United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Northwest Regional Director's Office
909 First Avenue, 8th Floor
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March 11, 2016

Northwest Power and Conservation Council
851 SW 6th Avenue, Suite 1100
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Dear Mr. Lorenzen,

Thank you for considering comments from the Northwest Region of the U.S. Geological Survey (USGS) as the Northwest Power and Conservation Council (NPCC) considers regional input on the Independent Science Advisory Board (ISAB) report titled, "Critical Uncertainties for the Columbia River Basin Fish and Wildlife Program." We recognize that this report constitutes an important, well-reasoned step in the Council's process for updating the 2006 Research Plan, which will culminate in the 2016 Research Plan. On September 16, 2013, the USGS provided then Chairman Bradbury with our review of the draft 2014 Fish and Wildlife Program Amendment. Since then, Council members and central staff have sought USGS assistance for updating the 2006 Research Plan. Naturally, we appreciate the opportunity to assist and offer input, and it is in the spirit of collaboration that we offer the attached comments.

Scientists from seven USGS Northwest Region Science Centers have contributed to the attached comments on the ISAB characterizations of the critical uncertainties facing the Fish and Wildlife Program. While their comments serve to confirm much of what is already described under the 14 Critical Themes, these reviewing scientists do offer some additional questions, explanatory material, and key relevant citations that we hope you find helpful.

In the first part of our comments, we address the more general process questions posed by the ISAB in the first three pages of the report. In the second part of our comments, we address in more detail the 14 Critical Themes identified in Part I of the ISAB report. To foster continuity in our attached comments, we asked our reviewers to address these common elements for each identified uncertainty:

- Confirmation that the ISAB is proposing to address all the pertinent questions and to offer additional questions for your consideration as appropriate;
- Can USGS provide the ISAB with additional information or relevant citations that may complement or supersede what is in the report; and

- Respond to the "Programmatic Comments," which we recognize as the most appropriate place for USGS to offer any alternative views of the scientific uncertainties as stated by the ISAB.

We appreciate this opportunity to provide comments on this ISAB report, which is of importance to all of us working in the Columbia River Basin in the areas of fish and wildlife.

Sincerely,

Richard C. Ferrero,
Regional Director Northwest Region

USGS Comments on Part 1 A Revised Set of Critical Uncertainties

We do not address Part 2 of the Independent Science Advisory Board (ISAB) report, "Summary of Progress toward Addressing 2006 Research Plan Critical Uncertainties," which evaluates the progress made by the Fish and Wildlife Program in implementing the research recommendations from the 2006 Research Plan. In Part 2 the ISAB has attempted to gauge progress by considering the relevance of individual projects in addressing an uncertainty question as well as the cumulative progress of all projects grouped under each theme. The results depicted in Figure 1 of ISAB's report sufficiently convey the heavy weighting to a small subset of the 14 themes that address uncertainties. We caution that the number of projects alone should not be considered a proxy for progress or the completeness of research accomplished since the 2006 Research Plan. Given the absence of a mechanism within the program for quantifying project benefits, or collecting data in a manner that makes project results comparable, the present qualitative assessment from the ISAB must suffice.

Rather than independently attempting to determine the degree to which the 2006 Research Plan has been implemented, we hope that our comments pertaining to Part 1 will illuminate how the NPCC might focus future efforts. Our comments explain some of the ways to develop a stronger basis for evaluation at a programmatic scale and address the ISAB recommendations to better focus funding, synthesize information, and form broader partnerships, as ways to make the program more effective.

Focus Funding – We agree with the ISAB recommendation for more focused funding of projects that address critical uncertainties. However, in addition to being more focused, funding will also need to be sustained for greater periods of time than the three year increments provided for research and restoration projects. Duration of effort marks a critical distinction between restoration and research. While a restoration project may be readily completed within three years, a research project that only collects three years of data makes it difficult to learn much about the status or trends for any species or issue, or the implications for the program. Adaptive management is informed by monitoring, and if properly designed such monitoring can generate information on physical and biological attributes relevant to multiple uncertainties.

Synthesize Information and Form Broader Partnerships – The synthesis of information can be fostered through deeper engagement with collaborative partnerships focused on coordination of monitoring and evaluation, such as the Pacific Northwest Aquatic Monitoring Partnership (PNAMP). This could improve resource and information sharing, increased quality and quantity of data and information, and reporting consistency. NOAA Fisheries and the U.S. Forest Service have large outreach initiatives underway to improve relations by forming partnerships. On behalf of the Great Northern Landscape Conservation Cooperative, the USGS has been sponsoring the Columbia Basin Partner Forum so that the region has a venue for coordinating their responses to the effects of landscape scale stressors on their trust resources. The Columbia River Toxics Reduction Task Force is an example of a single issue initiate that shares a basin-wide geography with the Fish and Wildlife Program.

The dissolution of the Columbia Basin Fish and Wildlife Authority has left the NPCC without an administrative structure in place to facilitate interactions with the community of tribal entities and state resource management agencies. For this reason we encourage NPCC participation in these other initiatives as a simple and immediate way to broaden its interface with the other

partners already working on the landscape scale stressors that affect the Fish and Wildlife Program, which has been focused on the All-H approach.

Establishing Program Infrastructure Needed to Address Uncertainties

For many years our scientists have conducted work supported by the Fish and Wildlife Program, provided the ISAB with science briefings in support of their report development, and have served, and continue to serve, on the ISAB today. Based on our collective experiences as "participant-observers" of the Fish and Wildlife Program, we offer suggestions for updating the infrastructure of the program. Our suggestions are in response to the ISAB's own findings, and constitute practical ways to implement those findings, by growing the scientific foundation of the program.

