Peer Review of the Scientific Basis for the Klamath River Temperature, Dissolved Oxygen, Organic Matter, and Nutrient TMDL

Reviewed by

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Reviewer Charge

The reviewer was asked to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. This was further amplified by a request that the reviewer make the determination of the soundness of science of the following sections:

1. Nutrient allocations and chlorophyll-a, *Microcystis aeruginosa*, and microcystin numeric targets to Copco 1 and 2 and Iron Gate Reservoirs developed to control blue-green algae blooms, associated toxins, and protect recreation and cultural beneficial uses.
2. Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.
3. Analysis of tributary effects of tributary stream flow rates on stream temperatures in the tributaries and mainstem of the Klamath River.
4. Assessing the linkage between water quality and fish disease.

Statement of Reviewer Areas of Expertise

The reviewer received formal training in Natural Resource Management with an emphasis in Fisheries Management and in Ecology, with an emphasis in the Physiological Ecology of Fish. The reviewer has since been employed as a fishery biology and fish culture professor, and teaches fish physiology, fish culture, and general fishery biology courses at the undergraduate and graduate level. The reviewer has conducted research on salmonid thermal biology (including rainbow trout and Chinook salmon) and, to a lesser extent, on the effects of other environmental factors such as dissolved oxygen levels. Thus the reviewer is most comfortable evaluating the temperature and dissolved oxygen portions of the TMDL.

The reviewer has limited experience with fish disease as a researcher. However, as part of a comprehensive review of California salmonid thermal biology, did survey the literature on the effects of temperature on a number of common salmonid pathogens, including *Ceratomyxa shasta.* Therefore, the reviewer is moderately comfortable with commenting on the linkage between fish disease and water quality.

Although the reviewer does some knowledge of nutrient dynamics in aquatic systems, the extent of that knowledge is limited. Therefore, the reviewer can only offer superficial comments upon the nutrient, chlorophyll-a, *Microcystis*, and microcystin portion of the proposed TMDL.

Reviewer Comments

Nutrient allocations and chlorophyll-a, Microcystis aeruginosa, and microcystin numeric targets to Copco 1 and 2 and Iron Gate Reservoirs developed to control blue-green algae blooms, associated toxins, and protect recreation and cultural beneficial uses.

The methods used to develop the proposed TMDL for nutrient allocations appear to be based on sound scientific practices and principles. Unlike some of the earlier work in the Klamath system that focused solely on the Klamath River mainstem, the information used to develop the TMDLs also incorporated contributions from tributary streams. It was also good to see the acknowledgement that the upper Klamath River region has a high natural nutrient load that historically caused significant blooms of phytoplankton and other forms of algae.

One concern with the nutrients/organic matter standards (Table 5.1) proposed for the Iron Gate Hatchery is that it may not be realistic to expect the hatchery to be able to achieve a zero net increase of nutrient and organic matter loads between the hatchery intake(s) in the reservoir and the hatchery discharge. By their very nature fish hatcheries will produce organic matter (excess feed, fish wastes, etc.) and while the use of settling ponds and careful control of feeding rates can reduce the amount of organic matter produced, they do not wholly eliminate it.

The use of the established World Health Organization standards for microcystin drew upon a body of existing public health research and by selecting the low heath effect level (<4 µg/L) shows due concern for minimizing the impacts on beneficial uses of the river. The correlations between the microcystin and the *M. aeruginosa* cell density research cited in the development of the *Microcystis* standard (e.g., Figure 2.5) seem appropriate.

Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.

