Juvenile Salmon Utilization of Freshwater Tidal Ecosystems: An Alternative Restoration Link?

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TIDAL FRESHWATER ECOSYSTEMS:
The estuarine ‘bridge” between fluvial and land-margin ecosystems

- tidal freshwater ecotone between fluvial and tidal processes
- diverse segments of often dramatically-different geology, climate, physiography and ecology, as well as type and level of development and watershed influence
- strong gradients in sedimentology, geomorphology, geochemistry, nutrient cycling, flora and fauna
- productive component, exporting organic matter and organisms to estuary and coastal ocean
- variation in important habitat-forming processes, important to understanding limiting factors on ecological processes, e.g., migration and rearing of anadromous fishes such as Pacific salmon
TIDAL FRESHWATER ECOSYSTEMS WERE ONCE DOMINANT FEATURES OF PACIFIC NORTHWEST COASTAL MARGIN
JUVENILE SALMON “ECOSCAPES”

OPPORTUNISTIC REOCCUPATION

ANADROMOUS PUNCTUATED MIGRATION

EXTENDED REARING

TIDAL / EVENT

OVERWINTERING

Optimum conditions:

- shallow water 0.3-1.5 m depth (sloughs, tidal channels, flats)
- vegetated edge (riparian, marsh, eelgrass)
- abundant epibenthic, drift and neustonic prey
- LWD?

euhaline-euryhaline  brackish-oligohaline  tidal-freshwater
**Perspective: On-Going Studies of Estuarine Influence on Recovery and Resilience of Salmon Populations in the Columbia River**

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  - Greer Anderson
  - Sarah Spilseth
  - Mary Ramirez

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Antonio Baptista, Principle Investigator
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**Oregon State University**
  - Lance Campbell

**Oregon Department of Fish and Wildlife**
Kim Jones, Principle Investigator

**Portland State University**
David Jay, Principle Investigator
  - Tobias Kukulka

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**Salmon at River’s End:**
The Role of the Estuary in the Decline and Recovery of Columbia River Salmon

2006
U.S. National Marine Fisheries Service
Seattle
HISTORIC AND CONTEMPORARY SALMON LIFE HISTORY CHRONOLOGIES

One brood year of chinook salmon in the Columbia River estuary

Source: J. Burke (2004), based on data from Rich (1920) & Dawley et al. (1985)
Columbia River estuary

Source: J. Burke, UW
EPA Ecoregion Levels III and IV used to develop Ecoregion Level 2 (top) and Hydrogeomorphic Reach Level 3 (bottom) of Hierarchical Columbia River Ecosystem Classification
Hydrogeomorphic Reach
Level 3 of Hierarchical Columbia River Ecosystem Classification

Map created by J.L. Burke and C.A. Simenstad, University of Washington, School of Aquatic and Fishery Sciences. Data Sources: Digital elevation model courtesy of Oregon - Washington BLM and USGS. Outline boundary courtesy of Earth Design Consultants, Inc.
Karlson Island Tidal Freshwater Wetland Slough, Cathlamet Bay, Columbia River Estuary

LANDSAT7 TM image from LCREP, Earth Design Consultants and University of Washington-Wetland Ecosystem Team studies, 2000-2003

TIDAL SWAMPS

Photo by C. Simenstad, Univ. Washington
TIDAL MARSHES

Russian Island Marsh, Cathlamet Bay, Columbia River Estuary

LANDSAT7 TM image from LCREP, Earth Design Consultants and University of Washington-Wetland Ecosystem Team studies, 2000-2003

Photo by C. Simenstad, Univ. Washington
Grays Bay (foreground), and Columbia River Estuary

TIDAL FLATS AND OPEN WATER

LANDSAT7 TM image from LCREP, Earth Design Consultants and University of Washington-Wetland Ecosystem Team studies, 2000-2003

Photo by R. Emmett, NMFS
The incidence of flows above 18,000 m$^3$/s (the pre-1900 estimated bankfull flow level) and above 24,000 m$^3$/s (the present bankfull flow level). The present bankfull flow level has only been exceeded in four years since 1948. Source: Bottom et al. (2005)

Scaleogram of observed flow at The Dalles, showing periods of 8 years (bottom) to 3.5 days (top). Irrigation depletion begins to affect freshet strength and the annual flow cycle noticeably after 1920. Flow regulation effects are evident in the 1960s and dominant after 1970. High-frequency power peaking (periods of 3.5 and 7 days) is evident after ~1970. Source: Bottom et al. (2005)

The incidence of flows above 18,000 m$^3$/s (the pre-1900 estimated bankfull flow level) and above 24,000 m$^3$/s (the present bankfull flow level). The present bankfull flow level has only been exceeded in four years since 1948. Source: Bottom et al. (2005)
1974 Scenarios –

