United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Office of the Northwest Regional Director
909 First Avenue, 8th Floor
Seattle, Washington 98104

September 16, 2013

Mr. Bill Bradbury
851 S.W. Sixth Avenue, Suite 1100
Portland, OR
97204

Dear Mr. Bradbury,

On behalf of the Northwest Region of the U.S. Geological Survey (USGS), I thank you for the opportunity to provide recommendations to amend the Northwest Power and Conservation Council (NPCC) Columbia River Basin Fish and Wildlife Program (hereafter referred to as Fish and Wildlife Program). Scientists from several of our nine science centers in the Northwest Region have developed specific high level recommendations on subjects for which you requested comments in your letter of March 26, 2013 (Council Document No. 2013-03). These include: mainstem habitat, evaluation of estuary habitat restoration, food webs, forage fish, fish tagging, Pacific lamprey, and sturgeon. These recommendations are based upon many decades of field and laboratory research and an extensive record of peer reviewed publications on Columbia Basin fish, wildlife, and water quality.

We also address topics characterized in the 2009 Fish and Wildlife Program as the "emerging habitat issues" of climate change, invasive species, and contaminants. These topics, collectively referred to as "landscape scale stressors," are being addressed by USGS within the Columbia Basin by projects addressing climate change in the Yakama and the Methow River Basins, aquatic invasive species in the mainstem Columbia River in partnership with Washington State University, and a multi-science center collaboration on contaminants in the Columbia River.

We also wish to recognize NPCC central staff who helped us understand the amendment process and the importance of sharing information with Tribal entities and state agencies as we formulated our thoughts. We responded by meeting with the Columbia River Inter-Tribal Fish Commission (CRITFC) regarding several research topics of mutual interest, and CRITFC in turn shared this information with other tribal sovereigns. We also participated in meetings of the Co-Managers work group and provided them with the input we now provide to you directly. As the primary purveyor of research and monitoring within the Department of the Interior, the USGS is both sensitive to Tribal and state issues, and interested in playing a leadership role for advancing relevant science in the Columbia River Basin.

Our USGS Columbia Basin Leadership Team agreed that the topic of fish and wildlife "Monitoring, evaluation, reporting, research and data management" was the most important issue

for the Council to consider during the amendment process. Our general recommendations on this issue are provided as responses to the questions you posed when calling for a regional process to set future direction and oversight of the Fish and Wildlife Program. The USGS appreciates the opportunity to participate in this important process.

Sincerely,

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GENERAL RECOMMENDATIONS from USGS addressing:

"Call for Regional Conversation about the Future Direction and Oversight of the Fish and Wildlife Program"

1. What should be the focus of the Fish and Wildlife Program over the next decade?

Landscape Scale Stressors – Resource management agencies within the region have long sought to return the health of the Columbia River Basin ecosystem to a more normative state. This goal has been institutionalized in the many regional planning documents that guide resource management agencies, including the Fish and Wildlife Program. For example, in their 2000 report *Return to the River*, the ISAB called upon the Fish and Wildlife Program to restore a greater degree of "naturalness" to the river (ISAB 2000-12). Yet as the future unfolds, it is becoming evident that it will be increasingly difficult to achieve a more natural state. The NPCC, management, and regulatory agencies should instead be preparing to manage natural resources under future conditions that will intensify the current landscape scale stressors such as climate change, water shortages, contaminants, invasive species, changes in water temperatures, hypoxia and acidification in our estuary, and wildfire. The idea that "on the ground projects" can generate sufficient benefits to recover listed species held merit historically, but a more holistic approach in now needed because of impacts from landscape scale stressors originating both within and outside of the Columbia River Basin.

In light of the challenges that lie ahead, the USGS recommends taking steps to shift the emphasis of the Fish and Wildlife Program from an approach that is curative to one that is preventative. This could be accomplished by complementing the current Fish and Wildlife Program with focused initiatives to facilitate the recovery of the ecological health of the Columbia River Basin in support of all fish and wildlife resources, such as ongoing work to restore ecosystem health of the Kootenai River. Another initiative is the Great Northern Landscape Conservation Cooperative (GN LCC), which is working to help its members prepare for and respond to landscape scale stressors. These landscape scale stressors are national and regional scale drivers that underpin many of the specific limiting factors that NPCC restoration projects attempt to address at a local scale. By emphasizing preventative measures that help the region adapt to landscape stressors, the Fish and Wildlife Program can help the region avoid additional listings under the Endangered Species Act. Also, it can help to avoid events such as the socioeconomic disruptions that would result if zebra or quagga mussels make their way into the Federal Columbia River Power System or if contaminants hamper a species recovery operation.

