Annual Report (FY01)

TITLE:	Estuarine habitat and juvenile salmon – Current and historic linkages in the lower Columbia River and estuary

PROJECT LEADER: Dan Bottom
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Blvd. E.
Seattle, Washington 98112
(206)-860-3313

ADMINISTRATIVE: Kurt Gores
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Blvd. E.
Seattle, Washington 98112
(206)-860-3270

ADMINSTRATIVE CODE: EST – P - 02

DATE OF SUBMISSION: November 2001

Project Summary

Estuaries are considered important to rearing of juvenile salmon and represent an integral component of the continuum of habitats that salmon occupy for significant periods of time. There is, however, a general lack of science-based information concerning attributes of these tidal freshwater and oligohaline transition zones needed to support juvenile salmon, particularly in the Columbia River estuary. Further, recent evidence supports the concern that flow in the Columbia River significantly affects the availability of estuarine habitats, that flow is much reduced compared to historic levels, and that seasonal flow patterns are much different now than a century ago. The long history of wetland loss in the Columbia River estuary coupled with change in flow patterns suggests that restoration of these habitats may benefit recovery of depressed salmon stocks. The need to develop effective restoration strategies led us to propose empirically identifying the benefit of these habitats to juvenile salmon by evaluating habitat-

salmon linkages in the lower Columbia River and estuary. We proposed a monitoring approach to identify associations between salmon and habitat in the lower Columbia River and estuary. We further propose a historic reconstruction of flow and sediment input in the system and historic reconstruction of critical salmon habitat using GIS for comparison to present day conditions and to gauge loss and factors associated with loss of critical habitats and to identify areas for future restoration. The approach will be to 1) determine the relationship between habitat and the presence, use, and benefit to juvenile salmon, with an emphasis on subyearling chinook salmon, in the lower Columbia River and estuary and 2) understand change in flow, sediment input, and availability of habitat in the lower Columbia River and estuary. To be successful, this approach requires that we both establish relevant empirical associations between habitat variables and juvenile salmon and accurately model physical changes in the lower Columbia River and estuary.

During later years of this proposed study, a modeling effort to evaluate the impact of physical change (natural and anthropogenically-induced variability) on the availability of critical salmon habitat is planned. To accomplish this objective, we plan to use the CORIE numerical modeling system for the lower Columbia River and estuary. This modeling system is being independently developed and validated. It will be used here to evaluate availability of habitat affected by variation imposed by both natural processes and anthropogenic manipulation of the system and further, to a limited extent, associations between salmon use and habitat type.

We report here accomplishments for the first year of the project. Accomplishments include 1) identification of beach seining sites along a transect near the mouth of the Columbia River with sampling to commence in August pursuant to receipt of federal and state permits, 2) selection of 2-3 replicate sites for detailed emergent wetland assessments for salmon-habitat linkages near Russian Island, 3) tested gear suitability using fyke nets to insure site drainage at low tide, 4) have taken an overflight with Coast Guard assistance to identify other wetland sites in more forested slough sites in Cathlamet Bay, 5) held meetings with LCREP and CREST to collect data and assess ongoing GIS efforts to insure complimentary of historical mapping of salmon habitats in the lower Columbia River and estuary, 6) deployed physical monitoring stations in the Cathlamet Bay region to compliment the existing network of real-time physical monitoring stations in the Columbia River estuary (CORIE), and 7) established historical tide series needed to fully characterize change in habitat opportunity. A more detailed description of accomplishments with respect to specific objectives and tasks follows.

