KARIN IMMERGUT, OSB #96314
United States Attorney
STEVE ODELL, OSB #90353
Assistant United States Attorney
District of Oregon
600 United States Courthouse
1000 SW. Third Avenue
Portland, OR 97204-2902
(503) 727-1000

RONALD J. TENPAS
Assistant Attorney General
SETH M. BARSKY, Assistant Section Chief
COBY HOWELL, Trial Attorney
BRIDGET McNEIL, Trial Attorney
MICHAEL R. EITEL, Trial Attorney
CYNTHIA J. MORRIS, Trial Attorney
Wildlife & Marine Resources Section
U.S. Department of Justice
Environment & Natural Resources Division
c/o U.S. Attorney's Office
1000 SW Third Avenue
Portland, OR 97204-2902
(503) 727-1023
(503) 727-1117 (fax)

Attorneys for Federal Defendants

UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

NATIONAL WILDLIFE FEDERATION, *et al.*

Plaintiffs,

v.

NATIONAL MARINE FISHERIES SERVICE, *et al.*

Defendants.

Civil No. 01-640-RE

2008 DECLARATION OF
Rich Hinrichsen

I, Rich Hinrichsen, declare as follows:

INTRODUCTION

1. I am the owner of Hinrichsen Environmental Research, a private consulting company in Seattle, Washington established in 1998.
2. I hold a Ph.D. in Quantitative Ecology and Resource Management from the University of Washington, a M.S. in Mathematical Sciences from Clemson University, and a B.S. in Mathematics from Central Washington University. Since the late 1980s I have developed mathematical models for Columbia River salmon ranging from juvenile downstream passage survival to life cycle population dynamics. Most recently I have developed extinction risk models that handle multiple salmon populations simultaneously. I also conducted the extinction risk analysis in the Comprehensive Analysis (CA) which was reviewed and used by the National Oceanographic & Atmospheric Administration (NOAA) in the 2008 Biological Opinion (BiOp).
3. I have reviewed the Declaration of Mr. Edward Bowles and the 2008 BiOp on Operation of the Federal Columbia River Power System, including the 11 Bureau of Reclamation Projects in the Columbia adopted May 5, 2008, by NOAA Fisheries ("2008 BiOp"), including its technical appendices and the Supplemental Comprehensive Analysis (SCA), also prepared by NOAA Fisheries. I have also reviewed the earlier CA prepared by the Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration and related documents. I am further familiar with and have reviewed previous biological opinions and related technical appendices and memoranda regarding the Federal Columbia River Power System

(FCRPS) and its operation following the listings of Columbia and Snake River stocks of salmon and steelhead. Finally, I have reviewed the declaration of Mr. Frederick Olney.

4. In this declaration, I respond to several comments in the Declaration of Mr. Edward Bowles, as well as one comment in the Declaration of Mr. Frederick Olney. These responses are based on my knowledge of the extinction risk analysis, which I developed and implemented. The purpose of these responses is to clarify the nature of the analytic work I did in the Comprehensive Analysis, which was reviewed and used by NOAA for the 2008 BiOp, and correct any mischaracterizations of that work. See, NOAA AR A.2, SCA Attachment I, Aggregate Analysis Appendix.

Confidence intervals

5. Before responding to the Bowles Declaration in detail, I begin with a brief description of a confidence interval, since it is fundamental to understanding what is meant by uncertainty of an estimate. High uncertainty means that it is possible for the true population parameter to be quite far from its estimated value. In a nutshell, confidence intervals are a standard statistical description of the uncertainty of an estimate. When confidence intervals are wide, it is understood that uncertainty is high; when they are narrow, uncertainty is low. A 95% confidence interval describes an interval that is constructed in such a way that if we constructed such intervals over and over again from different population samples, 95% of the intervals would contain the true parameter (measure of trend or extinction probability), and 5% of the intervals would not.1 When a confidence interval is wide and a new estimate is constructed from a different sample of the same population process, the resulting

[1] An interval is a range of numbers.

estimate could easily end up being quite far from the original estimate. When a confidence interval is narrow, the new estimate from a different random sample of the same process would tend to be close to the original estimate. Generally, in the BiOp, uncertainty tends to be high and confidence intervals are wide for estimates of trend and extinction probability. This occurs because there is often large variance in salmon population growth from year-to-year, and because there is uncertainty in salmon population data.

Uncertainty

6. In paragraph 51 of the Bowles Declaration, Mr. Bowles claims that NOAA Fisheries focuses on point estimates and does not explain the implication of considerable uncertainty around these estimates.

7. The BiOp does indeed discuss the implications of the high degree of uncertainty around point estimates of extinction. The BiOp notes that its dual reliance on quantitative modeling results and a host of qualitative considerations is an appropriate response to the uncertainty in the point estimates. The BiOp also notes that uncertainty in the extinction risk estimate increases with the time horizon used in the analysis. Thus, the BiOp's reliance on 24-year risk estimates (as opposed to 100-year estimates) results in greater precision. (See, for instance, NOAA AR A.1, FCRPS BiOp at pages 7-18 and 7-20. See also CA at pages A-6 – A-8.)

