## Estuary and Plume Proposals
## ProjectID: 30001

Historic habitat opportunities and food-web linkages of juvenile salmon in the Columbia River estuary: Implications for managing flows and restoration
**Sponsor:** NWFSC/NMFS
**Province:** Columbia Estuary
**FY03 Request:** $597,559
**5YR Estimate:** $2,698,559
**Short Description:** Evaluate the role of river flow on habitat opportunities and food web structure for juvenile salmon by comparing historic and current conditions using model simulations and empirically derived food-web linkages.
**Response Needed?** Yes

1. This proposal appears to overlap with two other proposals entitled "Plume" and "Organization" that address similar questions. Some clarification of the unique contribution of this proposal relative to the two others is needed.

The three research proposals raise similar management questions about the effects of flow and habitat change on salmon and adopt a complementary research approach that should help to integrate results across estuary and plume environments. Specifically, that approach involves three general categories of research activity: collection of empirical data to describe salmon-habitat relationships; reconstruction of historic climate, river flow, and habitat conditions; and simulation modeling to evaluate responses (measured as changes in "habitat opportunity") to past and future management scenarios. Our estuary proposal emphasizes two of these research categories—historic reconstruction and modeling—which will complement empirical data we are now collecting on salmon life histories and habitat relationships in an estuarine monitoring program recently initiated with Corps of Engineers' support. The similar modeling approach proposed by both the Estuary and Plume projects will allow us to assess potential tradeoffs for management actions that affect more than one stage of salmon life. For example, would changes in flow management intended to benefit salmon-habitat opportunity in the estuary promote or undermine habitat opportunities in the plume environment?

The activities in the estuary proposal are a direct response to the conceptual framework and research needs developed in our recent review of hydrosystem effects on the Columbia River estuary, *Salmon at River's End* (Bottom et al. 2001). That framework emphasizes the linkage between salmon life-history diversity and various physical habitat features needed to support these behaviors, including diverse habitats in the estuary. One important implication of our conceptual framework is that we not only must consider density-dependent interactions (food-chain and predator-prey relationships) that determine the productivity of estuarine habitats ("habitat capacity"). But we also must be concerned with physical and geographic factors that determine whether salmon can fully access the habitats that are potentially available to them ("habitat opportunity"). For example, the elevation of wetland habitats relative to natural tidal fluctuations or the geographic proximity of potential intertidal rearing areas to subtidal refugia can set limits on habitat opportunity (and the expression of diverse life-history traits)

independent of fish density or prey availability. Our estuary research is designed to account for both geographic and biological influences on estuarine-rearing salmon, which will jointly affect the results of any restorative efforts in the estuary.

Another important implication of our conceptual approach is that population structure and habitat conditions upstream may determine whether salmon can fully realize the potential rearing opportunities in the estuary. Elimination of ocean-type life histories due to habitat losses or other factors upriver, for example, could limit occupation of shallow estuarine habitats by small subyearling migrants. Recommendations based on our estuary research thus must be developed in the context of the entire salmon ecosystem.

Unlike the Plume and Optimization proposals, which address climatic and flow effects in an open, pelagic environment, the estuary proposal must also account for historic changes in the geomorphology, bathymetry, and habitats of the relatively shallow, semi-enclosed estuarine basin. Our assessments of historic change and future management scenarios in the estuary therefore must consider not only driving forces "external" to the system, such as climate and river flow, but also persistent changes to the morphology of the estuary basin itself from diking, filling, dredging, and other development activities that have reduced potential rearing opportunities for juvenile salmon. A prerequisite for understanding the quantity and quality of habitat changes and the ecological responses to them is to develop an accurate representation of the predevelopment estuary basin, including bathymetry, shoreline extent, and intertidal elevations.

2. The sponsors should be more specific about how they are going to use the historic information.

The historic bathymetric and topographic data we collect will serve two major purposes. First, it will establish the predevelopment baseline for the proposed simulation modeling. This baseline will be used in the model to characterize habitat opportunity and circulation and to assess independently their responses to specific estuarine alterations: changes in depth of the navigation channel, removal of peripheral wetlands by diking and filling, effects of flow regulation and irrigation. Earlier attempts to model habitat opportunity in the lower estuary (Bottom et al. 2001) were constrained by lack of data to depict the shallow, peripheral wetland areas that have been eliminated by diking and filling. The proposed process for digitizing original survey data would allow us to incorporate the area of historic estuarine wetland in all predevelopment simulations for the entire tidal river and floodplain to Bonneville dam.

The second use of the historic bathymetric and topographic data is to quantify habitat changes in the estuary by comparing predevelopment habitat types, distributions, and geomorphic complexity to present-day conditions. These results will be evaluated in the context of our ongoing monitoring efforts (funded by the Corps of Engineers), including studies of emergent and forested wetlands, to understand the implications of habitat change for juvenile salmon. The historic information thus provides a foundation for identifying restoration priorities.

