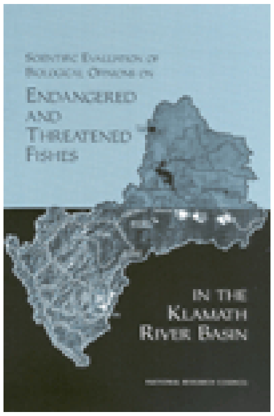

Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes in the Klamath River Basin: Interim Report

Committee on Endangered and Threatened Fishes in the Klamath River Basin, National Research Council

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SCIENTIFIC EVALUATION OF BIOLOGICAL OPINIONS ON ENDANGERED AND THREATENED FISHES IN THE KLAMATH RIVER BASIN

INTERIM REPORT

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

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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.

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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 in 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

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Scientific Evaluation
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SUMMARY

The Klamath River Basin, which drains directly to the Pacific Ocean 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 centuries 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 Coast (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 noncommercial 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. After 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 on 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 less than 3 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 conducted 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 mainstem dams and increased flows in the Klamath River main stem. Coordination and reduced ramping rates are well justified. However, the committee 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 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 important, 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. 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 result in 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 alteration 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 assessment 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 into the Pacific Ocean (Figure 1). Its isolation and diverse freshwater habitats, including perennial tributary and main-stem flows, extensive marshlands, and large shallow lakes, have favored the 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 2002), occupy primarily lakes as adults but also use tributary streams and 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 twentieth century, particularly after the 1960s, the populations declined substantially. 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 endangered under the federal Endangered Species Act (ESA) in 1988 (USFWS 1988).

FIGURE 1 Map of the Upper Klamath River Basin showing surface waters and landmarks mentioned in this report. Source: modified from USFWS.

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.

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 differed sharply from the two corresponding USBR assessments by calling for maintenance of higher lake levels and higher main-stem flows.

Year 2001 brought a severe drought to the Klamath River Basin. The U.S. Department of the Interior (DOI) determined that the actions to protect the endangered and threatened species called for in the biological opinions of the USFWS and NMFS must take priority over other uses of water. The amounts of water specified as reasonable and prudent alternatives (RPAs) in the biological opinions should be maintained to the degree possible before 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 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 to form a committee to review the two opinions. Sponsors of the review are USBR and the USFWS of the DOI and the NMFS of the U.S. 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). 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 broad-based study of the 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 endangered sucker and threatened coho species. 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 provided to the committee, however, all committee members are aware of the importance of any change in historical management of flows to water users in the Klamath Basin. Also, the committee is aware of the 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. Although the committee will not analyze economic or socioeconomic questions, it recognizes the interest of individuals and communities in the Klamath Basin in the conclusions of the committee.

Not only from an economic and social point of view but also from a perspective of ecological and biological resources, the work of the NRC committee focuses on its statement of task and on the inherent requirements of the ESA, 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 not yet been proposed for listing as threatened species but have not yet been listed (e.g., ESUs of steelhead and chinook salmon). The committee is charged, however, with studying the requirements of the shortnose and the Lost River suckers and the coho salmon and not those 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 because of its 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 reduced the sucker populations in Upper Klamath Lake to just a few thousand old (greater than 10 years) fish (USFWS 1988). More recent estimates that were 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 might range from a few tens of thousands to the low hundreds of thousands (USFWS 2001) but still are much lower than they were originally. Aside from the 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 past 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 nonpoint sources (Walker 2001), appears, however, 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 blue-green algal species *Aphanizomenon flos-aquae* (cyanobacteria) rather than the diatom taxa that apparently dominated blooms before 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, either no oxygen (anoxia) or lower than normal oxygen levels (hypoxia), and accumulates high concentrations of ammonia. Mixture of those bottom waters with the surface waters under the influence of changes in the weather likely causes mass mortality (Vogel et al. 2001). Although mass mortality has been recorded over the observed history of the lake, its frequency appears to have increased (Perkins et al. 2000). Major incidents were recorded for 1995, 1996, and 1997; low dissolved oxygen appears to have been the direct cause of mortality in these years (Perkins et al. 2000).

Impaired water quality also might stress fry through high pH in surface waters resulting from 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 the 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 evolutionarily foreign 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 might 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). Although 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.

The USFWS biological opinion states that the Klamath Project contributes directly to mortality and adverse environmental conditions for the endangered suckers. On this basis, USFWS presents a reasonable and prudent alternative (RPA) consisting, in summary, of requirements for minimum lake levels, interagency 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 the requirements listed in the RPA. Interagency 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.

