ISAB INDEPENDENT SCIENTIFIC ADVISORY BOARD

FOR THE NORTHWEST POWER AND CONSERVATION COUNCIL, COLUMBIA RIVER BASIN INDIAN TRIBES, AND NATIONAL MARINE FISHERIES SERVICE

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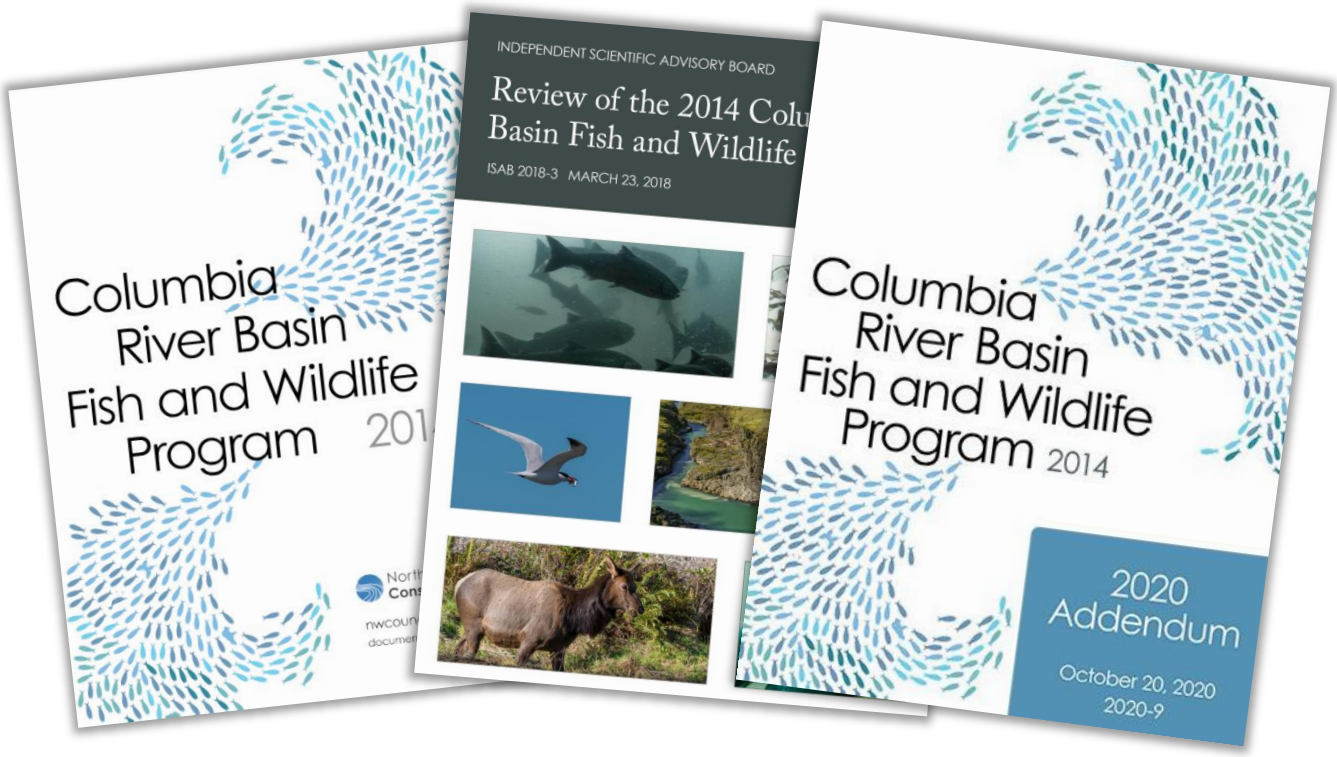
ISAB 2024 REVIEW OF THE COLUMBIA RIVER BASIN FISH AND WILDLIFE PROGRAM

Update of ISAB 2018 Report Findings on Review of 2014 Program and New Comments on 2020 Addendums



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ISAB 2024 REVIEW OF THE COLUMBIA RIVER BASIN FISH AND WILDLIFE PROGRAM

Update of ISAB 2018 Report Findings on Review of 2014 Program and New Comments on 2020 Addendums

EXECUTIVE SUMMARY

The Independent Scientific Advisory Board (ISAB) has a basic responsibility to evaluate the Columbia River Basin Fish and Wildlife Program (Program) of the Northwest Power and Conservation Council (Council) on its scientific merits in time to inform amendments to the Program. The Council's Fish and Wildlife Program now consists of the 2014 Program, 2020 Addendum, and subbasin management plans. This review focuses on the 2014 Program and its 2020 Addendum. The ISAB reviewed the 2014 Program in 2018 and shared its scientific findings with the region to help inform development of recommendations to amend the 2014 Program. The Council's amendment process for the 2014 Program began in 2018 and was completed with adoption of the 2020 Addendum. For the amendment process, rather than revising the entire 2014 Program, the Council decided to 1) focus on further defining goals and objectives for the Program, 2) develop indicators to measure Program performance, and 3) establish near-term implementation priorities. These additions to the 2014 Program were documented in the 2020 Addendum. Because the 2014 Program remains in place, recommendations in the ISAB's 2018 review still provide valuable guidance for future revision of parts of the Program that were not addressed in the 2020 Addendum. This ISAB report highlights and updates findings from the 2018 review of the 2014 Program that continue to be relevant and examines scientific progress in the 2020 Addendum.

After 40 years of implementation, the Program has guided significant improvements to fish passage, habitat protection and restoration, hatchery operations, and supporting research, monitoring, and evaluation. At the same time, the Basin is challenged by declining native fish populations, threats to biodiversity, and ongoing ecosystem degradation. The Program's scientific framework, goals and objectives are critical to guiding the Program's actions and evaluating their performance to improve fish and wildlife populations and their habitats, and meet mitigation responsibilities. We highlight the following important accomplishments and major recommendations for improvement to further guide Program actions and gauge their effectiveness.

Important Accomplishments

- Development of more quantitative Program Objectives.
- Strategy Performance Indicators that will track progress continuously for selected key metrics on the Council's online Program Tracker.

- Progress of the Upper Columbia United Tribes and support by the Council and BPA to develop plans to reintroduce anadromous fish above Grand Coulee and Chief Joseph dams.

Major Recommendations for Improvement

- Develop a standard analytical process and annually report the total run size of salmon and steelhead to track progress toward the goal of 5 million salmon and steelhead by 2025.

- Establish Strategy Performance Indicators to be tracked for each salmon and steelhead stock for the major subbasins.

- Establish a process to identify the multiple M&E activities within geographic areas, describe what is being monitored, and how the monitoring is being evaluated and reported.

- Assess how climate-related changes in temperature and flow variability could affect natural production, habitat conditions, and likely ranges of species, which could reduce the effectiveness of Program measures and investments. Develop anticipatory approaches to evaluate options for adaptation to climate change.

- Design an eDNA monitoring program for the Columbia River Basin and develop performance indicators based on the resulting monitoring information.

The 2018 ISAB Review of the Fish and Wildlife Program found many strengths in the Program — mainstem passage research, Protected Areas, reestablishing anadromous fish in the blocked areas, life cycle models, and public engagement. The 2020 Addendum focused primarily on improving the Program's Goals and Objectives, therefore many of the ISAB's recommendations for other sections of the 2014 Fish and Wildlife Program remain relevant and important to address. In this review of the 2020 Addendum and 2014 Program, we also note several additions that strengthen the scientific basis of the Program, the most important of which are more quantitative Program Objectives and new Strategy Performance Indicators that will track progress continuously for selected key metrics. Several Program objectives relate to contributing to achieving various abundance and distribution targets. Tracking these targets is hampered by data availability and funding for monitoring, thus new cost-effective methods, such as eDNA, and collaborations with other sources of data and information will be important additions to the Program.

Program-wide Strategies

Adaptive Management. The Fish and Wildlife Program has made progress in including adaptive management processes for individual projects, and the 2018 ISAB Review recommended additional improvements to guide adaptive management. We continue to encourage the Council to explicitly describe the Program-wide adaptive management process. The Strategy Performance Indicators (hereafter, for brevity, also referred to as "Indicators") in the 2020 Addendum enable the Council to assess progress through quantitative, trackable measures of intended outcomes more frequently and efficiently. We encourage the Council to develop an explicit process and timetable for Indicator summaries to better support future Program updates.

The ISAB continues to recommend synthesis reports for long-term projects and programs. Rigorous adaptive management of projects that span 20 years or more requires integration and cumulative evaluation as a cost-effective means to evaluate progress toward Program goals.

The ISRP and ISAB have highlighted the importance of recognizing and using different cultural perspectives and processes to inform and conduct science-based restoration and adaptive management. This is a matter of both scientific rigor and social justice. The ISAB encourages the Council to further include Indigenous cultural perspectives, adaptive management processes, and ecological knowledge alongside current scientific approaches benefit fish and wildlife and meet the Program's mitigation goals.

Vision. The 2018 ISAB Review recommended changes in the Vision statements to strengthen them scientifically. These were not revised and we make suggestions to improve the statements.

Scientific Principles. When the Council updates the 2014 Program and 2020 Addendum, the ISAB recommends that the Council revise the scientific principles of the Program based on the recommendations in the ISAB's 2018 review and additional suggestions from this ISAB review.

Goals and Objectives. The 2020 Addendum improved several Program Objectives by making them more specific and quantitative. A major improvement in the Addendum is the development of Strategy Performance Indicators, many of which are quantitative and can be tracked to evaluate the performance of strategies. The Indicators also provide flexibility, as the Council can modify them based on available or new information without requiring an amendment process. The Strategy Performance Indicators are being added to the

Council's online Program Tracker, which provides public access and transparency and allows for feedback and ongoing improvement.

One of the major concerns the ISAB expressed in the 2018 Review was the Program goal of "increasing total adult salmon and steelhead runs to an average of 5 million annually by 2025 in a manner that emphasizes the populations that originate above Bonneville Dam and supports tribal and non-tribal harvest." The ISAB recommends several actions to clarify and strengthen the Program's mitigation goal for salmon and steelhead abundance and its use to guide future actions:

Estimates of historical abundance. The Program should report the major changes in estimates of historical abundances and relate these to the abundance estimates of the Columbia Basin Partnership Task Force. Four major assessments since the start of the Program estimated maximum abundances of approximately 9 million returning adult salmon and steelhead in contrast to the Council's 1987 estimated range of 10 to 16 million fish.

Date for the abundance goal. The Program should develop a context for the abundance goal representing potential trajectories that are a) based on recent data and life-cycle models, and b) bounded by plausible scenarios with explicit assumptions of major limiting factors. These trajectories would identify possible near-term and long-term performance metrics to provide a context for short-term trends in Program performance and potential management responses.

Origin of Fish. The 2020 Addendum developed a Biological Objective to contribute to the Columbia Basin Partnership's targets for abundance of natural-origin salmon and steelhead stocks for major subbasins. The ISAB recommends the Council develop an explicit strategy that emphasizes protection of natural-origin fish while also meeting overall abundance goals to mitigate losses related to the hydrosystem.

Stocks and Subbasins. Goals or targets for salmon and steelhead abundance would be more useful if they were based on productivity, biological capacity of the habitat, genetic and life-history diversity, and density-dependent relationships for specific subbasins. While the Council may not have sufficient information to develop quantitative goals for each stock and subbasin, the ISAB recommends that the Council establish Strategy Performance Indicators to be tracked for each stock and subbasin.

Reporting Trends in Salmon and Steelhead Abundance. Total run sizes should be reported annually to consistently inform the Tribes, public, and management agencies in the Columbia River Basin. Council staff are currently developing a standard analytical process

to annually report the total abundance of salmon and steelhead, including returning fish and ocean and in-river harvest.

Additional Objectives. Further analysis of populations of salmon and steelhead using existing life history models could be used to refine the Columbia Basin Partnership targets and develop more scientifically sound abundance goals for the Fish and Wildlife Program. Ultimately, the causes and consequences for failing to meet the targets warrant scrutiny to guide effective mitigation actions.

The Program would be strengthened by explaining the context for its goals and objectives. Many goals are expressed as numerical targets, but without any context as to how much more might be needed for a recovery response. Such contexts also can identify successes and actions that lead to substantial gains in habitat, fish abundance, or survival.

Several of the Program's objectives are rudimentary or non-existent. Major program components that lack objectives cannot be evaluated rigorously for effectiveness. The ISAB recommends continued development of quantitative objectives and Strategy Performance Indicators.

Research. The 2018 ISAB Review endorsed the recommendations of the ISAB and ISRP's Critical Uncertainties Report. The Program would benefit from a periodic examination to identify uncertainties that can be confidently removed from the list and emerging uncertainties that need to be added as the state of the science changes and new gaps are identified.

Monitoring and Evaluation. The 2018 ISAB Review noted that key Program strategies and measures lack monitoring and evaluation plans and adequate funding. The Program still lacks an approach or process for expanding results from specific areas to the full Columbia River Basin. The Columbia River Basin Tributary Habitat Research, Monitoring, and Evaluation Strategy describes the major components of RM&E, but it does not create a comprehensive approach for monitoring and evaluation at the Basin scale as identified in the 2018 ISAB Review.

In a recent categorical review, the ISRP called for summaries of the collective monitoring and evaluation for major subbasins. The Council and staff concluded that the need to identify the collective M&E activities of projects is a much larger task for the Fish and Wildlife Program than was possible during the review. The ISAB recommends that the Program establish a process to identify the multiple M&E activities within geographic areas and clearly describe collectively what is being monitored, how it is being evaluated, and how it is being reported.

Specific Strategies

Ecosystem Function. The 2018 ISAB Review identified several areas for improvement in the Ecosystem Function strategy, but they were not addressed in the 2020 Addendum and should be considered in future Program revision. The ISAB emphasizes that the Ecosystem Function strategy should focus on the entire Columbia River ecosystem, rather than focusing only on habitat in the tributaries.

Habitat. The Program does not mention a landscape perspective for the Habitat Strategy. The 2020 Addendum simplified the indicators for habitat but did not include several of the suggested measures, especially inclusion of a landscape context. The habitat strategy indicators in the Addendum are measures of the quantity of habitat-related actions, and few if any are measures of habitat quality. The ISAB also recommends that the Council develop strategic approaches for prioritizing protection of high-quality habitats as well as restoration of degraded habitats.

Strongholds. The 2018 ISAB Review commended the Program for the Strongholds Strategy and made several recommendations to encourage multiple strongholds, promote strongholds that are sufficiently large, and improve functional connectivity. These recommendations remain relevant and should be incorporated into future updates of the Program.

Non-Native and Invasive Species. The 2018 ISAB Review found that the Program provided generally sound guidance on non-native and invasive species, but the ISAB recommended greater specificity. The strategy was not addressed in the 2020 Addendum, and the ISAB continues to support the recommendations of the 2018 ISAB Review. In particular, we strongly recommend explicit recognition of the importance of efforts to prevent new introductions and expansion of previously introduced species, as well as the need for coordination and communication with co-managers and the public.

Ongoing sentinel monitoring is critical to quickly detect non-native species, document their spread, and identify risks to critical populations. New eDNA methods provide a more cost-effective approach for monitoring non-native organisms at the basin scale than previous survey methods did. The ISAB recommends that the Program design an initial eDNA monitoring program for the Columbia River Basin and develop Strategy Performance Indicators based on the resulting monitoring information.

Predator Management. The 2018 ISAB Review found that the general measures in the Predation Management section of the Program are for the most part scientifically sound. The 2018 ISAB Review identified several gaps and suggested improvements but few of

them were addressed in the Addendum. The Council should consider the recommendations of the 2018 ISAB Review in future updates.

The ISAB advised that the Program should carefully assess the rationale for potential northern pikeminnow removals in mainstem Columbia River. Control measures might be warranted at locations where the hydrosystem creates artificial conditions that allow predators to have greater impacts on migrating juveniles, but control of native fish throughout the entire mainstem may not be supported by a more comprehensive analysis.

Water Quality. The 2018 ISAB Review recommended increased actions to improve water quality. The 2020 Addendum did not modify the strategy but it included three Strategy Performance Indicators related to temperature and one related to total dissolved gases. An area of progress since the ISAB's 2018 Review has been actions and federal investments as part of the Columbia River Restoration Act. Opportunities for the Fish and Wildlife Program and programs of the Columbia River Restoration Act to share efforts to reduce toxic chemicals could amplify habitat benefits for salmon, steelhead, and other aquatic organisms.

Climate Change. Climate change is a major challenge for fish and wildlife resources in the Columbia River Basin and a critical strategy gap in the Fish and Wildlife Program. The 2018 ISAB Review recommended several improvements and new Program-wide actions. These recommendations were not addressed in the Addendum, even though the first major Ecological Objective calls for the Program to address climate change. The lack of specific direction, actions, and Strategy Performance Indicators for climate change is one of the most critical gaps in the Fish and Wildlife Program that will influence its future success.

The Climate Change Strategy has no specific indicators but refers to indicators related to other strategies. Program planning, strategy, and actions can benefit from robust forecasting of climate, ocean, and in-river conditions and from selecting mitigation alternatives that contribute to habitat and population resilience under those forecasted conditions. Many projects in the Program recognize that climate change could affect the project outcomes but have not assessed risks or adjusted restoration efforts to adapt to climate change. Anticipatory approaches to evaluate options for adaptation are essential in scientifically sound restoration and hydrosystem management. Notably, the ISRP commended the US Fish and Wildlife Service, Lower Snake River Compensation Plan (LSRCP), for their climate vulnerability analysis.

The Program should consider how climate change might affect future water release and withdrawal strategies for the hydrosystem and influence salmon and steelhead survival throughout their life-cycles. The Program should assess how changes in temperature and

flow variability could affect natural production, habitat conditions, and likely ranges of species.

The frequency of warm years and the corresponding environmental conditions are expected to increase in the future. The survival of salmon may thus decrease more than recent averages illustrate. The collective ongoing poor survival of Columbia River salmon and steelhead warrants a comprehensive assessment of the long-term consequences of these trends and consideration of likely scenarios of climate change.

Mainstem Hydrosystem Flow and Passage. The 2018 Review noted that the Program's evaluation of passage and survival of anadromous salmonids has been thorough. The Hydrosystem and Passage Strategy includes a long list of quantitative indicators. Hydrosystem operations, however, change the carrying capacity of mainstem habitats and impact ecosystem function and species other than salmonids. Increased restoration of the connectivity between the mainstem and its floodplain and consideration of species other than salmon and steelhead in the mainstem Columbia River would strengthen the Program.

The ISAB recommends continued analyses of survival metrics for salmon and steelhead. We are preparing a separate report intended to improve the understanding, calculation, and interpretation of different survival measures. As the Council reexamines its major goal for abundance of salmon and steelhead, the life-cycle models and analyses of smolt to adult return ratios (SARs) and smolt to adult survival ratios (SASs) will be essential for developing a revised goal.

The ISAB recommends a comprehensive analysis of population trends and life-cycle modeling across multiple stocks within the Columbia River Basin to determine the stocks at greatest risk of extinction and to quantitatively assess potential success of alternative and more aggressive, management actions. The ISAB recommends the Program explore approaches to incorporate the influence of climate-related and density-dependent factors on the total life-cycle survival of Columbia River salmon across a broader range of possible hydrological and climate conditions.

One of the major issues explored in the Columbia River in recent years has been the potential breaching of the four lower Snake River dams to increase survival of juvenile and adult salmon and steelhead from the Snake River basin. The ISAB recommends the Program develop a more comprehensive and representative analysis of the outcomes of removing these dams.

Estuary. The 2018 ISAB Review recommended updating the Estuary strategy to focus on the lack of quantitative estimates of survival of juvenile salmon, steelhead, and other focal species. The Addendum called for repeating a research project to sample migrating juvenile salmon in the Lower Columbia River and estuary to assess benefits of estuarine use by interior salmon stocks. The ISAB commends the Council for recognizing the need for information on the abundance of salmon and steelhead in the estuary and their use of the main channel and adjacent floodplains and wetlands.

The hydrosystem's effects on the timing of the hydrograph, water temperature, organic matter transport, food sources, and water chemistry have major effects on the estuary and change from year to year, complicating the ecological interactions in the estuary. The Program would benefit from a more explicit understanding and management of the estuary and its linkages to the upstream river and nearshore marine environments.

Plume and Nearshore Ocean. The 2020 Addendum did not change the Plume and Nearshore Ocean strategy, other than to establish a Strategy Performance Indicator based on an overall measure of conditions in the plume and nearshore ocean. This Indicator provides no measure of Program success. If anything, it indicates the challenges facing species that use the plume and nearshore ocean environment and the need for Program actions to address the challenges.

The ISAB shares the Council's concerns about reduced funding for critical studies related to the estuary, plume, and nearshore ocean. There can be a mistaken assumption that we can do nothing about the ocean, so funding estuarine and ocean studies is outside of the Program's scope. Such an assumption fails to recognize that we manage the hydrology and environmental characteristics of the river, fish stocks and life histories, freshwater and estuarine habitats, which are linked inextricably with performance of salmon in these habitats and the ocean.

Wildlife Mitigation. The 2020 Addendum did not revise the Wildlife strategy; it established four Strategy Performance Indicators based on project implementation but none that measure wildlife status, abundance, or ecological characteristics. The ISAB supports the recommendations of the 2018 ISAB Review and encourages development of quantitative Strategy Performance Indicators that relate directly to the ecological status and characteristics of wildlife.

Fish Propagation. The ISAB continues to recommend an explicit assessment of the collective effects of the propagation efforts in the Columbia River Basin. The ISAB recommends the Program to evaluate the relative priorities for the Program's major

strategies and actions to mitigate the effects of the hydrosystem and maintain the diverse ecosystems of the Columbia River Basin.

