Review of Biological Opinion on the effects of Ocean Harvest of Salmon on Central Valley Chinook Salmon Evolutionary Significant Units (ESUs)

An External Independent Peer Review Report

produced by

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produced for

The Center for Independent Experts (CIE)

Executive Summary:

This review was conducted to identify the strength and weaknesses of the recent biological opinion formulated on the effect of ocean fisheries on a winter-run Chinook population subject to conservation concerns. The review focused primarily on the technologies and analytical methods to assess fishing impacts, the interpretation of the results in light of how the fisheries are managed, and if the best scientific information available was used to generate the opinions.

The major conclusions were that investigators have relied on proven and cost-effective methodologies to assess large-scale fishery impacts. Most of the results obtained are considered to be scientifically credible, which is no small feat given the various constraints caused by fishery management practices, existing monitoring programs, the life history attributes and demographic traits of winter Chinook, and their relatively low abundance and restricted distribution, and short time series of information from tagging programs. And in light of such constraints, some of the best scientific information available was used to provide the biological opinion.

The major weaknesses detected concern mainly the occasional use of overly simplistic hypotheses when assessing fishing impacts, the use of deterministic assessment methods that do not account well for observations errors and stochastic variation in some key processes, and the fact that the population viability analysis used to provide some of the biological opinions do not account for the range of the fishing impacts that would be predicted after accounting for some of the underlying uncertainties.

Some recommendations are offered in the hope that improvements can be made in the short term, without having to make major changes to current programs and operations. These are given below for each opinion requested under the Terms of Reference (ToR). Additional details

are provided in the main body of this report, but will not be re-iterated here for purposes of brevity.

ToR 1: Cohort reconstruction analysis used to estimate fishing harvest impacts.
Continue collecting and using CWT data to update future assessments. Some functions should be replaced by more realistic ones, including those on growth and survival to better account for the hypothesized recent changes in ocean conditions.

ToR 2: Interpretation CWT recoveries and cohort reconstruction analysis results in light of how the fishery is managed.
No major recommendations on this issue, although efforts should be made to determine the extent of unaccounted tag losses in some fisheries (like commercial trawl fisheries) that are likely not subject to extensive surveys to recover tagged salmon heads.

ToR 3: How could the cohort reconstruction data or analysis be improved?
Obtain data on the age and sex contributions to natural escapements to improve the assessment procedure. Verify the stream survey procedures used to ensure they do not cause violations of the mark-recapture model used for escapement estimation purposes, and determine if adjustments are required to deal with sample sample size issues. Consider tagging naturally produced Chinook to ensure they have demographic traits comparable to those of tagged hatchery releases. Conduct Monte Carlo simulations to account for various uncertainties, and generate frequency distributions of derived estimates to show the most likely impacts and their plausible ranges.

ToR 4: On the use of quantitative or qualitative ways to assess harvest impacts.
Consider using the stock reconstruction results in additional numerical simulation models designed to evaluate the potential impacts of various fishing plans. Test fishing operations coupled with the genetic analyses of bio-samples should also be considered, to provide the in-season indices of abundance required to justify fishery openings in the absence of reliable pre-season forecasts.

ToR 5: Formulating biological opinions using the best scientific information available.
While some of the best scientific information available is being used for biological opinions, better use of all the fishing impact information should be done to improve the assessments. Stock reconstructions and numerical simulations that can account for the underlying uncertainties should be conducted. The distribution of plausible outcomes should be used in the population viability analyses to determine the relative probability that the populations and the ESUs are in certain risk of extinction categories.

Background :

Fisheries in the U.S. Exclusive Economic Zone (EEZ) are managed by NOAA's National Marine Fisheries Service (NMFS) under authority of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA). NMFS is also responsible for administering the Endangered Species Act (ESA) with respect to most marine species, including anadromous salmonids. Section 7(a)(2) of the ESA requires federal agencies that propose an action which may affect listed species consult with NMFS to ensure that actions do not jeopardize the continued existence of threatened or endangered species. NMFS is responsible for authorizing ocean salmon fisheries in the EEZ, through its Sustainable Fisheries Division (SFD). NMFS also reviews the effects of those fisheries on listed species for which it has jurisdiction, through its Protected Resources Division (PRD).For the purposes of consultations on federal fishery management activities under the ESA, NMFS serves as both the action and consulting agency.

