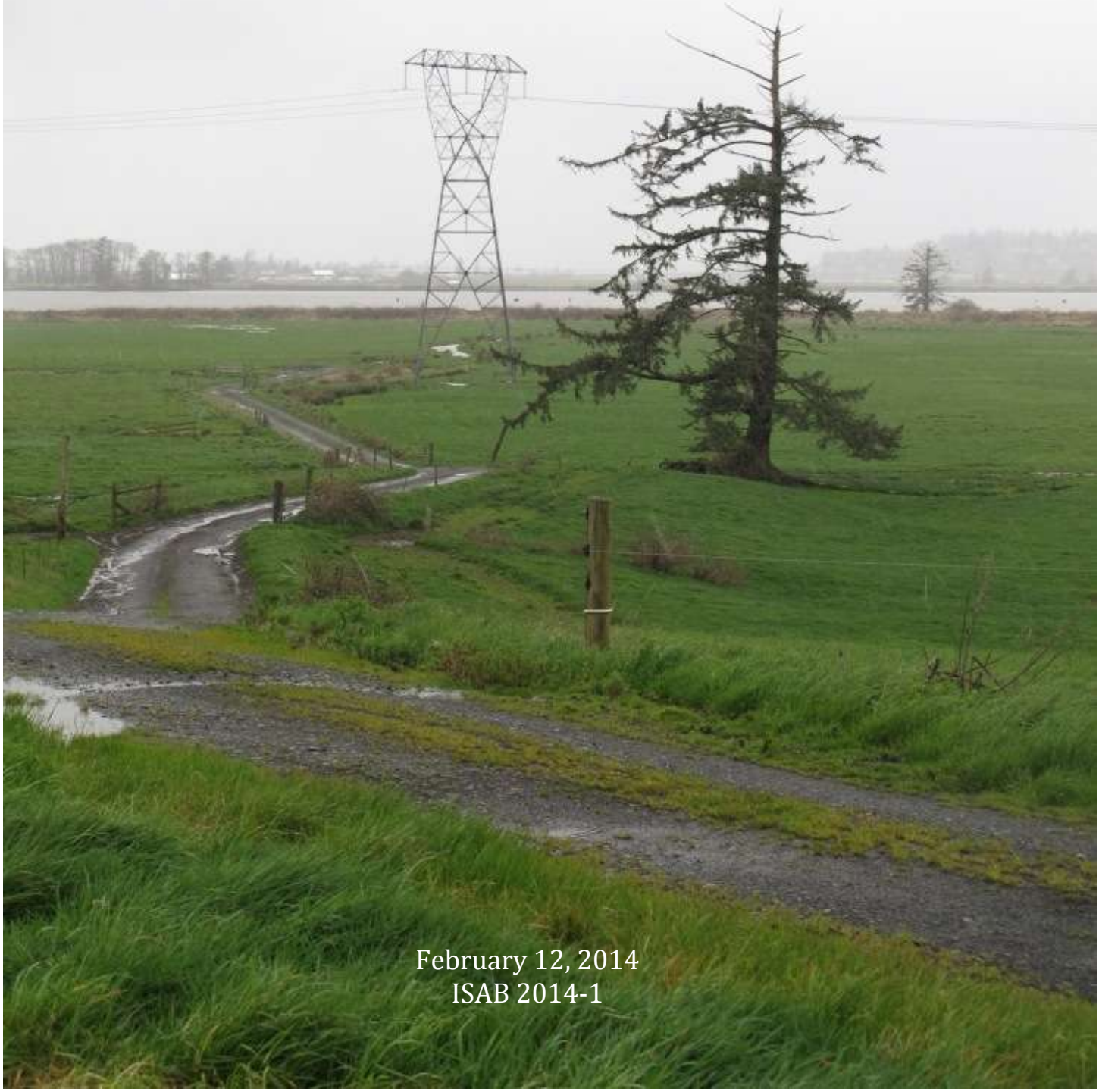
INDEPENDENT SCIENTIFIC ADVISORY BOARD

Review of the Expert Regional Technical Group (ERTG) Process for Columbia River Estuary Habitat Restoration



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Independent Scientific Advisory Board
for the Northwest Power and Conservation Council,
Columbia River Basin Indian Tribes,
and National Marine Fisheries Service
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204

ISAB Members

J. Richard Alldredge, Ph.D., Emeritus Professor of Statistics at Washington State University

Kurt Fausch, Ph.D., Professor of Fisheries and Aquatic Sciences, Department of Fish, Wildlife, and Conservation Biology at Colorado State University

Colin Levings, Ph.D., Scientist Emeritus at Centre for Aquaculture and Environmental Research, Department of Fisheries and Oceans, West Vancouver, British Columbia, Canada

Kate Myers, Ph.D., Research Scientist, Aquatic and Fishery Sciences, University of Washington (Retired)

Robert J. Naiman, Ph.D., Professor of Aquatic and Fishery Sciences at University of Washington

Greg Ruggerone, Ph.D., Fisheries Scientist for Natural Resources Consultants

Laurel Saito, Ph.D., P.E., Director of the Graduate Program of Hydrologic Sciences at the University of Nevada Reno

Dennis Scarnecchia, Ph.D., Professor of Fish and Wildlife Resources at University of Idaho

Steve Schroder, Ph.D., Fisheries Consultant and former Fisheries Research Scientist at the Washington Department of Fish and Wildlife

Carl Schwarz, Ph.D., Professor of Statistics and Actuarial Science at Simon Fraser University, Canada

Chris C. Wood, Ph.D., Scientist Emeritus at the Pacific Biological Station, Department of Fisheries and Oceans, Nanaimo, British Columbia, Canada

Staff

Erik Merrill, J.D., Independent Science Program Manager, Northwest Power and Conservation Council

ISAB Review of the Expert Regional Technical Group (ERTG) Process for Columbia River Estuary Habitat Restoration

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Background

In response to the Northwest Power and Conservation Council's November 2013 request, the Independent Scientific Advisory Board (ISAB) reviewed the Expert Regional Technical Group[1] (ERTG) process for assigning survival benefit units[2] (SBUs) for ocean- and stream-type juvenile salmon, as it applies to prioritization of habitat restoration projects in the Columbia River estuary. The 2011 Estuary Module developed by NOAA constrains the quantity of SBUs that the ERTG can assign to restoration projects. The Module lists 22 habitat restoration actions and associated subaction goals, and provides each restoration action with a set number of SBUs. The ERTG cannot assign more SBUs for a restoration action than the Module delineates.

