External Peer Review

Peer review was solicited from experts in salmon and steelhead biology. Dr. Walt Duffy has expertise in the ecology of Upper Klamath and Trinity Rivers Chinook salmon, and Dr. Andrew Kinziger has specific expertise on genetics issues of the Upper Klamath and Trinity Rivers Chinook salmon. Reviews are provided below (in no particular order and not associated with particular reviewer).

Reviewer 1

Review of "Upper Klamath and Trinity River Chinook Salmon Biological Review Team Report" authored by Williams et al.

The Biological Review Team (BRT) employed NOAA's official policy for recognizing evolutionary significant units as outlined by Waples (1991). There are two requirements for recognition of ESU's under this definition: (1) long-term reproductive isolation (100s of generations) resulting from an unique evolutionary event such that the entity is unlikely to re-evolve over ecological time-scales, and (2) represent an unique component of the evolutionary legacy, possessing ecological (or adaptive) uniqueness that is important for future evolutionary potential.

With regard to the second portion of the Waples ESU definition, Klamath River spring-run Chinook salmon qualify by exhibiting a numerous unique traits in contrast to fall-run including: entry time, egg size at-entry, fat content at-entry, smaller overall body size, and significant genetic differences (Snyder 1931, Kinziger et al., 2008a, Kinziger et al. 2008b, Kinziger et al. Unpubl., Hearsey 2011). However, Klamath River spring-run Chinook salmon do not meet the requirements stipulated by the second criterion. Genetic evidence indicates Klamath River spring-run Chinook have apparently evolved independently in several rivers within the Klamath Basin through a process of parallel evolution, including the Trinity, South Fork Trinity, and Salmon rivers (Kinziger et al. Unpubl.). (Spring run stocks that once returned above Iron Gate Dam are considered extinct.) Divergence between run-times is shallower than levels observed between geographic regions. These data suggest that spring and fall formed relatively recently and are likely to re-evolve in the event of extinction. Differences in run timing can evolve in short time-scales as established by introduction of Chinook stocks to New Zealand (Quinn et al. 1996, 2001, 2002).

However, units for conservation are defined in many different ways. My personal view is that there is evidence for reproductive isolation and adaptive divergence between Klamath River spring and fall Chinook salmon (described above) and thus each merit their own ESU. The fact that concordant differences are exhibited across multiple character types bolsters this view. Spring and fall are also of cultural importance, extending the duration of tribal subsistence fishery in the Klamath River. Klamath River spring and fall Chinook have been recognized and managed as different entities for almost 100 years (Snyder 1931), a testament to the well-known differentiation between these stocks.

Other comments:

I have some reservations concerning comparative analysis of Sacramento River Chinook salmon. Relationships between spring and fall could be obscured by transplantation activities which are thought to have a dramatic impact on genetic structuring of fall Chinook in that basin (Williamson and May 2005).

Literature Cited

Hearsey, J.W. 2011. Run timing, fat content and maturity of spring- and fall-run Klamath River Chinook salmon (*Oncorhynchus tshawytscha*). MS Thesis, Humboldt State University, Arcata, CA.

Kinziger, A. P., M. Hellmair, and D. G. Hankin. 2008a. Genetic structure of Chinook salmon (*Oncorhynchus tshawytscha*) in the Klamath-Trinity Basin: implications for within-basin genetic stock identification. Produced under contract agreement between the Hooopa Valley Tribal Fisheries Department and Humboldt State University Sponsored Programs Foundation. Project received financial support by U.S. Bureau of Reclamation, Klamath Basin Area Office. (Full contract title: GSI Klamath Chinook, project number 1.22-4275).

Kinziger, A. P., E. J. Loudenslager, D. G. Hankin, E. C. Anderson, and J. C. Garza. 2008b. Hybridization between spring- and fall-run Chinook salmon returning to the Trinity River, California. North American Journal of Fisheries Management 28:1426-1438.

Kinziger, A. P., M. Hellmair, D. G. Hankin, and J. C. Garza. In Preparation. Genetic structure of Klamath River Chinook salmon (*Oncorhynchus tshawytscha*). Manuscript draft provided by A. P. Kinziger, Department of Fisheries Biology, Humboldt State University, One Harpst Street, Arcata, California, 95521.