Adaptive Management – Adaptive management provides a valuable tool for ensuring that timely feedback from diverse activities informs the re-direction of future mitigation efforts to increase effectiveness. Since 2000, the Fish and Wildlife Program has acknowledged that adaptive management is the means for learning what is working and what is not in relation to key management questions, but has not fully operationalized adaptive management within the program. Decisions to re-direct program emphasis will be among the most important decisions made by the Council. In their seminal work applying adaptive management in the context of the Columbia River Basin, Professor Kai Lee and the late Jody Lawrence wrote:

> *As a strategy for implementation, adaptive management provides a framework within which measures can be evaluated systematically as they are carried out. Information from these evaluations should enable planners to estimate the effectiveness of protection and enhancement measures on a system-wide basis…Measures should make an observable difference. Monitoring must be designed at the outset.* <u>*Biological confirmation is the fundamental measure of effectiveness*</u>. (Emphasis added.)
>
> -- Lee and Lawrence (1986)

Monitoring and evaluation are key elements of adaptive management because they can be used to measure biological response. They encompass the collection of data and subsequent analyses of data to identify changes in fish and wildlife populations and the habitats that support them.

Today, the Fish and Wildlife Program still remains a restoration program that funds different restoration activities as "projects" which are discreet in geography, specific to an issue or species, and of three years duration. Although the integrity of the restoration projects is high, the project format is not designed to support long-term research, monitoring, or evaluation at a programmatic scale, no matter how many of them are completed. Thus, there is a mismatch between administrative processes the NPCC has in place for implementing short-term projects, and the long-term needs of the program for the research, monitoring, and evaluation necessary to inform and support adaptive management into the future.

Over several decades, the Northwest rate payers have made a substantive investment in the Fish and Wildlife program. It would therefore be prudent to establish a baseline of current conditions and inaugurate research and monitoring in support of early detection of changes that could inform (positively and negatively) progress within the Council's program and support adaptive

management. Examples include early detection of potentially lethal warmer water temperature in critical reaches; the role of cold water refuges and the resiliency of streams and eco-systems to climate stress; inflow of a new class of contaminants (personal care products) into the aquatic ecosystem; impacts to the regional economy from the effects of a Quagga/Zebra mussel invasion on the hydro-system operational structures; and, impacts to the ecosystem from other aquatic invasive species. The management of each of these challenges could be informed by the 2016 Research Plan.

The inherent complexity of these new challenges to the program makes it essential that the program evolve and grow to meet them. Now is the time for the program to incorporate and implement adaptive management in a practical and meaningful way so that it can provide the basis for: evaluation at a programmatic scale; redirecting program priorities; and, informing initial efforts to address the new "emerging priorities" in the 2014 Fish and Wildlife Program. These steps would make the program more efficient in terms of program goals and more cost effective.

Citation

Kai N. Lee and Jody Lawrence, "Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program" (1986) 16 Environmental Law 431 at 450.

Scale of Uncertainties Requires Interdisciplinary and Sustained Research – The ISAB recognized a disconnection between current practice and future needs in its comment *"that many of the questions listed in the Council's database are too broad for one or even a small set of research projects to address"* (page 3). The USGS agrees with the ISAB recognition that:

> *What is often needed, however, are studies lasting for a decade or more that involve multiple sub-basins and are conducted by integrating teams of professionals representing a diverse array of disciplines such as fisheries, ecology, hydrology, modeling and social science* (Page 3).

We agree with the approach suggested by the ISAB, because it looks beyond the single-variable hypothesis testing it has supported at the project scale and addresses the issues of geographic scale, time frame, and the need for an interdisciplinary methodology. Clearly, the Fish and Wildlife Program does not need a synoptic approach to research and science; i.e., study everything everywhere. Yet it would benefit from conducting work at a sufficient scale (sub-basin) and with sufficient replicates (multiple sub-basins) to provide a basis for extrapolation to like sub-basins across the region. It is critical that data be collected for sufficient time periods to support meaningful statistical analyses. Since many of the critical uncertainties are multidisciplinary in nature, an interdisciplinary approach to research could generate useful results.

One simple method for sustaining long-range research would be to follow the example of private sector entities who dedicate a small percentage of their overall budget to research, development, and evaluation. Because this is necessary to improve efficiency and effectiveness, it is considered the cost of doing business to remain competitive. For the Fish and Wildlife Program, the cost of adopting this approach would be outweighed by its value in making the program more

effective in the future and as an "insurance policy" for the significant past investment by the Northwest ratepayers in the Fish and Wildlife Program. As current research projects are completed, the funding that supported them could be held aside to accrue as a source of funding for the longer range and more fundamental research needs at the scale of the overall program. Thus, though re-allocation and the passage of time, the program could develop the capacity to support a research component for the program under existing funding levels.

Institutional Commitment: The Key to Implementation – The NPCC should make an institutional commitment to implementing the science necessary to support fact based decision making within the Fish and Wildlife Program. This does not mean that the Fish and Wildlife Program needs to change from a restoration program to a research program, but rather that it develop and incorporate a research component in order to make restoration activities more effective. Many of the NPCC partners already support well organized research as part of their own programs, and have scientists who can help the NPCC organize and implement its own research agenda, starting with the 2016 Research Plan.

For the 2016 Research Plan to succeed will require that the NPCC provide leadership and support the processes and funding necessary to implement its research priorities in a meaningful way. By including specific language to support and guide implementation, the 2016 Research Plan could be much more than a smaller list of research priorities drawn from the larger list within the ISAB Report. If there are difficulties with the initial implementation strategy, it could be modified based on what has been learned, when the 2016 Research Plan comes up for review in three years, and a different approach could be tried. Since a decade has already passed between the adoption of the 2006 Research Plan, and the development of a 2016 Research Plan, it is critical that the next three years are used to make a committed effort at implementation, so that learning can be achieved.

Other regional scale restoration programs in North America have grappled with this same challenge, and found a way to incorporate research into their programs in a complementary way; e.g., Chesapeake Bay, the Great Lakes. Although not simple, the rewards can be great, as fundamental science can inform management decisions at a programmatic scale. For example, identifying which parts of the Columbia Basin will be affected first by the stresses of climate change would provide a basis for avoiding the loss of additional restoration dollars into them.