A valuable addition in the 2020 Addendum was the development of a Biological Objective to contribute to achieving the targets for salmon and steelhead abundance developed by the Columbia Basin Partnership. The ISAB commends the Program for including these specific hatchery production targets but recommends a formal ongoing analysis to refine these estimates and relate them to the overall abundance goal for salmon and steelhead for the Columbia River Basin, especially wild-origin fish.

Other Strategies

One of the most significant advances in the Fish and Wildlife Program over the last decade has been the progress of the Upper Columbia United Tribes to develop plans to reintroduce anadromous fish into their historical habitats above Grand Coulee and Chief Joseph dams, which the ISAB commended in the 2018 Review. The 2020 Addendum included a revised biological objective, five Strategy Performance Indicators, and Implementation guidance for assessing the efficacy of reintroduction of anadromous fish above Grand Coulee and Chief Joseph dams. Within the last year, BPA and the federal government have developed policies and directed major funding to support the UCUT's reintroduction studies and efforts. The ISAB recommends revisions of the Program to reflect the collaborative actions and information in the new agreements. Also, the Upper Snake River Tribes Foundation is assessing the feasibility of salmon and steelhead reintroduction above the Hells Canyon Complex. The ISAB has reviewed their plans and encourages the Council to assist the Upper Snake River Tribes Foundation in these assessment efforts.

Future Changes in the Fish and Wildlife Program

The 2020 Addendum concluded that several major management and policy processes in the Columbia River Basin will require changes to the Program. In addition to the changes identified in the 2020 Addendum, the recent BPA MOU and Settlement Agreement, the White House Memorandum on Restoring Healthy and Abundant Salmon, Steelhead, and Other Native Fish Populations in the Columbia River Basin, and ongoing negotiations to modernize the Columbia River Treaty will greatly shape the future direction of the Program. While much progress has been achieved in many areas of the Fish and Wildlife Program and the collective actions of many stakeholders in the Basin, much of the aquatic and terrestrial biodiversity remains stressed, native fish populations continue to decline, and healthy, functioning ecosystems are imperiled by habitat degradation, fragmentation, and water scarcity. Continued restoration and conservation efforts as well as newer, more

effective approaches and strategies will be required to address constantly emerging threats and stressors. Our 2024 Review emphasizes increased support for reintroductions of salmon and steelhead in the blocked areas, new methods for climate assessment and monitoring non-native species, improvements in strategies for RM&E, and other actions to strengthen the Program. The ISAB hopes this review of the scientific strengths and potential areas for improvement will be valuable to the Council, its staff, federal and state fish and wildlife agencies, Tribes, and others in the Basin as they develop the next Fish and Wildlife Program.

ISAB 2024 REVIEW OF THE COLUMBIA RIVER BASIN FISH AND WILDLIFE PROGRAM

I. REVIEW CHARGE AND APPROACH

A basic responsibility of the Independent Scientific Advisory Board (ISAB) is to evaluate the Columbia River Basin Fish and Wildlife Program (Program) of the Northwest Power and Conservation Council (Council) on its scientific merits in time to inform amendments to the Program and before the Council requests recommendations from the region, including state and federal fish and wildlife agencies, the region's Indian tribes, and other interested parties (see the ISAB's Terms of Reference). The ISAB also is tasked with evaluating the Program's scientific principles to ensure their consistency with the best available science and practice. The ISAB's evaluation informs the fish and wildlife agencies, tribes, and interested parties as they develop recommendations, and the Council as it frames the amended Program. On February 27, 2024, the ISAB's Administrative Oversight Panel approved the ISAB to begin a review of the Program. The Council's amendment process is currently scheduled to begin in January 2025.

The ISAB reviewed the 2014 Fish and Wildlife Program in 2018 and shared its scientific findings with the region to help inform development of recommendations to amend the Program. The Council's amendment process began in 2018 and was completed with adoption of the 2020 Addendum. The ISAB's review (2018-3) included recommendations to improve numerous aspects of the Program. However, rather than revising and updating the entire Program, the Council decided to 1) focus on further defining goals and objectives for the Program, 2) develop indicators to measure Program performance, and 3) establish near-term implementation priorities. These additions to the Program were documented in the 2020 Addendum and addressed a long-standing aim of Council and ISAB recommendations to further define objectives and indicators to evaluate performance. The Council's Columbia River Basin Fish and Wildlife Program now consists of the 2014 Program, 2020 Addendum, and subbasin management plans. Because the 2014 Program remains in place, recommendations in the 2018 ISAB review still provide valuable guidance for future revision of parts of the Program that were not addressed in the 2020 Addendum. This ISAB report highlights and updates findings from the 2018 review of the 2014 Fish and Wildlife Program and examines scientific progress in the 2020 Addendum.

Briefings and discussions with Council staff to initiate the review provided critical context and helped the ISAB focus its review. The ISAB greatly appreciated presentations from

Patty O'Toole, Fish and Wildlife Division Director, and Kris Homel, Biologist for Program Performance, describing the Fish and Wildlife Program's evolution, the 2020 Addendums, and efforts to evaluate and report on Program performance (see Program Tracker). A briefing by John Shurts, General Counsel, and O'Toole on the US Government Commitments to restore wild salmon in the Columbia River Basin also provided useful context.

II. ISAB 2024 UPDATES ON ISAB 2018 REPORT FINDINGS AND NEW COMMENTS ON THE 2020 ADDENDUMS

This section includes brief summaries of the 2018 ISAB Review of the 2014 Program, the extent to which those findings have been addressed in the 2020 addendum, and whether they still apply as high priority or have decreased in priority. We also identify any important scientific issues that were not included in the 2018 review and should be considered in future revisions of the Program.

In the ISAB's 2018 review, the Council asked the ISAB to answer seven questions as part of the review of the Fish and Wildlife Program (2018-3, page 7). The ISAB used previous ISAB and Independent Scientific Review Panel (ISRP) reports, including earlier reviews of the Program, and the Council staff's Program Implementation Assessment Report (NPCC Staff 2017) to assess the strengths of the Program and recommend improvements. Overall, the ISAB found that most sections of the 2014 Program provided sound scientific guidance for actions to mitigate hydrosystem impacts and move toward recovery of fish and wildlife resources in the Columbia River Basin.

2018 ISAB Review

The ISAB found many strengths in the Program. Among these is Mainstem Hydrosystem passage research, which focuses mainly on survival of anadromous salmonids, elucidating the relative abundance and survival of hatchery versus naturally spawned fish, and considering the effects of run times on survival. Most of this work is very thorough and well done. The ISAB also sees great value in the Program's Protected Areas, which currently protect over 44,000 miles of rivers and streams of the Northwest from hydropower development, and the potential for the Stronghold Habitat strategy to protect native, wild, and natural-origin fish. These components of the Program are not widely recognized and warrant increased attention. The ISAB applauds the Program's strategy for Anadromous Fish Mitigation in Blocked Areas as the first steps toward reestablishing salmon and steelhead in one third of their original habitat. Public Engagement is also a strength of the Program as descriptions of strategy, rationale, principles, and general measures are straightforward and well-articulated. Although it is not a specific strategy of the Program, the ISAB also supports the Council's interest in life-cycle models, which the ISAB sees as important tools for evaluating many proposed changes in the system—both before and after.

As indicated above, the ISAB found many strengths in the Program and the strategies are scientifically based. Several major weaknesses include the ISAB's assessment that most Program goals need corresponding objectives, key strategies lack monitoring or evaluation plans or funding, and there is only limited guidance and use of adaptive management.

The Program update in the 2020 Addendum made significant progress on objectives and performance indicators, but many of the ISAB's recommendations in the 2018 review were beyond the scope of the Addendum and were not addressed. The Council provided explanations of why several of those recommendations were not addressed in the update of the Program, often because they would be considered in future updates or the Council considered existing components to be adequate (2020 Addendum Appendix: Findings on Recommendations and Responses to Comments). The ISAB reaffirms its recommendations for those improvements to the Program and provides additional recommendations and background information based on ISAB and ISRP reviews and reports since 2018. To assist the reader, the following sections of our 2024 review are consistent with the structure of the 2014 Fish and Wildlife Program and the 2018 ISAB Review.

II.1. MAJOR PROGRAM COMPONENTS

A. FRAMEWORK: ADAPTIVE MANAGEMENT

The 2018 ISAB Review found that the adaptive management section of the 2014 Program focuses mostly on research, monitoring, and evaluation (RME) and provides limited scientific guidance for developing effective adaptive management for projects. The ISAB recommended that the Program should develop rigorous decision-making processes based on regional strategies, address quantitative project objectives, develop coordinated monitoring and evaluation, and incorporate outcomes (i.e., lessons learned) into decision-making cycles that include project leaders, regional technical teams, and local rightsholders and stakeholders. (2018-3, pages 16 and 30).

Program-level Adaptive Management processes. The Fish and Wildlife Program has made progress in including adaptive management processes for individual projects, and the recommendations of the 2018 ISAB Review highlighted a framework for additional improvements to the guidance and background information provided to projects. We continue to encourage the Council to develop an explicit description of the Program-wide adaptive management process. We recognize that the complexity and geographic scope of the Program make detailed, frequently reviewed adaptive management processes challenging if not impossible to implement. The updates to the Program in 2000, 2014, 2020 represent a broad form of adaptive management that includes planning, implementation, evaluation, and learning at roughly decadal intervals. The development of Strategy Performance Indicators (SPIs) in the 2020 Addendum permits the Council to assess quantitative, trackable measures of the Program's intended outcomes more frequently and efficiently. The Program could develop an explicit process and a timetable for summaries of the Indicators, which would then serve as a foundation for future Program updates. In addition, Council staff's March 2024 report A Retrospective of the Council's Fish and Wildlife Program, 1980-2022 is an important accomplishment since the last ISAB review and should play a role in a Program-wide adaptive management process.

Synthesis reports. Synthesis reports by individual or multiple related projects (such as those within a common province, subbasin, or category) of the Program that integrate outcomes, analyze collective data, and create conceptual frameworks for future actions are an important tool for adaptive management in the Columbia River Basin. In the major categorical reviews since 2018 (Mainstem and Program Support Category Review - ISRP 2019-2, Resident Fish and Sturgeon Projects Review - ISRP 2020-8, and Anadromous Fish

Habitat and Hatchery Projects - ISRP 2022-1), the ISRP strongly recommended the development of synthesis reports for major projects or programs that have implemented restoration and conservation actions over several decades. These syntheses permit reflective evaluation and analysis for project actions, track changes in project objectives and methods, and share lessons learned. Past syntheses have been instrumental in guiding adaptive management and identified future actions that evolved directly from the synthesis efforts. Examples include the *Ocean Synthesis* (reviewed in ISRP 2012-3), the *CSS Ten-Year Retrospective Summary Report* (reviewed in ISAB/ISRP 2007-6), *Lamprey Synthesis Report* (reviewed in ISRP 2018-2), and the *Grande Ronde Model Watershed Synthesis* (reviewed in ISRP 2022-6). Synthesis reports benefit other projects across the Basin, disseminate lessons learned and best practices, and document broader impacts by describing how Program actions have influenced management, benefited society, improved effectiveness and efficiency, or resolved critical uncertainties.

The ISAB recognizes that syntheses require time and money, and Council staff and some projects have questioned the use of BPA funds for synthesis efforts. We feel that rigorous adaptive management for sets of projects that span 20 years or more of implementation and investment requires the integration and cumulative evaluation involved in a synthesis report as a cost-effective means to evaluate progress toward Program goals. Continued funding of long-term projects with no assessment of their broader impacts and collective success is not consistent with the fundamentals of adaptive management or the Program goals and objectives.

The Council should identify projects or groups of related projects that have developed spatially extensive, long-term data sets that would benefit the Fish and Wildlife Program through collective analysis and synthesis.

Multiple ways of knowing. During the course of the Resident Fish and Sturgeon Category Review (ISRP 2020-8), the ISRP highlighted the importance of recognizing and using different cultural perspectives and processes to inform and conduct science-based restoration and adaptive management. This is a matter of both scientific rigor and social justice. Scientists and managers are increasingly aware of how strongly cultural perspectives are embedded in our current scientific frameworks, at the expense of knowledge frameworks of other cultures, and potentially limit the success of ecosystem recovery. The ISRP has recognized the value of traditional ecological knowledge in past reviews, for example, the Confederated Tribes of the Umatilla Reservation's First Foods concept. The ISRP noted that the ISAB and ISRP together:

> "have a fundamental responsibility to address diverse cultures and perspectives in our science and its role in informing policy and management.

> We have a social and scientific responsibility to consider the cultural histories, rights, and trust agreements that shape current resource management and to consider the full extent of knowledge about the natural resources and landscapes the Columbia River Basin." (ISRP 2020-8)

The ISAB encourages the Council to pursue actions to include Indigenous cultural perspectives, adaptive processes, and ecological knowledge alongside current scientific approaches to inform sound science principles and benefit fish and wildlife in the Program. The scientific community and Indigenous scholars are still developing concepts and protocols for incorporating different knowledge systems, so addressing this issue itself is a priority that will require adaptive management.

2024 ISAB Recommendations

- Develop and include an explicit process and timetable for summaries of the Strategy Performance Indicators to inform the region of important areas requiring additional actions or adjustments prior to future Program updates.
- Explicitly support development of synthesis reports for major projects and subbasins that have implemented restoration and conservation actions over several decades.
- Include Indigenous cultural perspectives, processes, and knowledge systems alongside current scientific concepts to inform and enhance sound science principles and benefit fish and wildlife in the Program.

B. VISION

The 2014 Program Vision originated in the 2000 Program, has been reviewed several times by the ISAB, and has not changed substantively since 2000.

The Vision for the 2014 Program:

> "The vision for this program is a Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife, supported by mitigation across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem. This envisioned ecosystem provides abundant opportunities for tribal trust and treaty-right harvest, non-tribal

harvest, and the conditions that allow for restoration of the fish and wildlife affected by the construction and operation of the hydrosystem.

The vision will be accomplished by protecting and restoring the natural ecological functions, habitats, and biological diversity of the Columbia River Basin. Where this is not feasible, other methods that are compatible with self-sustaining fish and wildlife populations will be used, including certain forms of production of hatchery fish. Where impacts have irrevocably changed the ecosystem, the program will protect and enhance habitat and species assemblages compatible with the altered ecosystem."

The 2018 ISAB Review noted, "the Vision is largely a values and policy statement, but there are important scientific underpinnings and tradeoffs inherent in the language." The ISAB suggested five changes in the wording of the Vision to provide a stronger scientific foundation (2018-3, page 22).

The 2020 Addendum did not revise the Vision section of the Fish and Wildlife Program. The ISAB again advocates for the 2018 ISAB Review's suggested modifications of the Program's Vision statement. More than simple semantic revisions, these changes clarify key elements of the Vision and increase consistency with the Scientific Principles. We have updated the suggested modifications from the 2018 Review and encourage the Council to consider the following revisions in future Program updates.

- To recognize the need for a balance between the current status that many fish populations in the Basin are gravely imperiled and a future where restoration has resulted in many more self-sustaining populations, the ISAB suggests:

> The vision for this program is a Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife, and focuses on protecting and restoring natural habitats and communities to mitigate for the adverse effects caused by the development and operation of the hydrosystem across the Basin.

- To reflect that restoration and protection must sustain harvest obligations and be resilient for future change, the ISAB suggests:

> This envisioned ecosystem provides conditions that allow for restoration and protection of the fish and wildlife affected by the construction and operation of the hydrosystem, is resilient to climate change, and provides sustaining opportunities for tribal trust and treaty-right harvest and non-tribal harvest of populations.

- The ISAB questions whether the term "abundant . . . community of fish and wildlife" is objectively defined and sets expectations that cannot be met and sustained (beyond their aspirational intent). We recommend better definition of the term and clarity about intensive management actions:

> Where this is not feasible, other methods that are compatible with self-sustaining, naturally reproducing fish and wildlife populations will be used, including assisted migration above current barriers and certain forms of production of hatchery fish that do not degrade the fitness of wild populations.

- The ISAB recommends clarification of the Program's focus where science and societal and cultural values intersect:

> Where impacts have irrevocably changed the ecosystem, the program will protect and enhance habitat and self-sustaining species assemblages compatible with the altered ecosystem and societal values, but with a focus on species native to the watershed.

C. SCIENTIFIC PRINCIPLES

As described in the 2014 Program, the ISAB is "responsible for developing, reviewing, and recommending modifications to the Scientific Principles." In the ISAB's 2013 review of the 2009 Program (ISAB 2013-1), the ISAB recommended consolidating the existing principles, emphasized the theme of resilience, and added a new principle on socioeconomics and

public engagement.[1] The Council adopted the ISAB's suggested principles in the 2014 Program but simplified them for readability by a broad audience.

In its 2018 review (page 24), the ISAB recommended that the 2014 principles be further consolidated and revised to focus on management of the Columbia River Basin power-generating and irrigation-supporting ecosystem—principles that imply that certain actions and conditions are needed to restore salmon, steelhead, and other native fish and wildlife in the Basin. The ISAB continued to emphasize the 2014 themes of resilience, socioeconomics, and public engagement, but the ISAB also emphasized the importance of connectivity.

The Council did not amend the Scientific Principles section of the Program, finding the ISAB's revised principles largely consistent with the existing principles and other parts of the 2014 Program and 2020 Addendum. In the Appendix to the 2020 Addendum, the Council noted that:

> "The ISAB placed greater emphasis in its program review on the program's goals, objectives and adaptive management approach – on how the Council should assess program performance and use that information in a scientifically credible way - and that is where the Council has put its emphasis in this amendment process. When the time comes for a wholesale revision of the program's provisions, the Council will revisit this issue."

When the Council updates the 2014 Program and 2020 Addendum, the ISAB recommends the Council to revise the scientific principles of the Program based on the modifications recommended in the ISAB's 2018 review and *additional suggestions and revisions* from the ISAB added in this review.

Combined Recommendations from the 2018 ISAB Review and the 2024 ISAB Review

Principle 1: To restore salmon, steelhead, and other native fish and wildlife in the Columbia River Basin, policy makers, resource managers, and restoration practitioners need to take the entire ecosystem into account, including riparian and upland,

[1] See this link for a table showing a crosswalk between principles in the 2014 Program (page 27), the 2013 ISAB Review of 2009 Program (ISAB 2013-1), and the 2009 Program.

freshwater, estuarine, and ocean components, and the linkage and feedback between the natural and human systems.

- Ecosystems include all living things in a given area, interacting with their physical environment.
- Ecosystems in the Basin have evolved over millions of years, and human actions are recent influences on these ecosystems.
- Ecosystems are hierarchical; large-scale physical conditions set the stage for physical and biological processes that occur at smaller scales of space and time.
- Disturbance and change are ecological processes that maintain, alter, and restore ecosystems.
- Historical processes of disturbance and ecological change and their interactions with more recent human-caused changes determine the diversity, abundance, and productivity of plants and animals.
- To restore native fish and wildlife in the Basin, managers need to consider the entire coupled natural-human system and understand the linkages and feedbacks that have reduced abundance of fish and wildlife abundance and diversity over the last 200 years.

Principle 2: To restore and sustain diverse, abundant, and resilient populations of native fish and wildlife, policy and management actions will need to provide the diverse array of habitats that these animals require throughout their life cycles and the connections among them that allow access.

- Landscape perspectives provide essential physical and biological contexts for protecting and restoring river networks and the aquatic ecosystems that sustain native fish, wildlife, and plant communities.
- Factors that limit fish and wildlife abundance often change over time and differ across the landscape. Actions to address limiting factors must consider the full life cycle and geographic range of fish and wildlife species, while recognizing the broader context of large-scale environmental change.
- Although habitat degradation, harvest, and pollution are important factors causing declines in fish and wildlife populations, a substantial portion of the decline is a result of reduced or blocked access to habitats critical to completing their life cycles.
- In addition to anadromous fish that migrate to sea and back, many fish species considered “resident” also make long migrations (> 50 km) to spawning and rearing locations, so removing barriers to movement is needed to restore their populations.

- Many habitats critical to native fish are used only during wet seasons and have often been degraded by human actions because they are either dry or are not considered suitable habitat during summer.
- Restoring salmon, steelhead, resident fishes, and other native fish and wildlife will require sustaining connections among all habitats that these species require in rivers, lakes, estuaries, ocean, riparian zones, and uplands at appropriate times throughout their life cycles.

Principle 3: The diversity of life histories, genetics, populations, and biological communities allows ecosystems to adapt to environmental change. Maintaining this diversity is the key to sustaining native fish and wildlife into the future, especially in the face of natural and human-caused changes in climate, water quantity and quality, extreme events, exposure to non-native organisms including pathogens, and other conditions.

- Genetic diversity provides the raw material that allows populations of salmon, steelhead, and other native fish and wildlife to adapt to unpredictable or changing conditions.
- This genetic diversity interacts with phenotypic plasticity (differences induced by environmental conditions) to produce a portfolio of life history characteristics of fish and wildlife (e.g., different body sizes, timing of migrations), which differ in their suitability for specific conditions but which collectively confer resilience and increase capacity of populations to thrive under changing conditions.
- Artificially introducing genetic variation through population mixing, translocation, hybridization, domestication, or genetic modification from different species has associated potential risks and benefits. Current scientific knowledge is insufficient to predict how such actions will perform in the Basin's ecosystems or account for unintended consequences. Targeted approaches for translocations or artificial propagation should identify the recognized risks and benefits and incorporate monitoring and evaluation to assess the results and identify possible unanticipated outcomes.
- In addition to diversity of fish and wildlife, maintaining the diversity of other aquatic and riparian animals, plants, and microbes is critical for resilience and sustaining the fundamental biological production and physical conditions that allow fish and wildlife to persist in the Columbia River Basin.