Commercial and recreational ocean salmon fisheries off the U.S. West Coast that are authorized by NMFS under the MSA are managed under the Federal Pacific Coast Salmon Fishery Management Plan (FMP). Pacific Fishery Management Council (PFMC) provides input for the development of the FMP, including amendments, updated management measures and recommendations to the Secretary of Commerce through the NMFS for review and approval. The Secretary may approve the PFMC's recommendations for implementation as federal regulation if found to be consistent with the MSA and other applicable law, including the ESA.

Twenty-eight (28) salmon evolutionarily significant units (ESUs) are listed as threatened or endangered under the ESA on the U.S. west coast. The Sacramento River Winter-Run Chinook ESU has been listed as endangered. In the past, regulatory actions have been taken to reduce the incidental take of this ESU in the ocean salmon fishery.

An updated assessment of the ocean salmon fishery impacts on winter-run is required because the current biological opinion authorizing the incidental take of winter-run expires on April 30, 2010. PRD, SFD, and the Southwest Fisheries Science Center (SWFSC) agreed that the information required for this purpose included spatial and temporal data on ocean distribution, the spawner reduction rate (SRR, see later sections), and age-specific ocean fishery impacts. During Aug.-Nov. 2009, the SWFSC and PRD obtained and analyzed recovered coded wire tag (CWT) data of winter-run for 2000-2007. Preliminary estimates of fishing impacts from cohort reconstructions were obtained in October 2009. A Biological Assessment (BS) containing the results of final analyses and supplemental documentation was generated in early January 2010.

The NMFS Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects.

Description of the reviewer role and review activities:

The reviewer is requested to conduct an independent peer review of the NMFS project reports as specified in the Statement of Work (SOW) and Terms of Reference (ToR). The reviewer must complete the review according to required format and content as described in Annex 1 (given below):

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
3. The reviewer report shall include an Appendix 1 containing a bibliography of materials provided for the review, and an Appendix 2 containing copy of the CIE SOW.

The CIE reviewer must also complete the independent peer review addressing each ToR as described in Annex 2 (given below):

1. Evaluate the strengths and weakness of the cohort reconstruction analysis used to estimate the impact of fishing harvest on the ESUs considered in this Opinion.
2. Evaluate the interpretation of the coded wire tag recoveries and cohort reconstruction analysis, and any conclusions drawn about how these results are produced in light of how the fishery is managed.
3. How could the cohort reconstruction data or analysis be improved?
4. Are there additional quantitative or qualitative ways other than coded wire tag based methods to assess harvest impacts not considered in this Opinion?
5. Overall, does the biological opinion represent the best scientific information available?

The CIE reviewer must complete the following chronological list of tasks a timely manner as specified in the SoW, namely

1. Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2. Conduct an independent peer review in accordance with the ToRs.
3. No later than 9 February 2010, submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Summary of Findings:

<u>Document Reviews: Major Comments</u>

Some issues that raised concern were identified when reviewing the various reports. These include perceived computation problems, information gaps, tenuous or unsupported hypotheses, statements requiring clarifications, and possibly missed comments. The main issues are described below since they form the basis for some of the opinions provided later on in this report.

A: Cohort Reconstruction: O'Farrell et al. (2010)

1. Escapement: Surveys are conducted in natural streams to recover tags, and survey records also serve to compute Jolly-Seber (J-S) mark-recapture estimates of escapements and CWT escapements, partly via Eq. B-2. The J-S model is well-suited for estimating 'open' populations, whose abundance can change during the survey period due to immigration, emigration, and other factors. It requires the application of uniquely numbered marks to individuals during repeated surveys to tract their recapture histories. A crucial piece of information is the last time marked fish are recaptured during the surveys. O'Farrell et al. (2010) note that during surveys, fresh carcasses are externally tagged, and if later recovered during a subsequent survey, they are "chopped in half to preclude counting at a later date" (p. 6). Does this mean their marks are no longer recorded in later surveys? If so, the last time a mark could have been detected cannot be determined, so the disposal procedure can lead to a violation of a crucial assumption of the J-S model.

