Climate Change and Estuarine Rearing Opportunities for Juvenile Salmon

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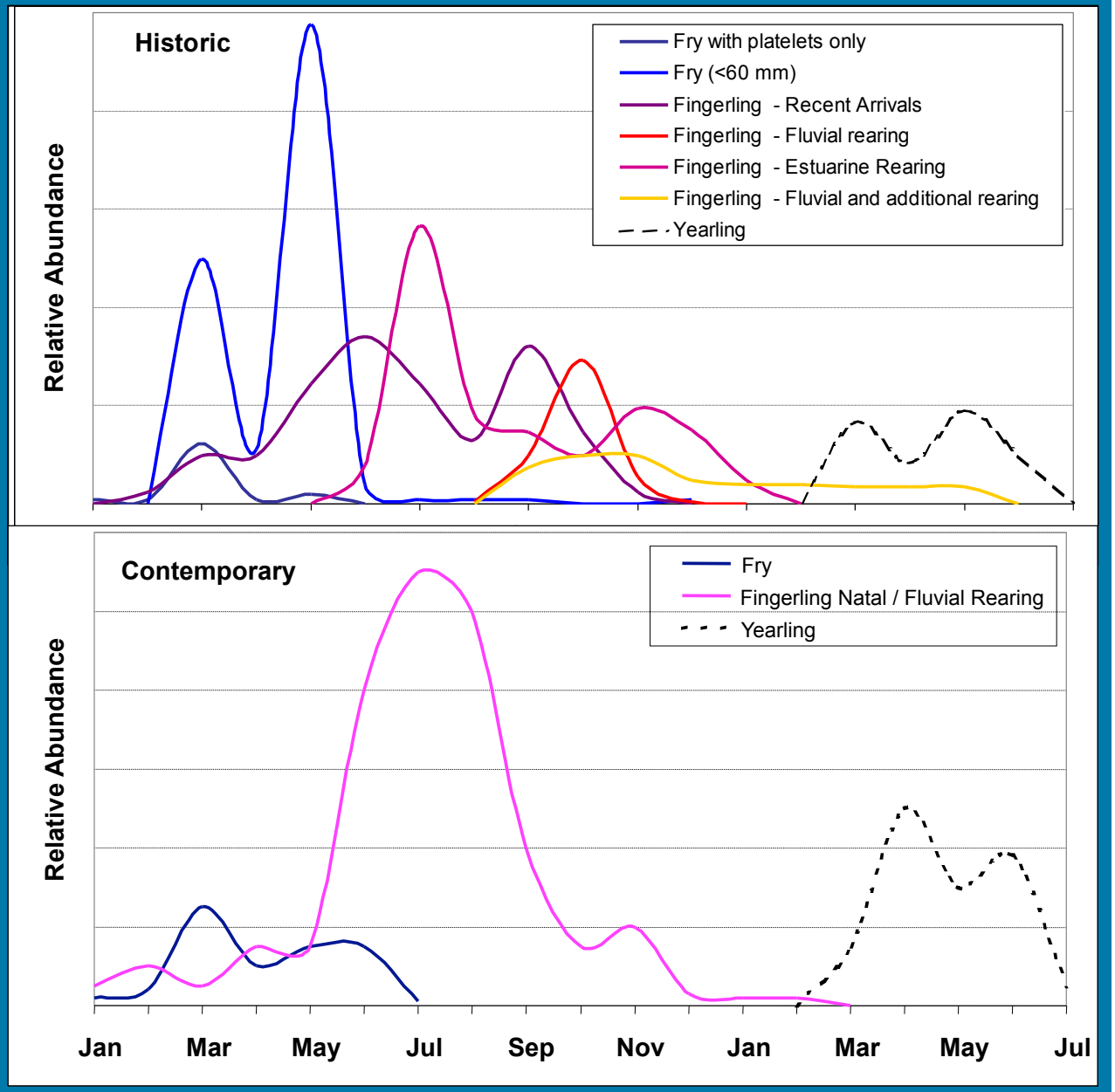
Life history variation of Columbia River Chinook Salmon