Principle 4: Fish and wildlife live within complex ecosystems highly influenced by humans. To achieve ecosystem resilience and persistence, policy makers, resource managers, and restoration practitioners must understand and acknowledge the societal and cultural values for these animals and their ecosystems and incorporate these values in their decision making.

- Ecosystem conditions affect all species, including the well-being of humans.
- Human behaviors, values, and institutions, including diverse cultures, provide the structures and perspectives that allow society to adapt to changing ecosystem conditions.
- Managing ecosystems effectively requires managers to implement actions in an experimental framework to learn, adapt, and use a structured process for iteratively testing and revising management systems.
- Effective mitigation and restoration will require policy and management actions that (1) are based on scientific principles and Traditional Ecological Knowledge, (2) address societal values, (3) recognize the strengths and weaknesses of decision-making processes, and (4) identify beneficial policy options.

D. GOALS AND OBJECTIVES

The 2014 Fish and Wildlife Program is based on the Framework that links the Vision and Scientific Principles to a series of Goals and Objectives, which are addressed through Strategies and Implementation Measures (see Figure 2 in the 2014 Program). An essential core of the Program are the Goals and Objectives, which are developed from recommendations from federal and state fish and wildlife agencies, Tribes, and the public. The Council refines and adopts Goals and Objectives from those recommendations. In the 2018 Review, the ISAB concluded that the Goals and Objectives section of the 2014 Program did not address ISAB recommendations from the 2009 Review, did not provide scientifically sound guidance on goals and objectives, and needed revision (2018-3, page 27). We raised several major concerns about specific goals and objectives in the 2014 Program and noted that most objectives in the 2014 Program were not quantitative and could not be tracked explicitly.

A major improvement in the 2020 Addendum is the addition of several quantitative objectives (2020 Addendum, Part 1, pages 8-35 and pages 103-108 of Appendix 4) and development of Strategy Performance Indicators, some of which are quantitative and can be tracked to evaluate the performance of strategies. The Council adopted the Goals, Objectives, and Strategies, but the Strategy Performance Indicators were not officially adopted because specific indicators, as evaluation tools, may change based on data availability and utility. This approach allows the Council to modify the Indicators based on available or new information without requiring an amendment process.

One of the major concerns of the ISAB in the 2018 Review was the Program goal of "increasing total adult salmon and steelhead runs to an average of 5 million annually by 2025 in a manner that emphasizes the populations that originate above Bonneville Dam and supports tribal and non-tribal harvest." This is an important component of the Program, and the original target date is only months away. This goal has received much attention (Smith 2015, Jaeger and Scheuerell 2023) and is an ongoing source of much confusion. In spite of the central role of the abundance goal for mitigating the effects of the Columbia River hydropower system, the scientific basis for the goal is frequently misunderstood. The following brief description of how the goal for salmon and steelhead was developed and evolved provides a foundation for our recommendations for its future revision.

Historical Development of the Goal of 5 Million Salmon and Steelhead

The Northwest Power Act of 1980 directed the Council to "protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries." The first Fish and Wildlife Program in 1982 was explicitly designed to develop "measures that address the adverse effects on fish and wildlife on the Columbia River hydroelectric system." Initially fish and wildlife agencies and the Tribes developed and recommended quantitative "goals" for spring, summer, and fall Chinook, sockeye, coho, and steelhead based on run sizes prior to the construction of McNary Dam. The Council considered these run size estimates for determining the losses of anadromous fish due to the hydrosystem at the time of the construction of McNary Dam. The Northwest Power Act authorized the Council to address losses caused "by the development and operation of *any* hydroelectric project on the Columbia River and its tributaries" (1982 Fish and Wildlife Program).The Fish and Wildlife Program was not authorized to mitigate for other factors responsible for salmon and steelhead declines, such as "irrigation, forestry, commercial and sport fishing, and cycles of nature (especially in the ocean)." The Council recommended the Bonneville Power Administration (BPA) to fund a study by the fish and wildlife agencies and tribes to identify the salmon and steelhead losses related to the Columbia River hydroelectric system and to propose goals for anadromous fish for each stock and each significant river basin.

The 1987 Fish and Wildlife Program established an initial goal of 5 million salmon and steelhead but did not include a target date. The Council based this interim goal on a Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin prepared by Council staff in 1986. The goal was determined by estimating:

1. the total annual adult run size in the Columbia Basin of both natural origin and hatchery salmon and steelhead returning to the mouth of the Columbia River plus the number of adults caught in the ocean for the years 1976 to 1981, the period just prior to adoption of the Council's initial Columbia River Basin Fish and Wildlife Program in 1982
2. losses of salmon and steelhead from all causes, and
3. losses from all hydroelectric projects in the Columbia River Basin.

These estimates were described in detail in the 1987 Fish and Wildlife Program in Appendix D: Salmon and Steelhead Losses and Appendix E: Hydropower-Related Losses.

The 1987 analysis estimated an average total run size of 10 to 16 million adult salmon and steelhead in the mid-19th century. Total run size, including adult escapement plus ocean and in-river harvest below Bonneville Dam, averaged 2.5 million adult fish from 1976 to 1981. At that time, 30% of the freshwater habitat for salmon and steelhead available prior to 1850 was inaccessible. Total basinwide losses due to all causes was estimated at 7 to 14 million adult fish. Of the total losses, hydropower-related loss estimates ranged from 5 to 11 million adult fish. At the start of the Program in 1987, approximately 80% of returning adult salmon and steelhead were caught in ocean and in-river harvest. The Council considered the 5 million fish goal to be an interim goal that represented the current run of 2.5 million fish and half of the estimated losses related to the hydropower system. With the expectation that the goal would be revised in the future to address full mitigation for hydrosystem-related losses.

In 1992, the Council amended the Fish and Wildlife Program in Strategy for Salmon, which provided the most detailed discussion of the process for developing the goal for salmon and steelhead and the Council's considerations for strategies and management actions. The Amendment confirmed the goal of 5 million fish but clarified that the Program was to attain that goal with "no appreciable risk to the biological diversity of fish populations" and the existing diversity of salmon and steelhead population at that time would be the baseline for assessing biological diversity over the long term. The Amendment included numerical targets for Chinook salmon run sizes in the Snake River Basin. At that time, the Council chose not to have a target date for the goal, commenting that "doubling provides an overall sense of the magnitude of the program's interim goal, not a stock-specific objective."

The Fish and Wildlife Program was amended further in 1994 and 1995, clarifying that the total run size included "the number of adult salmon of all species counted at Bonneville Dam, the number of fish spawning below Bonneville Dam and the estimated number of salmon caught in the ocean and in rivers below." It further clarified that the current runs of

2.5 million adult fish to a total of 7.5 million fish to reach the low end of the range of estimated hydrosystem-related losses. Similar to our recommendation in this review, the 1994 Amendment called for annual reporting of the total run size of salmon and steelhead to track Program performance. The Council also adopted four systemwide sub-goals to the 5 million fish goal:

- Halt declines in the populations and rebuild populations to a biologically sustainable level by the year 2000.
- Rebuild populations by 2030 to a level that will support commercial and sport harvest and contribute to the interim goal of doubling the abundance of salmon and steelhead.
- Rebuild populations beyond the level in the previous goals by 2194 to a level that will protect, mitigate and enhance fish and wildlife affected by the Columbia Basin hydroelectric system.
- Accomplish rebuilding efforts without loss of biological diversity.

The 2000 Fish and Wildlife Program expanded the basinwide vision and developed additional objectives and target dates for anadromous fish:

- Halt declining trends in salmon and steelhead populations above Bonneville Dam by 2005.
- Obtain the information necessary to begin restoring the characteristics of healthy lamprey populations.
- Restore the widest possible set of healthy naturally reproducing populations of salmon and steelhead in each relevant province by 2012. The objectives defined healthy populations as having an 80% probability of maintaining themselves for 200 years at a level that can support harvest rates of at least 30%.
- Increase total adult salmon and steelhead runs above Bonneville Dam by 2025 to an average of 5 million annually in a manner that supports tribal and nontribal harvest.
- Within 100 years achieve population characteristics that, while fluctuating due to natural variability, represent on average full mitigation for losses of anadromous fish.

The 2009 Fish and Wildlife Program did not change the goal for 5 million salmon and steelhead annually by 2025. It reemphasized the importance of restoring anadromous populations that originate above Bonneville Dam, where the majority of the hydropower-related losses had occurred. It maintained support for both tribal and non-tribal harvest.

The 2009 Fish and Wildlife Program was the first to identify the objective of achieving smolt-to-adult return rates (SARs) in the 2-6 percent range for listed Snake River and upper Columbia salmon and steelhead. Additionally, it stated that these survival standards should also apply to unlisted salmonids passing federal dams.

The 2014 Fish and Wildlife Program did not change the abundance goal for salmon and steelhead, but it developed High-Level Indicators documented online to track Program progress. It stated that it shares in the region's broader vision of natural-origin salmon and steelhead populations across the Basin that are diverse, resilient, productive, and sufficiently abundant to allow substantial opportunities for tribal and non-tribal harvest. The 2014 Program also called for the Council to work with the states, federal agencies, and Tribes to identify specific indicators for BPA-funded hatchery programs that could be tracked and reported to inform progress on meeting mitigation objectives for harvest, supplementation, reintroduction, and conservation.

In 2015, the ISAB completed its Density Dependence Report (ISAB 2015-1), which included a review of previous assessments of historical anadromous fish abundance by the Council, fisheries agencies, and Tribes (pages 38-53). The report evaluated the previous approaches to develop estimates of abundance and questioned some of the methods used. The ISAB concluded that the previous estimates of salmon and steelhead abundance (10 to 16 million fish) were too high given the available evidence and recommended a lower estimate of 5 to 9 million fish per year, with the primary evidence supporting an estimate of around 6 million fish per year.

During the 2020 amendment process, the Council noted the lack of consensus among fishery scientists and managers about the historical abundance of salmon and steelhead (NPCC 2020-9) and chose to maintain the anadromous fish goal. Importantly, the Council stated that even if the estimated losses were adjusted, the range and the resulting losses would still be of significant magnitude to support a 5 million abundance goal.

The recent 2020 Addendum further defined the 5 million salmon and steelhead goal by 2025 to be a 10-year rolling average to accommodate interannual variation in the Basin's conditions, biological responses to those conditions, and variation in abundances of individual species and populations. It continued the emphasis on increases in the abundance of the populations that originate above Bonneville Dam because most of the losses have occurred above Bonneville.

An important addition to the Program in the 2020 Addendum is the Biological Objective to contribute to achieving the targets for salmon and steelhead adult abundance by stock and subregion developed by the NOAA Marine Fisheries Advisory Committee's (MAFAC)

Columbia Basin Partnership Task Force (A Vision for Salmon and Steelhead, Phase 1 Report and Phase 2 Report). These reports provided targets for the different stocks of adult natural-origin anadromous salmon and steelhead by subbasin for low, medium, and high abundance levels of production. The recognition of targets for specific stocks and subregions is consistent with the 1982 Program's call for a study to propose anadromous fish goals for each stock and each significant river basin.

In summary, the overall approach for determining the goal for salmon and steelhead abundance has not changed since the 1987 Fish and Wildlife Program, but the goal for diversity, target dates, and specific Biological Objectives have better defined the interim goal to mitigate the effects of the Columbia River hydropower system. Even if the 5 million fish goal were obtained, the Program would not fully mitigate for the Council's estimated losses related to the hydropower system.

Future Development of the Abundance Goal for Salmon and Steelhead

The goal for abundance of salmon and steelhead in the Columbia River Basin has been a cornerstone of the Fish and Wildlife Program since its inception in 1982. While the general goal of 5 million adult fish of both natural and hatchery origin annually has been consistent throughout the Program, the target date and associated considerations have changed with Program revision and amendments. Even if the goal for 5 million anadromous salmon and steelhead is simply aspirational (i.e., it is unlikely achievable under current or near-term conditions), attention to the Program and its goals is likely to increase in the near future as the target date of 2025 fast approaches. To assist the Council in upcoming revisions of the Program, the ISAB suggests the following considerations in revising the goal for abundance of salmon and steelhead.

Estimates of Historical Run Sizes

Given the lack of consensus on the magnitude of historical run sizes of salmon and steelhead in the Columbia River, the ISAB recommends that the Fish and Wildlife Program should show a wider range, reflecting the different estimates, and reference the table shown below of the various historical abundance estimates provided in NOAA Marine Fisheries Advisory Committee's (MAFAC) Columbia Basin Partnership Task Force Phase 1 Report, A Vision for Salmon and Steelhead (page 76). Four major assessments since the start of the Program estimate maximum abundances of approximately 9 million fish.

TABLE 12. Historical run-size estimates, current run sizes, and harvest of salmon and steelhead in the Columbia River.

Species	Historical Columbia River Run (millions)				
	Northwest Power Planning Council, 1986	Chapman 1986	Pacific Fisheries Management Council, 1979	Independent Scientific Advisory Board, 2015	Columbia Basin Partnership, 2019[a]
Chinook	5.4-9.2	3.75-4.34	3.44	–	3.54
Spring	1.4-2.3	0.5-0.6	–	–	1.45
Summer	2.7-4.6	2.0-2.5	–	–	0.69
Fall	1.3-2.3	1.25	–	–	1.40
Chum	0.8-1.0	0.45-0.75	0.95	–	0.46
Coho	1.0-1.8	0.56-0.62	1.20	–	0.62
Sockeye	1.5-2.6	2.25-2.62	0.65	–	2.11
Steelhead	0.8-1.4	0.45-0.55	2.04	–	2.20
Winter	–	–	–	–	1.87
Summer	–	–	–	–	0.32
Total	9.6-16.3	7.5-8.9	8.28	5.0-9.0	8.93

[a] Based on population-specific inferences for natural-origin spawners prior to development.

Date for the Abundance Goal

The original Fish and Wildlife Program chose not to include a specific date for the abundance goal, but the 2000 Fish and Wildlife Program established 2025 as the date for attaining an average of 5 million salmon and steelhead annually. The ISAB recommends the Council develop a context for the abundance goal for mitigating the losses related to hydropower in the future that is represented by potential trajectories based on recent data and life-cycle models and is bounded by plausible scenarios with explicit assumptions of major limiting factors. These trajectories would identify possible near-term and long-term performance that could be tracked using Performance Indicators. The scenarios could include assumptions about trends and variation in regional climate, ocean conditions, river hydrology and temperature, predation, tributary habitat conditions, and non-native species interactions. An explicit set of scenarios and their associated trajectories would provide a context for interpreting short-term trends in Program performance and potential management responses.

Origin of Fish

The 5 million fish goal includes both natural-original and hatchery salmon and steelhead. The Council has always considered hatchery fish to be an acceptable form of mitigation, but it also has a mandate to protect salmon and steelhead in the Basin. This mandate is reflected in several Program goals to protect biological and genetic diversity of salmon and steelhead populations. Hence, the abundance goal might not be achievable or even desirable if it necessitates overdependence on hatchery fish to the detriment or exclusion of wild populations. The 2020 Addendum developed a Biological Objective to contribute to the Columbia Basin Partnership's targets for abundance of natural-origin salmon and steelhead stocks for major subbasins. The ISAB recommends the Council consider how to emphasize protection of natural-origin fish while also meeting overall abundance of abundance goals to mitigate losses related to the hydrosystem.

Stocks and Subbasins

The Program's abundance goal has always been a basinwide goal with an emphasis on abundance of fish above Bonneville Dam. Given the body of information on salmon and steelhead abundance and availability of habitat by subbasins and the quantitative goals identified for natural origin fish by the *Phase 2 Report of the Columbia Basin Partnership Task Force* (2020), the Program's abundance goal could be revised to include targets or ranges of abundance for spring Chinook, summer Chinook, fall Chinook, coho, and sockeye salmon and steelhead for the major subbasins. The Appendix of the 2020 Addendum notes that the Partnership:

> "did not identify responsibility for achieving the targets, but the Columbia River Basin hydrosystem's protection and mitigation program under the Northwest Power Act will contribute significantly toward achieving these targets."

Goals or targets for salmon and steelhead abundance would be more useful if they were based on inherent productivity, biological capacity of the habitat, genetic and life-history diversity, and density-dependent relationships for specific subbasins. While the Council may not have sufficient information to develop quantitative goals for each stock and subbasin, the ISAB recommends that the Council establish Performance Indicators to be tracked for each stock and subbasin.

Reporting Trends in Salmon and Steelhead Abundance

The abundance goal of 5 million salmon and steelhead is central to the Program and should be reported consistently and annually to inform the Tribes, public, and

management agencies in the Columbia River Basin. The ISAB's Density Dependence Report (ISAB 2015-1) provided estimates of salmon and steelhead from 1866 to 2010 (Fig. 1).

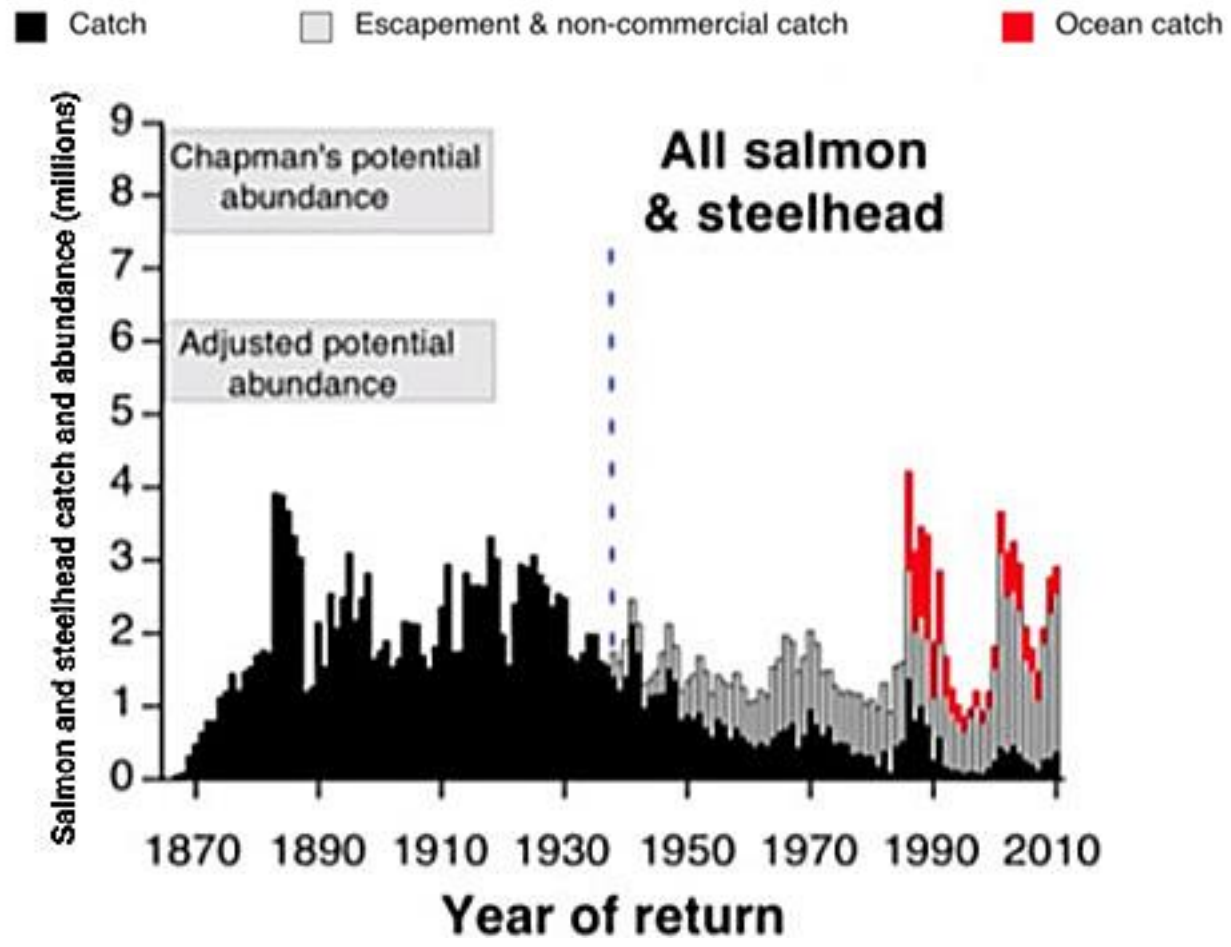

Figure 1. Reported commercial catch of salmon and steelhead from 1866 to 1937, total abundance (catch and escapement) of each species entering the Columbia River since 1938, and escapement, in-river catch and ocean harvests from 1986 to 2010 (from Figure III.1 in ISAB 2015-1).

Counts of salmon and steelhead at Bonneville Dam are part of the abundance goal for salmon and steelhead but do not include ocean harvest and harvest in the lower Columbia River. The trend in salmon and steelhead returning to Bonneville Dam from 1937 to 2022 shows that returns of salmon and steelhead to Bonneville Dam have generally increased since the Fish and Wildlife Program began in 1982 (Figure 2). However, the total run size may not have increased because ocean harvest may have decreased and in-river harvest shifted from lower river to above Bonneville Dam as a result of management changes. Nevertheless, the graphical representation of trends in salmon and steelhead abundance

illustrates the importance of consistent reporting of this important measure of Program success.

