry” years respectively. However, this habitat is less important for age 0 juvenile suckers because this life stage also occupies open water habitat and unvegetated shoreline areas.

November elevations are 4140.3, 4139.0, 4139.0, and 4138.1 for the four water year types. They are 0.8, 2.0, 1.9, and 2.4 feet lower than the average November baseline elevations for “above average”, “below average”, “dry” and “critical dry” years respectively. In November, lake elevation generally increases and water temperatures and algae growth decrease compared to October. Lake elevations resulting from the proposed action are substantially lower during all water year types than the baseline

Algae growth is relatively low in the winter compared to other seasons. Most fish are relatively inactive due to low water temperatures, and water quality conditions are generally good. However, harmfully low dissolved oxygen levels can occur during ice-cover conditions. Ice-cover conditions frequently occur from December through February, lasting from a few weeks to several months. The depletion rate of dissolved oxygen in the water column increases as the depth/volume of the lake decreases because the lower volume holds less oxygen relative to the biological oxygen demand of the sediments. Ice-cover also eliminates wind-induced mixing that adds oxygen to 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. There is a higher, although unquantified, risk of poor water quality at lower lake elevations compared to higher lake elevations.

December elevations resulting from the proposed action are 4141.0 for “above average,” 4138.8 for “below average” years, 4139.7 for “dry”, and 4138.9 for “critical dry”. These elevations are 0.4 feet lower than baseline elevations for “above average” and 2.7 foot lower for “below average” years. Average “dry” year (4139.7) and “critical dry” year (4138.9) elevations are 1.6 and 1.8 feet lower than average baseline elevations respectively. The proposed action December elevations are less than the baseline elevations during all water year types. There is an increased risk of harmful water quality during ice-cover conditions for the action compared to the baseline. This may result in increased fish stress.

January elevations resulting from the proposed action are 4141.5 for “above average” years”, 4139.5 for “below average”, 4140.3 for “dry” years, and 4140.1 for “critical dry” years. The difference between proposed action and baseline elevation is -0.1 for “above average”, -2.1 for “below average”, -1.1 for “dry” years, and –0.9 feet for “critical dry” years. Like December, there is an increased risk of harmful water quality during ice-cover events.

Historically, many shoreline springs provided important spawning areas for Lost River and shortnose suckers. Barkley Springs, Odessa Springs, Harriman Springs, and several others in Upper Klamath Lake have been altered and are currently not being used. 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). Coarse substrate areas at Sucker Springs, Silver Building Springs, Ouxy Springs and Cinder Flat become available for spawning (one foot deep or greater) at elevations of approximately 4140.0, 4139, 4140.5, and 4138 respectively. Table 5.2 presents a summary of the shoreline spawning habitat-lake elevation relationship.

February elevations are 0.2 feet lower for “above average” (4141.9), 0.2 feet higher for “below average” (4141.7), 0.8 feet lower for “dry” (4140.4) and 0.4 feet higher for “critical dry” years (4141.1). Shoreline spawning habitat ranges from 34.9 to 71.3 percent for the proposed action compared to 43.2 to 76.9 percent for the baseline. The percent difference in shoreline spawning habitat is –5.6, 4.7, -19.7 and 8.9 between the proposed action and baseline for “above average”, “below average”, “dry” and “critical dry” years respectively. February elevations resulting from the proposed action provide less shoreline spawning habitat during “above average” and “dry” years and more habitat during “below average” and “critical dry” years. However, since most shoreline spawning occurs in March and April, there is likely to be little effect on sucker spawning success during this month.

Lake elevations usually increase in March resulting in greater inundation of shoreline spawning areas. March elevations for the proposed action are 4142.5 for “above average”, 4142.7 for “below average” years, 4141.7 for “dry”, and 4142.0 for “critical dry” water year types. The difference between the March proposed action and baseline elevation is 0.1, 1.1, 0.5, and 0.3 feet for the four water year types respectively. Shoreline spawning habitat ranges from 66.6 to 92.1 percent for the proposed action and 43.2 to 86.9 percent for the baseline. The percent difference between the proposed action and baseline is 3.3, 27.8, 12.0, and 30.4 for “above average”, “below average”, “dry”, and “critical dry” years respectively. Average March elevations under the proposed action provide similar shoreline spawning habitat for “above average” years and more for “below average”, “dry”, and “critical dry” years than the baseline.

April elevations for the proposed action are 0.5 feet higher for “above average” (4142.9), 1.3 foot higher for “below average” (4142.8), 1.2 feet higher for “dry” years (4142.2) and 1.3 feet higher for “critical dry” years (4141.9) than baseline elevations. Shoreline spawning habitat ranges from 71.3 to 94.0 percent for the proposed action and 41.0 to 86.9 percent for baseline. The difference in habitat between the proposed action and baseline is 7.1, 28.8, 37.2, and 30.3 percent for “above average”, “below average”, “dry”, and “critical dry” years respectively. Overall, April elevations resulting from the proposed action provide slightly more shoreline spawning habitat for “above average” years and substantially more for “below average,” “dry”, and “critical dry” years compared to the baseline.

Larval suckers produced at lake shoreline and tributary stream spawning areas may be present from March through July (Simon et al. 2000). This life stage appears to be dependent on shallow shoreline areas; particularly those vegetated with emergent wetland plants (Cooperman and Markle 2000). This vegetation provides hiding cover from predation by fathead minnows and other fish, protection from high velocities and turbulence caused by wind and wave action, and complex structure for food items including zooplankton, macro-invertebrates and periphyton (Klamath Tribes 1996).

Emergent vegetation along the lower Williamson River may play an important role in larval sucker survival even though the amount of emergent vegetation habitat is relatively small because of diking and draining of shoreline wetlands. This habitat provides protection from predation and food resources for emigrating larvae that need to eat because their yolk is generally depleted. Most sucker larvae use these habitats for a short period as they migrate to the lake. Larval emigration can begin during April in the Williamson River. However, most emigration occurs during May and June.

The emergent vegetation habitat-to-lake elevation relationship for the lower Williamson River and major rearing sites in Upper Klamath Lake is shown in Table 5.3. The emergent vegetation habitat begins at about 4140.5 in the lower Williamson and 4139.5 in Upper Klamath Lake and increases at higher elevations.

May proposed action elevations are 1.0 feet higher for “above average” (4143.1), 1.6 foot higher for “below average” (4142.7), 1.7 feet higher for “dry” (4142.4), and 1.1 feet higher for “critical dry” years (4141.4) than average baseline May elevations.

Emergent vegetation habitat in the lower Williamson River during May ranges from 12.6 to 89.0 percent for the proposed action and 0 to 37.4 percent for baseline. The percent difference in habitat between the proposed action and the baseline is 51.6, 61.1, 50.1, and 12.6 for “above average”, “below average”, “dry” and “critical dry” years respectively. May emergent vegetation habitat in Upper Klamath Lake at Goose Bay and Tulana range from 31.2 to 91.2 percent for the proposed action and 7.7 to 53.7 percent for the baseline. The percent difference in Upper Klamath Lake emergent habitat between the proposed action and baseline is 37.5, 52.4, 50.7, and 23.5 for “above average”, “below average”, “dry”, and “critical dry” years respectively. The May elevations resulting from the action provide substantially more emergent vegetation habitat in the lower Williamson River and Upper Klamath Lake than baseline conditions for all water year types.

High April and May UKL elevations (near full pool) appear to be related to later initiation of *Aphanizomenon* blooms and lower bloom magnitude (Kann 1998). Several potential processes explain water quality benefits of high lake levels in the spring. By maintaining higher lake levels in April and May, less light reaches the bottom where resting stage algae (akinetes) germinate to start the bloom cycle possibly delaying the bloom (Barbiero and Kann 1994). Also, higher lake levels/volume can reduce the rate of lake warming that leads to algae bloom initiation (Welch and Burke, 2001). Blooms have started as early as mid-May and as late as early July (Wood et al. 1996, Kann 1998). The greater the depth during the growing season, the less frequent contact of algae cells with light, potentially decreasing the magnitude of the bloom events (Welch and Burke, 2001). In addition, water inflows from tributaries and other sources can have higher concentrations of bloom stimulating nutrients than the lake water (Kann and Walker 2000). Since these inflows are frequently at yearly high volumes, maintaining higher lake levels would have a dilution effect, possibly resulting in a bloom of lower magnitude (Klamath Tribes 1995). Later occurring blooms decrease the probability that larval suckers will experience harmful water quality conditions caused by algal blooms. The pH values during this time period have approached or exceeded lethal levels for larval and early juvenile Lost River and shortnose suckers determined in laboratory bioassays (Saiki et al. 1999). However, empirical data does not clearly demonstrate that water quality conditions in UKL influence the sucker populations. There is an un-quantified lower risk of initiating an early and higher magnitude bloom under the proposed action, when compared to the baseline in all water year types because lake levels are higher in April and May.

The proposed action June elevations of 4142.6 (above average), 4142.1 (below average), 4141.5 (dry), and 4140.1 (critical) are 1.2 feet higher than baseline for “above average”, 1.4 feet higher for “below average” years, 1.1 feet higher for “dry” years, and 0.2 feet higher for “critical dry” years. Since lake levels are generally higher for the proposed action than the baseline for all year types, there potentially is a lower risk of large-sized blue-green algae blooms and associated poor water quality, although empirical data does not clearly demonstrate that water quality conditions in UKL influence sucker populations.

Larval emigration continues in the Williamson River during June and shoreline habitat in Upper Klamath Lake becomes more important as more larval suckers enter the lake. June emergent vegetation habitat in the lower Williamson for “above average”, “below average”, “dry”, and “critical dry” years is 61.8, 37.4, 15.4, and 0 percent respectively for the proposed action. Emergent habitat for the baseline is 12.6, 1.4, 0.2, and 0 percent for “above average”, “below average”, “dry” and “critical dry” water year types respectively. The percent difference is 49.2 for “above average”, 36.0 for “below average”, 15.2 for “dry”, and 0 for “critical dry” years. Emergent vegetation habitat in Upper Klamath Lake ranges from 5.1 to 71.7 percent for the proposed action and 0 to 31.2 percent for baseline conditions. The percent difference between the proposed action and baseline Upper Klamath Lake emergent habitat is 40.5, 40.0, 25.5, and 2.1 for “above average”, “below average”, “dry” and “critical dry” years respectively. The proposed action results in greater depths and more inundation of emergent vegetation habitat than under baseline condition for “above average” and “below average”, and “dry” years and similar habitat conditions for “critical dry” years.

July elevations are 4141.5, 4140.7, 4140.3, and 4138.9 feet for “above average”, “below average”, “dry” and “critical dry” years respectively. For “above average” years the proposed elevations are 0.9 feet higher than the baseline for “above average”, 0.5 feet higher for “below average”, 0.3 feet higher for “dry” years, and 0.8 feet lower for “critical dry” years respectively. The higher July elevations resulting from the proposed action during “above average”, “below average”, and “dry” years may provide an un-quantified lower risk of large magnitude algae blooms and associated high pH and high and low dissolved oxygen levels than under the baseline conditions. This lower risk is associated with dilution, light limitation, and sediment re-suspension mechanisms. Maintenance of good water quality is important for adequate functioning of one of the primary elements of habitat. For “critical dry” years where the proposed action elevations are lower than the baseline there may be a higher risk of large-sized algae blooms and poor water quality. However, there is no empirical data to quantify this potential risk.

Emergent vegetation habitat ranges from 0 to 34.4 percent under the proposed action and 0.0 to 11.8 percent for baseline in July. The percent difference in Upper Klamath Lake emergent habitat between the proposed action and baseline is 22.6 for “above average”, 7.4 for “below average”, 4.9 for “dry”, and –2.0 for “critical dry” years. Although there is much less emergent habitat available in July than during May and June for the proposed action and baseline conditions, suckers are less dependent on this habitat for rearing than in previous months. Not only have larval suckers grown to a larger size where they are less vulnerable to predation but also they occupy a wider range of habitats including non-vegetated shoreline areas and open water areas (Simon et al. 2000).

Adult suckers generally occupy open water habitat greater than three feet deep except during the spawning season (Peck 2000). Further, they appear to be mostly concentrated in the northern portion of Upper Klamath Lake particularly during the summer and fall. The open water habitat-to-lake elevation relationship is displayed in Table 5.4. Most of the open water habitat for adult suckers is available during the spring and early summer (through July) under the proposed action and baseline conditions.

Blue-green algae blooms and die-offs are a dominant factor affecting UKL water quality during August and September. During algae die-offs low dissolved oxygen and high un-ionized ammonia concentrations can occur resulting in stressful conditions for fish. As mentioned above, there is not a clear relationship between water quality and water levels in UKL. When the bloom crashes, water column biological oxygen demand increases and at the same time, photosynthetic oxygen production is reduced throughout the water column. At lower elevations, the ratio of lake volume to sediment surface area decreases. As this ratio decreases, the depletion rate of dissolved oxygen in the water column increases because the lower water volume holds less oxygen relative to the BOD of the sediments. It has also been shown that increased re-suspension of sediments that is higher at low lake levels causes more depletion of oxygen and release of ammonia into the water column (Barica 1974). During calm periods, anoxic (no oxygen) conditions can occur at the lake bottom leading to greater production of ammonia that is subsequently mixed in the water column when winds occur. When mixing occurs the low dissolved oxygen is spread throughout the water column. Large algae blooms and subsequent crashes occurred during late summer in 1995, 1996, 1997 and 1998 (Perkins et al. 2000, Welch and Burke, 2001). However, there is no empirical data that describes the effect of these conditions on the suckers.

Recent information suggests that freshwater inflow areas thought to be sucker refuges when water quality degrades in Upper Klamath Lake are used less frequently than previously suspected (Reclamation 1996). Radio-tagged adult suckers generally concentrated in close proximity to, but not in, freshwater inflow areas before and during periods of poor water quality and sucker die-offs (Peck 2000). These areas are adjacent to Pelican Bay, Williamson River, Wood River and other tributaries and springs. The bottom elevations in these areas range form 4134.0 to 4136.0. Based on adult sucker radio telemetry studies, water depths of three feet and greater are necessary to provide adequate refuge habitat.

Water quality in these transition areas is generally better than that found elsewhere in the lake, but more variable because of the influence of lake water quality, proximity to bottom sediment, and wind-caused mixing and re-suspension of bottom sediment. Degraded water quality has been monitored in these areas when depths were shallow at elevations below 4139 (< 3 feet deep; Reclamation 1996).

August elevations resulting from the proposed action are 4140.5 for “above average”, 4139.6 for “below average”, 4139.0 for “dry”, and 4137.6 for “critical dry” years. These elevations are 0.2 feet higher than baseline for “above average”, 0.5 feet lower for “below average”, 0.9 feet lower for “dry “, and 2.0 feet lower for “critical dry” years. Adult sucker habitat ranges from 49.1 to 93.9 percent under the proposed action versus 80.8 to 92.2 percent for baseline. The percent difference between the proposed action and baseline adult habitats is 1.7, -9.7, -20.1 and -30.9 for “above average”, “below average”, “dry” and “critical dry” years respectively. The difference in adult habitat between the proposed action and baseline are relatively small for “above average” and “below average” years. However, there is substantially less adult habitat for the proposed action than the baseline for “dry” and “critical dry” years. This may result in crowding of fish and associated stress and higher risk of disease.

August water depths in water quality refugia areas range from 1.6 feet (4137.6) to 4.5 feet (4140.5) for the proposed action compared to 3.6-4.0 feet for the baseline. Since water depths for access and habitat in refuge areas are 3 feet or less for “dry” and “critical dry” years, adult suckers may be relegated to deeper areas that have poor water quality increasing the risk of fish kills. However, there is a lack of empirical data that indicates that fish health and survival was affected by changes in lake levels.

September elevations are 4139.8 for “above average”, 4138.9 for “below average”, 4138.2 for “dry”, and 4137.1 for “critical dry” years. These elevations are 0.6 feet lower than the baseline elevations for “above average”, 1.3 feet lower for “below average”, 1.8 feet lower for “dry” and 2.6 feet lower for “critical dry” years. The substantially lower elevations for all water year types may increase the risk of achieving harmfully low dissolved oxygen and high un-ionized ammonia conditions.

The September adult open water rearing habitat for the action is 85.2, 65.9, 55.9, and 44.1 percent for "above average", "below average", "dry" and "critical dry" years respectively. The amount of adult rearing habitat is 7.9 percent lower for the proposed action than the baseline for "above average", 25.5 percent less for "below average", 38.6 percent less for "dry" and 38.9 percent less for "critical dry" years. There is substantially less adult rearing habitat for the proposed action than the baseline for "dry" and "critical dry" years. This may result in crowding of fish and associated stress leading to increased risk of stress and disease. However, there is no data that demonstrates a direct relationship between lake levels and the risk of disease.

September water depths in water quality refugia areas range from 1.1 to 3.8 feet with the proposed action and 3.7 to 4.1 feet for the baseline. Access to and amount of water quality refugia habitat available as a result of the proposed action may negatively affect adult suckers during "dry" and "critical dry" years because water depths are less than three feet. Fish may be relegated to deeper areas that may have poor water quality increasing the risk of fish kills. However, there is no empirical data to connect lake levels and the welfare of the endangered suckers.

In summary, the effect of delivery from storage results in lowering of lake levels, reducing the amount of habitat available of shoreline spawning, larval and juvenile rearing in shoreline emergent vegetation, the amount of adult open water rearing habitat and depth in and access to water quality refuge areas. Lower lake levels also might increase the probability of larger algae blooms and poor water quality that may be stressful to suckers. Lake levels resulting from the proposed action start out higher during the spring than the baseline providing more shoreline spawning habitat, emergent vegetation habitat and lower risk of early and large-sized algae booms and associated poor water quality. During the summer, fall, and winter elevations for the proposed action are generally lower than the baseline possibly rearing habitat and possibly increasing the risk of poor water quality during algae bloom and decay cycles. With shallow depths in water quality refuge areas, adult suckers may not use these areas, instead remaining in areas with poor water quality where they are more susceptible to stress and disease.

5.2.4.2 Clear Lake and Gerber Reservoir

The following analysis for Clear Lake and Gerber Reservoir 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. Also, while there is a connection between water quality and lake levels, the association between these factors and sucker populations is not established.

Water delivery from storage during the spring and summer results in lower lake levels, volume and surface area in Clear Lake and Gerber Reservoir. The effects of the delivery results in a reduction in shoreline habitat occupied by larval and age 0 juvenile suckers and open water habitat for juvenile and adult suckers. This reduction of habitat may increase competition with other fish for food and space, fish and bird predation, and disease potentially resulting in stress and lower survival of endangered suckers.

During years when the surface area of Clear Lake is less than 4524 from February through April, access to spawning areas in Willow Creek is blocked. Low stream flows occur in dry years restricting passage to upstream spawning areas. Reproduction may be unsuccessful or extremely low resulting in a small year class or no year class.

Since a large percentage of the lake has a bottom elevation of about 4520 (most of the east lobe), lowering the lake below 4524 substantially reduces juvenile and adult habitat. 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.

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). Fish condition at higher lake levels in 1993-1995 were improved with increased body weight and fewer external parasites and lamprey wounds (Scoppettone et. al. 1995).

Lower lake levels may also result in degraded water quality including higher water temperatures and lower dissolved oxygen 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). The major concern for harmful and/or lethal water quality conditions is associated with winter ice cover periods. At low lake levels there is an increased risk of low dissolved oxygen and potential winterkill 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. In that year dissolved oxygen concentrations 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 at relatively low levels for several years. These conditions may adversely affect suckers because of crowding and the negative impacts associated with it including: 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 for extended periods. However, model simulations demonstrate that if the surface elevation of Clear Lake is at least 4521 on October 1, it is unlikely that the lake will drop below 4519 in the following year. Therefore, delivery of water that results in a lake level of less than 4521 before October 1 should be avoided.

During years when the surface area of Gerber Reservoir is less than about 4805 from February through April, access to spawning areas in Barnes Valley and Ben Hall creeks is restricted due to a blockage at the mouth of the creeks. Also, in dry years these streams typically have very low flows that may not be adequate for upstream passage of spawning adults. Under these conditions, reproduction may be unsuccessful or extremely low resulting in a small year class or no year class.

During dry years when minimum elevations reach 4801.7, the surface area 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, low dissolved oxygen), increased competition, and increased incidence of disease, parasites, and predators. Effects of low lake levels on larval and juvenile suckers is likely to be even greater than adults since they have lower food reserves, higher metabolism, lower mobility, and are more vulnerable to predators.

Lower lake levels may result in degraded water quality including higher water temperatures, higher pH values and lower dissolved oxygen 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).

5.2.5 Effects of Other Proposed Actions

Some delivery of stored water in UKL occurs during the winter in the Lower Klamath Lake area. This action probably does not have a negative effect on suckers in Upper Klamath Lake since water quality is good during the winter and there is no evidence of winterkill during ice-cover events.

Delivery of stored water from Clear Lake and Gerber Reservoir from April through September and natural flows increases the amount and quality of habitat in the Lost River from Clear Lake Dam to Wilson Dam because flows are generally higher than the baseline. Delivery of stored water from Upper Klamath Lake through Lake Ewauna and the Lost River Diversion Canal into the Lost River at Station 48 increases the quantity and quality of habitat from Wilson Dam to Anderson-Rose Dam.

A major effect of Project operation is the loss of large numbers of larvae, juvenile and adult suckers through entrainment at the A-Canal. Reclamation's proposed action includes screening the A-Canal by April 2004 to minimize take associated with project operations. The screen is expected to eliminate all entrainment of adults and juveniles (greater than 50 mm) and reduce entrainment of larval and early juvenile suckers. Reclamation completed an entrainment reduction project at Agency Lake Ranch in 2001. A screen is also to be installed at the outlet of Clear Lake in 2002. Entrainment reduction into the A-Canal, Clear Lake and Agency Lake Ranch should improve the survival rate of suckers particularly juveniles. This may lead to increases in individual year class and overall population size in UKL and Clear Lake.