Predictive Capacity – From a management perspective, an effective way to ameliorate such impacts is to grow our predictive capacity. This can be achieved by complementing the restoration activities under the Fish and Wildlife Program with a dedicated component for research, monitoring, and evaluation. By establishing a baseline of current conditions against which to measure trends, the Fish and Wildlife Program could develop the capacity to quantify benefits and more importantly associate them with casual factors. By understanding the relationships between physical and biological factors, predictive capacity could inform how new restoration projects can be deployed in the most effective way, such as by considering the type, timing, and distribution of projects in relation to the changes that are predicted from the

landscape scale stressors. For example, salmon predation modeling that was completed in the 1980s generated predictive capacity that led to many changes in predator control, juvenile bypass facilities, spill patterns, and increased interest in food webs. All of these changes have improved juvenile salmon survival.

For this reason we recommend that the Council, over the next five years, develop the capabilities necessary to estimate the carrying capacity of the system. The ISAB and ISRP have been calling for food web studies, which need to be conducted at a landscape scale to provide managers guidance for fish stocking and restoration. Scientific papers have already cautioned that too many juvenile salmon are being released, and now efforts to add sturgeon, lamprey and burbot are underway. Managers need guidelines for salmon stocking and fish restoration based on the capacity of the altered environments to support additional demands.

2. In what way should the Council exercise its responsibilities to maximize policy and Fish and Wildlife Program benefits and minimize process costs?

Role for Science in the Fish and Wildlife Program – For almost three decades the NPCC has supported the implementation of hundreds of excellent restoration projects. While the Fish and Wildlife Program has sought to address science-based management questions though these projects, it has done so without benefit of a dedicated science component within the Fish and Wildlife Program. This explains why long standing, critical scientific data gaps still persist, as the current funding model of project scale work in three year increments, is not designed to support the type of long term research and monitoring necessary to improve the effectiveness of the Fish and Wildlife Program, and thereby minimize costs.

The idea that fundamental science should be sponsored by the NPCC to support Fish and Wildlife Program objectives has long been recognized by many entities within the region, including the Independent Scientific Advisory Board (ISAB). In their report on *Columbia River Basin Food Webs* the ISAB identified the need to "to fill a very large number of perplexing information gaps and critical uncertainties impeding progress" (ISAB 2011-1). Previously, the Scientific Review Group (precursor to the ISAB), released a report titled the *Critical Uncertainties in the Fish and Wildlife Program.* The first and last sentences of the summary of the report follow:

> " We present and discuss critical ecological uncertainties that identify important gaps in our knowledge of the resources and functional relationships that determine fish and wildlife productivity in the Columbia River ecosystem....Finally, we again call for immediate development and implementation of a system-wide monitoring and evaluation Fish and Wildlife Program that also is responsive to critical uncertainties (SRG 93-3)."

We concur and recommend that the Fish and Wildlife Program could benefit from the inclusion of a dedicated research, monitoring, and evaluation component designed to reduce uncertainty and provide information for changing Fish and Wildlife Program focus and direction when warranted. By shrinking the uncertainty surrounding restoration options and supporting the quantification of their likely benefits, fundamental science and monitoring can help decision makers define and focus those options.

Aligning with Regional Scale Processes – The Columbia River Treaty (CRT) process is underway and members of the Sovereign Review Team (SRT) are discussing how to modernize the original treaty by bringing the consideration of "ecosystem function" into a new treaty. The Council members who are on the SRT should recognize that certain topics under discussion in the context of the Treaty are also important to the Fish and Wildlife Program, such as reconnection of the floodplains in the lower river, mainstem habitat issues, stresses to the estuary from hypoxia and acidification, and reintroduction of fish to the blocked areas in the headwaters of the Columbia River.

The 2009 Fish and Wildlife Program recognized the importance of mainstem habitat, which today is an issue within the CRT review processes, and therefore provides a clear opportunity to maximize policy and Fish and Wildlife Program benefits while minimizing costs. USGS scientists who have conducted decades of research on utilization of mainstem habitats by keys species such as salmonids and sturgeon are calling attention to this issue, through our participation in the Anadromous Fish Work Group of the CRT process, and in our recommendations for the FY 2013 Fish and Wildlife Program amendment process. Also important to mainstem habitat rehabilitation are landscape processes and activities that deliver contaminants to habits that have been restored or that are under consideration for restoration. These processes, if left unchecked, could greatly hamper mainstem habitat restoration.

Another overlapping issue is the effect of short-term system operation requests (SORs) on productivity. The Army Corps of Engineers, the U.S. Bureau of Reclamation, and utilities raise and lower reservoir levels on a short term basis to meet requests by recreational event sponsors, tribal fishers, and others. These short term fluctuations can disrupt littoral zone food webs by drying out shorelines or flooding riparian zones during a time when water levels are normally retreating. These events can be more extreme than the routine "load following" at dams since the effects occur throughout the reservoir, not just in the tail races.