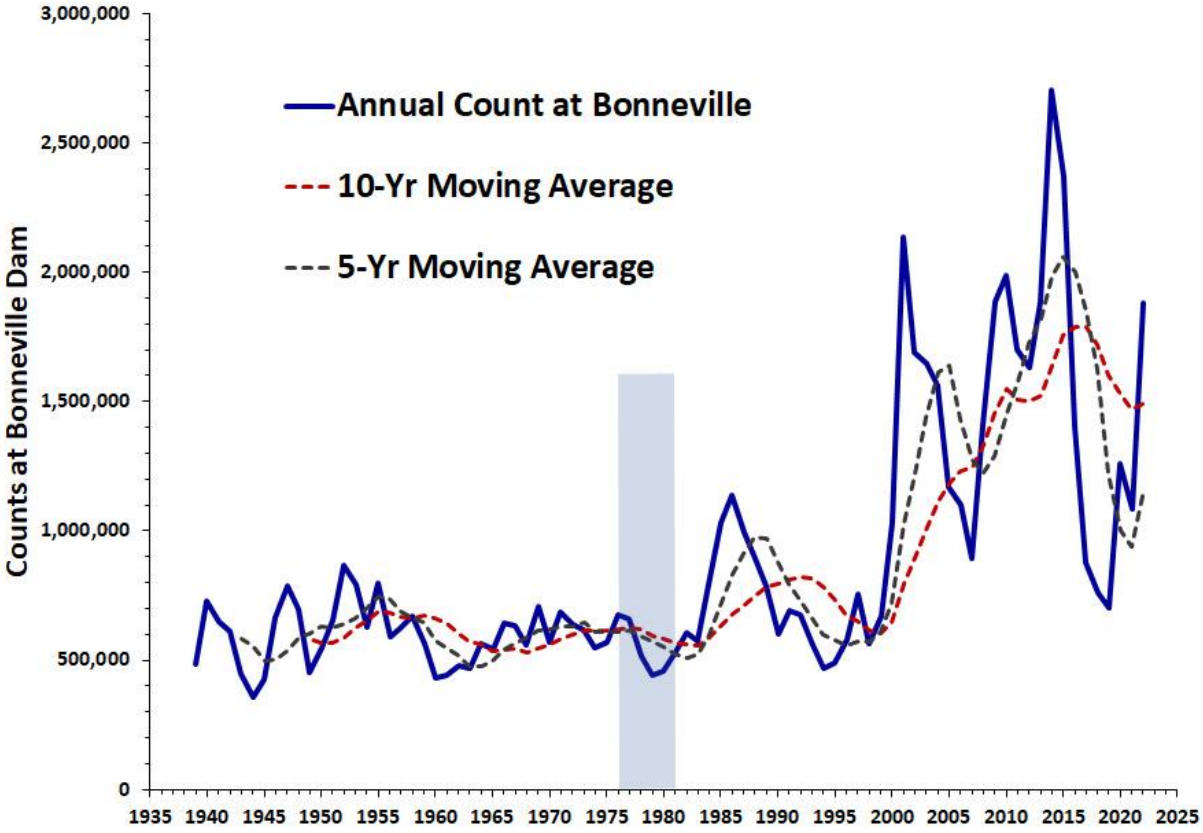

Figure 2. Annual counts of all salmon and steelhead at Bonneville Dam from 1938 to 2022 (Data from Columbia River DART) and 5-yr and 10-yr rolling averages. The shaded area represents the period originally used to develop the run size at the beginning of the Fish and Wildlife Program.

The ISAB recognizes the difficulty in accurately estimating the total annual adult run of natural and hatchery origin salmon and steelhead to the mouth of the Columbia River, including adults caught in the ocean. This complexity results from the multiple sources of information and differences in how salmon and steelhead are quantified as they return to the Columbia River and in fisheries. The counts at Bonneville Dam are a fundamental source of information. To account for the total run, the harvest of fish in the lower river below Bonneville Dam must be estimated to add to the run size. An even greater challenge for determining the total run size is estimating the ocean harvest of all salmon and steelhead. This requires obtaining catch data from multiple ocean fisheries throughout the Pacific Ocean and estimating the portion from the Columbia River. These data are

developed for many different geographic areas and must be analyzed separately and compiled to develop an estimate of the total ocean harvest. The estimation of total run size is made more difficult by the difference in reporting groups and annual management reporting timelines. Nonetheless, it is possible to develop a standard analytical process and implement it annually to develop estimates of total run size and also document the uncertainties and known sources of error. Council staff are currently working with state agencies, Tribes, and the Pacific Fisheries Management Council (PFMC) to get estimates for ocean harvests of Columbia River stocks. Rather than developing a one-time representation of the trends in annual run size that includes ocean and lower river harvest, they have been developing a data sharing approach that can be replicated consistently in future years. Though this information is not available for this report, Council staff will present the estimates and the ongoing analytical approach to the Council in the near future. The ISAB strongly recommends that the Fish and Wildlife Program develop and describe a consistent analytical approach to report the trend in one of its fundamental goals, the total abundance of salmon and steelhead for the Columbia River.

SMOLT-TO-ADULT RETURN RATES (SARS)

The 2023 CSS Report (CSS 2023) included a modeling analysis of the SARs that would be necessary to achieve the Partnership benchmarks for Snake River spring/summer Chinook salmon and steelhead (Chapter 6) and several CSS reports have evaluated the Fish and Wildlife Program's goals of 2% to 6% SARs for these populations. The analysis in 2023 found that additional actions in the hydrosystem would benefit salmon and steelhead populations, but they would not be sufficient to meet even the lower targets for SARs of the Columbia River Basin Partnership. The ISAB has reviewed the 2% to 6% SAR goals in the reviews of the CSS reports and found these targets to be scientifically credible. The ISAB is preparing a report to improve the understanding, calculation, and interpretation of the different survival measures, including SARs. SAR is a convenient metric for in-river passage of smolts and adults with PIT tags but does not explicitly distinguish natural mortality from fishing mortality. Further analysis of other populations of salmon and steelhead using existing life history models could be used to refine the Columbia Basin Partnership targets and develop more scientifically sound abundance goals for the Fish and Wildlife Program. Ultimately, the causes and consequences for failing to meet the 2-6% targets warrant close scrutiny to inform effective mitigation actions.

CONTEXT NEEDED FOR GOALS AND OBJECTIVES

The Fish and Wildlife Program would be strengthened by including or explaining the context for its goals and objectives. Many of the goals are expressed as numerical targets but without any context as to how much more might be needed for a recovery response. For example, if we restore 1000 acres of wetland, is that 1% of the total needing restoration, 5%, 10%? A number without a sense of the magnitude of the problem or need is of limited value. A positive example of providing a context is the Estuary Strategy Indicator in the 2020 Addendum:

> "Acres of estuary floodplain protected or restored per hydrogeomorphic reach. Compare to target of no net loss of native habitats and recovery of 40 percent of historic extent for priority habitats."

Even in this, the basis for a 40% recovery of historical habitat is not explained. In some cases, the context also can highlight successes as well as actions that lead to substantial gains in habitat, fish abundance, or survival.

The 2018 ISAB Review noted that several of the Program's objectives are rudimentary or non-existent, and that is still the case with the 2020 Addendum. If major program components lack objectives, they cannot be evaluated rigorously. Non-quantifiable objectives that cannot be tracked for performance evaluation may guide progress to being able to develop quantifiable objectives, but the intended outcomes and timelines for producing appropriate objectives still can be defined and evaluated. Where the objectives cannot be quantified presently because of technological or analytical limitations, objectives that identify actions to develop rigorous assessment methods would be appropriate. For Program objectives that are so complex because of large scale, highly variable processes (e.g., ocean conditions) or multiple interacting limiting factors, quantifiable objectives may not be possible. In these cases, Performance Indicators could track related phenomena to provide a context for performance of important factors that influence the success of the Program's mitigation and restoration actions. For example, estimation of ocean harvest of all salmon and steelhead from the Columbia River is important but extremely complex, as described previously. The Program could roughly estimate and report current run sizes as described above while creating a process-based performance index to develop an analytical approach to quantitatively estimate numbers of Columbia River salmon and steelhead numbers in ocean harvest with estimates of the associated error.

1. ADDITIONAL COMMENTS ON PROGRAM GOALS, OBJECTIVES, AND PERFORMANCE INDICATORS IN THE 2020 ADDENDUM (PART 1.A)

- ***Anadromous Salmon and Steelhead Goal and Objectives***

The Biological Objective S3 in the 2020 Addendum to "continue to improve juvenile passage survival through the hydrosystem" is vague, open ended, and thus is somewhat meaningless as a program objective. However, the 2014 Fish and Wildlife Program includes Goal 17 Objective (a) in Appendix D (page 158) to achieve juvenile fish passage performance standards, which incorporates a table of performance standards derived from the 2008 FCRCP BiOp.

Similarly, the Biological Objective for genetic diversity (S7) to "maintain genetic diversity over time" is vague and the measure of its performance is not defined. The Addendum does not define the spatial scale to which the objective refers. The White Sturgeon section uses this same language, but then adds "sufficient to respond to future conditions and permit population adaptation and persistence." That seems somewhat more specific but still could be more precise and quantifiable. Quantitative performance standards could be developed for specific socks of salmon and steelhead in different portions of the Basin as genetic information becomes available.

2024 ISAB Recommendations

1. Identify overall passage survival objectives for specific species/stocks for the entire hydrosystem.
2. Develop Performance Indicators for specific dams in the upper Columbia, Snake River, and mainstem Columbia River, similar to the stock-specific adult performance standards in Objective S4.
3. Develop quantitative Performance Indicators for genetic diversity of specific stocks of salmon and steelhead in different portions of the Basin as genetic information becomes available.

- ***All Other Native Aquatic Focal Species Goal and Objectives***

The criteria for selecting some species (e.g., Oregon chub) for special mention but not others are not clear. Are these focal species formally recognized as imperiled under ESA,

state statute, or tribal recognition? The Program's ecosystem perspective makes it important to identify the range of species within the ecosystem, both non-game and harvested species, and select focal species for developing goals and objectives based on explicit criteria.

Several of the goals are quantitative and specific, such as the objective to maintain the "number of alleles for groups of several similar-aged year classes of white sturgeon (minimum number examined = 50) at 14 standardized loci is ≥ 235." This is commendable, and where possible such objectives for genetic diversity should be linked to information that describes genetic diversity sufficient to respond to future conditions and permit population adaptation and persistence.

2024 ISAB Recommendations

1. Explain the criteria used to select focal species that have specific goals and objectives.
2. Relate objectives for genetic diversity to information that describes genetic diversity sufficient to respond to future conditions and permit population adaptation and persistence.

- ***Wildlife Goal and Objectives***

The Program does not explain how wildlife goals and objectives are established and under what criteria species are shifted from being the beneficiaries of recovery efforts to potential threats to other valued taxa such as salmon. For example, the American white pelican is a Species of Greatest Conservation Need under the State Wildlife Action Plan in Washington. How would their conservation status in the Fish and Wildlife Program change if studies document that they consume large number of salmon? Ecological Objective E4 is "Contribute to further reducing avian, pinniped and fish predators that negatively impact the habitat and populations of focal fish species in order to improve abundance and survival of these fish species." How does the Program and Council determine the priority for implementation when objectives conflict or are contradictory?

2024 ISAB Recommendations

1. Describe the basis for creating goals and objectives for focal wildlife species.
2. Identify the criteria used to identify some native species as focal species for recovery actions and other native species as threats that require control actions to limit their abundance and distribution.
3. Explain how priorities for implementation are determined when objectives conflict or are contradictory.

- ***Ecological Goal and Objectives***

Ecological objective 1 (E1) is to "contribute to maintaining and improving habitat quantity, quality, connectivity, and functions while taking into account climate change." Associated with E1 are seven strategy performance indicators (E1-1 to E1-7). All but one SPI relates to amounts of habitat protected or improved (E1-6 relates to the number of fish screens). None of these SPIs relate to climate change specifically. The lack of SPIs specific to climate change is one of the most critical gaps in the Fish and Wildlife Program that will influence its future success. This is further elaborated in Section II.2.A.7.

All but one of the Ecological Objectives start with "contribute to," which is not a strong target for a measurable objective. We realize that the Fish and Wildlife Program is not the only entity that is responsible for these ecological factors that influence fish and wildlife in the Columbia River Basin. However, would it be possible to identify joint targets based on regional collaborations? At the very least, could the objectives include "no net loss" or "no net increase," depending on the ecological target, as a minimal level of performance?

The second Biological Objective to "contribute to maintaining and improving water quantity and quality" is broad and undefined, at a minimum, the objective should reflect the Program's priority to protect and restore water temperature and minimize concentrations of Total Dissolved Gases that would have adverse effects on fish.

None of the Ecological Objectives mention food webs, in spite of their importance in the Program (ISAB 2011-1). Food webs are essential to fish recovery, so the goals and objectives should explicitly address their status and priorities.

2024 ISAB Recommendations

1. Develop specific Performance Indicators specific to climate change.
2. The Program should develop workshops to evaluate the consequences of climate change and its effect on model realism and how historical conditions can be used to represent future conditions.
3. Where partners agree, identify joint targets based on regional collaborations.
4. Consider objectives of "no net loss" or "no net increase" as a minimal level of performance when more specific quantitative ecological targets are not possible.
5. Even though quantitative objectives for food webs are difficult or not feasible, the implementation guidance could highlight importance, status, and priorities for food webs.

- ***Strategy Performance Indicators***

Where possible, Performance Indicators should be expressed not only in absolute terms (e.g., hectares of wetland restored, or km of stream made accessible) but also in terms that are relative to the need (e.g., "X km of stream are now accessible, doubling the length of that stream accessible to migratory, and increasing the accessible proportion in the subbasin from 30% to 40%"). Similarly, 1 cfs of water could be either meaningless or highly important, depending on the magnitude of discharge in a particular channel. Some measure of cfs as a function of how much is needed would be far more informative, but calculating how much is needed requires a complex assessment, possibly using life history models and analysis of historical habitat and population data. The Retrospective of the Council's Fish and Wildlife Program, 1980 – 2022 (Homel and Bach 2024) provides a valuable historical context for several of the major Performance Indicators.

2024 ISAB Recommendations

1. Identify Performance Indicators in terms that are relative to the need where possible, or explain context for quantitative Indicators in terms of the relation to the need.

E. RESEARCH

The 2018 ISAB Review identified research needs for specific components of the Program, for example, that the recommendations in the Executive Summary of the ISAB/ISRP's Critical Uncertainties Report (2016-1) would be useful in updating the Fish and Wildlife Program. The Critical Uncertainties report was used to develop the Council's Research Plan (2017) and included a review of the extent to which Fish and Wildlife Program research, monitoring, and evaluation projects were addressing key management questions in the Basin. The Program and region have made progress on some of these recommendations, and they will continue to be valuable guidance in future revisions and improvements in the Program. Moreover, the Program would benefit from a periodic examination for emerging uncertainties as the state of the science changes and as project syntheses identify gaps.

Recommendations from the ISAB/ISRP 2016 Critical Uncertainties Report

- Improve communication on research issues and results among project proponents, the public, governmental entities, the Tribes, and others involved with the Basin's water, land, and fish and wildlife resources. Communication leads to partnerships, pooling of resources, spreading of innovations, public support, and solutions that would be difficult for one or a few organizations to achieve alone.
- Foster efforts to synthesize information generated by independent studies by improving the rigor, consistency and availability of annual reports, convening workshops or symposia, and funding special projects as needed to compile, analyze, and review progress in addressing uncertainties.
- Recognize that research on the expected impacts of climate change and human development in the Basin should be taken into account when setting future Program objectives.
- Support research to identify thermal refuges and ways to secure availability and quality of water essential to achieving Program objectives.
- Recognize that toxic contaminants are pervasive in the Basin and support research to determine threats to fish, wildlife, and people because of their persistence and bioaccumulation in food webs.
- Support research to guide the management of non-native species. As conditions change, environments may increasingly favor non-native species, some of which are valued and can be managed.
- Continue supporting research on artificial propagation that will help to measure the benefits and risks to natural populations. Encourage research to help develop

biological escapement goals for the Basin's salmonid populations and refine approaches for harvesting surplus hatchery fish.

- Expand research to identify and track changes in population structure and genetic diversity of focal species. Loss of genetic diversity may compromise the long-term production and resilience of fish and wildlife in the Basin.
- Continue to support and demand rigorous monitoring and evaluation programs that have well-established objectives and potential for basinwide synthesis. Such evaluation is needed to understand the benefits and risks of Program actions and to manage adaptively.
- Recognize that evaluating the effectiveness of conservation actions is complicated by natural variability and statistical sampling error. Many years of careful monitoring are typically required to confirm small but meaningful changes in ecological outcomes from habitat restoration or supplementation projects.
- Support research on ecological interactions in mainstem, lower Columbia River, estuary, ocean plume, and ocean habitats. Understanding the factors in each habitat that limit population growth will improve management of all four H's (habitat, harvest, hatcheries and hydrosystem).

F. MONITORING AND EVALUATION

The 1996 Amendment to the Northwest Power Act requires monitoring and evaluation of results and benefits to fish and wildlife. The 2018 ISAB Review emphasized that monitoring and evaluation in the Program provides critical information to refine actions and maximize the efficient use of scarce resources. Monitoring and evaluation allow the Program to determine whether projects (e.g., habitat restoration, hydrosystem modifications, life-cycle models, fish propagation) have been implemented effectively (McDonald et al. 2007). The 2018 ISAB review indicated that key Program strategies and measures, such as those for habitat and wildlife, often lack monitoring and evaluation plans and adequate funding to address these important components of adaptive management. The need for critical information for habitat protection and restoration remains a central requirement of the Program (2018-3, page 30 and throughout the report 2020 Addendum, Part 1, pages 35-36).

Program requirements for monitoring and evaluation are major components of all ISRP reviews and most ISAB reports. One of the issues we raised in the 2018 Review of the Program was the termination of the Columbia Habitat Monitoring Program (CHaMP) and Integrated Status and Effectiveness Monitoring Program (ISEMP) and lack of systematic monitoring for the Columbia River Basin. Since the 2020 Addendum was developed, the Council, BPA, Tribes, and other partners finalized the Columbia River Basin Tributary

Habitat RM&E Strategy. Also, many of the Fish and Wildlife Program's partners participate in the Coordinated Assessments Partnership. These programs and documents provide a basis for the monitoring and evaluation in the Fish and Wildlife Program, but the Program still lacks an approach or process for expanding results from specific areas to the full Columbia River Basin. The Columbia River Basin Tributary Habitat RM&E Strategy describes the major components of RM&E (ecological concerns, implementation and compliance, regulatory compliance, habitat response, biological response, data management), but it does not create a comprehensive approach for monitoring and evaluation. The Program continues to lack the framework and resources for monitoring and evaluating the habitat and biological resources of the Columbia River Basin that the ISAB identified in the 2018 Review.

In the Anadromous Fish Habitat and Hatchery Projects Review (ISRP 2022-1), the ISRP found that approximately half of the habitat-related proposals did not adequately describe the monitoring and evaluation occurring in their project or subbasin. The ISRP frequently could not determine what was being monitored, what monitoring information was provided by other projects, or how information was shared and used in project evaluation and management decision making. In the preliminary review, the ISRP asked 10 groups of geographically related projects to provide summaries of their collective monitoring and evaluation in a matrix format. In the Fish and Wildlife Committee's October 2021 meeting, Council members and staff expressed support for the general rationale and concept of the matrix but did not feel the response loop was the appropriate process for collecting this information. The Council and staff concluded that the need to link the M&E activities of projects is a much larger task for the Fish and Wildlife Program. The ISRP felt that the request was appropriate for the response portion of the project review process but understood the concern and did not base their project review recommendations on the summaries provided by 6 of the 10 geographic areas, many of which were very useful. Consequently, the ISAB recognizes that there continues to be an information and coordination gap and recommends that the Program develop a process or mechanisms to identify the multiple M&E activities within geographic areas and clearly describe collectively what is being monitored, how it is being evaluated, and how it is being reported. The Program currently lacks this fundamental integration of monitoring and evaluation, and the Columbia River Basin Tributary Habitat RM&E Strategy does not provide coordinated monitoring and evaluation for geographical areas or subbasins.

A hierarchical framework is needed to provide information for evaluating the Program's outcomes across local project sites, river reaches, watersheds, subbasins, and the Columbia River Basin because it is not possible to collect and analyze data for all sites, watersheds, and populations. A scientifically rigorous, integrated RM&E program for a

geographic area would include information on habitat conditions at a subbasin or landscape scale, limiting factors, habitat and fish responses to major types of restoration actions, status and trends in fish and wildlife populations, life cycle models that integrate systemwide information throughout the life history of focal species, and explicit identification of benefits to fish and wildlife. Projects in the Lower Columbia River, Upper Columbia River, and Grande Ronde subbasin have created effective collaborative programs with most, if not all, of these RM&E components. The ISAB recommends that the Council incorporate the following recommendations from the ISRP's Anadromous Fish Habitat and Hatchery Projects Review (ISRP 2022-1) when updating the Fish and Wildlife Program and the implementation of the Columbia River Basin Tributary Habitat RM&E Strategy.

Recommendations from the 2022 Anadromous Fish Habitat and Hatchery Projects Review

- Create a hierarchical monitoring and evaluation framework, identify the major components of its RM&E program, establish the clearly defined RM&E relationships among projects, and ensure the transfer of information among those components.
- Create a process for developing matrices and narrative summaries of M&E actions within major subbasins and geographic areas.
- Develop a specific guidance document on the M&E requirements for individual projects with links to documents that describe the history and current strategy for M&E in the Columbia River Basin. [See the Columbia River Basin Tributary Habitat RM&E Strategy]
- Develop integrated RM&E programs for selected representative subbasins. These would build from the existing subbasins that currently have the potential to provide most of the RM&E requirements. The Program could then conduct a gap analysis to determine what portions of the Columbia River Basin or which fish species would not be represented by those integrated RM&E subbasins and target future RM&E integration for those areas or species.

