CENTER FOR INDEPENDENT EXPERTS (CIE) REVIEW OF THE KLAMATH RIVER FALL CHINOOK ASSESSMENT

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EXECUTIVE SUMMARY

Seasons and quotas for management of the harvest of Klamath River Fall Chinook are set by predicting the run with an assessment model, and tuning fishing effort and quotas (subject to some allocation constraints) with a harvest model in an attempt to meet specific conservation objectives. The assessment model involves a complicated cohort analysis based on returns from an extensive coded wire tag program. With respect to the narrow question about the assessment approach and methods and data, I think they constitute good enough science for the application, and are at the better end of the range of accepted good practice. There are options to enhance the integration of the assessment and estimation process, but it is not clear that this would lead to substantially different point estimates of the decision quantities (or to different decisions under the present decision rules). Integration probably would lead to easier reviewability and better quantification of the uncertainty, which in turn might facilitate power analyses to explore the potential for improving the estimates by investing in a directed way in more data collection.

BACKGROUND

The Klamath River Fall Chinook (KRFC) is a complex of naturally reproducing stocks occupying a large basin and augmented by strays from a large hatchery program. The runs in the last few decades are considerably diminished from earlier historic highs. The river has undergone considerable habitat degradation over the years, and the stock is subject to an epizootic. There is suspicion that higher production would be achievable if the population were allowed to rebuild to a higher spawning stock level. Recent policy has set a natural spawning escapement floor objective for management that is not being attained. Seasons and quotas are set by predicting the run with an assessment model, comparing to the objectives, and tuning fishing effort and quotas (subject to some allocation constraints) with a harvest model in an attempt to meet the conservation objectives. The assessment model involves a complicated cohort analysis based on returns from an extensive coded wire tag program.

The SOW for this CIE review requested an appraisal of the methods, approach, and data for the assessment used in the management procedure, and a determination whether this meets the standards of "best science."

DESCRIPTION OF REVIEW ACTIVITIES

My review was conducted by reading the materials provided on the RSMAS CIE website for this project (and listed here in the Documentation). No additional material was consulted, there was no discussion with other reviewers, there were no briefings, or iteration with the program under review. There was no attempt to reproduce any of the calculations in the assessment.

COMMENTS ON FOCUS OF THE REVIEW

My interpretation of the SOW is that the "conservation objectives" for management of the Klamath River fall chinook (KRFC) stated in the PFMC Salmon Framework Management Plan are to be treated as given, and the review is to be concerned with whether the "approach and methods" used in the management assessment for the implementation attempts to meet these objectives conform to the "best available science." This is a little odd, since the scientific reasonableness of the approach depends in part on the scientific reasonableness of the objectives, and further it turns out that the motivation for one of the critical concrete limits stated in the objectives depends in part on analyses that depend on the assessments. To this extent it really should be evaluated as a package deal.

The conservation objectives consist of an escapement floor, a relative escapement reduction limit, allocation constraints, and a harvest rate limit. The escapement floor is the key provision that recently has not been attained, and is feared will not be attained in the immediate future. The escapement floor also has a biological foundation in its relation to an attempt to manage for MSY. It is known that escapement floor (or constant escapement) management strategies in the context of salmon fisheries, are robust systems. So, scientifically, the escapement floor approach is a good idea.

The particular quantitative limit adopted for the natural spawning escapement floor in the PFMC Salmon Framework Management Plan is 35,000. The paper trail indicates that this was chosen in an attempt to manage for MSY of the natural spawning population. The analyses in support of the 35,000 figure as the MSY escapement for the natural spawning population use estimates of spawner numbers and recruitment obtained from the assessment procedure, assuming a dynamically homogeneous closed population. The actual natural spawning population is certainly not closed and probably not dynamically homogeneous. Hatchery spawned fish stray to the natural spawning grounds in nontrivial numbers in this system. The per capita productivity in natural spawning of hatchery spawned and natural spawned fish have not been estimated separately in the KRFC, so it is not known if they are the same. It is generally suspected in the science that these will not be the same. The estimation of MSY escapement for KRFC could profitably be re-examined in this light.

