


ISAB Review of the Upper Columbia United Tribes' Phase 2 Implementation Plan: Testing Feasibility of Reintroduced Salmon in the Upper Columbia River Basin

INDEPENDENT SCIENTIFIC ADVISORY BOARD

ISAB 2022-2 DECEMBER 8, 2022

Cover design by Eric Schrepel, Technical and Web Data Specialist, Northwest Power and Conservation Council

Photos clockwise from top left: Carol Evans, Chairwoman of the Spokane Tribes of Indians, opening remarks at Spokane Falls; Chinook salmon on redds at 21-mile campground, Sanpoil River; ISAB members Courtney Carothers and Yolanda Morbey, Grand Coulee Dam (photos by Erik Merrill); Waikiki Springs Nature Preserve, Little Spokane River (photo by Tom Wainwright).

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Review of the Upper Columbia United Tribes' Phase 2 Implementation Plan: Testing Feasibility of Reintroduced Salmon in the Upper Columbia River Basin (Phase 2 Plan)

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Acknowledgements

Numerous individuals and institutions assisted the ISAB with this report. Their help and participation are gratefully acknowledged.

The ISAB greatly appreciated the October 2022 site visit to the blocked Upper Columbia River Basin—Grand Coulee and Chief Joseph Dams, reservoirs, and tributaries—and the chance to hear from a wide range of tribal leaders; tribal, state, and federal scientists and fish managers; and Northwest Power and Conservation Council (NPCC) staff. Many of the tour leaders and participants are in the picture above at the visit to Waikiki Springs on the Little Spokane River.

Laura Robinson (Upper Columbia United Tribes, UCUT), Conor Giorgi (Spokane Tribe of Indians), Casey Baldwin (Confederated Tribes of the Colville Reservation), and Tom Biladeau (Coeur D'Alene Tribe of Indians) were especially helpful in organizing the site tour and providing information and support from the assignment's development to its completion.

The Upper Columbia United Tribes (UCUT) and its member tribes' leaders and staff provided invaluable historical, cultural, and scientific context on the tour and during September 2022 presentations to the ISAB: DR Michel (Executive Director, UCUT); Chairwoman Carol Evans, Warren Seyler, Rick Raymondi, and Chad McCrea (Spokane Tribe of Indians); Councilman Hemene James, Caj Matheson, and Ralph Allan (Coeur d'Alene Tribes); and Jeanette Finley (Confederated Tribes of the Colville Reservation).

In addition to the individuals listed above, the ISAB acknowledges useful September presentations from Toby Kock and Jill Hardiman (US Geological Survey, USGS) and tour dialogue with Kevin Malone (UCUT contractor); Brian Bellgraph (Pacific Northwest National Laboratories, PNNL); Ivan Snavely, Claire McGrath, Melinda Hernandez Burke, Scott Hoefer, and Marc Sanchez (US Bureau of Reclamation); Brian Hart, Lori Morris, Melissa Leslie, Laura Boerner, and Zachary Zimchek (US Army Corps of Engineers, USACE); Megan Kernan (Washington Department of Fish and Wildlife, WDFW); Dave Schaub, Rose Richardson, and Todd Dunfield (Inland Northwest Land Conservancy); and Bruce Howard, Chris Moane, and Rene Wiley (AVISTA).

ISAB members appreciated the opportunity to interact with and learn from Council staff Bill Edmonds, Ann Gravatt, Cathy Kellon, and Stacy Horton. And, special thanks to Stacy and also Patty O'Toole, Leslie Bach, Kendra Coles, and Trina Gerlack for coordinating the Council participation on the tour. Eric Schrepel designed the report's cover and assisted with the report's web posting.

The ISAB Ex Officio members helped define our review, organized briefings, provided context, and commented on drafts: Mike Ford, Bob Lessard, and Leslie Bach.

Review of the Upper Columbia United Tribes' Phase 2 Implementation Plan: Testing Feasibility of Reintroduced Salmon in the Upper Columbia River Basin (Phase 2 Plan)

Executive Summary

The Upper Columbia United Tribes (UCUT) requested that the Independent Scientific Advisory Board (ISAB) review their Phase 2 Implementation Plan: Testing Feasibility of Reintroduced Salmon in the Upper Columbia Basin (Phase 2 Plan). The Tribes are using a three-phased approach to investigate the feasibility of restoring salmon to the upper Columbia River Basin above Chief Joseph, Grand Coulee, and the Spokane River dams. This phased approach is called for in the Columbia River Basin 2014 Fish and Wildlife Program and was reaffirmed in the 2020 Addendum to the 2014 Program.

To permit a deeper understanding of the Phase 2 Plan, the UCUT and their collaborators led the ISAB members on a tour of Grand Coulee and Chief Joseph dams and the blocked area above them. Hearing from Tribal leaders and staff at the site visits was essential for a deeper historical context of the dams' effects on the blocked area ecosystem. We heard about the close relationships between salmon and Indigenous Peoples of these lands for millennia and the loss of salmon from their homelands for five human generations. We heard about the healing power of this reintroduction process for Indigenous spirituality, identity, and wellness. The Tribes also expressed their desire for the reintroduction to reconnect and benefit the entire Columbia River ecosystem for everyone, both Tribal and non-tribal. After reintroduction into the blocked area, salmon production would provide recreational and harvest opportunities for local and downstream communities, sport anglers, and commercial fisheries. The 2020 Addendum of the Fish and Wildlife Program acknowledges the importance of mitigating for the complete loss of anadromous fish and the losses to other fish and wildlife species in areas above Grand Coulee and Chief Joseph dams. The UCUT's reintroduction efforts also generate important contributions to the science of salmon ecology and of fish passage at high head dams.

This ISAB report addresses the scientific foundation of the Phase 2 Plan and provides information and advice on its major components. The following summary highlights our major findings on each component, which are described in more detail in the full report.

Scientific Framework

The Phase 2 Plan provides an overall roadmap to answer critical questions required to design an effective approach for reintroducing salmon above Grand Coulee and Chief Joseph dams. Over the next two decades, the stepwise approach and adaptive management process to understand the ecological and structural requirements for reintroduction will be critical for decision making and overall success. Such testing of the reintroduction concept is imperative because 80 years of blockage to fish migration by extremely large and complex dams and associated structures coupled with downstream stressors on

salmon populations create major uncertainties. The field studies, modeling, facilities designs, and initial reintroductions are coupled in a structured, strategic approach that will require continued refinement, documentation, and adaptive management.

Adaptive Management

The UCUT are developing an overall adaptive management plan that includes 1) a process to obtain information required to design reintroduction actions and 2) a process for making decisions about the types and sequences of reintroduction efforts. Flowcharts have been developed to help guide decision-making, which is an important starting point, but the decisions will be subject to many uncertainties that will require ongoing refinement as the project proceeds. The technical and policy teams could provide timely and effective coordination with state and federal agencies, Public Utility Districts, and other cooperators, and thereby strengthen initial decisions and actions.

Stepwise Process

The Phase 2 Plan uses a stepwise and flexible approach for prioritizing the sequence of field studies and development of fish passage facilities, which will inform next steps. The staged or incremental approach is appropriate, given the uncertainties in reintroducing salmon above these major dams. The proposed "steppingstone" approach will involve progressively establishing reintroduction efforts from lower to upper regions in the blocked area and sequencing studies to gain information on factors affecting the success of various juvenile release strategies and to better determine next management steps.

Data Analysis and Life Cycle Modeling

The Phase 2 Plan would be strengthened by more thorough description of how information from the field studies and Life Cycle Model will be integrated and used to make decisions. The field studies will provide critical data to inform a robust Life Cycle Model that will be useful to evaluate possible outcomes for salmon populations and to identify further studies. The field studies and modeling will generate large amounts of information and data. A unified database and clear analysis plan will support integration of the data with the model, inform long-term data management, and enhance adaptive management of the science and decision-making processes. The database should archive descriptions of field and analytical methodologies to ensure institutional memory.

The UCUT need to determine the characteristics of the Life Cycle Model needed in Phase 2 and decide how to modify the existing model or develop a new one. The Plan should include a strategy for using the model to prioritize field studies, analyzing sensitivity and uncertainty, identifying critical processes and parameters, ensuring long-term support for the model, and describing how model results will be applied in decision making.

Production

Previously, potential donor stocks critical for reintroduction were prioritized and selected through a practical and collaborative expert-based process. To project future natural production, estimates of available habitat and potential production of summer/fall Chinook and sockeye were based on scientifically sound, but relatively simple, assumptions and limited information. The survival and migration studies are critical for improving estimates of production potential and reducing uncertainty. The supporting studies will provide important information on factors that influence the production of reintroduced Chinook and sockeye salmon.

Fish Passage

The overall approach is scientifically sound for evaluating interim fish passage systems and ultimately informing the development and evaluation of more permanent facilities for movement of juvenile and adult salmon around Chief Joseph, Grand Coulee, and upstream dams. Anticipated performance metrics for juvenile and adult passage have been developed for all major dams. Estimates about upstream and downstream fish passage are based on reasonable assumptions and the best available data but may be overly optimistic given uncertainties about survival in the blocked area, passage efficiency and survival, and downstream survival. The productive capacity of the marine and freshwater environments to support salmon may be reduced in the future due to climate-related changes, reducing the survival of reintroduced salmon. The field studies will be essential for refining these estimates and decision thresholds and for clarifying requirements for the transition between interim and permanent passage facilities. It will be essential to consider benefits and risks of passage designs for other taxa, including ones whose migrations might be deemed beneficial (e.g., steelhead, Pacific lamprey, sturgeon) and ones whose migrations would be deemed undesirable, such as northern pike or American shad, when designing passage facilities

Support Studies

Overall, the study designs are well conceived and should reduce uncertainties about fish survival and dam passage. The ISAB commends the collaboration between the UCUT and their cooperating agencies and institutions, which is essential for the project. However, improved reliability of sources, numbers, and conditions of experimental fish is essential to address the assumptions and uncertainties. The ISAB recommends continued negotiation to ensure sufficient study fish for analytical power and encourages the Council and BPA to assist where possible to make the studies more robust and informative. Given the many critical assumptions being tested, sample sizes and study design should continue to be reviewed for adequacy in reducing uncertainty. Frequent or annual reports on the results of the studies will be needed to effectively inform the adaptive management process and create a long-term record of the findings.

Climate change and hydrological uncertainty may affect the success of reintroduction of salmon into the blocked area. Existing fish monitoring programs should be leveraged to gain more information over a longer period of time that reflects hydrologic variability so that the UCUT can determine whether modifications to the support studies and facilities designs will be needed.

Cost Analysis

The UCUT's cost projections are necessarily more uncertain the farther out into the future they extend. Some additional background, basis, and justification for cost projections is warranted for the research, monitoring, and evaluation (RM&E) of early stages (i.e., Step 1) of Phase 2. We encourage the UCUT to describe both funded and non-funded contributions by the Tribes and their collaborators to the reintroduction efforts to give readers a more complete understanding of the full extent of people and resources being dedicated.

Future Steps

The Phase 2 Plan clearly expresses the deep importance of reintroducing salmon to the UCUT members and the Upper Columbia River ecosystem. At the same time, it addresses a need identified in the Fish and Wildlife Program to mitigate for the complete loss of anadromous fish in the blocked area. As the ISAB previously concluded for the Phase 1 Plan, it is reasonable to expect that reintroduction could be successful to some extent, but there is substantial uncertainty about the numbers of adults that will return and the types of management that will be required to maintain them. The UCUT have created a strategic plan to obtain the information needed to address these uncertainties and have developed an adaptive management process to guide their decisions. The UCUT's reintroduction efforts face complex challenges due to the number of stakeholders, cooperators, large geographical scope, and long duration of the program. While some parts of the Plan may be overly optimistic, they use a cautious stepwise approach to ensure that the goals and management actions are rooted in a firm and attainable foundation of knowledge. The ISAB looks forward to providing feedback on updated plans and results as needed in the future.

I. Introduction

A. Review Charge and Background

In July 2022, the Upper Columbia United Tribes (UCUT)[1] requested and the Independent Scientific Advisory Board's (ISAB) Administrative Oversight Panel[2] approved the ISAB to review the UCUT's Phase 2 Implementation Plan: Testing Feasibility of Reintroduced Salmon in the Upper Columbia Basin (hereafter P2IP or Phase 2 Plan), which is part of the regional effort to investigate the reintroduction of anadromous fish above Chief Joseph, Grand Coulee, and the Spokane River dams through a three-phased approach. This phased approach is called for in the Columbia River Basin 2014 Fish and Wildlife Program, has been considered a Program emerging priority since 2014, and has been reaffirmed in the 2020 Addendum to the 2014 Program.

The ISAB reviewed the UCUT's Phase 1 Report in 2019, following the Council's recommendation that assessments for the potential of reintroduction receive science review (December 20, 2018 Decision Letter, page 20). The ISAB review (ISAB 2019-3) of the Phase 1 Report found that:

> *The Reintroduction Report is a broad analysis of key decision factors and potential outcomes, which provides a general proof of concept. Inherently, it takes general information from other locations and stocks of salmon and steelhead to determine whether reintroduction of any of the historical species of salmon and steelhead is biologically and physically feasible. While it is reasonable to expect that reintroduction could be successful to some extent, there is great uncertainty about the numbers of adults that will return and the types of management that will be required to maintain them. A strategic plan for future steps and an adaptive management process will be needed to address these uncertainties*.

The ISAB advised the Upper Columbia United Tribes to develop a strategic plan that includes an adaptive management process and cost analyses.

The Upper Columbia United Tribes developed the Phase 2 Plan to test the feasibility of restoring salmon to the upper Columbia River Basin. The Upper Columbia United Tribes presented the technical portions of the Phase 2 Plan to the Council's Fish and Wildlife Committee and the policy aspects to the full Council in November 2021. The Plan was submitted to Columbia Basin Tribes, Indigenous Nations, and state and federal agencies for their review, and the UCUT revised the Plan based on comments received. Appendix G of the Plan is a summary of the comments and how they were addressed.

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[1] The Upper Columbia United Tribes includes the Confederated Tribes of the Colville Reservation, the Coeur d'Alene Tribe, the Kalispel Tribe, the Kootenai Tribe of Idaho, and the Spokane Tribe of Indians.

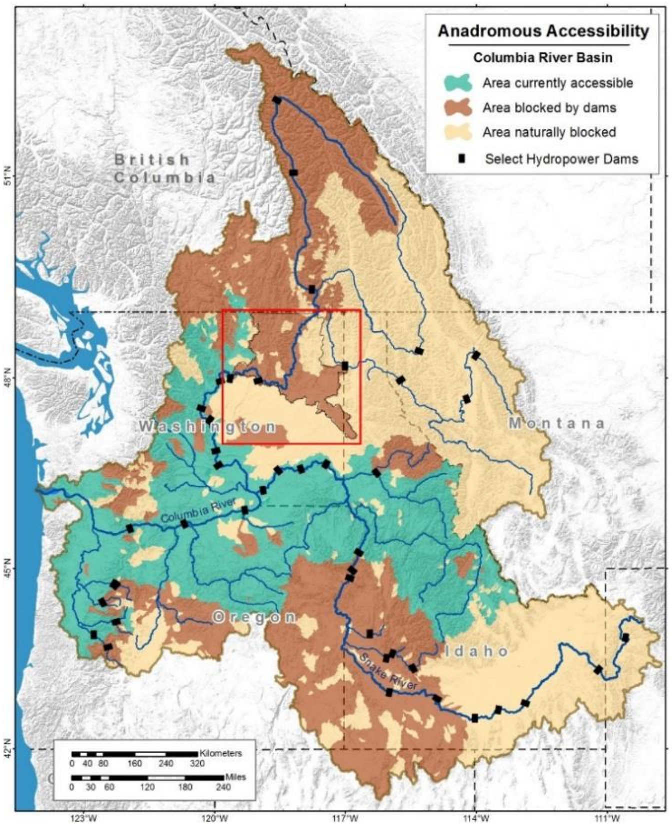
[2] The ISAB Administrative Oversight Panel consists of the Chair of the Northwest Power and Conservation Council, Guy Norman; the Executive Director of the Columbia River Inter-Tribal Fish Commission, Aja DeCoteau; and the Science Director of NOAA Fisheries' Northwest Fisheries Science Center, Kevin Werner.