List of Critical Uncertainties by Theme

In this section, text from the ISAB Report is shown in italics to provide a reference point for our comments, which appear in normal font and are numbered in sequence with in the report.

Theme 1. Public engagement (page 18) No comment

Theme 2. Human development (page 23) No comment

Theme 3. Tributary Habitat (page 24)

Pat Connolly (WFRC); Norm Buccola (OWSC)

We recommend these additional questions to the list of "sub-uncertainties" found on page 24:

2. *Can habitat restoration, removing barriers, and transporting fish above barriers sufficiently increase carrying capacity to recover native wild fish populations in the face of introduced hatchery fish and non-native invasive species that also compete for the same resources?*

2.2 (modification to existing 2.2) Will any increase in carrying capacity be usurped by non-native invasive species or deleterious effects due to the presence of contaminants, preventing recovery of native fish and wildlife populations.

2.5 Would the fish produced in tributaries and above barriers be similar enough or sufficient enough in life history diversity, genetic diversity, and size structure (juvenile and adult) relative to fish produced downstream to survive and provide expected benefits under the present migratory system, the ocean environment, the harvest pressure, the annual variability of conditions, and the other recognized stressors?

2.6 Will increased efforts directed towards understanding cold water refuges in tributaries (relationship to river stage and flow, role of ground water, hyporheic flow), other important water quality indicators (dissolved oxygen, ammonia, pH, for example) facilitate better understanding and mitigate for tributary impacts less recoverable within the main stem?

2.7 How can we identify and prioritize candidate restoration sites along tributaries with an emphasis on identifying sites offering resiliency under baseline climatic conditions and sites offering resiliency under impending future climate change.

Theme 4. Hydrosystem flow and passage operations (page 25)

John Beeman, Noah Adams, and Pat Connolly (WFRC)

Each of the five questions listed is appropriate given the current state of knowledge about the hydro-system and its effects on fishes.

1. Some of the sub-uncertainties of Uncertainty 1 (hydro-system operations and fish survival) are written specific to the life cycle of anadromous salmonids (juveniles moving downstream, adults upstream), and could be reworded to avoid that or be more explicit about it.

2. (Effects on different life-history types) could be re-written as an objective question rather than one containing the assumption that there is an effect. For example, removing the leading "How do" and trailing "thereby… operations" might do it. In addition to the rationale presented, water temperature differences are a reasonable rationale for Uncertainty 2, given the warm conditions fall Chinook migrate within relative to spring migrating stocks. Climate change would logically tie into that issue as well, though it is explicitly included as a more comprehensive topic in Uncertainty 4 (water temperature). The rationale for Uncertainty 2 seems too brief.

3. (Differential mortality of in-river vs. transported juvenile salmonids) remains one of the most important in the basin. Relative to Uncertainty 3, the work of Giorgi et al. (1998) also shows differences in fish guided into bypass systems relative to unguided fish (suggesting this has been known for quite some time). There is also evidence from PIT tags used to estimate system survival. The inclusion of Uncertainty 5 (reintroduction in to blocked areas) is important, because this is an issue of increasing visibility as result of the Columbia River Treaty process. The sub-uncertainties are appropriate; though 5.2 (what may work for upstream passage at tall dams) is self-limiting by assuming fish ladders will not work at tall dams (which may be correct). Note that the fish ladder used to pass Faraday and North Fork dams on the Clackamas River, Oregon is about 2 miles long and ascends over 200 feet.

4. At some point, perhaps within this construct about water temperatures, the effects of reducing the water used to pass fish at conventional spillways to provide training flows for fish passing spillway weirs should be addressed. The water used for training spill, particularly in the summer, will become increasingly important for other uses as the climate warms, making a critical assessment of the effects of reducing training spill volumes on fish passage a relevant question. Finally, the tributaries have a great influence, so we recommend that the fourth question in this theme include the word "tributary," and read as "How do current operations at main stem tributary dams and reservoirs affect water temperature and fish passage for adults and juveniles?

Citations

Giorgi, A.E., Swan, G.A., Zaugg, W.S., Coley, T., and T.Y. Barila. 1988. Susceptibility of Chinook salmon smolts to bypass systems at hydroelectric dams. North American Journal of Fisheries Management 8:25–29.

Theme 5. Mainstem habitat (page 28)

Ken Tiffan, Jim Hatten, and Craig Haskell (WFRC); Norm Buccola (OWSC)

1.*"Where, when, and at what frequency under different conditions do salmonids and other native species use cold water thermal refuges in the lower Columbia and Snake rivers?"***, could be reworded as: "Where, when, and why do salmonids and other native species use cold water thermal refuges in the lower Columbia and Snake rivers?"

Before areas of thermal refuge can be identified, species and life stage specific criteria of what constitutes a thermal refuge need to be identified. This section should therefore define and characterize what constitutes a thermal refuge.

This uncertainty focuses on the where, when and frequency of salmonid use of thermal refuges, but could also include the uncertainty of how much thermal refuge exists, and is available given fish behavior. Although the example sub-uncertainty provided suggests operational changes could be used to optimize temperatures, an additional unknown is how much capacity the current system has to effect such optimization.

1.1 This is also oddly worded and incomplete: *"what would be the effects of operational changes for optimizing water temperatures and water quality for fish in shoreline and riparian habitats, as well as for wildlife in these habitats?"* This could be rewritten as follows: "what would be the effects of operational changes for optimizing water temperatures and water quality for fish and wildlife in mainstem and off-channel habitats?"