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. However, Reclamation proposes to prepare a multi-year plan to design and install screens at other facilities. 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.

Another major effect is the lack of adequate passage facilities at Link River, Clear Lake, Gerber, Malone, Wilson, and Anderson-Rose Dams to allow suckers to move into areas of preferred habitat or to spawning areas in or above Upper Klamath Lake. Reclamation's proposed action includes installation of a new passage facility at Link River Dam by July 2006. Adequate fish passage will increase the access to Upper Klamath Lake by fish entrained through Link River Dam and those occupying downstream habitat seeking to migrate to spawning areas in Upper Klamath Lake or tributaries to Upper Klamath Lake. This may lead to a larger and more genetically diverse sucker populations. Reclamation also proposes to prepare a multi-year plan to design and install fish passage facilities at other dams.

5.2.6 Summary of Effects Analysis

When compared to the environmental baseline condition, the proposed action is likely to have the following effects on endangered suckers:

1. Diversion of flows to storage at Agency Lake Ranch is not likely to negatively affect endangered suckers in UKL because flow diversion occurs during the winter and spring when inflows exceed the flood control levels and water would be spilled at Link River Dam.

2. Diversion of flows from the Klamath River (Lake Ewauna to Keno Dam) is not likely to have a negative effect on suckers because water levels and resulting habitat remain fairly constant year round regardless of Project operation.

3. The following proposed diversion actions may result in dewatering or low flows that may have adverse effects on the suckers such as increased predation, increased risk of poor water quality, crowding fish, and reduced food availability. Proposed diversions include: flow diversion from Miller Creek below Gerber Reservoir during fall and winter storage; from Miller Creek below Miller Creek Dam during the delivery

period; from Lost River below Clear Lake to Malone Dam during fall and winter storage; from Lost River below Malone Dam to Bonanza during the delivery period; from Lost River below Wilson Dam to Tule Lake during the fall and winter diversion period; from Lost River below Anderson-Rose Dam to Tule Lake during the delivery period.

4. Storing water increases lake levels, resulting in more shoreline spawning habitat in UKL, increase larval, juvenile, and adult rearing habitat in all reservoirs, increases water quality refuge habitat in UKL, reduces risk of winterkill in all reservoirs, and reduces risk of poor water quality related to algae bloom and decay cycles in UKL. While these conditions are beneficial for the survival of all sucker life stages, there is a lack of empirical data to determine that any particular lake level is necessary to provide these benefits.

5. Delivering water from storage and impaired natural flows lowers lake levels; results in less shoreline spawning habitat in UKL; reduces larval, juvenile and adult rearing habitat in all reservoirs; decreases habitat area in water quality refuge areas in UKL; and increases the frequency and magnitude of potentially harmful water quality conditions related to algae bloom and decay cycles in UKL. However, there is a lack of empirical data to determine that any particular lake level is necessary to avoid these effects.

6. Delivering water from storage increases flow in Miller Creek and Lost River would provide more rearing habitat and would reduce the risk of poor water quality associated with algae and aquatic plant growth.

7. Because UKL levels would be generally higher during the late winter and spring than the baseline, there is more shoreline spawning and larval rearing habitat, potentially increasing spawning success and resulting in larger-sized year age classes. There is a lack of fish population data to demonstrate a clear association between higher lake levels and sucker recruitment.

8. The proposed action would reduce entrainment into the A-Canal, Agency Lake Ranch, and Clear Lake potentially increasing survival of juvenile and adult suckers and overall population size. Entrainment at other project facilities would occur, negatively affecting survival of all sucker life stages. Salvage and relocation of fish stranded below outlet structures will improve their chances for survival.

9. The proposed action would provide adequate passage of suckers at Link River Dam into areas of preferred habitat or to spawning areas potentially increasing their survival and reproductive success. Passage would remain blocked at other project facilities including Clear Lake, Gerber Reservoir, Malone, Wilson and Anderson-Rose dams.

5.3 EFFECTS ON COHO SALMON

5.3.1 Mainstem Klamath River

This section provides an analysis of the effects of the proposed action compared to the environmental baseline for coho salmon. Flows in the mainstem Klamath River downstream from Iron Gate Dam will be affected by changes in flows at Iron Gate Dam. This is illustrated by comparing the flows in the Klamath River downstream from Iron Gate Dam with the proposed action against baseline conditions (Tables 5.8 and 5.9). The analysis of effects is based in large part on habitat-discharge relationships presented in Table 5.10 and Figure 1. Reclamation determined that these preliminary habitat versus discharge relationships for the various anadromous fish species developed as part of the Hardy Phase II study as discussed in Chapter 3.0 were appropriate for use in this BA. Reclamation used only the data regarding habitat from the study, not the conclusions.

The act of storing and diverting impaired flows under the proposed action would affect the amount of suitable habitat available to coho salmon in the Klamath River mainstem. The relationship between changes in habitat quantity and quality, and the status and trends of fish and wildlife populations has been the subject of scientific research and publication, although not specific to the Klamath Basin. For detailed discussions of the relationship between habitat variables and the status of salmon populations, readers should refer to the work of FEMAT (USDA Forest Service et al. 1993), Gregory and Bisson (1997), Hicks et al. (1991), Murphy (1995), National Research Council (1996), Nehlsen et al. (1991), Spence et al. (1996), Thomas et al. (1993), The Wilderness Society (1993), and others.

The approach used in this assessment is intended to determine if the proposed action is likely to degrade the quantity and quality of natural resources necessary to support populations of coho salmon in the action area. However, there is a lack of data demonstrating a clear association between changes in Klamath River mainstem flow below Iron Gate Dam and the welfare of the salmon

Table 5.8 - Baseline flows as measured at Iron Gate Dam (values in cfs) by water year type

Time Step	Above Average	Below Average	Dry	Critical Dry
October	1565	1368	1084	811
November	2050	1986	1762	1136
December	2676	2832	2636	1516
January	3243	3240	2950	2097
February	4315	3133	2521	1774
March 1-15	4760	3270	2749	1791
March 15-31	5010	3283	2739	1783
April 1-15	4793	2978	2251	1627
April 16-30	4783	2919	2088	1584
May 1-15	4295	2582	1939	1515
May 16-31	4049	2366	1811	1369
June 1-15	3317	1956	1485	1045
June 16-30	2834	1692	1313	897
July 1-15	2180	1398	1002	746
July 16-31	1723	1183	827	668
August	1373	1064	805	600
September	1331	1097	892	651

Table 5.9 – Flows as measured at Iron Gate Dam (values in cfs) resulting from the proposed action by water year type

Time Step	Above Average	Below Average	Dry	Critical Dry
October	1345	1345	879	920
November	1337	1324	873	912
December	1387	1621	889	929
January	1300	1334	888	1101
February	1300	1806	747	637
March 1-15	1953	2190	849	607
March 15-30	2553	1896	993	547
April 1-15	1863	1742	969	874

April 16-30	2791	1347	922	773
May 1-15	2204	1021	761	633
May 16-31	1466	1043	979	608
June 1-15	827	959	741	591
June 16-30	934	746	612	619
July 1-15	710	736	547	501
July 16-31	710	724	542	501
August	1039	1000	647	517
September	1300	1300	749	722

Table 5.10 - Habitat-discharge relationships for salmon in Klamath River (Iron Gate Dam-Shasta River). Source: Hardy Phase II preliminary data

Discharge (cfs)	Percent of optimal habitat	
	Chinook spawn	Coho fry
500	66	59
713	81	46
927	91	44
1140	97	44
1393	100	47
1647	100	48
1900	97	51
2191	90	58
2482	82	65
2773	74	71
3064	65	76
3365	57	81
4086	40	91
4817	28	97
5548	21	100
6365	16	89
7183	13	85
8000	12	81

Figure 1 is a graphic representation of the data in Table 5.10. The general assumption underlyng habitat modeling is that aquatic species will react to changes in the hydraulic environment (Hardy and Addley 2001). In general, the relationship between flow and habitat starts at the origin (no flow, no habitat), increases (not necessarily in a uniform manner) with flow up to a point, and then declines if flows become excessive. These "habitat versus discharge" relationships were developed by first determining the hydraulic characteristics (e.g., depth and velocity) of the Klamath River mainstem channel between Iron Gate Dam and the Shasta River confluence as a function of discharge. This information was then integrated with habitat suitability criteria to produce a measure of available habitat (percent of optimal habitat) as a function of discharge (Hardy and Addley 2001). Habitat suitability criteria describe biological responses of target species and life stages to the hydraulic environment (i.e., how suitable a particular gradient of depth, velocity, substrate, cover, etc. is to a target species and life stage). For example, habitat suitability as a function of depth is represented on a scale of 0.0 to 1.0. A suitability value of 0.0 represents a depth that is wholly not suitable, while a 1.0 value indicates a depth that is "ideally" suitable. Specific relationships between the status of the salmon and Klamath River flow amounts have not been established.

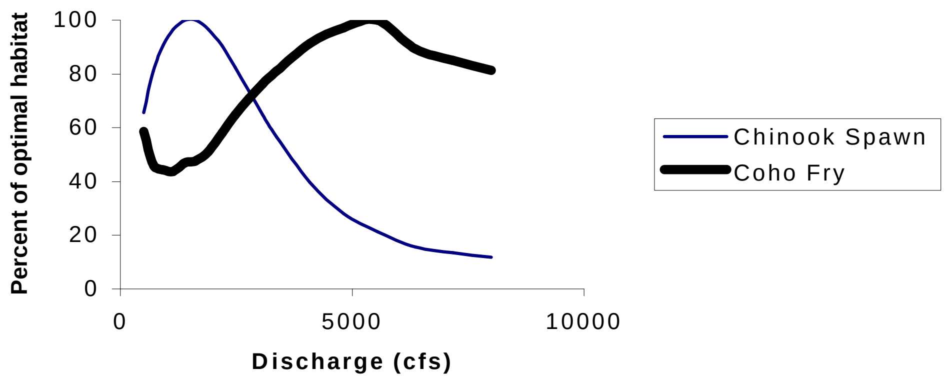

Figure 1. Habitat - discharge relationships for coho fry and chinook spawning in Klamath River, Iron Gate Dam - Shasta River. Source: Hardy Phase II preliminary data.

5.3.2 Analysis Approach

5.3.2.1 Flows as Measured at Iron Gate Dam

Figures 2 through 5 illustrate flows as measured at Iron Gate Dam with the proposed action (Table 5.9) and baseline flows (Table 5.8) for coho salmon for each water year type. The method used to determine the effects of proposed water delivery and storage on threatened coho salmon in the mainstem Klamath River is to compare flows as measured at Iron Gate Dam resulting from the proposed action with the baseline flow releases. However, there is a lack of data demonstrating a clear association between changes in Klamath River flow and the health of the salmon during the period from water year 1990 through water year 1999.

5.3.2.2 Habitat for Fry and Spawning Life Stages

The following approach was used to determine the effects of the proposed action on coho salmon habitat in the Klamath River. The baseline flows at Iron Gate Dam (Table 5.8) and the flows as measured at Iron Gate Dam resulting from the proposed action (Table 5.9) were integrated with the preliminary Iron Gate Dam to Shasta River habitat (percent of optimal habitat) versus discharge (cfs) relationships from the INSE (Hardy) Phase II study for coho fry and chinook spawning life stages (Table 5.10; Figure 1) to construct two sets of habitat values (with and without the proposed action). There is no available information on the relationship between Klamath River flows and coho salmon spawning habitat. However, since fall chinook salmon utilize the mainstem Klamath River for spawning during the same period that coho salmon spawn (INSE 1999), chinook spawning was considered the best surrogate life stage for coho migration and spawning.

These life stages were considered the highest priority for the following time periods:

- Coho fry - February - June 15
- Coho/chinook spawning - October - February

The impact assessment for coho fry was determined based on the percentage difference between the habitat values with the proposed action and the baseline. A similar analysis was done for chinook salmon spawning to assess effects on spawning and egg incubation habitat in the fall and winter.

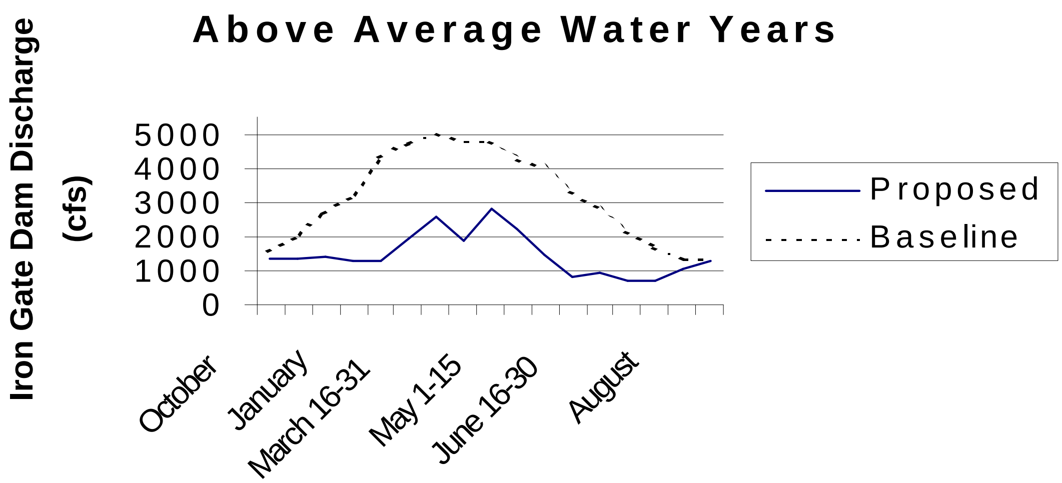

Figure 2. Iron Gate Dam flows during "above average" water year type under proposed action and baseline conditions.

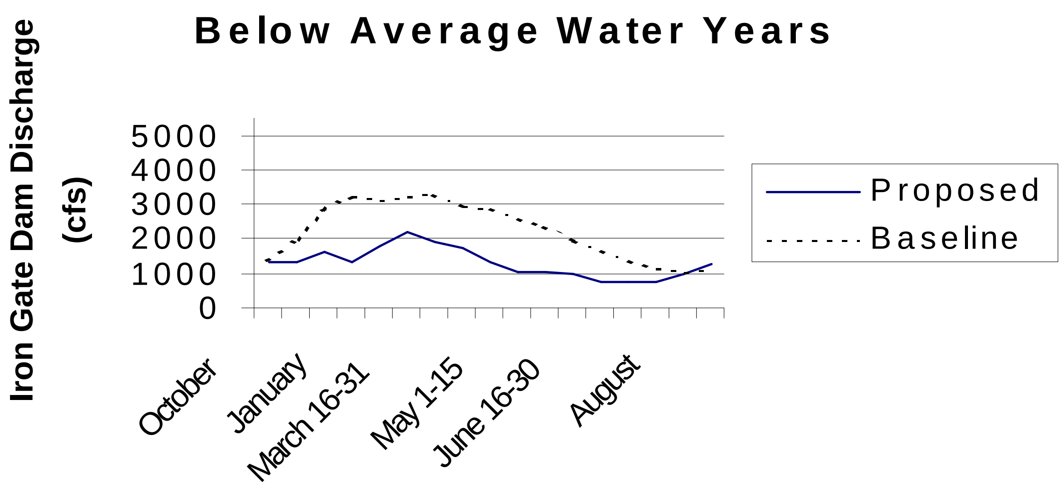

Figure 3. Iron Gate Dam flows during "below average" water year type under proposed action and baseline conditions.

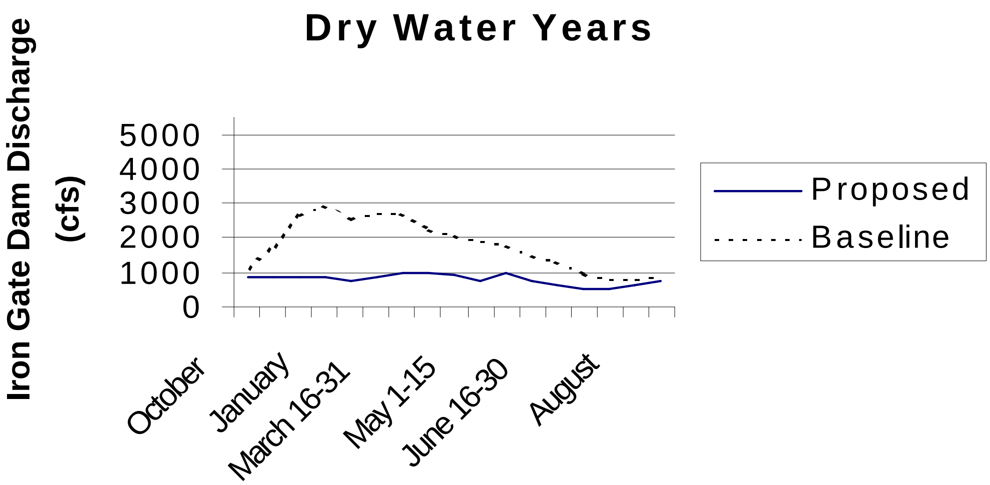

Figure 4. Iron Gate Dam flows during "dry" water year type under the proposed action and baseline conditions.

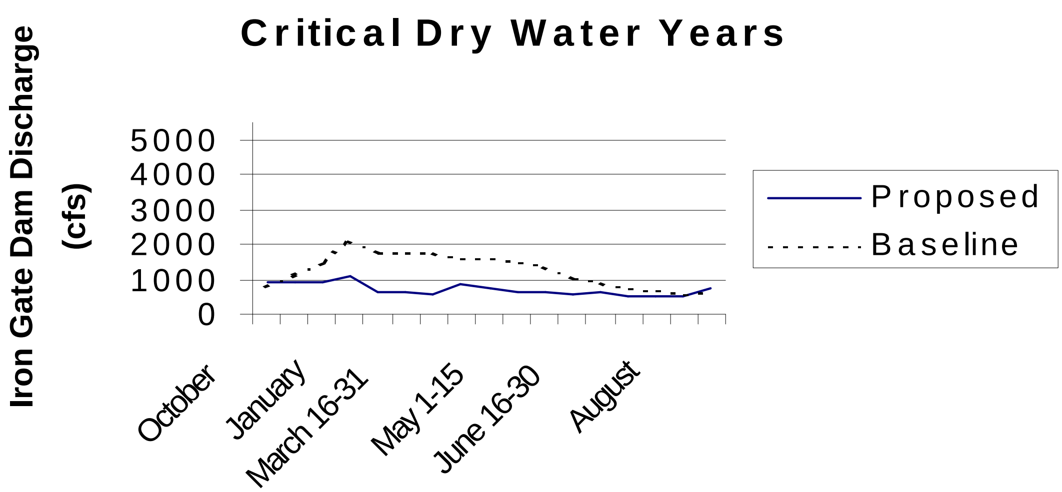

Figure 5. Iron Gate Dam flows during "critical dry" water year type under the proposed action and baseline conditions.

5.3.2.3 Summer Water Quality Analysis

By mid-June, water quality deteriorates in the Klamath River. High water temperatures and low dissolved oxygen levels create an unfavorable environment for salmon. Thus, use of habitat time series to assess the proposed action effects on coho salmon during the summer is not appropriate. The approach used for the water quality analysis included modeling Klamath River water temperatures at various flows using RMA-11 model during the summer (Deas and Orlob 1999). This model was considered the most appropriate model to use because it computes Klamath River water temperatures using an hourly time step and is sensitive to small changes in flow (Deas and Orlob 1999). The Systems Impact Assessment Model (SIAM) developed by the USGS was not used because it is less sensitive to flow changes than the RMA-11 (i.e., SIAM uses longer flow time steps (average daily) than the RMA-11 model). SIAM is most useful for general planning purposes. The one disadvantage of RMA-11 is that it only simulates water quality within the first 60 miles downstream from Iron Gate Dam (to Seiad Valley). In addition to modeling temperatures, Reclamation compared flows at Iron Gate Dam between the proposed action and the baseline during the summer for various water year types.

5.3.3 Effects of Diverting Flows and Storage

The following proposed flow diversions, although occurring upstream of Iron Gate Dam, may result in diminished flow downstream of Iron Gate Dam and thus may adversely affect the salmon. However, there is a lack of data demonstrating a clear association between a reduction in Klamath River flow and the welfare of the salmon. The expanded analyses of these effects are included in later sections on water delivery (5.3.7—Effects of water delivery for Klamath Project purposes). Diversion of flows for Project purposes occur at Agency Lake Ranch, Upper Klamath Lake, Clear Lake Reservoir, Gerber Reservoir, Lost River, Tule Lake, and Klamath River (Lake Ewauna to Keno Dam).

5.3.4 Effects of Putting Water into Storage (“Storing”)

Storing water for Project purposes occurs at Agency Lake Ranch, Upper Klamath Lake, Gerber Reservoir, and Clear Lake. Reclamation proposes to store water in UKL and other Project reservoirs year-round, with a significant portion of the water being stored during October through March. In some years, storing water is significant in April, May, and June. The following analysis only considers the effects of storing water from October through March.

Adult coho salmon migrate into the Klamath River from the ocean between September and January. The requirements of adult coho salmon during this time include a migratory corridor with suitable water depth and velocities, resting pools, and adequate water quality conditions (NMFS 2001). Successful immigration also depends on adequate fish passage conditions in the mainstem Klamath River and access to tributaries.

