Klamath River Expert Panel

ADDENDUM TO FINAL REPORT

Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon

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Executive Summary

The Secretary of the Department of the Interior is required to decide if implementation of the Klamath Hydropower Settlement Agreement (KHSA) and Klamath Basin Restoration Agreement (KBRA): (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and (2) is in the public interest. There are two alternative management scenarios before the Secretary of the Interior that must be addressed in the Secretarial Determination: (1) Conditions with the lower four dams on the Klamath River in place and ongoing programs under existing laws and regulation, also referred to herein as the "Current Conditions"; and, (2) Removal of the lower four dams on the Klamath River and implementation of KBRA, also referred to herein as the "Proposed Action".

The Chinook salmon Expert Panel (Panel) was convened to attempt to answer a list of specific questions (Appendix B) that had been formulated by the project stakeholders to assist with assessing the effects of these two actions on Chinook salmon (*Oncorhynchus tshawytscha*). The Panel carefully considered the following overarching question: Based on available information, is the Proposed Action likely to increase abundance of naturally spawned Klamath River Chinook salmon substantially above abundance expected under Current Conditions?

The Proposed Action appears to be a major step forward in conserving target fish populations compared with decades of vigorous disagreements, obvious fish passage barriers, and continued ecological degradation. The Panel concluded that a substantial[1] increase in Chinook salmon is possible in the reach between Iron Gate Dam and Keno Dam. An increase in Chinook salmon upstream of Keno Dam is less certain. Within the range of pertinent uncertainties, it is possible that the increase in Chinook salmon upstream of Keno Dam could be large, but the nature of the uncertainties precludes attaching a probability to the prediction by the methods and information available to the Panel. The principal uncertainties fall into four classes: the wide range of variability in salmon runs in near-pristine systems, lack of detail and specificity about KBRA, uncertainty about an institutional framework for implementing KBRA in an adaptive fashion, and outstanding ecological uncertainties in the Klamath system that appear not to have been resolved by the available studies to date.

Most reports and presentations received by the Panel predicted very optimistic results for Chinook salmon from the Proposed Action. The Panel is equally hopeful, but notes several factors that temper its enthusiasm. Those factors and its position, therefore, may seem pessimistic to some readers of this report. But the Panel sees its charge as listing concerns in the

[1] The term "substantial" should be understood here to mean a number of fish that contributes more than a trivial amount to the population. Thus, the Panel envisions a number very roughly about 10percent of the average number of natural spawners. This is on the order of 10,000 spawners, which is also within the range of calculations that have been made based on new habitat made available. The larger this threshold is, the more likely would be a negative conclusion about the likely success of the Proposed Action compared to Current Conditions. The Panel does not suggest that this figure is a likely increase or a minimum increase that is expected. It is used only as a benchmark for our discussions and to provide a basis for interpreting our response to the question.

spirit of scientific openness and as research challenges and opportunities that if resolved successfully will increase the likelihood of success resulting from the Proposed Action. The Panel concludes that achieving substantial gains in Chinook salmon abundance and distribution in the Klamath Basin is contingent upon successfully resolving the following nine factors:

1. **Water Quality**. The limitations on access to the upper basin because of water quality problems in Upper Klamath Lake (UKL) and Keno Reservoir (KR) are resolved. The water quality issues must be solved if the principle of minimizing ongoing intervention, as stated in the KBRA, is to be followed. Otherwise, the benefits of access to the upper basin habitat will not be fully realized.

2. **Disease**. Changes in hydrology, sediment movement, and spawning distribution reduce disease incidence to levels that do not cause high mortality in out-migrating juveniles or pre-spawning adults.

3. **Colonization of the Upper Basin**. Chinook salmon are able to migrate freely to the upper basin, adapt to new conditions, and successfully complete the upper basin portion of their life cycle.

4. **Harvest and Escapement**. Chinook salmon are sufficiently abundant after escaping the fisheries to colonize all habitats, including newly accessible habitat.

5. **Hatchery Versus Wild**. Straying of hatchery Chinook salmon to spawning grounds does not overwhelm the evolution of new life histories that develop to capitalize on new habitat.

6. **Predation**. Predation by redband trout and other predators is sufficiently low.

7. **Climate Change**. The buffering effect of greater upper basin access is not overwhelmed by climate change, or by a climate regime shift wherein drought and continued high agricultural water demands are persistent features.

8. **Fall Flows**. Any reduction in productivity of Chinook salmon associated with lower fall flows is sufficiently small compared to the magnitude of productivity gains.

9. **Dam Removal Impacts**. Dam removal does not have a substantial multi-year adverse impact on mainstem Chinook salmon.

The more of the listed factors successfully resolved, the greater the chances of successful rehabilitation of Chinook salmon in the Klamath Basin. Addressing all nine factors will maximize the chances for success of the Proposed Action. In the situation here, the uncertainties act to hinder success, although it is possible that uncertainty in some cases can also result in a larger response than planned or expected. The Panel acknowledges that the success of the Proposed Action may not require resolving all of the factors; but it cannot determine at this time the relative importance of the different factors to Proposed Action success – partly because they covary. The Panel has strong reservations that KBRA, as presently described, will address all these conditions to the extent required to achieve a substantial increase in upper basin Chinook salmon with reasonable certainty. This is based on the Panel's collective experience with other large-scale restoration programs. Insofar as KBRA is open-ended and must be capable of evolving and coping with uncertainty, the Panel was concerned about a tenth factor that will bear on that evolution:

10. **Scientific Leadership**. A governance structure for the overall program is established that includes a science program with a strong Lead Scientist. The science program, which must be integrated with the rehabilitation[2] program, should be tasked to implement modeling, monitoring, data management, analysis, assessment, and reporting. And, of course, the rehabilitation program will need to be funded adequately. The science program provides the feedback that is essential to adaptive management.

The Panel notes that formal modeling, based on thorough synthesis of information and using rigorous statistical methods for quantification and propagation of uncertainties, is the preferred approach for estimating probabilities of uncertain outcomes. The Panel has declined to attempt this by informal means.

The Panel reviewed the ongoing Chinook salmon life cycle modeling efforts and concluded that this effort was off to a promising start, but with considerable work yet to be done. If sufficient high quality data are acquired, and the modeling is completed and implemented successfully, such modeling could calculate the probabilities at which the Panel chose not to estimate. The Panel offers specific comments (Appendix A) to improve the development and implementation of the life cycle modeling.

[2] We use the word "rehabilitation" (a structurally and functionally adequate condition) throughout because "restoration" infers a return to natural conditions (which is currently impossible given the intensive and extensive economic development in the basin). Also see Roni et al. (2008).

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1.0 Introduction

The allocation of water among competing uses in the Klamath Basin (Figure 1) has long been contentious. In recent years, stakeholders began discussions to reach a settlement agreement that would help resolve some of the water resource management conflicts in the basin. In February 2010, two settlement agreements were signed. Six dams occur along the Klamath River between Upper Klamath Lake and Interstate 5 (Figure 2). These dams include Iron Gate, Copco 2, Copco 1, J. C. Boyle, Keno Dam, and Link River Dam. The Klamath Hydroelectric Settlement Agreement (KHSA) would result in the removal of Iron Gate, Copco 2, Copco 1, and J. C. Boyle dams, as well as facilities of the Klamath Hydroelectric Project located on the Klamath River and operated by PacificCorp. The removal of the four dams together with improvement of fish passage facilities at the remaining Keno Dam and Link Dam would permit upstream passage by anadromous fish to some historically occupied habitats. The Klamath Basin Restoration Agreement (KBRA) addresses basin-wide environmental rehabilitation and resource management. The Secretary of the Department of the Interior is required by March 31, 2012 to decide if implementation of the settlement agreements: (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and (2) is in the public interest.

1.1 Secretarial Determination

Two alternative management scenarios before the Secretary of the Interior must be addressed in the Secretarial Determination. The first is conditions with dams, under which there would be no change from current management (Current Conditions). The second is conditions without four of the six dams and with implementation of KBRA (Proposed Action). This alternative would include removal of the lower four Klamath River dams that are part of the Klamath Hydroelectric Project, and implementation of the full range of actions and programs of the KBRA.

To evaluate the impacts of these alternative scenarios on native fish resources in the Klamath River Basin, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) determined that existing and new scientific information regarding native fishes and environmental conditions must be reviewed and evaluated by expert panels. This report presents the findings of the Chinook salmon Expert Panel (Panel). Details relating to the review process and Panel selection are presented in Appendix D. Panelist resumes are presented in Appendix E.

Figure 1. Klamath River Basin

Figure 2. Klamath Hydroelectric Dams

1.2 Alternatives

The two alternatives considered by this Panel are Current Conditions and Proposed Action.

Current Conditions

No change from current management. The Panel understood the Current Conditions to include:

1. Continued operation of the Klamath Hydroelectric Project in the same manner it is currently operated;
2. Meeting the apparently contradictory flow and lake level requirements of the NMFS Biological Opinion for coho salmon and the USFWS Biological Opinion for shortnose and Lost River suckers in the Klamath Basin;
3. Implementation of Interim Conservation Plan (ICP) interim measures (PacifiCorp 2008);
4. Implementation of the Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan, as required by the Oregon Department of Environmental Quality (ODEQ 2002; 2010);
5. Implementation of the Action Plan for the Klamath River TMDLs addressing temperature, dissolved oxygen, nutrient, and *Microcystis* impairments in the Klamath River in California and Lower Lost River, as required by the California North Coast Regional Water Quality Control Board (NCRWQB 2010);
6. Various fishery management plans prepared by the Oregon Department of Fish and Wildlife and the California Department of Fish and Game;
7. Effects of climate change on the hydrology of the Klamath River watershed;
8. Periodic regime shifts in ocean productivity for salmonids; and
9. Implementation of ongoing rehabilitation actions (Stillwater Sciences 2010).

Proposed Action

Removal of the lower four Klamath Hydroelectric Project dams (Iron Gate, Copco 1, Copco 2, and J.C. Boyle, also known as the Project Reach), and the full range of actions to implement the KBRA. The Panel understood the Proposed Action to include:

1. Removal of the four dams and reservoirs listed previously;
2. Full implementation of the KBRA rehabilitation actions listed in Appendix C-2 of the KBRA and summarized by Stillwater Sciences (2010) for the watershed downstream of Keno Dam and by Barry (2010) for the watershed upstream of Keno Dam;
3. Implementation of the non-ICP interim measures listed in Appendix D of the KSHA; and,

4. Items 3-9 listed above for Current Conditions.

1.3 Role and Nature of Panel

The Panel was asked to make a scientific assessment of the impact of two strategies for river management (the Proposed Action and Current Conditions) on Chinook salmon of the Klamath River Basin (excluding the Trinity River). The overarching (key) question to the Panel was: will the Proposed Action lead to more Chinook salmon? In addressing the overarching question, the Panel was provided three sets of questions developed by the Technical Management Team (TMT), which included scientists with expertise in a variety of technical disciplines relevant to the review process, as well as interested stakeholders. The questions consisted of general questions as well as questions specific to Chinook salmon. The Panel used these additional questions for guidance rather than providing specific answers to each question. The original set of questions, including a summary table, background information, and commentary, are provided in Appendix B.

A wide variety of information was available to the Panel on the life history of Chinook salmon and the biological, chemical and physical environments in the Klamath Basin. The scope of the Panel's task was a week of reading before a one-week workshop consisting of two days of presentations and four days of writing and editing, which was followed by about one month of email correspondence, further reading, and editing. The Panel was provided nearly 800 documents and web-links, which would have taken many months of full-time work to read, digest, and synthesize. The effort by the Panel was considerably greater than the budgeted time, which was less than two weeks. Therefore, the Panel focused on the overarching question and a subset of the documents, and divided tasks according to each Panelist's expertise.

The timeliness, quality, documentation, and usefulness of the information available to the Panel were highly variable. The key challenge for the Panel, therefore, was to evaluate the information provided by agencies and stakeholders, to merge this information with the knowledge base that the Panel brought to the subject, and to logically describe potential outcomes of the two alternatives. The Panel did not have the time or resources to examine original data or re-do analyses, even when such actions seemed straightforward and appropriate for the assigned task. Thus, the analytical method of the Panel involved assessing and interpreting the likely reliability and relevance of the technical information supplied to it, evaluating the relevance of this information to the biology of Chinook salmon, and predicting the impacts of the two alternatives related to salmon abundance and harvest in the future.

Given this context, the findings presented in this report represent the collective expert opinion of the Panel developed during a six-day workshop. The assessment as conducted by this Panel combined qualitative and quantitative information with professional experience to estimate potential outcomes of the two alternatives, which in turn allowed the Panel to at least partially address the questions posed by project's stakeholders (see Appendix B).

The Panel compliments the TMT and other Klamath Basin scientists for the substantial body of research conducted and provided, their willingness to openly share insights about that research, and their thoughtful and helpful reviews of the draft Expert Panel Report on Chinook salmon.

2. Rationale for the Conditions for Success

The Panel carefully considered the following overarching question: Based on available information, is the Proposed Action likely to increase abundance of naturally spawned Klamath River Chinook salmon substantially above abundance expected under Current Conditions?

The Panel concluded that a substantial[3] increase in Chinook salmon is possible in the reach between Iron Gate Dam and Keno Dam. A modest or substantial increase in Chinook upstream of Keno Dam is less certain. Within the range of pertinent uncertainties, it is possible that the increase in Chinook salmon upstream of Keno Dam could be large, but the nature of the uncertainties precludes attaching a probability to the prediction by the methods and information available to the Panel. The principal uncertainties fall into four classes: the wide range of variability in salmon runs in near-pristine systems, lack of detail and specificity about KBRA, uncertainty about an institutional framework for implementing KBRA in an adaptive fashion, and outstanding ecological uncertainties that have not been resolved by the available studies to date.

Achieving substantial gains in Chinook salmon with the Proposed Action is contingent upon the following nine factors being adequately addressed, stated briefly:

1. **Water Quality.** The limitations on access to the upper basin because of water quality problems in Upper Klamath Lake (UKL) and Keno Reservoir (KR) are resolved. The water quality issues must be solved if the principle of minimizing ongoing intervention, as stated in the KBRA, is to be followed. Otherwise, the benefits of access to the upper basin habitat will not be fully realized.

2. **Disease.** Changes in hydrology, sediment movement, and spawning distribution reduce disease incidence to levels that do not cause high mortality in out-migrating juveniles or pre-spawning adults.

3. **Colonization of the Upper Basin.** Chinook salmon are able to migrate freely to the upper basin, adapt to new conditions, and successfully complete the upper basin portion of their life cycle.

4. **Harvest and Escapement.** Chinook salmon are sufficiently abundant after escaping the fisheries to colonize all habitats, including newly accessible habitat.

[3] The term "substantial" should be understood here to mean a number of fish that contributes more than a trivial amount to the population. Thus, the Panel envisions a number very roughly about 10percent of the average number of natural spawners. This is on the order of 10,000 spawners, which is also within the range of calculations that have been made based on new habitat made available. The larger this threshold is, the more likely would be a negative conclusion about the likely success of the Proposed Action compared to Current Conditions. The Panel does not suggest that this figure is a likely increase or a minimum increase that is expected. It is used only as a benchmark for our discussions and to provide a basis for interpreting our response to the question.

5. **Hatchery Versus Wild.** Straying of hatchery Chinook salmon to spawning grounds does not overwhelm the evolution of new life histories that develop to capitalize on new habitat.
6. **Predation.** Predation by redband trout and other predators is sufficiently low.
7. **Climate Change.** The buffering effect of greater upper basin access is not overwhelmed by climate change, or by a climate regime shift wherein drought and possible continued high agricultural water demands are persistent features.
8. **Fall Flows.** Any reduction in productivity of Chinook salmon associated with lower fall flows is sufficiently small compared to the magnitude of productivity gains.
9. **Dam Removal Impacts.** Dam removal does not have a substantial multi-year adverse impact on mainstem Chinook salmon.

The more of the listed factors successfully resolved, the greater the chances of successful rehabilitation of Chinook salmon in the Klamath Basin. Addressing all nine factors will maximize the chances for success of the Proposed Action. In the situation here, the uncertainties act to hinder success, although it is possible that uncertainty in some cases can also result in a larger response than planned or expected. The Panel acknowledges that the success of the Proposed Action may not require resolving all of the factors; but it cannot determine at this time the relative importance of the different factors to Proposed Action success – partly because they covary. The Panel has strong reservations that KBRA, as presently defined, will address all these conditions to the extent required to achieve a substantial increase in upper basin Chinook salmon with reasonable certainty. This is based on the Panel's collective experience with other large-scale restoration programs. Insofar as KBRA is open-ended and must be capable of evolving and coping with uncertainty, the Panel was concerned about a tenth factor which will bear on that evolution:

10. **Scientific Leadership.** A governance structure for the overall program is established that includes a science program with a strong Lead Scientist. The science program, which must be integrated with the rehabilitation[4] program, should be tasked to implement modeling, monitoring, data management, analysis, assessment, and reporting. And of course the rehabilitation program will need to be funded adequately. The science program provides the feedback that is essential to adaptive management

The following discussion presents the detailed rationale for each of the conditions for success. During the course of developing these discussions, the Panel reviewed both the general and Chinook salmon-specific questions (Appendix B). Upon reviewing the alternatives and the Chinook salmon-specific and general questions, the Panel decided that ten major factors or

[4] We use the word "rehabilitation" (a structurally and functionally adequate condition) throughout because "restoration" infers a return to natural conditions (which is currently impossible given the intensive and extensive economic development in the basin). Also see Roni et al. (2008).

conditions needed to be addressed. These are discussed below with answers to the review questions originally posed[5].

2.1 Water Quality (C-3, C-5, C-7, C-13)

Factor 1. The limitations on access to the upper basin because of water quality problems in Upper Klamath Lake (UKL) and Keno Reservoir (KR) are resolved. The quality issues must be solved if the principle of minimizing ongoing intervention, as stated in the KBRA, is to be followed. Otherwise, the benefits of access to the upper basin habitat will not be fully realized.

The Proposed Action offers greater potential than the Current Conditions in improving water quality for Klamath Chinook salmon. The Proposed Action should reduce nutrient loading and thermal inputs into UKL and KR to some extent if one assumes that the KBRA will provide otherwise unavailable funding for implementation of TMDL (total maximum daily loads) (ODEQ 2002, 2010). Under Current Conditions, it is less likely that TMDLs would be met. However, the major Proposed Actions for reducing those inputs, wetland rehabilitation and riparian re-vegetation, are unlikely to produce substantial improvements in water quality of UKL and KR for several reasons**.**

High natural loading of phosphorus (P) from the watershed (Eilers et al. 2004) is magnified by anthropogenic loading from irrigated agriculture and other sources; a low N:P ratio in the inputs favors blooms of nitrogen-fixing cyanobacteria in UKL. Growth and subsequent decay of the cyanobacteria release ammonium, elevate pH (converting ammonium to the toxic form of ammonia), depress dissolved oxygen (DO), and raise biochemical oxygen demand (BOD). This problem is particularly acute in KR, where additional loading of low-quality agricultural drain water combines with an annual die-off of cyanobacteria to produce a region of persistently low DO during the summer and fall. All of these effects are exacerbated by high summer-fall temperature and high sediment oxygen demand in KR.

The current problem caused by blooms of the toxic cyanobacteria *Microcystis aeruginosa* in the four lower reservoirs will likely be eliminated by the removal of the four dams, because *M. aeruginosa* generally grows best in stratified water and does poorly when the water is well mixed (Paerl et al. 2001). It is also nitrogen limited (Moisander et al. 2009), and presumably for that reason, does not bloom in UKL or KR. However, releasing excessive amounts of nutrients to the Klamath River, in the absence of the four lower dams (Asarian and Walker 2010), means that the river, versus the reservoirs, will process the nutrients (including algal uptake, transformation, adsorption/sedimentation and transport), perhaps in the form of excessive *Cladophora* biomass or increased periphyton production down river. Algal biomass and

[5] The notation or code used for the review questions is as follows: C and G refer to Chinook salmon and General questions, respectively. The numbers following the letter refer to the specific question. For example, C-5 is Chinook salmon question 5. Because the questions have multiple elements, a question may be addressed in more than one of the conditions for success. The original set of questions, including background information and commentary, are provided in Appendix B.

production will vary with distance from the project area, N and P concentrations, turbidity, and substrate stability. These changes could elevate pH, lower night time dissolved oxygen, and cause gas supersaturation during afternoons in local areas.

These problems are clearly central to the thinking that went into KBRA. The supporting documents show concern with attempting to mitigate these problems, and a commendable effort to model the processes involved. A substantial fraction of KBRA funding is aimed at reducing nutrient loading. Furthermore, the large uncertainties about the prospects for improving water quality have been acknowledged by a call for substantial funding for further investigations. These investigations are presumably intended to develop an effective plan for alleviating the problems with water quality.

The Panel is nevertheless very concerned that the magnitude of the proposed solutions may not match the scope and extent of the water quality problem. The principal question we ask is if the most effective methods for source reduction could be found and implemented, would the problems for fish be sufficiently reduced? More specifically for the scope of this Panel, would these actions ultimately allow free passage of adult Chinook salmon through KR and UKL?

The TMDLs call for a 40 percent reduction in external phosphorus loading to UKL**.** Is this sufficient to solve the water quality problems? The TMDL analysis predicts massive algal blooms in two of eight years under the TMDLs (citation in ODEQ 2010; analysis not provided). Thus, it appears that TMDLs may be insufficient to provide water quality conditions conducive to fish passage in all years. We might ask, then, what is the relationship between nutrient loading and algal biomass, and how much would peak-bloom algal biomass decrease for a given reduction in loading? There is a clear conceptual relationship between nutrient loading to a water body and algal biomass; as loading increases, there comes a point beyond which the rate of increase of biomass reaches an asymptote (Figure 3). This effect, due essentially to declining efficiency of the system to capture nutrients, has been observed in many places.

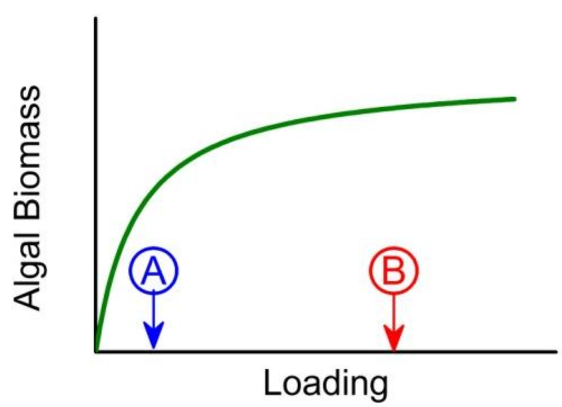


Figure 3. Conceptual relationship of steady-state nutrient loading from the watershed to biomass of cyanobacteria in a water body. Arrows indicate two regions of the relationship with different responses (see text).

If the initial nutrient loading is on the rising limb of the curve (Arrow A), then reductions in loading will result in nearly proportional reductions in biomass. Conversely, a starting point out much farther on the loading axis where algal biomass has saturated (Arrow B) will produce very little benefit for an incremental reduction in loading. There is some evidence that the Klamath system is on the saturated limb of the curve: cyanobacterial blooms in summer fail to use up all of the phosphorus but drive dissolved iron (a naturally-occurring micronutrient that is abundant in volcanic rocks) down to limiting levels (Kuwabara et al. 2009). Thus considerable reduction in phosphorus loading likely would be needed to reduce or limit cyanobacterial blooms. Therefore the Panel wonders where on this curve the system is at present, and whether this concept is part of the thinking that went into the proposed 40 percent reduction in loading.

Most KBRA actions for nutrient control call for construction of wetlands and riparian buffer zones to capture and sequester nutrients. The Panel asks whether the needed reductions can be achieved with an attainable area of wetlands, or conversely what reduction could be achieved by the wetlands to be constructed under KBRA (pending outcome of investigations). The following rough calculation illustrates our point. Some natural wetlands can sequester something on the order of 1 gram (g) of P per square meter per year, or about 0.01 tons (T) per hectare (Ha) per year (y) (T/Ha/y) (Mitsch et al. 1995). The total external loading of P to UKL is about 182 T/y (ODEQ 2002, Table 2-4). To sequester that amount of P would, therefore, require about 18,000 Ha of wetlands, which is about 78 percent of the area of UKL or about 40 percent of the area of irrigated agriculture in the UKL basin. This does not seem like a feasible level of effort for KBRA. A higher level of P sequestration, up to 0.1 T/Ha/y as observed in some treatment wetlands (Kadlec and Wallace 2009), or a lower goal for P sequestration, would increase the feasibility of P sequestration.

An additional difficulty, acknowledged in KBRA and in other documents, is the large pool of phosphorus and other nutrients in the sediment. The flux of these nutrients (called an "internal source") into the water column of UKL exceeds the loading from the watershed (Kuwabara et al. 2009). This implies a decades-long lag between reduction in nutrient loading from the watershed and effective reduction of concentrations in the lake.

Control of high temperatures in UKL and KR also seems infeasible. Modest increases in effective shade with TMDLs are projected to provide an additional 190 km of optimal stream fish habitat, reducing the length of suboptimal habitat from 61 percent to 17 percent in streams tributary to UKL. But UKL and KR will remain warm with June-September temperatures >20 ^{o}C meeting the proposed water quality criteria, but not protective of salmon (McCullough 2010; USEPA 1986; USEPA 2003). Although Strange (2010) reported that adult Klamath River Chinook salmon migrated upriver successfully at temperatures of 22-24 ^{o}C, migration was prevented when dissolved oxygen was <5 milligrams (mg) per liter (L) (mg/L). Following projected TMDL BOD reductions, dissolved oxygen is expected to meet the criteria for warm-water fish of 6.5 mg/L (30 day mean minima) and 4.0 mg/L (absolute minimum), whereas the respective cold-water criteria are 8.0 mg/L and 6.0 mg/L. The higher temperatures together with lower dissolved oxygen in KR and UKL may continue to pose a bottleneck for adult salmon migrating through the lake, even if TMDLs could be achieved.

We have serious reservations that the required waste load allocations will be achieved because: (a) effectively controlling diffuse pollution remains challenging at the basin scale; (b) all best management practices may not result in meeting TMDLs; (c) regulatory mechanisms for agriculture depend largely on education, voluntary compliance, and financial aid; (d) clear timetables and specification of particular actions are lacking; and (e) increased fire and drought frequency resulting from climate change will delay and possibly prevent attainment (AFS 2010; ODEQ 2002; ODEQ 2010).

Recommendations: Although water quality improvements are more likely under the Proposed Action than Current Conditions, the Panel is concerned by what may be an unrealistically optimistic view of the prospects for remediation of hyper-eutrophication, echoing the conclusions of the NRC (2004). The following recommendations are intended to help the agencies develop a better grasp of the level of effort and the kinds of actions that would be needed to effectively remediate the water quality problem.

Determine mass balances to roughly calculate the effects of each of the potential kinds of actions (e.g., riparian re-vegetation, wetland construction) on nutrient loadings and concentrations in the target water bodies. These calculations should explore the magnitudes of reductions potentially available by reasonable levels of rehabilitation.

Expand water quality modeling of UKL to include a 3-dimensional circulation model with cyanobacteria and sediment components. The purpose of this model would be to explore how hydrology interacts with loading, weather conditions, and other factors to influence blooms. Three-dimensional modeling is needed because circulation in UKL is wind-driven and algae float and is transported by wind action. Additional models (perhaps 1-D) should explore the interaction between eutrophication and sediment conditions.

Consider removal of Keno Dam and Reservoir, because the dam creates a 21-mile barrier to fish passage.

Evaluate reductions in irrigated agriculture for lands draining to UKL and the Lost River for their feasibility to reduce summer and fall nutrient additions from those waters. Consider managing the refuges to further emphasize their benefits for fish and wildlife, which can be in contrast to their agricultural objectives.

2.2 Disease (C-6, C-7, C-13)

Factor 2. Changes in hydrology, sediment movement, and spawning distribution reduce disease incidence to levels that do not cause high mortality in out-migrating juveniles.

The Proposed Action offers greater potential than the Current Conditions in reducing disease-related mortality in Klamath Chinook salmon. Incidence of infection and subsequent mortality caused by parasitism by two myxozoans in the Klamath mainstem has been well documented (e.g., Bartholomew 2006, Bartholomew et al. 2007, Stocking et al 2006, Hallett and Bartholomew 2006, Foott and Stone 2010). An intense infectious zone downstream of Iron Gate Dam is probably due to a confluence of high concentrations of the intermediate host (a polychaete worm) and large numbers of Chinook salmon carcasses, some of them highly infected. Worm abundance may be maintained at high levels by high concentrations of organic matter in the discharge from UKL, stable hydrology, and limited sediment movement and low sediment concentrations in the Klamath River.

Disease-related mortality appears, in many years, to contribute substantially to poor survival of out-migrating juvenile Chinook salmon passing through the infectious zone. Thus, the overall success of the Proposed Action for Chinook salmon appears to hinge to a large degree on the potential for reduction in disease.

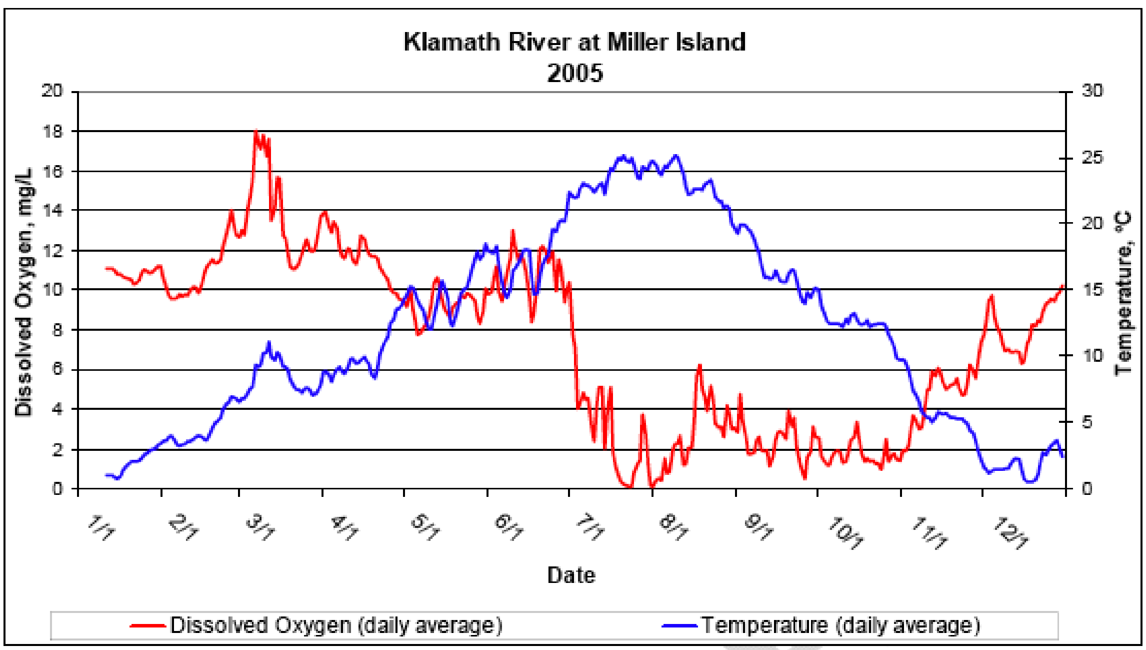
Although several aspects of the Proposed Action could lead to a reduction in disease-related mortality, uncertainty about these aspects is very high. Access by Chinook salmon adults to the upper basin could reduce incidence through dilution of the density of carcasses in any one reach. However, the extent of the reduction is uncertain (partly because of the presence of the Iron Gate hatchery and many carcasses nearby in the mainstem), and this scenario imposes a risk of simply moving the problem to wherever large spawning aggregations co-occur with high polychaete densities. Manipulation of flow or the remobilization of sand and fine gravel when the dams are removed could scour some of the worms, reducing their abundance, but this possibility has not been explored systematically. Reduction in food supply for worms through reductions in nutrient loading to UKL seems like a remote possibility (see Factor 1, Water Quality). Additionally, the predicted shift of several days of higher spring water temperatures (and consequent higher myxozoan infection rates for a given joint distribution of fish and parasites) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigrant survival to the degree that it increases disease incidence. However, earlier upriver Chinook salmon passage, spawning, emergence, and juvenile migration could offset the earlier actinospore release. The high uncertainty about these outcomes, and the importance of disease to the success of the Project, together imply that it would be wise to implement several investigations in parallel with the Proposed Action, including:

- Epidemiological modeling of the spatial/temporal interactions of worms, salmon, and parasites (see Appendix A13).
- Laboratory and flume studies using polychaetes isolated from the field or cultured (Willson et al. 2010) to determine critical shear stress, sediment concentrations and other information relevant to the impact of changing flow and sediment movement on the abundance of worms.
- Field experiments to extend laboratory results to more realistic conditions, including using high flow releases to attempt to scour and remove polychaetes.

2.3 Colonization of the Upper Basin (C-7)

Factor 3. Chinook salmon are able to migrate freely to the upper basin (Upper Klamath Lake), adapt to new conditions, and successfully complete the upper basin portion of their life cycles.

The Proposed Action offers greater potential than the Current Conditions in providing successful passage and colonization of the upper basin by Klamath Chinook salmon. Migration of adult Chinook salmon is influenced by low dissolved oxygen (Davis 1975, Alabaster 1989). ODEQ estimates that if the KBRA is fully implemented and actions have the desired effect, DO will rarely fall below 6.0 mg/L. Given the lack of details in the KBRA and the difficulty of the problem, it is uncertain whether the summer and fall low oxygen content of KR can be sufficiently improved (see Condition 1, Water Quality; ODEQ 2010). If the TMDL is not fully implemented, passage of adult Chinook salmon, especially fall-run, to the upper basin will likely be blocked by low oxygen from approximately early July through late November (Figure 4; see Water Quality).



Source: http://or.water.usgs.gov/proj/keno_reach/monitors.html

Figure 4. Graph of DO (mg/L) and temperature (ºC) in the Klamath River near Miller Island boat ramp, river mile 246 (KR).

This period encompasses a significant portion of the migration period for fall Chinook salmon, and some late arriving spring Chinook salmon (Hamilton et al. 2010), that might attempt to gain passage to the upper basin. Earlier migrating spring run Chinook salmon may pass through Keno Reservoir prior to the onset of low water quality, but the spring run currently has very few fish that might support recolonization of upriver areas. A perpetual trap-and-haul program may be needed to provide adult Chinook salmon, especially the fall run, with access to the upper basin during much of the migration period. Without solving the water quality problems, a fully self-sustaining run of fall Chinook salmon to the upper basin is unlikely.

Although trap-and-haul programs have been implemented in other watersheds, these activities can introduce stress and mortality to the fish. This intervention program also implies that managers will choose when to transport fish upstream and where to release the fish, rather than letting the fish choose the time and migration path that may be most appropriate for them to complete their life cycles. Furthermore, a trap and collection facility would need to be constructed some distance downstream of Keno Dam in an area where both dissolved oxygen and temperature are adequate for adult salmon. Considering the potential for stress during transport, it would make sense to trap fish before they are exposed to major ambient stress.

Juvenile Chinook salmon emigrating from the upper basin (UKL and tributaries) have the opportunity to pass though UKL and KR before temperature and dissolved oxygen reach stressful levels in approximately late June or early July (Figure 4). Juveniles traveling though UKL and KR may have difficulty locating the outlet at Link and Keno dams. Timing of the juvenile migration will determine whether juvenile Chinook salmon arrive at the estuary and ocean during a period that provides for relatively high survival there. These fish have not yet developed traits that would enhance survival related to timing of ocean entry and ocean conditions. Furthermore, climate change is expected to lead to a later onset of upwelling in the ocean (ISAB 2007), which may be counterproductive for upper basin salmon that must escape UKL and Klamath River before temperatures increase. Although Chinook salmon historically inhabited the upper basin, conditions in the upper basin and lake were much better before highly industrialized irrigated agriculture, and fish had evolved with the unique habitat features there, so Chinook salmon introduced to the upper basin may have lower productivity compared with the pre-dam populations.

The fraction of Chinook salmon that may successfully complete the portion of their life cycle in the upper basin is a key uncertainty. Life-cycle studies in the upper basin should begin as soon as possible to estimate the fraction of Chinook salmon that can complete their life cycles. This information, coupled with historical smolt-to-adult survival rates estimated from CWT returns, could be used to evaluate whether Chinook salmon could successfully establish in the upper basin as long as upstream transport is maintained.

If a positive secretarial determination is made, valuable information could be obtained via appropriate investigation in the approximately 8 years prior to dam removal. Adult Chinook salmon could be trapped at IGD and hauled to UKL and tributaries. At a minimum, the following data could be collected and used to develop and improve models of Chinook salmon production in the upper basin (see the Modeling section below, and Appendix A):

1. Characteristics of spawning sites selected by released Chinook salmon.

2. Fry and fingerlings produced per female in each tributary.
3. Juveniles produced per female measured at Link Dam and mortality associated with passage through UKL.
4. Juveniles produced per female measured at Keno Dam (PIT-tag juveniles here)
5. Juvenile migration timing and growth at each life stage.
6. Survival (recruitment) of PIT-tagged juvenile Chinook salmon returning to Keno Dam.

2.4 Harvest and Escapement (C-1, C-2, G-3, G-5, G-6 through G-9)

Factor 4. Chinook salmon are sufficiently abundant after escaping the fisheries to colonize all habitats including newly accessible habitat.

The Proposed Action offers greater potential for increased harvest and escapement of Klamath Chinook salmon than the Current Conditions. The current escapement floor for Klamath Chinook salmon is 35,000 fall Chinook salmon spawning naturally in the basin. This is estimated to be near the MSY escapement level for the present available habitat (all downstream of Iron Gate dam), and is estimated to be about 1/3 the carrying capacity of the present available habitat. Following dam removal, escapement will need to be increased to ensure adequate seeding of the additional accessible habitat. The need for greater escapement means that harvest levels may need to be reduced for at least several years or until the population builds up sufficient adults return to the Klamath River, to seed all habitats, including those in the upper basin, to levels that are sustainably harvestable at current harvest mortality rates. In the short term, harvest under Current Conditions could be higher than under the Proposed Action for a while. If Iron Gate Hatchery production is reduced or eliminated, that will further constrain sustainable harvest. The reduction in harvest levels during years of rebuilding could lead to greater harvest benefits in future years, if conditions described here are met. The proposed Chinook salmon model could be used to evaluate this tradeoff.

2.5 Hatchery versus Wild (C-8, C-10, C-12)

Factor 5. Straying of hatchery Chinook salmon to spawning grounds does not overwhelm the evolution of new life histories to capitalize on new habitat.

The Proposed Action offers greater potential than the Current Conditions in increasing fitness and survival of wild Klamath Chinook salmon. Successful colonization and completion of the life cycle of Chinook salmon in new habitats, especially those upstream of UKL, will require adaptations to new conditions especially with respect to timing, migration, and coping with conditions in UKL and KR. Development of traits leading to near-maximum survival will require time.

Interbreeding of hatchery and naturally spawned Chinook salmon inhibits development of locally adapted traits in salmon that colonize new habitats (e.g., timing of migration and spawning). Evidence indicates that hatchery salmon, including those originating from the destination watershed, have lower fitness in natural environments than wild fish (Araki et al. 2008). Furthermore, interbreeding of hatchery and naturally spawned fish can reduce the fitness of their progeny. Estimates of this reduction vary considerably but in some studies reproductive success was reduced by up to 90 percent (Araki et al. 2008).

The Proposed Action includes the proposal to eliminate production at the Iron Gate Hatchery approximately eight years after dam removal. Eliminating the hatchery will eliminate interbreeding of hatchery with naturally spawned salmon, and would likely increase the rate at which Chinook salmon develop traits adapted to their new habitats. This could increase survival of natural Chinook salmon. This would depend, in part, on the degree to which local Chinook salmon stocks have been integrated into the hatchery brood stock and the degree to which the current mixed hatchery and naturally spawning population maintained enough genetic potential for life history diversity to adapt to conditions in the upper basin. If the production at Iron Gate Hatchery is not reduced as planned, maintaining current hatchery production is expected to inhibit development of locally adapted traits to the extent that hatchery reared fish make up a substantial portion of the spawning escapement. In the lower Klamath River, similar concerns are associated with the Trinity River Hatchery.

2.6 Predation (C-5, C-7, G-2, G-4, G-10)

Factor 6. Predation by redband trout and other predators is sufficiently low.

The Proposed Action offers greater potential than the Current Conditions in reducing predation by non-native fishes on Klamath Chinook salmon between Keno and IGD; however, the Proposed Action could result in increased predation-related mortality by resident redband/rainbow trout, particularly in the upper basin. The interaction of juvenile Chinook salmon with populations of predators, including the abundant redband trout, creates a trade-off in the biological benefits of the proposed project. We focus on redband here because it is abundant year-round and piscivorous. Other predators including fish, birds, and mammals may have similar effects, especially in Upper Klamath Lake. Abundance of non-native predators (e.g., largemouth bass, yellow perch) now inhabiting the reach between Keno and IGD would decrease with the change from reservoirs to a river, and habitat conditions downstream of IGD are unsuitable for these species. However, both species occur in the Sprague River.

Healthy redband individuals and populations provide evidence that Chinook salmon might do well in the habitat upstream of IGD. Both species have co-existed previously, and microhabitat creation would provide some degree of spatial separation, both of which would suggest the potential predation effect could be relatively small. Chinook salmon currently coexist with resident rainbow trout downstream of IGD, but these resident trout are smaller and likely less piscivorous than redband trout in the Project Reach and the upper basin. It is unlikely that redband would exclude Chinook salmon from the newly available habitat or become a major impediment to their recolonization (ODFW 2008); however, the Proposed Action is supposed to also increase redband abundance, which would act to increase the potential predation mortality of redband on juvenile Chinook salmon. The Resident Fish Expert Panel Report anticipated a substantial increase in the range and abundance of redband in the project reach under the Proposed Action (Buchanan et al. 2011). This may increase predation on the juvenile Chinook salmon, thereby reducing or canceling the benefits to Chinook salmon due to expansion of habitat.

The proper perspective to assess the importance of predation is in terms of the survival of the juvenile Chinook salmon. It is unlikely that any increase in Chinook salmon will have a large effect on redband, which are generalist feeders, and there are ample numbers of other forage fish in UKL. The quantity of interest is the per capita mortality rate of Chinook salmon from redband predation. If this rate is a large part of total mortality, it can become important to the number of Chinook salmon juveniles that outmigrate, and thus to the long-term population abundance of Chinook salmon achieved with the Proposed Action. Under Current Conditions, Chinook salmon will not encounter the redband trout that are upstream of IGD.

If both Chinook salmon and redband abundances increase as projected under the Proposed Action, the predatory interaction will likely become more intense. It is unlikely that the increase in Chinook salmon numbers would directly cause an increase in redband numbers. However, a behavioral response by redband to increased Chinook salmon abundance is possible, by which the redband increasingly target Chinook salmon or aggregations of Chinook salmon, especially in UKL tributaries. This would increase the per capita mortality rate of Chinook salmon via redband predation beyond that expected with no change in behavior.

Even under the most favorable conditions for Chinook salmon of no increase in redband, no behavioral response of redband, and low occurrence of Chinook salmon in redband diets, the predation effect of redband could be important simply because of large numbers of piscivorous redband. Observing low incidence of Chinook salmon in redband diets does not necessarily mean that the predation mortality effect on Chinook salmon is small.

A staged approach is recommended to investigate redband predation on juvenile Chinook salmon if the Proposed Alternative is selected. First, the survival rate of juvenile Chinook salmon through UKL, and between KR and IGD, would be estimated via tagging studies of Chinook salmon juveniles. This rate would be compared to survival rates in other life stages or areas not exposed to predation. The Chinook salmon life cycle model also might be used to assess the importance of predation. Other approaches include diet investigations, bioenergetic modeling, and manipulation of redband abundance through the fishery. The recreational fishery for redband can be viewed as an opportunity for cost-effective tagging and diet information, and may provide ways to manipulate redband densities.

2.7 Climate Change (C-4, G-5)

Factor 7. The buffering effect of greater upper basin access is not overwhelmed by climate change, or by a climate regime shift wherein drought and continued high agricultural water demands are persistent features.

The Proposed Action offers greater potential than the Current Conditions for Chinook salmon to tolerate climate change and changes in marine survival. Expected climate changes over 50 years include freshwater warming of 1-3 ºC; altered timing, frequency, duration, and magnitude of peak flows; increased winter flood frequency (rain on snow events); decreased cold water extent by 8-99 percent; altered timing of marine upwelling; decreased marine pH (and marine productivity); and increased marine predators (e.g., Humboldt squid) (AFS 2010; Mote 2003). Peak stream flows already have shifted to earlier in spring and minimum flows have been reduced in summer (Leung and Wigmosta 1999). Earlier snow melting and higher air temperatures reduce stream flow, except in winter. Average air temperatures have increased 1 °C over the past 50 years (Mote 2003). Water temperature in the Klamath River has increased 0.5 °C per decade (Bartholow et al. 2005). Air temperature increase for the Pacific Northwest over the next century is projected to be 0.1-0.6 °C per decade (ISAB 2007). Additionally, because groundwater temperatures are typically 1-2 °C greater than mean annual air temperature (Kasenow 2009), the temperatures of groundwater flows are expected to rise slowly over decades, thereby reducing availability of cold-water refugia.

A compounding factor is that climate regime shifts are superimposed on long-term climate change. The influence of regime shifts can be seen in precipitation records at Keno and Tule Lake weather stations, where annual precipitation during 1927-1936 was approximately 20-26 percent less than precipitation during 2000-2009 (unpublished analysis of data by the Panel; WRCC 2011). Climate-related changes are predicted to increase freshwater disease, parasitism, and competition and predation by alien fishes (Battin et al. 2007; Farrell et al. 2008; Yates et al. 2008; Marcogliese 2001). Chinook salmon access to the upper basin under the Proposed Action could increase salmon capacity to respond to climate-driven changes in freshwater habitat by increasing access to additional cold water spawning and rearing refuges, and by diversifying geographic distribution and timing of adult migration and smolt entry into the ocean. The upper basin potentially adds much more cold water spawning and rearing habitat than the project reach. The buffering effect of access to the upper basin may be overwhelmed if a climatic regime shift occurs wherein the frequency of drought conditions increases, and if drought results in persistently increased agricultural water demand.

Climate change also affects anadromous fish by influencing marine productivity and the growth and survival of smolts and adults in the ocean. Although upwelling is predicted to increase with climate change, it may begin later and be less suitable for the predicted earlier ocean entry of smolts (ISAB 2007). Upwelling occurring later in the year may be especially counterproductive for juveniles responding to warmer spring waters in UKL and Klamath River if the warmer springs result in their emigrating to the sea at an earlier date. The warm phase of the Pacific Decadal Oscillation is often associated with reduced upwelling and reduced salmon production off the conterminous USA (Mantua 2009). Smolt to adult survival of Klamath Chinook salmon is already very low (CDFG 2011; USFWS 2011) and harvest targets have declined over recent decades (Limburg et al. 2011); further reduction in marine survival may offset potential expansion of the freshwater environment. Nonetheless, the Proposed Action offers greater potential than the Current Conditions for Chinook salmon to tolerate climate change and changes in marine survival.

2.8 Reduced Fall Flows

Factor 8. Any reduction in productivity of Chinook salmon associated with lower fall flows is sufficiently small compared to the magnitude of productivity gains.

The expected lower fall flows under the Proposed Action could cause a direct reduction in Klamath Chinook salmon productivity compared to the Current Conditions; however, improved water quality conditions following dam removal, including lower water temperatures and higher DO during migration periods, may reduce pre-spawning mortality and help offset the reduced productivity. Monthly mean flows in the Klamath River under the Proposed Action are expected to remain relatively unchanged compared with Current Conditions flows, except during October to December when flows may be approximately 10-25 percent lower after dam removal (Greimann 2011). Adult fall Chinook salmon migrate and spawn in the Klamath River during September to November. STT (2005) reported that productivity of Klamath Chinook salmon (i.e., residual from Ricker recruitment curve) was positively (though not highly) correlated with monthly flows during September, October, and November, suggesting that lower fall flows associated with the Proposed Action might be detrimental.

The Panel noted that water temperatures under the Proposed Action are expected to be approximately 3-8 °C lower during the spawning period (FERC 2007, Figure 3-51) and dissolved oxygen may be higher (see Water Quality), which would affect the same life stage as reduced fall flows. Pre-spawning mortality documented in the mainstem river may be related to high water temperature and moderately low dissolved oxygen. Improved water quality following dam removal might reduce pre-spawning mortality, and thereby help offset reduced productivity associated with lower fall flows. The net effect of these two changes is unknown. Additional analyses involving Chinook salmon productivity and flows, as described by STT (2005), would be informative. Six years have gone by since the STT (2005) analysis, so the number of cohort reconstructions available for analysis has gone up by 25 percent, and, in that time, sampling for wild juveniles has been instituted and systematic recording of water temperatures has begun, further increasing the data available for analysis to determine correlations with temperature and flow on production and survival of the various life stages. Correlations that were statistically borderline with the data in 2005 might now be resolved more definitively.

2.9 Dam Removal (C-14, G-1)

Factor 9. Dam removal does not have a substantial multi-year adverse impact on mainstem Chinook salmon.

Sediments flushed rapidly from the project reaches following removal of dam/reservoir projects from the Rogue (400,000 cubic meters of sand and silt) and Sandy (750,000 cubic meters of sand and silt) Rivers in Oregon (Major et al. 2008), and no negative effects on spawning salmon have been reported, perhaps because of limited mainstem spawning downriver of the dams or inadequate monitoring. One to 10 more years are needed for "total" flushing from the pools and upper bars where the sediments are deposited during low flows. However, approximately 17 percent of all naturally spawning Chinook salmon in the Klamath Basin spawned in the mainstem downstream of the dams during 2001-2009 (CDFG 2010). Therefore, sediments from Klamath project reservoirs may have significant effects on the survival of the run and brood present when the dams are removed. Assuming that dam removal begins in November to January, the Stillwater (2008; 2009; and 2010) and Bureau of Reclamation (Greimann 2011) modeling of erosion of reservoir deposits for seven scenarios predicted that sediment concentrations downstream of Iron Gate Dam will be as high as 10,000 mg/L, and exceed 1,000 mg/L for 0.5 to 4 months and 100 mg/L for 3-12 months. Dam removal during a wet year will reduce the duration of high sediment concentrations and therefore reduce any adverse affects on fish. The Proposed Action will involve considerable amounts of sand (300,000 to 400,000 tons, or roughly 849,505 to 1,132,674 cubic meters), some of which will be carried close to the bed where it may permeate the channel bed and reduce the quality of some spawning habitat. Calculations of bed-mobilizing flows (Ayres Associates 1999; Greimann 2011) indicate that the channel bed downstream of Iron Gate Dam should be mobilized by flood flows with recurrence intervals of about 2 years in the post-project period, but that the mobilized sands will not be flushed immediately from the system. Additionally, sand will continue to erode from the littoral reservoir deposits and pools for years after dam removal, and it is likely to take more than a decade for the bed fining caused by dam removal to be reversed. Sand storage and transport may degrade some spawning gravels in the mainstem for several years. The degree to which these persistent sands will reduce Chinook salmon spawning success in the lower mainstem Klamath River, relative to increased spawning in the project area, is unknown. Because this fall Chinook salmon stock returns predominantly as 3 and 4 year olds, a one-time heavy loss from one run or brood should be tolerable: when that reduced brood would have been returning as 3 year olds another brood will be returning as 4 year olds, and when that reduced brood would have been returning as 4 year olds another brood will be returning as 3 year olds. If more than one consecutive run or brood is lost, then this "backup" process gets overwhelmed. Heavy losses from more than one consecutive run or brood will produce some subsequent demographic echoes of greatly reduced runs and broods at intervals of roughly one generation, with attendant risks of various small-population phenomena. These risks include an Allee effect, loss of genetic diversity, community reconfiguration, and loss of positive feedback from conditioning of gravel and supply of carcasses.

2.10 Scientific Leadership (C-15)

Factor 10. A governance structure for the overall program is established that includes a science program with a strong Lead Scientist. The science program must be integrated with the rehabilitation program, and should be tasked and adequately funded to implement programs for modeling, monitoring, data management, analysis, assessment, and reporting. The science program provides the feedback that is essential to adaptive management.

The Proposed Action appears to have been developed with considerable thought and attention to the scientific issues. Nevertheless, as pointed out elsewhere in this report, uncertainty about the likely outcomes of the Proposed Action is large, and not all of the individual elements are likely to be effective. Furthermore, at the 50-year time horizon for the project, and even in the 8-9 years before dam removal, many things are likely to change including understanding, objectives, problems, and funding. This speaks strongly for the need for an adaptive, flexible, staged approach to the Proposed Action.

The Proposed Action is an experiment in that many of the outcomes are difficult to predict, particularly those of greatest interest to stakeholders (e.g., increasing abundance of Chinook salmon); however, as it is described, the Proposed Action lacks a clear program for scientific governance and therefore is not set up in an experimental adaptive framework.

There are various ways of governing and managing a large project under great uncertainty (NRC 2004). The traditional way is to use the knowledge available at the time the project is undertaken to guide initial action, with course corrections as the knowledge base improves. Thus any knowledge gain is incidental or external to the project. This approach fails to capitalize on the opportunities for learning that can be applied to improve the actions and amend the underlying goals and conceptual models.

Panel members have had considerable experience working with large rehabilitation programs, most of which have taken this rather rigid approach, with scientific involvement confined mostly to review panels and ancillary research or monitoring programs. With very few exceptions, these programs have spent large sums of money on actions that were believed in advance to be effective, without a mechanism for actually determining their effectiveness and applying lessons learned to adjust and refine actions. It is no surprise that many of the actions taken under these programs have, in fact, been ineffective, and program adjustment has been slow.

An alternative is to use an approach called adaptive management. By this the Panel means the fully experimental approach envisioned by the NRC (2004) and by some government agency policies (e.g., NMFS 2004). This approach was developed in recognition that the knowledge gained during the course of a long-term action could be very valuable because it might open up avenues for future course corrections, increased efficiency, and better use of resources.

Adaptive management (AM) has had a mixed record, mainly because of institutional resistance to its proper implementation and because many agencies use the term too loosely; the description of AM in the KBRA reflects this watered-down version in which the scientific activities are seen as external to the rehabilitation, and the KBRA as written has no provisions for the feedback necessary for adaptation of the program.

The purpose of AM is often misconstrued as calling for further study and delay of action, whereas it really means undertaking actions with every intent of achieving stated goals, but acknowledging that the path to, and achievability of, those goals is unclear from the outset. Thus, AM places accountability about the outcome of a program at the level of achieving goals, whereas most large rehabilitation programs aim any accountability at ensuring that the actions themselves are completed, irrespective of their effectiveness.

Adaptive management requires both: (1) an explicit statement of expectations in the form of models, metrics, and monitoring to evaluate progress; and (2) explicit loops from the synthesis of data and examination of outcomes back to all of the decision points. This process forces managers to think about how to measure and report performance, and how to determine when an action is or is not working as expected. Thus, the key elements that distinguish adaptive management from most other kinds of management are:

- Explicit stepwise statements of problems and goals, with check-in points and the spectrum of alternatives at branch points or trigger points specified in advance.
- Clear conceptual models of processes to be affected, and simulation models where data can support them.
- Clear expectations of outcomes of the action and potential alternatives, with multiple performance measures and indicators; predictions may be based on simulation modeling.
- Rigorously designed pre-project and post-project monitoring programs with embedded analysis for evaluating progress and selecting alternative or revised actions. The basin-scale monitoring should not only focus on target fish populations, but should include periodic rigorous assessments of ecosystem condition via probability sampling of fish and macroinvertebrate assemblages, productivity, and physical and chemical habitat monitored through use of standard field methods (e.g., Anlauf et al. 2011; Paulsen et al. 2008).
- An adequately funded team charged with evaluating results and making recommendations for revising goals, desired outcomes, models, and actions, with a strong Lead Scientist responsible and accountable for carrying out this program. It is essential to the success of this program that this team and the Lead Scientist begin work well in advance of the actual rehabilitation.

- A lead agency with the authority, funding, and will to maintain the process and make changes recommended by the evaluation team.

To institute adaptive management for the Proposed Action will require that scientific leadership be given a prominent role in program design and implementation. The Lead Scientist would be responsible to coordinate and promote monitoring and research, and to explain the implications of scientific findings to decision-makers and the public. Duties of the scientific program, based on experience in other large programs, would include:

- Fostering open and broad discussion of scientific issues
- Facilitating effective peer review of key documents
- Providing status and trend "report cards" or similar evaluation documents for decision makers and the public
- Building and maintaining openly available databases
- Maintaining and updating conceptual and simulation models for ongoing analysis and assessment.

For the rehabilitation program to be truly effective in achieving its goals, a budget for monitoring, data management and analysis, assessment, research, and reporting should be commensurate with the magnitude of the program and the pervasiveness of uncertainty. A budget on the order of 10 percent of the cost of the program would not be excessive. The KBRA documents indicate a budget for science on the order of $100 million, which seems adequate provided it is allocated and prioritized according to the needs of a strong science program as outlined above.

3. Remaining Issues

The following brief discussions relate to issues that the Panel thought important to discuss, but which were not related to the specific factors for success discussed above.

3.1 Normative Flow Regime (C-5)

Dam removal will have a minimal effect (1-6 percent) on peak flows within the Project Reach because of the small storage volumes of the four reservoirs and the high storage volume of UKL. Consequently, the frequency of bed material mobilization in the Project Reach is unlikely to be significantly altered by dam removal. Peaking flows within part of the Project Reach will be terminated. KPSIM modeling (Greimann 2011) indicates that 10-percent exceedance flows are expected to be higher in January to April and lower in October to December under the Proposed Action. Median and 90-percent exceedance flows are very similar under both alternatives. However, because of increased storage in UKL during winter to spring, peak flows in the Project Reach with the Proposed Action will not be as high as under Current Conditions. The Panel notes that the flow regime under the Proposed Action is still far from what unimpeded flows were in the past.

3.2 Spring Chinook Salmon (C-11)

The prospects for the Proposed Action to provide a substantial positive effect for spring Chinook salmon is much more remote than for fall Chinook salmon. The present abundance of spring Chinook salmon is exceptionally low and spawning occurs in only a few tributaries in the basin. Under the Proposed Action, the low abundance and productivity (return per spawner) of spring Chinook salmon will still limit recolonization of habitats upstream of IGD. Intervention would be needed to establish populations in the new habitats, at least initially. Harvests of spring Chinook salmon could occur only if spring Chinook salmon in new and old habitats survive and return at higher rates than at present. Therefore, habitat quality would need to be higher than at present, and KBRA actions would need to greatly improve survival of existing populations of spring Chinook salmon. Factors specifically affecting the survival of spring Chinook salmon have not been quantified.

The Proposed Action is predicted to produce slightly warmer mainstem water in spring (2-4 °C from February to mid-July) and cooler water in fall (~3-8 °C from mid-July to January; FERC 2007, Figure 3-50). Spring Chinook salmon enter the Klamath River from approximately April to July. Warm water in summer is known to constrain upstream movements of Chinook salmon (e.g., Strange 2011). The higher spring temperatures would further constrain upstream movements of spring Chinook salmon during the latter portion of the migration. Spring Chinook salmon spawn from late August through fall and must therefore find thermal refuges before then. Thermal refugia would be available in the project reach (e.g., Big Springs) if the fish colonize this reach, possibly spawning in tributaries such as Spencer Creek. Warm water and low oxygen in KR would inhibit or block late migrating spring Chinook salmon. This adverse effect along with the existing low productivity and abundance of natural spring Chinook salmon are likely to constrain rebuilding of spring Chinook salmon above Iron Gate Dam after its removal.

Because only very weak stocks of spring Chinook salmon exist in the basin, a temporary conservation hatchery for spring Chinook salmon will likely be needed. But a hatchery must remain a temporary technological fix, and considerable caution is needed to obtain gametes from existing stocks most likely to thrive in the upper basin. The Panel does ***not*** advise long-term hatchery supplementation if the objective is self-maintained, ecologically adapted, runs of spring Chinook salmon.

3.3 Biological Opinions

Both actions must consider the possibility of changes in management requirements produced by evolving Biological Opinions for currently listed species, and for additional species that are now vulnerable and might be listed in the future (the Klamath Spring Chinook salmon has been petitioned for ESA listing). This appears particularly problematic in the case of Lost River and shortnose suckers (*Deltistes luxatus* and *Chasmistes brevirostris*, respectively) versus Chinook salmon (not listed); the former would benefit from higher UKL water levels and the latter would benefit from increased flows. The current Biological Opinion may reserve more water for suckers than that offered under KBRA. Resolving such potential conflicts may trump or substantially alter agreements developed under the Proposed Action and Current Conditions.

The uncertainty about the Biological Opinions also complicates the comparison of the amount of water available in the system between the Proposed Action and Current Conditions. Resolution of the water aspects of the Biological Opinions includes some possibilities that would result in more water being available in the system under the Proposed Action (with Biological Opinions) than under Current Conditions with the resolved Biological Opinions.

There have been questions raised about the feasibility of the current Biological Opinion Reasonable and Prudent Alternatives (RPAs) under various climate scenarios. Different assumptions about future implementation of the Biological Opinion RPAs constitute different interpretations of "Current Conditions." These in turn, relative to interpretations of KBRA implementation, lead to different conclusions from ours about the probable magnitude of the benefit of the Proposed Action compared to the forecast "Current Conditions" (e.g., Hetrick et al. 2009).

3.4 KBRA Feasibility

The documentation and analyses of the likely composition of the KBRA presented to the Panel to date are insufficient to determine if KBRA can adequately address the listed factors (Section 2). Based on the Panel's past experiences with large rehabilitation projects in other systems, the stream rehabilitation literature (e.g., IMST 2006; Roni et al. 2008), and increased uncertainty of

KBRA funding, the Panel has strong reservations that KBRA will be implemented with sufficient effectiveness to achieve its stated goals.

3.5 Interactions among Target Species

The four Expert Panels addressed the potential for the Proposed Action to affect four different groups of fish. Although some parts of the various reports have addressed interactions among species (e.g., see factor on Predation in this report), the implicit assumption behind the design of the panel process is that interactions are less important than direct effects. The Panel does not know if this is true. Under the Proposed Action all of the fish species would overlap with all others at some part of their life cycles, and some of them use similar habitat. Thus, the Panel recommends that a specific analysis be conducted, using an appropriate suite of models, to investigate whether trade-offs or synergies may exist among the various species likely to be affected by the Proposed Action.

3.6 Remaining Dams and Diversions and Water Quality Degradation

Successful rehabilitation of Klamath Basin fish species will remain limited by Keno and Link Dams, Trinity and Dwinnell Dams, water diversions from the Klamath, Trinity and Salmon Rivers, farming and drainage of the Tule Lake and Lower Klamath Lake National Wildlife Refuges, continued and proposed increases in ground water pumping, and system-wide degradation of water quality (Bisson et al. 2009; Higgins 2011; NRC 2004; NRC 2008; Van Kirk and Naman 2008). The Panel recommends that the agencies more carefully examine and attempt to mitigate basin-wide limiting factors if they wish to maximize rehabilitation of the target fish species and stocks.

4. Modeling (C-9)

The Panel notes that formal modeling, based on high quality data, thorough synthesis of information, and using rigorous statistical methods for quantification and propagation of uncertainties, is the preferred approach for estimating probabilities of uncertain outcomes. The Panel, in its responses to the questions, has declined to attempt this by informal means. There is a Chinook salmon life cycle modeling effort under way which, if completed and implemented successfully, could calculate the probabilities that the Panel chose not to estimate.

The Panel determined that the provided documentation, combined with the briefing discussions, were sufficient to give us a fair understanding of the essential biological assumptions being used in the integrated life cycle modeling that is under development. The framework is Bayesian in spirit, with plans for Bayesian inference from retrospective data analysis to be used to obtain probability distributions for parameter estimates, and with the resulting quantification of parameter uncertainty being propagated forward in the 50 year projections (prospective analysis). This is a recognized and valid framework.

A synthesis document (Hendrix et al. 2011), prepared for a review subsequent to ours, confirms the impression of a healthy focus on the quantification of uncertainties: the word "uncertainty" appears 43 times in the 131 page report. The Panel cautions though, that it is not yet fully clear in the documentation that concrete plans are already in place for the very demanding task of quantification of all the parameter uncertainties upon which the technical rigor of the entire enterprise depends.

It would be a mistake to view the only purpose of the life cycle modeling simply as predicting the numbers of salmon over time. Model predictions of numbers of fish can usefully be interpreted as predictions relative to some reference condition (baseline, no-action, alternative action, etc.) rather than as an actual number of fish. Also, the modeling serves as a synthesis tool to identify critical information gaps. There are many pieces of information we do not know about the Klamath system, and none we know with absolute certainty. The process of developing the model, trying to reproduce historical conditions (hindcasting, data assimilation), simulating a variety of conditions (sensitivity analysis), making multiple runs with the same initial conditions to see how process variation plays out (ensemble results), combining results over alternative functional forms (model averaging) all within one set framework (the model) that must be internally consistent, tells us what we know and do not know about the full life cycle and where there may be bottlenecks. A model can also be useful to help focus the monitoring design and help select and refine effective actions for KBRA, as part of the overall adaptive management approach (Section 2.10. In other words, modeling helps us think about the system and its possible responses to environmental changes and management actions.

4.1 Overall Appraisal of the Modeling Effort

The Panel was encouraged by the proposed framework and approach for the Chinook salmon life cycle population modeling, although there is a long way to go to have a calibrated and functioning model available for exploratory and management simulations. We recommend the continuation of this effort, regardless whether the modeling is sufficiently completed in time to inform the Secretarial decision. If the decision is made to proceed with the Proposed Action, such modeling will be an essential element of the adaptive management program that will guide the effective and efficient implementation of the KBRA (see 2.10 Scientific Leadership). Whether or not the Proposed Action is approved, the modeling can provide the basis for improving our understanding of the system, pinpointing rehabilitation actions that show prospects to produce the most cost-effective results, and helping to distinguish between in-river effects and ocean effects. The modeling effort should be viewed as a long-term effort.

The Panel was impressed with the personnel that have been tasked with modeling. A good team has been assembled. The Panel wants to emphasize that this modeling is time-consuming and must be done with extreme care and attention to detail to ensure credibility. We hope that the assembled team is given sufficient time and resources, and that it has access to the extensive data and other appropriate scientific support to do this modeling effectively.

Although a presentation of modeling results would have helped the Panel in some aspects of its deliberations, having an opportunity to provide input in the middle of the process rather than the end is likely more useful to the overall effort. Below we list some of the issues and suggestions to improve and further the modeling effort. These issues are discussed in more detail in Appendix A. Our comments are based on the one day the Panel spent with the modeling group and examining the model documentation provided to the Panel, and also based on the Panel's experience with other similar modeling efforts and what factors have led to success.

More issues will arise once simulations are performed with the coupled models. The Panel cannot comment on the precision and accuracy of the model without examining model simulation results and comparing them to validation data.

The modeling issues and recommendations the Panel identified were: (1) dealing with the uncertainty about Chinook salmon productivity in the upper Klamath Basin, (2) assessing possible data integrity problems resulting from fragmented data analysis among the submodels, (3) ensuring effective communication and coordination within the Project, (4) removing computing limitation problems, (5) using the best designs for model simulations, (6) optimizing code architecture, (7) ensuring sufficient representation of climate change and ocean regime shift scenarios, (8) implementing accurate and fast exchange of information in submodel coupling, (9) reevaluating how density-dependent mortality is represented in each submodel and across submodels, (10) obtaining the proper level of complexity in the submodels, (11) making maximum use of raw data and Bayesian approaches for parameter estimation and propagation of uncertainty with predictions, (12) providing sufficient separation of harvesting from population dynamics, which are both in the harvest submodel, (13) using appropriate epidemiological approaches for the disease submodel, and (14) revisiting the choice of species to be modeled as the fall Chinook salmon model proceeds.

These issues and recommendations are intended to improve a modeling effort that is already showing promise. These issues are not necessarily problems now, but dealing with them sooner will reduce potential problems later.

The Panel also recommends that simpler versions of the life cycle model be developed and used in tandem with the coupled submodel approach. As part of Appendix A, we illustrate a simple, back-of-the- envelope approach to explore how much Chinook salmon production will need to increase to compensate for loss of fish with the closing of Iron Gate Hatchery.

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APPENDIX A
Detailed Comments on the Chinook Salmon Life Cycle Modeling

Appendix A: Detailed Comments on the Chinook Salmon Life-Cycle Modeling

This appendix discusses the major issues with the modeling that the Panel identified based on the modeling groups presentations and discussions. Additional issues, especially those related to model accuracy and precision, will arise as model development continues and a fully-functional model is available so that modeling results can be examined.

A-1 Upper Klamath Component

The largest single loose end in the proposed modeling is that the model component for Upper Klamath Basin fish production, which is using the EDT platform, falls outside the empirically grounded Bayesian framework proposed for the SALMOD component. There are no direct data for estimating some of the important fish dynamics parameters in that part of the system, and the prior that is being used is supplied by expert opinion. So, the prior in this component is very influential, and its validity depends entirely on the quality of the expert opinion that is "elicited" for use by the EDT model. Not only does this bear on the predictions, it also drives the quantification of uncertainty. If the experts are wrong in their opinions about the *uncertainty* of the estimates they are providing, then the calculated uncertainty quantification from the model predictions will be correspondingly wrong.

The use of EDT for modeling Upper Basin fish production will require great care to make sure that the experts understand the importance of their appraisal of the uncertainty of their own input. In addition, it will also require great care to explain to the eventual users of the predictions that the quantification of uncertainty was dependent on expert opinion, regardless of all the trappings of a fancy computer model. Theoretically, one way out of this impasse is to calibrate the expert opinion, in terms of a known track record of the experts' previous expert opinion in similar situations (or test cases) with known outcomes (where the experts did not know the actual outcome at the time they made their predictions). This may or may not be feasible here, but it is worth thinking about. Another option is to assess the effects of a range of uncertainties and assumptions in the modeling.

A-2 Data Integrity

The Panel was concerned with the way data analyses in support of the modeling appeared to be fragmented among the respective modeling subgroups in the team. Each submodel that made up the coupled model system seemed to have its own way of storing data, level of meta-data documentation, naming conventions, and analysis methods. Many plots in the presentations looked like they came from Excel. If this is true, this raises concerns about lack of transparency, possible inconsistent use of data across submodels, and the problematic situation of multiple versions of the same data being circulated. A single data archive should be established for the entire project, with a project-wide process for obtaining consensus about the data, data updates, and their interpretation.

A-3 Communication and Coordination within the Project

The Panel emphasizes the critical need for communication within the modeling team, and between the team and those who collected the data. The issue of communication among modelers arises from the division of labor of one person per submodel.

The Panel also sensed that the communication between the modelers and those who collected the data could be improved. It seemed that there was communication in terms of the modelers asking the data collectors for data, but whether this is being done as effectively as it should was not clear. Further, the data are scattered and it was not clear that the modelers were informed of all data sources and knowledgeable about the strengths, weaknesses, and nuances of those data. Effective communication among modelers and between modelers and others is critical.

The modeling team should improve its explanations of the overall model structure, and presentation of the submodels and how they fit together, to ensure transparency. The flowcharts in the Panel briefing presentations were confusing. A unified presentation of the entire model should be prepared.

A-4 Computing Limitations

Theoretically, computing limitations should not be an issue in this project. The agencies have access to high-end computing resources and the modeling team has members who are experienced in developing and running the respective submodels. However, the approach taken by the modelers of coupling the submodels can create computing limitations.

This is a long-term effort, and investment is required now to ensure the coupled models can be run seamlessly and conveniently to allow enough iterations for proper parameter estimation using Bayesian methods and for including uncertainty in predictions. The Panel suggests re-visiting how the coupled models are coded, diagnosing the computing bottlenecks, investigating multi-threading and parallel computing, and maximizing rapid information exchange among submodels. As this is a long-term effort, the Panel suggests that the idea of unifying the submodels into a single code be considered. The current model is a series of linked models and uses several different languages, some of which are slow to run. It would be better in the long run to recode everything in a single language such as Fortran or C or CV++, which lends itself to scientific computing and fast program execution.

The proposed use of the SIR algorithm for the Bayesian inference will probably reach a dimensionality obstacle. An MCMC approach should be implemented before the number of parameters requiring estimation increases further.

A-5 Design of Simulations

The idea of maintaining the ability to reproduce particular random sequences in simulations, so that paired comparisons can be made among alternatives, is good. This allows for interpretation at a simulation-by-simulation basis and in aggregate (e.g., probability distribution of differences).

The Panel recommends that a complementary analysis to simulating the effects of KBRA should reverse the question to be: what must KBRA accomplish in order to achieve the desired results for fish production? How the actions associated with KBRA will be represented in the model simulations was not clear. KBRA includes many actions, of which few have been defined in any detail. Yet, these need to be converted to information on how to change model inputs and parameters. Rather than trying to convert KBRA actions to changes in model inputs, modelers should perform a sensitivity analysis of the model to determine the combination of life stages, processes (growth, reproduction, mortality, and movement) and reaches that are most sensitive to changes. Then this information should be used to inform the design and specifics of the KBRA actions.

A-6 Code Architecture

Because KBRA involves potential changes in habitat quality and quantity and the timing of biological events (e.g., migrations), how these effects are represented in the model becomes critical to simulating the population-level effects of KBRA. Whether the present versions of some of the submodels can handle these changes is questionable. For example, the effect of habitat on mortality in SALMOD uses WUA to determine fish density, which then affects mortality rate. It appears that habitat effects are only manifested through density dependence, rather than as direct effect on an individual fish. Also, several of the events in the model were presented as dependent on day of year, which means that changing them (e.g., changing migration timing) will require modification of code, which is an invitation to introduce bugs. The Panel warns that representing processes with lookup-table-based approaches, especially dependent on day of year, can make simulating subsequent changes difficult and can result in odd model behavior.

A-7 Climate Change and Climate Sequences

The Panel recommends that the climate change and ocean regime shift scenarios be re-visited. It seemed that too few scenarios and realizations were examined. This may require an added coupled climate trajectory submodel to efficiently generate multiple realizations of process variation (e.g., random rearrangements of sequences of good and bad years within a particular scenario). Otherwise, the comparison of climate change and regime shift scenarios might be compromised by the small sample size of realizations within each scenario. Similarly, proper evaluation of fish population responses should be based on an ensemble of realizations of year-to-year climate and ocean variation for adequate representation of the probabilities of strings of good years or bad years.

A-8 Model Coupling

The approach taken of coupling existing submodels not only raises questions about computing limitations but also issues about information transfer and compatibility. This approach is attractive in the short-term because it is appears easier and faster to implement. However, it also leads to slower run time and high potential for errors in handshaking as information from one submodel is passed to the next submodel in the chain. The submodels use different units, time scales, and spatial scales, and so aggregation and disaggregation of information is required, and this increases the likelihood of incompatibilities between models and errors and artifacts from the sequential upscaling and downscaling of information. Some of the coupled submodels also communicate via file transfer, which is computationally very slow. All this should be addressed in the long run by recoding all the submodels into an integrated system with compatible (though not necessarily identical) spatial grids and time steps.

The ongoing development of the life cycle model, as documented in Hendrix et al. (2011) is proceeding submodel by submodel, some of which are being extracted from other existing stand alone models, and some of which are being developed de novo. In essence, when the model as a whole is run, calculations of numbers of fish will be handed from submodel to submodel. To the extent that the calibration and parameter estimation for the respective submodels is described in Hendrix et al. (2011), that too is proceeding submodel by submodel. Only the SALMOD component states a commitment to a Bayesian method. Several of the submodels will involve density dependence: Beverton-Holt in some, Ricker in one, and a "logistic" form in SALMOD. This submodel by submodel approach neglects the opportunity to calibrate the performance of the life cycle model as a whole to available data whose relationships cross submodel boundaries, notably spawners to recruits, and recruits per spawner in relation to covariates of interest such as flow and temperature. Plans should be made for calibration of the model at this level, and incorporating this into the uncertainty estimation. This should help achieve consistency between the life cycle model and the PSMC models, and should result in a better life cycle model that is calibrated to more of the information in the available data.

A-9 Density-Dependence

The Panel had questions about how density dependence was being represented within certain submodels, and whether there was double counting between submodels when both represented density-dependence. How does density dependence in the tributaries fit into the later density-dependence in the mainstem, and is this consistent with the full life cycle density dependence embodied in a stock recruit relationship? The timing and magnitude of density-dependence will also greatly influence predicted responses to changes in habitat and other factors. If an action occurs before density-dependence, then the responses of the fish may be dampened, whereas if the action is implemented in the model after substantial density dependence, a larger response to the action can be predicted. The interplay between density dependence in multiple life stages (and across submodels) and the timing of density dependence versus the timing of effects of proposed actions must be carefully considered.