The ERTG reviews the latest science to develop standard scientific Scoring Criteria for assessing the value of potential habitat restoration projects. A technical model combines the ERTG's findings with physical metrics to estimate the benefits of potential projects in terms of improved salmon survival. The results help the Bonneville Power Administration and U.S. Army Corps of Engineers (BPA/Corps, Action Agencies[3]) track progress toward Biological Opinion goals. The agencies also use the ERTG evaluation to direct funding, technical support, and other resources toward projects that have the greatest potential to improve survival of salmon and steelhead. The ERTG process focuses on the evaluation of restoration projects as a means to avoid jeopardy of ESA-listed salmonids caused by federal dam projects rather than the goal of fully restoring estuarine habitat for salmonids or other species.

To complete this review, the ISAB evaluated the ERTG's full set of documents, which are available at www.cbfish.org/EstuaryAction.mvc/Index. These documents include the ERTG's scoring criteria, general summaries of the ERTG process, descriptions of uncertainties faced by the ERTG in making calculations, and SBU reports containing project scores. Two ISAB members also attended the ERTG's December 4, 2013 annual public meeting with project sponsors to discuss the ERTG's evaluations of their projects. Finally, at the ISAB's January 17, 2014 meeting, the ERTG members and steering committee briefed the ISAB on the ERTG review process. The ISAB greatly appreciated the open nature of the review and the ERTG's efforts to fully describe their approach, constraints, uncertainties, and results.

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[1] The ERTG for estuary habitat restoration was established by the Bonneville Power Administration (BPA) and the U.S. Army Corps of Engineers (Corps) in response to the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (Reasonable and Prudent Alternative 37). The ERTG is a 5-*member* panel of scientists with expertise in habitat restoration, estuarine ecology, and fisheries biology (BPA/Corps 2014).

[2] A survival benefit unit is an index intended to represent the effect of Lower Columbia River Estuary habitat restoration on juvenile salmon survival (ERTG 2010c).

[3] The U.S. Bureau of Reclamation is also an Action Agency for the FCRPS BiOp but is not involved in the estuary restoration component of the BiOp at the level of BPA and the Corps.

The ERTG process is linked to the Columbia Estuary Ecosystem Restoration Program (CEERP). In September 2012, the ISAB completed a review of CEERP's 2012 Synthesis Memorandum, 2013 Strategy Report, and 2013 Action Plan Synthesis (see ISAB 2012-6). The ISRP reviewed estuary restoration projects as part of the Geographic Review Evaluation of Anadromous Fish Habitat Restoration Projects (ISRP 2013-11). The ISRP reviewed estuary research projects through the Council's Category Review of Research, Monitoring, and Evaluation and Artificial Production Projects (ISRP 2010-44) and the U.S. Army Corps of Engineers' Anadromous Fish Evaluation Program (ISRP 2011-24 and 2010-34). The ISAB also reviewed an early draft of NOAA's estuary module (ISAB 2008-2). Together these reports constitute a summary of restoration, planning, and monitoring efforts related to the ERTG process for Columbia River Estuary habitat restoration.

Summary Answers to the Council's Review Questions

The five questions asked by the Council and a brief summary of the ISAB's responses and recommendations follow.

1. *Are the ERTG Scoring Criteria used to assign survival benefits for habitat restoration based on sound science?*

The ERTG Scoring Criteria are partially based on sound science. The Scoring Criteria were developed by the highly qualified ERTG team, which has considerable experience with estuarine and salmonid ecology. However, there is room for improvement in the Scoring Criteria. In particular, reproducibility and transparency would be improved by more detailed documentation of methods and citations to the scientific literature establishing the ERTG's views and methods for assigning SBUs. The results and conclusions based on the ERTG Scoring Criteria are only partially supported by available scientific information. The Criteria have not been applied to comprehensive management elsewhere and are based largely on professional opinion. Thus, the ERTG's findings should be viewed as informed hypotheses that require research, monitoring, and evaluation to verify results and conclusions.

2. *Do the ERTG Scoring Criteria have the ability to differentiate and/or prioritize those projects that will succeed in increasing the survival of salmonids through their residence and migration in the Columbia River estuary?*

The ERTG Scoring Criteria are being used by Action Agencies (BPA/Corps) to differentiate and/or prioritize habitat restoration projects in the Columbia River estuary. However, the ability of projects to actually succeed in increasing the survival of salmon through their residence and migration in the Columbia River estuary cannot be determined from the Scoring Criteria. The ERTG Scoring Criteria can differentiate and/or prioritize the potential effectiveness of a project to increase survival of salmonids, assuming the accuracy of the score is reasonable. The statistical accuracy and precision of scoring of restoration projects are not estimated and are probably low in terms of the actual survival benefit expected from a specific project, but the accuracy and precision are likely greater for comparing the relative benefits of

one project ranked against another. The main advantage of the ERTG Scoring Criteria is that they facilitate structured and transparent decision making. However, their ability to differentiate and/or prioritize is only as good as the science behind SBUs in the primary planning document (Estuary Module). The main disadvantage of the scoring process is its subjectivity and variability of assigned scores, especially if there is a change in ERTG personnel. Whether or not the selected projects will actually succeed in increasing the estuarine survival of salmonids will remain uncertain until quantitative estimates of improvements in estuarine survival of salmonids become available.

3. *Do the processes identified in the ERTG Scoring Criteria reflect a landscape approach to restoring estuarine habitat through landscape ecology, resilience, and adaptive capacity?*

The processes identified in the ERTG Scoring Criteria reflect a landscape approach to restoring estuarine habitat through landscape ecology, resilience, and adaptive capacity, but only in a limited way. Ecological processes acting at the landscape scale, such as connectivity of habitats along salmonid migratory pathways, are recognized by the ERTG when subjectively scoring individual projects rather than by explicit criteria that guide scoring. Feedback processes due to connections among habitats are particularly important to resilience, but they are not explicitly quantified by the ERTG Scoring Criteria. Major socioeconomic processes such as salmon harvest, hatchery salmon production, hydrosystem operation, and urbanization also affect the diversity of salmon populations and habitats, and hence resilience, but do not seem to be considered in the scoring process. At present, the ERTG is operating under a high level of scientific uncertainty to qualitatively evaluate the identified processes. Quantitative estimates of processes are needed to develop adaptive capacity. Indeed, the limited purpose and scope of the ERTG Scoring Criteria and Terms of Reference for the ERTG do not promote a comprehensive landscape approach.