Iron Gate Dam flows (October through January) under the proposed action would vary from 912 to 1,101 cfs in “critical dry” water years to 1,300-1,387 cfs in “above average” water years (Table 5.8). This compares with baseline flows of 811-2,097 cfs in “critical” dry water years to 1,565-3,243 cfs in “above average” water years (Table 5.9). Historical records of Chinook salmon runs to Iron Gate Hatchery demonstrate that fish passage into the upper river has occurred in all year types including “critically dry” with flows at Iron Gate Dam as low as 700 cfs (Vogel and Marine 1994). Therefore, coho passage may not be affected by the flows resulting from the proposed action between September and January.

Passage conditions from the mainstem Klamath River into some tributaries have been a concern under relatively low flow conditions (Vogel and Marine 1994), particularly in “dry” and “critical dry” years.

Not only is access to the tributaries affected by mainstem passage conditions, but also by streambed and channel configurations and tributary flows. For example, substantial aggradation of large cobble and boulder material at the mouth of the Scott River creates a very shallow berm at low river flows that fish first entering this river must cross. The mainstem flow needed for salmon to enter tributaries is a data gap that could be determined by measuring mainstem and tributary channel profiles at the mouth of the tributaries and using a backwater hydraulic model to simulate various mainstem flows until a flow is simulated that inundates the mouth of the tributary. In addition, a streambed material analysis needs to be done at the mouth of the tributaries to determine the porosity of the substrate (M.Deas, per. comm..2002) During dryer years, low tributary flow may restrict passage independent of mainstem flows. The potential adverse effects to mainstem passage conditions and tributary access may result in spawning migration delays or straying due to natal stream inaccessibility. Because adult salmon do not feed during their freshwater spawning migration, individuals have a finite amount of energy reserves. Increased pre-spawning mortality and decreased spawning success may result from the proposed action and under baseline conditions in “dry” and “critical dry” water years.

Most coho salmon spawning typically occurs during December and January in the Klamath River Basin (Weitkamp et al. 1995). Although coho salmon have been observed spawning in the mainstem Klamath River (Reclamation 1998), it appears to be limited. Klamath River water temperatures during the spawning period would likely be within the acceptable range associated with coho salmon spawning in California (42-56 ^{o}F) (Briggs 1953).

Results of the spawning habitat analysis are summarized in Table 5.11. Examination of Table 5.11 shows that flows resulting from the proposed action generally improve spawning habitat conditions compared to the baseline. Most habitat increases occur during “above average” and “below average” water years in the December through February period. The highest gain occurs in February of an “above average” water year (+174%). Minor losses occur in October of “above average” and “dry” water years. Most spawning habitat losses occur during a “critical dry” water year, with the greatest habitat loss occurring in February (-24%) (Table 5.11).

Table 5.11 - Chinook spawning habitat (% optimal habitat); Baseline compared to proposed action.

	Above Average			Below Average			Dry		
Time Step	Baseline	Proposed	% change	Baseline	Proposed	% change	Baseline	Proposed	% change
October	100	99	-1	100	99	0	95	89	-7
November	93	99	6	95	99	5	98	88	-10
December	77	100	31	72	100	39	78	89	15
January	60	99	65	60	99	65	68	89	30
February	36	99	174	63	98	55	81	83	2

	Critical Dry		
Time Step	Baseline	Proposed	% change
October	86	90	6
November	97	90	-7
December	100	91	-9
January	92	96	3
February	98	75	-24

There is the potential effect during the spawning/egg incubation period of dewatering of incubating eggs if flows decline. Proposed action and baseline flows generally decline between January and March in “dry” water years (Table 5.8 and 5.9). Thus, lower flow resulting from the proposed action between

January and March may result in some dewatering of incubating eggs in the mainstem Klamath River. However, flow reductions will likely occur less frequently under the proposed action than the baseline.

Fry habitat in February and March is affected by the proposed action as shown in Table 5.12. Major decreases in fry habitat occur with the proposed action compared to the baseline in "above average", "below average", and "dry" water years (Table 5.12). Habitat losses range from –27% in March 1-15 of "below average" years to –51% in February of "above average" water years. Minor losses occur in "critical dry" water years (-11%). No increases in fry habitat occur in February or March. Coho fry may be affected by decreased carrying capacity and displacement of fry into less suitable habitat. As a result, survival of salmon fry may decrease. However, there is a lack of empirical data demonstrating a clear association between a reduction in Klamath River flow and the recruitment and survival of coho salmon in the Klamath River.

Examination of Figures 2 to 5 and Tables 5.8 and 5.9 shows that Iron Gate Dam flows with the proposed action would be less than baseline conditions during the time when water is put into storage for Project purposes in all water year types, with the exception of October of a "critical dry" year. This results in a reduction in fry habitat in the Klamath River.

Table 5.12 – Coho fry habitat (% optimal habitat); Baseline compared to proposed action.

	Above Average			Below Average			Dry		
Time Step	Baseline	Proposed	% change	Baseline	Proposed	% change	Baseline	Proposed	% change
February	93	46	-51	77	50	-36	66	46	-30
March 1-15	97	52	-46	80	58	-27	70	45	-36
March 16-31	98	66	-32	80	51	-36	70	44	-37
April 1-15	97	51	-48	75	49	-34	59	44	-26
April 16-30	97	71	-27	74	46	-37	56	44	-20
May 1-15	93	58	-37	67	44	-34	52	46	-12
May 16-31	91	47	-48	62	44	-29	50	44	-11
June 1-15	80	45	-44	52	44	-16	47	46	-3

	Critical Dry		
Time Step	Baseline	Proposed	% change
February	49	44	-11
March 1-15	50	44	-11
March 16-31	50	44	-11
April 1-15	48	45	-6
April 16-30	48	46	-4
May 1-15	47	44	-7
May 16-31	47	44	-5
June 1-15	44	44	0

5.3.5 Effects of Water Delivery for Klamath Project Purposes

Water delivery for Project purposes includes both 1) delivery of water from Upper Klamath Lake storage; and 2) diversion of water from impaired inflows. The delivery of water from Upper Klamath Lake storage does not adversely affect baseline conditions on the Klamath River below Iron Gate Dam. Thus, any adverse effects in the following analysis are attributable to diversion of water from impaired inflows only. Also, conclusions based on the following analyses recognize the lack of data demonstrating relationships between changes in Klamath River flow and the coho.

The most critical period for young-of-the-year (YOY) salmonids occurs from March to early June (FWS 1998). Young-of-the-year begin to emerge from spawning redds and seek out stream margins providing vegetated cover which, in turn, provides low velocity envelopes, protective cover from predators, and sources of food.

During this period, Reclamation is delivering stored water and diverting inflow. Table 5.12 shows that the diversion of impaired inflows generally adversely affects coho salmon fry habitat compared to the baseline. Decreases in habitat compared to the baseline occur between March and early June of all water year types, with the exception of no change in early June of “critical dry” water years. Habitat losses range from -3% in June 1-15 of “dry” water years to -48% in April 1-15 and May 16-31 of “above average” water years (Table 5.10). Greater percentages of habitat losses occur in wetter years compared to drier years. This is likely to result in an adverse effect on coho salmon critical habitat during this time period. Coho fry may be affected by decreased carrying capacity and displacement of fry into less suitable habitat. As a result, survival of salmon fry may decrease. However, there is a lack of empirical data demonstrating a clear association between a reduction in Klamath River flow and the recruitment and survival of coho salmon in the Klamath River.

Primarily in April, Reclamation sometimes stops a portion of the impaired inflows. This is illustrated in Figure 2. One concern with project operations is the effect of potential stranding of YOY coho salmon during decreases in Iron Gate Dam flows (NMFS 2001). For example, flows at Iron Gate Dam dropped from 3,300 cfs to 1,800 cfs the week of April 19, 1998, resulting in the stranding of coho fry (FWS 1998). The extent of mortality was unknown; however, FWS biologists rescued 7 coho salmon fry and 738 chinook salmon fry in three isolated edge water pools. The proposed action flows in the April 1-15 time period decrease and then increase in late April for “above average” water year types (Table 5.8). Reclamation will work closely with PacifiCorp and NMFS regarding flow changes at Iron Gate Dam that may occur during this period in any given year.

Water temperatures and water quality in mainstem Klamath River contribute to unfavorable environmental conditions for juvenile salmon during the summer (late June-September). Thus, an analysis of physical habitat as the main factor influencing salmon during this period is not appropriate.

The NRC (2002) did not find any scientific support for proposed minimum Iron Gate Dam flows as a means of enhancing the maintenance and recovery of the coho salmon population in the reasonable and prudent alternative (RPA) issued in NMFS’s (2001) BO. The NRC (2002) suggested that higher flows from July through September may actually harm coho salmon if the source is warmer than the receiving water. The NRC (2002) strongly encouraged that additional rigorous studies be conducted to address this issue. Also, increased flows may have a detrimental effect on the availability of thermal refugia created by groundwater seepage and small tributary flows (NRC 2002). Increased flows may reduce the size of these refugia by causing more effective mixing of small amounts of locally derived cool water with much larger amounts of warm water from upstream (NRC 2002). The NRC (2002) also noted, however, that progressive depletion of flows in the Klamath River mainstem would at some point be detrimental to coho salmon through stranding or predation losses. They concluded that there is no scientific justification at present for deviating from flows derived from operational practices in place for the period 1990 – 1999 (NRC 2002).

River flow can directly impact water temperatures in the Klamath River (Deas 2000). Flow and temperature simulations using the RMA-11 model in the sixty-mile reach from Iron Gate Dam to Seiad Valley suggest that during summer periods lower flows, as explained below, generally lead to slightly higher downstream temperatures (Table 5.13). Simulated temperature response for a typical mid-summer day at various Iron Gate Dam flows illustrates the flow-temperature interdependence. At 500 cfs, simulated daily mean water temperature increases 2.5 ^{o} C (4.9 ^{o} F) over the sixty mile reach from Iron Gate Dam to Seiad Valley, while at 3,000 cfs the simulated increase is roughly 0.9 ^{o} C (1.6 ^{o} F) (Table 5.12) (Deas 2000; Deas and Orlob 1999). Water temperatures are elevated at low flow rates because of an increase in transit time, less thermal mass allowing greater heating during the day, and shallower river conditions. At 500 cfs, a mean simulated temperature of approximately 25 ^{o} C was recorded at Seiad Valley, compared to about 23 ^{o} C at 3,000 cfs in mid-August (Deas 2000; Deas and Orlob 1999). Thus, high water temperatures can occur at high and low flows, depending on climatic conditions. The extent to which Project operation affects water temperature is complex and remains unclear (Hecht and Kamman 1996).

Young-of-the-year survival, growth, and recruitment depend on the availability of total habitat, including suitable macrohabitat (water quality and temperature) and suitable microhabitat (depth, velocity, and cover) conditions under different river flows. There is a lack of data demonstrating a clear association between changes in Klamath River flow and habitat and the status of the salmon. The availability of suitable microhabitat may not be a primary factor in the survival of YOY salmonids when acute water temperatures prevail. Chronic (>15 ^{o} C) and acute (>20 ^{o} C) water temperatures for salmonids in the Klamath River are based on an evaluation of existing published information on observed relationships between water temperature and chinook salmon tolerances (Bartholow 1995). These “thresholds” may create a population bottleneck by impacting YOY and juvenile coho in late July and August. The fact that juvenile salmonids persist in the Klamath River mainstem despite temperatures that generally exceed these chronic and acute temperature thresholds (Yurok Tribal Fisheries Program 1999, 2000) illustrates the complexity of this issue and warrants further study.

Temperature has direct effects on physical, chemical, and biological processes in most aquatic systems. High temperatures increase chemical reactions, metabolic rates, and decrease the solubility of gases such as oxygen, carbon dioxide and nitrogen (Deas 2000). Excessive water temperature can reduce productivity and increase mortality of aquatic organisms. Temperature affects fish physiology, specifically respiration, food intake, digestion, assimilation, and behavior.

Bartholow (1995) found no data supporting the contention that Klamath River salmonid stocks were more thermally tolerant than other west coast stocks. In fact, the small amount of information available indicates no difference (Bartholow 1995). However, there is evidence that juvenile chinook and coho salmon and steelhead persist in the Klamath River mainstem despite temperatures that generally exceed the chronic and acute temperature thresholds (Belchik 2000). Studies by Konecki et al. (1995) of juvenile coho salmon near St. Helens Washington found juvenile coho could tolerate water temperatures exceeding 24^{o} C (75.2^{o} F) and in some cases were observed in streams with temperatures as high as 29^{o} C (84.2^{o} F). To improve our knowledge on the ability of Klamath River salmon to acclimate or adapt to typical summer temperatures, controlled experiments are needed on the physiological response of Klamath River salmonid juveniles to elevated water temperatures (Williamson and Foott 1998). For example, site-specific determinations of critical thermal maximum (CTM) for coho juveniles in the Klamath River would be valuable.

The effects of diverting impaired flows during the June 1-15 period is influenced by the effect of various flows at Iron Gate Dam on water temperature in the Klamath River (M. Deas, per. comm.; Deas and Orlob 1999). The maximum release at the penstock of Iron Gate Dam is 1,750 cfs. Higher flows go over the spillway. For example, the baseline flow in an “above average” water year during June 1-15 would be 3,317 cfs (Table 5.8). Of this amount, 1,750 cfs would go through the penstock and 1,567 cfs would spill. The modeling results (Figure 7.6, page 140 from Deas and Orlob 1999) show that, around June 1, 1997, water temperatures in the reservoir declined from about 20 EC near the surface (7' deep) to about 15 EC at a depth of 39', which is the approximate depth of the outlet. Using a thermal balancing equation, the resultant river temperature after mixing would be:

(Flow (penstock)(1,750 cfs) times temperature (penstock) (15 ^{o}C)) plus (Flow (spillway) (1,567 cfs) times temperature (spillway) (20 ^{o}C)) divided byTotal river flow (3,317 cfs) = 17.4 ^{o}C.

This is 2.4 ^{o}C higher than the river temperature would be if only the maximum penstock flow of 1,750 cfs was released and would result in temperatures exceeding the chronic limit for salmon in the Klamath River. Thus, the river temperature would be cooler going into the summer with a flow release of 1,750 cfs compared to 3,317 cfs. The flow as measured at Iron Gate Dam resulting from diversion of impaired flows for June 1-15 in an "above average" water year would be 827 cfs (Table 5.8), which would result in lower downstream temperatures than the baseline flow. Deas and Orlob (1999) present flow and temperature relationships for the Klamath River downstream of Iron Gate Dam (including thermal response of Iron Gate Reservoir to increased flows, various operations, seasonal conditions, etc.) The tradeoff in lower flows would be an increase in travel time to reach Seiad Valley. According to Table 8.2 in Deas and Orlob (1999), hourly travel time for flow releases from Iron Gate Dam to Seiad Valley 60 miles downstream for 1,800 cfs and 3,400 cfs would be 38.8 and 30.4 hours, respectively; a difference of 8.4 hours. Since high summer temperatures is such a major issue in the Klamath River, it would seem reasonable to focus on alternatives to reduce water temperatures going into the summer at the expense of a relatively small difference in travel time compared to higher releases. Thus, there should be no effect from deliveries of impaired flows to agriculture in June 1-15 of wetter years on coho salmon compared to the baseline.

Implementing river flows greater than those resulting from the proposed action downstream from Iron Gate Dam from July through September will not likely reduce mean water temperature to levels below chronic and acute levels for salmonids (Table 5.13). Deas and Orlob (1999) reported that higher flows from Iron Gate Dam in August resulted in water temperatures being reduced slightly (Table 5.13), but not reduced below the chronic or acute levels typical of summer conditions. The temperature of water released from Iron Gate Dam and temperature records at Seiad from late June through early September in many water year types approach or exceed acute thermal thresholds and may be a contributing factor to fish kills in the mainstem. Although fish do survive these temperatures, the complex relationship between summer/fall mainstem river flows and water temperatures, and their effects on the fishery in the Klamath River, limits Reclamation's ability to assess the Project's effects and warrants further investigation.

Table 5.13 - Simulated effects of river flow on water temperatures in the Iron Gate Dam (River Mile (RM) 190) to Seiad Valley (RM 130) reach of the Klamath River for a typical mid-summer day (Source: Deas and Orlob 1999)

Simulated Iron Gate Dam flow (cfs)	Maximum diurnal temperature range in ^{o}C and (^{o}F)	Simulated net temperature increase in the Iron gate Dam to Seiad Valley reach in ^{o}C and (^{o}F)	Travel time between Iron Gate Dam and Seiad Valley (days)	Mean temperature at Seiad Valley in ^{o}C and (^{o}F)
500		2.5 (4.5)	2.5	25.0 (77.0)
1000	20-26 (68-79) @ RM 175	2.1 (3.8)	2.0	24.3 (75.7)
2000		1.3 (2.3)	1.5	23.5 (74.3)
3000	21-24 (70-75) @ RM 165	0.9 (1.6)	1.25	23.0 (73.4)

Diurnal water temperatures, including maximum and minimum values, are also affected by flow regime. For low flows, daily maximum temperatures are higher and daily minimum water temperatures are lower, while at higher flows water temperature daily maximums are lower and minimum temperatures higher (Table 5.13). These diurnal fluctuations are for the "node of maximum fluctuation" (approximately a half day's travel distance) and are not characteristic of the entire mainstem Klamath River. This phenomenon dampens with distance downstream from Iron Gate Dam. Only recently, since the early 1990s, have affordable instantaneous temperature measuring devices been available. Thus, field studies on diurnal temperature effects on fish have not been done. In the absence of information on diurnal temperature effects, temperature acclimation studies provide some indication of effects of temperature changes on fish. Armour (1991) reported on studies of the acclimation effects in juvenile chinook salmon which found fish subjected to higher initial water temperature could sustain higher maximum temperature than those acclimated to cold water. The data suggested that, even if fish are acclimated to 20 ° C, you can expect 50% mortalities can be expected if temperatures reach 25.1° C during the day. This is an area that also needs further study in the Klamath River (M. Deas and T. Shaw, per. comm. 2000).

Higher flows at Iron Gate Dam during July and August of drier water years provide minimal cool water benefit but they do moderate daily maximum and minimum temperatures and reduce travel time (Table 5.12). Experiments with pulse flows in 1994 indicate higher flows (1,500 vs 1,000 cfs) over a two-day period benefitted hatchery fish by helping to decrease their travel time to the Big Bar area (Craig 1994). Reduced travel time has been shown to increase survival by decreasing the time fish are subjected to in-river predation, disease, and stress and/or mortality associated with increasing water temperatures in the river (Craig 1994).

Size of fish at time of release also plays an important role in migrational timing. Larger YOY chinook marked with adipose clips and coded wire tags migrated at faster rates than smaller fish (Craig 1994). Thus, flows with warmer temperatures earlier in the spring may benefit coho by increasing growth rates and survival and allow larger smolts to migrate sooner and faster downstream (Craig 1998). Hardy and Addley (2001) used bioenergetic modeling and found that slightly warmer temperatures during the March 14-May 31period resulted in slightly faster growth of chinook fry in the Klamath River. This is another area that needs additional study.

Reclamation recognizes that tributaries can play a crucial role in creating local thermal refugia for juvenile coho salmon during the summer in the Klamath River. Belchik (1997) studied salmonid use of cool water areas in the Klamath River between Iron Gate Dam and Seiad Creek during July and August, 1996, an “above average” water year. He found that there was a significant relationship between numbers of juvenile salmonids and proximity of nearest cool water areas in Klamath River mainstem. He indicated that cool water areas provide key habitat for over-summering juvenile salmonids. Most cool water areas were located at mouths of tributaries (Belchik 1997). A similar study should be conducted during a “critical dry” water year because the contribution of tributaries under drought conditions is small (See Section 4.5.2-Critical Dry Water Year Water Quality Analysis). In addition, a study should be undertaken to more completely quantify accretions (Deas and Orlob 1999). The 2001summer period is an example of a “critical dry” water year situation where the impacts of tributary flow on water quality in the mainstem Klamath River were minor. In nearby Matolle River, which contains SONCC ESU coho salmon, juvenile coho reside almost entirely in tributaries but do not persist where summer daily maximum temperatures exceed 18 °C for more than a week (Welsh et al. 2001).

Reclamation’s proposed action would result in flows ranging from 501 cfs in July to 517 cfs in August at Iron Gate Dam during “critical dry” water years (Table 5.8). This compares with higher baseline flows of 600-746 cfs in July to August in “critical dry” water years (Table 5.9). During July -August, proposed action flows would range from 542-647 cfs during “dry” water years (Table 5.8). This compares with baseline flows ranging from 805-1,002 cfs for the same months (Table 5.9). For “below average” water years, proposed action flows would range from 724-1,000 cfs and baseline flows would range from 1,064 to 1,398 cfs in July and August. For “above average” water years, proposed action flows would range from 710 to 1,039 cfs and baseline flows would range from 1,373 to 2,180 cfs in July and August (Tables 5.8 and 5.9). Given available information, compared to the baseline, the proposed action may affect coho salmon during drier water years by increasing thermal stresses. Slightly warmer temperatures, greater fluctuations in diurnal temperatures, and increased travel time with the proposed action compared to the baseline, in addition to minor thermal relief from tributary contributions during drier water years, may add to an already stressful situation and increase the risk of juvenile salmon being more susceptible to diseases, parasites, and predation. This is another area that needs further investigation. This should not be a concern during wetter years when tributaries can have a favorable influence on water quality in the mainstem Klamath River, particularly at lower Klamath River flows as suggested by NRC (2002)(also see Section 4.5.2-Critical Dry Water Year Water Quality Analysis). Thus, Iron Gate Dam flows during water deliveries may affect SONCC coho salmon only during “dry” and “critical dry” water years.

The Klamath River has likely always been a relatively warm river system. Insolation and ambient air temperatures are primary factors affecting water temperatures in most rivers, including the Klamath. These climatic factors are completely independent and are not affected by Project operations. These factors influence water temperatures as distance increases downstream from Iron Gate Dam (Hecht and Kamman 1996; Hanna 1997). Currently-depressed salmonid populations combined with successful introduction of numerous warm water fish species into the reservoir system suggests that natural climatic factors combined with major landscape alterations in the Klamath River watershed and its tributaries have caused higher water temperatures, thus favoring fish species other than salmonids.