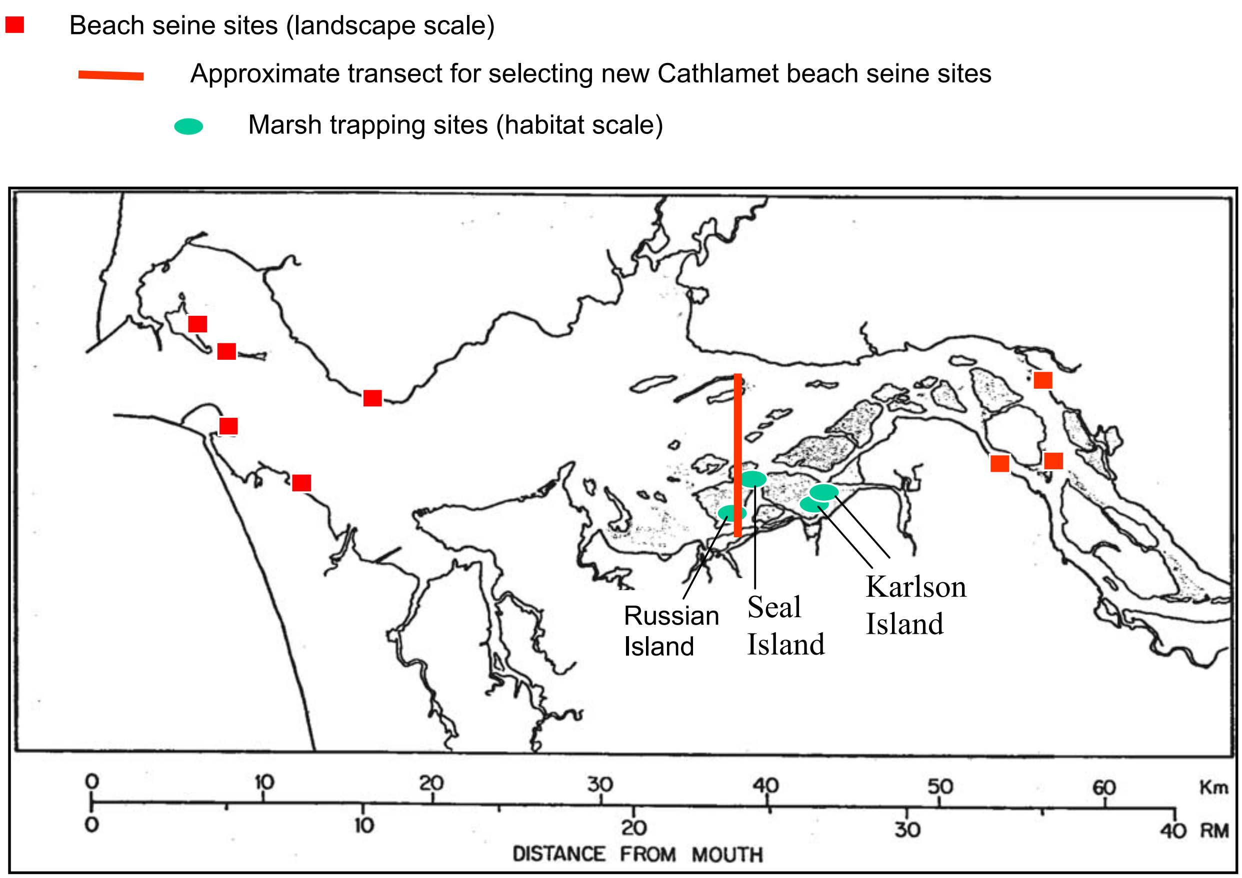
Accomplishments

Objective 1: Determine the temporal relationship between tidally influenced habitats (lower river and estuary) and the presence/absence, abundance, and benefit to juvenile salmon, with an emphasis on shallow water areas, dendritic channels, backsloughs, and main channel margins in the Columbia River.

The conjectured importance of shallow water areas and habitats along the river margin to estuarine-rearing salmon, the long history of wetland loss in the Columbia River estuary, the sensitivity of the tidal freshwater and oligohaline transition zone to small changes in salinity, and the lack of empirical information about the specific attributes of shallow-water habitats needed to support salmon led us to propose that evaluation of salmon and habitat associations in the tidally influenced lower river and estuary of the Columbia River. This approach requires that we accurately establish relevant empirical associations between habitat variables (both physical and biological) and juvenile salmon. For example, salinity conditions of estuaries influence the composition of emergent plant communities (e.g., Frenkel and Morlan 1991), which in turn, determines the quality and quantity of prey available to juvenile salmon in wetland habitats (Simenstad and Thom 1996). If we develop empirical associations between habitat attributes (e.g., salinity, depth, channel morphology, vegetation type, prey resources, etc.) and salmon distribution and performance (e.g., presence, abundance, residence time, and growth) in Columbia River wetlands, peripheral habitats, and central regions in the river, then we can either predict responses of juvenile salmon relative to predicted physical change or establish criteria useful for restoration efforts.

Task 1.1. Site selection, preliminary sampling: Establish transects and sites for evaluating habitat-salmon associations within the lower Columbia River and estuary.

