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Ms. Madden:

We appreciate the invitation from the Portland Harbor Natural Resource Trustee Council (Trustees) to participate in the development of a scientific foundation for the restoration planning being conducted under the Natural Resource Damage and Assessment Program for the Portland Harbor Superfund site. The "Expert Panel" (Panel) has been meeting since late 2009, with the goal of identifying a scientific framework and priorities to guide the development of a restoration plan.

In the course of this work, we completed a literature review (attached) of the habitat relationships and ecology of juvenile spring Chinook salmon in the lower Willamette River (LWR) to ensure our recommendations are based on the best available science. The Panel suggests that this review could become a living document that incorporates new information as it emerges, or past literature as it is deemed relevant. The literature review and the Panel recommendations could be posted online and would be available for all parties and the public, potentially assisting similar efforts in other locations.

In this letter, we summarize some key points from the literature review, discuss our primary recommendations, and identify areas of emerging knowledge. The views expressed here do not necessarily constitute the policies or positions of our respective agencies and institutions.

***Recommendations*:**

The Panel agrees with the initial focus on juvenile Chinook salmon; they comprise two evolutionarily significant units (ESUs) listed as threatened under the federal Endangered Species Act (ESA), are numerically dominant among salmonids in the LWR, and represent the species with the greatest socioeconomic impact to the region. Improvements to habitat will likely benefit multiple species, directly or indirectly. However, we encourage all parties to recognize the presence and importance of other species, whether ESA-listed (winter steelhead and coho salmon, multiple ESUs) or sensitive (white sturgeon, Pacific lamprey) and to consider their different habitat requirements when planning and implementing projects.

Geography/Focus Areas

We refer here to two geographic areas considered for habitat restoration efforts: the Portland Harbor area proper (approximately river kilometer 5.6 to 15.3), and the "broader focus area," including those locations downstream that may be affected by activities in the Portland Harbor.

In our review of the scientific literature (and best professional judgment), it is clearly evident that this area is important in many ways to juvenile Chinook salmon, perhaps best evidenced by their nearly constant presence (34 of 35 months in one study) and diverse life-history. Researchers also documented genetic diversity among fish utilizing off-channel habitat, extensive feeding, growth, and utilization of most available habitat types. As determined from radio telemetry work conducted, larger juvenile (yearling) fish do not appear to reside for long in the LWR (days to weeks), but this is likely a critical time as they prepare to transition to the Columbia River estuary and ocean. The residence time of subyearling juveniles is largely unknown but likely to be longer because migration rate is positively related to fish size (length).

We generally agree with the Trustees' approach to expend no less than 50% of the available resources for habitat restoration in the Portland Harbor area, though some Panel members recommended that more than 50% of the restoration should occur here. It is critical to apply restoration resources to the locations that have experienced the most significant habitat loss and industrial impacts, and virtually all Willamette basin salmon – juvenile or adult – must pass through this area. We recommend that the allocation of restoration efforts should be based on both minimum proportional distribution and also minimum linear distribution for connectivity. Connectivity is a critical ecological requirement for migrating fish, therefore the distribution of restoration efforts must also provide an effective linear sequence of restored habitats of "stepping stones" that provide habitat for resting feeding and predator avoidance along their migratory route. If restoration projects are limited to a small number of different areas, we recommend locating at least three projects within the Portland Harbor area with restored areas on both sides of the river. This minimum distribution would insure that fish could find several sites with suitable habitat within the lower Willamette River and subyearling fish could find habitat on either bank. The criterion for connectivity should be met before distributing restoration efforts outside the Portland harbor area to the broader focus area. We note that significant efforts are underway through the 2008 Willamette Project Biological Opinion to improve habitat, fish passage, water quality, and survival in the basin above Willamette Falls and other restoration projects are being implemented along the lower Columbia River by other agency and

conservation groups. Benefits realized from those efforts will undoubtedly be enhanced by restoration actions in the lower Willamette River.

In the broader focus area, we recommend any proposed restoration efforts focus on the area between the upstream end of Hayden Island and the downstream end of Sauvie Island. Previous recommendations suggested including the Columbia River to the mouth of the Sandy River. Although genetic "signatures" for Willamette spring Chinook salmon have been documented near the Sandy River, it is likely that these are a reflection of past hatchery practices that incorporated Willamette fish into the Sandy broodstock. Current work indicates Willamette-origin fish are present around Hayden and Sauvie islands, and on both sides of the Columbia River (see our discussion under *Uncertainties and emerging information*)

We include the Multnomah Channel in this recommendation, as juvenile Chinook salmon are routinely collected there during research efforts, and one study estimated 71% of radio-tagged Chinook salmon released near Willamette Falls used that route (or at least entered the channel). Returning adult fish also use this route, as evidenced by the popular and productive sport fishery that occurs there.