Estimated changes in the relative proportions of juvenile Chinook life histories



From Burke, 2005.
Data from Rich (1920)
& Dawley et al. (1985)

Outline

- The estuary setting
- Salmon use of shallow habitats
- Historical change in habitat opportunities
- Risks and implications of climate change

The Saline Estuary

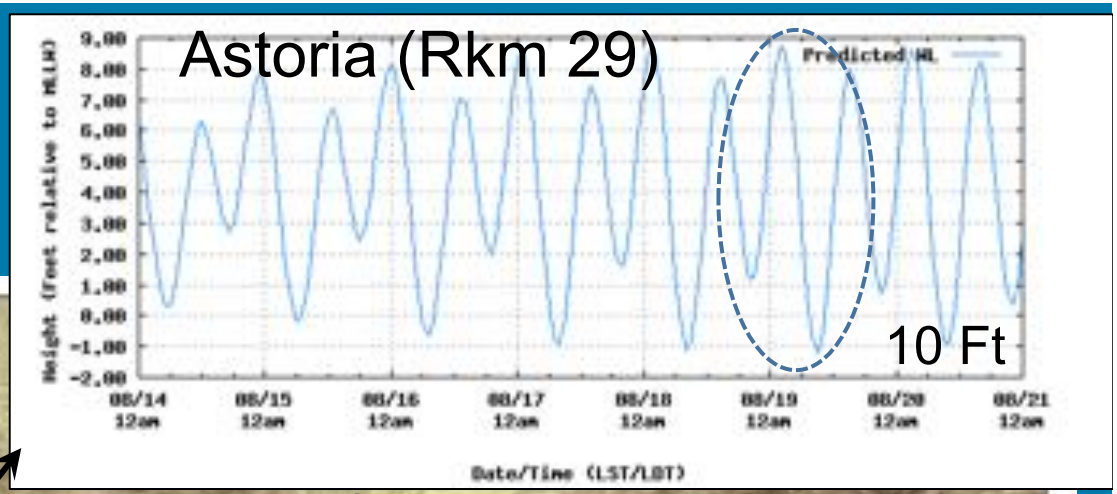
A semi-enclosed coastal body of water with a free connection to the open ocean in which salt water is diluted with runoff from the land