4. *Are there systematic and repeatable methods for quantitatively assessing the net changes in the Columbia estuary ecosystem that would produce data and analysis to validate the ERTG's survival benefit estimates?*

The review materials provided to the ISAB did not include systematic and repeatable methods for quantitatively assessing the net changes in the Columbia estuary ecosystem that would produce data and analysis to validate the ERTG's Survival Benefit estimates. Previous ISAB advice from the CEERP review (ISAB 2012-6) is still relevant: "A highly focused RME approach that estimates stock-specific survival rates in all major habitat types in the estuary and identifies habitats/locations where there are survival bottlenecks for species and stocks that migrate through Federal Columbia River Power System (FCRPS) is needed. Once these estuary bottlenecks are identified, it will be much easier to determine the most cost-effective approaches to habitat restoration that will be of benefit to Columbia River fish and wildlife."

5. *Are there other data available to complement the ERTG's approach or additional analysis that would make better use of available information to prioritize habitat restoration?*

The information from ERTG reports, meetings, and Action Agency documents specific to the ISAB's review suggests that other data are available to complement the ERTG's approach and additional analyses could make better use of available information to prioritize habitat restoration. Based on our responses to the Council's questions 1-4, we have a number of recommendations that address this question, as follows.

Question 1 (Sound Science)

- Write a new ERTG report that comprehensively describes the goals, methodology, assumptions, and limitations of the Scoring Criteria and SBU calculator, including citations to the relevant scientific literature.
- Submit a manuscript for peer review to a scientific journal on the ERTG Scoring Criteria and SBU calculator. This is common scientific practice for indices used as management tools, such as Breine et al. (2010). If published in the peer-reviewed scientific literature, the ERTG approach might also inform other expert panel processes.
- Report variability about the mean score for each Scoring Criteria as a way to display uncertainty among the members.
- Evaluate the reliability of the ERTG estimate of "*Optimal Fish Density*" for each subaction used to weight SBUs by providing a critical review of the scientific literature and methods used by the ERTG to derive these estimates.
- Evaluate the sensitivity of relative SBU scores among proposed projects to inconsistencies in information provided to ERTG by project sponsors.
- Provide written guidance for future ERTG members on the detailed methods used by each current member to assign a single score to Scoring Criteria with multiple potentially uncorrelated or unrelated attributes.
- As the ERTG does not itself conduct research, monitoring, and evaluation, the ISAB recommends implementation/continuation of the Columbia Estuary Ecosystem Restoration Program (CEERP) strategies to address key uncertainties identified by the ERTG and to develop methods for estimating salmon density.

Question 2 (Prioritization of Projects)

- Evaluate how well the scores have actually performed during project selection when the Action Agencies attempted to use the scores to differentiate between closely-ranked projects.
- A meta-analysis of published results from estuary habitat restoration projects and associated salmon survival studies in the Columbia River estuary might be useful for determining projects most likely to be beneficial. Within the Columbia River estuary, salmon survival data sets from acoustic tagging studies in channel habitats might be considered (e.g., Harnish et al. 2012; Rechisky et al. 2012, 2013; McMichael et al. 2013).

Question 3 (Landscape Approach)

- Provide more explicit consideration and documentation of how projects interact to produce benefits from a landscape perspective. Directly consider the need for restoration projects that support sequential rearing opportunities for subyearling and yearling life histories as they move from the upper estuary to the lower estuary.

- Develop explicit criteria that guide scoring with respect to socioeconomic factors (salmon harvest, hatchery salmon production, hydrosystem operation, urbanization) affecting the diversity of heterogeneous populations and habitats that confer resilience.
- View projects as vehicles for increasing knowledge through quantification of landscape processes identified by the ERTG Scoring Criteria so that, even if projects fail, learning will take place and scoring of projects will improve.

Question 4 (Validation of ERTG SBUs)

- Develop systematic, reproducible, and low-cost methods to collect assessment data to validate the Scoring Criteria. To improve feedback, the Scoring Criteria should be applied both before and after a project is completed. In this way, the Scoring Criteria could be improved if the projected benefits were not realized and the actual SBUs were different than projected. The ISAB views such application of the ERTG scoring process as an adaptive process.
- Test the soundness of the existing method of estimating total survival benefit by starting with the SBU calculator that predicts benefits from individual projects to apportion the estimated total benefit of implementing all subactions. Measure benefits from at a least a subsample of completed projects for which measurements are feasible. Such studies could, in principle, test the soundness of the existing method. The fact that the ERTG has chosen to include an additional weighting factor in the SBU calculator to correct for "inconsistent" estimates of fish densities associated with various subactions in the Estuary Module suggests that the estimated total benefit might be quite misleading. Independent assessment to corroborate the existing method could protect against this source of uncertainty. Monitoring should look at access to habitat and fish densities in the habitat before and after restoration, as well as residence time and growth. These attributes could be more easily measured than survival.
- Investigate whether SBUs should be accumulated on a reach basis to explicitly capture synergies between projects. Linkages between projects are assumed, for example the assumption that Deer Island is dependent on Columbia stock Ranch (see ERTG 2013-2), but it is not clear how these cumulative effects are taken into account in the SBU calculations.

Appendix: Full Answers to Council Questions

1. ***Are the ERTG Scoring Criteria used to assign survival benefits for habitat restoration based on sound science?***

To address this question, the ISAB reviewed the five Scoring Criteria and a weighting factor used to calculate Assigned Survival Benefit Units (SBUs) for habitat restoration (Fig. 1), and then whether Scoring Criteria (1) were developed by qualified personnel, (2) based on well-documented and reproducible methods, and (3) lead to verifiable results and conclusions that can be supported by available scientific information.

