Staff summary of Issues & Recommendations
Toxic Contamination

*Preliminary draft, please refer to full recommendations for complete review

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2009 Fish and Wildlife Program Section
Section II (page 16); Section VI (pages 43-44)

I. Overview

Many recommenders suggest the Council include in the program implementation section a requirement to implement actions to reduce toxic contaminants or their effects if those toxins are adversely affecting fish survival. Some recommenders suggest the location and types of known contaminants in the Columbia Basin be mapped, and a means of identifying contaminants of emerging concern be established. There are recommendations for the Action Agencies to investigate how anoxic conditions in the reservoirs may mobilize contaminants, particularly mercury. Also, there are recommendations for Bonneville to fund toxics-reduction efforts around the basin. One recommendation asked the Council to use the program to summarize the state of the science related to toxics and the effects on fish in a very far-reaching manner. Other recommendations oppose any expansion of the program into the realm of toxics.

II. Summary

Specific Language Changes

ODFW and WDFW recommend the following changes:
Under Habitat Strategies-Emerging Habitat Issues (p. 16), to include the following modified language [with changes shown in **bold**]: "…*Specific measures to deal with these emerging issues are included in the mainstem plan, **recovery plans,** and many of the subbasin plans.*"

PFMC, NSIA and Association of NW Steelheaders recommend adding the following new language in the Habitat Strategies-Emerging Habitat Issues (p. 16):
Support the Independent Scientific Advisory Board's (ISAB) recommendation to account for the impacts of toxic contaminants on populations in the basin to ensure a robust toxics program is scoped as an amendment.

ODFW, WDFW, USFWS, USRT, Nez Perce: In the Water Quality section on p. 44, revise the last bullet to read [changes shown in **bold**]: "*Implementing actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress*

associated with dam passage, leave juvenile salmon ***and adult and juvenile lamprey*** *more susceptible to disease and result in increased mortality or reduced productivity.*"

ODFW, CRITFC, USRTs and NOAA Fisheries recommend inserting new language into the Water Quality section on p. 44 recognizing fishery resources are affected by toxics accumulation due to development and operation of the federal hydropower system:
"Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence can be associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations can be a controlling factor on the chemical conditions such as anoxia which impact the distribution and bioavailability of toxics in the system. An example of a specific impact caused by the dams is to sturgeon; once anadromous, sturgeon are now blocked in reservoirs and subjected to contaminants year-around at contaminant levels exacerbated by the reservoirs."

General Categories of Toxics Recommendations

Regional Coordination on Toxic Contaminants

ODFW, CRITFC, Coeur d'Alene, Grande Ronde, UCUT, USRT, NOAA Fisheries and EPA
BPA should fund collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;
- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks, used to inform a state or federal legislative response.

BPA recommended the Program should acknowledge the potential leadership role of the Council in convening regional discussions of the impacts and mitigation of toxic contaminants, while acknowledging that mitigation and research on toxics is not the responsibility of the FCRPS.

Characterize the State of the Science Related to Toxics

NOAA-NWFSC
Develop an in-depth report synthesizing the state of the science on toxic chemicals in the Columbia River Basin which emphasizes: 1) the past, present, and (likely) future sources of toxics; 2) the known geographical extent of contaminants in sediments, tissues (fish and other species), and surface waters; 3) possible limitations of the recovery of priority fish populations, including salmon, steelhead, lamprey, smelt, and eulachon; and 4) key information gaps and associated needs for research and monitoring.

Support Basin-wide Monitoring and Characterization of Toxic Contaminants

EPA, USGS
Support basin-wide monitoring and characterization of toxic contamination, including the mapping of existing contamination, known toxic discharges, and contaminants of emerging concern (CECs) in relation to fish and wildlife populations and habitat restoration efforts in the Columbia River basin, including the estuary and coastal ocean.

Monitor and Assess Effects of Toxic Contaminants and Mitigate Their Impacts

ODFW, CRITFC, COEUR D'ALENE, GRANDE RONDE, SPOKANE, UCUT, USRT, LCREP, NOAA Fisheries, NOAA-NWFSC, EPA, American Rivers, Conservation NW, NSIA, Assoc. of NW Steelheaders and 43 individuals.
The Army Corps of Engineers, in coordination with BPA, should fund and implement a programmatic review and assessment of how hydropower projects affect problems associated with the migration and effects of toxic substances in the mainstem Snake and Columbia Rivers and opportunities for operational changes or other actions to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Develop sensitive and diagnostic indicators of chemical exposure and salmon health for use in regional toxic monitoring efforts.

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs
ODFW, CRITFC, GRANDE RONDE, USRT, SPOKANE, NOAA Fisheries, NOAA-NWFSC and USGS

- Fund studies to determine which toxic contaminants most limit the restoration success of anadromous and resident fish and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey that are known to be vulnerable to bioaccumulation of toxins.
- Map the footprint of existing contamination and the location of known toxic discharges in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program.
- Assess food web transfer, sediment transport, and biological effects of emerging (CECs) and legacy (DDT and PCBs) organic contaminants under current and different management regimes, and how those processes affect key Columbia River species and the success of restoration projects within the basin.
- Determine the extent to which toxics limit prey quality and abundance in degraded habitats.
- Investigate the cumulative and/or synergistic effects of multiple toxic contaminants, particularly pesticides, on riparian insects and other organisms that impact the carrying capacity of the Columbia River ecosystem, as well as interactions between these chemicals and non-chemical stressors, which can leave juvenile salmon more susceptible to disease and result in increased mortality or reduced productivity.

Incorporate Toxics into Ongoing Efforts to Restore and Improve Habitats
NOAA Fisheries and NOAA-NWFSC

- Consider toxic contamination in ongoing efforts to restore and improve habitats to avoid the unintended creation of ecological traps, or nuisance habitats, and
- Identify cost-effective pollution control measures and mitigation strategies and incorporate into restoration projects.

Reduce and Prevent Toxic Contaminants
ODFW, CRITFC, GRANDE RONDE, USRT, SPOKANE, NOAA Fisheries, EPA and LCREP

- Encourage the Environmental Protection Agency (EPA) to utilize the regulatory tools it has been granted by statute to protect against the [water quality] impacts of the FCRPS.

- Implement actions, such as those identified in LCREP's Comprehensive Conservation and Management Plan, to clean up, reduce or eliminate toxic contaminants in aquatic habitat to meet state, tribal and Federal water quality standards.
- Support implementation of actions, such as those identified in EPA's Columbia Basin Toxics Reduction Action Plan, that prevent toxic contamination from entering the Columbia River Basin.

Reduce Spills and Leakage of Toxic Contaminants at FCRPS Dams
YAKIMA TRIBES
Urge the Army Corps of Engineers to develop best practices for reducing and containing spills and leakage of PCB-laden lubricating fluids from FCRPS dams into the Columbia and Snake Rivers.

Develop Models to Extrapolate Toxicity Effects to the Population Scale
NOAA-NWFSC
Improve forecasting capabilities to more accurately understand how toxic control and cleanup efforts will improve individual salmon health and increase population abundance.

Adopt ISAB Recommendation for Addressing Hydrosystem Impacts on Upper Columbia White Sturgeon
SPOKANE, USGS
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.