Quinn, T. P., J. L. Nielsen, C. Gan, M. J. Unwin, R. Wilmot, C. Guthrie, and F. M. Utter. 1996. Origin and genetic structure of Chinook salmon, Oncorhynchus tshawytscha, transplanted from California to New Zealand: allozyme and mtDNA evidence. U.S. National Marine Fisheries Service Fishery Bulletin 94:506–521.

Quinn, T. P., M. J. Unwin, and M. T. Kinnison. 2001. Evolution of temporal isolation in the wild: genetic divergence in timing of migration and breeding by introduced Chinook salmon populations. Evolution 54:1372–1385.

Quinn, T. P., J. A. Peterson, V. F. Gallucci, W. K. Hershberger, and E. L. Brannon. 2002. Artificial selection and environmental change: countervailing factors affecting the timing of spawning by coho and Chinook salmon. Transactions of the American Fisheries Society 131:591–598.

Snyder, J. O. 1931. Salmon of the Klamath River, California. California Fish and Game Bulletin 34:130.

Waples, R. S. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of “Species” under the Endangered Species Act. Marine Fisheries Review 53(3): 11-22.

Williamson, K.S., and B. May. 2005. Homogenization of fall-run Chinook salmon gene pools in the Central Valley of California, USA. North American Journal of Fisheries Management 25:993-1009.

Reviewer 2

General Comments

I found the Upper Klamath and Trinity River Chinook Salmon Biological Review Team Report to be well written and, with two exceptions, comprehensive in its review of existing data. The two exceptions being very recent publications by Fujiwara and colleagues (2011) and Hearsey (2011). I've included complete citations for these two below.

I also generally agree with the approach taken by the BRT in their analysis, as well as the scope of the analysis. However, I suggest the BRT conclusion derived from genetic analyses be presented more clearly. I also offer an alternative, more conservative, conclusion of the population trend data.

In addition to the comments below, I have made minor comments in the margins of the report.

Evaluate the extent to which the new information supports the current UKTR Chinook Salmon ESU delineation, or the separation of spring-run and fall-run Chinook salmon into separate ESUs

While I do not disagree with the conclusion reached by the BRT that "…the new information supports the current IKTR Chinook ESU…", I suggest that the document more clearly present the criteria for distinguishing among populations that has been established by NOAA.

The National Research Council (NRC 2001) recommended that Klamath River spring Chinook salmon be managed as a distinct ESU due to "… the presence of genetic differences and of great differences in life history…" Since that report, published information from the Klamath River supports a conclusion that spring- and fall-run Chinook salmon be recognized as genetically distinct (Kinsinger et al. 2008). More recently, Hearsey (2011) reported finding differences in run timing among four stocks of Klamath Basin Chinook salmon, including spring- and fall-run fish. He also reported that Klamath River spring-run Chinook salmon had smaller body size, greater fat reserves, smaller egg and gonad size at time of entry to the river than did fall-run fish.

The BRT acknowledged that spring-run Chinook differ genetically and in life history expression from fall-run Chinook salmon. However, they state that ESUs are "… defined by deep evolutionary divergence…" Deep evolutionary divergence is, however, not clearly defined. I suggest that the BRT should more clearly address the distinction between their determination and the above findings, as well the recommendation for retaining the current UKTR ESU.

Assess the biological status of the supported ESU

The BRT concluded that the supported ESU "… is currently at low risk of extinction within the next 100 years." After reviewing pertinent sections of Good et al (2005) that provide a description on how trend analyses were done, I concur with the conclusion reached by the BRT.

I do, however, have some concerns regarding hatchery influence on Klamath River Chinook salmon. These concerns include:

With the exception of the Shasta River, the conclusion of the BRT was drawn from relatively recent data during a period when hatchery releases have been high. Hatchery production has likely had a great influence on population abundance during the period considered by the BRT. It does not appear that the BRT considered hatchery origin fish separately in their risk analysis, but rather considered trends in total abundance. Not separating non-hatchery origin fish from hatchery origin fish may mask trends exhibited by non-hatchery origin fish.