The Klamath basin is large compared to the homing resolution of spawning salmon, so this presents opportunity for development of local stocks with different respective productivities and different respective adaptations. From the background material provided it appears that local stock productivity differences and local adaptation have not been estimated for the KRFC, so the extent of these dynamic differences is not known. It is generally suspected in the science that these differences can be considerable. In the presence of substantial differences of productivity among stocks, managing harvest for MSY of the aggregate will overharvest the less productive stocks, and could eliminate some of them, with consequent loss of local adaptations, if present, and loss of genetic resources from the population as a whole. In this respect, the aggregate MSY objective is probably underprotective, if preservation of local subpopulations, local adaptation, and genetic diversity are explicit or implicit goals of management (and present belief is that they should be).

The degree of hatchery straying into the natural spawning area raises further conservation concern about the fitness effects on the natural spawning population of introgression with a hatchery stock. It is generally suspected, but unproven, that the fitness degradation could be considerable. For this reason, if fitness of the natural stock is a goal (and present belief is that it should be), it would be sound practice to limit hatchery production to meet a constraint on maximum fraction of hatchery strays in the natural spawning population. In a large important fishery, which the KRFC is, with an ambitious and strong monitoring program, it would make scientific sense to monitor specifically for fitness effects. The paper trail in the background material provided does not indicate policy attention to fitness considerations. The Management Plan conservation objectives might usefully be updated in this respect, and sophisticated monitoring for fitness effects would be appropriate for a flagship program of this significance.

Finally, the statement of the escapement floor objective is unclear about whether this is a limit reference point or a target reference point. The operation, as described, of setting each year's quotas and effort restrictions treats the escapement floor as a target reference point (which accordingly will be missed with appreciable frequency). The fact that missing this target in three consecutive years triggers a determination of overfished, and consequent requirement for a rebuilding plan, treats the 3-year status as a limit reference point.

Depending on the perceived onerousness of the overfished determination, it might be prudent to set the target higher in order to reduce the frequency of violating the limit. In general, my impression from the background material is that there has been insufficient policy attention to the implications of uncertainty, though the technical documents show an awareness of the issues.

SUMMARY OF FINDINGS

Best Science in Context

The term "best science" appears as a mandate in legislation and regulation, but it is not defined therein, and, though there have been good discussions in the scientific literature, I don't think there has yet been a definitive legal determination or a definitive scientific consensus. What follows are my own ideas as applied to the questions posed in the matter of the assessment of the Klamath River fall chinook.

The specific charge in this review is to consider the four components of the assessment process, namely:

(1) estimation of the previous year's river returns,

(2) cohort reconstruction of the natural and hatchery stock components based on coded-wire tag recoveries,

(3) forecast of the current year's ocean abundance and proportion of natural fish, and

(4) forecast of the current year's harvests and spawner escapement under proposed management measures, and evaluate them from the standpoints of adequacy and appropriateness of the

(a) approach,
(b) data,
(c) methods and assumptions,

and evaluate the uncertainty and judge whether this constitutes "the best available science for the intended purpose." I will take these questions in a somewhat different order that seems logical to me.

Adequacy and Appropriateness of the Data

Realistically, the data available for a program of this size are primarily a constraint rather than a design option. The analysis depends heavily on the time series nature of the data, and that history has already transpired. The main question then about past data is whether the analysis is effectively using all of the pertinent past information, and I think the answer is "yes." With respect to questions of design changes for future data collection, the cost must be taken into account. Undoubtedly more data would be better, in the abstract. But a specific power analysis needs to be done to quantify how much the precision of the assessment would be improved by a specified increase in quantity and quality of data, achieved by a concrete proposed design, so that the benefits of the improvement of the estimates could be weighed against the cost of the added data. I did not see from the documentation whether a power analysis of this sort has been done. The performance testing reported in the background material definitely does document the effect of assessment imprecision on the resulting performance in terms of relevant quantities such as mean harvest, variability in harvest, and frequency of closure.

Now, it is reasonable to ask whether a particular directed change, of modest magnitude and cost, in data collection would promise to make a disproportionately large improvement in precision. With the assessment targeting the current stated policy objectives, I did not see obvious opportunities for large improvements at little cost. I would be most curious about additional calibrations to pin down the correct expansions for the spawning ground estimates, which would improve the certainty of the post-season estimates of spawning escapement, but I am not sure how big a difference this would make to the pre-season estimation that drives the actual decisions. Maybe this is worth analyzing.

If the policy objectives were expanded, as I think they should be, to include considerations of local substocks, separation of contributions of hatchery strays to the apparent productivity, and concern about possible fitness degradation from hatchery introgression, then there definitely would need to be qualitative additions to the list of what is measured and how it is measured.