Anticipate and Minimize Future Pollution Threats
NOAA-NWFSC
- Develop new tools to predict the cumulative and interrelated impacts of regional human population growth, land use change, toxic terrestrial runoff, and climate change on salmon population viability.
- Implement new research to assess chemicals of emerging concern (CECs).

Limit Funding for Toxic Contaminants
BPA Customers (PPC, NWRP, PNGC, NRU) and BPA
Council should resist expanding the Program into measures that are not caused or related to the development and operation of the FCRPS because it will distract from the goals of the Act and dilute the effect of available funding from BPA's customers, particularly for calls to expand the Program to address invasive species and **toxics**. Mitigation and research on toxics is not the responsibility of the FCRPS.

ISAB Comments on Toxic Contaminants in Review of 2009 F&WL Program:
Artificial chemical proliferation in the Basin is a priority for resolution. In addition to contaminants of the past, there is a growing concern about emerging contaminants. The estuary and the coastal ocean communities are particularly vulnerable to the accumulation of contaminants because of their spatial position in the watershed. There is an urgent need to

quantify and map the spatial patterns of these chemicals; assess their transfer, accumulation, and persistence; and document their impact on native organisms and on the carrying capacity of the Columbia River ecosystem for juvenile salmonids. The Council has an opportunity to take an active role – through cooperation with regional partners – to ensure that monitoring of toxic contaminants and evaluation of their effects on fish and wildlife are addressed.

State Fish and Wildlife Agencies and Other State and State-Supported Agencies

ODFW (3) and WDFW (4)
Under Habitat Strategies-Emerging Habitat Issues (p. 16), include the following modified language [with changes shown in **bold**]: "…*Specific measures to deal with these emerging issues are included in the mainstem plan, **recovery plans,** and many of the subbasin plans.*"
Rationale: Recovery plans are also a source for actions addressing toxics, climate change, etc.

In the Water Quality section on p. 44, revise last bullet to read [with changes shown in **bold**]:
*"Implementing actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress associated with dam passage, leave juvenile salmon **and adult and juvenile lamprey** more susceptible to disease and result in increased mortality or reduced productivity."*

ODFW (3)
Insert new language into Water Quality section on p. 44 recognizing fishery resources are affected by toxics that have accumulated due to development and operation of the federal hydropower system : *"Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence can be associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations can be a controlling factor on the chemical conditions such as anoxia which impact the distribution and bioavailability of toxics in the system. An example of a specific impact caused by the dams is to sturgeon; once anadromous, sturgeon are now blocked in reservoirs and subjected to contaminants year-around at contaminant levels exacerbated by the reservoirs."*

Monitor and Assess Effects of Toxic Contaminants and Mitigate Their Impacts
Proposed new measure 1: BPA should fund a programmatic review and assessment of how hydropower projects exacerbate any problems associated with the effects of toxic substances and if any such correlation exists, the Council shall identify opportunities for operational changes or other activities to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Evaluate how environmental toxicants impact the reproductive fitness of fish that are impounded behind dams.

Regional Coordination on Toxic Contaminants
Proposed new measure 2: BPA should fund collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;
- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks, that could be used to inform a state or federal legislative response.

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs

Proposed new measure 3: Fund studies to determine which toxic contaminants most limit the restoration success of anadromous and resident fish and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey that are known to be vulnerable to bioaccumulation of toxins. The footprint of existing contamination and the location of known toxic discharges should be mapped in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program. Assess food web 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 success of restoration projects within the basin.

Proposed new measure 4: Investigate the cumulative and/or synergistic effects of multiple toxic contaminants, particularly pesticides, on riparian insects and other organisms that impact the carrying capacity of the Columbia River ecosystem.

Prevent Toxic Contamination

Proposed new measure 5: Recommend, support and fund actions that prevent toxic contamination from entering the Columbia River Basin.

LCREP (11)

Monitor for and Reduce Toxic Contaminants

Recommendation: The Program should fully incorporate water quality improvements and toxic contaminant reductions. Specifically, BPA should fund actions within the Estuary Partnership's Comprehensive Conservation and Management Plan to mitigate for the effects of toxic contamination on aquatic resources that are exacerbated in a river system heavily altered by the federal hydropower system. The Estuary Partnership's Management Plan actions pertaining to toxic contaminant reduction include:

• Action 10: Expand and sustain regional monitoring of toxic and conventional pollutants.

• Action 12: Clean up, reduce or eliminate toxic contaminants, particularly contaminants of regional concern.

Indian Tribes and Tribal Organizations

COEUR D'ALENE TRIBE (13)

Regional Coordination on Toxic Contaminants

Recommendation: The Council shall coordinate a leadership forum where governmental entities can discuss and develop a regional toxic reduction strategy. In addition to whatever priorities are identified at this forum, components of the strategy shall include: a) an accurate description of the existing footprint of toxic substances within the Basin, including the location of any authorized discharges or other sources; b) identification of the principal sources of toxic substances imported into the Basin; c) a coordinated process for identifying new contaminants of concern; and d) a 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks, that could be used to inform a state or federal legislative response.

Monitor and Assess Effects of Toxic Contaminants and Mitigate for Their Impacts

The Program should assess whether hydropower projects exacerbate any problems associated with the migration or effects of toxic substances; if any such correlation exists, the Council should assess whether operational changes or other activities could help mitigate the impacts.

CRITFC (14)

Recommendations to address toxic contamination proposed for Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Recommendation: Insert the following language into the Fish and Wildlife Program that recognizes fishery resources are clearly affected by toxics that have accumulated due to the development and operation of the federal hydropower system:

"*Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence is associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations are a controlling factor on the chemical conditions such as anoxia, which impact the distribution and bioavailability of toxics in the system. An example of a specific impact caused by the dams is to sturgeon; once anadromous, sturgeon are now blocked in reservoirs and subjected to contaminants year-around at contaminant levels exacerbated by the reservoirs.*"

Monitor and Assess Effects of Toxic Contaminants at FCRPS Projects

Measure 1: The U.S. Army Corps of Engineers, in coordination with BPA, should fund and implement a programmatic review and assessment of how hydropower projects affect problems associated with the effects of toxic substances in the mainstem Snake and Columbia Rivers and opportunities for operational changes or other actions to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Evaluate how environmental toxicants impact the reproductive fitness of fish that are impounded behind dams.

Rationale: Feist et al. (2005) evaluated whether evidence of reproductive endocrine disruption could be correlated to specific areas within the Columbia River system and found that fish residing in the reservoirs behind the oldest dams had the highest contaminant loads and incidence

of reproductive abnormalities. Their data suggest that endocrine-disrupting chemicals may be accumulating behind dams over time and that the exposure of fish to these chemicals may be affecting the growth and reproductive physiology of fish in impounded areas of the Columbia River.

The ecological risk of mercury toxicity is directly related to the production of the bio-accumulative and toxic organic form, methylmercury, which is driven by specific bio-geochemical parameters. Importantly, many of those parameters are directly linked to factors associated with water management activities such as water inundation and wetting and drying cycles, organic carbon and nutrient cycling and inputs from upland terrestrial habitats. Reservoirs are among the most common managed hydrological features on the western landscape with a high likelihood for enhancing methylmercury production, transport, bioaccumulation, and risk to fish, wildlife, and human health. Thus, a better understanding of linkages between reservoir management and mercury risk is needed in order to develop approaches to minimize the environmental risks due to mercury while still meeting critical water needs in the Columbia River Basin.