II.2. SPECIFIC STRATEGIES

The 2014 Program has three overarching strategies: 1) ecosystem function, 2) fish propagation including hatchery programs, and 3) other strategies. These strategies are comprised of sub-strategies. For example, the ecosystem function strategy is comprised of sub-strategies of habitat, strongholds, non-native and invasive species, predator management, protected areas, water quality, climate change, mainstem flow/passage, estuary, ocean, and wildlife mitigation. The 2020 Addendum identified Performance Indicators for most of those sub-strategies. The report below follows the Program's outline of strategies and sub-strategies.

The section of the 2020 Addendum on Strategy Performance Indicators (SPIs) on page 25 lists indicators for each strategy but states, "These indicators are not adopted into the program." To allow for flexibility, the indicators were not adopted into the Program so that they could be adjusted at any time, based on new information provided by managers. For example, one indicator is bull trout abundance. Managers noted that the available data were redd counts, not fish counts, so the indicator now reflects those available data. In contrast, goals and objectives were adopted in the Program and can only be modified through a Program amendment. The ISAB supports the Council's flexible approach to SPI modification.

A. ECOSYSTEM FUNCTION

The Ecosystem Function strategy is "an overarching Program strategy that incorporates many other strategies which will be assessed for implementation separately" (NPCC Staff 2017). One of the major focuses of the strategy has been to mitigate losses to functions in the mainstem that cannot be fully mitigated with actions in the mainstem itself. This mitigation is accomplished primarily through restoration of habitats and biological resources in tributaries (offsite).

The Ecosystem Function strategy is described only in the 2014 Program and is not addressed in the Addendum. The ISAB continues to support recommendations for several areas for improvement identified in the 2018 ISAB Review, which should be considered in future Program revision. The ISAB emphasized that the Ecosystem Function strategy should focus on the entire Columbia River ecosystem, rather than focusing on only habitat in the tributaries. It also highlighted that an ecosystem is a coupled physical-biological system that provides the environmental conditions (i.e., habitat) and biological production

(i.e., food) required to sustain restored populations of fish and wildlife, including riparian habitats, upslope terrestrial habitats, groundwater sources, the estuary, plume, and ocean. The ISAB offered improvements to the principles of the strategy and noted that the general measures appear to be an unorganized list of concerns raised by specific interest groups (2018-3, page 36; Appendix 4, also see the 2020 Addendum, Part 1, page 23). The general measures for ecosystem function could be more focused to avoid overlap and improve clarity.

1. HABITAT

Habitat is a critical component of the Fish and Wildlife Program because restoration of salmon, steelhead**,** and other native fish and wildlife populations cannot be successful without adequate suitable habitat. The 2018 ISAB Review emphasized that the Program, however, does not mention a landscape perspective, despite the ISAB's ongoing focus on this point (see ISAB 2011-4). Moreover, the ISAB was surprised that the Habitat Sub-strategy did not include links to the Program's adopted plans for 59 subbasins, as the ISAB recommended in its review of the 2009 Program (ISAB 2013-1). In addition, research, monitoring, and evaluation are not included in either the Principles or General Measures of the Habitat strategy (2018-3, page 37).

The 2020 Addendum simplified and condensed the indicators for habitat but did not include several of the suggested measures, especially the inclusion of a landscape context. The habitat strategy indicators in the Addendum are measures of the quantity of habitat-related actions and few if any are measures of habitat quality.

The ISRP Resident Fish and Sturgeon Category Review (ISRP 2020-8) recommended that the Council develop strategic approaches for prioritizing or weighting protection of high-quality habitats versus restoration of degraded habitats. In many reports and reviews, the ISRP and ISAB have strongly endorsed the importance of protecting high quality habitat rather than only restoring degraded habitats. Several projects in the Columbia River Basin have developed strategic processes for prioritizing or weighting protection of high-quality habitats relative to restoration of degraded habitats. The ISAB Upper Columbia Spring Chinook report (ISAB 2018-1) commended the prioritization systems for habitat protection and restoration in the Columbia River Basin (e.g., UCSRB 2014). The ISRP emphasized the need for an explicit prioritization strategy when the Colville Confederated Tribes extended the prioritization approach used in the Wenatchee, Entiat, and Methow subbasins to the Okanogan subbasin as well (ISRP 2020-1). Several other approaches have been used in the Columbia River system, such as Ecosystem Diagnosis and Treatment (EDT) in the

Okanogan subbasin, the blocked area above Grand Coulee Dam, and the Willamette River and its tributaries affected by US Army Corps dams. Qualitative Habitat Assessment was used for restoration planning for the Flathead/Kootenai in the early 2000s. The US Forest Service developed a network of Priority Watersheds in the Mid and Upper Columbia Basin for protection of high-quality habitat and also provided special management for Key Watersheds with high-quality habitat for anadromous fish. The ISAB and ISRP have strongly supported the use of these approaches for conservation and restoration, and the recommendations of the ISRP's Resident Fish and Sturgeon Category Review (2020-8) should be considered in updating the Habitat strategy.

Recommendations from the
2020 Resident Fish and Sturgeon Category Review

The Council should require project proponents proposing to protect high quality habitats and restore degraded habitats to:

- include explicit prioritization processes for assessing the relative benefits and tradeoffs of protection and restoration.
- identify metrics for desired outcomes (e.g., population abundance, survival, cumulative habitat quality, inundated floodplains, riparian forests, water temperature, rearing habitat, spawning habitat) in prioritization processes.
- indicate how protection of high-quality habitats would be prioritized or weighted relative to restoration of degraded habitats.
- assess the overall benefit for species of concern and the relative cost-effectiveness of protection and restoration actions.
- identify processes for evaluating protection efforts to confirm the intended long-term outcomes.

2. STRONGHOLDS

The 2014 Fish and Wildlife Program distinguishes Stronghold areas from habitats in general and defines their unique characteristics. Strongholds must:

1. Be designated by the states and tribes, in accordance with state law in the state in which they are located.
2. Provide the ability to manage for wild or natural-origin fish while minimizing impacts of hatchery fish, except where state and federal fish and wildlife agencies and tribes have determined that populations would decline to the point where supplementation efforts are appropriate to avoid extinction and stabilize native wild or natural-origin stocks.

3. Contain relatively intact habitat.
4. Provide the opportunity to create genetic strongholds with adequate buffers to shield them from non-native, invasive species.
5. Provide a reasonable chance of eradicating non-native, invasive species.
6. Be characterized by healthy and abundant fish populations or populations that readily could become healthy and abundant, few invasive species, low risk of habitat degradation, and relatively good ecosystem function.
7. Provide the ability to monitor and evaluate the effect on wild native fish and to provide and map non-hatchery reference watersheds for hatchery-wild stream comparisons, and
8. Encompass areas large enough to withstand human disturbances.

As stated in the 2018 Review, the ISAB sees great value in the Program's Protected Areas, which currently protect over 44,000 miles of rivers and streams of the Northwest from hydropower development, and the potential for the Stronghold Habitat strategy to protect native, wild, and natural-origin fish (2018-3, page 39). In 2018, the ISAB made several recommendations to improve the Stronghold Strategy.

Recommendations from the 2018 ISAB Review

The enormous conservation value of strongholds could be increased by:

1. Supporting and encouraging multiple, geographically distinct strongholds within and among subbasins of the Columbia River Basin.
2. Promoting strongholds that are sufficiently large to preclude risks of catastrophic demographic loss and losses of genetic diversity in the species each stronghold is designed to protect.
3. Working toward functional connectivity between strongholds and other habitats that could potentially hold fish, especially restored habitat areas. The stronghold could serve as a natural demographic source for recolonization of restored habitat by salmonids and other native aquatic species, similar in concept to Marine Protected Areas (MPAs).

The 2020 Addendum did not amend the Strongholds strategy, and the ISAB's previous recommendations are still relevant and should be incorporated into future updates of the Program. We note that a designated network of strongholds can efficiently guide conservation efforts to locations where those efforts are mostly likely to be successful, which is critical when financial or human capital are limited. Although the 2014 Program deferred to states and tribes with respect to designating strongholds, there is also value to

interagency cooperation in rigorously defining stronghold criteria for species that cross administrative boundaries, and we urge the Council to pursue such efforts. The ISAB Food Webs Report (2011-1) emphasized "It is clear that biotic conservation is most successful where actions are aimed at protecting ecosystems rather than by attempting to restore or reclaim them after the damage is done." This strategy is a promising, not fully realized, component of the Fish and Wildlife Program and should be highlighted more prominently in the Program (ISAB 2018-3, page 39).

3. NON-NATIVE AND INVASIVE SPECIES

The 2018 ISAB Review found that the Fish and Wildlife Program provided generally sound guidance, but the ISAB recommended greater specificity. The ISAB suggested that greater emphasis should be placed on preventing introductions of all non-native species, including the movement of currently established species. The review also recommended the addition of measures to prohibit introduction of native species outside their historical native range, unless it is carefully planned and implemented for conservation purposes, and with no damage to other native species (ISAB 2018-3, page 40). Ultimately, where such introductions are proposed, formal and robust risk assessments are warranted prior to the introductions, followed by monitoring for subsequent effects.

The 2018 ISAB Review recommendations for the strategy were not addressed in the 2020 Addendum, and the ISAB continues to support the recommendations. In particular, we strongly recommend explicit recognition of the importance of efforts to prevent introductions and the need for coordination and communication with co-managers and the public. The 2020 Addendum listed two Indicators for the strategy; however, both dealt only with boat inspections. The Indicators for non-native and invasive species could be expanded to include quantitative measures that focus on numbers and local abundance of non-native species in the Columbia River Basin, identity of strongholds (i.e., potential source populations) and life history patterns (e.g., habitat use, food habits, movements) of non-native species, expansion of the documented range of critical non-native species (e.g., northern pike, walleye, smallmouth bass), and outcomes of major control efforts.

In the ISAB Predation Impacts and Management Effectiveness Report (ISAB 2019-1), UCUT Reintroduction Reports (ISAB 2019-3, ISAB 2022-2), and Resident Fish and Sturgeon Category Review (ISRP 2020-8), the ISAB and ISRP emphasized the need to manage effective feedbacks between anglers, managers, and fish populations and ecosystems, rather than simply attempting to control non-native species themselves. The ISRP also recommended the creation of a multi-state task force for northern pike in collaboration

with the Invasive Species Councils in the Columbia River Basin, which was formed and is tracking the distribution of northern pike and monitoring for its presence downstream using eDNA. The Fish and Wildlife Program could incorporate more species measures similar to the actions and accomplishments listed above.

The ISAB's report on *American Shad in the Columbia River: Past, Present, Future* (ISAB 2021-4) reviewed information on the recent increases in numbers of American shad in the Columbia River Basin and the potential consequences for salmon and steelhead, other fish species, and birds and mammals that prey on them. More adult shad are counted at Bonneville Dam than all anadromous fishes combined. However, future interactions between shad, salmon, and the Columbia River ecosystem will keep changing as temperatures increase, sea-level rises, and river flows diminish. A warmer climate will likely favor shad over salmonids, and the abundances of shad, other fishes, and their predators are likely to show wide and unpredictable fluctuations. The ISAB report concluded that the currently known net effects of shad on salmonids are minor (Quinn et al. 2024), as there is a mix of positive and negative influences and outcomes. This reminds us that inter-specific interactions are complex, and basic research on non-native organisms is often needed to determine their likely effect and the most efficacious strategy for their management. Moreover, the fate of shad and understanding their impact in the ecosystem is not fully settled. There may yet be ways that their sheer numbers and biomass negatively affect - albeit indirectly – salmon and other native species.

Recommendations from the 2021 Shad Report

- Continued monitoring of shad numbers passing the dams in the Columbia River and major tributaries
- A formal scoping process among management agencies and other stakeholders to identify and prioritize the critical uncertainties
- A short-term [ca. five-year] goal of describing fundamental life-history patterns of the species in the Columbia River Basin
- Development of predictive life history models, starting with a general conceptual model of shad use of the Columbia River Basin
- Multi-species modeling to evaluate the potential importance of interactions between shad and anadromous salmonids and other native species.

In addition, the ISAB recommends that the Council develop specific Performance Indicators and Implementation measures to track the trends in shad populations in the

Columbia River and identify their potential risks for the ecosystem and anadromous salmonids.

The 2014 Fish and Wildlife Program provides a rationale for management of non-native and invasive animal and plants because they imperil native species through predation, competition for food, interbreeding, disease transmission, food web disruption, and physical habitat alteration. Because non-native species are threats to the Program's mitigation and restoration effort, ongoing monitoring is critical to quickly detect new non-native occurrences, document the spread of established populations, and identify potential harm to critical populations and habitats by non-native species. Monitoring for non-native organisms at the scale of the Columbia River Basin is challenging and costly, but new eDNA methods provide a more cost-effective approach for monitoring at the basin scale for many organisms (Young et al. 2022, Elmore et al. In press). Under rigorous quality assurance conditions, eDNA sampling and analysis is superior to traditional methods for detecting the presence of most fish and other aquatic vertebrates, mussels, and some invertebrates, but remains a work in progress for crayfish, cyanobacteria, and some invertebrates (Deiner et al. 2021). The ISAB recommends that the Fish and Wildlife Program design an initial eDNA monitoring program for the Columbia River Basin (cf. Altermatt et al. 2023) and develop performance indicators based on the information the monitoring program would provide. The costs and tasks of an eDNA monitoring could be shared with partners, including the Tribes, states, federal agencies, and municipalities.

4. PREDATOR MANAGEMENT

The 2018 ISAB Review found that the rationale, principles, and general measures specified in the Predation Management section of the Program are for the most part scientifically sound, justified, and fairly comprehensive. The ISAB pointed out that the Program acknowledges that changes to, and management of, the hydrosystem are linked to the issues in predator management. The Program also identifies habitat restoration as a key strategy to reduce predation pressure at various life stages in the salmonid life cycle.

The Implementation section of the 2020 Addendum calls for specific actions related to predation by northern pike, pinnipeds, and avian predators. It calls for BPA to fund and implement a northern pike removal effort in the Upper Columbia River Basin and work with relevant state agencies and tribes on a strategy to support this effort. It calls for the federal agencies, states, and tribes to support efforts to control pinnipeds, consistent with the intent of the 2018 sea lion legislation (Public Law 115-329). Lastly, it calls for the action agencies (Bonneville, Corps of Engineers, Bureau of Reclamation) working with state and

tribal partners to provide adequate funding to implement activities in the estuary and inland to reduce avian predation on listed juvenile salmon and steelhead. These actions are consistent with the overall recommendations of the ISAB reports and ISRP reviews on predation management.

Nevertheless, the 2018 ISAB review identified several gaps and suggested improvements in the Predator Management strategy, few of which were addressed in the Addendum. The Program has a goal of developing a single common metric to evaluate predation. The ISAB questioned this because a single metric cannot address all management concerns (e.g., short-term effects of predation on harvest opportunity and spawner abundance or long-term effects on population viability and ecosystem resilience and sustainability). In the Predation Metrics Report (ISAB 2016-1), the ISAB recommended two types of metrics be used in the context of life-cycle models: adult equivalence-factor and population-growth metrics. The ISAB also advised the Program to explicitly address the potential consequences of compensatory mortality[2] on fish responses to predation and design of predation management strategies. The 2018 Review called for developing better information to evaluate how actions in the Basin such as hydrosystem spill and flow, large releases of hatchery fish, habitat alterations, and harvest affect pinniped predation in the Columbia River plume and nearshore ocean.

The 2018 ISAB Review also emphasized that there are critical uncertainties about the role of other native and nonnative fish species, especially with their roles as competitors (i.e., density dependence) or predators at some life stages. The ISAB advised that the Program should carefully assess the rationale for potential expansion of northern pikeminnow removals to other mainstem dams in the lower Columbia River. Such actions, particularly on a native fish, should be based on quantitative studies of the possible consumption of juvenile salmon and steelhead and the interactive responses with other species of prey and predators. We emphasize that control measures might be warranted at locations where the hydrosystem creates artificial conditions that allow predators to have greater impacts on migrating juveniles, but control of native fish throughout the entire mainstem may not be supported by a more comprehensive analysis. Research on interaction of

[2] Compensatory mortality occurs when predation mortality at one life stage is offset to some degree by decreased mortality at the same or subsequent life stages. Examples of potential mechanisms driving compensatory mortality include (1) density-dependent survival due to factors other than predation, (2) selective predation based on fish size and condition, and (3) prey switching behavior of predators, which may be caused by a change in abundances of alternative prey species or when secondary predators increase predation on salmon following control of the primary predator (ISAB 2016-1).

native and nonnative species and incorporation of interactions into life-cycle models that evaluate salmon survival are needed.

Trade-offs of hydrosystem operations, cost effectiveness, public perception and support for non-native and predator control and removal should be further studied in the context of an integrated salmon life-cycle model. The effects of non-native species are complex and not necessarily all negative for salmon. For example, there is evidence that American shad could benefit salmon by serving as a predator buffer (Wargo Rub 2019, Good et al. 2022), and as a prey source during larval stages (ISAB 2021-4, Quinn et al. 2024). On the other hand, this predator buffer could have a detrimental effect. Petersen et al.'s (2001) discussion of bioenergetic analyses by Petersen and Ward (1999) suggested that the added benefit of a high-energy prey item like shad to the diet of northern pikeminnow could contribute to larger size and thus higher predation rates of this major predator on juvenile salmon and steelhead in the Columbia River system. Several possible actions identified since the development of the 2014 Fish and Wildlife Program offer constructive approaches that potentially incorporate evaluation of tradeoffs in predation management, hydrosystem operation, cost effectiveness, and public acceptance.

The 2017 Council staff's progress report on Program measures (NPCC Staff 2017) indicated that, since the 2014 Program, progress had been made on 10 of 14 Program measures for the predation management strategy. The 2018 ISAB Report pointed out that the Council had not formed a technical work group to determine the effectiveness of predator-management actions in the Basin, a general measure under the Predation management strategy. The ISAB encourages the Council to proceed with this measure of the Program and address several of the questions identified above.

In 2019, the ISAB completed the Predation Impacts and Management Effectiveness Report (ISAB 2019-1), which directly examined many of the issues the ISAB raised in the 2018 Program Review and answered the Council's questions about predation management in the Columbia River Basin. Several of the major conclusions of that report should be considered in updating and improving the Fish and Wildlife Program.

Selected Conclusions from the
2019 Predation Impacts and Management Effectiveness Report

- A system-wide, ecosystem-based approach for assessing and managing fish, avian, and pinniped predators collectively is needed to create a more effective and consistent framework for developing and implementing control actions. Assessing

impacts of all potential predators throughout the Columbia River Basin will require integrated analytical tools, such as life-cycle models, measurement of SARs, and density dependence analysis.

- Benefits associated with hydrosystem changes, habitat enhancement, or other management actions likely will be reduced or nullified if predator control does not occur. Substantial changes and additions in predator management in the Fish and Wildlife Program are needed.
- A better stratified sampling program needs to be implemented to estimate and evaluate Basin-wide predation. Information on Basin-wide predation is less well developed because not all predator groups are measured in each year. Information in the Basin should be collected throughout the system and statistically representative of the system.
- Fish consumed at different stages in their life cycle have different consequences for the eventual goal of increasing returning adult salmon. Generally, mortality later in the life cycle is more detrimental than mortality earlier in the life cycle. Economic costs of the different interventions could modify decisions about preferred management actions.
- Information on survival of salmon throughout the life cycle (e.g., the Comparative Survival Studies [CSS], survival estimates by upper Columbia River PUDs [Public Utility Districts], SARs) will be critical for development of a common metric to assess the impact of predation across all predator species. Survival in the ocean can be measured, but our understanding of the causal factors is much more limited.
- It is unlikely that the current life-cycle models will have adequate information to accurately model compensation by predators or prey in the near future, with the exception of avian predators for some salmonids.
- The life-cycle models should be run using a range of environmental conditions that are currently related to survival or may reflect future environmental conditions (e.g., climate change) to assess both the mean and variability in subsequent survival.
- Cost effectiveness of predator control needs to be included when deciding where and what kinds of predator control measures to implement. Assessment of cost effectiveness of different predator control programs in the Basin and their collective system-wide survival effectiveness are not consistent throughout the Fish and Wildlife Program.

5. PROTECTED AREAS AND HYDROELECTRIC DEVELOPMENT AND LICENSING

As stated for the Strongholds Strategy, the Protected Areas Strategy is an important and often overlooked component of the Fish and Wildlife Program (ISAB 2018-3, page 45). The strategy was not modified by the 2020 Addendum, but there are several indicators related

to FERC licensing listed for this strategy. The 2018 ISAB Review supported the possible actions described in Council's staff assessment report (NPCC Staff 2017) and recommended that Council staff should continue tracking proposals for new hydropower projects in protected areas. Overall, this is a valuable strategy for the Fish and Wildlife Program, which should be maintained and highlighted in the Council's products and information sources. The website for the Protected Areas could be linked to the Performance Indicators dashboard.

6. WATER QUALITY

The 2018 ISAB Review found the guidance in the Water Quality Strategy to be scientifically sound but recommended increased actions to improve water quality (ISAB 2018-3, page 46). The 2020 Addendum did not include modifications to the strategy, but three Performance Indicators are related to temperature and one related to total dissolved gases. The 2018 Review criticized the focus on temperature, total dissolved gases, and toxic contaminants (to a much lesser degree) and suggested the Program should expand its measures to address other aspects of water quality in the region (e.g., nitrogen, phosphorus, dissolved oxygen, pH).