Iron Gate and Copco 1 and 2 reservoirs currently experience summer conditions that are stressful, at best, for the resident salmonids. Based on the information in the supporting documents and the draft TMDL, there are times when salmonids will like experience lethal combinations of high temperatures and low dissolved oxygen levels. The approach taken in the proposed TMDL of a compliance lens (see Figure 5.9) is an interesting one, and in theory would provide the fish with narrow band of water with tolerable temperatures (< 19°C) and dissolved oxygen levels (> 85% saturation). Research on resident and anadromous salmonids in California suggests that they can maintain their body condition when exposed to temperatures in this range, and provided that the "compliance lens" affords them sufficient access to food resources, it should provide a useful refuge against a temperature-oxygen "squeeze". One question about this approach is whether such a lens will form given the thermal and hydraulic conditions in the reservoir, and, if it does form, whether it will persist in the face of stochastic events such as strong winds.

An additional comment on the temperature and dissolved oxygen allocations is that their intention is to support the COLD fish (i.e., salmonids), yet there are other native species (see reports by Moyle [2002] and the National Research Council [2004] {#3913} for a comprehensive list of the species present) in the system that deserve protection, especially in light of studies (e.g. Castleberry and Cech 1993 that demonstrate that the other native fishes are affected by elevated temperatures and low dissolved oxygen levels. These fish might benefit from the standards, but it would be useful to conduct a more comprehensive evaluation of how the standards would affect them.

Analysis of tributary effects of tributary stream flow rates on stream temperatures in the tributaries and mainstem of the Klamath River.

With the realization that conditions in the Klamath mainstem immediately below Iron Gate Reservoir can reach marginal levels (particularly in terms of temperature) during the hottest summer months, the inclusion of the tributary contributions as a function of their stream flow rates is very useful. The tributaries have historically been an important component of the system, both a spawning and rearing habitat for some of the anadromous salmonids, the provision of thermal refugia, and as sources of cooler, cleaner water, and ignoring those, as some previous studies have done, would have been fundamentally unsound (National Research Council 2007). As was the case with the nutrient standards, it was gratifying to see a modeling effort on the Klamath system that included the contributions of the tributaries to the thermal status of the system. The reviewer does not have enough of a background in hydraulic modeling to comment upon the technical nature of the modeling approach.

Assessing the linkage between water quality and fish disease.

Fish diseases, in particular *Ceratomyxa shasta* and Columnaris have been repeatedly cited as major fish health concerns in the Klamath basin, particularly given the high summer water temperatures and generally stressful conditions that can predispose fish for infection. The report summarizes the most recent information available on the relationship between disease and temperature, and also mentions the potential effects of the increased organic matter and nutrient load on the secondary host (polychaete worms). The proposed temperature standards for the Iron Gate Reservoir tailrace and the Iron Gate Hatchery (18.8°C) should provide some protection against severe disease outbreaks, although the temperature does fall within the range categorized as having a high disease risk for juvenile rearing and adult migration. Nevertheless, given the natural conditions in the Klamath system above Iron Gate, it is unlikely that a much lower temperature could be achieved.

Overall, the proposed total maximum daily loads for temperature, dissolved oxygen, organic matter, and nutrients have been developed using information from a wide variety of scientific sources, and using established scientific principles. While the reviewer does have some minor concerns about the implementation of the standards, and in particular about whether the “compliance lens” will function in reality as well as it does as a conceptual model, there is nothing in the draft TMDL document to warrant a comprehensive revision. The reviewer does hope, however, that once the TMDLs are adopted and implemented, the North Coast Regional Water Quality Control Board will continue to evaluate new data as it is collected and adjust the total maximum daily loads as necessary. The Klamath River system is a dynamic one, and the ongoing anthropogenic and climatic changes may lead to additional changes in the basin’s hydrology and ecology that will require modification of the TMDLs in the future.

Literature Cited

Castleberry, D. T., and J. J. Cech, Jr. 1993. Critical thermal maxima and oxygen minima of five fishes from the upper Klamath basin. California Fish and Game 78(4):145 - 152.

Moyle, P. B. 2002. Inland Fishes of California., 2nd. edition. University of California Press, Berkeley, California.

National Research Council. 2004. Endangered and threatened fishes in the Klamath River Basin: Causes of decline and strategies for recovery. The National Academies Press, Washington, D.C., USA.

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