   Accurate J-S estimates also require that marked and unmarked fish have the same probability of recapture (or catchabilities) during successive surveys, and adjustments are needed to reduce the bias of estimates based on small sample sizes. Seber (1982) note some requirements to ensure that the estimates are 'robust' (p. 506) and details on methods to reduce bias for small samples (p. 204). O'Farrell et al. (2010) provide insufficient information on such issues. In Appendix C, the CDFG (1989) is cited as the source for annual escapement estimates, but is 'unpublished'. Other references cited on p.6 are Willam and Kreb (2008) and USFWS (2008), but were not provided or readily available for this review.

   Further details are needed to judge if sufficient efforts were made to ensure the escapement estimates are sound. This is important given that the figures in Appendix D indicate that CWT escapements to natural systems occasionally outnumber the trap recoveries and can even surpass the fishery recoveries. Erroneous estimates of escapements to natural streams could have a substantial influence on the cohort reconstructions results.

The expansion factor derivation section does include a description of the equations used to compute various figures needed to determine the ‘expected’ CWT recoveries in a sample/ However, it does so without going into details about issues such as proportions of heads examined that that no CWT, proportions of CWTs that could not be identified when examined, how the number of successfully identified CWTs are expanded to account for missing or undecipherable CWTs, and the [suspected] proportion of wild Chinook with naturally missing adipose fins. A statement and references should be provided to explain these details.

2. River harvest: The 2000-2002 surveys did reveal some recoveries up to January 2001. There were no river fishery sampling after, and no information about potential losses due to poaching. Do current creel surveys have large coverage rates, and involve over-flights to monitor fishing activities in periods or regions not surveyed ? The actual number of in-river CWT recoveries could exceed the reported figures. If not, it should be stated that unaccountable removals are considered to be negligible and why.

3. Ocean harvest: All POFV landing points within a port area are supposedly sampled. Does this include private marinas? Any reference for the stratified random creel survey method used and its assumed coverage rate. CWT recovery estimates based on the product of observed recoveries and the reciprocal of a low coverage rate (<15 %) would be subject to considerable uncertainty, more so if there were unaccountable removals.

4. Cohort reconstruction: The figures on p_{oztzx} (Eq. 3) representing the proportion above a size limit are computed by reference to the SRWC length-at-age model, with the predicted means and standard deviation values given in Table A-1. Using the Table 1 figures, based on the unpublished report of CDFG (1989), may be problematic. Argue et al. (1983) noted there are seasonal changes in Chinook growth, with females growing more rapidly to attain a size limit sooner causing earlier fishing impacts. Perhaps the same is true for SRWC. Also, the Table 1 figures are obviously computed using a linear relation between the standard deviation (SD) and the mean size-at-age (SD≈mean*0.1). This is a common assumption in some assessment circles (see Fournier et al. 1990), but several analyses of combined tagging and age records for pelagic species indicated that that variation in size-a-age tends to increase until a certain age, and then decreases progressively for older ages with greater mean lengths. And finally, Lindley et al. (2009) also reported substantial changes in oceanic conditions off the US west coast, which could influence the SRWC growth rates during the period of interest.

   Given such facts, it would seem advisable to use alternative length-at-age distributions that can account for sex-specific growth rates, seasonal growth cycles, variation in length-at-age, and the effects of ocean conditions if there is reason to suspect that such factors can influence the size-at-age distribution of SRWC Chinook, and their rejection rates in some fisheries.

5. The drop-off mortality rate (*d*, p.5) may be different for the recreational and commercial fisheries. Substantial differences in trolling speed and hook shape would be important factors, so is the average size of the Chinook intercepted. A literature review might suggest that different and fishery-specific coefficients should be applied.

6. On p.11, it is stated that the monthly mortality rate for age 2 is 0.0561, "which corresponds to a 50% annual rate". The figure 0.0561 must be the 'instantaneous rate", that translates into annual survival rate = exp(-0.0561*12) = 0.51 or ≈49% mortality rate in the absence of fishing mortality. This section needs clarification, but more important is the lack of justification for using constant rates for some age groups and periods. Given changes in ocean conditions described by Lindley et al. (2010), there could be substantial variation in natural mortality rates acting on the the early life history stages of some cohorts. O'Farrell et al. (2010) should try to account for major hypothesized changes instead of relying on constant rates. As noted by Argue et al. (1983), assuming unrealistically low mortality rates in cohort reconstructions can translate into lower back-calculated recruitment figures, and excessive optimism about the effects of proposed conservation measures.