Adequacy and Appropriateness of the Assessment Approach

Given that the data are what they are, the chief question about the approach and methods is whether they are making effective use of the data to deliver credible assessments. I think the answer here is "yes." The critical measure of uncertainty, in the context of how the assessments are used for management, is revealed in the comparison of pre-season and post-season assessments of spawning escapement. The provided sample size of such comparisons is small (4), and it reveals a substantial error (ranging from a multiplicative error as large as 150% in the direction of underestimates, and as large as 30% in the direction of overestimates) but there is no glaring indication of bias, and the error magnitude is not surprising, considering the likely estimation error in both the quantities being compared. The provided management strategy evaluation shows that the optimum (in terms such as long term average harvest) location of the escapement floor is reasonably robust to the plausible range of error variance, though of course the error does degrade the mean performance as expected. The management strategy evaluation also indicates that no parties are being systematically cheated in the allocation as a result of the uncertainty.

In this context, then, the uncertainty, like the data, is what it is. The most that can be demanded is that the uncertainty itself be estimated, which it has, and that it be minimized through efficient analysis, which seems to be the case.

As for the scientific soundness of the approach and methods for the components of the assessments, all four components pass muster. The estimation of the previous year's river returns of natural spawners is based on combinations of redd counts, weir counts, and carcass mark recapture estimates. This is standard practice for obtaining abundance indices. The scaling to absolute abundance might be worth a closer look for cross-calibration. The cohort reconstruction of the natural and hatchery stock components based on coded wire tag recoveries, along with the estimates of absolute harvest and spawning escapement, is a well-accepted, though a very complicated method. This component is central to the provision of parameter estimates and state estimates for the two forecast components. The forecast of the current year's ocean abundance and proportion of natural fish is a straightforward regression based on the cohort analysis. The forecast of the current year's harvests and spawner escapement under proposed management measures, is straightforward book-keeping application of estimated rates to the results of the abundance and proportion natural spawning forecasts.

Best Science Revisited

This system is at the better end of the spectrum of assessment systems in actual management use. It is not quite at the cutting edge of methods currently under academic investigation, where there is a reasoned preference for integrated assessments (rather than passing on the point estimate from one component as an input to another component), and for Bayesian analysis to better account for uncertainties and enforce reasonable constraints on estimates. As the assessment system for KRFC evolves, consideration should be given to reconfiguring it as an integrated assessment and Bayesian analysis. This can use all the present underlying models, but it would package them differently and obtain parameter estimates in a somewhat different way. I think that would lead to a system that is easier to review in depth and for which uncertainty quantification and power analysis would be easier.

It should be noted that the kind of review I conducted within this CIE framework stops far short of attempting to duplicate any of the calculations or to compare the results to alternative analyses. For an assessment procedure of this complexity, attempts at duplication of calculations or comparison with alternative analysis would be a very large undertaking. But because of the complexity, the opportunities for calculational or coding errors are multifold, and the possibilities latent in the exploration of alternative analyses are worthwhile.

CONCLUSIONS/RECOMMENDATIONS

In summary, with respect to the narrow question about the assessment approach and methods, I think it is good enough science for the application, and at the better end of the range of accepted good practice. There was no mention in the background material of an existing competing analysis for this fishery using different data or different methods. If there were, that would give more point to asking which was "best."

There are options to enhance the integration of the assessment and estimation process, but it is not clear that this would lead to substantially different point estimates of the decision quantities. For better or for worse (I suspect worse), the present decision system uses only point estimates of these quantities. A restatement of the management objectives in probabilistic terms (distinguishing clearly between target and limit reference points) would create an opportunity to make use of the better quantification of uncertainty.

APPENDIX I: BACKGROUND MATERIAL

Goldwasser, L., M. S. Mohr, A. M. Grover, and M. L. Palmer-Zwahlen. 2001. The supporting databases and biological analyses for the revision of the Klamath Ocean Harvest Model. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

KRTAT (Klamath River Technical Advisory Team). 2006. Klamath River fall Chinook age-specific escapement, river harvest, and run size estimates, 2005 run. Unpublished report. Klamath Fishery Management Council, Yreka, CA.

KRTAT (Klamath River Technical Advisory Team). 2006. Ocean abundance projections and prospective harvest levels for Klamath River fall Chinook, 2006 season. Unpublished report. Klamath Fishery Management Council, Yreka, CA.