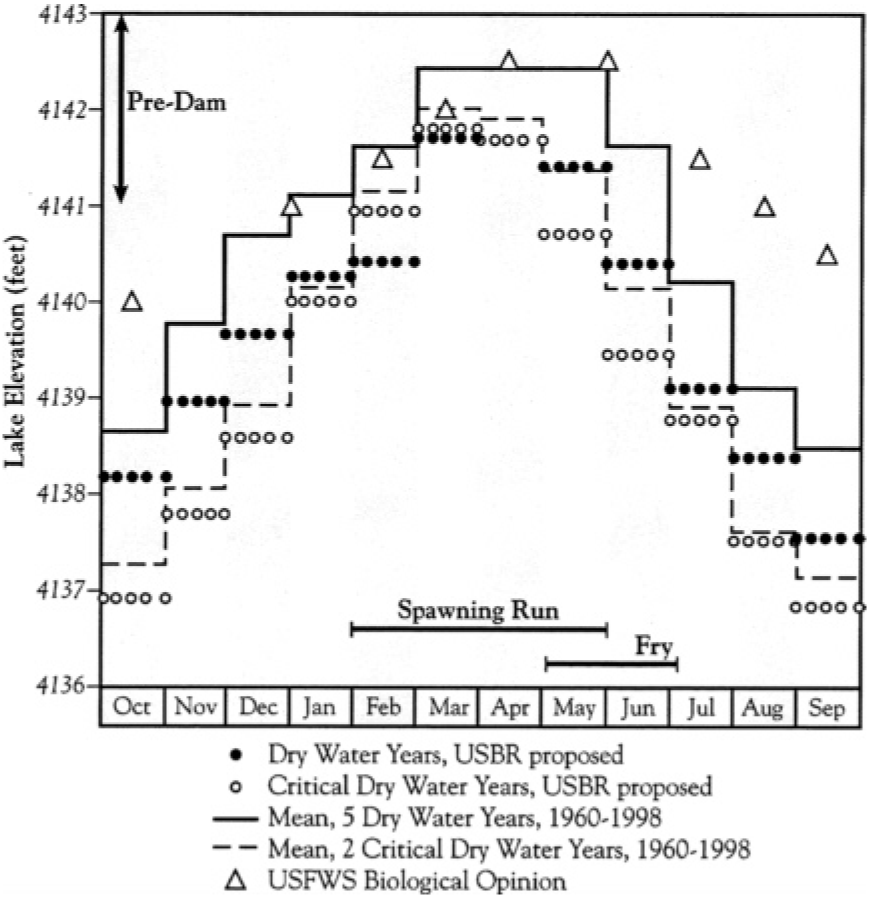

FIGURE 2 Overview of monthly levels for Upper Klamath Lake proposed by USBR through its biological assessment of 2001, USFWS through its biological opinion of 2001, and observed conditions for the years 1960–1998. Hydrologic categories used by USBR in its proposals (dry years or critical dry years) are explained in the text. Mean depths, excluding wetlands, corresponding to water levels are approximately as follows (feet): 4,137=3.5; 4,138=4.0; 4,139=4.8; 4,140=5.7; 4,141=6.6; 4,142 =7.6 (Welch and Burke 2001).

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 minimums (i.e., they do not vary from one type of water-level year to another). In contrast, assessment proposals of the USBR are framed for categories of water-level 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).

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).

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 often 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 and historical) reflect seasonality that is partly inherent in the runoff reaching Upper Klamath Lake and partly a by-product 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 minimums are below the mean lake levels for the historical operating regime in each of the two dry-year categories, because the USBR used the lowest recorded monthly lake levels as its proposed minimums for each category. 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 past 40 years, the use of these 40-year minimums as year-to-year minimums indicates that drawdown to the 40-year minimums 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 substantially lower mean lake levels in each of the hydrologic categories.

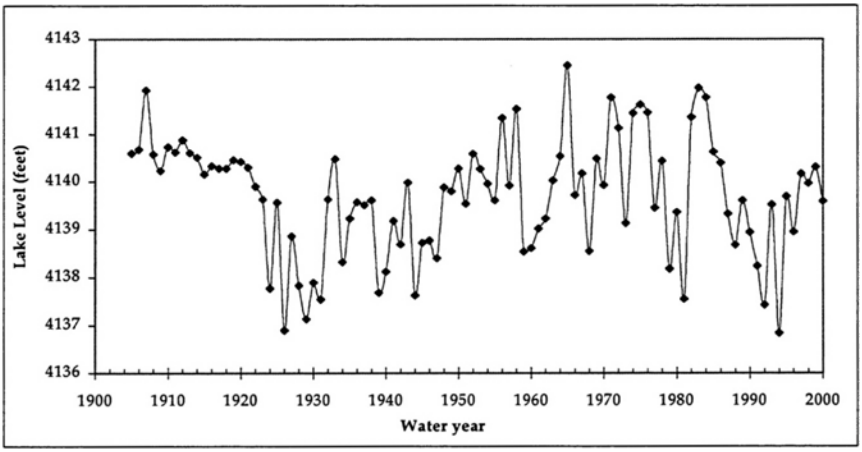

FIGURE 3 Historical record of level at the end of September for Upper Klamath Lake. Source: USBR.