7. Eq. 10-11 use the 'mean age-4 maturation rate' for the fully recruited cohorts, given in Table 3. The distribution of m_4 values is not symmetrical or bell shaped, and in such cases, the median is a better measure of central tendency. The m_3 and m_4 means are .93 and .96, and the medians are .95 and 1.0, so larger for groups. While the approximation of abundance and maturation rate for age-4 fish of the 2004 cohort may be viewed necessary to produce the most estimates possible, using approximations for two age groups of the 2005 cohort simply involves too many unsupported assumptions. The latter figures should not be used to show trends until additional data is obtained. The following section on computing minimum and maximum bounds for incomplete cohorts should also be eliminated, as it involves even more conjecturing

8. Results: The y axis for age-4 impacts in Fig.1 does not cover the top of the 2005 bar and should be rescaled. The caption of Table 3 says incomplete broods instead of incomplete cohorts, and 2005 brood year figures should be removed. The 2005 cohort figures should also be removed from Fig. 4-5, along with related comments in the text. When additional data becomes available in the future, the authors could do a retrospective analysis to see if the trends based on many assumptions are close to those based on complete figures, and if they are, consider using this argument to justify including the incomplete cohort figures in trends for future reports.

9. Is there any explanation as to why survival up to age-2 would vary by almost two orders of magnitude over such a short period (p.24)? Some scientists might suspect this could reflect [at least partly] changes in the condition of the smolts released in the streams each year.

10. Discussion: Before conjecturing on the effects of ocean regulation on p. 25 via a comparison of the Fig. 11 plots, O'Farrell et al. (2010) should note the issue reported by NMFS (2010b, p.21) on the "problems were associated with this study using fin-clips". A direct comparison of the harvest patterns does not accurately reflect the effects of fishing regulations implemented since 1990, but does reveal tendencies.

B: Biological Opinion (NMFS 2010a)

1. Above Table 3, it is stated "because the winter-run age 3 maturation exceeds 85% (Table 6), the escapement is generally dominated by age-3 fish. This implies that the ratio of the escapement in any given year divided by the escapement three years earlier will provide a close approximation of the CRR for that brood". How close is close enough?. There is no certainty that the ratio (escap_yr/escap_yr-3) is that close to SPR or CRR, partly because age-4 (or age 5) spawners can be >30% more productive than age-3 Chinook (that lay fewer/smaller eggs), and older age-groups could have accounted for <15% of the spawners in some years of interest. Without reading the report by Anderson et al. (2009) to check the SPR or CRR equations, and in the absence of information on the NMFS bio-standards for winter-run Chinook, one is led to question the accuracy of the productivity and viability thresholds (or their ranges) used to set conservation goals.

2. Table 3. Escapement figures in column 2 are based on RBDD counts until 2001, and then from carcass surveys. Could the major increase in escapement for 2001-2006 versus 1986-2000 be caused by changes in survey methods? Were comparative surveys conducted with both methods over 2-3 years to determine if they provide comparable estimates? The issue is raised again in the following section "A. Ocean salmon fishery and winter-run ESU". The authors confirm that estimates based on carcass surveys tend to be higher than RBDD estimates, but then conjecture that the increased spawning return was "most likely" the result of multiple other factors. The potential effects of changing survey methods on the escapement estimates should be assessed and documented. Abundance estimates based on carcass surveys may be substantially biased under some conditions, and not always in the same direction. The time series should be corrected, if need be, to more clearly reflect the actual changes.

3. Table 3. Is there a sound justification for the 5-year moving average of CRR ?

4. Section IV-A: There are Chinook by-catches of bottom and mid-water trawl fisheries off Washington, Oregon, and California. The allowed incidental takes were exceeded during (at least) 2002-2005. Are fin clipped Chinook sampled for CWT, or simply discarded for fear of penalties? The reported (if any) and unreported catches are not included in the cohort reconstructions, and may not be 'insignificant' as implied in the Moran et al. (2009) report cited. O'Farrell et al (2010) do not account for potential losses in the cohort reconstructions, but efforts should be made to account for potential losses.