2. *What role do changes to the historical mainstem habitat (prior to dam construction) have in changing the density-dependent responses of salmon, sturgeon, and other species (anadromous and resident)?" S*uggest rewording as follows: "How can we optimize hydropower operations to minimize mainstem density-dependent mortality in salmon, sturgeon, and other species (anadromous and resident)?" A critical sub-uncertainty that should be included is "What role can drawdowns play when critical bottlenecks occur, such as severe droughts, to more closely match pre-dam survival conditions?" (see Tiffan et al. 2006). This uncertainty could be clearer if reworded to emphasize current conditions rather than "changes to historical habitat." The real issue is understanding density dependence in relation to current habitat conditions.
Food webs are unmentioned as a habitat feature. How might operational changes affect the amount of available forage (phytoplankton, zooplankton) at the base of the food web? This is a critical yet, unaddressed habitat feature that is directly related to carrying capacity for juvenile salmonids and other species. What is the relation between hydropower operation, prey production, and the carrying capacity of mainstem habitats? I disagree with the notion that operational capacity affords little opportunity to influence mainstem habitat and food webs.

3. Critical uncertainty 3 was well crafted and the sub-uncertainties were appropriate. However, somewhere in this topic there needs to be a discussion about the need for a biological decision support system (BDSS) that is spatially explicit and capable of evaluating management decisions among many reaches. Until this occurs, the answers to the questions posed will be too complex to sort out. This was evident when the Bonneville Power Administration tried to evaluate biological responses to different flow regimes that may occur under the Columbia River Treaty.

However, there is probably little capacity to alter habitats in impoundments through operational changes given the constancy of water levels. Given this, one thing that is missing is the uncertainty associated with non-operational changes to habitat in impoundments such as the increase in aquatic *macrophytes* that may, or may not, be beneficial to salmonids.

4. The fourth uncertainty question: *Where, when and at what frequency under different conditions do salmonids and other native species use cold-water thermal refuges in the lower Columbia and Snake rivers?* This should also include the Willamette, since the Report states that it encompasses the mainstem of the Columbia, Snake, and Willamette Rivers. One of the things that seems to be missing from this uncertainty is the mention of river flow as a habitat feature that has a large influence on sturgeon spawning. Spawning habitat area cannot be uncoupled from flow.

A question like the following would help us better understand how cold water refuges function and how we might be able to protect, restore, or create these areas: "What are the geomorphic and hydrologic features that help to define cold-water refuges *with* sufficient dissolved oxygen to

support aquatic species of interest? How can we inform restoration efforts to better protect, restore, and engineer off-channel refuge areas?"

Critical uncertainty 4 was also well crafted and the sub-uncertainties were important. Much is already known about these topics. Sturgeon recruitment usually only occurs upstream of Bonneville Dam following large spring flows that the hydrosystem has suppressed. Multiple publications have shown how habitat and recruitment improve as flows increase. A BDSS could also help address this issue too.

Citations

Parsley, M., L. Beckman, and G. McCabe. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. *Transactions of the American Fisheries Society* 122:217-227.

Parsley, M. J., and L. G. Beckman. 1994. White sturgeon spawning and rearing habitat in the Lower Columbia River. *North American Journal of Fisheries Management* 14:812-827.

Tiffan K.F., Garland RD, Rondorf D.W. 2006. Predicted changes in sub-yearling fall Chinook salmon rearing and migratory habitat under two drawdown scenarios for John Day Reservoir, Columbia River. *North American Journal of Fisheries Management 26:894–907.*

Theme 6. Estuary, plume, and ocean (page 30)

Ken Tiffan, Craig Haskell and Marty Liedtke (WFRC)

1. The response needs to be better defined. The relation between habitat restoration and juvenile salmon survival at the site or estuary scale has yet to be quantified. Although challenging as stated, site specific survival and its relation to restoration is quantifiable. Monitoring estuary survival in addition to growth, residence, and condition should be a priority.

1.1. Well justified, but need to include role of estuary restoration.

1.2. More easily quantifiable for reservoirs than the estuary.

1.3 Add the phrase "Sea Level Rise" to sub-uncertainty 1.3 as follows, "How do climate change, hypoxia, ocean acidification, and sea level rise affect survival of focal fish species….and ocean?"

It is important to include sea level rise so that we can be more proactive in our estuarine restoration activities. By understanding today, how close certain habitats are to a tomorrow where they will transition from shallow water habitat to deep or from fresh water marsh to euryhaline, and so forth. USGS has developed a very relevant hierarchical ecosystem classification scheme that will give us predictive capacity for which future habitats may become inundated under new climate and sea level rise scenarios.

2. The word "responses" is vague. Which response and alternative restoration actions are being referred to? Many responses have been measured for years yet the value is questionable.

Perhaps adding some examples in parentheses would help. The concern is that easily measured responses (e.g., diet) would continue to be measured while more difficult responses (e.g., survival) would be neglected. The relation between habitat restoration and fish survivals remains challenging and poorly understood.

3. This uncertainty is well justified.

Connectivity –Whether estuarine restoration projects can contribute to increased juvenile survival and hence increased adult returns remains uncertain. Good estimates of residence time in rearing habitat that will likely influence survival are generally lacking. How fish move between rearing habitats and the importance of habitat connectivity and spatial distribution is poorly understood. The quantity of available habitat, and how that habitat is distributed throughout the migration and rearing reaches of the Lower Columbia River and estuary is not well known. The quality of that habitat, and the extent to which fish utilize these habitat, are also uncertain. Therefore, research to address these uncertainties could help inform decision making on what types of projects will be most effective, where the restoration projects should be sited, and how many projects will be necessary to restore sufficient habitat to support increases in adult returns.