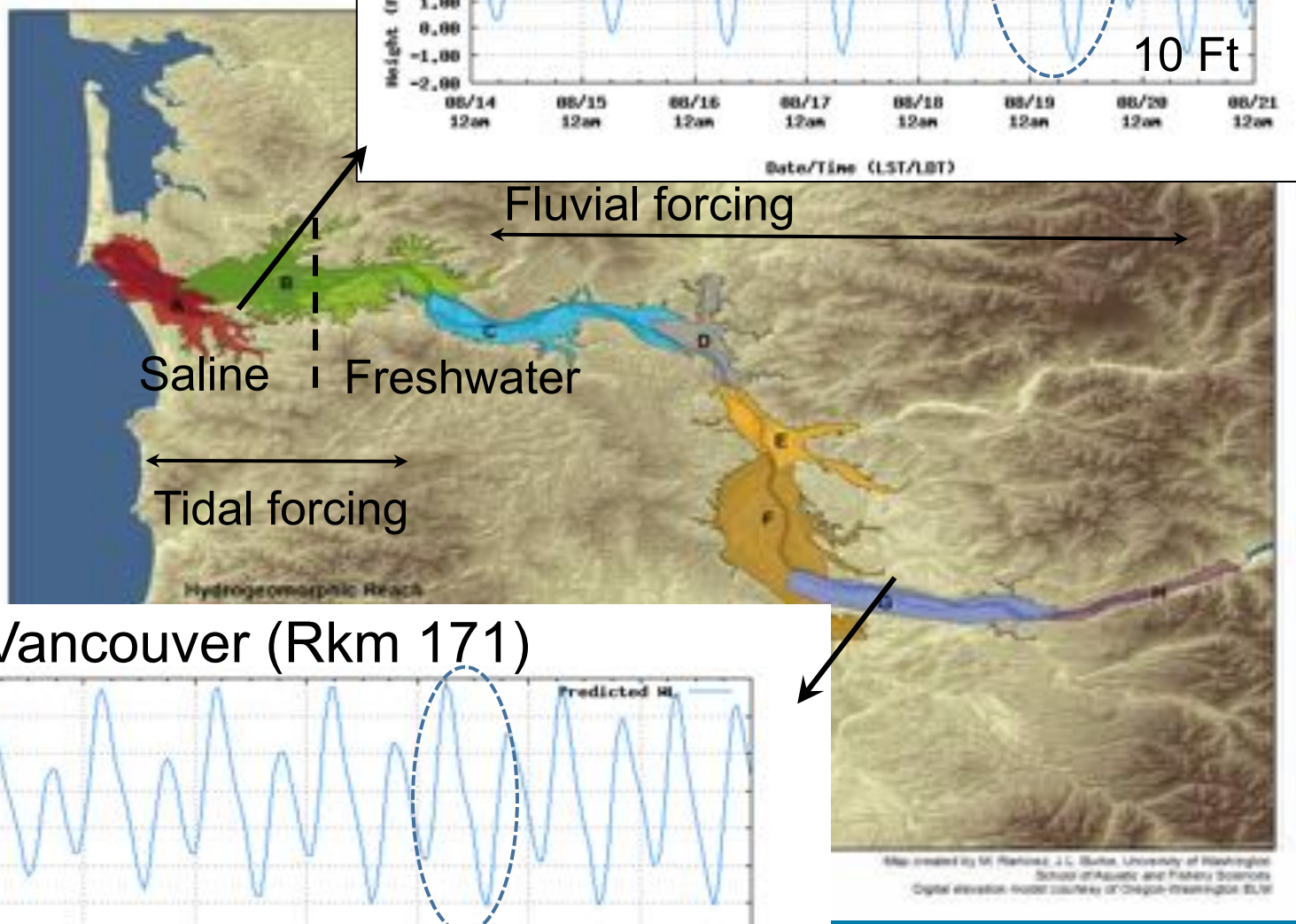
The Estuary as Tidal/River Gradient

…ecosystem gradients resulting from tidal/river forces that interact to shape “hydrological, geomorphological, geochemical, biological, and ecological processes” within the tidally-influenced portions of watersheds (Simenstad et al. 2011).