5. Section IV-A: Information on survival and ocean distribution is provided via the use of " a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within the ESUs". The underlying assumption is that hatchery and non-hatchery fish have similar life histories and migration patterns. This is a bad assumption. There is ample evidence from multiple studies that hatchery reared fish can have survival rates and migration patterns that differ substantially from natural stocks. Labelle et al. (1997) showed that coded-wire tagged coho of natural and hatchery origin that emigrated from the same or adjacent streams could exhibit large differences in survival, distribution and exploitation.

6. After Fig. 12: There seems to be two sections "3.". Also, it states that "The PFMC employs a standard 5% drop-off mortality rate, applied to all fishery contacts". What is the justification for this assumption? The cohort reconstructions should account for the potential variation in drop-off mortality rates.

C: Effects of ocean salmon fisheries (NMFS 2010b)

1. "The length of time the [fishing] areas are open in any one year depends on salmon stock abundances in excess of the conservation objectives and the spatial distribution of constraining stocks" (p.10). While the conservation objectives may be established before the fishery openings, there is no information provided on the in-season assessment procedure used by the fishery management authorities to determine if the run sizes are sufficiently large to allow the planned fishery openings.

2. The footnote on p.21 emphasizes that there were "problems were associated with this study using fin-clips". If so, the direct comparison of the harvest patterns does not accurately reflect the effects of fishing regulations implemented since 1990. At most, it would show tendencies. This needs to be emphasized.

D: Collapse of fall Chinook (Lindley et al. 2009)

1. The authors note (p. 14) that the PVA results are very sensitive to the data and model assumptions. The authors further emphasize (p.16) the need to "consider climate variation in future assessment".

E: Collapse of fall Chinook (Lindley et al. 2009)

1. The Pacific Fishery Management Council "forecast an escapement of ... based on the escapement of .. jacks" (p.5). Is this done routinely for winter Chinook as well ? Many studies have shown that poor correlations between salmon jack returns and subsequent adult returns. High pre-smolt growth rates induce greater jack return rates, and high pre-smolt growth rates are not well correlated with adult returns.

Conclusions: Opinions for ToRs 1-5

1. Evaluate the strengths and weakness of the cohort reconstruction analysis used to estimate the impact of fishing harvest on the ESUs considered in this Opinion.

According to Argue et al. (1983, p. 23) a cohort reconstruction is basically a “cohort analysis as developed by Pope (1972)”, and first used for salmon by Johnson (1974). This deterministic accounting procedure provides figures on past abundance levels by time/area strata by recursively summing these up backwards in time while accounting for losses due to harvest, natural mortality and emigration. The figures obtained can in turn serve to compute ‘derived estimates’ (as in O’Farrell et al., 2010), or as input to simulation models used for planning purposes (as in Argue et al., 1983). Given fishing effort by gear/time/area, catches by fishery strata, and escapements by stream/year, fishing impacts can be computed given some assumptions about unknown variables in the model formulation used. The results are influenced by the accuracy and completeness of the data, and the validity of the underlying assumptions.

O’Farrell et al. (2010) used a conventional, well-known procedure to determine fishing impacts on SRWC. No major errors were detected in the equations examined, and many assumptions appeared reasonable and well-supported. And, by contrast to the Argue et al. (1983) analysis, O’Farrell et al. (2010) used coded-wire tag (CWT) recovery data to compute stock-specific figures. Reliance on well-established analytical procedures, sound algorithms and stock-specific markers is considered as support for the ‘strength’ of the procedure used.

In terms of weaknesses, some assumptions in the O’Farrell et al. (2010) model are not well-supported. Some CWT recovery estimates are based on very few actual recoveries. There may be unaccounted CWT recoveries (or losses) in trawl fisheries (NMFS 2010a). The available time series of tagging information is very short (only a few complete cohorts). Some basic functions used should be replaced by more realistic ones. Those that account for processes such as growth and survival should be replaced functions that better account for changes in ocean conditions. And there is too little information on the precision and accuracy of many figures and parameters used. The combined effects of various uncertainties may lead some to question the accuracy of the fishing impact estimates. Despite such shortcomings, the estimates of fishing impacts on the 1998-2004 brood years making up the ESU are considered to be ‘plausible’.