The Panel had many questions about the use of spawner-recruit relationships to represent density-dependent mortality. The interpretation of the data, fitting to the data, and incorporation of environmental factors must be revisited and evaluated. There were model selection issues about using Ricker curves, whether the data supported density-dependence as implied by the fitted relationship, and recruitment defined to include both fry and smolts.

A-10 Model Complexity

The Panel recommends that a simple version of the model be maintained and updated in parallel with the complicated life cycle model. Developing a complicated model such as the fall-run Chinook salmon life cycle model must balance the demand for complexity with the level of detail that is needed to answer the question and that can be supported with empirical information. The same model may be perceived as too simple by some, and yet too complex and insufficiently supported by data by others. The art of modeling is developing a model with the temporal, spatial, and biological complexity best suited to answer the questions and, at the same time, that can also be reasonably justified and parameterized using available data. Much can be learned from having a large model (as it is being developed), and a sister smaller version, available to compare responses, test new algorithms, and diagnose large model behavior. The modeling team indicated that it started with a plan for a simpler model version but then kept adding complexity to get to the larger model it has now. The Panel recommends the simpler modeling effort also be implemented.

A-11 Parameter Estimation and Modeling Uncertainty

The approach to parameter estimation presented at the briefing relied on obtaining estimates of parameters of the various submodels and relationships separately, using distinct subsets of the entire data portfolio, and in some instances fitting to processed values (actually, estimates from other statistical operations or models) rather than raw data. This does not make full use of all the information content of the full data set, can obscure correlation structures in the error distributions, may miss error variance arising from the coupling of component models, and may miss error owing to the external statistical analyses or simulation modeling that produced the processed values to which the life cycle model was actually fit.

The modeling should work towards a goal of joint inference of as many of the parameters as possible simultaneously, using the entire coupled model system, and fitting to all of the raw data.

One of the principal pitfalls common with the Bayesian framework is the potential for undue influence of the role of insufficiently justified prior distributions. There are two main approaches to avoiding this problem. One is to have enough data so that the influence of the prior is suppressed. There are known diagnostics that can be used to check whether the data are sufficient to achieve this. The second approach, which may be needed if the data are not sufficient, is to base the prior itself on empirical information. The usual recognized procedures to accomplish this are termed Empirical Bayes and Hierarchical Bayes.

Finally, we note that the definitions of "environmental" and "demographic" uncertainty in Hendrix et al. (2011) leave unclear whether parameter uncertainty is being handled correctly, and definitely do not correspond to the usual definitions in the literature of stochastic population monitoring. In the literature, "environmental" variation is real environmentally driven variability in the population's year-to-year dynamics, "demographic" stochasticity is the chance sampling of demographic processes independently among individuals (e.g., sex ratio of offspring, chance variation in the number of individuals actually dying when the death rate is specified as a binomial rate, etc.), and "parameter" uncertainty is the uncertainty about the true value of a parameter which is only estimated from incomplete information. The essential difference among the three is revealed immediately in the coding for simulation of an ensemble of population trajectories: parameter uncertainty is sampled once per trajectory at the initiation of the trajectory and the sampled value of the parameter holds for the rest of the trajectory; environmental variation is sampled once per appropriate time step within a trajectory and the value only holds for that time step in that trajectory; demographic stochasticity is sampled independently for each individual within each time step in each trajectory.

A-12 Relationship to PFMC Harvest Modeling

The proposed life cycle model, if completed as proposed, will be a very comprehensive, mechanism-driven model, with a high degree of geographic detail, temporal detail, and representation of all life stages of the salmon population and the population dynamic processes of reproduction, growth, maturation, natural mortality and harvest of the natural spawning population, plus the contribution from the hatcheries. At the same time, the Pacific Fisheries Management Council (PFMC) has for many years been relying on more holistic modeling of extensive escapement and harvest data on the population to estimate population size and to manage harvest levels for a Maximum Sustained Yield (MSY) goal subject to a variety of policy constraints. In a sense, then, the PFMC modeling might be thought of as a kind of upscaling and subsetting of the life cycle model: in theory one should be able to integrate the life cycle model over the right regions of time and space and environmental variation to obtain the equivalent of the PFMC models.

For example, running the life cycle model for the years 1979-2005, integrating the results over space, accumulating ensembles over time encompassing environmental variation, and cumulating paired values of total natural spawners for each year with the total recruitment (calculated as the resulting brood's population size at age 3 before harvest) would reveal the overall spawner-recruit curve *implicit* in the life cycle model. Would this correspond reasonably closely to the Ricker spawner-recruit curve estimated by the Salmon Technical Committee of PFMC in 2005 in the course of examining the MSY management reference points? If it does not, then which is more correct? And how will this bear on revising the harvest management in the years ahead if KHSA and KBRA are implemented and the MSY escapement for the system changes?

Note that the estimates of recruit numbers (for use either in life cycle model calibration or in PMFC models) are the output of a PMFC model called the "cohort model" (Mohr 2006) which plays a central role in any retrospective analysis of spawner-recruit relationships, or ocean and estuary survival, but is not mentioned in Hendrix et al. (2011). A sound understanding of the statistical basis of the cohort model, with quantification of the uncertainty of its outputs, will be an important pre-requisite for use of these estimates in the calibration process for the life cycle model.

A-13 Disease

The Panel considered the disease submodel (or scalar) presented to the Panel as inadequate for simulating effects of disease on Chinook salmon population dynamics. Such look-up approaches are not an appropriate way to simulate disease effects on fish in population models, as factors such as exposure are not explicitly dealt with. The Panel recommends the disease submodel be revisited, and replaced by epidemiological approaches that deal with exposure and duration.

A-14 Revisiting the Choice of Species to Model and Model Use

The modeling group has set itself the goal of producing a model that quantifies the uncertainties of its predictions. This is a worthy aspiration. In a setting of sophisticated decision-making for adaptive management, quantification of uncertainty greatly increases the effective usability of model predictions. Having said that, our next question is whether ocean-type fall Chinook salmon should be the first choice for this flagship modeling effort in the Klamath project.

The fact that this fall-run Chinook salmon stock has extensive time series of data, and a legacy of modeling in connection with harvest management, is attractive. If the fall-run Chinook salmon modeling could be ready in time for the Secretarial Determination, its potential use might set a valuable precedent. Given that the modeling almost certainly will not meet that deadline, the question becomes: Assuming that the decision is to proceed with the project, what model uses will be most important after the Secretarial Determination?

ESA assessments definitely could benefit from the long time-horizon projections, probabilistic trajectories, and uncertainty quantification--which argue for consideration of coho salmon (*Oncorhynchus kisutch*) as the priority stock to be considered for modeling. There are also reasons to focus on Spring-run Chinook salmon, or on all target species as a group.

The other preeminent use for modeling of this sort would be for evaluating adaptive management alternatives (Section 2.10). So, given the long time frame of the Proposed Action, it might be worthwhile to explore concrete adaptive management plans for the Klamath rehabilitation project to identify the role that probabilistic population predictions might play in the actual decision structure for contemplated actions, and on that basis to decide which salmon populations to model.

A-15 Modeling and Synthesis: Back of the Envelope

The fall-run Chinook salmon life cycle modeling presented to the panel was represented as under development. The presentations did not include results or predictions for fish abundance or productivity, nor did they present actual estimates for critical dynamical parameters of the population. Considering the complexity of the system of coupled models, the apparent early state-of-development of the model, and the immature state of parameter estimation, it seems unlikely that the current modeling effort will produce concrete, thoroughly reviewed results in time for the 2012 secretarial decision.

In the absence of a mature integrated life cycle model for the Secretarial Decision, interest then centers on back-of-the-envelope (BOTE) calculations to bracket reasonable but rough quantitative predictions about the fish. Such BOTE calculations were not presented during the modeling briefings. When the Panel asked about such preliminary estimates during the briefing, the answer seemed to be that such BOTE calculations had occurred earlier in the modeling process but were then abandoned.

The panel was motivated to attempt its own BOTE with the material provided, and has made some very limited progress. Our progress essentially sharpened some questions. The initial question we chose to formulate and pursue was whether the goal of the Proposed Action of retiring hatchery production at Iron Gate hatchery could be attained without sacrificing harvest.

This BOTE was based mostly on information gleaned from the megatable Excel file and a related Excel file of hatchery releases and returns. The weakness of the megatable for this purpose was that it consisted of highly processed point estimates, not direct data. The panel at this point has incomplete information on how the estimates in the megatable relate to the original raw data, or what the appropriate confidence intervals on these estimates might be. The BOTE that follows uses some numbers from the megatable and associated hatchery file at face value. The Panel interpretations should be double-checked. Uncertainties inherent in the estimation procedures that give rise to the megatable should be taken into account, as should any pertinent caveats about the underlying data themselves. Special attention should be paid to assumptions about transferability to naturally spawned fish of rates estimated from CWT marked hatchery fish.

The Panel notes that some implications of the estimates in the megatable look odd, so the procedures and analyses leading up to the megatable need to be reviewed in depth. The apparent productivity calculated for the natural spawning looks quite high: estimates of the Ricker alpha are on the order of 7, the long term average returns divided by the long term average number of spawners comes out around 2 recruits per spawner at the average realized spawner density. Against this, the apparent smolt to adult return rates (SAR) from the two hatcheries (Iron Gate and Trinity) are low, around 0.5 percent for subyearling releases from Iron Gate, and lower from Trinity. If these SARs are assumed to apply to naturally spawned fish (we are not advocating this assumption, though this is not an uncommon assumption), then the egg-to-smolt survival (or smolts-per-spawner ratio) from natural spawning must be unusually high to account for the high apparent productivity. It is not clear how to reconcile an unusually high smolts-per-spawner ratio with the reported high disease mortality and temperature stress. This begs for a review that literally attempts to reproduce the calculations and models leading to the megatable, and does a thorough diagnosis and uncertainty analysis to see if everything really adds up and is consistent across all of the sources of information.

The numbers that follow are 1978-2009 averages of annual estimates taken from the megatable and Iron Gate Hatchery estimates Excel files.

- The total run is 120,910 fish per year.
- The total hatchery returns, Iron Gate hatchery plus Trinity hatchery, is 26,679 fish per year.
- Therefore the naturally spawned component of the total run is 94,231 fish per year.
- Iron Gate Hatchery by itself contributes 15,993 fish per year to the run.

Therefore, to replace the Iron Gate hatchery contribution to the run, will require an increment of natural returns equivalent to 17 percent of the total natural production downstream of Iron Gate (mainstem plus all tributaries including the Trinity River).

So now, in round numbers, we are led to consider two questions:

1. Does the Iron Gate to Keno reach, including reservoir reaches to be drained under the Proposed Action, plus the associated tributaries, provide useable spawning and rearing habitat at least equivalent to 17 percent of the Iron Gate to estuary Klamath mainstem plus all the associated tributaries (Trinity River, Shasta River, Salmon River, Scott River, and Bogus Creek in particular)?

   Recolonization seems relatively unproblematic for the watershed area from Iron Gate Dam to Keno Dam. Migration, life cycle, disease, and competition issues for fish spawning and rearing there probably will not be much different from those now confronted by fish spawning downstream of Iron Gate Hatchery , so useability of this habitat is not seriously in question. The quantity of accessible habitat that the Proposed Action will provide in the Iron Gate Dam to Keno watershed, quantified crudely as simple linear miles of mainstem and tributaries, is reported at 65 miles (Dunsmoor and Huntington 2006). The quantity of accessible fall Chinook salmon habitat at present, quantified crudely as simple linear miles of mainstem and tributaries, is reported at 289 miles (Tinniswood 2011). This crude BOTE analysis estimates that the Iron Gate to Keno reach will add 22 percent to the present natural spawning potential, so there are reasonable prospects that this component of the Proposed

Action will roughly compensate for the anticipated cessation of Iron Gate Hatchery production.

2. Would the amount of useable spawning and rearing habitat contributed by adding the area that would become accessible upstream of Keno Dam provide an actual surplus above the apparent break-even provided by the Iron Gate to Keno reach?

   The amount of potential habitat upstream of UKL is estimated by Huntington et al. (2006, Table 1), at roughly twice that of the Iron Gate to Keno watershed. But, the effectiveness of recolonization is very uncertain for areas upstream of Keno Dam because of the many problems posed by conditions in KR and UKL (see Conditions for Success above).

The conclusion of this BOTE, using estimates from the megatable that the Panel cannot vouch for and has some reason to question, is that the benefits in the Iron Gate to Keno reach of the Proposed Action stand a good chance of roughly achieving a break-even if Iron Gate Hatchery is retired. The prospects for a benefit appreciably exceeding break-even depends on Chinook salmon production upstream of Keno Dam, which is much more uncertain, primarily because of severe and relatively intractable water quality problems in KR and UKL.

APPENDIX B
Review Questions Submitted to Panel

July 20, 2011

Klamath River Expert Panel
Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon
Summary Table of Review Questions Submitted to the Panel

General Questions			
Question Number	**Question**	**Question Code Used in the Report**	**Report Section Containing the Panel's Response**
1	**Geomorphology**: The two alternatives will result in very different geomorphic dynamics of the Klamath River downstream of Keno Dam. We recognize that the dams are associated with bed starvation of gravels and removal of dams may mobilize sediments over the short-term and over decades. How will alternatives affect geomorphology in the short-term (1-2 years) and over the 50 year period of interest? Included in this question are the potential effects of KBRA restoration activities on geomorphology of tributaries throughout the Klamath Basin and subsequent effects on harvestable populations of fish. What are the expected short-term effects of dam removal on the fish abundance and how long will it take these populations to return to baseline levels?	G-1	2.9
2	**Water quality**: The panels will be provided with information on numerous water quality issues from throughout the basin including dissolved oxygen, pH, ammonia, blue green algae, microsystin toxin, phosphorus loading, and Total Maximum Daily Loads (TMDL). Water quality in the Klamath Basin presents a multiplicity of challenges to restoration of fish populations. The Stakeholders and Water Quality Subgroup will provide some insight concerning the likely trends in water quality during the 50 year period of interest. Under these water quality scenarios, how will the two alternatives differ in reaching the goal of harvestable fish populations?	G-2	2.6
3	**Water temperature**: If reviewers consider the broad distribution of salmonids, salmonids in the Klamath River Basin are at the southern limit of their range. Furthermore, the removal of dams is predicted to alter the seasonal pattern of water temperatures with higher spring and summer temperatures and cooler fall	G-3	2.4

General Questions			
Question Number	**Question**	**Question Code Used in the Report**	**Report Section Containing the Panel's Response**
	water temperatures. What are the likely effects of the water temperature regimes under the two alternatives on rearing, spawning, and use of thermal refugia by native salmonids that might be manifest in harvestable fish?		
4	**Habitat and restoration (KBRA)**: Habitat is essential to productive fish populations and the stakeholders have recognized this critical linkage in the crafting of the Klamath Basin Restoration Agreement. The review panel will receive information on the use of Ecosystem Diagnosis and Treatment (EDT) method for tributaries above Upper Klamath Lake and the 2-D model of mesohabitats in the project reach to estimate aquatic habitat under the two alternatives. In addition, the panel will be provided a description of KBRA effects on habitat in the Klamath River Basin. The two proposed alternatives will result in different paths and timelines for habitat management. What are the likely effects of the two alternative habitat management paths on the recovery of ESA-listed fish or in the level of harvest of fish populations?	G-4	2.6
5	**Climate change**: We recognize a high level of uncertainty is associated with climate change during the 50 year period we are studying for the Secretarial Determination. The review panel will receive information on predicted hydrology and temperature for several climate change scenarios that have been downscaled for the Klamath River Basin. To what extent might potential changes in habitat, the hydrograph, and thermal refugia mitigate the effects of climate change under the two alternatives? What are the likely effects of climate change on the harvest levels of fish under the two alternatives.	G-5	2.4 and 2.7
6	**Abundance**: How will the two alternatives affect abundance of the fish population and what are the expectations for the enhancement of the fisheries? This question may have several milestones along a timeline or population trajectory. For example, inasmuch as some fish populations have been extirpated from the upper Klamath Basin for more than 90 years, when might fish be available for tribal ceremonial use within the upper Klamath Basin? Using a time trajectory, when will a sustainable fishery start and at what levels? We recommend the Panel consider abundance at different time scales ranging from seasonal, inter-annual,	G-6	2.4

General Questions			
Question Number	Question	Question Code Used in the Report	Report Section Containing the Panel's Response
	and to decadal trends. Economic concerns are that extreme variation in fish populations can affect economic stability of fisheries and fishing communities or slow recovery of fish populations and will delay any economic benefits.		
7	**Productivity**: The metrics of productivity of fish populations may be measured several different ways. These methods include: 1) number of recruit spawners produced per parent spawner at low abundance, 2) juvenile outmigrants per adult spawner, or 3) red counts per redd count of the previous generation. Each of these examples may be expressed through commonly used stock-recruitment models, such as the Beverton-Holt or Ricker curves. We recognize that conditions resulting from the proposed alternatives may not restore fish productivity to levels associated with historical pristine conditions. What are the most likely expectations for productivity over time and what is the effect of productivity on the number of harvestable fish? (role of hatcheries and productivity?)	G-7	2.4
8	**Diversity**: Diversity refers to the variation in phenotypic characteristics such as individual size, fecundity, run timing, and life history patterns of fishes. Collective diversity of groups of subpopulations will reflect the diversity in the selective environments across the range of a fish species. The diversity enables the individuals to respond to changes resulting from subtle to catastrophic events across space and time. For populations lacking diversity the seasonal availability of adult (harvestable) fish to fisheries might result in very short and highly regulated harvest seasons. Historically, diversity of the salmonid populations may have been an important determinant of the seasonal patterns of harvest, the range in size of harvestable adults, and perhaps other characteristics of the fisheries. What will the effect of the two alternatives be on diversity of fish populations? How will the resulting diversity be manifest in the harvestable population of fish? How will potentially low baseline populations and/or introductions of hatchery fish affect diversity under the two alternatives?	G-8	2.4
9	**Spatial structure**: Spatial structure of the fish populations refers to the distribution of fish in various habitats used throughout their life history. Spatial structure enables fish populations to respond to localized catastrophic events	G-9	2.4

General Questions			
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	across the landscape or to longterm changes in the environment. For a fishery, spatial structure of the population may stabilize the opportunity to produce harvestable fish. Will the two alternatives result in improved spatial structure of fish populations and to what extent is that improved structure likely to result in harvestable fish?		
10	**Ecosystem restoration**: Numerous small dams across the U.S. have already been removed and several large dams in the West such as the Elwha Dam (105 ft) and Glines Canyon Dam (210 ft) in Washington State are scheduled for removal in the future. The goals of these dam removal projects range from restoring volitional movement of fish to restoration of entire ecosystems. One of the goals of the KBRA is to restore and maintain ecological functionality and connectivity of historic fish habitats. However, in most drainages, in addition to dams, widespread degradation of habitat and other forms of human perturbations have contributed to the decline of harvestable populations of salmonids. The signatories to the KHSA recognized that dam removal on the Klamath River is perhaps not a panacea for restoration of fisheries, and therefore also proposed the restoration activities of KBRA in an attempt to provide participation in harvest opportunities for fish species. How do the proposed alternatives address ecosystem function and connectivity sufficiently to recover the lost harvest opportunities of fish populations?	G-10	2.6

Literature Cited:

Hamilton, J., R. Quinones, D. Rondorf, K. Schultz, J. Simondet, S. Stressor. 2010. Biological synthesis for the Secretarial Determination on potential removal of the lower four dams on the Klamath River. Biological Subgroup for Secretarial Determination. Draft May 27, 2010. 128 pp.

Williams, T.H., et al. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon/Northern California Coast Evolutionary Significant Unit. NOAA-TM-NMFS-SWFSC-432 NOAA Technical Memorandum NMFS:113.

Chinook Salmon Specific Questions			
Question Number	**Question**	**Question Code Used in the Report**	**Report Section Containing the Panel's Response**
1	**Reintroduction and Access to Historical Habitat**: Chinook salmon historically ranged to above Iron Gate Dam (IGD) and into tributaries to Upper Klamath Lake (UKL) (Fortune et al. 1966; Chapman 1981; Lane and Lane Associates 1981; Huntington 2006; Hamilton et al. 2005, Butler et al. 2010 draft). Dam removal would open access to over 350 miles of historical habitat used by anadromous fish above UKL (Huntington 2006) and ~58 miles in the Hydropower Project Reach between IGD and UKL (Huntington 2006). An additional 23 miles of habitat will become available under the project reservoirs (Hamilton et al. 2010). Both Fall-run and Spring-run Chinook salmon, each potentially expressing more than a single freshwater rearing strategy when given the opportunity, occupied much of this habitat; under the dams-out alternative, type-1 Fall-run Chinook are expected to use at least 240 miles of this area. Which of the two proposed alternatives offers the greatest opportunity to increase natural spawning returns for A) Fall-run and B) Spring-run Chinook salmon for the entire Klamath watershed?	C-1	2.4
2	**Thermal Refugia**: Thermal refugia play a key role in the survival of juvenile Chinook salmon during rearing and outmigration (Sutton et al. 2007; Sutton and Soto 2010) and for adult Spring-run Chinook salmon during migration (Strange 2010). Under the dams out alternative, changes to the temperature are predicted (Bartholow et al. 2005) and access to thermal refugia upstream of IGD will be created. At the same time, access will be created to thermal refugia areas upstream of IGD. Under the dams out alternative, adult salmon access will be provided to cool-water tributaries (Fall Creek, 0.8 mi; Shovel Creek, 2.1 mi; and upper/middle Spencer Creek, 7.1 mi) above the dams, springs currently inundated by reservoirs, and groundwater areas above the Keno Reservoir (the Wood River, the Williamson River, and springs on the west side of Upper Klamath Lake). In addition, a large spring complex discharging directly to the mainstem Klamath River downstream from JC Boyle Dam provides ~225 cubic feet per second of cool water year round (USDI Bureau of Land Management 2003), creating a large thermal refuge area currently unavailable to salmon, particularly during summer and fall months. However, the thermal effects of these springs may be reduced	C-2	2.4

Chinook Salmon Specific Questions			
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	under different flow scenarios (Bartholow and Heasley 2005) and different flow scenarios would result from the dams out alternative because water would no longer be bypassed around the main-stem channel where this groundwater enters. In addition, there are existing thermal refugial areas downstream that may be affected by ongoing (dams in alternative) and future (KBRA under dams out alternative) restoration actions. How will the two alternatives affect the access to, the use of, these refugial areas by Spring-run and Fall-run Chinook salmon?		
3	**Phase Shift in Seasonal Temperatures**: Under current conditions there has been a phase shift in water temperature (approximately 18 days) below the Project because of the reservoirs thermal mass. Under the dams-in alternative, this thermal lag can result in both cooler spring and warmer fall temperatures relative to historic pre-dam conditions, below IGD. These effects are diminished downstream as a result of tributary accretions. The dams-out alternative is expected to shift water temperatures closer to what occurred prior to dam construction, with warmer and much more variable spring water temperatures in the vicinity of IGD and cooler fall temperatures (Bartholow et al. 2005; Dunsmoor and Huntington 2006). This may result in earlier cooling in the fall by about 5°C below IGD (Bartholow et al. 2005) and may be accompanied by earlier spawning of Chinook salmon in the mainstem Klamath River. How will these changes in water temperatures affect migrating A) Fall-run Chinook salmon in the late summer and early fall; and, B) Spring-run Chinook destined for locations near or above IGD in the late spring and early summer?	C-3	2.1
4	**Climate Change**: Effect of climate change in the Klamath Basin has been documented (as referenced in Hamilton et al. 2010). Bartholow (2005) found evidence of a 0.5ºC increase in water temperatures per decade in the lower Klamath Basin since the early 1960s and suggested the increase may be related to the cyclic Pacific Decadal Oscillation depending on future trends. Downscaled projections from three climate models predict average increases in annual Klamath Basin air temperatures of 2.1 to 3.6ºC by 2035-2045 and June-August increases of 2.2 to 4.8ºC (Koopman et al. 2009). Snowmelt streamflow timing is	C-4	2.7

Chinook Salmon Specific Questions			
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	likely to be 1 to 4 weeks earlier across the West (Stewart et al. 2005). Summer warming is predicted to be greater than warming during other seasons (Barr et al. 2010). Large cascade-type springs in the areas above the dams (e.g., J.C. Boyle) may mediate the warming effects of climate change (Tague et al. 2008; Tague and Grant 2009) and provide thermal refugia. How will the effects of climate change impact the success of salmon reintroduction to newly available habitats upstream of the dams, and to what degree do you think climate change over the next 50 years will affect Chinook populations under the two alternatives being considered?		
5	**Ecosystem Function**: The KBRA identifies as a goal the restoration of salmonid fisheries to allow full participation in harvest opportunities. A goal of the KBRA restoration program is to increase harvestable populations of salmonids through the restoration of ecosystem function. Restoration actions include providing access to suitable habitat for all life stages, appropriate flow regimes, and improved water quality (e.g., water temperatures, dissolved oxygen, and reduced algal toxins from cyanobacteria in the reservoirs). Under the two alternatives, to what degree are differences related to dam removal, hydrology, and water quality likely to increase or decrease Chinook populations, and advance or diminish salmonid fisheries in the 50-year period of interest?	C-5	2.1, 2.6, and 3.1
6	**Disease Effects on Chinook Salmon**: In many years, juvenile Chinook salmon currently suffer high disease (e.g., *Ceratomyxa shasta*) mortality in some reaches of the Klamath River below IGD. Downstream of IGD a zone of high infectivity has been identified where relatively high mortality of juvenile salmon occurs. In that zone attached algae that harbor the disease host (a polychaete) for *C. shasta* are abundant. Flow and sediment modeling for the reach also suggest a relatively high bed mobilization flow and mobilization return period perhaps twice as long as some reaches. Bartholomew and Foote (2010) propose that opening of habitat above the IGD will result in greater dispersal potential for myxospores as adult salmon migrate into new habitats, but also noted that their predictions had a great deal of uncertainty. Ongoing analysis and modeling suggests that salmon	C-6	2.2

Chinook Salmon Specific Questions			
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	mortality may be associated with water temperature history, flow history, spawning aggregations of adult salmon, and actinospore concentration (Bartholomew and Foott 2010 (draft); Russell Perry, U.S. Geological Survey, personal communication). What are the likely differences in conditions and run timing for fish health over the next 50 years under the two alternatives?		
7	**Migration of Adults and Juvenile Chinook**: Under current conditions, about 65 percent of the Chinook salmon spawn in tributaries downstream of IGD (CDFG 2010). However, the mainstem Klamath River is used as an upstream migration corridor for adults and a downstream migration corridor for outmigrating juveniles. How will the flow, temperature, and water quality conditions provided under the dam removal alternative affect the adult and juvenile migratory life stages of Chinook salmon?	C-7	2.1, 2.2, 2.3, and 2.6
8	**Hatchery Effects**: Under the dams-out alternative, Iron Gate Hatchery (IGH) operations would continue for at least 8 years following dam removal, assuming that an alternate water supply is secured, or from other hatchery production facilities if IGH is no longer operable following IGD removal[1]. Under the Dams-in alternative, IGH would continue operation for the entire period of analysis (50 years). What are the differences in Chinook salmon production that may occur under the two alternatives and how will these differences affect the advancement of salmonid fisheries?	C-8	2.5
9	**Uncertainty of Model Predictions**: The analyses of the two management alternatives on the Klamath River rely to some extent on simulations from several numerical models. Simulations of this type have some uncertainty (see McElhany 2010; NRC 2008, p. 120). The model simulations and outputs imply a level of quantitative information (e.g., certainty, accuracy, precision) for the 50-year period that may or may not be accurate. The outputs from selected models include water temperature (Bartholow 2005; Bartholow et al. 2005; Flint and Flint 2008), hydrology (Greimann 2010), climate change (Greimann 2010), sediment movement (Ayers Associates 1999; Stillwater Sciences 2008; 2009) and salmon production (Bartholow and Henricksen 2006; Hardy et al. 2006). A Fall-run	C-9	4.0

Chinook Salmon Specific Questions			
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	Chinook salmon life cycle production model is being developed to help evaluate the effects of the proposed action on Fall-run Chinook salmon. The model is comprised of various other models, some of which are mentioned above. When using multiple numerical models, an analytical framework identifying the inter relationships among models to effectively quantify and propagate uncertainty through the analysis may be desirable. Anderson et al. (2008) and Lichatowich (2005) provide insight into the need for and approach to analytical frameworks in processes where modeling plays a key role in decision making. Although uncertainty in future predictions of these models is undetermined, the models performance for historical periods is expected to be well characterized and underlying assumptions well documented. Please identify (1) additional information needs on biological assumptions associated with the Chinook salmon life cycle production model that may not adequately described; and, (2) provide suggestions to improve quantifying uncertainty given that these models are currently in development.		
10	**Harvest**: Under conditions with dams, commercial and in-river harvest would continue as restrictions and quotas (met before escapement) allow as has occurred in the past. Under the dams out alternative, the KBRA describes the expectations for the implementation of reintroduction and harvest of salmonids: "*In Phase II Reintroduction, Fish Managers will implement management actions to achieve objectives identified in the Phase II plan that will guide basin wide management of the re-established fish populations. The re-established populations in the Upper Klamath Basin will contribute to the Fisheries of the basin as a whole. Management actions will insure that tribal, commercial, and sport harvests are managed in a way that provides for escapement of salmon and steelhead into the Upper Klamath Basin at levels that sustain healthy populations* (KBRA 11.3.2). Also, in the initial period after dam removal, sedimentation associated with dam removal will adversely affect Chinook populations. Under the two alternatives, what would be the short-term and long term effects to harvestable Chinook populations, would you anticipate that they would increase substantially,	C-10	2.5

Chinook Salmon Specific Questions			
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	moderately, slightly, remain the same, or decrease?		
11	**Life History of Spring Chinook Salmon**: The Upper Klamath Chinook salmon population historically consisted of three runs, fall, late fall, and spring (NRC 2004). Among the Fall-run Chinook salmon, an ocean stream-type life-history pattern is predominant in juveniles, and for Spring-run Chinook, a stream-type pattern with a year or more of stream rearing before seawater entry is predominant (NRC 2004). Historically, Spring-run Chinook may have been nearly as abundant as Fall-run Chinook with perhaps 100,000 returning to tributaries such as the Sprague, Williamson, Shasta, Scott, and Salmon rivers (NRC 2004). Wild populations of Spring-run Chinook salmon are now mostly limited to the Salmon River and South Fork Trinity River and their numbers are very low. Estimates of the Spring-run Chinook run size in the Salmon River, since the early 1980s, have ranged from about 166 to 1,721 fish. Trinity River Hatchery releases approximately 1,000,000 Spring-run Chinook smolts and 400,000 Spring-run Chinook yearlings as mitigation for habitat loss upstream of the Lewiston Dam. Increased numbers of Spring-run Chinook salmon will diversify the timing of returning adult Chinook salmon and may increase harvest opportunities (see KBRA section 9.2.6 Fisheries Program Goals). What affect will removal of the dams, implementation of the KBRA, and reintroduction of Spring-run Chinook salmon to the upper basin, above IGD, have upon the spatial structure, genetic and phenotypic diversity, and abundance of Spring-run Chinook in the Klamath Basin? What is the likelihood that project alternatives will create sustainable runs of Spring-run Chinook salmon in the Project reach, or in stream reaches above Upper Klamath Lake?	C-11	3.2
12	**Recreational and Tribal Fishing**: The proposed action alternative is expected to increase the spatial distribution of Chinook salmon as far upstream as the Wood, Williamson, and Sprague rivers. How would resulting changes in life history timing affect in-river recreational and tribal fishing opportunities above and below IGD?	C-12	2.5
13	**Pre-spawning Mortality**: The pre-spawn mortality of adult salmon in the Lower Klamath River in 2002 is not typical and was attributed to unique conditions of	C-13	2.1 and 2.2

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	disease, river flow, and the abundance of adult salmon (CDFG 2004). However, Hetrick et al. (2009) found relatively high pre-spawn mortality in years 2001 to 2007 and attributed the mortality to the warmer-than-natural water temperatures relatively early in the season (Hetrick et al. 2009; Figure II-3). Thermal stress was also identified by Bartholow and Hendrickson (2006) as the cause of reduced egg viability in early spawning fish as compared to late segments of the Chinook run at IGD. How will flow, temperature, and water quality conditions provided under the two alternatives affect Chinook pre-spawning mortality and egg viability?		
14	**Sediment Releases and Water Quality During Dam Removal**: As a short-term (1-2 years) result of dam removal, total suspended sediments (TSS) concentrations may become quite high (e.g., 20,000 mg/L; Stillwater Sciences 2009; Hamilton et al. 2010). To place the expected sediment load in perspective, the highest daily suspended sediment load in the Klamath River at the Orleans gage during the January 1974 flood (second largest during the 81 year period of record) was greater than the median estimate of total annual sediment load released by dam removal (Stillwater Sciences 2010). The biological oxygen demand and sediment load resulting from dam removal may result in near anoxic water (i.e., no oxygen in the water column) below IGD until ameliorated by tributary accretions (Hamilton et al. 2010). The Fall-run Chinook salmon return as adults with a mixed age-class structure and the impacts of dam removal are expected to be relatively short term with populations recovering within 5 years of dam removal (Stillwater Sciences 2009). Please weigh the risks and benefits to Chinook salmon populations associated with the dam removal release of sediments and associated water quality issues compared to restoring the riverine functions for sediment recruitment and transport.	C-14	2.9
15	**Timelines and Assumptions**: The above questions assume that the KBRA actions and programs are put in place in a timely manner and restoration and adaptive management progresses as described (KBRA section 11.4.2 and 11.4.3). An earlier review by the National Research Council (2008) encouraged the use of adaptive	C-15	2.10

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	management in an attempt to make science and management more effective. While we do not expect the panel to review the vagaries of political or social processes, please comment on the timeframes, uncertainties, and assumptions for each of the alternatives.		

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[1] As outlined in Interim Measure 19: Hatchery Production Continuity in the KHSA. A post-IGD Mitigation Hatchery Plan must be submitted 6 months following an Affirmative Determination incorporating the results of a study on the viability of Iron Gate Hatchery following dam removal. This study has not yet been conducted and the plan has not yet been developed.			

June 25, 2010

General Questions for Klamath Review Panels

As part of the Secretarial Determination on the removal of four lower dams on the Klamath River, expert panels will be asked to conduct a scientific assessment. The panels will be asked to determine the most likely effects of the two proposed alternatives on the harvest of selected fish species, mostly salmonids. The two alternatives are:

No Action: No change from current management conditions, which includes ongoing programs under existing laws and authorities that contribute to the continued existence of listed threatened and endangered species and Tribal Trust species. This Alternative would be realized if a negative determination is made. This Alternative is referred to herein as the Current Conditions Alternative (Hamilton et al. 2010).

Proposed Action: Removal of the lower four Klamath River dams and the full range of actions/programs to implement the Klamath Basin Restoration Agreement (KBRA). This Alternative would be realized if a positive determination is made. This Alternative is referred to herein as the Dams-out Alternative.

The products or opinions from the panels will be used by the Economic Sub Team to evaluate the economics of the fisheries. In response to the needs for economic evaluation, the Biological Sub Team included questions of a quantitative nature that would be useful in the evaluation of salmonid fisheries enhancement as required in the Klamath Hydropower Settlement Agreement (KHSA). Inasmuch as the KBRA is part of an alternative under review, we used the broad definition of fish from the KBRA to mean: "the historic complement of species (including races) of fish that naturally occupied the Klamath River Basin". Furthermore, the KBRA defined harvest opportunities to mean: full participation in Tribal, ceremonial, and commercial, ocean-commercial and recreational harvest; and inriver recreational harvest opportunities for anadromous fish species. The time period for the evaluation of the alternatives is 50 years from 2012 to 2062.

We will pose general questions and species-specific questions to the panels. The species specific questions might address a life history attribute or habitat requirement unique to that species. General questions fall into two themes. The first theme examines future habitat conditions and the second theme the viability of fish populations associated with those habitat conditions. Selected questions on habitat address hydrology, water quality, habitat, habitat restoration, ecosystem function, and climate change. The second theme is the biological viability of fish populations as indicated by criteria such as those proposed by Williams et al. (2008): 1) abundance, 2) productivity, 3) diversity, and 4) spatial structure. We propose to use these criteria because they are a conceptually intuitive link to salmonid population size, to the recovery of ESA listed species, and to the potential for harvest resulting in an economic or cultural benefit.

The signatories to the KBRA acknowledged the federal ESA listed status of coho salmon, Lost River and shortnose suckers, and bull trout and the Biological Sub Team recognizes those species have been subject to prior ESA reviews. While the earlier reviews create a data rich record, we encourage the panels to conduct a diligent review of the best available information on each of the species with respect to the two alternatives and the 50 year time horizon which are unique to this review process. Furthermore, we recognize the incongruous nature of the current listing status and the request of projections of future harvest opportunities, but do the best you can.

Ideally, each projection of the fish population abundance, harvestable fraction, and spawning escapement would be provided on an annual basis over the 50 year analytical horizon with some estimate of uncertainty. While such a quantitative estimate may be ideal for economic analysis, the Biological Sub Team and Economics Sub Team recognize projection of fish population abundance may be largely unachievable for most of the species reviewed. Our expectations are that in lieu of quantitative estimates, ranked value of abundance or an expression of change such as "two fold increase" could be used. Also useful is the trajectory of population abundance over time, such as declining or increasing under each of the proposed alternatives. Furthermore, if mileposts along the 50 year timeline marking significant events such as the salmonid populations reaching self-sustaining status, a harvestable surplus, or escapement goals can be identified, then these can be applied to further analysis. Because all ecosystem components can not be quantified, the review panels are encouraged to express qualitative values when predicting quantitative values is not prudent.

Questions:

1) Geomorphology: The two alternatives will result in very different geomorphic dynamics of the Klamath River down stream of Keno Dam. We recognize that the dams are associated with bed starvation of gravels and removal of dams may mobilize sediments over the short-term and over decades. How will alternatives affect geomorphology in the short-term (1-2 years) and over the 50 year period of interest? Included in this question are the potential effects of KBRA restoration activities on geomorphology of tributaries throughout the Klamath Basin and subsequent effects on harvestable populations of fish. What are the expected short-term effects of dam removal on the fish abundance and how long will it take these populations to return to baseline levels?

2) Water quality: The panels will be provided with information on numerous water quality issues from throughout the basin including dissolved oxygen, pH, ammonia, blue green algae, microsystin toxin, phosphorus loading, and Total Maximum Daily Loads (TMDL). Water quality in the Klamath Basin presents a multiplicity of challenges to restoration of fish populations. The Stakeholders and Water Quality Subgroup will provide some insight concerning the likely trends in water quality during the 50 year period of interest. Under these water quality scenerios, how will the two alternatives differ in reaching the goal of harvestable fish populations?

3) Water temperature: If reviewers consider the broad distribution of salmonids, salmonids in the Klamath River Basin are at the southern limit of their range. Furthermore, the removal of dams is predicted to alter the seasonal pattern of water temperatures with higher spring and summer temperatures and cooler fall water temperatures. What are the likely effects of the water temperature regimes under the two alternatives on rearing, spawning, and use of thermal refugia by native salmonids that might be manifest in harvestable fish?

4) Habitat and restoration (KBRA): Habitat is essential to productive fish populations and the stakeholders have recognized this critical linkage in the crafting of the Klamath Basin Restoration Agreement. The review panel will receive information on the use of Ecosystem Diagnosis and Treatment (EDT) method for tributaries above Upper Klamath Lake and the 2-D model of mesohabitats in the project reach to estimate aquatic habitat under the two alternatives. In addition, the panel will be provided a description of KBRA effects on habitat in the Klamath River Basin. The two proposed alternatives will result in different paths and timelines for habitat management. What are the likely effects of the two alternative habitat management paths on the recovery of ESA-listed fish or in the level of harvest of fish populations?

5) Climate change: We recognize a high level of uncertainty is associated with climate change during the 50 year period we are studying for the Secretarial Determination. The review panel will receive information on predicted hydrology and temperature for several climate change scenarios that have been downscaled for the Klamath River Basin. To what extent might potential changes in habitat, the hydrograph, and thermal refugia mitigate the effects of climate change under the two alternatives? What are the likely effects of climate change on the harvest levels of fish under the two alternatives.

6) Abundance: How will the two alternatives affect abundance of the fish population and what are the expectations for the enhancement of the fisheries? This question may have several milestones along a timeline or population trajectory. For example, inasmuch as some fish populations have been extirpated from the upper Klamath Basin for more than 90 years, when might fish be available for tribal ceremonial use within the upper Klamath Basin? Using a time trajectory, when will a sustainable fishery start and at what levels? We recommend the Panel consider abundance at different time scales ranging from seasonal, inter-annual, and to decadal trends. Economic concerns are that extreme variation in fish populations can affect economic stability of fisheries and fishing communities or slow recovery of fish populations and will delay any economic benefits.

7) Productivity: The metrics of productivity of fish populations may be measured several different ways. These methods include: 1) number of recruit spawners produced per parent spawner at low abundance, 2) juvenile outmigrants per adult spawner, or 3) redd counts per redd count of the previous generation. Each of these examples may be expressed through commonly used stock-recruitment models, such as the Beverton-Holt or Ricker curves. We recognize that conditions resulting from the proposed alternatives may not restore fish productivity to levels associated with historical pristine conditions.

What are the most likely expectations for productivity over time and what is the effect of productivity on the number of harvestable fish? (role of hatcheries and productivity?)

8) Diversity: Diversity refers to the variation in phenotypic characteristics such as individual size, fecundity, run timing, and life history patterns of fishes. Collective diversity of groups of subpopulations will reflect the diversity in the selective environments across the range of a fish species. The diversity enables the individuals to respond to changes resulting from subtle to catastrophic events across space and time. For populations lacking diversity the seasonal availability of adult (harvestable) fish to fisheries might result in very short and highly regulated harvest seasons. Historically, diversity of the salmonid populations may have been an important determinant of the seasonal patterns of harvest, the range in size of harvestable adults, and perhaps other characteristics of the fisheries. What will the effect of the two alternatives be on diversity of fish populations? How will the resulting diversity be manifest in the harvestable population of fish? How will potentially low baseline populations and/or introductions of hatchery fish affect diversity under the two alternatives?

9) Spatial structure: Spatial structure of the fish populations refers to the distribution of fish in various habitats used throughout their life history. Spatial structure enables fish populations to respond to localized catastrophic events across the landscape or to long-term changes in the environment. For a fishery, spatial structure of the population may stabilize the opportunity to produce harvestable fish. Will the two alternatives result in improved spatial structure of fish populations and to what extent is that improved structure likely to result in harvestable fish?

10) Ecosystem restoration: Numerous small dams across the U.S. have already been removed and several large dams in the West such as the Elwha Dam (105 ft) and Glines Canyon Dam (210 ft) in Washington State are scheduled for removal in the future. The goals of these dam removal projects range from restoring volitional movement of fish to restoration of entire ecosystems. One of the goals of the KBRA is to restore and maintain ecological functionality and connectivity of historic fish habitats. However, in most drainages, in addition to dams, widespread degradation of habitat and other forms of human perturbations have contributed to the decline of harvestable populations of salmonids. The signatories to the KHSA recognized that dam removal on the Klamath River is perhaps not a panacea for restoration of fisheries, and therefore also proposed the restoration activities of KBRA in an attempt to provide participation in harvest opportunities for fish species. How do the proposed alternatives address ecosystem function and connectivity sufficiently to recover the lost harvest opportunities of fish populations?

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Questions for Expert Panel on Chinook Salmon in the Klamath River Basin

The following questions were prepared for the Secretarial Determination to serve as guidance to the expert panel reviewing Chinook salmon of the Klamath River Basin. The two alternatives are:

Conditions with Dams: For the purposes of this review, conditions with dams will assume no change from the current management, which includes on-going programs under existing laws and authorities that contribute to the continued existence of listed and threatened and endangered species and Tribal Trust species.

Conditions without Dams and with the Klamath Basin Restoration Agreement (KBRA): This alternative includes removal of the lower four Klamath River dams in the year 2020 and the implementation of the full range of actions and programs described in the KBRA. KBRA is a connected action with the Klamath Hydroelectric Settlement Agreement (KHSA) and for this review will be assumed to go forward with dam removal and a positive Secretarial Determination.

The two alternatives are described in more detail in Hamilton et al. (2010). The Chinook-specific questions may be considered along with a set of general questions provided to each of the four panels convened for the Secretarial Determination. The questions are not in order of priority and are not intended to constrain the discussion by the expert panel or limit the final product.

1) Reintroduction and Access to Historical Habitat: Chinook salmon historically ranged to above Iron Gate Dam (IGD) and into tributaries to Upper Klamath Lake (UKL) (Fortune et al. 1966; Chapman 1981; Lane and Lane Associates 1981; Huntington 2006; Hamilton et al. 2005, Butler et al. 2010 draft). Dam removal would open access to over 350 miles of historical habitat used by anadromous fish above UKL (Huntington 2006) and ~58 miles in the Hydropower Project Reach between IGD and UKL (Huntington 2006). An additional 23 miles of habitat will become available under the project reservoirs (Hamilton et al. 2010). Both Fall-run and Spring-run Chinook salmon, each potentially expressing more than a single freshwater rearing strategy when given the opportunity, occupied much of this habitat; under the dams-out alternative, type-1 Fall-run Chinook are expected to use at least 240 miles of this area. Which of the two proposed alternatives offers the greatest opportunity to increase natural spawning returns for A) Fall-run and B) Spring-run Chinook salmon for the entire Klamath watershed?

2) <u>Thermal Refugia:</u> Thermal refugia play a key role in the survival of juvenile Chinook salmon during rearing and outmigration (Sutton et al. 2007; Sutton and Soto 2010) and for adult Spring-run Chinook salmon during migration (Strange 2010). Under the dams out alternative, changes to the temperature are predicted (Bartholow et al. 2005) and access to thermal refugia upstream of IGD will be created. At the same time, access will be created to thermal refugia areas upstream of IGD. Under the dams out alternative, adult salmon access will be provided to cool-water tributaries (Fall Creek, 0.8 mi; Shovel Creek, 2.1 mi; and upper/middle Spencer Creek, 7.1 mi) above the dams, springs currently inundated by reservoirs, and groundwater areas above the Keno Reservoir (the

Wood River, the Williamson River, and springs on the west side of Upper Klamath Lake). In addition, a large spring complex discharging directly to the mainstem Klamath River downstream from JC Boyle Dam provides ~225 cubic feet per second of cool water year round (USDI Bureau of Land Management 2003), creating a large thermal refuge area currently unavailable to salmon, particularly during summer and fall months. However, the thermal effects of these springs may be reduced under different flow scenarios (Bartholow and Heasley 2005) and different flow scenarios would result from the dams out alternative because water would no longer be bypassed around the main-stem channel where this groundwater enters. In addition, there are existing thermal refugial areas downstream that may be affected by ongoing (dams in alternative) and future (KBRA under dams out alternative) restoration actions. How will the two alternatives affect the access to, the use of, these refugial areas by Spring-run and Fall-run Chinook salmon?

3) Phase Shift in Seasonal Temperatures: Under current conditions there has been a phase shift in water temperature (approximately 18 days) below the Project because of the reservoirs thermal mass. Under the dams-in alternative, this thermal lag can result in both cooler spring and warmer fall temperatures relative to historic pre-dam conditions, below IGD. These effects are diminished downstream as a result of tributary accretions. The dams-out alternative is expected to shift water temperatures closer to what occurred prior to dam construction, with warmer and much more variable spring water temperatures in the vicinity of IGD and cooler fall temperatures (Bartholow et al. 2005; Dunsmoor and Huntington 2006). This may result in earlier cooling in the fall by about 5°C below IGD (Bartholow et al. 2005) and may be accompanied by earlier spawning of Chinook salmon in the mainstem Klamath River. How will these changes in water temperatures affect migrating A) Fall-run Chinook salmon in the late summer and early fall; and, B) Spring-run Chinook destined for locations near or above IGD in the late spring and early summer?

4) Climate Change: Effect of climate change in the Klamath Basin has been documented (as referenced in Hamilton et al. 2010). Bartholow (2005) found evidence of a 0.5ºC increase in water temperatures per decade in the lower Klamath Basin since the early 1960s and suggested the increase may be related to the cyclic Pacific Decadal Oscillation depending on future trends. Downscaled projections from three climate models predict average increases in annual Klamath Basin air temperatures of 2.1 to 3.6ºC by 2035-2045 and June-August increases of 2.2 to 4.8ºC (Koopman et al. 2009). Snowmelt streamflow timing is likely to be 1 to 4 weeks earlier across the West (Stewart et al. 2005). Summer warming is predicted to be greater than warming during other seasons (Barr et al. 2010). Large cascade-type springs in the areas above the dams (e.g., J.C. Boyle) may mediate the warming effects of climate change (Tague et al. 2008; Tague and Grant 2009) and provide thermal refugia. How will the effects of climate change impact the success of salmon reintroduction to newly available habitats upstream of the dams, and to what degree do you think climate change over the next 50 years will affect Chinook populations under the two alternatives being considered?

5) Ecosystem Function: The KBRA identifies as a goal the restoration of salmonid fisheries to allow full participation in harvest opportunities. A goal of the KBRA restoration program is to increase harvestable populations of salmonids through the restoration of ecosystem function. Restoration actions include providing access to suitable habitat for all life stages, appropriate flow regimes, and improved water quality (e.g., water temperatures, dissolved oxygen, and reduced algal toxins from cyanobacteria in the reservoirs). Under the two alternatives, to what degree are differences related to dam removal, hydrology, and water quality likely to increase or decrease Chinook populations, and advance or diminish salmonid fisheries in the 50-year period of interest?

6) Disease Effects on Chinook Salmon: In many years, juvenile Chinook salmon currently suffer high disease (e.g., *Ceratomyxa shasta*) mortality in some reaches of the Klamath River below IGD. Downstream of IGD a zone of high infectivity has been identified where relatively high mortality of juvenile salmon occurs. In that zone attached algae that harbor the disease host (a polychaete) for *C. shasta* are abundant. Flow and sediment modeling for the reach also suggest a relatively high bed mobilization flow and mobilization return period perhaps twice as long as some reaches. Bartholomew and Foote (2010) propose that opening of habitat above the IGD will result in greater dispersal potential for myxospores as adult salmon migrate into new habitats, but also noted that their predictions had a great deal of uncertainty. Ongoing analysis and modeling suggests that salmon mortality may be associated with water temperature history, flow history, spawning aggregations of adult salmon, and actinospore concentration (Bartholomew and Foott 2010 (draft); Russell Perry, U.S. Geological Survey, personal communication). What are the likely differences in conditions and run timing for fish health over the next 50 years under the two alternatives?

7) Migration of Adults and Juvenile Chinook: Under current conditions, about 65 percent of the Chinook salmon spawn in tributaries downstream of IGD (CDFG 2010). However, the mainstem Klamath River is used as an upstream migration corridor for adults and a downstream migration corridor for outmigrating juveniles. How will the flow, temperature, and water quality conditions provided under the dam removal alternative affect the adult and juvenile migratory life stages of Chinook salmon?

8) Hatchery Effects: Under the dams-out alternative, Iron Gate Hatchery (IGH) operations would continue for at least 8 years following dam removal, assuming that an alternate water supply is secured, or from other hatchery production facilities if IGH is no longer operable following IGD removal[i]. Under the Dams-in alternative, IGH would continue operation for the entire period of analysis (50 years). What are the differences in Chinook salmon production that may occur under the two alternatives and how will these differences affect the advancement of salmonid fisheries?

9) Uncertainty of Model Predictions: The analyses of the two management alternatives on the Klamath River rely to some extent on simulations from several numerical models. Simulations of this type have some uncertainty (see McElhany 2010; NRC 2008, p. 120). The model simulations and outputs imply a level of quantitative information (e.g., certainty, accuracy, precision) for the 50-year period that may or may not be accurate. The outputs from selected models include water temperature (Bartholow 2005; Bartholow et al. 2005; Flint and Flint 2008), hydrology (Greimann 2010), climate change (Greimann 2010), sediment movement (Ayers Associates 1999; Stillwater Sciences 2008; 2009) and salmon production (Bartholow and Henricksen 2006; Hardy et al. 2006). A Fall-run Chinook salmon life cycle production model is being developed to help evaluate the effects of the proposed action on Fall-run Chinook salmon. The model is comprised of various other models, some of which are mentioned above. When using multiple numerical models, an analytical framework identifying the inter-relationships among models to effectively quantify and propagate uncertainty through the analysis may be desirable. Anderson et al. (2008) and Lichatowich (2005) provide insight into the need for and approach to analytical frameworks in processes where modeling plays a key role in decision making. Although uncertainty in future predictions of these models is undetermined, the models performance for historical periods is expected to be well characterized and underlying assumptions well documented. Please identify (1) additional information needs on biological assumptions associated with the Chinook salmon life cycle production model that may not adequately described; and, (2) provide suggestions to improve quantifying uncertainty given that these models are currently in development.

10) Harvest: Under conditions with dams, commercial and in-river harvest would continue as restrictions and quotas (met before escapement) allow as has occurred in the past. Under the dams out alternative, the KBRA describes the expectations for the implementation of reintroduction and harvest of salmonids: *"In Phase II Reintroduction, Fish Managers will implement management actions to achieve objectives identified in the Phase II plan that will guide basin wide management of the re-established fish populations. The re-established populations in the Upper Klamath Basin will contribute to the Fisheries of the basin as a whole. Management actions will insure that tribal, commercial, and sport harvests are managed in a way that provides for escapement of salmon and steelhead into the Upper Klamath Basin at levels that sustain healthy populations* (KBRA 11.3.2). Also, in the initial period after dam removal, sedimentation associated with dam removal will adversely affect Chinook populations. Under the two alternatives, what would be the short-term and long-term effects to harvestable Chinook populations, would you anticipate that they would increase substantially, moderately, slightly, remain the same, or decrease?

11) Life History of Spring Chinook Salmon: The Upper Klamath Chinook salmon population historically consisted of three runs, fall, late fall, and spring (NRC 2004). Among the Fall-run Chinook salmon, an ocean stream-type life-history pattern is predominant in juveniles, and for Spring-run Chinook, a stream-type pattern with a year

or more of stream rearing before seawater entry is predominant (NRC 2004). Historically, Spring-run Chinook may have been nearly as abundant as Fall-run Chinook with perhaps 100,000 returning to tributaries such as the Sprague, Williamson, Shasta, Scott, and Salmon rivers (NRC 2004). Wild populations of Spring-run Chinook salmon are now mostly limited to the Salmon River and South Fork Trinity River and their numbers are very low. Estimates of the Spring-run Chinook run size in the Salmon River, since the early 1980s, have ranged from about 166 to 1,721 fish. Trinity River Hatchery releases approximately 1,000,000 Spring-run Chinook smolts and 400,000 Spring-run Chinook yearlings as mitigation for habitat loss upstream of the Lewiston Dam. Increased numbers of Spring-run Chinook salmon will diversify the timing of returning adult Chinook salmon and may increase harvest opportunities (see KBRA section 9.2.6 Fisheries Program Goals). What affect will removal of the dams, implementation of the KBRA, and reintroduction of Spring-run Chinook salmon to the upper basin, above IGD, have upon the spatial structure, genetic and phenotypic diversity, and abundance of Spring-run Chinook in the Klamath Basin? What is the likelihood that project alternatives will create sustainable runs of Spring-run Chinook salmon in the Project reach, or in stream reaches above Upper Klamath Lake?

12) Recreational and Tribal Fishing: The proposed action alternative is expected to increase the spatial distribution of Chinook salmon as far upstream as the Wood, Williamson, and Sprague rivers. How would resulting changes in life history timing affect in-river recreational and tribal fishing opportunities above and below IGD?

13) Pre-spawning Mortality: The pre-spawn mortality of adult salmon in the Lower Klamath River in 2002 is not typical and was attributed to unique conditions of disease, river flow, and the abundance of adult salmon (CDFG 2004). However, Hetrick et al. (2009) found relatively high pre-spawn mortality in years 2001 to 2007 and attributed the mortality to the warmer-than-natural water temperatures relatively early in the season (Hetrick et al. 2009; Figure II-3). Thermal stress was also identified by Bartholow and Hendrickson (2006) as the cause of reduced egg viability in early spawning fish as compared to late segments of the Chinook run at IGD. How will flow, temperature, and water quality conditions provided under the two alternatives affect Chinook pre-spawning mortality and egg viability?

14) Sediment Releases and Water Quality During Dam Removal: As a short-term (1-2 years) result of dam removal, total suspended sediments (TSS) concentrations may become quite high (e.g., 20,000 mg/L; Stillwater Sciences 2009; Hamilton et al. 2010). To place the expected sediment load in perspective, the highest daily suspended sediment load in the Klamath River at the Orleans gage during the January 1974 flood (second largest during the 81 year period of record) was greater than the median estimate of total annual sediment load released by dam removal (Stillwater Sciences 2010). The biological oxygen demand and sediment load resulting from dam removal may result in near anoxic water (i.e., no oxygen in the water column) below IGD until ameliorated by tributary accretions (Hamilton et al. 2010). The Fall-run Chinook salmon return as adults with a mixed age-class structure and the impacts of dam removal

are expected to be relatively short term with populations recovering within 5 years of dam removal (Stillwater Sciences 2009). Please weigh the risks and benefits to Chinook salmon populations associated with the dam removal release of sediments and associated water quality issues compared to restoring the riverine functions for sediment recruitment and transport.

15) Timelines and Assumptions: The above questions assume that the KBRA actions and programs are put in place in a timely manner and restoration and adaptive management progresses as described (KBRA section 11.4.2 and 11.4.3). An earlier review by the National Research Council (2008) encouraged the use of adaptive management in an attempt to make science and management more effective. While we do not expect the panel to review the vagaries of political or social processes, please comment on the timeframes, uncertainties, and assumptions for each of the alternatives.

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[i] As outlined in Interim Measure 19: Hatchery Production Continuity in the KHSA. A post-IGD Mitigation Hatchery Plan must be submitted 6 months following an Affirmative Determination incorporating the results of a study on the viability of Iron Gate Hatchery following dam removal. This study has not yet been conducted and the plan has not yet been developed.

APPENDIX C
Comments and Responses on the Draft Report

July 20, 2011

Klamath River Expert Panel
Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon
Response to Independent Peer Review Comments on the Draft Report dated May 2, 2011

Independent Peer Review Foreword

The peer reviewers of the draft report are exceptionally well qualified to evaluate and provide constructive criticism on the document. Both reviewers hold Doctor of Philosophy Degrees; one in Wildlife and Fisheries Science and the other in Population Biology and Genetics. Together they have over 70 years of fisheries research and management experience related to anadromous fishes, with emphasis on Pacific salmonids species. They have written extensively on the subject, having published numerous scientific articles and contributed to a number of books on the biology, conservation, and management of salmon and other fisheries in Alaska and the Pacific Northwest.

The reviewers of the draft report took markedly different approaches to offering constructive criticism for improving the document. One reviewer was concerned with the overall structure and unevenness of the report and suggested adding topics and the expanding certain sections. The second reviewer generally limited comments to overall impressions of the Panel report and provided a few specific recommendations. Both reviewers recognized the limitations in the process for preparing the document. Nevertheless, both commented that the rational for the authors' conclusions should be more readily apparent and substantiated in greater detail.

Summary of Comments Received from Independent Peer Reviewers:

The first peer reviewer provided recommendations for improving the report's structure and content. It was pointed out that Section 4.1 was thoroughly executed and could serve as a model for the rest of the report sections. This reviewer suggested that Sections 2.1 through 2.10 could be improved by standardizing the format. One way of doing so was for the authors to provide explicit recommendations at the end of every section. This reviewer suggested that a number of topics briefly discussed in Section 2.5 be given more extensive treatment. These topics included 1) the extent of upper basin spawning habitats and their quality for likely colonization, 2) potential juvenile habitat use, 3) local adaptation in the upper basin, 4) juvenile migration patterns, and 5) juvenile downstream passage challenges at the remaining dams. Each of these topics could be given their own section or subsection. Expansion of Section 2.5 by adding examples of successful colonization was also recommended and some example references were provided on the second page of the verbatim comments.

The first reviewer felt that some of the questions posed to the panel in Appendix C were not fully addressed and required revisiting. Specific examples were noted on the second page of the verbatim comments. As have reviewers of the other draft Panel reports, the first reviewer recommended adding documentation in the form of literature citations for many of the statements found in the report.

The second peer reviewer had three general concerns. First, it was suggested that more background information be made available to facilitate reviews of the Panel's report. A specific request was to include river mile designations on the map figures and a clear definition of the area constituting Upper Basin. A second concern was that the report did not evaluate the "public interest" relative to the two management scenarios. The reviewer recommended the report clearly state that public interest review was beyond the scope of the document, if indeed that is the case. The third general concern was the difficulty of finding statements that directly support the Panel's conclusions. No specific recommendations for rectifying this concern were provided.

The second peer reviewer suggested improving the presentation of the ten conditions on which success of the Proposed Action is contingent by prioritizing list and since these conditions do not function independently, to show linkages between the conditions where they are anticipated. A similar suggestion regarding prioritization was provided by the first reviewer.

There are three specific reviewer comments that should definitely be considered. The first reviewer points out a potential discrepancy between Section 2.4 and Section 2.9 regarding water quality resulting with the Proposed Action. According to the reviewer, "This discrepancy raises the question of whether mainstem water quality is expected to improve or deteriorate under the Proposed Action and what those changes synergistically imply for Chinook production."

The second reviewer questions whether 10,000 spawners (Footnote, Page i) can be considered "substantial" in a watershed of the size of the Klamath. The relative merit of the spawner estimate is important to the overall conclusion of the report. Therefore the Panel should consider providing additional explanation about it. Lastly, the second reviewer noted that in the last paragraph on page 13, there did not seem to be any consideration of the 47% wetland reduction mentioned on the previous page. Whether or not the 47% reduction should be considered in the calculation should be clarified.

Comments Received from Peer Reviewers and Expert Panel Responses:

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
Peer Reviewer No. 1				
1			As requested under contract 1000116216, I was asked to review the draft report "Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon" by the Klamath River Expert Panel, dated May 2, 2011. I was directed to prepare a letter report critiquing the report's completeness, scientific approach, consistency of thought, and soundness of conclusions and, further, to determine if the document represents "sound science" and if conclusions in the report seem reasonable based on the best available scientific information. This review was meant to provide an evaluation or critique that the authors of the Chinook report can use to improve the draft. Therefore, I evaluated the clarity of hypothesis, the validity of the research design, the quality of the research design, the quality of the data collection procedures, the robustness of the methods employed, the appropriateness of the methods for the hypotheses being tested, the extent to which the conclusions follow from the analysis, and the strengths and limitations of the overall product. The outline of the review below follows these specific guidelines. I also made additional editorial comments to assist the authors in improving their final report.	This comment is noted.[1]
2			**Report Completeness** While it appears that the Panel employed a creative and effective approach to answer the basic questions posed to them regarding the two alternatives (i.e., the "Conditions" summary in Sections 2.1 – 2.10), the report is surprisingly brief, considering the depth of the issues. Although "The Panel did not have the time or resources to examine original data or	The Panel was given six days to prepare a report (four days in Arcadia) following two days of presentations. Presented information was often incomplete and

[1] The Panel acknowledged some comments with "This comment is noted" when the comment did not require a specific response or the information presented was already considered by the Panel. A response of "This comment is noted" meant that the comment was reviewed and the information was considered by the Panel; however, no changes were made to the report in response to the comment.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			re-do analyses, even when such actions seemed straightforward and appropriate for the assigned task." (Goodman et al. 2011, p. 9), my overall impression is that many of the topics could have been more thoroughly evaluated by the Panel. Several examples of this are cited next.	sometimes contradictory, e.g., what changes in flow would occur after dam removal? This raised many questions by Panel members. The Panel was also provided with a CD containing hundreds of .pdf reports. With more time, the Panel could have provided more in depth analysis.
			Report Completeness (cont.) There are several cases where further development of thought could improve the Panel's report. For example, the last sentence of the first full paragraph on p. 21 reads: "In the short term, harvest under Current Conditions could be higher than under the Proposed Action." (p.21). It seems important to additionally note that the reduced short-term harvest levels have the potential to be greatly compensated for by expected long-term harvest benefits. Furthermore, the Panel might have recommended evaluation of the relative possible harvest trade-offs with the Chinook model.	The report has been revised in response to this comment. Qualifications were added.
3			**Report Completeness (cont.)** Other topics that could benefit from more extensive treatment are: • The extent of upper basin spawning habitats and their quality for likely colonization, • Potential juvenile habitat use, • Local adaptation in the upper basin, • Juvenile migration patterns, • Juvenile downstream passage challenges at the remaining	The Panel lacks time to add the suggested text.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			dams	
4			**Report Completeness (cont.)** Further, Section 2.5 could have been more fully developed regarding the potential for successful colonization. For example, some recent work on the Cedar River in Washington has demonstrated that Chinook will colonize newly accessible habitat, at least in that relatively smaller watershed (Anderson 2011). Of course, the larger scale together with the water quality issues in the Klamath present a much more challenging problem for recolonization. Still, there is a body of literature on the relative success of recolonization of formerly occupied Pacific Northwest habitats with hatchery salmon (not usually successful), and of successful colonizations in the Great Lakes, South America, and New Zealand (e.g., Burger et al. 2000, Kinnison et al. 2008).	The Panel lacks the time to review this additional literature and compose text agreeable to all Panelists.
5			**Report Completeness (cont.)** Sections 2.1 through 2.10 are treated somewhat unevenly. In particular, Section 2.1 ended with four specific recommendations. Other sections contained recommendations but were not as explicit as Section 2.1. Still other sections had no recommendations. Increased consistency in approach under each of the sections would improve the Panel's report.	The Panel lacked recommendations for each section.
6			**Report Completeness (cont.)** Many of the questions posed to the Panel (Appendix C) were only partly or cursorily answered in the Panel's report. As an example of this, relevant portions of some of the first few questions are quoted here, with the unaddressed topics underlined. 1) Geomorphology: "Included in this question are the potential effects of KBRA restoration activities on <u>geomorphology of tributaries throughout the Klamath Basin and subsequent effects on harvestable populations of fish.</u>"	1. The Panel found too little information in the KBRA report to assess the likely geomorphological changes it might produce.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			3) Water temperature: "What are the likely effects of the water temperature regimes under the two alternatives on rearing, spawning, and use of thermal refugia by native salmonids [including juveniles] that might be manifest in harvestable fish?" 6) Abundance: "Using a time trajectory, when will a sustainable fishery start and at what levels?"	3. Access to thermal refugia depends on passage through UKL, about which the Panel has already commented. 6. The Panel found too little information with which to model future harvests.
7			**Scientific Approach** The Panel's report cannot be considered to have followed the usual approach of a scientific investigation wherein a hypothesis is stated, scientific methods are determined, data is collected, statistical analyses are performed, and conclusions are drawn relative to the hypothesis with an assessment of statistical confidence. Rather, the following quote describes the Panel's approach, given the review situation they were presented with. "Thus, the analytical method of the Panel involved assessing and interpreting the likely reliability and relevance of the technical information supplied to it, evaluating the relevance of this information to the biology of Chinook salmon, and predicting the impacts of the two alternatives related to salmon abundance and harvest in the future. Given this context, the findings presented in this report represent the collective expert opinion of the Panel developed during a six-day workshop. The assessment as conducted by this Panel combined qualitative and quantitative information with professional experience to estimate potential outcomes of the two alternatives, which in turn allowed the Panel to at least partially address the questions posed by project's stakeholders (see Appendix C)." (P. 9). My comments below are made with regard to the Panel's challenge as stated here, rather than in the context of a strict scientific investigation.	This comment is noted.
8			**Scientific Approach**	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			Clarity of Hypothesis The overarching, general hypothesis is clearly stated as: "Based on available information, is the Proposed Action likely to increase abundance of naturally spawned Klamath River Chinook salmon substantially above abundance expected under Current Conditions?" (p.11)	
9			**Scientific Approach (cont.)** *Validity of the Research Design* Given the challenging depth and extent of the Klamath restoration problem, the unevenness of the information provided to the Panel, and the time allowed to address the questions posed, establishment of a formal research design was inappropriate for the situation.	This comment is noted.
10			**Scientific Approach (cont.)** *Quality of the Research Design* The Panel's approach to encompassing all the limiting factors under the Proposed Action, and simultaneously answering the questions posed, was a creative method for dealing with the myriad complexities of the Klamath Basin they were to consider. While that design aided in a synthetic approach to evaluating the array of restoration challenges, the analysis was somewhat lacking in quality due to variable depth or evenness of treatment as described elsewhere in this review.	This study lacked a research design because it was not a research study; it was a project review.
11			**Scientific Approach (cont.)** *Robustness of the Methods Employed* The Panel's approach was robust in that it comprehensively included treatment of a wide array of topics. At the same time, the approach also lacked scientific or experimental robustness in that there was no opportunity to rigorously test hypotheses. Because their review and evaluation was solely based on information provided to them, and their expert professional opinions of the situation, it is impossible to assess the robustness of their evaluation.	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
12			**Scientific Approach (cont.)** *Appropriateness of the Methods for the Hypotheses Being Tested* The methods in this case are the Panel's collective body of expert knowledge and experience. While it would have been preferable for the hypothesis to be tested or evaluated quantitatively, it is reasonable that general conclusions about the stated hypothesis be made based on that expert opinion relative to the available information. (It is important to note that the modeling underway should support eventual quantitative testing of the hypothesis.)	This comment is noted.
13			**Consistency of Thought** The Panel's report has several sections that may benefit from reorganization. For example, Section 2.4 is entitled "Access to Upper Basin" and the "Condition" is stated that perpetual transportation (i.e., trap and haul) to the upper basin will be necessary if Condition 1 is not met. However, Section 2.4 is actually much broader than just the transportation issue. It also briefly covers the topics of reestablishment of Chinook in upper basin spawning habitats, habitat use, local adaptation, juvenile migration patterns, juvenile downstream passage at dams. Each one of those topics could be limiting in themselves and should be treated separately from the transportation topic. To follow the consistency of coverage in Sections 2.1 to 2.10, these topics should be treated in their own sections, while transportation is the topic of Section 2.4.	The report has been revised in response to this comment. Section 2.3 changed to: Colonization of the Upper Basin.
14			**Consistency of Thought (cont.)** There is a potential contradiction between two Sections of the report. Section 2.4 states that "If the Proposed Action is implemented, the summer and fall low oxygen content of KR is unlikely to improve…… … even if the TMDL could be achieved, passage of adult Chinook salmon to the upper basin will likely be blocked by low oxygen that occurs from approximately early July through late November…." (p. 19). Conversely,	The Panel responds that downstream water quality is unlikely to improve until Upper Klamath Lake water quality improves.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			Section 2.9 states: "The Panel noted that water temperatures during the Proposed Action are expected to be approximately 3-8 °C lower during the spawning period ……. and dissolved oxygen may be higher ….. Improved water quality following dam removal might reduce pre-spawning mortality and thereby help offset reduced productivity associated with lower fall flows." (p. 24). This discrepancy raises the question of whether mainstem water quality is expected to improve or deteriorate under the Proposed Action and what those changes synergistically imply for Chinook production.	
15			**Consistency of Thought (cont.)** It is interesting to note the thoroughness with which the Panel addressed the Chinook modeling process (p. 29 and Appendix D). Ideally, each of the other sections of the report would have been addressed to a similar extent.	This comment is noted. The Panel emphasizes the importance of a well-designed Chinook model for the overall process. One full day of presentations was spent on the Chinook model and the panel was asked to provide comments.
16			**Soundness of Conclusions**: The overarching conclusion is: "The Panel concluded that a modest increase in Chinook salmon is likely in the reach between Iron Gate Dam and Keno Dam if some of the conditions listed below are met. An increase in Chinook salmon upstream of Keno Dam is less certain because of the difficulties in satisfying all the conditions described below. The Panel has strong reservations that KBRA, even if fully implemented, will address all these conditions to the extent required to meet the goals of the program. The Panel concludes that achieving substantial gains in Chinook salmon with the Proposed Action is contingent upon the following conditions:…" (P.9).	This comment is noted.
17			**Soundness of Conclusions (cont.)**	This comment is noted.

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			Are conclusions in the report reasonable based on the best available scientific information? Because the conclusions, as quoted above, were made primarily based on expert opinion of the best pre-existing information, it is reasonable to answer this question in the affirmative. However, an important caveat is that more reliable and substantiated conclusions regarding the stated hypothesis are possible if the Panel, or another similarly qualified group, were given further funding and time. The results of the modeling should lead to more quantifiable and definitive conclusions, especially if the modelers accept many of the Panel' suggestions.	
18			**Soundness of Conclusions (cont.)** Some questions arose relative to the conclusions regarding the reach between Keno and Iron Gate dams (underlining added for emphasis): "The Panel concluded that a modest increase in Chinook salmon is likely in the reach between Iron Gate Dam and Keno Dam <u>if some</u> of the conditions listed below are met." (P. 9). It would be preferable if the report addressed which of the conditions are essential and which are optional for obtaining he referenced increase in Chinook salmon.	Passage through Upper Klamath Lake is not a limiting factor for Project Reach fish.
19			**Soundness of Conclusions (cont.)** *Extent to which the conclusions follow from the analysis* It is difficult to discern whether there is sufficient evaluation in the report to support the statement "The Panel has strong reservations that KBRA, even if fully implemented, will address all these conditions to the extent required to meet the goals of the program" (p.9). Without the benefit of fully understanding the restoration strategies planned in the KBRA, it is very difficult to tell from the Panel's report whether this conclusion is correct. Some additional specificity on the KBRA strategies, and why the Panel doubts their potential for success would be helpful. As it stands, the Panel's assessment of likely KBRA strategy success is only supported with relatively simple explanations, rather than specific, detailed rationale.	The report has been revised in response to this comment. Details of KBRA were not provided to the Panel so its effectiveness was not possible to determine. In addition, habitat rehabilitation efforts do not consistently lead to substantial increases in survival and abundance of salmon.

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20			**Soundness of Conclusions (cont.)** *Does the document represent "sound science"?* To the extent that the Panel members possess an impressive array of background scientific expertise and excellent credentials, their work is based on sound science. Many of the statements made were supported by citations and references to other works (while others were not). However, because of limitations on the Panel's time allowed for their work, there are cases where deeper investigations could have potentially elucidated more comprehensive and detailed responses to the questions posed.	This comment is noted.
21			**Soundness of Conclusions (cont.)** There are some instances where statements or recommendations do not appear to be fully substantiated by supporting scientific or other documentation. For example, while I would surmise that the Panel is correct, the recommendation: "Furthermore, the refuges should be managed for fish and wildlife versus agriculture if the basin management objective is rehabilitation of fish species." (p. 15), seems to made without any explanatory or substantiating language or citations. In some cases, the lack of substantiation primarily results from a tendency to not cite the sources supporting definitive statements, such as "The current escapement floor for Klamath Chinook salmon is 35,000 fall Chinook salmon spawning naturally in the basin." (p. 21).	This comment is noted.
22			**Soundness of Conclusions (cont.)** *Strengths and limitations of the overall product*. The primary strength of the Panel's report is its synthetic approach to evaluating the overall hypothesis based on voluminous, although uneven, available information and to do so within significant time constraints. The limitations of the report are described throughout this review but can be summed up as uneven and sometimes superficial treatment of important topics. Regardless, the Panel's report represents a significant contribution	This comment is noted. The Panel spent considerable time beyond its allotted budget to prepare the report and respond to 142 pages of comments. Unfortunately, it was not possible for the Panel to interpret

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			to Klamath Basin Chinook salmon restoration. Incorporation of reviewers' comments should make it even more useful.	inconsistent and incomplete information while also writing a polished report in such a limited time frame.
23			**Editorial Comments and Suggestions:** 1. The methods and nomenclature for addressing the questions posed to the reviewers is confusing in the report. The Table of Contents and the Section 2 headers indicate parenthetical reference to questions C-1 to C-15 and G-1 to G-10. These references are not clearly explained on page 11. Also, Appendix C contains two sets of questions but the reader is not easily guided to the two sets: one with general questions, and another set with Chinook specific questions.	The report has been revised in response to this comment. Additional clarification has been added to the report text and Appendix B.
24			**Editorial Comments and Suggestions (cont.)** 2. Item number 2 under the Proposed Action on Page 8 should be more accessible. It currently cites Stillwater Sciences 2010 and Barry 2010. However, since these restoration measures are integral to consideration of the effectiveness of the proposed action, they should be listed in an appendix to the Panel's report.	The suggestion to list these two documents in the appendix is appreciated; howevever, the Panel has elected not to do so because of their length. Both documents are readily accessible and readers are encouraged to obtain them for further information.
25			**Editorial Comments and Suggestions (cont.)** 3. It is curious and unusual, although not particularly detrimental, that the Panels' conclusions would be found newer the beginning of the report (page 11) rather than at the end, where conclusions are normally stated based on all the foregoing observations and analyses in such a report.	This comment is noted.
26			**Editorial Comments and Suggestions (cont.)**	This comment is noted. The

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			4. I note, in Section 2.3, Scientific Leadership, an appeal for Adaptive Management (AM). A current excellent example of a large-scale ecosystem restoration program that is incorporating AM, is the Puget Sound restoration program (Puget Sound Partnership). Although not using the term AM directly, there is a concerted effort to use performance measures, recovery indicators, and feedback mechanisms as the program progresses. See http://www.psp.wa.gov/pm.php for more info and examples on this. It may be an important citation for the Panel's report.	reference provided by this reviewer is appreciated.
			Editorial Comments and Suggestions (cont.) 5. The Section 2.5 title is potentially mis-labeled. The title "Lower Basin Colonization, Reproduction, and Harvest" is inconsistent with the description of Condition 5, just below: "Chinook salmon must be sufficiently abundant after escaping the fisheries to colonize all habitats including newly accessible habitat." (p.21). The former refers to the lower basin and the latter refers to the entire basin.	The report has been revised in response to this comment. The text has been clarified.
Peer Reviewer No. 2				
27			While the report is a concise summary of the Panel's considerations, I found the document difficult to review. As such, I expect the intended audience for the report will not fully appreciate the advice provided by this panel. My concern stems from three primary issues:	This comment is noted.
28			1) Lack of sufficient background information for an independent review or material provided to the Panel that was cited but not available to reviewers (see Proposed Action, page 8). While two maps were included, I had to search out the recent returns of Chinook salmon and encountered several terms used in the report that needed to be defined (e.g., use of River mile for locations, without any indication on the maps, and use of "Upper Basin" without any description of what areas are included, etc.). Most notably, there is no basis for the ~10,000 natural spawners as being a	The terms Upper and Lower Basin are familiar terms for the agencies and stakeholders. As stated, a higher number would only have made the conditions for success more difficult to attain.