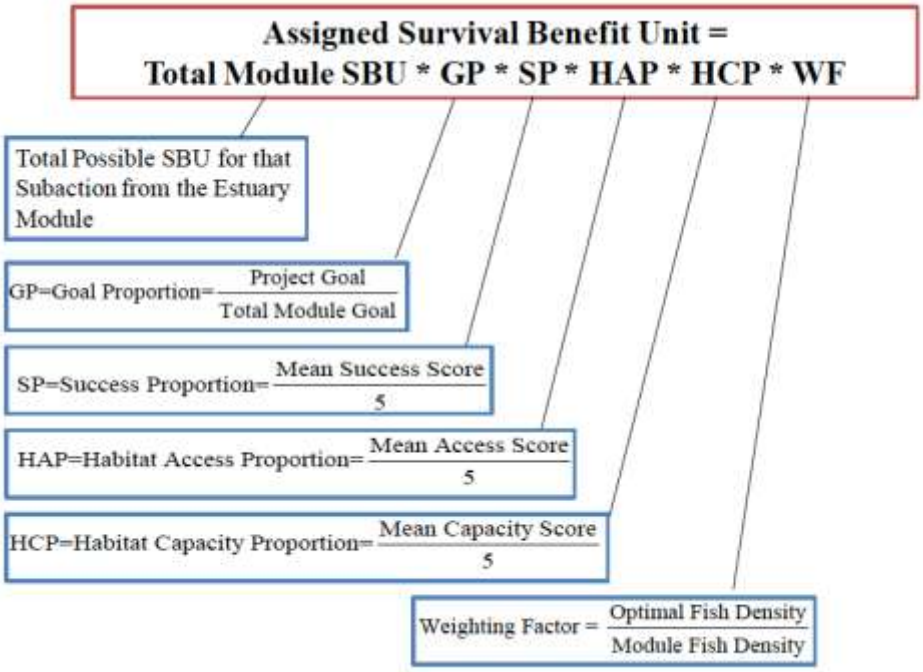

Fig. 1. The ERTG Survival Benefit Unit (SBU) calculator and Scoring Criteria (source: p. 4, ERTG 2010c).

<u>*Qualified personnel*</u>. The ERTG member information and qualifications are described in the Action Agencies' report, *Role of Science and Process for the Expert Regional Technical Group for Estuary Habitat Restoration Project*s (BPA/Corps 2014). The ERTG developed the SBU calculator and most of the Scoring Criteria used in the calculator, but not the total possible SBUs and total goals for particular subactions, which were developed separately using the planning method described in the Estuary Module (NMFS 2011). During the ISAB's review process, the ERTG demonstrated their professional qualifications, knowledge, and expertise through effective oral communication and explanation of scoring methods and identification of uncertainties related to the Scoring Criteria. Furthermore, the ERTG recognizes that its evaluations based on the Scoring Criteria are subjective and built upon informed scientific opinion. **The ISAB concludes that the Scoring Criteria were developed by qualified personnel.**

Documented and reproducible methods. The ISAB compliments the ERTG for initiating the report series. However, our review to determine if methods were documented and results reproducible was hindered by the lack of a single ERTG report that comprehensively describes the goals, methodology, assumptions, and limitations of the criteria. The ERTG reports and meetings state that Scoring Criteria are based on scientific information whenever possible; however, there are few references to literature, studies, or data that would clearly point to the science upon which the Scoring Criteria are based. Documentation of methods in the ERTG reports is of mixed quality. For example, a report that describes the Scoring Criteria provides no methods and cites only one scientific paper without including a complete reference (ERTG 2010b). Another report (ERTG 2013a) does a good job of documenting scientific uncertainties associated with ERTG Scoring Criteria, but also does not include any citations to the scientific literature. The difficulty of quantifying the survival benefit of restoration actions in the estuary is clearly recognized in several of the reports. The reports indicate that the scoring process continues to evolve over time as new information and challenges are brought forward.

The ERTG found some inconsistencies in the relationship between the potential number of juvenile salmon produced and the total possible SBUs (ERTG 2010c). As a result, they developed a weighting factor (WF, Fig. 1). The report states that existing literature was used to ascribe an "*Optimal Fish Density*" value for each subaction. However, no literature was cited. A footnote to the table in the report states that the weights are based in part on ERTG's view of optimal fish density (Table 1). This weighting approach appears to be a result of the need to maintain and build upon the original approach for evaluating benefits of habitat restoration. Some additional documentation of this approach is provided in a report, "*Feedback on Inputs to the Calculator to Assign Survival Benefits" (ERTG 2011a). One section of this report is titled "Use of salmonid density data from scientific literature to weight subactions."* The final sentence of this section states that the factors are based on "*extensive literature review*." However, the literature review was not included in the report. There are few references to indicate the sources of the final density numbers in the table (Table 2). The ISAB recognizes that optimal fish density associated with a specific habitat type is not simple to estimate from field observations. Fish densities are highly influenced by population size, time of year, environmental conditions, habitat type, and sampling gear at the time of sampling. It is not clear how optimal fish densities were calculated given uncertainties associated with field estimates and the apparent limited number of observations.

Table 1. Derivation of weighting factors by subaction in the Columbia River Estuary (CRE) Module (ERTG 2010c).

Table 1. Derivation of weighting factors by Subaction.

Module CRE	Description	Module Goal (acres or miles)	Module Fish Production (#/acre or mile)	Computed Module Fish Density (#/m^2)	ERTG Optimal Fish Density (#/m^2)	Weight*
CRE-1.4	Restore and maintain ecological benefits in riparian areas	28	2,500	0.625	0.1	0.16
CRE-9.4	Restore degraded off-channel habitats	6,000	25	0.006	0.1	16.7
CRE-10.1	Breach or lower the elevation of dikes and levees	5,000	65	0.016	0.1	6.25
CRE-10.2	Remove tide gates to improve the hydrology between wetlands and the channel	2,000	35	0.009	0.05	5.56
CRE-10.3	Upgrade tide gates	1,000	50	0.0125	0.025	2.0
CRE-15.3	Remove invasives	10,000	2.5	0.0006	0.0006	1.0

*Note: the relative value of the weights does not imply restoration priority. The weights simply reflect the relationships between the ERTG's view of optimal fish density and what was in the Module

Table 2. Final salmonid densities selected by ERTG from the scientific literature to weight subactions (ERTG 2011a).

