Synthesis of Multi-Year Coordinated Habitat, Fish and Fish Prey in Tidal Wetlands

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Presentation Outline

- Introduction to the Estuary Partnership and the Ecosystem Monitoring Program
- Sampling Methods
- Key Findings for Status Sites (for Habitat Opportunity, Capacity and Realized Function)
- Key Findings for Trend Sites
- Management Implications
Lower Columbia Estuary Partnership

• The lower Columbia River is a National Estuary Program, one of only 28 in the nation, authorized by Congress in 1987 amendments to Clean Water Act, § 320

• Estuary Partnership established in 1995 by the governors of Washington and Oregon and EPA
  ➢ Lack of focus on the lower river and estuary
  ➢ Bi State findings documented degradation of lower river

• Estuary Partnership developed a long-term aquatic monitoring strategy for the lower Columbia River in 1999 and this strategy is implemented with our Ecosystem Monitoring Program
Ecosystem Monitoring Program

• Comprehensive Status and Trends program (fish, fish prey, habitat and food web)
• To assess habitat capacity, opportunity and realized function of juvenile salmon in relatively undisturbed tidally influenced wetland
• Supports multiple 2008 FCRPS BiOp RPAs and Estuary Module RME actions
• Provides key information for regional restoration strategies and salmon recovery planning
• Funding from BPA/NPCC; On-going collaboration with UW, PNNL, USGS, NOAA, OHSU and CREST
Current Sampling Design (2005-2012)

- Implementation of the 2004 proposed design limited due to cost constraints

- Focus on providing:
  - spatial analysis of habitats (or “status”) across the lower river
  - a growing number of fixed sites for inter-annual variability (or “trends”)
  - Starting in 2007, co-located fish, fish prey and vegetation sampling

- Sampling occurs primarily in relatively undisturbed tidally influenced emergent wetlands
EMP Sampling Stratified by Reach
Habitat and Hydrology Methods
(Borde et al. 2012)

Sampling
- during peak biomass (July/August), one day per site
- Percent cover along transects, dominant species, species richness, vegetation elevation, water level elevation, sediment grain size, water temperature

Synthesis Analysis
- total 39 sites, Reaches C-H, 2005-2010
Fish and Fish Prey Methods

Fish and Fish Prey Sampling

- Monthly beach seine sampling between March and September
- Fish: Species richness, abundance, CPUE, stock id, length, weight, stomach contents, otoliths for growth rates, marked/unmarked, condition, contaminants
- Open water and emergent vegetation tows, taxonomy, abundance, biomass

Synthesis Analysis

- 12 sites, Reaches C-H, 2007-2010
Basic Water Quality Methods

Sampling
- Temperature, dissolved oxygen, pH monitoring from March-August
- Began primary production food web and basic water quality sampling at all fixed sites in 2011

Synthesis Analysis
- Two years of data from one site, Reach F, 2009-2010,
- Not included in regression analysis due to minimal overlap with other metrics
Ecosystem Monitoring Program Synthesis

• Spatial and temporal variability
• Baseline data on relatively undisturbed tidally influenced wetlands
• Preliminary status and trends information
• Explore relationships between each individual disciplines
• Use findings to re-design program to create an Estuarine Condition Index
Regression Analysis Questions

- Is fish diversity (or native fish diversity) correlated with other metrics?
- What variables might affect Chinook salmon abundance (CPUE)?
- What is the variability in Chinook abundance (by month and between sites and years)?
- What variables might affect unmarked Chinook lipid levels?

\[ WQ = \text{variable} + \text{variable} + WQ \]
Regression Analysis Methods

- Datasets for habitat, fish, fish prey for 2008-2010 (Reaches C, F, H)
- Post-hoc diagnostic plots run for each regression model to assess normality of the residuals, presence of outliers and leverage (influence) of individual data points

Low Sample Size

- Regression (Generalized Additive Models) modeling used in tandem with (Pearson’s product-moment) correlations coefficients to assess overall relationships of variables
- Used multiple years from same site (13 total sites had all three sets of data)
- Limited number of variables used in modeling to avoid overfitting and conserve degrees of freedom (two variables)
- Emphasis not on significance of models but on adjusted R-squared values