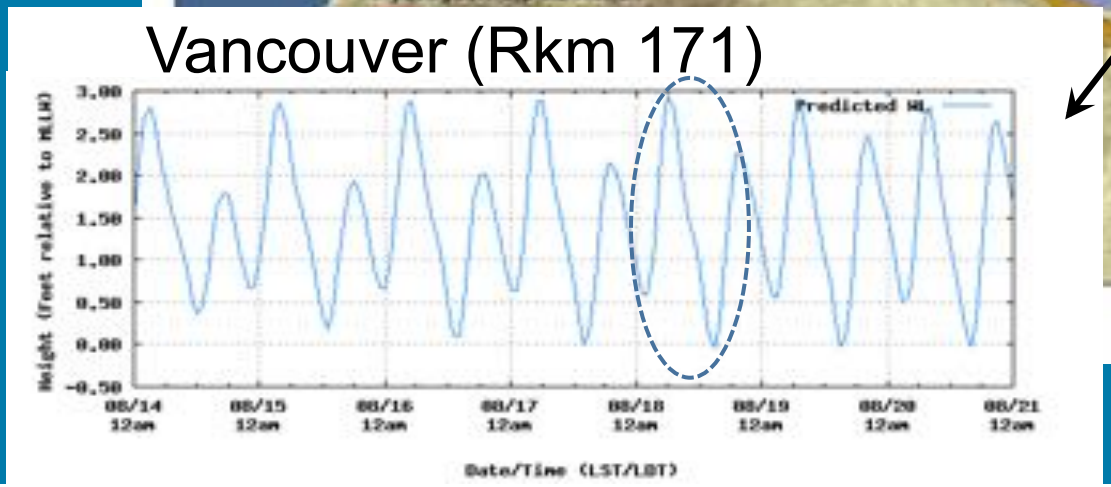
The Estuarine Tidal Gradient

2.0 – 4.0m amplitude

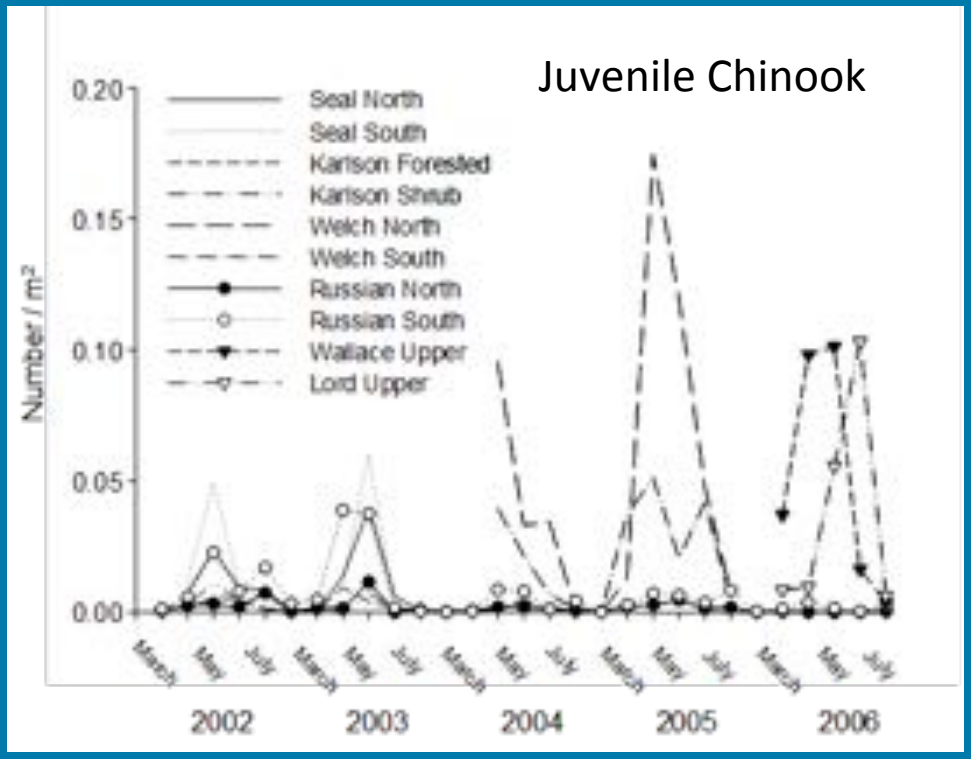




< 0.2m amplitude



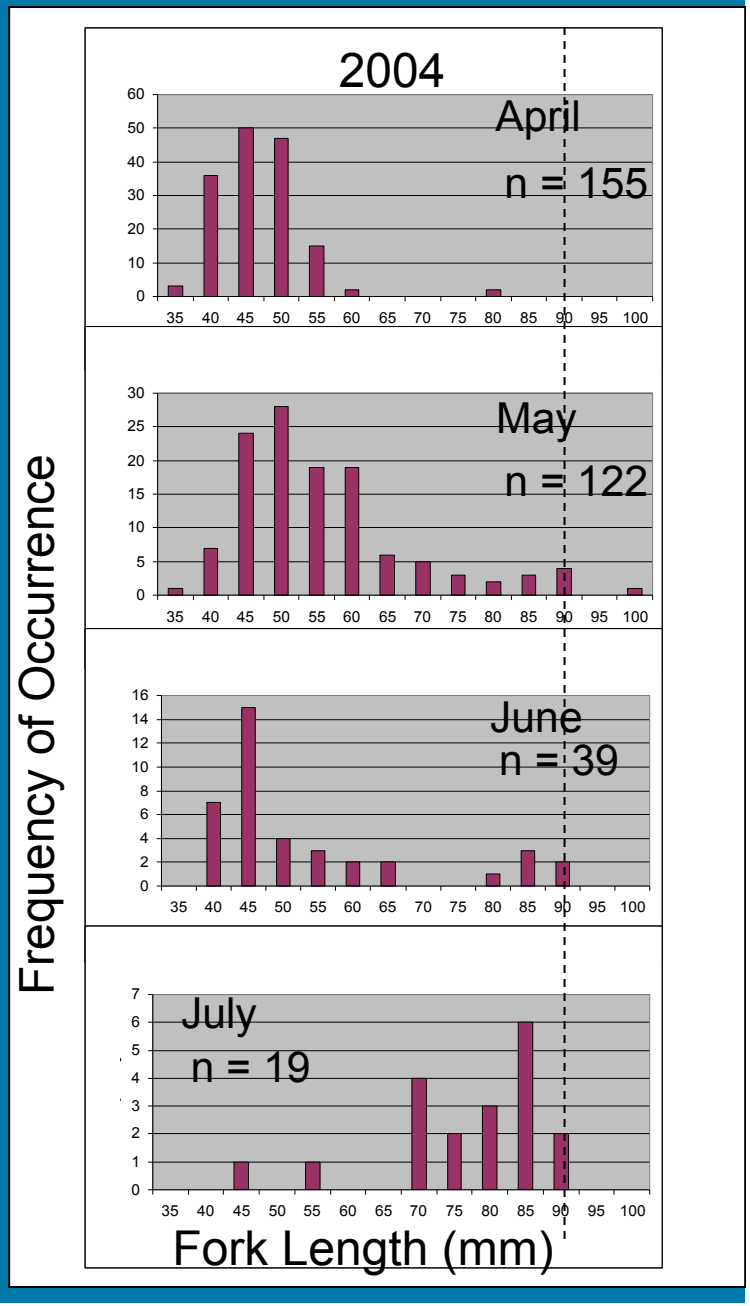