Forage fish – Forage fish are an important component of the ecosystem, providing a critical food source to avian species, mammals, and other species of fish important to tribal, recreational, and commercial harvesters such as the salmonids. The health of forage fish populations can provide an indicator of the health of the systems they inhabit, and the lower trophic levels that support them. Forage fish in the lower estuary include a broad group of species, including surf smelt, Pacific sand lance, Pacific herring, eulachon, and juvenile American shad. These species have diverse reproductive strategies but they all occur in the lower estuary during their life histories. Because the Fish and Wildlife Program has an emphasis on salmon restoration it is important that forage fish provide a major link between habitat and environmental conditions and the survival of salmon. Consequently, we recommend the 2016 Research Plan address:

- Identify spawning and rearing habits of forage fish in the estuary
- Determine the role of forage fish as alternate prey for birds in the lower estuary
- Elucidate the role eulachon may have as an alternative prey for sea lions
- Determine how restoration projects in the estuary may contribute to reproductive success and rearing of forage fish
- Identify the relation between Columbia River flow and forage fish abundance in the estuary
- Identify role forage fish have in survival of juvenile Chinook salmon, coho, and steelhead
- Determine how climate change, ocean acidification, and localized hypoxia are likely to affect forage fish in the coming decades

Theme 7. Contaminants (page 32)

Elena Nilsen and Ian Waite (OWSC); Tim Counihan (WFRC)

In general, there is a need for more focused evaluations of existing monitoring data to address ongoing questions related to trophic transfer, establishing natural background concentrations, and biological impacts (associating exposure to toxics with effects). Yet the sub-uncertainties identified are appropriate and do address the majority of contaminant concerns and data gaps. Programmatic comment 2 is missing a couple of key points and also should cite the available literature to identify key data gaps.

1. Under primary uncertainty (1) the term 'uses' should be changed to 'sources' or 'pathways'. Many of these compounds had uses before they got into the environment. Once they are contaminants or toxics in the environment, they no longer have a use. Under sub-uncertainty (1.1) the hydrologic scenarios and management actions of interest should be expanded to include additional key processes such as municipal storm water management, mitigation of agricultural runoff, and habitat restoration. We suggest an additional sub-uncertainty, to be (1.2) "What are the levels of concern for contaminants found in the basin?" Although levels of concern for contaminants of emerging concern are addressed under sub-uncertainty 2, there are few benchmarks available for a wide variety of contaminants present in the basin, and those benchmarks that exist often relate to acute toxicity. A better understanding is needed of the sub lethal effects of a large number of compounds on species of interest in the basin, and the implications for human health.

2. Under uncertainty (2) there should be a sub-uncertainty that specifically addresses the need to understand the cumulative and/or synergistic effects of multiple toxic contaminants on fish health and reproduction.

Programmatic Comment 2 Water Quality This section needs to cite the available literature (see below) to strengthen and clarify the very important points addressed and to identify the data gaps which need the most attention. It should also be noted within this section that higher contaminant levels in juvenile salmonids have been correlated to longer residence time in the Columbia River Estuary and that persistent organic pollutants have been measured in larval Pacific lamprey from the Columbia River at levels higher than thresholds determined for adverse health effects in juvenile salmonids. The need to investigate the vulnerability of Columbia River food webs to threats posed by contamination has also been recognized. These points are highly relevant to this section and to the Columbia River Basin Fish and Wildlife Program.

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Theme 8. Climate change (page 35)

Jim Hatten and Steve Waste (WFRC); Greg Fuhrer, Norm Buccola and Stewart Rounds (OWSC)

1. The critical uncertainties listed in this section are appropriate and important. We suggest for Critical Uncertainty 1, that the following sub-uncertainty be addressed: "How will climate change facilitate exotic species invasions and what can we do now to minimize threats to native biota?"

2. Critical uncertainty 2 is well crafted and the sub-uncertainties are relevant. We suggest adding a discussion about the need for a biological decision support system (BDSS) that links river operation models to fish habitat and survival models.

It seems that there should be a third uncertainty here: "Under the new highly dynamic climatic regime, what stream reaches or geographic regions may be stressed above and beyond the limitations of a species of interest, so that restoration efforts in those basins could be scaled back and better placed in more resilient locations?"

This raises the question: “What non-native, but endangered species may be looking to our region as a new home under climate "refugee status"? What geographic areas that can no longer support a declining species can now support some immigrating endangered species population?

Consider adding another sub-uncertainty:

2.5 (new) Under the range of hydraulic river operations possible today, how much flexibility exists to adaptively manage surface water and ground water systems under pending climate change scenarios that will impact fish and wildlife.

It is important to determine how much latitude exists within the current mode of operation for the Federal Columbia River Power System (FCRPS) to ameliorate climate change in the future. There are limits on the extent to which we can reshape flow, utilize cold water refuges, or move surface water into the ground water system. An assessment of how much latitude exists within each subbasin would constitute an important management tool.

Programmatic Comment 3 Water Security
Please add “flood risk management” to the statement in paragraph one, which reads “Water security issues that could affect the success of the Program include water quality and quantity issues, ….add flood risk management…delivery due to climate change.” Also add, "To what extent can managed releases from high-head dams mitigate or mask the effects of climate change by regulating water temperatures and thereby optimizing endangered fish habitat downstream of such structures?"

Citations

Bovee, K. D., T. J. Waddle, C. Talbert, J. R. Hatten, and T. R. Batt. 2008. Development and application of a decision support system for water management investigations in the Upper Yakima River, Washington. U.S. Geological Survey Open-File Report 2008-1251, 289 p.

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Theme 9. Non-native species (page 38)

Tim Counihan (WFRC); Ian Waite (OWSC)

1. *To what extent is the viability or abundance of native fish and wildlife species in the Columbia River Basin jeopardized by non-native species?*

1.1 Additional uncertainty: "What are the critical tradeoffs between the monitoring level, arrival prevention, and response planning for non-native species?"