2. Evaluate the interpretation of the coded wire tag recoveries and cohort reconstruction analysis, and any conclusions drawn about how these results are produced in light of how the fishery is managed.

The interpretation of the CWT recovery patterns appears to be sound, although some scientists may have reason to believe these may not reflect those of naturally produced Chinook (see NMFS 2010a). The cohort reconstruction analysis results, for the most part, are interpreted carefully and correctly, with the authors restraining from excessive speculation (except for SRR levels on the 2005 brood).

As for the question “ *and any conclusions drawn about how these results are produced in light of how the fishery is managed “,* the answer is ‘reasonably well’ given the various constraints. Cohort reconstruction results are influenced by the spatio-temporal distribution of fishing activities, regulations, monitoring, etc. How fisheries are managed influences the amount and quality of the CWT recovery data and what can be deducted from a basic analysis. These data provide incomplete information on ocean distributions, and less on migration patterns, unless fine temporal scale analyses are conducted with fishery interceptions along all migration routes. Imposing time/area closures can reduce fishing impacts, but may also provide less data for assessments, further limiting the conclusions that can be drawn. In the absence of information on movement patterns, one cannot predict with certainty the benefits of small time/area closures, in part because fish moving through closed fishing areas may be intercepted later on along the migration route, resulting in no net benefits (to the fish). The cohort reconstruction results could possibly be improved, but in light of how the fishery has been managed, they appear to be sufficiently sound for preliminary assessment of ESU status.

3. How could the cohort reconstruction data or analysis be improved?

The datasets used for future analyses should include empirical observations on the age and sex contributions to natural escapements. As noted in NMFS (2010a), age composition data could help compute the cohort replacement rate (CRR) recommended by Anderson et al. (2009).This would also help verify if the age-4 contribution to escapements estimated from only a few CWT recoveries are realistic, and if hypothetically faster growing females are subject to greater fishing impacts and make up <50% of spawners. The results could in turn affect the estimates of effective population sizes (N_e), as used by Lindley et al. (2007) to gauge population and ESU viabilities. The stream survey data used to generate the J-S estimates of total and CWT escapements should also be re-examined and adjusted (if need be) to ensure the resulting estimates are not systematically biased because of the survey procedure. Efforts should also be made to coded-wire-tag natural Chinook during their downstream migration at least for 2-3 years. This would not be easy (given their size, low abundance, etc.) but it would certainly help determine if there are substantial differences in the behaviour, growth, maturation, survival and migration between hatchery and wild SWRC Chinook that need to be accounted for.

As for improving the analysis (not the data), the authors should consider using alternative functions for growth and mortality rates. Estimates of fishery catchability coefficients should also be generated using the available data. The model should also be modified to account for stochastic variation and observation errors. In fact, even Lindley et al. (2007, p.5) recommend using procedures for ESU classification that account for observation errors. The model variables subject to major uncertainties should be identified. The plausible upper and lower bounds of the figures should be determined using published reports or using ‘expert-based priors’ (as used in Bayesian analyses) by combining and weighting expert opinions (see Morris 1977). Monte Carlo simulations should then be done to generate frequency distributions of derived estimates. The distribution shapes provide valuable insight on the likely impacts and their plausible ranges.

As additional information is gained, more sophisticated and robust estimation procedures should be considered to deal with departures from various underlying assumptions, generate parameter estimates based on a simultaneous analysis of all data sets, and account for the effects of process and observation errors. For instance, Flynn et al (2006) used a composite maximum likelihood model to estimate fishery impacts on salmon runs. Their model could be modified to include additional parameters for the present context.

4. Are there additional quantitative or qualitative ways other than coded wire tag based methods to assess harvest impacts not considered in this Opinion?