Columbia R. salmon rear in a diversity of wetland types along the entire tidal gradient



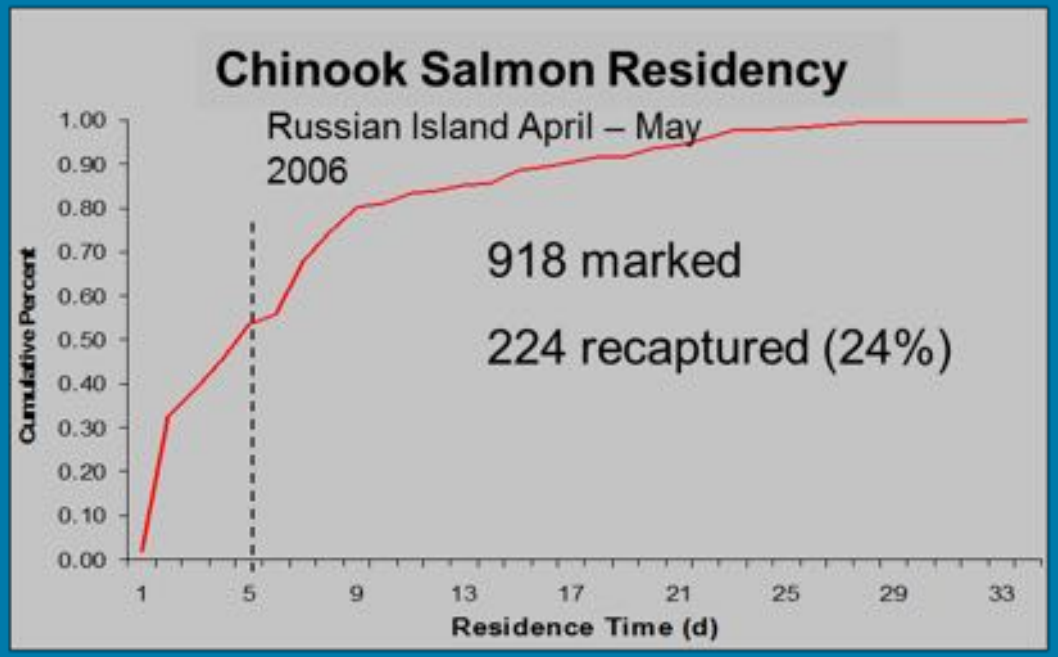
Estuarine habitat use by Juvenile Chinook is size-related