Although it is generally well documented that mercury concentrations in some organisms in aquatic ecosystems and reservoirs of the Columbia River Basin exceed those considered safe for ecosystem and human health, little is still known about which factors are most important in driving variation in mercury concentrations among reservoirs, and what management options present the most effective opportunities for controlling mercury risk. Therefore, a research focus that addresses the following items will better inform resource managers and facilitate future amelioration opportunities:

- Levels of mercury and variation in bio-indicator taxa across reservoirs in the Columbia River Basin.
- Influence of seasonal drawdown and flood-up patterns on methylmercury cycling and bioaccumulation in Columbia River Basin reservoirs.
- Influence of lake stratification, dissolved oxygen, and primary production on mercury cycling and bioaccumulation in Columbia River Basin reservoirs.
- The influence of fish growth, condition, and energetics on mercury bioaccumulation rates and fish mercury concentrations in Columbia River Basin reservoirs.
- The influence of food quality and energy content on mercury bioaccumulation rates and fish mercury concentrations in Columbia River Basin reservoirs.
- The role that variation in littoral versus pelagic foraging reliance plays in driving mercury bioaccumulation pathways in Columbia River Basin reservoirs.
- The influence of prey/forage fish community structure and species assemblages on mercury exposure in top predator fishes in Columbia River Basin reservoirs.
- Biochemical, behavioral, and reproductive effects of mercury in fishes and aquatic dependent wildlife in Columbia River Basin reservoirs.

Regional Coordination on Toxic Contaminants

Measure 2: BPA should help fund collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;
- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks, that could be used to inform a state/federal legislative response.

Rationale: Toxic contamination is a complex issue, and a coordinated, common approach by all co-managers is needed to mitigate the threat to fishery resources. The Council is in a position to provide leadership on this issue and to collaborate with ongoing efforts to reduce toxics in the Columbia River Basin. In September 2010, EPA and the Columbia River Basin Toxics Reduction Working Group released the Columbia River Basin Toxics Reduction Action Plan with 5 initiatives and 61 actions to reduce toxics in the Columbia River Basin (EPA, 2010). Regional collaboration in the past has produced significant advancements in toxics monitoring of fishery resources. In 2007, BPA, the Lower Columbia Estuary Partnership, NOAA Fisheries, and USGS produced the only robust sampling of toxics in juvenile salmon in the Columbia Basin (LCREP, 2007).

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs

Measure 3: The Program should fund studies to determine which toxic contaminants most limit the restoration success of anadromous and resident fish (and wildlife) and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey, as well as threatened and endangered salmonids, which are known to be vulnerable to bioaccumulation of toxins. The footprint of existing contamination and the location of known toxic discharges should be mapped in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program. Assess food web 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 success of restoration projects within the basin.

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 food webs. 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 into the environment of CECs is increasing, although little is known about their harmful levels and ecological effects. Several interdisciplinary 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 pathways, chemical fate and effects of endocrine disrupting chemicals in the food web in the lower Columbia River and found that bio-magnification of multiple contaminants occurred in resident fish and osprey eggs, environmental quality benchmarks were exceeded in some cases, and reproductive parameters showed impairment at some sites and were significantly negatively correlated with various contaminant concentrations (Nilsen et al., in

press; Nilsen and Morace, in press). In some species of vertebrates, these chemicals alter thyroid function, reduce sperm counts, and delay sperm maturation (Kuriyama et al., 2005) among other impacts. NOAA researchers have found multiple contaminants, including polycyclic aromatic hydrocarbons, PCBs, and DDTs in several stocks of Columbia River juvenile Chinook salmon (Yanagida et al. 2012; Johnson et al. 2013), often at concentrations associated with increased disease susceptibility (Arkoosh et al., 1998) and altered growth and metabolism (Meador et al. 2002, 2008). Juvenile salmon are also exposed to chemicals of emerging concern (CECs), such as environmental estrogens and the endocrine-disrupting flame retardants, polybrominated diphenyl ethers (PBDEs; LCREP 2007; Sloan et al. 2011). A better understanding of these effects on key first foods species is needed.

In addition to understanding bioaccumulation and exposure pathways though food webs, there is a need to assess the indirect food-web mediated effects of contaminants on key species. Modern insecticides, metals, and other contaminants are highly toxic to the insects and crustaceans that constitute the prey base for salmon and other fish species. This raises the possibility that insecticides and other contaminants are compromising the biological integrity of critical foraging habitats for ESA-listed species, and putting these stocks at risk by reduced prey quality and quantity (Macneale et al. 2010). New research is needed to better understand how water quality improvements will enhance aquatic community diversity and abundance, as well as prey quality. Critical uncertainties in understanding impacts of contaminants on key species and foodwebs in the Columbia River basin include:

- Chemicals of emerging concern (CECs) levels of concern to the health of key species including 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 contamination 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: Impacts of contaminants on sturgeon reproduction and rearing success within areas of known high productivity. Comparison of potential contaminant impacts on impounded versus unimpounded populations.
- Role of contamination on Pacific lamprey declines compared to threats from hydropower operations, such as dam passage. Assess levels of concern and effects of chemical mixtures.
- Investigate impacts of different hydrologic scenarios and management actions on contaminant distributions and food web transfer.
- Distributions, levels, and spatial patterns of contaminants of emerging concern (CECs) in the Columbia River basin including the estuary and coastal ocean.
- Impacts of contamination from abandoned vessels: Abandoned vessels should be inventoried and mapped in relation to potential impacts to aquatic species.

Measure 4: The Program should fund investigations of the cumulative and/or synergistic effects of multiple toxic contaminants particularly pesticides on riparian insects and other organisms that impact the carrying capacity of the Columbia River ecosystem, as well as interactions between these chemicals and non-chemical stressors.

Rationale: Mixtures of organophosphate and carbamate pesticides are commonly detected in fresh water habitat that supports key species of interest to the Fish and Wildlife program. These pesticides interfere with behaviors that are essential for salmon survival. Some pesticides interact to produce synergistic toxicity in salmon (Laetz et al., 2009) and showed greater degree of synergism at higher exposure concentrations. Several combinations of organophosphates were lethal at concentrations that were sublethal in single-chemical trials. Single chemical risk assessments are likely to underestimate the impacts of insecticides in river systems where mixtures occur.

Prevent Toxic Contamination

Measure 5: The Program should support actions that prevent toxic contamination from entering the Columbia River Basin.

Rationale: The fish and wildlife actions identified in the Columbia Basin Toxics Reduction Action Plan (2010) stresses that measures, which include pollution prevention and green chemistry, need to be supported to achieve a reduction of toxic contaminants in the Columbia River watershed. Pollution prevention measures are less expensive and more effective, efficient and reliable than treating, recycling, or cleaning up pollutants after use. Toxics reduction efforts will contribute to the survival of key species, will complement other activities underway to restore stocks, and will enhance the effectiveness of habitat restoration efforts.