In evaluating risk of extinction, including trends in abundance, the BRT acknowledged uncertainty about the impact of hatchery fish on abundance and productivity. However, the wording used in several sections of the report suggests any impacts are limited spatially to areas near hatcheries. Yet data presented in the report suggests hatchery contributions to natural spawning can, in some years, be substantial in four of the seven sub-basins considered. The NRC (2001) also addressed hatchery impacts on Klamath River Chinook salmon and speculated that up to half of the natural area spawners could be of hatchery origin.

Although the BRT appears to have included the contributions of hatchery fish in the risk assessment, they did not address the uncertain future on Iron Gate Hatchery. Under the Klamath Hydroelectric Settlement Agreement, "Fish hatchery operations will continue at the Iron Gate Hatchery for eight years following removal of the Iron Gate Dam. After eight years, hatchery production will continue, but may be at an alternate site". (U.S. Department of the Interior and California Department of Fish and Game 2011). There is no further mention made of continuing hatching operations on the Klamath River after this 16 year period.

Literature cited

Fujiwara, M., M. S. Mohr, A. Greenberg, J. S. Foott and J. L. Bartholomew. 2011. Effects of Ceratomyxosis on population dynamics of Klamath fall-run Chinook salmon. Transactions of the American Fisheries Society 40(5):1380-1391.

Good, T.P., R.S. Waples and P. Adams. 2005. Updated status of federally listed ESUs of west coast salmon and steelhead. NOAA Technical Memorandum NMFS-NWFSC-66.

Hearsey, J. W. 2011. Run timing, fat content and maturity of spring- and fall-run Klamath River Chinook salmon (*Oncorhynchus tshawytscha*). MSc Thesis, Humboldt State University, Arcata, CA.

Kinsinger, A. P., E. J. Loudenslager, D. G. Hankin, E. C. Anderson and J. C. Garza. 2008. Hybridization between spring- and fall-run Chinook salmon returning to the Trinity River, California. North American Journal of Fisheries Management, 28(5):1426-1438.

National Research Council. 2001. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. National Academies Press, Washington, DC.

U.S. Department of the Interior and California Department of Fish and Game. 2011. Klamath Facilities Removal environmental impact statement/environmental impact report (EIS/EIR). U.S. Department of the Interior, Washington, DC.

Response to reviewers' comments:

Two independent peer reviewers provided general comments on the findings of the BRT and also provided specific comments and suggestions regarding the presentation of the material in the report. Both the technical and editorial comments and suggestions were incorporated into the final report. Some key elements addressed through the peer review process included: 1) reference to a thesis (Hearsey 2011) that was inadvertently left out of the reviewer draft report, although the material was discussed at the BRT meeting and the citation and findings are discussed in the final report, 2) a reviewer asked for more detailed descriptions of how trends in annual spawner escapement and population growth rate were calculated and considered by the BRT – this material has been added to report in addition to a revised approach to calculate population growth rate that allows for the generation of confidence intervals and yields a nearly unbiased estimator of lambda, and 3) the BRT considered genetic data in their consideration of the contribution of hatchery fish in natural areas, a reviewer asked that this be made clear in the report – additional text has been added to address this issue.

One reviewer expressed the personal view that there is evidence for reproductive isolation and adaptive divergence between Klamath River spring-run and fall-run Chinook salmon and thus merit their own ESU. However, the reviewer found that spring-run Chinook salmon in the UKTR basin do not represent a unique component of the evolutionary legacy of the species, and therefore, do not meet one of the two requirements for recognition as an ESU under NMFS' ESU policy (the other requirement being long-term reproductive isolation resulting from an unique evolutionary event that is unlikely to re-evolve over ecological time-scales). One reviewer expressed concerns regarding hatchery influence on Klamath River Chinook salmon and felt that the BRT's conclusion was based on relatively recent data collected during a period when hatchery releases were high and therefore likely had a great influence on population abundance. In addition, the reviewer indicated that hatchery contributions in natural spawning areas may not be limited to areas adjacent to the two hatcheries in the basin. However, this same reviewer concurred with the conclusion reached by the BRT concerning the status of the ESU and did not disagree with the conclusion reached by the BRT that spring-run and fall-run Chinook salmon constitute a single ESU, although the reviewer asked that the document more clearly present

criteria used to distinguish among populations. The final document includes additional text that clarifies the BRTs approach and consideration of the issues raised by the peer reviewers.