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
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<tbody>
<tr>
<td>Campbell Slough</td>
<td>2008</td>
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<td>Campbell Slough</td>
<td>2009</td>
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<td>Campbell Slough</td>
<td>2010</td>
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<td>Franz Lake</td>
<td>2008</td>
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<td>Franz Lake</td>
<td>2009</td>
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<td>Hardy Creek</td>
<td>2008</td>
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<td>Jackson Island</td>
<td>2010</td>
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<td>Lord Walker Island</td>
<td>2009</td>
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<td>Ryan Island</td>
<td>2009</td>
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<td>Sand Island</td>
<td>2008</td>
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<td>Wallace Island West</td>
<td>2010</td>
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<tr>
<td>Whites Island</td>
<td>2009</td>
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<tr>
<td>Whites Island</td>
<td>2010</td>
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Regression Independent Variables

Prey
• Shannon-Weiner prey species diversity for emergent vegetation invertebrate tows
• Shannon-Weiner prey species diversity for open water invertebrate tows
• Species richness (number of species) for all prey species collected in May (May consistently was the month of highest Chinook CPUE)

Vegetation
• Shannon-Weiner species diversity values for native and non-native vegetation
• Shannon-Weiner species diversity values for native vegetation
• Shannon-Weiner species diversity values for non-native vegetation
• Average % cover of reed canary grass (most abundant plants species sampled)
• Average % cover of common spikerush (second most abundant species sampled)
• Average % cover of wapato (third most abundant plants species sampled)
• Species richness for all vegetation species (native and non-native)
• Species richness for native vegetation species
• Species richness for non-native vegetation species
Regression Independent Variables

Physical Metrics
- River kilometer for the various sites (measured from mouth of the river)
- Distance in meters that the site is from the main stem of the river
- Average elevation of the vegetation sample locations at the site related to the Columbia River Datum (CRD)

Fish
- Shannon-Weiner fish species diversity values for various sites and years
- Shannon-Weiner diversity values for native fish species for various sites and years
- Shannon-Weiner diversity values for non-native fish species for various sites and years
Spatial Status Key
Findings
Habitat Capacity, Opportunity and Realized Function

From Simenstad and Cordell (2000)

• **Habitat Opportunity** – capability of juvenile salmon to access and benefit from habitat (e.g. tidal elevation, water temperature)

• **Habitat Capacity** – conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality and therefore increased performance (e.g. availability and quantity of preferred invertebrate prey, physiochemical conditions that maintain prey communities etc.)

• **Realized Function** - physiological or behavioral responses attributable to occupation of the habitat that promote fitness and survival (e.g. habitat-specific residence time, foraging success, growth)
Habitat Opportunity
(Borde et al. 2012)

Hydrology
• Three general inundation patterns through the LCRE (upper, mid, lower)
Habitat Opportunity
(Borde et al. 2012)

• Emergent marshes occupy very small elevation range (0.5-3.0 m CRD), highest species diversity between 1.5 m and 2.5 m

• Most channels were accessible for at least 60 percent of the time (channel banks at least 40%) of the estimated peak juvenile salmonid migration period
Habitat Capacity

Vegetation (Borde et al. 2012)
- Five vegetation zones with the number of species (and non-native species) generally greatest in the middle portion of the LCRE (rkm 50 – 150)
- Seven taxa made up 68% of the cumulative cover
- Reed canary grass greatest cover (lower elevation range is ~1.4-1.8 m)

Prey (Johnson et al. 2012)
- Diverse assemblage of prey available, though no distinct patterns
- Dipterans present at all sites, strongly preferred prey
- Density of Diptera, and most other preferred taxa, is greatest in emergent vegetation tows
- Other abundant taxa (e.g., Calanoids, Cyclopoids, Oligochaetes) are avoided
Habitat Capacity

Fish (Johnson et al. 2012)
- Distinctive fish communities by reach, juvenile salmon found at all sites and in multiple months
- Chinook at highest densities in May and June; chum in April
- High summer water temperatures at most sites
- Chemical contaminants, especially below Portland/Vancouver
Realized Function
(Johnson et al. 2012)

- Increase in unmarked Chinook length and weight over the sampling season; not for marked Chinook
- Lipid content ranges similar among sites for unmarked Chinook, decreased at downstream sites for marked Chinook
- Growth rates lower in fish from Reach C (also in unmarked fish and West Cascades fall Chinook, both of which dominate in Reach C)
Multi-discipline Regression Analysis

Is fish diversity (or native fish diversity) correlated with other metrics?