Many other types of data are used to estimate fishery impacts on North American salmon stocks, via the use of genetic markers, PIT tags, radio-tags, sonic-tags, hydro-acoustic surveys, area-under-the-curve (AUC) surveys, direct enumeration, etc. In the present context, given considerations for the characteristics and locations of various interception fisheries, Chinook fry sizes, life history attributes, habitat use, monitoring conditions, and cost considerations, relying mainly on CWT technology seems justified.

Given the substantial investments and reliance on CWT technology and existing fishery/stock sampling programs, the most cost-effective course of action (in the short term) to improve the assessment of harvest impacts is to make better use of existing data. As noted earlier, cohort reconstruction results were used by Argue et al. (1983) in simulation models for fishery management planning purposes. The same approach applied here could make better use of investments in CWT application and recovery operations. Potential impacts of future fisheries could be assessed via the combined used of CWT based cohort reconstructions and simulation models. The potential impacts associated with various fishing scenarios and regulations could be further examined via the use of adaptive management practices (Walters 1986) involving the the deliberate manipulation of fisheries (large closures of 1-2 seasons), but would possibly be justifiable only if there were serious conservation concerns.

Fishery managers should also consider conducting some test fishing before and during the fishing season. This could help obtain a better idea of the impacts on age-2 fish (releases would be recorded), and of run strengths that are needed to justify the fishery openings in the absence of reliable pre-season forecasts (jack returns are poor indicators). It is doubtful that there would be enough CWT recoveries from test fishing alone, but genetic analysis of bio-samples could help determine the strength of the winter run, provided the NMFS would have a suitable reference database for the hatchery supplemented natural stocks.

5. Overall, does the biological opinion represent the best scientific information available?

There is no clear position on this issue. The short answer is ‘Yes’ and ‘No’. The opinions have been formulated using the best scientific information available, but some of the conclusions drawn are not based on the best interpretation of the various assessment results. At a minimum, the major uncertainties identified above concerning various data sets and hypotheses should be accounted for in the cohort reconstructions. These uncertainties can affect the cohort reconstruction results, which in turn, can influence the classification of the winter-run Chinook in terms of extinction risk. Lindley et al. (2009) emphasize the fact that the PVA results are very sensitive to the data and model assumptions (p.14). The authors go so far as to even suggest the need to “consider climate variation in future assessment” (p.16). The latter suggestion could also be implemented by using alternative cohort reconstruction functions for growth and survival that account for changes in fresh water and ocean conditions.

Despite the shortcomings of the assessment of fishery impacts, some of the recommendations stemming from the biological opinion very well justified. Given the uniqueness of the SWRC population, its limited fresh water habitat use, suspected long-term impacts of hatchery supplementation, and the potential impacts of even small ‘catastrophic’ events (slides, fires, etc.), the recommendations about improving access to some watershed (as proposed by Lindley et al. 2007) to rebuild and increase the number of sub-stocks are sound. In fact, that may turn out to be more beneficial to the SWRC population than imposing small changes to ocean fisheries.

Conclusions and Recommendations:

Considerable efforts were made to conduct a detailed assessment of the state of the Sacramento River winter-run Chinook population in recent years. This is a particularly difficult task in this data-deficient context, but investigators have done a good job in trying to provide scientifically defensible results using several scientifically defensible techniques and approaches. Miscellaneous suggestions are given above on various ways of improving the documentation and some assessments. What follows is a list of actions that could be taken to substantially improve the assessment without making major changes to the large-scale programs being conducted for monitoring and enhancement purposes. The actions recommended largely consist of ways to make better use of existing information by accounting for some of the known uncertainties, and determine the ‘relative probability’ that the population is in a given risk or viability category. The major recommendations provided are as follows.

ToR 1: Cohort reconstruction analysis used to estimate fishing harvest impacts.
Continue collecting and using CWT data to update future assessments. Some basic functions used should be replaced by more realistic ones. Those that account for processes such as growth and survival should be replaced by functions that better account for changes in ocean conditions.

ToR 2: Interpretation CWT recoveries and cohort reconstruction analysis results in light of how the fishery is managed.
No major recommendations are suggested, although efforts should be made to determine the extent of unaccounted tag losses in some fisheries (like commercial trawl fisheries) that are likely not subject to extensive surveys to recover tagged salmon heads.