8. In the BiOp (and the federal action agencies' Comprehensive Analysis) we estimate and report the confidence intervals around the point estimates. Uncertainty is generally quite high in any analysis of salmon population dynamics, indicating that if another sample were to be drawn from the same population process, a quite different

point estimate might result. This is more a comment on the state of our knowledge than the degree of peril for salmon populations. But, the estimates developed for the BiOp use maximum likelihood estimation, which is standard in statistical practice. The point estimates represent the most accurate estimates possible for comparison with the standard (e.g. 1.0 for trend, or 5% for extinction probability). The approach of using the actual point estimate for comparison with a standard is an accepted practice from a statistical point of view, as long as uncertainty is acknowledged. For example, the criteria for placing species on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List compare point estimates of population status against a standard. In that instance, an estimated population size reduction of 90% or greater over the most recent three generations can place a population in the IUCN's Critically Endangered category. For example, a recent IUCN red list assessment of sockeye salmon used the approach of comparing a point estimate (estimated decline in abundance over 12 years based on linear regressions) to a standard (e.g., decline of 80%) to determine risk status. See IUCN Red List Assessment for Oncorhynchus Nerka, 24 September 2008.

Abundance

9. In paragraph 15 of the Bowles Declaration, Mr. Bowles asserts that a minimum abundance that minimizes extinction risks due to random processes and genetic decay has long been recognized in the scientific literature as an important status criterion for populations. And he states that the BiOp did not consider abundance as a metric in its status assessment.

10. This is not the case. Abundance is fundamental to the extinction risk analysis that was conducted in the BiOp Extinction itself is a condition in which abundance declines to zero individuals in a population. Extinction risk is a function of initial abundance, quasi-extinction threshold, and reproductive failure threshold. These are each abundance-based criteria that determine, along with measures of trend and variance, the probability of extinction of any population. Initial abundance is the starting point for the population projections. When initial abundance is low, there is a higher likelihood of a population eventually becoming extinct. When initial abundance is high, extinction is less likely. When projected spawners fall below the quasi-extinction threshold for four consecutive years, the population is considered extinct. When the number of spawners falls below the reproductive failure threshold, the spawners are assumed to produce no offspring. In summary, abundance was considered and incorporated into the survival prong of the analysis, which was based on extinction risk. *See,* NOAA AR A.2, SCA Attachment I, Aggregate Analysis Appendix.

"Volatility"

11. In paragraph 23 of the Bowles Declaration, Mr. Bowles asserts that the BiOp does not consider the "volatility" of populations.

12. Volatility is not a common statistical term. It appears Mr. Bowles is referring to the concept of variability. Variability is the appropriate statistical term to describe the randomness inherent in a data set. Variance is a statistical measure of how much observations vary over time. When variance is high, the observations tend to vary a great deal from year to year; when variance is low, they vary little. Salmon

populations characteristically have a very large amount of variability and this is fundamental to the extinction probability calculations. (It is also fundamental to the significant uncertainty in any quantitative analysis of salmon population dynamics.) As variance increases, it is more likely that a population will fall below the quasi-extinction threshold, and therefore extinction probability tends to increase. Again, extinction probability is a function of trend, variability, and initial abundance. Each of these is explicitly taken into consideration in the BiOp extinction risk modeling. *See,* NOAA AR A.2, SCA Attachment I, Aggregate Analysis Appendix. Variability is also important in determining the confidence intervals for trend and extinction probability. As variability about the trend increases, confidence intervals for trend and extinction probability tend to widen. (See, for example, NOAA AR A.2, SCA, Attachment 1, Aggregate Analysis Appendix, for a mathematical discussion of the manner in which variability/variance is included in the estimation of extinction risk.) In summary, variability was used in the BiOp both to characterize extinction risk, used for the survival prong, and to characterize uncertainty in the point estimates. NOAA AR A.1.

ICTRT and BiOp approaches.

13. In paragraphs 27-29 of the Bowles Declaration, Mr. Bowles contrasts the approaches employed by the Interior Columbia Basin Technical Recovery Team (ICTRT) and in the BiOp. He asserts that the ICTRT and BiOp population viability analysis (PVA) approaches differ in significant ways. This is not the case. The ICTRT and BiOp population viability analyses differ in details, but they are fundamentally similar. For both the ICTRT and BiOp approaches, the fundamental quantities include

productivity (rate of population growth at when spawner abundance is low), density dependence (description of how growth levels off as the population increases), variability (how much growth rate varies from year to year), and initial abundance. In both approaches, the same data sets were used. Both approaches also used a quasi-extinction threshold (QET), where extinction was assumed to occur when spawner numbers fell below QET for four consecutive years. And both approaches used a reproductive failure threshold (RFT), where zero offspring were assumed to be produced when spawner numbers fell below RFT in a single year. The BiOp did not construct a viability curve, which traces hypothetical abundance and productivity values that yield a 5% extinction risk over 100 years, because such an approach is not needed to answer the fundamental question about current extinction risk. That question needs to be answered by calculating the extinction risk based on actual estimates of abundance and productivity, not hypothetical values. Furthermore, the ICTRT's viability curve approach does not display confidence intervals on extinction risk, which is an important consideration that is fully acknowledged in the BiOp. NOAA AR B.194, Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs, Review Draft March 2007, ICTRT. The ICTRT's viability curves would properly be displayed by depicting the envelopes that describe the considerable uncertainty about the viability curves. An envelope is like a confidence interval, except it gives upper and lower bounds on an entire curve (e.g., viability curve), not just a point estimate. These envelopes will tend to be quite wide, especially when using 100-year extinction probabilities.