Additional research is needed to assess the impact of on-going Project operations and other activities in the Klamath Basin on anadromous fish. Recent studies by CCFWO, the Yurok Tribe of California and the Karuk Tribe are valuable in understanding the Klamath River fisheries and the overall mechanics of the watershed. Additional studies are needed to gain a comprehensive understanding of the Klamath Basin aquatic ecosystem and should focus on obtaining 1) information on spatial distribution and temporal abundance of fish (all life stages) within the mainstem river and it’s tributaries, 2) the relationship of flow and the availability of spawning, incubation, rearing, and outmigration habitat, 3) the effects of water quality on egg to smolt survival, 4) reliable data on run strength in the mainstem using direct enumeration, 5) detailed information on pollution sources and relative contribution of each source to the nutrient loads in the Klamath River, and 6) site-specific temperature effects on fish.

5.3.6 Effects of Other Proposed Actions

There should not be any additional effects on coho salmon from the other proposed actions.

5.3.7 Summary of Effects

Implementation of the proposed action (when compared to the environmental baseline) is likely to have the following effects on threatened SONCC coho salmon and critical habitat for SONCC coho salmon. For the items summarized below, it should be restated that there is a lack of data demonstrating a clear association between changes in Klamath River flow and the welfare of the salmon:

1. Diversion of water to storage for Project purposes, although occurring upstream of Iron Gate Dam, may affect threatened coho salmon.

2. Delivery of water from storage for Project purposes at Upper Klamath Lake has no effect on coho salmon.

3. Delivery of impaired flows that result in Iron Gate flows lower than the baseline may affect coho salmon.

5.4 EFFECTS ON BALD EAGLES

The FWS's April 5, 2001 final BO concluded that Reclamation's proposed action (i.e., continued operation of the Project to deliver a water supply for irrigated agriculture and refuges) for 2001 is not likely to jeopardize the continued existence of the bald eagle. Reclamation agrees with this conclusion.

The 2001 Annual Operations Plan for the Project, which was developed in conformance with the FWS and NMFS biological opinions, resulted in severely reduced agricultural and refuge water supplies that benefit bald eagles. Reclamation was able to obtain water in 2001 through cooperative means from water users in the Basin to provide the protections sought by the FWS, and would continue to take similar cooperative actions in the future. The BO also stated that Reclamation's action is likely to result in a significant reduction or elimination of the prey base for the bald eagle due to reduced or curtailed water deliveries to areas that contain important eagle feeding habitat. The BO included non-discretionary reasonable and prudent measures (RPM) to minimize incidental take of bald eagles.

Reclamation believes any effects on the bald eagle that may have occurred during 2001 resulted primarily from the FWS's and NMFS' RPA requirements and not entirely from Reclamation's proposed actions. Certain conservation measures may be appropriate relative to long-term operations of the Project, however, and Reclamation would like to discuss these with the Service during further consultation.

Reclamation believes that the proposed action would provide adequate water deliveries to support eagles in most years. When considered in its entirety, the proposed action may affect bald eagles.

CHAPTER 6.0 - CUMULATIVE EFFECTS

6.1 CUMULATIVE EFFECTS

Cumulative effects are those effects of future non-Federal (State, local governments, or private) activities on endangered and threatened species or critical habitat that are reasonably certain to occur within the action area of the Federal activity subject to consultation.

6.2 LOST RIVER AND SHORTNOSE SUCKERS

6.2.1 Clear Lake Watershed

Most of the land in the Clear Lake watershed is federally owned. Proposed federal actions that may affect listed species will undergo section 7 consultations and thus are not considered in this section. Remaining land is privately owned and is mostly open juniper-bunchgrass rangeland with some small forest areas of ponderosa pine. Few people live in the area. Reclamation anticipates that most of this land will be used as it has in the past as range (grazing) and forest (logging).

Private land grazing in the Clear Lake watershed is not considered to be a significant threat because limited areas of private rangeland are located in the watershed. Grazing in the Clear Lake watershed has previously destabilized streambank vegetation resulting in erosion, siltation, reduced quality of gravel and cobble spawning areas, increased water temperatures, wider and shallower stream channels, and lowered water tables. Conditions of rangelands are anticipated to continue to improve with proactive management.

Forestry practices on private lands may also contribute to water quality declines in the upper Clear Lake watershed, but because commercial forest comprise such a small area and will be infrequently harvested that Reclamation does not consider future forestry practices a significant threat in this watershed.

Introduced fishes such as brown bullhead, fathead minnow, Sacramento perch, pumpkinseed, green sunfish, bluegill, and largemouth bass are likely to continue to persist in the Clear Lake watershed. However, because relatively stable sucker populations co-exist with abundant non-native fish populations in Clear Lake and its tributaries, Reclamation does not consider non-native fish to be a major threat.

Transportation of hazardous materials along roadways in the Clear Lake watershed and use of herbicides, and pesticides appear to be a small risk owing to their infrequent presence in the watershed.

6.2.2 Gerber Reservoir Watershed

There are several small private water developments in the Gerber Reservoir watershed. These developments are used primarily for livestock operations. Each of these operations use a combination of dams, reservoirs, and ditches to distribute water or use dikes, ditches and canals to irrigate their lands for pasture and hay, and grain cultivation.

The effects of these impoundments on the shortnose sucker populations in the Gerber Reservoir watershed are unknown. During wet periods suckers are suspected to occupy some of these impoundments. Water storage may increase instream flows during the summer. The impoundments also may trap sediments keeping them out of downstream pools and riffles where suckers reside or spawn. The net effect of these developments may be neutral or even beneficial to suckers.

Land use in the Gerber Reservoir watershed is similar to that of Clear Lake, perhaps with more commercial timber on private lands. Future forestry and grazing practices that follow established best management practices are not considered to be a significant threat to shortnose suckers in the Gerber Reservoir watershed.

Introduced fish including fathead minnows, yellow perch, crappie, brown bullhead, largemouth bass, pumpkinseed, and green sunfish are likely to persist in the Gerber Reservoir watershed. However, because relatively stable shortnose sucker populations co-exist with abundant non-native fish populations in Gerber Reservoir, Reclamation does not consider non-native fish to be a major threat.

Transportation of hazardous materials along roadways in the Gerber Reservoir watershed and use of herbicides and pesticides appear to be a small risk owing to their infrequent presence in the watershed.

6.2.3 Lost River

Most of the low-lying land in the valleys adjacent to the Lost River (Langell Valley, Yonna Valley, and Poe Valley) are privately owned and used for agriculture. These lands contribute nutrients, sediment, fertilizers, herbicides and pesticides to the Lost River and the Tule Lake sumps that will affect listed suckers. Many of these lands receive water from the Klamath Project. Several dairy operations are found in the Langell and Poe Valleys that contribute nutrients to the Lost River. Additionally, nutrients from residences along the River and sewage treatment facilities in Bonanza, Merrill, and Tule Lake on occasion make their way into the River. Other potential sources of nutrients include a feed processing plant in Merrill and food processing facilities in Hatfield.

There are approximately 60 unscreened pump or gravity diversions in the Lost River and Tule Lake Sumps. Most of these diversions will likely continue to entrain endangered suckers.

Fish passage is blocked at three private diversion dams on the Lost River including Lost River Ranch, Harpold Dam and Bonanza Dam. These seasonally operated dams prevent upstream migration of suckers during the spring and summer.

6.2.4 Upper Klamath Lake Watershed

Private landowners along streams tributary to UKL annually exercise their State of Oregon rights to withdraw water for irrigation and livestock watering. The total amount of water that is annually withdrawn before it reaches UKL has not been determined but it is thought to be substantial. It is estimated that about 110,000 acres benefit from diversions above the Project boundaries. Nutrient enriched return flows from these upstream agricultural lands coupled with the reduced inflows to the lake, because of irrigation depletion, likely contribute to the eutrophication in UKL.

Despite high background total phosphorus (TP) levels in UKL tributaries and springs (Kann and Walker 1999, Rykbost 1999), data exists from several studies to indicate that TP loading and concentrations are elevated substantially above these background levels. Considerable contributions of phosphorus stemming from wetland loss, flood plain grazing, flood irrigation, and channel degradation, likely accounts for a high percentage of the nutrient loading. The estimate of anthropogenic contribution of TP loading to Upper Klamath Lake is 40% (Kann and Walker 2000). These values are very similar to the 40% anthropogenic TP contribution estimated by Walker (1995) for Agency Lake.

Approximately 15,000 acres of drained wetlands around UKL are being restored. The immediate benefit from these lands is that management will emphasize water quality improvement in UKL. Management actions on these lands that once contributed nutrients to UKL have been stopped or significantly reduced. Restoration on the Running Y Ranch Resort includes up to 500 acres of marsh habitat. Other activities likely to occur include large-scale riparian restoration along the major tributaries of UKL through fencing and improved grazing practices, and wetland restoration. The Nature Conservancy recently purchased Tulana and Goose Bay Farms, 8,000 acres at the mouth of the Williamson River. Acquisition and restoration of this property has great potential for restoring sucker habitat, and improving water quality in UKL. TNC has also purchased an additional 7,000 acres at Sycan Marsh expanding its preserve to over 25,000 acres. This acquisition and restoration of the Marsh should improve water quality and hydrologic function in the Sycan and Sprague Rivers, tributaries to UKL.

There are approximately a dozen large, non-federal, unscreened diversions in UKL that supply water to about 15,000 acres of agricultural lands and restored wetlands around UKL. These diversions will likely continue to entrain substantial numbers of larvae and juvenile suckers.

6.2.5 Agency Lake and Wood River Watershed

Numerous ranches in the Fort Klamath area divert significant quantities of water out of the various streams and springs in the watershed upstream and adjacent to Agency Lake north of UKL. The natural streams in this area include: Sevenmile Creek, Fourmile Creek, Annie Creek, Crooked Creek, and the Wood River. Additionally, water from various natural springs is diverted to various maintained ditches that supply irrigators in the area. Major ditches conveying water from the natural creeks and springs to the irrigators include: Bluespring, Sevenmile, and Melhase Ditches. Return flows from these ditches are collected into several canals that connect with and are adjacent to Agency Lake. These canals contain water year round and include: West, Sevenmile, Central, and North Canals among others. The Meadows Drainage District and many individual landowners divert water through the aforementioned ditches.

Larval and juvenile Lost River and shortnose suckers are known to occur in the Wood River, Seven Mile Creek and Crooked Creek. It is suspected that some of these suckers may be spawning in the Wood River and Crooked Creek. Depending on how far these spawning fish migrate upstream, the adult spawners, embryos, and emerging larvae of these suckers may be impacted by water diversions from these tributaries. If spawning suckers are in downstream reaches of the Wood River and Crooked Creek below irrigation diversions when water deliveries to the ditch systems are diverted out of the channel, then the spawning behavior of these fish may be disrupted resulting in no sucker spawning in that year. If suckers succeed in spawning within the reaches upstream of the diversion ditches, the larval life-stage would potentially be subject to diversions into canals and fields, reduced flows and resulting elevated water temperatures during incubation and larval emigration.

Depending on land practices, use of fertilizers, herbicides, and other chemicals, the number of reuses, and erosion in this agricultural area, the water quality (including dissolved oxygen, turbidity, and temperature) of these return flows could range from fair to poor. The return water, upon collection in the downstream canals, could then potentially impact the water quality of Upper Klamath Lake Marsh, Wood River Marsh and near-shore habitats of larval, juvenile, and/or adult suckers or other fishes present. Nutrient rich irrigation return water reaching Agency Lake could result in algae blooms and anoxic conditions within Agency Lake itself. These noxious blooms and resulting degraded water quality could potentially result in fish kills in Agency Lake during the late summer months.

6.2.6 Williamson River Watershed

In the Upper Williamson River watershed, past grazing and forestry practices have adversely affected stream morphology, with the result that the river has become entrenched. Agricultural practices in the drainage could have the same effects as those listed above for the Agency Lake drainage. Private landowners have taken measures to improve watershed conditions in recent years through proactive land management.

Unscreened, non-federal, irrigation diversions on the lower Williamson River in the area of concentrated larval migration and rearing may be reducing sucker recruitment to UKL. Irrigation diversions also reduce stream flows. Residential development along the lower Williamson River could adversely affect riparian areas when native vegetation is removed and stream banks are modified. These developments may also contribute nutrients through septic tank leaching, and fertilizer runoff from lawns.

6.2.7 Sprague River Watershed

Chiloquin Dam, located just upstream of the Sprague River's confluence with the Williamson River, is estimated to have restricted access to more than 95% of the potential spawning habitat for the LRS and SNS and is considered one of the more significant reasons contributing to the decline of the suckers (USFWS 1993). Although fish passage facilities on the dam have been installed, the dam has restricted annual migrations for endangered suckers (USFWS 1993). Legislation is pending in Congress to study fish passage options in preparation for implementation of a solution.

Spawning and rearing habitat in the Sprague River has been degraded by channelization, sedimentation, increased water temperatures, high nutrient concentrations, and the resulting high algae and aquatic plant growth. These problems originate in the Sprague River Valley, upstream of the present-day spawning areas, where agricultural activities have degraded the riparian habitat. In addition to the resulting loss of spawning habitat and rearing habitat, the Sprague River is a major contributor of excess nutrients to the hypereutrophic UKL. Long-term successes of spawning habitat restoration efforts in this river system depend almost entirely on rehabilitation of the upstream reach of the Sprague River (USFWS 1992). Several landowners have initiated riparian and wetland restoration projects in the Sprague River Valley. These projects should improve watershed conditions and reduce nutrient loading to UKL.

6.2.8 Keno Reservoir

At least 55 unscreened private and irrigation district agricultural diversions exist on Keno Reservoir. Oregon Department of Fish and Wildlife has eight diversions for the Miller Island Wildlife Area, three of which are screened and plans are underway to screen others.

Water quality on Keno Reservoir can at times be degraded due to treated sewage from two municipal sewage treatment plants, storm water and non-point source runoff from the City of Klamath Falls. Lumber mills along the Klamath River near Klamath Falls also contribute to water quality problems in the river. The Klamath Straits Drain, which receives return flows and storm runoff from private agricultural lands, municipalities, dairies, and refuges and the Project, contributes nutrients, sediment, herbicides and pesticides to the Klamath River. Other inputs include the Lost River Diversion Canal, Link River, and sediment sources. The highly enriched sediments were caused in part by decades of intensive lumber mill operations and log rafting on Lake Ewauna during the first 60-70 years of the 20th century. The impoundment of the nutrient rich waters in the reservoirs are known to contribute to algae blooms within the reservoirs and cause downstream algal nuisance conditions in the river.

The wastewater treatment facilities are likely to reduce their pollution loads to Keno Reservoir over the next decade to comply with the Clean Water Act TMDL (Total Maximum Daily Load) process.

6.2.9 Other Cumulative Effects

The transportation of hazardous materials by truck and train along the eastern and southern margin of UKL and over tributaries could result in spills and negative impacts to the listed and unlisted species in the basin's waters. Algae and Daphnia harvesting in UKL may result in the take of larval and juvenile suckers. The use of chemicals such as pesticides, herbicides, and mosquito or midge control chemicals could result in negative impacts to listed species throughout the basin. The diversion of water directly from UKL by private (non-Project) water users may result in the taking of suckers and reduction of habitat.

6.3 COHO SALMON CUMULATIVE EFFECTS

6.3.1 General Cumulative Effects on Coho Salmon

Past and ongoing effects of State and private activities on anadromous fish species in the Klamath Basin are significant. Since 1906, fish habitat conditions throughout the watershed including headwater streams, Upper Klamath Lake (UKL), the Klamath River from Link River Dam to Klamath California, IGD and tributaries below IGD have been altered by human activities. Marshlands surrounding Upper Klamath Lake have been converted to agricultural use diminishing the capacity of the lake to reduce nutrient levels.

Klamath Basin anadromous fisheries have declined precipitously since the early 1900's (INSE 1999). Normally, robust populations can withstand environmental perturbations and recover over time; however, this has not been the case for anadromous fishes in the Klamath River for the following reasons. Loss of fish habitat, problems with chronic and acute water temperatures and excessive nutrients, commercial over harvest, and climatic changes have resulted in declining populations of steelhead, chinook and coho salmon. The combination of timber management practices, agricultural practices, placer mining, water diversions in the Scott and Shasta River watersheds and the construction of hydroelectric dams appear to have individually, and cumulatively caused significant reduction in spawning, rearing, and emigration habitat throughout the watershed. Loss of these habitats has resulted in declining populations.

During the last 40 years, a large body of information has been collected regarding the effects of water temperature on salmonid adult migration, spawning, egg incubation, alevin emergence, fry and juvenile rearing. Bartholow's (1995) literature review of salmonid temperature tolerances and study of Klamath River water temperatures support the premise that high summer temperatures ($\geq$15E C from late June through early September) have a detrimental effect on coho and chinook salmon and steelhead trout.

High water temperatures found in the river are primarily a function of climate and massive landscape changes that have occurred throughout the Klamath River watershed. Water temperatures recorded at Klamath in the early 1900's (pre-project) indicate the Klamath River was, on average, several degrees cooler than present (M. Belchik, Yurok Tribe, per. comm.1998). Additionally, flow blockage by dams and degradation of tributary habitat have eliminated most or all of the thermal refugia areas in the upper portion of the Klamath River below IGD thus forcing greater reliance on mainstem habitat (M. Belchik, Yurok Tribe, per. comm.1998).

Fish kills occur in the lower Klamath River and Upper Klamath Lake due to poor water quality. For example, bacterial fish diseases such as *F. columnaris* thrive in high water temperatures typical of the summer months in the lower river. *Aeromonus hydrophylla*, another bacterial disease and anchorworm, a parasitic copepod, are also indicators of the stresses affecting the fisheries. High water temperatures and low dissolved oxygen combined with bacterial diseases and parasites were largely responsible for the 1997 and 2000 fish kills downstream from IGD. Dead salmon are typically collected annually during the second week in August in fish traps monitored by the Service at Big Bar (river mile 50). These deaths are attributed to heavy algal loads and high water temperatures (T. Shaw, Service, per. comm. 2000).

Water diversions from Klamath River basin tributaries have played a significant role in the decline of Klamath River salmonids. Historically, tributaries played a vital role in sustaining coho, steelhead, and chinook stocks in the Klamath Basin. Diversions on tributaries during the irrigation season (May to October) reduce stream flow. These low flows prevent fall chinook from migrating up the Scott River past Etna Creek (river mile 42.2) during average to dry years (D. Rogers, CDFG. per. comm., cited in Vogel 1997). Low flows also limit coho and steelhead juvenile rearing habitat and can strand juvenile fall chinook, coho, and steelhead when the irrigation season begins (CH2M Hill 1985 cited in Vogel 1997). These activities have also altered water temperature, water quality, and the duration, frequency, and magnitude of Klamath River flows.

Watershed conditions in the Klamath River Basin exhibit a legacy of over a hundred years of livestock grazing, some of which was very intensive. The Shasta and Scott Rivers have a long history of stream diversions. Diversion dams block salmon from migrating upstream. Riparian vegetation has been extensively reduced or removed along the Shasta and Scott rivers, as well as other tributaries, causing increased water temperatures and lack of instream cover for salmon and steelhead. Unscreened or ineffectively screened diversions have resulted in fish strandings. In one documented case on a tributary of the Scott River, the following stranded fish were counted: 1,488 young steelhead and 105 young coho salmon (Taft and Shapovalov 1935 cited in Vogel 1997). Agricultural practices in the Lost, Shasta, and Scott River watersheds may have released herbicides and pesticides into the Klamath River. However, no evidence exists indicating adverse affects of pesticides or herbicides on Klamath River resident or anadromous fish. Livestock wastes and fertilizer runoff contributes excess nutrients (nitrogen and phosphorus) to the stream. As a result, aquatic plant and algae growth is stimulated. After these plants die, the decomposition process by bacteria can demand more oxygen than the living plants produce, which lowers the oxygen levels in the stream (Vogel 1997). In combination with high temperatures and low streamflow, these decreased oxygen levels can be stressful or lethal to adult and juvenile salmon. Critically low levels of oxygen have been measured in the Shasta River in recent years (D. Maria, CDFG, per. comm. cited in Vogel 1997).

Upper Klamath Lake and the Klamath River are highly eutrophic systems from naturally and man-caused phosphorous and nitrogen compounds and pollution in the form of ammonia and nitrates. Waste water from Klamath sewage treatment plant, U.S. Timberlands, and South Suburban sewage; leachates from the Columbia Plywood log storage facility; return water from the Project area; and irrigation returns in the Scott and Shasta watersheds all contribute to the high nutrient load and biological oxygen demand in the Klamath River above and below IGD. High nutrient levels promote plant and algal growth, which cause diel fluctuations in the river’s dissolved oxygen level because of plant respiration. Water quality degradation resulting from of these activities cannot be discounted as a major factor contributing to the decline of Klamath River steelhead, coho, and chinook.

Commercial ocean fisheries have also reduced salmonid stock abundance in the Klamath River system up to 70 percent (Rankel 1980 cited in Vogel 1997). Marine harvest in the Oregon Coast and SONCC ESUs occurs primarily in nearshore waters off Oregon and California (Weitkamp et al. 1995). Commercial landings of coho salmon in Washington, Oregon, and California show relatively constant landings between 1882 and 1982, ranging between 1.0 and 2.5 million fish, with a low of 390,000 fish in 1920 and a high of 4.1 million fish in 1971 (Shepard et al. as cited in Weitkamp et al. 1995). Coho salmon landings off the California and Oregon coast ranged from 0.7 to 3.0 million in the 1970s, were consistently below 1 million in the 1980s, and averaged less than 0.4 million in the early 1990s prior to closure of the fisheries in 1994 (Pacific Fishery Management Council (PFMC) 1995 cited in NMFS 1997a). This decline largely reflects reductions in allowable harvest, which were imposed in response to perceived declines in production (Weitkamp et al. 1995).