- Small subyearlings favor shallow secondary channels
- Few fish > 90 mm
- Few recruits after July

Chinook Length Frequency in Wetland Channels



Many juvenile Chinook salmon reside in the same wetland complex for days or weeks



- Median residency ~5 days, 14% > 2 weeks
- Fish residing ≥ 2 weeks grew 10-20 mm at a rate of 0.53 mm/day
- Some fish use small channels intermittently

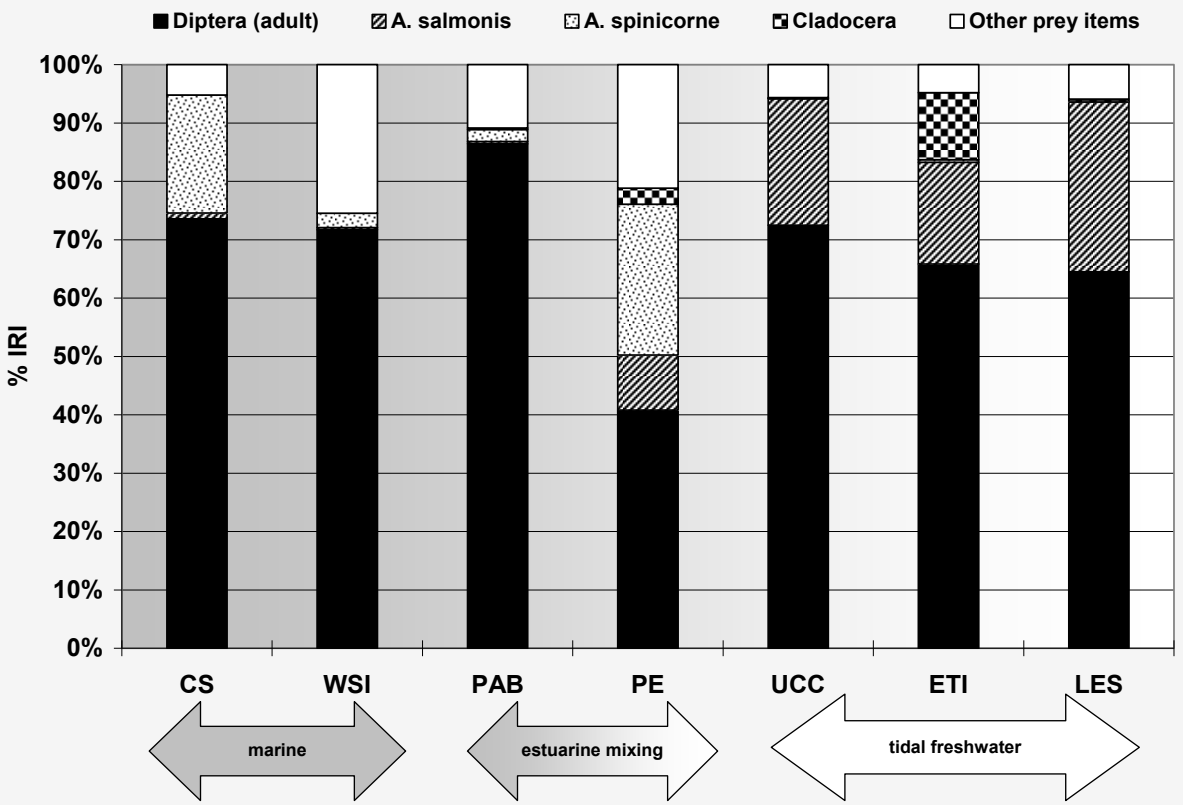
(From McNatt et al. 2016)