14. It is worth noting here that the 100 year extinction risk estimates developed for the CA and used in the BiOp often had 95% confidence intervals of 0 and 1 (0-100%). The fact that extinction probability is between 0 and 100% is known without the use of statistics. These extremely wide confidence intervals indicate that the point estimates are unreliable. The ICTRT's 100 year risk analysis, as manifested in their viability curves, is subject to the same degree of uncertainty. The ICTRT chooses not to display that uncertainty, however. In summary, the BiOp's population viability analysis differs in detail, but is similar in its approach because of its reliance on the same data sets and a similar general population modeling approach.

ICTRT survival gaps

15. In paragraphs 25 and 26 of the Bowles Declaration, Mr. Bowles describes the ICTRT survival gaps, and seems to suggest that they are fundamentally different than the gaps employed in the BiOp .

16. Although the methods for calculating gaps differ between ICTRT and BiOp, the ICTRT and BiOp approaches are fundamentally similar. Both the ICTRT and BiOp gaps are based on the needed increase in productivity, expressed as recruits per spawner, to achieve a 5% extinction risk. The BiOp relies on data developed for the ICTRT and uses similar definitions of extinction. (Extinction occurs when spawner counts fall below a critical level in four consecutive years). See, NOAA AR A.1, FCRPS BiOp at 7-6 – 7-7. See also, NOAA AR A.2, SCA Attachment I, Aggregate Analysis Appendix.

17. In summary, Mr. Bowles overstates the case. Fundamentally, he seems to be blurring the distinction between the ICTRT's attempt to define the biological criteria

that would represent a viable salmonid population over the long term (100 years) with the BiOp's attempt to quantify the risk that a population may become extinct within a relatively short timeframe (24 years). These are different inquiries that use very similar tools (as noted above). The gaps these inquiries attempt to estimate are in a similar currency, but represent improvements needed to achieve different goals and standards.

Variance

18. In paragraph 63 of the Bowles Declaration, Mr. Bowles claims that variance was not addressed. This assertion is incorrect.

19. See above discussion on "volatility."

Some gaps not calculated.

20. In paragraph 68 of the Bowles Declaration, Mr. Bowles states that gaps for some populations were not estimated and claims that they could have been estimated with only a few simple calculations.

21. Actually, in some cases, maximum likelihood estimates for the extinction modeling parameters did not exist so it was impossible to estimate gaps. As noted above, maximum likelihood estimation has a long proven track record in classical statistics, and we made the decision to not rely on other methods when maximum likelihood estimates could not be obtained. This is briefly discussed at page 7-15 of the BiOp, NOAA AR A.1, at 7-15, and in greater detail in NOAA AR A.2, Attachment 1 to the Aggregate Analysis Appendix of the SCA.

Snake River Steelhead Extinction Risk Modeling Results

22. In paragraph 40 of the Declaration of Mr. Frederick Olney, Mr. Olney suggests that there is an inconsistency between various productivity and trend metrics NOAA uses in the BiOp and the extinction risk modeling results for Snake River A-run and B-run steelhead populations. The extinction risk modeling indicates higher risk for the ICTRT's "average" A-run steelhead population as compared to the ICTRT's "average" B-run steelhead population. See, NOAA AR A.2, Attachment 1 to the Aggregate Analysis Appendix of the SCA. Yet NOAA's estimates, for example, of geometric mean recruit-per-spawner productivity indicate higher productivity for the average A-run population than for the average B-run population. In Mr. Olney's professional judgment, this indicates that NOAA must have erred in the estimation of extinction risk.

23. There is, in fact, no error in the modeling results. The important parameters for the extinction risk modeling exercise are the initial abundance, the "a" parameter of the Ricker production function (or intrinsic productivity), the variance, the equilibrium spawners (or Ricker "a" divided by Ricker "b"), and the autocorrelation parameter. With the exception of initial abundance, the parameters estimated for the average A-run steelhead population would indicate a higher risk of extinction.

24. The ICTRT's average A-run population parameters for intrinsic productivity and equilibrium spawners are both lower than those parameters for the average B-run population, which will tend to lead to higher estimates of risk. The average A-run population parameters for variance and autocorrelation are higher than those parameters for the average B-run population. As indicated in the BiOp, as variance

and autocorrelation increase, extinction risk increases. Mr. Olney's concerns are not supported by the key modeling parameter estimates. See, NOAA AR A.1, FCRPS BiOp at 7-19. See also, NOAA AR A.2, Attachment 1 to the Aggregate Analysis Appendix of the SCA.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 24, 2008, in Seattle, Washington.

Rich Hinrichsen