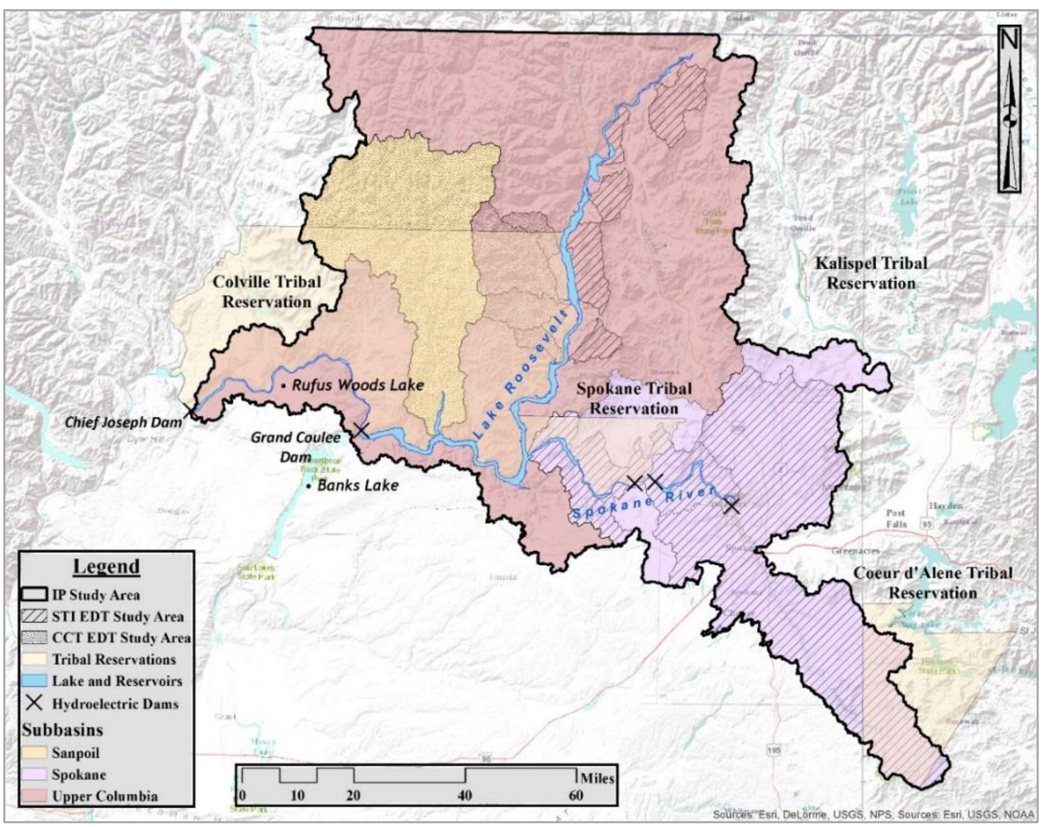
The Upper Columbia United Tribes have several primary objectives in Phase 2 of reintroduction of anadromous salmonids above Chief Joseph and Grand Coulee dams:

1. Test the key biological assumptions made in Phase 1 considered critical for the success of the reintroduction effort.
2. Establish the sources (and regulatory approvals) of Chinook (*Oncorhynchus tshawytscha*) and sockeye (*Oncorhynchus nerka*) salmon donor stocks and broodstock that will be used to produce the juveniles and adults required to conduct biological studies and test fish passage facilities.
3. Develop the interim hatchery and passage facilities required to evaluate reintroduction.
4. Provide the data and analyses needed for Phase 3 decision-making, including data necessary to determine the need, type, and costs of permanent fish passage systems and hatchery production facilities.
5. Conduct the studies and implement Phase 2 reintroduction work such that it does not:
    - introduce ESA-listed species into the blocked area
    - require major operational changes to the hydrosystem such as power production, flood control, or irrigation
    - reduce salmon harvest downstream

This ISAB report discusses several portions of the upper Columbia River Basin. For clarity, we refer to the area of the basin above Chief Joseph and Grand Coulee dams as the blocked area and the mainstem Columbia River and its tributaries between McNary Dam and Chief Joseph Dam as the upper Columbia River (Figure 1). Some text and results of analyses in the Reintroduction Report and the ISAB review distinguish the portions of the blocked area in the United States and Canada. We refer to the section of the Columbia River from the head of Lake Roosevelt to Hugh L. Keenleyside Dam and Christina Lake in British Columbia as the Transboundary Reach.

Figure 1. The blocked area of the U.S. portion of the Upper Columbia River Basin shown in context (red box) of the full Columbia River Basin, depicting anadromous accessibility. The lower map shows the blocked area boundaries within the United States. Sources: Columbia River basin map, Pacific States Marine Fisheries Commission (from ISAB 2015-1, page 58); U.S. blocked area map, Conor Giorgi.





B. Review Questions

The UCUT's request letter, July 21, 2022, includes a set of questions, listed below, for the ISAB's review of the Phase 2 Implementation Plan. ISAB Ex Officio[3] and Executive Committee members and Tribal, Council, and NOAA fish and wildlife staff provided input on the request letter and questions. The ISAB's review addresses the questions and focuses on the scientific soundness of the overall approach including the biological studies, interim fish passage planning process, hatchery/rearing approaches, and the adaptive management process.

1. Are the core elements of the P2IP based on sound scientific principles and methods? What are the strengths, uncertainties, and limitations of each element of the P2IP and are there any critical gaps in the identified steps or the overall stepwise approach? If there are gaps or technical flaws, how might they be addressed?
    a. Does the ISAB have suggestions to enhance the adaptive management framework or the adaptive management of each step, particularly if the project proponents are required to shorten the timeline?
    b. Is the approach for evaluating interim fish passage consistent with other fish passage projects constructed elsewhere in the Basin? Does the ISAB have suggestions for the tribes and agencies to improve the design and evaluation aspects of developing fish passage?
    c. Are the proposed studies appropriate for evaluating juvenile and adult fish survival and behavior and addressing critical uncertainties related to salmon reintroduction and the development of interim fish passage facilities? Does the ISAB have any suggestions related to the replication of these studies as interim fish passage facilities are installed throughout the life of Phase 2?
2. Does the P2IP adequately address the recommendations from the ISAB review of the Phase 1 Report?

C. Review Process and Cultural Perspectives

The ISAB bases its review and answers to the UCUT's questions, conclusions, and recommendations on a review of the Phase 2 Plan, supporting documents provided by the UCUT, their responses to questions submitted by the ISAB, and a targeted but not exhaustive literature review. On September 15, 2022, the UCUT briefed the ISAB on critical aspects of their Phase 2 Plan and feasibility work completed for their Phase 1 Report (see link for presentations). Subsequently, the Tribal leaders and staff scientists led a field tour of the blocked area of the upper Columbia River Basin on October 13-14, 2022. The tour included invaluable discussions with the UCUT and tribal representatives, regional scientists, and Council staff. The tour began at Spokane Falls, a historical fishing site for the tribes, with powerful opening

[3] Ex officio members — Robert Lessard for CRITFC and the Columbia Basin Tribes, Michael Ford for NOAA Fisheries, and Leslie Bach for the Council—are liaisons between their agencies and the ISAB, assist in the ISAB's operation and administration, help develop and support assignments, and provide scientific and policy context for reviews.

remarks by Carol Evans, Chairwoman of the Spokane Tribes of Indians, and D.R. Michel, UCUT Executive Director. The next stops were Grand Coulee and Chief Joseph dams, where we learned about fish passage and migration and behavior studies through Lake Roosevelt and Lake Rufus Woods reservoirs. The first day ended with a visit to the Sanpoil River, a tributary of Lake Roosevelt, where we witnessed Chinook on redds. We also saw similar Chinook behavior and redds downstream of Spokane Falls. These fish from the Tribes' cultural releases of adult salmon provide important evidence of potential for success in reintroduction efforts.

Carol Evans, Chairwoman of the Spokane Tribes of Indians (photo by John Epifanio)

On the second day, we visited some of the dams along the Spokane River where we discussed fish passage issues, including a stop at Long Lake Dam, and also visited potential spawning and rearing habitat at Waikiki Springs along the Little Spokane River. The tour concluded with a stop at sqweyu' along Hangman Creek, a potential future site for fish acclimation ponds and habitat restoration. Importantly, the tour demonstrated the breadth of developing partnerships and coordination among the Tribes and federal, state, and local entities.

Hearing directly from Tribal leaders and staff at the site visits was an essential component of our visit. We heard that the reintroduction of salmon to the Upper Columbia Tribes' homelands is much more than ecological restoration. We heard about the close relationships between salmon and Indigenous Peoples of these lands for millennia and the relatively recent but profound rupture of these relationships. It has now been five generations without salmon in these homelands. We heard that this reintroduction is a step toward correcting a deep historic wrong. We heard the power of this reintroduction process for the Tribes is helping to restore spirituality, identity, and wellness. Salmon reintroduction is an important part of healing multi-generational traumas. We also heard that the Upper Columbia Tribes want the reintroduction to be a benefit for everyone, both Tribal and non-tribal. After reintroduction into the blocked area, salmon production would provide recreational and harvest opportunities for local and downstream communities, sport anglers, and commercial fisheries. The UCUT's reintroduction efforts also generate important contributions to the science of salmon ecology and of fish passage at high head dams.

The Phase 2 Plan clearly expresses the deep importance of reintroducing salmon to the Upper Columbia Tribes and the Upper Columbia River ecosystem. Contemporary fisheries science increasingly is recognizing the need to include Indigenous cultural perspectives and knowledge systems alongside western approaches. While the Phase 2 Plan is based primarily on western science, the UCUT may consider including additional Indigenous perspectives and protocols for bridging Indigenous knowledge with results of western science where appropriate throughout the Phase 2 (and future) studies and assessments. For example, because salmon may be viewed as kin relatives in Indigenous cultures or ways of being, appropriate protocols for various stages of salmon reintroduction may look different than approaches coming from western cultures. Similarly, assessing and measuring success of these processes may look differently when viewed from Indigenous and western cultural perspectives and knowledge systems. Recent attempts to bridge diverse Indigenous and western fisheries knowledge systems recognizes and maintains the integrity and validity of each (e.g., Reid et al. 2020; Alexander et al. 2021; Silver et al. 2022), and such perspectives may be helpful in this or future stages of reintroduction.

II. Answers to the UCUT's Questions

The UCUT requested that the ISAB answer a set of questions about various elements of the Phase 2 Plan (P2IP) and review the strengths, data uncertainties, and limitations of each element. We summarize our major findings in brief answers below, and additional details are provided in the section on Scientific Review of Core Elements of the Reintroduction Report that follows.

1. **Are the core elements of the P2IP based on sound scientific principles and methods? What are the strengths, uncertainties, and limitations of each element of the P2IP and are there any critical gaps in the identified steps or the overall stepwise approach? If there are gaps or technical flaws, how might they be addressed?**

   The Phase 2 Plan provides an overall roadmap for the next two decades of field studies and analyses to answer critical questions required to design an effective approach for reintroducing salmon above Grand Coulee and Chief Joseph dams. Much of the focus, appropriately, is on near-term actions in the first six years of Step 1. The stepwise approach and adaptive management process will be critical for decision making and overall success because 80 years of blockage to fish migration by extremely large and complex dams and associated structures in addition to downstream stressors on salmon populations create major uncertainties. Many details about initial actions, model development and data management, adaptive management processes, and budgets will benefit from continued refinement, especially in the early years of Phase 2, to focus on priority actions.

   In the previous Phase 1 Report, general information and estimates related to donor stock selection, available habitat, and potential production of summer/fall Chinook and sockeye were based on scientifically sound but relatively simple concepts and information. The resulting estimates of production have wide confidence intervals and many areas of uncertainty. The survival and migration studies are critical for improving the precision of these estimates and the confidence in decisions made based on those estimates.

   The Decision Flow Charts are very helpful for illustrating the kinds of information that will inform future actions, the quantitative thresholds, and the logic-path for making decisions. One can debate the specific metrics and thresholds, but it helps to see them displayed in this manner. Such diagrams should be provided for descriptions of the adaptive management process and future additions to the process.

   Overall, the UCUT has broadly and extensively considered the support programs critical for the Phase 2 objectives and activities needed to implement the studies identified for Phase 2. The program will be adapted as efforts are undertaken and results are accumulated, and these studies will be critical for thorough evaluation, increasing the likelihood of success.

   The ISAB recognizes that cost projections become more uncertain the farther out into the future they extend. Some additional background, basis, and justification for cost projections is warranted for the RM&E of early stages (i.e., Step 1) of Phase 2. We encourage the UCUT to describe both funded and non-funded contributions by the Tribes and their collaborators to the reintroduction efforts to give readers a more complete understanding of the full extent of people and resources being dedicated.

a. Does the ISAB have suggestions to enhance the adaptive management framework or the adaptive management of each step, particularly if the project proponents are required to shorten the timeline?

- Because of the long duration of Phase 2 field studies and management actions, the UCUT recognize the need to develop coordinated adaptive decisions on both the sequence and design of field studies and on operational management actions.

- The technical and policy teams described briefly in the Phase 2 Plan will be extremely valuable for timely and effective coordination with state and federal agencies, Public Utility Districts (PUDs), vendors, and cooperators. Early formation and engagement of these two teams will strengthen decisions and actions in Step 1. The Upper Columbia Blocked Area Anadromous Fish Working Group (Upper Columbia BAAFWG), formed in 2021-2022, might fulfill the role of the policy and technical teams, but the UCUT should make certain the important functions for policy and technical decisions are being provided to achieve the program's aims.

- The Phase 2 Plan needs to explain how information from the field studies and Life Cycle Model (LCM) will be used together in the adaptive management process. The integration of the field studies and LCM needs to be developed early in the Plan and described more clearly.

- A unified database will improve analysis of field data from different studies and the integration of the information with the LCM. Such a database should include description of field and analytical methodologies to ensure institutional memory over the project's lifespan. It is a common practice to initiate data collection and defer the development of a database, but this typically leads to errors and confusion with the many sources of data in the long term. Development of such a centralized warehouse for data and analytics early in the Phase 2 could enable the resulting information to inform program decisions more easily and effectively.

- A robust Life Cycle Model provides a useful structure for identifying data needs requiring field study. The UCUT need to determine the characteristics of the LCM important to Phase 2 and to decide how to proceed with modifying the existing model or developing a new model.

- The strategy for the LCM should address application of the model to prioritize field studies, identify missing information, account for environmental uncertainty, and conduct sensitivity and uncertainty analysis. This should help identify critical processes and parameters. The strategy should also include the plans for long-term support for the model and clarify how model results will be applied in decision making. The full report below includes detailed suggestions for strengthening the model.

b. Is the approach for evaluating interim fish passage consistent with other fish passage projects constructed elsewhere in the Basin? Does the ISAB have suggestions for the tribes and agencies to improve the design and evaluation aspects of developing fish passage?

- The overall approach for evaluating interim fish passage is consistent with scientifically robust methods for developing and evaluating an interim system for movement of juvenile and adult salmon around Chief Joseph, Grand Coulee, and upstream dams. It also reflects an appropriate approach for sequentially conducting research and develop more permanent facilities.

- The combination of PIT tags, coded wire tags, acoustic tags, and parentage-based tagging approaches is appropriate. Each will provide critical information for developing and implementing passage alternatives. Collectively, their individual strengths and limitations make them complementary rather than redundant.

