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

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Lower Columbia Estuary Partnership

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

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

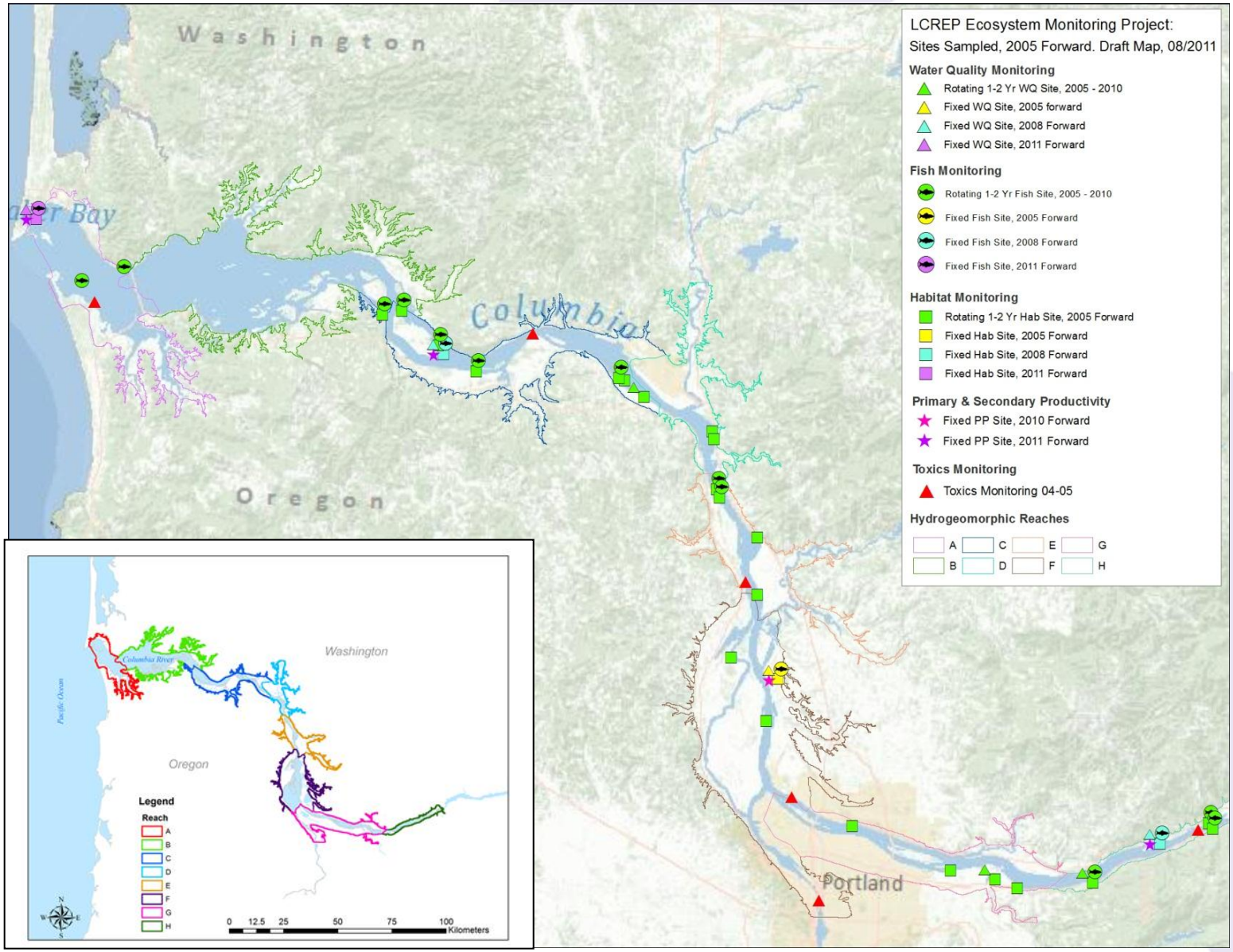
Current Sampling Design (2005-2012)