YAKIMA TRIBES (17)

Recommendation to be added to Emerging Habitat Issues in Habitat Strategies section on p. 16.

Reduce Spills and Leakage of Toxic Contaminants at FCRPS Dams

Recommendation: Urge the US Army Corps of Engineers to develop best practices for reducing and containing spills and leakage of PCB-laden lubricating fluids from FCRPS dams into the Columbia River.

Rationale: The current FWP encourages the Action Agencies to collaborate with state, regional, and federal entities in identifying, reducing, and monitoring toxic contaminants entering the Columbia River. The Council admits this function will not be a significant part of its implemented habitat measures, presumably because the direct link with FCRPS operations is tenuous in many cases. However, it is clear that FCRPS dams operated by the Corps routinely and without significant regulatory consequence spill or permit leakage of PCB-laden oils and lubricants into the Columbia/Snake rivers. These point sources can be identified and directly linked to hydrosystem operations and must be controlled. The Council, with the assistance of EPA as necessary, should provide oversight to end this unacceptable practice.

GRANDE RONDE TRIBE (18)

Recommendations to address toxic contamination proposed for Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Monitor and Assess Effects of Toxic Substances and Mitigate Their Impacts

Recommendation 28: BPA should fund a programmatic review and assessment of how hydropower projects exacerbate any problems associated with the effects of toxic substances and if any such correlation exists, the Council shall identify opportunities for operational changes or other activities to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Evaluate how environmental toxicants impact the reproductive fitness of fish that are impounded behind dams.

Rationale: Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence can be associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations can be a controlling factor on the chemical conditions such as anoxia which impact the distribution and bioavailability of toxics in the system.

Feist et al. (2005) evaluated whether evidence of reproductive endocrine disruption could be correlated to specific areas within the Columbia River system and found that fish residing in the reservoirs behind the oldest dams had the highest contaminant loads and incidence of reproductive abnormalities. Their data suggest that endocrine-disrupting chemicals may be accumulating behind dams over time and that the exposure of fish to these chemicals may be affecting the growth and reproductive physiology of fish in impounded areas of the Columbia River.
The ecological risk of mercury toxicity is directly related to the production of the bioaccumulative and toxic organic form, methylmercury, which is driven by specific biogeochemical parameters. Importantly, many of those parameters are directly linked to factors associated with water management activities such as water inundation and wetting and drying cycles, organic carbon and nutrient cycling and inputs from upland terrestrial habitats. Reservoirs are among the most common managed hydrological features on the western landscape with a high likelihood for enhancing methylmercury production, transport, bioaccumulation, and risk to fish, wildlife, and human health. Thus, a better understanding of linkages between reservoir management and mercury risk is needed in order to develop approaches to minimize the environmental risks due to mercury while still meeting critical water needs in the Columbia River Basin.

Although it is generally well documented that mercury concentrations in some organisms in aquatic ecosystems and reservoirs of the Columbia River Basin exceed those considered safe for ecosystem and human health, little is still known about which factors are most important in driving variation in mercury concentrations among reservoirs, and what management options present the most effective opportunities for controlling mercury risk. Therefore, a research focus that addresses the following items will better inform resource managers and facilitate future amelioration opportunities:

- Levels of mercury and variation in bio-indicator taxa across reservoirs in the Columbia River Basin.
- Influence of seasonal drawdown and flood-up patterns on methylmercury cycling and bioaccumulation in Columbia River Basin reservoirs.

- Influence of lake stratification, dissolved oxygen, and primary production on mercury cycling and bioaccumulation in Columbia River Basin reservoirs.
- The influence of fish growth, condition, and energetics on mercury bioaccumulation rates and fish mercury concentrations in Columbia River Basin reservoirs.
- The influence of food quality and energy content on mercury bioaccumulation rates and fish mercury concentrations in Columbia River Basin reservoirs.
- The role that variation in littoral versus pelagic foraging reliance plays in driving mercury bioaccumulation pathways in Columbia River Basin reservoirs.
- The influence of prey/forage fish community structure and species assemblages on mercury exposure in top predator fishes in Columbia River Basin reservoirs.
- Biochemical, behavioral, and reproductive effects of mercury in fishes and aquatic dependent wildlife in Columbia River Basin reservoirs.

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs

Recommendation 29: The Program should fund studies to determine which toxic contaminants most limit the restoration success of anadromous and resident fish (and wildlife) and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey, as well as threatened and endangered salmonids, which are known to be vulnerable to bioaccumulation of toxins. The footprint of existing contamination and the location of known toxic discharges should be mapped in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program. Assess food web 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 success of restoration projects within the basin.

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 into the environment of CECs is increasing, although little is known about their harmful levels and ecological effects. Several interdisciplinary studies have been carried out in recent years to assess impacts of different classes of contaminants in several levels of the foodweb in Columbia River.

The USGS Columbia River Contaminants and Habitat Characterization (ConHab) project investigated transport pathways, chemical fate and effects of endocrine disrupting chemicals in the foodweb in the lower Columbia River and found that bio-magnification of multiple contaminants occurred in resident fish and osprey eggs, environmental quality benchmarks were exceeded in some cases, and reproductive parameters showed impairment at some sites and were significantly negatively correlated with various contaminant concentrations (Nilsen et al., in press; Nilsen and Morace, in press). In some species of vertebrates, these chemicals alter thyroid function, reduce sperm counts, and delay sperm maturation (Kuriyama et al., 2005), among other impacts. NOAA researchers have found from studies on juvenile Chinook salmon that exposure to urban contaminants, such as chemicals of emerging concern (CECs), was linked to an increase in disease susceptibility (Arkoosh et al., 1998). A better understanding of these effects on key first

foods species is needed.

Critical uncertainties in understanding impacts of contaminants on key species and foodwebs in the Columbia River basin include:

- Chemicals of emerging concern (CECs) levels of concern to the health of key species including 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 contamination 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: impacts of contaminants on sturgeon reproduction and rearing success within areas of known high productivity. Comparison of potential contaminant impacts on impounded versus unimpounded populations.
- Role of contamination on Pacific lamprey declines compared to threats from hydropower operations, such as dam passage. Assess levels of concern and effects of chemical mixtures.
- Investigate impacts of different hydrologic scenarios and management actions on contaminant distributions and foodweb transfer.
- Distributions, levels, and spatial patterns of contaminants of emerging concern (CECs) in the Columbia River basin including the estuary and coastal ocean.

Reduce Toxic Contaminants

Recommendation 30: Implement actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress associated with dam passage, leave juvenile salmon and adult and juvenile lamprey more susceptible to disease and result in increased mortality or reduced productivity.

Rationale: Pacific lamprey is a culturally significant species. In the area of anadromous fish, salmon and steelhead tend to receive the spotlight but focus should also be directed to Pacific lamprey given their historic distribution includes a large portion of the Columbia River Basin and the direct effect hydropower has on the species is significant.

Regional Coordination on Toxic Contaminants

Recommendation 31: BPA should help fund collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;

- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks used to inform a state/federal legislative response.