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			"substantial" benefit of the actions. Footnote 1 does briefly discuss this value but given the extensive uncertainty discussed throughout this report and extent of the Proposed Action ... this measure of success seems very modest in a watershed of this scale.	
29			2) Lack of apparent consideration of Part 2 of the Secretary's consideration ("is in the public interest"). The Panel apparently equates the "substantial" (Footnote 1) change in Chinook returns (measured as number of natural spawners) as a measure of the public interest ... but that is clearly more directly a measure of the Chinook restoration objective and many other metrics could be used as a measure of public interest. Since public interest will involve considerations beyond the scientific assessment, it is quite possible that the second portion of the Secretary's consideration was not part of this Panel's deliberations. If so, that should to be clearly stated early in the report.	The Panel felt that increased salmon numbers are in the public interest.
30			3) Difficulty in identifying arguments that clearly support conclusions of the Panel. While the Panel concludes that objectives in the Klamath River basin would be better met through the Proposed Action than by maintaining the Current Conditions, it is surprisingly difficult to find statements that clearly support their conclusion. When a statement is made, it is frequently accompanied with concerns for significant levels of uncertainty in their assessment. Uncertainty in outcomes is a reality in ecological restorations of this magnitude but I am left with a sense of over-whelming levels of uncertainty in this action ... and that sense returns me to concerns about how to define the best public interest, and how decisions should proceed. I strongly support the Panel's comments in Section 2.3 Scientific Leadership and the role of an adaptive management approach; including targeted research and monitoring to assess interim goals set within an adaptive management framework.	The report has been revised in response to this and other comments.
31			My other general comment relates to the list of ten conditions for success.	The Panel has elected to not

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			While I agree that each of the conditions has merit, I don't believe that each is of equal concern, which is implied by a list. Nor, do I think that the ten issues will function independently. In an advisory document such as this, I would certainly prefer that the conditions be prioritized, the conditions should be linked when such interactions are anticipated, and if impacts are highly likely then remedial actions could be suggested. Why climate change would be eighth in the list is beyond me; unless the Panel did discuss prioritization and determined that the Proposed Actions would reduce the impact of climate change relative to the Current Condition ... I would agree that this is quite likely. But underestimating or stating the potential impacts of climate change on the Proposed Action would be a significant error in my opinion.	prioritize the conditions (factors).
32			**<u>Comments by Conditions in Section 2</u>** 2.1 Water Quality: My assessment of this section is that the proposed actions fail on the issue of public interest. The authors present strong doubt and uncertainty that water quality issues will be resolved and express a lack of confidence in the actions; concluding that they are "concerned by what may be an unrealistic view of the prospects for remediation ..." (page 14). In the last paragraph, page 13, I was confused by the calculations of wetland area needed as I did not see any consideration of the 47% reduction stated on the previous page. If the 47% reduction should not be applied in the calculation, this should be clarified. On page 14, I have serious reservations that "effective shading" alone can provide 190 km of ***optimal*** stream fish habitat; particularly given the information on oxygen and temperatures within the same paragraph.	The report has been revised in response to this comment. Stream shading and lake water quality conditions are different elements.
33			**<u>Comments by Conditions in Section 2 (cont.)</u>** 2.2 Disease: Is the conclusion of this section simply that the anticipated outcomes are very uncertain? I could not determine what the conclusion of the Panel was in this section. In their assessment, is condition 2	The Panel believes that the agencies know the parasite histories, life histories and their effects on survival.

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			achievable? I agree with the concerns identified by the panel, but the section is not convincing that the condition can be met. Unfortunately, the scope of the problem is poorly described for an independent review. For example: a) Is either of the myxozoans new to the basin, and is there evidence of genetic resistance to these parasites? The latter could be critical to success, see: Bower, S et al. 1995. J. Aquat. Anim. Health 7(3):185-194. b) What is the evidence that these particular species "contribute substantially to poor survival of outmigrating juvenile Chinook ..." (page 15)? I would hope there is strong evidence since the panel states that success of Proposed Action "appears to hinge to a large degree on the potential for reduction in disease." c) What is the infective mechanism between the parasites host and juvenile Chinook? The authors suggest three investigations for consideration ... I presume that their first suggestion on epidemiology would address this. I am uncertain about the idea of flushing the host as I don't see why this would not simply displace the problem to a location further downstream. Depending on the answer to the infection question, displacing the host could be sufficient to control impacts.	
34			**Comments by Conditions in Section 2 (cont.)** 2.3 Scientific Leadership: (this section would be better described as scientific process and leadership) Given the depths of uncertainty expressed throughout this report, I fully support the panel's recommendations in this section. After the years of reviews and debate, I am surprised at the remaining level of uncertainty in these questions ... but I expect that is actually strong support for the development of an adaptive management framework to assess future actions within. *I would also suggest that the 4th paragraph, page 17 is a key statement in this report.*	The report has been revised in response to this comment.

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			In my personal experience in applying adaptive management (AM), the common failing is not following the prescribed experimental pathways needed for learning and assessing alternative actions. This commitment needs to be addressed before simply embarking on an AM process.	
35			**<u>Comments by Conditions in Section 2 (cont.)</u>** 2.4 Access to Upper Basin: At this point in the report, I realized that the text does not describe what the Upper Basin actually is (I assumed it to mean above Keno dam), and that I did not appreciate the value of Figure 4 as I didn't know how to place it within the basin (reference to river miles but no means to estimate that from the maps). I would agree that relying on transporting adults under high temperatures and with a known pathogen present is risky and could certainly result in high pre-spawning mortalities. This drew into question just how important Chinook in the upper basin really was to success of the Proposed Action. How many Chinook would be expected to recolonize the area, and if fall Chinook were to be distributed above the lake, do you have any evidence that the juveniles will navigate through the lake with the appropriate timing etc in order to reach the sea? The authors suggest a major program to define Chinook life history before one could really assess this condition. I am again drawn to the question of how important is the upper basin to the restoration of fall Chinook ... it would of course help to actually know the area being discussed (i.e., what is the upper basin?).	The report has been revised in response to this comment. Location clarified in text. Lake currents should suffice as keys for salmon movement through Upper Klamath Lake.
36			**<u>Comments by Conditions in Section 2 (cont.)</u>** 2.5 Lower Basin Colonization, ... : This statement is certainly true but could take longer than just "several years". Initial recolonization could be quite inefficient as new habitat is developed and the Chinook adjust to using it.	This comment is noted. The text already includes this thought.
37			**<u>Comments by Conditions in Section 2 (cont.)</u>**	The Panel was not asked to

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			2.6 Hatchery versus Wild: This issue will lead to some tough decisions. While I am aware of the hatchery and wild literature, the issue to first consider is maintaining genetic diversity within small natural populations. In recolonizing new habitats, you might anticipate some very small local spawning groups that would be at risk of inbreeding effects ... which could well have greater effects on productivity than out-breeding with hatchery fish. This is a condition that we should anticipate problems with restoring the natural spawning populations and plan actions to manage these potential problems. For example: a) A strong recommendation to monitor the genetic variation in the spawning groups. b) If the hatchery is eventually to be closed, why not change the role of the hatchery now to assist recovery? Use the hatchery system (or modify it) to maximize genetic diversity (variation) in juveniles and out-plant them to different habitats. *Do not maintain a brood lines*, but randomly draw parents from the annual return and conduct genetic assessments to maintain diversity. c) I would recommend that all hatchery production is mass marked for assessment of hatchery returns and distribution of these returns.	deliberate on whether a conservation hatchery should be used to assist rebuilding. This is a good question. Ideally, excess spawners from the lower basin would be transported to new areas as necessary. The Snake River basin privides information on supplementation hatcheries and captive broodstock programs (www.fws.gov/lsnakecomplan/). They have been useful for preventing extinction but not for rebuilding natural populations because habitat and survival issues have not been improved.
38			**Comments by Conditions in Section 2 (cont.)** 2.7 Predation: I support the comments of the panel but would strongly suggest that whatever actions are taken should assure that some data on this topic is acquired so you are not reliant upon the model.	This comment is noted.
39			**Comments by Conditions in Section 2 (cont.)** 2.8 Climate Change: Given the comments in previous conditions (previous in text sequence) and levels of uncertainty expressed, I would have little confidence about the “buffer effect of the greater upper basin” (again,	The report has been revised in response to this comment.

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			assuming I correctly understood what the upper basin was). My appreciation for potential climate impacts would certainly suggest that the buffer capacity will be exceeded and I wonder why that is not the approach recommended by the panel. Surely, given all the uncertainties expressed and the potential magnitude of climate change, a more precautious approach is best. I do however agree with the panel's final point (page 24) that the Proposed Actions offers greater potential for Chinook to adjust to climate change than maintaining the current conditions would.	
40			**Comments by Conditions in Section 2 (cont.)** 2.9 Reduced Fall Flows: I would be less concerned about this effect given the projected reductions in temperatures and increases in dissolved oxygen; but that assumes that the reduced flows will not preclude larger areas of spawning and rearing habitats. These are issues that can clearly be monitored and assessed.	This comment is noted. The Panel agrees that this issue probably has less effect on Chinook than other issues, but the assessment reflect recent efforts by the Pacific Fishery Management Council.
41			**Comments by Conditions in Section 2 (cont.)** 2.10 Dam Removal: It is difficult to believe that this condition will be met. My preferred approach to this issue would be to anticipate an impact and develop a mitigation/recovery plan to support the Action over the first few brood years after removal of dams. The plan would be incorporated with sections 2.5 and 2.6 by establishing a program to protect the genetic diversity of the Chinook through intensive genetic monitoring and brood stock management in the first few generations. To proceed with removal of dams and simply assume that the impacts don't have a substantial multi-year effect seems very risk prone and not a sufficiently careful action.	This comment is noted.
42			Sections 3 and 4: Section 3 provides useful comments. I agree with the	This comment is noted.

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			panel that these topics merit further discussion and inclusion. Section 4, I did not really consider as I did not have technical material to review and defer to the panels advice.	
43			My final comment relates to the panel's description of the Role and Nature of the Panel. Their description is useful in explaining the process and likely the product. The scope of past reviews and assessments, of the Proposed Action, and of the potential consequences to the public interest are each huge. These conditions don't seem conducive to a six-day workshop and reporting ... but I may well not fully appreciate the background efforts outside of the workshop.	This comment is noted. The Panel agrees that allotted time for this review was insufficient.

July 20, 2011

Klamath River Expert Panel
Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon
Response to General Comments on the Draft Report dated May 2, 2011
(Addendum to Final Report dated July 20, 2011)

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Comments and Responses Provided in the Final Report dated June 13, 2011				
1	Jon Hicks, Bureau of Reclamation (BOR)	15, 1	Keno Dam was constructed for flood control to relieve flooding caused by a natural rock reef know as the Keno Reef. The Keno Reef held surface water elevations nearly identical to those under dam operations. The entire operations system between the Link River and Keno, including points of gravity diversion, was developed based upon the historic water surface elevations corresponding to the Keno Reef. Water quality modeling has shown no demonstratable differences in water quality between the Keno Dam in place and the historic Keno Reef in place. In addition, Keno Dam remaining in place and the continuation of historical operations is a requirement in the KBRA and KHSA.	As stated, the concern of the Panel mostly involves the migration barrier created by Keno Dam. If Keno Dam and Keno Reef have nearly identical elevations, how does the Dam relieve flooding? Flooding is a natural phenomenon that typically involves wetlands, which the KBRA are purported to increase.
2	Jon Hicks, Bureau of Reclamation (BOR)	15,2	Water quality measurements over the past 15 years have demonstrated that the irrigated land within the Klamath Reclamation Project is a net nutrient sink. The Project returns only about 50% of the nutrients it diverts from Upper Klamath Lake and the Klamath River. Reductions in nutrients from Upper Klamath Lake will have a direct correlation to a nutrient reduction returning from the Klamath Project. Regarding the Refuges: The Wildlife Refuges within the Reclamation Project boundaries are primarily managed for waterfowl. The only recognized species of fish residing in a refuge is the endangered sucker in Tule Lake Sump 1A. This species is protected under a biological opinion through deliveries of irrigation water. In addition, the agricultural lands within the refuge boundaries are operated in accordance with the Kuchel Act of 1964 which recognized the benefit to both agriculture and a food source for water fowl. Elimination of agriculture from the refuges would not provide any additional water to the refuges because their water right claim is junior to the irrigation claim.	It is the Panel's opinion that wetlands remove nutrients more efficiently than croplands; presumably this is one reason the KBRA supports increasing wetland acreage. Somehow the endangered suckers thrived without industrial agriculture and engineered flows. It is the Panel's opinion that naturalizing flows and land uses would aid the endangered suckers.

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3	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	8, two changes, one in each sub-section	There are two types of "interim measures" pledged by PacifiCorp: (a) ICP measures that would be required by the Services under Current Conditions as well as the Proposed Action, and (b) *Non*-ICP measures that only kick in as a result of the KHSA under the Proposed Action. These two types of interim measures need to be much more carefully distinguished from each other in allocating actions to Current Conditions or Proposed Actions. In other words, ICP measures carry over to the Proposed Action but with the ADDITIONAL non-ICP interim measures included under the KHSA, listed in KHSA Appendix D. These additional non-ICP interim measures were unfortunately omitted entirely in the draft text. To prevent confusion, under Current Conditions, Measure 3 should be reworded as follows (new text in italics): "3. Implementation of *ICP* interim measures (PacifiCorp 2008);" Under Proposed Action the text should include (new text in italics, omitted text in redline strikeout): 3. *Implementation of the non-ICP interim measures listed in KHSA Appendix D*; 4. Items 3-9 listed above for Current Conditions. This would make it much clearer that ICP interim measures happen under both scenarios, but additional non-ICP interim measures in KHSA Appendix D also happen but only under the Proposed Action.	The report has been revised accordingly.
4	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 14, 1st full ¶	Discussion of the impacts of seasonal warm water and related water quality changes do not distinguish the likely differences in responses as between fall-run Chinook and spring-run Chinook, both of which historically occurred in the basin in large numbers. It is also well known that the predominant runs in the upper Klamath Basin above the current locations of the dams were spring-run Chinook, whose life-history pattern would be to come in much earlier in the year than fall-run, a pattern that likely evolved precisely to avoid the "bottleneck" poor water quality conditions in UKL identified as of concern in these sections.	This comment is noted.[1]
		Also pg.20, 1st full ¶	The current reintroduction plan intends to repopulate as much as feasible with spring-run Chinook as closely akin genetically to the original stocks from above the dams as possible. Remnant spring-run stocks genetically adapted to upper river conditions do still exist in the Salmon River, and just below Iron Gate Dam, and these are likely very closely akin to the original (but now extirpated) spring-run Chinook runs that existed above the dams – or as close as it is now possible to come to those natal spring-run Chinook stocks now extirpated above the dams with current Klamath stocks.	This comment is noted.

[1] The Panel acknowledged some comments with "This comment is noted" when the comment did not require a specific response or the information presented was already considered by the Panel. A response of "This comment is noted" meant that the comment was reviewed and the information was considered by the Panel; however, no changes were made to the report in response to the comment.

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			The Panel should discuss and more carefully distinguish the differences in potential responses to UKL and upper basin water quality conditions, which worsen in the late summer in fall, as between the two major Chinook life-histories, spring-run and fall run. All Chinook stocks are not the same and would not respond the same way to in-river conditions because of natural differences in adult returning spawner timing of runs. Presumably, the life-history patterns for spring-run Chinook would help them avoid most of the worst of the seasonal water quality and elevated UKL temperatures simply because they come in much earlier when flows are higher, colder and of better water quality than would fill-run Chinook. This is doubtless why the spring-run dominated the upper basin historically. Wouldn't spring-run Chinook, especially if closely matched to the natal genetic spring-run stocks that once dominated the upper basin above the dams, tend to be more successful in recolonizing once occupied spring-run Chinook habitat than fall-run Chinook could be expected to be? Some discussion of this hypothesis, and ways to test it, would be warranted.	The report has been revised in response to this comment. Text modified to state, "especially fall run," and emphasis placed on fall run in the following paragraph as well. This comment is noted. See sections 2.4 and 3.2 for discussion involving issues with spring Chinook. Spring Chinook runs are depleted throughout the California and the Northwest. Low abundance and productivity of spring Chinook in the Klamath will limit recolonization as discussed.
5	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	21, Sec. 2.5	In the oceans, spring-run Chinook and fall-run Chinook have different migration routes and run timings and therefore presumably do not much intermingle at sea, though more information on these life-history differences at sea would be useful to validate this. But assuming that is true, since commercial harvests are geared only to catching fall-Chinook (e.g., starting May 1st in California), it should be relatively easy for fisheries managers to re-set seasons so as to avoid the spring-run Chinook through appropriate area and time restrictions as much as possible. Assuming that spring-run Chinook, which originally dominated the basin above the current location of the dams, are likely to be the stocks that most effectively repopulate the upper basin after dam removal (and spring-run will be the stock of choice for re-seeding), it should therefore be relatively easy to avoid most impacts on recolonizing spring-run Chinook in the commercial ocean fisheries. Some discussion of the need for such an analysis so as to as much as feasible reduce fall-run Chinook fisheries impacts on spring-run Chinook would be warranted, with any recommendations for further research likely to affect PFMC research decisions. This ability to selectively separate fisheries impacts on different runs of Chinook is much less true in the case of Tribal in-river net fisheries, and some recreational fisheries, some of which also catch spring-run. However, those impacts should be readily controllable by Tribal Fisheries Department regulation, and by State Fish and Wildlife agencies.	This comment is noted. Suggestions are beyond the scope of effort of this Panel.

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6	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pp. 21-22, Sec. 2.6 (hatchery fish impacts)	The Draft's comments on hatchery and wild fish interactions, and the poorer survival rates of hatchery-origin fish vs. wild stocks is generally true, but needs to be adapted in the discussion to the specific circumstances of the Klamath Basin, where hatchery fish are much less a component of overall Chinook populations than in many other basins such as the CA Central Valley and the Columbia. Also, Iron Gate Hatchery broodstock now come primarily from Klamath natal wild stocks so as to minimize genetic dilution, a practice which should become clear policy and which should be mentioned in your comments as a high priority for future hatchery management to prevent some of the genetic dilution problems the current text indicates can occur. CDFG calls all fish not actually breeding in a hatchery "natural" fish, even if its ancestry lived in hatcheries, rather than "wild" to take into account the fact of continuing circulation of stocks and genetic strains between hatchery and wild habitats. However, this lack of distinction also can also mask declines of truly wild stocks. Iron Gate Hatchery has not raised spring-run Chinook for many years, and raises only fall-run today. Spring-run Chinook, which are better adapted to upper basin conditions, simply did not do well in the lower river to which they are now confined. Also, it is uncertain whether or not Iron Gate Hatchery will be maintained once it is transferred to the State of California in 2020 under the Proposed Action, and after the eight (8) year period beyond dam removal under the Proposed Action that PacifiCorp will still be paying for its operations. After that time, the hatchery might well still be maintained if needed to help support recolonization, being phased out as recolonization takes hold. This is a decision that would likely be made based on circumstances at that time, including how successful recolonization has actually been, but which would be no sooner than 2028. It would be very helpful to have the Expert Panel's guidance as to how such future hatchery management should be shaped to maximally encourage recolonization of the upper basin by spring-run Chinook after dam removal, and how and when Iron Gate Hatchery should be actually phased out.	This comment is noted.
7	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pps. 23-24, Sec. 2.8 on Climate Change	Some additional but very important positive benefits from the Proposed Action were ignored in the Draft, and should be discussed in much more detail, including: (1) A 330,000 acre-feet future "diversion cap" will be imposed by the KBRA on future Klamath irrigation Project Irrigation demand, as a future water right limitation which does not currently exist. See CHART 1 attached. This "diversion cap" is especially important in reducing Irrigation Project diversions in lower precipitation years (in which the Irrigation Project typically used more water than average in the past because the soil moisture was already low), and this dry year diversion reduction will help a great deal in buffering the impacts of future droughts on the lower basin flows and its salmon populations.	This comment is noted.

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			(2) Positive impacts of dam removal because the late summer and fall water temperatures in-river are expected to be reduced in the future below current September highs by elimination of the huge "heat sinks' of the slack-water reservoirs behind the dams, which now heat water flows downriver. Right now September in-river water temperatures can and do hit more than 20^{o} C., which are threshold levels at which juvenile salmonid mortalities are greatly increased.	Presumably, UKL and KR will remain as large bodies of warm, enriched water with low DO.
			(3) High water temperatures coupled with very low late summer water flows in the river below Iron Gate Dam were among the major causation triggers identified by CDFG for the 2002 adult fish kill, which happened in September of 2002 (see CDFG 2004, *September 2002 Klamath River Fish Kill: Final Analysis of Contributing Factors and Impacts,* available among other sites at: www.pcffa.org/KlamFishKillFactorsDFGReport.pdf. Under the Proposed Action, however, water temperatures in the Klamath River below the dams in future Septembers would be reduced (i.e., the hot water reservoirs would be gone) and more water would be available for fish (especially in dry years), due to the KBRA "diversion cap," for augmenting flows to the lower river in future Septembers. This combination of higher *and* colder September in-river flows under the KBRA would make future fish kills such as occurred in September 2002, much less likely to occur, as verified in the KBRA "White Paper" (Hamilton, J., Hampton, R, et al. (2010) in your Bibliography). *Reducing the risk and frequency of future major adult spawner fish kills such as occurred in September 2002, would seem to be a major benefit of the Proposed Action with KBRA, but is not even mentioned in the Draft text.*	Presumably, UKL and KR will remain as large bodies of warm, enriched water with low DO.
8	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 24, Sec. 2.9 (reduced fall flows)	Reducing fall Iron Gate Date target minimum flows (which of course may not be actual flows in a flood flow stage if there is high winter rainfall) is an important operational change to the hydrology of the basin that provides a much-needed offset to fish mortality by allowing higher-volume spring "flushing flows" than currently are deliverable by: (1) making sure sufficient water is stored in UKL early on in each water year to make sure that, *even if the following water year is a very dry/critically dry year,* we have maximized water reserves for fish early on, and (2) by providing higher spring flushing flows for fall-run Chinook juvenile outmigration, we can flush those juveniles to the estuary faster and earlier in the spring, so as to miss most of the major outbreaks of *Ceratomyxa shasta* spores which peak in their concentrations early and mid-summer when in-river water temperatures increase rapidly. *C. Shasta* is much more virulent, while juvenile salmon are more stressed and thus more vulnerable to infection, in warmer waters than in cold. In other words, it is presumed that, by saving enough water in the winter to be flushing more juvenile fall-Chinook smolts out earlier in the spring time, before the emergence of most *C. shasta* spores, we can greatly decrease juvenile infection rates (and thus mortality) from this warm-water triggered disease. This is why some spring flows projected in the KBRA and in the Coho BiOp (which are based on the same updated science) are slightly higher than Hardy Phase II Study flow recommendations, and why Dr. Hardy approved these operational changes as beneficial for fish. But to make that happen, in the annual zero-sum water game in each water year, one has to set aside that water from the winter flows by reducing flows below Iron Gate Dam in the winter so as to maximize storage as quickly as feasible in UKL. If we did not do that early on, and then went straight into a major drought year, we would have allowed too much water to flow downriver in the winter and early spring, and then be caught short with too little UKL storage to provided flow benefits to the	The 330,000 af of water guaranteed to agriculture seems contrary to spring flushing flows, at least in dry winters. The logic about the reduction of infection seems sound, and the entire issue of infection warrants a careful analysis including modeling and experimental work. If substantial changes in water temperature and flows that affect this process can be reasonably anticipated, these changes should be brought into the analysis. As the situation now stands, there are too many disconnected pieces of the puzzle to come to a solid conclusion. Furthermore, this particular aspect of the disease problem was not brought to the Panel's attention before. As for the holding back of winter flows, this is an operational detail that did not appear in the information on KBRA that the Panel received.

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			salmon in the spring, including the higher spring flushing flows to improve juvenile fall-run Chinook survival rates in-river. This additional benefit of holding back winter flows to assure that we have enough water "in the bank" in the form of storage at UKL, to provide beneficial fish flows even in a drought year, should also be discussed as an offsetting benefit to compensate for any reduced productivity due to lower winter Oct. – January. This sort of fish mitigation and enhancement action would only be possible under the Proposed Action, through the KBRA.	
9	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 24, Sec. 2.10	Iron Gate Dam also traps natural spawning gravel that would otherwise contribute greatly to lower river spawning and rearing habitat. That reach below Iron Gate Dam is, according the FERC FEIS, severely gravel-deprived for nearly 50 miles downriver until natural gravel accretion from tributaries and natural erosion can in-fill these losses. This offsetting positive impact of dam removal and the release of trapped sediments should therefore also be discussed, i. e., the restoration of spawning gravel to current highly gravel-depressed areas in the reach up to 50 miles below Iron Gate Dam will likely increase spawner success within this 50 mile reach as fines from dam removal clear the waterways, helping to make up for prior sediment-related population losses more quickly.	This is likely true, but the sediment analyses from the reservoirs reported small amounts of spawning gravels. The Bureau of Reclamation (Greimann et al., 2011) show that the effects of dam removal on bed material gradation, bed elevations, and magnitude and frequency of bed material mobilizing flows only extend downstream from Iron Gate to Cottonwood Creek a distance of about 7 miles.
10	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 27, Sec. 3.1	The statement is made in the Draft (last line of this section 3.1) that "The Panel notes that the flow regime under the Proposed Action is still far from what unimpeded flows were in the past." While true, this statement is less than informative as to any *improvements* from one option or the other. The question should also be answered whether, under the Proposed Action, the resulting flows would be CLOSER to unimpeded flows than under the Current Conditions, or further from them. In other words, will the rehabilitation (including dam removal) measures in the Proposed Action get us closer to the historical hydrology of unimpeded flows, or farther from it? And would getting closer to unimpeded flows (i.e., more "normative" flows better mimicking the natural hydrology Chinook salmon evolved with) be better or worse for Chinook salmon populations in the river generally?	The rest of the paragraph in the report from which this sentence is taken addresses this comment.
11	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 28, Sec. 3.3	The conflict between upper basin and lower basin Biological Opinions (BiOps) is between suckers and coho salmon, not between suckers and Chinook salmon, as stated, implying that Chinook are ESA listed. Chinook salmon are not ESA-listed in the basin at this time. While Chinook have *similar* water needs to coho, they are not quite the same. Coho also mainly occupy and in habitat tributaries such as the Scott and Shasta in relatively large numbers, where they would not be affected in any major way by dam removal except as they migrate to and from the estuary into those tributaries in the lower river.	As stated, the suckers benefit from retaining more water in Upper Klamath Lake; Chinook salmon benefit from flushing flows. Those are contrary goals.
12	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 28, Sec. 3.3	The Draft text categorically states the following: "The current Biological Opinion [presumably the Coho BiOp] reserves more water for fish than that offered under KBRA." I would be very surprised if that were in fact true, at least in many years. At best it is a gross oversimplification of a complex situation and should be qualified in a number of ways to be accurate. As opposed to Current Conditions, in which the BiOps are presumably currently being met, the Proposed Action (specifically the KBRA once implemented) provides several *additions* to the current	Text revised to specify "more water for suckers" rather than fish in general, and to acknowledge that there is uncertainty with the Biological Opinions and possible outcomes include more water being available under the

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			in-river water supply that can be used to augment current flows to the lower river salmonids. These water additions to in-river flows are generated several ways under the KBRA, including: (1) *permanently* capping future Klamath Irrigation Project irrigation water demand at (330,000 acre-feet to 385,000 acre-feet, depending on the water year UKL inflow exceedences), which is much less than the maximum the Project has historically used in dry and drought years, thus reducing Irrigation Project water demand by nearly 100,000 acre-feet in these dry years, and thus providing the Klamath Irrigation Project less water than allowed under the current Coho BiOp in many years (see discussion below and CHART 1 attached); (2) reduces upper basin off-Project irrigation demand by about 30,000 acre-feet; (3) providing for additional wetlands storage of water to then be made available as "environmental water" for fish of nearly 100,000 acre-feet (see KBRA Sec. 18) through various wetlands restoration projects required in the KBRA. Thus the KBRA would *add up to 230,000 more acre-feet (AF) of water to the system* [i.e., up to 100,000 AF from reduced Project demand, plus 30,000 AF from reduced off-Project demand, plus up to 100,000 AF from additional stored water in projects required by the KBRA] than currently is available. If, as appears to be the case, the Coho BiOp flows are being met now, and then one adds up to *an additional 230,000 acre*-feet of water under the KBRA, it is self-evident that, at least in water years like the current one, the KBRA-required flows will be considerably greater than those minimum flows required by the ESA alone. Also, if you look over the record of the past 10 years or so and compare the KBRA "diversion cap" versus the ESA BiOp minimum water flow targets for fish, it is true that the ESA required MORE water conservation [i.e., left more water left in UKL and the river for fish] than the KBRA alone would have done in *some*, but not *all* years. For instance, ESA BiOp constraints required LESS water to be delivered to the Klamath Irrigation Project than the KBRA "diversion cap" alone would have allowed in years 2001, 2003, 2004, 2005 and 2010, but also the Irrigation Project was able to get MORE water to meets its irrigation demands under the ESA alone in years 2002, 2007, 2008 and 2009 than would have been allowed it under the KBRA "diversion cap." This comparison was developed by comparing the KBRA "cap" amounts to the Project Operations Plans water diversion targets for each year available at: www.usbr.gov/mp/kbao/operations_planning.html and from Bureau of Reclamation online archives. [Note: the Operations Plans are projected uses for the Klamath Irrigation Project, so should be compared to the actual record of usage to tighten up the numbers above, but those projections are targets that are generally closely met each year through BOR Irrigation Project flow and intake controls, so they provide a good estimate or actual use.] So it is a very great over-generalization to say that the ESA provides more water for fish than under the "diversion cap" of the KBRA. This would only be true in some, but by no means all, years. It is definitely not true in most drier years, where the KBRA "diversion cap" makes the most difference to the fish. This error and over-generalized statement should definitely be corrected.	Proposed Action.

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			There have been strong statements made by, among others, the Hoopa Tribe that in fact the KBRA "diversion cap" does not hold back sufficient water from the Klamath Irrigation Project to meet minimum ESA BiOp needs for fish, but the Hoopa Tribe analysis is seriously flawed and has been completely refuted by subsequent analysis by the Yurok Tribe. It is also irrelevant, since it is the ESA – not the KBRA – that determines the minimum flows for ESA-listed coho in the lower river in any particular year. The KBRA cannot trump federal law. Hence whether the ESA applies or the KBRA applies, the limitation that requires the MOST water for fish (and the least for the Klamath Irrigation Project) will prevail in each particular water year. Both must work together. So long as there are ESA-listed fish in the system, the ESA BiOps have the force of law insofar as minimum UKL water levels and lower river minimum flows for coho salmon are concerned.	
13	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	General comment throughout	The Panel's analysis needs to distinguish more clearly between likely spring-run and fall-run Chinook responses to various environmental and water-related factors. This is only clearly done in Sec. 3.2. Because of differences is run and spawning timing the responses of these two major Chinook runs would be different in response to many in-river environmental factors. These differences should be more carefully delineated throughout the document. When the complex life histories of Chinook salmon are only referred to as "Chinook," but without distinguishing in any way between fall-run and spring-run Chinook, important differences in life-histories and likely differences in response to environmental factors in-river are *de facto* ignored. Also, the question should be asked as to what is the value of greatly expanding habitat areas for spring-run to the overall genetic diversity of Chinook as a whole species in the basin? What impact do the Current Conditions have on truncating the natural genetic diversity of these runs, so that today the fall-run Chinook is the only remaining strong run? Even though fall-run Chinook are highly dominant in the basin today, would that not change once the dams are down and access is once again available to what was largely spring-run habitat above the dams? Wouldn't a restoration of the original genetic diversity across the Chinook species in the basin be beneficial to its sustainability and future survival? The Panel draft should also discuss the impacts of the Current Conditions and Proposed Act on these genetic diversity factors.	This comment is noted. The Panel is not optimistic about resurgence in the abundance of spring Chinook as suggested here. Spring runs are depressed throughout the Northwest and California, including areas without dams. Very little quantitative information was provided to the panel about spring Chinook salmon in the Basin. Spring Chinook was discussed in its own section.
14	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)		Missing key study in your Bibliography: CDFG 2004, *September 2002 Klamath River Fish Kill: Final Analysis of Contributing Factors and Impacts,* available among other sites at: www.pcffa.org/KlamFishKillFactorsDFGReport.pdf. Several of the measures required in the KBRA, in particular the 330,000 acre-feet Klamath Irrigation Project "diversion cap," and the various measures to reduce overall late summer and fall water temperatures (including elimination of the warm-water "heat sinks" of the reservoirs with dam removal) are crafted specifically to make such adult fish kills as occurred in September 2002 much less likely. (see above discussion in comment 5). In this light, the omission of this key study from the Panel's Draft Bibliography, and failure to include any references in the discussion in the text to having considered its conclusions, is a bit startling. The 2002 fish kill was the most dramatic biological collapse in the Klamath in living memory, history or Tribal oral tradition (which goes back thousands of years), and many of the rehabilitation measures in the KBRA are directed toward preventing such system-wide fish stock collapses in the future. It was	The Panel did not receive that document among the ~3GB of materials provided, although we did receive the Yurok tribe's report on the fish kill. The Panel was aware of the fish kill and some of the information surrounding its causes.

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			one of the references cited in the January 5, 2011, document *Questions for Expert Panel on Chinook Salmon in the Klamath River Basin,* and if it has not already been, should definitely be considered by this Panel.	
15	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	General	One major topic that is missing or inadequately addressed in the Draft Report is the impact of the Proposed Action (both dam removal and KBRA water augmentations) on lower river Chinook populations, i.e., those that are and will continue to be spawning and rearing below Iron Gate Dam. We believe that the populations of Chinook spawning and rearing below Iron Gate Dam would likely respond positively (i.e., increase in numbers) through the Proposed Action for at least the following reasons: (1) Increases in average flows to the lower river though a combination of (a) the Klamath Irrigation Project “diversion cap” water demand reductions which will provide up to an additional 100,000 acre-feet of water left in the river in dry years as compared to historic Project usage of 1961-2000 (see CHART 1 in prior comments); (b) reduction of water demand by an additional 30,000 acre-feet in the off-Project lands (KBRA Sec. 16.2.2); (c) while not “new water,” making available up to ~100,000 acre-feet of additional stored water from winter flow flows, to use for fish protection during other seasons, to be captured in the various new wetlands water storage projects required under KBRA Sec. 18.2. These flow augmentation impacts have been analyzed somewhat in the KBRA synthesis “White Paper” (in your Draft Report Bibliography as Hamilton, J., M. Hampton, R. Quinones, D. Rondorf, J. Simondet, and T. Smith (2010), *Synthesis of the effects of two management scenarios for the Secretarial Determination on removal of the lower four dams on the Klamath River.* However, there is no discussion of this White Paper in the text, nor any consideration of how the flow augmentation provisions of the KBRA would impact lower river Chinook populations ASIDE from, and likely prior to, dam removal itself. (2) The longer-term beneficial effects of dam removal itself (i.e., after initial sediment surges that will occur immediately after actual physical dam removal have settled down) on the lower river ecosystem and on Chinook spawning and rearing habitat, including: (a) reduced temperatures in the late summers and fall, reductions from the very high baseline temperatures today which especially impact fall-run Chinook; (b) improvements in various other water quality parameters related to water temperatures, such as DO, pH, percent ammonia, fewer high temperature diurnal “spikes” that would tend to be of shorter duration, etc., that would all tend to improve with reductions in summer-time and fall average temperatures and the restoration of a free-flowing river where there are now only heat-sink reservoirs; (c) restoration of natural spawning gravel and future gravel recruitment in the currently highly gravel-starved river reach as much as 50 steam-miles below Iron Gate Dam; (d) elimination of much or most of the current *Mictocystis aeruginosa* infestation, which is averse to fast flowing waters, and which generates microcystin toxin that bioaccumulates and has already been found in tissue lower river salmonids and invertebrates, and which may adversely affect Chinook survival over the long-run; (e) a greater “scouring” capacity in river reaches below Iron Gate Dam (because of reintroduction of gravel in currently gravel-poor reaches after dam removal) and thus potentially more capacity for annually scouring out current “hot spot” infestations of the	2c. See previous comment on the downstream sediment impacts of dam removal. 2e. Scouring by sand size particles is likely to be more effective since the sand is mobilized more frequently then the gravels and the sand is transported within the water column whereas the gravel is going to be transported along the bed. 2f. While there may be potential for beneficial channel alteration as a result of an increased sediment load the extent of the benefit will be controlled by local hydraulics and sediment transport capacity. Therefore, no reach wide benefit can be assumed. See also the discussion in the panel report on the small differences in flows likely between the two alternatives.

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			freshwater polychaete for *Ceratomyxa shasta* – thus at least in theory reducing juvenile Chinook mortality from *C. shasta* in bottleneck areas where it is now alarmingly high; (f) with the restoration of a more normal gravel and sediment loads, plus resumption of normal sediment recruitment mechanisms (i.e., sediment will no longer trapped behind dams), the rebuilding of some of the normal sinuosity and back-channel stream habitat areas where Chinook spawn and rear – i.e., in other words, improved spawning and rearing habitat in areas which are currently gravel and sediment impoverished. There may be other positive impacts on Chinook survival rates from dam removal in addition to the above. In short, there should be detailed discussions on the benefits of the Preferred Action on ALL Chinook populations, at all locations in the river, not just a focus on recolonization efforts above where the dams are today. We cannot get an accurate picture of the full impacts of the Proposed Action unless both upper and lower impacts on Chinook are delineated in detail.	
16	Glen Spain, Pacific Coast Federation of Fishermen's Associations (PCFFA)	Pg. 21, Sec. 2.4	ADDITIONAL COMMENTS AND CLARIFICATIONS: There is, at this very early stage in the planning for restoration of Chinook runs to the upper basin under the Proposed Action, no real way to know what changes this Chinook reintroduction might imply as necessary to current fishery management practices as we know them today. Much of this may depend upon whether fall-run Chinook, spring-run or some hybrid mix of Chinook runs ultimately recolonizes the upper basin (assuming they can in fact succeed in doing so) and in what numbers and how quickly they reestablish, the times it takes them to reestablish, and how those newly seeded runs differ genetically and in their life-histories from lower river fall-run Chinook.	This comment is noted.
			And while there is certainly a correlation between strong spawner escapements and returns of adults from that year's young three to four years later, it should be acknowledged that its correlation is not all that strong. Several times in the past there have been very large spawner returns in the Klamath arising from very small prior adult spawner escapements, i.e., the so-called "power broods." It is likely that ocean conditions, then-unrecorded *C. shasta* outbreaks, and annual changes in in-river carrying capacity from multiple environmental factors (some affected by the dams) are major confounding intervening factors that make assuming a straightforward correlation between initial spawner escapement size, and success of that future generation in terms of later returns, rather perilous.	This comment is noted.
			Thus while it is generally true that "in the short term, harvest under Current Conditions could be higher than under the Proposed Action," as the Panel notes in its Draft, this impact is certainly not a given, and such temporary restrictions as might one day be necessary on existing harvests of Klamath fall-run Chinook could be greatly mitigated and reduced, especially if the Reintroduction Plan and Monitoring Plans under the KBRA included better ways to distinguish between the stocks that are recolonizing the upper basin (which may be largely spring-run Chinook instead of harvestable fall-run), and those already well established Klamath stocks contributing significantly to fall-chinook harvests in the lower river and oceans.	"Could be higher" does not mean "will certainly be higher." The Panel responds that it was difficult enough to assess likely first-order effects.
			To help fisheries managers to control unwanted harvest impacts in the future on these upper basin recolonizing stocks, it would be very helpful for the Panel to go into much more depth here in this Section on its recommendations on what scientific information should be collected, and what monitoring should be done, to better distinguish between relatively abundant existing lower basin	This comment is noted. The Panel was only allocated one day of effort each to respond to comments. Although the panel made some recommendations,

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			fall-run Chinook stocks typically available for some controlled harvests, and those stocks that may temporarily need to be (at least until reintroduction is reasonably successful) protected from harvest impacts as much as practicable to allow them to rebuild. Those recommendations would be most helpful to state and federal fisheries managers, to those who will develop both the KBRA Reintroduction and Monitoring Plans, and to the PFMC in crafting better analytical tools that could be needed after 2020 to minimize any adverse impacts or additional restrictions on in-river Tribal, recreational and ocean commercial harvests of fall-run Chinook -- as well as to minimize adverse impacts on recolonizing stocks while still fragile.	further effort by the panel to generate additional recommendations has gone into as much depth as time and budget allow. Designing an effective monitoring program is far beyond the limited Panel's scope, and those of us who have been involved in such efforts know the tremendous effort, local knowledge, and outside review required.
17	D. Chesney	Appendix D D-15 paragraph 4	Details on methods used for escapement estimates used in the megatable (weir counts, carcass surveys and redd counts) can be found in: Klamath River Fall Chinook Salmon Age-Specific Escapement, River Harvest, and run Size Estimates, 2010 Run. Klamath River Technical Team, 24 February 2011. These reports are released yearly and are available on pcouncil.org.	The Panel did not have the time or budget to research to the extent needed the details of these data. They were included to illustrate the comments of the Panel and were included for illustrative purposes.
18	Resighini Rancheria	Page 28, Section 3.4	The Resighini Rancheria agrees with their findings that the KBRA is not likely to succeed in abating water pollution problems and that re-establishment of Chinook salmon runs to the Upper Klamath Bain is likely to be confounded. The Chinook Expert Panel states that their professional judgment is that chances for KBRA success are low (emphasis added): "The documentation and analyses of the likely composition of the KBRA presented to the Panel to date are insufficient to determine if KBRA can adequately address the listed conditions (Section 2). Based on the Panel's past experiences with large rehabilitation projects in other systems, the stream rehabilitation literature (e.g., IMST 2006; Roni et al. 2008), and increased uncertainty of KBRA funding, ***the Panel has strong reservations that KBRA will be implemented with sufficient effectiveness to achieve its stated goals."*** (Page 28, Section 3.4)	This comment is noted.
19	Resighini Rancheria	Page 12, Section 2.1	**KBRA Actions Insufficient to Solve Water Quality Problems** The Chinook Expert Panel notes that phosphorous often limits plant growth in aquatic systems, but is not limiting in the Klamath River because it is supplied by Upper Basin volcanic terrain. They point out that nitrogen fixing blue green algae (cyanobacteria) created extremely enriched conditions and nuisance levels of aquatic plant growth that elevate ammonium and pH and depress dissolved oxygen (D.O.) levels, all fo which can be harmful to Chinook salmon. "This problem is particularly acute in Keno Reservoir, where additional loading of low-quality agricultural drain water combined with an annual die-off of cyanobacteria to produce a region of persistently low D.O. during the summer and fall. All of these effects are exacerbated by high summer-fall temperature and sediment oxygen demand in Keno Reservoir." (Page 12, Section 2.1) The Chinook Expert Panel used U.S. Geologic Survey (2011) D.O. and termperature data to show water quality problems in Keno Reservoir at Miller Island in 2005 (Figure 1). The Washington Department of Econogy (WDOE 2002) reports that chronic D.O. levels of less than 3.0-3.3 mg/l are lethal to Chinook salmon and that adults avoid areas of less than 6 mg/l. Figure 1 is annotated with	This comment is noted.

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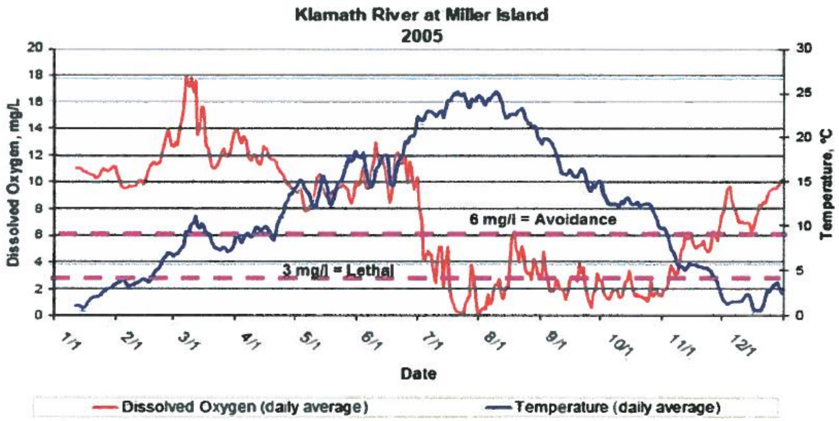
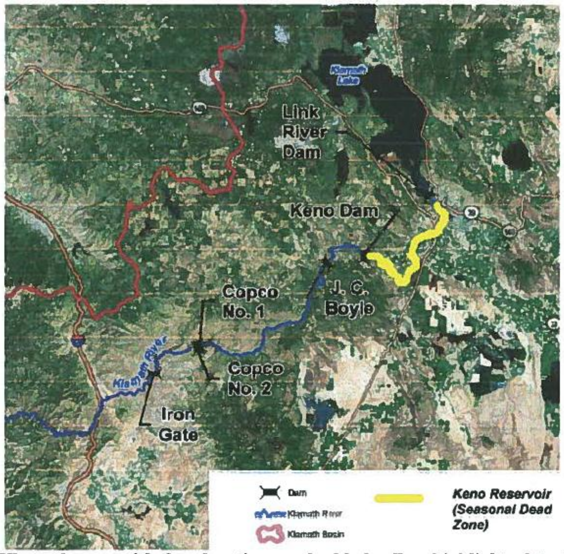
			these references and clearly shows fluctuations below the lethal level for months at a time in 2005. Thus, passage of adult Chinook slamon through Keno Reservoir is highly unlikely unless nutrient pollution is reduced. As pointed out in comments on the coho-steelhead Expert Panel report (Higgins 2011) and on the KBRA Draft Drought Plan (Resisghini Rancheria Tribal Council 2011), significant quantities of nutrients coming from publicly owned lands in the Tule LAke and Lower Klamath Lake National wildlife Refuges contribute to anoxia in Keno Reservoir.  **Figure 1. This chart shows fluctuations of water temperature and dissolved oxygen in Keno Reservoir in 2005 with lethal levels extending from July through October. Taken from Goode et al. 2011 where it appears as Figure 4. Threshold references from WDOE (2002).**  **Figure 2. Upper Klamath map with dam locations and added yellow highlight of the Keno Reservoir denoting the location of Chinook passage problems. From Figure 2 in Goodman et al. (2011)**	

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20	Resighini Rancheria	Page 15, Section 2.1	The Chinook Expert Panel urges consideration of more extensive wetland and lake restoration to recover the Klamath's limnological balance: "Reductions in irrigated agriculture should be considered for evaluation I nlands draining to UKL and the Lost River (including Lower Klamath lake and Tule Lake) for their feasibility to reduce summer and fall nutrient additios from those waters. Furthermore, the refuges should be managed for fish and wildlife versus agriculture if the basin management objective is rehabilitation of fish and species." (Page 15, Section 2.1) The KBRA instead guarantees that the Klamath Project will remain at 200,000 acres and that wetlands and former lake beds in both the Tule Lake and Lower Klamath lake National Wildlife Refuges will continue to be industrially farmed for the next 50 years.	This comment is noted.
21	Resighini Rancheria	19, 3	A major rational for the KBRA and KHSA is the restorageion of Chinook salmon runs in the Upper Basin, but the Expert Panel says that will not likely occur while Keno Reservoir continued to be oxygen depleted for weeks or months a year (emphasis added): "This period (of anoxia) encompasses a significant portion of the migration period for both fall and spring Chinook salmon that might attempt to gain passage to the upper basin. Therefore, a perpetual trap-and-haul program may be needed to provide adult Chinook salmon with access to the upper basin during much of the migration period. ***Without solving the water quality problems, a fully self-sustaining runo f Chinook salmon to the upper basin is unlikely."***	This comment is noted.
22	Resighini Rancheria	15, 6	**Fish Disease Problems May Persist Under the KBRA** The Chinook Expert Panel recognized the current conditions below Iron Gate Dam cause highly favorable conditions for the fish disease organism Ceratomyxa shasta and Mayunkia speciosa, its intermediate polychaete host (Stocking et al. 2006). The cencentration of C. Shasta spores is greatly increased because adult Chinook salmon harbor them and carcasses are concentrated due to the dam and the proximity of Iron Gate Hatchery. The Expert Panel postulates that disease problems may not be remedied because of excess nutrients, but rather the location where they occur may change: "Although several aspects of the Proposed Action could lead to a reduction in disease-related mortality, uncertainty about these aspects is very high. Access by Chinook salmon adults to the upper basin could reduce incidence through dilution of the density of carcasses in any one reach. However, the extent of the reduction is uncertain (partly because of the presence of the Iron Gate hatchery and many carcasses nearby in the mainstem), and this scenario imposes a risk of simply moving the problem to wherever large spawning aggregations occur." The nutrients coming from the highly polluted Keno Reservoir are likely to cause profuse algae blooms in mind gradient streams segments where stream scour is less frequent. Chinook salmon also favor these low gradient reaches for spawning; therefore, mild gradient reaches currently submerged under Iron Gate and Copco reservoirs will likely be points fo concentration for both algae and Chinook slamon spawning, setting up zones for fish disease risk similar to the one currently below iron Gate Dam.	This comment is noted.

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23	Resighini Rancheria	12, 3	Asarian et al. (2010) point out that available nitrogen at the locatio nof Iron gate Dam after removal of Klamath Hydroelectric Project (KHP) reservoirs will increase in the month of July through September by 45-58%. The Chinook Expert Panal acknowledged the potential significance of the increased nutrient load in the Lower Klamath River. "Releaseing these excessive amounts of nutrients to the Klamath River in the absence of the 4 lower dams means that the river, versus the reservoirs, will process the nutrients, perhaps in the form of excessive Cladophora biomass or increased periphyton production down river. These changes could elevate pH, lower night time dissolved oxygen, and cause gas supersaturation during afternoons in local areas. The Expert Panel did not dwell on the fish health effects of increased pH and decreased D.O. on susceptibility of juvenile Chinook to disease, but they are likely to elevate cumulative stress and lower disease resistance in the Lower Klamath River (Hoopa TEPA 2008).	This comment is noted.
24	Resighini Rancheria	Section 3.3 Section 2.2, 4th paragraph	**Concern Regarding KBRA Flows, Climate Cycles and Climate Change** The Chinook Expert Panel expresses concern that the flows under the KBRA will be less thatn those required by the National Marine Fisheries Service Biological Opinion (NMFS 2010) for coho salmon. "The current Biological Opinion reserves more water for fish than that offered under KBRA. Resolving such potential conflicts may trump or substantially alter agreements developed under the Proposed Action and Current Conditions." The principal departure of flows will be reduction in the Lower Klamath River during the winter while Upper Klamath Lake will be maintained at higher levels. Although the latter may benefit sucker species, another major reason for keeping water stored in the lake is its availability for agriculture in the Klamath Project (Resighini Rancheria 2011). As noted in previous comments (Higgins 2011, Resighini Rancheria 2011), we believe that further departure of flows from those with which Chinook and other Pacific salmon species co-evolved will lessen the chances for their restoration and long term survival based on ecological restoration principals (SEC 2004). The Expert Panel did express concern over increased disease risk due to reduced flows in spring under the KBRA: "The predicted shift of several days of higher spring water temperatures (and consequent higher myxozooan infection rates) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigrant success to the degree that it increases disease incidence." The Chinook Expert Panel lists a number of expected changes in the Klamath River Basin as a result of climate change, such as increased air and water temperature, decreased snow pack, reduced base flows, and increased flood flows (rain or snow events). They acknowledge multi-decade long patterns in precipitation due to the Pacific Decadal Oscillation (P.D.O.) that may be exacerbated in the future by climate change. They examined weather records and found precipitation at Keno and Tule Lake during past PDO dry cycles (1927-1936) was 20-26% less than our current wet cycle (2000-2009). This suggests that planning should include reduction in the footprint of agriculture and water demand because future dry cycles will likely be even more extreme.	This comment is noted.

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		Section 2.8	The migratory access to the Upper Basin due to dam removal is referred to as having a buffering effect on Chinook salmon by the Expert Panel, but they express concern that it will be insufficient for populations to be maintained or expanded because of climate change and undiminished agricultural water use under the KBRA: "The buffering effect of greater upper basin access must not be overwhelmed by climate change, or by a climate regime shift wherein drought and continued high agricultural water demands are persistent features." The Resighini Rancheria (2011) shares these concerns because KBRA (Appendix E-5) model runs for future drought or extreme drought years indicate that flows will drop to as low as 442-512 cubic feet per second (cfs) from July through September, when 758 cfs in September 2002 triggered the 70,000 adult salmon fish kill.	
25	Resighini Rancheria	17, 1	**Scientific Prioritization and Adaptive Management** The Chinook Expert Panel did not see a strong linkage between scientific studies in the Klamath Basin and how they would drive management under the KBRA. They are concerned that the KBRA is similar to other large scale programs that are more concerned that restoration "actions themselves are completed, irrespective of their effectiveness." "Panel members have had considerable experience working with large rehabilitation programs, most of which have taken this rather rigid approach, with scientific involvement confined mostely to review panels and ancillary research or monitoring programs. With very few exceptions, these programs have spent large sums of money on actions that were believed in advance to be effective, without a mechanish for actually determining their effectiveness and applying lessons learned to adjust and refine actions. It is no surprise that many of the actions taken under these programs have, in fact, been ineffective." Adaptive management is a process where information is strategically collected to gauge success of a program's activities and subsequent actions are modified based on new understanding derived from study results. Although the KBRA (11.4.3) invokes adaptive management, the Chinook Expert Panel does not believe there is a commitment to it in practice (emphasis added): "Adaptive management has had a mixed record, mainly because of institutional resistance to its proper impelmentation and because many agencies use the term too loosely; the description of adaptive management in the KBRA reflects this watered-down version in which the scientific activities are seen as external to the rehabilitation, and ***the KBRA as written has no provisions for the feedback necessary for adaptation of the program."*** (Page 17, Section 2.3)	This comment is noted.
26	Resighini Rancheria	General	The Chinook Expert Panel recognizes that much more agriculturalland needs to be returned to marsh and lakes than is currently planned by the KBRA, if salmon recovery is to be achieved. They find the prospects of successful re-introduction fo Chinook Salmon into the Upper Basin unlikely because of unabated, acute pollution within the Keno Reservoir. They also express concern that similar conditions to those below Iron Gate Dam that cause frequent disease juvenile salmonid epidemics will occur at other geographic locations because of persistent nutrient problems.	This comment is noted.

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27	Resighini Rancheria	General	Many of the Chinook Expert Panel conclusions are similar to those of the just completed coho salmon and steelhead Expert Panel (Dunne et al. 2011). The Resighini Rancheria hopes that the perspective provided by these imminent experts will materially change the direction of the KBRA and KHSA or lead to their termination.	The Panel has no position on alteration or termination of the KBRA or KHSA.
28	Klamath Water Users Association (KWUA)	ii, 8	The draft report seems to makes assumptions regarding climate change.	This comment is noted. The usual approach to incorporating climate change into analyses is to make assumptions about what changes may occur under climate change into the future. These assumptions are based on extensive analyses done by others, and are, by their nature, highly uncertain.
29	Klamath Water Users Association (KWUA)	ii, 8	What and where does the panel consider as "*continued high agricultural water demands*"? What and where in the panel's estimation is a "*low*" water demand? This statement is subjective and seems to demonstrate a bias against other beneficial uses of water.	The current and proposed demands are considered high. Low demand would be that which would allow full rehabilitation of the sucker and salmon species. This is a bias toward fish (the focus of the review) versus toward agriculture (the current focus of the local economy). The Panel is not making a choice here, simply reflecting on societal choices favoring farming over fishing.
30	Klamath Water Users Association (KWUA)	ii, 9	Please see specific comment (#15) below with regard to fall flows.	See below. As noted, the Panel relied upon modeling data provided by Bureau of Reclamation.
31	Klamath Water Users Association (KWUA)	5, 2	The determination to be made by the Secretary of the Interior is, in essence, whether the removal of four dams is in the public interest. As presented to the panel, the issues also apparently contemplate KBRA implementation. We do not understand that the Secretary will make any specific determination about the KBRA itself when he makes a determination concerning the dams. Regardless, as discussed below, we also have serious concerns about the panel's venturing into areas that are irrelevant to the determination to be made, particularly where this occurs based on an apparent general objection to irrigated agriculture.	The Panel was requested to review dam removal and KBRA implementation as a package. The Panel has no objection to irrigated agriculture. We consume the products from it.
32	Klamath Water Users Association (KWUA)	8, "Current Conditions" #4	The Klamath River TMDL is under reconsideration by the Oregon Department of Environmental Quality.	This comment is noted.
33	Klamath Water Users Association (KWUA)	11, section 2.1, last paragraph	We believe the characterization of the KBRA as providing funding otherwise unavailable for implementation of TMDLs is imprecise. The regulatory TMDL process is just that. Here, the parties seek to improve water quality, recognizing that TMDLs will exist, and we anticipate harmonizing our efforts with the state regulatory processes to the extent that it makes sense to do so.	If more federal money is available, more TMDL recommendations are likely to be implemented.

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34	Klamath Water Users Association (KWUA)	12, first full paragraph	The term "*magnified*" is of concern and appears judgmental. See comments (#8, 10, 11, 14, and 15) below regarding irrigation and water quality.	Agriculture magnifies (increases) natural levels of nutrient loadings.
35	Klamath Water Users Association (KWUA)	12, first full paragraph, third sentence	Currently reads: *"This problem is particularly acute in KR, where additional loading of low-quality agricultural drain water combines with an annual die-off of cyanobacteria to produce a region of persistently low DO during the summer and fall."* From 1998 to 2000, Oregon State University scientists studied nutrient loading from the drainage of agricultural lands near Upper Klamath Lake as well as springs, artesian wells, and other sources, including the role of the Klamath Irrigation Project. "Findings indicate contributions from agricultural lands adjacent to Klamath Lake have been overestimated, and the Klamath Irrigation Project is probably a net sink for nutrients diverted out of Klamath Lake and Klamath River."[2]	The Panel was not provided this report in its initial review. From this statement, it is unclear whether the entire basin is separated from KR as regards nutrient loading. The upper Klamath system is loading nutrients at higher than background levels; the most likely source is altered land use (i.e., agriculture).
36	Klamath Water Users Association (KWUA)	14, first full paragraph, last sentence, "(c)"	The authors make academic assumptions about what may or may not work related to regulation of agriculture.	The Panel responds that those limitations were taken from the cited literature.
37	Klamath Water Users Association (KWUA)	15, first paragraph "Removal of Keno Dam and Reservoir"	We believe that the "*Scientific Assessment*" should actually be limited to what was asked of the preparers. Please cite where the possible removal of Keno Dam is listed in either of the two scenarios being analyzed. The KBRA specifically calls for the retention of Keno Dam. We are particularly disturbed that the panel does not understand the purposes and function of Keno Dam. Keno Dam is essential to the use of water for roughly 100,000 acres of irrigated land, and all of Tule Lake and Lower Klamath National Wildlife Refuges. Besides being outside its task as we understand it, the panel's passing suggestion of study of removal of Keno Dam is not at all well-informed. It should be deleted.	The Panel respectfully disagrees. Keno Dam appears to be a physical and chemical migration barrier to migrating salmon, and may still limit the potential success of salmon rehabilitation. The statement was shortened by removing the reference to hydropower benefit.
38	Klamath Water Users Association (KWUA)	15, second paragraph "Reductions in irrigated agriculture"	The panel's general disdain for irrigated agriculture is again apparent in the second paragraph on page 15.[3] This two-sentence paragraph, which does not address the questions posed to the panel, appears to be based on stereotype and an overall lack of understanding. We begin with the second sentence, which offers the off-hand remark that "*the refuges" should be managed for "fish and wildlife versus agriculture"* if the basin management objective is rehabilitation of fish species. <u>One</u> of the basin management objectives is rehabilitation of fish species. Another is enhancement of wildlife. <u>Another is preservation and protection of agricultural communities</u>. The panel proposes to pronounce the first two good, and the third evil, with an uninformed observation that has virtually nothing to do with Chinook salmon and whether removal of the hydroelectric dams is in the public interest.	The Panel respectfully disagrees. The text was slightly modified to emphasize that the fish and agriculture were objectives that can conflict. More generally, the Panel stands by its statement that the conversion of wetlands to irrigated agriculture increases nutrient inputs to surface waters and reduces the capacity of those wetlands to buffer floods & low flows. Those changes affect both fish and farming. These statements are well

[2] Rykbost, K.A., & Charlton, B.A. (2001). Nutrient loading of surface waters in the Upper Klamath Basin: Agriculture and natural resources. [Electronic version]. Corvallis, Or.: Agricultural Experiment Station, Oregon State University. Retrieved from Oregon Institute of Technology Library, Klamath Waters Digital Library: http://klamathwaterlib.oit.edu/u?/kwl,391.

[3] Again we must wonder whether or not the panel read the KBRA and if so, whether the panel understands its intent. See KBRA, p. 4, Section 1.3 Goals of the Agreement.

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			There are six refuges in the basin. We assume the panel is talking here about Lower Klamath and Tule Lake National Wildlife Refuges, parts of which are, and have always been, leased for agriculture. The panel does not appear to understand that refuges use water, including use of water for wetlands or other habitats. This is water that does not go down the Klamath River. On a per-acre basis, overall water depletion is greater on wetlands than it is on croplands. If refuge wetlands were not watered, there would be more water in the river for salmon and more water in Upper Klamath Lake for suckers. We do not understand how the panel might believe the refuges will be managed to benefit salmonid populations (as opposed to their management objectives for waterfowl and wildlife). Would one create a massive lake in Tule Lake National Wildlife Refuge to replace the cropland? (The water loss to the river would be substantial.) Is the panel's suggestion related to water quality? If so, on what basis, and would not removal of the massive bird populations from the refuges improve water quality? Would salmon populations be increased by a permanent prohibition of all fishing "*versus*" changing land use in Tule Lake National Wildlife Refuge? We raise these questions not because we have objection to refuge uses or fishing. In fact the opposite is true. We raise them to illustrate that superficial, value-oriented pronouncements not supported by careful thought and facts are unhelpful, at best.	documented in the literature, and reflect neither disdain nor opinion on the part of the Panel.
			The panel apparently does not know that the KBRA would, for the first time ever, establish firm deliveries of water for wetlands and other habitats on Lower Klamath Refuge. The panel apparently does not know that refuges have acquired substantial farmland in recent past years, and that the KBRA supports expansions of refuge areas. The panel wrongly assumes that there are no wildlife values in the agricultural lease lands (or other farm and ranch lands). The panel does not appear to be aware of the innovative walking wetlands program on the refuges that provides substantial wildlife and agricultural benefits. The panel does not seem to be aware of the management of Sump 1B on Tule Lake Refuge that has been pursued via a partnership of Tulelake Irrigation District and the U.S. Fish and Wildlife Service. It is the misfortune of irrigators in the Klamath Project that the lease lands, so valuable to our community, make a handy political target, particularly when influenced by stereotype and a lack of detailed understanding. Please do not contribute to this problem. We are equally concerned with the suggestion that reductions in irrigated agriculture be considered as a water quality enhancement measure. Preliminarily, we understand well the challenges that exist in regard to water quality. That is why we support collaborative projects and solutions. The panel raises questions as to whether certain measures will work. It does not subject its own general statement regarding agricultural lands to the same scrutiny. The water that the Klamath Project returns to the Klamath River in the summer, when water quality is of greatest concern, is water that originates in Upper Klamath Lake. As best we know, it is accepted that the Klamath Project is a net nutrient sink; in other words, it takes out a greater load of nutrients than it puts back in. We are aware that the concentrations of nutrients returned is greater than the concentrations in Keno Reservoir at some times (we are uncertain of the percentage of time). Regardless, the panel does not recognize that irrigation water quality is a function of Upper Klamath Lake water quality.	The Panel is doubtless unaware of a vast number of facts, findings, and opinions about the system. The Panel had one day of presentations and an overwhelming 3GB of documents that still did not include all of the information that would be needed for a thorough understanding of the problems. Therefore the Panel was forced to focus on the most salient points. Again, the Panel has no position on the value of irrigated lands or any other economic or political topic, and none of its members have a stake in the outcome. The statements about reduction of irrigated agriculture are made in the context of a rough mass balance and the sorts of actions that would be necessary to actually achieve water quality goals.

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39	Klamath Water Users Association (KWUA)	28, section 3.3 "Biological Opinions," second to last sentence	Currently reads: *"The current Biological Opinion reserves more water for fish than that offered under KBRA."* We understand the authors of this report were asked to focus on the effects on Chinook salmon, not suckers or coho, or redband trout, or sturgeon or lamprey etc. But this sort of loose statement is indicative of the problems that have plagued resource management in the Klamath Basin for years. As you know, Chinook are not listed under the ESA; the Klamath River Biological Opinion that is in place is supposed to be designed to prevent jeopardy to Coho. Under the current Biological Opinions, exactly which fish species get "*more*" water? See also, comment # 15.	Text changed from "reserves" to 'may reserve' One of the Panel's concerns is that by assessing the various fish species in separate reports, the Agencies would miss some potential conflicting objectives—such as this one. It felt it would be valuable to raise this issue.
40	Klamath Water Users Association (KWUA)	28, section 3.4 "KBRA Feasibility"	This has no place in a scientific report.	The Panel respectfully disagrees. It was asked to evaluate both the KBRA and the dam removal as the Proposed Action. Therefore, it is required that the Panel consider the feasibility of the KBRA as part of its deliberations.
41	Klamath Water Users Association (KWUA)	28, fourth paragraph	The panel again appears to condemn irrigated agriculture in the final paragraph on page 28, and the final sentence appears to suggest that all of the settlement parties' efforts simply be thrown out the window. <u>Please see all prior comments</u>. We are sure the panel knows that there was land reclaimed throughout the United States over history. In the case of Tule Lake and Lower Klamath lakes, this occurred roughly a century ago. We cannot conceive how Tule Lake was of any consequence to salmon. We do not know whether Lower Klamath Lake benefitted salmonids, or stranded salmonids. We do not thus know why the panel continues to harp on the issue of the long-ago settlement of our basin. We do not know why the panel assumes there are proposed increases in groundwater pumping (or what level is being prepared to another level) or why it believes that has caused or will cause a problem for salmon. We have commented earlier on the draft report's uninformed statements concerning Keno Dam. If Link River Dam is a problem, would the panel propose restoring the natural reef that formed Upper Klamath Lake (or the natural reef at Keno)? What would the implication be for flow, fish passage, Upper Klamath Lake suckers, etc.?	The Panel agrees that the proposed dam removal and KBRA are likely to improve conditions for fish (including Chinook salmon) over current conditions. What the panel is being cautious about is the certainty that the proposed actions will make substantial improvements, especially when many other potential limiting factors remain in the basin, specifically for Chinook salmon.
42	Klamath Water Users Association (KWUA)	29-30, third and fourth paragraphs	The panel refers to *"reduced"* fall flows under the KBRA. There are certain things to consider. First, there is no such thing as "*KBRA flows*" specifically. Rather, it is anticipated that future management will be more flexible than in the recent past, and in response to interests of fisheries. We understand that the panel has been presented with hydrologic simulations and assume those represent the efforts of knowledgeable people in regard to how water might be managed in the future. But the KBRA does not dictate what fall (or other) flows will actually be. Second, the panel is obviously comparing this hydrology to another set of hydrologic assumptions that equate to *"current"* management. As the panel notes on page 8, there are certain issues with the existing Biological Opinions that are problematic.	This comment is noted. The Panel relied upon flow scenarios provided by the Bureau of Reclamation. The Panel understands projections of flows and the assumptions and limitations of hydrologic simulations. It is very difficult to simulate vaguely defined future flexibility. In the Panel's experience operational flexibility has not necessarily resulted in environmental benefits in other systems.
43	Klamath Water Users Association (KWUA)	A-1, first paragraph, second sentence	Currently reads: "*To ensure that the panelists and their work products were not biased, it was Atkins' responsibility to …*" We believe additional work is required to meet this objective.	The report has been revised in response to this comment.

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44	Dr. Allison Aldous, The Nature Conservancy (TNC)	12, 6	"*The TMDLs call for a 47 percent reduction in external phosphorus loading to UKL. Is this sufficient to solve the water quality problems?*" I don't think we have sufficient evidence and an adequate model, that take internal loading and lake hysteresis into account, to derive this number with a high degree of certainty. I agree with the authors that it is worthwhile to question this number.	This comment is noted.
45	Dr. Allison Aldous ,The Nature Conservancy (TNC)	13, 3	The authors use literature values to calculate the P sequestration potential of wetlands. We have found that the recently restored wetlands around Upper Klamath Lake **released** P upon reconnection (Aldous et al. 2005; 2007; Wong et al. 2010). Kuwabara, sampling at a much finer scale, found the same result. Furthermore, Kuwabara demonstrates a continued benthic efflux of P, even 3 years after restoration. Similar results have been recorded for other wetlands around UKL. It is not known if – or when – these wetlands will stop releasing P (and N) and begin to sequester these nutrients. Thus current science does not support the use of lake fringe wetlands as nutrient sinks. This result (P efflux) is not uncommon (this phenomenon is summarized in Aldous et al. 2007). In a 2009 study, I found the Sycan marsh (close to the headwaters of the Sycan River) also was a source of N and P. To my knowledge, no one else has examined the potential for other wetlands in the Klamath Basin to sequester or reduce their release of nutrients. However, wetlands are well known for their low P sequestration potential on a per area basis. However, it is also important to recognize that restoring wetlands, especially those around UKL, has resulted in the cessation of pumping ag tail water off into the lake. So even if the wetlands never sequester P, there might be the possibility that you can get them to some kind of equilibrium with respect to N and P fluxes. Overall, the authors rightly question the capacity to use watershed and wetland management to solve the nutrient loading problem, and I agree that this issue warrant further analysis.	The Panel had some of these papers but was more interested in the longer time scale over which sequestration might occur. The Panel used literature values for sequestration mainly to illustrate the need for a more careful analysis of the likely reductions through the KBRA actions. Such an analysis should of course take into account the most recent and well-documented information about the entire time course of nutrient fluxes. The report does mention Jim Kuwabara's study and its implications for reduction in P loading.
46	Dr. Allison Aldous ,The Nature Conservancy (TNC)	13, fig 3 and 13,2	The relationship between nutrient loading and primary production (Fig 3), and the subsequent description of hysteresis, is different from what is generally reported in the literature. What is more common in the literature, is more of an s-shaped curve – there is a lag in P loading before you see a response in lake trophic state, after which it follows Michaelis-Menten kinetics, as they have depicted. A more common description of hysteresis is that the trajectory of lake recovery with a decline in nutrient loading follows a different curve, rather than re-tracing the original curve. Scheffer's 2001 paper in Nature, while a little old at this point, is a good reference for both of these points.	The Panel responds that the report is trying to make a somewhat different point – this is described as a conceptual diagram (and though it is not described as such, this is really a steady-state conceptual diagram), the idea being that the system can saturate with respect to nutrients at which point you get much less for your nutrient-reduction efforts than if the system is not saturated. The time course of recovery was not the point, although the hysteresis should be considered if a real analysis of this topic is conducted, as the report suggests.
47	Dr. Allison Aldous ,The Nature Conservancy (TNC)	12, 2	Please provide a citation for the statement, "*High natural loading of phosphorus (P) from the watershed*..."	The report has been revised in response to this comment.

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48	Yurok Tribe		The Yurok Tribe respectfully submits the following comments regarding the above mentioned report. Overall, we found that this review provided helpful information about moving forward with the restoration of anadromous fish in the Klamath Basin. The report outlines the significant challenges which must be overcome for the KBRA and dam removal to be successful in rebuilding fish runs in the Klamath Basin. The Yurok Tribe received assistance from several consulting experts in water quality, who prepared their analyses on behalf of the Klamath Intertribal Water Quality Working Group. These investigators are: Eli Assarian of Kier and Associates, Inc., Dr. Jacob Kann Aquatic Ecosystem Sciences, LLC, and Jed Redwine of ATKINS. These authors are noted by name, other comments originate collectively from the Yurok Tribal Fisheries Program.	This comment is noted.
49	Yurok Tribe	i, 3	KBRA rehabilitation activities are intended to improve conditions for anadromous fish throughout the Klamath Basin, not simply in the areas above Iron Gate Dam. The panel appears to have reached the conclusion that the implementation of the KBRA will not have any effect to the productivity and/or carrying capacity of the Klamath Basin below Iron Gate Dam. There is little or no mention of the benefit of restoration (rehabilitation) actions in the Klamath Basin below Iron Gate Dam (IGD), nor is there mention of the benefits to lower Basin fish populations by reducing incidence of disease and addressing water quality issues (temperature and nutrients) by removing the dams/reservoirs (as discussed more thoroughly below in our comments regarding disease and water quality). Although it can be difficult to predict with accuracy productivity increases due to KBRA restoration actions, the whole point of the lower basin restoration action program is to increase productivity, and in some cases, capacity with regard to anadromous fishes. Appendix C-2 of the KBRA[4] budgets $140,000,000 toward aquatic and upland restoration (rehabilitation) activities in the Shasta, Scott, mid-Klamath tributaries, the Salmon River and lower Klamath tributaries. Even if only partially implemented, this is a substantial investment in restoration. The sum total of these projects over time is intended to increase the productivity of the lower basin system. Increased productivity will enable higher returns, and greater resilience of populations. It is true that no comprehensive restoration plan exists as of yet, but that does not appear to be sufficient basis for concluding no benefit from those actions. There is potential for great benefits, if restoration actions are fully funded, scientifically grounded, and effectively implemented. Although some restoration activities will take place at a lesser scale absent the KBRA, it is clear that the KBRA intends to fund restoration (rehabilitation) actions at a far larger scale, and under the guidance and planning of a coordinated council (the Klamath Basin Coordination Council) and its associated Technical Advisory Team.	The Panel respectfully disagrees. The Panel does believe that KBRA will have beneficial effects. It is simply uncertain about what amount of money eventually will be spent, what will actually be implemented, and what the ecological effects of those efforts will be in increasing Chinook salmon. A statement has been added that says: "Within the range of pertinent uncertainties, it is *possible* that the increase in Chinook salmon upstream of Keno Dam could be large, but the nature of the uncertainties precludes attaching a probability to the prediction by the methods and information available to the Panel."

[4] We acknowledge that these figures are subject to change.