Virgin flow, without dikes

Virgin flow, with dikes

Observed flow, no dikes

Dark blue = floodplain inundation

Observed flow, with dikes

Source: D. Jay, PSU
Columbia River Temperature

1. Pre-Hanford
2. Hanford
3. Flow regulation
4. Temp reg

Bonneville May-Aug Water Temp

Source: D. Jay, PSU
HISTORIC AND MODERN COLUMBIA RIVER ESTUARY FOOD WEBS

Pre-1870

Modern (1980)

DETRITUS

FLUVIAL INPUT

EMERGENT PLANTS

BENTHIC ALGAE

BENTHOS

PHYTO-PLANKTON

ZOO-PLANKTON

EMERGENT PLANTS

BENTHIC ALGAE

BENTHOS

PHYTO-PLANKTON

ZOO-PLANKTON

OCEANIC EXPORT

Capacity: **Site**, Seasonal and Fish Size Differences Along Estuarine Gradient

2002-2005 Sampling Sites
Chinook CPUE 2002-2005

- CPUE range: 0-550 ind / haul
- Spatial trend: FW>M>LE
- Annual trend: Broad peak (Feb-Jul), Sharp drop in Aug
- Interannual trend: Subyearling Chinook found all year
Capacity: **Site**, Seasonal and Fish Size Differences Along Estuarine Gradient

**Composition of Common *Oncorhynchus tshawytscha* Prey by Sampling Site**

- **Corophium salmonis**
- **Corophium spinicorne**
- **Cladocera**
- **Decapoda larvae**
- **Diptera adult**
- **Osteichthys**

Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory
Columbia River Estuary
Juvenile Salmon Habitat-Life History Relationships

Capacity: Site, **Seasonal** and Fish Size Differences Along Estuarine Gradient

### Composition (IRI) of Common *O. tshawytscha* Prey by Month

<table>
<thead>
<tr>
<th>Common Prey Taxa</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tbody>
<tr>
<td>Corophium salmonis</td>
<td>50%</td>
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<tr>
<td>Corophium spinicorne</td>
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<tr>
<td>Cladocera</td>
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<td>Decapoda larvae</td>
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<tr>
<td>Diptera adult</td>
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<tr>
<td>Osteichthys</td>
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</tr>
</tbody>
</table>

Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory
Capacity: Site, Seasonal and **Fish Size** Differences In Specific Wetland Habitats

**Composition (IRI) of Common *O. tshawytscha* Prey by Fish Size**

<table>
<thead>
<tr>
<th>Common Prey Taxa</th>
<th>30-59</th>
<th>60-79</th>
<th>80-99</th>
<th>100+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corophium salmonis</td>
<td><img src="data.png" alt="Graph Data" /></td>
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<td><img src="data.png" alt="Graph Data" /></td>
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<tr>
<td>Corophium spinicorne</td>
<td><img src="data.png" alt="Graph Data" /></td>
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<tr>
<td>Cladocera</td>
<td><img src="data.png" alt="Graph Data" /></td>
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</tr>
<tr>
<td>Diptera adult</td>
<td><img src="data.png" alt="Graph Data" /></td>
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<td><img src="data.png" alt="Graph Data" /></td>
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</tr>
<tr>
<td>Osteichthys</td>
<td><img src="data.png" alt="Graph Data" /></td>
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Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Feeding selectivity (M.A. Lott & L. Stamatiou)

Source: C. A. Simentad and J. L. Burke, UW/SPFS Wetland Ecosystem Team
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Diet composition (M.A. Lott & L. Stamatiou)

JUVENILE CHINOOK DIET COMPOSITION
RUSSIAN ISLAND SOUTH EMERGENT MARSH, 2002

Source: Lott (2004)
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Diet composition (M.A. Lott & L. Stamatiou)

Source: Lott (2004)
Capacity has changed at comprehensive and habitat-specific scales: Prey availability (M.A. Lott)

RUSSIAN ISLAND SOUTH, MARCH-AUGUST 2002
INSECT FALLOUT TRAP

Average count/m²

March April May June July August

Source: Lott (2004)
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Bioenergetic effects (A. Bieber et al.)

Source: Lott (2004) and A. Bieber, UW/SAFS Wetland Ecosystem Team
SUMMARY

• Tidal freshwater ecosystems are complex and highly variable ecotones between fluvial and estuarine processes

• Particularly important in dynamic migration and rearing of juvenile Pacific salmon

• Watershed and floodplain changes have modified that function, particularly relative to salmon life history diversity

• Both habitat opportunity and capacity in lower estuary extensively supplemented by tidal freshwater?

• Restoration strategies tend to discount potential role of freshwater tidal ecosystems, especially scrub-shrub and forested tidal wetlands and floodplains, in salmon recovery
DO ECOSYSTEM CHANGES IN THE COLUMBIA RIVER ESTUARINE LANDSCAPE ALTER THE OPPORTUNITY AND CAPACITY TO SUPPORT OCEAN-TYPE JUVENILE PACIFIC SALMON?

It’s likely more dependent on ecoscape structure, habitat complexity and population resilience, than productivity per se...........the future of which is very vulnerable to flow regulation and climate change! Role of tidal freshwater reaches particularly ignored and underestimated?