Rationale: Toxic contamination is a complex issue, and a coordinated, common approach by all co-managers is needed to mitigate the threat to fishery resources. The Council is in a position to provide leadership on this issue and to collaborate with ongoing efforts to reduce toxics in the Columbia River Basin. In September 2010, EPA and the Columbia River Basin Toxics Reduction Working Group released the Columbia River Basin Toxics Reduction Action Plan with 5 initiatives and 61 actions to reduce toxics in the Columbia River Basin (EPA, 2010). Regional collaboration in the past has produced significant advancements in toxics monitoring of fishery resources. In 2007, BPA, the Lower Columbia Estuary Partnership, NOAA Fisheries, and USGS produced the only robust sampling of toxics in juvenile salmon in the Columbia Basin (LCREP, 2007).

NEZ PERCE TRIBE (25)
Recommendation to address toxic contamination proposed for Water Quality section on page 44 in the Mainstem section of the Program – revise the final bullet as follows:

- Implementing actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress associated with dam passage, leave juvenile salmon ***and adult and juvenile lamprey*** more susceptible to disease and result in increased mortality or reduced productivity.

SPOKANE TRIBE (26)
Include the following guidance language in the Biological Objectives of Program on p. 11:

Reduce and Prevent Toxic Contamination and Monitor/Assess Effects of Toxics on Food Web

- The Council should state in the Program that it will actively encourage the Environmental Protection Agency (EPA) to utilize the regulatory tools it has been granted by statute to protect against the [water quality] impacts of the FCRPS; and
- The Council should recommend, support and fund implementation actions to reduce toxic contaminants in the water to meet tribal, state and federal water quality standards. The federal action agencies should partner with and support tribal, federal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and its tributaries, and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the

hydropower system, and provide for safer fish consumption by humans. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress associated with dam passage, leave juvenile salmon more susceptible to disease and result in increased mortality or reduced productivity.

Incorporate ISAB recommendations for addressing hydrosystem impacts on Upper Columbia River White Sturgeon (on p. 47 of Sturgeon part in Mainstem section)**:**

- 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: White Sturgeon in the Upper Columbia River (UCR) are a considered a "Species at Risk" by the Canadian federal government, are a species of active research for the Washington Department of Fish and Wildlife (WDFW), and are the focus of a recent UCR White Sturgeon Recovery Plan developed by U.S. and Canada entities. That plan highlights a number of issues as contributing to poor white sturgeon populations and greatly diminished natural recruitment, including but not limited to, habitat diversity, flow regulation, water temperature, water clarity, total dissolved gas (TDG), *contaminants*, food availability, fish community alteration, predation, exploitation and incidental catch. Selected topics have benefited from recent studies by USGS, US EPA, WDFW, and the Colville and Spokane Tribes, but issues such as habitat diversity, flow regulation effects, temperature and elevated trace-element concentrations in bed sediments are in need of research. Multiple lines of evidence indicate trace element contamination in the sediments of the UCR may be a critical habitat stressor to the reproductive success of white sturgeon in the reach between Lake Roosevelt and the International Border. Preliminary evidence suggest that hydrosystem operations in the mainstem river play a controlling factor on exposure of white sturgeon to dissolved trace elements mobilized from river bed sediments.

UCUTs (27)
Regional Coordination, Assess Effects of Toxic Contamination and Mitigate Their Impacts
Coordinate a regional leadership forum where governmental entities can discuss and develop a regional toxics reduction strategy, and assess whether operational changes to hydropower projects can help mitigate the fate and transport of toxic substances due to the Columbia River Power System.

USRTs (28)
Recommendations to address toxic contamination proposed for Water Quality section on pp. 43-44 in the Mainstem section of the Program.
Recommendation: Insert the following language into the Fish and Wildlife Program that recognizes fishery resources are clearly affected by toxics that have accumulated due to the development and operation of the federal hydropower system:

"*Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence is associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations are a controlling factor on the chemical conditions such as anoxia, which impact the distribution and bioavailability of toxics in the system. An example of a specific impact caused by the dams is to*

sturgeon; once anadromous, sturgeon are now blocked in reservoirs and subjected to contaminants year-around at contaminant levels exacerbated by the reservoirs."

Revise the final bullet addressing toxic contamination proposed in the Water Quality section on page 44 in the Mainstem section of the Program as follows:

- Implementing actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the mainstem, combined with the stress associated with dam passage, leave juvenile salmon ***and adult and juvenile lamprey*** more susceptible to disease and result in increased mortality or reduced productivity.

Review and Assess Effects of Toxic Contaminants and Mitigate Their Impacts
Measure 1: BPA should fund a programmatic review and assessment of how hydropower projects exacerbate any problems associated with the effects of toxic substances and if any such correlation exists, the Council shall identify opportunities for operational changes or other activities to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Evaluate how environmental toxicants impact the reproductive fitness of fish that are impounded behind dams.
Rationale: (Same rationale as CRITFC and Grande Ronde Tribe.)

Regional Coordination on Toxic Contaminants
Measure 2: BPA should help fund collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;
- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks used to inform a state/federal legislative response.

Rationale: (Same rationale as CRITFC and Grande Ronde Tribe.)

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs
Measure 3: The Program should fund studies to determine which toxic contaminants most limit the restoration success of anadromous and resident fish (and wildlife) and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey, as well as threatened and endangered salmonids, which are known to be vulnerable to bioaccumulation of toxins. The footprint of existing

contamination and the location of known toxic discharges should be mapped in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program. Assess food web 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 success of restoration projects within the basin.
Rationale: (Same rationale as CRITFC and Grande Ronde Tribe.)

Measure 4: The Program should fund investigations of the cumulative and/or synergistic effects of multiple toxic contaminants particularly pesticides on riparian insects and other organisms that impact the carrying capacity of the Columbia River ecosystem, as well as interactions between these chemicals and non-chemical stressors.
Rationale: (Same rationale as CRITFC.)

Prevent Toxic Contamination
Measure 5: The Program should support actions that prevent toxic contamination from entering the Columbia River Basin.
Rationale: (Same rationale as CRITFC.)

Federal Agencies

NOAA FISHERIES (30)

Recommendations to address toxic contamination proposed for Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Recommendation: Insert the following language into the Fish and Wildlife Program that recognizes fishery resources are clearly affected by toxics that have accumulated due to the development and operation of the federal hydropower system:

"*Fishery resources are clearly affected by the development and operation of the federal hydropower system. Dam presence is associated with the accumulation of contaminated sediment (Colas et al., 2013) and the presence of reservoirs and their operations are a controlling factor on the chemical conditions such as anoxia, which impact the distribution and bioavailability of toxics in the system. An example of a specific impact caused by the dams is to sturgeon; once anadromous, sturgeon are now blocked in reservoirs and subjected to contaminants year-around at contaminant levels exacerbated by the reservoirs.*"

Monitor and Assess Effects of Toxic Contaminants and Mitigate Their Impacts

Measure 1: Coordinate on a programmatic review and assessment of how hydropower projects affect problems associated with the effects of toxic substances in the mainstem Snake and Columbia Rivers and opportunities for operational changes or other actions to help mitigate these impacts and reduce toxic contamination. Determine how seasonal anoxia in dam reservoirs controls the release of toxics and other pollutants from the sediments to the water column and how the uptake and transfer of these toxics and pollutants transfer up the food web and negatively impact fish. Evaluate how environmental toxicants impact the reproductive fitness of fish that are impounded behind dams.