Subaction	Optimal Density	Module Density	Weight
1.4	0.1	0.625	0.16
9.4	0.1	0.006	16.67
10.1	0.1	0.016	6.25
10.2	0.05	0.009	5.56
10.3	0.025	0.0125	2.00
15.3	0.0006	0.0006	1.00

Three factors (Success Proportion, Habitat Access Proportion, and Habitat Capacity Proportion) in the SBU calculator (Fig. 1) are proportions based on a subjective assessment of Scoring Criteria described in ERTG 2010b. The justification for these criteria is not presented, although many of them are self-explanatory. More problematic, however, is that only a single score is identified for the multiple (potentially uncorrelated) attributes associated with each factor. For example, the maximum score of 5/5 for "Certainty of Success" is awarded based on the following list of attributes: "*restoring a natural process or landforms; proven restoration method; highly likely to be self-maintaining; little to no risk of detrimental effects; highly manageable project complexity; minimal to no uncertainties regarding benefit to fish, minimal to no exotic/invasive species expected.*" No guidance is provided on how to score certainty of success for projects that meet some but not all of these criteria; for example, some projects might restore natural landforms with a proven method but have a high risk of detrimental effects from invasive species. Similarly, a score of 5/5 for "*Potential Benefit for Habitat Capacity/Quality*" requires the following list of potentially uncorrelated attributes: *"maximum*

natural habitat complexity; well-developed natural disturbance regime and ecosystem functions; extensive channel and edge network and large wood; much prey resource production and export; no invasive species or nuisance predators; water quality/temperature quality excellent; site relatively large (>100 acres).” Again no guidance is given for scoring a project site that, for example, includes maximum natural habitat complexity and excellent water quality but that is small in size and has moderate to high potential for invasive species and predators. The attributes considered in criteria for “*Potential Benefit for Habitat Access Proportion/Opportunity*” are more likely to be positively correlated with one another, so scoring mixed rank values will be less of a concern.

In addition, it is not clear from ERTG documents if the rankings are based on the mean scores of ERTG members or if a consensus is developed for a score. Examination of project SBU reports shows that values associated with some sub-actions were presented with a high level of resolution (e.g., access benefit = 3.92, certainty of success = 4.77, capacity benefit = 4.42). The ISAB speculates that if mean values of the ERTG scores are used, it may be worthwhile to report variability about the mean score as a way to display uncertainty among the members.

The ISAB discussed the scoring process with the ERTG at the January 17, 2014 meeting in Portland, and learned that each ERTG member initially scores a project independently. At the fine scale, members use different processes for developing overall scores. They do not assign weights for each attribute. Scoring reflects a balance between judgment and Module subaction guidelines (ERTG 2011b). According to the ERTG, scoring of attributes is very difficult to quantify because of the confounding of subactions and habitat types. Some individuals will score to the hundredths decimal place, others to the nearest numeral. Each member’s score is reported, and then the five scores are averaged. Once, the ERTG did an evaluation of the variation among individual member scores but never used the results. The ERTG noted that in general there is little variation among individual scores. However, sometimes individual scores are changed through a discussion process among the group. While the ERTG recognizes that scoring is very complex and making it less subjective is a goal, there is often no information to guide additional quantification. In summary, the SBU calculator provides a systematic method for ranking projects, by taking into account their scale and likelihood of success, but has some flaws in scoring procedures that are common to “expert opinion” assessments.

The soundness of the final SBU estimate for each proposed project will depend primarily on the quality of the estimates of total possible SBUs identified in the Estuary Module (NMFS 2011). However, the soundness of the order in which proposed projects are ranked by the SBU estimates might be most sensitive to inconsistencies in project information provided to ERTG by the sponsors. The ERTG recommended using an additional weighting factor in the SBU calculator to correct for “*inconsistent*” (i.e., unsound) estimates of fish densities associated with various subactions in the Estuary Module. It is stated on page 4 of ERTG 2011-01 (“*Feedback on Inputs to the Calculator to Assign Survival Benefit Units*”) that “*weighting does not change the number of SBU possible. It only reallocates SBU among subactions.*” However, it seems that the overall effect of weighting on possible SBU will depend on the balance of weights <1 and >1; if all estimates of fish density in the Estuary Module were greater than the corresponding estimates of optimal density (from the ERTG), then all weights would be <1 and the total

number of SBU possible would be reduced accordingly. In any event, adding the weighting factor was presumably considered necessary to more correctly characterize the rank order of potential benefits among projects.

According to BPA/Corps (2014), "*for purposes of repeatability and transparency, the ERTG recognized the need to standardize elements of the existing method to assign survival benefit units*," which "*increased the scientific rigor of the ERTG process*." The ERTG calculator along with ERTG member opinion is intended to provide a systematic process for prioritizing restoration projects that are hypothesized to enhance salmonid survival in the estuary. Most of the factors that are likely to influence the benefits from individual projects appear to be considered within the Scoring Criteria and in the ERTG process. However, both the criteria and the process are very subjective, and as previously discussed, the procedures actually used to assess project attributes are not clearly documented. Nevertheless, transparency of the scoring process is improved by providing opportunities for project proponents to discuss scoring by the ERTG if proponents disagree with the score. For example, the ISAB attended the December 4, 2013 ERTG meeting in Portland, Oregon, during which a proponent stated that her project would provide key habitat for an ESA-listed frog species, but nevertheless the project received a low score. The ERTG responded that the project was scored low because the ERTG process is focused on survival of ESA-listed salmonids and it does not directly consider benefits to other species except in the context of how those species may benefit salmonids.

The ISAB concludes that reproducibility and transparency would be improved by more detailed documentation of methods and citations to the scientific literature establishing ERTG's views and methods for assigning SBUs.

Verifiable results and conclusions. The verification of results and conclusions is difficult because the ERTG Scoring Criteria are based on a science platform that is unique to the Columbia River estuary. While the survival benefits are linked to assumptions about habitat that may be widely held in the scientific literature, these assumptions are not well documented in ERTG reports, are not explicitly comparable to mainstream ecological concepts, and have not been applied to comprehensive management elsewhere. For example the concept of habitat capacity is an idea that was raised by ERTG members, published in the peer reviewed literature, and its management uses were explained in a recent Columbia River Ecosystem Restoration Program synthesis memo (Thom et al. 2013), but it is not explicitly comparable to mainstream ecological concepts such as carrying capacity, as previously noted by the ISAB (ISAB 2012).