2. *What are the primary pathways of introduction of invasive and non-native species, and what management actions could limit new introductions or mitigate the impact of invasive species?*

2.2 Additional uncertainty: "What are the costs and benefits associated with prevention versus control?"

The ISAB report defines two critical uncertainties related to invasive species. We agree that the two questions posed are clearly critical uncertainties. However, the section on non-native species does not clearly provide a rationale for the tenet that this is a critical and urgent information need. The section does not acknowledge the large body of literature that documents previous effects of non-native organisms on the economy and ecology of other systems. Acknowledging the consequences of species introduction in other locations would strengthen the ISAB Report. In general the section seems to focus on introduced fishes but should also mention and acknowledge the potential effects of other known invaders (e.g., Emerson et al. 2015). Including this literature in this section could help readers understand the need for filling this critical uncertainty.

We are puzzled that the potential for a *dreissenid* mussel invasion is not mentioned at all in this section. Currently there is no support from the Fish and Wildlife Program in the regional efforts to manage the potential infestation of *dreissenid* mussels in the Columbia River, despite the report of the Council's own Independent Economic Analysis Board which quantifies potential damage to hydrosystem operations at $500M annually. Failing to act to limit new introductions or discover new introductions soon after they occur is a failed strategy that has occurred time and again across the country and throughout the world and resulting in significant economic and ecological consequences. In light of the significant evidence to support this, we recommend that ISAB should state this explicitly.

In addition to listing the critical uncertainties, we suggest the report could go one step further and outline the need to understand the potential consequences for the Fish and Wildlife Program of not addressing these and other critical uncertainties. Other reports completed by the ISAB have outlined critical information needs (e.g., ISAB 2011-1), but the information needs remain unanswered. In the absence of a proactive response to this issue, the Fish and Wildlife Program is likely to discover invasive organisms after they have become well established. The states and tribes charged with managing natural resources and rate payers will then be faced with the consequences of what are typically costly mitigation actions.

Previous efforts to document invasive species should also be acknowledged in the section. In the Columbia River Basin, initial efforts to survey the current status of aquatic invasive species have been initiated in the lower and middle Columbia River (LCRANS; Sytsma et al. 2004; MCRANS, Draheim et. al.2007). These efforts established an accounting of invasive species in these reaches but stated that there are still many important data gaps and recommended that a multi-faceted sampling strategy was necessary to detect new invasions and to document invasion rates, effects, and the efficacy of management efforts. The sampling locations for both LCRANS and MCRANS were not selected using a probabilistic framework, or designed to cover the breadth of habitats that exist in these reaches, so inferring status and trends will be confounded by the lack of a survey design. A well designed status and trends monitoring program of habitats and biota in the mainstem rivers and tributaries, that incorporates the taxonomic expertise needed to discern invasive organisms, will provide information to researchers to help them better understand drivers affecting the potential for colonization sites, the likely spread of exotics and therefore the extent of interactions with native species.

While much work is being done to develop monitoring programs for tributaries (e.g., CHaMP) in the Columbia River Basin, similar work for the mainstem Columbia and Snake rivers is lacking. The University of Washington (UW) and USGS recently developed a framework for a habitat classification scheme that will be used to identify and delineate different ecosystem scales in the lower Columbia River (Simenstad et al. 2011, USGS Open-File Report 2011-1228). This detailed classification scheme can serve as a platform to develop a probabilistic based design to 1) place previous invasive species sampling efforts into context: extent of different habitats sampled, determine types of habitats not sampled and prioritize habitat complexes for further sampling and to provide estimates of sample variability for biota and habitat types sampled (i.e., LCRANS - Sytsma et al. 2004) and 2) design a rigorous statistically based long-term aquatic and terrestrial monitoring program that incorporates invasive species. A comprehensive geographical information system platform is associated with this classification system and would serve as a template for a statistically rigorous habitat based invasive species monitoring program. The USGS is continuing this work by extending the Classification in the Columbia River above Bonneville Dam.

Citations

Draheim, R., Sytsma, M., Miller, R. and Cordell, J., 2007. Middle Columbia River Aquatic Nonindigenous Species Survey. Center for Lakes and Reservoirs, Portland State University, OR, and the University of Washington, WA. http://www. clr. pdx. edu/docs/MCRANS_Final_Rprt. pdf.

Emerson, J.E., Bollens, S.M. and Counihan, T.D., 2015. Seasonal dynamics of zooplankton in Columbia–Snake River reservoirs, with special emphasis on the invasive copepod Pseudodiaptomus forbesi. *Aquatic Invasions*, *10*(1), pp.25-40.

Simenstad, C.A., Burke, J.L., O'Connor, J.E., Cannon, C., Heatwole, D.W., Ramirez, M.F., Waite, I.R., Counihan, T.D. and Jones, K.L., 2011. *Columbia River estuary ecosystem classification—concept and application* (No. 2011-1228, pp. i-54). US Geological Survey.

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Theme 10. Predation (page 39)

Ken Tiffan and Craig Haskell (WFRC)

The uncertainties mentioned seem appropriate and cover a wide range of predation-related issues.

Programmatic Comment 5 Predator Control The call for maintaining the diversity of habitats in this comment is probably sound, but does raise uncertainty regarding differences in predation risk associated with different habitat types. While this is well understood for some habitats (e.g., dam tailraces), it is poorly understood for different habitats within main-stem habitats, and how it differs by species. Another uncertainty is whether hatchery and natural-origin are equally vulnerable to predation and how that can be quantified at the population level. Both Oregon and Washington have now implemented system wide unrestricted recreational take of smallmouth bass, walleye, and channel catfish for 2016. Will this provide any opportunity to evaluate predation on salmonids based on angler harvest of these species?

Theme 11. Fish propagation (page 43)

Pat Connolly (WFRC)

Add these additional questions to the list on Page 43-46:

"What are the most effective ways of using hatchery fish to enhance natural production?"

"What are the indicators and thresholds for when use of hatchery supplementation can be terminated and natural production is able to succeed on its own?"