- 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**

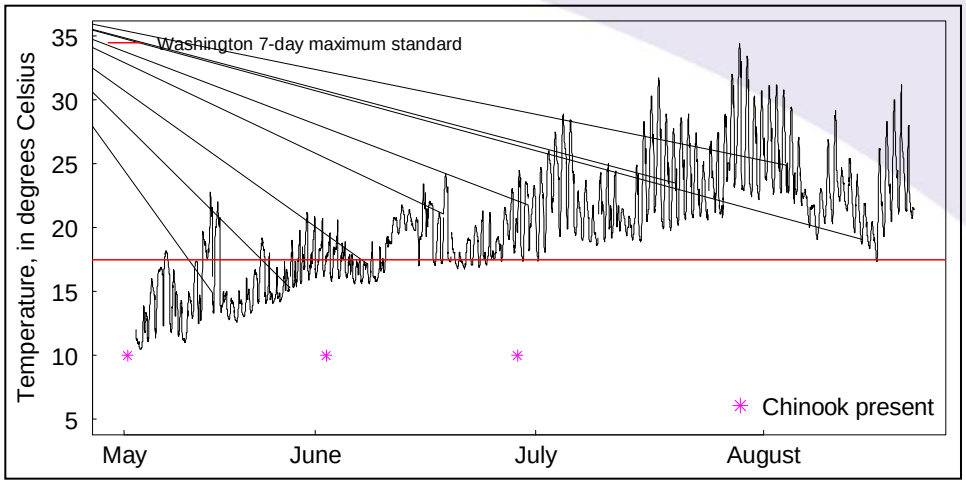
Basic Water Quality Methods

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?

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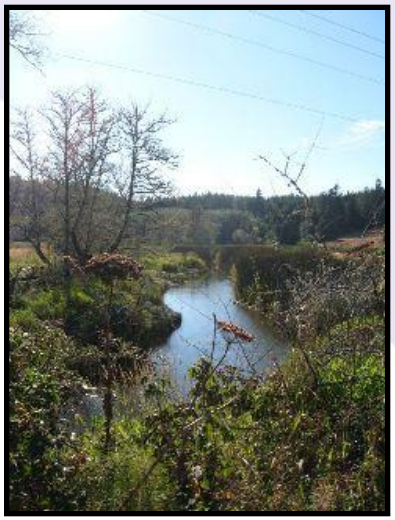

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Regression Analysis Methods

- **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

Site	Year
Campbell Slough	2008
Campbell Slough	2009
Campbell Slough	2010
Franz Lake	2008
Franz Lake	2009
Hardy Creek	2008
Jackson Island	2010
Lord Walker Island	2009
Ryan Island	2009
Sand Island	2008
Wallace Island West	2010
Whites Island	2009
Whites Island	2010

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)

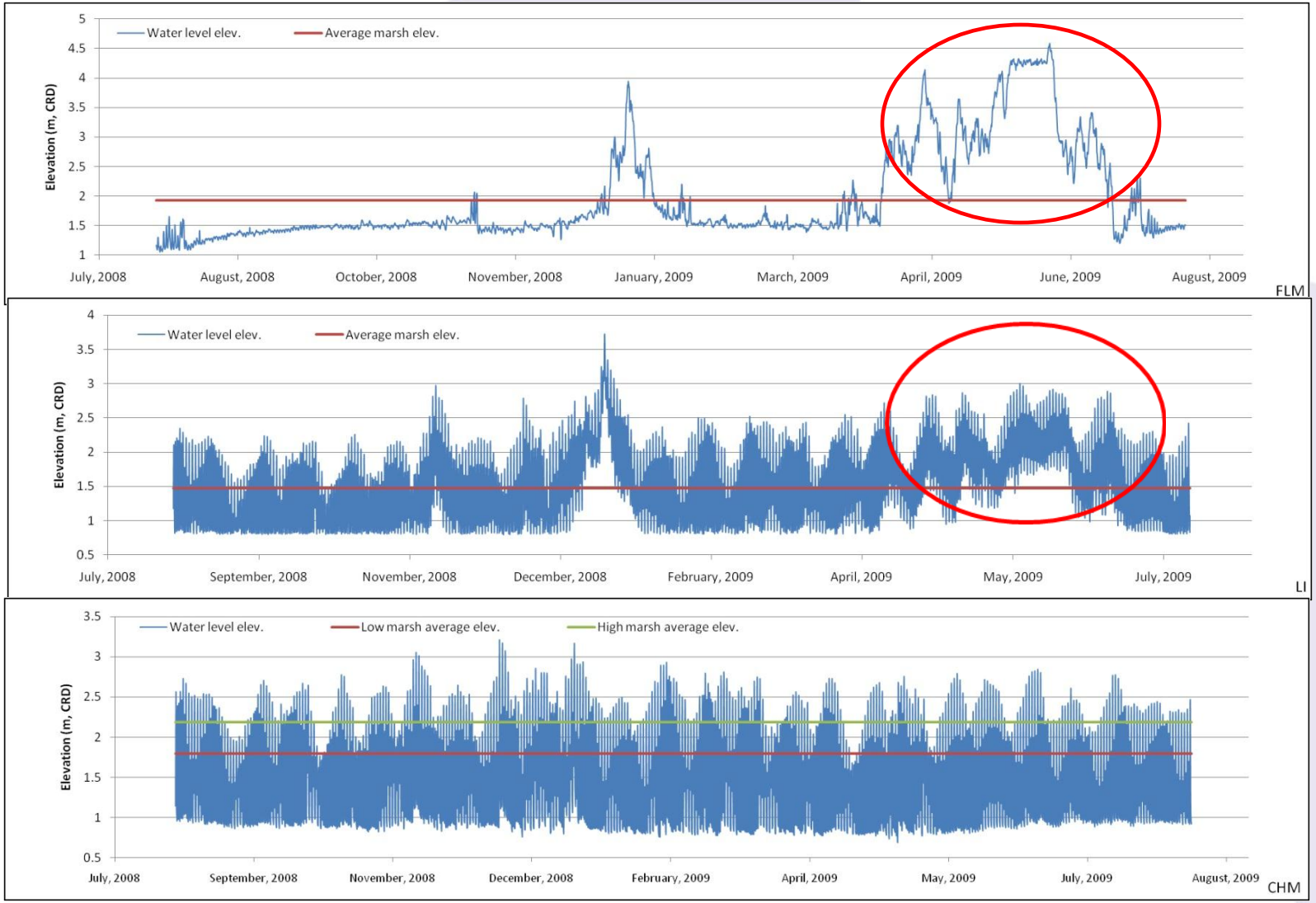
- ***Habitat Capacity*** – conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality and therefore increased performance (e.g. availability and quantity of preferred invertebrate prey, physiochemical conditions that maintain prey communities etc.)