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 and emergent vegetation), and water quality (low oxygen in summer, need for deep-water refugia in summer and fall, and 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 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 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 9-year water-quality monitoring record that has been fully analyzed (Figure4). 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 past 10 years occurred in 1995 and 1996, which were years of intermediate water level, and not in 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 were years 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.

Higher water levels are potentially supported on the 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.

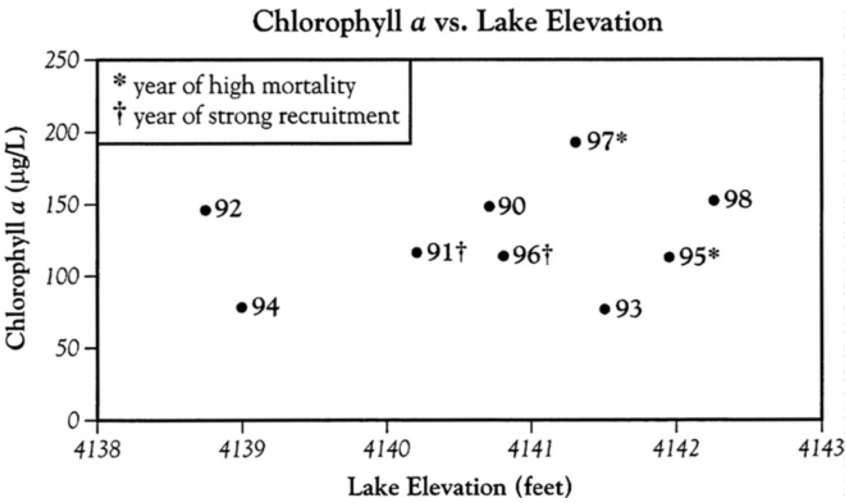

FIGURE 4 Relationship of chlorophyll *a* and median August lake level in Upper Klamath Lake between 1991 and 1998. Chlorophyll data are averages reported by Welch and Burke (2001). Recruitment and mortality data are from USFWS (2001).

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. 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.

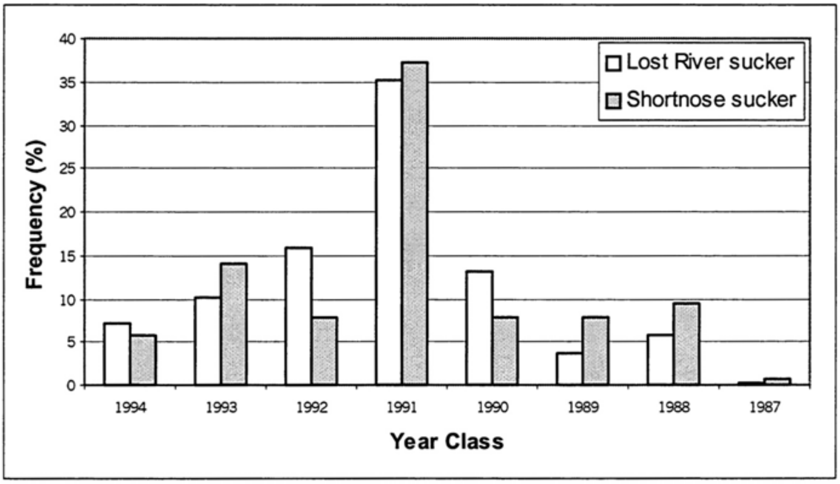

FIGURE 5 Estimated age frequency distributions using opercles from Lost River suckers and shortnose suckers collected from 1997 fish kill in Upper Klamath Lake, Oregon. Estimates did not include all suckers collected, but were calculated using only suckers from which a length measurement (fork length) was obtained. Data are truncated from 1987 to 1994, additional information exists on other year classes of suckers. Source: USGS, unpublished data, 2001.

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.

Despite a monitoring record of substantial length, there is no clear evidence of a connection between the lake levels and the welfare of the two sucker species in Upper Klamath Lake. Lake levels cannot be reduced, however, below those observed in the past 10 years without risk of adverse occurrences that are not described in the detailed monitoring record (1990-present; analyses complete through 1998). A negative association between the wel fare of the species and the lake level could emerge if lake levels are reduced below those of recent historical experience. The absence of any 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.