Accomplishment – We established sites for evaluating habitat-salmon associations within the lower Columbia River and estuary (Figure 1). To evaluate the effects of landscape-scale factors on salmonid habitat use, beach seining stations are concentrated (1) in the area above Cathlamet Bay (near Puget Island), where juvenile migrants must first choose whether to remain in the main channel or select low-energy backwater environments (lower Elochaman River, East Tenasillahe



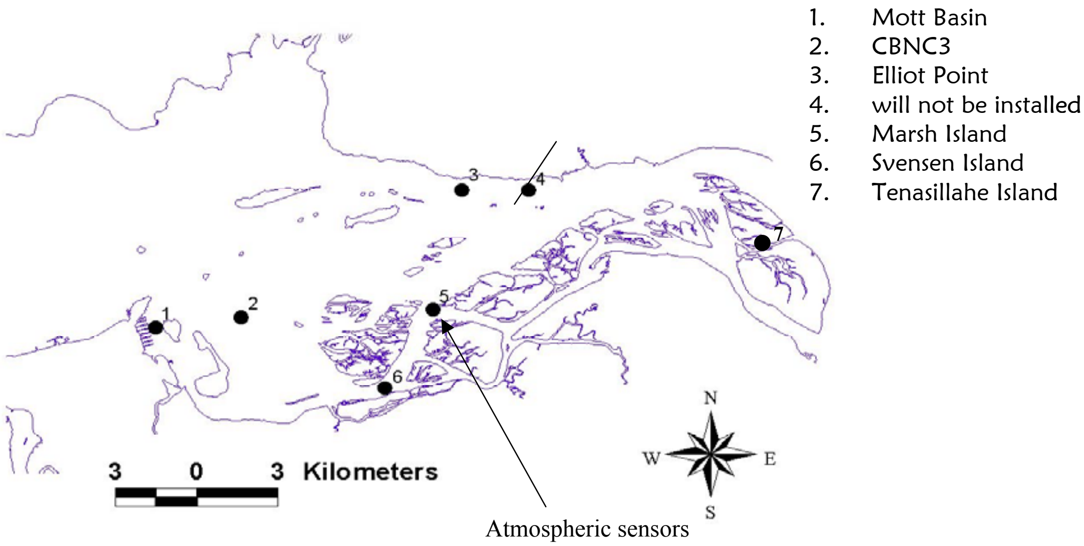
Island, and Upper Clifton Channel), and (2) habitats near the estuary mouth, where juvenile life-history diversity and relative abundances among ocean migrants may provide an overall indicator of estuary performance (West Sand Island, Pt. Elise, Clatsop Spit, and Pt Adams Beach). In addition, we have made a preliminary assessment for sampling the diverse shallow-water habitats, energy regimes, and salt-water transition zone within Cathlamet Bay, where fish size and physiological state may substantially affect habitat selection and salmonid performance.

We have selected for intensive sampling a representative suite of tidal channels and sloughs in emergent and shrub/forested tidal wetlands in order to evaluate rearing by juvenile salmon species and life history types in these peripheral, shallow-water habitats (habitat-scale factors). We selected study sites in Cathlamet Bay because it represents the largest concentration of shallow wetlands and spans the full oligohaline-brackish estuarine gradient available to juvenile salmon entering the Columbia River estuary. In 2001, we selected a pair of replicate tidal channels at Russian Island and forested and shrub sloughs at Karlson Island for monitoring fish use and prey resources of Cathlamet Bay wetlands. We plan on expanding on this design in 2002 by adding a second pair of emergent-wetland sites nearby at Seal Island (Figure 1). This additional pair will allow us to evaluate effects of landscape position and wetland proximity to the main estuary channel on fish use and performance. The suite of sites we have chosen depict a useful habitat succession for evaluating wetland dynamics and relationships to the estuarine life history of juvenile salmon: low emergent marshes near the main estuary channel; protected emergent wetlands in the interior of Cathlamet Bay; diverse, early successional swamps of willow and other shrubs; later successional conifer-hardwood swamps.

Task 1.2. Characterize physical factors: Monitor physical variables that control and affect the availability of habitat in the lower river and estuary, such as flow velocity, salinity, and temperature

Accomplishment - A sub-network of real-time CORIE field stations (Figure) was installed in Year 1 and extending intoYear 2. The sub-network has been used to collect continuous measurements of water level (through pressure), salinity (through conductivity) and temperature, from sensors installed at one level in the water column. These stations and their base sensors will be maintained in following years.

The CORIE web site already reports most of the data above on a real-time base. Preliminary additional web products (including access to archival data and data climatology) are scheduled for release in October 2002. Web products will be extended and refined in following years.