Rationale: (Same as CRITFC and Grande Ronde Tribe.)

Regional Coordination on Toxic Contaminants

Measure 2: Sponsor collaborative partnerships through a forum where governmental entities and co-managers can discuss and develop regional toxic-reduction strategies. In addition to whatever priorities are identified at this forum, components of the strategy should include:

- Identification of the principal sources of toxic substances that impact the Basin;
- A coordinated process for identifying emerging contaminants of concern; and
- A 30-year implementation schedule to achieve toxic reduction objectives, with decadal benchmarks used to inform a state/federal legislative response.

Rationale: (Same rationale as CRITFC and Grande Ronde Tribe.)

Assess Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs

Measure 3: Encourage support for actions in collaboration with other agencies and co-managers to determine which toxic contaminants most limit the restoration success of anadromous and resident fish (and wildlife) and, in particular, determine how contaminants interfere with the reproduction and/or rearing success of key species such as white sturgeon and Pacific lamprey, as well as threatened and endangered salmonids, which are known to be vulnerable to bioaccumulation of toxins. The footprint of existing contamination and the location of known toxic discharges should be mapped in relationship to fish and wildlife populations and habitat restoration efforts and monitored as part of a basin-wide monitoring program. Assess food web

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 success of restoration projects within the basin.
Rationale: (Same rationale as CRITFC and Grande Ronde Tribe.)

Incorporate Toxics into Ongoing Efforts to Restore and Improve Habitats
Measure 4: Consider toxics in ongoing efforts to restore and improve habitats to avoid the unintended creation of ecological traps, or nuisance habitats and identify cost-effective pollution control measures and mitigation strategies.

Rationale: One important need in this category is support for localized monitoring efforts that will provide baseline data where habitat restoration is planned and/or ongoing. Recent findings of elevated levels of bioaccumulative compounds, especially PBDEs, in juvenile salmon from some relatively undisturbed sites in the lower river, where habitat restoration projects are mostly likely to conducted, indicates the need for site-specific investigations of contaminants in salmon prey and/or water and sediments to determine if there are local contaminant sources in these areas. Collection of data on toxicants in floodplain lakes may be another special concern. Assessing the suitability of these habitats for restoration has been identified as a priority by the Expert Regional Technical Group (ERTG), and the potential for contaminant accumulation in these lakes is high due to low flows and lack of flushing.

In addition to identifying areas where habitat restoration effects could be effected by toxic contaminants, there is a need to incorporated pollution reduction and mitigation techniques into restoration projects when toxics may be a concern, and to conduct effectiveness monitoring for toxics at such sites to make sure these efforts are working. The sources of many pollutants in salmon habitats are well known. These range, for example, from historically contaminated sediments to road runoff and agricultural return flows. For some specific land uses, it may be less important to document the extent of exposure to salmon than to conduct research to help understand which source control measures are most effective in reducing toxicological injury. This includes, for example, using biologically based methods to monitor the effectiveness of stormwater filtration, riparian buffers, sediment capping, and other mitigation options.

Reduce and Prevent Toxic Contamination
Measure 5: Support implementation of the Columbia Basin Toxics Reduction Action Plan to the extent applicable to the FCRPS.

Rationale: The fish and wildlife actions identified in the Columbia Basin Toxics Reduction Action Plan (2010) stresses that measures, including pollution prevention and green chemistry, need to be supported to achieve a reduction of toxic contaminants in the Columbia River watershed. Pollution prevention measures are less expensive and more effective, efficient and reliable than treating, recycling, or cleaning up pollutants after use. Toxics reduction efforts will contribute to the survival of key species, will complement other activities underway to restore stocks, and will enhance the effectiveness of habitat restoration efforts.

NOAA-NWFSC (31)

Both the Independent Scientific Advisory Board (2013) and the Independent Scientific Review Panel (2013) recommended that toxics be addressed within the Fish and Wildlife Program, as certain types of chemical exposure have the potential to undermine the long-term efforts by the Bonneville Power Administration (BPA) and the Council to restore salmon habitat and promote the recovery of listed stocks. We strongly encourage BPA and the Council to act on these recommendations. The NOAA NW Fisheries Science Center encourages Program support, in collaboration with other agencies and co-managers, for the following recommended actions related to toxic contamination (proposed for Water Quality section on pp. 43-44 in the Mainstem section of the Program).

Characterize the State of the Science Related to Toxics

Recommendation: *Develop an in-depth report synthesizing the state of the science on toxic chemicals in the Columbia River Basin.*

The synopsis should emphasize: 1) past, present, and (likely) future sources of toxics; 2) the known geographical extent of contaminants in sediments, tissues (fish and other species), and surface waters; 3) possible limitations of the recovery of priority fish populations, including salmon, steelhead, lamprey, smelt, and eulachon; and 4) key information gaps and associated needs for research and monitoring.

Monitor and Assess Effects of Toxic Contaminant Exposure and Accumulation

Recommendation 1: *Conduct targeted monitoring for vulnerable fish species to address data gaps specific to contaminant exposure and accumulation.*

Rationale: Field assessments conducted to date by NOAA and the Lower Columbia Estuary Partnership have profiled persistent bioaccumulative toxicants in juvenile fall Chinook salmon from Lower Columbia River population segments (LCREP 2007; Sloan et al. 2010; Yanagida et al. 2012; Johnson et al. 2013). However, as highlighted recently in a needs assessment by the Columbia River Toxics Workgroup (EPA 2010), much less is known about exposure risks to interior Columba Basin spring and fall Chinook or any stocks of coho, chum, and steelhead. Similarly, toxic threats to eulachon, lamprey, and sturgeon are very poorly understood and need to be investigated.

Recommendation 2: *Conduct synoptic monitoring to profile toxics in surface waters in relation to distinct land uses and associated pollution sources.*

Rationale: The U.S. Geological Survey and others have conducted extensive, albeit now somewhat dated, monitoring of pesticides related to agricultural practices. This monitoring has been extended more recently to pharmaceuticals and other contaminants of emerging concern in the Lower Columbia River Estuary, in relation to municipal wastewater discharges (Morace 2012; Nilsen and Morace in press). However, a lack of environmental fate and persistence data for many contaminants makes it difficult to estimate water quality conditions based on land use activities over large spatial scales.

Recommendation 3: *Develop sensitive and diagnostic indicators of chemical exposure and salmon health for use in regional monitoring efforts.*

Rationale: Ongoing advances in molecular biology are rapidly expanding the toolbox of biological indicators to assess chemical exposure and toxicity in field-collected salmon from different habitats throughout the Columbia River Basin. In tandem with parallel advances in

analytical chemistry, these new tools will greatly expand regional understanding of how water quality degradation affects salmon health and survival. This includes non-lethal sampling from threatened and endangered species. More work is needed to develop and implement these next-generation biomarkers, particularly those that are specific to distinct classes of chemical contaminants (e.g., pharmaceuticals, petroleum hydrocarbons, modern pesticides, PCBs, etc.).