Timber harvest activities and silvicultural practices dating back to the early 1930's have resulted in extensive degradation of fish habitat in the lower Klamath River watershed and have contributed to the decline of Klamath River salmonids. Road construction associated with these activities and practices created impassable barriers to steelhead and salmon spawning areas in Coon, Crawford, Little Girder, and Beaver Creeks (Taft and Shapovalov 1935 cited in Vogel 1997). Logging caused aggradation in the lower reaches of Blue and Roach Creeks, blocking spawning access during low water (ESA 1980, Payne 1989 cited in Vogel 1997).

Mining in the Klamath River Basin has damaged fish habitat from heavy silt loads. One study of mining impacts was performed in 1934 by the U.S. Bureau of Fisheries (Taft and Shapovalov 1935 cited in Vogel 1997). An analysis of hydraulic mine operations on the East Fork Scott River involved taking samples of benthic macroinvertebrates located on riffles above and below a tributary carry considerable mining silt. Above the silted site, the gravels contained an average of 249 organisms per square foot while below the muddy tributary the average was 36 organisms per square foot (Vogel 1997). These stream fauna represent important food for salmon and steelhead and their loss reduces the capacity of the stream to support fish populations.

In addition to reduction in fish food, silt from placer mining covers salmon redds and suffocates the salmon eggs (Smith 1939 cited in Vogel 1997). The level of egg mortality seems related to the amount of silt. Also, pools filled in with silt leave no hiding or rearing places for fish (Vogel 1997).

Generally, the available water supplies in the Upper Klamath River Basin are insufficient to meet the competing demands for water supplies of the basin in every water year type. Water rights in most of the Upper Klamath Basin are currently unquantified and unadjudicated. The State of Oregon is proceeding with an adjudication of the Klamath River in Oregon. The Upper Klamath Basin Working Group is working with private entities throughout the Upper Klamath Basin to prioritize watershed restoration projects and implement restoration projects on a large and small scale using federal and private funding. It is likely that additional wetland areas will be reclaimed and restored, and degraded riparian areas fenced and restored. Reclamation is seeking additional sources of water and storage capacity to assist in meeting the competing demands for water in the basin.

The timing of flow events is also important because the life cycles of many aquatic and riparian species are timed to either avoid or exploit flow events of different magnitudes. The timing of high or low flow events provides environmental cues for fish to initiate spawning (Montgomery et al. 1983), egg hatching (Naesje et al. 1995), rearing (Seegrist and Gard 1972), and migration (Trepanier et al. 1996).

Although no Klamath River-specific data exists, generally a positive flow-versus-survival relationship has been found in most geographic areas where this relationship has been studied (Cada et al. 1994). This generally means that as river flows increase, fish survival increases. However, there are studies that have demonstrated that a positive relationship does not occur uniformly for all ranges of flows (Vogel 1998).

Studies have shown that high flows maintain ecosystem productivity and diversity. For example, high flows remove and transport fine sediments which otherwise would fill interstitial spaces in productive gravel habitats (Beschta and Jackson 1979). Other studies support the premise that higher flows would result in higher salmonid smolt survival because these fish would outmigrate faster and reduce exposure time to poor mainstem habitat conditions (Wagner 1974, Lundquist and Ericksson 1985, Glova and McInerney 1977, and Smith 1982 cited in McCormick and Saunders 1987).

High mainstem river spring flows may be necessary to provide rearing habitat for fry and juvenile coho and other salmonids outmigrating from the tributaries. Degraded fish habitat and poor water quality conditions in some tributaries, especially in low water years, may prematurely force the outmigration of salmonids into the mainstem Klamath River.

Trinity River flows affect the Klamath River downstream from its confluence with the Klamath River. It is assumed that non-federal land-use practices in the Trinity Basin will continue in a manner consistent with ongoing practices. Thus, any future cumulative effects on coho salmon (that originate from reaches of the Klamath River above the mouth of the Trinity River) contributed from the Trinity River will remain consistent with on-going effects. These effects consist primarily of flow-related effects and their relationship to upstream and downstream migrations of coho salmon. Any changes in Trinity River conditions resulting from changes in operations of the Trinity River Division of the Central Valley Project will be the result of a federal action. Thus, any such potential changes have been, or will be subject to a Section 7 consultation and thus are not considered as part of cumulative effects.

Until improvements in non-Federal land and water management practices are actually implemented, Reclamation assumes that future private and State actions will continue at similar intensities as in recent years

CHAPTER 7.0 - DETERMINATION OF EFFECTS

7.1 INTRODUCTION

The following determination of effects for the Lost River and shortnose suckers, Southern Oregon/Northern California Coast coho salmon Evolutionary Significant Unit (SONCC) and bald eagle consider direct and indirect effects of the proposed action on the listed species together with the effect of other activities that are interrelated or interdependent with the action. These effects are considered along with the environmental baseline and the predicted cumulative effects.

7.2 LOST RIVER AND SHORTNOSE SUCKERS

Based upon the analysis in this BA, Reclamation has determined the following effects of the action on endangered suckers:

- Diversion of water to storage for Project purposes from Klamath River may affect endangered suckers.
- Storing water for Project purposes may affect endangered suckers.
- Delivery of water from storage for Project purposes may affect endangered suckers.
- Other proposed actions (screening and fish passage) may affect, but are being implemented to beneficially affect endangered suckers.

7.3 COHO SALMON

Based upon the analysis in this BA, Reclamation has determined the following effects of the action on threatened coho salmon:

- Diversion of water to storage for Project purposes, although occurring upstream of Iron Gate Dam, may affect threatened coho salmon.
- Delivery of water from storage for Project purposes at Upper Klamath Lake has no effect on coho salmon.
- Delivery of impaired flows that result in Iron Gate Flows lower than the baseline may affect coho salmon.

7.4 BALD EAGLE

Reclamation's February 13, 2001 biological assessment stated that the proposed action (i.e. continued operation of the Project to deliver a water supply for irrigated agriculture and refuges) would provide adequate water deliveries to support eagles in most years. Reclamation believes that the effects of the proposed action in this BA would be similar to those described in the 2001 biological assessment. Therefore the proposed action may affect, but is not likely to adversely affect bald eagles.

CHAPTER 8.0 - LITERATURE CITED

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APPENDIX A - POTENTIAL ACTIONS TO ASSIST WITH PROTECTION, CONSERVATION AND/OR RECOVERY OF LISTED SPECIES

1. INTRODUCTION

Reclamation has identified a number of potential discretionary actions that could assist with protection, conservation and/or recovery of the listed species. Reclamation would consider participating, along with other partners, in implementing the following actions, subject to authorization and funding. The actions described in this Appendix could be used as elements of a reasonable prudent alternative for Project operation to avoid jeopardy, elements of appropriate recovery plans for the listed species, or voluntary conservation measures/actions to benefit the listed species. Actions identified and selected for implementation would be accomplished within the 10-year period of Project operations described in the biological assessment.

Any reasonable and prudent alternative (RPA) to avoid jeopardy must be consistent with the intended purpose of the action, implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, and must be economically and technologically feasible. In order to meet these criteria, any RPA designed to avoid the likelihood of jeopardizing the continued existence of listed species considered in this BA must also be consistent with operation of a viable irrigation project.

2. POTENTIAL ACTIONS BENEFITING ALL LISTED SPECIES

A. Winter Irrigation

Reclamation would implement a winter irrigation program. Winter irrigation would make use of spills (water that cannot be stored and that exceeds needs for downstream flows or other committed uses) to replenish soil moisture. Winter irrigation would result in reduced irrigation demand during the early growing season. This would specifically reduce shortages to irrigation in the early growing season when lake level requirements constrain water deliveries to agriculture. It would also benefit the lake by reducing the amount of water needed during the growing season.

Reclamation proposes to evaluate the potential to use winter irrigation under the authority of the Klamath Basin Water Supply Enhancement Act. Factors that must be considered are the magnitude and timing of spills which would determine the availability of water, the amount and location of lands that could be expected to take advantage of winter water, the amount of water needed to winter irrigate those lands which will vary depending on meteorological conditions, operational constraints such as the timing of water deliveries (weather must be considered) and changes to the delivery system that might be needed, the costs of providing winter water, and how winter water will affect the demand and operation of the existing water storage system.

It is assumed that all winter irrigation would be in the Tule Lake area, that (based on historic pre-irrigation deliveries to leased lands on the Tule Lake refuge) annual winter irrigation would be at the rate of 1.0 acre-foot per acre, that deliveries would only be made to the extent that spills from Gerber and Upper Klamath Lake were available in sufficient quantity, and that the existing irrigation and on-farm systems could be used. Reclamation estimated that about 30,000 acres of Tule Lake area lands would use winter water. This may be a conservative estimate. Reclamation's analysis showed that 30,000 acre-feet of winter water could be delivered in 31 of the 37 years of record. No water could be delivered in two years, and lesser amounts could be delivered in the other four years. This winter irrigation would reduce April and May irrigation demand by the same amount as water was delivered in the winter.

B. Ecosystem Restoration

Reclamation would support planning and implementation of ecosystem restoration projects in the Klamath Basin related to Project operation. Reclamation will take the responsibility to develop a comprehensive plan to provide direction for research efforts, installation of restoration projects, and monitoring of results. The plan would be developed with the networking of stakeholder groups within the basin. The plan would provide direction for activities undertaken by federal, state, local agencies, and interests groups through 2012. Specific goals and objectives of the plan would be built around the main focus of the Oregon Resource Conservation Act of 1996 (ORCA P.L. 104-208, Title 2, Section 201); ecological restoration, economic development and stability projects, and reduce impacts of drought conditions.

C. Coordination and Planning

Reclamation would meet with the FWS, NMFS, Klamath Basin Tribes, PacifiCorp, and irrigation districts on a periodic basis, as needed, to coordinate and discuss water supply conditions, species status and available options for Project operation. The review would include updates on endangered species status, water quality research and monitoring, ecosystem restoration projects, water supply enhancement planning and implementation projects. Reclamation and the FWS, in coordination with the above entities, would develop an implementation schedule for the actions. The schedule would help develop funding requests and to assure timely accomplishment of the measures and progress towards meeting specific goals to improve water quality, take minimization, and recovery of endangered species. Technical review meetings would be scheduled annually. The purpose of the meetings would be to compile, analyze, and summarize information from the previous year's activities and plan activities for the coming year. Reclamation and the Service would jointly prepare an Endangered Species Act compliance summary report by February 1 annually for submittal to the Regional Director of Reclamation's Mid-Pacific Region and the Service's Manager, California/Nevada Operations Office.

D. Performance Monitoring

1. Reclamation would develop and implement a program to monitor progress in implementing Project operations and these actions (with no less than an annual report). The program would include: (1) baseline monitoring of water quality and habitat conditions in the Project area; (2) description of measures proposed for implementation; (3) the progress actually accomplished in implementing the measures and; (4) the actual results of implemented measures (i.e. as predicted, or more/less than predicted). Reclamation would submit annual progress reports to FWS to assist in determining if the actions are achieving satisfactory progress in accomplishing the goals and objectives prescribed for the listed species. The performance monitoring may result in modification of these actions or Project operations, as appropriate, in response to new information or changed conditions relevant to the Project's effects.

2. Reclamation would coordinate with the FWS in an annual progress review of implementing Project operations and these measures. The purpose of the review would be to assess progress made in removing threats to, or in recovering, the endangered suckers. Significant differences from the predicted results of these measures and Project operations may affect the progress toward achieving specific goals to remove threats, reduce risks, minimize take and assist recovery of endangered species. Such changes in progress could result in re-initiation of consultation. The FWS would make an annual determination of whether sufficient progress has been made in meeting the goals of these measures and Project operations.

3. POTENTIAL ENDANGERED SUCKER ACTIONS

A. Entrainment Reduction

Reclamation would implement specific measures to reduce entrainment of endangered suckers in the Project service area. This action is already included in Chapter 2 of the BA as part of the proposed action. Reclamation would fund a multi-year program to construct and complete entrainment reduction measures in the Project service area. Reclamation would also prepare a monitoring plan to evaluate the effectiveness of entrainment reduction measures. The monitoring plan would be subject to FWS review.

B. Fish Passage

Reclamation would develop and implement specific measures to provide adequate passage of endangered suckers in the Project service area. Reclamation would fund a multi-year program for these measures. Reclamation would also prepare a monitoring plan to evaluate the effectiveness of fish passage measures. The monitoring plan would be subject to FWS review.

C. Upper Klamath Lake Water Quality Refugia Location Study

Reclamation would implement a study to determine the role of water quality refugia areas on adult endangered sucker survival. The importance of these areas on adult sucker survival in the lake is not well understood. The study plan would build on existing radio-telemetry and water quality data and make necessary recommendations for additional studies. The draft plan would be provided to the FWS for review and comment and would likely be a two-year study. Implementation of a two-year study would begin in 2002. An annual progress report would be completed and a final report with management recommendations would be prepared for the FWS review and approval (estimated completion date would be 2004)

D. Upper Klamath Lake (Emergent) Vegetation Study

Reclamation would undertake a study to assess the role of emergent vegetation in larval/juvenile endangered sucker survival. Habitat needs for larval and juvenile suckers in Upper Klamath Lake, including lower Williamson River, are not adequately known. This has a direct bearing on water quality management because emergent vegetation may become unavailable to larvae and juveniles in the lake at lower lake levels. The study would also address emergent wetland restoration needs. Reclamation would provide a study plan to the FWS for review and comment by January 2002. This would likely be a two-year study. An annual progress report would be completed and a final report with management recommendations would be prepared for FWS review and comment (estimated completion date would be 2004).

E. Upper Klamath Lake-Associated Wetlands Study

Reclamation would develop a study plan to assess the performance of three types of lake-associated wetlands, focusing on seasonal nutrient dynamics and decompositional processes and products, and provide recommendations for “in-lake” and “behind-the-dike” reclaimed wetland management that are intended to mimic pre-settlement wetland nutrient uptake and dispersion. The study would also evaluate the role of marsh decomposition products on *Aphanizomenon* growth. Water quality modeling would be conducted, including in-lake wetlands and wetlands that are being developed behind dikes, to determine the significance of these restoration efforts on water quality and fish survival. This would likely be a three-year study. Annual progress reports would be provided to the FWS. A final report including management recommendations and additional study needs would be provided for FWS review and comment (estimated completion date would be 2005).

F. Link River-Lake Ewauna-Keno Reservoir Habitat Study

Reclamation would develop a study plan to determine the timing of endangered sucker movements in relationship to season and flows, sizes and species composition of suckers in the Link River. The study would address the ability of suckers to pass obstructions in the river below Link River Dam at different flows. Radio-tracking of adult suckers in the Keno Reservoir-Link River reach is proposed as a means to determine when adult suckers migrate, and to provide information on habitat use in this reach. Reclamation would also examine habitat requirements for suckers in Link River, Lake Ewauna, and the Keno Reservoir. The study would focus on what habitats are available to suckers and monitor sucker survival in these areas. The study plan would be provided to the Service and other interested parties for review and comment. This is likely to be a two-year study. Annual progress reports would be provided to the FWS. After the second year, Reclamation would provide the FWS with recommendations for specific actions to restore endangered sucker habitat in Link River, Lake Ewauna and Keno Reservoir (estimated completion date would be 2004).

G. Pilot Oxygenation Study and Project

Reclamation would develop a pilot oxygenation study plan and project. Endangered sucker die-offs in recent years have been associated with low dissolved oxygen conditions in Upper Klamath Lake. Although efforts are underway to improve long-term water quality in the lake through reduced nutrient loading, watershed restoration, and wetland restoration, the benefits from these programs are likely years away from being realized. A short-term program that may improve adult sucker survival in Upper Klamath Lake is introduction of oxygen into a portion of the lake that suckers could use as a refugia during periods of low dissolved oxygen. Construction and operation of the pilot project would occur over a two-year period, if it is determined to be feasible and likely to be successful. An effectiveness-monitoring plan would be prepared for review. An annual progress report would be completed and final report with management recommendations prepared (estimated completion date would be 2004).

H. Upper Klamath Lake Water Quality Program Review and Study

Reclamation would coordinate with the Service to convene a meeting(s) with water quality technical experts to discuss a program for study/monitoring of Upper Klamath Lake water quality/algal growth and nutrient cycling. The meeting would be intended to provide information for Reclamation’s use in development of a draft multi-year water quality monitoring/research plan(s) for FWS review. (estimated completion date would be 2003)

I. Upper Klamath Lake Endangered Sucker Spawning Enhancement Pilot Project

Reclamation would, in coordination with the Service, develop a study plan for a pilot project to enhance existing endangered sucker shoreline spawning habitats through addition of spawning substrate and re-establishment of spawning at previously-used spawning areas through use of hatch boxes or some other intervention. Reclamation would implement and monitor the pilot project. Annual monitoring would evaluate spawning use, hatching success and early mortality. Annual reports would be prepared for FWS review. (estimated completion date would be 2005)

J. Agency Lake Ranch Operation and Management

Reclamation would operate and manage Agency Lake Ranch to store water for Project use, improve water quality and increase habitat on the ranch, to the extent feasible. Existing dikes around the property constrain Reclamation’s ability to store water.

4. POTENTIAL THREATENED COHO SALMON ACTIONS

A. Groundwater Development Study

Reclamation would 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-may include pilot program.

B. Shasta River Flow Study

Reclamation would fund a study on the availability of water for instream flows and develop an instream flow recommendation for the Shasta River from Dwinell Dam to Parks Creek.

C. Shasta River Wetlands Restoration Program

Reclamation would provide funding and technical assistance for implementation of the Shasta River Wetlands Restoration Program.

D. MOA with California Department of Water Resources

Reclamation would enter into a Memorandum of Agreement with California Department of Water Resources to provide funding to develop the state's ability to assure appropriate use of existing water rights to protect anadromous fish habitat and to provide funding for irrigators to install measurement devices on all existing diversions and encourage the State to enforce over-withdrawal.

E. Fish Passage at Existing Irrigation Dams

Reclamation would provide funding for an inventory and evaluation of fish passage barriers at existing small irrigation dams in the Shasta and Scott Rivers, and work with facility owners to install corrective measures to remove fish passage barriers.

F. Other Fish Passage Barriers

Reclamation would provide funding for an inventory and evaluation of other impediments to fish passage in the Shasta and Scott Rivers, and work with the California Fish and Game Department to seek funding, and work with facility owners, to implement measures to remove fish passage impediments.

G. Coordination of Diversions

Reclamation would work with the California Department of Water Resources to develop a Memorandum of Agreement to encourage coordination among Shasta River and Scott River water users regarding timing of diversions to avoid dewatering reaches of the river used by anadromous fish.

H. Screen Diversions

Reclamation would provide funding and technical assistance, in cooperation with state, federal and tribal agencies, to assist in screening remaining unscreened diversions in Shasta and Scott Rivers.

I. Fish Rescue Efforts

Reclamation would provide staff/equipment and participate in coordinated multi-agency fish rescue efforts in the Shasta and Scott Rivers, and seek a Memorandum of Understanding with those agencies to provide rescue and/or assist fish rescue efforts, when requested.

J. Project-Related Agricultural Return Flow Water Quality Improvement

Reclamation would study methods to treat and/or recycle agricultural return flows from the Klamath Project service area before release into the Klamath River. Reclamation would conduct a feasibility study under P.L.106-498 to develop off-stream storage in the Lower Klamath Lake area to store additional water, improve water quality and provide habitat. Reclamation would conduct a study of treatment marshes to determine the feasibility of using this as a method to improve water quality of the Klamath Straits Drain.

K. Purchase and/or Lease Water Rights (Shasta and Scott Rivers)

Reclamation would work with a non-governmental organization to develop a plan for acquiring water rights in the Shasta and Scott Rivers. Reclamation would seek a funding source to purchase water rights as identified in the plan. Reclamation would research and identify water rights, develop a basis of negotiation and seek out willing sellers over a five-year period (program scope estimated to be about 8,000 acres or 25,000 acre-feet).

APPENDIX B - INTERIM REPORT FROM THE COMMITTEE ON ENDANGERED AND THREATENED FISHES IN THE KLAMATH RIVER BASIN

Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes in the Klamath River Basin

National Research Council
February 2002

PREPUBLICATION COPY

Interim Report from the Committee on Endangered and Threatened Fishes in the Klamath River Basin

Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes in the Klamath River Basin

This prepublication version of Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes of the Klamath River Basin has been provided to the public to facilitate timely access to the committee's findings. Although the substance of the report is final, editorial changes may be made throughout the text and citations will be checked prior to publication. The final interim report will be available in April 2002.

Committee on Endangered and Threatened Fishes in the Klamath River Basin

Board on Environmental Studies and Toxicology

Division on Earth and Life Studies

National Research Council

National Academy Press
Washington, D.C.