3. In what way can the Council and the regional Fish and Wildlife Program be more effective, efficient and streamlined, and generate more value for the resource investment?

Fulfilling the Promise of Adaptive Management – The Fish and Wildlife Program could become more effective and efficient by implementing a dedicated research, monitoring, and evaluation component that can provide the basis for learning and support adaptive management. Although often ignored, monitoring comprises the missing ingredient for a practical approach to adaptive management in the Columbia River Basin. Evaluation provides the basis for re-directing Fish and Wildlife Program emphases or charting a new course; ensuring Fish and Wildlife Program accountability; and, detecting unanticipated events that could impact the Fish and Wildlife Program. For these reasons, the USGS recommends that the Fish and Wildlife Program include an ecological monitoring component as the basis for measuring changes in physical, chemical, and biological attributes of the Columbia River Basin in a way that can detect trends. This would support the evaluation of the effects of landscape scale stressors such as climate change, invasive species, and contaminants on the ecosystem that the Fish and Wildlife Program strives to restore.

These landscape scale stressors already contribute to the limiting factors that prevent the Fish and Wildlife Program from meeting its biological objectives, a situation that will become exacerbated in the future. Consequently, we recommend developing a monitoring and reporting framework for limiting factors that would complement the current monitoring and reporting of species and populations. Science can inform the development of this framework, help identify reasonable objectives and limiting factors, and identify critical uncertainties to guide further research.

The implementation of the Biological Opinion and the salmonid Recovery Plans seek to (1) determine causal linkages between restoration projects and the benefits they confer and (2) quantify those benefits in support of delisting decisions. In light of the significant investment of public resources and the passage of several decades, a dedicated research, monitoring, and evaluation component would modernize the Fish and Wildlife Program and aid in protecting the investment in restoration and recovery already made by the Fish and Wildlife Program.

SPECIFIC RECOMMENDATIONS from USGS addressing:

"Potential Areas for Specific Stakeholder Feedback on the Current Fish and Wildlife Program"

In this section we provide recommendations on the specific topics identified in the "Request for Recommendations to Amend the Fish and Wildlife Program." We have organized this input under categories of: species, habitat, and processes. The profile of each topic includes: reference to where the topic appears in the various sections of the current Fish and Wildlife Program; a recommendation; and, a supporting rationale.

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SPECIES

Lamprey

Current Fish and Wildlife Program: various sections

Recommendation: Research is needed on lampreys and the Fish and Wildlife Program should expand its two primary strategies to address these additional topics:

- Implementing a PIT-tagging Fish and Wildlife Program for lampreys throughout the Columbia River Basin, which would not only provide new insight into juvenile fish passage issues, but would also provide unprecedented information on lamprey biology and life history (e.g. growth rates, time spent in the ocean, and homing efficiency—or a lack thereof).
- Determine the potential effects of climate change on lampreys, including the effects of increasing water temperatures and changing runoff regimes on lamprey energetics and performance.
- Embark on studies of juvenile lamprey passage, including research using PIT-tags and active acoustic transmitters.
- Determine the effects of contaminants on lamprey biology, physiology, and performance.
- Explore the feasibility of lamprey aquaculture for supplementing and restoring depressed populations.
- Expand work into lamprey genetics, including population structure and delineation.
- Develop various models for lampreys, including population dynamics and bioenergetics models. Such tools, like those for salmonids, would be useful for predicting the potential effects of environmental stressors and restoration measures on lamprey populations.

Rationale: The current Fish and Wildlife Program discusses two primary strategies for the conservation and restoration of Pacific lamprey populations in the Columbia River basin, including addressing general passage issues and determining the extent of predation on lampreys. While these strategies address important issues for lampreys, and should be continued, they do not go far enough for developing a complete understanding of the limiting factors lampreys face today. To truly make lamprey conservation and restoration a significant part of the Fish and Wildlife Program, the above-listed recommended strategies need to be addressed.

In addition to these specific strategies, the amended Fish and Wildlife Program should also consider the various issues and actions discussed in several recent lamprey management plans, including those developed by the U. S. Army Corps of Engineers, the Columbia River Intertribal Fish Commission and other tribal entities, the U. S. Fish and Wildlife Service, and the Columbia Basin Lamprey Technical Work Group.