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50	Yurok Tribe	15, 2	**Future Disease Scenarios** *"Although several aspects of the Proposed Action could lead to a reduction in disease-related mortality, uncertainty about these aspects is very high."* We recommend that the committee consider rephrasing the above statement from "could" to "is likely to" based on several lines of reasoning (discussed in subsequent paragraphs). However, even if the committee believes that disease reductions are not likely to occur but only a possibility, then it is important for the sake of transparency and logic to mention or discuss the following topics that are currently missing in the report: 1) the potential for major reductions in myxozoan disease related mortality with implementation of the Proposed Action; 2) the likely significant increases in survival of juvenile Chinook salmon and possible to likely subsequent increases in productivity of populations from BELOW Iron Gate Dam if major reductions in disease related mortality occurs; and, 3) the potential for a continuation or significant worsening of disease related mortality under Current Conditions for Chinook salmon below Iron Gate Dam over the next 50 years, especially given global warming predictions. While there are still unknowns in regards to these parasites' lifecycle, ecology in the river, and prognosis of infected fish, the information available to date demonstrates that there is a reasonable level of certainty about many major aspects of this disease problem. A strong argument can be made that the hypothesis best supported by current information, as discussed in the report, is that the hyper-infectious zone is created by the overlap of the highest polychaete densities (exacerbated by dam related habitat stabilization and food resource augmentation from reservoir plankton) with the highest numbers of adult salmon carcasses in the Klamath River (exacerbated by migratory blockage from the dams and production from Iron Gate Hatchery). This hypothesis also leads to the prediction that dam removal and phasing out of hatchery production at Iron Gate Hatchery alone would provide major reductions in *C. shasta* mortality among juvenile salmonids (and also that any relocations of the problem area would require not just a concentration of carcasses but a spatial overlap of concentrated carcasses **AND concentrated polychaetes**). We acknowledge that substantial uncertainty exists in our collective understanding of some specific aspects of myxozoan disease dynamics, which means that other, less likely outcomes cannot be ruled out and could occur. However, we conclude that biologically significant reductions in disease related mortality is not only one potential outcome of the Proposed Action but also the one best supported by the available evidence. Conversely, we also conclude that it is likely that the frequency and severity of years with high disease related morality will increase over the next fifty years under Current Conditions due global warming AND the constraints of having the dams and hatcheries still in place along with limited availability of water to create artificial scouring flows of sufficient frequency, duration, and magnitude. These general conclusions are also the conclusions reached after comprehensive environmental review as part of the FERC relicensing EIS for the Klamath Hydroelectric Project as evidenced by the quotes below (emphasis added): FERC Final EIS - "Based on our previous analysis, removal of one or more of the larger project reservoirs (particularly Iron Gate and Copco reservoirs) would **likely** reduce the incidence of disease in the lower Klamath River migratory corridor and would reduce the risk of further declines before	The Panel agrees that the hypothesis described here is well supported, but that neither means that it is correct or that the problem will go away when the Project is implemented. The main point of this section of the Panel report is that several investigations could greatly reduce the uncertainty about this. Since the disease issue is critical to success of the project, reducing uncertainty should be a key goal of activities leading up to the project. The numbered points here are simply reiterations of the opinions previously expressed, and about which Panel members were skeptical, particularly given the refusal of one presenter to acknowledge <u>any</u> uncertainty. The opinions of whoever wrote the FERC EIS are of no help in this matter, nor are the U.S. Fish and Wildlife statements to be taken as ultimate response or solution to this complicated issue. The Panel reviewed the available scientific information, including what was presented at the one-day workshop.

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			habitat restoration efforts in the upper basin begin to take effect and strategies for restoring passage to instream habitat can to be developed, tested, and implemented." "We conclude that substantial disease losses are **likely** to continue and have the potential to become more severe given the current basinwide trend of increasing water temperatures, unless substantive measures are implemented to reverse disease occurrence downstream of Iron Gate dam." "We conclude that disease losses in the lower Klamath River migratory corridor have most **likely** contributed to recent declines in the number of fall Chinook salmon, and have the potential to cause fall Chinook salmon populations in the basin to decline further, unless measures can be found to reduce losses from disease, particularly in warm years and when low flows occur." This conclusion is also consistent with the conclusions reached in the analysis of likely outcomes of dam removal and implementation of the KBRA conducted by the US Fish and Wildlife Service (Hetrick et al. 2010), which was reviewed by Dr. Scott Foott and Dr. Jerri Bartholomew and endorsed by an independent reviewer. The conclusions from the Executive Summary are quoted below along with the reviewer's comments (emphasis added): FWS Executive Summary - "Removal of the PacifiCorp Project dams is **likely** to alter the distribution of myxospores, an intermediate life stage of myxozoan parasites released from salmonids, by dispersing adult spawning salmon and resident trout found below IGD. The fish passage barrier created by IGD and the adjacent Iron Gate Fish Hatchery have concentrated the density of spawning adult salmon in the IGD to Scott River reach, thereby exacerbating release of infectious myxospores within this reach. The greater abundance of myxospores released by dense concentrations of spawning salmon within this reach results in higher infection rates in polychaetes, which proliferate in this relatively stable hydrologic reach. "Removal of PacifiCorp Project dams **would facilitate** the occurrence of higher peak flows, restoration of mid-sized (gravel) sediment input below IGD, and result in variable flows that could intermittently scour and desiccate polychaete colonies and their habitats, resulting in reduced actinospore loads the following spring." Reviewer - "The compilation identifies the parasite *Ichthyophthiriu*s and the bacterial disease columnariasis (*Flavobacterium columnare*) as important factors affecting survival of upstream migrating adult salmonids. The myosporidians *Ceratomyxa shasta* and *Parvicapsula minibicornis* are likewise identified as key factors reducing survival of juvenile salmonids. While all of these organisms are believed to be endemic to the area, altered water quality parameters have clearly exacerbated their adverse impacts. The compilation appropriately points to **anticipated fish survival benefits** associated with improved juvenile and adult fish health resulting from increased flows, reduced temperatures, and reduced reservoir areas. These **benefits are likely to be substantial** as predicted based on water management experiences in other river systems such as the Rogue and Willamette."	

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51	Yurok Tribe	15, 3	**Spring Water Temperatures** *"Additionally, the predicted shift of several days of higher spring water temperatures (and consequent higher myxozooan [sp] infection rates) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigrant success to the degree that it increases disease incidence."* We agree with the above statement but in the interest of fairly and accurately accounting for probable outcomes of thermal shifts with the Proposed Action and associated uncertainty, it is important to acknowledge several important dynamics: 1) under Current Conditions, spring time temperatures are already well above the 10°C threshold for release of actinospores and are already sufficient to result in infections levels that are epidemic during the important rearing and outmigration months of April, May, and June; 2) significant reductions in actinospores (as discussed above) are possible to likely with the Proposed Action, the benefits of which would overwhelm any increases in infectivity due to minor to moderate increases (maximum and mean) water temperatures; 3) a return to normative earlier increases in spring time water temperatures would also result in faster growth of juvenile Chinook salmon and earlier outmigration for a portion of fish, thus avoiding exposure to the increased actinospore levels as the season progresses and increasing survival for such fish; 4) the thermal shift with dam removal means that later migrating salmonids will be exposed to **lower** water temperatures than under Current Conditions and adult Chinook salmon returning to spawn will also be exposed to lower water temperature in the fall that could have benefits in terms of subsequent myxospore production. In summary, we recommend adding the following statement or something to the effect: **the thermal shifts predicted with the Proposed Action could also increase Chinook salmon outmigrant success to the degree that it decreases exposure to infectious actinospores**. FERC Final EIS - "PacifiCorp's water quality modeling also indicates that the seasonal temperature shift caused by the project reservoirs serves to lower water temperatures in the spring through most of July in low flow years, but increases water temperatures below Iron Gate dam starting in late July (figure 3-50). **This shift likely reduces vulnerability to disease for early-migrating smolts, but increases stress and disease for the later migrating fish.** The magnitude of the temperature shift is likely less in higher water years, and the transition from a net cooling to a net warming effect likely occurs earlier than occurs in low water years."	The Panel agrees that the quoted statement is somewhat misleading and the report has been amended so that the phrase in parentheses reads: "and consequent higher myxozoan infection rates for a given joint distribution of fish and parasites." A sentence has also been added regarding the timing of migrations.
52	Yurok Tribe	15	**Adaptive Flow Management** The *C. shasta* collaborative management team, of which the author is a member, developed and ranked a list of all possible management actions that could reduce disease morality of juvenile salmonids in the Klamath River, including research and monitoring plans of which many are under implementation. Of these, the only plausible action, aside from dam and hatchery removal, with a reasonable probability of significant benefits was high flow releases sufficient to scour, displace, and/or bury polychaete colonies. Multiple lines of evidence suggested flows in the range of 5,000 to 6,000 cfs in the vicinity of Iron Gate Dam are necessary to produce desired velocities to begin producing significant polychaete mortality (see citations in Bartholomew and Foott 2010), in particular disturbing the relatively instable habitats on FPOM/sandy pool and eddy bottoms that have	It is the Panel's opinion that Upper Klamath Lake and Keno Reservoir lack the release capacity to manage high flushing flows and that higher lake levels are needed to improve conditions for listed suckers. Future field and flume experimental work (Bartholomew, 2011 presentation to Panel) will likely clarify the critical hydraulic forces and sediment loadings

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			been proliferating with phenomenal densities of polychaetes since the last flooding event in the winter of 2005/2006 (~10,000 cfs). A major problem with this approach as a management tool under Current Conditions is that project reservoirs lack, not only large capacity storage, but also release capabilities sufficient to reach the above flow thresholds unless a spill event occurs or is mandated and manufactured. Under Current Conditions, however, there is no formal management structure in place to facilitate this type of flow management and PacifiCorp is resistant to undertake any non-mandated operational changes that could affect power generation as any spill events (flows above 3,000 cfs) are lost power generation and profits. Specifically, PacifiCorp actively manages project reservoir to always avoid spills if at all possible, which has reduced the frequency of small to moderate spill events (i.e. bankfull) and thereby contributing to polychaete habitat stability. In other words, with Current Conditions the only management action with a reasonable probability of significantly reducing polychaete abundance (at least for a few years), and thereby actinospore abundance, is artificial flooding but the management structures constrain flexibility for implementing such an action. With the Proposed Action, however, there will be management structures in place (environmental water technical team) to allow for the type of flexible flow strategies discussed above. In addition, the remaining dams (Link and Keno) will have no power generating capacity thus removing any incentive to prevent spill events to maximize power generation. Under both scenarios, artificial pulse flows to kill polychaetes is constrained by the availability of sufficient volumes of water (i.e. water year types), but under the Proposed Action there is a formal process to facilitate water management in an adaptive manner to target polychaete mortality when the opportunities arise, which is not the case under Current Conditions.	required to scour and reduce polychaete colonies.
53	Yurok Tribe	15, 1	**Disease Feedback Mechanisms** In lieu of and complementary to a quantitative epidemiology model, conceptual models and an effects matrix are useful for evaluating alternative hypothesis and for reducing scientific uncertainty about anticipated, probable, plausible, and unlikely outcomes of dam removal and implementation of the Proposed Action versus Current Conditions. A conceptual model is shown in Figure 1 (attached at end of this comment matrix), which assists in evaluating the hypothesis that disease conditions will be significantly improved under the Proposed Action. Of particular importance to note is the positive feedback loop created by elevated numbers of polychaetes producing a hyper-abundance of actinospores that in turn heavily infects returning adults subsequently producing high numbers of myxospores conveniently concentrated at the top of the area of high polychaete abundance and so the cycle repeats resulting in increasing polychaete infection levels and actinospore abundance over time. Of course there will be annual variation and stochastic events but the overall trend predicted over a 50 year horizon is alarming given current disease levels and projected climate change. Conversely, implementing the Proposed Action, based on the mathematics implied by the conceptual model, could create a negative feedback loop between actinospores and myxospores, which could have significant benefits over time. While it is plausible that localized, smaller hot spots for polychaete abundance and infection could be created above the site of Iron Gate Dam, there is not the same quality and quantity of polychaete or spawning habitat in the vicinity of Keno Dam nor will there be a hatchery built there. This hypothesis is also supported by an updated effects matrix, which lists the most likely outcome for each major *C. shasta* life cycle factor without ranking (Table 1 attached to end of this comment matrix). This table	The Panel's concern revolves around whether infected fish and polychaetes will remain near hatcheries or develop near other aggregations of spawners or salmon holding areas.

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			shows the consistent qualitative improvements anticipated under the Proposed Action compared with Current Conditions. It is also important to remember that, while the current hyper-infectious zone extended to Seiad Valley, there are still substantial infection rates to populations as far downstream the Salmon and Trinity Rivers in some years that would benefit from upstream reductions in actinospores (e.g. 10- 20%; True et al. 2010).	
54	Yurok Tribe	15, 2	*"Disease-related mortality appears, in certain years, to contribute substantially to poor survival of out-migrating juvenile Chinook salmon passing through the infectious zone. Thus, the overall success of the Proposed Action appears to hinge to a large degree on the potential for reduction in disease."* Change to "in most years" to be consistent with monitoring results.	The report has been revised in response to this comment. The report has been changed to read "many" years. It is not known as fact whether or not it is actually "most" years, and the Panel lacks the time and budget to conduct an analysis of the frequency of these events.
55	Yurok Tribe	15, 3	*"However, the extent of the reduction is uncertain (partly because of the presence of the Iron Gate hatchery and many carcasses nearby in the mainstem)…"* Under the Proposed Actions, Iron Gate Hatchery will be phased out after no more than 8 years and its currently unclear if suitable replacement water source for the hatchery can be secured when the dams are removed.	See remainder of sentence in the report.
56	Yurok Tribe	16, 1	**Uncertainty and Further Studies** We agree with the need for further disease studies including the ones listed by the Expert Panel. Fortunately, all of these studies and more are funded and underway. Unfortunately, none of these studies will be complete in time for the Secretarial Determination decision, thus decisions must be made based on our current level of understanding of myxozoan disease dynamics in the Klamath River. While there is indeed very high levels of uncertainty in some areas of our understanding of disease dynamics and likely outcomes, there is much less uncertainty in other areas including the correlation of the spatial overlap of Iron Gate Dam with Iron Gate Hatchery, high polychaete densities, and the hyper-infectious zone that is resulting in serious and high levels of disease related mortality to juvenile salmon from populations of Chinook salmon below Iron Gate Dam. The spatial convergence of dams, hatcheries, and high myxozoan infectivity has been noted in other rivers such as the Cowlitz (which does not have nutrient problems). Uncertainty is a reason to question whether anticipated reductions to disease related morality will be fully realized, but we do not believe it is justification to omit discussion regarding the potential of significant improvements to fish disease with the Proposed Action or the potential for significant worsening with continuation of Current Conditions. Even when the above studies are completed, uncertainty will remain because there is no way to simulate in the laboratory or the field, the effects of removing the dams and the hatchery. Thus removing the dams and the hatchery is the only "experiment" that can be conducted that will resolve this uncertainty. It seems prudent to recommend resolving this uncertainty by moving forward with the "experiment" of the Proposed Action, while acknowledging the potential for unintended consequences and potential for minor to major reductions in disease related morality. The potential for significant reductions in disease	The Panel's recommendation for additional studies did not preclude making the SD before the studies are complete; rather the Panel stated that "…investigations should be implemented in parallel with the Proposed Action. " However, the Panel does not agree that uncertainty cannot be reduced by conducting studies – and obviously neither do the scientists now conducting the studies, or their funding agencies. It would be foolhardy to conduct the "experiment" of the Proposed Action while significant, but reducible, uncertainties remain.

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			related morality is logically a likely outcome if the leading hypothesis (as described by the Expert Panel) that explains the current disease problem is true. **Literature Cited** Bartholomew J.L. and J. S. Foott. 2010. Compilation of information relating to myxozoan disease effects to inform the Klamath Basin Restoration Agreement. Draft Report. 55p. FERC Final EIS…. Hetrick, N. J., et al. 2009. Compilation of information to inform USFWS principals on the potential effects of the proposed Klamath Basin Restoration Agreement (Draft 11) on fish and fish habitat conditions in the Klamath Basin, with Emphasis on Fall Chinook Salmon. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA.	
		15 and 16 (all)	True K., J.S. Foott, A. Bolick, S. Benson and R. Fogerty. 2010. FY 2009 Investigational Report: Myxosporean Parasite (*Ceratomyxa shasta* and *Parvicapsula minibicornis*) Incidence and Severity in Klamath River Basin Juvenile Chinook Salmon, April-August 2009. U.S. Fish & Wildlife Service California – Nevada Fish Health Center, Anderson, CA.	
57	Yurok Tribe	16, 5 (section 2.5)	The Yurok Tribe agrees with the Panel's call for the establishment of a science program, and supports the recommendations of the National Research Council (2004). We are working, along with other science entities within and outside of, the Klamath Basin on a conceptual model framework encompassing the ecosystem of the Klamath Basin including the upper and lower portions of the Basin.	This comment is noted.
58	Yurok Tribe	19, 3 (Section 2.4)	Agree that water quality challenges must be addressed both in short and long-term, (i.e. trap and haul or other measures) for adult fall-run Chinook runs to pass through Keno Reservoir. However, available evidence (Klamath Project Relicensing EIS FERC 2007) shows that spring Chinook will likely finish their adult migration prior to DO sag in early July. While the lower Klamath spring-run has been trending later in the summer, the wild stocks (Salmon River) generally complete their migration well before early July, traversing the lower river in April and May, and early June. Even if current spring Chinook adult migration is bimodal (with one peak in April-May, and another later in June) it is probable that over time the Upper Basin stock run timing will select for earlier run timing when water quality is not a problem. Based on screw trap data in the Klamath River, we believe that the vast majority of juvenile fall-run and spring-run Chinook will pass through Keno prior to the onset of water quality problems. Those fish using a stream-type life history strategy will have areas of Upper Klamath Lake (i.e. Pelican Bay, mouth of the Williamson) as very large-scale refugia, as well as areas of cold-water spring input in the Sprague, Wood, Lower Williamson Rivers, and Spring Creek. Reference: Federal Energy Regulatory Commission (2007). Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.	The report has been revised in response to this comment. Text modified to state "especially fall run," and emphasis placed on fall run in the following paragraph as well.

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59	Yurok Tribe	21, 1 (section 2.5)	Currently, adult chinook spawner densities below IGD (including the mainstem and Bogus Creek) can be extremely high (an extreme example being 45,000 adults that returned to Bogus Creek in 1995). Removal of IGD will result in the redistribution of some of these fish from areas of high density (as noted elsewhere in the report, this will likely help minimize disease problems facing juvenile salmonids in this area) to the areas of new habitat (above IGD). Whether this redistribution, and associated straying of the progeny of these fish will be sufficient to recolonize these new habitats is a technical question that will need to be addressed by the Fishery managers; as noted in sections 11.3.1.c and 11.3.2 of the Klamath Basin Restoration Agreement. As noted in the KBRA, the role of harvest management (and conservation hatcheries) in the recolonization efforts will be determined by the Managers. It seems premature for the report to state "The need for greater escapement means that harvest levels will need to be reduced for at least several years, or until adults return to the Klamath River, to seed all habitats….." It seems more appropriate to suggest that harvest levels **may** need to be lowered, dependent upon the success of recolonization from existing areas of high fish densities and potential conservation hatchery efforts. It also seems appropriate to note that the increased capacity of the basin to produce fish, due to new habitats being opened up following dam removal, will likely allow increased numerical harvest of fish (even though harvest rates may stay the same or be altered).	The report has been revised in response to this comment. The text has been modified to include uncertainty. This is a lot of Chinook salmon for a small creek. How many of these 45,000 Chinook were hatchery fish? How many progeny returned from these 45,000 spawners? This is important because the IGH will likely close down after dam removal.
60	Yurok Tribe	28, 3 (section 3.3)	*The current Biological Opinion reserves more water for fish than that offered under KBRA.* Based on the following evidence, we believe that there is insufficient information to reach this conclusion. The "no-action" hydrology presented to the expert panel is intended as a best estimate of flows as they would occur if the 2010 BiOp was in effect for 50 years (instead of 10); however it has become clear that real-world implementation of this BiOp is far more complex. Although the flow modeling that was provided to the expert panel shows only minor differences between BiOp flows and Proposed Action flows, there is no certainty that such flows will be provided under the 2010 coho salmon BiOp, as we explain more fully below. The 2010 BiOp has required flows (Table 18) as an Reasonable and Prudent alternative (RPA) that are expressed in exceedances, with no guidance as to how to meet those exceedances, and no method to reconcile 50 year model results and exceedances with the 10 year life span of the BiOp. Hence, the Bureau of Reclamation seems to believe they are free to meet these flow "requirements" in any way that they see fit. In the past year, the Bureau of Reclamation has used three different management regimes to meet the elusive Table 18 RPA flows. To illustrate the lack of predictability associated with the current BiOp (without accounting for unknown future BiOps), we attach two reports recently issued by the Bureau of Reclamation regarding flow management under the 2010 BiOp. The first memo, titled "Modeling Process for Klamath Operations", issued in December 2010, outlines a method for achieving BiOp flows that uses a concept called Water Supply Index (WSI), which, when modeled using the WRIMS model over the 1961-2009 period resulted in flows exceedances that matched the requirements of the BiOp. This modeling (which is different than the WRIMS modeling presented to the expert panel) has never, to	The report has been revised in response to this comment. The text has been revised to specify "more water for suckers" rather than fish in general, and to acknowledge that there is uncertainty with the BOs and possible outcomes include more water being available under the Proposed Action.

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			our knowledge, been distributed, or reviewed by parties outside of the Bureau of Reclamation, and modeling results are not part of this report. Subsequent to the issuance of this memo, the Bureau of Reclamation determined that the WSI would result in unacceptable impacts to agricultural interests in the Upper Klamath Basin, so the Bureau proposed a new management regime called the Variable Base Flow methodology. The 2011 Klamath Project Operations Plan, which has a description of the VBF is attached. Again, the Bureau of Reclamation says in this report that WRIMS modeling indicates that river flows will "track" the Table 18 requirements, but no model results are provided for review and analysis. The point of this comment is to show, with evidence, that BiOp flows into the future are unpredictable and unstable, and management under BiOp requirements will introduce new uncertainties not addressed by the Panel. The BiOp's may, or may not, result in reductions of water use by irrigated agriculture, and can be changed at any point in the future. The BiOp does not address any of these issues, but simply analyzes what is necessary to prevent "jeopardy" to the continued existence of certain endangered species. In our view, this introduces far more uncertainty than management under KBRA, even if imperfectly implemented.	
61	Yurok Tribe	28, 5 (Section 3.6)	The KBRA has safeguards built into it that limit increased use of groundwater such that groundwater pumping can have no more than a 6% impact on springs or streamflow (KBRA section 15.2.4), which would represent an approximate 70% reduction in current usage (Marshall Gannett, USGS pers. comm.). In the absence of the KBRA, if irrigated agriculture is restricted due to the demands of BiOps, there is nothing to stop them from intensively using groundwater resources to make up the difference, particularly on the California side of the Project which has no protective regulations regarding groundwater usage. The KBRA, on the other hand does have safeguards against the overuse of groundwater, even on the California side.	The Panel believes that it will be just as difficult to regulate groundwater pumping as it has been to regulate the over-allocation of surface water diversions in the Basin.
62	Jacob Kann	12,1	**Water Quality Comments** The Yurok Tribe received assistance from several consulting experts in water quality, who prepared their analyses on behalf of the Klamath Intertribal Water Quality Working Group. These investigators are: Eli Assarian of Kier and Associates, Inc., Dr. Jacob Kann Aquatic Ecosystem Sciences, LLC, and Jed Redwine of ATKINS. These authors are noted by name, other comments originate collectively from the Yurok Tribal Fisheries Program. The commenters are noted by author. "However, the major Proposed Actions for reducing those inputs, wetland rehabilitation and riparian re-vegetation, are unlikely to produce substantial improvements in water quality of UKL and KR for several reasons." The statement that proposed actions are unlikely to produce substantial improvements in water quality cannot be supported based on reasons that follow in the Expert Panel document (see below for more detail), and provide an overly pessimistic view of the potential for water quality improvement. While it is reasonable to assume that significant reductions in load are required to meet TMDL water quality standards, it does not follow that improvements in water quality cannot be supported. Mass balance constraints dictate that the "internal loading" is actually recycling of excess P loads from the watershed. While there is technical uncertainty about the time scale of the response, there are numerous examples throughout the world where reductions in loading to	The Panel worked with the information at hand, and individual members' knowledge of other systems, and the literature on these topics. None of the Panel members is an expert in nutrient dynamics of shallow lakes. However, if there really is evidence to support the claims in KBRA and elsewhere about nutrient reductions, this evidence was not forthcoming in our discussions or readings, and therefore we could not take it into account.

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			shallow lakes have resulted in substantial reductions in algal biomass. The uncertainty in the time-frame for response can be reduced in the future as the lake responses to reductions in external load are monitored under a range of hydrologic conditions. New states of P equilibrium have been noted to be reached in 10-15 years despite high sediment regeneration of P (e.g., Jeppesen et al. 2007) Reference: Jeppesen, E., et al. 2007. Shallow lake restoration by nutrient loading reduction—some recent findings and challenges ahead. Hydrobiologia (2007) 584:239–252	
63	Jacob Kann	12,2	"High natural loading of phosphorus (P) from the watershed is magnified by anthropogenic loading from irrigated agriculture and other sources; a low N:P ratio in the inputs favors blooms of nitrogen-fixing cyanobacteria in UKL." Of note here is the fact that despite high "natural loading" of P to UKL, the shift to the massive blue-green blooms of *Aphanizomenon* (AFA) is a relatively recent phenomenon. This has been demonstrated by two independent paleolimnological studies (Eilers et al. 2004; Colman et al. 2004) showing the shift to AFA dominance in UKL occurring around the beginning of the 20th century, concurrent with many of the land use changes at that time (e.g., wetland and riparian losses, cattle grazing, river and stream channelization and other agricultural activities). The recent nature of the shift indicates that there is a high potential for restoration activities to manifest in reduced biomass of algae in UKL, reduced organic matter transport downstream, and general improvement in water quality. In fact, time series analyses suggest an improvement in both water clarity and algal biomass in UKL during the past decade (Jassby and Kann 2010). References: Colman, S. M., J. P. Bradbury, and J. G. Rosenbaum. 2004. Paleolimnology and paleoclimate studies in Upper Klamath Lake, Oregon. J. Paleolimnology. 31: 129-138. Eilers, J.M., J. Kann, J.Cornett, K. Moser, and A. St. Amand. 2004. Paleolimnological evidence of a change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon. Hydrobiologia 520: 7-18. Jassby, A., and Kann, J. 2010. Upper Klamath Lake monitoring program: preliminary analysis of status and trends for 1990-2009. Prepared for Klamath Tribes Natural Resources Department, Chiloquin, Oregon.	The Panel agrees that P loadings from altered basin-wide land uses In the past 100 y have exacerbated UKL nutrient conditions. The question is whether those land use changes can be reversed sufficiently to make a difference in a eutrophic lake. The timing of the shift in land use and loading does not necessarily imply that reversing it will be easy or even possible.

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64	Jacob Kann	12,3	The current problem caused by blooms of the toxic cyanobacteria *Microcystis aeruginosa* in the four lower reservoirs will likely be eliminated by the removal of the four dams, because *M. aeruginosa* is intolerant of turbulent water. We recommend adding the following sentence to clarify the linkages to Chinook salmon: This is a critical finding given that microcystin toxin stemming from the reservoirs has been found to be bioaccumulated in Chinook salmon livers migrating upstream in the Klamath River (Kann et al. 2011). Kann, J., G. Johnson, and C. Bowman. Preliminary 2010 Microcystin Bioaccumulation Results for Klamath River Salmonids(Updated 4-7-2011). Tech Memo Prepared For Karuk Tribe Department of Natural Resources. PO Box 282, Orleans, CA	This comment is noted. The accumulation of toxin in livers may be a concern but this is new information that we did not have at the time of the Panel meeting, and the Panel does not know of evidence for population-level effects on Chinook salmon.
65	Jacob Kann	12,3	"It is also nitrogen limited (Moisander et al. 2009), and presumably for that reason, does not bloom in UKL or KR." The description of *Microcystis* dynamics is not entirely correct. First, Moisander et al. (2009) showed that while *Microcystis* was often N limited, it was also often co-limited by P. Second, the fact that *Microcystis* is primarily N-limited is not the reason it does not grow in UKL; this has more to do with the fact that it does not fix nitrogen as does AFA. Thus, even though the low N:P ratios in UKL are indicative of N-limitation, the limitation is overcome by fixation of N by AFA, allowing it to out compete *Microcystis*. Both AFA and *Microcystis* require high P concentrations to dominate and form high biomass blooms.	These statements are contradictory. AFA must fix nitrogen to reach bloom levels; *Microcystis* cannot, therefore it cannot grow in UKL. If that is not an indication of N limitation, what is? And from Moisander et al. (abstract): availability of N during the summer is a key growth-limiting factor for the initiation and maintenance of toxic *Microcystis* blooms in Copco and Iron Gate Reservoirs in the Klamath River.
66	Eli Asarian	12, 3	Wording for the following excerpt of the report is unclear, overly simplified, and the cited reference does not say what it is purported to say. "However releasing these excessive amounts of nutrients to the Klamath River in the absence of the 4 lower dams means that the river, versus the reservoirs, will process the nutrients, perhaps in the form of excessive Cladophora biomass or increased periphyton production down river. These changes could elevate pH, lower night time dissolved oxygen, and cause gas supersaturation during afternoons in local areas (Asarian et al. 2010)." Alternate suggested wording: "Due to the elimination of the reservoirs' nutrient-removal capacity and hydrologic residence time, dam removal is predicted to increase nutrient concentrations at Iron Gate Dam (Asarian et al. 2010). Total phosphorus (TP) is predicted to rise only 2-4% for June-October and 10-12% for July-September, while the predicted increase for total nitrogen (TN) is larger at 37-42% for June-October and 48-55% for July-September. The magnitude of the concentration increase is predicted to diminish with distance downstream of Iron Gate. Increased N and P could result in increased periphyton biomass (if biomass is nutrient-limited, which is unclear) which could cause increased diel fluctuation of pH and dissolved oxygen; however, the prevalence of nitrogen-fixing periphyton species in the Klamath River suggests that ultimate periphyton biomass may be determined more by P than N, and increases in P concentration are predicted to be quite low. In addition, other effects of dam/reservoir removal are likely to reduce periphyton growth. These include a more dynamic hydrograph and increased	Available data support the comment that the bed material downstream of the dam has coarsened and the critical discharges required for mobilization have increased (Greiman et al. 2011).

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			substrate mobility (which will increase scour of periphyton), and a decrease in water clarity (which will reduce light available to periphyton). The net biological effects of these opposing forces (nutrient concentration vs hydrology, substrate, and light) are unclear, due to limited understanding of the factors governing periphyton biomass in the Klamath River." It is a well-established fact that dams interrupt sediment transport and resulting in armored, stable substrates in downstream river reaches (Biggs 2000). PacifiCorp's geomorphic studies conducted for its Final License Application confirm this has occurred in the Klamath River below Iron Gate Dam (FERC 2007). Such stable substrates encourage periphyton growth (Biggs 2000). References: Biggs, B.J.F. 2000. New Zealand Periphyton Guideline: Detection, Monitoring, and Managing Enrichment of Streams. Prepared for Ministry of Environment. NIWA, Christchurch. Available online at: http://www.mfe.govt.nz/publications/water/nz-periphyton-guide-jun00.pdf	
67	Jacob Kann	12, 6 continuing to 13,1 and Figure 3.	"There is a clear conceptual relationship between nutrient loading to a water body and algal biomass; as loading increases, there comes a point beyond which the rate of increase of biomass reaches an asymptote (Figure 3). This effect, due essentially to declining efficiency of the system to capture nutrients, has been observed in many places." No citation is provided for the conceptual relationship depicted in Figure 3; such relationships are anything but "clear." The relationship between nutrient loading and nutrient <u>concentration</u> must first be established (as was done for the UKL TMDL) and then the relationship between nutrient concentration and algal biomass concentration, and blue-green biomass in particular, is established. As noted above there can be a delay in the lake P concentration in response to loading reduction due to sediment regeneration; however, the reduction in P concentration and algal biomass can occur even at a constant loading reduction, not requiring the implied continued reduction as depicted in Figure 3. Moreover, such relationships (as depicted in Figure 3) can be linear, or even concave upward if other positive feedback pathways are operating. For example, as algal biomass decreases, pH decreases have the potential to further reduce P availability through control on P desorption from sediment (e.g., Sondergaard 1988). Increases in available light as biomass is reduced may also shift species composition to more desirable species (non-bloom formers). Uncertainty in the time-to-response notwithstanding, the major point here is that such an overly simplistic conceptual relationship does not accurately portray the UKL system. In fact, such saturation type curves are typically found in deep lakes with high P concentrations and different algal species, for which light or nitrogen limitation are more important. Again, continued loading reduction as implied by the conceptual figure is not necessary for reductions in concentration to occur. In other words, the sediment "memory" or P legacy can equilibrate to a set external loading reduction (e.g., the 40% reduction as shown in the TMDL) without a requirement that P loading needs to be continually reduced. References: Sondergaard, M. 1988. Seasonal variations in the loosely sorbed phosphorus fraction of the sediment of a shallow and hypereutrophic lake. Environ. Geol. Water. Sci. 11:115-121.	The Panel responds that this was meant to be a simple <u>conceptual</u> model and though not so described in the submitted draft (which has since been amended), it is a steady-state model that does not account for transients. The Panel suggests that the commenter re-read this section. This was not an attempt to "accurately portray the Upper Klamath Lake system"; the Panel lacks the hubris to attempt that. If you read a bit further you see the sentence "Therefore the Panel wonders where on this curve the system is at present, and whether this concept is part of the thinking that went into the proposed 47 percent reduction in loading." The Panel is not <u>stating</u> where it is, but <u>wondering</u>. This is meant to point out why the Panel is skeptical about the potential reduction in nutrients. Thus, it represents a challenge to the people studying Upper Klamath Lake and those interested in the loading reductions necessary to effect substantial change compared to those that are possible.

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68	Jacob Kann	13,2	*"There is some evidence that the Klamath system is on the saturated limb of the curve: cyanobacterial blooms in summer fail to use up all of the phosphorus but drive dissolved iron (a naturally-occurring micronutrient that is abundant in volcanic rocks) down to limiting levels (Kuwabara et al. 2009)."* Citation of Kuwabara et al. (2009) as evidence for the idea that UKL is on the saturated limb of the curve is incorrect. First, P limitation in UKL is a seasonal event tied to bloom periodicity. In other words, evidence clearly shows that the early season bloom growth and the bloom peak is P limited (e.g., Lindenberg et al. 2009; Kann 2010). There is abundant evidence based on Chlorophyll:TP ratios greater than 1 and Chlorophyll vs. TP regression slopes>1 that the biomass is limited by P, especially during initial bloom growth through the initial bloom peak. The Kuwabara et al. (2009) paper measured P in the water column subsequent to the annual bloom crash in August, a time when decomposition of the algal biomass releases large concentrations of soluble P (SRP); that period is not a time period when P is limiting because the bloom has already died back. Measured levels of SRP are clearly suppressed during the initial bloom increase in June and into mid-July in most years, and only increases after the bloom has crashed (e.g., Lindenberg et al. 2009; Hoilman et al. 2008; Kann 2010). Numerous other UKL USGS reports that supersede the Kuwabara report support the concept of P limitation (e.g. Lindenberg 2009). Furthermore, aside from Kuwabara having measured SRP during the bloom crash, when we do not expect P to be limiting, the suppression of dissolved iron has not been observed in other years. In order to determine the role of iron one would need to measure it during the period of active bloom growth, not during the bloom crash. Subsequent work by Kuwabara et al. (2010), shows large amounts of iron being released from recently flooded wetlands adjacent to UKL, as well. The significant point here is that the work cited in this paragraph <u>does not</u> provide evidence that UKL is on the saturated limb of the curve. References: Hoilman, G.R., Lindenberg, M.K., and Wood, T.M. 2008. Water quality conditions in Upper Klamath and Agency lakes, Oregon, 2005: U.S. Geological Survey Scientific Investigations Report 2008–5026, 44 p. Kann, J. 2010. Upper Klamath Lake 2009 Data Summary Report. Prepared for Klamath Tribes Natural Resources Department by Aquatic Ecosystem Sciences LLC. Kuwabara, J.S., Topping, B.R., Carter, J.L., Parchaso, F., Asbill, J.R., Cameron, J.M., Asbill, J.R., Fend, S.V., Duff, J.H., and Engelstad, A.C., 2010, The transition of benthic nutrient sources after planned levee breaches adjacent to Upper Klamath and Agency Lakes, Oregon: U.S. Geological Survey Open-File Report 2010-1062, 27 p. [http://pubs.usgs.gov/of/2010/1062/]. Lindenberg, M. K., G. Hoilman, and T. M. Wood. 2009. Water quality conditions in Upper Klamath and Agency Lakes, Oregon, 2006. U.S. Geological Survey Scientific Investigations Report 2008-5201, 54 p.	The Panel had to go on what information was available and did not have time to get into the details of bloom dynamics, or conduct a detailed analysis of this topic. That would not be the task of a Panel in any case, but the task of the proponents of this project, and the community of scientists working on Upper Klamath Lake. Perhaps this section of the Panel's report is a bit provocative, but it is deliberate so to counter the naïve assumption that the proposed KBRA actions will necessarily result in elimination of problem blooms in the lake.
69	Eli Asarian	12, 6 and 13, 2	The panel apparently mis-interprets the UKL TMDL (ODEQ 2002) in saying that it calls for a 47% reduction in external P loading. The UKL TMDL calls for a 40% reduction (see ODEQ 2002 Figures 2-26 and 2-27).	The report has been revised in response to this comment.

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70	Jed Redwine and Eli Asarian	13, 3	The panel states: "The following rough calculation illustrates our point. Wetlands can sequester something on the order of 1 g P per square meter per year or about 0.01 T/Ha/y (Mitsch et al. 1995). The total external loading of P to UKL is about 182 T/y (ODEQ 2002 Table 2-4). To sequester that amount of P would, therefore, require about 18,000 Ha of wetlands, which is about 78 percent of the area of UKL or about 40 percent of the area of irrigated agriculture in the UKL basin. This does not seem like a feasible level of effort for KBRA." We are concerned that the panel is being overly pessimistic about the potential water quality benefits of the proposed treatment wetland and water quality improvement program. The panel's rough calculation of the area of wetlands required to meet the TMDL P reductions has two shortcomings, discussed in the paragraphs below: - The areal P removal rates cited are out-dated and likely too low. - The calculation assumes it is necessary to reduce external P load to UKL by 100%, whereas the UKL TMDL only called for a 40% reduction. Effectively designed treatment wetland systems and naturally functioning wetlands have demonstrated wide variability in rates of sequestration since Mitsch et al. (1995) summarized this guideline for long-term sustainable uptake associated with peat-building processes. Treatment wetland retention rates vary locally by at least an order of magnitude (1.0 – 10 g P/m^2/yr) with a median of 6.0 gP/m2/yr (Kadlec and Wallace 2009 who reviewed 282 FWS treatment wetland systems) depending upon the locally occurring interaction of a set of processes that collectively govern phosphorus cycling in the wetland. The concentration range and relationship between forms of inflow and outflow TP strongly influence annual P retention rates. Concentrating the fraction of phosphorus moving through the river in particulate and organic forms allows a significant portion of the annual external loading budget to be removed directly. Plant colonization and biomass accumulation processes at thousand acre scales exert strong influences on annual phosphorus accumulation rates. Marshes are known to accumulate high concentrations of P locally and at landscape scales produce nutrient gradients that resolve over decades (Childers et al. 2003, Reddy et al. 2011). In an unmanaged condition, this process contributes to higher outflow concentrations over time, but effective management produces the opportunity to use the treatment wetland system to concentrate nutrients in smaller spatial areas that can then be harvested or otherwise managed in order to enhance the system-level retention rate significantly. Even treatment wetlands that aren't harvested have demonstrated higher removal rates. Niswander and Mitsch (1995) report estimated removal of 2.9 gP/m2/yr in their constructed wetlands in Ohio. While the panel correctly states that there is not yet a concrete plan with detailed time tables, budgets, and mass-balance analyses, the information presented above regarding the efficacy of wetland treatment suggests that it is premature for the panel to dismiss the prospects for wetland treatment to abate water quality problems in UKL and the Klamath River. The following updated version of the panel's wetland area calculation shows that the required wetland areas needed to improve water is likely much less than the panel estimates:	As with other comments, the Panel had to rely on information gathered in a very short time, and therefore does not mean for this to be any more than a "rough calculation" to illustrate our point. The cited P removal rate was apparently at the low end of the range (taking these statements at face value). If it were higher, less area would be required. But this misses the whole point of our calculation, which was to challenge the proponents and scientists to do this analysis. The report did not "dismiss" the prospects of wetland treatment. The report expressed the Panel's skepticism about wetland treatment. Skepticism, especially about what you think you know, is a hallmark of an effective scientist. The Panel was just trying to be effective. The calculations done by the Panel are meant to try to put some context (however crude and preliminary) on the Panel's statements. The review process would have been better served if these types of calculations, more rigorously done, had been presented to the Panel. The Panel is supposed to be skeptical about vagueness. As for what the TMDL calls for, that is also beside the point, as the discussion was about how much reduction in loading was possible with a given amount of wetland construction. The Section was edited to include a bit more uncertainty.

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			Total UKL external load in metric tons (from ODEQ 2002 Table 2-4): 180 MT Necessary reduction in UKL external loading (ODEQ 2002): 40% of 180 MT = 72 MT Area of wetland required to remove 72 MT of P at various areal rates: 7200 Ha if 0.01 MT/Ha/yr (minimum P removal rate from Kadlec and Wallace 2009), 1200 Ha if 0.06 MT/Ha/yr (mean P removal rate from Kadlec and Wallace 2009), 720 Ha if 0.1 MT/Ha/yr (maximum P removal rate from Kadlec and Wallace 2009). All of these areas are far small than the panel's calculation of 18,000 Ha, and are likely within the range that could be reasonably implemented within the KBRA framework. References: Childers, D.L., R.F. Doren, R. Jones, G.B. Noe, M. Rugge, and L.J. Scinto. 2003. Decadal Change in Vegetation and Soil Phosphorus Pattern across the Everglades Landscape. Journal of Environmental Quality 32:344–362. Kadlec, R.H. and S.D. Wallace. 2009. Treatment Wetlands, 2nd edition. CRC Press. Boca Raton, FL. Mitsch W.J., J.K. Cronk, X.Y. Wu, R.W. Nairn, and D.L. Hey. 1995. Phosphorus retention in constructed fresh-water riparian marshes. Ecological Applications 5:830-845. Niswander, S.F. and W.J. Mitsch. 1995. Functional analysis of a two-year-old created in-stream wetland: Hydrology, phosphorus retention, and vegetation survival and growth. Wetlands 15(3): 212-225. DOI: 10.1007/BF03160701 Reddy, K.R., S. Newman, T. Z. Osborne, J. R. White, H. C. Fitz. 2011. Phosphorous Cycling in the Greater Everglades Ecosystem: Legacy Phosphorous Implications for Management and Restoration. Critical Reviews in Environmental Science and Technology 41, (S1): 149-186.	
71	Eli Asarian	13, 4	The panel states: "Mass balances should be developed to roughly calculate the effects of each of the potential kinds of actions (e.g., riparian re vegetation, wetland construction) on nutrient loadings and concentrations in the target water bodies. These calculations should explore the magnitudes of reductions potentially available by reasonable levels of rehabilitation." We completely agree with this recommendation. In fact, this effort is scheduled to be done as part of KHSA Interim Measure 10. Interim measure 10 will include a workshop (tentatively scheduled for fall 2011) for stakeholders and experts to explore nutrient removal technologies (including treatment wetlands), and includes funding for a consulting team to develop feasibility studies for application of a variety of technologies. In addition, KHSA Interim Measure 11 provides funding to conduct research on addressing water quality issues. In-progress research funded under this measure includes investigation of wetland treatment technologies as well as mechanical removal of particulate organic matter at Link Dam. Recent USGS studies (Sullivan et al. 2009, 2010) have found that a large portion of the oxygen demand in Keno Reservoir is particulate organic matter (live and decaying *Aphanizomenon flos-aquae*). The panel's report should mention Interim Measures 10 and 11.	The Panel is encouraged to hear that a serious effort will be undertaken on mass balance. It would have been helpful to have that information already available to the Panel. This is the broader issue of the juxtaposition of the timing of the steps (one of which is Panel review) in the decision-making.

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<tr><th>Comment Number</th><th>Comment Author</th><th>Page, Paragraph</th><th>Comment</th><th>Panel Response</th></tr>
<tr><td></td><td></td><td></td><td>References:

Sullivan, A.B., Deas, M.L., Asbill, J., Kirshtein, J.D., Butler, K., and Vaughn, J., 2009, Klamath River water quality data from Link River Dam to Keno Dam, Oregon, 2008: U.S. Geological Survey Open File Report 2009-1105, 25 p. Available online at: <http://pubs.usgs.gov/of/2009/1105/>

Sullivan, A.B., Snyder, D.M., and Rounds, S.A., 2010, Controls on biochemical oxygen demand in the upper Klamath River, Oregon: Chemical Geology, v. 269, no. 1-2, p. 12-21, doi: 10.1016/j.chemgeo.2009.08.007. Available online at: <http://or.water.usgs.gov/proj/keno_reach/download/chemgeo_bod_final.pdf></td><td></td></tr>
<tr><td>72</td><td>Eli Asarian</td><td>19, 1</td><td>The panel writes: "…the TMDL for the Lost River and Link River Dam, which discharge into KR, is set for warm water fishes (e.g., 6.5 mg/L DO over 30 days, or 4 mg/L absolute minimum). The minimum short-term dissolved oxygen standard reported by ODEQ (2002) for migrating salmon is 6 mg/L. Therefore, even if the TMDL could be achieved, passage of adult Chinook salmon to the upper basin will likely be blocked by low oxygen that occurs from approximately early July through late November (Figure 4; see Water Quality)."

Model outputs from the mainstem Klamath TMDL (ODEQ 2010) indicate that with successfully TMDL implementation, instantaneous dissolved oxygen will barely drop below 6.0 mg/L at Keno Dam (and other sites upstream in Keno Reservoir are presumably similar though figures are not shown in the TMDL):

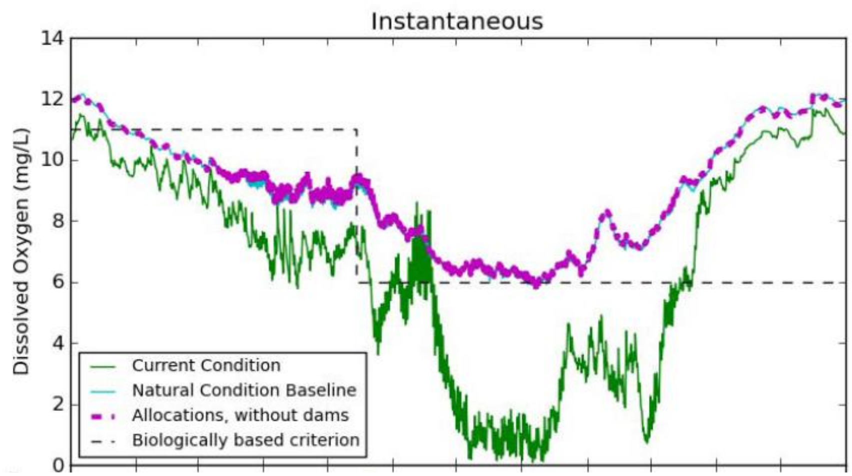

Figure 2-33 from ODEQ 2010. Predicted DO in Klamath River at Keno Dam). Note: while the figure is for the TMDL allocations (i.e. successful implementation) without dams, the with-dams allocation is quite similar (within ~0.01 mg/L).

These modeling results indicate that the panel's statement that "Therefore, even if the TMDL could be achieved, passage of adult Chinook salmon to the upper basin will likely be blocked by low oxygen</td><td>The report has been revised in response to this comment. See additions to the text.</td></tr>
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			that occurs from approximately early July through late November" appears to be overly pessimistic and incorrect. We recommend accurately portraying the model results in the TMDL analysis or removing your statement altogether.	
73	Jacob Kann	14,5	"Modeling of water quality in UKL should be expanded to include a 3-dimensional circulation model with cyanobacteria and sediment components. Three-dimensional modeling is needed because circulation in UKL is wind-driven and algae float and are transported by wind action. Additional models (perhaps 1-D) should explore the interaction between eutrophication and sediment conditions." The purpose for such modeling is entirely unclear and this statement is very general. What water quality parameters should be modeled? What is the goal of such modeling? Is the goal to make predictions for the lake as a whole? Time to P equilibrium? pH , D.O.?, etc. We recommend adding clarifying language to answer the questions listed above.	The report has been revised in response to this comment. A statement has been added to identify the purpose of the modeling. Developing such a model takes time, effort, and knowledge. The parameters to be modeled should be determined by people more familiar with the system.
74	J.S. Foott	D13 appendix	Comment : agree with panel	This comment is noted.
75	T. Shaw	Fig 6, 7	Great maps!	This comment is noted.
76	Hamilton	General	The Section "Questions and Responses" (see Coho/Steelhead EP Report, Section 3) is missing.	The reader is directed to Appendix B for a complete list of the review questions and the Panel's responses, including identification of which questions correspond with the question codes used in the report, and which sections of the report provide the Panel's responses to the questions.
77	Hamilton	General	Under each section (Water Quality, Disease, etc.) the questions that the Panel is addressing need to be listed, as in Section 2.3 of the Coho/Steelhead EP Report.	The Panel opted to list the charge questions in Appendix B. The Panel notes that the coho/steelhead report became unwieldy and the main messages more difficult to follow when the Panel followed the suggestion of this reviewer and included questions within the main text. There is really one overarching question that subsumes all of the charge questions, and this question must be addressed very clearly by the Panel. The format of the Chinook report achieves this much more clearly than the format used for the coho/steelhead report.

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78	Hamilton	General	Hetrick et al. (Hetrick et al. 2009) provides ample evidence of the benefits to salmonids below IGD associated with restoration to a more normative hydrograph under KBRA flows. With KBRA flows alone, there are appreciable increases in Chinook salmon below IGD. This was a one reference that would assist the Panel in answering questions, in particular questions 7 and 10. It does not appear that effects of the Proposed Action below IGD were considered here and should have been. Hetrick et al. 2009 has been peer reviewed and this review is available (please contact me if interested in this review).	The report has been revised in response to this and other comments.
79	Hamilton	General	We may have failed to provide a clear understanding of trap and haul associated with future management. The need for trap and haul would be seasonal in response to poor water quality during a limited portion of the year (U.S. Department of the Interior 2007)[p. C-61]; (National Marine Fisheries Service 2006)[Table 4 p. A-40]. Seasonal trap and haul would be primarily around Keno reservoir.	The Panel agrees, but expects trap/haul will be needed most years in the fall.
80	T. Shaw	General	Given the amount of time necessary to conduct the research, consolidate material, and evaluate the complex chemical, physical and biological factors associated with Klamath dam removal, I thought this evaluation was fairly well done and well written; hats off to the Chinook Expert Panel members. With that said, there are some sections of the report that I question and have disagreement. Maybe the panel should step back and think about the history and what the future entails before making blanket statements such as: *"10,000…the larger the threshold is, the more likely would be a negative conclusion…"* *"…Keno Dam…the dam creates a 21-mile barrier to fish passage…"*, and *"…the Panel was not optimistic that the Proposed Action would have substantial effects on spring-run Chinook salmon."* *"Sediments flushed rapidly from the project reaches following removal of dam/reservoir projects from the Rogue (400,000 cubic meters of sand and silt) and Sandy (750,000 cubic meters of sand and silt) Rivers in Oregon (Major et al. 2008), and <u>no negative effects on spawning salmon were observed</u>."* *However, approximately 17 percent of all naturally spawning Chinook salmon in the Klamath Basin spawned in the mainstem downstream of the dams during 2001-2009 (CDFG megatable). Therefore, <u>sediments from Klamath project reservoirs may have significant effects on the survival of the run</u> and brood present when the dams are removed.* The historical populations of Chinook, with numbers once totaling in the 100s of thousands and their successful life history strategies maintained this runs for thousands of generations. These populations were severed at the spine, at a remote location over 150 miles downstream of their natal spawning and rearing grounds. The Copco I dam, built in nearly 100 years ago was completed in 1918, but the so-called "promised ladder "was never realized. So within a blink of an evolutionary eye, access was eliminated. During the same era, efficient commercial seining operations in the estuary, a bountiful ocean fishery, a new snag fishery at the base of Copco I, and the unimaginable mortalities associated with daily peaking operations at Copco, put an end to the once mighty Upper Klamath Chinook runs. The last ruminant population arrived at Iron Gate Hatchery in the mid-70s, but they all died due to lack of sufficient cool water to maintain the adult holding ponds through the	The report has been revised in response to this comment. The references to the Rogue and Sandy dam removals and the reported lack of adverse impacts on spawning salmon was included to provide information on some actual, rather than hypothesized response. Whether a similar lack of response will occur on the Klamath with order of magnitude increases in the volume of released sediment is unclear. Depending on the type of water year during the sediment release period the predicted sand content of the bed material downstream of Iron Gate after 24 months ranges from 20% (dry years) to 8% (wet years) (Greiman et al., 2011), so the likelihood of severe impairment to spawning salmon will depend in large part on the post-dam removal hydrology. 50-yrs after dam removal, it is likely that pre-dam channel morphology will be established. Future flow and sediment regimes will mimic the historical patterns. The commenter offers a very interesting scheme of yes or no voting on a series of pertinent statements. The Panel already attempted to

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			summer. Now, almost 100 years later, we have an opportunity to eliminate THE primary factor(s) directly affecting access to the upper Klamath Basin. This is a known, undisputable fact; dam removal will provide access to habitat upstream. The other physical, biological, and chemical factors inhibiting the ability for the runs to reach historical population levels is not a relevant issue to today's society. Technological advancements in the next 50 years are an unknown. Nevertheless, given the exponential rate of developments in genetics, chemistry, physics, and biology over the past 100 years, one can assume that our future scientists would have the solutions. The will be saying; "Thank goodness, those scientists, engineers, and powers that be decided to remove the dams back in 21st century." That allowed the physical processes of the river to equilibrate, with the river relocating its historical channel and with sediment supply now a benefit to the aquatic and riparian ecosystem, not a perceived hindrance. The future riparian areas will be mature and functional riparian microclimates will be counteracting the ongoing localized climatic changes. The valuable leaf litter and woody debris recruitment that are dependent upon by communities of macorinvertabrates will again be available and not captured behind the dams. In addition, the "river ecosystem engineers", the beaver will once again The river ecosystem engineer, the beaver will once again do their magic by turning a single –thread channel into a meadow, pond or multichannel, free-flowing stream, a very difficult task in a reservoir. However, compared to these physical, long-term factors associated with dam removal and the channel riparian evolution, technological advances in genetic sequencing over the next 50 years may provide the solution to bringing back extirpated species. "*The comparison of genetic data from remains in museums to data banks with DNA sequences of living tortoises made it possible to identify relatives of extinct animals, Caccone said. However, it will take at least four generations of selective breeding - about 100 years - to bring a genetically identical member of C. elephantopus "back to life."* Given 4 generations of salmon, that could occur in less than 20 years… As far as the very respectable expert panels member's broad range of expertise, knowledge, skills and experiences, I would be very interested in a vote, of Yay or Nay from each individual to the following: 50 years after dam removal: a. The channel is re-established reaching a point of sediment transport equilibrium, b. The riparian communities matures and functionality is restored, c. The Co-managers are led by the "Lead-Scientist" and a successful implementing of an adaptive management process is underway. Predictable outputs are derived by good science with restoration projects and resource management decisions having an immediate, positive influence on the target species and life stage. d. The restoration and conservation measures are effectively addressing the limiting factors. e. Research is ongoing and fully funded to staying ahead of restoration and resource management activities.	respond to many questions in the charge to the Panel and offered many statements in the report. The Panel respectfully declines to respond to the statements offered by the commenter.

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			f. A flow and sediment transport regimes mimics the shape and function of the natural hydrograph. g. Given the advancements in science over the past 100 years then projecting into the future (2020-2070) technology may reach another level of unimaginable achievements. Then think about the Klamath Tribe's denial of their access to Spring Chinook for almost 100 years The Question(s) 1) Will the micro and macro habitat between Iron Gate and Link River Dam, 50 years after dam removal, support a viable run of (a-e)? 2) Will this run, between Iron Gate and Link River dam, increase the viability of the stocks below the existing Iron Gate dam? 3) Will the micro and macro habitat above Upper Klamath Lake, 50 years after dam removal, support a viable run of (a-e)? 4) Will this run, upstream of Upper Klamath Lake, increase the viability of the runs below the existing Iron Gate dam? a) Spring Chinook? b) Fall Chinook? c) Coho? d) Fall Steelhead? e) Winter Steelhead?	
81	Hamilton	General and Page i	In the Executive Summary and Under each Section of 2.0, the Panel concludes 'Conditions' for achieving substantial gains of Chinook salmon with the Proposed Action. <u>These 'Conditions' seem to have replaced the questions</u> (again, see Coho/Steelhead EP Report) that are to be answered. This needs to be corrected and the document brought back into scope to focus on the questions.	The Panel responds that the questions answered are indicated by the letters and numbers in the headings, with further explanation in the text and in Appendix B. The Panel chose to cast the report this way rather than as a one-to-one response to the questions because of the difficulty that caused in the coho/steelhead report, and because the questions had such a high degree of redundancy. The document will not be reorganized as the Panel thinks this is the most efficient way of presenting its findings. In addition, at a briefing to the Panel, the Panel recalls that Mr. Dennis Rondorf (USGS) emphasized that the Panel should focus on the fundamental (overarching) question: will the Proposed Action result in more Chinook salmon?

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82	Hamilton	General comments	The hard work of the panel and contractor are appreciated. The panel faced a difficult challenge in processing an enormous amount of material in a very short time frame. That they have been able to review the mountain of information provided so far is remarkable. The information provided herein is in the spirit of assistance with a huge, difficult, and complicated task. The questions posed to the contractor are in the context of settlement and a very critical management decision being made on timeline consistent with the Settlement timeline. Unfortunately, the SD management process affords the opportunity of conducting very little new research and cannot assume unlimited time or resources. The intent was that the report will render management level opinions to inform the Secretary in regard to whether or not the two alternatives will advance salmonid fisheries. The panel was convened to answer the questions because it is acknowledged that models, quantitative tools, and, in some instances data, are lacking. These are not the only tools available, however, to answer the questions. Logical reasoning and the consideration of how the results of dam removal studies on other rivers might or might not apply to the Klamath River should be discussed in the report and applied, if only in qualitative terms. If necessary, the report has the option of providing caveats with an opinion. If necessary "The panel should be encouraged to identify levels of risk or uncertainty about future predictions." (Page 4 of the contract). The questions posed to the contractor were developed through an open process, with thoughtful consideration by agencies and settlement partners. The biggest problem with the report is that it does not address the questions clearly, and in many places, has lost the intent of the original question and lost the comparison of the two alternatives. Well beyond the scope of the contract and objectives, the report has in many places ventured into the broad identification of 'Conditions' for achieving substantial gains of Chinook salmon with the Proposed Action and, surprisingly, referred to these 'Conditions' with unfounded certainty. These ventures take away from the responsibility of the contractor to have the panel focus on the questions.	Given the amount of material, the limited time to review it, and bearing in mind the adverse comments on the length of previous reports, the panel was forced to consolidate the questions into a manageable objective. The answers to several of the questions are the same. An interested reader can read the short report and simply align the questions (Appendix B) with the information provided to make the connections. It seems unrealistic to expect the Panel to estimate absolute levels of certainty or uncertainty of proposed actions. The Panel report does address the ultimate question of whether the proposed actions will lead to substantially more salmon. The conditions attached to the answer reflect the uncertainty in providing this answer. See also response to previous comment.
83	M. Hampton	i	6. Hatchery versus Wild: Hatchery mitigation requirements will cease in 2028 and production numbers may be reduced during this period depending on the success of salmon production upstream. In addition genetic monitoring will occur to allow for effective management of natural and hatchery interactions during the period following dam removal. However, there may be a need to develop a conservation hatchery to aid reintroduction efforts to areas upstream of UKL and it is anticipated that this effort would also be limited to the specific goals that compliment reintroduction of self sustaining populations.	The report has been revised in response to this comment. This uncertainty concerning hatcheries adds uncertainty concerning disease. The development of a conservation hatchery would seem to be a good idea, but this alternative was not presented to the Panel in specific terms. However, it is worth noting that supplementation efforts with spring Chinook salmon in the Snake River have not led to increases in natural salmon when compared with control streams (www.fws.gov/lsnakecomplan/).

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84	Rondorf, U.S. Geological Survey (USGS)	I footnote	The footnote defining the term substantial is a very important because it tells the reader about the size threshold for the potential increase under the Proposed Action and the deliberations that the Panel used to reach that number. Rather than relegating this important information to a footnote the reader would benefit if the Panel could integrate into the Executive Summary. Although it is only a benchmark, the threshold is central to interpreting the Panel's response to the question on the Proposed Action and to more detailed questions and conditions.	The Panel disagrees; this number is only meant to be a benchmark for our evaluation. It should not be set as an Agency or Tribal goal or objective.
85	M. Hampton	ii	4. Access to Upper Basin. The panel assumes that immigration of all races of Chinook salmon would be impacted by existing poor water quality conditions (Temp., DO) in the Keno Reach and in UKL. Spring Chinook immigration through these reaches is anticipated to occur prior to the onset of adverse water quality conditions in Keno and UKL. Therefore, transport of this life history strategy will likely not be required. Increased spring flows under the KBRA should also improve migratory conditions for this run.	The report has been revised in response to this comment. Some spring Chinook may arrive prior to low water quality in Keno Reservoir assuming other factors allow the spring population to grow. Please note that the flow scenarios provided to the panel by Bureau of Reclamation did not show consistently higher flows below Iron Gate Dam, on average, after dam removal (See Fig. 4 in the coho/steelhead report).
86	Hamilton	P12, para 3, line 3	Please provide a cite that *M. aeruginosa* is intolerant of turbulent water.	The report has been revised in response to this comment.
87	Hamilton	P13, para 3, line 5	KBRA will provide a fixed allocation of water to the USFWS Refuge <u>and associated wetlands</u> (48-60 TAF (Mar-Oct) and 35 TAF (Nov-Feb). Allocations reduced in drought years). Under the No Action alternative/current conditions, the Refuge <u>and wetlands</u> are the fourth in priority among other Project water obligations and, in many years, inadequate water (Mauser, D. and T. Mayer. 2011). This is also summarized in Hamilton et al. 2010. Mauser, D. and T. Mayer. 2011. Effects of the Klamath Basin Restoration Agreement on Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges. Draft Report. 75p.	The Panel was not made aware of this report in time to review it thoroughly as a group.
88	Hamilton	P15, para 1 and 2	*Removal of Keno Dam and Reservoir should be evaluated for future consideration, because the dam creates a 21-mile barrier to fish passage without providing any hydropower benefit at Keno or Link dams.* *Reductions in irrigated agriculture should be considered for evaluation in lands draining to UKL and the Lost River (including LKL and TL) for their feasibility to reduce summer and fall nutrient additions from those waters. Furthermore, the refuges should be managed for fish and wildlife versus agriculture if the basin management objective is rehabilitation of fish species.* While these points seem to be well supported by available information and general literature, they do not address the questions and are management recommendations that are beyond the task of the panel.	The Panel responds that, in a review such as this, it is important for a scientific panel to consider the context of the current and proposed actions, and to do otherwise would be inconsistent with the very nature of a scientist. It would not make sense to establish a panel of experienced scientists and expect them to remain within the narrow confines of their charge. Some people may think removal of dams and KBRA will "restore" habitat but it is worthwhile to identify additional factors that are not being considered by the proposed project.

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89	Hamilton	P15, para 4, line 2	*Thus, the overall success of the Proposed Action* <u>*for salmon*</u> *appears to hinge to a large degree on the potential for reduction in disease.* This point applies to salmon during a portion of the year. It does not apply to Klamath steelhead because they are resistant to *C. shasta*. This is an important distinction. The evaluation of the Proposed Action's success cannot hinge upon effects to salmon alone.	The report has been revised in response to this comment. Changed to read "to Chinook salmon," the topic of this report.
90	Hamilton	P15, para 5, line 10	*The predicted shift of several days of higher spring water temperatures (and consequent higher myxozooan infection rates) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigrant success to the degree that it increases disease incidence.* This may be the case. However, FERC (p 3-314) concluded that the shift in thermal phase would likely result in earlier spawning of fall-run Chinook salmon, a longer incubation period, earlier emergence and growth, and encourage earlier emigration (Federal Energy Regulatory Commission 2007). Thus, why is it any less likely that lower late summer and fall water temperatures under the Proposed Action wouldn't increase salmon outmigrant success to the degree that it decreases disease incidence?	See response above. A change has been made to the phrase in parentheses, and a sentence added, that address this comment.
91	Hamilton	P15, para 5, line 9	*Reduction in food supply for worms through reductions in nutrient loading to UKL seems like a remote possibility (see Condition 1, Water Quality).* While this may be the case, reductions in nutrient loading through the removal of reservoirs and the assimilative capacity of a free running river under the dams out scenario should be considered here.	The Panel believes that Upper Klamath Lake will continue delivering nutrient rich water to the river whether the dams are in or out.
92	Hamilton	P16, para 2, line 1	*2.3 Scientific Leadership (C-15)* There was no question provided on Scientific Leadership.	The Panel believes that a strong scientific leader is needed to coordinate the rehabilitation program. The potential for success of the Proposed Action hinges on the success of implementation of KBRA. Given all the uncertainties, the success of KBRA will depend on scientific leadership and organization. Ongoing scientific investigations and monitoring are mentioned in KBRA, so the intent to support science is there, but our experience with other large programs suggests that leadership is a critical requirement for success.
93	Hamilton	P19, para 2, line 11	Please provide a cite that *…conditions in the upper basin and lake were much better then..* Please provide a cite or further reasoning that that *Chinook salmon introduced to the upper basin may have lower productivity compared with the pre-dam populations.*	As stated, environmental conditions were better during the pre-dam era and before highly industrialized agriculture and Chinook populations had evolved under those conditions.

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	Rondorf, U.S. Geological Survey (USGS)	Page I, 3	"The Panel concluded that a modest increase in Chinook salmon is likely in the reach between Iron Gate Dam and Keno Dam if **some of the conditions** listed below are met." "upstream of Keno Dam is less certain because of the difficulties in satisfying **all the conditions** described below." Is the Panel implying that Conditions such as "Access to Upper Basin" are just not applicable to the IGD to Keno reach or can the threshold be for IGD to Keno be achieved if most but not all conditions are met?	The report has been revised in response to this comment.
94	Hamilton	Page i, para 3, line 4 and page 11, para 2, line 2	*..some of the conditions..* Does this mean any of the conditions? If not, which conditions?	Each condition is a limiting factor.
95	Hamilton	Page i, para 4, line 2 and P 11, para 4, line 1 and P 12, para 5, line 5 and P 14, para 2, line 13 and P 20, para 2, line 3	*Limitations on access to the upper basin because of water quality problems in Upper Klamath Lake (UKL) and ….* *Condition 1. The limitations on access to the upper basin because of water quality problems in Upper Klamath Lake (UKL)…. must be resolved.* *…would these actions ultimately allow free passage of adult Chinook salmon through…UKL?* *Higher temperature together with lower dissolved oxygen in…UKL may continue to pose a bottleneck for adults salmon migrating through the lake even is TMDLs could be achieved.* *Juveniles traveling though UKL …may have difficulty locating the outlet at Link …dams.* Questions regarding passage and survival through UKL have been discussed in documents that the panel may not have considered. Attached is a copy of Maule et al. 2009 which was published in the North American Journal of Fisheries Management. As the panel has identified, one critical uncertainty to successful reintroduction of populations of anadromous fish into historical habitat above and within Upper Klamath Lake is whether emigrants will be able to pass through UKL. To address this critical uncertainty, Maule et al. 2009 assessed the physiological development of one salmonid stock proposed for reintroduction and determined the physiological impacts. While this study was not exhaustive, it did demonstrate that age-0 Chinook salmon transferred to the lake for 2 weeks in late May gained mass and length. These age 0 Chinook were exposed to adverse temperature (>20 C) and DO (6mg/L) conditions. Despite being confined to net pens and having no access to more suitable refugial areas (in particular, extensive cool groundwater on UKL's west side, including Pelican Bay – see below), these age-0 Chinook continued smoltification development and survived the study period well. Age-1 fish had 100% survival during the two weeks they were in UKL in late October under the same conditions. These findings suggest a positive survival window for Chinook in UKL of at least late October through the end of May. Also attached is Dunsmoor and Huntington 2006. Their conclusion (p28) was that the prevailing currents within UKL will likely provide sufficient cues to upstream migrants to enable their rapid movement through UKL to the Williamson River. They concluded that juvenile downstream migrants should likewise benefit from these currents, which will help them move toward the lake outlet. Juveniles that would find their way into the northerly currents along the west shore may well be delivered to Pelican Bay, a cold, spring-water dominated embayment (~3 km^2) of UKL surrounded by wetland, in which Klamath Lake redband trout reside through the summer months. Pelican Bay would offer these juveniles near optimal rearing habitat.	Most of our concerns are related to adult passage through Upper Klamath Lake. The Panel considered documents that were provided and some documents that Panel members found on their own. We had not seen the Maule paper and it is being introduced too late in the process to consider. The listed concern with juveniles was in regards to migration not growth, and with finding the outlet at both Link and Keno Dams.

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			Dunsmoor, L. and C. Huntington (2006). Suitability of Environmental Conditions within Upper Klamath Lake and the Migratory Corridor Downstream for Use by Anadromous Salmonids Technical Memorandum for the Klamath Tribes**:** 80p. Maule, A. G., et al. (2009). "Physiological development and vulnerability to *Ceratomyxa shasta* of fall-run Chinook salmon in the Upper Klamath River watershed." North American Journal of Fisheries Management **29**: 1743-1756.	
96	Hamilton	Page i, para 4, line 3	*The water quality issues must be solved if the principle of minimizing ongoing intervention, as stated in the KBRA, is to be followed.* Self-sustaining populations of anadromous fish is an objective of KBRA, not a principle that cannot be violated. KBRA clearly provided funding for and anticipated seasonal Trap and Haul in its Appendix C-2.	That is why it is stated as contingent. If this principle or objective is to be followed or achieved, the water quality issues must be solved. Does KBRA anticipate trap and haul forever?
97	Rondorf, U.S. Geological Survey (USGS)	Page ii, # 5	"salmon must be sufficiently abundant", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
98	Rondorf, U.S. Geological Survey (USGS)	Page ii, #10	"removal must not kill", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
99	Rondorf, U.S. Geological Survey (USGS)	Page ii, #2	"distribution must reduce disease" , see comment Rondorf, USGS, Page i-ii	See response to comment 106.
100	Rondorf, U.S. Geological Survey (USGS)	Page ii, #3	"science program must be integrated", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
101	Rondorf, U.S. Geological Survey (USGS)	Page ii, #4	"salmon must be perpetually transported", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
102	Rondorf, U.S. Geological Survey (USGS)	Page ii, #6	"spawning grounds must not overwhelm", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
103	Rondorf, U.S. Geological Survey (USGS)	Page ii, #7	"predators must be sufficiently low", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
104	Rondorf, U.S. Geological Survey (USGS)	Page ii, #8	"access must not be overwhelmed", see comment Rondorf, USGS, Page i-ii	See response to comment 106.
105	Rondorf, U.S. Geological Survey (USGS)	Page ii, #9	"flows must be sufficiently", see comment Rondorf, USGS, Page i-ii	See response to comment 106.

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106	Rondorf, U.S. Geological Survey (USGS)	Page i-ii	My compliments to the Panel for deliberating on a subject with so much complexity and so little certainty and reaching a decision on the 10 key conditions that must be met to achieve a substantial increase in Chinook salmon numbers. In general, I do not disagree with the conditions, but I am concerned about the narrow scope of some of the conditions and use of the words "must be." I have two concerns about the 10 conditions. The first is that several of the conditions are topics of narrow scope that are really parts of much wider problems areas. For example, #9 fall flows "must not have a substantial multi-year adverse impact on mainstem Chinook salmon. Is the reader to conclude that fall flows are a key or critical issue and other flows such as spring and summer not so much? A second example is #10 "dam removal must not kill more than one brood" Given the multi-age life history of fall Chinook salmon, the portion spawning in the mainstem Klamath, and the plasticity of the life history is this really a "Must not " condition? I could better understand this condition if it made special reference to spring Chinook salmon. I recognize that the Panel used the term mainstem Chinook salmon, perhaps that could be defined for greater clarity. The second observation is that the words "must or must be" were used in each of the conditions. However, I am concerned that these conditions may be abstracted from the report and used as a simple list of ten criteria for decisions on Chinook salmon related to the Proposed Action. The term "must is probably not consistent with the level of uncertainty the panel has expressed about the findings. For example, (Page 16, 1st Line) "The high uncertainty about these outcomes." The Panel cites NRC (2004) (Page 16, Para 5) with reference to "managing a large project under great uncertainty" The Expert Panel report on coho and steelhead (Dunne et al. 2011:p iii) listed six uncertainties that were obstacles to drawing convincing conclusions about the two alternatives for dams on the Klamath. I applaud the Panel for their decisiveness in identifying 10 succinct conditions that will likely be determinants of a substantial increase in Chinook salmon. However, I have some reservations about how the broad audience that is likely to read the report might use the "list of ten." The simplicity or specificity of some of the conditions is surprisingly narrow given the complexity of the problem. Some of your potential audience may interpret the list of ten as being a pretty short list to solve such a longstanding problem. Furthermore, the strong language as indicated by "must be" could benefit from some qualification about the level of uncertainty from the Panel. I encourage the Panel to reexamine the conditions to determine if they are to narrow and to put the use of the conditions in perspective relative to uncertainty expressed in this report.	The report has been revised in response to this comment to state: "The more of the listed factors successfully resolved, the greater the chances of successful rehabilitation of Chinook salmon in the Klamath Basin. Addressing all nine factors will maximize the chances for success of the Proposed Action. The Panel acknowledges that the success of the Proposed Action may not require addressing all of the factors; but it cannot determine at this time the relative importance of the different factors to Proposed Action success." The factor of Scientific Leadership was moved outside of the list of the nine. Regarding No. 9, the condition reflects the anticipated lower fall flows after dam removal and uncertainty with regard to how these reduced fall flows might affect adult Chinook salmon. Please see section 2.9 of report. Regarding No. 10, please see discussion in Section 2.10 The Panel sees the point about "must," but in revisiting the Conditions we see only one that could be worded differently (#10, Leadership). However, our experience with other large programs tells us that this condition is the one most likely to be neglected, and it really is critical to success of the program. Of course, the salmon don't care what kind of leadership you have, but this is an essential element of managing under uncertainty; thus it is critical for having a robust decision-making process for dealing with the uncertainties.
107	S. Lindley	Pg D-7, top	An analysis of Klamath chinook stock and recruitment is available online: http://www.pcouncil.org/wp-content/uploads/G1b_KlamathConsObj_STT_Rpt.pdf	The analysis report provided in this comment is referenced in the Panel's report.

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108	S. Lindley	p D-6, para D!2 and pg D-7, para 4.	The megatable contains the results of various surveys, and are not an output of any cohort reconstruction or other population dynamics model. The underlying data would be from field surveys (e.g., numbers of carcasses marked, tagged, recovered in various places and times; estimates of the numbers of anglers, their catch per unit effort). I'd argue that we wouldn't want to model those observation processes directly, but use estimates of the uncertainty in the resulting estimates in the modeling (although such estimates aren't routinely reported, unfortunately). Detailed information on how the megatable is produced is available from the PFMC at http://www.pcouncil.org/wp-content/uploads/age_comp_2010_24feb11.pdf.	This comment is noted. The idea of the analysis was to illustrate the role of simpler models.
109	Rondorf, U.S. Geological Survey (USGS)	Page I #1	"issues must be solved" see comment Rondorf, USGS, Page i-ii	See response to comment 106.
110	M. Hampton	8	Current Conditions: The Panel might be interested to know that a Habitat Conservation Plan for PacifiCorp operations is currently available for public review. In general, the HCP builds upon the Interim Measures that were developed during the negotiation of the KHSA.	This comment is noted.
111	Hamilton	Page 8	*1.3 Role and Nature of Panel* _The contract was to address specific questions, not provide management "conditions for success" or direction. This is beyond the scope of the contract.	The Panel determined that the 10 conditions (factors) for success offered a succinct means of answering the questions. It is the Panel's viewpoint that answering the posed questions in the coho/steelhead report resulted in an unwieldy report with redundant answers to multiple questions.
112	T. Shaw	Page 8, number 2	Delete "apparently contradictory;" Focusing on just lake level and river flow minimum requirements, when over 450,000 acre feet of water is diverted from the system, leaving fall lake elevations at near record lows following the irrigation season. Water resource managers must then optimize refill, while targeting on minimum river flows teetering around flood elevation levels throughout the winter. Maximizing storage for the upcoming agricultural season also satisfies the passage requirements of sucker during their spawning migration to lakeshore springs. In addition, Refuge demands for water necessary to accommodate the millions of birds of the pacific flyway are often ignored when the lake refill targets are behind schedule.	The Panel respectfully disagrees with the suggested change. The text has not been changed. In the opinion of the Panel, the flow and level requirements are "apparently" contradictory.
113	T. Shaw	12,3	One of the most obvious and direct effects dams have on water quality is the creation of abrupt changes in dissolved oxygen (DO) concentrations. One is that the physical reaeration capability of a pool is much lower than that of a free flowing reach of similar length. Reaeration is directly related to stream velocity and inversely related to depth. Consequently, since pooling decreases velocity and increases depth, natural physical aeration in a pool proceeds at a much slower rate. Butts et al. showed that for the Rock River in Illinois the average reaeration constant for an 11-mile pool was only 11 percent of the average of the one calculated for the preceding 11-mile upstream free-flowing reach. The problem of low aeration rates in pools is compounded by the fact that more oxygen is used in the pool relative to a free-flowing reach since the detention time is increased because of lower velocities. This enables microorganisms suspended in the water and micro- and microorganisms indigenous to the bottom sediments in the pools to use more of the DO resources in a given area to satisfy	This comment is noted.