The Columbia Slough has significant water quality issues and an abundance of introduced fish species; we do not recommend this area be included in the broader focus area for restoration unless those issues are addressed. The eventual reconnection of the slough to the mainstem Columbia River would likely be very beneficial, and would change our position on the priority of restoration actions here.

The literature review and our discussions support a strong focus on restoring active channel margin (ACM), off-channel, and tributary habitats. The scientific evidence is very strong in demonstrating the importance of nearshore habitats to juvenile Chinook salmon, especially subyearlings. It is important to note that the small (fry or subyearling) fish we refer to are virtually all naturally produced (hatcheries release much larger fish), so their role in the ultimate regional goal of recovering "wild" populations is critical. We highly recommend the preservation of existing shallow water beaches and forested riparian habitat, and suggest that such preservation be credited as restoration when it is part of a larger project footprint that includes active restoration.

While small tributaries may not contribute substantially to broad-scale population recovery, they may serve as important habitats (e.g., thermal refuges) to outmigrating salmonids. We recommend focusing on tributary confluences within the LWR and relying on site-specific information about historic and potential use to determine the

project footprint at these sites. The availability of cool, clean water can help identify important historic tributaries.

Habitat Value

The Panel discussed a suite of issues related to the proposed habitat values (HEAs):

We determined that ACMs with invasive vegetation are less valuable than unvegetated ACM because (1) invasive vegetation prevents recolonization of native vegetation, and (2) invasive vegetation provides a seed source that will contribute to the spread of invasive plants. We therefore recommend revising the HEA value for ACM slope <5:1 from 0.9 to 0.75.

Undulating shorelines may or may not be more valuable than linear shorelines. Many high catch areas for subyearling Chinook salmon in the LWR (based on the literature review) were straight, homogenous beaches. Further, the river will tend to reshape whatever shoreline type is designed. The most important factor to consider in designs is that they are geomorphologically sustainable and hydrologically appropriate. All proposed projects should allow habitat-forming processes to shape a natural shoreline, and we recommend against any artificial constraints to these processes, including placement of engineered log jams in the LWR. The value of projects incorporating such constraints should be reduced relative to the value of ideal (unconstrained) habitats.

The Panel has some concerns with the placement of large wood along the mainstem shoreline. In a large river, wood behaves like sediment, moving with flow and tidal fluctuations; in the lower Willamette, large pieces tend to move during floods and settle above ordinary high water. Instead of manually placing large wood accumulations (jams), we recommend creating conditions that allow large wood to accumulate naturally. Conserving (or restoring) forested riparian and upland areas will be essential to the natural recruitment of large wood. The effect of predation on juvenile salmonids by northern pikeminnow, bass, walleye, and other predators has not been sufficiently studied in the Willamette basin, but is a well-known limiting factor in the Columbia and other rivers. As shoreline large wood is known to attract predators (logs and artificial jams are often used to enhance warmwater fisheries in lakes), care should be taken to avoid wood placement where salmonid and predator habitats overlap. We recognize the intrinsic value of large wood as a contributor to primary production and potential cover for salmonids; concerns about attracting predators may even be outweighed by these benefits. However, much of the high-value habitat identified through the literature review (i.e. beaches) did not have significant accumulations of large wood.

We do not recommend considering deep water within the navigation channel as having a different habitat value relative to other deep water. Biologically we conclude there is very little difference, as the evidence suggests small fish are found primarily near shore, and larger fish (e.g., smolts in the radio tag studies) were distributed evenly across the river channel. One special case might be when the ACM is in very deep water, i.e. near sheetpile walls (seawalls) in the Portland Harbor area. Among the many fish-habitat analyses conducted by the Oregon Department of Fish and Wildlife (ODFW) in the LWR, only one relationship was consistent – juvenile salmonid density was significantly lower at seawall sites, suggesting they have little value as fish habitat.

Overwater structures: We propose a zero habitat value for floating structures (log rafts, barges, etc.) when anchored over shallow water habitat or ACMs. In addition to increasing the potential for attracting predators, these structures may physically alter or make otherwise good habitat inaccessible (for example, during low tide or low flows). Recent work has demonstrated these structures can affect primary and epibenthic productivity by limiting light and restricting the growth of vegetation. Floating structures may affect the ability of juvenile salmonids to forage, avoid predators and navigate. An eight-year study in Lake Washington conducted by the U.S. Fish and Wildlife Service showed that juvenile Chinook salmon avoided areas directly beneath overwater structures regardless of life history stage, especially at night.