Objective 2: **Characterize historical changes in flow and sediment input to the Columbia River estuary and change in habitat availability throughout the lower river and estuary.**

Long-term changes in the flow and sediment transport regime of the Columbia River and its estuary have had a profound effect on Columbia River salmonids and availability of habitat for salmon. Human influences include the hydropower system (the largest single factor), irrigation withdrawal, navigational development, diking and filling, and changes in land use throughout the basin. These human alterations interact with each other and are difficult to separate from the influence of climate. Climate processes include a long-term increase in temperature, a decrease (relative to the 19th Century) in flow, and fluctuations in flow related to the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO) cycle. Factors that have strongly affected salmonids include:

- Major alterations to the salinity regime of the estuary.
- Changes in the rate at which habitat is created and modified.
- A decrease in spring freshet and summer flow volumes, coupled with the occurrence of peak flows earlier in the year.
- Elimination of overbank flow and resultant loss of flood-plain habitat and woody debris.
- Reductions in turbidity that may affect predation on juvenile salmonids.
- Changes fluvial and estuarine temperature affecting both juveniles and adult salmon.
- Reductions in sediment input to the estuary due to flow regulation, likely coupled with increases in fine sediment input higher in the basin.

- Losses and closures of spawning habitat.

Understanding how flow and sediment input into the Columbia River system has evolved in the past to the present will provide critical information to develop appropriate management strategies in the context of natural and anthropogenic factors known to negatively affecting estuarine processes including the maintenance of shallow-water habitats used by juvenile salmon.

Task 2.1. Climate and human effects on river flow and sediment input: Use recent geological history, and flow and sediment transport data to determine 1) the frequency and likely magnitude of major floods and sediment input events (e.g., the Mt. St. Helens eruption), 2) changes in water and sediment input to the system related to climate and human alteration, and 3) the variations between sub-basins of climate and anthropogenic effects.

Accomplishments - Efforts in the first year focused on distinguishing changes in flow and sediment transport due to three factors: climate change, flow regulation and agricultural diversion. A paper describing the results has been submitted to *Geophysical Research Letters* (Jay and Naik, 2001). The submitted manuscript has been posted on the web at www.ese.ogi.edu/~jaylab. Selected results are shown in Figures 3 and 4. It is evident that flow regulation has caused the largest changes in both flow and sediment transport, though climate change has affected the seasonality of these hydrologic properties.

<u>References</u>:

Jay, D. A., and P. K. Naik, 2001, Separating human and climate impacts on Columbia River hydrology, *Geophys. Res. Letters.*

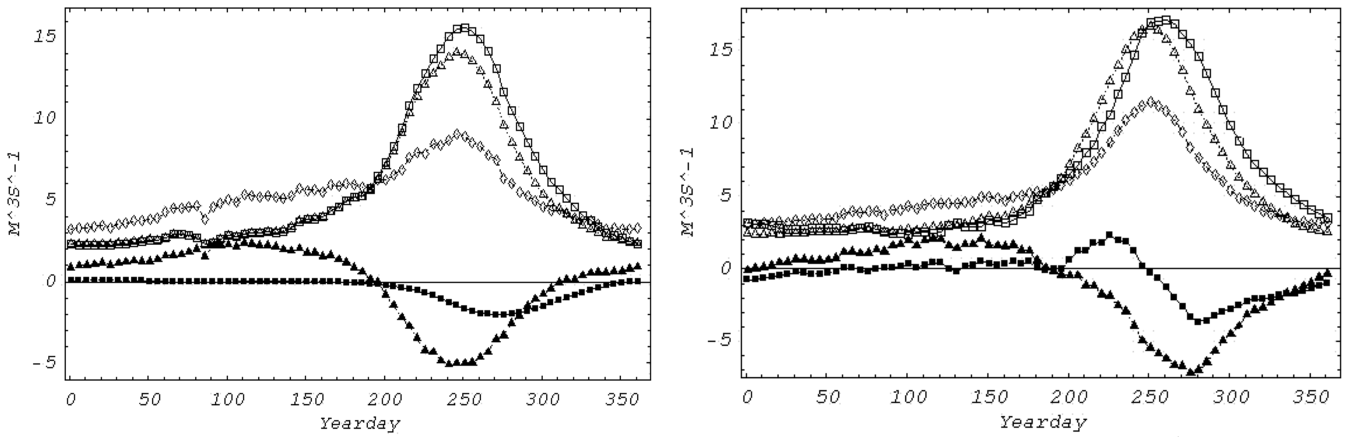


Figure 3a (left). Alteration of the CR flow cycle: the 1971-1999 virgin (©), adjusted (⌠) and observed (⌇) flows, and the effects of flow regulation (∫) and irrigation depletion (◊).

Figure 3b (right). Historical changes in the CR flow cycle: virgin flows for 1879-1899 (©) and 1946-1999 (⌠), the 1946-1999 observed (⌇) flow, the total change between 1879-1899 and 1946-1999 (∫), and the climate change (◊) for the period.