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

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WILLIAM M. LEWIS, JR. (*Chair*), University of Colorado, Boulder Colorado
RICHARD M. ADAMS, Oregon State University, Corvallis, Oregon
ELLIS B. COWLING, North Carolina State University, Raleigh, North Carolina
EUGENE S. HELFMAN, University of Georgia, Athens, Georgia
CHARLES D. D. HOWARD, Consulting Engineer, Victoria, British Columbia, Canada
ROBERT J. HUGGETT, Michigan State University, East Lansing, Michigan
NANCY E. LANGSTON, University of Wisconsin, Madison, Wisconsin
JEFFREY F. MOUNT, University of California, Davis
PETER B. MOYLE, University of California, Davis
TAMMY J. NEWCOMB, Virginia Polytechnic Institute and State University, Blacksburg, Virginia
MICHAEL L. PACE, Institute for Ecosystem Studies, Millbrook, New York
J.B. RUHL, Florida State University, Tallahassee, Florida

Staff

SUZANNE VAN DRUNICK, Project Director
RUTH E. CROSSGROVE, Editor
JENNIFER SAUNDERS, Research Assistant
MIRSADA KARALIC-LONCAREVIC, Research Assistant
HEATHER A. MCDONALD, Project Assistant

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Glen Spain, Pacific Coast Federation of Fishermen's Associations
Sue Ellen Wooldridge, U.S. Department of Interior

The committee's work also benefited from the written and oral testimony submitted by the public, and we appreciate their participation.

Acknowledgment of Review Participants

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Michael T. Brett, University of Washington
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John J. Magnuson, University of Wisconsin, Madison
Douglas F. Markle, Oregon State University
John M. Melack, University of California, Santa Barbara
Lisa Speer, National Resources Defense Council
Edwin A. Theriot, U.S. Army Corps of Engineers
David A. Vogel, Natural Resource Scientists, Inc.
Eugene B. Welch, University of Washington

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by John C. Bailar, III, University of Chicago, and Paul G. Risser, Oregon State University. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Preface

The federal Endangered Species Act of 1973 has been invoked extensively for the protection of aquatic species in the western United States. Aquatic fauna of the West show extensive endemism because of genetic isolation associated with aridity and with the drainage of many rivers directly to the Pacific. Human intervention in the water cycle of the West is especially pervasive because of the general scarcity of water and the extensive redistribution of water in support of economic growth. Also, the West is growing and developing very rapidly. Thus, an unusual combination of biogeographic, hydrologic, and socioeconomic circumstances conspire to raise the likelihood that the legal protection of aquatic species will come into conflict with development and use of water in the West.

Fishes of the Klamath River Basin are the focus of perhaps the most prominent current conflict between traditional uses of water in the West and requirements established by law for the protection of threatened and endangered species. This case is especially interesting in that the federal government is playing two potentially conflicting roles. Through the U.S. Bureau of Reclamation, the Department of the Interior is attempting to serve the needs of irrigators for water that is derived from the federal Klamath Basin Project. Not only is the delivery of water a contractual obligation of the government, it also is traditional in the sense that water delivery has occurred through the project for almost a century. At the same time, the U.S. Fish and Wildlife Service of the Department of the Interior and the National Marine Fisheries Service of the Department of Commerce are attempting to protect three threatened or endangered fishes of the Klamath Basin drainage (the Lost River sucker, the shortnose sucker, and the Klamath Basin coho salmon). Interested parties, some of whom have livelihoods or cultural traditions at stake, include farmers, commercial fishing interests, Native Americans, environmental interests, hunters, and hydropower production interests. Conflicts became openly angry during 2001 when irrigators were deprived during a severe drought of traditionally available water through the government's issuance of jeopardy opinions on the endangered and threatened fishes. Economic losses were substantial and the changes in water management were a source of great frustration to irrigators.

The Endangered Species Act (ESA) sets a framework for determination of future water use and management in the Klamath River Basin. The ESA is tightly focused on the requirements for survival of the threatened and endangered fishes, the survival of which is not negotiable under the ESA. Therefore, if the fishes require more water, ESA directs that they shall have it, which would imply that water managers and users must augment their water supplies, reduce their demands, or reach other accommodations consistent with the requirements of the species.

While the ESA gives priority to the needs of threatened and endangered species, it also requires that any allocation of resources to these species be justified on a scientific or technical basis. The burden for scientific and technical justification falls mainly on the federal agencies, and especially the U.S. Fish and Wildlife Service and National Marine Fisheries Service, which are the source of biological opinions on the species. Assessment of the requirements of any species in a manner that is scientifically or technically rigorous is difficult and often cannot be accomplished quickly. The agencies have assembled considerable data and have interpreted the data as showing need for higher flows in the Klamath main stem and higher lake levels in the upper part of the basin.

External review increases confidence in scientific and technical judgments, and is especially important when such judgments underlie important policy decisions. Accordingly, the Department of the Interior and Department of Commerce have arranged through its agencies for the National Research Council to form the Committee on Endangered and Threatened Fishes in the Klamath River Basin, whose charge is to conduct an external review of the scientific basis for the biological opinions that resulted in changes of water management for year 2001. The committee is to conduct its work in two phases. The first phase, which is reported here, gives an interim assessment of the evidence behind the biological opinions. A second phase, which will occur over approximately the next year, will take a broader approach to evaluation of evidence for long-term requirements of the threatened and endangered fishes.

In formulating its interim assessment, the committee has been greatly assisted by individuals who have provided it with information orally and in written form. The committee is especially indebted to the invited speakers and members of the public who attended the first meeting of the committee and also to NRC staff members Heather McDonald, Jennifer Saunders, David Policansky, and Suzanne van Drunick and to Leslie Northcott of the University of Colorado.

All NRC committee reports are subject to external peer review as well as internal quality control processes. The committee and the NRC are grateful to the reviewers who contributed their time and expertise to the review process.

The NRC committee is pleased to provide scientific and technical assessments that it hopes will be helpful to federal agencies as they attempt the difficult process of guiding water management toward practices that are consistent with the welfare of threatened and endangered species while also accommodating to the fullest practical extent other uses of water in the Klamath River Basin.

William M. Lewis, Jr., Chair
Committee on Endangered and Threatened
Fishes in the Klamath River Basin

Contents

Summary

The Klamath River Basin, which drains directly to the Pacific from parts of southern Oregon and northern California, contains endemic freshwater fishes and genetically distinctive stocks of anadromous fishes. Endemic freshwater fishes include the shortnose sucker (*Chasmistes brevirostris*) and the Lost River sucker (*Deltistes luxatus*). These long-lived and relatively large species, which live primarily in lakes but enter flowing waters or springs for spawning, were sufficiently abundant during the nineteenth and early twentieth century to support commercial fisheries. During the last half of the twentieth century these species declined so much in abundance that they were listed in 1988 as endangered under the federal Endangered Species Act (ESA). In addition, the genetically distinctive Southern Oregon/Northern California Coasts (SONCC) coho salmon (*Oncorhynchus kisutch*), an evolutionary significant unit (ESU) of the coho salmon, depends on the Klamath River main stem for migration and on tributary waters for spawning and growth before entering the Pacific for maturation. The Klamath Basin coho has declined substantially over the last several decades, and was listed as threatened under the ESA in 1997.

Factors contributing to the decline in abundance of the endangered suckers and threatened coho in the Klamath River Basin are diverse and in some cases incompletely documented. Factors thought to have contributed to the decline of the endangered suckers include degradation of spawning habitat, deterioration in the quality of water in Upper Klamath Lake, overexploitation by commercial and non-commercial fishing (now regulated), introduction of competitive or predaceous exotic species, blockage of migration routes, and entrainment of fish of all ages in water management structures. Factors contributing to the decline of coho salmon are thought to include earlier overexploitation by fishing as well as continuing degradation of tributary habitat and reduced access to spawning areas. The threatened coho salmon also may be affected by changes in hydrologic regime, substantial warming of the main stem and tributaries, and continuing introduction of large numbers of hatchery-reared coho, which are derived only partly from native stock.

The U.S. Bureau of Reclamation's (USBR) Klamath Basin Project (Klamath Project) is a system of main-stem and tributary dams and diversion structures that store and deliver water for agricultural water users in the Upper Klamath Basin under contract with the USBR. Subsequent to the listing of suckers in 1988 and coho in 1997, the USBR was required to assess the potential impairment of these fishes in the Klamath River Basin by operations of the Klamath Project. In the assessments, which were completed in 2001, the USBR concluded that operations of the project would be harmful to the welfare of the listed species without specific constraints on water levels in the lakes to protect the endangered suckers and flows in the Klamath River main stem to protect the threatened coho salmon.

After release of the USBR assessment on the endangered suckers (February 2001), and following procedures required by the ESA, the U.S. Fish and Wildlife Service (USFWS) in April 2001 issued a biological opinion based on an extensive analysis of the relevant literature and field data. The biological opinion states that the endangered

suckers would be in jeopardy under USBR's proposed Klamath Project operations. The USFWS proposed a reasonable and prudent alternative (RPA) for operation of the Klamath Project. The RPA requires screening of water-management structures to prevent entrainment of suckers, adequate dam passage facilities, habitat restoration, adaptive management of water quality, interagency coordination in the development plans for operating the Klamath Project during dry years, further studies of the sucker populations, and a schedule of lake levels higher than those recommended by the USBR in its assessment.

The National Marine Fisheries Service (NMFS), which assumes responsibility for the coho because it is anadromous, issued a biological opinion in April 2001 indicating that the operation of the Klamath Project as proposed by the USBR assessment of January 2001 would leave the coho population in jeopardy. The NMFS formulated an RPA incorporating reduced rates of change in flow (ramping rates) below main-stem dams to prevent stranding of coho, interagency coordination intended to optimize use of water for multiple purposes, and minimum flows in the Klamath River main stem higher than those proposed by USBR.

During 2001, a severe drought occurred in the Klamath River Basin. The U.S. Department of the Interior (DOI) determined that the newly issued biological opinions and their RPAs must prevail; thus, water that would have gone to irrigators was directed almost entirely to attempts to maintain minimum lake levels and minimum flows as prescribed in the two RPAs. The severe economic consequences of this change in water management led DOI to request that the National Research Council (NRC) independently review the scientific and technical validity of the government's biological opinions and their RPAs. The NRC Committee on Endangered and Threatened Fishes in the Klamath River Basin was formed in response to this request. The committee was charged with filing an interim report after approximately 2 months of study and a final report after about 18 months of study (see statement of task, Appendix). The interim report, which is summarized here, focuses on the biological assessments of the USBR (2001) and the USFWS and NMFS biological opinions of 2001 regarding the effects of Klamath Project operations on the three listed fish species. The committee has provided in the report a preliminary assessment of the scientific information used by the agencies and other relevant scientific information, and has considered the degree to which the biological opinions are supported by this information. During November and early December 2001, the committee studied written documentation, heard briefings from experts, and received oral and written testimony from the public, and used this information as the basis for its interim report.

The Committee's Principal Findings

The NRC committee concludes that all components of the biological opinion issued by the USFWS on the endangered suckers have substantial scientific support except for the recommendations concerning minimum water levels for Upper Klamath Lake. A substantial data-collection and analytical effort by multiple agencies, tribes, and other parties has not shown a clear connection between water level in Upper Klamath Lake and conditions that are adverse to the welfare of the suckers. Incidents of adult mortality (fish kills), for example, have not been associated with years of low water level. Also, extremes of chemical conditions considered threatening to the welfare of the fish have not coincided with years of low water level, and the highest recorded recruitment of new individuals into the adult populations occurred through reproduction in a year of low water level. Thus, the committee concludes that there is presently no sound scientific basis for recommending an operating regime for the Klamath Project that seeks to ensure lake levels higher on average than those occurring between 1990 and 2000. At the same time, the committee concludes that there is no scientific basis for operating the lake at mean minimum levels below the recent historical ones (1990-2000), as would be allowed under the USBR proposal. Operations leading to lower lake levels would require acceptance of undocumented risk to the suckers.

For the Klamath Basin coho, the NMFS RPA involves coordination of operations as well as reduction of ramping rates for flows below the main-stem dams and increased flows in the Klamath River main stem. Coordination and reduced ramping rates are well justified. The committee, however, did not find clear scientific or technical support for increased minimum flows in the Klamath River main stem. Although the proposed higher flows are intended to increase the amount of habitat in the main stem, the increase in habitat space that can occur through adjustments in water management in dry years is small (a few percent) and possibly insignificant. Furthermore, tributary conditions appear to be the critical factor for this population; these conditions are not affected by operations of the Klamath Project and therefore are not addressed in the RPA. Finally, and most importantly, water added as necessary to sustain higher flows in the main stem during dry years would need to come from reservoirs, and this water could equal or exceed the lethal temperatures for coho salmon during the warmest months. The main stem already is excessively warm. Juvenile fish living there probably tolerate its temperature only because of the presence of groundwater seepage or small tributary flows that provide pockets of cool water. Addition of substantial amounts of warm water could be detrimental to coho salmon by reducing the size of these thermal refuges. At the same time, reduction in main-stem flows, as might occur if the USBR proposal were implemented, cannot be justified. Reduction of flows in the main stem would lead to habitat conditions that are not documented, and thus present an unknown risk to the population.

Conclusion

On the basis of its interim study, the committee concludes that there is no substantial scientific foundation at this time for changing the operation of the Klamath Project to maintain higher water levels in Upper Klamath Lake for the endangered sucker populations or higher minimum flows in the Klamath River main stem for the threatened coho population. The committee concludes that the USBR proposals also are unjustified, however, because they would leave open the possibility that water levels in Upper Klamath Lake and minimum flows in the Klamath River main stem could be lower than those occurring over the past 10 years for specific kinds of climatic conditions. Thus, the committee finds no substantial scientific evidence supporting changes in the operating practices that have produced the observed levels in Upper Klamath Lake and the observed main-stem flows over the past 10 years.

The committee's conclusions are subject to modification in the future if scientific evidence becomes available to show that modification of flows or water levels would promote the welfare of the threatened and endangered species under consideration by the committee. The committee will make a more comprehensive and detailed consideration of the environmental requirements of the endangered suckers and threatened coho in the Klamath River Basin over the next year, during which time it will develop final conclusions.

1. Introduction

The Klamath River Basin is isolated from other fresh waters by its direct drainage to the Pacific (Figure 1). This isolation and a diversity of freshwater habitats including perennial tributary and main-stem flows, extensive marshlands, and large shallow lakes, have favored genetic isolation of freshwater and anadromous fishes in the basin. Thus, the Klamath River Basin contains endemic freshwater fishes as well as genetically distinctive stocks of anadromous fishes that are shared with nearby basins on the Oregon and California coasts.

Endemic freshwater fishes of the Klamath River Basin include the shortnose sucker (*Chasmistes brevirostris*) and the Lost River sucker (*Deltistes luxatus*). These two species, which are long-lived, reach relatively large sizes, and have high fecundity (Moyle 1976), occupy primarily lakes as adults but use tributary streams as well as springs for spawning. The two sucker species were abundant in Upper Klamath Lake and elsewhere in the drainage prior to 1900; they were used extensively by Native Americans as well as settlers, and were the basis for commercial fisheries (USFWS 2001). During the 20th century, and particularly after the 1960s, the populations substantially declined in abundance. Reduction in abundance of the suckers has been generally attributed to changes in water quality, excessive harvesting, introduction of exotic fishes, alteration of flows, entrainment of fish into water management structures, and physical degradation of spawning areas (USFWS 2001). Both the shortnose sucker and the Lost River sucker were classified as federally endangered under the Endangered Species Act (ESA) in 1988 (USFWS 1988).

The main stem and tributaries of the Klamath River support endemic populations of a genetically distinctive population of coho salmon (*Oncorhynchus kisutch*). This group of coho is part of the Southern Oregon/Northern California Coasts (SONCC) evolutionarily significant unit (ESU), which also occupies several other drainages near the Klamath River Basin. These fish mature in marine waters off the California and Oregon coasts, move up the Klamath main stem and into tributaries for spawning, descend back to the main stem for the smolt phase, and then exit to the Pacific. The present distribution of the species within the Klamath Basin extends to the Iron Gate Dam, although it probably extended farther upstream prior to the construction of main-stem dams (NMFS 2001).

Stocks of native coho salmon have declined greatly in the Klamath River Basin over the past several decades. Potential causes of the decline include overexploitation (now largely curtailed), habitat degradation, manipulation of flows in the main stem, excessive warming of waters, degradation or blockage of tributaries, and introduction of large numbers of competitive hatchery-reared coho salmon only partially derived from the native stock (NMFS 2001). The SONCC coho ESU was classified as federally threatened under the ESA in 1997.

In response to the listing of the two sucker species and the SONCC coho, the Bureau of Reclamation (USBR), which operates the Klamath River water distribution project (Klamath Project), prepared biological assessments of the effects of Klamath Project operations on the suckers and on the coho (USBR 2001a, b). Because the listing processes for these fish referenced water level in Upper Klamath Lake and other lakes in the Upper Klamath Basin and amounts of flow in the main stem of the Klamath River below Iron Gate Dam as potential points of concern for the welfare of the species, the USBR assessments were intended to make a case for specific flows and water levels in portions of the basin strongly affected by operations of the Klamath Project.

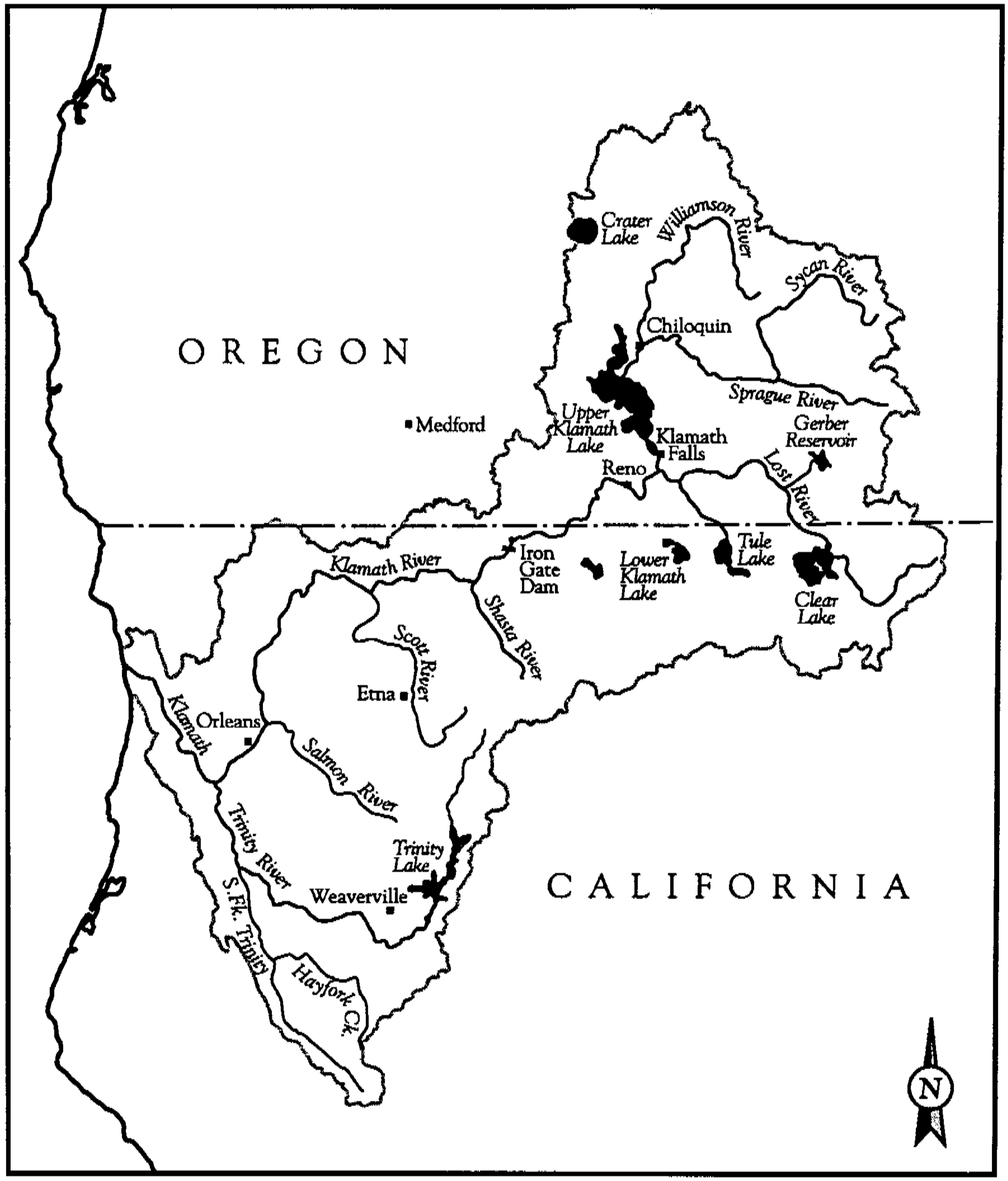

Figure 1. Map of the Upper Klamath River Basin showing surface waters and landmarks mentioned in this report (modified from USFWS sources).

In response to the USBR assessment of the endangered suckers, the U.S. Fish and Wildlife Service (USFWS) issued a biological opinion (USFWS 2001). A separate biological opinion was issued on the coho population by the National Marine Fisheries Service (NMFS 2001), which has the prime responsibility for ESA actions on these fish because they are anadromous. The two biological opinions differ sharply from the two corresponding USBR assessments in that they call for maintenance of higher lake levels and higher main-stem flows than the assessments.

Year 2001 brought a severe drought to the Klamath River Basin. The Department of the Interior (DOI) determined that the biological opinions on the endangered and threatened species must take priority over other uses of water, and that the amounts of water specified as reasonable and prudent alternatives (RPAs) in the biological opinions should be maintained to the degree physically possible prior to the provision of water for consumptive use as specified by contracts between irrigators and the USBR through its Klamath Project. Consequently, most of the water that otherwise would have been delivered to irrigators through the Klamath Project was not delivered. Substantial agricultural losses occurred, along with damage to the economic base of the Klamath River Basin (actual losses are still being estimated, but the work of Adams and Cho (1998) shows that direct losses to farmers alone would probably exceed $20 million) .

Given the strong economic consequences for implementation of the biological opinions through their effect on the Klamath Project, the DOI determined that the scientific basis for the two opinions should be reviewed. The National Research Council (NRC) was asked, through the National Academy of Sciences, to form a committee to study the two opinions. Sponsors of the review include the USBR and the USFWS of the Department of the Interior and the NMFS of the Department of Commerce. A portion of the work of the NRC committee and the committee's interim conclusions are summarized in this report.