Assess the Effects of Toxic Contaminants on Native Fish and Wildlife and Food Webs

Recommendation 1: *Evaluate the health of underrepresented species, including lamprey, eulachon, and sturgeon.*

Rationale: The effects of toxics on several culturally and recreationally important fish species in the Columbia River Basin are practically unknown. Certain species may be particularly vulnerable to bioaccumulative and persistent organic pollutants (POPs; e.g., PCBs and DDTs) because they are long-lived (sturgeon) or lipid-rich (lamprey and eulachon). Field and laboratory studies are needed to assess the impacts of these and other contaminants on individual survival and population abundance.

Recommendation 2: *Investigate the combinatorial [synergistic]impacts of chemical mixtures on salmon and other fish.*

Rationale: As the discipline of ecotoxicology evolves, it is becoming increasingly clear that chemicals can interact in mixtures to produce much greater toxicity to fish than expected based on the potency of individual chemicals in isolation. Of particular relevance for the interior Columbia River Basin, mixtures of certain common agricultural insecticides have recently been shown to produce synergistic neurobehavioral toxicity in juvenile salmon. Chemicals at trace concentrations can therefore have unexpectedly severe impacts on fish when they co-occur in aquatic habitats with synergists. Mixture interactions are not well understood, and more work is needed to guide future pollution reduction strategies.

Recommendation 3: *Investigate interactions between chemical and non-chemical habitat stressors.*

Rationale: For fish throughout the Columbia River Basin, exposures to contaminants usually take place against a backdrop of many other habitat stressors. Environmental factors such as elevated water temperature and low dissolved oxygen are known to increase the relative impacts of many toxics. Conversely, contaminants can exacerbate the adverse effects of non-chemical factors that determine fish survival. In salmon, for example, the dietary accumulation of POPs can compromise the immune system, thereby increasing mortality rates in subsequent encounters of environmental pathogens. Due to these types of interactions, actual losses from wild fish populations in the Basin are likely higher than would be predicted from the results of chemical toxicity testing under ideal (i.e., non-stressful) laboratory conditions. The future role of climate change deserves particular attention, in the context of reduced flows (less dilution for pollution) and summer thermal extremes enhancing chemical toxicity. Warming water temperatures and changing precipitation patterns resulting from climate change are expected to have a deleterious impact on Pacific salmonid populations throughout the Columbia Basin, including approximately 40% salmon habitat loss in Oregon and Idaho and 22% loss in Washington by 2090 (ISAB 2007).

Recommendation 4: *Determine the extent to which toxics limit prey quality and abundance in degraded habitats.*
Rationale: Healthy riverine and estuarine food webs are essential for salmon growth and survival. Salmonids rely extensively on a prey base of insects and crustaceans, many of which are considerably more sensitive to pesticides, metals, and other contaminants. Modern insecticides, for example, are (by design) toxic to riparian and aquatic insects, and are also commonly detected in agricultural watersheds in the interior Columbia River Basin. This raises the possibility that insecticides and other contaminants are compromising the biological integrity of critical foraging habitats for ESA-listed species. (Macneale et al. 2010) Macroinvertebrates also accumulate POPs and are therefore an exposure conduit for salmon, including otherwise healthy stocks from the interior Basin that must out-migrate through a gauntlet of toxic "hot spots" in the Lower Columbia River Estuary. New research is needed to better understand how water quality improvements will enhance aquatic community diversity and abundance, as well as prey quality, thereby accelerating salmon recovery.

Develop Models to Extrapolate Toxicity Effects to the Population Scale
Recommendation: *Improve forecasting capabilities to more accurately understand how toxic control and cleanup efforts will improve individual salmon health and increase population abundance.*
Rationale: Whereas toxicity takes place at or below the scale of an individual fish, vulnerable stocks in the Columbia River Basin are managed at the scale of wild populations. An enduring challenge in ecotoxicology is to link the health of individual animals to these higher scales. Some preliminary work has been done in this area, including models of population effects of current use pesticides and bioaccumulative contaminants in Pacific salmon stocks. Additional refinement is needed to adapt these models to address specific stocks of concern, and to incorporate threats from multiple contaminants. These population models can then be used to forecast future extinction risks associated with pollution, to estimate the relative importance of pollution as a limiting factor for the recovery and delisting of threatened or endangered salmonids, and to estimate the degree to which successful toxics reduction actions will contribute to stock productivity.

Incorporate Toxics into Ongoing Efforts to Restore and Improve Habitats
Recommendation 1: *Avoid the unintended creation of ecological traps, or nuisance habitats.*
Rationale: One important need in this category is support for localized monitoring efforts that will provide baseline data where habitat restoration is planned and/or ongoing. Recent findings of elevated levels of bioaccumulative compounds, especially PBDEs, in juvenile salmon from some relatively undisturbed sites in the lower river, where habitat restoration projects are mostly likely to be conducted, indicates the need for site-specific investigations of contaminants in salmon prey and/or water and sediments to determine if there are local contaminant sources in these areas. Collection of data on toxicants in floodplain lakes may be another special concern. Assessing the suitability of these habitats for restoration has been identified as a priority by the Expert Regional Technical Group (ERTG), and the potential for contaminant accumulation in these lakes is high due to low flows and lack of flushing.

Recommendation 2: *Identify cost-effective pollution control measures and mitigation strategies that work.*

Rationale: In addition to identifying areas where habitat restoration effects could be affected by toxic contaminants, there is a need to incorporate pollution reduction and mitigation techniques into restoration projects when toxics may be a concern, and to conduct effectiveness monitoring for toxics at such sites to ensure these efforts are working. The sources of many pollutants in salmon habitats are well known. These range, for example, from historically contaminated sediments to road runoff and agricultural return flows. For some specific land uses, it may be less important to document the extent of exposure to salmon than to conduct research to help understand which source control measures are most effective in reducing toxicological injury. This includes, for example, using biologically-based methods to monitor the effectiveness of stormwater filtration, riparian buffers, sediment capping, and other mitigation options.

Anticipate and Minimize Future Pollution Threats

Recommendation 1: *Develop new tools to predict the cumulative and interrelated impacts of regional human population growth, land use change, toxic terrestrial runoff, and climate change on salmon population viability.*

Rationale: As noted recently by both the U.S. Commission on Ocean Policy and the Pew Oceans Commission, nonpoint source pollution is one of the most significant emerging threats to aquatic species worldwide. This is particularly true of the Pacific Northwest, where large increases in population growth and development are expected to dramatically increase the loading of toxic chemicals to salmon habitats in the years ahead. Non-point source pollution is driven largely by weather patterns, and thus future changes in climate will have important implications for the chemical quality of salmon habitats.

Recommendation 2: *Implement new research to assess chemicals of emerging concern.*

Rationale: Since salmon recovery efforts in the Pacific Northwest will continue to evolve over the next several decades, it is critical that new research anticipates (to the extent possible) emerging threats to species that are either listed or likely to be listed under the ESA in the foreseeable future. This includes chemicals associated with current and future human activities throughout the region, such as brominated flame retardants, pyrethroid insecticides, and endocrine-disrupting pharmaceuticals. Preliminary studies by USGS and NOAA have highlighted the presence of pharmaceuticals and personal care products in Columbia River waters, and exposure of juvenile salmon to environmental estrogens. Additional work is needed to better understand the extent and effects of such exposure in salmon.