Theme 12. Harvest (page 46) No comment

Theme 13. Population structure and diversity (page 48 to 49)

Pat Connolly (WFRC)

2. *What is the current range of biological diversity (life history and genetic) of fish and wildlife populations in Columbia River Basin ecosystems, and how is that diversity in focal populations influenced by geographic location and changing environmental conditions?*

We agree that knowing the range of life history and genetic expressions is critical, as is being able to compare this to the historical range of diversity. It is also important to understand the magnitude of expression of specific diversity elements is important.

Perhaps actions to shift the magnitude or dispersing the magnitude among expressed life history strategies and genetic diversity would be as worthy of a goal for increased resilience as would be enhancing the range of diversity. The ability to affect range of diversity may or may not be possible, while enhancing some underrepresented but present diversity that stills proves successful seems more likely.

3. *What life history strategies are utilized by Columbia River Basin fishes (e.g., Pacific salmon, lamprey, sturgeon, eulachon), and how do they influence survival and growth in tributaries, the mainstem above and below the dams, estuary, and ocean plume?*

We agree that identifying the life history strategies utilized is a critical step. It is equally important to understand which life history strategies are not being utilized or not being adequately expressed; e.g., because of low survival, and why they are not (see comments above). This requires an assessment of what life history strategies were historically utilized and what strategies might be utilized more or less as the system changes, through restoration, climate expression, or increased human use and pressure. Assessments should strive to assign extent; i.e., what percent of the population expresses a specific life history strategy; assign a survival factor (e.g., egg-to-spawner, fry-to-spawner); and, assign a contribution to the next generation (e.g. from a specific life history strategy).

Theme 14. Monitoring and evaluation methods (page 52)

Tim Counihan (WFRC)

The key to adaptive management and addressing climate change is long term, sustained monitoring in a structured decision process that allows synthesis and reporting against a predicted scenario. Monitoring in support of the Fish and Wildlife Program should be designed to address large critical uncertainties.

There are four critical uncertainties (41-44) listed that are associated with the overarching "Monitoring and Evaluation" theme. In general, the discussion of the activities associated with this broad topical area is limited given the breadth and importance of the topic. Since being able to document the status and trends of fish and wildlife that are the primary subjects of the Fish and Wildlife Program is fundamental to assessing the efficacy of the costly mitigation actions being implemented this topic deserves more attention, detail, and critical uncertainties. In light of the importance of the section, we suggest that it appear at the beginning of the report, rather than at the end. We offer some additional critical uncertainties that are not listed:

> Can the current monitoring and evaluation components of the Fish and Wildlife Program discern the status and trends of key fish and wildlife species with an acceptable level of statistical certainty?
>
> Have the monitoring and evaluation components of the Fish and Wildlife Program established a baseline that describes the status and trends of key fish and wildlife species from which changes in population status can be judged?

Can the current monitoring and evaluation components of the Fish and Wildlife Program discern the status and trends of key habitats with an acceptable level of statistical certainty?

Have the monitoring and evaluation components of the Fish and Wildlife Program established a baseline that describes the status and trends of key habitats from which changes in status can be judged?

Each of these critical uncertainties should also have a listing of sub-uncertainties that specifically address focal fish and wildlife species (e.g., lamprey, salmon and steelhead populations, white sturgeon, native fish assemblages, pika, etc.) and habitats (e.g., tributary vs. mainstem Columbia River versus estuary, etc.).

In the introductory section the statement: "A higher-level review with stakeholders would be useful in identifying additional concerns with monitoring and evaluation methodology" is made. While we agree with this statement, we encourage the ISAB to acknowledge and utilize the efforts of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) to facilitate and report discussions on this topic.

41. *Can a common probabilistic (statistical) site selection procedure for population and habitat status and trend monitoring be developed cooperatively?*

In many respects this does not seem like critical uncertainty because the answer to this question is clearly "yes." Perhaps what the ISAB means to ask is "Has a common probabilistic (statistical) site selection procedure for population and habitat status and trend monitoring been developed cooperatively?" While a common probabilistic site selection procedure can be developed cooperatively, perhaps a more relevant question is "Can the common procedures meet individual project needs while providing information that can inform questions at larger spatial scales." While this section focuses on tributaries, mainstem and terrestrial habitats are also imporntant.. The discussion mixes project monitoring, fish and wildlife monitoring, experimental design, and response design (i.e., sampling protocols) and is therefore unclear in the context of the Critical Uncertainty. For example, having a common sampling protocol among projects would certainly be helpful if rolling data up to a larger spatial scale, but it does not address Critical Uncertainty 41. Critical uncertainties for each of these components should be listed and discussed separately. There is also no mention that master samples have already been developed for large portion of the mainstem Columbia River (see: http://www.pnamp.org/sites/default/files/istm_mainstem_framework_final_2014-01-21.pdf). The reference to www.monitoringmethods.org should acknowledge PNAMP. That is (PNAMP; see: www.monitoringmethods.org). The section describing the contributions of the "Fish and Wildlife Project(s)" to Critical Uncertainty 41 also mixes issues that should be sorted out.

Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) used a probabilistic site selection procedure to select sites for long term monitoring. In the first project, they standardized sampling at a fixed set of "trend" sites and no longer select new sites. This will increase the power to detect trends ("index sites"), but now it is difficult to compute an estuary wide measure.

Unfortunately, these "trend" sites were not randomly selected within a probabilistic framework, despite the fact that there had been a GRTS draw completed at that time. So, if they "no longer select new sites" and the original sites were not selected in a probabilistic fashion, it is unclear what the ISAB means by: *"Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) used a probabilistic site selection procedure to select sites for long term monitoring."* Given the importance of the status and trends of the Columbia River Estuary to the Fish and Wildlife Program and the Biological Opinion for the FCRPS, this topic deserves a more complete discussion. We believe that if the additional detail is added that sorts out the mixed topics and components of "Monitoring and Evaluation" as recommended above, the contributions of individual projects would become more clear.