The two biological opinions and the two biological assessments contain valuable literature reviews. The committee cites these documents in lieu of the primary literature for much of the background subject matter of this report, but cites individual studies that are of particular importance to the committee's conclusions wherever appropriate.

Tasks of the NRC Committee

The work of the NRC Committee on Endangered and Threatened Fishes in the Klamath River Basin is divided into two phases (see statement of task, Appendix A). The first phase, reported here, involves a preliminary assessment of the scientific validity of the two biological opinions and their RPAs, particularly as they relate to the near-term operation of the Klamath Project. In a second phase, the committee will conduct a more broad-ranging study of evidence related to the welfare of the endangered and threatened species. Whereas the interim report focuses specifically on the biological opinions, the final report may extend beyond the biological opinions to deal more extensively with water pollution or other such subjects that are not directly under control of the Klamath Project. This effort will culminate in a second report that will give the committee's consensus view of the long-term requirements of the species.

Although the interim report specifically deals with the two biological opinions, the committee also gives its conclusions about the two biological assessments upon which the biological opinions are based. If the biological opinions were rejected fully or in part, the presumed alternative for operation of the Klamath Project would be as prescribed in the USBR assessments. Thus, the committee must not only evaluate the validity of the biological opinions, but also extend the same sort of evaluation to the assessments.

The tasks of the committee encompass only the scientific and technical issues that are relevant to the three endangered and threatened fish species mentioned above. The committee is not charged with investigating or reporting on economic dislocation or with forecasting the economic consequences of continued implementation of flows specified in the biological opinions. Given the background materials that were provided to the committee, however, all committee members are acutely aware of the great importance of any change in historical management of flows to water users in the Klamath Basin. Also, the committee is aware of the great and long-standing interest of Native American tribes of the Klamath River Basin in the maintenance and expansion of fish stocks, including Tribal Trust species not covered in this report, and of the interests of numerous other parties in water resources, wetlands, and the welfare of fishes and other aquatic life. While the committee will not analyze economic or socioeconomic questions, the strong and multiple interests of individuals and communities in the Klamath Basin in the conclusions reached by the committee are well recognized by the committee members.

Not only from an economic and social viewpoint, but also from the perspective of ecological and biological resources, the work of the NRC committee is tightly focused by its statement of task and by the inherent requirements of the Endangered Species Act, which prohibits federal actions that jeopardize continued existence of listed species through interference with their survival or recovery (50 CFR 402.02). The Klamath River Basin is home to hundreds of species of fish and wildlife and to distinctive native ecosystems, including wildlife refuges of national significance. Many of these natural resources have been greatly restricted or altered through human action. In fact, changes in the flow regime in the Klamath River may affect other fishes that have been proposed for listing as threatened species but are not yet listed (e.g., ESUs of steelhead and chinook salmon). The committee, however, is charged with studying specifically the requirements of the three fish species mentioned above, and not of other species in the Klamath River Basin.

2. Evaluation of the Biological Opinion on Shortnose and Lost River Suckers

Populations of the shortnose and Lost River suckers currently are present within Upper Klamath Lake on the north side of the Klamath River drainage and within Clear Lake (which operates as a reservoir) and Gerber Reservoir on the Lost River, to the southeast (Figure 1). Small groups of individuals, some or all of which may be nonreproducing, are found elsewhere in the Klamath River drainage, including Tule Lake sump (USFWS 2001). Conditions in the lakes are relevant to the USFWS biological opinion largely through proposals for minimum lake levels that are intended to reduce mortality and improve spawning success, recruitment (addition of new individuals to the population), growth, and condition of the suckers.

The population sizes of endangered suckers in Upper Klamath Lake and elsewhere within the Klamath Basin are uncertain, but the abundances of these populations, which once were large enough to support commercial fisheries, are much lower than they were when agricultural development and water management began. Unfortunately, quantitative estimates of population sizes are not available. During the 1980s, qualitative evidence indicated that declines might have taken the sucker populations in Upper Klamath Lake to just a few thousand old (> 10 years) individuals (USFWS 1988). More recent estimates made possible incidentally by episodes of mass mortality suggest, however, that the populations are considerably larger than they appeared to be in the 1980s, and that some recruitment to the adult age classes has occurred in most or all years of the last decade (see below). Population sizes may range from a few tens of thousands to the low hundreds of thousands of individuals (USFWS 2001), but still are much lower than they were originally. Aside from decline in abundance over the long term, other indications of problems within the sucker populations include absence of spawning at a number of sites historically used for spawning, apparent increase in mass mortality of adults ("fish kills"), and weak recruitment in most years (USFWS 2001).

The water quality of Upper Klamath Lake has changed substantially over the last several decades. The lake appears to have been eutrophic (rich in nutrients and supporting high abundances of suspended algae) prior to any anthropogenic influence (Kann 1998). Mobilization of phosphorus from agriculture and other non-point sources (Walker 2001), however, appears to have pushed the lake into an exaggerated state of eutrophication that involves algal blooms reaching or approaching the theoretical maximum abundances. In addition, algal populations now are strongly dominated by the single bluegreen algal species *Aphanizomenon flos-aquae* (Cyanobacteria) rather than the diatom taxa that apparently dominated blooms prior to nutrient enrichment (Kann 1998, Eilers et al. 2001).

Evidence indicates that changes in the water quality of Upper Klamath Lake have increased mass mortality among adult suckers. Under certain conditions, the bottom portion of the water column in the lake develops oxygen depletion and accumulates high concentrations of ammonia. Mixture of these bottom waters with the surface waters under the influence of changes in weather is the likely cause of mass mortality (Vogel et al. 2001, Horne 2001). While mass mortality has been recorded over the entire observed history of the lake, its frequency appears to have increased (Perkins et al. 2000). Major incidents were recorded for years 1995, 1996, and 1997; low dissolved oxygen appears to have been the direct cause of mortality in these years (Perkins et al. 2000).

Impairment of water quality also may stress fry through the creation of high pH in surface waters as a result of high rates of photosynthesis, although exposures to the highest pH probably are too brief to cause mortality (Saiki et al. 1999). In addition, the present trophic state of the lake potentially poses a threat of mortality in winter, when anoxia can occur under ice if oxygen demand is high. Although not yet observed, winter mortality could occur in the future (Welch and Burke 2001).

Factors of concern other than water quality include the presence of exotic species capable of inducing types of predation and competition that are foreign in an evolutionary sense to these endemic species. Hybridization occurs but the degree of threat associated with it is unknown; the native suckers probably showed some interbreeding prior to human intervention (Markle et al. 2000). In addition, access of the suckers to historically significant spawning areas has in many cases been blocked or the spawning areas themselves have been physically degraded to such an extent that they cannot serve their former roles (USFWS 2001). Overfishing or habitat degradation may have eliminated portions of the population that were using specific spawning areas and, although fishing no longer occurs, these subpopulations cannot be regenerated without manipulation of existing stocks in combination with habitat restoration.

Suckers of all sizes are entrained by water management structures (USFWS 2001). While screening of these structures has long been recognized as an important means of reducing mortality of the endangered suckers, it has not yet been accomplished. Also, interaction of multiple stresses may increase vulnerability of the endangered suckers to disease, degrade their body condition, and cause them to show a high incidence of anatomical abnormalities (Plunkett and Snyder-Conn 2000).

The USFWS biological opinion states that the Klamath Project is detrimental to the endangered suckers through its direct contributions to mortality and adverse environmental conditions. On this basis, USFWS presents a reasonable and prudent alternative (RPA) consisting, in summary, of requirements for minimum lake levels, coordination and adaptive management, screening to prevent entrainment of fish, creation of improved passage facilities, steps toward improvement of habitat and water quality, and additional studies. The RPA is intended to avoid jeopardizing listed species either directly or through adverse modification of critical habitat (50 CFR 402.02).

With the exception of the recommendation on lake-level maintenance, there is good scientific or technical support for all of the requirements listed in the RPA. Coordination and adaptation of management are advisable, especially because the information base is evolving rapidly and because annual optimization of strategies for using water is an obvious need. Given the documented loss of suckers to entrainment and the blockage of their access to spawning waters at known locations (USFWS 2001), requirements of the RPA calling for mitigation of these problems also seems highly defensible. Potential for improvement of habitat and water quality must be viewed as incremental rather than comprehensive, but even incremental improvements offer the prospect of increasing the viability of the sucker populations, and thus seem justified. Recommendations on water level are more difficult to evaluate, however.

Figure 2 shows the water levels given by USFWS in its RPA (2001) as well as two other lake level regimes (USBR recommended and historical). The USFWS requirements are given as absolute minima, i.e., they do not vary from one type of water year to another. In contrast, assessment proposals of the USBR are framed in terms of various categories of water year; categories shown in Figure 2 are characterized as critically dry (lowest 4%) and dry (approximately 12% of years just wetter than the critically dry ones).

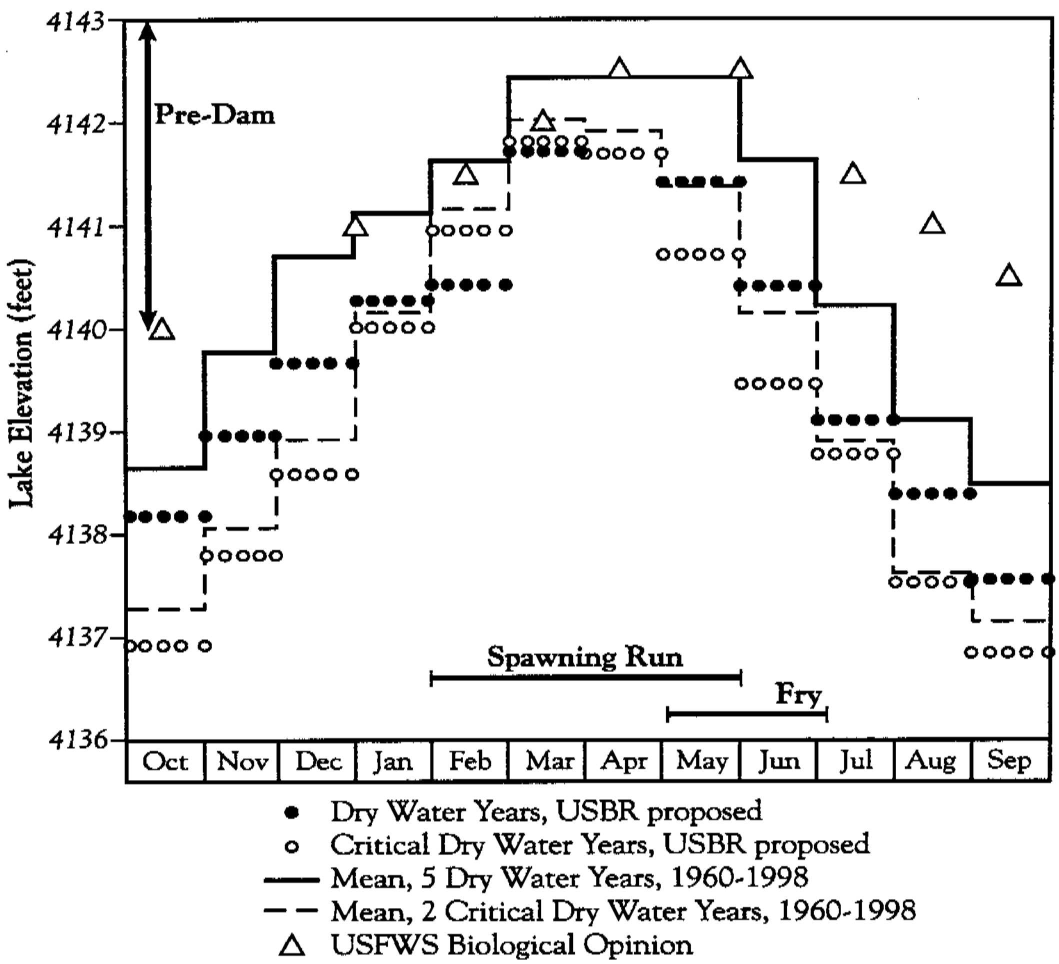

Figure 2. Overview of monthly levels for Upper Klamath Lake proposed by USBR through its biological assessment of 2001, USFWS through its biological opinion of 2001, and observed conditions for the years 1960 – 1998. Hydrologic categories used by USBR in its proposals (dry years, critical dry years) are explained in the text. Mean depths, excluding wetlands, corresponding to water levels are approximately as follows (feet): 4137 = 3.5; 4138 = 4.0; 4139 = 4.8; 4140 = 5.7; 4141 = 6.6; 4142 = 7.6 (Welch and Burke 2001, Figure 2-5).

The span of lake level records that the USBR chose to use in its analysis (1960-1998) reflects the full interval of operations for the completed Klamath Project. Even earlier records are available, extending back to the creation of Link River Dam in 1919 (Figure 3), but the interval between 1919 and 1960 would not be typical from the viewpoint of current project operations. Records prior to 1919, extending back to 1905, also are available (Figure 3); they show higher maximum and minimum lake levels than have been typical of Upper Klamath Lake since closure of the dam. In addition, operation of the Klamath Project has created a higher amplitude of intraannual variation in lake level and a change in seasonality of intraannual change in lake level as compared with the original condition of the lake (USFWS 2001, III. 2., page 38).

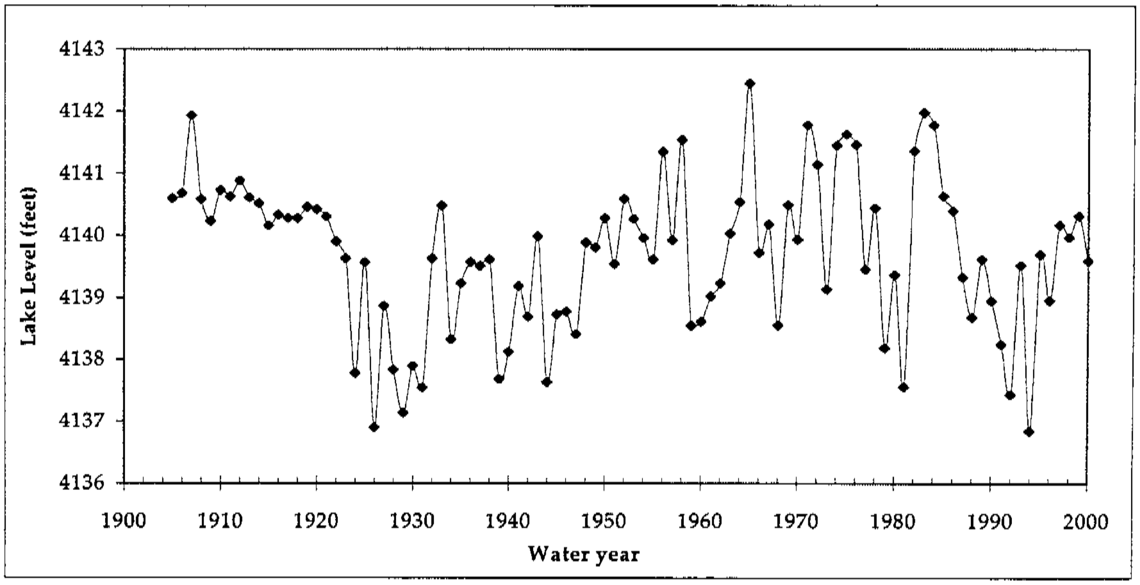

Figure 3. Historical record of level at the end of September for Upper Klamath Lake (from USBR sources).

While the operating interval between 1960 and 1998 is very useful for judging the degree of variability that can be expected in lake levels over a long period of years with the Klamath Project in place, the possibility for use of lake-level data in environmental analysis is limited to a much shorter interval. Interaction between lake level and environmental variables or indicators of the welfare of the endangered fish is dependent on concurrent information for lake level, environmental conditions, and fish. While information of a sporadic or anecdotal nature is available over as much as 100 years, routinely-collected data on environmental characteristics and fish are available only since 1990 or later. Thus, while the long-term lake level record seems to invite statistical analysis of the welfare of fish in relation to lake level, the information at hand is actually limited to a period of ten years or less. This limitation explains the focus of this report and of the USFWS biological opinion on data extending over approximately the last ten years. All three lake-level regimes (USFWS RPA, USBR recommended, historical) reflect seasonality that is partly inherent in the runoff reaching Upper Klamath Lake and partly a byproduct of water withdrawals. The degree of seasonality in the USFWS RPA is considerably lower, however, than the seasonality of the other two regimes depicted in Figure 2, and minimum levels are highest overall for the USFWS RPA. The USBR proposed minima are below the means for the historic operating regime in each of the two dry-year categories because the USBR used the lowest recorded monthly lake levels for each category as its proposed minima. From the viewpoint of lake levels, water years are almost independent of each other because the lake has little capacity for interannual storage.

The USBR proposal would allow more drawdown of lake level than has been characteristic in the past. Although the lake levels proposed by USBR have been observed over the last 40 years, the use of these 40-year minima as year-to-year minima indicates that drawdown to the 40-year minima would be possible in any year of future operations if USBR's proposals were accepted. If USBR chose to operate the project by using greater average drawdown than has been observed over the past 40 years, the result would be significantly lower mean lake levels in each of the hydrologic categories.

Control of lake levels as a means of advancing the welfare of the endangered suckers raises more difficult scientific issues than the other requirements listed by the USFWS in its RPA. The recommendation for water-level control is based on concerns related to habitat (shoreline spawning areas, emergent vegetation), and water quality (low oxygen in summer, need for deep water refugia in summer and fall, possibility of adverse conditions under ice cover).

Impairment of water quality, primarily through eutrophication of Upper Klamath Lake, is a cause of mortality and stress for sucker populations. As indicated above, the present scientific evidence for this association is credible. An essential premise of the lake-level recommendations, however, is that the adverse water quality conditions known to stress or kill the endangered suckers are associated with the lowest water levels within the recent historical range of levels (since 1990, when consistent documentation first began). Presumption of this connection, which is essential to the arguments for specific lake levels that are proposed in the RPA, is inconsistent with present information on Upper Klamath Lake.

Control of phosphorus in Upper Klamath Lake offers the potential of suppressing population densities of algae, thus improving water quality in the lake (Welch and Burke 2001). No relationship between lake levels and population densities of algae (as shown by chlorophyll) is evident, however, in the nine-year water-quality monitoring record that has been fully analyzed (Figure 4). Thus, the idea of relieving eutrophication through phosphorus dilution caused by higher lake levels is not consistent with the irregular relationship between chlorophyll and lake level. Also, lake level fails to show any quantifiable association with extremes of dissolved oxygen or pH (see data presented by Welch and Burke 2001). For example, the most extreme pH conditions recorded for the lake over the last ten years came in 1995 and 1996, which were years of intermediate water level, and not with years 1992 and 1994, when water levels were lowest (these two years had the lowest recorded water levels since 1950). Furthermore, a substantial mass mortality occurred in 1971, the year of highest recorded water levels since 1950 (USFWS 2001) and, within the last ten years, mortality of adults was highest in 1995, 1996, and 1997, none of which was a year of low water level. The absence of notable adult mortality in any year of low water during the 1990s might in fact suggest an association the reverse of the one postulated in the biological opinion, although the evidence is statistically inconclusive. The USFWS itself has found no association of mass mortality with lake levels (USFWS 2001, III.2.70). Intensified eutrophication now affects the characteristics of the lake every year, and thus may constitute a threat to the suckers regardless of interannual variation in water level.

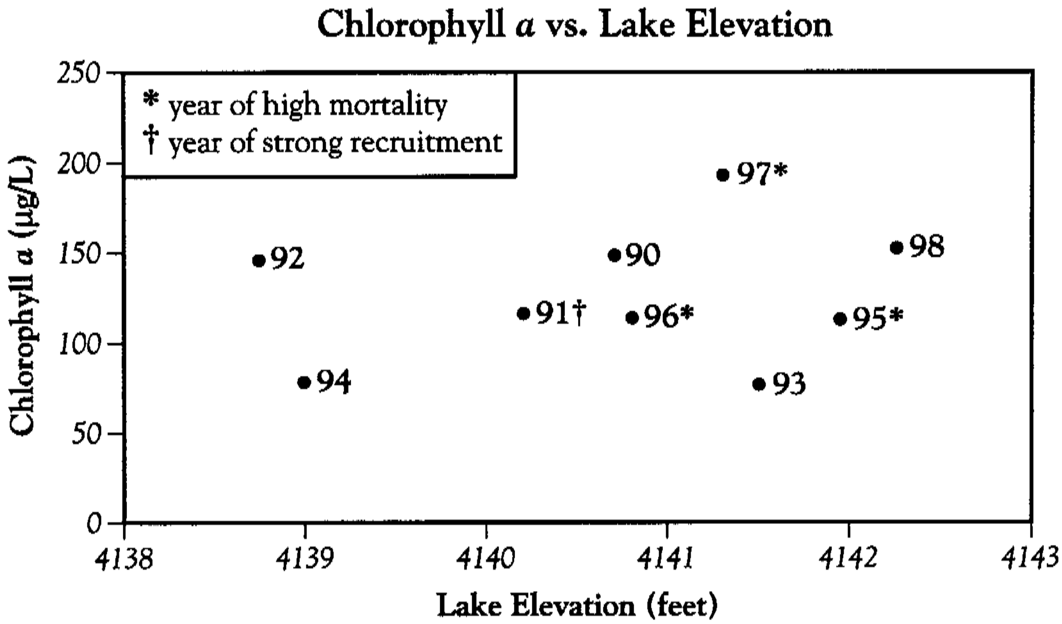

Figure 4. Relationship of chlorophyll *a* and median August lake level in Upper Klamath Lake between 1991 and 1998. Chlorophyll data are averages as reported by Welch and Burke 2001. Recruitment and mortality information is as reported by USFWS 2001.