Sturgeon

Current Fish and Wildlife Program: Page 12, 39, 41, 43, 47-49, 53, and 55

Recommendation: The council should incorporate the following recommendations for addressing hydro system impacts on sturgeon, several of which were recommended by the ISAB:

- Include the draft Columbia Basin White Sturgeon Planning Framework in the Fish and Wildlife plan. It is expected that the Fish and Wildlife amendments will include summary information from the framework that will include overarching conclusions and recommendations for specific actions based on the basin-wide assessment.
- Provide a means to integrate information on sturgeon populations that can be used in an overall assessment of sturgeon population or demographic trends within the basin. The Fish and Wildlife Program should require the development of a method to store and quickly analyze information on sturgeon populations and restoration actions throughout the basin.
- Develop spatially explicit habitat models for all life stages of white sturgeon to quantify habitat throughout the year. These models should incorporate the specific aspects of hydro system operations, such as duration of fluctuations in water releases that affect spawning, dispersal, growth, and survival of white sturgeon.

Rationale: Sturgeon management, restoration, and recovery must increasingly involve thinking and acting collectively as a trans-disciplinary team, one that is composed not just of fishery managers and biologists but also includes specialists in the fields of ecological food webs, reservoir operations, flow dynamics, and sediment transport within the highly altered Columbia Basin. This is especially important as initiatives such as artificial supplementation or habitat improvement are proposed, defended and implemented. In February 2013, the states and tribes developed a draft Columbia Basin White Sturgeon Planning Framework at the direction of the NPCC. This was in response to ISRP reviews of specific sturgeon projects, which noted that an effective basin-wide management and RM & E plan for white sturgeon was lacking and was the most important need for planning future sturgeon research and restoration actions.

The Fish and Wildlife Program should require the development of a method to store and quickly analyze information on sturgeon populations and restoration actions throughout the basin, which would foster communication on difficult issues. This would provide the capability to understand how management or restoration activities in one sturgeon management unit would influence abundance, management, or restoration in other management units. For instance, there is no requirement for coordinated marking of sturgeon captured in stock assessment activities or marking of hatchery produced sturgeon released for supplementation. Without coordinated marking, there may be duplication in external marks used or uncertainty in origin of fish captured in downstream fisheries.

As outlined in the Framework Plan, there is a critical need to develop predictive models of sturgeon productivity based on physical and biological criteria. There are a number of factors related to impoundment and dam operations that contribute to reduced white sturgeon populations and greatly diminished natural recruitment, including habitat fragmentation, loss of habitat diversity, flow regulation, water temperature, water clarity, total dissolved gas (TDG),

contaminants, food availability, fish community alteration, and predation. The amount, distribution, and complexity of benthic substrates that provide spawning and foraging areas for white sturgeon needs to be determined. This information, coupled with hydraulic and hydrodynamic models, would form the basis for assessing habitat available for white sturgeon throughout the basin. Proper characterization of habitat availability throughout the basin would benefit fisheries managers in estimating sustainable population sizes and stocking rates where applicable. The models would also enable prediction of the effects of hydropower and flood risk management operations on sturgeon populations.

Forage Fish in the Estuary and Nearshore Ocean

Current Fish and Wildlife Program: various

Recommendation: Research is needed on forage fish in the lower estuary and nearshore ocean areas. We recommend the Fish and Wildlife Program include the following:

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

The proposed amendment will update the Fish and Wildlife Program to reflect a move toward ecosystem management approach to provide salmon with their total life cycle needs including an adequate supply and diversity of food to support growth and improve survival rates.

Rationale: Forage fish are an important component of the ecosystem, providing a critical food source to avian species, mammals, and other species of fish important to tribal, recreational, and commercial harvesters such as the salmonids. The health of forage fish populations can provide an indicator of the health of the systems they inhabit, and the lower trophic levels that support them.

Forage fish in the lower estuary include a broad group of species, including surf smelt, Pacific sand lance, Pacific herring, eulachon, and juvenile American shad. These species have diverse reproductive strategies but they all occur in the lower estuary during their life histories. For example, surf smelt and Pacific sand lance may use beaches for spawning while Pacific herring may spawn on nearshore macroalgae. Eulachon (currently listed as Threatened under the U.S. Endangered Species Act) and American shad are anadromous and can produce large numbers of juveniles that disperse downstream and enter the estuary. We recognize the Fish and Wildlife Program has an emphasis on salmon restoration and believe that forage fish are a major link between habitat and environmental conditions and the survival of salmon.

HABITAT

Estuary

Current Fish and Wildlife Program: Page 32

Recommendation: Research is needed to address the uncertainty regarding the types of habitat needed for juvenile salmon survival, the effectiveness of estuarine projects to restore juvenile habitat, and whether these restoration actions contribute to juvenile survival and increased adult returns.