USFWS (33)

Revise the final bullet addressing toxic contamination proposed in the Water Quality section on page 44 in the Mainstem section of the Program as follows:

- Implementing actions to reduce toxic contaminants in the water to meet state, tribal and federal water quality standards. The federal action agencies should partner with and support federal, tribal, state, and regional agencies' efforts to monitor toxic contaminants in the mainstem Columbia and Snake rivers and evaluate whether these toxic contaminants adversely affect anadromous or resident fish important to this Program. If so, implement actions to reduce these toxic contaminants or their effects if doing so will provide survival benefits for fish in mitigation of adverse effects caused by the hydropower system. In particular, investigate whether exposure to toxics in the

mainstem, combined with the stress associated with dam passage, leave juvenile salmon ***and adult and juvenile lamprey*** more susceptible to disease and result in increased mortality or reduced productivity.

PFMC (34)
Under Habitat Strategies-Emerging Habitat Issues (p. 16), include the following recommendation: *Support the Independent Scientific Advisory Board's (ISAB) recommendation to account for the impacts of toxic contaminants on populations in the basin to ensure a robust toxics program is scoped as an amendment.*
Rationale: There has been a lack of comprehensive planning regarding the issue of toxic contamination in the Columbia River Basin.

BPA (35)
Regional Coordination on Toxic Contaminants
Recommendation: The Program should acknowledge the potential leadership role of the Council in convening regional discussions of the impacts and mitigation of toxic contaminants, while acknowledging that mitigation and research regarding toxics is not the responsibility of the FCRPS.
Rationale: Under the Northwest Power Act, toxic contaminant response generally falls outside the impacts and mitigation responsibilities of the FCRPS and other hydro operators in the Basin. BPA acknowledges there are multiple point and nonpoint sources of toxic pollutants that should be addressed by a process that goes beyond the Program. BPA commends EPA's leadership through the Columbia River Toxics Reduction Workgroup.

EPA (37)
The EPA encourages the Council to consider increasing the emphasis on fish and wildlife recovery actions that better assess and/or reduce toxic contaminants in the Columbia River Basin under the Columbia River Basin Fish and Wildlife Program. Toward that end, EPA recommends specific recommended actions to reduce toxic contamination throughout the Basin for the Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Regional Leadership and Coordination on Toxic Contaminants
Recommendation: The Council, through its Program, should provide leadership on basinwide collaboration in area of toxic contamination.
Rationale: The Council has demonstrated great leadership in fish and wildlife recovery collaboration throughout the Basin; applying that collaborative leadership in the area of toxic contamination would likely result in increased toxics assessment and reduction actions. A specific example would be to increase the dialogue and conversation on the scientific effects of toxic contaminants on fish and wildlife to better understand impacts on fish and wildlife recovery efforts.
Support Basinwide Monitoring and Characterization of Toxic Contaminants
Recommendation: Support basinwide monitoring and characterization of toxic contamination, including the mapping of existing contamination and known toxic discharges in relation to fish and wildlife populations and habitat restoration efforts.

Rationale: An increased understanding of existing toxic contamination will bring financial accountability to the Council's program to ensure that the benefits of resources allocated to fish and wildlife recovery will not be diminished by potential effects of toxic contamination.

Monitor and Assess Effects of Toxic Contaminants at Hydropower Projects
Recommendation: Provide a review and assessment of how hydroelectric projects affect toxic contaminants in the Columbia River Basin and how toxic contaminants can impact the fish that are impounded behind the dams.
Rationale: Fish species have been affected in various ways by the development and operation of the regional hydropower system. Dam presence can be associated with the accumulation of toxic sediments and the presence of reservoirs and their operations can be a controlling factor on the chemical conditions, such as anoxia and mercury, which can impact the distribution and bioavailability of toxics in a reservoir system and in turn may impact recovery efforts.

Prevent and Reduce Toxic Contamination
Recommendation: Promote and provide resources to support regional actions that prevent toxic contamination from entering the Columbia River Basin.
Rationale: There are many opportunities to invest in important collaborative work efforts that can significantly reduce toxic contaminant loading to the Columbia River Basin and significantly improve fish health and promote fish recovery. Examples of successful work efforts to date include the Yakima River Basin sediment reduction efforts, which successfully and dramatically reduced DDT in fish in the Yakima River; WyEast Resource Conservation and Development Area pesticide reduction work, partially funded through the Council's Fish and Wildlife Program; pesticide stewardship partnerships in the Walla Walla Basin, which reduced organophosphate pesticides by 90% in the Walla Walla River; and the successful agricultural take-back programs throughout the Columbia River Basin, which have collected for safe disposal more than 2 million pounds of banned and unused legacy pesticides that will not contaminate nearby rivers and streams.

USGS (38)
USGS recommends specific actions for the Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Assess Effects of Toxic Contaminants on Key Fish and Wildlife Species and Food Webs
Recommendation: Request the appropriate agencies to assess food web 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 food webs 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 food webs. 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 food web 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 food webs. 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 food web 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.

BPA Customers, Other Utilities and River Users

PPC, NWRP, PNGC, NRU [44]

Limit funding for Toxic Contamination*:* Council should resist expanding the Program into measures that are not caused or related to the development and operation of the FCRPS because it will distract from the goals of the Act and dilute the effect of available funding from BPA's customers, particularly for calls to expand the Program to address invasive species and **toxics**.

Environmental and fishing groups -- and individuals in support (either by explicit connection or by similar recommendations)

AMERICAN RIVERS (49)
For the Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Monitor and Assess Effects of Toxic Contaminants and Mitigate Their Impacts
Recommendation: The Fish and Wildlife Program should call for and conduct an assessment of how hydropower projects may exacerbate toxic contamination issues affecting human health, fish and wildlife populations, and the wider ecosystem, and create a program to reduce and mitigate for those effects.
Rationale: Fish and wildlife are negatively affected by toxic contaminants in the Columbia River system, and some of that contamination is likely due to the existence and operation of the federal hydrosystem.

CONSERVATION NORTHWEST (53)
For the Water Quality section on pp. 43-44 in the Mainstem section of the Program.

Monitor and Assess Effects of Toxic Contaminants and Mitigate Their Impacts
Recommendation: The Fish and Wildlife Program should call for an assessment of how hydropower projects may exacerbate toxic contamination issues affecting human health, fish and wildlife populations, and the wider ecosystem, and create a program to mitigate for those effects.
Rationale: There is growing evidence that fish and wildlife are negatively affected by toxic contaminants in the Columbia River [hydropower] system.

NSIA & ASSOC. of NW STEELHEADERS (62)
Recommendation for Habitat Strategies-Emerging Habitat Issues on p. 16.

Recommendation: The Council should support the ISAB's recommendation to account for the impacts of toxic contaminants on populations in the Columbia River Basin by ensuring a robust toxics program is included in the Program.
Rationale: There has been a lack of comprehensive planning regarding the issue of toxics contamination in the Columbia River Basin.

Individuals

The Council received recommendations from 43 individual commenters on the subject of toxic contamination. All of them had similar recommendations to the American Rivers (49) recommendation above.

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