- It is not always clear how the studies to determine performance metrics at interim passage facilities will inform performance of the permanent passage facilities because interim and permanent passage facilities will be different. Some consideration is warranted of the limitations of applying initial study results to different future situations.

- Some current assumptions about upstream and downstream fish passage may be overly optimistic. This uncertainty illustrates the need for the studies described in the Plan but also suggests that the initial LCM might not be realistic.

    - At times the Phase 2 Plan refers to techniques for fish passage facilities for which their performance is not well established (e.g., juvenile guidance structures, Whooshh). This is an unfortunate result of the immaturity of the field of fish passage engineering, and in no way a criticism of the Plan. However, by relying on facilities that are not widely demonstrated to be effective, the Plan may be overly optimistic at times.

    - In some specific cases, upper bound (or most optimistic) values seem to have been used. These upper bounds could affect decisions illustrated in the Decision Flow Charts in complex ways. Field studies will base some of these assumed parameters on reality, but the outcomes could substantially alter the project cost or create uncertainty in the outcomes of reintroduction.

- It will be essential to consider benefits and risks of passage designs for other taxa, including ones whose migrations might be deemed beneficial (e.g., steelhead, Pacific lamprey, sturgeon) and ones whose migrations would be deemed undesirable, such as northern pike or American shad, in the design and operation. Designs for passage facilities should allow for the passage of desirable species but should consider options to control passage of species that may be ecologically harmful.

c. **Are the proposed studies appropriate for evaluating juvenile and adult fish survival and behavior and addressing critical uncertainties related to salmon reintroduction and the development of interim fish passage facilities? Does the ISAB have any suggestions related to the replication of these studies as interim fish passage facilities are installed throughout the life of Phase 2?**

- Overall, the study designs are well conceived and should reduce current uncertainties about fish survival and dam passage. The steppingstone approach of progressively establishing reintroduction programs from lower to upper regions in the anadromous blocked zone is a strength of the reintroduction plan, allowing for an effective sequence of studies and future actions associated with juvenile releases.

- To effectively inform the Adaptive Management process, results from provisional analyses should be reported annually or in a suitable timeframe (rather than waiting for full completion of studies) to ensure sufficient power and utility of data acquisition from the proposed studies.

- As the UCUT are aware, obtaining sufficient numbers of fish from appropriate sources may be a major challenge in the early Phase 2 studies. Continued and improved cooperation by management agencies, PUDs, and other partners will be critical to the success of the program.

- It may be logistically expedient to test a single, abundant, highly ranked donor stock in the initial experimental studies. However, the UCUT might consider comparing multiple donor stocks, at least experimentally, to determine whether they differ in important ways that would affect long-term success.

- The Plan assumes that salmon will imprint on, and return to, the place where they are released rather than the hatchery where they were incubated and reared prior to release. In cases where hatchery facilities are not close to Chief Joseph and Grand Coulee dams, this could cause straying and decrease returns of adult salmon to facilities for passage into the blocked area. Studies of juvenile release and adult returns should include the ability to evaluate this assumption.

- Parentage-based tagging (PBT) is a practical method to estimate adult returns per spawner and also allows identification of the relative reproductive success and contribution of fish of hatchery and natural origin, different stocks, ages, sizes, etc. Such information will guide the project based on sound science. However, this method will not account for fishery interceptions, and so, as noted elsewhere, it indicates return to the point of capture rather than survival through natural mortality events and recruitment to the fisheries.

- Climate change and hydrological uncertainty may affect the success of salmon reintroduction into the blocked area. These sources of mortality, exacerbated by high temperatures, may have profound effects on salmon populations throughout the Columbia River Basin. Indirect effects of climate change may also influence success as a result of climate influences on the ecology of predators, competitors, and prey in freshwater, estuarine, and marine habitats. Existing fish monitoring programs should be leveraged to gain more information from the proposed studies over a longer time scale that reflects hydrologic variability and determine whether modifications to these programs will be needed.

- Early studies to evaluate downstream movement and survival of juvenile Chinook should reduce uncertainties about dam passage. The ISAB commends the collaboration between the USGS, PNNL, and the Coeur d'Alene, Colville, and Spokane Tribes. Improved reliability of sources, numbers, and conditions of experimental fish is essential to address the assumptions and uncertainties. The ISAB recommends continued negotiation to ensure sufficient study fish for analytical power and encourages the Council and BPA to assist where possible to make the studies more robust and informative.

- The studies to evaluate movement of juvenile sockeye salmon through Lake Roosevelt are well conceived, and again the collaboration among the partners is commendable. The studies face similar challenges with the sources, numbers, and conditions of experimental fish and the planning of the duration and transition to subsequent studies in later steps of Phase 2.

- Discussion of the potential application of the Whooshh system for upstream passage of adult salmon above Chief Joseph and Grand Coulee dams (Appendix E) lacks information about the results of previous trials at Chief Joseph Dam. Also, it does not address the numerous questions about the Whooshh system raised by the ISAB in the review of the Phase 1 Report. The substantial questions about its application require much more information before the UCUT can make even preliminary decisions in this regard.

2. Does the P2IP adequately address the recommendations from the ISAB review of the Phase 1 Report?

- The UCUT thoroughly addressed many of the ISAB's recommendations from the review of the Phase 1 Report.
    - The Phase 2 Plan incorporated the steppingstone approach of progressively establishing reintroduction programs from lower to upper regions in the anadromous blocked area for a) implementing studies of juvenile and adult salmon movement and survival and b)

progressively establishing reintroduction programs from lower to upper regions in the anadromous blocked area.

  - The UCUT are developing an overall adaptive management plan that includes a) processes to obtain information required to design reintroduction actions and b) processes for making decisions about the types and sequences of reintroduction efforts. This existing plan is strong, and it will require continued improvement and implementation.

  - Anticipated performance metrics for juvenile and adult passage have been developed for all major dams. The metrics are based on observed data from other dams with similar characteristics. The UCUT provided supplemental materials with details about specific metrics and assumptions of the model.

  - In response to the ISAB's questions about the effects of total dissolved gases (TDG) on fish survival in and below the blocked area, the UCUT assessed regional TDG concentrations and concluded that they are similar to concentrations in downstream areas and are therefore not issues in low flow and normal years. TDG will be monitored and evaluated throughout the implementation of the Phase 2 Plan.

- Two major aspects of the ISAB's review of the Phase 1 Report are not thoroughly addressed.

  - The UCUT have responded to some of the questions about the model raised by the ISAB in the Phase 1 Review, but several have not been addressed. A few aspects of the LCM have been updated or modified from Phase 1, but the model largely is unchanged from Phase 1. Many decisions will be required to implement the use of the model in research and adaptive management in Phase 2. The UCUT will consult with NMFS and other modelers to determine whether to update the existing LCM or develop a new model. The ISAB supports this approach and provides additional comments in this review, with the hope that they may contribute to aspects of the review and decisions on the LCM development.

  - The ISAB identified several major questions about the Whooshh system and suggested critical steps, but the information in Appendix E does not address them directly and the information is still needed.

III. Scientific Review of Core Elements of the Reintroduction Report

This section addresses the UCUT's request for the ISAB to identify the strengths, data uncertainties, limitations of each element of the Phase 2 Implementation Plan, and any critical gaps in the analyses.

Chinook redd viewing, Spokane River (photo by Tom Wainwright)

A. Scientific Framework

Overall comments

Phase 2 is envisioned as a 20-year plan of incremental learning and implementation. Given the substantial uncertainties inherent in salmon reintroduction above two major dams and several smaller dams on the Spokane River, this staged incremental approach is appropriate and represents a strength of the Phase 2 Plan. By undertaking Phase 2 in such an incremental manner, the UCUT proponents and their partners can examine the validity of assumptions in a manageable way and ensure that the program's goals for Phase 3 (and beyond) are rooted in a firm and attainable knowledge base. The UCUT developed an adaptive management process to obtain information required to design reintroduction actions and make decisions about the types and sequences of reintroduction efforts. Phase 2 uses field data collection and an LCM approach to develop targets, assess consequences of the observed responses and research findings, and integrate available information. Anticipated performance metrics for juvenile and adult passage have been developed for all major dams.

The ISAB witnessed fish on spawning grounds in Spokane River and Sanpoil River and is encouraged by the evidence of spawning activities by Chinook salmon from cultural release programs which use trap-and-haul. The ceremonial salmon releases have provided participation and a sense of healing for Tribal members, awareness and support in the larger regional community, and initial information to inform field studies, the life cycle model, and management actions. For example, the release of adult salmon into a river that they did not experience as juveniles during rearing and migration stages might well have caused the salmon to immediately depart downstream. The fact that they did not do so is significant and encouraging. It is the ISAB's understands that these programs will continue, and this is encouraged. In addition to the ongoing studies grounded in western science, any other information or observations that arise from these programs could prove useful in the adaptive management process.

The adaptive management process will be critical for the success of the Phase 2 efforts. Because of the long duration of Phase 2, the UCUT will need to develop coordinated adaptive decisions on the sequence of field studies and operational management actions. The UCUT have begun to develop essential components of an adaptive management process, such as teams for major tasks, targeted data collection and analysis, and an LCM to generate and assess targets and metrics for important actions. However, the Phase 2 Plan does not clearly describe how the empirical field studies and the LCM will be used together and how the information will be integrated or used in the decision matrices.

Based on the UCUT's response to ISAB questions and the field tour, the ISAB learned that the UCUT are using the existing administrative structure for adaptive management decisions, which is advised by the science teams, Tribal fisheries managers, and Council members from the five Tribes. Future documentation of the Phase 2 Plan should describe or define these decision-making groups and how they operate to make adaptive decisions. The Plan also should describe details of the adaptive management process, such as timelines for management meetings, documentation of decisions and management actions, periodic synthesis and review meetings, or Tribal and general public involvement. The ISAB recognizes that each of the five UCUT tribes have internal decision-making processes, but it is not clear how existing tribal processes are incorporated into the adaptive management process. The Phase 2 Plan indicates that a technical and a policy team may be formed for efficient and timely communication with state and federal agencies, PUDs, major vendors, and other regional entities. The ISAB considers these separate but coordinated teams to be important components, especially in the early program development in Step 1. If the UCUT decide to use the Upper Columbia BAAFWG to fulfill the role of the policy and technical teams, they should ensure that the important functions for decisions are being achieved.

A major part of Phase 2 is designed to generate information for adaptive management decisions for the Tribes' efforts to reintroduce salmon into the blocked area. The adaptive management process will use the LCM, in tandem with the data collection and analyses, to generate actionable information during Phase 2 (though it is not always clear how and which information will translate into decisions). Given its importance, the assumptions and structure of the LCM need to be assessed and possibly modified, or a new model may need to be developed instead, for reasons detailed below. The model should be modified to represent local conditions and information as much possible, using field-based data to improve model accuracy and precision, ultimately combining field data and modeling to answer issues identified as part of adaptive management process. In addition to the field studies and LCM for evaluating alternatives, the UCUT may want to develop additional protocols for tracking progress toward achieving social or cultural metrics.

Accomplishing the major components of the scientific framework in a systematic, effective, and transparent manner will require the following activities, some of which are absent in the Phase 2 Plan; specifically:

1. clarify where the LCM will be used in the adaptive management process versus where field data will be used
2. create a unified database for analyses of field data and for the LCM
3. assess the confidence in the empirical studies and LCM and identify uncertainties for both
4. distinguish between sensitivity and uncertainty analyses in the LCM
5. prioritize how to improve the LCM through simulation testing and comparison to the field data
6. develop protocols for updating the LCM
7. organize and specify the steps in the adaptive management processes.

These activities are discussed in more detail below.

1. Life cycle model and the analysis of field studies

Strengths

Both the LCM and empirical studies are important elements in management decisions to reintroduce salmon into the blocked area. The LCM is not the ultimate product of the sequence of studies, nor is it the only basis for decisions. However, the model is the one tool for integrating the outcomes of all the scientific studies and understanding possible consequences of alternatives for adult returns. The LCM is a line of evidence that will be considered, along with empirical evidence, and strengthened as more study results and information become available.

The integration role of the LCM, coordinated with field data collection, in the planning, design, and adaptive management is a strength of the proposed actions in Phase 2. The deterministic spreadsheet model provides a documented and transparent tool for assessing the observed or potential performance of management and restoration actions. The model can be used in management and policy settings to address questions and aid discussions and decision making. A strength of the program is that they have an LCM in place as a good foundation and starting point for further model development as more data becomes available. As field studies provide more information and more regional information becomes available, the model will need to incorporate locally observed information in fish passage, movement, and survival to become more robust and representative of the blocked area and upper Columbia River.

Limitations, data uncertainties, and critical analytical gaps

The role of field studies

The ISAB does not expect that the primary purpose of Phase 2 is to “build a better” LCM but rather to ground-truth scientific assumptions that are embedded with the LCM and critical to the success of the program. For this to be effective, the data collection and modeling need to be coordinated. The ISAB understands that data collection will be used in three ways: (1) alone as a basis for statistical analysis to answer specific questions for adaptive management decisions, (2) in combination and synthesized with LCM results so they can be used together to answer questions, and (3) as a basis for testing the LCM to identify model improvements that most effectively improve LCM predictive skill.

Single unified database for the collected data

A lesson learned from other large-scale restoration projects is that the establishment of a unified database is critical and worth the upfront investment relatively early in projects (Gaff et al. 2000, Rose et al. 2015). This avoids the scenario of data being scattered across projects and people, while others struggle to work with dozens of poorly documented modeling codes and spreadsheets. With today's technology, setting up documented protocols, submission requirements, QA/QC, meta-data, a is much less complicated and expensive than it was in past years, if it is developed early in the project. Collection and curation of the data should be rigorously planned and coordinated in the program. In addition, to the extent possible, the database should rely on or be compatible with other key long-term datasets in nearby systems. Ultimately, as this project moves to a longer time horizon, capturing and curating data, metadata, and methods will be critical to the institutional memory of the project.

The Plan for Phase 2 should clearly identify where and how the collected data (e.g., acoustic telemetry data and PIT tag data, habitat data, water quality and environmental data) will be stored, documented, and archived. The ISAB is aware of the Colville Tribe's Resident Fish Database (described in monitoringresources.org), the Spokane Tribe's Water Quality Database, and the PSMFC PTAGIS system for PIT tag data. In response to questions from the ISAB during the field tour, the UCUT indicated that obtaining funding for data management and reporting is a high priority in the near-term, but details of data management and reporting have not been worked out. They will use current tribally managed databases (e.g., Chief Joseph Hatchery's In-Season Implementation Tool) as frameworks until they develop one or more databases to meet the needs of the reintroduction effort. The database or databases will be linked to existing platforms (e.g., PTAGIS, DART, RMIS) to support Phase 2 analyses as well as provide transparency of the reintroduction effort. This strategy is a reasonable short-term solution in the absence of a funded data management program, but the ISAB recommends development of a centralized, unified data management system in the long term.

Continued use and development of the LCM

On the field tour and in a written response, the UCUT informed the ISAB that they will be meeting with LCM modelers from NOAA in early 2023 to discuss the UCUT's existing LCM and potential further development or alternative modeling approaches. To guide the future development of the LCM, the UCUT's policy and technical staff will determine what questions the model is expected to answer, questions that need not be addressed, level of certainty required for decision making, and how to interpret and report model results. The UCUT staff also will recommend additional steps to identify important parameters in the model and approaches for sensitivity and uncertainty analysis.

Collaboration with NOAA modelers should be valuable, especially if it results in clarifying LCM uses and needed revisions, as well as how field data will be used in the model.