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

Sediment Budget for Lower Columbia River

Recommendation: The Council should consider updating the Fish and Wildlife Plan to request that the appropriate agencies assess key components of a sediment budget for the lower Columbia River including:

- Inputs and outputs for a defined reach should be determined. A logical study reach would extend from Bonneville Dam to the mouth. This would be most complete if it included main-stem measurements of flux at or near (1) Warrendale (just downstream of Bonneville), (2) Beaver Army terminal (downstream of major tributary inputs but upstream of the bay-head depositional zone), and (3) a location near the mouth so as to understand net transport out of the lower Columbia River. Ideally, these locations should be supplemented by measurements allowing independent estimates of sediment brought in by major tributaries, particularly the Cowlitz and Willamette Rivers.

- Both bedload and suspended load measurements should be determined, and sufficient observations made so as to allow estimating total flux at each measurement location. As noted above, the management issues involving these components of the overall sediment flux are distinct.

Rationale: The volume of sediment entering and passing through the lower Columbia River downstream of Bonneville is highly uncertain. Recent studies have estimated the sediment budget for the lower Columbia River, based on very limited data—primarily measurements made between 1963 and 1969 on the Columbia River, measurements made between 1911-1912 and 1962-1964 on the Willamette River, and 1980-1984 measurements on the Cowlitz River. None of these measurements include bed-load transport, which may contribute a significant portion of the sand flux. Even despite high uncertainties, analysis shows that the volume of sediment moving through the lower Columbia River has probably been reduced by 60 percent since the late 19th century owing to sediment retention behind dams, changes in flow patterns, and changes in climate. Sand transport has likely been reduced by 85 percent over this time. But all of these inferences are based on hindcasting premised on very sparse data and assumptions regarding bed-load transport. Sediment transport in the lower Columbia River is pertinent to many ecological attributes and management issues, including: habitat formation and erosion, Columbia River littoral cell conditions, navigation dredging, contaminant transport and fate, and future changes in flow.

Habitat Protection and Restoration

Recommendation: The Council should consider updating the Fish and Wildlife Plan to include assessments of how streamflow, sediment, and large woody debris interact under current management regimes. It would be valuable to understand whether and how those geomorphic processes)sustain the success of aquatic and floodplain restoration projects for biological benefits. The lower alluvial segments along the Willamette River and its major salmon bearing tributaries provide one example of a suitable location for a pilot of these assessments because of the many floodplain and aquatic habitat restoration projects in this area.

Rationale: Geomorphic interactions between streamflow, sediment, and large woody debris are essential to creating and maintaining aquatic and floodplain habitats for fish and wildlife. Throughout the Columbia River Basin these interactions have been fundamentally altered as a result of dam construction, flood control, land use change, large woody debris removal, bank stabilization, and channel alignment. Although little is known about the magnitude and future trajectory of these changes, agencies and organizations are investing significantly in land acquisitions and river restoration projects in the basin. USGS suggests the Council consider research, monitoring, and evaluation to better understand the hydrologic and geomorphic context of potential restoration sites by: identifying geomorphically functional floodplains; mapping floodplain landforms and their vegetation; and, determining the likely future trajectories of these landforms and vegetation communities.

Monitoring Habitat-Generating Processes in Response to Restoration

Recommendation: The Council should develop a monitoring plan using unmanned aircraft systems (UAS) technology to assess inundation and water temperature conditions across a range of stream morphology and land-use patterns. These data would ideally be utilized in concert with more traditional data describing sediment transport and occurrence of large wood to provide insight into the habitat-generating processes associated with restoration projects, especially focused in low gradient and unconfined valley segments. In these segments, UAS technology could capture critical habitat forming processes, such as patterns of floodplain and side-channel inundation and channel migration, as well as locate thermal refugia or areas of significant groundwater discharge to streams. Key streams to target for this monitoring would include salmon bearing tributaries to the Willamette River that are the focus of environmental flow releases, as well as low gradient and unconfined valley reaches in more remote eastern Oregon basins.

Rationale: A range of habitat restoration and conservation activities are underway in the Columbia Basin to mitigate the detrimental effects of human impacts. Many of these efforts are focused on restoring elements of the natural flow regime (low flows and peak flows) that support access to floodplain and side-channel habitat, minimizing summer stream temperatures, and increasing channel complexity to promote thermal refugia. Typical monitoring data to evaluate these responses are labor-intensive to collect, and generally focus on relatively small stream reaches making it difficult to generalize about restoration effectiveness at a larger scale. Incorporation of remote-sensing data into the research, monitoring, and evaluation of restoration activities will provide an important technological boost to the capacity to assess the response of key fish habitat-forming processes at the basin scale, which is becoming increasingly important as the size of restoration projects expands.