The 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 as extensive as that 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 provides reasonable support for lake levels in Clear Lake no lower than the recent drought-related minimum (1992–1993:4,519 feet). The RPA reasonably adds a margin of two feet (4,521) 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 (about 2,500–3,000 cubic feet per second) (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 suggest that the entire ESU has about 10,000 spawning coho salmon of nonhatchery origin per year (Weitkamp et al. 1995). Only a small portion of that number is associated with the Klamath Basin, where several important tributary runs have been reduced to a handful of fish (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 currently are restricted mainly to numerous small tributaries entering the main stem directly (Yurok Tribe 2001, as cited in NMFS 2001). Large tributaries have been severely degraded, show excessively high temperatures, and are dammed in critical places. Although a minor amount of spawning 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 move or are swept into the main stem, where they can be found in small numbers well into July. 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. Smolts, 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, 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 spawning is likely 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).

Habitat is an undeniable requirement for all life stages; however, 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 even though habitat for salmonids increases with higher flows, the percentage increase of habitat space corresponding to increases in flow during dry years is relatively small (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 when 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, as judged by the literature on thermal tolerance, 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.

Modeling has shown that higher releases of water to the main stem can reduce water temperature slightly (Deas and Orlob 1999) while also reducing the amplitude of daily temperature fluctuations, 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 NMFS 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 minimum flows 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 NMFS RPA proposed low flows are well above historical operating conditions, which in turn are above the minimum flows proposed by USBR.

The proposed low-flow limits on the Klamath River might not benefit the coho population significantly. Although the provision of additional flow seems intuitively to be a prudent measure for expanding habitat, the total habitat expansion that is possible with the limited water available in dry years is not demonstrably important to maintenance of the population. In wet years, any benefits from increased flow will be realized without special limits. 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 might 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. Thus, the addition of larger amounts of water from the sequence of reservoirs above Iron Gate Dam might 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.

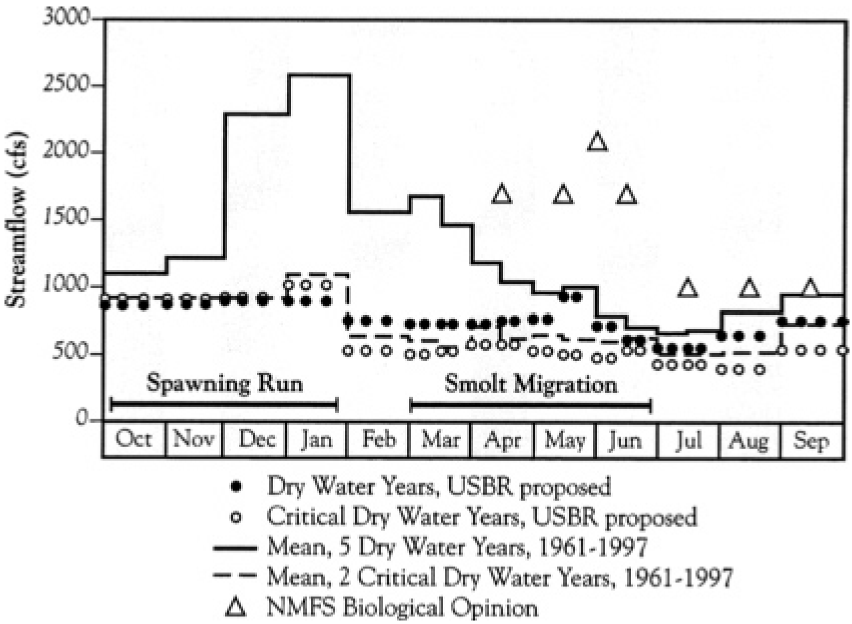

FIGURE 6 Three flow regimes for the Klamath River below Iron Gate Dam: USBR (2001b, minima for dry and critical years) proposed minimum flows for dry and critical years, historical mean minimum flows for dry and critical dry years, and RPA minimum flows (NMFS 2001). Hydrologic categories used by USBR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

Increased flows also could have a detrimental effect on the availability of thermal refugia (mainly mouths of small tributaries). Thermal refugia may be most accessible and most extensive at low flows. Increase in flows might 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 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 past 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 might be useful, but convincing evidence of a relation between the welfare of the coho and environmental conditions must be drawn to some extent from direct observation. For example, when related to specific flow conditions, year of class strength, abundance of various life history stages, or other biological indicators of success would greatly improve the utility of modeling and other information. The small size and scattered nature of the present native coho population makes collection of such data difficult, however.

The RPA requirements related to ramping rates and interagency 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 because of the need to optimize use of water for multiple purposes.

4

CONCLUSIONS

The NRC Committee on Endangered and Threatened Fishes in the 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. The committee also 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 for 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 levels (1990–2000), as could occur through implementation of the USBR assessment, would pose unknown risks, because 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 NMFS, its RPA requirements, and supporting documentation. The committee also heard 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 USBR, however, as given in its biological assessment, could result in more extreme suppression of flows than has been seen in the past and cannot be justified. 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 result in improvements in stocks of endangered suckers and coho salmon in the Klamath River Basin over the long term.

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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 perform the following:

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.