The BPA/Corps (2014) state, "*uncertainties related to ERTG Scoring Criteria are particularly important because they affect the risk CEERP managers must contend with when deciding on which projects to fund*." The ISAB reiterates its concern, expressed in the review of the estuary module (ISAB 2008-2), that the relatively "*informal procedure to develop rating schemes adds another layer of uncertainty on top of the scientific uncertainty."* Professional opinion is a key part of the SBU process because sufficient data are often lacking. For example, when evaluating potential salmon densities associated with floodplain lakes in the estuary, the ERTG noted that they often did not have depth contours for those lakes (ERTG 2013a), and at the January 17, 2014 meeting the ERTG further expressed concern about the lack of salmonid density data for

these habitats. Fortunately, the ERTG team is highly qualified and has considerable experience with estuarine and salmonid ecology.

The ERTG recognizes many scientific uncertainties related to the Scoring Criteria (ERTG 2012b). The Scoring Criteria are not tied into any of the published estimates of salmon survival within the various reaches of the Columbia River estuary and lower river (see ISAB response to Q5). As well, there have been preliminary efforts to link habitat restoration (Cooney and Holzer 2011) to explicit measures of survival, but the status of this modeling work is unclear. The ERTG states, "*SBUs have been developed as a surrogate for survival. We need validation of whether literature estimates of habitat capacity and opportunity provide a reasonable approximation of the salmon survival response to the restoration actions*" (ERTG 2012b). The ISAB is aware of the Columbia Estuary Ecosystem Restoration Program (CEERP) strategy to develop methods for estimating salmon density (Sather et al. 2012) and to address ERTG uncertainties (BPA/Corps 2012), and these efforts are likely to lead to future improvements in the ERTG Scoring Criteria.

The ISAB concludes that because the ERTG Scoring Criteria are based largely on professional opinion, the findings should be viewed as informed hypotheses that require research, monitoring, and evaluation to verify results and conclusions.

In summary, **the ISAB concludes from its review of ERTG documents and meetings with ERTG that the Scoring Criteria are partially based on sound science.**

2. ***Do the ERTG Scoring Criteria have the ability to differentiate and/or prioritize those projects that will succeed in increasing the survival of salmonids through their residence and migration in the Columbia River estuary?***

The ERTG Scoring Criteria can differentiate and/or prioritize the potential effectiveness of a project to increase survival of salmonids, assuming the accuracy of the score is reasonable. The statistical accuracy (degree of closeness to the true value) and precision (reproducibility) of scoring of restoration projects are not estimated by the ERTG. Accuracy is presumably low on an absolute basis (e.g., the actual survival gained by a specific project if implemented), but the accuracy of scoring the relative benefit of one project ranked against another is likely better. Scoring the relative benefit of projects is the primary goal of the process. Funding agencies then use this information along with project costs to approximate benefit-cost ratios when deciding which projects to fund.

The ISAB did not find information in the review documents as to how well the scores have actually performed during project selection when the Action Agencies attempted to differentiate between closely ranked projects. For example, the SBU scores likely can be used to divide scored projects into four parts (25% quartiles), but how well do scores distinguish among those projects within the top 25%? Is it possible to evaluate if the priority system is actually working? For example, is there enough contrast between accepted projects to see if the "best" project actually did perform better than the "worst" project? Or is it the case that, with a limited budget, only a small number of projects are approved and all are highly scored so no "learning" can take place?

The main advantage of the ERTG Scoring Criteria is the capability to facilitate structured and transparent decision making. However, the ability to differentiate and/or prioritize is only as good as the science behind the SBUs in the Estuary Module (see response to Question 1). The main disadvantages of the scoring process are its subjectivity and the potential for differences in assigning scores, especially if ERTG personnel change. This problem has been observed in other uses of indicators (e.g., those for ecosystem-based fisheries management, Rochet and Rice 2005). The steps in selecting indicators are known to be prone to subjectivity and value judgment, and differences in scores between experts are the main factor contributing to variability in evaluation results (Rochet and Rice 2005).

Of the three Scoring Criteria (success, access, capacity) for subactions, access has the best and most scientifically credible ability to differentiate/prioritize potential projects. There is considerable uncertainty about ranking success because the long-term implications of the restoration are generally not known, especially if a specifically designed monitoring program is not in place and funding for maintenance (e.g., ongoing invasive species control) is not available. The uncertainty of ranking capacity is related to the lack of explicit guidance on how to assign a single score to potentially uncorrelated attributes (see discussion Question 1).

A key issue is the lack of quantitative estimates for estuarine survival of juvenile salmonids. Clearly, the ERTG Scoring Criteria have assisted the action agencies in differentiating and prioritizing projects. Whether or not the selected projects will succeed in increasing the estuarine survival of salmonids will remain uncertain until quantitative estimates of improvements in estuarine survival due to estuarine habitat restoration become available.

In summary, it is clear that the ERTG Scoring Criteria can differentiate among projects and provide a priority ranking. The question of whether the project prioritization will increase survival of salmonids is uncertain. Part of the adaptive nature of the ERTG process must involve monitoring and evaluation of changes in estuarine survival due to habitat restoration with feedback loops of results to the ERTG so improvements in the scoring process can be based on quantitative information.

While ERTG Scoring Criteria are being used to differentiate and/or prioritize habitat restoration projects in the Columbia River estuary, the ISAB concludes that the ability of projects to actually succeed in increasing the survival of salmon through their residence and migration in the Columbia River estuary cannot be determined from the Scoring Criteria.