PROCESSES

Impacts of Contaminants on Key Species and Foodwebs

Recommendation: The Council should consider updating the Fish and Wildlife Plan to request that the appropriate agencies assess foodweb transfer, sediment transport, and biological effects of emerging and legacy organic contaminants under current management regimes, and how those processes affect key Columbia River species and the potential success of restoration projects within the basin. Critical uncertainties in understanding impacts of contaminants on key species and foodwebs include:

- Distributions, levels, and spatial patterns of contaminants of emerging concern (CECs) in the Columbia River basin, including the estuary and coastal ocean.
- Transfer, accumulation, and persistence of CECs in estuarine, coastal ocean, and riverine foodwebs. Additive and/or synergistic effects of chemical mixtures on species of interest.
- Levels of chemicals of emerging concern (CECs) that adversely affect the health of key species, such as Pacific lamprey, white sturgeon, and salmonids.
- Impacts of CECs on the carrying capacity of the Columbia River ecosystem for juvenile salmonids and other key species.
- Impacts of contaminants on habitat restoration success (contaminants of concern should be assessed and monitored as part of current and future river restoration programs.)
- Role of contamination in reduced rearing success of white sturgeon in impounded pools of reservoirs versus unimpounded areas. Impacts of contaminants on sturgeon reproduction and rearing success within areas of known high productivity.
- Role of contaminants (levels of concern and effects of chemical mixtures) on Pacific lamprey declines compared to threats by dam passage. .
- Investigate impacts of different hydrologic scenarios and management actions on contaminant distributions and foodweb transfer.
- Investigate the potential impacts of trace element contamination of UCR sediments on the quality of critical white sturgeon habitat throughout the UCR from Lake Roosevelt upstream to the International Border.

Rationale: Various stressors threaten native fishes and other wildlife in the Columbia River basin. Urbanized large aquatic ecosystems are experiencing increasing contamination of water and sediment and ultimately foodwebs. Contaminants of concern include both legacy compounds such as DDT and PCBs that are still present in the system, as well as chemicals of emerging concern (CECs) such as pharmaceuticals and personal care products. Use and release of CECs into the environment are increasing, although little is known about their harmful levels and effects on organisms. Several studies have been carried out in recent years to assess impacts of different classes of contaminants in several levels of the foodweb in the Columbia River. The USGS Columbia River Contaminants and Habitat Characterization (ConHab) project investigated transport and fate of endocrine disrupting chemicals and their effects on the foodweb in the lower Columbia River. This study found that biomagnification of multiple contaminants occurred in resident fish and osprey eggs, exceeding environmental quality benchmarks. In some cases reproductive parameters showed impairment that was negatively correlated with various contaminant concentrations. Better understanding of these effects on key first foods species is needed.

Climate Change

Recommendation: The Council should update the Fish and Wildlife Plan to assess the potential effects of climate change on river hydraulics, temperature, and sediment movement in tributaries and mainstem reaches of the Columbia River Basin and the collateral effects on aquatic biota. Critical uncertainties in understanding future impacts of climate change on target aquatic species include:

- Changes in the magnitude, timing, and persistence of stream flows throughout the year.
- Changes in stream temperatures.
- Changes in sediment transport and habitat formation.
- Effects of flow changes on salmonids, sturgeon, and lamprey.
- Impacts of climate change on habitat restoration success.
- Shifts in the food web and resultant impacts on bioenergetics.

Rationale: Changes in the timing and magnitude of stream flows impact aquatic species in the Columbia River Basin. Up to 15 percent of the Columbia River's annual flow has been lost in the last century due to climate change and anthropogenic consumptive use (e.g., agriculture and municipal diversions). Furthermore, 14 mainstem hydroelectric dams and dozens of tributary dams modify the amount of water, thermal energy, and sediment moving through fish and aquatic habitats. Flow magnitude and timing have been severely disrupted, affecting spawning and rearing habitats of sturgeon, lamprey and salmon. Such changes have resulted in drastic declines in the populations of most salmonid and sturgeon stocks, with only a small percent of salmonids being of wild (non-hatchery) origin.