It will be important to determine the characteristics of an LCM managers will need in Phase 2 and decide how to proceed with modifying the existing model or developing a new LCM. The LCM, in whatever formulation is used, is a critical tool for designing and guiding Phase 2, but the Phase 2 Plan does not describe how the LCM will be updated and does not address the ISAB's questions and concerns about the LCM from the ISAB's review of the Phase 1 Report. We encourage the UCUT to develop a strategy for how the LCM will be used in Phase 2 and how it will be improved initially in Step 1. The strategy for improving and applying the LCM will need to address several fundamental aspects of model development, including long-term support, using the model to prioritize field studies, sources of mortality that are missing or weakly represented, environmental uncertainty, sensitivity and uncertainty analysis, and identifying critical processes and parameters.

Since the Phase 1 Reintroduction Report, the UCUT obtained funding to update the LCM to encompass the Spokane River watershed and its three hydroelectric dams. The UCUT also have added user functions for the model, including a user guide, built-in user guide for entering data, ability to enter coefficients of variation for multiple variables, a Pacific Decadal Oscillation (PDO) function for representing random (lognormal) variability of ocean survival, and ability to track the number of juvenile and adult Chinook or sockeye arriving at each point (reservoir, dam, mouth of Columbia). The Sensitivity/Monte Carlo Simulation has been removed from the most recent version but may be updated or revised based on consultation with NMFS and other life cycle modelers. The ISAB believes that the ability to perform sensitivity analyses and Monte Carlo simulations will be important to the adaptive management process, and restoration of these capabilities should be a priority.

Best practices are available for developing, documenting, and using models for ecosystem restoration that include guidance on formulating a well-balanced model. Other large-scale restoration programs have faced these challenges, and several major reviews of best modeling practices for conservation and restoration programs (Jakeman et al. 2006, Swannack et al. 2012, Rose et al. 2015) can help guide the UCUT in its continued development of the LCM in Phase 2.

Long-term model support

The UCUT will need to identify how to support the model with long-term certainty about the technical development, documentation, maintenance, and institutional memory of the model. For a long-term program like Phase 2, it is likely that scientific personnel will change; thus, background documentation, database linkages, and technical support will be critical.

A major task for developing and maintaining the LCM is specifying protocols and procedures for how the LCM code and documentation will be updated with new knowledge. These protocols and procedures include: (1) assuring that changes are correctly implemented in the model, (2) conducting version control to ensure old and new model results are interpreted correctly, (3) documenting and labeling specifics for the results, users guides, and formulas and code, (4) using standard test cases to enable documentation of results from the same conditions with the old and new improved versions, and (5) periodically updating the project team and designated staff (other than developers) about access and status of the model source code. Item (5) is a legacy plan to ensure the model and code will be functional throughout the duration of the program, especially for one expected to last decades. It is not unusual for staff to leave or hardware and software companies to change, and in some cases, no one may know the model and code well enough to update it. Current tracking of model versions by the developer is useful, but the UCUT modelers will need an independent, systematic procedure for tracking and updating the LCM in Phase 2.

Identifying critical processes and parameters

In Phase 2, the UCUT will need to identify critical information needed for the LCM. This information is typically in the form of: (1) field and laboratory data highlighting a process missing from the model that is now deemed important to include (e.g., straying to source hatcheries, straying within the blocked area), (2) refinement of existing process formulations already in the model but model-data comparisons have shown them to be too inaccurate (e.g., more detailed migration, ocean effects), (3) need for a greater range of environmental variation as driving variables (e.g., multiple drought years), and (4) higher accuracy and precision in the values of the key parameters in the process representations that are greatly influencing model predictions (i.e., critical parameters). The major methods for identifying critical information to improve the realism (accuracy, precision, robustness) of an LCM and other ecological models are model-data comparisons, sensitivity analysis, and uncertainty analysis. As part of such model analyses, a key component is to use intermediate variables (not just the final prediction variables) and other diagnostics generated within the model calculations (e.g., abundance by life history stage) to understand why the model generated the final prediction results. This mechanistic understanding, in addition to the focus on the final prediction variables, greatly adds to the usefulness of modeling.

The Monte Carlo option that was originally part of the LCM in Phase 1 is an example of how Monte Carlo capabilities can be included with a life cycle-type model and offers the mechanics for performing a wide range of types of sensitivity and uncertainty analyses4 (Saltelli et al. 2008). This analytical capacity, or equivalent Monte Carlo option as the modeling progresses, will be important in future applications of the LCM and other models. Documents from Phase 1 showed some useful intermediate outputs (e.g., numbers at each life stage and event) were already being generated and reported. However, the ISAB did not see a strategic plan on how the UCUT team would use the Monte Carlo approach for sensitivity and uncertainty analysis with the existing and proposed field data and intermediate model variables for understanding to identify critical processes (assumptions) and parameters (coefficients) in the context of how the LCM uses them. Monte Carlo uses correlation-based methods to determine which parameters or processes most influence the different model output prediction variables. One can then conduct

[4] Sensitivity analysis examines the importance of parameters based on small changes in local parameter space, which is typically a baseline or reference condition. This can be done with Monte Carlo methods or by modifying one parameter at a time. Uncertainty analysis quantifies the range of possible predictions by allowing for realistic and simultaneous variation in parameters and inputs to compare among scenarios or identify improvements in measurements to reduce prediction uncertainty.

simulations based on plausible ranges of important parameters or processes and project how such information would increase model confidence and whether it would change decisions. There are many examples of such analyses being applied to fish population dynamics models. An effective strategic plan needs to be developed that is highly detailed and specific to the model, data, and decisions of each situation. Describing the analysis workflow for identifying critical information for the LCM is essential as it will contribute to design of the field studies and improvement of the LCM results and interpretation.

Using the model to prioritize field studies

One goal of Phase 2 is to improve the LCM (or equivalent new model) as more information becomes available. When considering how to improve the LCM, it is important to try to distinguish between the precision and accuracy of model predictions. Both are important aspects of the information that is being obtained for management decisions and for the model. Investigators often focus on precision by collecting more data on model inputs, but reducing bias to increase accuracy often has more impact on adaptive management-related decisions. Thus, the benefits of collecting new types of data (even as shorter-term special studies) that complement ongoing data collection rather than simply more of the same data should be considered.

Monitoring data are critical for informing decisions and providing the basis for model evaluation. Similarly, the LCM or a similar model can be used to improve the monitoring and other field data collection activities. Model analyses can be used to adjust sampling locations and frequencies and to provide more accurate and precise response variables from the monitoring data. The LCM represents the key processes (growth, mortality, reproduction, movement) affecting predicted responses (i.e., from mechanistic understanding of model results) and thus can also be used to identify where and when such rates, and the factors that control them, should be measured. These focused process studies typically differ from usual monitoring programs; the former involve intensive measurements specific to a process and over a relatively short time period (a few weeks to a few years), often in specific locations. The results are then used to augment the monitoring data and thereby improve the model themselves and increase the confidence level of decisions.

The project team will need to design a process for using the model to inform field studies and determining how the collected data will be used to estimate model inputs (Swannack et al. 2012, Rose et al. 2015). The strategy should include two-way flows of information. The model can be used to inform more effective data collection (Model → Data) and the results of the field studies can be used to improve process representations and parameter values (Data → Model). The collective results could be used to understand how additional information would affect outputs and decisions and make the Phase 2 efforts more efficient and effective. Such assessments will be important because it is impossible to collect everything to attain a desired level of confidence in the model, thus priorities must be set for efficiency. For example, some processes or parameters may be poorly understood, or local data are lacking, yet they may not affect model confidence or help distinguish among scenarios of alternative management actions. In such cases, studies of those processes or parameters will not change model results and therefore not inform management decisions. Thus, the model can help identify the uncertainties that matter most and distinguish them from large but relatively unimportant uncertainties.

The Phase 2 Plan would benefit from clarifying how the field data and LCM will be used, and by identifying the major processes that are likely to influence model results and management decisions to prioritize further data collection.

Sources of mortality that are missing or weakly represented

More broadly, the UCUT are focusing its analyses and attention on the possible reintroduction approaches and management activities in the blocked area, where it has some authority to implement actions. The ISAB agrees that this is reasonable but encourages the UCUT to also consider the impacts of downstream sources of mortality on their reintroduction efforts and the LCM provides a tool for such analyses.

Some important sources of mortality are missing or only weakly represented in the LCM. For example, while passage and in-river harvest are included, other key sources of mortality outside the blocked area (e.g., avian and marine mammal predation) are not (ISAB 2019). The UCUT acknowledge the importance of non-native fishes in the system in their responses to the ISAB's 2019 Review, and they have indicated they have programs to control them, but predation is not explicitly represented in the LCM. Predation by northern pike, smallmouth bass, walleye, and avian predators are only represented indirectly as part of reach-specific survival rates. Effects of predation downstream of Chief Joseph Dam are represented as part of the overall downstream survival rates. As the Tribes obtain more data on predators upstream of Grand Coulee Dam, the LCM may serve as a valuable decision-making tool to determine the potential impacts of predators on the program's success and to evaluate possible alternative management actions. While incorporating downstream sources of mortality will make LCM analyses more complex, they may be useful to document constraints that may limit reintroduction success and that might be addressed by the broader Columbia River fisheries management community. Successful reintroduction may require downstream actions, but this will not be known without including downstream mortality factors in the LCM.

Environmental uncertainty

The LCM does not include environmental stochasticity, which is an important source of uncertainty in using the model to make decisions about the reintroduction. The existing model was developed with Monte Carlo capabilities for assessing parameter uncertainty. In contrast, environmental variation is more often about how different year-types, alone or sequences, affect model predictions. Environmental variation, such as flows (e.g., sequences of high and low flow years, droughts, high flow-events) and temperature (e.g., more warm years), should be included in future life cycle modeling. This can be done by explicitly adding the influences of specific environmental variables on processes into the model; however, this involves developing a new model or overhauling the structure of an existing model and redoing the calibration and testing. The UCUT could better understand their models' behavior and potential consequences of environmental variability by manipulating the effects of these uncertainties through implicit changes, even when sources of uncertainty are not explicitly represented (see Rose et al. 2015). For example, it is not necessary to have a river flow variable in the model to examine the effects of river flow on model predictions, at least in a preliminary manner. Available information on how river flow would affect existing processes (e.g., mortality, growth) in the model can be used to impose realistic changes in the available model parameters that then mimic the effects of river flow, without explicitly having river flow as a driving variable in the model. This is relatively simple and low-effort method for getting information on how model predictions would be affected by environmental stochasticity.

The UCUT have recently added a PDO component to the model to represent variability of ocean survival with variable user-selected time intervals from 1954 to 2013 (response memo from the UCUT, November 7, 2022), but the ISAB has not reviewed the details of this modification of the model. They are considering other indices or metrics of ocean conditions as well. The LCM could be modified further to explicitly incorporate realistic climate variation. Given the 21-year span of Phase 2, and the longer span for Phase 3, environmental conditions are likely to change substantially. This could be approached by using downscaled global climate model predictions for stream flows and temperatures (e.g., Ficklin et al. 2014), and possibly for ocean conditions (although ocean conditions are more difficult to predict).

The consequences of short-term and long-term representation of environmental variation should be included as the model is modified and the use of the model should be adjusted accordingly for decision making. The present LCM appears to be run in two modes: equilibrium values and fixed numbers of years. Some important questions may be better answered by examining short-term responses based on initial conditions. Without environmental variation, the robustness of the results from a life cycle model is questionable for shorter-term simulations (<20 years) and is better suited, in general, for equilibrium predictions. The longer the simulation, the more inter-annual variation averages out. However, longer simulations also introduce problems if there are decadal trends (e.g., ocean conditions, regional weather patterns) that are ignored. Fixed-duration simulations should include information on any trends.

Minor comments

1. The ISAB noted considerable regional excitement and willingness to cooperate and participate in the project/program. An expectation of input and participation may accompany this willingness. To maintain the enthusiasm and trust, it will be important to be transparent upfront about who will have a voice as a contributor/stakeholder and who will be part of the larger community of neighbors.

2. The UCUT likely will need to run the LCM differently than the Graphical User Interface in Phase 2, and they will want to change both parameters and structure. It will be important to have that capability. The modelers need to develop and document objective rules, protocols, and procedures for updating the model.

3. It appears that density-dependence occurs with the multi-stage Beverton-Holt model. Is this the only place where the habitat assessment results are used?

4. Presenting Monte Carlo results as cumulative distribution functions is better than frequency histograms with odd looking bin intervals.

5. Does red in the decision charts suggest an operational, decisional, or other dead end?

2. Stepwise process

Strengths

Phase 2 studies have adopted the principle of following a stepwise and flexible approach, and flowcharts have been developed to help guide decision-making. The Plan provides clear justification for prioritizing the sequence of phased fish passage actions and using field observations to inform next steps. The staged or incremental approach is appropriate, given the uncertainties inherent in reintroduction of salmon above two major dams and several other smaller dams farther upstream. In several instances, the UCUT incorporated a "steppingstone" approach of progressively establishing reintroduction programs from lower to upper regions in the anadromous blocked zone to allow for research on potential impacts of juvenile releases. The stepwise process prioritizes understanding outmigration and dam passage survival of juvenile Chinook and sockeye released at Rufus Woods Lake, Sanpoil River, Hangman Creek, Little Spokane River, and the Transboundary Reach. This is a reasonable approach based on the likelihood of contribution to production in the blocked area after reintroduction. The performance in these areas will be critical for the success of the program.

Another aspect of the stepwise approach is the reliance on trap-and-haul to move adult salmon from below Chief Joseph Dam using transport trucks. This is both cost effective in the short term and requires less capital construction. This also facilitates initial studies of movement, survival, spawning, and behavior. Incorporating parentage-based tagging (PBT) is a useful component of the early steps, as it should provide valuable information on variation in the number of adult returns per spawner and possibly performance of different donor stocks or rearing areas within the blocked area.

Limitations, data uncertainties, and critical analytical gaps

The approach is phased but schedules for specific steps and stages in the 20-yr projected duration of Phase 2 are very general. The ISAB recognizes the necessity for flexibility and the uncertainty about the exact timing and specific actions over that period. Flexibility in study design may complicate the aggregation of data across years in multi-year studies. These issues underscore the importance of effective and explicit adaptive management for the UCUT reintroduction plan, a need that will be greater than what is required for most regional restoration programs. A lengthy project like this also calls for up-front planning of the database, as has been noted earlier in this review.

A key aspect of the stepwise process is stated clearly in the Plan. "Only after all critical assumptions are replaced by locally collected data, including evaluations of interim passage facilities, and the model is rerun, can conclusions be drawn about feasibility." Generally, this is a strength of the strategy. However, this stepwise process has limitations when it comes to connecting the performance of the interim and permanent fish passage facilities because the characteristics and associated fish passage may differ substantially, as described under the fish passage section below.

3. Adaptive management approach

Strengths

The adaptive management process will be critical for the success of the Phase 2 efforts. Because of the long duration of Phase 2 field studies and management actions, the UCUT will need to develop coordinated adaptive decisions on the sequence and design of field studies and facilities development in Step 2. The UCUT have begun to develop essential components of an adaptive management process, such as teams for major tasks, targeted data collection and analysis, and an LCM to create and assess targets and metrics for important actions. The existing UCUT administrative structure is being used for adaptive management decisions, which is advised hierarchically by the science teams, Tribal fisheries managers, and Council members from the five Tribes.

The Phase 2 Plan indicates that a technical and a policy team might be formed for efficient and timely communication with state and federal agencies, PUDs, major vendors, and other regional entities. The ISAB considers these coordinated teams to be important components of Phase 2, especially in the early program development in Step 1.

The strategy is generally strong, relying on models, local data collection, and quantitative, performance-based decision trees. Actions are prioritized to maximize learning and minimize costs, and are informed by established science (e.g., USACE's fish passage compendium). The process also involves annual review of LCM outputs and field data to inform modifications. However, questions remain about how information from the field studies and LCM will be used together in the adaptive management process.