The ISAB reviewed several proposed projects and experiments related to total dissolved gases (TDGs) in the Columbia River Basin since the 2018 Review. We raised questions about the effects of TDG below Grand Coulee Dam in the review of the UCUT Phase I Reintroduction Report (2019-3), and the Tribes responded by including TDG monitoring in the Phase 2 Plan (ISAB 2022-2). Monitoring of TDG and its consequences for reintroducing salmon above Priest Rapids and Grand Coulee dams will continue as part of the recent funding for Phase 2 of the Reintroduction Plan. This water quality monitoring should be included in the general measures for the Water Quality strategy in future updates of the Program. The ISAB also reviewed the proposed NOAA spill experiment (ISAB 2018-2) and recommended a number of biological questions that should be addressed in monitoring experiments to measure the effects of spill on both TDG and fish exposed to high concentrations of TDG.

An area of progress since the ISAB's 2018 Program Review has been actions and federal investments as part of the Columbia River Restoration Act. In 2020, EPA awarded over $2 million to projects for work related to Clean Water Act Section 123, $6.9 million in Bipartisan Infrastructure Law funding to reduce toxics in fish and water throughout the Basin in 2022, and over $72 million in 2023, demonstrating a growing program. Future

updates of the Fish and Wildlife Program should identify direct linkages to these programs and monitoring efforts in the Implementation section.

The Program's efforts to improve water quality related to temperature and total dissolved gases are commendable, but the ISAB encourages the Council to revise the Program to address the effects of toxics and potential remediation actions more directly. As noted in the 2018 ISAB Review, NOAA Fisheries identified toxic chemicals as a major obstacle to salmon recovery in the Columbia River (Lundin et al. 2017). Research in the Pacific Northwest has documented effects of toxic chemicals on growth (Spromberg and Meador 2006, Mebane and Arthaud 2010), migration (Ross et al. 2013), reproduction (Spromberg and Meador 2006, Scholz et al. 2011), disease and immune system function (Jacobson et al. 2003, Spromberg and Meador 2006), predator avoidance (McIntyre et al. 2012), and survival (Meador 2013). A recent analysis of estimated acute and delayed mortality rates for seaward migrating juvenile Chinook salmon in the Superfund site in the lower Willamette River is an example of the potential benefits for salmon populations by reducing toxic chemicals. Based on estimates from a life cycle model, improving juvenile survival by 54% could increase adult Chinook salmon population abundance by more than 20%, possibly through remediation of toxics in the Superfund site. Reservoirs in the Columbia River hydrosystem increase sediment storage and long-term accumulation of adsorbed toxic chemicals (EPA 2009). Future collaboration of the Fish and Wildlife Program with water quality improvements to reduce toxic chemicals funded by the Columbia River Restoration Act and other entities would benefit habitat for salmon, steelhead, and other aquatic organisms.

7. CLIMATE CHANGE

Climate change is likely to transform the Columbia River Basin and its native biological diversity at a broad landscape scale (ISAB 2007-2). Thus, it is a major challenge for fish and wildlife resources in the Columbia River Basin and a critical strategy gap in the Fish and Wildlife Program. The 2018 ISAB Review emphasized that scientific evidence is unequivocal that human actions are driving climate change and ocean acidification. The ISAB recommended the Council to increase its efforts to promote public awareness, convene science/policy workshops, and encourage the development of alternative energy sources (2018-3, page 47) that contribute less to greenhouse gases. We add that the development of new or substitute energy resources should receive thorough consideration for their impacts and favorability to salmon and steelhead, other coldwater species, and local wildlife.

Our 2018 Review recommended several improvements in the Program, requirements of projects, and new Program-wide actions. These recommendations were not addressed in the Addendum, even though the first major Ecological Objective calls for the Program to address climate change. The 2020 Addendum indicates that climate change will be addressed broadly across multiple strategies and actions within the Program and with regional partners.

> "With regard to program and project implementation, there is no one specific action to focus on to address climate change impacts. The need instead is to work across all aspects of the program to understand the implications of climate change and how to make the most effective decisions for fish and wildlife in that context." (2020 Addendum, Part 2, page 38)

The lack of specific direction, actions, and Performance Indicators is one of the most critical gaps in the Fish and Wildlife Program that will influence its future success. The Climate Change Strategy has no specific indicators but refers to indicators related to Mainstem Flow, Water Quality, and Ocean Strategy Performance Indicators. Actions broadly within the Program and best-practices can benefit from robust forecasting of climate conditions and from selecting mitigation alternatives aimed at habitat and population resilience that accommodate those forecasted conditions.

Given the overwhelming importance of climate change for the future of the Program and the Columbia River ecosystems, the Program must explicitly identify and implement climate-related research, synthesis with regional partners, climate-resilient restoration planning and actions, and public outreach and communication. A set of tools and a menu of best practices need to be identified and continually refined for the Program and its collective projects to respond to the forecasted changes to the landscape. Several recent ISAB reports and ISRP reviews address the need to include climate change analysis and identify actions to reduce the risks related to climate change. The ISRP called for improvements in climate change analysis and adaptation in numerous projects in the three major categorical reviews since 2018 (ISRP 2019-2 Mainstem Categorical Review, ISRP 2020-8 Resident Fish and Sturgeon Category Review, and the ISRP 2022-1 Anadromous Fish Habitat and Hatchery Projects Review).

Many project proposals stated that climate change could affect the projects but did not propose any actions to assess risks or adjust restoration efforts to adapt to climate change or reduce the risks. Anticipatory approaches to evaluate options for adaptation are essential in scientifically sound restoration and hydrosystem management. In these reviews, project proponents were asked to describe how they considered climate change in project planning and implementation. The ISRP reviewed the extent to which projects

addressed this request and found a mixed response.[3] The ISAB and ISRP continue to emphasize that project proponents need to describe how climate change directly influences project selection, design, location, implementation, and monitoring in future proposals. In March 2024, the ISAB began a review of best practices for planning and designing restoration and mitigation actions in the face of climate change (see task description). The ISAB looks forward to sharing report findings with the Council and region by early 2025.

Climate change could substantially affect the survival of salmon and steelhead in the Columbia River Basin. SARs, one of the primary measures of survival in the Fish and Wildlife Program, are affected by climate change and corresponding variability in freshwater and ocean environments. The review of Welch et al. (2020) paper on Chinook salmon SARs along the West Coast highlighted the effects and interplay of ocean survival and climate change. Welch et al. (2020) suggested that management programs should consider the possibility that contemporary survival is driven primarily by broader oceanic conditions rather than local, upriver factors. The ISAB concurred that current SARs for Chinook populations from the Columbia Basin and in other systems are generally low, with recent values below 2% being common, and that the values in the Columbia River Basin are not outliers when compared to rivers throughout the North American range of the species. Low SAR values from marine survival affect the realization of long-term population-level benefits of freshwater management actions. Welch et al. (2020) concluded that improvements in passage through the hydrosystem and restoration of tributary habitats would have little effect on SARs because of the effects of climate change on ocean conditions and therefore have only small effects on Chinook salmon populations, a finding which could have major implications for how salmonids are managed in the Columbia River Basin. The ISAB concluded that the Welch et al. (2020) suggestions about the effectiveness of freshwater habitat actions to improve salmon survival are unsupported by the data and their inferences about management implications are premature. However, the ISAB emphasized that the Welch et al. (2020) analysis underscores the need to further investigate SAR values across populations and to continue investigating oceanic and freshwater contributions to low SARs as a critical uncertainty in the basin that is related to ongoing climate change.

[3] Following the Anadromous Fish Habitat and Hatchery Projects Review, Council staff evaluated the extent to which project proposals covered the proposal questions on climate change, identified a few projects with exemplary approaches, and invited the proponents to present their approaches to the Council's Fish and Wildlife Committee: *Examples of climate change considerations in project planning and implementation* (June 2022).

The ISRP commended the US Fish and Wildlife Service, Lower Snake River Compensation Plan (LSRCP), for their climate vulnerability analysis in the Review of LSRCP Spring/Summer Chinook Production Programs (ISRP 2023-1). Their modeling approach analyzes potential climate-related changes in temperature and water availability for the specific hatcheries and how these, in turn, will affect salmon production. The approach also includes a decision-support framework detailing how climate factors contribute to salmon growth and how changes in those factors might trigger specific hatchery management actions. Similar analyses could guide other hatchery programs and habitat restoration projects throughout the Columbia River Basin, prioritized by potential climate risk and population status.

Conditions in the mainstem Columbia River are likely to change with climate trends (e.g., temperature, flow magnitude and timing) and with predator populations (especially fish and birds). The 2023 ISAB review of the CSS Annual Report (ISAB 2023-2) noted the implicit assumption that the observed record of conditions in the river and ocean adequately describes the likely range of future scenarios and questioned whether this assumption is justified. The ISAB encouraged the CSS to explore approaches to incorporate the influence of climate-related and density dependent factors on the total life-cycle survival of Columbia salmon in future reports. The Program should develop workshops to evaluate the consequences of climate change and its effect on model realism and how historical conditions can be used to represent future conditions.

Finally, the Fish and Wildlife Program should consider how climate change might influence factors that affect future water release strategies in the hydrosystem and full life-cycle survival of salmon and steelhead. The Program should consider how changes in temperature and flow variability, and possible reductions in summer flow could affect natural production, as well as habitat conditions along the migratory corridor. Declining baseflow attributed to climate change are already impacting hydropower production in some systems (Andreoni 2024), which may have rippling effects throughout the Columbia River hydrosystem and ecosystem.

8. MAINSTEM HYDROSYSTEM FLOW AND PASSAGE

The actions and analyses related to the hydrosystem and fish passage are a major portion of the Program. The Hydrosystem and Passage Strategy has a long list of quantitative indicators (2020 Addendum, Part 2, page 41). The 2018 Review noted that Program work on passage and survival of anadromous salmonids has been thorough and well done. Hydrosystem operations, however, change the carrying capacity of mainstem habitats and

impact ecosystem function and species other than salmonids. The Program needs to address mainstem habitat conditions and floodplain connectivity as elements in density-dependent regulation of fish (2018-3, page 49). Increased attention to the mainstem and its floodplain and to species other than salmon and steelhead in the mainstem Columbia River would strengthen the Program. While the Indicators for the hydrosystem and fish passage do not include other species, there are separate Indicators for Pacific lamprey, white sturgeon, and eulachon (see below).

The ISAB reviews the annual reports of the Comparative Survival Study (CSS) of the Fish Passage Center (FPC). The FPC has developed a valuable long-term database on the hydrological performance of the hydrosystem and its effects on salmon and steelhead survival during their seaward migration as juveniles, at sea based on detections of tagged smolts and returning adults, and during their upstream migration as returning adults. The CSS reports since 1998 summarize the trends and provide analyses of the effects of the hydrosystem on salmon, steelhead, and other species in the Columbia River Basin. These studies are invaluable to the Fish and Wildlife Program, and several of our recommendations in our reviews of the CSS Annual Reports from 2019-2023 are directly relevant to needs for the Program.

BYPASS SYSTEMS AND SPILL

The CSS concluded that bypass systems result in hydrosystem-related delayed mortality (i.e., below Bonneville Dam, in the estuary, and early marine period). Their analyses indicated that increased survival likely is related to increased spill. While these trends are consistent with the intended benefits to juvenile salmonids, models indicate that they are not sufficient to even meet the lower targets for SARs of the Columbia River Basin Partnership. Based on initial results, additional actions or other changes in conditions would be necessary to achieve SARs of 2% or greater. This ongoing study will provide critical information about flow management strategies in the Columbia River Basin. The ISAB concurred with the CSS in their conclusion that future analyses should evaluate the impact of daily load following on juvenile fish survival and travel time.

SMOLT-TO-ADULT RETURNS AND SURVIVAL OF UPSTREAM MIGRANTS

Smolt-to-Adult Return rates (SARs) are an important regional measure of salmon and steelhead survival. The CSS reports have provided valuable analyses of SARs, which are critical metrics for interpreting trends and status of salmonid stocks in the Columbia River

Basin and guiding management alternatives for the hydrosystem. Trends in SARs in the Columbia River Basin are a major concern (Ford 2022). SARs for all hatchery and wild stocks of spring Chinook, fall Chinook, steelhead, and sockeye in the upper Columbia and Snake rivers are below the Northwest Power and Conservation Council's 2% minimum SAR objectives (CSS 2023, ISAB 2023-2). Only wild spring Chinook salmon and wild steelhead from the mid-Columbia (i.e., farther downriver) meet the minimum objectives in most years.

We are preparing a report to improve the understanding, calculation, and interpretation of the different survival measures (see task description). As we have noted in several reports, SAR is a convenient metric for the in-river passage of smolts and adults with PIT tags but not a good way to measure survival at sea because it does not explicitly separate natural mortality from fishing mortality. The ISAB recommends continued analyses of survival metrics for salmon and steelhead and more consistent calculation and application of survival estimates, including comparisons between PIT tag and CWT based estimates for a range of populations.

Recent CSS analyses examined the level of SARs needed to realize the Columbia Basin Partnership (CBP) benchmarks and determined whether that level of SAR is consistent with the prescribed Council goals. The CSS concluded that substantially larger SARs than the 2%-6% recommended ranges from the CSS reports will be needed to meet the CBP recovery goals. Evaluation of SARs for some unlisted, interior species, such as sockeye in the Upper Columbia (Wenatchee and Okanogan) could improve our understanding of factors that influence SARs. Some of these species are doing extremely well, and it could be informative to understand why their survival is higher. As the Council reexamines its major goal for abundance of salmon and steelhead, the life-cycle models and analyses of SARs will be essential for developing a revised goal in the future.

In addition to concerns about SARs, from 2008 to 2022, an average of 74% of adult Snake River Chinook salmon migrating upstream past Bonneville Dam survived to Lower Granite Dam, but in the warm year of 2015, only 52% of the adults survived from Bonneville to Lower Granite Dam. The frequency of warm years is likely to increase in the future, and the survival of adults may decrease more than recent averages illustrate. The collective ongoing poor survival of Columbia River salmon and steelhead warrants a comprehensive assessment of the long-term consequences of these trends and consideration of likely scenarios of climate warming.

Recent regional analyses have raised major questions about trends in the status of salmon and steelhead stocks and management of the hydrosystem. The analysis and paper by Welch et al. (2020), the FPC rebuttal, and the ISAB review (ISAB 2021-3) raised important

issues about freshwater versus marine survival and the potential to achieve target SAR values through freshwater management actions. Such questions should be investigated further considering broader regional data as a context for the Columbia River Basin but also more detailed analyses with methods better tailored for the data-extensive Columbia Basin populations (ISAB 2021-5).

The Council's SARs targets generally are not being met to indicate either stability (avoiding jeopardy) or growth (leading to de-listing). The failure to meet survival levels required to maintain or increase population abundances could imply that the populations are more or less destined for future functional extirpation. The 2%/4%/6% SARs levels that the Council adopted were based on a series of modeling analyses (Marmorek et al. 1998, Peters and Marmorek 2001), and most subsequent analyses and population trends support the lower level as a threshold for population maintenance (Petrosky et al. 2020, CSS 2022). The ISAB recommends a comprehensive analysis of population trends and life-cycle modeling across multiple stocks within the Columbia River Basin to determine the stocks at greatest risk of extinction and quantitatively assess the potential success of alternative, and perhaps more aggressive, management actions.

UNCERTAINTIES AND RISK ASSOCIATED WITH BREACHING OF THE LOWER SNAKE RIVER DAMS

One of the major issues explored in the Columbia River System Operations Environmental Impact Statement (CRSO-EIS) and Biological Opinion in recent years has been the potential breaching of the four lower Snake River dams to increase the survival of juvenile and adult salmon and steelhead from the Snake River basin. CSS annual reports (2017, 2019, 2021), a recent peer-reviewed paper (Storch et al. 2022), and a NOAA Fisheries salmon and steelhead rebuilding report (NMFS 2022) concluded that removal of the Snake River dams would have substantial benefits for salmon and steelhead. The CSS analyses projected that substantial increases in SARs are only likely if the lower Snake River dams are breached and spill is maximized at the lower Columbia River dams. However, the causes of the declines in abundance of many Chinook salmon populations along the coast continue to be a topic of scientific debate (e.g., Atlas et al. 2023), as are the actions to reverse those declines (Welch et al. 2020, ISAB 2021-3). While scientists are weighing the effect of breaching on survival, major policy discussions are ongoing and influenced by these studies, so their importance cannot be overemphasized.

The ISAB (2023-2) concluded that CSS analyses of dam removal in the Snake River and several regional publications substantially underestimate the complexities and resulting uncertainties associated with dam breaching. These analyses generally assume the river ecosystem will immediately return to a condition represented simply by shorter water

transit time and fewer encounters with the powerhouse facilities of dams and that other factors affecting SARs will remain the same. The ISAB does not feel that ecological processes at play after dam breaching can be reduced to water travel time and exposure of smolts to structures. While general hypotheses about ecological recovery are well established and supported by case studies of moderate-sized or small dams (Bellmore et al. 2019), removal of large dams can have uncertain effects, particularly for ecosystem processes (vegetation recovery, predator and prey communities, water quality, primary production, straying and life history diversity, and others) in the years immediately following dam breaching. Further, variables representing the ecosystem condition may not be representative of a likely future state that involves greater climatic and ecological variability independent of the dam breaching. Consequently, quantitative predictions of the environmental conditions and effects on salmon will be uncertain. The ISAB recommends the Program develop a more comprehensive and representative analysis of the outcomes of removing the Snake River dams. The benefits clearly can be substantial, but the uncertainties are high and not yet thoroughly evaluated.

As noted above in the Climate Change section, life-cycle models used in the Fish and Wildlife Program to evaluate the consequences of breaching the Snake River dams incorporate a narrow range of hydrological and climate conditions comparable to those in recent years. While the models are informative, the uncertainty when using hydrological and climate conditions outside the range of recent records is much greater and unquantified. The implicit assumption that the observed record of conditions in the river and ocean adequately describes the likely range of future scenarios is likely unjustified. The ISAB recommends the Program, probably through the CSS, explore approaches to incorporate the influence of climate-related and density dependent factors on the total life-cycle survival of Columbia salmon across a broader range of possible hydrological and climate conditions in future reports.

HYDROSYSTEM INFLUENCES ON THE HYDROLOGICAL REGIMES OF THE COLUMBIA RIVER, ESTUARY, AND PLUME AND NEARSHORE OCEAN

Analyses of the influences of the hydrosystem on the hydrology and water quality is often focused on specific reaches of the Columbia River Basin, and evaluation of the consequences of the hydrosystem can equally ignore the effects of the hydrosystem in other portions of the Basin. An integrated analysis of the effects of the altered hydrological regimes caused by the hydrosystem throughout the river, estuary, and plume could address the changes in the timing and duration of discharge, temperature, organic matter transport, and water chemistry. These analyses could compare current conditions and their interannual variability to historical conditions and explore potential future changes in

the face of climate change. Many reports of the ISAB, reviews by the ISRP, analyses by the CSS, and others in the Basin have highlighted the observed or possible effects of alterations in migration timing, habitat availability and use, and water quality on fish in the Columbia River system. The ISAB has recommended sensitivity analysis to investigate the impact of climate change for potential future flow regimes (ISAB 2020-1). Our reviews also recommended the CSS to explore whether there is enough information to estimate how much improvement in habitat and other "controllable" aspects of the hydrosystem are needed to improve SARs (ISAB 2019-2). The ISAB recommends a comprehensive analysis that integrates all of the portions of the Columbia River Basin recognized in the Fish and Wildlife Program and considers the effects of future climate change to identify management issues and need for new and possibly different research.

9. ESTUARY

The 2018 ISAB Review recommended that the Estuary strategy be updated to focus on the lack of quantitative estimates of survival of juvenile salmon, steelhead, and other focal species there (2018-3, page 50). The review highlighted that non-migratory or non-native fishes in the estuary receive little attention in the Program despite their potential interactions with the migratory fishes. The ISAB Shad Report (2021-4) examined the abundance and habitat use of shad in the estuary and potential relationships with salmon and steelhead. The ISAB considered the lack of quantitative estimates of survival of juvenile salmon, steelhead, and other focal species to be the most important information gap limiting the Estuary strategy. The 2020 Addendum called for one specific action in the Implementation section and developed a Strategy Performance Indicator for the Estuary. In addition, three Performance Indicators for Predator Management include the estuary within their spatial extent.

The Addendum called for repeating a 2016-2017 research project to sample juvenile out-migrating salmon in the Lower Columbia River and estuary to assess benefits of estuarine use by interior salmon stocks (Weitkamp et al. 2022). The Council considered the information useful for understanding the benefits of estuary habitat restoration and habitat use by stocks and variations in size and growth rate. The ISAB commends the Council for recognizing the need for information on the abundance of salmon and steelhead in the estuary and their use of the main channel and adjacent floodplains and wetlands.

The ISAB recommends revision of the Program's Implementation section to substantially increase the research on the abundance of stocks and life histories as they enter the estuary and as they migrate out of the estuary. The study of nearly 200 km of the Columbia

River estuary in 2016 and 2017 showed that juvenile salmon and steelhead were actively feeding and growing as they moved downstream and that there is potential for hatchery and wild salmon to compete. Both the mainstem habitat and adjacent wetland habitats were important sources of food. Interannual variation in diets was high, which may reflect contrasting river conditions between years. Recent studies in the Columbia and Fraser rivers found that subyearling Chinook salmon reside in the estuary longer (weeks to months) than previously known and enter the estuary over a wider range of time than previously thought and (McNatt et al. 2016, Chalifour et al. 2020).

The 2020 Addendum included one Performance Indicator for the Estuary strategy, which was related to the spatial extent of habitat restored in the estuary:

> "Acres of estuary floodplain protected or restored per hydrogeomorphic reach. Compare to target of no net loss of native habitats and recovery of 40 percent of historic extent for priority habitats."

