Independent Scientific Review Panel
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Review of the Ocean Synthesis Report:

The Marine Ecology of Juvenile Columbia River Basin Salmonids: A Synthesis of Research 1998-2011

An ISRP Retrospective Report

ISRP 2012-3
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ISRP review of the Ocean Synthesis Report

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Background

In response to the Northwest Power and Conservation Council's January 19, 2012 review request letter, the ISRP reviewed the report, *The Marine Ecology of Juvenile Columbia River Basin Salmonids: A Synthesis of Research 1998-2011* (hereafter the ocean synthesis report).

In the Council's final recommendations (July 2011) for the Review of Research, Monitoring and Evaluation and Artificial Production Projects (RME and AP), the Council recommended that the three project sponsors conducting ocean research under the Council's Fish and Wildlife Program, jointly complete a comprehensive synthesis report summarizing their ocean research. The studies are the *Ocean Survival of Salmonids Study,* which the National Marine Fisheries Service, National Oceanic and Atmospheric Association (NOAA), began in 1998; the *Canada-USA Salmon Shelf Survival Study*, which Fisheries and Oceans Canada (DFO) has conducted since 1999; and the *Coastal Ocean Acoustic Salmon Tracking* project (formerly Pacific Ocean Shelf Tracking Project), which was initiated by Kintama Research Services Ltd. (Kintama) in 2005. The project sponsors responded to the Council's recommendation by preparing the ocean synthesis report. The report consists of two volumes, the main body of the report and associated appendices.

The Council's January 19, 2012 request letter to the ISRP describes the rationale for creation of the synthesis report and includes questions to guide the ISRP review:

> At the time of the review the Council was unclear about how the projects are collectively addressing the ocean strategies in the 2009 Fish and Wildlife Program. Specifically, it was unclear how the information gathered will distinguish ocean condition effects from other effects, and how it would inform salmonid freshwater management by allowing managers to account for variable ocean conditions. The Council, noting the above issues and the ISRP's concern regarding the lack of an overarching plan or clear coordination of analyses and results, recommended the development of a synthesis report.
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> The Council suggested that the ocean synthesis report should be responsive to the Program's strategies, and the ISRP's comments. The following points were to be included in the synthesis:
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> - what was investigated
> - what conclusions can be drawn now
> - the expected time frame for the research to yield further conclusions
> - potential implications and recommendations for salmon management
> - how any funded ocean research projects will be coordinated in the future
> - how data collection is standardized and data made widely accessible
> - related ocean research conducted by others not funded under the program, including an assessment of opportunities to draw information and conclusions useful for the Program from that other research

The Council's final recommendation for the review, along with the ISRP recommendations, also suggested that the following topics be considered by the proponents in the synthesis: 1) an inquiry into salmon life history diversity and density dependence matters, 2) the possible development of simulations and predictive models to vary harvest or hatchery releases in relation to ocean condition, and 3) suggestions for improved coordinated efforts to understand how ocean conditions affect the growth, survival and ocean distribution of anadromous fish.

Based on these recommendations, the staff requests that the ISRP review the synthesis report and consider the following questions:

- Does the report adequately address the points emphasized by the Council in its recommendation?
- Is the information well synthesized and described?
- Are the critical gaps addressed?
- Are there elements proposed for future work that are not consistent with the Program?

The ISRP's review findings follow below with a review summary answering the Council's questions followed by specific comments on the ocean synthesis report. These specific comments are organized by the synthesis report's table of contents, which were in turn well organized to address the Council's and ISRP's questions and concerns. A few additional questions by the Council (Tom Karier) are addressed in the ISRP's comments on specific sections of the report.

ISRP Review Summary

This is the ISRP's final review of the ocean synthesis report. The authors presented their report to the ISRP during a teleconference on February 9, 2012. During this teleconference the authors and the ISRP agreed that the development and reporting of a synthesis of results was a useful process. The process encourages and enhances cooperation and coordination among projects, and provides a mechanism for demonstrating collective progress toward addressing the ocean strategies in the 2009 Fish and Wildlife Program. The ISRP recommends continuation of the synthesis-reporting process.

Answers to Council's questions

1. Does the report adequately address the points emphasized by the Council in its recommendation?

The ISRP concludes that the report adequately addresses the points emphasized by the Council in its recommendation. While the ocean projects represent only a small part of the Council's 2009 Fish and Wildlife Program, the projects are making important contributions. The ocean science synthesized in this report demonstrates order-of-magnitude advances in our knowledge of the role of the ocean on the early marine life history of Columbia River Basin salmon, since the pioneering marine research on the topic in the 1980s. Nevertheless, the ISRP concludes that there needs to be a stronger link between studies of marine ecological processes and salmon survival estimates. The acoustic tagging work has achieved the goal of demonstrating basic feasibility. However, in terms of being a complete pilot study, there are problems with the limited types of fish tagged and overall sample size. That stated, survival data are needed to increase the meaningfulness of the research on processes.

2. Is the information well synthesized and described?

In general, the ISRP concludes that information in the report is well-synthesized and described, particularly the process study work by NOAA and DFO. The acoustic tagging work, with brief statements and publication lists, does not include enough details to be as well integrated into the report as the other studies. Future syntheses should improve reporting of this integration. In addition, some of the findings presented by the three projects are confusing and stated rather conclusively, without providing solid evidence. Clarification of the metrics being reported should be improved. The ISRP attempts to provide constructive questions, suggestions for further clarifications, and recommendations for improvements to the report in our detailed comments below.

3. Are the critical gaps addressed?

The ISRP is encouraged that the research has progressed to the point of being able to ask questions and obtain results concerning how ocean conditions influence interactions between hatchery and wild salmon, stock-specific responses, and potential density-dependence. It is clear that complex interactions of factors influence survival so careful prioritization is necessary to identify the most crucial data gaps in future work. In particular, the ISRP recommends that obtaining stock-specific data on oceanic effects on salmonid survival wherever possible is important. A more systematic approach to any additional survey work is recommended for both the existing objectives and for the gaps and uncertainties identified by the ISRP in the RME and AP categorical review (ISRP 2010-44).

4. Are there elements proposed for future work that are not consistent with the Program?

All of the elements proposed for future work are consistent with the Program. The ISRP concludes that there is still a need for the NOAA project to develop a strategic plan that prioritizes their hypotheses, objectives, and work elements to provide critical management information. NOAA does not clearly state their research priorities, just that they will prioritize (Appendix H). DFO does a good job of prioritizing research actions under various funding levels (Appendix I). Further improvements to coordination among the three ocean projects and between ocean and freshwater projects are needed to maximize the benefits of research, monitoring, and evaluation to Columbia River salmonids.

In conclusion, the ISRP recommends that the Council maintain an ongoing dialog with the ocean research projects and projects in other realms to ensure that (1) the Council understands what these projects can and cannot contribute to Columbia River Basin salmon restoration and management, and (2) project proponents understand the questions and issues facing the Council and regional co-managers. For example, one of the stated benefits of ocean research is the ability to estimate how ocean survival affects overall life-cycle survival. However, estimates of total smolt-to-adult marine survival can be obtained without ocean research and monitoring, and might be sufficient for some management questions. For other management questions estimates of daily survival calculated by the ocean projects are important, for example in determining whether expediting the movement of fish from one habitat to another improves overall survival. The ISRP's view is that information provided by the ocean projects' process studies on what, when, where, and how ocean mortality occurs will lead to improved hatchery, hydrosystem, harvest, and habitat management practices needed to help restore Columbia River Basin salmon.

I. ISRP Comments on the Executive Summary and Introduction

- **Executive Summary**

The ISRP recommends that at the beginning of the synthesis report, perhaps in the executive summary, the authors should clearly describe the primary purposes or reasons for understanding survival of salmonids with respect to management issues in the Columbia River Basin. For example a description such as: "There are two purposes/reasons for understanding survival of salmonids: (1) for forecasting runs and setting harvest regulations, and (2) for optimizing survival rates. Management activity in the Columbia River Basin focuses on freshwater, therefore, we need to evaluate effects on survival of changes made in freshwater, for example release times, size/condition, numbers, various stocks, wild/hatchery, barged/not barged, and river flow. The effects on survival need to be evaluated in the (1) hydrosystem, (2) estuary, (3) plume, and (4) ocean." The concept is simple but might clarify the need for the research for those not familiar with the management issues. The emphasis is that everyone, including those working in the ocean, needs to be working together.