A strength of the Phase 2 Plan is the specific quantitative decision thresholds for likelihood of successful reintroduction (e.g., 90% juvenile survival rate threshold, 82% for the combined GCD + CJD, 73% at Spokane River Dams). On the tour and in the written response to ISAB questions, the UCUT informed the ISAB that the metrics are based on observed data from other hydroelectric projects with similar characteristics when available, such as use of juvenile Chinook survival through high head dams in the Willamette River basin for initial survival values at Chief Joseph and Grand Coulee dams. Survival data for dams operated by PUDs in the upper Columbia River also were used to determine thresholds. Many of these values were explained briefly in the supplemental materials documentation for the LCM in the Phase 1 Report. Using these survival thresholds, the LCM projected population productivity greater than 1.0 in several major production areas in the blocked area, indicating that they were a reasonable starting point for developing juvenile bypass systems. Given the differences between some of the out-of-basin systems used for reference and the uncertainties about the actual collection and bypass systems that may be developed, these metrics should be revised as local data on juvenile survival are obtained in the Phase 2 studies.

Limitations, data uncertainties, and critical analytical gaps

The ISAB encourages the UCUT to develop a conceptual representation of their adaptive management process. Literature on adaptive management for large conservation programs could provide useful ideas and approaches to provide some organization to planning and actions (e.g., Fabricius and Cundill 2014).

Such a conceptual view helps provide structure for the adaptive management process that will guide many decisions that will be made in Phase 2.

The Phase 2 Plan does not describe or define the actual or operational decision-making structure that will be used in adaptive management, but the UCUT responded to questions from the ISAB. The UCUT organization includes three group processes — a Fish Committee, Senior Managers, and Commissioners. The Fish Committee is composed of technical staff from the Tribes who provide recommendations that get ratified through the higher policy level groups (Senior Managers and Commissioners). Each tribe has its own process for decision making, but joint efforts such as salmon reintroduction are coordinated through the UCUT process. The UCUT developed a process for obtaining stakeholder review and input in Phase 1. Input from stakeholders is summarized in the Phase 2 Plan, and the UCUT plan to continue a similar stakeholder process in Phase 2.

Because the number of adults returning per spawner (AR/S) is subject to many other factors beyond the control of the UCUT team or others in the basin (e.g., ocean conditions, predation, fisheries, etc.), it may not be the most sensitive parameter to be used in making high-impact decisions. In some of the decision trees for selecting preferred passage systems (e.g., Figure 13), the decision is based on whether the expected juvenile survival could increase the AR/S > 1, rather than the performance metrics (i.e., juvenile survival rate > 90%). AR/S also is used as the main decision criteria in the "population management" decision trees (Figs. 6 and 8) rather than specific passage efficiencies. It is used as a secondary criterion in some of the passage facility evaluation trees, but only to determine whether it is worth building the facility when survival is marginal, which is similar to the population management decisions (Figs. 6 and 8).

In some of the decision trees (Figure 13), an outcome for not meeting the performance metric (e.g., not achieving juvenile survival > 90%) may be “Do not build facility” or “Restart the action development process.” It is not clear what the repercussions are for this decision on the benefits of reintroduction. Does this mean that managers just accept a lower survival rate? As noted above, the adaptive management process for a long-term project like this requires such performance metrics and decision trees. Anticipatory consideration and description of alternative responses when metrics are not achieved would strengthen the planning process and adaptive management.

B. Production

Overall comments

The UCUT Phase 1 Report extensively discussed donor stock selection, available habitat, and potential production of summer/fall Chinook and sockeye. Overall, the ISAB's review of the Phase 1 Report found that the general estimates were based on scientifically sound but relatively simple concepts and information. The resulting estimates of production have wide confidence intervals and many areas of uncertainty. The survival and migration studies conducted to date will improve these estimates, but much research and analysis remain to be done. The ISAB is impressed with the obvious effort that has been devoted to this current proposal. The quality of the Plan clearly reflects both a dedication to the eventual success of a reintroduction effort, consideration of ISAB input on the Phase I report, and a desire for data-driven and hypothesis-driven research and monitoring.


Chinook on redds, Sanpoil River (photo by Tom Wainwright)

Population structure

The evaluation of donor stock analysis and risks in Phase 1 was supported by multiple lines of evidence. Moreover, the criteria considered and weighed by stakeholders and experts (described by Hardiman et al. 2017) included published technical information as well as observations and experiences from those participants, leading to a sensible list of prioritized donors. While no stock is ideal in all respects, the identification and selection of the stock of summer/fall Chinook from the Chief Joseph Hatchery was logical, given the proximity, current distribution in the region, and lack of risk to natural-origin stocks. Other stocks in the upper Columbia River region (e.g., natural-origin Okanogan River Chinook, and hatchery-origin fish from Wells and Entiat stocks) were also highly ranked. Similarly, several stocks of sockeye salmon (Lake Roosevelt native kokanee, Okanogan River sockeye, Lake Wenatchee sockeye, Penticton Hatchery sockeye) were highly ranked. The ISAB had some concerns that the kokanee, while locally adapted to the system in some ways, might tend to remain rather than migrate. Given the broader concerns regarding juvenile downstream passage, use of an anadromous stock (i.e., Okanogan) seems wise.

In the initial experimental studies, it may be expedient to test a single, abundant, highly ranked donor stock for Chinook and sockeye salmon. However, recent studies using two sockeye salmon stocks (Lake Wenatchee and Lake Osoyoos) for reintroduction in Cle Elum Lake revealed differences in movement patterns prior to spawning, spawning locations, timing, habitat use, and productivity (Matala et al. 2019). The UCUT might consider comparing multiple donor stocks for both Chinook and sockeye, at least experimentally, to determine whether they differ in important ways that would affect long-term success. Such use of multiple stocks might also be beneficial in case future availability or relative ranking of the alternative donor stocks change as a consequence of environmental conditions in freshwater or marine habitats, availability, or other considerations.

Fishery exploitation and natural mortality at sea

The present version of the LCM estimated potential equilibrium adult abundance (NEQ) of 850 to 33,000 adult summer/fall Chinook and 75,000 adult sockeye salmon (natural-origin and hatchery-origin). Sockeye production in the blocked area could be self-sustaining without long-term supplementation with hatchery fish, in part because the species is only lightly fished at present. In contrast, the high exploitation rate on Chinook seems likely to require ongoing hatchery supplementation following reintroduction to compensate for the exploitation. The high freshwater and marine harvest rates, currently estimated at 57% by the Pacific Fishery Management Council's FRAM model (Appendix H), may limit summer/fall Chinook. The proponents know this, but the proposal would benefit from greater clarity on the natural and fishery mortality rates for the two species, and the ways in which the reintroduction goals can be accomplished without affecting marine and in-river fisheries.

Climate change

The ISAB notes that effects of a changing climate may have an over-riding influence on the success of any reintroduction efforts and urges the proponents to plan for the expected effects and also to consider less obvious kinds of effects. Model uncertainties will increase as the climate becomes increasingly different from past conditions (e.g., mean and peak temperatures, magnitude and timing of snowpack and snowmelt, flow regimes) and also more variable. It would be helpful to consider explicitly the effects of such variability and uncertainty, with respect to conditions for juveniles rearing in freshwater habitats, migrations to sea, mortality there, and both *en route* and prespawning mortality of adults. These sources of mortality, exacerbated by high temperatures, are well documented within the Columbia River Basin (Bowerman et al. 2021) and elsewhere (e.g., Hinch et al. 2012; Barnett et al. 2020; Westley 2020), and may have profound effects on the success of this project and runs in the system at large. Indirect effects of climate change may also influence success as a result of climate influences on the ecology of predators, competitors, and prey in freshwater, estuarine, and marine habitats.

Homing and migration behavior

The proponents indicated that the tagged juvenile hatchery-origin sockeye and Chinook salmon will provide information on SAR and other such metrics, but there are assumptions about imprinting and homing that should be identified and tested explicitly, or information currently in hand that should be indicated. Specifically, is it assumed that they will imprint on, and return to, the place where they were released rather than the hatchery where they were incubated and reared prior to release? The fish may indeed do so, but this assumption should be stated clearly, along with rationale supporting this assumption, or any relevant results, even if preliminary. The text might also remind the reader which hatcheries are the sources of these fish, and a map showing the rearing and release locations would be helpful. Similarly, the Plan states that "hatchery summer/fall Chinook adults … will be released to the [Rufus Woods] lake each year." Is it assumed that they will find a suitable stream for spawning rather than wander the lake? Any evidence for this tendency to ascend streams to spawn would be helpful. If this is not known, it would be an important area of future research. The cultural releases also provide some useful information about post-release movements, spawning behavior, and reproductive lifespan. Specifically, ISAB members were taken to a site on the Sanpoil River where Chinook salmon were evidently actively involved in reproductive behavior, and we were told that these fish had been released some weeks or even months previously. Including this kind of information would tend to allay concerns that the fish would immediately leave a non-natal site.

1. Geographic scope, salmon production areas

The geographic scope for summer/fall Chinook salmon production areas includes Rufus Woods Lake, the Transboundary Reach, the Sanpoil River, and the Spokane River, and for sockeye salmon includes the Transboundary Reach, Christina Lake, and the Sanpoil River. These production areas follow from the Phase I report.

Strengths

The decision to focus on the production of Chinook and sockeye from a few locations in the short-run is an asset, as it will permit more thorough examination of key processes, increase statistical power to detect effects, and strengthen the overall proof of concept, relative to a more widespread, diffuse approach. The habitat quality in the Sanpoil River is high, and that site is accessible for surveys and monitoring.

Limitations, data uncertainties, and critical analytical gaps

The section on geographic scope is brief and might be improved by summarizing and explicitly referencing the information on area and habitat conditions described in greater detail in the Phase 1 Report. The ISAB considers that readers will be grateful to see the key information in the Phase 2 Plan rather than having to consult previous versions as the process for evaluating reintroduction moves forward.

One key uncertainty to be examined is whether the selected broodstocks can produce young that are sufficiently adapted to survive the sequence of life history stages and return as adults to the interim passage locations, and ultimately reproduce above the dams. As the proposal indicates, wild/naturally produced fish are preferred but are not likely to be available in the short term. Hatchery-origin fish may be less productive than those of wild origin, especially if the source has a lower proportion of natural influence (PNI). Therefore, the scoring system and ranking outcomes should be discussed in the context of data and assumptions about such effects of productivity differences.

The estimates in Table 6 and elsewhere may prove overly optimistic; there would seem to be many assumptions about juvenile downstream survival, survival at sea, and fisheries. At a minimum, the caption should make any such assumption clear, in brief. Figures 4 and 5 provide estimates of uncertainty, but what about model prediction bias? For example, there can be large regime-dependent differences in ocean survival. It would be helpful to explain what is assumed here and where it is documented.

Marine survival monitoring is now, or has been, carried out separately for other stocks in the basin. Which are most representative of the fish to be used in the reintroduction effort? Specifically, the marine distributions differ markedly among Columbia River Basin stocks, and distribution can strongly affect fishery exploitation rates (in addition to return timing). Have the assumptions been fine-tuned with this in mind, and can this too be indicated? Can marking studies (e.g., with CWT or PIT tags) be conducted on the surrogate as well as the reintroduction groups to validate any such assumption?

The proponents indicate that spawning and rearing habitat for Chinook includes 17 miles of large river habitat above Lake Rufus Woods, 230 miles in the Spokane River, and 36 miles in the Transboundary Reach. For sockeye, there are nearly 40 miles in the Sanpoil River. Models predict a large potential for production, although it is unclear how it would be distributed between natural-origin and hatchery-origin fish over short-term, then longer-term time frames. Information on the extent to which the quality of this habitat is stable would also be useful to consider. Is the habitat quality likely to be largely constant among years or degraded from some known or anticipated process? Are the proportions of suitable spawning and rearing habitat similarly stable and appropriately balanced for production? While any changes may be infrequent or small at any time, collection of field data to monitor habitat condition may help detect processes that might affect future production. In addition, information on the likely utilization by natural and hatchery origin fish will help evaluate the extent to which production goals may be realized.

The proposed studies on upstream and downstream dam passage and reach-specific survival (using acoustic tags and PIT tags) are feasible because they occur over small spatial and temporal scales and will provide quantitative estimates with estimates of error that are localized and can be incorporated into life cycle models. However, any assessments based on PIT and especially sonic or radio tags must be carefully examined for possible bias with respect to body size. If smaller fish are excluded from tagging, or experience lower survival, the interpretation of the results might be affected. Similarly, very large fish might residualize, and this possibility should be considered, especially in relation to flow regimes. Both sockeye and Chinook salmon show the capacity to remain in freshwater habitats rather than migrate to sea, and this outcome would seem counter to the outcomes envisioned by the proponents.

The Plan would benefit from a more refined map (or series of maps if a single map proves overly complicated), showing the tributaries in the blocked area mentioned in the Plan and expected to play a part in the reintroduction process. It would also be important to identify Lake Roosevelt and Rufus Woods Lake, and other key water bodies. Perhaps Figure 5-1 in the Phase 1 Report could be modified and incorporated in the Phase 2 Plan. ISAB realizes that mapmaking is complex, as different spatial scales and levels of detail are required to show all sites mentioned in the text, without the visual clutter that can accompany excessive detail. However, the only map in the Phase 2 Plan (Figure 3) could be improved in several regards. First, the myriad small, unidentified tributaries might be removed, and only larger tributaries mentioned in the document need to be shown and identified. Second, the broadest scale panel should be expanded to illustrate the Columbia River within Canada. Although this review is only for U.S. waters, depicting the Canadian portion of the watershed and major dams in Canada will help readers understand the spatial relationships and water sources that are so important, as well as components producing salmon in Canada (e.g., Osoyoos Lake system). Indeed, a series of maps would be more helpful than a single one, and the subsequent ones might show progressively finer scales, including release locations mentioned later in the Plan, such as Rufus Wood Lake and Lake Roosevelt.

Minor points of clarification

For clarity, it would be helpful to explain what is meant by "summer-fall Chinook." Given the great diversity in downstream migration behavior in the basin, it might be helpful to also consider whether the juveniles might migrate all the way to the ocean in their first year of life, rear in reservoirs on the way, or enter the following spring. Recent papers have emphasized the great variation in migratory behavior of Chinook, and the implications for overall productivity (e.g., Copeland et al. 2014; Bourret et al. 2016; Schroeder et al. 2016; Apgar et al. 2021). Connections to these studies and reviews would strengthen the proposal.

It would be very helpful to define all abbreviations on first use, and in tables so that readers not familiar with, for example, HOR and NOR, can fully understand the text and tables.

2. Summer/fall Chinook production potential

Strengths

Parentage-based tagging (PBT) is a practical method to estimate adult returns per spawner in Rufus Woods Lake, even though it will not be possible to identify stage-specific survival, nor can fishery exploitation be distinguished from mortality. Nevertheless, it also allows identification of the relative reproductive success and contribution of, for example, fish of hatchery and natural origin, different stocks, ages, and sizes. The ISAB encourages the proponents to record such attributes of the parents and offspring, as such information will guide the project based on sound science.

The Decision Flow Charts (Figure 6, 7, 8) are very helpful, as they allow readers to understand the kinds of information that will inform future interim or ultimate actions, the quantitative "cutoff points" to be used, and the logic-path for making decisions. One can debate them (e.g., how the 90% juvenile survival threshold was selected), but it helps to see them displayed in this manner.

Limitations, data uncertainties, and critical analytical gaps

General comments

Estimates of adult production are highly uncertain, and projections have wide confidence intervals. Likely adult returns/spawner (AR/S) will require experimental studies for all species. This is one of the major focuses of the initial stages of Phase 2 and will require careful design, analysis, and assessment. The definition provided for adult recruits/spawner is the ultimate performance metric. However, without knowing things like catch (marine and freshwater) and *en route* mortality, it will be difficult to understand where the limitations occur. AR/S will vary over time, and it will be important to know why. PIT tags and PBT are very powerful but cannot distinguish fishing from natural mortality at sea, and anything that can be done to address this issue will be beneficial. The coded wire tagging, in conjunction with other methodologies, could provide a more thorough understanding of factors affecting the returns of adult Chinook salmon. The ISAB encourages the proponents to consider this where possible.