The Council did not include additional changes in the Estuary strategy:

> "In developing the Addendum, the Council concluded that changes in the Estuary sub-strategy text were not needed – that the program's provisions on estuary habitat improvements, estuary ecosystem function, floodplain habitat restoration and reconnection (including as an emerging program priority), food web considerations and other matters are consistent with the substance of these recommendations and sufficient to provide support for implementation." (Appendix of the 2020 Addendum)

The ISAB appreciates the advances in the Program in understanding the importance of the estuary for salmon, steelhead, other fish species, wildlife, and ecosystem functions, but several aspects of the Estuary strategy could be strengthened, and doing so would greatly benefit the entire program.

Most of the actions and Performance Indicators are related to assessment and restoration of habitat area in the Lower Columbia River estuary, but none directly evaluates or tracks the abundance of stocks and life histories of salmon and steelhead. The 2018 ISAB review cited previous ISAB advice from the Columbia Estuary Ecosystem Restoration Program CEERP review ISAB 2012-6:

Recommendation from the 2012 CEERP Review

A highly focused RME approach that estimates stock-specific survival rates in all major habitat types in the estuary and identifies habitats/locations where there are survival bottlenecks for species and stocks that migrate through Federal Columbia River Power System (FCRPS) is needed. Once these estuary bottlenecks are identified, it will be much easier to determine the most cost-effective approaches to habitat restoration that will be of benefit to Columbia River fish and wildlife.

The Anadromous Fish Habitat and Hatchery Projects Review (ISRP 2022-1) found that most monitoring in the estuary is measuring water quality or acres of habitat restored, and few of the projects in the Program actually measure the composition and abundance of salmon, steelhead, and other fishes. Some restoration projects document the occurrence of hatchery fish using restored habitat based on PIT tag detections, but this does not provide quantitative measures of abundance and life history types of wild and hatchery fish. Though Lower Columbia River projects have asserted that ecosystem restoration in the estuary has provided direct (onsite) and indirect (offsite) benefits to salmon, the ISRP questioned the strength of the supporting evidence and validity of the conclusion (also see ISAB 2014-1).

The 2020 Addendum pointed out that the information from the 2016-2017 study (Weitkamp et al. 2022) is critical to connecting how salmon use the lower river, estuary, plume, and nearshore ocean. To better understand the linkages between these environments, the Program needs to determine the abundance of stocks and life histories as they enter and leave the estuary. Recent studies in the plume have shown that mortality increases as fish move through the plume and the changes in the location of plume strongly affects growth. Moreover, survival has been strongly linked to smolt timing as well as size, so studies need to integrate these factors (Scheuerell et al. 2009).

The Fish and Wildlife Program generally considers the estuary to be a discrete terminal area of the Columbia River Basin and attempts to address habitat conditions there. An overlooked aspect of the lower Columbia River estuary is its linkages to management actions for fish populations, propagation, and the hydrosystem upstream of the estuary. The hydrosystem's effects on the timing of the hydrograph, water temperature, organic matter transport, and water chemistry have major effects on the estuary and change from year to year, complicating the ecological interactions in the estuary. Timing of salmon and steelhead migrations have been altered by habitat and hydrosystem modifications, and hatchery releases result in pulses of fish moving through the estuary, often at times that differ substantially from historical migration periods. Survival through the lower Columbia

River and plume are often combined based on available data from Bonneville Dam, but the estuary and plume are distinct regions with greatly different factors that determine the survival of migrating juveniles and adults. The Program would benefit from a more explicit understanding and management of the estuary and its linkages to the upstream river and nearshore ocean (Bisbal and McConnaha 1998).

10. PLUME AND NEARSHORE OCEAN

The Program cannot alter ocean conditions and their impacts on salmon survival, but it has major influences on the salmon and steelhead that enter the ocean, the relative abundance of hatchery and wild stocks, life history types, timing of migration, and hydrological conditions in the river. The 2020 Addendum did not change the Plume and Nearshore Ocean strategy, other than to develop a Performance Indicator: "NOAA's stop light indicator chart of ocean conditions." This Indicator is based on an overall measure of conditions in the plume and nearshore ocean, is not related to actions in the Program, and provides no measure of Program success. Instead, it is an indicator of the challenges facing species that use the plume and nearshore ocean environment and the need for Program actions to adjust management to deal with the challenges.

The 2018 ISAB Review pointed out that most ocean mortality of salmon occurs in the initial phase of entry into the plume and nearshore ocean, though this period is difficult to study, estimates are imprecise, and causal mechanisms remain unclear. The review recommended that this strategy should be updated to guide and implement projects and actions aimed at filling large gaps in population-specific information on these effects (including hatchery/wild interactions) in an ecosystem and life-cycle context (2018-3, page 53). It also recommended that the description of the strategy should clarify which species are included by listing focal species in the strategy statement. Indicators in the 2020 Addendum for Pacific lamprey, sturgeon, and eulachon include metrics specific to the estuary, plume, and nearshore ocean. As noted for the Estuary strategy, a number of studies have shown or indicated high levels of mortality soon after entering the ocean, and additional monitoring and better understanding of causes would strengthen the Program. Most monitoring has focused on juvenile salmonids and the 2018 Review recommended expanding the monitoring to include returning adult salmonid survival and other focal species in the Columbia River plume/nearshore ocean. Later ocean mortality of older age classes may be more prevalent than previously considered. For example, predators such as resident killer whales selectively prey on larger Chinook salmon. Predation on adults may also be changing faster than in past decades. For example, the current sea lion

abundance and predation on adult salmon and especially spring Chinook are higher than in the past.

The 2014 Fish and Wildlife Program calls for a number of general measures that specifically include the plume and nearshore ocean. It highlights the importance of protecting ecosystem functions in the Columbia River estuary and near-shore ocean discharge plume and connecting those functions to actions within the Columbia River mainstem. The Program calls for "continued monitoring of the Columbia River plume and ocean conditions, assessment of impacts on salmonid survival, and evaluation of the limits of restoration potential in the basin given variable ocean conditions." Many of these general measures in the Program are consistent with the ISAB's recommendations for Program improvements in this review.

The Council established the Ocean and Plume Science and Management Forum (Ocean Forum), which maintains a regional dialogue to update the Program on recent information and emerging issues. The 2020 Addendum called for the repeat of the 2016 and 2017 study of the estuary and plume and indicated that several descriptive studies of the plume and nearshore ocean by cooperators were important sources of information. It is clear the Council and its Fish and Wildlife Program consider the effects of the plume and nearshore ocean to be major factors of the Program's goals and objectives.

The Implementation section of the Addendum highlighted its concern about the reduced funding for the research program that is necessary to support the Plume and Nearshore strategy.

> "Monitoring and research actions that generate a basic, important level of information about the ocean are thus a core part of the program and need to be preserved. Over the last decade Bonneville has significantly reduced support for the ocean research program, resulting in a more than sixty percent reduction since 2011. The Council supports restoring funding for this element of the program to the level needed to address the following existing and new monitoring and research components . . ."

The ISAB shares the Council's concerns about the reduced funding for these critical studies related to the estuary, plume, and nearshore ocean. There can be a mistaken assumption that we can do nothing about the ocean, so funding estuarine and ocean studies is unnecessary. This perspective fails to recognize that we manage the hydrology and environmental characteristics of the river, fish stocks and life histories, freshwater and estuarine habitats, which are linked inextricably with the performance of salmon in these habitats and the nearshore ocean. Continued erosion of the studies required to

understand changing ocean conditions severely weakens the Program's ability to adapt its management actions to this critical component of the Columbia River Basin.

11. WILDLIFE MITIGATION

Construction and Inundation Losses have been assessed for most dams, but Operational Losses have not been assessed or addressed except for at Libby and Hungry Horse dams and through settlement agreements covering the Willamette Basin, IDFG's share of mitigation at Albeni Falls, and IDFG's share of mitigation at Deadwood Dam. These losses remain an area of the Program that requires attention and additional effort (ISAB 2018-3, page 54). The ISAB also recommended basin-level analyses and summary of the overall effects of BPA's wildlife mitigation efforts, which was recommended in the ISRP review of the Wildlife Projects (ISRP 2017-7).

The 2020 Addendum did not revise the Wildlife strategy but developed four Performance Indicators, all of which are based on project implementation and not on wildlife status, abundance, or ecological characteristics. The ISAB supports the recommendations of the 2018 ISAB Review and encourages development of Performance Indicators that are quantitative and relate directly to the ecological status and characteristics of wildlife.

B. FISH PROPAGATION INCLUDING HATCHERY PROGRAMS

The 2018 ISAB Review concluded that the potential success of this Program strategy depends on: (1) fish possessing genetic and phenotypic characteristics well-suited for the recipient natural environment and genetically-compatible with recipient populations, and (2) the capacities of the environments receiving the fish to accommodate these recruits. Unfortunately, methods for predicting the suitability of production fish to a receiving location's environment are not well established. Recommendations for brood stocks tend to favor locally adapted stocks or nearest-neighbor sources to avoid stock mixing. When using nearest-neighbor sources, multiple capacities need to be addressed, including spawning habitat limitations, juvenile nursery capacity, thermal refuges, among others. Ultimately, the greatest need is to address whether releases are additive and compatible to wild production rather than compensatory or competitive with local populations.

The 2018 Review recommended that the Program should also examine the total impact of fish releases made by the many diverse programs. For instance, do cumulative hatchery releases of juvenile salmonids overwhelm available food resources in subbasins, the

mainstem, estuary, or ocean plume? (2018-3, page 56). In our Predation Management review (ISAB 2019-1), the ISAB noted that hatchery fish might buffer predation by protecting wild fish that are concurrently migrating with hatchery releases. Conversely, the timing and location of hatchery releases could act as attractants for fish and avian predators at the expense of wild fish. The complex outcomes of hatchery release strategies require continued investigation by the Fish and Wildlife Program.

The 2018 ISAB Review commended the scientific guidance for propagation of salmonids and made suggestions for 1) considering the capacity of the river systems and 2) examining collective effects of hatcheries for salmonids and other fish species. The 2018 ISAB Review noted that genetic and habitat suitability and cumulative effects of multiple hatchery programs need to be considered in the artificial propagation programs also for white sturgeon, Pacific lamprey, kokanee, resident trout, burbot, and non-native fishes.

In a program as large and complex as the Fish and Wildlife Program, there is a tendency to assume or accept as self-evident that the collective benefits of the multiple components will be substantial and the conflicting effects of different strategy will not diminish the overall success of the program. The 2018 ISAB Review highlighted the risk of diminishing the importance of protecting and restoring native fish and their habitats.

Comment on Vision of the Program from the 2018 ISAB Review

The challenges of managing extensively altered landscapes and river networks often cause decision makers and managers to shift their focus to artificial replacement of fish through hatchery production, and goals for naturally produced native fish are viewed as secondary and unattainable.

The ISAB continues to recommend an explicit assessment of the *collective effects* of the propagation efforts in the Columbia River Basin and an evaluation of the relative priorities of the Program's major strategies and actions to mitigate for the effects of the hydrosystem and maintain the diverse ecosystems of the Columbia River Basin.

A valuable addition in the 2020 Addendum was the development of a Biological Objective to contribute to achieving the targets for salmon and steelhead abundance developed by the Columbia Basin Partnership. The first Performance Indicator for the Fish Propagation and Hatchery Strategy is progress toward Partnerships targets for hatchery production of specific stocks of salmon and steelhead. The ISAB commends the Program for including these specific hatchery production targets but recommends a formal ongoing analysis to

refine these estimates and relate them to the overall goal for abundance of salmon and steelhead for the Columbia River Basin.

The ISRP reviewed the Lower Snake River Compensation Plan's program for spring and summer Chinook salmon and examined their monitoring and evaluation of benefits and risks of supplementation (ISRP 2023-1). The review found all of the supplementation programs have, to varying degrees and adequacy, ongoing assessments of supplementation and commended the program for its extensive ongoing monitoring and evaluation efforts.

The remaining six Fish Propagation and Hatchery Indicators in the 2020 Addendum call for tracking objectives for sturgeon, cutthroat trout, kokanee, redband trout, Pacific lamprey, and burbot hatcheries and comparing the outcomes to hatchery management plans and approved master plan. The ISAB assumes that quantitative hatchery objectives will be tracked as performance measures. The Program should clearly describe how these Performance Indicators will be evaluated collectively and how the Fish Propagation and Hatchery strategy will be coordinated and adjusted with the other major strategies in the Program.

C. OTHER STRATEGIES

1. WILD FISH

The 2018 ISAB Review suggested a more comprehensive framework of habitat quality across watersheds and connectivity throughout the hydrosystem. A revised strategy should include measures to increase habitat quality, increase the number of restored habitats across watersheds, and increase connectivity throughout the hydrosystem (2018-3, page 57). The 2020 Addendum did not include Program modifications to consider the wild fish management policies and actions at a broader and more integrated landscape scale as recommended by the ISAB 2018 Review. The Council did not directly comment on this ISAB recommendation and did not include any actions to address it:

> "The Council concluded that the provisions of the Wild Fish strategy and Ecosystem Function strategy and sub-strategies provide the necessary support for implementing native resident fish protection and enhancement to mitigate for hydrosystem impacts. The Council included in Part I of the 2020 Addendum goals, objectives, and performance indicators relating to native resident fish populations, including Redband Trout (including

> Redband Trout in the Deschutes River) in particular. … The Council did not identify any particular implementation need that required attention in Part II of the Addendum." (Appendix of the 2020 Addendum)

A positive addition in the 2020 Addendum was the development of a Biological Objective to contribute to achieving the targets developed by the Columbia Basin Partnership. The first Performance Indicator for the Wild Fish strategy is progress toward the Partnership's targets for adult abundance escapement targets for natural-origin salmon and steelhead. The ISAB commends the Program for including these specific targets but, as with the Propagation and Hatchery strategy, recommends a formal ongoing analysis to refine these estimates and relate them to the overall goal for abundance of salmon and steelhead for the Columbia River Basin.

The Performance Indicators also included quantitative indicators to track 1) abundance of populations identified through Coordinated Assessments Partnership, 2) total counts at Bonneville Dam, Lower Granite Dam and Willamette Falls, and 3) trends in genetic diversity measures (heterozygosity, allelic diversity, private alleles, heterogeneity, population structure, etc.). The ISAB encourages the Program to relate the two Indicators for abundance to the subbasin targets established by the Columbia Basin Partnership. We also encourage development of specific quantitative targets for the genetic diversity measures to the extent possible.

2. THE USE OF HATCHERIES FOR REINTRODUCTION

One strategy in the Fish and Wildlife Program was to use hatcheries where appropriate for reintroduction of fish into areas where they had been blocked or extirpated. The 2018 ISAB Review of the Program identified several key principles that should be added to the Program to guide reintroduction efforts (ISAB 2018-3, page 59).

Recommendations from the 2018 ISAB Review

Donor Populations:

1) Preference should be given to donor stocks in close proximity to the receiving system; ideally, donor and recipient locations should not be more than 100 km apart. If donor

and recipient populations reside in the same watershed, upstream populations should be favored over downstream donor populations.

a. Rationale:

i. Geographically close river systems often have similar environments, so better adaptability may be expected from local transplants.

ii. Fish from geographically close river systems will reduce the risks of strays from the project interbreeding with neighboring populations. Strays from such systems are likely already occurring naturally.

iii. Local transplants also reduce the risk of introducing foreign pathogens or parasites.

iv. Straying is expected to be less when upstream donors are used. Additionally, these fish are expected to have adequate energy stores during the adult migration to reach recipient locations.

2) Infrastructure should be present in the donor system(s) to allow for the capture of adequate broodstock.

3) The donor population(s) should be robust enough to tolerate the extraction of broodstock for up to three generations. Alternatively, a release program could be put in place to return juveniles to donor stocks to ameliorate the effects of broodstock mining.

a. Rationale:

i. Receiving environments will differ from conditions in the donor watershed. Genetic diversity of adult broodstock needs to be sufficient to allow natural selection.

ii. Ideally, three or more donor populations and all possible crosses among them) should be used. The use of multiple broodstocks and hybrids is expected to increase genetic diversity in the transplanted fish and lead to more rapid adaptation to the new environment. Gametes from 300 or more adult fish (at a 50/50 sex ratio) should be used to create a robust effective population size and ensure adequate genetic diversity.

4) The donor populations should possess life history characteristics that are biologically compatible with the recipient location.

a. Donor stocks should have migration and spawn timing, adult body sizes, ages at maturity, and length of juvenile freshwater residency deemed to be suitable in the recipient location.

b. Stream elevation, temperature regimes, flow, stream gradient, and substrate type in donor and recipient streams should be similar.

c. Migration route length, and for some species (e.g., sockeye) route orientation, should be similar between donor and recipient locations.

d. Diseases present in the recipient location should be similar to those found in the donor populations.

Receiving Sites:

1) Habitat suitable for anadromous salmonids should be present, including characteristics such as stream elevation, gradient, current velocities, depths, temperatures, water chemistry, substrate type and composition, stream cover, and channel stability.

2) There should be adequate food supplies to support the juveniles produced from a reintroduction program.

3) Surveys should be conducted before reintroduction to determine the presence and abundance of possible competitors and predators.

4) Modeled effects of climate change on the temperature regime and hydrograph of the recipient watershed should indicate that the location will remain suitable for salmonids.

5) Suitable infrastructure should be available to capture adults and juveniles if the recipient location is above an impassable barrier.

Fish Culture:

1) Hatcheries used in conjunction with transplanting programs should be operated using well-established genetic principles.

2) Depending upon circumstances, use of translocated adults, eyed eggs, fry, parr, and smolts may be appropriate in reintroduction programs. Parentage-based tagging, otolith thermal marking, and other available marking and tagging tools should be used on all hatchery releases to enable system-wide monitoring and evaluation.

3) Relatively large releases of hatchery juveniles ($\geq$ 0.5 million; $\leq$ 1 million) are encouraged at the beginning of a reintroduction effort. Once adults return and are

allowed to spawn naturally, release numbers should be based on expected capacity of the recipient freshwater habitat. Releases of hatchery juveniles may occur annually for up to three or more generations.

a. Rationale:

i. As mentioned under Donor Populations, genetic diversity enables populations to respond to changing environmental conditions.

ii. If releases occur at the smolt stage, predation losses (%) of the released fish may be reduced due to predator saturation or prey size-selectivity.

iii. The carrying capacity of the recipient location should be used to guide the number of adults and hatchery-origin juveniles released after adults produced from the program begin to spawn in nature. Continued releases of large numbers of juveniles and adults may result in low survival in the area where reintroduction is occurring and may also have negative impacts on adjacent wild populations.

4) The use of multiple donor populations adjacent to the recipient location is encouraged as is the creation of hybrids among donor stocks.

a. Rationale:

i. Hybrids are expected to break down genetic homeostasis and greatly increase genetic variability. Stocks chosen for cross-mating should be geographically close and well-matched to the new environment. Although this strategy increases the risk of outbreeding depression, its effects are expected to be minimal if recommendations for release numbers are followed.

ii. The use of multiple donor populations also reduces the number of adults that will be needed from each donor population to meet egg take or adult translocation goals.

5) Release timing of smolts should coincide with expected outmigration timing in the recipient location.

6) Acclimation sites or other methods (e.g., imprinting at the embryonic stage to waters from targeted spawning locations) should be employed to reduce straying and locate project adults in desired spawning and rearing areas.

7) To reduce straying and increase adaptation to the recipient location, adult progeny returning to the recipient location should be incorporated into hatchery broodstocks. The eventual goal is to cease the importation of outside fish and rely entirely on adults

produced from the reintroduction effort. Initially, the inclusion of jacks or early maturing males is also encouraged, since they represent fish that successfully survived and returned to the new location.

Monitoring, Evaluation, and Adaptive Management Requirements:

1) Quantitative and time explicit project objectives are in place to track the results of a reintroduction program.

2) Both monetary and infrastructure resources are available to conduct implementation and effectiveness monitoring.

The ISAB and ISRP have recommended these principles, and actions based on them, in several reviews following the 2018 Review. Most notably, these principles were major components of the UCUT's Phase 1 and Phase 2 Reintroduction Plans (see ISAB 2019-3 and 2022-2). The ISAB reviewed the donor source selection and risk assessment processes to be scientifically credible.

The ISAB reiterates that potential benefits of reintroduction efforts have to be weighed against possible negative effects of reintroduced fish on capacity in different areas, their conceivable genetic effects via straying on adjacent populations, and possible predatory and competitive interactions with other fishes, as well as the potential harm to donor populations. Also, it is important to determine whether the cause for the extirpation has been eliminated. We support the principles for fish reintroduction recommended by the 2018 ISAB Review and encourage the Council to incorporate them into the Reintroduction strategy description in the next update of the Program.

3. ANADROMOUS FISH MITIGATION IN BLOCKED AREAS

One of the most significant advances in the Fish and Wildlife Program over the last decade has been the progress of the Spokane Tribe of Indians, Confederated Tribes of the Colville Reservation, Coeur d'Alene Tribe of Indians, and the Upper Columbia United Tribes (UCUT) to develop plans to reintroduce anadromous fish into their historical habitats above Grand Coulee and Chief Joseph dams. The 2014 Fish and Wildlife Program included provision for potential future reintroduction of fish species in the Columbia River Basin. The 2018 ISAB Review applauded the Anadromous Fish Mitigation in Blocked Areas strategy as first steps toward reestablishing salmon and steelhead in one third of their original habitat (ISAB 2018-3, page 63).

The 2020 Addendum included a revised biological objective, five Performance Indicators, and Implementation guidance for reintroduction of anadromous fish above Grand Coulee and Chief Joseph dams. The objective calls for the Program to work with co-managers and tribes to contribute to the assessment and expansion of anadromous fish in the blocked area. Two of the Performance Indicators track studies and implementation plan development, and three Indicators track miles of accessible habitat and fish abundance. Importantly, the Implementation guidance highlights the severe losses of anadromous fish in this portion of the Basin and notes that they have been under-mitigated through the Northwest Power Act. It calls for significantly increasing the level of mitigation for these losses without compromising the Program's efforts elsewhere in the Basin. The revised strategy also notes that the 2014 Program includes collaborative efforts to restore ceremonial fisheries in some blocked portions of the Columbia River Basin through trap and transport operations. The Program supports continued collaborative efforts to enhance ceremonial fisheries on hatchery-origin salmon and steelhead over the next five years.