42. *Can a scientifically credible trend monitoring procedure based on remote sensing, photography, and data layers in a GIS format be developed?*

As with Critical Uncertainty 41, the answer is clearly "yes" and there are examples in the literature that indicate that this can, and has been done, in other areas. We suggest rephrasing the question as "*Has a scientifically credible trend monitoring procedure based on remote sensing, photography, and data layers in a GIS format been developed in the Columbia River Basin?* This topic should also be broken out into various geographical contexts (headwaters, tributaries, mainstem, estuary, terrestrial, subbasins, etc.). We suggest acknowledging the Ecosystem Classification (Simenstad et al. 2011; see: https://pubs.er.usgs.gov/publication/ofr20111228) which is largely based on remote sensing data.

We think that the criticality of this uncertainty is "High" and not medium. That is, if the current activities cannot discern status and trends, then developing remote sensing capabilities is critical. There is an over emphasis on the tributaries and the section should also include mainstem and terrestrial habitats. Also, no mention is made of the extensive bathymetric work that has been completed for the mainstem of the Columbia River. This should be included in this section as well, since bathymetry is collected via remote sensing.

43. *Can empirical (e.g., regression) models for prediction of current abundance or presence-absence of focal species concurrent with the collection of data on status and trends of wildlife and fish populations and habitat be developed?*

This is unclear, because empirical models can be developed concurrent with data collection. We suggest that the question really is whether they can produce information that would support credible management scenarios. We are uncertain why there is a focus on regression given the breadth of statistical frameworks that could be employed to address this topic. The discussion of this critical uncertainty also suggests another that could be added. For example:

"Are the current Monitoring and Evaluation components of the Fish and Wildlife Program sufficient to provide information that would inform and validate statistical models that predict the current abundance or presence or absence of focal species?"

44. *Make best professional judgment, based on available data, as to whether any new research in the spirit of the Intensive Watershed Monitoring approach should be instigated immediately. Most new intensive research should arise as a result of the interaction of existing inventory data with new data arising in population and habitat status and trend monitoring.*

We agree with ISAB that this uncertainty is hard to interpret and we recommend replacing it with the question they list: "What new intensive research might achieve synergies from combining existing inventory data with new data arising from population and habitat status and trend monitoring?" Given this new question the ensuing discussion should be expanded. The statement that refers to ISEMP and CHaMP: "These programs, however, have not generated (nor are they expected to generate) any emerging issues needing further intensive research." This statement is unsupported and conclusory. One of the benefits of long-term monitoring is the discovery of "unintended" consequences or unexpected trends that would otherwise not be discernable with short term projects. The ISAB's rationale for this statement is unclear.

Other Topics

Food Web – One topic that was not directly addressed in this report is the food web. This may be because there is a recent ISAB report on the food web. Nonetheless, there are a number of uncertainties and questions regarding the food web that are covered in the food web report that could be incorporated in this report. Nutrients and nutrient balances are largely unaddressed throughout the report with respect to anadromous fish (marine derived nutrients), water quality and human health with the exception of what to do with surplus hatchery fish. Also, although hypoxia in the plume and estuary is mentioned, the relation between hypoxia and upstream nutrient balances needs to be quantified.

Reintroduction of Anadromy to the Blocked Areas – Potential objectives for the reintroduction of anadromous fishes in the Upper Columbia River upstream of Chief Joseph Dam include: sustaining tribal, sport, and commercial fisheries and the delisting of endangered stocks. Objectives should be developed to guide field activities and management scenarios with a high probability of success for reintroduction in terms of species, life stage, habitat, and fish passage technologies. Short- and long-term reintroduction methods should be assessed such as balancing the use of hatcheries for translocation and supplementation with reliance on natural recolonization (e.g., see Allen et al. *In Press*), as well as determining the benefits for harvest, conservation, and cultural significance. An adaptive management framework would be a valuable tool for developing, implementing, and evaluating efforts in support of the reintroduction initiative. The workshop participants developed a list of key considerations to be considered in assessing the feasibility of the different components of reintroduction. These include:

1. Intrinsic potential of habitat (reintroduction feasibility and prioritization)
2. Most suitable species for reintroduction,
3. Pilot reintroduction programs and the source of donor stocks,
4. Critical uncertainties and information needs,
5. Technical feasibility of facilities and infrastructure to accommodate reintroduction, and
6. Issues that require life cycle modeling, such as survival and habitat connectivity.

Citation

Allen, M.B., R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson. and P.J. Connolly, *In Press*. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – Planning efforts and recolonization results. Fisheries.

Lamprey – Pacific lamprey is an important species both culturally and ecologically, but little is known about this species' upstream distribution prior to Grand Coulee Dam. Today, the population status is considered to be at high risk (Luzier et al. 2011) in the Columbia River basin. The Pacific Lamprey Conservation Initiative (June 2012) has been recently developed to promote implementation of conservation measures for Pacific lamprey throughout their range in Alaska, Washington, Oregon, Idaho, and California (*http://www.fws.gov/pacific/Fisheries/sphabcon/lamprey/pdf/Pacific_Lamprey_CI.pdf*). The NPCC's (2014) Fish and Wildlife Program has identified strategies for the conservation and restoration of Pacific lamprey populations in the Columbia River basin. The reintroduction of lamprey to the blocked areas of the Columbia River will require new passage facilities and a better understanding of their biology and life history needs. These issues could be addressed in the 2016 Research Plan.

Citations

Luzier, C.W., H.A. Schaller, J.K. Brostrom, C. Cook-Tabor, D.H. Goodman, R.D. Nelle, K. Ostrand, and B. Streif. 2011. Pacific lamprey (*Entosphenus tridentatus*) assessment and template for conservation measures. U.S. Fish and Wildlife Service, Portland, Oregon.

Northwest Power and Conservation Council. 2014. Fish and Wildlife Program 2014. Document 2014-12. Portland, OR. *https://www.nwcouncil.org/media/7148624/2014-12.pdf*