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			respiratory needs. The detention time in the aforementioned Rock River pool was 2.23 days compared with the free-flowing reach time of travel of only 0.68 days. Weirs and dams create pools, which have DO levels inherently above or below those normally expected in a free-flowing stream of similar water quality. If the water is nutrient-rich but not grossly polluted, excessive algal growths can be expected to occur in the pools resulting in wide fluctuations of diurnal DO levels. During the day, super saturation may occur because of algal cell photosynthesis, whereas during the night almost total depletion may occur because of the respiratory needs of the algae. Essentially the pools act as biological incubators for plankton. However, in the absence of sustained photosynthetic oxygen production, DO concentrations may often fall below desired levels since the waste assimilative capacities of the pools are often much lower than those of free-flowing reaches of the same stream. In addition, dams promote the accumulation of sediments upstream. If these sediments are polluted or laden with organic material, additional strain is put on the DO resources since the quantity of oxygen needed to satisfy sediment oxygen demand (SOD) is directly related to the detention time and inversely related to depth, as shown by Butts et al. Spring and tributary accretions that once naturally diluted nutrient loading are now trapped by the reservoirs due to density differences causing that cool clear water to sink, with the majority of reservoir releases occurring near the surface to maximize "head." Essentially, a fixed volume of water is preserved allowing more time for benthic organisms to deoxygenize the water as flow rates decrease. The reduction in oxygen levels behind the dams can be partially compensated for by aeration at the dam site. This localized aeration cannot make up for the overall damage rendered in the pools, but it can establish or control conditions in the next succeeding downstream reach. Sharp drops in DO concentrations often occur immediately below some dams, which spill directly onto shallow rocky scarps. Since the dams sustain relatively stable, high DO levels and the rocks provide ideal substrates, zoogleal growths are promoted (similar to that which persists on trickling filter rocks) when dissolved biochemical oxygen demand (BOD) exists in stream waters. Much of the rational to decrease nutrient loading into UKL was not a Chinook Salmon issue, but focused on suckers.	
114	Rondorf, U.S. Geological Survey (USGS)	13, 2	The estimate of Productions using wetlands is a useful exercise. Mitsch et al. (1995) abstract "These constructed wetlands retained about the same amount of phosphorus per unit area (0.5-3 g $P/m^2/yr$) as have several other natural and constructed wetlands receiving similar concentrations of phosphorus. Note 1-4 g $P/m^2/yr$ for natural wetlands in Midwestern USA in discussion. Also note high-flow wetlands were almost as effective as low-flow wetlands. The Panel used 1 g $P/m^2/yr$ in the example and this is not unreasonable. However using the range of 0.5 to 3 g $P/m^2/yr$ would provide the reader considerably more information and not add much complexity to the example or the text. Would the Panel's conclusion be the same for the range?	See response to comment 45. If we were doing the analysis we would certainly include a range of values and other sources of uncertainty to come up with an envelope of potential outcomes. However, our purpose was not to do the calculation but to suggest that a rigorous analysis along these lines was needed.
115	T. Shaw	14, 2	Salmonid adapt to adverse conditions by natural selection and improved, successful life history strategies. If one concludes that high temperatures during any particular month(s) of the year will not facilitate perpetuation of multiple salmonid runs, then there would not be any adults making it to the Iron Gate hatchery or any tributary above the Trinity. Even the Trinity has adverse temperature conditions during certain summer periods. Cold-water accretions and earlier cool temperatures of the fall may compensate earlier temperature warming. In addition, much of the habitat will have the relatively warmer spring dominated base flow incubation temperatures. However, adverse condition will be experience, with different races of Chinook taking advantage of various migratory windows	This comment is noted.

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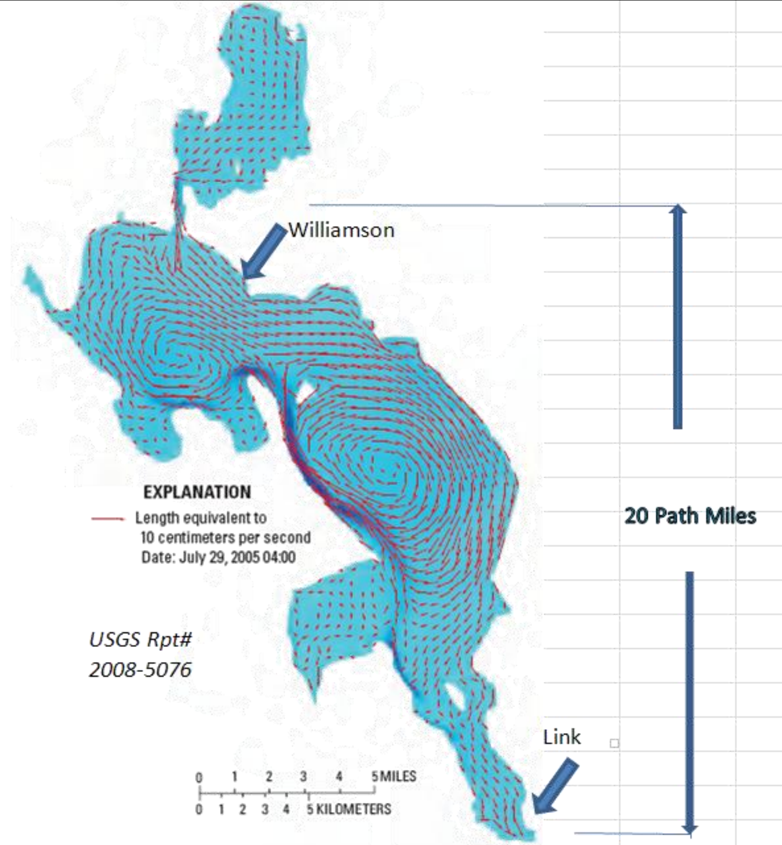
			and migration strategies. Juveniles entering UKL will most likely follow the wind driven, clockwise lake current with about 20 miles between the mouth of the Williamson and Link dam. The highest wind and associated currents occur during late night hours, with corresponding currents reaching 1-2 ft/s and the timing of juvenile salmonid movement. If juveniles enter a thermally challenged segment of stream, they will take advantage of the multiple thermal refuge areas typical of seeps, springs and tributaries during the daytime hours, and then emigrate in the late evening when conditions cool or must wait until a front move in, and then follow that cooler pulse of water downstream. Spring Chinook adults migrate during the Spring months, when temperatures are low and flow is high. They take advantage of this increased flow to reach upper, spring fed holding areas that still exist above UKL. The juveniles do not migrate when temperature are adverse, with little chance these fish will be "trapped between Link River dam and Keno. Fish that spawn below Link will limit conditions affecting their ability to out-migrate other than disease, which will obviously diminish with dam removal. One must also consider the size of fish that will be migrating. Salmon originating from above UKL will be at least twice the size of fish that began their dispersal/emigration from the vicinity of Iron Gate and Shasta, and less time at exposure to pathogens. Their size and migration rates will continuously increase through the late spring entering the ocean at a substantially larger size than Chinook originating from below Iron Gate. Ocean survival will be much higher for these upper basin originated smolts. For example, comparisons between fingerling and yearling Chinook releases from Iron Gate demonstrated that yearlings have a 4X higher survival to adulthood than the fingerlings. What would the survival of successful Chinook smolts originating from the Sprague, how does this increase in survival play into the habitat, harvest equation. Given a reduction of disease and an increase in smolt survival 10000 adults producing 12,500,500 eggs, with 20-smolt survival. For example, Assuming, 10,000 natural adults, under existing conditions below Iron Gate, produce 12.5 M eggs (2.5 K eggs/fem), survival to juvenile is 20 %, and a 50 % mortality of the remainder due to Ceratomyxosis, with 50% surviving to smolt. After the ocean and harvesters taking an additional 99% of the remainder, 12.5K adults returning spawn. Under the dams out, below Iron Gate survival to juveniles increases by 5 % due to the increased spring flows and habitat related survival under KBRA. Disease effects and the survival to smolts goes to a relatively natural rate of 17 % mortality, with similar ocean and harvest survival of 1 %, and the remaining 26.5K adults return to spawn. However, under the dams out, above Iron Gate, survival increases by another 5 %, in association with abundant high quality habitat and limited completion. The juvenile to smolt survival also increase to 70 %, with natural levels of pathogens, but being both larger and faster, the smolt exposure to C. shasta and competition for quality resources are less. Now, remember the 4X fingerling ocean to adult return survival rate? That equates to 135K adults return to spawn.	

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			 **Figure 8.** Simulated depth-averaged currents under prevailing (northwest) wind conditions, Upper Klamath Lake, Oregon.	
116	Rondorf, U.S. Geological Survey (USGS)	14, 2, L 13	"We have reservations….." At this location the topic again changes in the text to the Panel's reservations. This is an important summary point that would justify the start of another paragraph.	The report has been revised in response to this comment.
117	Rondorf, U.S. Geological Survey (USGS)	14, 2, L 8	Topic sentence for this paragraph starts out with "high temperatures." "Following projected TMDL BOD reductions" at this point the text changes topic from temperatures to dissolved oxygen as a topic so recommend new paragraph	The two are linked and the text returns to temperature at the (new) end of the paragraph.
118	Rondorf, U.S. Geological Survey (USGS)	14, 2, L8	BOD reductions, is BOD defined as an abbreviation in the text at this point. It is not defined as to what it is and is not mentioned again in the text of this paragraph. Reader would benefit from knowing role of BOD as a determinant of DO.	BOD is defined, or at least spelled out, on Page 10.

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119	Hamilton	Page 14, para 2, line 10	*Following projected TMDL BOD reductions, dissolved oxygen is expected to meet the criteria for warm-water fish of 6.5 mg/L (30 day mean minima) and 4 mg/L (absolute minimum), whereas the respective cold-water criteria are 8.0 mg/L and 6.0 mg/L.* Please provide a citation. What absolute DO minima apply to Klamath Chinook salmon appear to be an open question. Age 0 Chinook were exposed to adverse temperature (>20 C) and DO (at or below 6mg/L) conditions in UKL (Maule et al. 2009) (Figure 8). These age-0 Chinook continued smoltification and survived the study period well.	Although salmonids have the capacity to survive DO $\leq$ 6 mg/L , the physiological costs of doing so increase greatly as DO decreases (see USEPA 1986, as referenced in the Panel's report).
120	M. Hampton	15	I concur with the Panel's recommendation regarding the need to investigate potential removal of Keno Dam to reduce impacts to aquatic resources and migration impediments.	This comment is noted.
121	Rondorf, U.S. Geological Survey (USGS)	15, 2	Are LKL and TL undefined abbreviations at this point in the text?	The report has been revised in response to this comment.
122	J.S. Foott	15, 5	"However, the extent of the reduction is uncertain (partly because of the presence of the Iron Gate hatchery and many carcasses nearby in the mainstem), and this scenario imposes a risk of **simply moving the problem to wherever large spawning aggregations occur**." **Comment:** Both high polychaete abundance and myxospores shedding carcasses are needed for an infectious zone. For instances, similar level of Cshasta infected carcasses occur in the Trinity but low polychaete abundance precludes the formation of an infectious zone. The assertion in bold text is not accurate.	The report has been revised in response to this comment. Text changed to indicate aggregations of both carcasses and polychaetes are required.
123	Rondorf, U.S. Geological Survey (USGS)	15, 5 L 12	"under the Proposed Action could reduce Chinook salmon outmigration success to the degree that it increases disease incidence." Suggest inserting "(i.e., survival)" as I assume that success is implicitly defined as survival.	The report has been revised in response to this comment. The Panel responds that survival is not equivalent to success. The term success has been changed to survival in the text.
124	Rondorf, U.S. Geological Survey (USGS)	15, 5, L 10	"several days of higher spring water temperatures " This effect would likely be offset to some degree by earlier spawning of fall Chinook because of cooler water temperatures in fall. As a result, emergence and the onset of dispersal and rearing is likely to be earlier. Overall, the life history of fall Chinook would return to being more synchronous with the rest of the aquatic ecosystem. Seasonal development of juvenile fall Chinook salmon and the myxozooans would return to a more natural (with many perturbations remaining) balance as a result of a thermal regime similar to conditions they evolved under. Therefore, the Panel's conclusion that "consequent higher myxozoan infection rates" seems more speculative than the above scenario I describe. I do not understand how the Panel's conclusion can be supported if the life history of fish and pathogen are considered at the same time.	The report has been revised in response to this comment. Text has been added to indicate that a difference in timing could alleviate the problem.
125	J.S. Foott	15,5	"Additionally, the predicted shift of several days of higher spring water temperatures (and consequent higher myxozooan infection rates) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigrant success to the degree that it increases disease incidence." Comment: A key concept is the timing of rearing and smolt migration with actinospore release (typically around 12-13C). If warmer spring temperature results in higher growth rates and a sooner outmigration, it could offset an early actiospore release.	The report has been revised in response to this comment. The Panel notes that changes in migration timing will influence survival at sea, positive or negative, depending on availability of prey at sea.

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126	T. Shaw	15. last	The statement implies that Iron Gate Hatchery will still be operating, 50 years into the future, feeding the worms with actinospores, not so. There will be no Iron Gate. In addition, densities of polychaete colonies above Iron Gate within high density spawning areas and infected carcasses, of the correct genotype, that leads towards Ceratomyxosis, at rates being observed below Iron Gate, seems to me as push of reality, meaning unlikely, but a very good observation.	The Panel remains uncertain concerning where aggregations of Chinook salmon and polychaetes will co-occur.
127	T. Shaw	General page 15	This report is very well written and a pleasure to read, a breath of fresh air!	This comment is noted.
128	T. Shaw	16,	Very good to use 2004 NRC for planning, adaptive management and processes to support research, action/reaction, more research, followed by restoration and monitoring until limiting factor becomes insignificant. I will always remember the quotable quote: *"Many federal and state agencies in the basin mistake input for output when evaluating their performance." The* 2006 NRC is also very good reading and informative. I also agree with the lead Scientist concept but good luck finding one without strings and one that will stick it out for the long run.	This comment is noted. The California Bay Delta and the USEPA EMAP/NARS found such a scientist; we agree that the long term commitment is another potential pitfall.
129	T. Shaw	16, 1	Excellent point we are working on some and could use your help on others.	This comment is noted.
130	Rondorf, U.S. Geological Survey (USGS)	16 sect 2.3	The section on Scientific Leadership is sequestered in the text between conclusions about water quality on p 15 and Figure 4 illustrating Dissolved Oxygen and date on p 19. Seems like a very odd placement for a message that I believe the Panel feels is very important. Recommend relocating section to a more strategic location in the report.	The report has been revised in response to this comment. The section was moved to be distinct from the other nine factors.
131	M. Hampton	19	The report states "This period encompasses a significant portion of the migration period for both fall and spring Chinook salmon that might attempt to gain passage to the upper basin. Therefore, a perpetual trap-and-haul program may be needed to provide adult Chinook salmon with access to the upper basin during much of the migration period. Without solving the water quality problems, a fully self-sustaining run of Chinook salmon to the upper basin is unlikely." Historical accounts by Fremont on May 6, 1846 indicate that large numbers of salmon were present at the oulet of UKL on May 6 which well before the onset of adverse water quality conditions that may inhibit salmon migration. Fortune (1966) describes two historical runs in the Klamath Highlands one in May and June and the other in August. Based on this run timing migratory conditions for Spring Chinook salmon would appear to be suitable. Did the panel consider adult spring Chinook run times as described above when they contemplated potential benefits for this life history tactic to utilize the upper Klamath in the analysis.	The report has been revised in response to this comment. See Section 2.4 and 3.2. The text modified, but concerns from the Panel remain.
132	T. Shaw	19	DO and Temperatures can be avoided by the different life stages and life history strategies. A Chinook will not enter hot water or DO starved. High abundance may lead to oxygen depletion, but adult migration timing does not correspond to high temperatures. Trap and haul does not make logical sense since the adults would not be there. The adults would head back down stream if they encountered adverse conditions during upstream migration.	This comment is noted. The Panel is not convinced that DO in fall will improve much over existing conditions. While low DO might not cause 100% blockage, the low DO would inhibit population recolonization and recovery.
133	M. Hampton	20	The suggested studies described by the Panel at the bottom of the page are welcome and will likely be incorporated into the reintroduction and monitoring plans that are identified under the KBRA.	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
134	T. Shaw	20,	Excellent points but does not justify that adult Fall and Spring Chinook would not survive and establish a self-supporting population. I agree, the salmon of the upper basin are gone, extirpated. There may be some lingering traces of their genetic make-up and diversity still amongst the Klamath and Rouge systems and I support developing a stock of Spring and Fall Chinook from various Klamath specific tributary populations and adjacent watersheds, including the Snake. This would insure extremely genetically diverse groups of adults that would have a higher likelihood of success. Apparently, adaptation occurs rapidly. I am supportive of the recommended studies.	This comment is noted.
135	M. Hampton	21	2.5 Lower Basin Colonization, Reproduction, and Harvest. The current fishery management plans allow for adjustments to the escapement floor on an annual basis to incorporate poor environmental conditions and/or new information as it becomes available. If productivity increases due to reduced disease and/or improved habitat conditions then management to the floor should allow for additional escapement to seed newly available habitat areas. I fully concur that harvest management must used to insure adequate escapement numbers are reached. In addition, it will likely require several generations for successful life history tactics to develop that are able to take advantage of new habitat areas and the conditions they provide. In the end, this should greatly improve the diversity of the life history tactics resulting in more diverse populations that are reasonably resilient to unanticipated adverse conditions, such as acts of god, that will likely occur through time.	This comment is noted. The report has been revised in response to this comment. See slight text change.
136	T. Shaw	21,1	There will still be opportunities for harvest of hatchery adults and a good rational for 100% mark of all hatchery Chinook. Currently 25%, until the run is extirpated.	This comment is noted.
137	M. Hampton	22	2.7 Predation. The panel provides a pretty thorough discussion of the potential interactions between redband and Chinook. However, the panel does not include any discussion of the current predatory affects of resident rainbow trout upon Chinook populations downstream of IG. Incorporation of this relationship from a qualitative perspective would add additional balance to the comparison between the two alternatives. Microhabitat preferences of the two species do provide spatial separation to some extent that may reduce predatory interactions however, as the panel describes, if redband behavior patterns shift to target Chinook fry exclusively then impacts to productivity will certainly be a factor. Since these species have evolved together isn't it reasonable to assume that predatory interactions will not significantly reduce production, particularly if diverse habitat types are present. Regardless, survival of Chinook smolts under these conditions would still provide an overall benefit to total production in these new habitat areas.	The report has been revised in response to this comment. Text modified to clearly state that co-existence and microhabitat would act to reduce any predation effects.
138	T. Shaw	22, 2	I agree that hatchery interbreeding can have short-term domestication effects; however, there are no fish in the upper basin, so no traits to domesticate. Many of the hatchery traits will shed immediately upon emergence and swim-up.	This comment is noted. The "shedding" of hatchery traits associated with hatchery strays to upper basin would lead to reduced survival. The commenter is referred to the report text.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
139	T. Shaw	22, 2	Yes, this is a fish eat fish world, however rainbows, dollys and associated Chinook, Coho, pink, sockeye and chum do very well in a rainbow rich environment. These young of year occupy alternative habitat during periods of high fish predator abundance and limited food supply. However, I would expect the redband population to benefit with the reintroduction of salmon and steelhead to the upper basin. The redband already have set up shop and have a territorial advantage, and can take advantage of the vulnerable life stages. Eventually, the population should stabilize, with sufficient numbers to fill available habitat, with excess exploring inhabiting new territory or consumed by predators.	This comment is noted.
140	Hamilton	Page 22, para 4, line 4	*This may increase predation on the juvenile Chinook salmon, thereby reducing or canceling the benefits to Chinook salmon due to expansion of habitat.* These species co-existed and evolved with each other for eons. Kiffney et al. 2008 found overall biomass of rearing fish increased after dam removal when both resident and anadromous species occurred together. Kiffney, P. M., et al. (2008). "Changes in fish communities following recolonization of the Cedar River, WA, USA by Pacific salmon after 103 years of local extirpation." River. Res. Applic. 25: (Published online 12 June 2008 in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/rra.1174): 438–452.	The report has been revised in response to this comment. Text has been modified to clearly state that co-existence and microhabitat would act to reduce any predation effects.
141	Hamilton	P 23, para 3, line 11	*Additionally, because groundwater temperatures are typically 1-2 °C greater than mean annual air temperature (Kasenow 2009), the temperatures of groundwater flows are expected to rise, thereby reducing availability of cold-water refugia.* Groundwater temperatures may very well be typically 1-2 °C greater than mean annual air temperature (I could not obtain a copy of Kasenow 2009 to understand the context of this statement). However, while hydraulic pulses can move through a groundwater system relatively rapidly, on the time scale of months or years, the actual advective travel time of water is much longer (Gannett 2010). Large amounts of groundwater discharge into the Wood River subbasin, the lower Williamson River area, and along the margin of the Cascade Range (Gannett et al. 2007). Large scale springs, such as in the Cascades, with travel times on the order of decades to centuries can be expected to damp climatic temperature variations on the order of decades (Manga 1999) thus diminishing the effect of climate change in groundwater influenced areas of the Klamath watershed.	The report has been revised in response to this comment. The Panel lacked the time to review these publications, and its attention was not drawn to them until now.
142	Hamilton	P 23, para 3, line 11	*Climate-related changes are predicted to increase freshwater disease, parasitism, and competition and predation by alien fishes.* Please provide a citation.	The Panel responds that this is simple bioenergetics: increased temperatures increase interactions until temperatures become excessive for coldwater biota. See Battin et al. 2007, Farrell et al. 2008, Yates et al. 2008, and Marcogliese 2001, as referenced in the Panel's report.

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143	T. Shaw	24, 3	Yes, flows will be lower in the fall but not due to climate change, but due to the allocation process under KBRA. This drop in fall flows corresponds to an increase in spring flows. In addition, these outputs are a product of the Klamath Project water allocation model, WRIMS with simulations of KBRA allocations over the historical period of record. We, the Technical Advisory Group, reached a consensus that higher Spring flows that increase the habitat availability for fry Chinook outweigh the slight loss of spawning habitat.	This comment is noted. The projected flows provided by the Bureau of Reclamation to the Panel (see also Fig 4 of the coho/steelhead report) did not show consistently higher spring flows, on average. The inconsistent reporting of flow information to the panel is problematic. The Panel recognizes that this is due in part to uncertainty in what the Biological Opinion flows are likely to be.
144	Hamilton	P 24, para 2, line 8	*Upwelling occurring later in the year may be especially counterproductive for juveniles responding to warmer spring waters in UKL and Klamath River if the warmer springs result in their emigrating to the sea at an earlier date.* Salmon have phenotypic plasticity and a high reproductive capacity (Healy 2009). In the Columbia River system, Chinook salmon responded rapidly to anthropogenic habitat changes (Connor et al. 2005; Williams et al. 2008). Here, a fall-run Chinook salmon population may have experienced life-history evolution, in response to water temperature alteration within a few generations. Historically, juvenile fall-run Chinook salmon from the Snake River migrated as subyearlings to the ocean. With changed riverine conditions, some juveniles now migrate as yearlings, but more interestingly, the yearling migration tactic has made a large contribution to adult returns over the last decade. Klamath fall-run Chinook have the same plasticity and would likely respond in a similar manner to new temperature regimes and newly restored habitat. Healy, M. C. (2009). "Resilient salmon, resilient fisheries for British Columbia, Canada." Ecology and Society 14(1):2: 12 p. Connor, W. F., et al. (2005). "Two alternative juvenile life history types for fall Chinook salmon in the Snake River Basin." Transactions of the American Fisheries Society 134: 291-304. John G. Williams, et al. (2008). "Potential for anthropogenic disturbances to influence evolutionary change in the life history of a threatened salmonid." Evolutionary Applications: p271-285.	The Panel responds that fisheries managers and fishers are optimistic. The long-run history of fisheries is one of decline given long-term economic growth and development. See Limburg at al. 2011, as referenced in the Panel's report. The fish likely will adapt as they have for millennia—but there will be bioenergetic costs for that adaptation. Using the Columbia as an adaptation success story is an excellent example of the poor success of such adaptation because multiple salmonid stocks remain ESA-listed in the Columbia and Snake systems, despite billions invested in their recovery.
145	Hamilton	P 24, para 2, line 8	*The warm phase of the Pacific Decadal Oscillation is often associated with reduced upwelling and reduced salmon production.* Please provide a citation.	See Mantua 2009, as referenced in the Panel's report.
146	Hamilton	P 24, para 2, line 8	*Smolt to adult survival of Klamath Chinook salmon is already very low…* These rates are primarily from Klamath hatchery fish, correct? For wild fish, survival rates are likely different. Please provide a citation.	Yes, see CWT values from mknechtle@dfg.ca.gov. While wild salmon survival rates may be somewhat higher than hatchery Chinook, they are typically highly correlated. See www.fws.gov/lsnakecomplan/ for comparisons. See references in the Panel's report.

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147	T. Shaw	25	There are many inferences in this section and contradicting statements. For example, in the Rogue and Sandy River, there was no negative effect on spawning. However, on the Klamath, there may be a significant effect, possibly multiple broods. Sandy River Marmot Dam removal: http://www.youtube.com/watch?v=-uveOUYhNWk&safety_mode=true&persist_safety_mode=1 Sandy River, the next summer: http://www.youtube.com/watch?v=t5XCwmzt5ow&safety_mode=true&persist_safety_mode=1 The greatest potential positive effect would be the disruption of the polychaete habitat from coarse sediment and possible sand scour. I am curious what rational was used to make this inference. There is substantial mainstem spawning on the Rogue, but not effect. Why would once conclude that 17% increases the likelihood of effect. As you well know, Salmon are very particular about their redd placement, with the hydraulics of the pit and mound coupled with the intergravel flows and egg depths can deflect this suspended, turbid water rather than capture the mobile sediment. One must also consider the flow events that are of the magnitude and duration sufficient to transport fine and coarse sediment. These events are typically, "piggy backed" with other accretions maintaining the transport capabilities all the way into the ocean. Most of the fines and sand that are deposited will end up on the on the river's hydrologic floodplain (the land adjacent to the base flow channel residing below bank full) or bench. The distance from the sediment source and redd locations should also be evaluated. Coarse sediment will only travel so far. Coarse sand from Copco reservoir is unlikely to affect any eggs in upper extent of mainstem spawning, 10 miles below Copco I dam. In addition, there is substantial spawning in the mainstem Klamath in Happy Camp, 80 miles below Iron Gate. However, please do not get me wrong, the drawdown and nick erosion processes that will occur during dam removal will have some effects unless a fortunate high flow experience occurs similar to the Marmot dam example. . When one considers the historical impacts from hydraulic and dredge sluice mining, the splash dams associated with historical timber harvest practice and the "blow outs" that occurred due to "Humboldt" type stream crossings, one can appreciate the resiliency of the salmonids.	See previous response to comment #80. See previous edit to this sentence.
148	T. Shaw	27, 2,3	I am very surprised anyone would call a July Salmon a Spring Chinook. Spring Chinook begin entering the Klamath River mouthy as early as February, with the timing of the typical run occurring from late March to mid-June. The can be found in the upper Trinity and Salmon Rivers in early June.	According to Hamilton et al. 2010 (P. 44), spring Chinook return from March through July.
149	Rondorf, U.S. Geological Survey (USGS)	27, sec 3.1	"Consequently, the frequency of bed material mobilization in the project Reach is unlikely to be significantly altered by dam removal." This may be accurate for the Project Reach. However, under current conditions the Project influences reaches downstream of Iron Gate Dam. Flow regimes and sediment load from Bogus Creek to Willow Creek are expected to reduce mobilization flows from about 10,000 cfs under Current Conditions to 3-7,000 under the Proposed Action. Similarly, in the Willow Creek to Cottonwood Creek reach, mobilization flows will be reduced from about 10,000 cfs under Current Conditions to about 5-9,000 cfs under the Proposed Action. The conditions would reduce the return years of the mobilization flows from 3-5 years to 1.5-3.2 years so the mobilization flows would occur more often. This may also be an important relation for disease downstream of Iron Gate Dam. The text in section 3.1 Normative Flow Regime has a very limited perspective of normative flow and relation to river continuum.	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
150	T. Shaw	27,1	The Klamath never did have high peak flows compared to a snowmelt driven watershed like the Trinity. The expansive marshlands of the Sprague, Williamson, UKL, and LKL metered the flows. Under KBRA, we expect additional spills due to the aggressive refill flow regime. However, I agree that the flow regime under either alternative is far from unimpeded. A push for mimicking the natural hydrograph on a daily basis would have additional benefits, with potential implementation under KBRA, but very little to no opportunities under existing conditional	This comment is noted.
151	Hamilton	P 27, para 4, line 3	*Spring-run Chinook salmon enter the Klamath River from approximately April to July.* Historically, some spring-run Chinook salmon were noted much earlier in the Klamath River. The 1901 Klamath Republican (in Lane and Lane Associated 1981) reported salmon at Klamath Falls in March. This would have meant an entry into the Klamath from the ocean even earlier and may have indicated a life history that avoided periods of high harvest and/or poor water quality. If so, it is likely that this life history, once cut off from over-summering habitat above UKL, disappeared. The Proposed Action would provide the opportunity to reestablish such a life history and increase resilience of the population through this diversity.	This comment is noted. The Panel agrees that the proposed action would provide this opportunity but there are additional constraints for spring Chinook that must be successfully overcome, as discussed in the report.
152	Hamilton	P 28, para 3, line 2	*Based on the Panel's past experiences with large rehabilitation projects in other systems, the stream rehabilitation literature (e.g., IMST 2006; Roni et al. 2008), and increased uncertainty of KBRA funding, the Panel has strong reservations that KBRA will be implemented with sufficient effectiveness to achieve its stated goals.* During the period of implementation of the Klamath Act (starting in the mid-1980's) and large scale Klamath River restoration projects to date, one run of anadromous fish has been Federal ESA listed for the Klamath River. In comparison, during the same period in the Columbia River, 13 runs have been listed. Based on this comparison and the Klamath restoration track record, is the panel's negative outlook on the Proposed Action for the Klamath really warranted?	But the Klamath has fewer populations to list, and 2 species of resident fish have been listed. The Panel is NOT negative, simply uncertain.
153	M. Hampton	29	4.0 Modeling The Fish Production Modeling Team would like to thank the Panel for their review and suggestions regarding the Full Life-Cycle Fish Production Model. The panel might be interested to know that since the expert panel workshop in January, along with the extremely aggressive schedule that became unrealistic to meet with the full version of the model, the Fish Production Modeling Team shifted direction towards development of two simplier models that will be used to inform the economic evaluation and possibly help inform and improve understanding for development of the full version of the model in the future. Reports for each of the efforts should be available on May 16 and are going to be reviewed by the Center for Independent Experts through NMFS.	The Panel is happy to hear this and concurs.
154	Rondorf, U.S. Geological Survey (USGS)	29, 3	"appropriate investigation in the 10 years prior to dam removal" Inasmuch as the Secretarial Determination will be made in 2012 and dam removal is scheduled in 2020, this would be closer to eight years.	The report has been revised in response to this comment. The text has been changed accordingly.
155	John Duff	Page 1-15	Reviewed Pages 1-15 and find it suitable for dissemination	This comment is noted.
156	M. Knechtle	I, 2	"substantial" increase needs to be clarified. It is stated that "substantial" refers to an increase of 10% natural fish (roughly 10,000) but how is the total abundance effected in the absence of IGH produced Chinook? Will there be more fish under the proposed action or less?	The Panel responds that there will be more fish; the issue is what constitutes substantially more.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
157	M. Knechtle	General comment	In cases where there was uncertainty in the outcome there appeared to be much more focus on the potential negatives vs. the potential positives with respect to fish response.	This comment is noted. The Panel responds that this is partly due to the optimistic slant of how the material seemed to be presented to the Panel. Also, complicated actions to increase fish in a system are subject to problems if any of the individual pieces fail or do not respond as expected. It is possible, but more unlikely, that the uncertainty in some of the factors could result in higher production of fish than assumed. We added a sentence to the text that uncertainty could also increase the response. In addition, this comment could be true; it could also be true of how the reader reads uncertainty.
158	M. Knechtle	General Comment	Throughout the document the panel repeatedly described their skepticism that the KBRA would be fully implemented. It was my understanding that one of the assumptions of the review process (listed on page 8) was to assume that there was full implementation of the KBRA rehabilitation actions.	Such an assumption seemed unfounded to the Panel, given our knowledge of other large programs Furthermore, the actions planned under KBRA were described in only very sketchy terms, making it difficult to determine whether even full implementation would result in meaningful change.
159	M. Knechtle	20, 3	"Life-cycle studies in the upper basin should begin as soon as possible…." What would the source of these fish be? Later in the document the panel recommends that hatchery fish influence be limited in the upper basin. Just wanted to make sure the panel was not recommending seeding the upper basin with fish that it recommend to limit.	The Panel responds that this is a reasonable question that stakeholders should ask themselves. One idea is to trap and haul adults now as suggested in the report.
160	M. Knechlte	21, 1	Based on the projected river returns harvest levels may not need to be reduced.	This comment is noted.
161	M. Knechtle	21,2	Straying of hatchery Chinook salmon to spawning grounds must not overwhelm the evolution of new life histories…" Please further describe "overwhelm."	This statement is intended to mean "reduce the fitness of progeny."
162	M. Knechtle	25,1	Can the cubic meters of sand and silt above the Sandy and Rouge examples be compared to what is estimated for the Klamath proposed action?	The sediment volumes in the Klamath will be an order of magnitude higher than those of the Sandy and Rogue Rivers.
163	M. Knechtle	25, 1	"The proposed action will involve considerable amounts of sand (300,000 to 400,000 tons)….." Can this be reported in cubic meters for context with previously stated examples?	The report has been revised in response to this comment.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
164	M. Knechtle	25, 1	"Calculations of bed-mobilizing flows indicate that the channel bed downstream of Iron Gate Dam should be mobilized ……." How far downstream of IGD will the bed load be mobilized roughly every two years and of what particle size?	Based on the Bureau of Reclamation analysis (Greiman et al. 2011), it appears that the bed material downstream of IGD will be mobilized by about the 2-yr peak flow for a distance of approximately 15 miles. D_{50} will be about 50-60 mm.
165	M. Knechtle	D-7,4	"The panel at this point has incomplete information on how the estimates……" For a more detailed description of the annual estimation process that generates the numbers provided in the mega-table see annual Age Comp Reports (Klamath River Fall Chinook Salmon Age Specific Escapement River Harvest and Run Size Estimates (Year) Run).	The Panel was not provided the information and had insufficient time and resources to dig up the information.
166	Ron Larson and Matt Barry, U.S. Fish and Wildlife Service (USFWS)	13,2	In this section, the Panel analyzed the potential nutrient (specifically phosphorus or P) reduction benefits coming from the restoration of wetlands and riparian habitats in the Upper Klamath Lake sub-basin under the KBRA. Based on some assumptions, the Panel concluded that too large of an area of the lake would need to be converted to wetlands to reduce external P loading sufficiently and thus they were skeptical of the expected benefits of the KBRA. Annual external phosphorus loading to the lake equals 182 MT (ODEQ 2002). The target reduction of the TMDL is 40% or 73 metric tons (MT)/y (ODEQ 2002). Snyder and Morace (1997) identified that pumping of water from drained wetlands around the lake represented 29% (53 MT) of the total P loading. With the acquisition of Tulana and Goose Bay properties by TNC and the proposed acquisition of an additional 13,000 acres of drained wetland around the lake by the KBRA, ~ 42 MT/y of P loading to the lake would be eliminated. Additionally, the KBRA plans to reduce P-loading by restoration and protection of 80 percent of riparian habitats in the Sprague, Wood, and Williamson valleys. Based on reported P-trapping efficiencies of ~90 percent for 15 m-wide vegetated filter strips (Majed et al. 2003), the proposed KBRA riparian restoration is anticipated to reduce P-loading to the lake by an additional 16 to 32 MT/y. Therefore, the planned restoration by the KBRA is anticipated to result in P loading reductions equal to 58-74 MT/y, and thus is close to the targeted reduction of 73 MT by the TMDL and therefore is anticipated to make a substantial contribution to achieving the TMDL objectives. References: Majed, A-Z. R.P. Rudra, H.R. Whiteley, M.N. Lalonde, and N.K. Kaushik. 2003. Phosphorus removal in vegetated filter strips. Journal of Environmental Quality. 32(2): 613-619. ODEQ [Oregon Department of Environmental Quality]. 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). May 2002. Snyder, D.T. and J.L. Morace. 1997. Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath and Agency Lakes, Oregon: U.S. Geological Survey Water-Resources Investigations Report 97-4059.	See response to comment above. The Panel was not provided with this information and has no way to evaluate it. The Panel did a rough calculation to illustrate the thought processes that should go into an analysis of this. Given the assumptions we made, the conclusion is that a lot of wetland would be needed to control P loading. If some other method is proposed, calculations should be based on that. The Panel also wonders whether the TMDL targets will achieve the goal of improving water quality for fish. The Panel was not presented or provided with any analyses that would answer that question. Thus, the Panel is left with a large amount of uncertainty, and we suggested in the report that the uncertainty could be greatly reduced by some analyses.

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167	Dennis Lynch, U.S. Geological Survey (USGS)	3,3	I believe "contingent" is too strong of a word in this sentence. It is binary. It is too conditional of a statement. For example, some improvements in water quality may lengthen the period of time that Chinook can successfully pass through the Keno Reach or reduce the stress of those that do pass through. So total success toward making UKL and Keno passable year round is not needed to achieve significant benefit. Another example, the success of the Chinook recovery is not contingent upon formation of a governance structure with a strong lead scientist. It might increase the chances of success, but it is not mandatory for success as the statement implies. I believe better wording is: The Panel concludes that achieving substantial gains in Chinook salmon in the Klamath Basin will be affected by the following conditions: Adopting this statement would require removing some or all of the "musts" in the 10 statements and replacing them with less "binary" language	The report has been revised in response to this comment. The text has been modified, and the following added: "The more of the listed factors successfully resolved, the greater the chances of successful rehabilitation of Chinook salmon in the Klamath Basin. Addressing all nine factors will maximize the chances for success of the Proposed Action. In the situation here, the uncertainties act to hinder success, although it is possible that uncertainty in some cases can also result in a larger response than planned or expected. The Panel acknowledges that the success of the Proposed Action may not require addressing all of the factors; but it cannot determine at this time the relative importance of the different factors to Proposed Action success." The Panel felt that substantial success was contingent on resolving the 10 limiting factors.
168	Dennis Lynch, U.S. Geological Survey (USGS)	30, 3	The panel was not asked to speculate on the funding probability of KBRA or if various levels of government will be effective in implementing it. These statements are outside of the scope of their assignment. On a broader note, I suggest removing the entire KBRA paragraph. The NRC has stated for the Klamath Basin the need to act holistically in problem solving (e.g. restoration planning) and improving the ecosystem and science. KBRA and KHSA are attempts by stakeholders to deal with problems at a large scale. From my perspective, and without judging the particular merits of KBRA or KHSA, a basin-wide approach for restoration (which must be a "large" program in a basin the size of Klamath), is a reasonable and perhaps wise approach. I am concerned about this panel's stated bias against the value and effectiveness of large programs like KBRA (based on your past negative experience), even before KBRA has been fully described. I was hoping for a more objective analysis of the pros and cons of KBRA and KHSA as it relates to Chinook rather than a dismissive statement like "….the Panel has strong reservations that KBRA will be implemented with sufficient effectiveness to achieve its stated goals."	The Panel respectfully disagrees. The Panel feels it is unwise to assume what one hopes for will occur by hoping so. This is especially true for two States and a Nation that are already deeply in debt. It is appropriate for the Panel to consider the likelihood of KBRA being implemented as an uncertainty. The Panel would have been less uncertain about KBRA effectiveness if it had received information on the certainty of KBRA implementation and monitoring. The Panel agrees that the best approach is a basin-wide approach. However, there are many ways to conduct such an approach and not all of

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				them are likely to be successful. This is the reason for the caveats. It is naïve to assume the program will be successful because it is big and because most of the stakeholders are on-board.
169	Dennis Lynch, U.S. Geological Survey (USGS)	29,2	With dam removal and KBRA the opportunities for creating more and greater peak flow events is available, particularly if further research shows these events are helpful for reducing juvenile salmon disease (by flushing out the polycheates). With the dams in place, there are power-revenue reasons to minimize the number and size of peak flow events. However, with the Environmental Water Program in KBRA, and no loss of power revenue due to peaking without dams, there are better opportunities to reshape the hydrograph. One of the guiding principles for using water obtained in KBRA's Environmental Water Program (Section 20 of KBRA): "**a.** Replicating the natural hydrologic regime under which the Fish Species evolved likely represents the best flow regime to conserve and recover Klamath River anadromous fish stocks and listed suckers in Upper Klamath Lake." Creating periodic high flow events with this Environmental Water is thought to have a lot of promise by many scientists in the basin, and thus the extensive research presented to the panel. Page 138 of KBRA "…….The Secretary shall make management decisions regarding Managed Environmental Water, so as to maximize benefits for the Klamath Basin's fish and wildlife and to achieve the water management goals of this Agreement. Once subject to its Charter, the TAT shall provide recommendations to the Secretary on how best to distribute and use this Managed Environmental Water for this purpose. In carrying out this function, the TAT shall ensure broad technical and public participation, use the best available and most current technical and scientific information…….." So even though the hydrographs you saw comparing dams in and dams out (with KBRA) did not (and could not) adequately capture these yet to be designed hydrograph changes, there is the Environmental Water Program in KBRA that should not be overlooked because it could provide alterations in flows that could prove valuable for Chinook and other salmonids.	The report has been revised in response to this comment. The Panel acknowledges the information provided within this comment; however, states that Upper Klamath Lake will still limit major flow fluctuations, like all natural lakes do.
170	Dennis Lynch, U.S. Geological Survey (USGS)	15,6	Yes, there is often uncertainly about the efficacy of rehabilitation programs. And there is rarely enough research to give even close to 100% certainly that a course of action will be effective. We were hoping this panel, in spite of these uncertainties, would offer guidance on whether or not various parts of KBRA and KHSA offered promise to helping a struggling ecosystem, based on existing research, literature, and your informed opinions. This paragraph suggests that KHSA and KBRA might lead to a reduction in fish disease……..but then it is caveated with many cautionary notes, such as "Although several aspects of the Proposed Action could lead to a reduction in disease-related mortality, uncertainty about these aspects is very high…… " The question that remains for me is whether or not the panel believes that there is a good possibility of disease reduction given the cumulative effects of flow alterations (e.g. more peak flows), less crowding of fish, lower density of fish carcasses, change in the food supply for the worms with no reservoirs, etc? If so, it would be worth stating. If not, it would also be worth stating.	The Panel reiterates that aspects of the project could lead to reduction in disease, but the uncertainties preclude us from being more sanguine about this. If the research reduces these uncertainties and the conclusion is that there is a high probability of disease reduction, great!

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171	Dennis Lynch, U.S. Geological Survey (USGS)	12,1	Wetland rehabilitation and riparian revegetation are not the primary programs for improving nutrients in UKL and KR. They could be very helpful for reducing external nutrient loads, along with decommissioning of roads, and reducing agriculture in the upper basin, along with other actions. The more important program would be the effort to reduce water quality problems in UKL and KR, most likely through control of internal loading of P in UKL ($50 million dollar program in KBRA, Appendix table C-2). In-lake chemical treatment of water/sediments in UKL currently offers promise, but KBRA includes funds for more research on this topic to guide what program has the most promise. The top sediments in UKL are only enriched about 2 fold for P (as compared to background), enrichment is generally only in the top 20 cm, and only certain parts of the lake show major enrichment. So I believe it is premature to conclude that efforts to control nutrients (via KBRA and TMDLS) will be ineffective. Moreover, reductions in P in UKL may have the additional benefit of reducing N to P ratios and possibly shifting the algal assemblage away from species that (1) produce toxins, (2) result in major phytoplankton crashes and subsequent DO problems in UKL, and (3) settle quickly in the Keno Reach and create hypoxic conditions for many miles in the summer months. In short, the TMDLs and KBRA may do much more for nutrient control over 50 years than you are surmising, with the long-term benefit of making the upper basin more accessible for Chinook without reliance on trap and haul. But we do recognize that it is difficult to determine what may happen with KBRA because it is not fully developed yet.	If the nutrient inputs are not reduced, they will soon overwhelm the in-lake treatments or require perpetual in-lake treatment. The Panel agrees that if all the possible improvements occur, there will be benefits to Chinook salmon. This comment is noted. The Panel agrees with this comment about what KBRA <u>may</u> do, but remains concerned about what it <u>will</u> do.
172	D. Snyder, U.S. Geological Survey, Oregon Water Science Center (USGS OWSC)	11-15	I don't have much to add with regard to the sequestration of phosphorus except to say that an estimate of the long-term sequestration could be determined by evaluating the phosphorus content in the peat soils of the undrained wetlands and determining the time representing the deposition period. The period of the last few hundred years prior to anthropogenic modifications of the lake would likely be most representative. Though my report (Snyder and Morace, 1997) has P content values from the undrained wetlands, I am not sure I have sufficient time markers or data to determine a deposition rate.	This comment is noted.
173	D. Snyder, U.S. Geological Survey, Oregon Water Science Center (USGS OWSC)	13	I would suggest that someone confirm if the value cited on p. 13 of the Chinook Document which uses the value of 182 T/y of P to UKL includes agricultural loading from areas such as the Wood River Wetland, the Agency Lake Ranch, and the Williamson River North and South Deltas (see my report for values of some of these areas which I believe were used in the TMDL). These areas are being managed differently than they were when Jennifer Morace and I did calculations of P losses from wetlands and P loading to UKL. These areas are now being inundated for longer periods of time preventing the aerobic decomposition of the peat soils and subsequent release of P. The value of T/y of P to UKL may need to be revised to account for these changes. Then a new calculation on the area of the wetlands to needed to sequester the external P load could be calculated. Of course, the area below UKL is another story. I do not know if any restoration is planned there that would reduce the release of P from the peat soils for areas that flow in to the Klamath below Link R. dam.	The Panels responds that such confirmations should all be part of the analysis the Panel suggested was required. Again, the values used by the Panel were principally for illustration.

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174	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	Gen'l	I want to acknowledge the efforts of the Panel who were asked to complete a very difficult and complex assignment within what was likely an unrealistic timeline. Throughout their report they make statements that reinforce basic principles of hydrology, limnology, fisheries science, ecology, etc, most of which were appreciated and entirely consistent with the guiding motivations that drove our ecological and fisheries-related interests in the settlement process and formation of the KBRA. Unfortunately, the Panel seemed to expend a considerable amount of time and effort formulating management recommendations, which would have been more appropriately spent focusing specifically on the questions asked of them. For example, the Panel commented extensively on the need for an overarching, structured science program having a "strong lead scientist." Managers in the basin are fully aware of this need, which was well described by the National Research Council (NRC 2004; NRC 2007) and an influential reason for the inclusion of the requirement for the development and implementation of a Restoration Plan, Monitoring Plan, and Reintroduction Plan to be developed under the KBRA (note that the restoration and monitoring plans are being combined into an integrated document, the concepts and framework of which are provided in the attached outline that has been approved by KBRA parties). Under the KBRA, a Technical Advisory Team will develop an Annual Water Management Plan and make recommendations to the Secretary of the Interior that rely on science-based, adaptive management in real time that adjusts to changing environmental and biological conditions. This is a significant change from current management in which flow releases from IGD result from a decision-making paradigm governed by priorities, commitments, uncertainty, and opposing science rather than a coalition of science. Priorities driving "current conditions" have been identified as maintenance of UKL elevations and IGD flow releases dictated through ESA processes, providing full deliveries to the Klamath Irrigation Project in an undefined amount (including higher demand in dry years than in wet years), hydropower production, and maintaining flows necessary to meet needs of Tribal Trust species. Adherence to these priorities, in combination with the uncertainty in the water supply and agricultural demands early in the water year (prior to the availability of reliable water supply forecasts), have resulted in a conservative approach to IGD flow releases. Storage in UKL is maximized while maintaining ESA required minimum flow releases from IGD until flood curve lake elevations are reached, at which time spill occurs. Under the current management regime, inter- and intra-annual variability in flow patterns in the reach below IGD are diminished and the flow pattern in the resultant hydrograph deviates from the shape of the natural hydrograph with respect to magnitude, frequency, duration, timing, and rate of change necessary to maintain or restore processes that sustain natural riverine characteristics and biota.	Several other comments were positive regarding this item. The Panel noted approvingly that KBRA contains some language about monitoring and a substantial budget for science. However, having a governance structure and appropriate people in place to run that science program is absolutely essential for it to fulfill its promise. The Panel notes that the statements about adaptive management in KBRA appear to refer to a watered-down version. If in fact the plan is to institute a real adaptive management program, then the Panel stands corrected, but the recommendations stand.
175	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	ii footnote	"rehabilitation" versus "restoration" I greatly appreciate the Panel bringing this to the attention of the Klamath Basin "Rehabilitation" Agreement.	This comment is noted.
176	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	Ii, 3	Appreciate the Panel clearly defining their intended meaning of the word "substantial" as used here and elsewhere in the report. Given the importance of this definition to the relevance of the document, I would encourage the Panel to 1) move this definition to the main body of the report and 2) provide a definition for the related use of "modest increase"	This comment is noted. The Panel prefers not to give this definition such prominence, as it may be misinterpreted to imply a numerical target which was not the intent.

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177	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	i, 5	The Panel was provided two sets of hydrology to consider, one representing "current conditions" and the other for the "proposed action." A direct comparison of these data sets shows relatively small differences in predicted flows in the mainstem Klamath River. The current conditions alternative, however, is largely driven by NOAA's 2010 Biological Opinion, which is not a viable and therefore durable standard given the current management paradigm previously discussed. This was clearly demonstrated this March (a wet water year) when the IGD flow releases required under NOAAs 2010 BIOP were not met. It's a telling statement that the BIOP flows couldn't be met given the well above average cumulative inflow and high snowpack. I'm not suggesting that the flow requirements in NOAAs Opinion are not warranted, but rather, they are not implementable given the management paradigm that dominates current conditions due to either perceived or potential impacts to UKL elevations and Agricultural deliveries. In general, I don't believe the flows represented in the hydrology for the current conditions that was provided to the Panel is reflective of what would happen in the future (as it hasn't in the past) and therefore, should not be directly compared to the hydrology for the proposed action. To help demonstrate these differences, I strongly encourage the Panel to review the attached Figure labeled I-5 from Hetrick et al (2009) that summarizes March through October deliveries to the Klamath Irrigation Project for the historical period of record, water years 1961-2000 and deliveries met in the KBRA simulation under the water allocation proposed in the KBRA. Note that in addition to depicting significant decreases in agriculture deliveries established by the allocation cap of KBRA, the graphs show the conservative approach taken in the KBRA simulation by assuming that it in average and wetter water years 1) the Klamath Project will take more water than it did historically and 2) the Project will use more water than it did historically. As demonstrated in the historical hydrology, current conditions will be driven by agricultural demands rather than by a non-durable BIOP and that as such, ag demands will differ between alternatives and these differences will be reflected in higher river flows. Given this view on the sets of hydrology presented to the Panel, It is not surprising that the Panel omitted any reference or acknowledgement of potential gains in Chinook salmon production in the reach below Iron Gate Dam under the proposed action, as it relates to the water allocation specified in the KBRA and resulting potential hydrology. As such, I strongly encourage the Panel to review sections of the Hetrick et al. 2009 report that describe anticipated changes in flow and associated changes in habitat availability for Chinook salmon (expressed as a percentage of the maximum), and potential changes in modeled production of juvenile Chinook salmon under the water allocation specified in the KBRA (sections highlighted in yellow in the attached table of contents - synopsis provided below). In general, modeled flows under KBRA reported by Hetrick et al. (2009) would exceed historical Iron Gate Dam (IGD) flows (water years 1961-2000) and were similar to the Hardy Phase II recommendations (Hardy et al. 2006a) for the 30, 50, 70, and 90% exceedences during the critical Chinook salmon fry rearing (March-April) and Chinook (May) and coho salmon (June) juvenile rearing months. At the 10% exceedence, KBRA model flow outputs and historical IGD flows (water years 1961-2000) were generally similar,	If the Panel should not have used the flows presented as representing current conditions, what flows should be used? The Panel was asked to compare two alternatives, one of which was current conditions with the Biological Opinion. Although the Panel heard of concerns about the durability of the Biological Opinion, the Panel had no basis for assuming an alternative flow regime.

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			Habitat values reported by Hetrick et al. (2009) for KBRA model output flows were consistently higher than habitat values calculated for historical IGD flows (water years 1961-2000) for the March-June emergence and rearing life stages of Chinook and coho salmon for exceedences greater than 10%. At the 10% exceedence level, habitat values estimated for the KBRA model were higher than estimates for historical IGD flows during the October, November spawning period and during March of the rearing period, but were similar to one another for April-June. Model simulations reported by Hetrick et al. (2009) predicted that production of fall Chinook salmon smolts below IGD would significantly improve in years resembling historical below average and average production years in response to implementing the water allocation proposed in the KBRA prior to dam removal. In years where modeled historical production was high, potential for improvement under both the KBRA water allocation flows and Hardy et al. (2006a) Phase II flow schedules was consistently low because habitat availability was already at or near the maximum values possible given the existing channel configuration. Conversely, years where modeled historical production of fall Chinook salmon was low provided the greatest opportunity for improvement under any of the alternative flow schedules. Percent change in modeled juvenile Chinook salmon production from the historical water years 1961-2000 baseline and the KBRA simulation for the 10 highest historical production years (upper 25th percentile) averaged about +6 % and for the 10 lowest historical production years (lower 25th percentile), about +45 %. Percent change in production from the historical baseline and the Hardy et al. (2006a) Phase II simulations for the 10 highest historical production years averaged about -7% and about +50 % for the 10 lowest historical production years. In years when modeled fish production increased significantly over historical (water years 1961-2000) baseline predictions (>10 % over baseline), improvements in production often occurred as a result of increased flows in the spring and/or reduction in intensity and/or frequency of fall spills. Early fall spills reduced estimates of adult spawning habitat availability, while increases in spring flows over historical baseline conditions resulted in increased fry and juvenile rearing habitat availability. Implementing either the KBRA water allocation model outputs or Hardy et al. (2006a) Phase II flow recommendations was predicted to decrease the occurrence of poor (below 25^{th} percentile) production years in the future by about 2/3. Reducing the average occurrence of low production years from 1 out of every 4 years downward to 1 out of every 10 years is significant given the dominant 3 to 4 year life cycle of fall Chinook salmon in the Klamath Basin.	
178	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	Executive Summary	"*An increase in Chinook salmon upstream of Keno Dam is less certain because of the difficulties in satisfying all the conditions described below. The Panel has strong reservations that KBRA, even if fully implemented, will address all these conditions to the extent required to meet the goals of the program. The Panel concludes that achieving substantial gains in Chinook salmon with the Proposed Action is contingent upon the following conditions*:" My interpretation of the logic underlying this paragraph is as follows: To achieve substantial gains in Chinook salmon production, all of the ten conditions listed by the Panel "must be met," yet the Panel "has strong reservations" that KBRA "will meet all these conditions. Isn't is therefore logical to	The report has been revised in response to this comment. The text has been modified, and the following added: "The more of the listed factors successfully resolved, the greater the chances of successful rehabilitation of Chinook salmon in the Klamath Basin. Addressing all nine factors will maximize the chances for

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			assume that the Panel has "strong reservations" as to the potential for full implementation of the KBRA and removal of the fours dams to achieve "substantial gains" in Chinook salmon production? That said, I am concerned and somewhat surprised with the bold certainty portrayed by the Panel in describing the list of conditions that "must" or "must be" to achieve what the Panel defines as "substantial gains" in production. In a strict sense, does the Panel believe that if all the conditions were met with the exception of say, two broods being lost that full implementation of the KBRA would fail to meet its intended goal? What if all the conditions were met except the Lead Scientist for the overall program turned out to be a "mediocre" rather than "strong" scientist? The "must or must be" absolute edicts established by the Panel are not consistent with their use of uncertainty elsewhere in the report. For example, (Page 16, para 1) "*The high uncertainty about these outcomes*"… and the Expert Panel report on coho and steelhead (page iii of Dunne et al. 2011i) lists six uncertainties that were obstacles to drawing convincing conclusions about the two alternatives. Yet when it comes to the meeting the ten conditions stated by the Panel, they have taken a very definitive stance with no uncertainty with regard to their position and the specificity of the conditions hey established. As such, I strongly encourage the Panel to reword the "10 conditions" with consideration to removing the use of "must" statements.	success of the Proposed Action. In the situation here, the uncertainties act to hinder success, although it is possible that uncertainty in some cases can also result in a larger response than planned or expected. The Panel acknowledges that the success of the Proposed Action may not require addressing all of the factors; but it cannot determine at this time the relative importance of the different factors to Proposed Action success."
179	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	8	Description of alternatives. Please review attached Table 1 for other important differences specified under the KBRA.	This comment is noted.
180	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	15	I strongly encourage the Panel to consider the following points with regard to disease conditions. The KBRA provides flexibility to manage flows to respond to real-time climatic and biological conditions that will create variability in flows and resulting habitat conditions and reestablish natural instability and disturbance of microhabitats preferred by polychaetes. Disturbance of polychaete habitats is anticipated to reduce the abundance of polychaete populations and may reduce infection rates within remaining polychaete colonies. Stable, monotypic, nutrient- and diatom-rich flows that occur below IGD provide an optimal environment for production of filter-feeding benthic invertebrates like polychaete worms. Fluctuating flows that mimic, albeit to a lesser degree, conditions experienced under a natural flow regime, will eliminate the monotypic stable flow conditions in which polychaetes are known to proliferate. The greater thermal diversity that will be experienced following removal of the Klamath River dams and reservoirs is likely to result in greater invertebrate diversity and less favorable environmental conditions for production and survival of a single species such as the polychaete worms. Removal of the PacifiCorp Project dams is likely to alter the distribution of myxospores, an intermediate life stage of myxozoan parasites released from salmonids, by dispersing adult spawning salmon and resident trout found below IGD. The fish passage barrier created by IGD and the adjacent Iron Gate Fish Hatchery have concentrated the density of spawning adult salmon in the IGD to Scott River reach, thereby exacerbating release of infectious myxospores within this reach. The greater	See previous response to comment #52. These arguments were presented to the Panel and their logic seems pretty solid. However, each step in this chain of logic has the potential for things not to go as expected. In the Panel's report, the Panel acknowledged that the suite of actions could have this highly desirable effect. However, given the reliance of the entire program on the success of this particular element (and this is a real "must"), it seems foolhardy to proceed as if all this were known and certain. The report makes recommendations about investigations that could greatly reduce the uncertainty, and apparently some of these are underway.

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			abundance of myxospores released by dense concentrations of spawning salmon within this reach results in higher infection rates in polychaetes, which proliferate in this relatively stable hydrologic reach. Removal of PacifiCorp Project dams would facilitate the occurrence of higher peak flows, restoration of mid-sized (gravel) sediment input below IGD, and result in variable flows that could intermittently scour and desiccate polychaete colonies and their habitats, resulting in reduced actinospore loads the following spring.	
181	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	15, 5	"*However, the extent of the reduction is uncertain (partly because of the presence of the Iron Gate hatchery and many carcasses nearby in the mainstem), and this scenario imposes a risk of simply moving the problem to wherever large spawning aggregations occur.*" Both high polychaete abundance and myxospores shedding carcasses are needed to establish and maintain an infectious zone. As an example, similar levels of carcasses infected with C shasta are observed in the Trinity River, but low polychaete abundance precludes the formation of an infectious zone. The Panel's assertion in italics above is not accurate.	The report has been revised in response to this comment. The sentence referenced has been revised to indicate co-occurrence is needed to establish an infections zone.
182	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	ii footnote	"rehabilitation" versus "restoration" I greatly appreciate the Panel bringing this to the attention of the Klamath Basin "Rehabilitation" Agreement.	This comment is noted.
183	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	Pg 16, 1	All three studies mentioned by the Panel are currently underway or are fully funded and soon to be initiated.	The Panel is happy to hear this.
184	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	16	Scientific Leadership – See attached outline for current direction this effort is moving in. Note that many of the settlement parties are members of the Trinity River Restoration Program, which was referenced as an example to model in the 2004 NRC report. Having helped establish the Trinity Program, we are well aware of the challenges in implementing an effective adaptive management program. On the other hand, we have learned from our and others' mistakes and are better positioned to avoid these pitfalls on the Klamath.	The Panel is glad to hear this. Had the details of this program been made available it could have saved us some work.
185	N. Hetrick, U.S. Fish and Wildlife Service (USFWS)	Pg 19	I don't anticipate that a potential thermal barrier in July-mid Sept will overlap temporarily with either upstream migrant adults or downstream migrant juveniles. Springers should arrive Apr/May/June. I don't necessarily believe trap and haul will be needed and should, if all possible, be avoided.	This comment is noted. The report has been revised in response to this comment.
186	C. Creager	Pages 11-15	I think that the conclusions of this section are driven by a series of questionable assumptions and a very incomplete review of existing studies in UKL. The response to external decreases in nutrient loading do have merit because of the large amount of nutrients that can / are mobilized out of the sediments. However the hypothesized conceptual relationship of response to reduced loading is not supported. I think Kuwabara et al. 2009 is a poor choice on which to base an interpretation of internal nutrient / algal dynamics in UKL. It is certainly a piece of the puzzle. However what we have to remember is that the Kuwabara study is based on two sampling events one before the bloom and one after the bloom with no sampling during the bloom. The interpolation of the role of iron during the bloom really needs further study. My understanding is that TP is limiting through bloom development -- the ratio of chl-a to TP is well over 1 during this period. One of the difficulties of both the panelist approach and our own is that we don't adequately anchor our discussion in changes over time. There are enough paleolimnology studies available (cited in Steve Kirk ODEQ comments) and land use history that we could do a better job of framing the central	The report has been revised in response to this comment. The Panel understands that there are other ways of making calculations than those that presented in its report. The point of that effort, though, was not to make a quantitative claim about the possible extent of loading reductions, but to demonstrate a conceptual process and rationale for calculating what the loading reductions might be, or what would be required to achieve selected reductions. The Panel presented the

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			issue -- how has the Klamath Basin ecosystem changed over time. That understanding provides a better starting point for water quality recovery trajectories. There is a much broader range of pollutant reduction projects being considered by water quality agencies than is reflected in the panels assessment. The current suite of TMDL water quality improvement projects is not yet complete. IM 10 is currently underway and its objective is to evaluate a wide range of pollutant removal technologies and approaches. It is important to note that there is a substantial difference between the removal efficiencies of restored natural wetlands (example used by authors) and treatment wetlands. IM 10 will also be evaluating biomass removal, sediment sequestration, diffuse source treatment systems, among others. And why would you want to sequester the total nutrient loading in restored wetlands? I don't think anyone has ever advocated for this. In addition, if UKL does prove to be problematic for coming back into some reasonable level of nutrient equilibrium one of the options being evaluated is in-channel treatment wetlands above the former location of JC Boyle and Copco Reservoirs (if the determination is to remove) -- which would protect the lower ~ 200 miles of river while the upper basin recovers over a longer period of time. I have serious issues with their concluding paragraph that is not well informed about the scale and diversity of TMDL implementation actions. For example there is no mention of the Klamath Tracking and Accounting Program that is currently under development. This report as written will create additional unfounded issues that water quality agencies will have to spend valuable time and resources to overcome. For whatever reason they chose to use a series of worst possible scenarios and very limited review of water quality studies upon which to base their very discouraging recommendations. One thing I plead to you -- please do not release this document with the estimate of converting 40% of the existing farmlands to wetlands. That is not an option, it is not the planned TMDL approach, it is not the most cost-effective manner to work towards TMDL nutrient objectives. I can't tell you how much damage that assertion would do in the wrong hands.	numerical estimate as a provisional estimate based on the assumptions given, and based on the information available to us. The text was edited a bit to indicate uncertainty in the estimates. The Panel was not apprised of, or not aware of, many aspects of KBRA, including this one. The information we had on KBRA was mainly in the Agreement, where the actions included are described superficially. Nobody presented the details of these actions at the workshop. The Panel requests that the commenter re-read the referenced section in the report and the commenter will see it does not advocate converting farms to wetlands. Rather, it uses that example to show how, under the listed assumptions, there would not be enough wetland around to get rid of the excess P.

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Additional Comments and Responses not Provided in the Final Report dated June 13, 2011				
187	L.Dunsmoor, Klamath Tribes	General	The Klamath Tribes were unable to adequately comment on this panel report, because the comment period was much too short during a period of intense activity on multiple fronts. Therefore, we reserve the right to make further comments in the future. Citations herein refer to the same citation list as in the report. All comments were authored by Larry Dunsmoor, Senior Aquatics Biologist for the Klamath Tribes.	This comment is noted. The Panel understands and also lacked sufficient time.
188	L.Dunsmoor, Klamath Tribes	General	Perhaps the most important part of the Proposed Action is the least tangible in some ways. We have moved from intensely antagonistic, conflict-based management to one of collaborative management. The changes that we have experienced in recent years are not complete, but they are still progressing, and they are profound. Coupled with the extensive monitoring programs in the Proposed Action, the stage is set to proceed with what we know, and adapt to what we learn. The Panel's report fails to assign significance to this dynamic, which is not surprising since there was insufficient time for the Panel to understand and appreciate the extent to which this transformation sets the stage for success.	The Panel understands and appreciates this change in attitude, but it was not explicitly presented in the technical documents. It is a major source for optimism.
189	L.Dunsmoor, Klamath Tribes	11, 1st ¶ in 2.1	The Panel identifies reduced nutrient loading and "thermal inputs into UKL" as likely effects of the Proposed Action. While thermal loading to the UKL tributaries is indeed a significant issue, I do not believe that a similar case can be made for thermal loading to UKL. The lake is large and shallow, has a large surface area to volume ratio - it will equilibrate to air temperature, regardless of the thermal inputs received from tributaries or other extant sources. As ODEQ (2010) puts it on pg 2-28: "Upper Klamath Lake is not considered a source to thermal impairment because the temperature of water discharged from Upper Klamath Lake likely follow the natural thermal regime. The naturally wide and shallow bathymetry and long residence time of Upper Klamath Lake would have allowed water temperature to reach equilibrium with heat fluxes." Insofar as UKL is concerned, nutrient loading (both internal and external) is the central issue.	The Panel agrees and refers the commenter to the remaining narrative in Section 2.1 of the report that states, "Modest increases in effective shade with TMDLs are projected to provide an additional 190 km of optimal ***stream*** fish habitat, reducing the length of suboptimal habitat from 61 percent to 17 percent in ***streams tributary to UKL***.." The report does not address the effects of the Proposed Action on direct thermal loading to UKL itself, but rather, to its tributary streams.
190	L.Dunsmoor, Klamath Tribes	11, footnote 3	While I understand the Panel's desire to somehow gauge the significance of the Chinook response to the alternatives, I suggest that some additional concepts are important considerations beyond some expectation that overall Chinook populations will increase. First, the Klamath Tribes live above these dams, and reserved their rights to the upper basin's anadromous fish resources when they entered into a treaty with the US. Copco 1 Dam was built without fish passage despite the Tribes' protests, and their access to anadromous fish was suddenly lost. It would be enormously significant to the Klamath Tribes if re-established Chinook runs were much lower than 10,000 (although the more the better). Second, do the alternatives not differ in terms of the likelihood of persistence of Chinook? I find the Panel's views to be remarkably pessimistic in regard to rehabilitating water quality and habitats under the Proposed Action; indeed, it seems that uncertainty is consistently translated into pessimism in this report. While I disagree with the Panel on many important points, the pessimism expressed in regard to the Proposed Action should be accompanied by an analysis that is absent from	The Panel agrees; 10,000 was simply a number that the Panel used for defining "significant." Uncertainty can be viewed as pessimistic; the Panel prefers to view it as uncertainty. Conversely, the statements of the stakeholders can be viewed as optimism based on the same uncertainty. There is much uncertainty surrounding KBRA funding, implementation, and effectiveness. There is much certainty that if the four dams are not removed, the Klamath

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			the report. Namely, an analysis of the likelihood of persistence of various stocks under the two alternatives. If the Panel really believes that the monumental rehabilitation program under the KBRA and KHSA is unlikely to substantially increase abundance, what does the Panel think will happen if we don't implement the settlement agreements?	Chinook salmon will continue to decline.
191	L.Dunsmoor, Klamath Tribes	12, 1st ¶	The Panel interprets the KBRA measures for reducing external loading to UKL to be primarily wetland rehabilitation and riparian re-vegetation, and concludes that these are unlikely to produce substantial improvements in water quality to UKL. In fact, the scope of the Proposed Action is much broader, and while the Panel is correct to be concerned about water quality conditions, their skepticism regarding the proposed rehabilitation measures goes too far, and is based in a failure to appreciate the magnitude of what is indeed being proposed. Section 2.5.3 of ODEQ (2002) quantifies external sources of nutrients to UKL. KBRA actions that will reduce external loading match up pretty well, as follows (Barry et al. 2010): a. re-connect about 12,700 acres of re-claimed wetlands to Agency Lake, ceasing P-laden ag return flows from former wetlands; b. rehabilitate riparian plant communities throughout most of the valley-floor tributary systems above UKL, with emphasis on the Sprague, which is the largest external source; c. rehabilitate floodplain function through breaching/removal of levees, emphasis on the Sprague; d. reduce consumptive use (and associated return flows) sufficient to increase inflow to UKL by 30,000 acre ft on an average annual basis, emphasis on the Sprague and Wood; e. establish a General Conservation Plan (similar to HCP) above UKL to incentivize landowners to carefully manage their riparian corridors; f. rehabilitate upland dryland pasture to reduce reliance on irrigation and facilitate access to non-floodplain grazing; g. provide ranch management planning assistance, which will enhance riparian communities at the least, and may result in altered irrigation practices as well; g. rehabilitate the channelized South Fork Sprague, which is a major source of suspended sediment to the main stem Sprague (Matthews 2007), and a major source of nutrients as well; h. rehabilitate Seven Mile Creek, a major nutrient source. The Klamath Tribes, and many other parties to the KBRA, are confident that these actions will significantly reduce the external load to UKL. There are uncertainties in regard to what the ultimate results will be, but they are less severe than those the Panel expresses.	The Panel appreciates these proposals; it is uncertain about their funding, implementation, and effectiveness given the size of the UKL nutrient loading and internal sources.
192	L.Dunsmoor, Klamath Tribes	12, last ¶	The UKL TMDL calls for a 40% reduction in external P loading, not 47%. It also provides analysis that concludes attaining this reduction (with no commensurate reduction in the internal load) would indeed significantly reduce algal biomass and activity (e.g. pgs 63-64 in ODEQ (2002), and Fig 2-17 in ODEQ (2010).	The report has been revised in response to this and other related comments.

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193	L.Dunsmoor, Klamath Tribes	13, last ¶	Here the analysis contemplates removing the entire external P load. The system is naturally eutrophic, how is it appropriate to use complete removal of the external P load as a metric for the feasibility of the KBRA? Further, the KBRA contemplates many more actions than just wetland sequestration (see comment 4) that are likely to moderate the external load.	The Panel responds that the example is only meant to indicate the amount of reduction needed to substantially lower total P loading in UKL.
194	L.Dunsmoor, Klamath Tribes	14, 2nd ¶	"Control of high temperatures in UKL…": first, see comment 2, there is no way to "control" temperature in UKL, and no TMDL targets such a thing. Much concern about temperatures in UKL and KR is expressed here, based on an apparent perception that temperatures will remain warm with June-September temperatures >20 °C. A series of annual plots of water temperatures in and between UKL and the KR below Iron Gate Dam during Aug-Oct relative to fall Chinook run timing to Iron Gate Hatchery is presented in Figure 1 (appended to comment table). A few things are apparent. First, temperatures below Iron Gate are almost always higher and less variable than at the sites upstream, including UKL. This is clearly a result of the thermal inertia imposed on the system by the hydro project reservoirs (Dunsmoor and Huntington 2006 and citations therein). Second, run timing to the hatchery is an expression of what fall Chinook can and are doing in the system under present conditions. If these fish were encountering water temperatures in UKL instead of those below Iron Gate, they would be better off. Conclusions in the panel's report expressing doubt about future performance due to continued high temperatures cannot be reconciled with current conditions in UKL, or with the likely effects of dam removal on the thermal regime, which were evaluated by Dunsmoor and Huntington (2006) and are not addressed in the Panel's report.	The Panel responds that UKL and KR temperatures may be lower than those at IGD, but they are still high. The Panel notes that Dunsmoor and Huntington (2006) was reviewed in preparation of the report. The graphs confirm the "apparent perception" of summer temperatures above 20°C generally until September. This means that adult fall upstream migration will be constrained to the period after August, juvenile downstream migration will be constrained to early spring (or late fall), and UKL will probably be largely unavailable as rearing habitat during the summer.
195	L.Dunsmoor, Klamath Tribes	14, top ¶, last sentence	The decades-long lag assumes no in-lake efforts to remediate the internal load. Nutrient reduction efforts in the KBRA are intended for UKL and Keno Reservoir. We intend an integrated approach that treats both the internal and external loads. And yes, it will take time.	The Panel agrees that both will be needed, wise to implement, and slow to be effective.
196	L.Dunsmoor, Klamath Tribes	15, 1st ¶	Keno Dam does not create a fish passage barrier. Seasonal passage difficulties arise from seasonal nutrient and organic matter loading from UKL.	The Panel agrees that the major barrier is water quality; but fish passage slows at dams, and this coupled with poor water quality is stressful to fish and likely to increase pre-spawning mortality.
197	L.Dunsmoor, Klamath Tribes	15, 2nd ¶	This paragraph displays poor understanding of the Proposed Action. KBRA reduces and caps Project water diversions. Wetland treatment of Project return flows may be a viable approach to reducing loading, and will be evaluated. Refuge management is simply not pertinent to the charge of this Panel – it will have no effect on Chinook. Nonetheless, the Panel should be aware that the KBRA increases and firms up the water supply for the refuges, and adds fish and wildlife management to the purposes of the Reclamation Project. These, in conjunction with walking wetlands, represent great improvements in the refuges.	The Panel remains concerned that irrigation diversions to refuges means less water in the Klamath system for fish, but it also understands that compromises are necessary for attempting to balance, to some degree, fish production versus agricultural production.

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198	L.Dunsmoor, Klamath Tribes	15, last ¶, last sentence	Here the ramifications to life cycle timing of the dam-removal-induced increase in spring-time water temperatures are discussed as a negative. A necessary assumption would be that spawning timing would not shift. In fact, spawning timing will likely be earlier (Dunsmoor and Huntington 2006) and more successful (lower pre-spawn stress and mortality, more benevolent spawning temperatures). Reversion of the system to a more naturally variable thermal regime (as opposed to the monotonic dynamics and minimal diel variance under Current Conditions) is likely to be ecologically beneficial in many complex ways during much of the year.	The Panel hopes that this is the case for the sake of Chinook salmon; it is uncertain about the degree to which this will occur.
199	L.Dunsmoor, Klamath Tribes	19, plot	Low DO in Keno Reservoir is a significant problem. One idea that will be evaluated is the mechanical removal of particulates at or near the UKL outlet as a way to reduce nutrients in all downstream waters, and to improve DO (and other constituents) conditions in Keno Reservoir. The excerpt below summarizes the thinking on why such an approach is worth evaluating. From page 2-27 in ODEQ (2010): "Sullivan et al. (2009) reported a mean 5-day BOD of 12.6 mg/L and a 30-day BOD of 28.6 mg/L in Link River. In Keno impoundment, most forms of BOD were significantly and positively correlated with particulate carbon, suggesting an important link between algae and BOD. They conclude that a reduction of the load of particulate algal material from the Upper Klamath Lake could limit the magnitude of low DO periods in the Keno impoundment. The organic load from Upper Klamath Lake causes significant BOD load with subsequent settling of particulate matter to sediments in Keno impoundment contributing to internal nutrient loads and increased sediment oxygen demand (discussed below as internal sources). Warm water leaving Upper Klamath Lake is presumed to be natural due to the natural wide and shallow morphology."	The Panel agrees that particulate reduction would likely improve water quality; it remains uncertain about how this might be implemented.
200	L.Dunsmoor, Klamath Tribes	19, 1st ¶, second sentence	This statement is not well supported. It says that, despite the major efforts envisioned under the KBRA, it is unlikely to improve – that is, it will not change from the current condition. The conclusion is at odds with the TMDL analyses. DO dynamics will closely follow algal dynamics, and the TMDL analyses conclude large changes in algal dynamics. Efforts to sequester P in UKL sediments are of great interest to the parties. For example, strategic application of treatments to discrete areas of UKL with high P flux from the sediments may interact with the in-lake circulation patterns and disrupt algal dynamics in both the treated areas and areas "downstream."	The Panel is uncertain about the funding, implementation, and effectiveness of the Proposed Actions.
201	L.Dunsmoor, Klamath Tribes	19, 3rd ¶	Active reintroduction is planned for both fall and spring Chinook above Upper Klamath Lake.	The Panel hopes that the implementation and effectiveness of those introductions will be rigorously monitored.
202	L.Dunsmoor, Klamath Tribes	Pg 19, 2nd ¶, and pg 27, last ¶	We expect spring Chinook to move through UKL in the spring, and hold in cold areas like the Williamson and Wood rivers and their tributaries, and perhaps in Pelican Bay and its associated springs (where adult redbands summer). Seasonal DO barriers would not be an issue for fish employing such a strategy. Such a strategy is not mentioned by the Panel. Neither is any life history strategy other than an ocean type.	The Panel was provided very little information about upper Klamath spring Chinook salmon.
203	L.Dunsmoor, Klamath Tribes	20, 1st ¶	Trap and haul is to be a seasonal phenomenon, and phased out once nutrient reduction measures effect a reduction in algal dynamics sufficient to allow passage.	The Panel is uncertain about the funding, implementation, and effectiveness of the Proposed Actions.