The authors state, "spring Chinook salmon (*O. tshawytscha*) migrate rapidly through the estuary; their survival is highest in the estuary, lowest in the Columbia River plume, and similar within the Columbia River hydrosystem corridor and the coastal ocean." However, there is no indication of what survival metric is being reported. It makes a difference if the metric is daily survival, overall absolute survival, or percentage survival of the fish in that habitat. This is a source of confusion throughout the report.

P. vi. The authors state that avian predation "modulates" salmon survival at the local level. It would be helpful to have an explanation of what modulation is.

- **Problem Statement**

The problem is clearly stated as, "periods of high or low ocean productivity can mask underlying trends in freshwater habitat productivity and could lead to a misinterpretation of the proximate cause of the trend." The ISRP strongly agrees that this problem deserves attention.

The first paragraph describes population trends from the late 1800s through the 1980s and 1990s. What are the present trends? To better illustrate the problem, a graphic depicting the available time series of population trends would be helpful.

The authors state an important conclusion, "it is now clear that variability in marine ecosystem productivity drives much of the variability in adult salmon returns." The authors need to explain how they arrived at this conclusion and cite the relevant publications.

The Council's and BPA's objective to quantify interannual variability in marine recruitment success and the NOAA project's objective to understand mechanisms affecting recruitment success are not clearly linked in this section. Clarification as to whether both objectives are focused on "marine recruitment success" at the same ocean age or life history stage would be helpful.

- **Historical Context**

This short section provides a brief review of research in the 1970s and 1980s that led to recommendations for a hypothesis-testing and process-study approach, rather than a correlative approach. However, later in the report, correlative approaches are used frequently by the authors to evaluate relationships between variables.

- **Objectives and Scope of the Three BPA Ocean Projects**

The objectives and scope of the three ocean projects are not explicitly presented. The initial coordination of sampling gear and methods by NOAA and DFO is a work element rather than an objective. A clear identification of the ocean zones being monitored and biological and physical oceanography being sampled by each project was omitted from the primary report. A brief discussion of Appendix A, which provides a table with this information, in the main body of the report would be helpful. This would establish the foundation of the assumptions and construct of evaluating the primary hypotheses. Figure 1 would be more useful if NOAA, DFO, and Kintama's Coastal Ocean Acoustic Salmon Tracking (COAST) survey locations within the three coastal oceanic zones were indicated. A list with definitions of technical terms and acronyms used in the report would be useful. An explicit definition of "juvenile" is needed. Does "salmon" include steelhead? Clearly, the focal species for most of the results reported in this synthesis are Chinook and coho salmon. For the NOAA/DFO projects the lack of focus on steelhead is related to trawl selectivity and life-history diversity, but this is not discussed in the introduction.

- **Hypotheses Tested**

The hypotheses to be tested are prominently and unambiguously presented. The hypotheses cover the likely sources of important contributions to survival and mortality of Columbia River Basin juvenile salmon in plume and coastal ocean habitats from Oregon to southeastern Alaska during their first summer-fall at sea. However, linkage between the actual data being collected and arriving at a conclusion about the hypotheses from observational data is not well developed. How did the authors use observational data across years that are not well replicated to evaluate and then decide upon the importance of the plume, estuary, bottom-up and top-down processes, and specific limiting factors? Are all of these factors clines or gradients or are there thresholds? Perhaps the headings in the later sections of the report should be matched to those hypotheses as they are addressed.

Hypotheses related to growth and survival of Columbia River Basin salmon and steelhead in more distant ocean habitats, for example western Gulf of Alaska, central Aleutians, southeastern Bering Sea, Alaska gyre, and subarctic current, are not addressed in this section. Also missing in this section of the synthesis report is discussion of fishing mortality and density-dependent interactions between hatchery and naturally-produced salmon (see section IX-data gaps). Explanation of the assumptions underlying the selection of hypotheses to be tested would be useful and should be addressed for each hypothesis later in the text.

- **Coordination and Collaboration among Ocean Projects**

Coordination and collaboration among the ocean projects appears to be fairly strong, particularly between NOAA and DFO, which collaborate through sample, data, and research cruise personnel exchanges and joint analyses and publications. There is no mention of collaboration between these projects and the Kintama project in this section of the report.

An annual NOAA workshop that has been running since 1998 to share data and discuss annual project results among participants of all three projects is not mentioned in this section. Are the proceedings of these annual meetings recorded or documented? It would be good to do so in some public venue.

- **Research Synergies with Programs not Funded by BPA**

The proponents provide an impressive list of synergies with other programs. However, the 2010 COAST collaborative study with Pacific Northwest National Laboratory (PNNL) to compare survival estimates from Juvenile Salmon Acoustic Telemetry System (JSATS) tags and Vemco tags used by COAST in the lower Columbia River is not mentioned in this section and should be added to this list.

For some programs listed, it is not clear whether the work is ongoing or completed. How critical are the data provided by these programs to the successful completion of the BPA-funded projects' objectives? What happens if an ongoing core program like the Newport Hydrographic Line is not funded? A brief evaluation of overlap or duplication of research, monitoring, and evaluation (RM&E) efforts between BPA-funded projects and synergistic programs would be useful. The synergies suggest that NOAA has a strategic plan to conduct a large-scale, multifaceted ocean research and monitoring program with diverse external funding sources, including BPA, but this is not discussed.

II. Physical and Biological Oceanographic Processes that Affect Juvenile Salmon

This well-written and informative section reviews much of the relevant literature on ocean effects. Although most studies indicate that early marine mortality is most important, ocean processes later in life may also affect survival, for example over-winter survival and subsequent-year survival. Conditions during such periods might be important for forecasting adult salmon returns.

- **California Current**

P. 12. The lack of correlation between phytoplankton and zooplankton biomass and Columbia River salmon survival, and the lower plankton biomass in the Alaska Coastal Current (ACC) than the Northern California Current (NCC), does not rule out the role of productivity of these trophic levels because plankton turnover is more important than standing stocks. This comment also applies to Figure 11. Additionally, juveniles of some salmonids do not feed directly on zooplankton. Typically, pink, chum, and sockeye salmon juveniles are planktivorous, while Chinook, coho, and steelhead juveniles are piscivorous.

Lipid-rich and lipid-poor copepods communities are one of the best indicators of salmonid growth and survival in the NCC, even though juvenile salmonids rarely feed on copepods in this region. The links between copepod communities and higher trophic levels, for example larval fishes and euphausiids prey are important.

The relationships between the distribution and abundances of hake, seabirds, and forage fishes vs. survival of salmonids are logical. Are they supported by direct measures of consumption rates?

There is no mention of what is known about Pacific Decadal Oscillation (PDO) effects on freshwater and estuarine rearing conditions and survival of juvenile salmon.

The recent increase in PDO shifts between negative to positive phases are described as providing a wider range of experimental conditions. However, the authors do not explain how this might affect their results. For example, short-term trends may be masked by food-web effects if physical changes are too rapid. It would seem that a four- or five-year pattern of "good" and "bad" conditions might be optimal.

- **Columbia River Plume**

Plume volume as well as the offshore/inshore extent and north/south distribution may be important to salmonid growth and survival as well as the distributions of predators, prey and forage fishes. A northward vs. offshore flowing plume may have very different effects on different stocks, for example yearling vs. subyearling Chinook.

III. Ocean Migration and Distribution of Columbia River Basin Juvenile salmon

The BPA-funded ocean research provides a wealth of new information on stock-specific migration patterns of Columbia River Basin juvenile salmon with important implications for identifying the spatial and temporal scales of ocean conditions that might influence survival. All three studies contribute substantially to these results.

- **Coast-Wide Distribution Patterns**

In general, this section is well done within the limitations of the sampling. The ISRP recognizes the coastal ocean is a very challenging habitat to work in, and the proponents should be commended for their success in gathering new and important data.

P. 16. The statement, "individuals from each source population may adopt either a subyearling or yearling life history pattern," implies a concept of "switching" life history types. It would be worthwhile to have the statement supported by a reference.

P. 17. The COAST project results are mentioned. Citation of the latest COAST annual report would clarify where results are reported.

P.17. The authors imply that the COAST study results differ from those found in earlier studies during the 1980s. Yet the overall patterns they describe seem to be consistent with patterns of movements discerned from coded wire tag recoveries in offshore and terminal fisheries in the 1970s and 1980s. Are there major differences between those older studies and current knowledge, as the authors suggest? How thoroughly have the coded wire tag returns from harvest fisheries been analyzed to make clear comparisons?

P. 17. The authors state, "Our ocean studies have identified three patterns of migration. First, some Columbia River basin salmon move rapidly northward soon after they enter the ocean in spring and early summer (Figure 5)." Both figures (Figs. 5 and 6) focus on the Snake River, but in the text, stock complexity is discussed. It would be helpful to give stock-specific plots in an appendix instead of referring to publications.