- ***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 →

Year	Average CPUE	Standard Deviation
2008	48.5	76.5
2009	48.5	61.4
2010	81.7	114.7

Multi-discipline Regression Analysis

Site	Year
Campbell Slough	2008
Campbell Slough	2009
Franz Lake	2009
Lord Walker Island	2009
Pierce Island	2009
Ryan Island	2009
Whites Island	2009

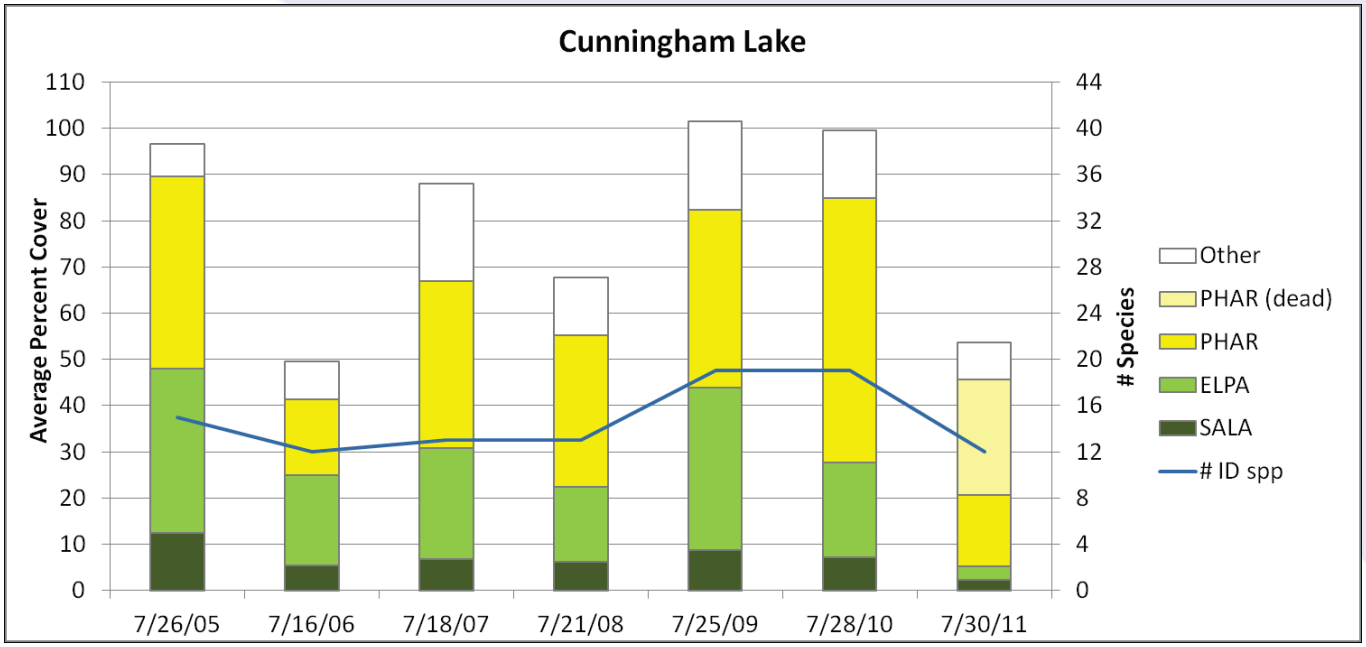
What variables might affect unmarked Chinook lipid levels?