ToR 3: How could the cohort reconstruction data or analysis be improved?
Acquire more information on age and sex contributions to natural escapements, so as to determine if further model adjustments are desirable. Ensure that the stream survey procedures

used do not lead to violations of the Jolly-Seber mark-recapture model, and if so, try to make adjustments to reduce the effects of small sample sizes on the escapement estimates. Investigate the feasibility of tagging naturally produced Chinook to ensure the results observed from tagged hatchery releases are representative. Conduct Monte Carlo simulations to account for various uncertainties, and generate frequency distributions of derived estimates to show the most likely impacts and their plausible ranges.

ToR 4: On the use of quantitative or qualitative ways to assess harvest impacts.
Investigators should consider using the results of stock reconstructions as input for further numerical simulations to evaluate the potential impacts of various fishing plans. They should also consider conducting test fishing, and using in-season indices coupled with genetic analysis of bio-samples to justify fishery openings. Genetic analysis techniques similar to those used by Beacham et al. (2005) are rapidly gaining acceptance as being simple, efficient, cost-effective methods ways to providing information on salmon stock compositions in mixed stock fisheries where a high level of discriminating power is required.

ToR 5: Formulating biological opinions using the best scientific information available.
The biological opinions rely on some of the best information available and in a cost-effective manner. Where the biological opinions fall short is in making best use of all the information that could be provided on fishing impacts. Stock reconstructions and numerical simulations that account for the major underlying uncertainties need to be conducted. The distributions of plausible outcomes need to be used as input to the PVAs to determine the relative probabilities that the populations and the ESUs are in certain risk of extinction categories.

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Appendix 1

Bibliography of the materials provided by the CIE for this review

On January 12, 2010, six reports were sent by Dan.Lawson@noaa.gov to the reviewer by e-mail. The reports received, as cited in the previous Reference Section, are Lindley et al. (2007), Lindley et al. (2009), NMFS (2009), NMFS(2010a), NMFS(2010b), and O'Farrell et al. (2010).

Appendix 2

Statement of Work
(T1016-04, v 20 July 2009)

External Independent Peer Review by the Center for Independent Experts

Biological Opinion on the effects of Ocean Harvest of Salmon on Central Valley Chinook Salmon Evolutionarily Significant Units (ESUs).

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in Annex 1. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.com.

Project Description: This biological opinion will evaluate the impacts of Ocean Harvest of Salmon on ESA-listed Chinook salmon ESUs in California's Central Valley. The biological opinion will analyze issues such as level of take of listed ESUs vs. non-listed ESUs managed under the Salmon Fishery Management Plan of the Pacific Fishery Management Council, and the impact of this level of take on the survival and recovery of ESA-listed .The Terms of Reference (ToRs) of the peer review are attached in Annex 2.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of (1) salmon cohort reconstructions through the use of coded wire tag in assessment of salmon population abundance and distribution, and 2) salmon population ecology. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents or reports for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the Schedule of Milestones and Deliverables.

Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
Conduct an independent peer review in accordance with the ToRs (Annex 2).
No later than 9 February 2010, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

5 January 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
12 January 2010	NMFS Project Contact sends the CIE Reviewers the report and background documents
19 January – 2 February 2010	Each reviewer conducts an independent peer review as a desk review
9 February 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
23 February 2010	CIE submits the CIE independent peer review reports to the COTR
2 March 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and

Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall completed with the format and content in accordance with Annex 1,
(2) each CIE report shall address each ToR as specified in Annex 2,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Key Personnel:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:
   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

Biological Opinion on the effects of Ocean Harvest of Salmon on Central Valley Chinook Salmon Evolutionarily Significant Units (ESUs).

1. Evaluate the strengths and weakness of the cohort reconstruction analysis used to estimate the impact of fishing harvest on the ESUs considered in this Opinion.
2. Evaluate the interpretation of the coded wire tag recoveries and cohort reconstruction analysis, and any conclusions drawn about how these results are produced in light of how the fishery is managed.
3. How could the cohort reconstruction data or analysis be improved?
4. Are there additional quantitative or qualitative ways other than coded wire tag based methods to assess harvest impacts not considered in this Opinion?
5. Overall, does the biological opinion represent the best scientific information available?