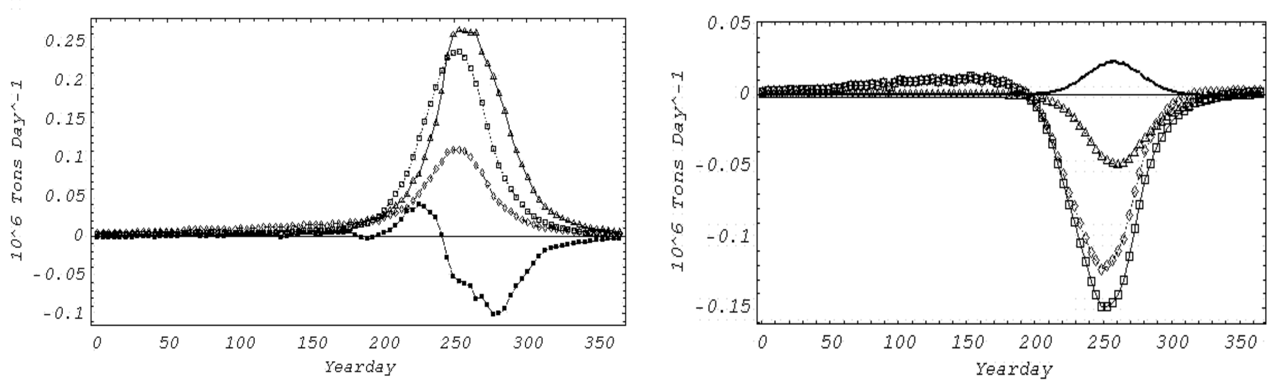


Figure 4a (left). Changes in the CR total load: 1879-1899 (⌠) and 1971-1999 virgin (©) flow total loads Q_{SV}, total load associated with the 1971-1999 observed flows Q_{SO} (⌇), and the 1879-1899 to 1971-1999 effect of climate change ⌠Q_{SC} (◊).

Figure 4b (right). Factors changing the CR total load for 1971-1999: total reduction 1879-1899 ⌠Q_{TS} (©), reduction due to flow regulation ⌠Q_{RS} (⌇), reduction due to irrigation ⌠Q_{IS} (⌠), and joint effect of irrigation and regulation ⌠Q_{AS} (—).

Task 2.2. Habitat change analysis: Using GIS analysis and recent satellite photos, evaluate historic changes in the geographic distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids from the estuary mouth to Bonneville Dam.

We propose to digitize for GIS analysis and reclassify (consistent with current habitat classes available from satellite imagery) the historic habitat coverage developed by Thomas (1983). From recent satellite imagery, we will select river segments representative of the major geomorphic types present between Puget Island and Bonneville Dam. From historic survey maps of the estuary, we propose to expand the digitized coverage developed from Thomas (1983) by classifying estuarine and floodplain habitats within the representative river segments selected above. Also, through GIS analysis, determine changes in the composition and spatial distribution of floodplain and aquatic habitats for the extended digital coverage above (Thomas 1983 plus representative river segments) by comparing historic habitat conditions with current conditions classified from recent satellite imagery. (Classification of satellite imagery will be completed independently through the Lower Columbia River Estuary Program.) The above analysis should include the development of a bathymetry map for the shallow areas of the estuary, to the extent allowed by the remote sensing imagery; at a minimum, vertically-referenced delineation of islands will be conducted.

Accomplishments - We are generating historic habitat maps for the estuary from topographic surveys (T-sheets) conducted in the late 1800s at a scale of 1:10,000. These maps provide the historic template for habitat analysis by evaluating changes in the geographic distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids from the estuary mouth (Rkm 0) to Rooster Rock (Rkm 206). A protocol was developed to reconstruct the historical habitat in a GIS to generate a geographically correct seamless coverage of the entire estuary at a resolution higher than existing map data. In addition, we devised a protocol for habitat change analysis, using historic floodplain and estuarine conditions to recent classified satellite imagery, with the aid of Columbia River Estuary Study Taskforce (CREST), Lower Columbia River Estuary Program (LCREP), and Earth Design Consultants, Inc, (EDC, Inc.). The areas of Puget Island (Three Tree Point to West Port; Rm 31- Rm 45), Fisher Island (Grims Island to Walker Island; Rm 54 – Rm 61), Sauvie Island (Kalama to the south end of Bachelor Island; Rm 76- Rm 94), and Sandy River (Lady's Island to Rooster Rock; Rm 117- Rm 128) in were chosen, based on geomorphologic characteristics, as pilot sites to demonstrate the historic habitat reconstruction and habitat change analysis.