Figs. 5 and 6. The spatiotemporal patterns in CPUE are assumed to reflect movement patterns. However, if this is a period of low marine survival then decreases in CPUE might also reflect mortality. This was not discussed in this section of the report.

- **Fine-Scale (Spatial and Temporal) Habitat Usage Patterns and Factors Affecting Distribution**

Consistent year-to-year patterns of distribution by species and freshwater rearing types (yearling, subyearling) are thought to reflect genetic adaptations, whereas interannual shifts are thought to reflect variation in local habitat characteristics. Much of the data cited in this section are unpublished, in review, or in press, and information provided in the report is insufficient to review the results.

The nearshore habitat, that is, within a few kilometers of the coast including the intertidal zone, was correctly identified in the teleconference as an area that needs more work, and will likely become more important as more life history variants of fall Chinook are discovered (Burke 2004). Density-dependence may also be an issue in the nearshore. It would be worthwhile to give a perspective on how many Columbia River stocks have actually been identified at sea relative to the number of stocks that are being managed/conserved in the Basin. Details on genetic stock identification of Columbia River stocks are provided in Appendices H, I, and J. A brief summary in the main text of the report would help give a sense of the complexity of the problem if each stock is to be managed separately, which is how the freshwater restoration work tends to be framed.

P. 19 (3rd paragraph). The authors need to clarify that these are bottom contour depths, assuming that fish were caught in surface tows.

P. 19 (3rd and 4th paragraphs). The authors provide two conclusions about the effects of upwelling current, the first that strong upwelling disperses salmon distribution offshore and weak upwelling compacts distribution inshore, and the second (Trudel et al. 2009) that salmon do not appear to alter their general migration paths by prevailing currents, for example upwelling.

These results suggest to the ISRP that salmon may respond to other factors such as distribution of their prey. Is the observed dispersal during stronger upwelling years consistent with the idea that in strong upwelling years there is more offshore transport and more production offshore, leading to more offshore movement and therefore distribution over deeper waters? Direct measurements of prey distributions with respect to upwelling, plume structure and salmon dispersal are needed.

P. 20. The mention of magnetic field is distracting and speculative.

P. 20. The discussion of lipids in relation to migration is speculative and Miller's work is unpublished.

P. 20 (Fig. 7). Are the stock-specific differences in frequency distributions in Fig. 7 statistically significant?

The observation that different trawl survey lines recovered different stocks of Columbia River Basin salmon in specific time periods is interesting. From the figures it is challenging to understand how many fish were actually caught and classified. There is no mention of what the capture rate may have been. The authors should clearly state their assumption that the data are representative of the stock distribution, yet are based on small sample sizes.

- **Cross-Shelf Distribution of Tagged Smolts**

The assumption is that the data on fish distribution and abundance are representative of the stock's ocean distribution. Acoustic tagging results have shown that cross-shelf distribution off Willipa Bay extends beyond the outer edge of the 2011 shelf sub-array (46-km offshore). If most fish are actually distributed somewhere else, the data have little meaning with regard to the fish stocks and are relevant only to the distribution of stocks in the geographic regions surveyed.

IV. Marine Growth and Condition and Linkage to Adult Returns

In general, this is a thorough, well-documented section. The report briefly provides evidence that growth is related to prey abundance and prey quality. Most of the evidence was provided in references to other reports rather than in charts, and therefore it is difficult to make detailed review comments.

Here and elsewhere in the report, growth measured by otolith increments after "seawater entry" may not be equivalent to ocean growth if based on Sr/Ca ratios, as these change after estuarine entrance. Otolith and scale growth indices may also change before actual ocean entry. This issue is addressed in Appendix H and should be at least briefly discussed and cited in the main body of the report.

P. 23. Insulin-like growth factor (IGF) is a good indicator of growth, but all reported measures of growth are on survivors and do not account for size-selective mortality. How does IGF vary with size distributions of a stock? Is there a positive association between body size and IGF?

P. 23 (4th paragraph). Beckman (2011) looks potentially useful for describing and understanding IGF, but this paper is missing from the reference list.

- **Interannual Variation in Salmon Food and Growth**

Fig. 9. This figure shows coho salmon IGF increasing with prey biomass. It would be interesting to indicate "warm" versus "cold" years.

Were "food consumption rates" actually measured by Trudel et al. (2011)?

- **Marine Growth and Adult Abundance**

The relationships between early ocean growth and abundances of Columbia River salmonids (Tables 2 and 10) are good evidence that availability of nutritious prey is related to growth. The findings are very promising, although the time series are still short (4 to 11 years depending on the stock); additional years of effort are needed to refine these relationships, which have promise for addressing management issues such as forecasting. However, the estimates of abundance associated with early marine growth could be improved.

The adult abundance estimates are mainly based on dam counts, often above Bonneville. What are the assumptions here? Does this assume similar abundances of smolts entering the ocean in all years, and similar in-river survivals of returning adults? The Oregon Production Index, Hatchery (OPIH[1]) seems to be a better measure of survival below Bonneville. Can PIT-tag data on smolt to adult survival rates (SARs) from Bonneville to Bonneville be used to support some of these conclusions?

Presently these abundance values only reflect abundance of the dominant age group of salmon and steelhead, and they do not account for year-to-year variation in age at maturation, including differences in maturation rates between hatchery and natural salmon and steelhead, which are known to be significant. Appendix D shows that the adult abundance counts are positively correlated with SARs, as they should be, but there is still considerable variability between abundance of the dominant age and overall survival of the stock. Ideally, data on age of salmon should be collected from salmon and steelhead passing key counting areas, such as Bonneville Dam, so that brood tables and total return data from smolt migrations can be estimated with greater accuracy. These types of data are routinely collected in other salmon fisheries, and they should be in the Columbia, as well. As a recommendation for the region

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[1] OPIH is an estimate of total freshwater escapement, adjusted for ocean and freshwater catch, for hatchery coho salmon throughout the Oregon Production Index Area (Monterey Bay, California to Willapa Bay, Washington). Used as the numerator in calculating SARs for the OPIH. Definition source: http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ic-glossary.cfm#OPIH.

rather than solely for the ocean researchers, the ISRP encourages discussions with agencies and managers about the need for abundance data by age and hatchery versus natural stock. These data would be highly valuable for other efforts to manage, harvest, and conserve salmonids in the Basin.

- **Juvenile Chinook Growth and Condition vs. Life History Type**

Indices of survival were positively correlated with growth and condition of spring Chinook in the ocean, but the opposite was found for subyearling fall-run Chinook. Subyearling Chinook had lower body condition and higher survival when early ocean conditions were favorable. Two hypotheses were suggested and both seem plausible, but further work on this issue should also incorporate predators during warm versus cool years. In Alaska, high abundances of sockeye salmon are associated with reduced length-at-age of smolts and adults in response to density dependence in freshwater and during the homeward migration. Furthermore, some studies of salmon growth at sea have documented catch-up or compensatory growth, that is, slower growing fish grow faster at a later period (Ruggerone et al. 2009), which might also explain this observation.

The lower mean condition of subyearling Chinook salmon during cool, productive years is interesting. Examining size-selective mortality may be useful based on size at ocean entry and at capture based on otolith increments. Another explanation for this is that subyearling Chinook salmon are found very close to shore, an area with the coldest waters during strong upwelling, and these cold temperatures may slow growth.

In Fig. 10, plume inshore/offshore and north/south distributions may be more important than plume volume. COAST should examine Antonio Batista's plume maps to better define how survival is related to the actual low-salinity plume structure.

Fig. 10 shows relationships between fall Chinook counts at Priest Rapids Dam and several indices, including early marine condition of smolts. Why was the Priest Rapids Dam count used when most fall Chinook, including the highly abundant natural Hanford reach stock, occur downstream of Priest Rapids Dam? Standing stocks do not equal productivity. Do seasonal estimates of these factors show the same trends as mean annual SST, Chl A, and zooplankton? Were these relationships in Fig. 10 similar in 2001 and 2008, outlier years?

Subyearling Chinook spend much more time in the river and estuary than yearling Chinook during the year of migration. Also, Hanford stock natural fall Chinook are very abundant in the Columbia, and they will have greater dependence on and residence time in these habitats than hatchery subyearling stocks. Density-dependent growth is more likely to occur in the natural fish that depend more on these habitats. Thus, the analysis of fall Chinook should be conducted on marked versus unmarked salmon to see if the patterns hold for both groups.