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204	L.Dunsmoor, Klamath Tribes	20, 2nd ¶	UKL is food rich. While it will indeed be important to select stocks whose early life stages effectively move through UKL, it is likely that those fish will experience high growth rates while in the lake. Larger downstream migrants can be expected to have higher survival rates, generally speaking. There are potential positives as well as negatives.	The Panel agrees with this statement.
205	L.Dunsmoor, Klamath Tribes	20, 3rd ¶	This strategy does not allow for adaptation to upper basin conditions. We lost our upper basin stocks when Copco 1 Dam cut them off. Now, we need to reconstruct upper basin stocks. It will take time. We do not expect instant success. Early returns are likely to be small, and it may take multiple years of working with different sources stocks to find the right approach. Coupling pre-adaptation return rates with historical SARs which are affected by the present limiting factors (hydro dams, nutrients, etc.), which in turn are targeted for improvement by the KHSA and KBRA, is likely to produce a worst-case view of the potential for Chinook re-establishment. Page 21, 1st paragraph under 2.6 makes several of the same points as I make above. The two sections seem to be incompatible.	The Panel concurs that the statements made in this comment are true, but the Panel only worked with the information it was provided.
206	L.Dunsmoor, Klamath Tribes	21, 2.5	This seems to attribute no lower basin benefits to habitat rehabilitation or to dam removal. What are current trajectories of populations under Current Conditions? It is true that some curtailment of harvest may be required, it just seems once again that pessimism rules the day, and too little (or no) benefit is ascribed to restorative measures.	The Panel is uncertain about lower river improvements, other than in the project reach.
207	L.Dunsmoor, Klamath Tribes	24, 1st ¶	Consumptive use by agriculture is reduced under the KBRA, especially during dryer years when Project use of surface water is reduced by up to about 100,000 acre ft. Above UKL, inflows are to be increased by 30,000 acre ft through retirement of water uses.	The Panel is uncertain about the funding and implementation of the Proposed Actions.
208	L.Dunsmoor, Klamath Tribes	24, 2nd ¶	"Nonetheless, Current Conditions offers less potential than the Proposed Action to _____.." Could fill in the blank here with almost anything. This structure should appear throughout this report on every topic. How does one alternative perform relative to the other?	The report has been revised in response to this comment.
209	L.Dunsmoor, Klamath Tribes	28, sections 3.4 and 3.6	Here I find a conundrum. 3.4 says the KBRA is likely to fall short. 3.6 says managers should attempt to mitigate basin-wide limiting factors. The reasoning here is circular and negative. We are told that we cannot successfully implement our basin-wide plan to rehabilitate limiting factors, and then told that we should try to rehabilitate basin-wide limiting factors. If the intent is to say that the KBRA does not target the right restorative actions, then I would ask, how certain is the Panel on this point? Did the Panel's brief exposure to the Klamath enable such a sweeping declaration? The Panel's list of basin-wide limiting factors is not compelling. For example, activities on the refuges are a non-issue in terms of basin-wide limiting factors. Diversions are not an issue on the Salmon. Groundwater pumping proposed under the KBRA is carefully constrained, developed in close consultation with USGS groundwater hydrologists, and will cease upon cresting the threshold of adverse effects; it cannot be credibly cited as a basin-wide limiting factor. No mention is made of the hydro project blocking all fish passage into the upper basin, or its negative effects downstream. Nutrients, the associated trophic state of UKL and the KR, and the hydro project dams are the primary limiting factors. Water and habitat management, and disease, are important as well. The KBRA addresses these areas and more.	The Panel is uncertain about the funding, implementation, and effectiveness of the proposed KBRA actions. It agrees that if all those actions, and others, are implemented that conditions are likely to improve for Chinook salmon.

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210	PacifiCorp	ii, bullet 3	PacifiCorp agrees with the Panel's recommendation that a science program be integrated with both the KBRA and KHSA processes. PacifiCorp concurs with NRC (2008) that a strong scientific process supporting the Secretarial Determination and potential dam removal must be conducted under an independent science structure. Such an independent science structure, under the direction and participation of independent scientists with a high degree of specific topical expertise, is essential for an objective and balanced appraisal of Project effects and the effects of dam removal – both potentially beneficial and detrimental, and including uncertainty and risk. This approach is consistent with NEPA requirements. Reference: National Research Council (NRC). 2008. Hydrology, Ecology, and Fishes of the Klamath River Basin. Committee on Hydrology, Ecology, and Fishes of the Klamath River, Board on Environmental Studies and Toxicology, Water Science and Technology Board, Division on Earth and Life Studies. The National Academies Press. Washington, D.C. 250 pp.	This comment is noted.
211	PacifiCorp	11, Section 2.1	While the Panel notes that there is considerable uncertainty in the ability of KBRA to improve water quality, they should also note that even if postulated water quality improvements are effective they are unlikely to be achieved (and maybe not even implemented) prior to the planned 2020 dam removal date. Thus, even under the most optimistic conditions envisioned, river conditions above Keno Dam, as well as below, will be problematic for salmonids for some time after dams are removed. If, as the Panel notes, impacts to Chinook must be kept to a single brood-year, then more consideration should be given to the timing of dam removal compared to the timing of water quality improvements.	The Panel believes that dam removal is the greatest limiting factor precluding Chinook salmon rehabilitation. Time will also be needed for new Chinook salmon stocks to evolve to the evolving water quality conditions. Delaying dam removal seems an unwise proposal.
212	PacifiCorp	12, paragraph 3	PacifiCorp does not agree with the Panel that *Microcystis aeruginosa* will be eliminated by dam removal because it is intolerant of turbulent water. *M. aeruginosa* and its toxin microcystin have been detected above California public health guidelines in riverine areas of the mainstem Klamath River in both slack water and open channel habitats. Also, in 2009, levels of microcystin above the Oregon advisory threshold were detected in riverine areas of the North Umpqua River (near the confluence of Elk Creek) after four dogs died. Detections of *M. aeruginosa* occur along the entire length of the Klamath River. Sampling under the KHSA program has consistently identified *M. aeruginosa* in samples collected upstream of the Project reservoirs at Link River dam, at the outlet of Upper Klamath Lake. Microcystin (a potential toxin produced by *M. aeruginosa*) has been systematically detected in summer and fall months at this location in recent years. Gilroy et al. (2000) and Phinney et al. (1959) previously reported blooms of *M. aeruginosa* in Upper Klamath Lake, but at lesser levels than the more dominant *Aphanizomenon flos-aquae*. In a recent study by VanderKooi et al. (2010), microcystins were detected both in samples of the particulate material from the Upper Klamath Lake and dissolved in lake water. References: Gilroy, D.J., K.W. Kauffman, R.A. Hall, X. Huang, and F.S. Chu. 2000. Assessing potential health risks from microcystin toxins in blue-green algae dietary supplements. Environ Health Perspect. 108(5): 435-9.	The report does not state that *M. aeruginosa* will be eliminated by dam removal because it is intolerant of turbulent water. Rather, the report states that "*The current problem caused by blooms* of the toxic cyanobacteria *Microcystis aeruginosa* in the four lower reservoirs will likely be eliminated by the removal of the four dams, because *M. aeruginosa* generally grows best in stratified water and does poorly when the water is well mixed (Paerl et al. 2001).". The degree to which *M. aeruginosa* would persist in the system upon removal of the four dams is uncertain.

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			Phinney H.K., Peek C.A. and McLachlan M.C. 1959. A survey of the phytoplankton problems in Klamath Lake. Oregon State University, Department of Biology, mimeograph, 52 pp. VanderKooi, S.P., Burdick, S.M., Echols, K.R., Ottinger, C.A., Rosen, B.H., and Wood, T.M., 2010, Algal toxins in upper Klamath Lake, Oregon: Linking water quality to juvenile sucker health: U.S. Geological Survey Fact Sheet 2009-3111, 2 p.	
213	PacifiCorp	12, paragraph 3	The Panel's findings regarding the implications of fate and transport of nutrients under Current Conditions and the Proposed Action (including dam removal) coincide with previous findings from PacifiCorp studies (PacifiCorp 2005, 2006, 2008a, 2008b). However, PacifiCorp recommends that the Panel more clearly explain the statement that the river "will process nutrients." Seasonally the river will sequester a certain fraction of available nutrients in algal biomass, but the fate of other nutrients may include transformation, sedimentation/burial, adsorption, or transport through the system. Given the appreciable seasonal upstream load, and relatively short transit time (approximately 45 days versus 5 days for with-dam and without-dam conditions, respectively), the river may not process all nutrients. The implications of the persistence of material from upstream will have potential impacts on the Klamath River to the estuary, and potentially within the estuary. Water quality impacts on the estuary may be important for juvenile salmonid rearing, and should be considered. The potential increase in additional benthic algal growth, perhaps in the form of excessive *Cladophora*, as identified by the Panel, is important, particularly in spatial terms. Benthic standing crop in much of the river below Iron Gate dam during mid-summer is at a high density and accumulating additional mass may be less important than lengthening the extent of benthic production in the reach between Keno dam and Iron Gate dam. This spatial expansion would occur without reservoirs because inundated areas would be available for colonization, as would non-inundated reaches now subject to variable flow regimes (e.g., hydropower peaking reach) which currently support very low algal standing crops. The implications of increased spatial and temporal distributions of benthic algal biomass will have implications for water quality, as well as potential implications associated with organisms associated with fish disease (e.g., *Ceratomyxa shasta*). References: PacifiCorp. 2005. Potential Negative Effects on Klamath River Water Quality and Fisheries from Dam Removal and Related Liability Concerns. Klamath Hydroelectric Project Settlement Negotiations. Power Point presentation, Sacramento, California. February 28, 2005. PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River, Klamath Hydroelectric Project (FERC Project No. 2082). Appendix B in PacifiCorp. 2006. Comments and Recommendations on the Draft Environmental Impact Statement for Hydropower License Klamath Hydroelectric Project FERC Project No. 2082-027 Oregon and California. Prepared for: Federal Energy Regulatory Commission Office of Energy Projects Division of Hydropower Licensing. Prepared by: PacifiCorp. November 2006. PacifiCorp. 2008a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Prepared for the California State Water Resources Control Board. March. PacifiCorp. 2008b. Application for Water Quality Certification Pursuant to Section 401 of the Federal	The report has been revised in response to this comment.

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			Clean Water Act and ORS 468B.040 for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Prepared for the Oregon Department of Environmental Quality. March.	
214	PacifiCorp	12, paragraphs 4 and 5	The Panel notes "the large uncertainties about the prospects for improving water quality have been acknowledged by a call for substantial funding for further investigations" (page 12). In the subsequent paragraph, the Panel identifies a concern with the magnitude of the proposed solution and extent of the problem. PacifiCorp appreciates the need for additional funding and studies, and refers the Panel to Wee and Herrick (2005) for a comprehensive historical review of water quality conditions in and around Upper Klamath Lake and the decades of studies aimed at improving water quality. Reference: Wee, S.R. and J.M. Herrick. 2005. Water Quality of Upper Klamath Lake: A History of Scientific Investigations. September. 79 pp.	This comment is noted.
215	PacifiCorp	14, paragraph 2	The Panel identifies that high temperature (together with low DO) will continue to pose a bottleneck for salmon migration in the Klamath River and Upper Klamath Lake, and the Panel expresses serious reservations that allocations identified in the TMDLs can be achieved. PacifiCorp and others have identified issues surrounding the temperature analyses in the California Klamath River TMDL for both the tributaries and mainstem reaches in California, that indicate overly optimistic assumptions in estimating water temperatures under a compliant condition. These assumptions include topics associated with solar radiation, shading, inter-annual variability, and climate change.	This comment is noted.
216	PacifiCorp	14, paragraph 3	The Panel expresses concern "by what may be an unrealistic view of the prospects for remediation of hyper-eutrophication, echoing the conclusions of the NRC (2004)". PacifiCorp agrees with this concern, and has commented extensively on the California Klamath River TMDL that nutrient loading reductions (of phosphorus and nitrogen) on the order of 70 to 90 percent required by the TMDL are unrealistic and unprecedented for a river basin of this scale. Even the TMDL acknowledges that achieving such reductions would be a decades-long process.	This comment is noted.
217	PacifiCorp	15, last paragraph	The Panel states "Reduction in food supply for worms through reductions in nutrient loading to UKL seems like a remote possibility." This conclusion is supported by water quality conditions in other systems infected with *C. shasta*. The Cowlitz River for example has high incidence of fish mortality due to *C. shasta* but has nutrient and stream temperature levels substantially better than the Klamath River. The Panel may want to contact Dr. Bartholomew for her opinion on this topic; a personnel citation from the recognized expert on the topic would strengthen the paper.	This comment is noted.
218	PacifiCorp	15, last paragraph	The Panel states "the predicted shift of several days of higher spring water temperatures (and consequent higher myxozoan infection rates) in the lower Klamath River under the Proposed Action could reduce Chinook salmon outmigration success to the degree that it increases disease incidence." The Panel may also want to note that the shift in stream temperatures under the dams out alternative may result in later emergence timing for fall Chinook salmon. Such an outcome may mean that fry/juveniles are exposed to the parasite when stream temperatures are higher in the spring. Increased stream temperatures result in higher mortality rates from exposure to the parasite.	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
219	PacifiCorp	16, bullet 2	PacifiCorp agrees that flume and laboratory studies are needed to assess the impacts of changing flow and sediment movement on the abundance of worms. In fact, PacifiCorp's Fish Disease Fund, which is an important component of PacifiCorp's Habitat Conservation Plan for Coho Salmon (PacifiCorp 2011), has funded a flume study to measure the hydraulics and/or sediment composition that produces mortality in polychaetes in a controlled laboratory setting. The information gained from this study will useful in determining management measures that may be suitable for reducing polychaete abundance. Reference: PacifiCorp. 2011. PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon. Prepared by PacifiCorp Energy, Inc, Portland, OR. Submitted to the National Marine Fisheries Service, Arcata Area Office, Arcata, CA. March 15, 2011.	This comment is noted.
220	PacifiCorp	16, section 2.3	PacifiCorp fully agrees with the recommendation to establish a lead scientist for the effort, as well as a governing structure.	This comment is noted.
221	PacifiCorp	21, section 2.5	The Panel should be aware that the 35,000 fish escapement target includes both natural and hatchery origin fish that spawn naturally. In recent years, approximately 35 percent of the natural spawners in the mainstem Klamath River and Bogus Creek (which supplies 15-20 percent of the natural spawners) have been of hatchery origin. Thus, approximately 4,500 fish spawning naturally in Bogus Creek, the Shasta River, and the Klamath River mainstem are of hatchery origin. In addition, approximately 46 percent of the natural spawners in the Trinity River are of Trinity hatchery origin. Thus the closure of Iron Gate Hatchery will also mean that harvest will need to be curtailed not only to seed upper basin habitat, but also to ensure sufficient natural spawning in lower basin habitat as well. If producing fish locally adapted to the upper basin is important for re-establishing populations in these areas, then harvest management would also likely have to be altered to protect returning adults. It seems unlikely that upper basin populations in the near term could support the same level of harvest as their lower river counterparts. Thus the assumption that harvest may need to be curtailed only until all habitats are seeded seems speculative.	This comment is noted. The Panel does not specify the time it will take for adequate seeding.
222	PacifiCorp	21, section 2.5	The Panel states "In the short term, harvest under Current Conditions could be higher than under the Proposed Action." Given the Panel's back of the envelope (BOTE) analysis that concludes fall Chinook production under the Proposed Action about replaces Iron Gate Hatchery production, it would seem that harvest "will" be higher under Current Conditions than under the Proposed Action over both the short and long term given the uncertainty in achieving the 10 conditions identified in the Executive Summary.	The Panel assumes that a river-lake system, if sufficiently rehabilitated, will yield more fish than a hatchery.
223	PacifiCorp	25, section 2.10	The Panel states " Calculations of bed-mobilizing flows (Ayres Associates 1999; Greimann PPT Presentation 1/10/2011) indicate that the channel bed downstream of Iron Gate Dam should be mobilized by flood flows with recurrence intervals of about 2 years in the post-project period." The Panel should be more precise when presenting this data. Downstream of IGD could refer to a single mile, or the entire 190 miles of river that exist below this dam. Our understanding of the most recent analyses indicates that the change in flow recurrence extends only to the Shasta River.	The Panel lacks sufficient information to predict the extent of bed mobilization.
224	PacifiCorp	29, section 4.1	PacifiCorp is supportive of the Chinook salmon population modeling effort moving forward. This effort builds on the extensive modeling work conducted as part of FERC relicensing proceedings (PacifiCorp 2005a, 2005b). The results of this modeling effort indicated that program success would be highly dependent on outcomes associated with *C. shasta* control, stream temperature, migration	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			success through UKL, harvest rates and life history assumptions (especially emergence timing of fall Chinook). References: PacifiCorp. 2005a. Response to November 10, 2005, FERC AIR AR-2. Ecosystem Diagnosis and Treatment (EDT) Analysis PacifiCorp, Portland, Oregon. PacifiCorp. 2005b. Response to FERC AIR GN-2.Fish Passage Planning and Evaluation. PacifiCorp, Portland, Oregon. (March)	
225	PacifiCorp	29, section 4.1	PacifiCorp continues to be surprised that the extensive data collection, analysis and modeling work performed during FERC relicensing proceedings was not considered by the coho Panel and now the Chinook Panel. In their final report, the coho Panel noted that they were asked to ignore EDT modeling results and were not provided with some documents or information they requested. Did this also occur in the Chinook Panel review? If this was indeed the case, then the Panel should document this and include it in the final report. It was PacifiCorp's assumption that the Panel was an independent body that would be allowed to use whatever tools or information they deemed necessary to properly evaluate the action.	The commenter's assumption regarding the Panel's independent role is correct. EDT modeling was reviewed. There was no information requested by the Panel that was not provided. The time afforded to the Panel in reviewing information and preparing the report was extremely limited. The amount of information available and provided is overwhelming, and to review all available information would have required substantially more time and effort than what was provided under the scope of the Panel's task. Nevertheless, the Panel was most efficient in reviewing the very large amount of information provided and available to them, and no information was purposely disregarded or dismissed by the Panel.
226	PacifiCorp	Appendix D, page D1	The write-up on EDT is misleading as it refers to the model as an "Expert Opinion" model wherein the opinions of experts are "elicited" for the parameters being modeled. The Panel then notes that the validity of the model "depends entirely on the quality of the expert opinion." This is not the case. The EDT model is a scientific model in that it attempts to explain the mechanisms behind phenomena to form an overall working hypothesis of a watershed and population (Hilborn and Mangel 1997). The working hypothesis captured in the scientific model can become the "compass and gyroscope" of adaptive management (Kai Lee, 1993). As a scientific model, EDT is completely deterministic. Because EDT is deterministic, there are no components that are inherently uncertain. It is assumed that all relationships between fish habitat and fish production are known, and the model therefore does not include probability functions around parameters. The EDT model consists of four major components: 1) a reach level environmental description, 2) a set of species/life-stage habitat "rules" that relate the environmental condition to life stage survival and capacity , 3) biological data on target species adult and juvenile age-structure, run -timing, sex-ratio, fecundity and ocean survival, and 4) integration of the reach by life stage estimates to the population level based on a disaggregated Beverton-Holt function (Moussalli and Hilborn 1987).	The Panel disagrees with the EDT assumption that all relationships between fish habitat and fish production are known. The Panel also believes that EDT is over-parameterized and based on too little monitoring data for a system as complex as the Klamath Basin.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			The reach level environmental description is based on 46 stream habitat attributes (e.g. flow, stream temperature, macroinverterbrate abundance, large wood and habitat types etc.). For the Klamath, a fisheries technical group spent two years collecting the data required to "populate" the habitat attributes in the model. The Panel is correct that some inputs for modeling are based on expert opinion (e.g. bed scour) the majority of the inputs were based on "the best available data" at the time of model construction. The quality and source of the data used in the model are documented in the database. All data inputs were reviewed by the technical team. Key modeling assumptions regarding *C. shasta* effects to Chinook were reviewed by experts in the field. Biological data were based on the Chinook populations inhabiting streams downstream of Iron Gate Dam. References: Moussalli and Hilborn, 1987. Optimal Stock Size and Harvest Rate in Multistage Life History Models. Canadian Journal of Fisheries and Aquatic Sciences 43(1); 135-141. Kai N. Lee. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press. ISBN 978-1559631988. 255 pp. Ray Hilborn and Marc Mangel. 1997. The Ecological Detective: Confronting Models with Data. Princeton University Press. ISBN 978-0691034973. 330 pp.	
227	PacifiCorp	Appendix D, page D-1, paragraph 3	The Panel suggests s that modeling be "calibrated" using results or comparisons to other situations. PacifiCorp agrees with this approach as we found it very helpful in supporting conclusions in the first round of modeling. On page 3-1 of Response to FERC AIR AR-2 (PacifiCorp 2005a), you will see that this was indeed done for the previous modeling effort by comparing modeling results to the observed fall Chinook population inhabiting the mainstem Klamath River (does not include tributaries). The results of this analysis were summarized in a single graph for mainstem Klamath River Fall Chinook salmon adult returns:	This comment is noted.

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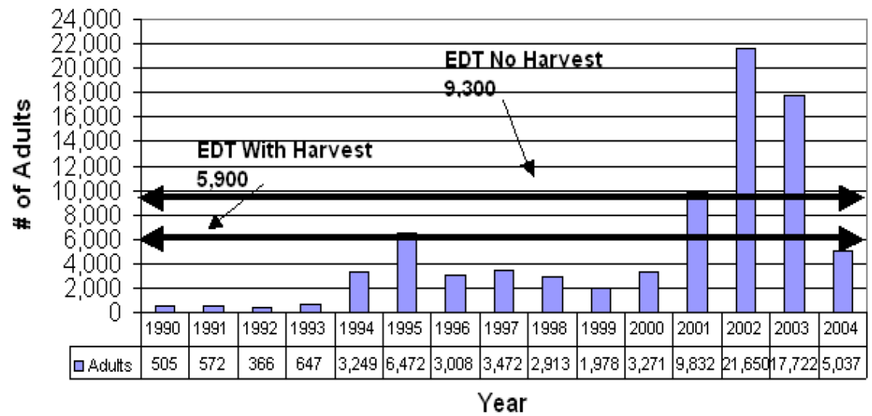
<tr><th>Comment Number</th><th>Comment Author</th><th>Page, Paragraph</th><th>Comment</th><th>Panel Response</th></tr>
<tr><td></td><td></td><td></td><td>


The results from this analysis were used to demonstrate that model inputs provided a reasonable estimate of fish production potential of the basin; on a long term average. The Panel was also provided the information in Table 1 below on EDT estimates versus observed run sizes in lower river tributaries as part of a presentation at the first expert panel workshop.
Table 1. EDT estimates versus empirical run size estimates.
<table>
<tr><th>Area</th><th>CH Race</th><th>EDT</th><th>Empirical</th><th>Difference</th></tr>
<tr><td>Below IGD</td><td>Fall</td><td>5,889</td><td>5,500</td><td>7%</td></tr>
<tr><td>Shasta R.</td><td>Fall</td><td>3,137</td><td>3,996</td><td>-21%</td></tr>
<tr><td>Salmon R.</td><td>Spring</td><td>611</td><td>732</td><td>-17%</td></tr>
<tr><td>Salmon R.</td><td>Fall</td><td>1,926</td><td>2,205</td><td>-13%</td></tr>
</table>
Reference:
PacifiCorp. 2005a. Response to November 10, 2005, FERC AIR AR-2. Ecosystem Diagnosis and Treatment (EDT) Analysis PacifiCorp, Portland, Oregon.
</td><td></td></tr>
<tr><td>228</td><td>PacifiCorp</td><td>Appendix D, page D-5, section D-12</td><td>The modeling assumption that treats the entire basin as a single population as is currently done for harvest is inappropriate. It is highly unlikely that upper basin populations will have similar productivity and capacity values as fish populations in the lower river. The Upper basin populations are at an elevation of 4,000 ft, have incredibly different habitat conditions between streams, and must migrate through harsh conditions to and from spawning grounds.</td><td>This comment is noted. The Panel was only suggesting that BOTE modeling may be a useful, efficient and less expensive means of evaluating assumptions and changes such as those mentioned by PacifiCorp.</td></tr>
</table>

<table>
<tr><th>Comment Number</th><th>Comment Author</th><th>Page, Paragraph</th><th>Comment</th><th>Panel Response</th></tr>
<tr><td>229</td><td>PacifiCorp</td><td>Appendix D, page D-6, section D-14</td><td>Panel recommendations in this section could be strengthened. For example, is fall Chinook (ocean-type) the right choice for modeling outcomes above Keno Dam? All stream habitat upstream of Keno Dam is at an elevation greater than 4,000 ft. Does the Panel know of any ocean-type Chinook populations inhabiting streams at this elevation?</td><td>The Panel lacks the time now to add such details, but agrees with the reviewer.</td></tr>
<tr><td>230</td><td>PacifiCorp</td><td>Pg D-7, 1st paragraph</td><td>The panel should consider removing the back-of-the-envelope analysis from the paper as it detracts from the paper's findings and credibility. Having to use the words back-of-the-envelope, crude, etc. to caveat the results should be a red flag as to its appropriateness for such a paper. Slightly different assumptions would reverse the findings, as discussed in PacifiCorp's comments below.</td><td>The Panel used the BOTE calculation as a reference point, because the presentations and background material given to the Panel did not provide anything that the Panel thought was better for the purpose.</td></tr>
<tr><td>231</td><td>PacifiCorp</td><td>Appendix D, page D-7, section D-15</td><td>"The presentations did not include results or predictions for fish abundance or productivity, nor did they present actual estimates for critical dynamical parameters of the population."

PacifiCorp presented data on fish abundance predictions at the meeting in question for previous modeling work (PacifiCorp 2005a) The numbers provided below in Table 2 represent fish production upstream of Iron Gate Dam.

Reference:

PacifiCorp 2005a. Response to November 10, 2005, FERC AIR AR-2 Ecosystem Diagnosis and Treatment (EDT) Analysis PacifiCorp, Portland, Oregon.

Table 2. EDT estimates of Klamath River Chinook salmon production under dam removal scenarios.
<table>
<tr><th>Dam Removal Scenario</th><th>Adult Capacity</th><th>Adult Abundance</th><th>Juvenile Capacity</th><th>Juvenile Abundance</th></tr>
<tr><td>Fall CH: No Harvest</td><td>13,690</td><td>8,802</td><td>1,327,423</td><td>760,257</td></tr>
<tr><td>Spring CH: No Harvest</td><td>2,818</td><td>2,352</td><td>102,659</td><td>67,948</td></tr>
<tr><td>Fall CH: Habitat Restored</td><td>15,853</td><td>9,939</td><td>1,334,062</td><td>783,963</td></tr>
<tr><td>Spring CH: Habitat Restored</td><td>7,486</td><td>6,152</td><td>211,142</td><td>151,544</td></tr>
</table>
</td><td>The Panel responds that EDT "estimates" do not carry a lot of scientific weight in the Panel's opinion. EDT is an expert opinion system.</td></tr>
</table>

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
232	PacifiCorp	Appendix D, page D-8, paragraph 1	The Panel should be aware that Iron Gate and Trinity Hatchery produce a substantial component of the naturally spawning fall Chinook population in the Trinity River (50 percent), mainstem Klamath River (35 percent recently), and Bogus Creek 35 percent (all approximate). Thus, estimates of the productivity of the natural stock are highly influenced by these hatchery strays which constantly seed the system with additional spawners.	This comment is noted and was considered.
233	PacifiCorp	Pg D-8, middle of page	Based on our calculations, the BOTE analysis predicts that 20,731 fall Chinook may be produced in the reach from Iron Gate Dam to Keno Dam. The current write-up for the BOTE analysis then states: "Recolonization seems relatively unproblematic for the watershed area from Iron Gate Dam to Keno Dam. Migration, life cycle, disease, and competition issues for fish spawning and rearing there probably will not be much different from those now confronted by fish spawning downstream of Iron Gate Hatchery , so usability of this habitat is not seriously in question." This statement is more conclusive than any other statement presented in the main body of the report. But, isn't this statement in direct conflict with the assertions made in the body of the paper that "substantial" (defined by the Panel as about a 10 percent gain or 10,000 fish) gains are only possible if the 10 issues identified on page ii are effectively addressed or achieved? The Panel should clarify if the 10 issues apply to the BOTE analysis as well.	The Panel considered the limiting factors in its BOTE model.
234	PacifiCorp	Pg D-9, first paragraph	While it is recognized that this is a back-of-the-envelope estimate, such an estimate should still be based on fish habitat utilization, biology and the type of habitat being compared to develop the estimate. Using estimates of Chinook production from an area of the basin that includes the four largest tributaries (Scott, Shasta, Salmon and Trinity) to a section of river where the largest stream is Spencer Creek, seems questionable. The difference in fish production between mainstem Klamath River and tributary habitat can be seen in the megatable data cited previously by the Panel. Average mainstem spawning for the 190 miles of habitat below Iron Gate Dam has averaged about 8,500 adult fall Chinook from 2000-2009. This equals 44.7 fish per mile. In contrast your BOTE assumes that each mile of habitat produces 326 fish. If the 44.7 fish per mile value was used then total production for 65 miles of habitat could be as low as 2,900 adults. It should be noted that in FERC relicensing the modeling effort indicated that with habitat restored, the area between IGD and Keno would produce on average about 3,900 adult fall Chinook; far below what is currently produced by the Iron Gate Hatchery (See Table 3-6 of PacifiCorp 2005. Response to November 10, 2005, FERC AIR AR-2 Ecosystem Diagnosis and Treatment (EDT) Analysis PacifiCorp, Portland, Oregon.)	Please see response to comment 228 above.
235	B. Barr, Geos Institute	1, 2	"The panel concluded that a modest increase in Chinook salmon is likely in the reach between Iron Gate Dam and Keno Dam." Given that any production from this reach is notable over the baseline condition, which is zero production, more qualification seems needed for this statement. We suggest that the panel describe the contribution relative to the current mainstem Klamath River production currently downstream of Iron Gate Dam.	This comment is noted.

Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			While we understand that spawning habitat conditions in the impounded reaches are difficult to project following dam removal, we would point out that pre-Copco Dam maps suggest 5 to 7 miles of low gradient, sinuous, and multi-thread channel along the Klamath mainstem in the area currently impounded by Copco 1 Dam. Given these characteristics, it would not be unreasonable to expect substrates in the reach to be good, if not ideal, for salmonid spawning. Numerous small springs are also noted on pre-Copco Dam maps, suggesting a multitude of small temperature refuge areas along this reach. Surely these features, if rehabilitated appropriately, would contribute excellent spawning opportunities for fall Chinook salmon. During years of high fall Chinook salmon escapement in the Klamath River, spawning fish congregate in large numbers over long periods in the several miles immediately downstream of Iron Gate Dam. These fish spawn on top of one another, making red superimposition a large concern. The inability of these fish to spread out over a larger area during spawning not only diminishes production, but also puts the eggs of early returning, early spawning fish at substantial survival risk. Removing Iron Gate, Copco 2, and Copco 1 Dams would alleviate some of the pressure on the large numbers of spawning fall Chinook salmon at the base of Iron Gate Dam, reducing the amount of redd superimposition to some degree, allowing eggs from earlier returning and early spawning portions of the population to exhibit higher survival, and potentially exposing several miles of high quality spawning habitat.	
236	B. Barr, Geos Institute	11, 2	The Draft Scientific Assessment does not explicitly describe expected or projected effects of dam removal and attendant changes on production of fall Chinook salmon in the Klamath River mainstem reaches from Iron Gate Dam downstream to the mouth. While these projections are understandably difficult to make, the panel should offer some expectation or the reasons behind why such an expectation cannot be made at this time. For example, 3 to 8° C lower water temperatures during the fall could make substantial contribution to fall Chinook adult survival and fitness leading up to the spawning period. These advantages could contribute to increased production throughout the Klamath mainstem. Greater survival among those earliest spawning fall Chinook could lead to a shift in the timing of outmigrating fall Chinook juveniles earlier in the spring or to larger size of outmigrants. These shifts could further lead to increased survival and higher smolt to adult return ratios. Also, the ability of the Technical Advisory Team to affect stream flows does seem to be considered in the Panel's deliberations throughout the document. While certainly difficult to quantify and project, this is one of the strongest factors of the KBRA and should be discussed by the panel in some way.	The report has been revised in response to this comment. The Panel generally agrees with this commenter that there may be additional positive effects of dam removal with regard to lower fall temperatures, higher DO, and potential increase in survival, fitness, and production.
237	B. Barr, Geos Institute	15, 5	At the tail end of this paragraph, the Panel suggests that the projected shift to higher spring water temperatures could lead to higher myxozooan infection rates. While this is undoubtedly possible, a more complete story of how Chinook salmon may respond to the projected shift in thermal regime should be described here. Several potential responses seem informative in this regard. While spring temperatures are likely to be somewhat higher following dam removal, fall temperatures are projected to be quite a bit lower (3 to 8° C) under this scenario. This shift should allow fall Chinook returns and spawning to occur earlier in the year than present. It seems reasonable that this shift in run timing and spawning could lead to earlier outmigration (or more prolonged	The report has been revised in response to this comment. The Panel generally agrees with this commenter that there may be additional positive effects of dam removal with regard to a response to lower fall temperatures and a possible of a shift in outmigration periods such as myxozooan exposure is reduced or avoided.

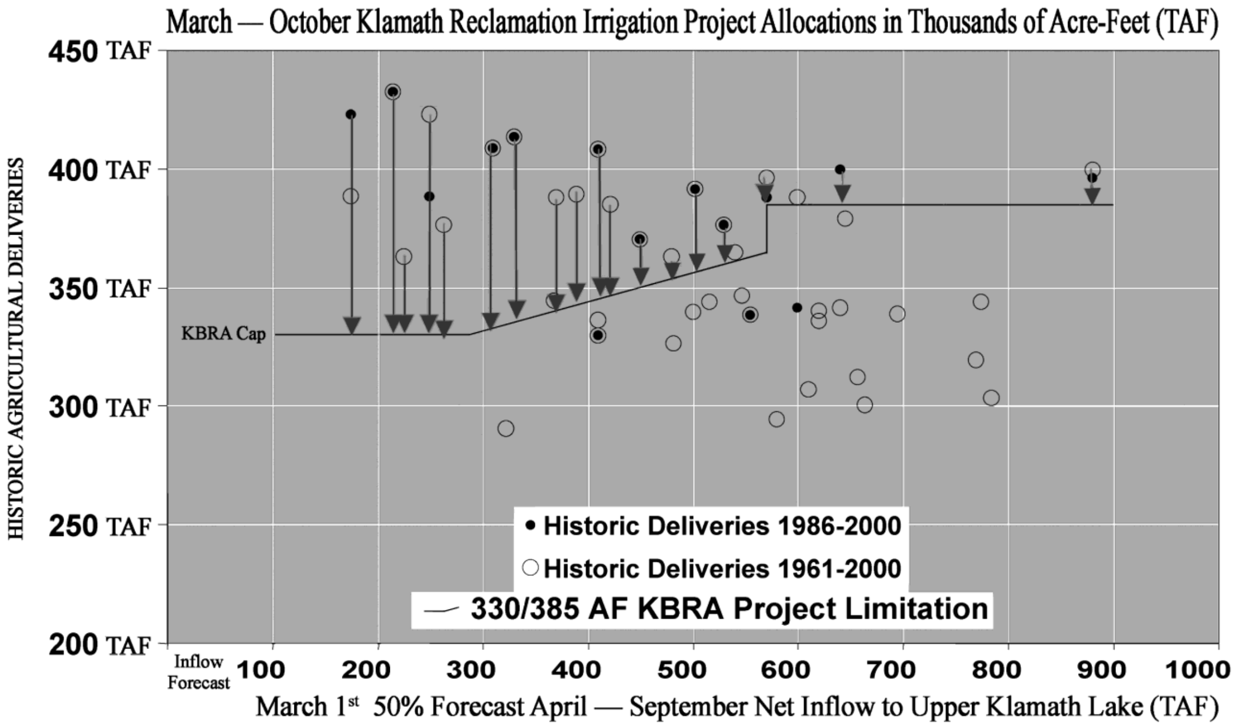
Comment Number	Comment Author	Page, Paragraph	Comment	Panel Response
			outmigration) that puts proportionally fewer outmigrating fall Chinook at high risk of myxozooan infection. It seems that researchers should investigate the relationship of water temperature at the times of peak carcass concentrations to infection rates (assuming the relationship is unknown).	
238	B. Barr, Geos Institute	I, 3	The certainty with which the contention that all 10 of these items are essential for substantial gains in Chinook salmon production in the Klamath River is stated is overblown. I suggest that you recharacterize these items in order of their relative importance to gains in Chinook salmon.	The report has been revised in response to this and other similar comments.
239	B. Barr, Geos Institute	General	Please take the time to review the report that the US Fish and Wildlife Service produced in 2009 (Hetrick et al., titled Compilation of Information to Inform USFWS Principals on the Potential Effects of the Proposed Klamath Basin Restoration Agreement (Draft 11) on Fish and Fish Habitat Conditions in the Klamath Basin, with Emphasis on Fall Chinook Salmon) and use information from that report to further inform your descriptions in this panel report. In many ways, that report augments your projections, but it also sheds light on a number of facets of the questions you contemplate and others that you did not. It seems to me THE MOST ESSENTIAL DOCUMENT for your review prior to completing this panel report.	This comment is noted. The Panel notes that the document referenced by the commenter was reviewed in the preparation of the report.

Additional References, Tables, and Figures
Provided by Commenters

PCFFA (Glen Spain) – Comments 3 through 16

CHART 1 – KBRA" diversion cap" vs. Historic Klamath Irrigation Project Useage 1961-2000

The arrows show the direction and amounts that irrigation demands would have been reduced had the KBRA "diversion cap" been in effect in those years. The "diversion cap" is also a *maximum*, not a minimum, and thus does not require any more water to be delivered in wet years than historically was used. The major benefits of the KBRA "diversion cap" are clearly in drier years during which having more in-river water is most important for fish protections generally. Under current practice, the *drier* the water year the *more* water is removed by the Irrigation Project, thus exacerbating the impact of every drought on fish in the river. The KBRA "diversion cap" would reverse that past practice, leaving more water in the river the drier the water year. This is a major KBRA fish benefit that was not discussed in the Draft text.



Yurok Tribe, Asarian, Kann, Redwine – Comments 48 through 73

Table 1. Effects matrix showing likely qualitative outcomes of the Proposed Action vs. Current Conditions on major components of the *C. shasta* life cycle based on available information to date. A score of + means disease conditions are predicted to improve, a score of - means disease conditions are expected to worsen, and a score of o means no change or conflicting outcomes. The score and the life cycle components are not ranked in terms of relative importance in this matrix.

This table associated with Comment 52

***C. shasta* life cycle**	**Current Conditions**		**Proposed Action**	
component	**score**	**comments**	**score**	**comments**
polychaete abundance	-	favored habitat enhanced, geomorphic/flow stability, and diet	+	some new habitats available, favored habitat degraded with geomorphic/flow instability increased and phytoplankton diet reduced
polychaete diet	-	continued enrichment by phytoplankton from reservoirs and elevated nutrients increasing epiphytic algae for diet and habitat	+	phytoplankton associated with reservoirs reduced or eliminated, reduced nutrients and epiphytic algae
polychaete habitat	-	enhanced by geomorphic/flow stability, interruption of natural sediment supply, high nutrients and epiphytic algae	+	greater geomorphic/flow instability (including pulsed scour flows) and restoration of modest natural sediment inputs and eventual reduction in nutrients and epiphytic algae
myxospore production	-	adults highly infected producing large numbers of myxospores; compounding negative effect	+	reduction in myxospore output due to lower actinospore numbers from reduced numbers of polychaetes; compounding beneficial effect
myxospore distribution	-	spawned out adults concentrated near Iron Gate Dam and Hatchery, myxospores wash down into highest polychaete densities	+	spawned out fish distributed more evenly and not as well matched with high polychaete densities, hatchery production release points will change and disperse
adult salmonid mortality	-	higher risk of pre-spawn mortalities because of elevated levels of infection, which also increases myxospore output	+	lower risk of pre-spawn mortality and reduced myxospore output
juvenile salmonid mortality	-	unacceptably high mortality levels due to overwhelming numbers of actinospores, infected juveniles release myxospores which contribute to adult re-infections	+	decreased mortality levels as actinospore numbers fall below natural resistance thresholds, less myxospore output from infected juveniles
actinospore production	-	extremely high on average due to high polychaete numbers and elevated infection rates; compounding negative effect on myxospore levels	+	reduced due to lower polychaete numbers, decreased and dispersed myxospore production; compounding beneficial effect on myxospore levels
actinospore distribution	-	highest at top of anadromous distribution with actinospores washed downstream maximizing exposure to juveniles from upstream production areas	+	dispersed and not concentrated at top fish production areas; UKL serves as sink
genotypes	o	all types below IGD, type II not above IGD	o	type II Chinook genotype with accompany Chinook into the upper basin but will mainly affect Chinook
fish condition	o	significant stressors comprise fish condition and immunity (pH, ammonia, microcystis, pesticides, etc)	o	some stressors expected to decrease (microcystis), others may increase
temperature regime	o	cooler spring temps, especially from IGD to Scott River, but still above threshold for actinospore release and infection; warmer fall temps	o	warmer spring temps, especially from IGD to Scott River, but still actinospore abundance likely to decrease; cooler fall temps

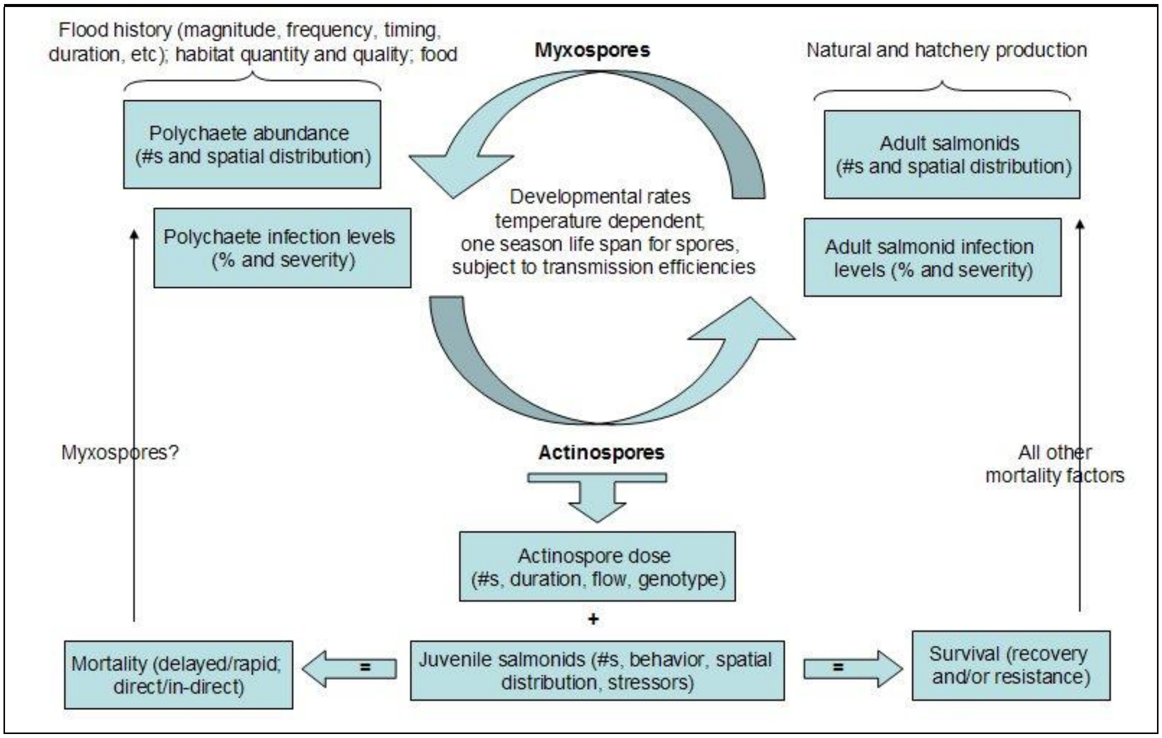


Figure 2. A working conceptual model of C. Shasta in the Klamath River allowing an evaluation of various hypotheses.

N. Hetrick (USFWS) – Comments 174 through 185

N. J. Hetrick, T. A. Shaw, P. Zedonis, J. C. Polos, and C. D. Chamberlain. 2009. Compilation of information to inform USFWS principals on the potential effects of the proposed Klamath Basin Restoration Agreement (Draft 11) on fish and fish habitat conditions in the Klamath Basin, with Emphasis on Fall Chinook Salmon. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA.

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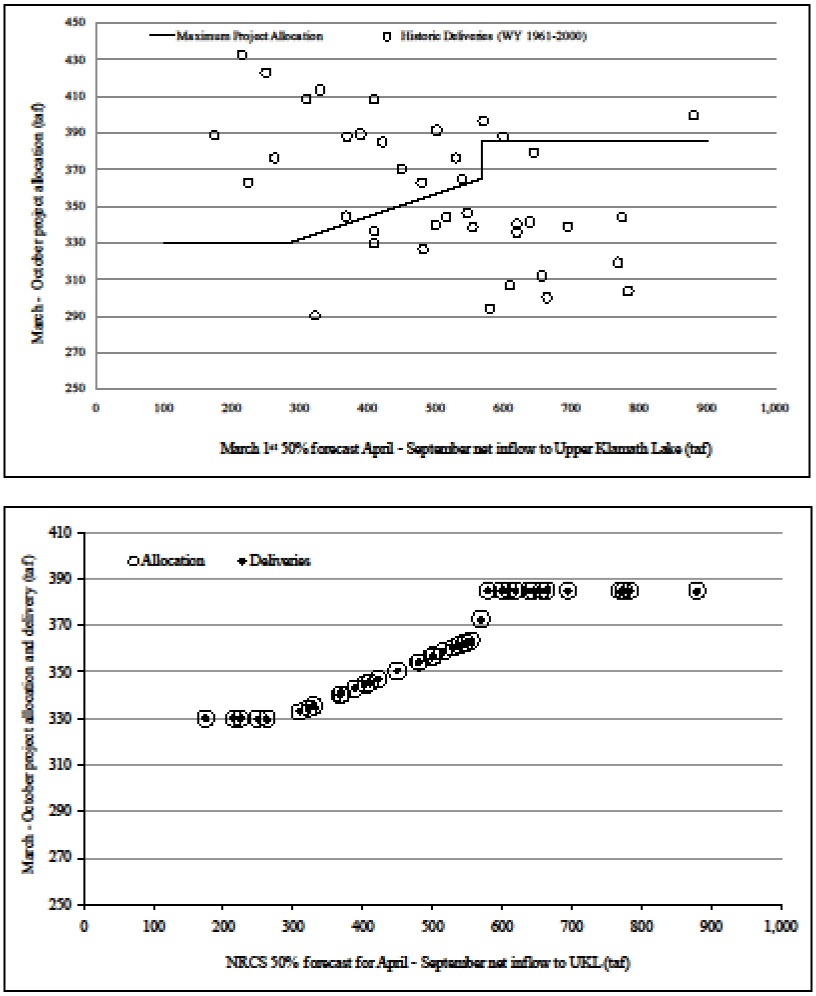


Figure I-5. Summary of March through October deliveries to the Klamath Irrigation Project for the historical period of record, water years 1961-2000 (top) and deliveries met in the WRIMS Run-32 Refuge simulation (bottom) under the water allocation proposed in the Klamath Basin Restoration KBRA. Graphs depict the conservative approach taken in the R-32 Refuge WRIMS simulation by assuming that it in average and wetter water years 1) the Klamath Project will take more water than it did historically and 2) the Project will use more water than it did historically.

Table 1. Status of various activities that influence fish production in the Klamath River under current conditions, the FERC relicensing process, and under the Klamath Basin Restoration Agreement (no= will not occur, yes = will occur, ? = likelihood of occurrence unknown – from Hetrick et al. 2009).

Activity	Status Quo	Dams Remain Fish Passage Installed	Restoration Agreement
Basin-wide Restoration Plan	?	?	Yes
Increased Funding, Scope, and Pace of Restoration Actions	No	No	Yes
Reintroduction Plan above IGD	No	Yes	Yes
Reintroduction of Anadromy to Upper Klamath Basin	No	Yes [a]	Yes
HCP Above UKL	No	?	Yes
Acquisition of Water Rights above UKL	No	No	Yes
Increased Storage and Restoration in UKL Wetlands	Yes	Yes	Yes
Capped Allocation of Water to KIP & Increased Environmental Water	No	No	Yes
No Adverse Impact from KIP Groundwater use	No	No	Yes
Drought Management Plan	?	?	Yes
Real-time Management of Environmental Water	No	?	Yes
Funding for Water Quality Work in Keno Reservoir	No	No	Yes
Removal of PacifiCorp Project Dams	No	No	Yes
Anadromous Fish Habitat at Present Reservoir Sites	No	No	Yes
Improved Water Quality in Lower Klamath River	Limited	Limited	Yes

L. Dunsmoor (Klamath Tribes) – Comments 187 through 209

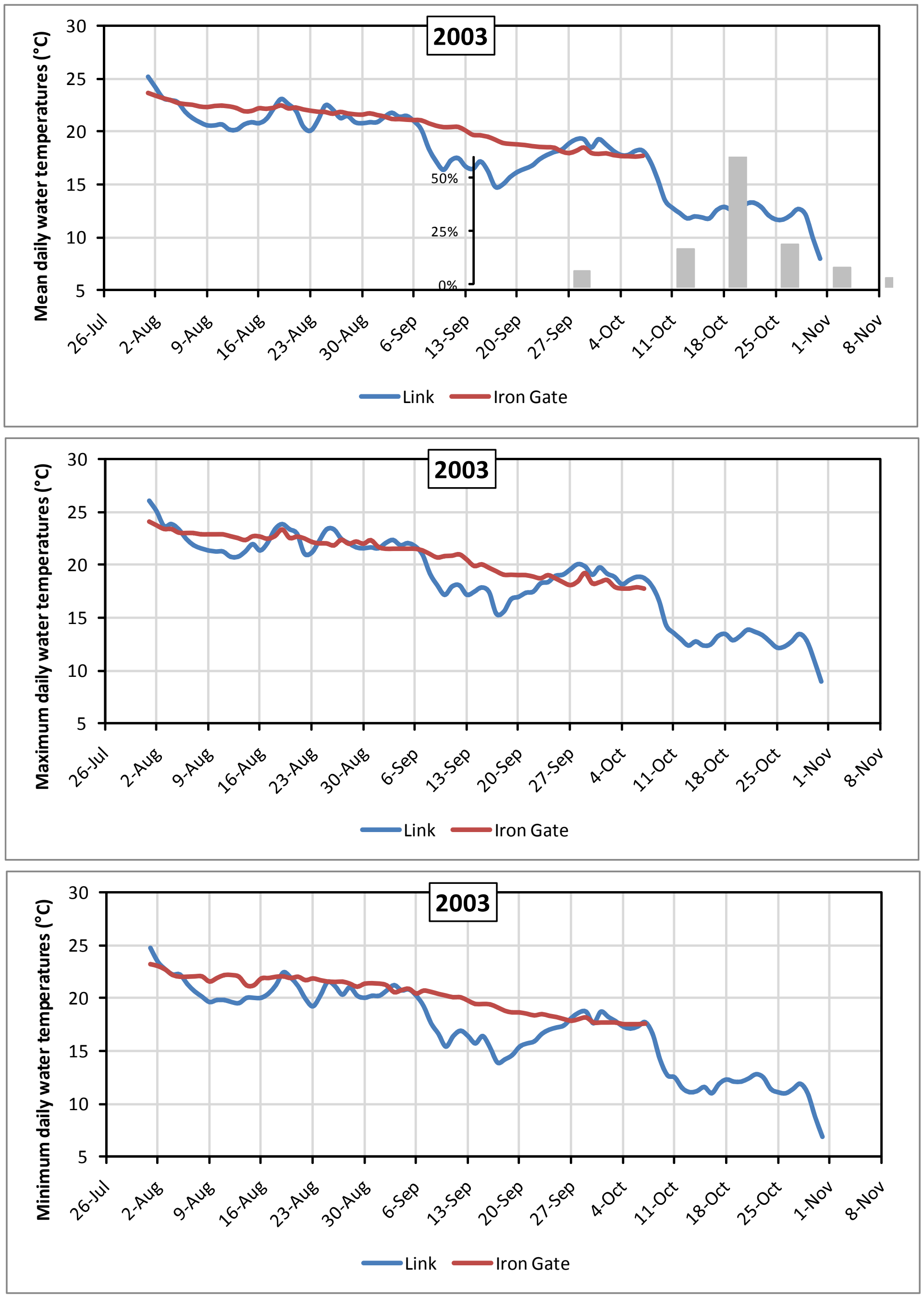
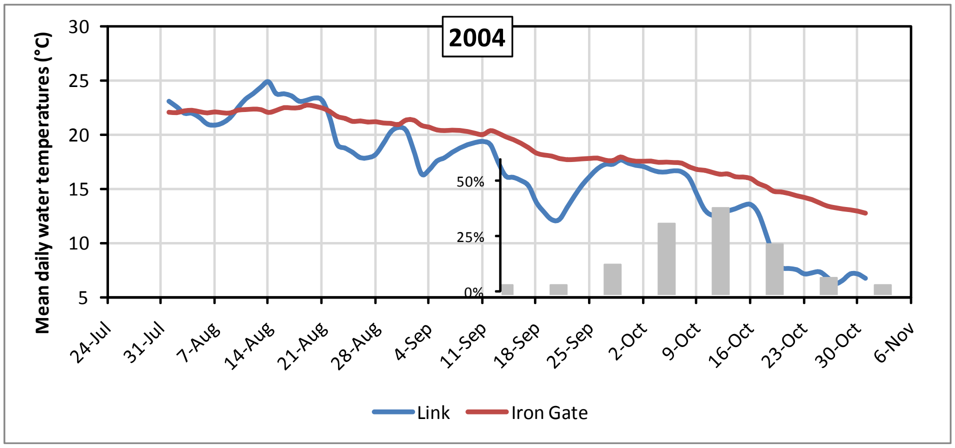
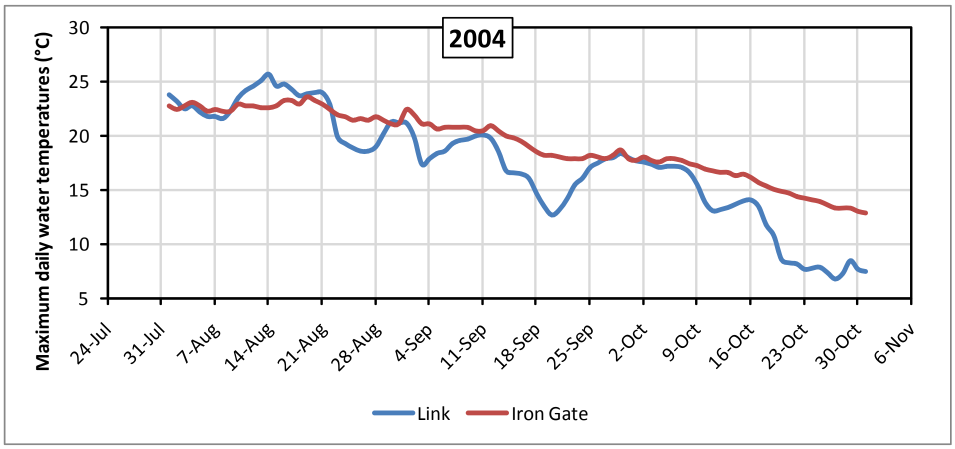


Figure 1. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Iron Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.





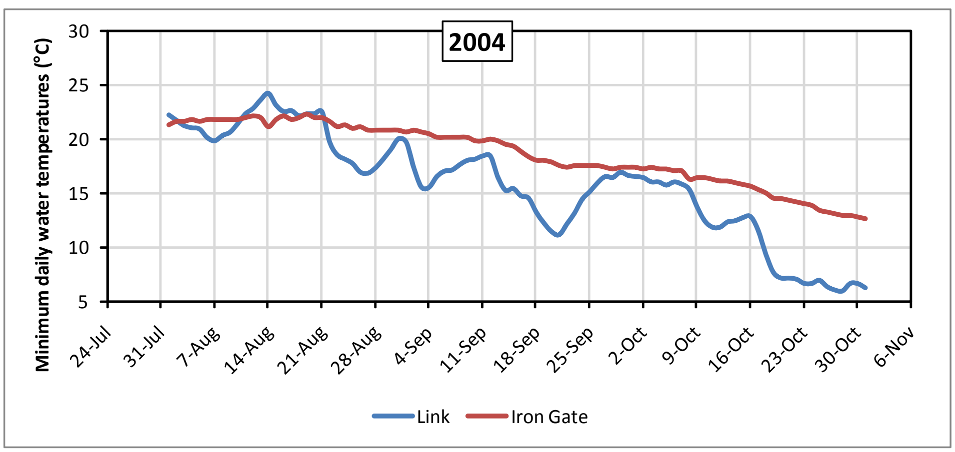


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

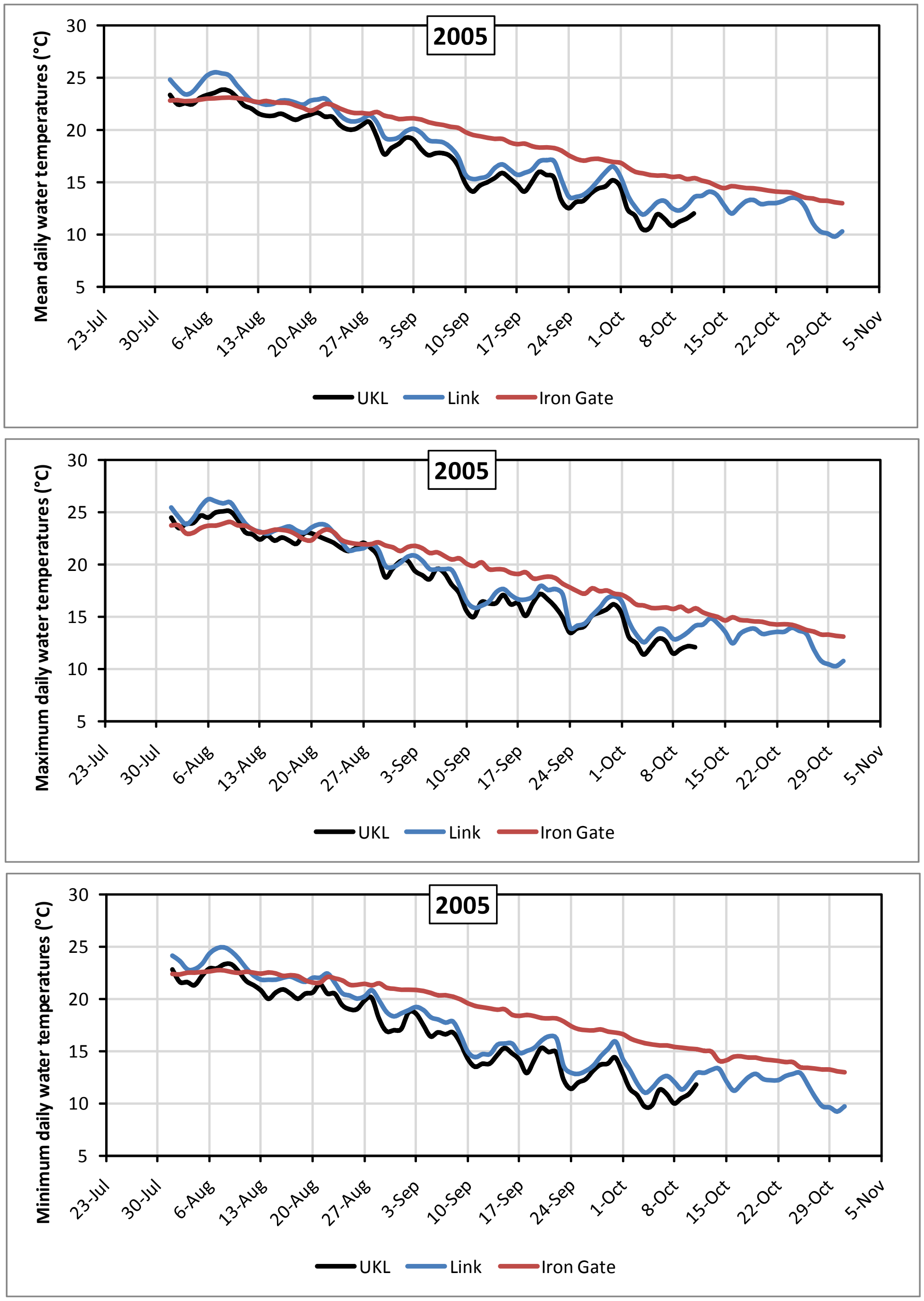


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

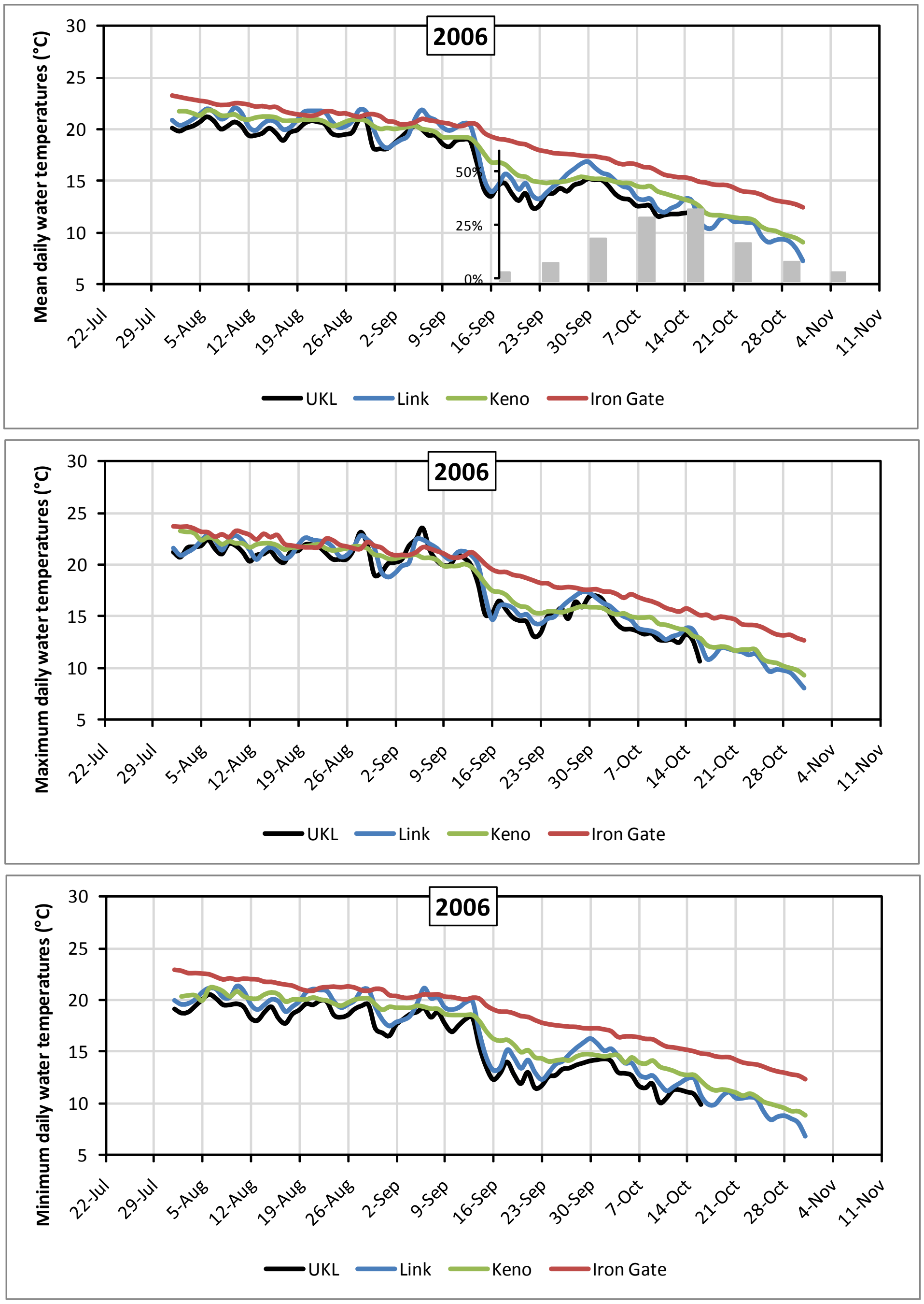


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

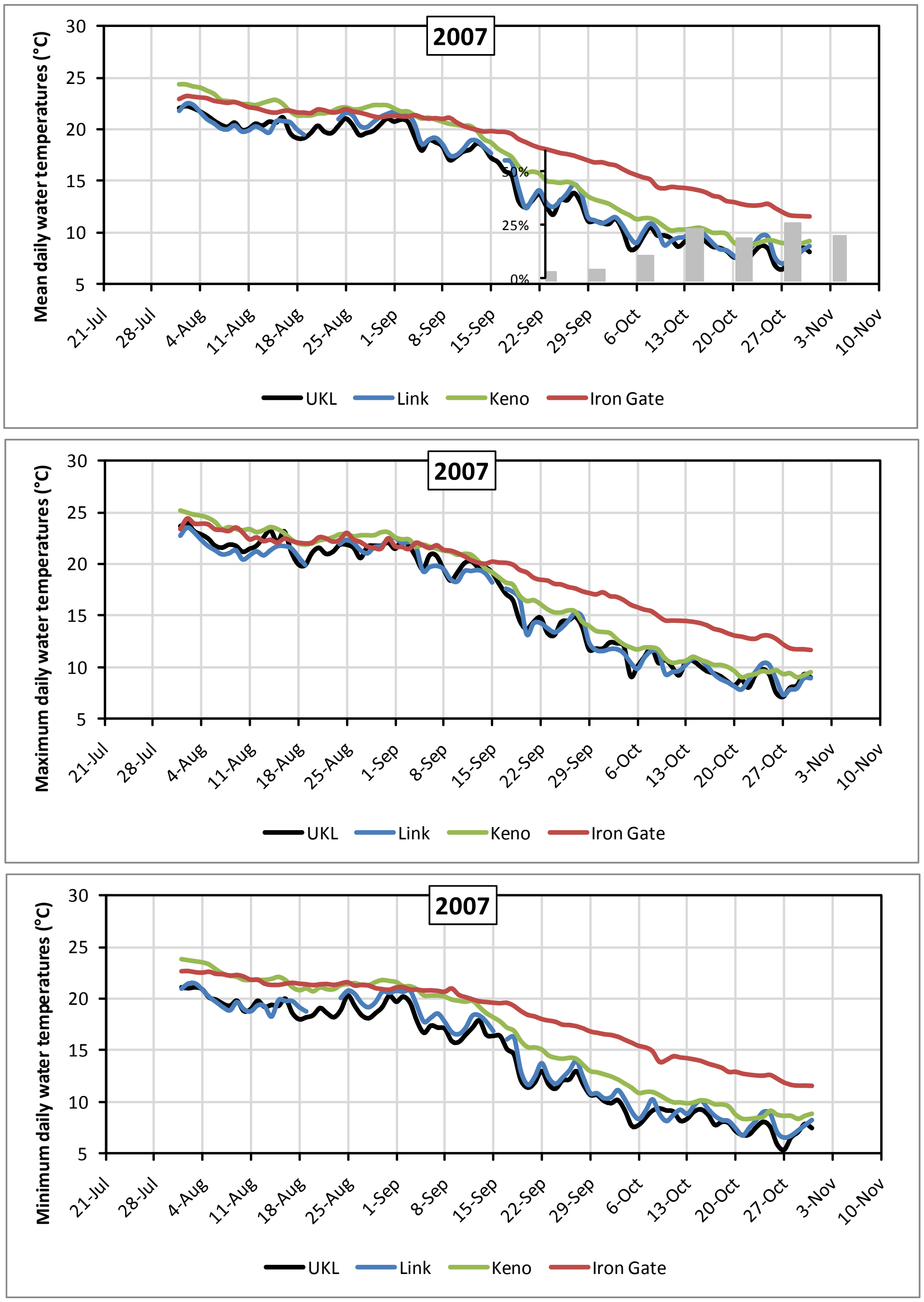


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

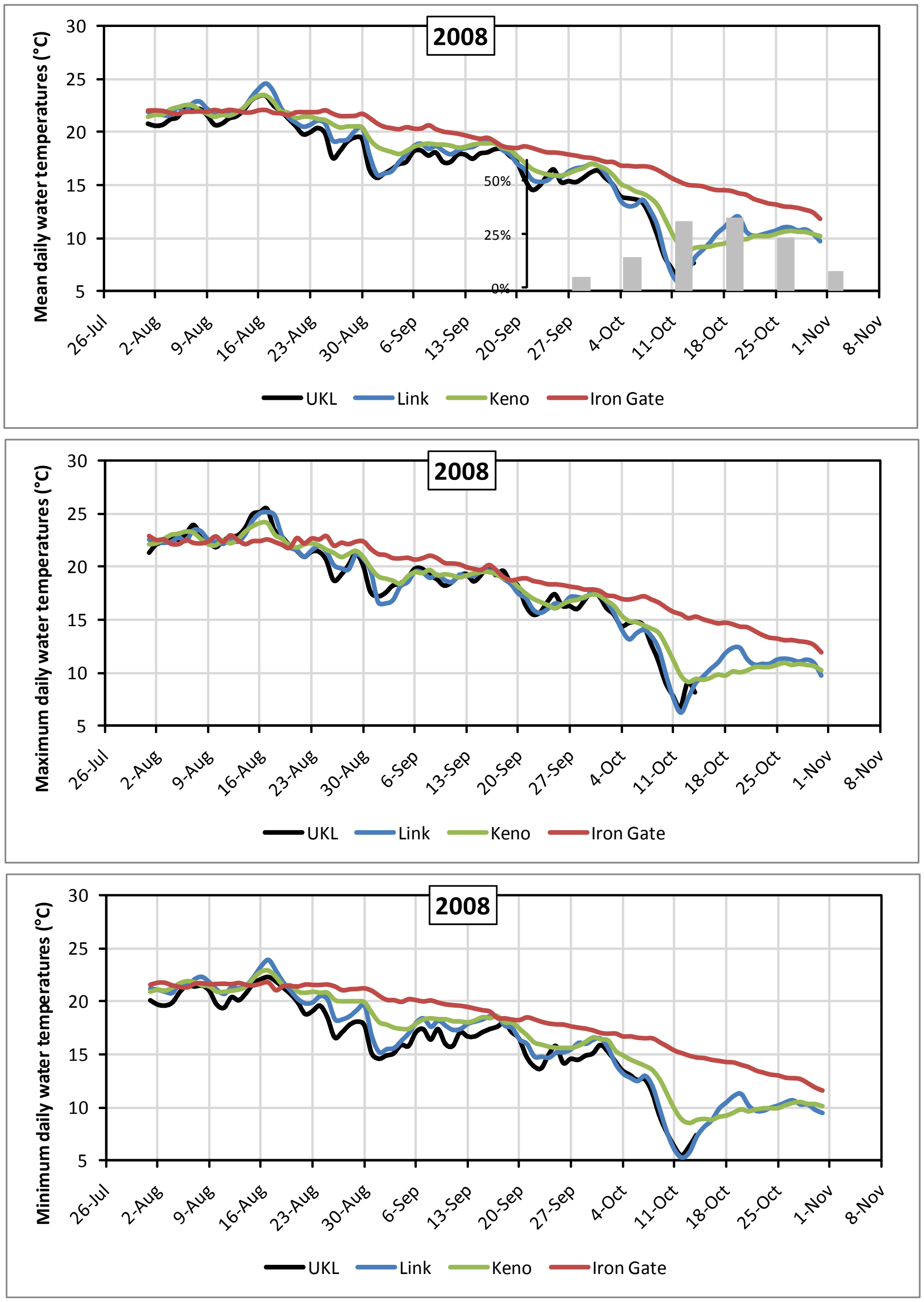


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.