As a general editorial comment, the ISAB requests that the Plan and any related documents take care to clearly define key terms and use them consistently. Specifically, with respect to productivity, "returns per spawner" is not synonymous with "recruits per spawner" and these expressions should not be used interchangeably. In fisheries science, the term "recruits" is applied to those individuals surviving natural mortality to the age and size when they "recruit to fisheries" and thus become vulnerable to be caught. In the case of Chinook salmon, this is complicated by the fact that mortality (e.g., from marine mammals) continues well past the age and size when they are also subject to retention in fisheries, in addition to discard mortality of sub-legal fish. Nevertheless, those that return to the spawning grounds reflect both natural mortality (typically, recruits per spawner) and the proportion caught. This is sometimes referred to as exploitation rate but that term should be used with respect to units of time, such as "mortality rate of 0.3 per year."

Specific comments

Genetic methods need to be tailored to the specifics of the project and population. Therefore, the methodology of parentage-based tagging of adults should be summarized in greater detail, ideally with some consideration of not only the techniques (single-pair matings, more than one male for each female, etc.) but likely sample sizes and numbers of markers with power to detect patterns of interest against the background variation in reproductive success seen in comparable parentage studies. In the UCUT Salmon Reintroduction Technical Team Memo (dated November 4, 2022) responding to the ISAB's question 13 about this issue, the UCUT responded:

> *"Parental Based Tagging (PBT) is a critical monitoring tool to estimate the adult returns per spawner. We will take a tissue sample from all adult fish transported into the blocked area, thereby establishing the potential parents. We will then sample the returning natural origin adults captured in collection facilities at the base of Chief Joseph Dam and assign them back to parents from specific release groups and brood years and calculate the adult returns per spawner.*
>
> *In the early stages of implementing salmon reintroduction, we have agreed to sample translocated adult salmon for the M-clade of IHN, which is a potential risk to native Redband Trout and is the only regulated pathogen that has not yet been detected in the blocked area. There is a policy-based risk/benefit decision regarding the pathogen testing that we anticipate will be revisited during the adaptive management process. A fish health sub-group within the Blocked Areas Anadromous Fish Working Group is currently examining and characterizing the risks IHN poses to naïve populations of O. mykiss spp, which will guide these policy discussions."*

This answer provides sufficient description at this stage. While the work for PBT may be contracted to external groups (e.g., the Hagerman Lab operated by CRITFC or other), additional description of methods and expected analytical outcomes provided by the likely contractor will be valuable.

Page 40 (first sentence) refers to “Adult salmon released to spawn.” Might it be possible to determine whether they actually spawned, or at least survived and entered a suitable stream? Otherwise, perhaps failure to locate or ascend suitable spawning areas complicates interpretation of failure to produce returning offspring. For example, the relationship between females released and redd counts would be useful.

3. Sockeye salmon production potential

Strengths

Many of the ISAB comments above, pertaining to Chinook, apply here as well.

Limitations, data uncertainties, and critical analytical gaps

The proponents noted that the “sockeye production estimates from the LCM are highly uncertain.” Which stages (e.g., fry or smolt) are considered least certain? What role might be played by predators in this system? Given the extensive research on sockeye in the interior of British Columbia in general, and the Osoyoos River system in particular, the ISAB encourages the proponents to communicate as much as possible with scientists and managers in that system, and Canada more generally.

Specific comments

The Euphotic Volume Model was described in the Phase 1 Report, but it might be helpful to define it here as well and explain the relationship between EV and sockeye salmon production. Koenings and Burkett (1987) wrote, “The algal light compensation point or euphotic zone depth (EZD) was defined as the depth to which 1% of the surface PAR [photosynthetically active radiation (400 – 800 nm)] penetrates (Schindler 1971). The EZD and lake surface area (km^2) were used to calculate the euphotic volume (EV) or the magnitude of the trophogenic zone.” Broadly speaking, a larger euphotic volume means better growing conditions for juvenile sockeye and other planktivores. Among lakes, sockeye smolt production tends to increase with EV (Lloyd et al. 1987; Koenings and Burkett 1987).

4. Total dissolved gas levels in the blocked areas

Strengths

The Phase 2 Plan evaluated total dissolved gases in the blocked area and compared the concentrations to other dams downstream of Chief Joseph Dam. High values were observed during certain seasons in other dams downstream, often associated with high discharge. The Plan indicates that total dissolved gases will be monitored, especially in Lake Roosevelt downstream of the Transboundary Reach, but the Plan argues that these issues with dissolved gases should not preclude moving forward with the reintroduction program. This is reasonable, but it highlights the importance of developing more extensive monitoring of dissolved gases with an eye toward practices or technologies to reduce TDG effects.

It is also good to see the recommendation to track upstream operations in Canada, but the ISAB suggests that this recommendation be more specific (e.g., maintain frequent contact with upstream water managers prior to and during any smolt releases).

Limitations, data uncertainties, and critical analytical gaps

How does the intent to release smolts in March and April to avoid high levels of total dissolved gas correspond to the optimal times of release for sockeye and Chinook smolts? Peven (1987) reported that sockeye smolts counted at Rock Island Dam showed a distinctly bimodal timing. The early mode smolts, in mid-April, were from the Wenatchee River, and the later mode, at the end of May, were from Osoyoos Lake. Some further consideration of the timing of sockeye and Chinook would thus be useful, as timing of release and migration affect many aspects of subsequent survival, growth, and life history.

C. Fish passage

Overall comments


Grand Coulee Dam (photo by Erik Merrill)

Generally, this chapter tackles the complex and uncertain topic of fish passage with thoughtful planning and strategy. The ISAB found two areas where further consideration and clarity may be warranted.

First, it is not always clear how the studies to determine performance metrics at interim passage facilities will inform performance of the permanent passage facilities since interim and permanent passage facilities may differ. "The results from fish passage survival studies will be used to update LCM inputs and generate expected fish production resulting from installation of each passage strategy." Is it realistic to think that the passage efficiencies at the interim passage facilities (spill and turbines for downstream, trap and haul for upstream) will represent the permanent passage facilities, which are expected to involve different infrastructure (surface collectors for downstream, unknown exactly for upstream)? If the second goal of interim fish passage is to develop prototypes, but only trap and haul will be used for upstream passage, and existing downstream routes (spillway, turbines) are used for downstream passage, how is this goal achieved? Further, the passage decision tree appears to rely on field observations. Figures 9 and 10 have surprisingly high collection efficiencies and survival rates, based on expected values from the literature. How realistic are these, and what is the impact of overestimating them on the final designs? Given that passage efficiencies are important LCM inputs and that the interim measures may not provide reasonable estimates of the trap efficiencies and passage survival for the permanent facilities, how are the trap efficiencies and passage survival metrics for the permanent facilities to be estimated? What study results are going to provide those metrics for the permanent facilities at Grand Coulee Dam and the Spokane River dams?

Second, assumptions about upstream and downstream fish passage may be overly optimistic for several reasons. First, at times the Phase 2 Plan refers to passage facilities that are not well established. This is an unfortunate result of the immaturity of the field of engineering fish passage, and in no way a criticism of the Plan. However, in relying on these facilities that are not widely demonstrated to be effective, the Plan appears to be overly optimistic at times. For example, the Plan indicates that guidance structures may be needed to increase passage survival up to the 90% performance metric. However, these guidance structures have been of limited value in several cases, and the mechanisms for their success and failure are not well established (Williams et al. 2012). The estimates will need to be revisited to ensure realistic values reflective of local conditions are used.

In some specific cases, upper bound (optimistic) values seemingly have been used. For example, the 90% performance metric for downstream juvenile passage for passage through turbines and spill do not seem to reflect the preliminary data that USGS reported on for these passage routes. These upper bounds translate into the decision trees in complex ways. For example, in Figure 12, the decision tree notes that if adult collection efficiency is below 90%, “accept decreased performance” is one of the potential outcomes. Field studies will help base some of these assumed parameters on reality, but the outcomes could substantially increase the project cost and/or create uncertainty in the outcomes of reintroduction. For example, the Plan describes the need for multiple juvenile collectors at Grand Coulee Dam. These points help justify the need for the outlined studies but also suggest that the initial LCM might not be terribly realistic and allude to remaining open questions about the outcomes of reintroduction.

Third, while the ISAB understands that this passage plan is focused on high-priority salmonids, considering the benefits and/or risks for other taxa (e.g., steelhead, Pacific lamprey, sturgeon, northern pike, other species of concern) in the design and operation is essential. Designs for passage facilities should allow for their passage if beneficial and provide options to control passage if there are risks of expanding or facilitating movement of undesirable species.

1. Phase 2 studies

Strengths

The overall approach seems generally well-described in this section, and the Plan follows a reasonable set of principles for guiding Phase 2 prioritizations. According to the UCUT’s response to ISAB questions, the marking plan for juvenile releases of summer Chinook (adipose fin present, PIT, and coded wire tag) is a system not used by other hatcheries or programs in the Columbia River downstream of the blocked area. CWT will be applied to all Chinook release groups to ensure adequate numbers of identifiable returning adults to Chief Joseph Dam for adult tracking and behavior studies. CWT will not be used on sockeye, as they are not a species that is evaluated for CWT in downstream fisheries or on the spawning grounds. PIT tags will be used for rapid non-lethal detection of hatchery-origin fish released from the blocked area, but funding may not be adequate to tag the estimated sample sizes of 160,000 Chinook and sockeye, each, in all years.

Limitations, data uncertainties, and critical analytical gaps

A number of unanswered questions and recommendations arose for the ISAB while reviewing this chapter, including:

- Given the many assumptions being tested and their importance to future decisions and the overall success of this project, the study plan should continue to evaluate if sample sizes are sufficient for reducing parameter uncertainty. In some cases, it may be warranted to get more information from tagged fish (e.g., more detectors, manual telemetry, presence/absence surveys) than putting out more tags and getting limited information about those tagged fish. While the Plan includes a power analysis suggesting that proposed sample sizes are adequate, it appears that it is a model-based analysis. Methods for the power analysis could be clarified, and sample sizes should be re-evaluated regularly via the adaptive management process by incorporating ongoing empirical results.

- The ISAB found it difficult to understand the timing and sequencing of some of the proposed studies, which led to questions about whether some studies are sufficient for their intended purpose. For example, the appendices describe single-year studies, but the work schedule in Appendix A indicates that the acoustic-tag studies will be repeated for three years during Step 1, and then in years 10, 11, 20 and 21 during Step 2, while the PIT-tag studies will be conducted on an annual basis throughout both steps. The Plan is also unclear about how much effort (numbers of tags, number of years) is allocated to the acoustic tags relative to the PIT tags. Appendices B and C describe very limited one-year JSATS pilot studies. During the tour, it was clarified that the first three years of acoustic tagging is intended to provide baseline migration-time and behavior information, while the out-year studies are intended to evaluate passage experiments (Conor Giorgi, pers. comm.). Going forward, a Gantt chart, similar to what is provided in Appendix A but specific to the cycles of the core studies, would help reduce questions and confusion about the sufficiency of the studies.

- The proposed studies to estimate reach- and dam-specific survival and movement will address key data uncertainties for the two target species and life stages (outmigrant vs. adult). On the other hand, the proposed studies will do little to address uncertainties about climate change and the effects of hydrological variables as potential drivers of survival and movement. It is not clear if existing fish monitoring programs can be leveraged to gain more information from the proposed studies over a longer time scale that reflects hydrologic variability or whether modifications to fish and/or hydrological monitoring programs will be needed.

- The Plan could be clearer on how SAR was calculated. It is not clear if SAR included harvest and if so, what types of harvest (Welch et al. 2021). Also, it would be helpful if the cumulative mortality after passing through all the reaches could be provided in Table 7. As noted elsewhere in this review, “recruits” and “returns” are different.

- A minor editorial suggestion is that the ISAB at times found it difficult to find relevant details, and future readers would benefit from more specific directions than “Detailed descriptions of initial Step 1 studies are provided in Appendices B, C, and D.”

2. Passage system analysis and ongoing RM&E

Strengths

The general approach outlined here is strong and the adaptive management of limiting factors is very reasonable, although more detail is needed to describe what both the RM&E and adaptive management and science process will involve.

Limitations, data uncertainties, and critical analytical gaps

This section is quite vague about how RM&E and adaptive management will be implemented. If the RM&E approach to be taken will follow an approach that is already documented, it would be helpful to reference that in this section. To the extent possible, the ISAB recommends that an experimental approach be considered, including the use of statistical references/controls (e.g., BACI or similar design) to establish cause and effect.

3. Development and design

Strengths

The description of the three phases of fish passage facility development is logical and well-conceived, and the schematic diagrams are very helpful.

Limitations, data uncertainties, and critical analytical gaps

- On page 55, it states that depending on available resources, a computational fluid dynamics model and physical model of the forebay and tailrace will be developed. These models would then be used to refine potential facility locations and gather further data on attraction flows and fish behaviors. Our impression is that these models would be critical to the success of these efforts. If such models do not already exist, their development should be prioritized.

- The short-term survival of >85% at Chief Joseph Dam (p. 54) is encouraging. Do data exist on the cumulative mortality effects of Chief Joseph plus other downstream dams and impoundments including, but not limited to, Grand Coulee? This information may influence decisions about the need for juvenile passage facilities.

4. Chief Joseph passage

Strengths

The decision pathways are clearly laid out in the flow chart figures. Such diagrams should be provided anywhere there is an adaptive management decision to be made.

Limitations, data uncertainties, and critical analytical gaps

- The decision flow charts have numerical criteria, but do not state the level of acceptable uncertainty in meeting those criteria. For example, a precautionary approach might require that the lower quartile of the survival rate estimate exceed the criterion before the result is considered to be adequate.

- If juvenile survival at Chief Joseph Dam is estimated to be 90% or greater, juvenile passage facilities may not be required, which is reasonable. However, will survival be evaluated over time for possible changes? If survival declines over time due to changing hydrology or other conditions, will the decision process trigger the need for a passage facility?

- Similar to the comment above, some sort of summary of survival expectations from the various potential downstream passage systems would be useful for planning passage and hatchery operations in the future. Will adult returns be sufficient, even if 90% of juveniles survive passage? Returns/smolt will vary among years and understanding reasons for this variability may be an important part of adaptively managing the system. Chinook smolts have been coded-wire tagged at Wells Hatchery. CWT data allow estimation of survival and exploitation for Chinook and could help UCUT scientists understand variability in adult returns/smolt (e.g., Chinook Technical Committee 2022).

5. Grand Coulee passage

Strengths, limitations, data uncertainties, and critical analytical gaps

Strengths (and limitations) for the passage analysis at Grand Coulee are similar to those at Chief Joseph Dam.

6. Spokane River dams

Strengths, limitations, data uncertainties, and critical analytical gaps

Strengths (and limitations) for the passage analysis at the Spokane River dams are similar to those at Chief Joseph Dam.

On page 7, the Plan states that high levels of spill may result in low juvenile passage mortality, but the validity of this assumption needs to be demonstrated, especially in light of the results on high TDG at some of the locations in the system during the fish passage season for the primary target species (July to October) and at all locations during high flow years (Appendix F). Studies of 48-hour juvenile passage mortality on the Willamette dams indicate that spill mortality can be as high as ~33% for a single spillway (Hansen et al. 2017). In addition, the Plan notes that degassing structures at Long Lake were recently installed and may increase passage mortality, but details on these structures are not adequate to understand the importance of the issue or its impact of fish mortality. The studies outlined for evaluating passage at these dams will be very important for understanding local mortality during spill events, although it is not clear how those values will relate to passage mortalities when permanent fish collection and bypass facilities are installed.