P. 26. The speculations about why fall Chinook subyearling condition was found to be lower in high return years are symptomatic of interpretation problems for this kind of exploratory analysis. The problem is that when correlations oppose our hypotheses, we have little choice but to invoke density dependence. The use of the acoustic tag tracking data to assess actual mortality of these fish may assist in interpretation. It may also be possible to look at growth post-hoc from returning fish, although that also has its biases as the survivors are probably far from a random sample of out-migrant fish. A high correlation between returning years of a cohort, for example the old Oregon Production Index [OPI [2]] or similar, is commonly a good indicator that year class abundance was set earlier than that period.

As a recommendation for the region rather than solely for the ocean researchers, the ISRP suggests that use of scale growth measurements from returning adult salmon may also be useful as a method of post-hoc assessment (Friedland et al. (2009a,b), with the provision that these fish are the survivors and may not reflect the growth of fish in the ocean at an earlier time. Maturation effects on growth are a confounding factor for post-hoc scale analysis of adults. The ISRP recognizes that a retrospective analysis of scales may be difficult because of uneven historical sampling. At present, improved scale sampling at various life stages is needed to enable useful future analyses.

- **Regional Variation in Growth Rates and Survival**

Growth, based on IGF, is higher north of Vancouver Island even though zooplankton abundance (net sampling) and SST are much lower (SST of WCVI is still quite adequate: 10.5°C). To what degree do zooplankton in the nets reflect prey in coho and spring Chinook salmon stomachs? Zooplankton abundances again do not equal production.

Without knowing habitat-specific residence times of individual fish measured for growth hormone, it is difficult to link growth to local habitat conditions. For example, higher IGF levels in ACC fish might simply reflect arrival within one week of fish that achieved high IGF levels in other habitats. Is there evidence showing that yearling Chinook that residualize in CCS habitats survive to maturity? What is the habitat-specific measure of survival used for coho salmon in Fig. 11?

- **Winter Growth and Mortality**

DFO is sampling in Canadian waters during late winter. The initial DFO data indicate that this may be important (80-90% mortality). This issue is addressed in Appendices H and I. In addition, it should be at least briefly discussed and cited in the main body of the text. The report concludes that mortality of juvenile Chinook during winter was 80-90% based on CPUE data in Fig. 13. What evidence is available showing that the vertical and horizontal distributions of these fish did not change from fall through winter? Even a slight change in fish distribution and sampling effort and distribution could influence a shift in CPUE, yet the report presented this mortality as a fact. The report also concludes that mortality is not size-selective off WCVI, but it does not mention how the degree of size-selective mortality is measured (along WCVI and in

[2] An index of marine survival of coho salmon released from public hatcheries from Monterey Bay, California, to Willapa Bay, Washington; marine survival is calculated from the number returning the following year divided by the number of smolts released from public hatcheries (e.g., Pearcy 1992, Cole 2000). This old index has been replaced by OPIH (see footnote 1).

the Gulf of Alaska). Can the authors really conclude that fall Chinook do not experience size-selective mortality during early marine life based on these limited data?

Winter growth and survival needs to be researched by NOAA in the NCC. Using CPUE in fall and winter may be suspect, however, if salmon occupy deeper water in the winter where surface trawls do not sample, and if different stocks or sizes occupy different depths. Data from other trawl surveys may be useful.

Is the basis for differences in size-selective mortality between stocks residing in southern regions of the coast (WCVI), such as fall Chinook, and stocks rearing in the Gulf of Alaska, such as spring Chinook, based mainly on winter temperatures? For example, winter SST off the WCVI in the first ocean year appears to have an important influence on cohort strength of Columbia River Upriver Bright fall Chinook (Hyun et al. 2007).

V. Mechanisms Influencing Salmon Growth and Survival

This is a very interesting summary of the food web in the ocean with many new data generated on pathways. Results are clearly important to provide context for survival and distribution data. However, there are limitations on conclusions using food web analyses because of interactions with physical processes.

The shifts in the parasite communities with the PDO and SST, the decline of infections between early and late cruises, and the relationships between occurrence and habitats of BKD and survival are all revealing.

- **Bottom-Up Processes (prey and parasites)**

Perhaps the most important and robust finding relative to the bottom-up hypothesis for managers and forecasters of year class strength is the strong association with lipid-rich boreal copepods and salmon survival as stressed by M. Trudel during the teleconference (see also Figure G-1 in report). The concept is similar to the “plankton watch” idea that was first described a few decades ago and is now commonly used in hatcheries in Japan and in some hatcheries in Alaska to time pink and chum salmon releases to achieve optimum survival at ocean entry.

Different relationships between the composition of salmonid stomach contents and cool and warm phases of the PDO in the NCC and farther north are relevant, as are the relationships between food habits and coho survival. Salmonid food habits data, e.g., lipid content of diets, may provide better measures of growth and survival than the abundance of northern copepods. Is lipid content of salmonid prey higher in cool years? Where are the data showing food habits vs. survival?

P. 31. The authors' finding that, “No significant differences in stomach contents were noted between years with differing oceanographic regimes (PDO) in either the region off Vancouver Island or Southeast Alaska” seems to conflict with other results indicating that the ecosystem and prey community in both regions change with PDO. The authors also state that stable isotope profiles differed significantly by species, region, water source, and oceanographic regime. If stomach contents were similar why would these profiles differ? Could prey quality differ? Additional explanation would be useful.

P. 31. “Trophic level also increased with size, and degree of piscivory was generally higher in warmer than colder years for both species.” Does this mean that the prey fish must therefore benefit from feeding on the warm-water zooplankton or fewer non-fish prey are available in warm water?

New data on parasite load as a trophic indicator and the selection of prey fishes with high lipid content in the diets of juvenile salmon are very interesting and an excellent contribution to marine food web studies.

- **Top-Down Processes (predation and pathogens)**

The predation hypothesis is logical, but results are somewhat equivocal. Because fewer years of “experience” with various predators are available, with the possible exception of hake, inferences on survival are weaker. Predation and bottom-up effects on survival are interactive and interdependent and show growing fish are likely most vulnerable to predation. Is there any indication whether predation is additive or compensatory?

Information on predation is less complete than information on plankton as predator abundances and distributions are more difficult to assess and time series are often lacking.

Hake CPUE in research trawls seems to be a fairly good predictor for coho and fall Chinook returns, but are there any direct diet data indicating some certainty that Pacific hake are taking these species in high numbers? The report also indicates that seabirds such as common murre and sooty shearwaters found in relative high densities in the Columbia River plume may be important predators on juvenile salmon, but more diet samples are needed to confirm this hypothesis.

As the authors acknowledge, the hake predictor (Fig. 15) is correlated with the PDO, warm SSTs, and poor feeding conditions for salmonids. Again, hake CPUE is plotted against adult returns to Bonneville. Why not use the OPIH for coho, since most originate below Bonneville? Are the data on seabird abundances and food habits in the plume from the same months as outmigrations of smolts? The correlation between density of birds in May of one year and the adult coho returns is presumably lagged by one year.

Further interpretation of the correlation between bird predation and salmon survival on “good” and “bad ocean” condition years (slide 11 of teleconference, not in synthesis) is merited. If the bird surveys were in the plume area then this feature also becomes a factor since the Brosnan work (Fig 20) suggested a relationship between survival and residency in the plume.

Some discussion about the possibility of other viral disease effects would be germane (Miller et al. 2011).

- **Inferences from Ecosystem Modeling**

The modeling of top-down and bottom up-processes is a new approach for this project. It would be useful to find out what model was used to generate the plots on food web efficiency in Figure 17. More details on how productivity is estimated for all trophic levels would help. Does the model assume that ultimately all juvenile salmonid mortality is from predation, not disease or starvation? Can interannual differences be estimated? Sensitivity analyses should be very helpful to sort possible ranking of predators as they influence salmon survival.

The ISRP suggests the concept and approach in a recent paper in Science (Cury et al. 2011) that discusses seabird response to forage fish prey depletion may be of value. The relationship for salmon may be similar. The key point is that the threshold for seabird reproductive problems approximated one-third of the maximum prey biomass observed in long-term studies.

VI. Freshwater and Ocean Survival Estimates

The COAST work is very innovative and has produced some excellent results, with some limitations, especially the position of detection arrays relative to the shelf width. Conclusions about where the bulk of the tagged smolts move needs to be tempered with these caveats. Although the COAST project work is not well-integrated with the rest of the ocean synthesis report, a broad integration is being attempted and is helpful to put the COAST work in context. However, some important findings seem to conflict with other findings in the Basin, as discussed below.