Currently, there are dozens of threatened and endangered fish stocks in the Columbia Basin and it is vital that the eminent threats posed by climate change be understood in order to protect, restore, and enhance their habitats and populations. Much work needs to be done to quantify the ecological flows necessary to maintain the various life stages of aquatic species, with particular emphasis on the magnitude, persistence, and timing of flows. Changes in stream temperatures have the potential to change trophic structures and food webs, with unforeseen consequences to aquatic biota that rely on them. The better we understand the potential consequences of climate change on aquatic biota the more we can do to prevent and mitigate the damages that will likely result from it. Stream reaches and fish stocks that are the most sensitive to streamflow and temperature alterations need to be identified so mitigation, restoration, and enhancement plans can be developed or modified to minimize risks posed by climate change. Changes in the Columbia River Treaty that recognize and address the potential effects of climate change are vital to maintaining and restoring the ecological health of the Columbia River. Lastly, strategic plans that focus on proactive activities such as assisted relocation, flow augmentation, and stream cooling techniques need to be developed so managers have the ability to minimize the risks posed by climate change to aquatic species in the Columbia Basin. Currently there is no established way to track changes in key components of the Columbia and Snake River ecosystems through time. Establishing a long-term integrated monitoring program will provide a way to track changes in the ecosystem through time and will help validate predictive models that predict climate effects.

Habitat Responses to Changes in Future Stream Flow Conditions from a Modernized Columbia River Treaty

Recommendation: The Council should consider updating the Fish and Wildlife Plan to request that the appropriate agencies support adaptation of the DELFT3d model to a hierarchical habitat classification tool to identify key-recoverable habitats in the lower Columbia River.

Rationale: The USGS, University of Washington, and Pacific Northwest National Laboratory, through the Lower Columbia River estuary Partnership and with support from BPA, developed a hierarchical habitat classification scheme for the Columbia River Estuary. This tool works extremely well to create ecosystem snapshots for many resource management purposes. Presently, however, this tool has no connectivity to stream flow or river level and thus cannot be used to predict the frequency and duration of inundation of habitat complexes given differing stream flow regimes. A modernized Columbia River Treaty would likely reshape the hydrograph to confer benefits to fish habitats and fish population, including more frequent spring-peaking flows and reconnection with floodplain habitats. Additionally, future flows shaped by climate change and sea-level rise will produce more winter peak flows and lower summer flows, and habitats and aquatic life in downstream reaches will experience increases in acidification and hypoxia. The ability to adapt a hydrodynamic model to the classification tool will help identify where and what habitats to restore (e.g. through land acquisitions and levee breaching) that will best serve aquatic life and sensitive life histories into the future, and that will be most cost effective. Such a tool would be valuable to the management of salmon, lamprey, eulachon, and mussels as well as other first foods.

Fish Tagging

Current Program: Fish Tagging Forum

Recommendations: In addition to the review of the Decision Memorandum of the Council's Fish Tagging Forum (Forum):

- Consider less expensive deployments of JSATS or other active telemetry systems to measure compliance with BiOp performance standards.; and,
- Future studies of passage and survival in the hydro system should focus on further efficiencies in water use.

Rationale: 1) The Forum recommended a 20-year interval between dam passage performance testing at hydro dams. "The Forum recommends a twenty or more year interval between JSATS studies at USACE operated dam(s) unless major modifications to the structures or operations at the dams require updated information about fish survival at the dam(s)". This may be due to the high cost of studies currently conducted. There could be less expensive alternatives, allowing for more frequent performance testing intervals. In addition to the operation changes mentioned in the recommendation, the Council should keep abreast of biological changes that may affect dam passage and survival. For example, the reduction in size of juvenile fall Chinook salmon passing hydro dams over the last decade is one example of how a biological change may affect passage and survival. In sum, given the rapid rate of the evolution of tagging technologies, and the changing physical environment of the Columbia River basin, more frequent testing could reveal changes or trends that should inform management decisions more frequently than every 20 years.

2) The use of voluntary spill and surface passage routes (for example, spillway weirs) has been largely responsible for achieving BiOp performance standards at hydroelectric dams, but further efficiencies in water use may be possible. For example, achieving acceptable dam passage survival at Little Goose Dam is based on an operation including 30 percent of the river passed over the spillway, and passage at The Dalles Dam is based on 40 percent spill. At dams fitted with surface passage structures, like Little Goose Dam, most of the spilled water is used not for passing fish, but for improving egress conditions downstream after passage (this is generally referred to as "training spill"). Although the use of surface passage devices such as spillway weirs has improved fish passage in general, the amount of training spill used before and after the installation of these devices has changed little. Over time, concerns about the effects of global warming will increase the value of the water used for fish passage, and in particular that portion used for training spill. Some model predictions suggest the high flows typical during spring will be shifted to winter, making use of restricted water during spring and summer even more costly (Kock et al., 2012). Field studies or modeling efforts to refine the volume of water used for training spill could be conducted to determine what effect reductions in water volume would have on the dam passage and survival of juvenile salmonids. Potentially, reductions in training spill could be used to generate power.

Independent Economic Analysis Board (IEAB), 2013, Cost-effectiveness of fish tagging technologies and programs in the Columbia River Basin. Northwest Power and Conservation Council Report IEAB 2013-1, Portland, Oregon, 54 p.