This estuary proposal will not classify historic habitat types or quantify changes that have occurred since the predevelopment period. Instead it develops a detailed (1:10,000 scale) and

spatially-correct (GIS) rendition of the predevelopment estuary that is needed before such analyses can be completed. We will merge historic hydrographic data (e.g., depth information) with historic topographic data (e.g., extent of shoreline and floodplains) to create a single, seamless digital coverage for the entire estuary/tidal river from the mouth to Bonneville Dam. No such base map is presently available at a resolution sufficient to characterize habitat features relevant to salmon. The approach we are proposing would allow us to take full advantage of recent technologies (e.g., Geographic Information Systems) and data sources (e.g., remote imagery) to later classify habitat types and quantify changes.

Our proposed analysis of historic tidal and river-flow data will serve several purposes. The tidal data is needed to geo-reference results of bathymetric surveys that were conducted before the Columbia River datum was defined in 1911. Data for historic changes in river flow are needed to evaluate hydropower, irrigation, and climatic impacts on flow and sediment transport, which, in turn, may influence tidal-fluvial habitat and salmon. Finally, we will also assess inter-annual and decadal variations in climate to define historic disturbance patterns that affect the physical environment of the estuary and the frequency of inundation of tidal-floodplain habitats. Indices for the El Niño-Southern Oscillation and the Pacific Decadal Oscillation are now available back to 1860, which predates records for Columbia River flow by several decades. We have developed a method for using historical tidal records (available for Astoria from 1853) to provide a consistent estimate of river flow that can be compared to climate records.

3. How is this work different from that in the Thomas report?

The Thomas analysis of habitat change was limited to the lower Columbia River estuary below Puget Island (near RM 45). It did not include the large tidal region that extends upstream to Bonneville Dam. Unfortunately, even the area covered by Thomas cannot be used to develop a more complete estuary coverage useful for assessing changes in salmon habitat. First, the Thomas data were not developed in a geographically corrected (GIS) format, and the original version cannot be reproduced (digitized) because the data overlays have been lost. Because the polygons of various habitat types are not spatially corrected, the habitat measurements are not precise. The spatial resolution of the Thomas analysis was 1:40,000, a scale that does not permit detailed representation of habitat composition or structure. His four wetland classes, for example, do not distinguish scrub-shrub from forested wetlands. The 1:10,000 coverage we will create will provide a much more useful resolution for classifying habitats and discerning geomorphic features important to juvenile salmon, including small dendritic channel networks, shoreline features, and shallow-water areas.

4. Is the Corps currently conducting similar work, extended from the Thomas report?

Two independent habitat projects have been completed since the Thomas (1983) report:

(1) A project by CREST (Graves 1995) that duplicated some of the Thomas criteria and data sources but included the entire area up to Bonneville Dam, and

(2) A Corps-funded analysis of estuarine habitat change by an OSU graduate student (Allen 1999) based on aerial photographs taken in 1948, 1961, 1973, 1983, and 1991.

While these reconstructions provide visual representations, they cannot be used in a GIS-based analysis to accurately quantify wetland changes or historic habitat structure for salmon. The CREST project (Graves 1995) provided some additional historic vegetation information from the original General Land Office surveys but adopts the same coarse spatial resolution as Thomas (1983) (1:40,000). Again, the results are not geographically accurate, they cannot be corrected spatially, and the original data cannot be located. Allen's (!999) results are also at a very coarse resolution (1 ha minimum, 1:48,000) and do not represent the many habitat changes that had already occurred prior to 1948.

Our current monitoring project with the U.S. Army Corps of Engineers is supporting development of a rigorous GIS-based protocol for analyzing estuarine habitat change. The pilot study focuses on a few selected reaches within the tidal river upstream of the Thomas analysis. The habitat classes and methods for analyzing habitat change developed in the pilot study can be applied to other areas of the estuary once the historic bathymetric/topographic baseline suggested in this proposal has been completed.

5. The subcontractor is not noted in the budget section.

The subcontractors are noted on page 8 of the itemized budget forms submitted in support of this proposal. The listed subcontractors include the Oregon Graduate Institute at the Oregon Science and Health University (OGI @ OSHS), the University of Washington (UW), and Oregon State University (OSU).

6. Is the budget complete given the comments in 9G?

We do not understand the question. Section 9G refers to Facilities and Equipment. We have indicated that all the cooperating institutions have the appropriate capabilities to conduct the proposed research. If the question can be clarified, we will be pleased to provide any additional information needed to address the panel's concerns.

**References**

Allen, T.H. 1999. Arial distribution, change, and restoration potential of wetlands within the lower Columbia River riparian zone, 1948 – 1991. Dissertation, Oregon State University. OSU Press: Corvallis, OR. 280 p.

Bottom, D.L., C.A. Simenstad, A. M. Baptista, D. A. Jay, J. Burke, K. K. Jones, E. Casillas, and M. H. Schiewe. 2001 [prepublication draft]. Salmon at river's end: The role of the estuary in the decline and recovery of Columbia River Salmon. U. S. National Marine Fisheries Service. 271 p.

Graves, J.K., J.A. Christy, P.J. Clinton, and P.L. Britz. 1995. Historic habitats of the lower Columbia River. Columbia River Estuary Study Taskforce, Astoria, OR. 14 p.

Thomas, D. W. 1983. Changes in the Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program. Astoria. 51 p.