- **Coastal Ocean Acoustic Salmon Tracking (COAST) Objectives**

The authors addressed objectives (i) and (iv) quite well, demonstrating the feasibility of using acoustic tags to examine early/initial ocean migration and distribution patterns for spring Chinook emigrating from the Columbia River. The ability to collect acoustic data on juvenile salmonids in the ocean also has definite advantages over trawl surveys for following individual fish and specific groups of fish over extended time periods. The ISRP commends the COAST project for helping to initiate the use of an important tool for answering many questions related to this critical part of the life history that we have known little about. To address objective (ii), the proponents presented freshwater, estuarine, plume, and ocean survival estimates for Snake River Dworshak hatchery spring Chinook (2006, 2008, and 2009) and Yakima spring Chinook (same years) from the mid-Columbia. The expression of the theories to be experimentally tested in objective (iii) seems inconsistent with the way delayed mortality and differential delayed mortality are usually expressed. This causes confusion (see comments below).

The authors need to add a short section discussing data limitations near the beginning of this section of the synthesis report. The authors make some major conclusions regarding dam effects, transportation, and relative survival comparisons, and they would have more credibility by qualifying their conclusions. For example, the authors do a reasonably good job of describing the limitations of their data in their 2010 Annual report to BPA (www.cbfish.org/Project.mvc/Publications/2003-114-00), as well as providing model assumptions for various estimates, but this information is not provided in the synthesis report. There is no explanation in the synthesis report for the 2010 change in study design. Specifically, instead of using Dworshak or Yakima hatchery fish in 2010, the authors collected their fish for acoustic tagging at Lower Granite Dam and John Day Dam. These were run-of-the river fish of unknown stock origin but most likely yearling spring Chinook. At John Day they estimate that 22% of the fish were Snake River origin based on historical stock composition data reported by Ferguson (2009). The reason for the design change was to do a collaborative/comparative study to look at in-river survival estimates – JSAT/PNNL vs. Vemco/COAST acoustic tags. The results of this study were not presented in this section of the synthesis report or in the 2010 Annual BPA Report, but it is stated that the results are reported in Skalski and Buchanan (2010). Appendix J on page 53 briefly reports the results of this study, and this study should be cited in the main text of the synthesis report. In the synthesis report, the 2010 data are sometimes included when presenting cross-year comparisons and should be deleted, qualified, or carefully footnoted.

The sample sizes of tagged fish appear to be small, especially when partitioned among different treatment and reference groups. The authors have been doing this study for a number of years and provided a power analysis indicating precision and benefits by increasing numbers of tagged fish as part of their 2010 proposal, "Study Design Power Analysis for the Categorical Review Proposal." This analysis should be cited in the main text of the synthesis report.

P. 39 (1st paragraph), the authors describe four habitats monitored by the array that allow contrasting mortality. However, the "coastal ocean" habitat (Willapa Bay to Lippy Point, NW Vancouver Island, 483 km) includes subhabitats that might affect survival of specific stocks. Examples might include plumes from coastal rivers, Strait of Juan de Fuca, frontal zones, and large eddies. Some discussion of these features might be useful.

- **Survival Estimates in the Columbia River, Estuary, Plume, and Coastal Ocean**

The ISRP advises that care should be exercised by the authors when discussing rate of mortality for the smolts that survive to enter a habitat to ensure that rates are not confused with absolute number of mortalities. It would be useful to discuss results in the context of SARs in the Columbia River Basin. Another way of looking at the idea is that increasing survival of freshwater life-history stages from freshwater habitat improvements also needs to be considered. For example, the results of Cumulative Risk Initiative (CRI) analysis of yearling Chinook from the Snake River ESU, indicated the largest gains to population growth would come from increasing first year survival in freshwater and during very early ocean entry (Kareiva et al. 2000; reviewed in ISAB 99-7).

P. 40 (last paragraph). It is not clear how, as stated, “most of the mortality occurs within and beyond the first 1-2 months in the coastal ocean” when up to 50% of the mortality can occur in the hydrosystem.

P. 41. The statement on page 41 is important: “Survival estimates are the metric commonly reported in salmon studies, but can be misleading because survival to adult return is the product of survival in successive life history periods.” However, the usefulness of the perspective presented, whereby only 13% of the mortality occurs in the hydrosystem and 87% from Bonneville Dam to adult return, is unclear given that up to 50% of the mortality occurs in the hydrosystem.

The ISRP found the discussion of the comparative survival estimates confusing – going back and forth between the text p. 41 and Table 3 (rates per day, ratios/ etc.). The ISRP recommends that the authors simplify this discussion. In their 2010 Annual Report to BPA, the authors provide a good summary (Tables J.1 and J.2, pp. 394-395), which provides detection data, by location of all fish for all 5 years. The 2010 report is an excellent albeit long (495 pp.) report synthesizing all years of the study.

P. 41. The relative measure of mortality gives a much different view than a comparison of absolute mortality. For example, the assertion that, “mortality still to be experienced beyond the river mouth (Astoria) is 20 times greater than the combined mortality experienced in the hydrosystem and the unimpounded lower river and estuary to Astoria (Table 3)” is not consistent with the estimate that up to 50% of the mortality occurs in the hydrosystem. As another example, the statement, “By the time the smolts reach Lippy Point, the northern end of the California Current region and the start of the region of good growth conditions, the majority of the mortality seems to have been experienced” appears to be based on a reduction in survival from 2% to 0.5% (Table 3), but in terms of relative mortality that is a 75% mortality rate.

The ISRP found the calculation of mortality ratio in Table 3 (see p. 41-42) and the proportion of total mortality during each life stage to be confusing. The mortality rate in the hydrosystem is reported to be 65.5% and the mortality rate from Bonneville to adult is 98.5% in order to achieve an overall mortality of 99.5%. So, the rate of mortality beyond the hydrosystem is 98.5/65.5 = 1.5 times greater than that in the hydrosystem. Using the same values, the survival ratio is .345/.0145 = 24. This survival ratio (24) is reported as a mortality ratio in Table 3. The report concludes the proportion of total mortality represented by the hydrosystem is only 4% (96% of the mortality occurs in lower river and ocean). The mortality rate at sea is certainly greater than that of smolts in the hydrosystem, but it is not clear that the approach to calculate the proportion of total mortality in each life stage is valid.

P. 41 (2nd paragraph). This paragraph provides a simple example of the type of analysis presented in Table 3. However, the ISRP applied this approach to the data in Table 3 and came up with a different answer than that at the bottom of P. 41, e.g., mortality proportion is 20% (not 4%): 0.345^5 = 0.005 overall SAR; 1/5 = 20% not the 4% listed at the bottom of page 41. Clarification on this approach is needed. By use of the mortality ratio, the authors seem to be comparing "forces of mortality" in a competing risk framework, but the ISRP does not think this is appropriate given the sequential nature of the fish passage.

- **Survival Rate in Different Habitats**

The report examines survival rates in different habitats. The authors suggest that managers may not want to increase the transportation rate of smolts though the hydrosystem because mortality in the plume and ocean is high. The analysis indicates that daily survival in the hydrosystem, estuary, and ocean is similar and that survival in the plume may be somewhat lower. This analysis does not consider the importance of linking smolt emigration timing with timing of ocean productivity, a relationship that has been altered by the hydrosystem. This analysis is informative, but it should also incorporate findings of inriver survival and overall SARs in relation to passage time though the hydrosystem. Does daily survival increase or decrease when fish pass through the system more quickly? Analyses by the Comparative Survival Study (CSS) show that travel time declines rapidly over the course of the season. The date of migration should be considered.

P. 43. Figure 19. The survival rates have been normalized to a per kilometer or per week basis; however, the raw survival rates might be just as useful. For example, suppose that fish only spend 1 day in the estuary but spend 50 days in the plume. Wouldn't the "actual" survival be more relevant of a comparison that takes into account the actual times spent in the habitats? This looks like what was done starting on page 45. Consequently, statements such as found on the second paragraph of page 44 that "plume survival rates were lower than hydrosystem survival rates on average" need to be reworded as "plume survival rates per day or per km were lower than ...."

Results of the habitat-specific survival investigations seem to be equivocal for the estuary (Fig. 19) as survival was better than expected in some years, but not others. Given the habitat restoration work being done in the estuary, the proponents might note that the amount of habitat available, especially for subyearling Chinook, is increasing and is a confounding effect for their analyses. It is not clear how the results showing high survival rates in the estuary can be reconciled with McComas et al. (2008), who estimated survival from Bonneville to the seaward end of the estuary (Astoria) as follows: “Estimates of survival ranged from 0.584 to 0.824 for yearling Chinook and from 0.185 to 1.005 for subyearling Chinook salmon.”