3. ***Do the processes identified in the ERTG Scoring Criteria reflect a landscape approach to restoring estuarine habitat through landscape ecology, resilience, and adaptive capacity?***

The processes identified in the ERTG Scoring Criteria do not explicitly reflect a landscape approach (ISAB 2011), although the processes reflect some attributes of landscape ecology, resilience, and adaptive capacity. The ERTG reports provided to ISAB for this review do not address this issue. However, during the January 17, 2014, meeting the ERTG stated that they try

to build synergy into the evaluation of identified processes by considering whether a particular project complements others within the same estuarine reach, which is in part a landscape approach. The Action Agencies' document on the role of science and process for the ERTG (BPA/Corps 2014) defines their view of how the processes identified in the ERTG Scoring Criteria are related to a landscape approach:

> The Success Proportion, Habitat Access Proportion, and Habitat Capacity Proportion variables were designed to account for basic elements of restoration science. Success pertains to ecological success in terms of the project's restoration of natural processes, self-maintenance, and expectation for invasions of non-native species[x] [NRC 1992]. The restoration approach for a site should be matched to the level of disturbance at the site and in its landscape[xi] [Shreffler and Thom 1993]. Habitat access "appraises the capability of juvenile salmon to access and benefit from the habitat's capacity"[xii] [Simenstad and Cordell 2000]. Examples would be tidal elevation and geomorphic features. Habitat capacity involves "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality"[Q] [Simenstad and Cordell 2000], such as invertebrate prey productivity, salinity, temperature, and structural characteristics. The ERTG assesses these variables in the context of a site's landscape, as recommended by the National Research Council[xiii] [NRC 1992, pp. 347–348], and similar to the landscape approach recently championed for the Northwest Power and Conservation Council's Fish and Wildlife Program[xiv] [ISAB 2011].

The annotated footnote (xiii) to the National Research Council recommendation provides further explanation:

> [xiii] The National Research Council (NRC 1992, pp. 347–348) viewed landscape ecology as a method for designing integrated aquatic ecosystem restoration projects. It concluded that, "*Wherever possible...restoration of aquatic resources...should not be made on a small-scale, short-term, site-by-site basis, but should instead be made to promote the long-term sustainability of all aquatic resources in the landscape*."

Of particular importance to the science of landscape ecology is pattern (landscape structure) and scale (both spatial and temporal), which need to correspond to the form and levels of mechanisms controlling processes of interest, for example, salmon survival. The processes identified in the ERTG Scoring Criteria apply primarily to local patterns and scales of potential (individual) projects brought to the ERTG for scoring, whereas the pattern and scale of juvenile salmonid ecosystems encompass diverse habitats from freshwater tributaries to the coastal ocean for Chinook salmon and to the high seas (international waters of the Gulf of Alaska) for steelhead during the year of ocean entry (freshwater-ocean continuum; Simenstad and Cordell 2000).

Although the processes identified in the ERTG Scoring Criteria may be adequate to rank the benefits expected from individual projects, there is no explicit evaluation of interactions between projects documented in the ERTG reports. The fact that project scores are added up suggests that all projects are treated as producing complementary, non-overlapping benefits.

However, it is easy to imagine cases in which some projects might be redundant, or in which synergies might result from combinations of projects, or in which a particular project might be necessary to bridge a gap that would otherwise preclude benefits from other projects. Presumably major gaps would be avoided by including a suite of projects (e.g., on a reach) that address all subactions. Even so, more explicit consideration and documentation of how projects interact to produce benefits (i.e., a landscape perspective) might achieve greater overall benefits.

Connectivity of habitats along migratory pathways (not to be confused with habitat access/opportunity) is recognized by ERTG. However, this and other landscape issues seem to be considered when subjectively scoring projects rather than by explicit criteria that guide scoring with respect to landscape ecology, resilience, and adaptive capacity. The uncertainties document (ERTG 2012a) describes landscape structure issues to be considered. However, the ISAB is unclear about how this document is being used by the ERTG. For example, is there a synergistic or interactive benefit of providing restoration actions along the entire migration route rather than focusing effort in one location?

Processes identified in the ERTG Scoring Criteria are primarily focused on static planning (BiOp) goals for survival of ocean- and stream-type Chinook salmon and steelhead in the estuary (Ferguson 2006a,b; NMFS 2011). The focus on ESA-listed salmonids limits consideration of other species and the full spectrum of habitat restoration activities at a landscape scale. In addition, the Scoring Criteria do not include key processes such as operations of spill and water releases at dams, precipitation, and timing of volume of flow likely affect estuarine conditions. Climate change, species diversity, and novel ecosystem effects (species composition and abundance vastly different than historical conditions) and connections and feedbacks between freshwater and ocean habitats are missing from the equation.

The ISAB agrees with the Action Agencies (BPA/Corps 2014) that the processes identified in the "Success" criterion best reflect a landscape approach to resilience (capacity to absorb and adapt to disturbance and change – while maintaining essential functions; ISAB 2011). In the context of a comprehensive landscape approach, however, achievement of success (and resilience) also involves "*socioeconomic understanding and engagement, applying the concepts of landscape ecology, collaboration and shared governance, and the use of true adaptive managemen*t" (ISAB 2011). As explained above, connections and feedbacks among processes that increase resilience are not explicitly addressed by the processes identified in the ERTG Scoring Criteria. In addition, the identified processes do not reflect major socioeconomic factors (salmon harvest, hatchery salmon production, hydrosystem operation, urbanization) affecting the diversity of heterogeneous populations and habitats that confer resilience.

In terms of a comprehensive landscape approach, adaptive capacity (not to be confused with habitat capacity) includes processes of diversity and function, experimentation, active learning, and diffusion (broad acceptance and use of effective actions) (ISAB 2011). As discussed in ISAB's response to Question 2, adaptive capacity must involve monitoring and evaluation of changes in estuarine survival of salmon due to habitat restoration so improvements in the process can be based on quantitative information. At present, ecological processes identified in the ERTG

Scoring Criteria are qualitatively evaluated by experts operating under a high level of scientific uncertainty. Quantitative estimates are needed. The social aspects of adaptive capacity appear to be implicit via the ERTG's relationships with sponsors of potential projects and landowners. Direct feedback and learning from pre- and post-project research, monitoring, and evaluation, and social engagement with the community at large and civic institutions (see Knowles and Myatt-Bell 2001) would further contribute to identification and quantification of key processes affecting salmon survival (and associated metrics) in the estuary. However, at present these activities, including public and stakeholder outreach, are the purview of the entities that the ERTG serves. Because of the limited purpose and scope of the ERTG Scoring Criteria and Terms of Reference for the ERTG, processes identified in the Scoring Criteria only partly reflect a comprehensive landscape approach.