7. Production areas upstream of Lake Roosevelt

Strengths, limitations, data uncertainties, and critical analytical gaps

Survival of juvenile Chinook and sockeye migrating through Lake Roosevelt seems to be a major uncertainty, and notes about next steps and planned studies for that area are very limited in the Phase 2 Plan. Given the high cost and logistical challenges of operating a head-of-reservoir collection system, the UCUT indicates that it is a low priority compared to the studies in the lower portion of Lake Roosevelt and its tributaries. The ISAB agrees with this operational decision but confirms that this is an important uncertainty to track in Phase 2.

The ISRP reviewed 13 proposals for Lake Roosevelt during the Resident Fish Review in 2020, including three for kokanee monitoring and one for northern pike control. Thus, there are clearly efforts underway to understand and manage the fish in Lake Roosevelt, but it is not directly addressed in the Phase 2 Plan. Given the expected importance of Lake Roosevelt to the survival of anadromous Chinook and sockeye, it will be important to use available data and information on survival and sources of mortality in Lake Roosevelt, and also indicate any logistical efficiencies that these other studies might provide.

8. Implementation strategy for redband trout/steelhead

Strengths, limitations, data uncertainties, and critical analytical gaps

The Plan notes that steelhead are not considered in the feasibility evaluation due to ESA constraints, which is reasonable. The ISRP supports the approach outlined for redband trout, which proposes activities like those proposed for sockeye (e.g., transporting, tagging, genetic testing, pathogen testing, etc.) for redband trout encountered at passage facilities.

9. Study design to evaluate downstream movement and survival of juvenile summer/fall Chinook in the Upper Columbia River Basin

Strengths

It is good to see this study of juvenile Chinook movement and survival developed collaboratively among the USGS, PNNL, and the Coeur d'Alene, Colville, and Spokane Tribes. The study is designed well and should reduce uncertainties about dam passage. The UCUT and collaborators have considered several potential problems (poor survival, uncertain travel times, etc.) that could limit results. They have also provided cost estimates that appear to be reasonable. The double-tagging proposal (JSATS and PIT tags) is beneficial and should allow monitoring of both fish behavior around the dams (JSATS) and survivals below the project area (PIT). The USGS study of downstream movement and survival of juvenile Chinook above Grand Coulee Dam is an example of the UCUT's effective collaborations. Toby Kock of USGS presented a briefing to the ISAB on "A Pilot Study to Evaluate Downstream Migration Behavior and Survival in the Blocked Area of the Upper Columbia River." It provided preliminary findings and identified requirements for the future studies of juvenile Chinook movement and survival. Ongoing collaborations with USGS and other collaborators will provide additional expertise and strengthen the studies to better understand movement and survival of juvenile salmon.

Limitations, data uncertainties, and critical analytical gaps

The biggest limitation to the downstream migration and survival study is that it seems limited to a single year (though Section 2.5.1 implies it may be repeated during years 1-6). While one year can provide some initial experience, it will not provide sufficient information for decision-making regarding later work. Year-to-year variation in river conditions needs to be included. If the study is to be conducted throughout years 1-6, the budget should document start up and annual costs separately.

This study is a bit sparse on details of data management and analysis. Is it correct to assume that the analytic approach described in Appendix C will also be used here?

The expected ca. 70-day life of the JSATS tags may be a problem for some of the proposed upper release sites (cf. Toby Kock presentation to ISAB) and could bias results toward faster-migrating individuals. Alternately, tag life can be extended by reducing the ping rate from 3 seconds to 5 or 10 seconds, but that may reduce detections. Also, 750 tags total with a range of 75 to 200 releases per site is likely to make interpretation difficult if tag survival or life-span is lower than expected. The team might consider releasing more tags at fewer sites initially, then expanding release sites in later years if early results are satisfactory. In addition, any possible fish size biases related to the selection of fish for tagging and their migration and survival should be noted.

The team has given thought to problems associated with release timing and unknown travel times above Chief Joseph Dam, but this could be a substantial limitation to the pilot phase study. The team might consider adjusting their initial release distributions to provide better travel-time estimates in Year 1 so that subsequent releases can be more efficient.

The UCUT could consider developing and using surrogate juvenile Chinook in hatchery environments that exhibit morphology, behavior, and other traits more like natural-origin juveniles. Methods have been developed for surrogate Chinook that exhibit traits and performances that more closely resemble wild fish than hatchery fish in the Willamette River system (Noakes et al. 2014, Pollock 2020, Cogliati et al. 2022). This approach is being used at production scale by ODFW.

No consideration appears to be given to effects of tagging with an acoustic tag on behavior and survival (e.g., Wargo Rub et al. 2020). Can the double-tagged fish be detected by both PIT and JSATS detectors in enough places to get at JSATS tagging effects relative to PIT-only? This question applies to both sockeye and Chinook studies.

10. Study design to evaluate juvenile sockeye salmon movement and survival through Lake Roosevelt, Grand Coulee Dam, Rufus Woods Lake, and Chief Joseph Dam

Strengths

In general, the proposed studies, which are comprised of five objectives, seem feasible, the methods are justified, limitations of the acoustic telemetry are considered, and the mark-recapture methods to estimate survival have been well thought out. This appears to be a well-referenced, well-thought-out approach. The authors have done well to consider the complicated sockeye life-history patterns, especially considering the potential for both subyearling and yearling outmigrants and the issues of tag life-span. The double-tagging proposal (JSATS and PIT tags) is beneficial and should allow monitoring of both fish behavior around the dams (JSATS) and survival below the project area (PIT). It is good to see this developed collaboratively among the USGS, PNNL, and the Coeur d'Alene, Colville, and Spokane tribes.

Limitations, data uncertainties, and critical analytical gaps

- As in Section 9, it is not clear to the ISAB if this is a single-year or multi-year study.
- The research depends on obtaining adequate numbers of experimental fish from the Okanagan Alliance. Further communication to establish formal agreements should begin soon. Are there any contingency plans if fish are not available from Canada? In a related concern, the ISAB questions if the number of fish being tagged and monitored will be enough or if they should

attempt to tag more. Early results should be used to inform sample size requirements for future studies.

- No consideration is given to effects of tagging with an active acoustic tag on behavior or survival (e.g., Wargo Rub et al. 2020).
- It appears that no consideration has been given to environmental (i.e., hydrological) covariates which may serve as good indicators of climate change and which may affect survival and passage timing. Are hydrological monitoring data available, and how can they be integrated into the statistical models to evaluate their effects on survival?
- It would be useful to list other metrics, besides survival, that could be summarized in reports. For example, these could include reach- and or dam-specific transit times, passage date, passage time of day, other characteristics of run timing, and within and among individual variability.
- Limited consideration has been given to tracking fish in the Transboundary Reach, where natural production may be sizable. Since other Phase 2 studies will involve the release of Chinook salmon from the Transboundary Reach (Northport, WA), could releases of sockeye salmon be considered and would the additional information balance the extra costs?
- What proportion of young sockeye in Canada's Okanagan Lake migrate as subyearlings vs yearlings?
- Might some of the fish return to the Okanagan system in Canada?
- What is the assumed survival of tagged subyearlings to yearlings? For example, how many fry need to be tagged to result in 200-400 tagged yearlings (Table 1) (and all other release groups)?
- Would it be possible to release fish large enough to have JSAT or acoustic tags that would be able to be detected much closer to the mouth of the Columbia River?

11. Implementation plan for evaluating survival of reintroduced anadromous salmon with PIT Tags upstream of the blocked area of the Columbia River

Strengths

In general, the proposed studies seem feasible, the methods are justified, limitations of the various tracking technologies are considered, and the mark-recapture methods to estimate survival have been well thought out. Please see comments above for Section 10 which also apply here

Limitations, data uncertainties, and critical analytical gaps

The limitations of the proposed studies in Appendix D are largely the same as those described in Appendix B and C. In addition, the details and targets for PBT are vague. The ISAB reiterates concerns about other factors affecting estimates of smolt-to-adult return rates. Without knowing things like catch (marine and freshwater) and *en route* mortality, how will one understand where and why these important losses occurred? One can expect that AR/S will vary over time and it will be important to know why. Establishing causality will require someone to monitor what is happening downstream and in the ocean. Is this work planned or already underway?

12. Adult upstream passage concept for Chief Joseph and Grand Coulee Dams

Strengths, limitations, data uncertainties, and critical analytical gaps

The ISAB Review of the Phase 1 Report (ISAB 2019-3) identified several major questions about the Whoosh system and suggested critical steps:

> *"However, during the ISAB tour of facilities (August 27-28, 2019), Toby Kock (USGS) and the Whooshh representative indicated that in earlier trials the internal water misting system along the tubes failed, leading to mortalities as high as 100% in three of four trials. Therefore, more research on best approaches to employ the Whooshh Cannon (e.g., how to attract, aggregate, guide, and select fish of various sizes into multiple cannons) is needed to ensure high survival. Furthermore, both the Chief Joseph and Grand Coulee dams are high head structures, so trials should be performed that mimic the length and elevation gain needed in a Whooshh tube to get fish over these dams. In short, we do not know if the adult salmon can find the cannon entrance in a 'real life' situation, how much elevation the tubes can overcome, how well they would operate under variable and less than ideal flow conditions, and whether there will be delayed or latent effects on the salmon even though they survive the passage. Such latent effects might depend on whether the fish are released into the reservoirs directly, trucked, or transported in some other manner after the Whooshh process. Presumably, the final solution to adult passage will involve multiple means of getting adult salmon over the dams, with or without Whooshh technology."*

None of these questions from the 2019 ISAB Review are answered in the Phase 2 Plan. Do the UCUT or Whooshh Innovations have any information to address any of these questions? In 2019, the Whooshh system was set up at the base of Chief Joseph Dam. The ISAB was present at the start of its installation and had an opportunity to go down to the barge and see the general system. The tubes had not been installed yet, so we did not see the system in operation. What were the outcomes of the initial trials of the Whoosh system at Chief Joseph Dam? On the field tour, the UCUT scientists indicated that Whooshh did not submit a report on the 2019 field test of the system but said that the salmon did not enter the Whooshh barge. Noise associated with the motors on the barge might have been a possible reason.

In addition, some specifications for the Whooshh system are based on historical river flow conditions, which can influence both forebay and raceway elevations. Has any consideration has been given to future conditions that could result from changing climate, and can the design and operations provide flexibility to account for that uncertainty in any way?

The ISAB also encourages the sponsors to connect with experts within the Government of Canada or BC Government for details on the application of Whooshh at Big Bar in the Fraser River, Canada.

D. Phase 2 study support programs

Overall comments

Overall, the UCUT have given broad and extensive consideration to the support programs critical for the Phase 2 objectives and activities—such as interim trap-and-haul, pathogen testing, hatchery production facilities—that will be needed to implement the studies identified for Phase 2. The ISAB appreciates the effort put into producing these descriptions.


Long Lake Dam
(photo by Erik Merrill)

Ultimately, the ISAB as well as the UCUT recognize that the program will be adapted as efforts are undertaken and results are accumulated. However, it is critical to provide as much information as possible to permit thorough evaluation and program success.

The ISAB did not easily identify any data or analytical needs for the engineering designs and for the implementation of any new interim or permanent passage facilities (upstream ladders, floating surface collectors, downstream bypass conduits, etc.). These topics were explored and partly described during the October 2022 site visit, but firm designs and considerations will require more extensive engineering consultation. These should be included in future reports as they evolve.

The ISAB recognizes that cost projections become more uncertain the farther out into the future they extend. Some additional background, basis, and justification for cost projections is warranted for the RM&E of early stages (i.e., Step 1) of Phase 2. We encourage the UCUT to describe both funded and non-funded contributions by the Tribes and their collaborators to the reintroduction efforts to give readers a more complete understanding of the full extent of people and resources being dedicated.

1. Trap-and-haul programs

Strengths

As described in the Plan, the interim trap and haul programs are focused on returning adult summer/fall Chinook and sockeye collected at the base of the Chief Joseph Dam. Transport will then deliver adults in prescribed number and species to desired release locations for each RM&E (P2IP) objective. Ultimately, the implementation of trap-and-haul for passage of both juvenile and adult salmon is logical and likely has fewer initial uncertainties associated with its expected performance than other passage options due to its record of use in the basin. The ISAB witnessed adult Chinook on spawning grounds in the Spokane River and the Sanpoil River and is encouraged by the evidence of spawning activities by salmon from cultural release programs which used trap-and-haul. It is our understanding that these programs will continue (see Section C – Passage, for specific comments), and any qualitative or quantitative data that can be documented from these programs could prove useful in the adaptive management process.

Limitations, data uncertainties, and critical analytical gaps

The description of the trap-and-haul system and methodology is very brief and largely represented by Figures 9, 10, 11, and 14. A more detailed description of, and some additional basis for, the most probable system design and locations of facilities is warranted prior to implementation. This request includes any novel engineering design specifications not already in use in the basin. In addition, the Plan could summarize known survival rates for juvenile and adult trap-and-haul operations based on reports and publications from the upper Columbia River and Snake River to support and frame this interim approach. Moreover, the ISAB also recommends the UCUT examine a comparison of return success from volitional vs. directed release sites for both hatchery and natural production as a secondary step in future out years before the program is fully operational.

2. Pathogen testing

Strengths

From the beginning of their efforts to reintroduce salmon into the blocked area, the UCUT have recognized the fundamental need to address disease and pathogens concerns, especially containment. The need for screening for disease and pathogens during both production and in the wild has been amplified by the absence of anadromous salmonids over the past 80 years. If native runs had been maintained since blockage, the concerns about susceptibility to pathogens and disease—especially IHNV for steelhead—might not be as critical as host-pathogen relationships would have been ongoing. Ultimately, pathogen testing in the hatchery and for returning adults will follow WDFW requirements as identified in the Section 5 on Regulation and Policy.

A lengthy discussion surrounding pathogens and diseases was a significant part of the Phase I report and ISAB review. The details for this were referenced in Table B2 from Hardiman et al (2017). The ISAB review of the Phase 1 Report discusses the consideration of disease more thoroughly on pages 20-22 (ISAB 2019-3). The ISAB concluded that:

> "*For the most part, the review of disease risk in the Reintroduction Report was thorough and based on regional experience and expertise with major fish pathogens, but it was brief, and the reader was primarily referred to Hardiman et al. (2017). Consequently, documents such as Hardiman et al. (2017) and the expertise of contributors should be included as appendices in future documents*."

Limitations, data uncertainties, and critical analytical gaps

In the current review, the ISAB identifies a couple of additional considerations for the UCUT. First, in describing the studies of transplanted natural-origin adults upstream of Grand Coulee Dam, quarantine methods (especially, location and duration) are not described in Appendix D. Second, in the review of the Phase 1 Report, the ISAB recommended development of a parentage-based tagging (PBT) program for all adults released above the blocked area to potentially identify whether a pool of donors carried any inherently significant disease resistance. The Phase 2 Plan incorporated PBT as part of the adult reintroduction studies, but it does not describe how assessment of relative disease resistance will be examined. PBT does not directly assess disease resistance parts of the genome, thus the design of such a program would need to include separate measures of the disease resistance of the offspring or parents to measure it. Understanding that such approaches and expertise may not be available in-house at present, the ISAB recommends consultation with outside PBT and epidemiological experts for design of studies to use the PBT measurements to better understand parental effects on disease resistance. Such experts may be available at USFWS Technology centers, the Hagerman Lab, WDFW labs, or academic institutions.