Kock, T. J., T.L. Liedtke, D.W. Rondorf, J.L. Serl, M. Kohn, and K.A. Bumbaco. 2012. Juvenile coho salmon during winter: Implications of climate change in the Pacific Northwest. North American Journal of Fisheries Management 32:1070–1079.

Food Web Research

Recommendation: Incorporate ISAB priorities for understanding food webs to support the ability of the Fish and Wildlife Program to help sustain an abundant, productive, and diverse community of fish and wildlife in the Columbia River Basin. Build on and expand existing Fish and Wildlife projects that have collected food web data to incorporate concepts and research needs identified as ISAB priorities. Continue to support work under species-specific projects whose results would be applicable to other related species. Support new food web research approaches and technologies beyond those identified by the ISAB as they are developed. Although the ISAB report was comprehensive, flexibility should be maintained to support projects that address new and emerging challenges regarding food webs such as invasive species. Establish a long-term monitoring program to track trends in food web dynamics in the mainstem Columbia and Snake Rivers and tributary systems through time.

Rationale: The ISAB food web report calls for investigating how the Columbia River basin food web supports the growth and survival of listed salmonids and other native fishes. By conducting research that builds upon existing data and expertise the region could move towards a more holistic understanding of food web function., the effects of existing invasive species, the potential for food web alterations from new biological invasions, and habitat alterations. The amendment process therefore provides an important opportunity to update the Program to reflect an ecosystem management approach that could provide salmon with their total life cycle needs including an adequate food web to support growth and improve survival.

Aquatic Invasive Species

Recommendations: The Council should update the Fish and Wildlife Plan to:

- Support efforts by the 100th Meridian Group, Columbia River Basin Team and others to move efforts to control Aquatic Invasive Species (AIS) from being "reactionary" to being "preventative".
- Support efforts by the 100th Meridian Group, Columbia Basin Team to establish early-detection capabilities for zebra mussels and other invasive species in the Columbia River Basin.
- Establish long-term integrated monitoring programs in the mainstem Columbia and Snake Rivers and tributary systems that incorporate the taxonomic expertise to identify new and existing invasive species so that factors affecting their distribution (e.g., climate change, habitat alterations) can be tracked through time.
- Establish long-term integrated monitoring programs in the mainstem Columbia and Snake Rivers and tributary systems that incorporate the taxonomic expertise to establish the distribution of existing invasive species so that the potential for these species to affect habitat restoration activities can be determined.
- Support research that seeks new and innovative ways to control or eradicate new and existing infestations of invasive species.
- Support research that seeks to determine the effects of existing invasive species on efforts to restore anadromous fish and healthy ecosystems in the Columbia River Basin (CRB).

Rationale: Despite the economic and cultural significance of natural resources in the Columbia River Basin (CRB), little is known of the current distribution and abundance of invasive species and their effects on food webs, fish recovery, and habitat restoration efforts in the CRB. Little information exists on the best management practices for preventing the introduction and establishment of new invasive species and the early detection of new invaders. Many introduction pathways (the geographic pattern of an invasion) and vectors (the vehicle or activity by which a nonnative species is intentionally or unintentionally transported and introduced to a new habitat) are unregulated or remain open because existing regulations are not enforced. Some pathways may be more successful than others due to climatic compatibility and life history ranges of potential invaders. Assessments like a pathway analysis, facilitated by an integrated long-term monitoring program, would help identify high risk vectors at a regional scale. Management actions could then target a high risk pathway (such as hull fouling on commercial ships originating from a highly invaded estuary) rather than an entire vector (in this case, all commercial ships). A fundamental understanding of the diversity and patterns of vectors operating in a region is essential to reducing new introductions into the CRB.

For example, zebra and quagga mussels have recently invaded many western water bodies, causing extensive economic and environmental damage. However, the CRB has yet to be invaded by these species. Research is required to develop methods for preventing the mussels' spread, allow early detection, and define strategies for controlling and managing hydroelectric, irrigation and urban water facilities if the mussels are introduced to the CRB. While zebra

mussels constitute the most visible current threat, the concepts presented here apply to other potential invaders as well.

The region's capacity for predicting the spread of AIS will improve with the identification of the types of habitats and physical and biological conditions that can support the establishment of new invasive species and substantial vectors for new introductions. The development of an integrated monitoring program in the CRB will provide the foundation for assessments of current ecological condition and provide baseline biotic data from which to measure changes in community composition. The baseline and distribution data, when viewed in the context and linked to habitat conditions, will in turn facilitate the development of predictive models to inform Decision Support Systems to prioritize control efforts and to predict the effects of invasive species on potentially expensive habitat restorations.