P. 44, Table 4. It is a source of great confusion to show survival rates that differ little but claim large differences in mortality due to confusing use of terminology and notation. For example, if survival in the hydrosystem is 31.5% as in Table 3 then mortality is 68.5%. Therefore, in Table 3 footnote notation one might conclude SEarly + MEarly = 0.315 + 0.685 = 1. An alternative interpretation might be that if mLate /mEarly = SEarly/SLate as in Table 3 footnote then 1/mEarly = SEarly so mEarly x SEarly = 1 which is not true given the values 0.315 and 0.685 above. Another explanation for the derivation of the mortality ratio is to take the reciprocal of the survival ratio. The point is that there is much room for confusion and inappropriate conclusions if terminology is not clearly defined.

The observation that hydrosystem survival rate, and other domains as well, is important and is similar to comments made by the ISAB during the 2002 to 2005 period regarding flow augmentation, travel time, etc. (e.g., ISAB 2003-1). The ISAB concluded that reach survival was not the appropriate analytical endpoint when evaluating flow effects because there would be no benefit if survival of fish moving to the next reach was the same or lower than in the preceding reach. For example, if there was 90% survival at flow X and average travel time was 2 days, and survival was 85% at flow Y with average travel time 3 days, nothing would be gained by the first scenario if fish in the third day in a different reach had the same or possibly even reduced survival.

- **Plume Survival and Residence Time**

See the ISRP comments above regarding confounding factors. The authors need to provide information on whether fish size, date of plume entry, and hatchery vs. natural stock are considered in the analyses of survival and residence time in the plume.

Figure 21. Residence time in the plume is plotted against upwelling and river discharge; however, the figure is confusing. The same axis was apparently used for both scaled discharge and the unscaled standard deviation of the upwelling with different colors representing the different plots. Consequently, every data value is plotted twice, once in black and once in color. The ISRP recommends splitting this into two plots.

- **Testing Delayed and Differential-Delayed Mortality Theories**

The results of the latent mortality investigations are interesting but comparisons of Snake River survival with Yakima River survival are subject to the problems identified in the earlier ISAB reports on this topic, specifically using various tributaries as “controls” (ISAB 97-2). Is there evidence that Yakima River smolts are identical to Snake River yearling smolts in every way other than Snake River dam passage including estuarine and ocean entry timing? That is, are the Yakima River smolts an appropriate “control”? It would be useful to have some discussion of other NOAA researchers’ findings to put the COAST work in perspective, for example the literature reviewed in the 2012-1 ISAB report, especially Marsh et al. (2010).

For fish passing through the dams, the key question is whether additional latent mortality occurs in fish passing through the bypass system versus through the spill gates. A variety of analyses using PIT tags indicate that fish passing through the bypass system have greater latent or delayed mortality after Bonneville than fish that do not pass through the bypass system.

The authors of the latent mortality analyses need to clarify that values in Figure 22 were based on survival downstream of Bonneville Dam and whether the values are reach specific survival or across all areas leading up to that array. The ISRP assumes the analyses are based on survival downstream of Bonneville as implied in the opening paragraph.

No difference in early marine survival is detected in the survival of Dworshak versus Yakima spring Chinook even though Dworshak fish experienced additional dams (Snake River dams). No difference in early marine survival is detected in the survival of transported versus inriver Dworshak spring Chinook. A factor complicating the delayed mortality test is that these stocks are probably genetically distinct and may have naturally different survival rates and distributions in the ocean. All of the estimates have fairly wide confidence intervals, although there is not systematic pattern in support of a hypothesis. What is the survival rate from release to Bonneville? Sample size should be indicated on charts. These stocks likely have been PIT tagged, therefore the acoustic tag data should be compared with PIT tag data which spans early and late marine life. For example, for Cle Elum hatchery, about 5% of the fish from up to 18 raceways receive PIT tags. Approximately 35 to 43 thousand PIT-tagged fish are released each year. Exact numbers per release year can be obtained from Bill Bosch, Yakama Nation data manager, and PTAGIS. This type of comparison might indicate whether some latent mortality occurs after early marine life, that is, beyond the period recorded by COAST.

The tests of delayed and differential-delayed mortality based on limited years, stocks, and fish within seasons needs to be carefully compared with NOAA and Fish Passage Center data before arriving at generalizations. Without these comparisons, managers will receive a mixed message about latent mortality without information about why the findings seem to be conflicting.

A critical issue seems to be whether transport is actually worth pursuing. The question raised above "What was the survival rate from release to Bonneville?" of groups that are barged vs. groups that make in-river migrations will partially answer this question. If delayed mortality caused by barging is greater than the survival benefit obtained from barging once the fish are liberated then there are no benefits. Post-release survival benefits associated with barging may be dynamic, changing with conditions present in the lower river, estuary, and plume. Looking at these questions in a rigorous manner through planned releases should help determine when or if transportation provides benefits. For operations and management, an estimate of average transport benefit is not that useful. More useful would be to know, for example, whether transport provided essential benefits during years of extremely poor (1998, 2005) or good (2008) ocean conditions (Table 5). An operational/management challenge is whether survival can be predicted from ocean conditions, and whether transportation can be implemented in an ad hoc fashion. For example, could managers determine in January that they needed to transport in April and get all the equipment in order? Or, do they realistically need to transport every year to keep the equipment functional, so transportation is in place to provide an important benefit once or twice a decade. These are policy/management questions with a scientific foundation.

Ocean survival cannot be based on data collected only by these ocean projects. The overall ocean survival and partitioning into different ages and ocean locations is by subtraction from overall SAR based on PIT tags, or other methods. Survival in some regions is drawn from the ocean monitoring of acoustic tags, but those studies only cover part of the life-cycle. This is not clearly explained by the authors.

In any case, side-by-side comparison with PIT tag and fishery recoveries for the years and stocks of interest would provide explicit identification of inconsistencies in the estimates and an opportunity to better understand the ramifications of alternative interpretations of the data.

VII. Forecasting and Management Tools

The diverse array of indicators, either singly, or as composites using PCA, in Table 5 covary but have potential to forecast adult returns in later years. This research should continue and should examine how indicators differ in forecasting different stocks, for example, Willamette, Lower Columbia, and Snake stocks of spring Chinook.

Most of the indicators relate to early ocean conditions, a period thought to be critical in the survival. However, in some years conditions during the winter or following years may be most important. For example, 1982 was a strong upwelling year, and jack returns of coho salmon were high, predicting a banner year class the following year. Then the 1983 El Niño blew in and returns were dismal, that is, 58% of predicted adult returns died during their last year at sea (Pearcy 1992). This underscores the need to understand how second and any subsequent year survival can be affected by oceanic conditions and why understanding it can improve our predictive forecasting capability.

Year-class survival of marine fishes has often been predicted with success, only to fail in the future as noted by the authors in the ocean synthesis report introduction. This indicates the complexity and dynamic nature of the marine environment and the behavioral and distributional responses of fishes. What about using the indicators to hindcast, where a long time series of SARs and physical variables are available, for example OPI coho? Cold-water copepods appear to be a good predictor in the present data set. They are correlated with the PDO and upwelling variables, so physical variables could be use to explore a long time series that extends through years with conditions not represented in the present, short-term present data. Would hindcasting reveal reasons why Logerwell et al.’s (2003) model for coho failed?

Outlier years (2001, 2005, 2008) may erode “mechanistic” understanding of the linkages but they provide important, unique information about physical forcing and biological responses. Such “aberrant years" are rationale for additional years of this research in hopes of catching major climatic changes or reinforcing existing forecasts.

Based on the numerous relationships and correlations listed in this and previous sections, how good is predictive capability based on results to date? Will the relationships hold up in future assessments? Do the authors expect them to?

The complete dismissal of the jack index on page 52 seems unwarranted. The jack predictor of OPIH Columbia River coho could be compared with the authors' other indicators.

VIII. Management Implications

This comprehensive section clearly states the importance of dialogues between researchers, managers, and policy makers. The attention of managers and policy makers will likely focus on this chapter; therefore, it would be prudent for the ocean projects to highlight their accomplishments and the relevance of findings to management.

The ISRP's view is that ocean research is highly relevant and important, in part as a tool to split out survival associated with the ocean from that in freshwater. Managers should recognize that viable salmon populations must have sufficient productivity in freshwater in order to overcome low productivity that can occur for prolonged periods in the ocean. From this perspective, it may be worthwhile to investigate whether hatchery salmon growth and natural salmon production in freshwater can be adjusted to the extent possible, for example in the hydrosystem, to enhance survival of both hatchery and natural populations during anticipated years of poor ocean productivity.