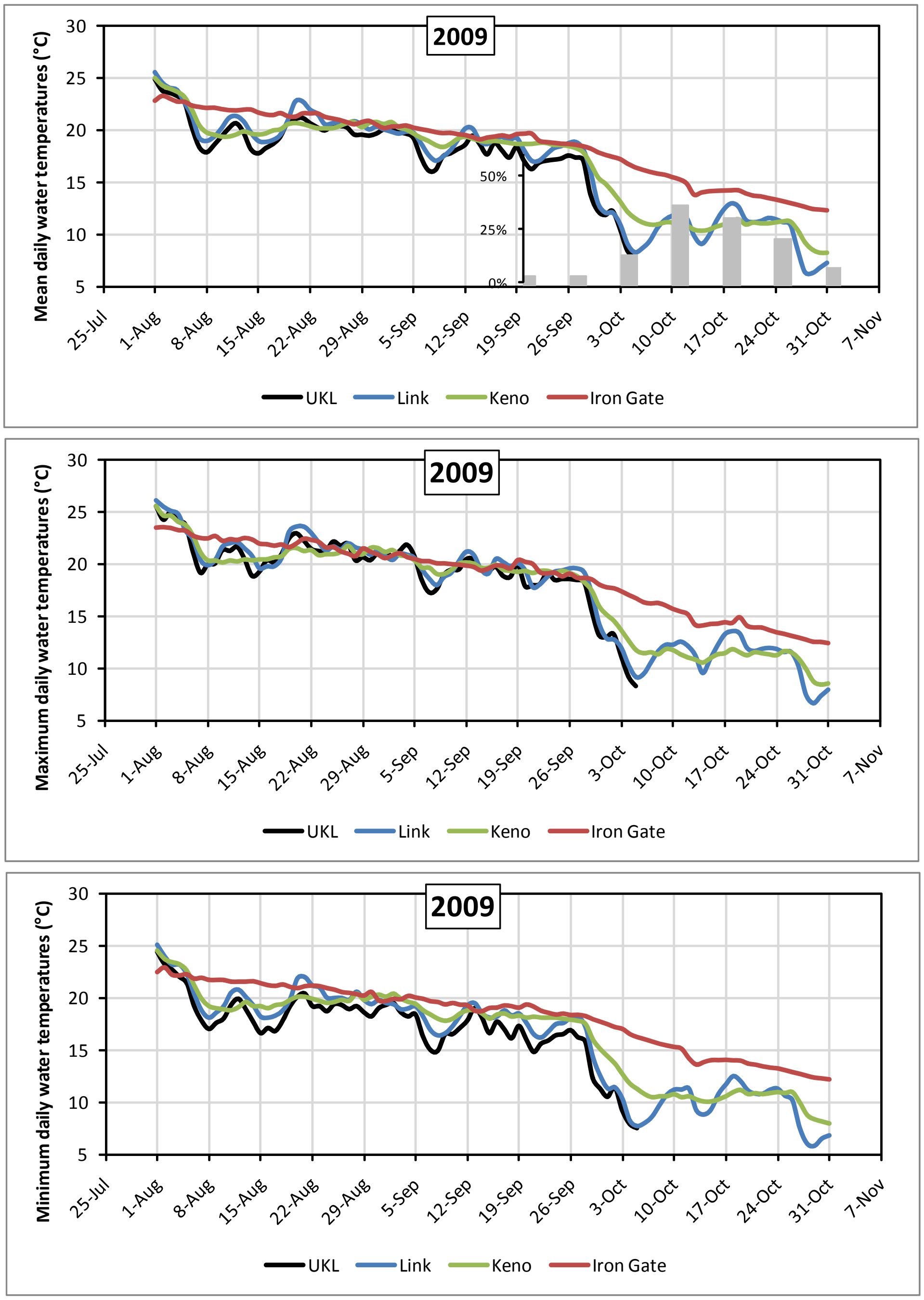
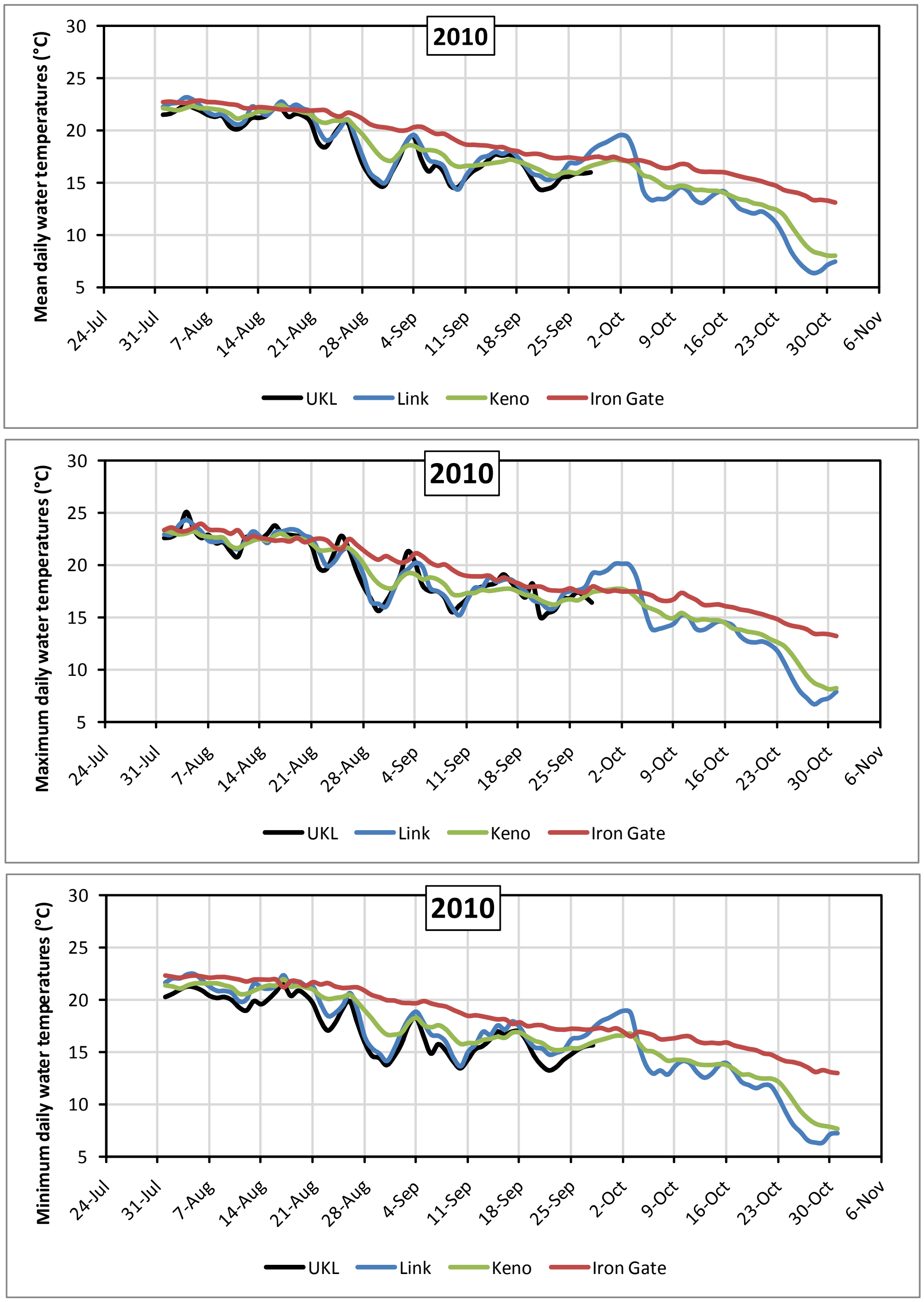


Figure 1 - continued. Mean, maximum, and minimum daily water temperatures during August-October for selected sites in the upper Klamath River system. All data are from continuously recording thermographs operated by either the USGS or USFWS. The UKL site is immediately north of Buck Island (USGS); the Link and Keno sites are at USGS gauge sites that are short distances downstream of their respective dams; and the Iron Gate site is at the Irona Gate Hatchery Bridge downstream of the dam (USFWS). Weekly returns (as percent of annual total) of fall Chinook to the Iron Gate Hatchery are represented by the histogram.



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APPENDIX D
Review Process

Appendix D: Review Process

D.1 Expert Panel

At the request of the USFWS, Atkins (formerly PBS&J) convened an independent expert panel to evaluate the potential effects of the two alternative scenarios on Chinook salmon (*Oncorhynchus tshawytscha*) in the Klamath River Basin. It was Atkins' responsibility to: 1) manage the process in which panelists were screened and selected; 2) facilitate the Panel deliberations; and 3) assist with the preparation of the Panel's conclusions in a report to the USFWS.

Through existing contacts and referral networking, Atkins identified a pool of almost 60 potential panelists for the lamprey, resident fish, coho salmon and steelhead, and Chinook salmon expert panels. Prior to commencing the initial screening process for the assembly of all of the expert panels, Atkins had no working relationship, and only limited direct knowledge of most of the panelists' expertise or professional affiliations. Attempts were made to contact all potential candidates for the Chinook salmon Panel. The goal was to provide a balanced panel of six experts. The Chinook salmon Expert Panel was designed to include an ecohydrologist, fish ecologist, fish population modelers, and experts on Chinook salmon ecology. Due to availability over longer timeframes, expertise, and a lack of conflict of interest, some of the Panelists participated in multiple expert panels.

Three additional criteria required of each panelist were:

- Ability to meet the timeframe for the review process;
- Ability to provide an expert review that would be widely regarded as both credible and independent; and,
- Candidates had to be free from potential or perceived conflicts of interest.

Brief biographies for each of the panelists selected for the Chinook salmon Expert Panel are as follows (full resumes have been provided previously to the USFWS and are included in Appendix E):

- **Dr. Wim Kimmerer,** Research Professor at the Romberg Tiburon Center, San Francisco State University, has a PhD in Biological Oceanography from the University of Hawaii. Dr. Kimmerer has 30 years' experience in research and analysis in a wide variety of topics including the ecology of tropical lagoons, fisheries management planning, eutrophication, plankton ecology, and the status of Chinook salmon in California's Central Valley. His current research focuses on the San Francisco estuary, with emphasis on effects of human activities on the estuarine ecosystem. Dr. Kimmerer was a member of the CALFED Ecosystem Restoration Program Core Team which developed a strategic plan for the program, and was co-Chair of the Ecosystem Restoration Program Science

Board. He is a science advisor to the Delta Science Program and to the Subtidal Habitat Goals Project.

- **Dr. Kenneth Rose,** E.L. Abraham Distinguished Professor of Louisiana Environmental Sciences, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge. He received his PhD in Fisheries from the University of Washington. Dr. Rose develops and evaluates population and community models of fish, including age-, stage-, and individual-based models. Dr. Rose has published over 100 papers on various aspects of ecological and fisheries modeling. He has served on many regional and national advisory committees, including the National Research Council committee on a sustainable San Francisco Delta, the Ecosystem Management committee for the Gulf of Mexico Fisheries Management Council, and multiple review panels for biological opinions and reasonable and prudent alternatives related to salmonids in the San Francisco estuary.

- **Dr. Daniel Goodman,** Professor, Ecology Department, Montana State University, Bozeman. He received his PhD from Ohio State University in 1972. His primary research area is parameter estimation for use in probabilistic environmental models, with applications in population viability analysis for endangered species, and management of harvested populations.

- **Dr. Mike Harvey,** Program Manager, Surface Water Group, Tetra Tech, Inc., Fort Collins, Colorado. He received his PhD in fluvial geomorphology from Colorado State University in 1980. Dr. Harvey has spent the last 30 years applying the principles of fluvial geomorphology to river and habitat rehabilitation for both warm- and cold-water species. He specializes in the application of hydrologic, hydraulic and sediment transport modeling in the river environment and has extensive experience in evaluating geomorphic responses to dam removal. He is an internationally recognized expert in fluvial geomorphology with numerous publications to his credit.

- **Dr. Robert Hughes,** Adjunct Associate Professor, Department of Fisheries and Wildlife, Oregon State University and Senior Research Scientist, Amnis Opes Institute, Corvallis, Oregon. He received his PhD in Fisheries from Oregon State University. Dr. Hughes' research interests are in bioassessment and biomonitoring of aquatic ecosystems, focusing on regional scale surveys, large rivers, and fish assemblages, concerning which he has published over 100 peer reviewed publications. He has served on Oregon's Independent Multidisciplinary Science Team since 2004, as an External Reviewer for the European Fish Index project, as a Research Reviewer for the National Research Agency of France (ANR), as a Senior Advisory Panelist for Great Lakes Environmental Indicators, and as a consultant on ecological monitoring programs to the governments of Brazil and China.

- **Dr. Greg Ruggerone,** Vice President, Natural Resource Consultants, Inc., Seattle, Washington. Dr. Ruggerone received his PhD in Fisheries from University of Washington where he is currently an affiliated research scientist with the School of

Fisheries. Dr. Ruggerone brings 30 years of experience in anadromous fisheries ecology and management to the Panel. He has conducted applied research in salmonid predator-prey interactions, species competition, climate change effects on salmon production in the ocean, effects of habitat changes on salmonid production, limnological studies, effects of hydropower operations on downstream smolt and upstream adult migrations, and harvest management. He has participated in extensive field studies in applied fisheries biology and management in Alaska and the Pacific Northwest.

The opinions presented in this report reflect those of the Panelists and not the views of their respective employers or professional affiliations.

D.2 Review Process

Atkins was awarded the contract to conduct the expert panel work for all four panels on June 15, 2010. At that time, Atkins' staff began assembling a pool of potential candidates for the Chinook salmon Expert Panel. The initial review schedule for this Panel was delayed by the USFWS in early August. The final expert Panel was confirmed on November 8, 2010. Background files were provided by the USFWS and submitted to the Panel for review as they became available beginning December 21, 2010. The Panel members convened for a meeting in Eureka, California, on January 10 through 15, 2011. The first two days of the meeting (January 10-11) consisted of briefings provided to the Panel by members of the Technical Management Team (TMT) subgroups, which included scientists with expertise in a variety of technical disciplines relevant to the review process, as well as interested stakeholders. The Panel worked on this report in private for the remainder of the week.

During the course of its work the Panel relied on numerous documents as cited in this report. Key documents reviewed by the Panel included:

- Presentations from the TMT subgroups and stakeholders on January 10 and 11, 2011;
- KHSA, February 18, 2010;
- KBRA, February 18, 2010;
- Synthesis of the Effects of two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River, Final Draft dated November 23, 2010 (Hamilton et al. 2010);
- Evaluation of Instream Flow Needs in the Lower Klamath River, Phase II Final Report (Hardy et al. 2006);
- Upper Klamath Basin Restoration: KBRA Actions upstream of Keno Dam (Barry 2010) and downstream of Keno Dam (Stillwater Sciences 2010);
- Endangered and Threatened Fishes of the Klamath River Basin: Causes of Decline and Strategies for Recovery (NRC 2004);

- Hydrology, Ecology, and Fishes of the Klamath River Basin (NRC 2008); and,
- Articles published in the scientific literature and agency reports.

During the meeting, each Panelist took responsibility for specific sections of this report and provided a draft of text to the other Panel members. Atkins' staff facilitated the meeting but provided no substantive technical input. By the completion of the meeting, an initial draft version of the Expert Panel Report had been reviewed and generally approved by each Panel member. The draft version of the report was then revisited for finalizing by the Panel after the meeting. At the request of the TMT, the release of the draft report was delayed as a result of comments received on the draft coho salmon and steelhead report. During the delay period, the Panel continued to edit the draft report. The draft version of the report was then revisited by the Panel after the meeting, and a final draft was prepared and posted for stakeholder and agency comment on May 2, 2011. Through a separate, independent scientific peer review process, the draft report was also submitted to two independent reviewers for comment. Comments on the draft report were received through May 12, 2011. Additional comments were received late on May 13, 2011. Comments were carefully cataloged, reviewed, and responded to, as appropriate, by the Panel to create a final report that was distributed to the stakeholders and agencies, and posted to the project's website on June 13, 2011.

On June 15, 2011, it was brought to the attention of Atkins that several comments submitted during the draft document review period (May 2 through May 12, 2011) had not been received or incorporated into the final document that was released on June 13, 2011. At the request of the TMT, Atkins subsequently notified the stakeholders and agencies on June 20, 2011 that an addendum to the final report would be prepared by the Panel to include responses to the additional comments received and any resulting revisions to the report. Therefore, this report represents an addendum to the final report dated June 13, 2011. A complete list of all comments received on the draft report, along with the Panel's responses, is provided as Appendix C to this addendum report.

APPENDIX E
Panelists' Resumes

Résumé: Daniel Goodman

Department of Ecology
Montana State University
Bozeman MT 59717

Personal History:

Born in Cincinnati, Ohio, May 20, 1945

Education:

Ohio State University, B.Sc. in Biology, Cum Laude, 1966
Ohio State University, Ph.D. in Zoology, 1972

Career History:

1987-present	Professor of Biology, Montana State University
1987-1993	Adjunct Professor of Biology, University of California, San Diego
1981-1987	Associate Professor of Biology, Montana State University
1975-1983	Assistant Professor of Population Biology, Scripps Institution of Oceanography
1972-1974	Research Associate, Program on Science, Technology & Society, and Division of Biological Sciences, Cornell University

Field Projects:

1967	Ecological investigations of ice worms on Casement Glacier, Alaska.
1968	Limnological investigations and reference sample collection on Tower Island in the Galapagos.
1970	Raising a sediment core from the lake Birket Ram, Golan Heights, Israel.

Awards and Honoraries:

Phi Beta Kappa
Woodrow Wilson Fellowship

Committees:

Board of Trustees, The Institute of Ecology 1979-82
Condor Advisory Committee, Cal Fish & Game Commission 1981-85
Committee of Scientific Advisors, US Marine Mammal Comission 1985-89
Scientific Committee, International Whaling Commission 1986-88
Science Advisory Board, US Environmental Protection Agency
Research strategies subcommittee 1987-88
Long-term ecological research subcommittee 1987-1989
Gobal climate research subcommittee 1989
Ecological processes and effects committee 1989-1994
Independent Science Advisory Board for Salmon Recovery, Northwest Power Planning Council 1996-2005
Independent Scientific Review Panel, Northwest Power Planning Council 1997-2005

Scientific Review Panel for Artificial Production, Northwest Power Planning Council 1998-1999
Hawaiian Monk Seal Recovery Team, National Marine Fisheries Service 2002-present
Review Panel for Groundfish Fishery Control Rule North Pacific Fishery Management Council, chair 2002
Science Panel, North Pacific Research Board 2002-2005
Bering Sea Integrated Ecosystem Modelling Oversight Committee, North Pacific Research Board, chair 2006-2010
Fish Passage Center Oversight Committee, Northwest Power Planning Council 2007-present
Validated Sampling Plan Review Panel, Department of Homeland Security 2007-present
Silvery Minnow PVA Working Group, Middle Rio Grande Endangered Species Collaborative, 2008-present
Cook Inlet Beluga Recovery Team, National Marine Fisheries Service 2010-

Current Graduate Courses:

Scientific Method
Introduction to Quantitative Biology
Mathematical Demography and Population Management
Multivariate Analysis of Ecological Data
Parameter Estimation for Ecological Models

Current Graduate Students:

Gina Himes-Boor

Completed PhD dissertations of advisees:

Cullen, J.J.	1980. Chlorophyll maximum layers of the Southern California Bight and mechanisms of their formation and maintenance. University of California, San Diego.
Methot, R.D.	1981. Growth rates and age distributions of larval and juvenile Northern anchovy, Engraulus mordax, with inferences on larval survival. University of California, San Diego.
Dengler, A.T.	1981. Spatial distributions of phytoplankton: limitations of power spectral techniques. University of California, San Diego.
Lopez, G.W.	1981. Population studies on Tisbe cucumaria (Copepoda; Harpacticoida). University of California, San Diego.
Barlow, J.P.	1982. Methods and applications in estimating mortality and other vital rates. University of California, San Diego.
MacCall, A.D.	1983. Population models of habitat selection, with application to the Northern anchovy. University of California, San Diego.

Gustafson, D.L. 1990. Ecology of aquatic insects in the Gallatin River drainage. Montana State University.

Boveng, P.L. 1993. Variability in a crabeater seal population and the marine ecosystem near the antarctic peninsula. Montana State University.

Easter-Pilcher, A.L. 1993. Analysis of the listing of species as endangered or threatened under the Endangered Species Act. Montana State University.

Berkson, J.M. 1996. Modeling the restoration of a metapopulation: Implications for resource management. Montana State University.

Harting, A.L. 2002. Stochastic simulation model for the Hawaiian Monk Seal. Montana State University.

Eguchi, T. 2003. Bayesian mark recapture estimates of population size for the Eastern Bottlenose Dolphin. Montana State University.

Wright, C.K. 2004. Improved wetland detection in Yellowstone National Park by combination of Landsat thematic mapper imagery, image texture, and ancillary GIS information. Montana State University.

Hennen, D.R. 2004. The Steller sea lion (Eumetopias jubatus) decline and the Gulf of Alaska/Bering Sea commercial fishery. Montana State University.

Schwarz, L.K. 2007. Survival rate estimates of Florida manatees (Trichechus manatus latirostris) using carcass recovery data. Montana State University.

Taylor, R.L. 2009. A multistate mark recapture analysis to estimate reproductive rate in the endangered Steller sea lion *Eumatopius jubatus*

Kaeding, L,R. 2010. Assessment of factors that may have affected the cutthroat trout population of Yellowstone Lake during the three recent decades. Montana State University.

Himes Boor, G.K. 2010. Applying novel approaches to old data sets: utilizing opportunistic observations and Bayesian estimation to describe spatial patterns for Steller sea lions. Montana State University.

Completed Masters theses of advisees:

Boveng, P.L. 1985. Effects of nutrient enrichment on Georgetown Lake plant communities. Montana State University.

Wade, P. R. 1987. Distribution and abundance of phytoplankton taxa in the Eastern Scotia Sea. Montana State University.

Adkison, M.D. 1989. Spatial pattern in the influence of sulfur dioxide emissions from Arizona and New Mexico copper smelters. Montana State University.

Ward, E. 2003. Evaluating trends and biases in shipboard tuna vessel data used in the estimation of dolphin abundance. Montana State University.

Publications and reports:

1970 Ideology and ecological irrationality. BioScience 20: 1247-1252.
1971 (with W.B. Parrish) Ultrastructure of the epidermis of the ice worm, Mesenchytraeus solifugus. J. Morph. 135:71-86.
1971 (with P.A. Colinvaux) Recent silica gel from a saline lake in the Galapagos Islands. Abstr. Ann. Mtng. Am. Soc. Pet. Geol. and Soc. Econ. Paleont. and Miner.
1971 Ecological investigations of ice worms on Casement Glacier, S.E. Alaska. O.S.U. Research Foundation, Institute of Polar Studies, Report No. 39.
1972 The paleoecology of the Tower Island bird colony: a critical examination of diversity-stability theory. Ph.D. Dissertation, Ohio State University.
1973 Standards for occupational exposure to pesticides. In, Report of OSHA Project, College of Adminsitrative Science, Ohio State University.
1974 Natural selection and a cost-ceiling on reproductive effort. Am. Nat. 108:247-268.
1974 The validity of the diversity-stability hypothesis. Proc. First Int. Congr. Ecology. pp. 75-79.
1975 The theory of diversity-stability relationships in ecology Quart. Rev. Biol. 50:237-266.
1976 Ecological expertise. In, H.A. Feiveson, F. Sinden and R.H. Socolow (eds.) Boundaries of Analysis. Ballinger, Cambridge, Mass. pp. 317-360.
1978 (with F.M.H. Reid, E. Stewart, and R.W. Eppley) Spatial distribution of phytoplankton species in chlorophyll maximum layers off Southern California. Limnol. Oceanogr. 23:219-226.
1978 Management implications of the mathematical demography of long lived animals. NTIS (PB-289 678) 80 pp.
1979 (with R.H. Whittaker) The classification of species according to demographic strategy. I. Population fluctuations and environmental heterogeneity. Am. Nat. 113:185-200.
1979 Competitive heirarchies in laboratory Drosophila. Evolution. 33:207-219.
1979 Regulating reproductive effort in a changing environment. Am. Nat. 113:735-748.
1979 Calculating vital rates from spotted porpoise age distributions. NMFS Status of the Porpoise Stocks Workshop, Doc. 51.
1979 On the interpretation of age distributions. IUCN & WWF Workshop on Biology and Management of Northwest Atlantic Harp Seals, Working Paper 7.
1979 Applications of eigenvector analysis in the resolution of spectral pattern in spatial and temporal ecological sequences. In, G.P. Patil and M.L. Rosenzweig (eds.), Contemporary quantitative ecology and related ecometrics. Statistical ecology series. Vol. 12. International Co-operative Publishing House, Fairland, Maryland. pp. 139-155.
1980 Demographic intervention for closely managed populations. In, M. Soule and

B. Wilcox (eds.), Conservation biology. Sinauer, Stamford, Con. pp. 171-195.

1980 The maximum yield problem: distortion in the yield curve due to age structure. Theor. Pop. Biol. 18:160-174.

1980 (with A.M. Barnett, E. Demartini, R. Larsen, P.D. Sertic, and W. Watson). Predicted larval fish losses to San Onofre Nuclear Generating Station Units 1, 2, and 3, and preliminary estimates of the losses in terms of equivalent forage fish. Report to Marine Review Committee of the California Coastal Commission.

1981 Life history analysis of large animals. In, C.W. Fowler and T.D. Smith (eds.) Dynamics of large mammal populations. Wiley-Interscience, New York, pp. 415-436.

1981 The limits to microcosms: problems in the interpretation of toxicity results from laboratory multispecies test systems. Cornell University, EPA Ecotoxicology Workshop, Working Paper.(ERC Report No. 12, May 1982).

1981 Final report of the shadow effects simulation project: depressions of planktonic populations associated with operation of the cooling system of the San Onofre Nuclear Generating Station. Report to the Marine Review Committee, California Coastal Commission.

1982 Optimal life histories, optimal notation, and the value of reproductive value. Am. Nat. 119:803-823.

1982 (with D.P. DeMaster, D.J. Miller, R. DeLong and B. Stewart) Assessment of California Sea Lions/fishery interactions. Proceedings, 47th North American Widlife and Natural Resources Conference. Portland, Oregon.

1982 An assessment of the status of the Northwest Atlantic stocks of hooded seals. Int. Cons. Exp. Mer., Seal Working Group, Working Paper.

1982 Analysis of the harp seal management models. Int. Cons. Exp. Mer., Seal Working Group, Working Paper.

1982 Exploratory analysis of connectivity indices as discriminators of biological oxygen demand. Report to EPA, Environmental Research Laboratories, Duluth.

1982 Dynamic response estimation of population status relative to maximum net productivity level. California Coastal Commission, Ocean Studies Symposium, Proceedings.

1983 Discrete time parametrization of the life history. NMFS, Pre-Status of the Porpoise Stocks Workshop, NOAA.

1983 Converting estimates of fraction pregnant to an estimate of fecundity. Report to NMFS, NOAA.

1983 Multivariate quantitative structure-activity relationships for the prediction of biological oxygen demand in organic compounds. Report to EPA, Environmental Research Laboratory- Duluth.

1983 (with T. Gerrodette and J.P. Barlow) Two computer programs to project populations with time varying vital rates. NOAA Technical Memorandum NMFS-SWFC-28.

1983 Thermal modeling for the Madison River-Ennis Reservoir system: effects of modifications on downstream river temperatures. Report to Blue Ribbons

Area Wide Planning Commission.

1984 Statistics of reproductive rate estimates, and their implications for population projections. Rep. Int. Whal. Commn., Special Issue 6:161-173.

1984 Risk spreading as an adaptive strategy in iteroparous life histories. Theor. Pop. Biol. 25:1-20.

1984 (with R.W. Eppley, and F.M.H. Reid) Summer phytoplankton assemblages and their environmental correlates in the Southern California Bight. J. Mar. Res. 42:1019-1049.

1984 (with R.H. Whittaker and J.W. Morris) Pattern analysis in savannas-woodlands at Nylsvley, South Africa. Mem. Botanical Survey of South Africa. Special Volume 49. 51pp.

1984 Considerations of age structure in back projection calculations for the northern offshore spotted dolphin population. NOAA Admin. Rept. LJ-84-26C.

1984 Uses of the gross annual reproductive rate calculation in the spotted dolphin assessment. NOAA Admin. Rept. LJ-84-22C.

1985 The minimum viable population problem: the demography of chance extinction. NOAA Admin. Rep. NMFS, SWFC LJ-84-44C.

1985 (with T. Gerrodette and J.P. Barlow) Confidence limits for population projections when vital rates vary randomly. Fish. Bull. 83:207-217.

1985 (with P. Smith) Determining a history of fish location with an archival tag: precision of latitudinal estimates using temperature and depth records. In, J.R. Hunter, et al. (eds) The dynamics of tuna movements, an evaluation of past and future research. IATTC. pp 161-178.

1986 (with M. Taper, and S. Hinkins) Geographic patterns in lake chemistry: Analysis of the EPA Eastern Lake Survey. Report to EPA.

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1987 The demography of chance extinction. In, M.E. Soule (ed) Viable populations. Cambridge U. Press. pp 11-34.

1987 Considerations of stochastic demography in the design and management of reserves. Nat. Res. Model. 1(2): 205-234.

1987 How do any species persist? Lessons for conservation biology. Conservation Biology. 1(1): 59-62.

1987 (with H. Braham). The role of special scientfic permits in relation to the comprehensive assessment. Int. Whal. Commn. Working Paper SC/39/02. 8 pp.

1987 Comments on the sea lion food-habits data: scat contents in the collections from San Clemente Island. NOAA Admin. Rep. LJ-87-07C. 13 pp.

1987 Systematic evaluation of scientific research permit requests: application to the Southern Hemisphere minke whale example. Rep. Int. Whal. Commn. 38:

1987 (with D.G. Chapman). Comments on annex R2 "A preliminary consideration on a method for estimating age-dependent natural mortality from age composition obtained by random sampling." Rep. Int. Whal. Commn. 38:

1988 Dynamic response analysis. I. Qualitative estimation of stock status relative to maximum net productivity level from observed dynamics under harvest. Marine Mammal Sci. 4:183- 195.

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1994 (with S. Blacker and J. Clark). Application of data quality objectives to a Hanford waste tank remediation problem. Env. Test. & Anal. 3(4):39-43.

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2009 The future of fisheries science: merging stock assessment with risk assessment for better fisheries management. Ch. 28, pp 537-566 in, R.J. Beamish and B.J. Rothschild (eds.) The Future of Fisheries Science in North America. Springer. 736 pp.

MICHAEL D. HARVEY

TITLE: Program Manager Geomorphology

BIRTH DATE: May 19, 1947

CITIZEN: New Zealand

VISA STATUS: U.S. Permanent Resident

EDUCATION:

B.S. 1969 University of Canterbury, New Zealand
Soil and Water Engineering

M.S. 1973 University of Canterbury, New Zealand
(Hons) Soils, Hydrology

Ph.D. 1980 Colorado State University
Fluvial Geomorphology

REGISTRATION: Professional Geologist, Wyoming

PROFESSIONAL EXPERIENCE:

2009-	Program Manager Geomorphology, Tetra Tech, Inc.
1994- 2009	Vice President, Mussetter Engineering, Inc.
1991-1994	Vice President, Resource Consultants & Engineers, Inc.
1990-1991	President, Water Engineering & Technology, Inc.
1988-1990	Vice President, Water Engineering & Technology, Inc.
1983-1988	Senior Research Scientist and Associate Professor of Geology, Colorado State University
1981-1983	Senior Research Associate, Colorado State University
1977-1980	Research Associate, Colorado State University
1975-1977	Project Leader, Water and Soil Division Ministry of Works and Development, New Zealand
1973-1974	Scientist, Water and Soil Division Ministry of Works and Development, New Zealand
1970-1971	Soil Conservationist, Water and Soil Division Ministry of Works and Development, New Zealand

PROFESSIONAL SOCIETIES:

Geological Society of America (Fellow)
American Geophysical Union

TEACHING:

Courses Individually and Team Taught at Colorado State University:

1983-1986	ER 454	Geomorphology
1983-1984	ER 376	Field Methods
1984	ER 592	Seminar in Glacial Geology
1984-1987	ER 480	Continental Depositional Processes
1984	ER 696	Group Study in Engineering Geology
1985	ER 544	Engineering Geology
1986-1987	ER 692	Geomorphology Seminar
1983-1984	ER 440	Watershed Problem Analysis
1983-1984	CE 413	Environmental River Mechanics
1983	CE 717	River Mechanics

Short Courses and Seminars:

2008 Southern Sandoval County Arroyo Flood Control Authority. Erosion Design Guide. Short Course
2002 Working at a Watershed Level, A workshop on water resource issues in California's Central Valley, California State University, Fresno, CA
2001 Advanced Streambank Protection Training Course, U.S. Army Corps of Engineers, Vicksburg, MS
1994 Sediment and Erosion Design Guide Short Course, Albuquerque Metropolitan Arroyo Flood Control Authority
1993 Sediment and Erosion Design Guide Short Course, Albuquerque Metropolitan Arroyo Flood Control Authority
1991 Soil Conservation Service, Design of Stable Earth Channels, Fort Worth, Texas
1990 USACE Hydrologic Engineering Center (HEC) - Application of engineering geomorphology to HEC-6 modeling, Davis, California
1988 USACE Hydrologic Engineering Center (HEC) - Applied geomorphology, Davis, California
1988 Soil Conservation Service - Geomorphology and channel design, Fort Worth, Texas
1987 Soil Conservation Service - Use of Geomorphology in Erosion Control and Channel Design, Portland, Oregon
1986 Office of Surface Mining - Design of Reclaimed Channels - Salt Lake City, Utah
1984 Erosion and River Behavior Analysis - Colorado State University
1984 Soil Conservation Service - Stream Mechanics - Colorado State University
1983 Soil Conservation Service - Geomorphology in channel design, Fort Worth, Texas, Greenville, S.C., Washington, D.C.

COMMITTEES:

American Society of Civil Engineers Hydraulics Division, River Bank Erosion Task Committee
National Academy of Sciences, Earth Surface Processes Panel

HONORS:

Fellow, Geological Society America, 1995

LITIGATION SUPPORT AND TESTIMONY

Qualified as an expert in geomorphology and provided expert testimony as follows:

U.S. Court of Claims
J.R. Cooper vs. U.S. (Case No. 681-84L)—1986
M.A. Powers et al. vs. U.S. (Case No. 434-75)—1989
B. Bagwell et al. vs. U.S. (Case No. 439-87L)—1996
C.S. Green et al. vs. US (Case No. 00-167L)—2002
R.C. Ingram, Jr. et al. vs. US (Case No. 03-2430L)—2006

U.S. Federal Court Cheyenne, Wyoming
C.R. Hanson vs. U.S.—1981

District Court, Water Division No. 1, State of Colorado
State of Colorado vs. U.S. (Case No. W-8439-76)—1990

Superior Court of California, Yuba County
Multiple plaintiffs vs. Reclamation District 784 and the State of California (Case No. 2104)—1994

Superior Court of California, San Benito County
Sandman, Inc. vs. County of San Benito and Board of Supervisors (Case No. 22107)—2000

Superior Court of California, San Joaquin County
Reclaimed Island Lands Company vs. State of California and RD 2107, the Dept of Water Resources of the State of California (Case No. 004313)—1999

U.S. District Court for the District of Idaho
Napias Creek (Case No. 94-0159-S-HLR)—1996

Fifth Judicial District, State of Idaho, County of Twin Falls
Snake River Basin Adjudication (Case No. 39576)
(Consolidated Case No. 63-25243)—1998

Fifth Judicial District, State of Idaho, County of Twin Falls
Snake River Basin Adjudication (Case No. 39576)
(Consolidated Case No. 02-10063)—2001

Superior Court of California
Sandman, Inc. vs. County of San Benito and Board of Supervisors (Case No. 22107)—2001

U.S. District Court of Kansas
Jacquline Seyler v. Burlington Northern Santa Fe Corporation and AMTRAK (Case No. 99-2342-KHV)—2002

Superior Court of California, San Benito County
Sandman, Inc. vs. County of San Benito and Board of Supervisors (Case No. 22107)—2002

Superior Court of Arizona, County of Mariposa
The Burlington Northern and Santa Fe Railway Company v. The State of Arizona et al. (Case No. CV98-14172)—2002

U.S. District Court for the Eastern District of California
California Sportfishing Protection Alliance v. Diablo Grande, Inc. (Case No. F-00-597- OWWDLB)—2001

Superior Court of California, Mono County
Louis A. deBottari v. California Department of Transportation (Case No. 12449)—2004

Superior Court of California, County of San Joaquin
Reclaimed Island Land Co. v. RD 2107 and the State of California (Case No. 0043113)—2000

District Court of El Paso County, Colorado
Speight Partnership and Greenview Trust v. City of Colorado Springs and El Paso County (Case No. 01CV1290)—2008

PUBLICATIONS:

Harvey, M.D. and Mussetter, R.A., 2009. Modeling of Fine and Coarse Sediment Dynamics in the Upper Colorado River: Implications for Biological Productivity. Proceedings 7th International Symposium on Ecohydraulics, Concepcion, Chile, January 12-16.

Mussetter, R.A., Harvey, M.D. and Harner, R.F., 2009. Relationship between Physical Characteristics, Flow Regime and Riparian Vegetation in Coarse-grained Streams. Proceedings,7th International Symposium on Ecohydraulics, Concepcion, Chile, January 12-16.

Schumm, S.A. and Harvey, M.D., 2008. Engineering Geomorphology. In Sedimentation Engineering: Processes, Measurements, Modeling and Practice, ASCE Manuals and Reports on Engineering Practice, Manual No. 110, H.H. Garcia (Ed), American Society of Civil Engineers, Reston, VA.

Harvey, M.D., Trabant, S.C., and Levitt, J.E., 2008. Modeling Sedimentation Rates at Proposed Lake Ralph Hall, North Sulphur River, Texas. Proceedings of the 50 Years of Soil and Water Research in a Changing Agricultural Environment Conference, National Sedimentation Laboratory, September 3-5, Oxford, Mississippi.

Harvey, M.D. and Mussetter, R.A., 2008. Geomorphic, Hydraulic and Sediment Transport Challenges Facing Restoration of the Upper San Joaquin River from Friant Dam to the Merced River, CA. Proceedings of the 50 Years of Soil and Water Research in a Changing Agricultural Environment Conference, National Sedimentation Laboratory, September 3-5, Oxford, Mississippi.

Harvey, M.D., Trabant, S.C., and Levitt, J.E., 2007. Predicted Sedimentation Rates at Proposed Lake Ralph Hall, North Sulphur River, Texas. Presented at the Texas Water 2007 Conference by the Texas Section of the American Water Works Association (TAWWA) and the Water Environment Association of Texas (WEAT), Fort Worth, Texas, April 10-13.

Mussetter, R.A., Harvey, M.D., and Parkinson, S., 2007. Boat Wake Erosion of Sand Bars in Hells Canyon of the Snake River, Idaho and Oregon. World Environmental and Water Resources Congress 2007, ASCE, Tampa, Florida, May.

Harvey, M.D., Sanborn, S.C., Llewellyn, D.K., and Medley, N.M., 2007. Habitat restoration in the Albuquerque Reach of the Middle Rio Grande: Basis of Design. Proc., AWRA 2007 National Conference, Albuquerque, New Mexico.

Harvey, M.D. and Trabant, S.C., 2006. Evaluation of Bar Morphology, Distribution, and Dynamics as Indices of Fluvial Processes in the Middle Rio Grande. Abstract for Middle Rio Grande Endangered Species Collaborative Program, First Annual Symposium, Albuquerque, New Mexico, April.

Mussetter, R.A., Harvey, M.D., and Harner, R.F., 2005. Physical characteristics, flow regime and riparian vegetation in coarse-grained streams, Idaho Batholith, USA. Poster presented at the Sixth Gravel-bed Rivers Conference, Austria, September 5-9.

Mussetter, R.A. and Harvey, M.D., 2005. Design Discharges for Arroyos in an Urban Setting. Proceedings of the EWRI 2005 World Water and Environmental Resources Congress, Anchorage, ASCE, Alaska, May 15-19.

Harvey, M.D. and Mussetter, R.A., 2005. Difficulties of Identifying Design Discharges in Steep, Coarse-Grained Channels in the Arid Southwestern US. Proceedings of the EWRI 2005 World Water and Environmental Resources Congress, Anchorage, Alaska, May 15-19.

Armstrong, S., Miller, W., Mussetter, R.A., Harvey, M.D., and Thomas, D.B., 2004. Aquatic Habitat and Hydraulic Modeling Study, Rio Grande at Bosque del Apache National Wildlife Refuge. Poster session for the 2004 Festival of Cranes, San Antonio, New Mexico, November.

Harvey, M.D., Trabant, S.C., Lunger, J.R., and Llewellyn, D., 2004. Bar Dynamics in the Bosque del Apache National Wildlife Refuge. Poster session for the 2004 Festival of Cranes, San Antonio, New Mexico, November.

Mussetter, R.A. and Harvey, M.D., 2004. Geomorphic, Hydrologic, Hydraulic and Sediment Transport Analyses: Tools for Evaluating In-channel and Channel-margin Habitat Dynamics. Proceedings of the 3rd Missouri River and North American Piping Plover and Least Tern Workshop, Sioux City, Iowa, April 12-14.

Harvey, M.D. and Mussetter, R.A., 2004. Fine Sediment Dynamics in Coarse-Grained Streams; Implications for Biological Productivity in Urbanized Western Streams. Proceedings of the EWRI Environmental Resources Congress 2004, Salt Lake City, Utah, June.

Harvey, M.D. and Morris, C.E., 2004. Downstream Effects of Urbanization in Fountain Creek, Colorado. Proceedings of the EWRI Environmental Resources Congress 2004, Salt Lake City, Utah, June.

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Lunger, J.R., Harvey, M.D., and Mussetter, R.A., 2004. Investigation of Habitat Formation and Fish Use during a Range of Flows in a Sand-bed Stream, the Pecos River, New

Mexico. Abstract for the proceedings of the American Geophysical Union, Hydrology Days 2004, Colorado State University, Fort Collins, Colorado, March.

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Harvey, M.D., Mussetter, R.A., Morris, C.E., 2003. Fine Sediment Dynamics in the Upper Colorado River During Spring and Summer Baseflows. Presented to the Upper Colorado River Basin Researcher's Annual Meeting, Grand Junction, Colorado, January 16.

Mussetter, R.A., Harvey, M.D., and Trabant, S.C., 2002. Historical and Present Day Sediment Loads in the Middle Rio Grande, New Mexico. Proceedings of Hydrology Days, 2002 American Geophysical Union, Colorado State University, Fort Collins, Colorado, April 1-2.

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Mussetter, R.A., Harvey, M.D., Wolff, C.G., and McDowall, D.G., 2000. Whitewood Creek Reclamation Plan: A Sound Basis for Design. 2000 Joint Conference on Water Resources Engineering and Water Resources Planning and Management, Minneapolis, Minnesota, July 30-August 2.

Thomas, D.B., Abt, S.R., Mussetter, R.A., and Harvey, M.D., 2000. A Design Procedure for Sizing Step-Pool Structures. 2000 Joint Conference on Water Resources Engineering and Water Resources Planning and Management, Minneapolis, Minnesota, July 30-August 2.

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Harvey, M,D. and Smith, T.W., 1998. Gravel Mining Impacts on San Benito River, California. Proceedings of the 1998 International Water Resources Engineering Conference, Hydraulics Division, ASCE, Memphis, Tennessee, August, pp. 3-5.

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Mussetter, R.A., Lagasse, P.F., Harvey, M.D. and Anderson, C.A., 1994. Procedures for evaluating the effects of sedimentation on flood hazards in urbanized areas in the southwestern U.S. Proceedings of Water Resources Planning and Management Div. ASCE, Phoenix, Arizona.

Harvey, M.D. and Mussetter, R.A., 1994. Geologic, geomorphic and hydraulic controls at spawning locations for endangered Colorado squawfish. EOS Trans. Amer. Geophys. Union, v. 75, 269 p.

Jorgensen Harbor, D., Schumm, S.A. and Harvey, M.D., 1994. Tectonic control of the Indus River in Sindh, Pakistan. In Schumm, S.A. and Winkley, B.R. (eds), *The Variability of Large Alluvial Rivers*, American Society of Civil Engineers Press, New York, pp. 161-176.

Harvey, M.D. and Schumm, S.A., 1994. Alabama River: Variability of overbank flooding and deposition. In Schumm, S.A. and Winkley, B.R. (eds), *The Variability of Large Alluvial Rivers*, American Society of Civil Engineers Press, New York, pp. 313-337.

Harvey, M.D. and Flam, L., 1993. Prehistoric soil and water detention structures (Gabarbands) at Phang, Sindh Kohistan, Pakistan. Geoarchaeology, v. 8(2), pp.109-126.

Germanoski, D. and Harvey, M.D., 1993. Asynchonous terrace development in degrading braided channels. Physical Geography, v. 14(4), pp. 16-38.

Jorgensen, D.W., Harvey, M.D., Schumm, S.A. and Flam, L.B., 1993. Morphology and dynamics of the Indus River: Implications for the Mohen Jo Daro Site. In Shroder, J.R. (ed), *Himalaya to the Sea: Geology, Geomorphology and the Quaternary*, Routledge, pp. 288-326.

Harvey, M.D., Mussetter, R.A., and Wick, E.J., 1993. A physical process-biological response model for spawning habitat formation for the endangered Colorado Squawfish. *Rivers*, v. 4 (2), pp. 114-131.

Mussetter, R.A., Harvey, M.D., and Lagasse, P.F., 1993. Fine sediment deposition and erosion at a Squawfish spawning bar, Yampa River, Colorado. Proceedings of the Int. Conference on Hydroscience and Engineering, Washington, D.C., Wang, S. (ed), v. 1 (B), June, pp. 265-272.

Schumm, S.A. and Harvey, M.D., 1993. Engineering Geomorphology. Proceedings of the ASCE National Conference on Hydraulic Engineering, San Francisco, California, July, Shen, H.W., Su, S.T., and Wen, F. (eds), v. 1, pp. 394-399.

MacArthur, R.C., Hamilton, D.L., Harvey, M.D. and Kekaula, H.W., 1992. Analyses of special hazards and flooding problems in tropical island environments. Proceedings of the ASCE, Hydr. Div. Annual Meeting, Baltimore, pp. 1061-1066.

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Biedenharn, D.S., Combs, P.G., Harvey, M.D., Little, C.D. and Watson, C.C., 1991. Systems design approach in Northern Mississippi. Proceedings of the 5th Federal Interagency Sedimentation Conference, Las Vegas, Nevada, Fan, S.S. and Kuo, Y.H. (eds), pp. 3.8-3.15.

Fischer, K.J., Harvey, M.D. and Sing, E.F., 1991. Site prioritization for bank protection, Sacramento River, California. Proceedings of the 5th Federal Interagency Sedimentation Conference, Las Vegas, Nevada, Fan, S.S. and Kuo, Y.H. (eds), pp. 3.47-3.54.

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ROBERT M. HUGHES (phone: 541-754-4516; email: hughes.bob@epa.gov)

EDUCATION: Ph.D., Fisheries and Wildlife, Oregon State University, Corvallis, OR, 1979; M.S., Resource Planning and Conservation, University of Michigan, Ann Arbor, MI, 1973; A.B., Psychology/Biology, University of Michigan, Ann Arbor, MI, 1967.

EMPLOYMENT HISTORY: Oregon State University, Corvallis, OR, Courtesy Associate Professor 2009-Present; Amnis Opes Institute, Corvallis, OR, Senior Researcher, 2009-Present; Federal University of Lavras, Lavras, Minas Gerais, Brazil, Visiting Senior Professor 2010; Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil, Visiting Senior Professor, 2009; Oregon State University, Corvallis, OR, Senior Research Professor, 2004-2009; Dynamac, Corvallis, OR, Regional Aquatic Ecologist, 1996-2004; ManTech, Corvallis, OR, Research Scientist, 1982-1996; University of Illinois, Corvallis, OR, Visiting Research Scientist, 1981-1982; U.S. Environmental Protection Agency, Corvallis, OR, Ecologist, 1980-1981; Western Michigan University, Corvallis, OR, Visiting Assistant Professor, 1978-1980; Western Michigan University, Kalamazoo, MI, Assistant Professor, 1977-1978.

EXPERIENCE OVERVIEW:

Dr. Hughes has over 30 years of experience in sampling and analyzing data for fish assemblages in various parts of the United States. He has used his expertise to develop and evaluate indicators for the Environmental Monitoring and Assessment Program (EMAP), to evaluate ecoregions, and to generate biological criteria. He also has extensive experience in sampling and analyzing data of benthos, sedimentary diatom, zooplankton, and periphyton assemblages. His experience includes sampling in small streams and ponds, as well as the Great Lakes and large navigable rivers. Dr. Hughes was a key member of the research team that developed and field-tested the ecoregion concept that led to the map of the ecoregions of the United States. He co-chaired the National Workshop on Instream Biological Monitoring and Criteria in 1987, co-authored EPA's Rapid Bioassessment Protocols for Fish and Benthic Macroinvertebrates in 1989 and its EMAP Field Protocols for Fish Assemblages and Fish Tissue in 2006, and provided technical expertise to the EPA's Steering Committee on Biological Criteria 1988-1990. Dr. Hughes edited three AFS books in 2005-2006, and has authored over 100 peer reviewed publications. He has received 6 EPA awards for best scientific paper or technical contribution, was awarded the best paper in Transactions of the American Fisheries Society in 2008, was elected 2nd Vice President of the American Fisheries Society in 2010, has been a guest speaker eight times each in Europe and South America and twice in China, and was awarded the 2006 Environmental Stewardship Award by the North American Benthological Society.

DIRECT SUPERVISORY AND PROJECT MANAGEMENT EXPERIENCE:

<u>Project Management.</u> For EMAP, Dr. Hughes served as indicator coordinator working closely with 14 scientists at three EPA laboratories and four universities. Dr. Hughes designed and implemented a 19 lake pilot study to evaluate indexing and assessment issues for bird, fish, benthos, zooplankton, and diatom assemblages in New England. He was the senior author for the EMAP-Surface Waters chapters in the 1990 EMAP Ecological Indicators report and the 1992 Ecological Indicators Symposium Proceedings, as well as for the indicator chapter in the 1993 Lake Pilot report. He is co-author of the fish assemblage and fish tissue chapters in the EMAP field protocols for wadeable streams and non-wadeable rivers. He has drafted technical guidance for biological indicator development and selection. Dr. Hughes has delivered EMAP briefings to 3 peer review panels and given 41 EMAP talks at scientific meetings. He was also a founding member of the Biological Assessment Work Group within EPA Region 10, has excellent working relationships with agency

scientists outside of EMAP as well as inside the program, and is currently aiding professors at 6 Brazilian universities in their efforts to implement rigorous bioassessment programs across 3 states and the Sao Francisco Basin.

In addition, Dr. Hughes secured a contract with 3 federal agencies to develop a strategy for restoring and protecting stream/riparian ecosystems on nonfederal lands. This responsibility included tracking the work assignment, preparing the technical proposal, and writing portions of the strategy. From 2001-2003, he contracted with the USEPA Office of Water to develop guidelines for state biocriteria. From 2004-2009, Hughes was fully funded as principle investigator on research grants (from USEPA, USDA, NOAA, USFWS, OWEB).

Supervision. Before directing all his attention to scientific research, Dr. Hughes supervised five team leaders and 50 staff. In this position he suggested new areas of research, acquired project funding, designed studies, prepared research protocols, supervised field crews, analyzed data, and prepared reports and peer-reviewed manuscripts for publication. He administered the budget and was responsible for hiring, travel, training, employee evaluations, and counseling, as well as for applying corporate policies and quality assurance and health and safety protocols.

Graduate Students. Dr. Hughes has served on the committees of 8 graduate students:
Miriam Aparecida de Castro, M.Sc., Programa de Pós-Graduação em Ecologia Aplicada, Departamento de Biologia, Universidade Federal de Lavras (UFLA), Lavras, Minas Gerais, Brasil (2010-2012).
Déborah Regina Oliveira Silva, M.Sc., Laboratório de Ecologia de Bentos, Instituto de Ciências Biológicas, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil (2010-2013).
Nara Tadini Junqueira, M.Sc., Programa de Pós-Graduação em Ecologia Aplicada, Departamento de Biologia, Universidade Federal de Lavras (UFLA), Lavras, Minas Gerais, Brasil (2009-2012).
Maxime Logez, Ph.D., Ecologie des Hydrosystèmes Fluviaux, Université Claude Bernard Lyon 1, Lyon, France (2007-2010) Dissertation Reviewer.
Don Zaroban, Ph.D., College of Natural Resources, University of Idaho, Moscow, Idaho (2005-2010).
Dan McGarvey, Ph.D., Department of Biology, University of Alabama, Tuscaloosa, Alabama (2003-2007).
Pascal Irz, Ph.D., Laboratoire Ecologie des Systèmes Lagunaires, Université Montpellier II, Montpellier, France (2001-2006) Dissertation Reviewer.
Susan Reithel, M.Sc., Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon (2002-2006).

Graduate Committee Reviewer for 2 UFLA students (1 M.Sc.; 1 Ph.D.), Lavras, MG, Brazil 2010.

Departmental Service
Member Budget Committee, Department of Fisheries & Wildlife (2009-2010).
Member & Chair, Registry of Distinguished Graduates Committee (2007 & 2008, respectively)
Museum Committee

Community Service
Youth, High School, & Adult Soccer Referee (1983-Present)
President, Mid-Valley Soccer Referees Association (2005-2007)
Oregon High School Soccer Referee of the Year (2003)
Secretary, Mid-Valley Soccer Referees Association (1993)
Founding Member, Mid-Valley Soccer Referees Association (1990)
Chief Referee, American Youth Soccer Organization-Corvallis/Philomath (1987-1989)

TECHNICAL EXPERIENCE AND ACCOMPLISHMENTS:

EMAP Field Surveys. Dr. Hughes developed and tested methods for sampling fish in non-wadeable Oregon rivers, wrote sampling protocols, trained field crews, and submitted the results for publication. These methods are now being employed throughout the western USA, and he trained crews in the 12 western states. The approach has been modified to assess the condition of 7 large rivers in the Pacific Northwest and to evaluate the physical habitat of agricultural streams across the USA.

Modification of the Index of Biological Integrity. Dr. Hughes refined the Index of Biotic Integrity (IBI) for use in small Oregon streams, Appalachian streams, a large Oregon river, the Seine River of France, the Kshipra and Khan Rivers in India, Pacific Northwest rivers, a large Nevada river, and rivers and streams of the western USA. He assisted Brazilian colleagues to develop IBIs for fish assemblages there. These studies indicated the applicability of the fundamental ecological foundation of the IBI, as well as the ability to set biological criteria for acceptable conditions in rivers. The latter is an essential requirement of indicators.

Use of Available Data to Assess Ichthyogeographic Patterns. Dr. Hughes used a computer data base of 9100 historical fish collection records to evaluate Oregon ecoregions, examine habitat use patterns of fish species, and develop models for predicting fish species richness. These papers demonstrated how available data could be used to assess regional patterns in fish assemblages. Knowledge of regional patterns is essential in accurately assessing the condition of water bodies. He used this database to help select catchments and basins for restoration and protection in a project for the Oregon Senate. Hughes also compiled a national data base of 6000 sites to compare fish assemblage clusters with landscape classifications. Results indicated that only half the within-group fish-assemblage similarity could be explained with existing landscape classifications or abiotic data from the sites.

Field Studies of Ohio and Oregon Stream Ecosystems. Dr. Hughes designed and implemented field studies of 120 small Oregon streams, 110 small- to medium-sized Ohio streams, and the lower 280 km of the Willamette River. In these studies he selected sites, determined parameters to be studied and collection methods, designed equipment, and supervised data analyses and report writing. Fish, benthos, and periphyton assemblages were sampled. Results of these studies indicated the usefulness of ecoregions for determining typical and potential conditions, for setting quantitative standards, and for extrapolating and reporting ecological data. They led to widespread acceptance of ecoregions as a general framework for biological criteria and to the feasibility of conducting regional surveys of streams.

Use of Reference Streams to Assess Attainable Conditions. In a small pilot, Dr. Hughes studied the applicability of ecoregions to select reference streams for assessing impacts and recovery of two Montana streams extensively disturbed by mining wastes. Fish and benthos assemblages and periphyton metabolism were assessed. This was one of the first studies to demonstrate that least disturbed streams in an ecoregion can be used to set standards for other similar sized streams in the same region. It led to a widely cited and used book chapter on regional reference sites and remains a primary method for determining acceptable condition for EMAP surface waters and many state water quality agencies. Dr. Hughes has also developed a set of tiers for the USEPA Office of Water, with which states can compare the relative disturbance levels of reference watersheds.

Development of Metrics of Ecological Integrity. In 2 pilot studies of 28 streams of the western Corn Belt and northwestern Colorado, Dr. Hughes developed techniques to assess ecological integrity of streams through the use of physical habitat and fish assemblage structure. This study provided the foundation for a paper calling for a national biological survey of streams. He has conducted similar work more recently on New England lakes and western USA streams and rivers.

PROFESSIONAL AFFILIATIONS & ACTIVITIES:

Oregon Chapter of the American Fisheries Society: President
Elect 1993-1994, President 1994-1995, Past-President 1995-1996.

Western Division of the American Fisheries Society: Program Chair 1996, Vice-President 2004-2005, President-elect 2005-2006, President 2006-2007, Past-President 2007-2008, Chair Environmental Concerns Committee 2008-2009.

Parent American Fisheries Society:
Second Vice President 2010-2011; Water Quality Section President Elect 1997-1999, President 1999-2001, Past President 2001-2003, & Newsletter Editor 2001-2004; Chair Nominating Committee 1999; Member Nominating Committee 1998,1999, 2008; Resource Policy Committee 1999, 2010; Governing Board 1999-2001 & 2005-2007; Management Committee 2005-2007; Distinguished Service Award Committee 2007; Economic Policy Task Force 2008; Outstanding Chapter Award Committee 2008; Associate Editor North American Journal of Fisheries Management 2001-2003.

North American Benthological Society: Science & Policy Committee co-chair 2002-2011, Conservation & Environmental Issues Award Chair 2002-2003.

Hidrobiologia (Romanian Society of Limnology) Editorial Board 2007-present.

Environmental Management: Editorial Board 2000-2003.

USEPA Office of Water: Ecological Indicators Work Group 2007-2009, Steering Committee on Biological Criteria 1988-1990 & Tiered Aquatic Life Uses 2002-2007, STAR Research Panelist 1996.

State of the Nation's Ecosystems Report, External Reviewer, 2008.

External Evaluator, European Fish Index, January 2007-May 2009

University of Minnesota: Senior Advisory Panelist, Great Lakes Environmental Indicators 2001-2005.

National Research Agency of France (ANR) Research Reviewer 2006.

Water Environment Research Federation: Water Quality 2000, Aquatic Ecosystems Group 1999-2000.

Oregon Department of Environmental Quality:
Technical Reviewer, Willamette River Study 1990-1992
Technical Advisory Committee, Dissolved Oxygen Criteria 1992-1994
Technical Advisory Committee, Biological Criteria 2000-2004.

Oregon Watershed Enhancement Board: Independent Multidisciplinary Science Team 2004-2012.

U.S. Fish and Wildlife Service Fisheries Academy: Instructor, Biological Diversity, Corpus Christi, TX 1993.

HONORS, AWARDS & INTERNATIONAL PRESENTATIONS:

Fulbright Scholar Grantee, Federal University of Lavras, Lavras, Minas Gerais, Brazil, June-December 2010. Taught three 1-credit courses: 1 on IBI Development; 2 on Stream Physical Habitat Assessment.

Award of Special Recognition, Western Division of the American Fisheries Society, 2010.

Best Paper Award Transactions of the American Fisheries Society 2008

Fulbright Senior Scholar Award, Federal University of Minas Gerais, Belo Horizonte, Brazil, November-December 2007. Taught a 5-credit graduate course on Biomonitoring and Bioassessment at UFMG.

Distinguished Graduate Award, Fisheries & Wildlife Department, Oregon State University, June 2007.

Environmental Stewardship Award, North American Benthological Society, 2006

USEPA:
EPA Scientific and Technological Achievement Award (corecipient) 2010
EPA Scientific and Technological Achievement Award (corecipient) 2008
EPA Scientific and Technological Achievement Honorable Mention (corecipient) 2003
ERL-C Technical Achievement Award (Co-recipient) 1991
ERL-C Best Scientific Paper Award (Co-recipient) 1986, 1988, 1990
ERL-C Technical Contribution Award (Co-recipient) 1989
EPA Scientific and Technological Achievement Award (corecipient) 1987

DYNAMAC, Technical Achievement Award 1998, 1999, 2000, 2001, 2002, 2003

ManTech, President's Award for Excellence 1995

Invited Presentation. Use of fish assemblages for assessing ecological condition at river, basin, region, and continental scales. International Workshop on Water-quality Biomonitoring and Assessment, Nanjing, China, October 2010 (travel sponsored).

Invited Presentation. Ecological survey design principles. Fiocruz, Rio de Janeiro, RJ, Brazil, August 2010 (travel sponsored).

Invited Presentation. Patterns and processes in riverine fish diversity: a macroecological approach. Annual Meeting of the Mexico Chapter of the American Fisheries Society, Ensenada, Baja California, Mexico, May 2010 (travel sponsored).

Invited Presentation. Use of fish assemblages for assessing ecological condition at river, basin, region, and continental scales. Annual Meeting of the Mexico Chapter of the American Fisheries Society, Ensenada, Baja California, Mexico, May 2010 (travel sponsored).

Plenary Speaker, Regional and National Scale Bioassessments. First Minas Workshop on Water Monitoring, Foundation Technology Center of Minas Gerais, Belo Horizonte, MG, Brazil, November 2009 (travel sponsored).

Invited Presentation, Use of the Index of Biological Integrity in Environmental Assessments, State University of Sao Paulo, Sao Jose do Rio Preto, Brazil, November 2009 (travel sponsored).

Invited Presentation, Use of the Index of Biological Integrity in Environmental Assessments, Federal University of Lavras, Lavras, Brazil, October 2009 (travel sponsored).

Invited Presentation, Sampling Effort Considerations for Environmental Assessments, Federal University of Lavras, Lavras, Brazil, October 2009 (travel sponsored).

Plenary Speaker, Workshop on Strategies for the Evaluation of Aquatic Ecosystem Integrity: Neotropical Applications, Amazon Institute of Scientific Investigations, University of Bogota, Bogota, Columbia, October 2009 (travel sponsored).

Invited Presentation, Use of the Index of Biological Integrity in Environmental Assessments, Catholic Pontifical University, Belo Horizonte, Brazil, October 2009 (travel sponsored).

Invited Presentation. Sampling Effort & Indicator Considerations for Environmental Assessment of the Athabasca Oil Sands Region, Hatfield Consultants. Fort MacMurray, Alberta, July 2009 (travel sponsored).

Plenary Speaker, Improving the Ecological Status of Fish Communities in Inland Waters. University of Hull, Hull, England, April 2009 (travel sponsored).

Invited Participant, World Mountain Documentary Festival, Xining, Qinghai, China, September 2008 (travel sponsored).

Invited Participant, Vegetation Classification Workgroup, Sydney, New South Wales, Australia, July 2008 (travel sponsored).

Invited Plenary Talk, Biomonitoring of Hydrographic Basins Workshop. Federal University of Minas Gerais, Belo Horizonte, Brazil, December 2007 (travel sponsored).

Invited Presentation, Federal University of Lavras. Lavras, Brazil, November 2007 (travel sponsored).

Invited Presentation, Rural Federal University of Rio de Janeiro, Seropedica, Brazil, November 2007 (travel sponsored).

Invited Presentation, Technical University of Lisbon, Lisbon, Portugal, October 2007 (travel sponsored).

Invited Presentation, EFI+ Consortium Meeting, Technical University of Lisbon, Lisbon, Portugal, October 2007 (travel sponsored).

Invited Expert, Expert Workshop for Instream Flow Needs Monitoring Requirements in the Lower Athabasca River, Calgary, Alberta, March 2007 (travel sponsored).

Invited Presentation, University of Lisbon, Lisbon, Portugal, October 2006 (travel sponsored).

Invited Presentation, Center for Agricultural & Environmental Engineering Research (Cemagref), Aix en Provence, France, April 2006 (travel sponsored).

Invited Presentation, University of San Simon, Cochabamba, Bolivia, November 2005 (travel sponsored).

Invited Presentations, Federal Universities of Minas Gerais (Belo Horizonte) and Rio de Janeiro (Rio de Janeiro), Brazil, July 2003 (travel sponsored)

Invited Presentation, British Columbia Ministry of Water, Land & Air Protection, University of British Columbia, Vancouver, BC, May 2003 & 2005 (travel sponsored)

Invited Presentation, European Community Work Group on Reference Condition, Uppsala, Sweden, May 2001 (travel sponsored)

Invited Seminar & Short Course, Congress of Brazilian Ichthyologists, Sao Leopoldo, Brazil, January 2001 (travel sponsored)

Invited Seminar, Wroclaw University Museum of Natural History, Wroclaw, Poland, June 1994 (travel sponsored)

Invited Seminar, French National Museum of Natural History, Paris, France, June 1990 (travel sponsored)

RESEARCH GRANTS & CONTRACTS IN LAST 25 YEARS

Fulbright Brasil, 2010, $17,000
Washington Department of Ecology, 2010, $500,000
Rogue Valley Council of Governments, 2010-2013, $210,000
Fundação de Amparo à Pesquisa do Estado de Minas Gerais 2009-2010, $24,000
Oregon Watershed Enhancement Board, 2009, $25,000
National Marine Fisheries Service, 2008-2009, $73,622
U.S. Fish & Wildlife Service, 2007-2009, $32,109
Natural Resources Conservation Service, 2007-2009, $80,000
U.S. Environmental Protection Agency, 2005-2009, $383,585
U.S. Environmental Protection Agency 2004-2009, $1,789,252
U.S. Environmental Protection Agency, 2002-2005, $747,000
U.S. Environmental Protection Agency, 1999-2002, $50,000
National Marine Fisheries Service, 1994-1996, $300,000
French Museum of Natural History, 1989-1990, $20,000
U.S. Environmental Protection Agency, 1988, $25,000
U.S. Environmental Protection Agency, 1986-1987, $30,000
U.S. Environmental Protection Agency, 1986-1987, $45,000

OTHER PROFESSIONAL ACTIVITIES:

Manuscript reviewer for Ambio, American Midland Naturalist, Annals of the Association of American Geographers, Aquatic Living Resources, Biodiversity & Conservation, Canadian Journal of Fisheries & Aquatic Sciences, Community Toxicity Testing, Ecography, Ecological Applications, Ecological Indicators, Ecological Modeling, Ecology of Freshwater Fish, Environmental Management, Environmental Modeling & Software, Environmental Monitoring & Assessment, Fisheries Management & Ecology, Fisheries Research, Freshwater Biology, Freshwater Wetlands and Wildlife, Hydrobiologia, International Journal of Limnology, Journal of Applied Ecology, Journal of Great Lakes Research, Journal of the North American Benthological Society, Landscape Ecology, Limnologica: Ecology & Management of Inland Waters, North American Journal of Fisheries Management, Northwest Science, Oecologia, River Research & Applications, Transactions of the American

Fisheries Society, Zoologica, and numerous federal and state reports.

Member of research team studying winter limnology of Crater Lake National Park.

Invited author of the reference condition chapter in an EPA edited book on biological criteria and of three entries for Kluwer's environmental encyclopedia.

Sponsored participant in national workshops on large rivers and biological assessment (Denver 2009, San Antonio 2007, Cincinnati 2006, Baltimore 2001, Washington, DC 2000; Opal Cr, OR 1999; Chicago, IL 1999; Baltimore, MD 1998).

SPECIAL TRAINING: Courses in writing, supervisory, and managerial skills 1985-1989; Electrofishing, U.S. Fish & Wildlife Service Fisheries Academy, Duluth, MN 1991.

PUBLICATIONS:
Peer Reviewed Publications (108 published, 7 in press, 9 in review, **bold indicates major author**)

Journals (67 published, 2 in press, 9 in review)
Alonzo Gonzalez, C., D. Garcia de Jalon, M. Marchamalo, J. Gortazar, and R.M. Hughes. In Review. Open methodological framework (OMF) for determining reference conditions in fluvial ecosystems: an application to the composition of the fish fauna in Navarre (Spain). Environmental Management.

Hughes, R.M., P.R. Kaufmann, and M.H. Weber. In Press. Strahler order versus stream size. Journal of the North American Benthological Society.

Hughes, R. M., A. T. Herlihy, and W.J. Gerth. In Review. Estimating vertebrate and benthic macroinvertebrate species richness in raftable Pacific Northwest rivers for bioassessment purposes. Environmental Monitoring & Assessment.

Hughes, R. M., A. T. Herlihy, and J. C. Sifneos. In Review. Predicting aquatic vertebrate assemblages from environmental variables at three multistate geographic extents. Freshwater Biology.

Limburg, K.E., R.M. Hughes, D.C. Jackson, and B. Czech. In Review. Population Increase, economic growth, and fish conservation: collision course or savvy stewardship. Fisheries

Molozzi, J., J.S. França, T.L.A. Araujo, T.H. Viana, R.M. Hughes, and M. Callisto. In Review. Diversidade de habitats físicos e sua relação com macroinvertebrados bentônicos em reservatórios urbanos. Iheringia Série Zoologia

Moya, N., R.M. Hughes, E. Dominguez, F-M Gibon, E Goita, and T. Oberdorff. In Press. Macroinvertebrate-based multimetric predictive models for measuring the biotic condition of Bolivian streams. Ecological Indicators.

Oliveira, R.B.S, R. Mugnai, C.M. Castro, D. F. Baptista , and R.M. Hughes. In Review.
Towards a rapid bioassessment protocol for wadeable streams in Brazil: development of a multimetric index based on benthic macroinvertebrates. Ecological Indicators.

Pan, Y., R.M. Hughes, A.T. Herlihy, and P.R. Kaufmann. In Review. Non-wadeable river bioassessment: spatial variation of benthic diatom assemblages in Pacific Northwest rivers, USA. Freshwater Biology.

Segurado, P, J.M. Santos, D. Pont, A. Melcher, D. Garcia Jalon, R.M. Hughes, and M.T. Ferreira. In Review. Estimating species tolerance to human perturbation: expert judgment versus quantitative approaches. Ecological Applications.

Shirazi, M.A., D.P. Larsen, and R.M. Hughes. In Review. A model for predicting U.S. water quality from soils. Journal of Environmental Quality.

Flotemersch, J. E., J. B. Stribling, R. M. Hughes, L. Reynolds, M. J. Paul, and C. Wolter. In Press. Site length for biological assessment of boatable rivers. River Research & Applications

Hughes, R.M., A.T. Herlihy, and P.R. Kaufmann. 2010. An evaluation of qualitative indexes of physical habitat applied to agricultural streams in ten U.S. states. Journal of the American Water Resources Association 46:792-806

Steel, A., R.M. Hughes, S. Schmutz, S. Muhar, M. Poppe, C. Trautwein, M. Fukushima, H. Shimazaki, J. Young, B. Feist, A. Fullerton, and B. Sanderson. 2010. Meeting the challenges of landscape scale riverine research: a review. Living Reviews in Landscape Research 4:1-60.

Woody, C.A., R.M. Hughes, E.J. Wagner, T.P. Quinn, L.H. Roulsen, L.M. Martin, and K. Griswold. 2010. The U.S. General Mining Law of 1872: change is overdue. Fisheries 35:321-331.

Ibañez, C., J. Belliard, R.M. Hughes, P. Irz, A. Kamdem-Toham, N. Lamouroux, P.A. Tedesco, and T. Oberdorff. 2009. Convergence of temperate and tropical stream fish assemblages. Ecography 32:658-670.

Kanno, Y., J.C. Vokoun, D.C. Dauwalter, R.M. Hughes, A.T. Herlihy, T.R. Maret, and T.M. Patton. 2009. Influence of rare species on electrofishing distance– species richness relationships at stream sites. Transactions of the American Fisheries Society 138:1240-1251.

Oliveira, J.M., R.M. Hughes, M.T. Ferreira, A. Teixeira, P. Morgado, R.M. Cortes, and J.H. Bochechas. 2009. A preliminary fishery quality index for Portuguese streams. North American Journal of Fisheries Management 29:1466-1478.

Pinto, B.C.T., F.G. Araujo, V.D. Rodriguez, and R.M. Hughes. 2009. Local and ecoregion effects on fish assemblage structure in tributaries of the Rio Paraíba do Sul, Brazil. Freshwater Biology 54:2600-2615.

Pont, D., R.M. Hughes, T.R. Whittier, and S. Schmutz. 2009. A predictive index of biotic integrity model for aquatic-vertebrate assemblages of western U.S. streams. Transactions of the American Fisheries Society 138:292-305.

Hughes, R.M., and D.V. Peck. 2008. Acquiring data for large aquatic resource surveys: the art of compromise among science, logistics, and reality. Journal of the North American Benthological Society 27:837-859.

LaVigne, H.R., R.M. Hughes, and A.T. Herlihy. 2008. Bioassessments to detect changes in Pacific Northwest river fish assemblages: a Malheur River case study. Northwest Science 82:251-258.

LaVigne, H.R., R.M. Hughes, R.C. Wildman, S.V. Gregory, and A.T. Herlihy. 2008. Summer distribution and diversity of non-native fishes in the main-stem Willamette River, Oregon, 1944-2006.

Northwest Science 82:83-93.

McGarvey, D.J., and R.M. Hughes. 2008. Longitudinal zonation of Pacific Northwest (U.S.A.) fish assemblages and the species-discharge relationship. Copeia 2008:311-321.

Meador, M.R., T.R. Whittier, R.M. Goldstein, R.M. Hughes, and D.V. Peck. 2008. Evaluation of an index of biotic integrity approach used to assess biological condition in western U.S. streams and rivers at varying spatial scales. Transactions of the American Fisheries Society 137:13-22.

Stoddard, J. L, A.T. Herlihy, D.V. Peck, R.M. Hughes, T.R. Whittier, and E. Tarquinio. 2008. A process for creating multi-metric indices for large-scale aquatic surveys. Journal of the North American Benthological Society 27:878-891.

Hughes, R.M., and A.T. Herlihy. 2007. Electrofishing distance needed to estimate consistent IBI scores in raftable Oregon rivers. Transactions of the American Fisheries Society 136:135-141.

Lomnicky, G.A., T.R. Whittier, R.M. Hughes, and D.V. Peck. 2007. Distribution of nonnative aquatic vertebrates in western U.S. streams and rivers. North American Journal of Fisheries Management 27:1082-1093.

Peterson, S.A., J. Van Sickle, A.T. Herlihy, and R.M. Hughes. 2007. Mercury concentration in fish from streams and rivers throughout the western United States. Environmental Science and Technology 41:58-65.

Peterson, S.A., D.V. Peck, J. Van Sickle, and R.M. Hughes. 2007. Mercury concentration in frozen whole-fish homogenates is insensitive to holding time. Archives of Environmental Contamination and Toxicology 53:411-417.

Whittier, T. R., R. M. Hughes, G. A. Lomnicky, and D. V. Peck. 2007. Fish and amphibian tolerance values and an assemblage tolerance index for streams and rivers in the western USA. Transactions of the American Fisheries Society 136:254-271.

Whittier, T.R., R.M. Hughes, J.L. Stoddard, G.A. Lomnicky, D.V. Peck, and A.T. Herlihy. 2007. A structured approach to developing indices of biotic integrity: three examples from western USA streams and rivers. Transactions of the American Fisheries Society 136:718-735.

Pinto, B.C.T., F.G. Araujo, and R.M. Hughes. 2006. Effects of landscape and riparian condition on a fish index of biotic integrity in a large southeastern Brazil river. Hydrobiologia 556:69-83.

Peterson, S. A., J. Van Sickle, R. M. Hughes, J. Schacher, and S.Echols. 2005. A biopsy procedure for determining filet and predicting whole fish mercury concentration. Archives of Environmental Contamination and Toxicology 48:99-107.

Czech, B., P. L. Angermeier, H. E. Daly, E. P. Pister, and R. M. Hughes. 2004. Fish conservation, sustainable fisheries, and economic growth: no more fish stories. Fisheries 29 (8):36-37.

Hughes, R.M, S. Howlin, and P.R. Kaufmann. 2004. A biointegrity index for coldwater streams of western Oregon and Washington. Transactions of the American Fisheries Society 133:1497-1515.

Klemm, D.J., K.A. Blocksom, F.A. Fulk, A.T. Herlihy, R.M. Hughes, P.R. Kaufmann, D.V. Peck, J.L. Stoddard, W.T. Thoeny, M.B. Griffith, and W.S. Davis. 2003. Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing Mid-Atlantic Highlands streams. Environmental Management 31:656-669.

Reynolds, L., A.T. Herlihy, P.R. Kaufmann, S.V. Gregory, and R.M. Hughes. 2003. Electrofishing effort requirements for assessing species richness and biotic integrity in western Oregon streams. North American Journal of Fisheries Management 23:450-461.

Mebane, C.A., T.R. Maret, and R.M. Hughes. 2003. An index of biological integrity (IBI) for Pacific Northwest rivers. Transactions of the American Fisheries Society 132:239-261.

Cao, Y., D.P. Larsen, R.M. Hughes, P.L. Angermeier, and T.M. Patton. 2002. Sampling effort affects multivariate comparisons of stream communities. Journal of the North American Benthological Society 21:701-714.

Hughes, R.M., P.R. Kaufmann, A.T. Herlihy, S.S. Intelmann, S.C. Corbett, M.C. Arbogast, and R.C. Hjort. 2002. Electrofishing distance needed to estimate fish species richness in raftable Oregon rivers. North American Journal of Fisheries Management 22:1229-1240.

Peterson, S.A., R.M. Hughes, A.T. Herlihy, K.L. Motter, and J.M. Robbins. 2002. Regional evaluation of mercury contamination in Oregon freshwater fish. Environmental Toxicology and Chemistry 21:2157-2164.

Bryce, S.A., R.M. Hughes, and P.R. Kaufmann. 2002. Development of a bird integrity index: using bird assemblages as indicators of riparian condition. Environmental Management 30:294-310.

Cao, Y., D.P. Larsen, and R.M. Hughes. 2001. Evaluating sampling sufficiency in fish assemblage surveys: a similarity-based approach. Canadian Journal of Fisheries and Aquatic Sciences 58:1782-1793.

McCormick, F.H., R.M. Hughes, P.R. Kaufmann, A.T. Herlihy, and D.V. Peck. 2001. Development of an index of biotic integrity for the Mid-Atlantic Highlands Region. Transactions of the American Fisheries Society 130:857-877.

Thomas, D. L., P. Pajak, B. McGuire, C. Williams, S. Filipek, and R. M. Hughes. 2001. Farm Bill 2002: a discussion of the conservation aspects of the Farm Bill from a fisheries perspective. Fisheries 26:36-38.

Whittier, T.R, R.M. Hughes, and D.V. Peck. 2001. Comment: test of an index of biotic integrity. Transactions of the American Fisheries Society 130:169-172.

Dixit, S.S., Dixit, A.S., Smol, J.P., Hughes, R.M. and Paulsen S.G. 2000. Water quality changes from human activities in three northeastern USA lakes. Lake and Reservoir Management 16:305-321.

Hawkins, C.P., R.H. Norris, J. Gerritsen, R.M. Hughes, S.K. Jackson, R.K. Johnson, and R.J. Stevenson. 2000. Evaluation of the use of landscape classifications for the prediction of freshwater biota: synthesis and recommendations. Journal of the North American Benthological Society 19:541-556.

Hughes, R.M., S.G. Paulsen, and J.L. Stoddard. 2000. EMAP-Surface Waters: a national, multiassemblage, probability survey of ecological integrity. Hydrobiologia 422/423:429-443.

O'Connor, R.J., T.E. Walls, and R.M. Hughes. 2000. Using multiple taxonomic groups to index the ecological condition of lakes. Environmental Monitoring and Assessment 61: 207-228.

Van Sickle, J. and R.M. Hughes. 2000. Classification strengths of ecoregions, basins and geographic clusters for aquatic vertebrates in Oregon. Journal of the North American Benthological Society 19:370-384.