- +prey diversity (in open water and emergent vegetation tows) and +percent cover common spikerush (Adj R-squared: 0.78, 0.63)

- Native fish diversity: +Percent cover common spikerush and -species richness for native and non-native vegetation (Adj. R-squared: 0.78)

What variables might affect Chinook salmon abundance (CPUE)?

- +Species richness for native and non-native vegetation, -prey species diversity from emergent vegetation invertebrate tows, -river kilometer (adj. R-squared: 0.61)
Multi-discipline Regression Analysis

What is the variability in Chinook CPUE (for marked/unmarked, by month and between sites and years)?

- Ratio of marked and unmarked Chinook 13:1 for status sites, 1:1 trend sites
- High variability between months, sites and years

High Variability
Multi-discipline Regression Analysis

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<tbody>
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<td>Campbell Slough</td>
<td>2009</td>
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<tr>
<td>Franz Lake</td>
<td>2009</td>
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<tr>
<td>Lord Walker Island</td>
<td>2009</td>
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<tr>
<td>Pierce Island</td>
<td>2009</td>
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<td>Ryan Island</td>
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<tr>
<td>Whites Island</td>
<td>2009</td>
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What variables might affect unmarked Chinook lipid levels?

- site elevation and +prey diversity from emergent vegetation tows (Adj. R-squared: 0.30)
Trends Key Findings
Habitat and Hydrology Trends

- Hydrologic variability between years drives variability in vegetation cover, composition, and biomass.
- Boundaries between vegetation species consistent between years, but high water years may shift elevational ranges.
- Reductions of *P. arundinacea* cover is related to increased water levels; however, reductions were not persistent between years.
Fish and Fish Prey Key Findings

- Low inter-annual variability in fish communities, patterns of salmon occurrence, and indicators of salmon fitness
- Consistency in preferred salmon prey between years
## Multi-discipline Regression Trends

What is the variability in Chinook CPUE between years and is it correlated with habitat or prey variables?

<table>
<thead>
<tr>
<th>Site and Year</th>
<th>Average CPUE</th>
<th>Standard Deviation</th>
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</thead>
<tbody>
<tr>
<td>Campbell Slough 2007</td>
<td>24.3</td>
<td>31.6</td>
</tr>
<tr>
<td>Campbell Slough 2008</td>
<td>10.5</td>
<td>12.2</td>
</tr>
<tr>
<td>Campbell Slough 2009</td>
<td>19.8</td>
<td>24.1</td>
</tr>
<tr>
<td>Campbell Slough 2010</td>
<td>36.6</td>
<td>37.9</td>
</tr>
<tr>
<td>Franz Lake 2008</td>
<td>21.3</td>
<td>35.5</td>
</tr>
<tr>
<td>Franz Lake 2009</td>
<td>9.3</td>
<td>8.1</td>
</tr>
<tr>
<td>Whites Island 2009</td>
<td>9.0</td>
<td>11.8</td>
</tr>
<tr>
<td>Whites Island 2010</td>
<td>39.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

- Abundance of diptera in May, +species diversity of non-native vegetation, and +percent cover of reed canary grass were the most important variables.
Implications for Management

• Tidal marshes providing productive rearing and refuge areas for multiple juvenile salmon species and stocks
• Narrow elevation range of emergent marshes-- vulnerable to hydrologic changes
• Status sites: Prey diversity correlated with fish diversity, Chinook salmon abundance and lipid levels
• Trend sites: Reed canary grass productive for prey? Need to investigate relationship between preferred prey (Diptera) and type of wetland vegetation at site
• Incomplete picture without food web and water quality data at these sites
Questions?