- - site elevation and +prey diversity from emergent vegetation tows (Adj. R-squared: 0.30)


Trends Key
Findings

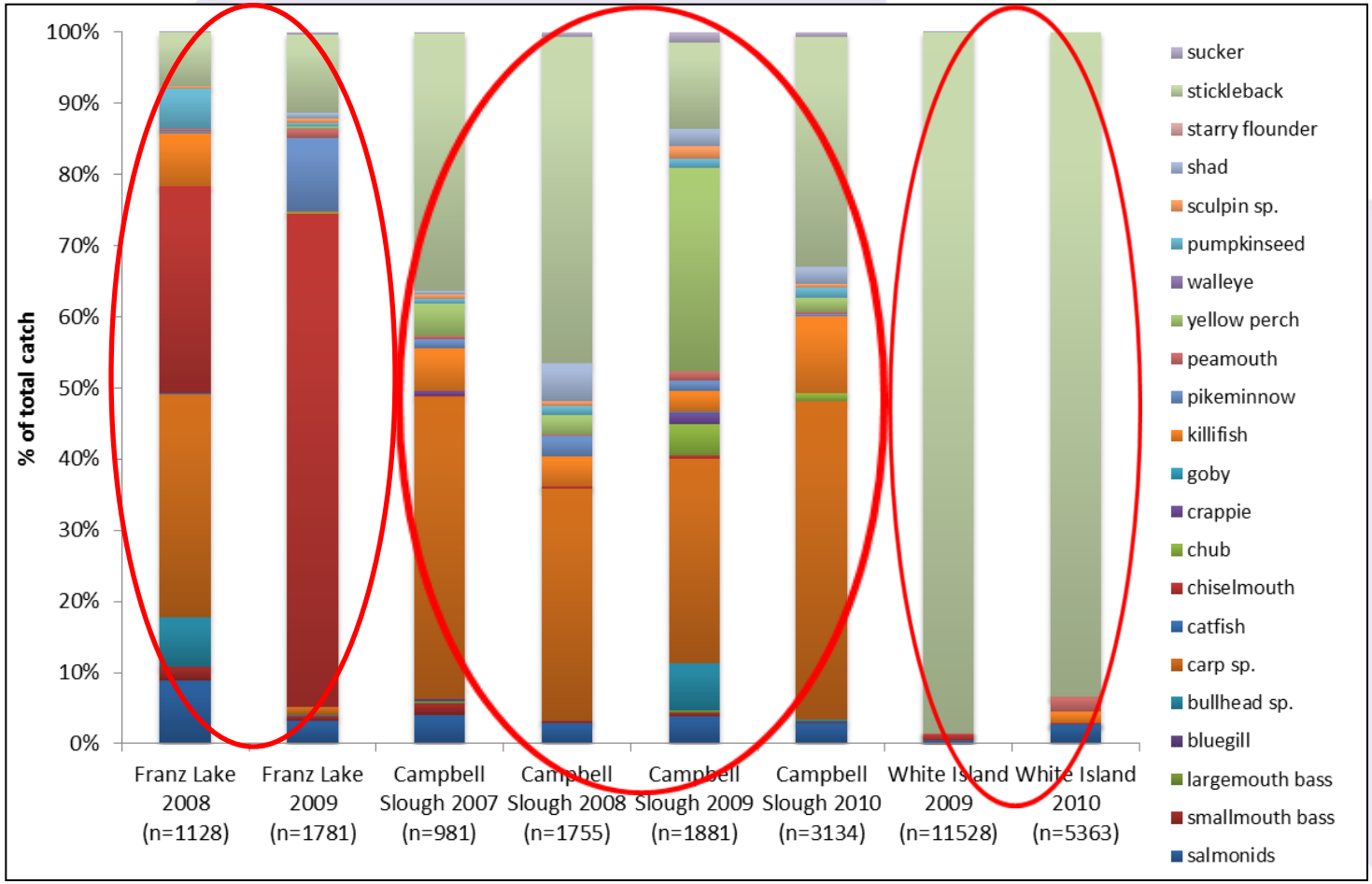
Habitat and Hydrology Trends

- 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?

Site and Year	Average CPUE	Standard Deviation
Campbell Slough 2007	24.3	31.6
Campbell Slough 2008	10.5	12.2
Campbell Slough 2009	19.8	24.1
Campbell Slough 2010	36.6	37.9
Franz Lake 2008	21.3	35.5
Franz Lake 2009	9.3	8.1
Whites Island 2009	9.0	11.8
Whites Island 2010	39.0	24.0

- +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?