Allen, A.P., T.R. Whittier, P.R. Kaufmann, D.P. Larsen, R.J. O'Connor, R.M. Hughes, R.S. Stemberger, S.S. Dixit, R.O. Brinkhurst, A.T. Herlihy, and S.G. Paulsen. 1999. Concordance of taxonomic richness patterns across multiple assemblages in lakes of the northeastern USA. Canadian Journal of Fisheries and Aquatic Sciences 56: 739-747.

Allen, A.P., T.R. Whittier, P.R. Kaufmann, D.P. Larsen, R.J. O'Connor, R.M. Hughes, R.S. Stemberger, S.S. Dixit, R.O. Brinkhurst, A.T. Herlihy, and S.G. Paulsen. 1999. Concordance of taxonomic composition patterns across multiple lake assemblages: effects of scale, body size, and land use. Canadian Journal of Fisheries and Aquatic Sciences 56: 2029-2040.

Bryce, S.A., D.P. Larsen, R.M. Hughes, and P.R. Kaufmann. 1999. Assessing relative risks to aquatic ecosystems: a mid-Appalachian case study. Journal of the American Water Resources Association 35: 23-36.

Dixit, S.S., J.P. Smol, D.F. Charles, R.M. Hughes, S.G. Paulsen, and G.B. Collins. 1999. Assessing water quality changes in the lakes of the northeastern United States using sediment diatoms. Canadian Journal of Fisheries and Aquatic Sciences 56: 131-152.

Rathert, D., D. White, J.C. Sifneos, and R.M. Hughes. 1999. Environmental correlates of species richness for native freshwater fish in Oregon, USA. Journal of Biogeography 26: 257-273.

Zaroban, D.W., M.P. Mulvey, T.R. Maret, R.M. Hughes, and G.D. Merritt. 1999. Classification of species attributes for Pacific Northwest fishes. Northwest Science 73: 81-93.

Ganasan, V., and R.M. **Hughes**. 1998. Application of an index of biological integrity (IBI) to fish assemblages of the rivers Khan and Kshipra (Madhya Pradesh), India. Freshwater Biology 40: 367-383.

Hughes, R.M., P.R. Kaufmann, A.T. Herlihy, T.M. Kincaid, L. Reynolds, and D.P. Larsen. 1998. A process for developing and evaluating indices of fish assemblage integrity. Canadian Journal of Fisheries and Aquatic Sciences 55: 1618-1631.

Landers, D.H., R.M. Hughes, S.G. Paulsen, D.P. Larsen, and J.M. Omernik. 1998. How can regionalization and survey sampling make limnological research more relevant?. Verhandlungen Internationale Vereinigung Limnologie 26: 2428-2436.

Paulsen, S.G., R.M. **Hughes**, and D.P. Larsen. 1998. Critical elements in describing and understanding our nation's aquatic resources. Journal of the American Water Resources Association 34: 995-1005.

Whittier, T.R., and R.M. Hughes. 1998. Evaluation of fish species tolerances to environmental stressors in lakes of the northeastern United States. North American Journal of Fisheries Management 18: 236-252.

Winter, B.D., and R.M. Hughes. 1997. AFS position statement on biodiversity. Fisheries 22(1): 22-29.

Peterson, S.A., R.M. Hughes, D.P. Larsen, S.G. Paulsen, and J.M. Omernik. 1996. Regional lake quality patterns: their relationship to lake conservation and management decisions. Lakes & Reservoirs: Research and Management 1:163-167.

Oberdorff, T., and R.M. Hughes. 1992. Modification of an index of biotic integrity based on fish assemblages to characterize rivers of the Seine Basin, France. Hydrobiologia 228:117-130.

Hughes, R.M., and R.F. Noss. 1992. Biological diversity and biological integrity: current concerns for lakes and streams. Fisheries 17(3):11-19.

Hughes, R.M., T.R. Whittier, C.M. Rohm, and D.P. Larsen. 1990. A regional framework for establishing recovery criteria. Environmental Management 14:673-683.

Bond, C. E., E. Rexstad, and R.M. Hughes. 1988. Habitat use of twenty-five common species of Oregon freshwater fishes. Northwest Science 62:223-232.

Hughes, R.M., and D.P. Larsen. 1988. Ecoregions: An approach to surface water protection. Journal of the Water Pollution Control Federation 60:486-493.

Larsen, D.P., D.R. Dudley, and R.M. Hughes. 1988. A regional approach to assess attainable water quality: An Ohio Case Study. Journal of Soil and Water Conservation 43:171-176.

Miller, D.L., P.M. Leonard, R.M. Hughes, J.R. Karr, P.B. Moyle, L.H. Schrader, B.A. Thompson, R.A. Daniels, K.D. Fausch, G.A. Fitzhugh, J.R. Gammon, D.B. Halliwell, P.L. Angermeier, and D.J. Orth. 1988. Regional applications of an index of biotic integrity for use in water resource management. Fisheries 13(5):12-20.

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Hughes, R.M. 2002. The human disturbance gradient. USEPA Biocriteria Workshop, Annapolis, MD, March (**travel sponsored**).

Hughes, R.M. & R. Wildman. 2001. Changes in fish assemblage structure in the mainstem Willamette River, Oregon. American Fisheries Society. Phoenix, AZ, August.

Hughes, R.M. 2001. Tropical and subtropical adaptations of an index of fish assemblage integrity. Unisinos, Sao Leopoldo, Brazil. January (**travel sponsored**).

Kaufmann, P.R. & R.M. Hughes. 2001. Minicourse. Assessing the associations among fish, habitat, and land-use on a regional scale. Unisinos, Sao Leopoldo, Brazil. January (**travel sponsored**).

Hughes, R.M. 2001. Experiences from the USA on reference conditions and classification of ecological status for lakes and watercourses. Water Framework Directive Workshop. Uppsala, Sweden. May (**travel sponsored**).

Hughes, R.M. 2000. Bioassessment and biocriteria. University of Washington School of Fisheries Seminar. Seattle, WA. Nov (**travel sponsored**).

Hughes, R.M, S. Howlin & P.R. Kaufmann. 2000. Development and application of an index of biological integrity for coldwater streams. Stream Team Seminar. Corvallis, OR, April.

Hughes, R.M. 1999. Reference conditions. Upper Mississippi River Biocriteria Workshop, Onalaska, WI. October (**travel sponsored**).

Hughes, R.M. 1999. Reference conditions. Reference Site & Condition Workshop, Lawrence, KS. April (**travel sponsored**).

Hughes, R.M. 1998. EMAP: a national, multiassemblage, probability survey of ecological integrity. International Conference on Ecological Assessment of Rivers, Vienna, Austria. November .

Hughes, R.M. 1997. Environmental correlates of species richness in Oregon freshwater fishes. Oregon State University Departmental Seminar. Corvallis, OR, November.

Hughes, R.M. 1994. The biological integrity of the Willamette River drainage: Past, present, and future. Conference on the Willamette River Basin: Today's Water Policy Issues, Tomorrow's Reality, Corvallis, OR, October.

Hughes, R.M. 1994. Applications of an index of fish assemblage health to rivers in Europe, India, and North America and a proposal for Poland. Gdansk and Wroclaw, Poland, June (**travel sponsored**).

Hughes, R.M. 1994. Why do we need institutional change? Public Symposium on Conservation of Pacific Salmon, Corvallis, OR, April.

Hughes, R.M. 1994. The future: why we need institutional change. Pacific Salmon and Their Ecosystems, Seattle, WA, January (**travel sponsored**).

Hughes, R.M. 1993. Development of biological criteria to assess biological integrity. Annual Meeting, Oregon Chapter, Institute of Hydrologists, Corvallis, OR, October.

Hughes, R.M. 1993. Regional patterns in aquatic ecosystems: examples from New England Lakes and Arkansas, Michigan and Oregon streams. Annual Meeting, American Fisheries Society, Portland, OR, September.

Hughes, R.M. 1993. Developing biological criteria and assessing acceptable condition for a population of lakes. Presented at the Annual Meeting of the North American Benthological Society, Calgary, Alberta, Canada, May.

Hughes, R.M., S.G. Paulsen, and D.P. Larsen. 1993. Aquatic ecosystem health: a national need and a practical approach. Annual Meeting of the Aquatic Ecosystem Health and Management Society, Blacksburg, VA, May.

Hughes, R.M. 1993. Assessment of watershed health. Oregon Water Resources Research Institute. Oregon State University, Corvallis, OR, April.

Hughes, R.M. 1993. Indicators of aquatic ecosystem health. Department of Fisheries & Wildlife, Oregon State University, Corvallis, OR, April.

Hughes, R.M. 1992. A proposed system of aquatic preserves for the State of Oregon. Annual Meeting of the North American Benthological Society, Louisville, KY, May.

Hughes, R.M. 1992. Development of biological indicators for assessing lake condition. Annual Meeting of the North American Benthological Society, Louisville, KY, May.

Hughes, R.M. 1992. EMAP indicators development and status. EMAP-Surface Waters Peer Review, Dallas, TX, April.

Hughes, R.M. 1992. Indicator status. Annual Meeting of the New England Association of Environmental Biologists, Laconia, NH, March.

Hughes, R.M. 1991. EMAP and ecoregions as assessment tools. EPA Region VIII Water Quality Assessment and Monitoring Workshop, Denver, CO, September.

Hughes, R.M. 1991. Indicator issues for EMAP's pilot in the Northeast. Annual Meeting of the New England Association of Environmental Biologists, Fairlee, VT, March.

Hughes, R.M. 1990. The use of ecoregions in biomonitoring. Biological Monitoring of Freshwater Ecosystems. International Society of Limnology, West Lafayette, IN, November.

Hughes, R.M. 1990. Biocriteria and rapid bioassessment. Rapid Bioassessment in NonPoint Source Monitoring Workshop, U.S. Environmental Protection Agency, Region X, Corvallis, OR, October.

Hughes, R.M. 1990. Ecoregional reference sites. Florida Department of Environmental Regulation, Tallahassee, FL, October.

Hughes, R.M. 1990. EMAP surface waters indicators. International Symposium on Ecological Indicators, Ft. Lauderdale, FL, October.

Hughes, R.M., and R. Noss. 1990. Biological diversity in inland surface waters. Annual Meeting of the American Fisheries Society, Pittsburgh, PA, August.

Hughes, R.M., and T. Oberdorff. 1990. Modification of an index of biotic integrity based on fish assemblages to characterize rivers of the Seine Basin, France. National Museum of National History, Paris, France, June (**travel sponsored**).

Hughes, R.M. 1990. Selection of regional reference sites for developing biocriteria. EPA Region IV workshop, Montgomery, AL, May.

Hughes, R.M. 1990 regional references sites and biocriteria. U.S. Environmental Protection Agency Science Advisory Board Research Review, Corvallis, OR, April.

Hughes, R.M. 1990. Landscape level assessment of biotic integrity. Annual meeting of the Oregon Chapter American Fisheries Society, Welches, OR, February.

Hughes, R.M., and J.F. Ely. 1989. Biological criteria. National Symposium on Water Quality Assessment, Fort Collins, CO, October.

Hughes, R.M. 1989. Regional use of a fish assemblage index for water resource assessments. Society of Environmental Toxicology and Chemistry, Toronto, ON, October.

Hughes, R.M., and J.M. Omernik. 1989. Use of ecoregions for managing Oregon's water resources. Governor's Strategic Water Management Group, Salem, OR, August.

Hughes, R.M., and J.M. Omernik. 1989. Use of ecoregions for stratifying Oregon's fishery potential. Pacific Fishery Environmental Council, Corvallis, OR, June.

Hughes, R.M. 1989. What can biological monitoring tell us about the environmental health of aquatic ecosystems? International Symposium on the Design of Water Quality Information Systems, Fort Collins, CO, June.

Hughes, R.M., and J.M. Omernik. 1989. Use of ecoregions to estimate fishery habitat potentials in the Columbia Basin. Northwest Power Planning Council, Portland, OR, April.

Hughes, R.M. 1989. Ecoregional biological criteria. National Conference on Water Quality Standards for the 21st Century, Dallas, TX, March (**travel sponsored**).

Hughes, R.M. 1989. Applicability of ecoregional reference sites for developing biological criteria. EPA Region 4 Workshop on Biomonitoring and Biocriteria, Athens, GA, March (**travel sponsored**).

Hughes, R.M., and J.M. Omernik. 1989. Applications of ecoregions and biocriteria to Arizona water resource standards. Arizona Department of Environmental Quality, Phoenix, AZ, January (**travel sponsored**).

Hughes, R.M., and J.M. Omernik. 1988. Ecoregions and biological criteria. Office of Water Briefing, Washington, D.C., December.

Hughes, R.M., and J.M. Omernik. 1988. Ecoregions and biological criteria. Presented at the Chesapeake Bay Program, Annapolis, MD, December.

Hughes, R.M., and J.M. Omernik. 1988. Ecoregions and the IBI: Applications to the Seine Basin, France. Briefing for Seine Research Director, France Museum of Natural History, Corvallis, OR, December.

Landers, D.H. and R.M. Hughes. 1988. Ecoregions and water quality standards. Presented to the Administrator, U.S. Environmental Protection Agency, Washington, D.C., November.

Hughes, R.M. 1988. The IBI: A quantitative, easily communicated assessment of the health and complexity of entire fish communities. Southeast Stream Ecology Workshop, Eufaula, AL, October (**travel sponsored**).

Hughes, R.M., and D.P. Larsen. 1988. Use of ecoregions to develop biological criteria for assessing recovery of aquatic ecosystems. Symposium on Lotic Ecosystem Recovery, Duluth, MN, October (**travel sponsored**).

Hughes, R.M. 1988. Application of biological criteria to water body management. Briefing for Director of Air & Toxics Division, Region X, U.S. Environmental Protection Agency, Corvallis, OR, September.

Hughes, R.M. 1988. Use of the IBI to assess hazardous waste sites. Ecological Assessment Methods for Hazardous Waste Sites, Seattle, WA, July.

Hughes, R.M. 1988. Use of the IBI to monitor water resource quality. Briefing for Chief, Office of Water Quality, U.S. Geological Survey, Corvallis, OR, July.

Hughes, R.M., and T.R. Whittier. 1988. Regional patterns in water chemistry data of Colorado. Program Review for Director of Water Division, Region VIII, U.S. Environmental Protection Agency, Denver, CO, July.

Hughes, R.M. 1988. The use of ecoregions in developing management strategies for surface waters. Oregon Department of Environmental Quality, Portland, OR, June.

Hughes, R.M. 1988. The rationale for biological criteria and biological monitoring. National Monitoring Workshop, U.S. Environmental Protection Agency, Annapolis, MD, June.

Hughes, R.M. 1988. The regional integration project's FY-90 research proposal. Water Quality Based Approach Work Group, U.S EPA, Cincinnati, OH, January.

Hughes, R.M. 1987. A rationale and methodology for quantitative, regional biological standards. Science Advisory Board, U.S. Environmental Protection Agency, Research Triangle Park, NC, November.

Hughes, R.M. 1987. Use of ecoregions for determining objective, regional biological and chemical standards. Briefing for Deputy Administrator of U.S. Environmental Protection Agency, Corvallis, OR, March.

Hughes, R.M. 1987. Use of ecoregions and the index of biotic integrity for water quality monitoring. Briefing for U.S. General Accounting Office, Corvallis, OR, February.

Hughes, R.M. 1987. Ecoregion development and evaluations. Briefing for Special Assistant to Director, U.S. Environmental Protection Agency Office of Environmental Processes and Effects Research, Corvallis, OR, January.

Hughes, R.M. 1986. Use of a regional approach for assessing attainable trophic state of lakes. Briefing for authors of Lake Restoration Guidance Manual, Portland, OR, November.

Hughes, R.M. 1986. Use of the index of biotic integrity for assessing water quality. Biennial Meeting of U.S. Environmental Protection Agency Regional Biologists, Cincinnati, OH, September.

Hughes, R.M. 1986. Use of ecoregions and the index of biotic integrity. Briefing for Chief Scientist, Indonesia Institute for Fisheries, Corvallis, OR, August.

Hughes, R.M. 1986. Applications of the index of biotic integrity. U.S. Environmental Protection Agency Headquarters Seminar, Washington, D.C., June.

Hughes, R.M. 1985. Regional and longitudinal patterns in fish assemblages. Graduate Civil Engineering Seminar, Oregon State University, Corvallis, OR, October.

Hughes, R.M. 1985. Use of regional reference sites to assess water quality. U.S. Environmental Protection Agency Region VIII Seminar, Denver, CO, September.

Hughes, R.M. 1985. Evaluations of aquatic ecoregions. Ecoregion and IBI Workshop, Leesburg, VA, May.

Hughes, R.M. 1985. Relationship of Oregon ecoregions and ichthyogeographic patterns. Annual Meeting of Oregon Chapter American Fisheries Society, Salishan, OR, January.

Hughes, R.M. 1984. Aquatic ecoregions and water quality: An Ohio case study. U.S. Environmental Protection Agency Region VI Seminar, Dallas, TX, November.

Hughes, R.M. 1983. Fish and water quality changes in the Willamette River. Briefing for Oregon Department of Environmental Quality, Salem, OR, November.

Hughes, R.M. 1983. The Ohio ecoregion study research plan. Presented at the U.S. Environmental Protection Agency, Region V, Chicago, IL, February.

Hughes, R.M., and J.D. Giattina. 1982. Water resource quality of the Willamette Valley. Briefing for Oregon Department of Environmental Quality, Portland, OR, November.

Hughes, R.M. 1982. A conceptual framework for assessing attainable conditions in aquatic ecosystems. Briefing for the Director, U.S. Environmental Protection Agency Office of Environmental Processes and Effects Research, Corvallis, OR, November.

Contributed Presentations (8 international, 31 national, 23 regional/state):

Hughes, R.M. 2010. Strahler order versus stream size. Western Division of the American Fisheries Society, Salt Lake City, Utah, April.

Williams, K.J., & 14 coauthors. 2009. A universal framework for adapting and refining ecological classifications and mapping to land management outcomes. INTECOL, Brisbane, QLD, Australia, August.

Hughes, R.M. & A.T. Herlihy. 2009. Longitudinal variability in rivers: implications for survey design. Improving the Ecological Status of Fish Communities in Inland Waters. University of Hull, Hull, England, April.

Hughes, R.M., T.R. Whittier, A.T. Herlihy, H.A. LaVigne & J. Adams. 2009. The aliens are coming! (or at least expanding their ranges in a river near you). Annual Meeting of the Oregon Chapter of the American Fisheries Society, Bend, OR, February.

Hughes, R.M. & A.T. Herlihy. 2008. Longitudinal variability in rivers: implications for survey design. Annual Meeting of the American Fisheries Society, Ottawa, ONT, August.

Hughes, R.M. & A.T. Herlihy. 2008. Longitudinal variability in Pacific Northwest rivers: implications for regional river survey design. Annual Meeting of the North American Benthological Society, Salt Lake City, UT, May.

Hughes, R.M. & A.T. Herlihy. 2008. Longitudinal variability in Pacific Northwest rivers: implications for regional river survey design. Annual Meeting of the Western Division of the American Fisheries Society, Portland, OR, May.

Hughes, R.M. & A.T. Herlihy. 2008. Longitudinal variability in Pacific Northwest rivers: implications for regional river survey design. Annual Meeting of the North Pacific International Chapter of the American Fisheries Society, Bellingham, WA, March.

Hughes, R.M. & A.T. Herlihy. 2008. Longitudinal variability in Pacific Northwest rivers: implications for regional river survey design. Annual Meeting of the Idaho Chapter of the American Fisheries Society, Post Falls, ID, February.

Hughes, R.M., A.T. Herlihy, and J.C. Sifneos. 2007. Predicting fish assemblages from environmental variables at three multi-state scales. Annual Meeting American Fisheries Society. San Francisco, CA, September.

Herlihy, A.T. and R.M. Hughes*. 2007. Stressor-response relationships at national and regional scales for fish and benthos assemblages. Annual Meeting American Fisheries Society. San Francisco, CA, September.

Hughes, R.M., A.T. Herlihy, and J.C. Sifneos. 2007. Predicting fish assemblages from environmental variables at three multi-state scales. Annual Meeting North American Benthological Society. Columbia, SC, June.

Hughes, R.M., A.T. Herlihy, and J.C. Sifneos. 2007. Predicting fish assemblages from environmental variables at three multi-state scales. Annual Meeting Oregon Chapter American Fisheries Society. Eugene, OR, February.

Hughes, R.M., A.T. Herlihy, and J.C. Sifneos. 2007. Predicting fish assemblages from environmental variables at three multi-state scales. Annual Meeting Montana Chapter American Fisheries Society. Missoula, MT, February.

Hughes, R.M., and J.L. Stoddard. 2006. Ecological assessment of western USA streams and rivers. American Fisheries Society. Lake Placid, NY, September.

Hughes, R.M., and J.L. Stoddard. 2006. Ecological assessment of western USA streams and rivers. North American Benthological Society. Anchorage, AK. June.

Hughes, R.M. and G.L. Lomnicky. 2006. Distribution of non-native aquatic vertebrates in western USA streams and rivers. Western Division, American Fisheries Society. Bozeman, MT. May.

Hughes, R.M. 2005. Rigorous biological assessment of large rivers. Northwest Bioassessment Workgroup. Port Townsend, WA. November.

Hughes, R.M. 2005. Habitat assessment considering both biota and mechanisms of geomorphic and anthropogenic influence on streams. American Fisheries Society. Anchorage, AK. September.

Hughes, R.M. 2005. Economic causes of fish endangerment in the USA. American Fisheries Society. Anchorage, AK. September.

Hughes, R.M. 2005. Selecting reference sites—an approach for biological criteria and watershed assessment. North American Benthological Society. New Orleans, LA. May.

Hughes, R.M., G. Lomnicky, & T.R. Whittier. 2004. Non-native aquatic vertebrates: results from EMAP's western pilot. Ecological Society of America. Portland, OR, August.

Hughes, R.M. 2004. How reference sites and probabilistic surveys were used to characterize stream condition across large geographic areas using macroinvertebrate assemblages. North American Benthological Society. Vancouver, BC, June.

Hughes, R.M. 2004. Assessing ecological conditions in USA surface waters: EMAP's approach for fish assemblages. National Military Fish & Wildlife Association. Spokane, WA, March.

Hughes, R.M. 2004. A biointegrity index for coldwater streams of western Oregon and Washington. Western Division, American Fisheries Society, Salt Lake City, UT, March.

Hughes, R.M. 2004. A biointegrity index for coldwater streams of western Oregon and Washington. Oregon Chapter, American Fisheries Society, Sunriver, OR, February

Hughes, R.M. 2003. A biointegrity index for coldwater streams of western Oregon and Washington. Northwest Bioassessment Workgroup. Priest Lake, ID, October

Hughes, R.M. 2003. Species-sampling effort relationships for nonwadeable rivers of the western USA. American Society of Ichthyologists and Herpetologists. Manaus, Brazil, June.

Hughes, R.M., T.R. Whittier & G.A. Lomnicky. 2003. Fish assemblages of reference and disturbed streams of forested regions of the western USA. North American Benthological Society. Athens, GA, May.

Hughes, R.M. 2002. Electrofishing distance and number of species collected from three raftable western rivers. American Fisheries Society, Baltimore, MD, August.

Hughes, R.M., Y. Cao & D.P. Larsen. 2002. Sample size affects multivariate comparisons of stream assemblages. North American Benthological Society, Pittsburgh, PA, June.

Hughes, R.M. 2002. Electrofishing distance and number of species collected from three raftable western rivers. Oregon Chapter American Fisheries Society, Sunriver, OR, February.

Hughes, R.M. 2001. Concerns surrounding landscape-scale disturbance by humans. Annual Meeting, North North American Benthological Society, LaCrosse, WI, June.

Hughes, R M, S.A. Bryce, & P.R. Kaufmann. 2000. An avian index of biological integrity. Annual Meeting North American Benthological Society, Keystone, CO. May.

Hughes, R.M. & 6 coauthors. 2000. Effect of electrofishing distance on number of fish species collected in navigable Oregon rivers. Annual Meeting Oregon Chapter American Fisheries Society. Eugene, OR, February.

Hughes, R.M, S. Howlin & P.R. Kaufmann. 2000. Development and application of an index of biological integrity for coldwater streams. Annual Meeting Oregon Chapter American Fisheries Society. Eugene, OR, February.

Hughes, R.M. & 6 coauthors. 1999. Effect of electrofishing distance on number of fish species collected in navigable Oregon rivers. Annual Meeting Pacific Northwest Bioassessment Workgroup. Port Angeles, WA. November.

Hughes, R.M, S. Howlin & P.R. Kaufmann. 1999. Development and application of an index of biological integrity for coldwater streams. Annual Meeting Pacific Northwest Bioassessment Workgroup. Port Angeles, WA. November.

Hughes, R.M, S. Howlin & P.R. Kaufmann. 1999. Development and application of an index of biological integrity for coldwater streams. Annual Meeting American Fisheries Society. Charlotte, NC. August.

Hughes, R.M., S.A. Bryce, P.R. Kaufmann, and D.P. Larsen. 1998. Assessing the relative risks to aquatic ecosystems. Annual Meeting American Fisheries Society. Hartford, CT. August.

Hughes, R.M., R.B. Yeardley, J.M. Lazorchak, and S.G. Paulsen. 1998. Fish tissue contamination by Mercury in northeast USA lakes. Annual Meeting American Fisheries Society. Hartford, CT. August.

Hughes, R.M., R.S. Stemberger, A.T. Herlihy, and S.G. Paulsen. 1998. Effect of climate change on zooplankton richness in lakes of the northeastern USA. Annual Meeting American Fisheries Society. Hartford, CT. August.

Hughes, R.M. 1998. Use of species effort curves and historical information for assessing fish assemblages of large Oregon rivers. Annual Meeting North American Benthological Society. Charlottetown, PEI. June.

Hughes, R.M. 1997. Guild classification of Pacific Northwest fishes. Annual Meeting American Fisheries Society. Monterey, CA. August.

Hughes, R.M. 1997. An index of biological integrity for cold water streams of the Pacific Northwest. Annual Meeting American Fisheries Society. Monterey, CA. August.

Hughes, R.M. 1997. Environmental correlates of species richness in Oregon freshwater fishes. North American Benthological Society. San Marcos, TX. May

Hughes, R.M. 1997. Development and application of an index of fish assemblage integrity for wadeable streams in the Willamette Valley, Oregon, USA. North American Benthological Society. San Marcos, TX. May

Hughes, R.M. 1996. Developing and testing an IBI for wadeable Willamette Valley, Oregon, streams. American Fisheries Society. Dearborn, MI. August.

Hughes, R.M. 1996. Environmental correlates of species richness in Oregon freshwater fishes. Western Division American Fisheries Society. Eugene, OR, July

Hughes, R.M. 1995. The value of probability surveys for assessing aquatic ecosystem health. North American Benthological Society. Keystone, CO, June.

Hughes, R.M. 1995. Regional assessment of fish assemblage biodiversity. Oregon Chapter of the American Fisheries Society. Ashland, OR, February.

Hughes, R.M. 1994. Comparisons of multi-metric and multivariate results for fish assemblages of New England Lakes and Oregon streams. Annual Meeting of the North American Benthological Society, Orlando, FL, May.

Hughes, R.M., D.P. Larsen, J.M. Omernik, C.M. Rohm, and T.R. Whittier. 1987. Applications of ecoregions to water resource assessment and management Annual Meeting of the Canadian Association for Landscape Ecology and Management, Guelph, Ontario, May.

Hughes, R.M., and J.R. Gammon. 1986. Evaluation of the indices of biotic integrity and well being for use on a large Oregon river. Annual Meeting of the American Fisheries Society, Providence, RI, September.

Hughes, R.M., D.P. Larsen, J.M. Omernik, and S. Peterson. 1986. Aquatic ecoregions and reference wetlands: a conceptual approach for study and management of the nation's wetlands. Symposium on Freshwater Wetlands and Wildlife, Charleston, SC, March.

Hughes, R.M. 1985. Use of ecoregions to assess and develop standards for nonpoint source pollution. Annual Meeting North American Lake Management Society, Kansas City, KS, May.

Hughes, R.M. 1980. The use of watershed/stream classification to detect regional patterns in fish assemblages. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Corvallis, OR, June.

Hughes, R.M. 1979. Fish communities as measures of water resource quality. Annual Meeting of the Oregon Chapter of the American Fisheries Society, Eugene, OR, February.

Hughes, R.M. 1977. Effects of thermal pollution on model stream communities. Savannah River Ecology Laboratory Symposium on Thermal Pollution, Aiken, SC, October.

Hughes, R.M. 1977. Effects of thermal pollution on fish behavior. Annual Symposium of Fish Ethologists, Normal, IL, September.

Hughes, R.M. 1977. Salmonid productivity in experimental streams. Annual Meeting of the Northwest Scientific Association, Monmouth, OR, April.

Hughes, R.M. 1977. Effects of elevated temperature on juvenile salmonids. Annual Meeting of the Oregon Academy of Science, Eugene, OR, February.

<u>Symposia Organized/Chaired (5 international, 14 national, 7 regional/state):</u>

Hughes, R.M. 2010 (session chair). Evaluacion Biologica de Comunidades de Peces de Agua Dulce. Annual Meeting of the Mexico Chapter of the American Fisheries Society. Ensenada, BS, Mexico.

Hughes, R.M. & J. Mead. 2009 (session co-chair). Population and economic growth versus biodiversity conservation. Annual Meeting of the North American Benthological Society. Grand Rapids, MI. May.

Angermeier, P.L. & R.M. Hughes, R.M. 2007 (session co-chair), Building better science and management: the advantages of integration. American Fisheries Society. San Francisco, CA. September.

Hughes, R.M. 2007 (session chair), Understanding ecological condition of surface waters: approaches and assessments. American Fisheries Society. San Francisco, CA. September.

Hughes, R.M. 2007 (session chair). Fish Ecology 1. Annual Meeting of the North American Benthological Society. Columbia, SC. June.

Hughes, R.M., M. Meeuwig & C. Guy 2006. (program co-chairs) Western Division, American Fisheries Society. Bozeman, MT. May.

Hughes, R. M. 2006. (session chair) Large river assessments. Monitoring Workshop. Aix en Provence, France. April.

Hughes, R.M. & L. Reynolds. 2005. (session co-chair) Habitat—what is it, how is it measured, and how do fish assemblages respond to it? American Fisheries Society. Anchorage, AK. September.

Hughes, R.M.. & B. Czech. 2005. (session co-chair) Connections between economic growth and fish conservation. American Fisheries Society. Anchorage, AK. September.

Hughes, R.M. & T. R. Whittier. 2005. (session co-chair) Determining and using reference condition in biological assessments. North American Benthological Society. New Orleans, LA. May.

Hughes, R.M. 2004. (session chair) Regional stream bioassessments. Western Division, American Fisheries Society, Salt Lake City, UT, March.

Hughes, R.M. & L. Wang. 2004. (session co-chair) Influences of landscape on stream habitat and biological communities. American Fisheries Society. Madison, WI, August.

Hughes, R.M. 2004. (session chair) Landscape ecology I: forests and rivers. Ecological Society of America. Portland, OR, August.

Hughes, R.M. 2004. (session chair) Use of statistical (probabilistic) surveys for assessing surface waters. North American Benthological Society. Vancouver, BC, June.

Hughes, R.M. 2004. (session chair) Fish assemblage assessment. Oregon Chapter, American Fisheries Society, Sunriver, OR, February

La Violette, N. & R.M. Hughes. 2003. (session co-chair) Worldwide decline in fish assemblages: the index of biotic integrity as an assessment tool. American Fisheries Society. Quebec, QB, August.

Hughes, R.M. 2003. (session chair) Regional scale monitoring: results from Oregon and the Western USA. Oregon Chapter, American Fisheries Society. Eugene, OR, February.

Hughes, R.M. & H. Li. 2001. (session co-chair) Invasive alien species. Joint Annual Meeting of the Oregon Chapters of the American Fisheries Society and the Wildlife Society. Portland, OR. February.

Hughes, R.M. 2000. (session chair) Determining good sites from bad. Annual Meeting North American Benthological Society, Keystone, CO. May.

Hughes, R.M. 1998. (session chair) Integrated assessment methods. International Conference on Ecological Assessment of Rivers, Vienna, Austria. November.

Hughes, R.M. 1998. (session chair) The relative importance to fish assemblages of catchment vs. riparian conditions. Annual Meeting American Fisheries Society. Hartford, CT. August.

Hughes, R.M. 1997. (session chair) Effects of land use and landform on aquatic ecosystems. Annual Meeting American Fisheries Society. Monterey, CA. August.

Hughes, R.M. & T.P. Simon. 1996 (session co-chair) National applications of IBI to stream condition assessment. Annual Meeting American Fisheries Society. Dearborn, MI. September.

Hughes, R.M. 1996. (program chair) Annual Meeting Western Division American Fisheries Society. Eugene, OR, July.

Hughes, R.M. 1988. (session chair) The use of ecoregions for managing state water resources. Annual Meeting U.S. Association for Landscape Ecology, Albuquerque, NM, March.

Hughes, R.M. & W. Davis. 1987. (workshop co-chair) A rationale for ecoregional biological criteria. National Workshop on Instream Biological Monitoring and Criteria, Lincolnwood, IL, December.

Hughes, R.M. & S.A. Peterson. 1986. (session co-chair) Regional analyses of lake water quality. Annual Meeting North American Lakes Management Society, Portland, OR, November.

Hughes, R.M. 1980. (session chair) General ichthyology. Annual Meeting American Society of Ichthyologists and Herpetologists, Corvallis, OR, June.

William J. ("Wim") Kimmerer, Ph.D.

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Current Position

Research Professor, Romberg Tiburon Center for Environmental Studies, San Francisco State University.

Education

University of Hawaii, Ph.D. 1980, Biological Oceanography
U.S. Navy Nuclear Power School, 1968
Purdue University, B.S. 1967, Chemistry

Research and Professional Experience

1994-present	Senior Research Scientist & Research Professor, Romberg Tiburon Center, San Francisco State University
1986-1995	Senior Scientist, BioSystems Analysis Inc.
1982-1985	Research Fellow, University of Melbourne (Australia), Zoology Dept.
1980-1982	Research Associate/Assistant Director, Hawaii Institute of Marine Biology
1976-1980	Research Assistant, University of Hawaii
1973-1980	Graduate student, University of Hawaii
1972-1973	Flight instructor
1967-1972	U.S. Navy submarine force, final rank Lieutenant

Research and Professional Interests

The ecology of estuaries and coastal waters, with emphasis on the San Francisco estuary. I study the influence of the physical environment including freshwater flow, tidal currents, and turbulence on behavior, movement, and population dynamics of plankton and fish; predatory control of species composition and abundance of plankton and fish populations; functioning of ecosystems, populations, and material cycling; and human impacts on aquatic ecosystems and the interaction of science and management. I apply a variety of methods to investigate these processes including laboratory studies, field studies, mechanistic modeling such as particle tracking, individual-based models, and hydrodynamic models, and statistical analyses using traditional as well as modern and Bayesian methods.

Research Projects (San Francisco Estuary)

- Primary production and foodweb dynamics supporting delta smelt
- Population dynamics of copepods and other plankton
- Impacts of changing freshwater flow on the estuarine ecosystem
- Effects of introduced species, particularly introduced clams and copepods
- Effects of water circulation on transport and responses of biota
- Effects of water diversions on populations of delta smelt and salmon and their food
- Potential causes of the recent decline in abundance of several fish species
- Individual-based modeling of delta smelt
- Participant, workshops at National Center for Ecological Analysis and Synthesis on the Pelagic Organism Decline in the San Francisco Estuary
- Environmental controls on Chinook salmon

Management-Related Projects

- Chair, Estuarine Ecology Team, Interagency Ecological Program for the San Francisco Estuary, 1995 – present.
- Co-Chair, Science Board, CALFED Bay-Delta Ecosystem Restoration Program, 2000-2005
- Advisor to the CALFED Lead Scientist on the Environmental Water Account
- Co-convenor, CALFED Ecosystem Restoration Program workshop on adaptive management, 2002
- Co-convenor, CALFED workshops on salmonids and delta smelt, 2001 and 2003, hatchery impacts on Battle Creek, California, 2003, and Environmental Water Account review, 2006.
- Member, Steering Committee and Technical Advisory Committee, Delta Risk Management Strategy (Department of Water Resources)
- Scientific advisory panel, Blue Ribbon Task Force for a Vision for the California Delta
- Review panel, U.S. Fish and Wildlife Service 2008 Biological Opinion on delta smelt.
- Advisory committees, Bay Delta Conservation Plan
- Member, Delta Native Fishes Recovery Team
- Science Advisor, San Francisco Bay Subtidal Habitat Goals Project
- Advisory panel, California Water Resources Control Board hearing on flow standards

Other Professional Activities

- Honorary Fellow, California Academy of Sciences
- Co-founder and former President, California Estuarine Research Society, an affiliate society of the Estuarine Research Federation
- Advisory committee, Georgia Coastal Estuaries LTER Program
- Invited participant in workshops at the University of Rhode Island (effects of freshwater flow on estuaries), Louisiana Universities Marine Consortium (coastal restoration), and the University of British Columbia (science needs for coastal management)
- Associate Editor, San Francisco Estuary and Watershed Science
- Reviewer for professional journals including Limnology and Oceanography, Marine Biology, Marine Ecology Progress Series, Estuaries and Coasts, Estuarine, Coastal, and Shelf Science, ICES Journal of Marine Science, Environmental Biology of Fishes

- Reviewer of grant proposals for the National Science Foundation, EPA, and Seagrant offices, and panelist for NSF
- Chair, Search Committee for Director of the Romberg Tiburon Center, 2008

Selected Publications (last 6 years)

Kimmerer, W.J. 2004. Open-Water Processes of the San Francisco Estuary: from physical forcing to biological responses. San Francisco Estuary and Watershed Science [online serial]. Vol. 2, Issue 1 (February 2004), Article 1. http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1

Kimmerer, W.J. 2005. Long-term changes in apparent uptake of silica in the San Francisco Estuary. Limnology and Oceanography 50: 793-798

Kimmerer, W.J., M.H. Nicolini, N. Ferm, and C. Peñalva. 2005. Chronic food limitation of egg production in populations of copepods of the genus *Acartia* in the San Francisco Estuary. Estuaries 28: 541–550.

Kimmerer, W.J. 2006. Response of anchovies dampens foodweb responses to an invasive bivalve (*Corbula amurensis*) in the San Francisco Estuary. Marine Ecology Progress Series 324:207-218.

Bouley, P.B. and W.J. Kimmerer. 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series 324:219-228.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32(6): 270-277.

Kimmerer, W.J. and M.L. Nobriga. 2008. Investigating dispersal in the Sacramento-San Joaquin Delta using a particle tracking model. San Francisco Estuary and Watershed Science. [online serial]. Vol. 6, Issue 1, Article 4.

Kimmerer, W. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. [online serial]. Vol. 6, Issue 2, Article 2.

Choi, K-H. and W. Kimmerer. 2008. Mate limitation in an estuarine population of copepods. Limnology and Oceanography 53:1656-1664

Brown, L.R., W.J. Kimmerer, and R.L. Brown. 2008. Managing water to protect fish: a review of California's Environmental Water Account. Environmental Management. 43:357-368.

Choi, K.-H. and W. Kimmerer. 2009. Mating success and its consequences for population growth of an estuarine copepod. Marine Ecology Progress Series 377: 183–191.

Kimmerer, W.J., E.S. Gross, and M.L. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts 32:375-389.

Grimaldo, L., W. Kimmerer, and A.R. Stewart. 2009. Dietary segregation of pelagic and littoral fish assemblages in a highly modified tidal freshwater estuary. Marine and Coastal Fisheries 1:200-217

Kimmerer, W. J. and A.L. Gould. 2010. A Bayesian approach to estimating copepod development times from stage frequency data. Limnology and Oceanography Methods 8:118-126

Mac Nally, R. and others 2010. An analysis of pelagic species decline in the upper San Francisco Estuary using Multivariate Autoregressive modelling (MAR). Ecol. Appl. 20: 1417-1430.

Thomson, J., W. Kimmerer, L. Brown, K. Newman, R. Mac Nally, W. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecol. Appl. 1431 -1448: 1431 -1448.

Gould, A.L. and W.J. Kimmerer. Growth, reproduction, and development of the cyclopoid copepod *Limnoithona tetraspina* in the San Francisco Estuary. Marine Ecology Progress Series 412:163-177.

Paganini, A., W.J. Kimmerer, and J.H. Stillman. 2010. Metabolic responses to environmental salinity in the invasive clam *Corbula amurensis*. In press, Aquatic Biology.

Kimmerer, W.J. 2010. Modeling delta smelt losses at the south Delta export facilities. In press, San Francisco Estuary and Watershed Science.

Selected Presentations

Kimmerer, W.J. 2008. Water quality and the foodweb of the upper San Francisco Estuary. Invited presentation to the Bay-Delta Public Advisory Committee, January 2008.

Kimmerer, W.J. 2008. Variation of Physical Habitat for Estuarine Fish with Freshwater Flow. Invited, Interagency Ecological Program Annual Meeting, Asilomar, CA, February 2008.

Kimmerer, W.J. 2008. Modeling Approaches for Delta Smelt and Other Fishes in the San Francisco Estuary. Invited presentation to the CALFED Independent Science Board, May 2008.

Kimmerer, W.J. 2008. Structure and Function of the Low-Salinity Zone Foodweb in The San Francisco Estuary. Invited, CALFED Science Conference, Sacramento, October 2008.

Kimmerer, W. 2009. Introduction to Zooplankton Dynamics in Estuaries. Invited introductory talk, Coastal and Estuarine Research Federation, Portland OR, November 2009.

Kimmerer, W. 2010. Effects of climate and other long-term changes on estuaries: a zooplankton perspective. Invited plenary talk, Conference on Climate Change Impacts on Estuarine and Coastal Ecosystems. Boulogne, France.

Kimmerer, W. 2010. The Pelagic Foodweb of the upper San Francisco Estuary: Changing Conditions and Changing Understanding. Delta Science Conference, Sacramento.

Selected Current Funding

U.S. Bureau of Reclamation (Sacramento). Pelagic Organism Decline/Habitat Study Group Investigations. Kimmerer (lead PI) with R. Dugdale, F. Wilkerson, J. Stillman, A. Parker, L. Sullivan, E. Gross, M. MacWilliams.

NSF Biological Oceanography: Feeding and food limitation in copepod nauplii, the neglected life Stage. With S. Cohen, RTC.

CALFED: Foodweb Support for the Threatened Delta Smelt and other Estuarine Species in Suisun Bay and the Western Delta. Kimmerer, lead PI, with R. Dugdale, E. Carpenter, A. Parker (SFSU), R. Cohen (Ga. Southern U.), J. Thompson (USGS), and G. McManus (U. Conn.).

KENNETH A. ROSE

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EDUCATION:

Ph.D., Fisheries, University of Washington, 1985.
M.S., Fisheries, University of Washington, 1981.
B.S., Biology and Mathematics, State University of New York at Albany, 1975.

PROFESSIONAL EXPERIENCE:

2001 - present Professor, Louisiana State University
(named EL Abraham Distinguished Professor in Louisiana Environmental Sciences – 2009)
1998 - 2001 Associate Professor, Louisiana State University
1987 - 1998 Scientist, Oak Ridge National Laboratory
1983 - 1987 Consultant, Martin Marietta Environmental Systems

PROFESSIONAL INTERESTS:

Develop and apply mathematical and simulation models to better understand and forecast the effects of natural and anthropogenic factors on aquatic population populations and communities; use of models in resource management and risk assessment.

TEN EXAMPLE PUBLICATIONS (from a total greater than 120)

Rose, K.A. 2000. Why are quantitative relationships between environmental quality and fish populations so elusive? Ecological Applications 10: 367-385.

Clark, J.S., S. Carpenter, M. Barber, S. Collins, A. Dobson, J. Foley, D. Lodge, M. Pascual, R. Pielke, W. Pizer, C. Pringle, W. Reid, K. Rose, O. Sala, W. Schlesinger, D. Wall, and D. Wear. 2001. Ecological forecasts: an emerging imperative. Science 293: 657-660.

Rose, KA., J.H. Cowan, K.O. Winemiller, R.A. Myers, and R. Hilborn. 2001. Compensatory density-dependence in fish populations: importance, controversy, understanding, and prognosis. Fish and Fisheries 2: 2930327.

Rose, K.A., and J.H. Cowan. 2003. Data, models, and decisions in US marine fisheries management: lessons for ecologists. Reviews for Ecology, Evolution and Systematics 34: 127-151.

Rose, K.A. 2005. Lack of relationship between fish population responses and their life history traits: inaccurate models, incorrect analyses, or importance of site-specific factors. Canadian Journal of Fisheries and Aquatic Sciences 62: 886-902.

Roth, B.M., K.A. Rose, L.S. Rozas, and T.J. Minello. 2008. The relative influence of landscape configuration and inundation on brown shrimp (*Farfantepenaeus aztecus*) production in northern Gulf of Mexico salt marshes. Marine Ecology Progress Series 359:185-202.

Murphy, C.A., K.A. Rose, M.S. Rahman, and P. Thomas. 2009. Testing and applying a fish vitellogenesis model to evaluate laboratory and field biomarkers of endocrine disruption in Atlantic croaker (*Micropogonias undulatus*) exposed to hypoxia. Environmental Toxicology and Chemistry 28: 1288–1303

Rose, K.A. A.T. Adamack, C.A. Murphy, S.E. Sable, S.E. Kolesar, J.K. Craig, D.L. Breitburg, P. Thomas, M.H. Brouwer, C.F. Cerco, S. Diamond. 2009. Does hypoxia have population-level effects on coastal fish? Musings from the virtual world. Journal of Experimental Marine Biology and Ecology. doi:10.1016/j.jembe.2009.07.022.

Breitburg, D. L., Craig, J.K., Fulford, R.S., Rose, K.A., Boynton, W.R., Brady, D., Ciotti, B.J., Diaz, R.J., Friedland, K.D., Hagy, J.D., Hart, D.R., Hines, A.H., Houde, E.D., Kolesar, S.E., Nixon, S.W., Rice, J.A., Secor,D.H., and Targett, T.E. in press. Nutrient enrichment and fisheries exploitation: interactive effects on estuarine living resources and their management. Hydrobiologia.

Ito, S., K.A. Rose, A.J. Miller, K. Drinkwater, K.M. Brander, J.E. Overland, S. Sundby, E. Curchitser, J.W. Hurrell, and Y. Yamanaka. In press. Ocean ecosystem responses to future global change scenarios: A way forward. Marine Ecosystems and Global Change. Oxford University Press.

SYNERGISTIC ACTIVITIES

Fellow, American Associate for the Advancement of Science Associate

Editor, Trans. Am. Fish. Society (1995-97), Ecological Applications (1997-00), Can. J. Fish Aquat. Sciences (08-), Marine and Coastal Fisheries (08-), San Francisco Estuary and Watershed Science (08-).

Member, Reef Fish Stock Assessment Panel, Gulf of Mexico Council, 1998-2006

Member, Independent Science Board of the CALFED Bay Authority (term over)

Member, Review Panel of the CALFED Environmental Water Account (6 years)

Member, Independent review panel of the Long-Term Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) Biological Opinion on Salmon, January 2009.

Member, Independent review panel of the Long-Term Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) Biological Opinion on Delta Smelt, Convened by the US Fish and Wildlife Service, November 2008.

Member, Independent review panel of the Delta Risk Management Strategy for the San Francisco Bay ecosystem, 2007-2008.

Member, Review Team of NOAA's Biological Opinion on Endangered Salmon in the San Francisco Estuary, 2005.

Member, Ecosystem Management Science and Statistical Committee for the Gulf of Mexico Fisheries Management Council.

Member, Scientific Steering Committee of the NSF-sponsored Bering Sea Study (BEST) Program.

Member, Scientific Steering Committee of the US GLOBEC Program.

Plenary Speaker, Complex Systems Theory, Post-Modernism, and Science and Scientists in the CALFED Era. 2006 CALFED Science Conference, Sacramento, Oct 2006.

Plenary Speaker, Fisheries Science and Management: New Era of Collaboration or Business as Usual?, American Fisheries Society 133rd Annual Meeting, Quebec City, Aug 2003.

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CURRICULUM VITAE

GREGORY T. RUGGERONE

EDUCATION

Ph.D. Fisheries, University of Washington, 1989.
M.S. Fisheries, University of Washington, 1981.
B.S. Biological Sciences, University of California, Irvine, 1978.

EXPERIENCE

1993-present Vice-President, Fisheries Scientist, Natural Resources Consultants, Inc. Responsible for salmon investigations in the Pacific Northwest and Alaska. Affiliated research scientist, Alaska Salmon Program, School of Fisheries, University of Washington.

1990-1993. Principal Fisheries Biologist. University of Washington, Fisheries Research Institute. Project Leader/ Co-PI, Alaska Salmon Program. Responsible for directing several research projects at FRI's Alaska field stations and supervision of graduate students.

1989-1990. Senior Fisheries Biologist. University of Washington, Fisheries Research Institute. Project Leader for the Alaska Salmon Program (see above responsibilities).

1984-1989. Predoctoral Research Associate. University of Washington, Fisheries Research Institute. Project Leader for the Chignik Lakes Salmon Research Program. Responsible for directing research projects and supervision of students.

1982-1984. Fisheries Biologist. Jones & Stokes Associates, Inc. Responsible for environmental studies related to fish and fisheries in Alaska, Washington and California.

1982. Consultant. BioSonics, Inc. Examined juvenile salmon migration at a Columbia River dam using hydroacoustic techniques.

1979-1981. Research Assistant. University of Washington, Fisheries Research Institute. Field research on salmon at the Wood River lakes, Alaska.

1978-1979. Biologist. California Department of Fish and Game. Assisted several marine fisheries projects, including the annual CALCOFI anchovy survey.

1978. Biologist. University of California, Irvine. Department of Ecology and Evolutionary Biology. Received Student-Originated-Studies grant from the National Science Foundation to examine the effects of groundwater removal on natural spring communities in the Owens Valley, CA.

1977-1978. Lab Technician. University of California, Irvine. Department of Ecology and Evolutionary Biology. Field biologist for rocky intertidal studies.

PROFESSIONAL SERVICE

Society Memberships

American Institute of Fishery Research Biologists, NW District Director (1993-1994), Regional Director (1994-1995)
American Fisheries Society

Scientific Referee

Aquatic Living Resources
Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative
American Fisheries Society
Canadian Journal of Fisheries and Aquatic Sciences
First International Symposium on GIS in Fishery Science
Fisheries Oceanography
Fishery Bulletin
Fourth World Fisheries Congress, American Fisheries Society
Gulf of Alaska Ecosystem Monitoring Program (GEM)
Gut Shop 1993
Marine Stewardship Council
National Science Foundation
Nature
North American Journal of Fisheries Management
North Pacific Research Board
North Pacific Anadromous Fish Commission
Marine Stewardship Council
Ohio Sea Grant College Program
Pacific Salmon and Their Ecosystems: Status and Future Options
PICES
Reviews in Fish Biology and Fisheries
Transactions of the American Fisheries Society
West Coast National Undersea Research Center, NOAA

Committees
Science Technical Committee, Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative
Chignik Regional Aquaculture Association, Scientific Advisor
Independent Scientific Advisory Board, Columbia River, Ad Hoc member

AWARDS AND SCHOLARSHIPS

American Institute Fisheries Research Biologists, Research Award, 1992 (Visiting scientist in Russia)
John Cobb Memorial Scholarship, 1989
American Institute Fisheries Research Biologists, Research Award, 1988
Seattle Poggie Club (Fisheries) Scholarship, 1986
National Science Foundation Student-Originated-Studies Grant, 1978
University of California, Irvine President's Council Grant, 1977
Dean's Honor List: 1974, 1975, 1976, 1977

SUPERVISION OF GRADUATE STUDENT RESEARCH

Griffiths, J. 2009. Assessing the implications of changing geomorphology and climate on the habitat characteristics of Black Lake, Alaska. M.S. Thesis. University of Washington, Seattle.

Westley, P. 2007. Biocomplexity and rapid natural habitat change in the Chignik Lake system, Alaska. M.S. Thesis. University of Washington, Seattle.

Chasco, B. 2004. Inseason run size forecasting of Chignik sockeye salmon. M.S. Thesis. University of Washington, Seattle.

Harvey, C.J. 1994. Upstream migration of fishes in Black River, Chignik Lakes, Alaska. M.S. Thesis. University of Washington, Seattle. 154 p.

Bumgarner, J.D. 1993. Long-term trends in the growth of sockeye salmon from the Chignik Lakes, Alaska. M.S. Thesis. University of Washington, Seattle. 86 p.

Hanson, R. 1992. Brown bear (*Ursus arctos*) predation on sockeye salmon spawners in two tributaries of the Wood River Lake system, Bristol Bay, Alaska. M.S. Thesis. University of Washington, Seattle. 124 p.

Berejikian, Barry A.. 1992. Feeding Ecology of Rainbow Trout with Comparisons to Arctic Char in Iliamna Lake, Alaska. M.S. Thesis. University of Washington, Seattle. 72 p.

Zimmermann, M. 1991. Trends in the freshwater growth of sockeye salmon from the Wood River Lakes and Nushagak Bay, Alaska. M.S. Thesis. University of Washington, Seattle. 119 p.

PUBLICATIONS

Journals and Book Chapters

Ruggerone, G.T., J.L. Nielsen, and B.A. Agler. 2009. Linking marine and freshwater growth in western Alaska Chinook salmon, *Oncorhynchus tshawytscha*. Journal of Fish Biology 75: In press.

Ruggerone, G.T., J.L. Nielsen, and B.A. Agler. 2009. Climate, growth and population dynamics of Yukon River Chinook salmon. North Pacific Anadromous Fisheries Commission Bulletin. In Press.

Ruggerone, G.T., and J.L. Nielsen. 2009. A review of growth and survival of salmon at sea in response to competition and climate change. American Fisheries Society Symposium 70: In press.

Ruggerone, G.T., R.M. Peterman, B. Dorner, and K.W. Myers. 2009. Magnitude and trends in abundance of hatchery and wild pink, chum, and sockeye salmon in the North Pacific Ocean. In review.

Ruggerone, G.T., S. Goodman, and R. Miner. 2009. Behavioral response and survival of juvenile coho salmon to pile driving sounds. In review.

Westley, P.A.H., R. Hilborn, T.P. Quinn, G.T. Ruggerone, and D.E. Schindler. 2008. Long-term changes in rearing habitat and downstream movement by juvenile sockeye salmon (*Oncorhynchus nerka*) in an interconnected Alaska lake system. Ecology of Freshwater Fish 17:443-454.

Ruggerone, G.T., J.L. Nielsen, and J. Bumgarner. 2007. Linkages between Alaskan sockeye salmon abundance, growth at sea, and climate, 1955-2002. Deep Sea Research II 54:2776-2793.

Rand, P.S., C.P. Kellon, X. Augerot, M. Goslin, J.R. Irvine, and G.T. Ruggerone. 2007. Comparison of sockeye salmon (*Oncorhynchus nerka*) monitoring in the Fraser River basin, British Columbia, Canada and Bristol Bay, Alaska. North Pacific Anadromous Fish Commission Bulletin 4:271-284.

Nielsen, J.L. and G.T. Ruggerone. 2007. Climate Change and a Dynamic Ocean Carrying Capacity: Growth and Survival of Pacific Salmon at Sea. *Proceedings Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon.* American Fisheries Society Symposium, Anchorage, AK. September, 2005. In press.

Ruggerone, G.T. and F. Goetz. 2004. Survival of Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) in response to climate-induced competition with pink salmon (*O. gorbuscha*). Canadian Journal Fisheries and Aquatic Sciences 61:1756-1770.

Ruggerone, G.T., and J.L. Nielsen. 2004. Evidence for competitive dominance of pink salmon (*Oncorhynchus gorbuscha*) over other salmonids in the North Pacific Ocean. Reviews in Fish Biology and Fisheries. 14:371-390.

Ruggerone, G.T., M. Zimmermann, K.W. Myers, J.L. Nielsen, and D.E. Rogers. 2003. Competition between Asian pink salmon (*Oncorhynchus gorbuscha*) and Alaskan sockeye salmon (*O. nerka*) in the North Pacific Ocean. Fisheries Oceanography. 12:3:209-219.

Nielsen, J. L. and G. T. Ruggerone. 2005. Global change, anthropomorphic effects and nonlinearity in Bering Sea sockeye salmon populations. *In* V.R. Burkett, D. A. Wilcox, R. Stottlemyer, W. C. Barrow, D. B. Fagre, J. Barton, J. Price, J. L. Nielsen, C. Allen, D. L. Peterson, G. Ruggerone, and T. Doyle. Nonlinear dynamics in ecosystem response to climate change: Case studies and resource management implications. Ecological Complexity 2: 357-394.

Ruggerone, G.T., E. Farley, J. Nielsen, and P. Hagen. 2005. Seasonal marine growth of Bristol Bay sockeye salmon (*Oncorhynchus nerka*) in relation to competition with Asian pink salmon (*O. gorbuscha*) and the 1977 ocean regime shift. Fishery Bulletin 103:2:355-370.

Ruggerone, G.T., and D. Rogers. 2003. Multi-year effects of high densities of sockeye salmon spawners on juvenile salmon growth and survival: a case study from the *Exxon Valdez* oil spill. Fisheries Research. 6:379-392.

Quinn, T.P., S.M. Gende, G.T. Ruggerone and D.E. Rogers. 2003. Density dependent predation by brown bears (*Ursus arctos*) on sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 60: 553-562.

Ruggerone, G.T., J. Nielsen, E. Farley, S. Ignell, P. Hagen, B. Agler, D. Rogers, J. Bumgarner. 2002. Long-term trends in annual Bristol Bay sockeye salmon scale growth at sea in relation to sockeye abundance and environmental trends, 1955-2000. North Pacific Anadromous Fish Commission Tech. Rept. 4:56-58.

Ruggerone, G.T., R. Hansen and D. Rogers. 2000. Selective predation by brown bears (*Ursus arctos*) foraging on spawning sockeye salmon. Canadian Journal of Zoology 78:6:974-981.

Ruggerone, G.T. 2000. Differential survival of juvenile sockeye and coho salmon exposed to low dissolved oxygen during winter. Journal Fish Biology 56:1013-1016.

Mahnken, C., G. Ruggerone, W. Waknitz, and T. Flagg. 1998. A historical perspective on salmonid production from Pacific rim hatcheries. North Pacific Anadromous Fish Commission Bulletin 1:38-53.

Harvey, C.J., G.T. Ruggerone, and D.E. Rogers. 1997. Migrations of three-spined stickleback, nine-spined stickleback, and pond smelt in the Chignik catchment, Alaska. Journal of Fish Biology. 50: 1133-1137.

Ruggerone, G.T and C.J. Harvey. 1995. Age-specific use of habitat by juvenile coho salmon and other salmonids in the Chignik Lakes Watershed, Alaska. Pages 45-60 *in* Salmon Ecosystem Restoration: Myth and Reality (M.L. Keefe, ed.). Proceedings of the 1994 Northeast Pacific Chinook and Coho Salmon Workshop. American Fisheries Society. Eugene, OR.

Rogers, D.E. and G.T. Ruggerone. 1993. Factors affecting the marine growth of Bristol Bay sockeye salmon. Fisheries Research 18: 89-103.

Ruggerone, G.T and D.E. Rogers. 1992. Predation of sockeye salmon fry by juvenile coho salmon in the Chignik Lakes, Alaska: implications for salmon management. North American Journal of Fisheries Management. 12: 87-102.

Ruggerone, G.T. 1992. Threespine stickleback aggregations create potential predation refuge for sockeye salmon fry. Canadian Journal of Zoology 70: 1052-1056.

Ruggerone, G.T. 1992. Predation on sockeye salmon by fish and wildlife in Alaska. Pp. 20-21. In C.D. Levings and G.A. Hunter (eds), An Account of a Workshop on Research Approaches to Predation/Competition Questions in River Fish Communities. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2150.

Rogers, D.E., and G.T. Ruggerone. 1992. FRI forecasts of the 1992 sockeye run to Bristol Bay. Pp. 13-16 *in* 1992 Alaska Salmon Markets, G. Knapp (ed.). University of Alaska, Fairbanks.

Ruggerone, G.T. 1991. Salmon redux (salmon population resilience and habitat in Alaska). BioScience 41: 284.

Ruggerone, G.T. 1991. Partial xanthism in an adult chum salmon (*Oncorhynchus keta*) near Chignik, Alaska. California Fish and Game 77: 55-56.

Ruggerone, G.T, T.P. Quinn, I. McGregor and T.D. Wilkinson. 1990. Horizontal and vertical movements of maturing steelhead trout, *Oncorhynchus mykiss*, in Dean and Fisher channels, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 47: 1963-1969.

Ruggerone, G.T. 1989. Coho salmon predation on juvenile sockeye salmon in the Chignik Lakes, Alaska. Ph.D. Dissertation. University of Washington, Seattle. 151 p.

Ruggerone, G.T. 1989. Gastric evacuation of single and multiple meals by piscivorous coho salmon, *Oncorhynchus kisutch*. Environmental Biology of Fishes 26: 143-147.

Ruggerone, G.T. 1989. Gastric evacuation rates and daily ration of piscivorous coho salmon (*Oncorhynchus kisutch*) Walbaum. Journal of Fish Biology 34: 451-463.

Ruggerone, G.T. 1986. Consumption of migrating juvenile salmonids by gulls foraging below a Columbia River dam. Transactions of the American Fisheries Society 115: 736-742.

Perkins, D.J., B.N. Carlsen, R.N. Miller, C.M. Rofer, G.T. Ruggerone, M.F. Fredstrom, and C.S. Wallace. 1984. Effects of groundwater removal on natural spring communities in the Owens Valley, CA. Pp. 515-527 *in* R. E. Warner and K.M. Hendrix, eds. California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, CA.

Ruggerone, G.T. and D.E. Rogers. 1984. Arctic char predation on migrating sockeye smolts at Little Togiak River, Alaska. Fishery Bulletin 82: 401-410.

Technical Reports

Rogers, D.E. and G.T. Ruggerone. 1980. Alaska salmon studies: The study of red salmon in the Nushagak District. Ann. Rep. FRI-UW-8019. University of Washington, Seattle. 48 p.

Ruggerone, G.T. 1981. Arctic char predation on migrating sockeye smolts at Little Togiak River, Alaska. M.S. Thesis. Fisheries Research Institute, University of Washington, Seattle. 57 p.

Ruggerone, G.T. 1982. Salmonid habitat quality of 22 creeks in the Mt. Baker/Snoqualmie National Forest, Washington. Prepared for the U.S. Forest Service with Jones & Stokes Associates, Bellevue, WA. 40 p.

Ruggerone, G.T. and R. Denman. 1982. Salmonid spawning and rearing habitat survey: Illabot Creek. Prepared for Seattle City Light with Jones & Stokes Associates, Bellevue, WA. 15 p.

Ruggerone, G.T. 1983. Fishery enhancement potential of the Hanford Reach, Columbia River. Prepared for U.S. Army Corps Engineers, Seattle District, with Jones & Stokes Associates, Bellevue, WA. 64 p.

Van Veldhuizen, H. and G.T. Ruggerone. 1983. Analysis of Ocean Discharge Criteria Evaluation limitations for the St. George Basin (Lease Sale 70, southeastern Bering Sea). Prepared for the Environmental Protection Agency with Jones & Stokes Associates, Bellevue, WA.

Van Veldhuizen, H. and G.T. Ruggerone. 1983. Analysis of Ocean Discharge Criteria Evaluation limitations for Navarin Basin (Lease Sale 83, Bering Sea). Prepared for the Environmental Protection Agency with Jones & Stokes Associates, Bellevue, WA. 37 p.

Van Veldhuizen, H., J. Cabreza, G.T. Ruggerone and others. 1983. Ocean Discharge Criteria Evaluation: Diapir Field OCS Lease Sale 71 (Arctic Ocean). Prepared for the Environmental Protection Agency with Jones & Stokes Associates, Bellevue, WA. 175 p.

Ruggerone, G.T., and M. Green. 1984. San Antonio Creek hydroelectric project: Exhibit E. Application for exemption for a small hydroelectric project from licensing. Prepared for Jones & Stokes Associates, Sacramento, CA. 22 p. 1984.

Ruggerone, G.T. 1984. Review of the Draft EIS (fisheries section) for the Susitna River, Alaska, hydroelectric project. Prepared for the Environmental Protection Agency with Jones & Stokes Associates, Bellevue, WA. 41 p.

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Growth and Survival of Salmon in Response to Competition at Sea and Climate Change. State of Salmon 2009 Conference, *Bringing the Future into Focus.* Innovative Approaches to Applying Conservation Principles. February 2-5, 2009. Vancouver, BC

Abundance and relative contribution of hatchery and wild salmon in the North Pacific Ocean. NPAFC International Symposium on the Bering-Aleutian Salmon International Surveys (BASIS): Climate Change, Production Trends, and Carrying Capacity of Pacific Salmon in the Bering Sea and Adjacent Waters. November 23-25, 2008. Seattle, WA, USA

Management Data for Long-term Monitoring of Salmon Growth and Survival versus Climate Change. Long Term Research and Monitoring Project (LRMP), North Pacific Anadromous Fish Commission. April 7-11, 2008. Sokcho, South Korea.

Growth and Survival of Salmon in Response to Competition and Climate Change: Implications for Interactions of Wild and Hatchery Salmon. Symposium: Population Growth, Climate Change and Fish Habitat in the Columbia River Basin. American Fisheries Society Western Division Conference, May 4-9, 2008; Portland, OR.

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Predation on sockeye salmon by fish and wildlife in Alaska. Department Fisheries and Oceans Canada. Cultus Lake, British Columbia. February 1991.

Preseason forecast of Bristol Bay salmon runs, 1990. The 5th Annual Bristol Bay Fisheries Conference. Dillingham, AK. April 1990.

Predator-prey interactions and fisheries management. Joint Institute for Marine and Atmospheric Research and National Marine Fisheries Service Seminar. Honolulu, HI. July 1989.

CONFERENCE AND SEMINAR PRESENTATIONS

The salmon MALBEC project: a North Pacific-scale study to support salmon conservation planning. American Fisheries Society North Pacific International Chapter Annual Meeting. Tacoma, WA. June 6-8, 2007. Introduction presented by N. Mantua.

Hatchery Versus Wild Salmon Production in the North Pacific Ocean. American Fisheries Society North Pacific International Chapter Annual Meeting. Tacoma, WA. June 6-8, 2007.

Hatchery Versus Wild Salmon Production in the North Pacific Ocean. 9th Salmon Ocean Ecology Meeting. Newport, OR. March 14-16, 2007.

Ocean Climate Change and Collapse of the World's Largest Sockeye Salmon Population. 9th Salmon Ocean Ecology Meeting. Newport, OR. March 14-16, 2007.

Salmon MALBEC: Model for Assessing Links Between Ecosystems. (N. Taylor- presented). 9th Salmon Ocean Ecology Meeting. Newport, OR. March 14-16, 2007.

Retrospective Analysis of Yukon and Kuskokwim Chinook Salmon Growth. AYK SSI Symposium on the Sustainability of the AYK Salmon Fisheries. Anchorage, AK. February 6-9, 2007.

Growth and survival of salmon in response to climate change, competition, and a dynamic ocean carrying capacity. Global Challenges Facing Oceanography and Limnology. American Society of Limnology and Oceanography, June 2006.

Salmon age structure and variable resilience of Bristol Bay sockeye salmon to climate change. Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon in the Future. 135th Annual Meeting American Fisheries Society, September 2005.

Growth and survival of salmon in response to climate change and a dynamic ocean carrying capacity. The Evolution and Ecology of Biocomplexity as Key to Fisheries Sustainability. 135th Annual Meeting American Fisheries Society, September 2005.

Linkages between climate, growth at sea, and abundance of sockeye salmon in Bristol Bay, Alaska, 1955-2000. GLOBEC Symposium: Climate Variability and Sub-Arctic Marine Ecosystems. Victoria, B.C. May 2005.

Survival and Growth of Puget Sound Chinook Salmon in Response to Climate-induced Competition with Pink Salmon: Implications for Habitat Protection and Restoration. Sustainability and Restoration: a practical partnership for the 21st. Society for Ecological Restoration. Seattle, WA. April, 2005.

Top-down and bottom-up linkages among climate, growth, competition, and production of sockeye salmon populations in Bristol Bay, Alaska, 1955-2000 (S2-2068). North Pacific Marine Science Organization (PICES) 13th annual meeting. Honolulu, HI. (Presented by J. Nielsen). October, 2004.

Survival of Puget Sound chinook salmon in response to climate-induced competition with pink salmon. Northwest Salmonid Recovery Conference. Seattle, WA. October, 2004.

Linkages between climate, growth, competition, and production of sockeye salmon populations in Bristol Bay, Alaska, 1955-2000. Study of Environmental Arctic Change (SEARCH) open science meeting, Office of Polar Processes, National Science Foundation. Seattle, WA. (Presented by J. Nielsen). (http://siempre.arcus.org/4DACTION/wi_pos_displayAbstract/7/601). October 2003.

Survival, growth, and age at maturation of Puget Sound chinook salmon released during odd- versus even-numbered years: evidence for interspecific competition with pink salmon during early marine life. 5th Annual Salmon Ocean Ecology Meeting. Newport, OR. February, 2003.

Seasonal marine scale growth of Bristol Bay sockeye salmon during odd- and even-numbered years: evidence for competition with Asian pink salmon and seasonal food web dynamics in the North Pacific Ocean and Bering Sea. 5th Annual Salmon Ocean Ecology Meeting. Newport, OR. February, 2003.

Long-term trends in annual Bristol Bay sockeye salmon scale growth at sea in relation to sockeye abundance and environmental trends, 1955-2000. 4th Annual Salmon Ocean Ecology Meeting, 15-16 January, 2002, Santa Cruz, CA.

Differential Marine Growth of Sockeye Salmon During Odd and Even Years: Evidence for Density-Dependent Effects of Pink Salmon Abundance on Nushagak Bay and Chignik Sockeye Salmon, 1955-1997. Pink and Chum Salmon Workshop. University of Washington, Seattle. March 2001.

Natural Habitat Degradation in a Major Salmon Watershed: A Lesson in Salmon Population Resilience and Decline. Washington Lakes Protection Association Conference. SeaTac, WA 2000.

Historical analysis of sockeye salmon growth among populations affected by large escapements associated with the Exxon Valdez oil spill. Legacy of an oil spill: ten years after the Exxon Valdez oil spill. Anchorage, AK. March 1999.

A historical perspective on salmonid production from Pacific rim hatcheries. First Symposium of the North Pacific Anadromous Fish Commission. Hokkaido, Japan. w/ C. Mahnken, NMFS. October 1996.

Factors influencing the survival of salmon in Alaska and the Pacific Northwest. Visitation Retreat & Cultural Center, City of Federal Way, WA. October 1995.

The application of remotely-sensed data to salmon harvest management and operational planning of the salmon industry in Alaska. Third Thematic Conference: Remote Sensing for Marine and Coastal Environments. Seattle, WA. September 1995.

Initial water quality assessment of the Upper Hood Canal Watershed. Presentation to the Upper Hood Canal Watershed Management Committee. Seabeck, WA. November 1994.

Investigations of salmon populations, hydrology, and limnology of the Chignik Lakes, Alaska, during 1993. Chignik Regional Planning Team. Anchorage, Alaska. December 1993.

Population dynamics and winter ecology of sockeye salmon. 1993 Sockeye-Kokanee Workshop. Richmond, British Columbia. March 1993.

Long-term trends in the growth of sockeye salmon from the Chignik Lakes, Alaska. 1993 sockeye-kokanee workshop. Presented by J. Bumgarner. Richmond, British Columbia. March 1993.

Migrations of juvenile sockeye salmon and other fishes into and out of Black Lake, AK. Chignik Regional Aquaculture Association. Everett, WA. December 1992.

Factors affecting the early marine growth of Bristol Bay sockeye salmon. Workshop on the growth, distribution, and mortality of juvenile Pacific salmon in coastal waters. Sidney, British Columbia. October 1992.

Migrations of juvenile sockeye salmon and other fishes into and out of Black Lake, AK. Chignik Regional Planning Team. Anchorage, AK. October 1992.

Sockeye salmon run fluctuations and winter habitat quality of Black Lake, Ak. Chignik Regional Planning Team. Anchorage, AK. April 1992.

Habitat and sockeye salmon dynamics in a unique Alaskan lake. The 54th Annual Meeting of Pacific Fishery Biologists. Semi-am-hoo Resort, Blaine, WA. March 1992.

Responses of juvenile salmon to low oxygen levels in Black Lake during February 1992 and the forecast of adult sockeye returning to Chignik in 1992. Chignik Seiners Association, Shilshole Marina, Seattle, WA. March 1992.

The Alaska Salmon Program of the Fisheries Research Institute, University of Washington. Poster presentation at FISH EXPO 1991. Seattle, WA. October 1991.

Enhancing harvests of Chignik salmon through predator control and habitat rehabilitation: a cost-benefit analysis. Chignik Seiners Association. Seattle, WA. January 1991.

Rehabilitation and enhancement of sockeye salmon returning to Black Lake, Alaska. Chignik Regional Aquaculture Association. Seattle, WA. November 1990.

Factors influencing the large fluctuations of adult sockeye returning to Black Lake, Alaska: results of the 1990 winter investigation. Chignik Seiners Association. Chignik, AK. June 1990.

Bycatch of Pacific salmon by the domestic trawl fishery. The 5th Annual Bristol Bay Fisheries Conference. Dillingham, AK. April 1990.

Salmon projects of the Fisheries Research Institute in Alaska. Annual Meeting of the National Food Processors Association. Seattle, WA. March 1990.

Predator impacts on salmon populations. Annual Meeting of the National Food Processors Association. Seattle, WA. March 1989.

Threespine stickleback (Gasterosteus aculeatus) *aggregations as a refuge from predation for sockeye salmon fry* (Oncorhynchus nerka). National meeting of the Animal Behavior Society. Missoula, MO. August 1988.

Forecasts of Chignik salmon and the effects of predation by coho on sockeye survival in the Chignik Lakes, Alaska. Presentation to the Chignik Seiners Association and salmon processors. Chignik, AK. June 1988.

Salmon forecasts and research activities of the Fisheries Research Institute in the Chignik Lakes, Alaska. Presentation to the Chignik Seiners Association and salmon processors. Chignik, AK. June 1987.

Evaluation of the fisheries monitoring program to determine effects of the proposed Navy Home Port, Everett, WA. Presentation to Engineers and Navy personnel. Federal Way, WA. Oct. 1987.

Salmon forecasts and research activities of the Fisheries Research Institute in the Chignik Lakes, Alaska. Presentation to the Chignik Seiners Association and salmon processors. Chignik, AK. June 1986.

Consumption of migrating juvenile salmonids by gulls foraging below a Columbia River dam. Meeting of the Northwest Chapter, American Fisheries Society. Bellingham, WA. March 1986.

Alaska salmon research by the University of Washington. Seattle Poggie Club. Seattle, WA. April 1986.

Predator-prey interactions of piscivorous coho salmon and juvenile sockeye salmon in the Chignik Lakes, Alaska. Fisheries Research Institute Seminar, University of Washington. October 1986.

Salmon Research in Alaska: Past, Present, and Future. Organized seminar series at Fisheries Research Institute, University of Washington. October- December, 1986.

Salmon forecasts and research activities of the Fisheries Research Institute in the Chignik Lakes, Alaska. Presentation to the Chignik Seiners Association and salmon processors. Chignik, AK. June 1985.

EXPERT WITNESS TESTIMONY

Dam effects on salmon	Reconstructed salmon harvests by Tulalip Tribe had Sultan Diversion Dam not been built in 1916. Estimated fish passage through high gradient cascades. (case mediated & settled, 2005).
Exxon Valdez Oil Spill	Effects of oil spill on salmon tenders in Alaska (deposition, case settled) 2003.
Skokomish Tribe v. Tacoma Power	Tribal harvests had the dams not been built, 1926-1998. Ability of salmon to pass Big Falls prior to inundation by reservoir. (report, deposition, case removed in summary judgment) 2001.
Salmon Forecast Accuracy	Preseason and inseason run size forecast accuracy; insurance claim for 1998 Bristol Bay run failure (report, case settled) 2000.
Calkins v. Burger King	Probability of biotoxin accumulation in pollock from the Bering Sea (report, case settled) 2000-2001.
Proposed Cross Cascade Pipeline	Effects of refined oil pipeline on salmon and habitat (report, deposition, pipeline explosion ended proposed pipeline) 1999.
Dam Effects on Salmon	Chinook and steelhead runs reconstructed to estimate historical (85 yr) runs and harvests had dams not been built. (report, mediation settlement) 1998.
Exxon Valdez Oil Spill	Effects of oil spill on salmon harvests in Alaska (reports, deposition, trial testimony) 1994.
Glacier Bay Oil Spill	Effects of oil spill on salmon harvests in Cook Inlet, Alaska (report, deposition) 1989.
Touchet River Chemical Spill:	Effects of ammonia spill on salmonids in Touchet River, WA (deposition) 1983.