The ISAB concludes that the processes identified in the ERTG Scoring Criteria, in a very limited way, reflect a landscape approach to restoring estuarine habitat.

4. ***Are there systematic and repeatable methods for quantitatively assessing the net changes in the Columbia estuary ecosystem that would produce data and analysis to validate the ERTG's survival benefit estimates?***

The ERTG documents reviewed by ISAB do not include methods that could be used to validate ERTG's survival benefit estimates at the ecosystem level. Methods for assessing net trends in ecosystems and their services are varied (e.g., remote sensing and GIS, natural resource and biodiversity inventories, ecosystem models, evaluation of trends in high level indicators of ecosystem condition, and case studies of ecosystem response to drivers). To be effective, all of these methods require careful and systematic collection of data at appropriate space and time scales. One potential benefit of the ERTG process is that sponsors are required to provide quantitative data on the expected scale and nature (area, elevation, number of access points, etc.) of their projects. That said, the ERTG project assessment methods do not appear to include provisions that could allow predicted pre-project survival benefits to be measured or verified after selected projects are completed. As previously discussed, research, monitoring, and evaluation are not within the ERTG's purview.

Although it seems reasonable for the ERTG to attribute expected benefits to individual projects as a percentage of potential benefits identified in the Estuary Module, it is not currently feasible to verify these benefits at the project scale. Survival during passage through the estuary might be monitored by using tagged fish if monitoring arrays were established above and below the estuary. However, this approach for estimating survival would not distinguish between fish that used the target habitats (wetlands) and those that passed through the estuary using only channel habitats (e.g., Weitkamp et al. 2012). The restoration projects are conducted in shallow off-channel habitats that are mainly used by ocean-type (subyearling) Chinook salmon and sometimes coho and chum salmon and less so for stream-type salmonids. Stream-type (yearling) Chinook salmon and steelhead mostly use the main channel, and there are a number of published estimates of survival in that habitat using archival tagging technologies (e.g., Harnish et al. 2012; Rechisky et al. 2012, 2013; McMichael et al. 2013). It is more difficult to measure "*within off channel habitat*" survival of sub-yearling Chinook salmon

because of tag size constraint and the general logistics of tracking fish in the shallow water. In fact, this is a challenge that has not been met in estuaries elsewhere. However, collaborative acoustic-tagging research with feedback to the ERTG might lead to a systematic and repeatable method for estimating estuarine survival of salmonids that could be used to validate the ERTG's survival benefit estimates.

Monitoring of smolt to adult survival might provide some information about the benefit of estuarine projects. However, these effects are not readily isolated from effects of ocean conditions, which also influence smolt to adult survival. Nevertheless, it is worthwhile to monitor survival during each life stage. Perhaps fall Chinook data from the intensively monitored Abernathy Creek watershed (WDFW) could be tied into the estuary restoration/survival model developed by Cooney and Holzer (2011). The draft model described in the paper does take access into account. The ISAB is unaware of work underway for further survival analyses to assess net changes at the ecosystem level.

The ERTG pre-project assessment methods are described with explanations of terminology in the ERTG reports (ERTG 2010a,b, 2011b, 2013a). Pre-assessment guidelines for project description (ERTG 2010a) could be revised and updated to include more detailed/specific metrics to ensure that similar metrics are evaluated for each project. For example, *"Condition of physical metrics"* is vaguely defined as a description of the project's major stressors and physical controlling factors, and a footnote to this definition further specifies that these are *"basic physical and chemical conditions that construct and influence the structure of the ecosystem."* This definition is followed by a series of questions: "*What is the average tidal range, salinity? What is the ordinary-high-water tide elevation? Extreme-high-water elevation? Two-year flood elevation?*" and it is unclear if the answers to these questions are the metrics that will be used to describe the basic physical and chemical conditions of the project area. For habitat, the metric is even more vague, with a guideline to "*describe the key results of a vegetation survey*." Minimal characteristics to be described need to be included, or specific acceptable vegetation surveys mentioned (e.g., available on www.monitoringmethods.org), to avoid large project-to-project variation in the types of data collected and the methods used to collect data. Further, processes identified in the ERTG Scoring Criteria have a temporal component (e.g., seasonal connectivity is mentioned; ERTG 2010b), but the project template does not appear to consider such temporal aspects (ERTG 2010a). Invasive species are a potential driver of ecosystem change. The descriptions of the project template and the ERTG Scoring Criteria appropriately mention invasive species (ERTG 2010a,b), but the table of guidance on Estuary Module actions and subactions relevant to the ERTG process (ERTG 2011b) does not. The ISAB encourages further development of systematic, repeatable, and low-cost methods to collect assessment data to validate SBU estimates via feedback to the ERTG from post-project monitoring of projects that were selected, or make sure that existing methods for getting RME data (e.g., monitoring.org, PNAMP, etc.) can be used by the ERTG.

The first step toward validating the ERTG's survival benefit estimates would be to document effectiveness of completed projects with feedback to ERTG via monitoring: how much of each habitat type was actually produced, what is the percentage increase in a specific habitat type, and to what extent did ocean-type and stream-type salmonids use the new habitat compared

with the previous habitat? Were salmonid densities in the habitat consistent with expectations used in the SBU calculator? How long did individual fish use the new habitats and how much did they grow? Were there unexpected problems, such as increased predator abundances associated with new habitat, or did fish stranding in the new habitat increase when water levels fluctuated?

In conclusion, **the review materials provided to the ISAB did not include systematic and repeatable methods for quantitatively assessing the net changes in the Columbia estuary ecosystem that would produce data and analysis to validate the ERTG's Survival Benefit estimates.** Previous ISAB advice from the CEERP review (ISAB 2012-6) is still relevant: "A highly focused RME approach that estimates stock-specific survival rates in all major habitat types in the estuary and identifies habitats/locations where there are survival bottlenecks for species and stocks that migrate through Federal Columbia River Power System (FCRPS) is needed. Once these estuary bottlenecks are identified, it will be much easier to determine the most cost-effective approaches to habitat restoration that will be of benefit to Columbia River fish and wildlife."

5. ***Are there other data available to complement the ERTG's approach or additional analysis that would make better use of available information to prioritize habitat restoration?***

This question is answered in this report's summary section.

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