KRTT (Klamath River Technical Team). 1986. Recommended spawning escapement policy for Klamath River fall-run chinook. Unpublished report. Klamath Fishery Management Council, Yreka, CA.

Mohr, M. S. 2006. The cohort reconstruction model for Klamath River fall Chinook salmon. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

Mohr, M. S. 2006. The Klamath ocean harvest model (KOHM): model speciation. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

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Mohr, M. S. 2006. The Klamath ocean harvest model (KOHM): model performance. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

NWFSC/SWFSC (Northwest Fisheries Science Center/Southwest Fisheries Science Center). 2006. Comments on the Klamath River fall-run Chinook salmon fisheries management plan escapement floor. Unpublished report. National Marine Fisheries Service, Seattle, WA.

Prager, M. H. and M. S. Mohr. 1999. Population dynamics of Klamath River fall Chinook salmon: stock-recruitment model and simulation of yield under management. Unpublished report. Klamath Fishery Management Council, Yreka, CA.

Prager, M. H. and M. S. Mohr. 2001. The harvest rate model for Klamath River fall Chinook salmon, with management applications and comments on model development and documentation. North American Journal of Fisheries Management 22:533-547.

STT (Salmon Technical Team). 2000. STT recommendations for hooking mortality rates in 2000 recreational ocean chinook and coho fisheries. Unpublished report. Pacific

Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2005. Salmon Technical Team report on the technical basis for the Klamath River fall Chinook conservation objective. Unpublished report. Pacific Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2005. Klamath River fall Chinook stock-recruitment analysis. Unpublished report. Pacific Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2006. Review of 2005 ocean salmon fisheries. Unpublished report. Pacific Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2006. Preseason report I: stock abundance analysis for 2006 ocean salmon fisheries. Unpublished report. Pacific Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2006. Preseason report II: analysis of proposed regulatory options for 2006 ocean salmon fisheries. Unpublished report. Pacific Fishery Management Council, Portland, OR.

STT (Salmon Technical Team). 2006. Preseason report III: analysis of council adopted management measures for 2006 ocean salmon fisheries. Unpublished report. Pacific Fishery Management Council, Portland, OR.

APPENDIX II: STATEMENT OF WORK

Consulting Agreement between the University of Miami and Dr. Dan Goodman

<u>Statement of Work</u>

Klamath River Fall Chinook Salmon
Assessment Approach and Methods Review

Background

The primary purpose of this technical review is to assess whether the approach and methods presently used to conduct the annual fishery assessment of Klamath River fall Chinook (KRFC) salmon constitute the best available science for this purpose.

KRFC salmon are a key stock for salmon fisheries management in California and Oregon waters. The Pacific Fishery Management Council's (PFMC) Salmon Framework Management Plan identifies explicit annual conservation objectives for KRFC, including (i) at least 35,000 adults must be allowed to escape fisheries to spawn in natural areas (minimum spawner "floor"), and (ii) the number of adults that would spawn in natural areas absent fisheries may be reduced by fisheries by no more than 2/3 (maximum spawner reduction rate). Allocation of the KRFC annual harvestable surplus to various user-groups is also explicit, including the (a) Klamath River tribes share of overall harvest, (b) Klamath River recreational share of nontribal harvest, (c) Klamath Management Zone recreational share of ocean harvest, and (d) California commercial share of ocean commercial harvest. The KRFC ocean age-4 annual harvest rate is also used as a proxy measure of the ocean harvest rate on California Coastal Chinook (ESA-threatened), and for this purpose may not exceed 16%.

Fishery management measures are crafted by the PFMC each year to achieve these annual KRFC objectives. Whether the proposed management measures are expected to achieve these objectives requires an annual assessment of KRFC stock status and the fishery impacts expected under these measures. It is imperative that the approach and methods used to conduct this assessment constitute the best available science for this purpose.

Objectives of the CIE Review

The KRFC annual assessment consists of four principal sub-assessments: (1) estimation of the previous year's river returns, (2) cohort reconstruction of the natural and hatchery stock components based on coded-wire tag recoveries, (3) forecast of the current year's ocean abundance and proportion of natural fish, and (4) forecast of the current year's fishery harvests and spawner escapement under PFMC-proposed management measures. The Center for Independent Experts (CIE) shall review each of these sub-assessments to ensure that the respective approaches and methods constitute the best available science for the respective purposes.