In the updated 2020 Addendum, the Council included a statement for BPA to:

> "Implement a broad suite of actions to mitigate for the complete loss of anadromous fish and the losses to other fish and wildlife species in the Lake Roosevelt and Spokane River areas above Grand Coulee and Chief Joseph dams, as well as ongoing operational impacts. Increase significantly the level of mitigation for these losses without compromising the substantive protection and mitigation activities elsewhere in the basin."

The Addendum also specified that BPA and others:

> "Continue to make progress on the program's phased approach to evaluate the possibility of reintroducing anadromous fish above Grand Coulee and Chief Joseph dams."

The ISAB reviewed UCUT's Phase 1 and Phase 2 Reintroduction Plans (ISAB 2019-3, ISAB 2022-2) and concluded that it is reasonable to expect reintroduction to be successful to some extent. The plan, its adaptive management process, and stepwise approach are essential to gain understanding of the critical processes and components of the reintroduction. Several of the questions or issues the ISAB raised in the 2018 Review have been discussed in the UCUT reintroduction plan reviews and most of them are being examined in the Phase 2 studies.

In September 2023, BPA and other federal agencies and departments signed a Memorandum of Understanding and Settlement Agreement with the Confederated Tribes of the Colville Reservation, the Coeur d'Alene Tribe, and the Spokane Tribe of Indians for funding implementation of the Phase 2 Implementation Plan projects for reintroducing specific non-Federally protected salmonid stocks above Chief Joseph and Grand Coulee dams in the Upper Columbia River Basin. Under the Settlement, BPA will commit $200 million over 20 years to fund the continuing investigation of the reintroduction of anadromous fish above Grand Coulee Dam.

In a related agreement, the recent White House Memorandum on Restoring Healthy and Abundant Salmon, Steelhead, and Other Native Fish Populations in the Columbia River Basin (September 23, 2023) established a policy to:

> "pursue effective, creative, and durable solutions, informed by Indigenous Knowledge, to restore healthy and abundant salmon, steelhead, and other native fish populations in the Basin; to secure a clean and resilient energy future for the region; to support local agriculture and its role in food security domestically and globally; and to invest in the communities that depend on the services provided by the Basin's Federal dams to enhance resilience to changes to the operation of the CRS, including those necessary to address changing hydrological conditions due to climate change."

The memo directed the Bonneville Power Administration, other federal agencies, and Tribes to utilize their authorities and available resources to advance that policy established in section 1 of this memorandum. The U.S. also signed a Memorandum of Agreement with Six Sovereigns (Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Nez Perce Tribe, the State of Oregon, and the State of Washington (the "Six Sovereigns"). The Tribes and states provided a proposed Columbia Basin Restoration Initiative (CBRI) to the United States. As part of the CBRI, the Bonneville Power Administration will invest $300 million over 10 years to restore native fish and their habitats throughout the Columbia River Basin. One of the recommendations of the CBRI is to implement the UCUT's Phase Two Implementation Plan to reintroduce and provide passage of priority anadromous species above Chief Joseph and Grand Coulee dams.

The ISAB recommends revisions of the Program to reflect the collaborative actions and information in the new agreements, White House MOU, and the two ISAB reviews of the Phase 1 and Phase 2 plans. The Fish and Wildlife Program will need updates to the Anadromous Fish Mitigation in Blocked Areas strategy and Implementation actions to reflect the new status of the reintroduction effort. We encourage the Council to develop

Performance Indicators for their efforts to enhance ceremonial fisheries on hatchery-origin salmon and steelhead in other blocked areas within the Basin.

The Upper Snake River Basin above the Hells Canyon Complex is an especially large and important blocked area where significant steps are being taken to assess the feasibility of salmon and steelhead reintroduction. The ISAB recently reviewed the Upper Snake River Tribes Foundation's loss assessment for spring/summer Chinook in the watersheds above the Hells Canyon Complex (ISAB 2024-1). The ISAB encourages the Council to assist the Upper Snake River Tribes Foundation in these assessment efforts.

4. RESIDENT FISH MITIGATION

The 2018 ISAB Review recommended clarification and reorganization of principles guiding resident fish mitigation activities (ISAB 2018-3, page 65) and included specific modifications and recommendations in Appendix 4. Many of those suggestions were not incorporated into the 2020 Addendum, and they should be considered in a future update of the Program. The Performance Indicators for the Resident Fish Mitigation strategy were a valuable addition to the Program. The 2020 Addendum developed five quantitative Performance Indicators for the Resident Fish Mitigation strategy for bull trout, cutthroat trout, and redband trout. The ISAB encourages the Council to add quantitative Performance Indicators for other resident fish species and consider the suggestions in the 2018 ISAB review for clarification of principles guiding resident fish mitigation activities.

One area of Program implementation that should be addressed is the identification of quantitative hydropower loss assessments and hydropower-related quantitative mitigation goals. The 2020 Addendum states "the program does not include quantitative hydropower loss assessments and hydropower-related quantitative mitigation goals for aquatic species other than anadromous salmon and steelhead, with the one exception of the impacts of Hungry Horse and Libby dams on certain resident fish species." The ISAB recommends continued effort to quantify the losses and develop mitigation goals for resident fish.

5. STURGEON

The 2018 ISAB Review recommended analysis of the carrying capacity of the mainstem Columbia River for white sturgeon and investigation of bioaccumulated toxic

contaminants, given the goal to mitigate for loss of sturgeon for sport harvest and consumption (ISAB 2018-3, page 67).

In the Appendix of the 2020 Addendum, the Council noted:

> "The ISAB, in its review of the 2014 Program, made similar recommendations, noting particularly that the relationship between hydrosystem operations, passage obstacles, and sturgeon reproductive success needs more investigation." They concluded, "the provisions in the 2014 Program's Sturgeon strategy provide effective support for these recommendations, and so the Council concluded those provisions need not be revised at this time. Implementation of measures to benefit sturgeon also remains one of the program's emerging priorities."

The Addendum did not provide any measures to respond to the ISAB's call for studies of dam passage effects and potential passage improvement for sturgeon or comprehensive toxic contaminant studies. However, the Addendum called for the USACE and BPA to evaluate whether alternative flow regimes might increase sturgeon productivity and recruitment in the lower Columbia below McNary Dam and if so, whether and how operations could be altered to provide those flow regimes without compromising protection for salmon, steelhead and lamprey. The ISAB recommends that these studies would need to address how the alternative flows would affect habitat and other fish populations in the lower Columbia River and estuary.

In the review of the project to Evaluate Sturgeon Populations in the Lower Columbia River (project #1986-050-00) as part of the Resident Fish and Sturgeon Category Review, the ISRP highlighted that recruitment indices for John Day Reservoir have been at or near zero since 2013. The review also noted that recruitment upstream of McNary Dam and in Snake River reservoirs has not been monitored since 2011 and 2005. The 2020 Addendum called for the USACE and BPA to increase sturgeon population monitoring between McNary and Priest Rapids dams and in the lower Snake River so that stock status is regularly reported for each area and pool, which is consistent with the ISRP's recommendations for increased and more consistent monitoring of sturgeon abundance. Because of the uncertainties about sturgeon recruitment rates, the ISRP also recommended the use of precautionary exploitation rates until data from these project additions are available. The ISRP also questioned whether trauma from repeated catch and release might reduce reproductive success of mature individuals and recommended efforts to determine the incidence of multiple recapture events and reproductive consequences for individual fish. The ISAB supports these recommendations and encourages the Program to implement the

suggested studies on dam passage effects, contaminants, and effects of repeated catch and release.

The ISAB commends the 2020 Addendum's development of quantitative Performance Indicators for sturgeon in each of the reservoirs of the mainstem Columbia and Lower Snake rivers, middle Snake River, upper Snake River, and Transboundary Upper Columbia. Indicators also were developed for annual recruitment indices and length frequency distributions of wild white sturgeon populations in all impounded and non-impounded reaches. The Addendum also included an Indicator for overall genetic diversity of white sturgeon in the Columbia River system.

6. LAMPREY

The 2018 ISAB Review made several suggestions for additions or considerations in revising the Program: 1) more information on the genetic structure of Pacific lamprey in the Basin, 2) additional studies of river and brook lampreys, and 3) quantitative objectives for Pacific lamprey at major locations where they can be counted (ISAB 2018-3, page 68).

The ISAB commends the Council for directly addressing the third point by including four quantitative or semi-quantitative objectives for Pacific lamprey, including 1) a three-year rolling average of 200,000 adults at Bonneville Dam by 2025, progressing toward 1,000,000 by 2035; 2) a reduced risk of extirpation and improved adult abundance, measured at 5-year intervals, across its historical range in the Columbia River basin, including across all six Pacific Lamprey Regional Management Units (RMU); 3) a passage efficiency for adult Pacific Lamprey of at least 80% at each dam on the mainstem Columbia and Snake Rivers, and 4) passage efficiency and survival standards for juveniles progressing toward those used for juvenile salmonids–as well as nine quantitative Strategy Performance Indicators.

The 2020 Addendum included four objectives for lamprey, including an adult abundance target of a three-year rolling average of 200,000 at Bonneville Dam by 2025, progressing toward 1,000,000 by 2035. The Addendum identified nine quantitative Performance Indicators for the Pacific Lamprey strategy. The ISAB again commends the Council for developing quantitative Performance Indicators for the Pacific Lamprey strategy. These objectives and Performance Indicators directly addressed the 2018 ISAB Review's recommendation for quantitative objectives for Pacific lamprey at major locations where they can be counted.

Pacific Lamprey Strategy Indicators in 2020 Addendum

- Total end-of-year dam count at Bonneville Dam

- Geographic distribution as indicated by total end-of-year counts at Willamette Falls, Columbia and Snake River dams
- Abundance of juvenile and larval outmigration tracked at John Day Dam and Bonneville Dam
- PLCI Risk category as reported by RMU every five years
- RMU abundance and distribution indicators as reported every five years
- Adult passage efficiency for each Columbia and Snake mainstem dam
- Annual weighted average mortality rate for Pacific Lamprey macrophthalmia at Bonneville, McNary and John Day dams
- Annual weighted average injury rates for Pacific Lamprey macrophthalmia at Bonneville, McNary and John Day dams
- Juvenile and larval passage efficiency for each Columbia and Snake mainstem dam.

In the Findings on Recommendations and Responses to Comments in the 2020 Addendum, the Council noted:

> "Lamprey measures – including operations and passage, habitat actions, considerations of lamprey production, other research and population monitoring – are currently implemented under a set of commitments by the federal action agencies, especially the Corps of Engineers and Bonneville through the Accords. This implementation should continue as aggressively as possible."

The ISAB recognizes the progress represented in the 2020 Addendum and encourages the Council to build on this progress. We suggest several improvements for lamprey management in the Program.

We echo the ISAB's previous recommendation that more information is needed on the genetic structure of Pacific lamprey returning to the Basin. Recent work has demonstrated that Pacific lamprey exhibit homing to some degree, and that current programs to reintroduce lamprey into formerly occupied spawning habitats are generating adult returns at Bonneville Dam. Genetic evaluations are fundamental to understanding the long-term success and consequences of these reintroductions, and basinwide sampling of specimens is critical to tracking and refining recovery efforts.

Recent research has revealed the presence of additional species of river and brook lamprey (presently in the genus *Lampetra*, but proposed for assignment to a new genus,

Occidentis). As juveniles, members of this genus are often indistinguishable from Pacific lamprey (*Entosphenus tridentatus*) but have more limited distributions and exhibit both resident and anadromous life histories that may render them vulnerable to some aspects of the hydrosystem and its operations.

There is some indication that Pacific lamprey are accumulating a variety of anthropogenically generated toxins. The Program's implementation measures related to water quality and toxic chemicals should consider implications of toxic accumulation for lamprey, sturgeon, other species, as well as salmon and steelhead.

7. EULACHON

The 2018 ISAB Review called for increased monitoring of eulachon after the NMFS Recovery Plan (2017), especially to better understand how the hydrosystem's changes in timing, magnitude, and duration of the hydrograph might affect eulachon (ISAB 2018-3, page 69).

The 2020 Addendum included qualitative program goals and objectives for the program to contribute to maintaining a stable and increasing population trend for eulachon, with a specific performance indicator to track spawning stock biomass for the Columbia River to assess whether eulachon biomass is stable and/or increasing, all as part of program performance. The population status and trends for eulachon are related to the numbers of fish rather than biomass. The ISAB encourage the Council either to explain why the Indicator is based on biomass of eulachon or to revise the Indicator to be based on numbers of eulachon and efforts to model eulachon populations as part of the NMFS Recovery Plan (2017).

The Council also explicitly recognized the implementation commitments in the 2019 Columbia River System Biological Opinion, which included consultation on the effects on listed eulachon and increased monitoring in the lower river and estuary. Because of the level of uncertainty involved with eulachon, including any effects of the hydrosystem, the Council concluded that it should be left to the federal action agencies and NOAA, working with the relevant states and tribes, to sort out responsibility for implementing these measures and those in the recovery plan. The ISAB suggests that the Council proactively assist the federal agencies and determine the Program's responsibilities for management actions to maintain a stable and increasing population trend for eulachon.

8. PUBLIC ENGAGEMENT

The 2018 ISAB Review noted that the Public Engagement strategy is a strength of the Program and the descriptions of the rationale, principles, and general measures are straightforward and well-articulated (ISAB 2018-3, page 71). The review discussed the transaction costs of public engagement and noted that benefits of alternative collaborative and participatory decision-making should be evaluated for their cost effectiveness. The 2020 Addendum includes nine Public Engagement Strategy Indicators, most of which deal with reporting, reviews, annual updates, and supporting collaborative programs and databases.

The Mainstem and Program Support Review (ISRP 2019-2) identified communication, information sharing, and public engagement as a major programmatic issue. The 2019 ISRP review and earlier reviews (e.g., ISRP 2012-6) recommended greater emphasis on evaluating the efficacy of information sharing activities, such as user satisfaction, impact on restoration design and decision-making, user needs, and application of new techniques. The development of the qualitative Performance Indicators will provide more transparent and informative summaries of the overall efforts to maintain and enhance public engagement in the Fish and Wildlife Program.

D. SUBBASIN PLANS

From 2004 to 2011, the Council adopted subbasin management plans for 59 of the 62 identified subbasins as part of the Program. The plans were developed by subbasin planning teams consisting of state and federal fish and wildlife agencies, Tribes and other regional and local organizations. The 2018 ISAB Review pointed out that the 2014 Fish and Wildlife Program does not discuss specific subbasins to be updated or a process to identify and initiate updating for specific basins (ISAB 2018-3, page 72). The ISAB recommended that the Program should describe criteria that would trigger a subbasin plan update and identify candidate subbasins. The 2020 Addendum did not make such modifications.

In the Appendix on Findings on Recommendations and Responses to Comments in the 2020 Addendum, the Council concluded that:

> "The Council's approach has been to recognize recovery plans as appropriate follow-on planning to the subbasin plans, and to recognize the measures in the recovery plans as a source of measures to draw from for

implementation to benefit the relevant listed species. That would seem to be as effective for now – and much more cost-effective – than altering the subbasin plans themselves to match recovery plans and other follow-on planning. The day may come when the subbasin plans themselves need updating, but the Council did not find in the recommendations a pressing need for that now. Linking project reviews and subbasin plan updates will be a method to consider at that time as well."

Several subbasins of the Columbia River have developed a number of geographically specific databases and project guidance approaches:

- Restoration Atlas of the Grand Ronde Model Watershed
- Upper Grande Ronde Tributary Assessment
- Columbia Estuary Ecosystem Restoration Program database and 5-Year State of the Estuary Reports
- Okanogan Basin Monitoring and Evaluation Program
- Integrated Recovery Program of the Upper Columbia River Salmon Recovery Board
- Umatilla Initiative
- Lower Snake River Compensation Plan

The 2018 ISAB review recommended updating Subbasin Plans or developing a process to identify specific Subbasin Plans that need updating. In many ways, the geographic frameworks listed above have evolved from the Subbasin Plans and incorporate new technology for environmental databases, analytical tools, models, and decision making. The ISAB recognizes that many of these new approaches are more functional, link directly to RM&E data, can be used in the design of restoration projects, and provide information more readily in many forms to assist in planning and implementation. Currently such geographic approaches are being developed independently and differ greatly across projects. We encourage the Fish and Wildlife Program to convene a workshop to describe the various approaches and their history, share lessons learned, and identify collaborations that would benefit the entire Basin and the projects within the Program.

E. IMPROVING COST-EFFECTIVENESS EVALUATION

The Northwest Power Act states the Program should "utilize, where equally effective alternative means of achieving the same sound biological objective exist, the alternative

with the minimum economic cost."[4] Additionally, the 1996 amendment to the Northwest Power Act requires the Council to "determine whether the projects [fish and wildlife projects recommended to Bonneville] employ cost-effective measures to achieve program objectives."[5] This charge is described in the Implementation Procedures in the 2014 Program. A 2012 report by the Independent Economic Analysis Board describes the connection, progress, and potential for analysis related to cost-effectiveness strategies for the Fish and Wildlife Program (IEAB 2012).

The 2018 ISAB Review noted that cost-effectiveness analysis has not been undertaken to rank and prioritize projects despite Program guidance (2018-3, page 74). The review described several approaches for assessing cost effectiveness. This aspect of project design and implementation was highlighted in the review of spring Chinook salmon in the Upper Columbia River (ISAB 2018-1). The 2018 ISAB Review of the 2014 Program noted that developing quantitative estimates of either costs or biophysical impacts of projects is challenging but encouraged the Council to expect projects to attempt to use cost effectiveness analysis in their planning and management.

The 2020 Addendum did not include a Program-wide call for cost-effectiveness analyses but did include recognition of importance of cost-effective decisions. The section on Ecosystem-based Approach for Predator Management stated:

> "It is important to understand which predator management actions have the greatest effect on adult returns and SARs and retarget efforts on those actions for cost-effective predation management."

F. IMPROVING PROGRAM IMPLEMENTATION AND COMMUNICATION

The ISRP's Resident Fish and Sturgeon Category Review (ISRP 2020-8) identified communication between BPA, Council, and ISRP (and ISAB) as a major Programmatic Issue. The ISRP recommended 1) better communication and documentation of BPA decisions affecting project implementation and review and 2) better sharing relevant

[4] Northwest Power Act, §4(h)(6)(C), 94 Stat. 2709

[5] Northwest Power Act, 94 Stat. 2710, as amended by Pub.L. 104-206, § 512(4)(h)(10)(D)(vi), September 30, 1996, 110 Stat. 3005

information with the ISRP. It also encouraged more active participation of BPA staff in Category Reviews.

The 2020 Addendum directly calls for improved communication between the Council and BPA communications about changes to projects.

> **Protect productive work during budgetary processes (p. 45)**
>
> "Bonneville shall provide regular public information to the Council on project implementation, so that the Council can understand whether and how implementation differs from the work recommended after project review. In particular, Bonneville shall provide timely notice to the Council when Bonneville implementation decisions result in a material change in the scope, desired outcomes or budget of a project. The Council will review this information and assess whether further Council recommendations are warranted, including further ISRP review. The Council will develop with Bonneville a written agreement for sharing this information, to assist the Council in its project review, program development and program performance efforts."

Despite the recommendations in the ISRP's 2020 review and 2020 Program addendum, in the Anadromous Fish Habitat and Hatchery Projects Review (ISRP 2022-1), the ISRP observed similar problems with communication and recommended continued effort to enhance communication and transparency between the Council, BPA, Council staff, and the ISRP in the scientific review process. The ISRP concluded this area of Program operations and implementation could be improved and possibly addressed in future revisions of the Fish and Wildlife Program.

The ISAB appreciates the Council highlighting the need for improved communication between BPA, the Council, staff, the ISRP, and the ISAB. The ISAB understands that the Council and BPA have initiated discussion and some specific actions to lead to the improvements in communication called for in the 2020 Addendum. The scientific rigor of the Fish and Wildlife Program requires effective communication between BPA, the Council, and the ISAB and ISRP. We recommend that future updates of the Program should include a specific and regularly scheduled process for the Council, BPA, and the ISAB and ISRP review areas where communication between these entities should be improved to better implement the Fish and Wildlife Program.

G. FUTURE FISH AND WILDLIFE PROGRAM REVISION

The 2020 Addendum concluded that several major management and policy processes in the Columbia River Basin will require changes to the Program:

> **Plan future implementation of the Fish and Wildlife Program (p. 46)**
>
> "The next few years will see the completion of the Columbia River System Operations EIS and a decision on a preferred alternative, new Biological Opinions, a need either to extend the Accords or in some other way adapt how the program is implemented, and other major developments. In this light, the Council will begin consultation soon with the state and federal fish and wildlife agencies and tribes and Bonneville about alternatives for future implementation of the fish and wildlife program."

In addition, the changes identified in the 2020 Addendum; the recent BPA MOU and Settlement Agreement; the White House Memorandum on Restoring Healthy and Abundant Salmon, Steelhead, and Other Native Fish Populations in the Columbia River Basin; and the ongoing negotiations to modernize the Columbia River Treaty will greatly shape the future direction of the Program. The ISAB hopes this review of the scientific strengths and potential areas for improvement will be valuable to the Council, its staff, federal and state fish and wildlife agencies, Tribes, and others in the Basin as they develop the next Fish and Wildlife Program.

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