- **Ocean Variability as a Context for 4-H Management**

Partitioning of ocean survival trends is needed so that the effects of the 4-Hs can be evaluated. The effectiveness of restoration as estimated from adult returns must account for all sources of mortality, including ocean mortality. Ideally, this partitioning will be accomplished for wild and hatchery stocks, in-river vs. barged, individual ESUs, and different life histories to help determine in-river, estuarine, or ocean responses to the 4-Hs.

SARs provide important information on long-term survival of different tag groups for integrated survival from Bonneville and return, or for lower Columbia River coho. Combining SARs with forecasts of early ocean life from indicators and acoustic and other estimates of survival may preclude assumptions that dam counts measure survival and shed light on later ocean survival.

P. 55, paragraph 4: "SARs are available only for a very few salmonid populations . . . and they do not tell when or where mortality occurred." The first part of this statement is not correct. SARS are available for many populations, although many are hatchery stocks, for example see the recent ISRP review of the Lower Snake River Compensation Program (ISRP 2011-14). SARs based on PIT tags have been used to examine mortality above the hydrosystem, within the hydrosystem, and downstream of Bonneville Dam.

However, when using PIT tags to estimate parameters like SARs it should be understood that these tags might significantly reduce survival. Knudsen et al. (2009), for instance, found that SARs of PIT-tagged fish were 25% lower on average than those on cohorts that did not receive PIT tags. Moreover the post-release survival of PIT-tagged fish ranged from 10 to 33% lower than non-tagged companion groups. Studies similar to that performed by Knudsen et al. are currently taking place in the basin.

- **Improving Recruitment/Return Forecasts**

The ISRP is encouraged that the authors are working with the United States v. Oregon Technical Advisory Committee (TAC) to improve recruitment/return forecasts. The ISRP agrees that this predictive work cannot continue without continuing long-term at-sea monitoring and observations.

- **Other Management Issues**
  - **Ecosystem-based management**

The ISRP recognizes that information from the authors' ocean surveys and food-web analyses (section V) were instrumental in informing the Pacific Fishery Management Council's (PFMC) deliberations and decision to adopt a complete ban on commercial fishing for all species of krill in U.S. West Coast federal waters.

  - **Life history diversity and salmon population resilience**

Growth at sea should be evaluated as a key factor influencing variation in maturation rates and its effect on sibling ratio forecasts. Furthermore, because each salmon population has a potentially unique maturation rate, sibling ratios should be calculated on individual populations to the extent possible. The most obvious population groups that should be separately analyzed are hatchery and natural populations which have been demonstrated to have very different maturation rates and SARs. More attention to differences in life history characteristics of hatchery and natural salmon (ISAB 2012-2) is needed in the analyses of data even if some of the hatchery salmon are not 100% marked.

The ISRP agrees with the authors' recommendations encouraging diversification of hatchery releases with different release numbers, times, sizes, and stocks as experiments to provide information on both ocean and other sources of mortality, and possibly to hedge bets in light of climate change (portfolio effect). Moreover, it is vital to mark all hatchery fish so that wild/hatchery and ESUs can be reliably separated. Dialogues with CRITFC should continue.

In a number of places in the report and appendices, it is mentioned that not all hatchery fish (Chinook and coho) are adipose clipped and even in hatcheries where fish are supposed to be fin clipped a significant percentage of them can escape clipping or are able to regenerate adipose fins due to poor clips, for example page 18, Appendix H. This has caused the proponents to be unsure whether unmarked fish are naturally produced individuals or hatchery fish that were unmarked. This complication has interfered with some of their hatchery and wild fish comparisons. Diet overlap, distribution patterns, arrival timing into different habitats and so on, for example, are impacted by uncertain identification. Also both the sponsors and ISRP members have acknowledged that knowing the origin and release strategy associated with hatchery fish would be valuable because interactions between stocks, life history or hatchery strategies, and ocean conditions could be examined.

CWTs (in the snout and other body locations), PIT tags, and elastomer marks can provide this information. These tagging and marking methods, however, require that fish be individually handled at the time they are tagged or marked. This has two effects, first it may induce unwanted physiological consequences and influence post-release performance (e.g. Knudsen et al. 2009), and second it generally means that not 100% of the fish from a hatchery are tagged or marked because of the expense of tag or mark application. Mass marking methods that can be applied to every fish without direct handling represent another approach. Parent-Based-Tags based on SNPs can potentially provide origin information for hatchery fish but may not be suited for examining the effects of different release strategies. This difficulty arises when juveniles produced from the same parents are incorporated into different hatchery release groups. GSI methods that rely on variation in microsatellite alleles provide another important tool that has been used to identify stock origins. However, like Parent-Based-Tags it is probably not suited for identifying hatchery fish that have experienced different release strategies.

The most widely used mass marking method for Pacific Salmon is thermal marking. Bar codes are induced into the microstructure of otoliths by making abrupt changes in incubation temperatures from the eyed-stage of development to yolk absorption (Volk et al. 2005). These temperature changes create visible bands, and spaces and numbers of bands are used to create codes that are linked back to specific groups of hatchery fish (Volk et al. 1994). Currently, over 30% (more than 2 billion) of the hatchery origin salmonids released into the North East Pacific ocean (North Pacific Anadromous Fish Commission; *see*: [www.npafc.org/new/science_ otolith.html](www.npafc.org/new/science_otolith.html)) are thermally marked. Approximately 34 million Columbia River Chinook salmon receive thermal marks every year. All the fall Chinook produced by the Priest Rapids Hatchery and Spring Creek National Hatchery, for example, are thermally marked. In 2010 that amounted to 28 million fish, a significant proportion of the fall Chinook released above Bonneville. Additionally, 7 million spring Chinook from the Willamette Hatchery are thermally marked. These marked fish represent an important resource for the sponsors, one that they have not yet utilized.

The Kintama Group states that they have frozen samples of juvenile salmon that remain to be processed. Otoliths from these fish could be extracted an analyzed to determine if any of them originated from groups of thermally marked fish. Additionally, Canada releases thermally marked Chinook that could be recovered in the areas that are being sampled. Unclipped fish could also be examined to see if they possess a thermal mark. If NOAA and DFO researchers have retained their samples, similar otolith extractions and decodings could occur. Such work might help resolve some of their existing questions about the origin of sampled fish.

Otoliths from fish that have not received thermal marks have the potential to identify wild and hatchery individuals. Ratios of isotopes in otoliths from hatchery fish are likely different than those originating from natural origin fish in the freshwater portions of their otoliths. This is due to the dietary differences the two types of fish experienced. Marine based diets for hatchery fish and freshwater based diets for the natural origin recruits may induce distinctive isotope signatures. Consequently, decoding of otoliths and possible microchemistry evaluations of these structures provide promising hatchery-wild and for thermal marks stock-release strategy identification methods for the proponents. These marks have been called “stealth” marks and could be an alternative to tribes who do not adipose clip or otherwise mark their fish because of cultural reasons. This recommendation is directed at the region's fish and wildlife managers, but the ocean researchers would benefit from analyzing otolith data.

- **River Flow and the Columbia River Plume**

The ISRP agrees survival rate comparisons per unit time have important implications for managing river flow and the plume because tagging results indicate it is important to consider both residence time and survival rate per unit time.

Climate change is predicted to affect the timing and volume of Columbia River flows, river and estuarine temperatures, and the seasonality of upwelling in the future. How will lower peak flows and higher in-river temperatures during smolt outmigrations affect survivals of different stocks in the plume and in-river? As stated, modification of flows may be a tool for management in the future. Simulating how future changes will affect estuary, plume and ocean conditions is encouraged by the ISRP.

- **Addressing "Latent" and "Differential" Mortality**

The COAST project did not find evidence of latent or differential mortality in transported vs. in river salmonids. How can this conclusion be reconciled with the previous statement that SARs of transported fish based on PIT tags is less than what is expected given that river survival of transported fish is much higher than that of river migrating fish? Is it possible that delayed mortality occurs after the period monitored by the COAST project? The COAST project offers an alternative approach to PIT tags when addressing these important issues. However, greater interaction and discussion is needed to determine why PIT tag data and acoustic tag data seem to be providing conflicting information. Given this apparent conflict, investigators should consider new and old evidence of tag shedding and tag-induced mortality, which can be significant and variable from year to year (Knudsen et al. 2009, Jonasson et al. 2011).

The ISRP concludes that experiments conducted to date as described in the synthesis are not adequate to address latent and differential mortality.