Higher water levels potentially could be supported on grounds of improved survival of fry or juveniles rather than suppression of adult mortality. Higher water levels could reduce the likelihood that spawning areas around the lake would be dewatered and could be favorable to fry or juveniles. Abundance of juvenile suckers has been monitored since 1991 on the basis of seining (Simon et al. 2000a). This information, which must be used cautiously because it is not quantitative, indicates low abundances of juveniles in the drought years 1992 and 1994 but not in drought year 1991. Abundances also were low in non-drought years 1997 and 1998. Simon et al. (2000a) have reported generally declining abundance during the non-drought interval 1995-1998. They have also shown (Simon et al. 2000a, b) that the abundance of age 1+ suckers consistently has been very low, suggesting a bottleneck at this life stage, but interpretation of the data is complicated by very low efficiency for catching fish older than one year. Overall, the study of young fish shows no clear pattern associated with lake level.

The most reliable current information on recruitment is through analysis of age-class structure of adult suckers (USFWS 2001, III. 2., page 43). This data record is not consistent with the underlying assumptions of proposals for maintenance of higher water levels. The strongest recruitment (as inferred from relative abundances of adult year classes) observed over the last ten years was for 1991 (Figure 5), which falls within the lowest 15% of lake levels since 1950. Furthermore, as shown by the continuing strength of the 1991 year class in 1995 and beyond, the year class showed good survival through the dry years of 1992 and 1994. While the use of emergent vegetation by fry is cited as a reason for maintaining high water levels, the combination of high recruitment in 1991 and low recruitment in other years (as inferred from year class data) casts doubt on the importance of this factor, at least within the operating range of the 1990s. Furthermore, fry of the Upper Klamath Lake populations appear to use submerged as well as emergent macrophytes (Cooperman and Markle 2000), and thus may not be highly sensitive to the reduction in access to emergent vegetation that occurs in dry years (Dunsmoor et al. 2000). Overall, the presumed causal connections between lake levels and recruitment of the sucker populations in Upper Klamath Lake do not have strong scientific support at present.

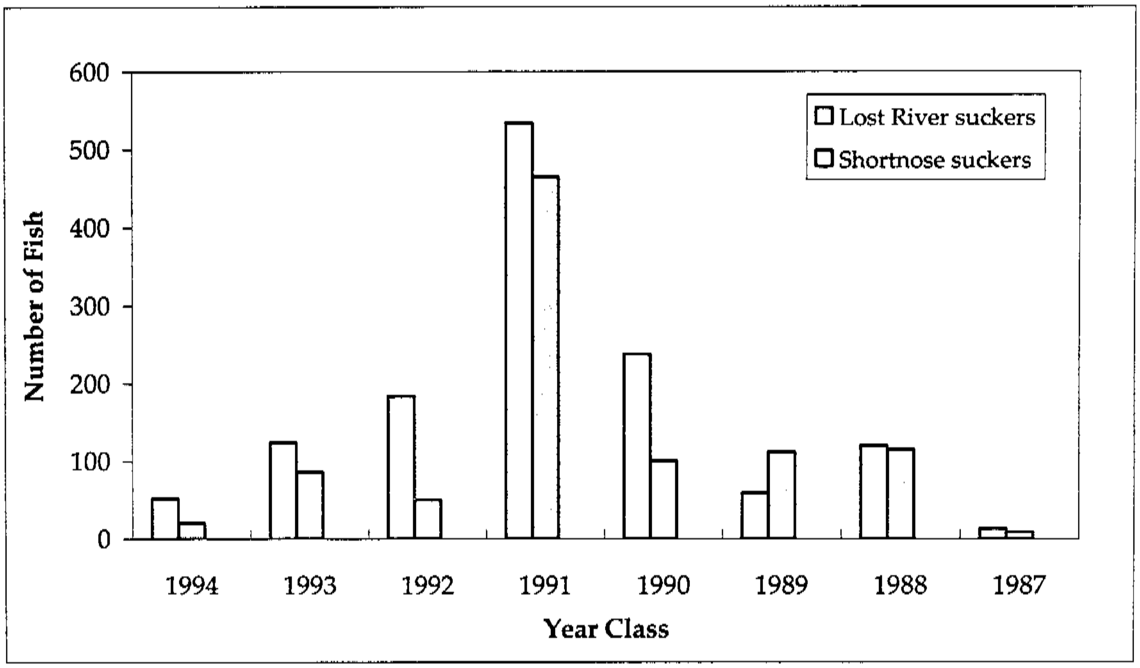

Figure 5. Relative strength of year classes for endangered suckers as reconstructed from survey of mass mortality in 1995, 1996, and 1997 (combined). Source: USGS and USFWS records.

Mortality possibly could be caused by multiple factors that interact with lake level. For example, mortality of suckers is influenced by changes in water column stability; an extended period of stability leading to decline of oxygen near the bottom can be followed by sudden mixing of the entire water column associated with a change in weather (high wind velocity). Thus, interpretation of information on lake level is complicated by the influence of weather. There is no evidence as yet, however, that the significance of undesirable mixing events is higher when lake levels are low than when they are high. As a result, mixing as a cause of water quality conditions leading to mortality cannot be interpreted at this time in terms of lake level.

While there is no clear evidence, despite a monitoring record of substantial length, for connection between lake levels and the welfare of the two sucker species in Upper Klamath Lake, lake levels cannot be reduced below those observed in the last ten years without risk of the occurrence of adverse events that are not described in the detailed monitoring record (1990-present; analyses complete through 1998). A negative association between welfare of the species and lake level could emerge if lake levels are reduced below those of recent historical experience. The absence of any presently evident empirical connection between the observed lake levels and the welfare of the endangered suckers cannot be taken as justification for continuous or frequent operation of the lake at the lowest possible levels, given that the effects of operating the lake at lower levels are undocumented. Thus, while the observational record contradicts important underlying assumptions of the RPA, it does not provide an endorsement for the lake levels proposed in the USBR biological assessment, which if implemented could take interannual mean lake levels well below those of recent historical observation.

Potential benefits of higher lake levels in Clear Lake, Gerber Reservoir, and Tule Lake sump are more difficult to evaluate because the record of analysis and observation for these water bodies is not so extensive as it is for Upper Klamath Lake. These lakes have not suffered notable mass mortality in association with low lake levels, but Clear Lake populations showed poor body condition following severe drawdown in the early 1990s. The USFWS gives reasonable support for lake levels in Clear Lake no lower than the recent drought-related minimum (1992-1993: 4519 feet). The RPA reasonably adds a margin of two feet (4521) to allow for water loss in the absence of withdrawals under drought conditions.

3. Evaluation of the Biological Opinion on Klamath Basin Coho Salmon

Coho salmon enter the main stem of the Klamath River for spawning typically in their third year, primarily between October and December. Over most of this interval, main-stem flows below Iron Gate Dam often are high (ca. 2500-3000 cfs: NMFS 2001). Thus, standard methods for observing and counting spawning fish are not easily applied, and the size of the spawning population is unknown. Approximations put the entire ESU at about 10,000 spawning coho salmon of non-hatchery origin per year (Weitkamp et al. 1995), of which only a small portion is associated with the Klamath Basin, where several important tributary runs have been reduced to a handful of individuals (NMFS 2001).

Spawning coho in the Klamath Basin are restricted to use of tributaries that they can reach from the main stem up to Iron Gate Dam. Original spawning runs probably were largest in large tributaries, but presently are restricted mainly to numerous small tributaries entering the main stem directly (Yurok Tribe 2001). Large tributaries have been severely degraded, show excessively high temperatures, and are dammed in critical places. Although a minor amount of spawning and growth may occur in the main stem, the main stem serves adults primarily as a migration route.

Fry appear in late fall or winter, when water levels are highest. Most fry probably remain in the tributaries but some may move to or be swept into the main stem. Juvenile coho become smolts and emigrate to the ocean between March and mid-June; peak migration occurs in mid-May (NMFS 2001). In general, juvenile coho can be expected to occupy places where summer temperatures are low (12-14°C appears to be optimal for growth). They are also favored by deep pools with complex cover, especially large woody debris, which is essential for survival over winter (Sandercock 1991). Such conditions exist primarily in tributary streams of the Klamath Basin.

The reduction in stocks of native coho salmon in the Klamath River Basin has been caused by multiple interactive factors. Drastic reduction in spawning and juvenile habitat has occurred through impoundment and physical alteration of tributaries. Also, large numbers of smolts are released annually from the Iron Gate hatchery. These fish, which are derived from a combination of Klamath Basin and Columbia River coho, likely compete with or have other negative effects on wild native coho at all stages of their life history during which they are in contact, including the smoltification-emigration period, the ocean growth period, and spawning (Fleming and Gross 1993, Nielsen 1994, NRC 1996).

Physical habitat in the main stem is a potential concern for the welfare of the coho in several life stages. The spawning run must have adequate flows for passage, which would be impaired by excessively shallow water (e.g., through amplification of predation losses). Access to tributaries is a related consideration for the spawning run, given that little if any spawning occurs in the main stem. Also, fry that enter the main stem must find cool, well-shaded pools, or return to a suitable tributary. Smolts moving downstream must find suitable temperature, flow, and habitat conditions compatible with their physiological transformation during migration (Wedemeyer et al. 1980).

While habitat is an undeniable requirement for all life stages, the assessment of habitat suitability is difficult and subject to considerable uncertainty. Numerical methods are now being applied to the estimation of habitat area in relation to flow (INSE 1999). These methods are commonly used in evaluating habitat, but in final form they require extensive field measurements that are not yet available. Initial modeling suggests that, while greater amounts of habitat for salmonids accompany higher flows, the percentage increase of habitat space corresponding to increases in flow that are possible during dry years is relatively small (a few percent: INSE 1999, NMFS 2001).

Water temperature is a major concern for the welfare of the Klamath Basin coho salmon. Summer temperatures appear to be especially critical. In the nearby Matolle River, which contains coho that are part of the SONCC ESU, the juvenile coho reside almost entirely in tributaries but do not persist where summer daily maximum temperatures exceed 18°C for more than a week (Welsh et al. 2001). Summer temperatures in the Klamath River main stem are suboptimal or even lethal to juveniles (NMFS 2001). High temperatures are the result of reduced flow in the main stem and in tributaries as a result of diversions, warming of water in lakes prior to its flow to the main stem, and loss of shading. Climate variability, although probably responsible for some interannual thermal variation, is unlikely to be an important factor by comparison with changes in flow and loss of riparian vegetation. Juvenile coho probably are able to use the main-stem habitat only through behaviorally-mediated thermal regulation involving selection of areas of groundwater entry ("cold pools") or small tributary flows that have cooler water than most of the main stem.

Modeling has shown that higher releases of water to the main stem can reduce water temperature slightly (Deas and Orlob 1999), provided that manipulation of flow itself does not raise the base temperature (see below). It is unlikely, however, that the small degree of cooling that could be accomplished in this way would affect survival of coho salmon because temperatures would continue to be suboptimal. Further modeling is in progress.

The biological opinion issued by the National Marine Fisheries Service for the Klamath Basin coho salmon states that the Klamath Project harms coho in the Klamath main stem (NMFS 2001). The NMFS presents an RPA with three components: (1) higher monthly minimum flows for the main stem of the Klamath River for April through November as a means of maximizing habitat space in the main stem and suppressing maximum water temperatures, (2) suppression of ramping rates below Iron Gate Dam, and (3) coordination involving other agencies.

Figure 6 shows the minimum flows that are given by NMFS as part of its RPA, and shows minimum flows proposed by USBR as part of its biological assessment as well as historical low flows in dry and critical dry years (note that in selected months flows can be higher in critical dry years than in dry years because of water management practices). The RPA-proposed low flows are well above historical operating conditions, which in turn are above the minima proposed by USBR.

The proposed low-flow limits on the Klamath River may not be of significant benefit to the coho population. While the provision of additional flow seems intuitively to be a prudent measure for expanding habitat, the total habitat expansion that is possible given the limited amount of water that is available in dry years is not demonstrably of much importance to maintenance of the population. In wet years, any benefits from

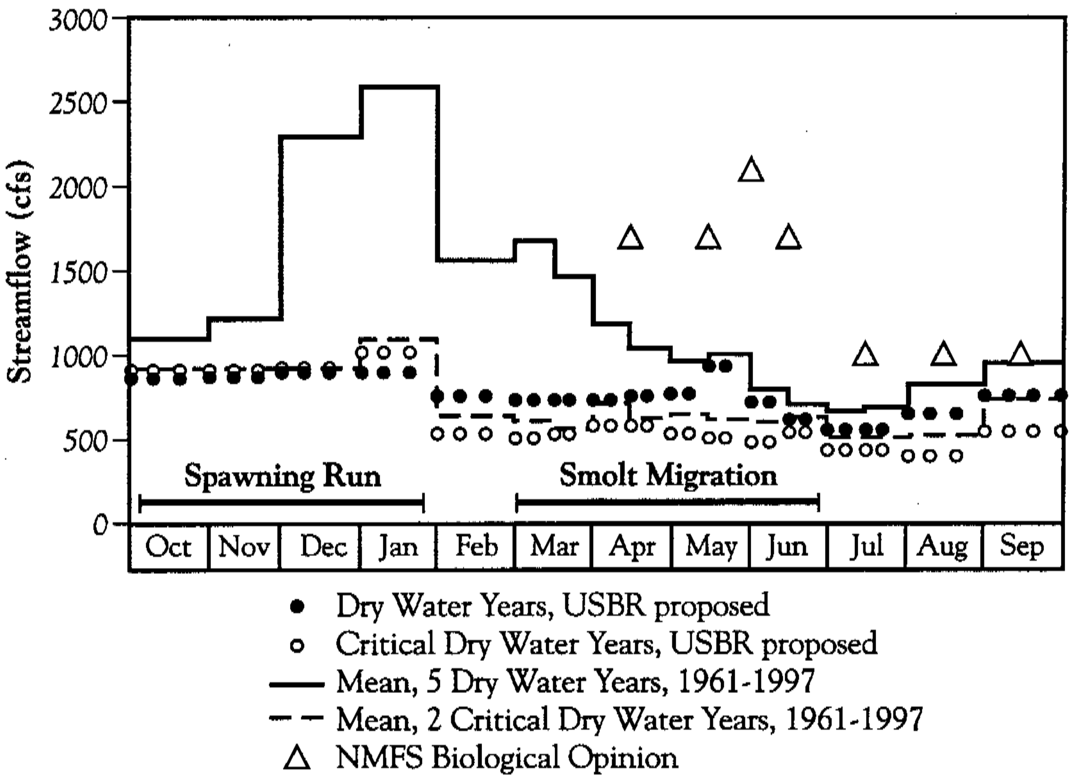

Figure 6. Three flow regimes for the Klamath River below Iron Gate Dam: USBR proposed (USBR 2001b: minima for dry and critical years), historical mean minima for dry and critical dry years, and RPA minimum flows from NMFS (2001). Hydrologic categories used by USBR in its proposals (dry years, critical dry years) are explained in the text.

increased flow will be realized without special limitations. Year classes that have high relative strength should have emerged from the wet years of the recent past flow regime if flow is limiting. This does not appear to have been the case in the past decade, however. Thus, factors other than dry-year low flows appear to be limiting to survival and maintenance of coho.

Higher flows may work to the disadvantage of the coho population from July through September if the source of augmentation for flow is warmer than the water to which it is added. Flows in the main stem include not only water passing the Iron Gate Dam, but also accruals from ungaged sources consisting of groundwater and small tributaries. This accrual water is likely to be much cooler than the water coming from upstream sources, which has been warmed by retention in lakes. Thus, the addition of larger amounts of water from the sequence of reservoirs above Iron Gate Dam may be disadvantageous to the fish. This issue apparently has not yet been studied in any rigorous manner, yet it is critical to the evaluation of higher flows in the warmest months.

Increased flows also could have a detrimental effect on the availability of thermal refugia. Thermal refugia created by groundwater seepage and small tributary flows may be most accessible and most extensive at low flows. Increase in flows may reduce the size of these refugia by causing more effective mixing of the small amounts of locally derived cool water with much larger amounts of warm water from points upstream.

Progressive depletion of flows in the Klamath River main stem would at some point be detrimental to coho salmon through stranding or predation losses. Thus, incremental depletions beyond those that are reflected in the recent historical record could be accomplished only with increased risk to coho salmon. At the same time, the available information provides little support for benefits presumed to occur through the increase of flows beyond those of the last decade. While single-year or multiple-year averages of low-flow extremes beyond those presently reflected in the record cannot be supported, there also is presently little evidence of a scientific nature that increased low flows will improve the welfare of the coho salmon.

Modeling of temperature and habitat may be useful, but convincing evidence of a relationship between the welfare of the coho and environmental conditions must be drawn to some extent from direct observation. For example, year class strength, abundance of various life history stages, or other biological indicators of success, when related to specific flow conditions, would greatly improve the utility of modeling and other information. The small size and scattered nature of the present native coho population will make collection of such data difficult, however.

The RPA requirements related to ramping rates and coordination seem supportable. Given direct field observation of the stranding of coho at the current ramping rates (NMFS 2001) and the mortality that is implicit in these observations, reduction in ramping rates seems a reasonable and prudent measure for protection of coho. Coordination, a final requirement of the RPA, is an obvious necessity given the need to optimize use of water for multiple purposes.

4. Conclusions

The NRC Committee on Endangered and Threatened Fish Species in the Upper Klamath River Basin has studied the USBR biological assessment on the shortnose and Lost River suckers, the USFWS biological opinion with its reasonable and prudent alternative (RPA) on these same species, and supporting documentation and has heard oral presentations and open public comment on the issues related to these endangered fishes in the Klamath River Basin. The committee finds strong scientific support for the requirements of the RPA except the requirement for specified minimum lake levels in Upper Klamath Lake. Extensive field data on the fish and environmental conditions in Upper Klamath Lake do not provide scientific support for the underlying premise of the RPA that higher lake levels will help maintain or lead to the recovery of these two species. At the same time, operation of Upper Klamath Lake at mean minimum levels below the recent historical ones (1990-2000), as could occur through implementation of the USBR assessment, would pose unknown risks in that these conditions have not been observed over the last 10 years, the interval over which good environmental documentation is available. The present scientific record is consistent with use of operational principles in effect between 1990 and 2000.

The NRC committee has studied the USBR biological assessment on the Southern Oregon/Northern California Coasts evolutionary significant unit of the coho salmon in the Klamath River Basin and the accompanying biological opinion prepared by the National Marine Fisheries Service, along with its RPA requirements, as well as supporting documentation, oral presentations of scientists contributing to research on this issue, and open public testimony. The RPA contains requirements for minimum flows in the Klamath River below Iron Gate Dam, limitations on ramping rate below Iron Gate Dam, and interagency coordination. The committee finds reasonable scientific support for the suppression of ramping rates as given in the RPA and for coordination. The committee does not find scientific support for the proposed minimum flows as a means of enhancing the maintenance and recovery of the coho population. The proposal of the USBR, however, as given in its biological assessment, could lead to more extreme suppression of flows than has been seen in the past, and cannot be justified either. On the whole, there is no convincing scientific justification at present for deviating from flows derived from operational practices in place between 1990 and 2000.

The conclusions of the NRC committee as presented above apply to interim management of the Klamath Project. The committee will make a separate analysis of the scientific evidence, including any new evidence, supporting various actions that might lead to improvement in stocks of endangered suckers and coho salmon in the Klamath River Basin over the long-term future.

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6. Appendix

STATEMENT OF TASK

The committee will review the government's biological opinions regarding the effects of Klamath Project operations on species in the Klamath River Basin listed under the Endangered Species Act, including coho salmon and shortnose and Lost River suckers. The committee will assess whether the biological opinions are consistent with the available scientific information. It will consider hydrologic and other environmental parameters (including water quality and habitat availability) affecting those species at critical times in their life cycles, the probable consequences to them of not realizing those environmental parameters, and the inter-relationship of these environmental conditions necessary to recover and sustain the listed species.

To complete its charge, the committee will:

1. Review and evaluate the science underlying the Biological Assessments (Reclamation 2001) and Biological Opinions (USFWS 2001; NMFS 2001).

2. Review and evaluate environmental parameters critical to the survival and recovery of listed species.

3. Identify scientific information relevant to evaluating the effects of project operations that has become available since USFWS and NMFS prepared the biological opinions.

4. Identify gaps in the knowledge and scientific information that are needed to develop comprehensive strategies for recovering listed species and provide an estimate of the time and funding it would require.

A brief interim report will be provided by January 31, 2002. The interim report will focus on the February 2001 biological assessments of the Bureau of Reclamation and the April 2001 biological opinions of the U.S. Fish and Wildlife Service and National Marine Fisheries Service regarding the effects of operations of the Bureau of Reclamation's Klamath Project on listed species. The committee will provide a preliminary assessment of the scientific information used by the Bureau of Reclamation, the Fish and Wildlife Service, and the National Marine Fisheries Service, as cited in those documents, and will consider to what degree the analysis of effects in the biological opinions of the Fish and Wildlife Service and National Marine Fisheries Service is consistent with that scientific information. The committee will identify any relevant scientific information it is aware of that has become available since the Fish and Wildlife Service and National Marine Fisheries Service prepared the biological opinions. The committee will also consider any other relevant scientific information of which it is aware.

The final report, due March 30, 2003, will thoroughly address the scientific aspects related to the continued survival of coho salmon and shortnose and Lost River suckers in the Klamath River Basin. The committee will identify gaps in the knowledge and scientific information that are needed and provide approximate estimates of the time and funding needed to fill those gaps, if such estimates are possible. The committee will also provide an assessment of scientific considerations relevant to strategies for promoting the recovery of listed species in the Klamath Basin.