3. Interim hatchery production

Strengths

The interim hatchery production section aims to acquire regulatory approvals (as identified in Section 5), to produce experimental RM&E fish (summer/fall Chinook and sockeye) for research objectives, and ultimately to determine the scale and scope of Phase 3 production and releases. Although not expressly stated as such, this section is aimed at establishing a robust proof-of-concept for full Phase 3 implementation. The UCUT will examine three possible approaches: current land-based facilities; new net pet production; and permanent new facilities.

During Phase 2, the approach to utilize and re-direct production capacity at existing hatchery facilities and infrastructure in the interim or short term is logical based on logistics, efficiency, timing, and cost. The Douglas Public Utility District has agreed to provide space in the Wells Fish Hatchery. This should be included in the Plan when the collaboration is confirmed, and the details should be documented (e.g., numbers of fish, duration of agreement, facilities rent or operations costs).

Limitations, data uncertainties, and critical analytical gaps

Depending on scale and scope, it is uncertain whether any (or all) of the three approaches (current land-based, net pen, new facilities) require a formal Three-Step Master Plan, either new or amended. The UCUT should explore this issue, as well as any new or amended Hatchery Genetics and Management Plan (HGMP) for hatchery production. If a current program is "re-aligned" to direct its current production to this project's objectives, there are expected consequences to the programs currently relying on the fish. A short description of this consideration is warranted. During the site visit, the UCUT staff indicated they have been in communication with NOAA Fisheries about any HGMP issues. A short summary confirming what is or is not required warrants documentation.

The details (space, water, capacity, duration, etc.) of the Douglass PUD/Wells Fish Hatchery provision—mentioned in the "Strengths" above—is important to document via a MOU or other appropriate means, as well as for any other potential interim facilities considered to avoid unexpected interruption of fish availability for RM&E purposes.

E. Cost analysis

Phase 2 program costs

Strengths

While there are substantial uncertainties in projecting future cost estimates, such uncertainties are inherent in a long-term, sequential program for reintroducing salmon into the blocked area above Chief Joseph and Grand Coulee dams. The processes that led to these dams and barriers to native fish have created complex physical, ecological, institutional, and cultural challenges that make accurate cost projections of a phased solution difficult. The Phase 2 Plan provides a general estimate of the potential cost of the projected 21-yr effort. Equally important for cost projections would be a near-term cost estimate for the baseline studies for Step 1 in Years 1-6. The ISAB encourages the UCUT to develop a much more specific cost analysis for Step 1 as soon as is feasible.

Studies will be prioritized on their ability to gather the most critical data and conduct analyses of those data at the lowest cost. Lower cost fish passage alternatives are preferred when fish benefits are similar. The description of cost analysis and evaluation of cost effectiveness is extremely brief at this point. A more detailed and rigorous description of costs and how the UCUT plan to make financial decisions will be needed early in Phase 2.

The Phase 2 Plan indicates that it developed cost estimates for passage systems based on an NPCC literature review (2016) and a 2002 study of passage costs for Chief Joseph Dam (USACE 2002). Admittedly, it is difficult to develop accurate cost estimates in the initial years of Phase 2 because the actual structure and passage systems will be determined based on the initial studies of juvenile and adult movement and behavior.

Limitations, data uncertainties, and critical analytical gaps

The ISAB encourages the UCUT to update a more specific budget for Step 1 when feasible. As mentioned above, the unknown outcomes of studies, evolution of studies, and the ultimate designs for hatchery and passage facilities make the cost analysis highly uncertain. In their response to questions from the ISAB, the UCUT provided a specific budget for the 6-yr Step 1 and highlighted that supply issues and inflation make development of specific cost estimates challenging. Additionally, the lack of reliable and consistent availability of a rearing facility makes short-term costs for the Phase 2 studies highly uncertain from year to year. The ISAB recognizes these challenges and encourages the UCUT to maintain and update their cost estimates for Step 1 of the Phase 2 Plan annually and make these challenges clear to regional decision makers in future documentation of the Plan.

Estimates for RM&E (based on 2022 values) are given for five steps in Phase 2. What are components of these estimates? The UCUT had to make assumptions based on current RM&E costs and projected levels of effort in each of the steps. These details should at least be provided in an appendix.

New infrastructure and potential retrofit costs associated with rearing facilities, net pens, and acclimation facilities are provided, but there is no explanation of the source or basis for the estimates or the details of each of the interim hatchery components. Which specific costs from the NPCC literature review (2016) and a 2002 study of passage costs for Chief Joseph Dam (USACE 2002) were used? Some costs are adjusted to a 2020 cost basis while others use 2022 as the basis for cost estimates. Why is there a difference? Given that most of these expenses will not occur immediately, why are the cost estimates not based on a projected implementation schedule? Admittedly, such a schedule would be uncertain, but there is even more uncertainty when basing costs on a pre-Phase 2 date.

Given the age of the data sources and recent trends in inflation and cost and availability of materials, the uncertainty for such costs is high. The UCUT could provide upper and lower bounds for their estimates based on explicit assumptions and cost-related factors. Recent inflation and market trends will mean that projected costs will be substantially higher than the estimates in the Phase 2 Plan.

How did the UCUT determine the 30% factor used in the estimates for the interim and permanent systems? Estimates of the cost range of permanent juvenile fish passage at Chief Joseph Dam and Grand Coulee Dam ($41 to $77 million) are assumed to be the median cost estimate (+/- 30%) of the costs of other surface collector systems in the region (Table 17). The UCUT also assume that costs for an interim juvenile passage facility ($12.3 – $23.1 million per collector) will not exceed 30% of the range for a full-scale surface collector (Table 17). What is the source for the 3% estimate for Operations and Maintenance (O&M) capital costs associated with upstream and downstream interim passage?

Combined Phase 2 cost estimates

Strengths, limitations, data uncertainties, and critical analytical gaps

Fundamentally, the combined cost estimates are sums of the costs described for each of the Phase 2 steps and components (Table 20).

The RM&E costs are taken directly from Table 14. Costs for hatchery facilities, interim and permanent passage facilities, and O&M are lumped into a single estimate for Infrastructure and Operations even though ranges of costs are reported for fish passage facilities. Were maximum costs in Tables 18 and 19 used to project combined costs? We cannot determine how the combined costs for this column in Table 20 are calculated. Additional explanation is needed.

The combined costs in Table 20 are reported as 2022 values, but the costs for RM&E are based on 2022 values and the costs for hatchery facilities and passage facilities are based on 2020 values. Are the values adjusted to a common date? If not, they should be adjusted. Also, it would be more informative to base the combined costs for the sequence of steps on a projected implementation schedule, as discussed above.

F. Policy and regulatory considerations

1. Overall comments on Section 5

Strengths

Overall, the section (and supporting materials provided in Appendix G) comprehensively identifies the various numerous pathways the project must address as the Phase 2 (and subsequent phases) progresses. Those identified include policy and regulatory requirements at the US Federal level; State of Washington; County; Mid-Columbia PUD; Tribal; and "other."

As described the section represents a necessary intent to complete each step by the Technical and Policy Teams. The Phase 2 Plan lists several previous efforts at re-establishing salmonids in vacated habitats which can serve as a general roadmap for the implementation of proposed reintroduction by other groups and agencies. The UCUT recognize that policy and regulatory considerations are major tasks and will develop two teams, one for policy issues and another for technical issues. They indicate that the Upper Columbia Blocked Area Anadromous Fish Working Group (Upper Columbia BAAFWG) was formed in 2021-2022 and might fulfill the role of the policy and technical teams. While the UCUT have likely considered which approvals are required immediately versus longer term, documenting these as a roadmap might help avoid unnecessary or last-minute delays.

Limitations, data uncertainties, and critical analytical gaps

The proposed dates for completing these requirements need to be added to this section. While not a specific scientific set of issues, our experiences working with many agencies indicate that often the review and permitting processes take longer than imagined. Moreover, in some instances approval or permitting by one agency is predicated on the approval of another. Therefore, the ISAB recommends including a table that addresses the sequence of permissions needed. For example:

Agency/Entity	Expected Timeframe	Nature of Permission, Approval, or Collaboration (e.g., consultation, permit, MOU, Letter of Support, etc.).	Notes:
e.g., NOAA; USFWS	e.g., COMPLETED	e.g., ESA Section 7	e.g., no listed ESUs are targeted, no non-target listed species to be jeopardized… p. 82 indicates consultations have been completed
e.g., WDFW	e.g., 1 year	e.g., Fish Health permit	e.g., certifications will occur annually on an ongoing basis
e.g., Canada First Nation	e.g., 6 months	e.g., Letter of Support? MOU? Other?	

The proposal states "Regulatory agencies ... have already been consulted on these existing programs and evaluated their effects to ESA-listed extant populations." The ISAB is unclear whether this was a formal consultation or if a modified one is required.

While the Phase 2 Plan indicates that this project will be of interest to Canada First Nations, there may be other binational consultations that are warranted. For example, the U.S. State Department through the International Joint Commission (IJC) has a process for examining transboundary water quality and quantity impacts. Moreover, if this project in any way impacts the US-Canada Salmon Treaty, this needs to be addressed—even if it is simply stated that the Treaty does not apply (if that is the case). The Columbia River Treaty is currently under negotiation with expected resolution in the next few years. Once ratified, this treaty's requirements, if changed significantly, might influence this proposal and subsequent phases. Finally, there are both national and local NGOs that likely support the project's goals and could provide or leverage additional in-kind contributions to the project. If these latter have been identified, these might be included in the recommended table as "Collaboration." Ultimately, these suggestions are identified to avoid any unanticipated delays.

2. Obtaining juvenile salmon for RM&E

Part of existing programs

Strengths

The Plan indicates that the scale of experimental releases for the four experimental objectives can be met potentially through four options: 1) existing production programs, 2) within the +10% of existing program production goals, 3) surplus juveniles from existing programs, or 4) new production. Specifics regarding the ranges of releases for summer/fall Chinook and sockeye are outlined in Appendices B-D and appear appropriate as a first step to detection of PIT-tagged migrating juveniles and recapture of adults estimating adult survival. Based on actual observed juvenile detections and adult survival estimates, these numbers may need to be adjusted to meet program objectives regarding parameter uncertainty after data from early field studies permit a robust power analysis.

As described above in Section B - Production, the hatchery sources were prioritized based on the risk and donor stock assessment from Phase 1 (Hardiman et al. 2017). In their response to questions from the ISAB, the UCUT agreed that, ideally, they would have used the highest priority donor stocks in quantities that meet or exceed the needs of implementing the studies and reintroduction efforts. They point out that policy limitations and regulatory hurdles have the strongest influence on availability of donor sources and where rearing of juveniles can occur. Out of necessity in the short term, they focus on lower priority stocks and alternative rearing facilities until policy issues and limitations can be resolved.

Limitations, data uncertainties, and critical analytical gaps

Beyond the risk and donor stock assessment, it would be useful for the UCUT to include a brief description of the regulatory attributes and limitations of the major production programs that are available. For example, they have been clear in the Phase 1 Report and Phase 2 Plan that the Chief Joseph Hatchery currently cannot be used to produce fish to be released in the blocked area under current BPA contract conditions. The UCUT are working with the Federal Action Agencies to find a solution because the Chief Joseph Hatchery is logistically most appropriate. A more comprehensive description of the characteristics of all likely and potential production programs would be useful documentation for the long-term record and to guide decisions and trade-offs as they explore options.

Within +10% of existing programs' production goals

Strengths, limitations, data uncertainties, and critical analytical gaps

This option has advantages because the production has been permitted and is covered by an existing Hatchery Genetics and Management Plan (HGMP). Given the earlier ISAB comment on prioritizing hatchery sources (and the criteria for these priorities), it is unclear whether the surplus production will be restricted to a prioritized facility. This 10% over-production and surplus juveniles from existing programs may require addition clarification as to how these differ and play-out in practice, especially if any contractual limitations on use of current hatchery sources continues.

Surplus juveniles from existing programs

Strengths, limitations, data uncertainties, and critical analytical gaps

This option has advantages because the production has been permitted and is covered by an existing Hatchery Genetics and Management Plan (HGMP). Here again, providing the prioritization of the hatchery sources will inform whether this is a preferred option. A clear concern would arise if such a surplus were not to be produced or available, creating trade-offs with current programs.

New production

Strengths, limitations, data uncertainties, and critical analytical gaps

This section describes a contingency plan of accessing brood for the experimental program in the case where current production or brood are insufficient for producing needed juveniles. As this contingency may not be needed, no consultation has been conducted at this time. Ultimately, this option may become more relevant in the long-term. While the UCUT should develop a potential plan for creating a new production facility, it will not be a viable option for the first 10-15 years of Phase 2. As a contingency, the potential need for new production should be included in the adaptive management process.

Phase 2 release and marking strategies

Strengths, limitations, data uncertainties, and critical analytical gaps

Table 21 is helpful and the proposed possible PBT can contribute, but it is unclear whether it will be conducted as a study objective. How would they decide who will perform this, and what is design?

3. Population management

Strengths

Unmarked summer/fall Chinook return to the Chief Joseph Dam tailrace will be identified as natural-origin fish destined for Wenatchee, Methow, and Okanogan Rivers. Once natural production is achieved above Chief Joseph Dam, these returns may congregate with the fish destined for these other rivers. The UCUT proponent suggests that the PBT may be useful to discriminate among the sources. In practice, however, the entire mixed group may be treated as a single population depending on the underlying architecture of population genetic variation among the groups.

The Phase 2 Plan demonstrates that the UCUT are well aware of the potential impacts of natural-origin adult summer/fall Chinook from the blocked area on downstream populations. Presumably, analogous impacts to downstream sockeye applies as well, although this does not appear included. This should be confirmed or clarified.

Limitations, data uncertainties, and critical analytical gaps

Some additional description of “acceptable limits” is warranted. The Phase 2 Plan indicates that managers will need to decide or define what these loss limits are. The Phase 2 Plan does not indicate which “fishery managers” will determine an acceptable demographic loss of natural-origin adults. Are these the fishery managers involved in the U.S. v. Oregon framework or some other? Moreover, including some basic criteria (e.g., demographic, genetic, physiological, life history, or other) is worth some brief description. Finally, is there a justification for the decision to treat the fish passed over Chief Joseph Dam as a single population of common source and genetic architecture? It may prove to be a practical matter at the beginning but may change if/when populations become established. This should be included as an element of the adaptive management process.

G. Phase 3 decision-making

Strengths

This section provides a lengthy and broad list of factors to be considered, and briefly outlines a desire for collaborative decision making. While the specific details are yet to be provided in this Plan, this should be viewed in the time scale that the decision point (Phase 3) may be as many as 20 years away. Phase 3 will include full scale reintroduction of Chinook and sockeye into the blocked area, but Phase 2 will require almost three decades. The ISAB recognizes this section is effectively a placeholder and bullets of likely factors that will be part of Phase 3. The Phase 2 Plan indicates the alternatives would be evaluated based on the following factors:

- Ability to achieve conservation, harvest, and cultural goals for each species
- Construction and O&M costs of fish passage and hatchery facilities
- Effects on extant salmonid populations, including ESA-listed salmonid populations downstream of Chief Joseph Dam
- Effects on established marine and freshwater salmon fisheries
- Effects on dam operations
- Effects on hatchery operations
- Impacts to resident species and fisheries upstream of the dams

Other factors may emerge through the implementation of Phase 2 and should be added as appropriate.

The development and review of these alternatives will be performed in collaboration with stakeholders and presented to policy and decision-makers for a determination of a reintroduction program supported by permanent passage and production facilities.

Limitations, data uncertainties, and critical analytical gaps

The ISAB notes that Sections 2.12 and 6 are repetitive. This may be by design, but it is unclear why the redundancy is needed. The Plan should include a discussion of how the Adaptive Management relates to the incremental decision-making and adjustments throughout Phase 2 and ultimately how it will be revised and continued in Phase 3. The latter will take form after the initial portion of Phase 2 is underway and yielding results. Annual reporting should include how these factors are being considered.

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