Monitoring

We strongly recommend the implementation of monitoring at restoration project sites. Monitoring should be of sufficient rigor to detect changes in physical characteristics and biota of restored sites over time, and should use standardized, broadly applicable, and widely accepted methods so that monitoring is repeatable and scientifically defensible. We suggest this can best be accomplished through a third party (or parties), which could be funded by PRP contributions to a monitoring "bank." This approach would allow key parameters to be monitored and compared across all restoration projects.

Uncertainties and emerging information:

While we believe our review of the existing scientific literature was thorough and sufficient to use as a basis for informed restoration decisions, it is important to recognize that there are many uncertainties and emerging issues pertaining to our knowledge of salmon biology and their interactions with the environment. We list a few examples here:

1) Much remains unknown about the life-history diversity of Willamette spring Chinook salmon. Historically, juvenile spring Chinook were categorized only as "stream type," living in fresh water for a year or more before migrating to the ocean. Biologists now recognize at least four major life-history patterns (fry migrants, spring subyearling migrants, fall subyearling migrants, and yearling migrants), and research in progress has identified up to 14 potential life-history pathways (our review of published literature did not include abstracts from professional meetings, but this research by ODFW was presented at the 2011 national meeting of the American Fisheries Society and published as a professional abstract).

   The best available data suggest that yearling juveniles generally contribute most to returns of adult Chinook salmon in the Willamette River (the reason hatchery fish are released as smolts), but significant contributions to adult recruitment by subyearlings has been demonstrated, and this life-history type may have historically been the primary contributor to adult returns. In studies of the interior Columbia basin and British Columbia streams, this life history has been shown to be viable. Good freshwater conditions (allowing fish to avoid predators, dams, pollution, high temperatures, and sub-optimal habitats) can lead to improved survival to the ocean and increased contributions to adult returns. Most importantly, this diversity of life-history types provides resilience to the population - a "bet-hedging" strategy.

   We have described a few of the more obvious behavioral differences among juvenile Chinook life-history stages in this letter, and strongly recommend considering all life-history types when developing a comprehensive restoration strategy.

2) While prevalent in the LWR, small juvenile Chinook salmon are difficult to study because of their fragility and the lack of adequate means to mark or tag them without causing injury or death (also potentially biasing studies). Similarly, the ODFW LWR study captured small fish primarily with beach seines in shallow water, where other gear types were ineffective, so comparisons among habitat types were not possible. Because migration rate has been shown to increase with fish length for Chinook salmon, we hypothesize that small (fry or subyearling) fish spend more time in the LWR than larger juveniles. We expect advances in tagging technology and research being conducted in support of the 2008 Willamette Project Biological Opinion will improve our understanding of the behavior and habitat use of small juvenile Chinook salmon in the near future.

3) The effects of predation on juvenile salmonids by native and exotic fish species in the Willamette Basin are incompletely explored. Only one peer-reviewed study was entirely devoted to this topic – 31 years ago. The recent expansion of predators such as smallmouth bass in the lower Willamette River and the extensive documentation of predation on salmonids in the Columbia and Yakima rivers suggest this is an important potential limiting factor, and should be considered in the context of habitat restoration.

4) Use of the Oregon and Washington sides of the Columbia River by Willamette juvenile spring Chinook salmon is an emerging topic. Researchers are currently conducting sampling for juvenile Chinook salmon on a monthly basis in the lower Columbia River, including locations near the Sandy River delta, Hayden Island, and Sauvie Island. The fish are genetically sampled to determine their stock of origin. Willamette-origin fish have been documented in these locations on both sides of the river, but it is too early to make conclusions about relative habitat use. We hypothesize that subyearling fish, being shoreline oriented, likely enter the Columbia River from the Willamette and remain on the Oregon side for some time. The larger, more mobile smolts (or yearlings) are more likely to traverse the river channel and use habitat on the Washington side to some extent (based on published radio telemetry studies in the mainstem Willamette River).

5) As discussed above, the biological costs and benefits of using large wood as a restoration tool in the mainstem Willamette River remain uncertain.

Thank you for the opportunity to participate in this important work. We are hopeful our collaborative efforts will lead to greater protections for threatened spring Chinook salmon and improvements to the lower Willamette River ecosystem.

Sincerely,

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