The CIE reviewers must have expertise in the population dynamics and assessment of Pacific salmon, and experience with cohort reconstruction and projection methods is beneficial. Extensive experience in Pacific salmon fisheries dynamics modeling, assessment, management, coded-wire tag analysis, and in-depth knowledge of the Klamath River and its tributaries is desirable.

Each reviewer will be supplied with a document entitled “Klamath River fall Chinook salmon: assessment approach and methods – an overview”, and an electronic copy of all reports and papers cited therein. The CIE individual reviewer will review each of the four principal sub-assessments as described in this overview document and the materials cited therein, according to the following terms of reference.

CIE Review Terms of Reference (apply to each sub-assessment):

1. Evaluate the approach: determine if it is adequate and appropriate for the assessment.
2. Evaluate the data: determine if it is adequate and appropriate for the assessment.
3. Evaluate the methods and assumptions: determine if they are adequate and appropriate for the assessment.
4. Evaluate the uncertainty: determine the primary sources of uncertainty in the assessment.
5. Determine whether the data, approach and methods constitute the best available science for the intended purpose.

Specific Activities and Responsibilities

The CIE shall provide three reviewers to participate in a letter review of the KRFC annual fishery assessment approach and methods – two individual reviewers and one reviewer to compile a summary document. A third reviewer, chosen by the SWFSC, will be:

- Dr. Robert Kope (NMFS, Northwest Fisheries Science Center)

The CIE will select three reviewers; two to provide written individual reports, and a third to develop a summary report of the three individual reports. The third reviewer will not develop an individual report, but will be solely responsible for development of the summary report. The CIE individual reviewers’ duties shall not exceed a maximum of 7 work days for development of the individual report. The CIE summarizer’s duties shall not exceed a maximum of 6 work days for development of the summary document. The reviewers shall conduct his/her review duties from their primary locations, and by conference call as necessary and coordinated through the CIE. The CIE reviewers will write the individual and summary reports on their findings and conclusions regarding the above terms of reference. See Annex 1 and 2 for additional details on the report outlines.

All reports from the CIE individual reviewers and the CIE reviewer responsible for developing the summary document shall be sent to Dr. David Die, via email at david.die@rsmas.miami.edu, and to Mr. Manoj Shivlani, via email at mshivlani@rsmas.miami.edu. The SWFSC shall provide the individual report from Dr. Robert Kope to Dr. David Die, via email at david.die@rsmas.miami.edu, and to Mr. Manoj Shivlani, via email at mshivlani@rsmas.miami.edu by December 7, 2006 for distribution to the CIE summary reviewer. The CIE will not be responsible for review and approval of the report by Dr. Robert Kope. The following table provides the specific timeline for report submission, review and approval.

Activity	Submission	Deadline
Distribution of NMFS documents	Documents provided by the SWFSC to the CIE, CIE reviewers, and the NMFS reviewer.	November 15, 2006
Individual reports submitted	Submission of draft CIE individual reports to the CIE and to summarizer. The report by Dr. Robert Kope will be submitted to the SWFSC, who will provide a copy to the CIE for distribution to the CIE summary reviewer. [/1]	December 7, 2006
CIE approval of CIE individual review reports	CIE reviews and approves the CIE individual review reports. CIE provides final individual review reports to the summary reviewer and to Lisa Desfosse.	December 21, 2006 [/2]
Summary document	Draft summary document submitted to CIE by third CIE reviewer.	January 4, 2007 [/2]
NMFS approval of individual reports	NMFS approves CIE individual reports.	December 29, 2006 [/2]
CIE approval of summary document	CIE reviews and approves summary document and provides to Lisa Desfosse.	January 18, 2007 [/2]
NMFS approval of summary document	NMFS approves summary document.	January 22, 2007 [/2]

[1/] The CIE will not be responsible for review and approval of the individual report by Dr. Robert Kope. The CIE will distribute this report to the CIE summary reviewer upon receipt from the SWFSC.

[2/] Dates assume that all individual reports are submitted to the CIE by December 7, 2006. Any delays in submission of individual reports will result in delays in other activities and potential extension of these deadlines.

Submission and Acceptance of Reports

The CIE shall provide via e-mail the CIE individual and summary reports according to the table of deliverables to Dr. Lisa Desfosse (lisa.desfosse@noaa.gov) for review of compliance with this Statement of Work by NOAA Fisheries and approval by the COTR, Dr. Stephen K. Brown. The COTR shall notify the CIE via e-mail regarding acceptance of the reports. Following the COTR's approval, the CIE shall provide the COTR with pdf versions of the final reports.