IX. Data Gaps, Uncertainties, and Research Needs

The ISRP is encouraged that the research has progressed to the point of being able to ask questions and obtain results concerning how ocean conditions influence interactions between hatchery and wild salmon, stock specific responses, and potential density-dependence. It is clear that complex interactions of factors influence survival so careful prioritization is necessary to identify the most crucial data gaps. The ISRP recommends that obtaining stock-specific data on oceanic effects on salmonid survival wherever possible is important.

The ISRP concludes that there is a need for a systematic approach to additional survey work by these ocean projects in order to address both the existing objectives and the gaps and uncertainties identified by the ISRP in the RME and AP categorical review (ISRP 2010-44).

- **Information Requested by the ISRP**
    - **Density Dependence**

This topic seems to be covered in the NOAA response to the ISRP (Appendix H), but the results on this difficult question are still equivocal for Chinook salmon in the ocean. The authors' paper submitted to Environmental Biology of Fishes may present more details. At present the authors' statement on page 17 of Appendix H, "With high spatial and trophic overlap, potential competition for food resources during years of low prey abundance may result in density-dependent growth suppression for both natural and hatchery produced salmon," seems to be their major conclusion, but remains untested and should be addressed.

- **Hatchery/Wild Interactions**

Incomplete marking of hatchery salmonids can complicate analyses, as indicated by the authors. Nevertheless, analysis of hatchery versus natural salmonids is highly important because their life history, growth, and survival can be significantly different. Mixing of data collected from hatchery and natural salmonids can lead to greater variability or to misleading findings if most samples are derived from hatchery fish when natural fish differ significantly in the measured characteristic. To what extent have the ocean projects, along with the Council, discussed the need for mass marking with agencies, managers, and hatchery personnel? See the ISRP's recommendation above regarding use of otolith thermal marks. To what extent have analyses been conducted on marked versus unmarked salmonids, other than the study described in Appendix H, while recognizing that unmarked fish include some hatchery origin fish? This type of analysis would provide some initial indication whether the mixing of hatchery and natural salmonids in the dataset causes bias.

- **Steelhead Ecology**

Little is known about early marine survival of steelhead; more work is needed. The authors do not explain the potential mechanism for the abrupt increase in steelhead in trawl survey catches since 2006, but it is encouraging that samples are now sufficient to initiate studies of the health, growth, and food habits of juvenile steelhead. The ISRP considers development of a comprehensive genetic baseline for identifying stocks of steelhead in mixed-stock ocean catches to be a high priority.

- **Research Needs**

The authors have presented a substantial list of 12 topics, all of which could yield new science on Columbia River salmon in the river, estuary, and ocean. The information below could go into a table in the synthesis report. These research needs should be prioritized. The team should present the topics at their proposed workshops, an additional item on their list of research needs, to get feedback from managers on which topics are most important to them.

Future scenarios including the effects of ocean acidification, proliferation of low-oxygen dead zones, and climate change are critical ocean research issues with enormous data gaps not addressed by the research needs listed in this synthesis report.

- **Top-Down Processes (*H2*)—***Avian predators*:

The proposed new research using hydroacoustics to assess forage fishes would be more effective with side-scan sonar to detect surface schools or shoal of fish than downward directed echo sounders.

Research on avian predators should focus on the lower estuary. This entails cooperation among ongoing sampling of migrants (GSI, CWT, PIT, acoustic tags—COAST/JSATS) to identify stock composition and ocean entry timing, predation by colonial nesting seabirds, and PIT tag detections from trawling in the estuary.

- **Additional Acoustic Tagging (H5)**

What is meant by the statement that acoustic tagging of additional Chinook stocks "is important for validating the finding that ocean survival rates currently match freshwater survival rates, and should be continued before major changes to management are implemented"? What is meant by "matching survival rates"? What management changes might happen?

- **Future coordination and collaboration**

To what extent are these projects dependent on BPA funds versus funds from other sources? Do BPA funds serve as matching funds? It may be worthwhile for the ocean projects to describe the linkage of BPA projects with associated projects to highlight the need for funding from all sources. What questions are being asked by the other funding sources?

The ISRP commends NOAA for their research in the estuary that provides improved estimates of ocean entry times, sizes, condition and growth of fishes. Future coordination here could include assessment of colonial bird predation, and COAST and JSATS acoustical tagging results.

One topic not addressed in the report is evidence for declining ocean survival. The survival portions of the report seem to say the hydrosystem was not the critical region. While ocean survival rate may be smaller than believed, recovery of these fish will likely require efforts at improving survival in several regions/life-stages. Ocean survival rate may be small, but larger numbers of individuals are lost at other life-stages even though survival rate is greater. The Cumulative Risk Initiative (CRI) by NOAA used a sensitivity analysis to evaluate where the most benefit for salmon recovery could be obtained among estuary, hydrosystem, freshwater rearing (ISAB 99-7). The ISRP concludes that there is a need for NOAA or Council to consider the current findings and partitioned life-cycle survival in light of the earlier conclusions and how these are reflected in the priorities of the Biological Opinion (BiOp) and Council's Fish and Wildlife Program.

Appendices

- **Appendix A**

Appendix A provides a useful summary of region, periods, and metrics covered by NOAA and DFO ocean projects. A brief discussion of Appendix A in the synthesis text would be useful, particularly with respect to how the regions, periods, and metrics relate to the projects' assumptions and construct of evaluating the primary hypotheses.

- **Appendix B**

Appendix B provides a list of joint publications by the projects. These, as well as citations included in the report, indicate good progress. A complete list of all published, submitted, and in-review publications by all three projects would be a welcome addition to the synthesis report.

The American Fisheries Society symposium in 2006 resulted in many joint publications. The ISRP encourages the authors to organize similar symposia in the future.

- **Appendix C**

Appendix C provides supplemental information on the technical feasibility of using acoustic telemetry for assessing the mortality and migration of Spring Chinook salmon. The investigators imply that acoustic tagging has little effect on salmon as long as handling is minimized. Recent analysis of PIT-tagged fish show fairly high tag loss rates and tag-induced mortality rates (Knudsen et al. 2009 and subsequent unpublished analyses). The potential bias or variability caused by tag loss and tag-related mortality should be carefully evaluated each year.

- **Appendix D**

Appendix D provides supplemental information on smolt-to-adult return indices used by NOAA and DFO as response variables. As discussed in our previous comments, the ocean project sponsors should talk with agencies and managers involved in collecting the data and highlight the need for stratifying annual abundance data by age group and hatchery versus natural stock.

- **Appendix E**

Appendix E provides a table of basinwide hatchery Chinook releases 1998-2009 compiled from the Regional Mark Processing Center database and adult returns to Bonneville as well as estimated marine survival compiled from the University of Washington's Columbia River Dart website.

- **Appendix F**

Appendix F provides a brief comparison VEMCO and JSATS telemetry systems. The ISRP agrees with the conclusion that "the use of JSATS for estimating survival in the coastal ocean would likely be logistically and economically infeasible for Columbia River smolts."

- **Appendix G**

Appendix G provides supplemental information on the relationships between ocean conditions off the west coast of Vancouver Island and adult returns to Bonneville 1-2 years following ocean entry.

- **Appendix H**

Appendix H provides NOAA's response to ISRP comments on the Ocean Survival of Salmonids Study's 2010 proposal. The ISRP appreciates the detailed responses to our questions and concludes that they are adequate. Some of the responses pertain to ISRP comments on the main text. It would be useful to cite information in the response in the appropriate places in the main text of the synthesis report.

The ISRP recommended development of a strategic plan that prioritizes hypotheses and management objectives. The huge variety of research objectives, methods, analyses, models, and hypotheses argues for prioritization, especially if future funding is limited. NOAA researchers recognize that it is time to develop a strategic plan, and state that the plan will be incorporated into the 2012 Statement of Work. Hypotheses will be prioritized to focus on the bottom-up control hypothesis involving enhanced ocean conditions as the primary factor leading to increased adult returns to the Columbia River Basin. The plan also needs to prioritize management objectives, but this was not discussed.

- **Appendix I**

Appendix I provides DFO's response to ISRP comments on the Canada-USA *Salmon Shelf Survival Study's* 2010 proposal. The ISRP appreciates the detailed responses to our questions and concludes that they are adequate. Some of the responses pertain to ISRP comments on the main text. It would be useful to cite information in the response in the appropriate places in the main text of the synthesis report.

- **Appendix J**

Appendix J provides Kintama's response to ISRP comments on the *Coastal Ocean and Salmon Tracking Study's* 2010 proposal. The ISRP appreciates the detailed responses to our questions and concludes that they are adequate. Some of the responses pertain to ISRP comments on the main text. It would be useful to cite information in the response in the appropriate places in the main text of the synthesis report.

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