Bottom et al. 2008

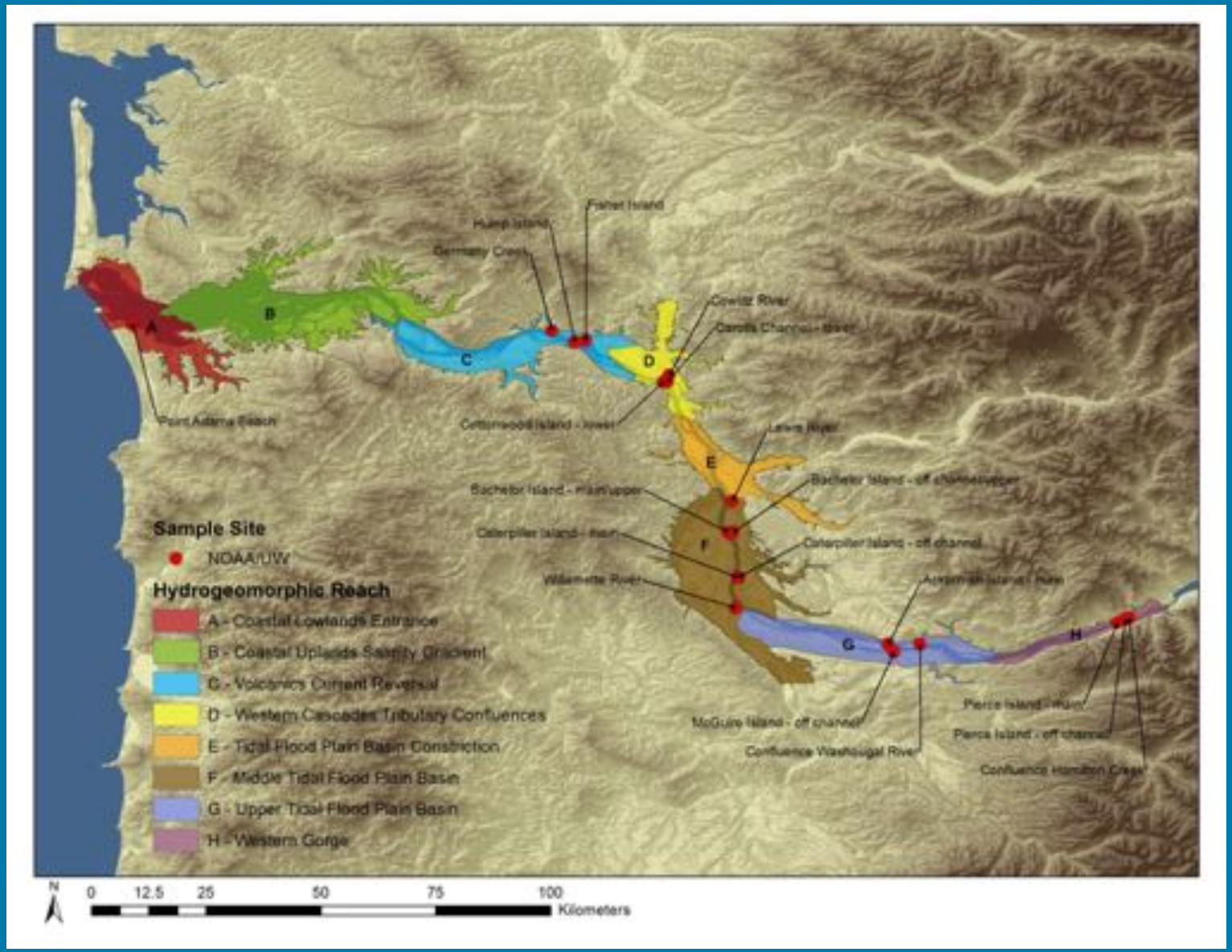
Food Web Benefits of Shallow Habitats for Juvenile Salmon

- Diets dominated by insects & amphipods produced in wetlands and other shallow habitats
- Even larger juveniles that don't frequent wetland channels feed on prey produced in wetland habitats

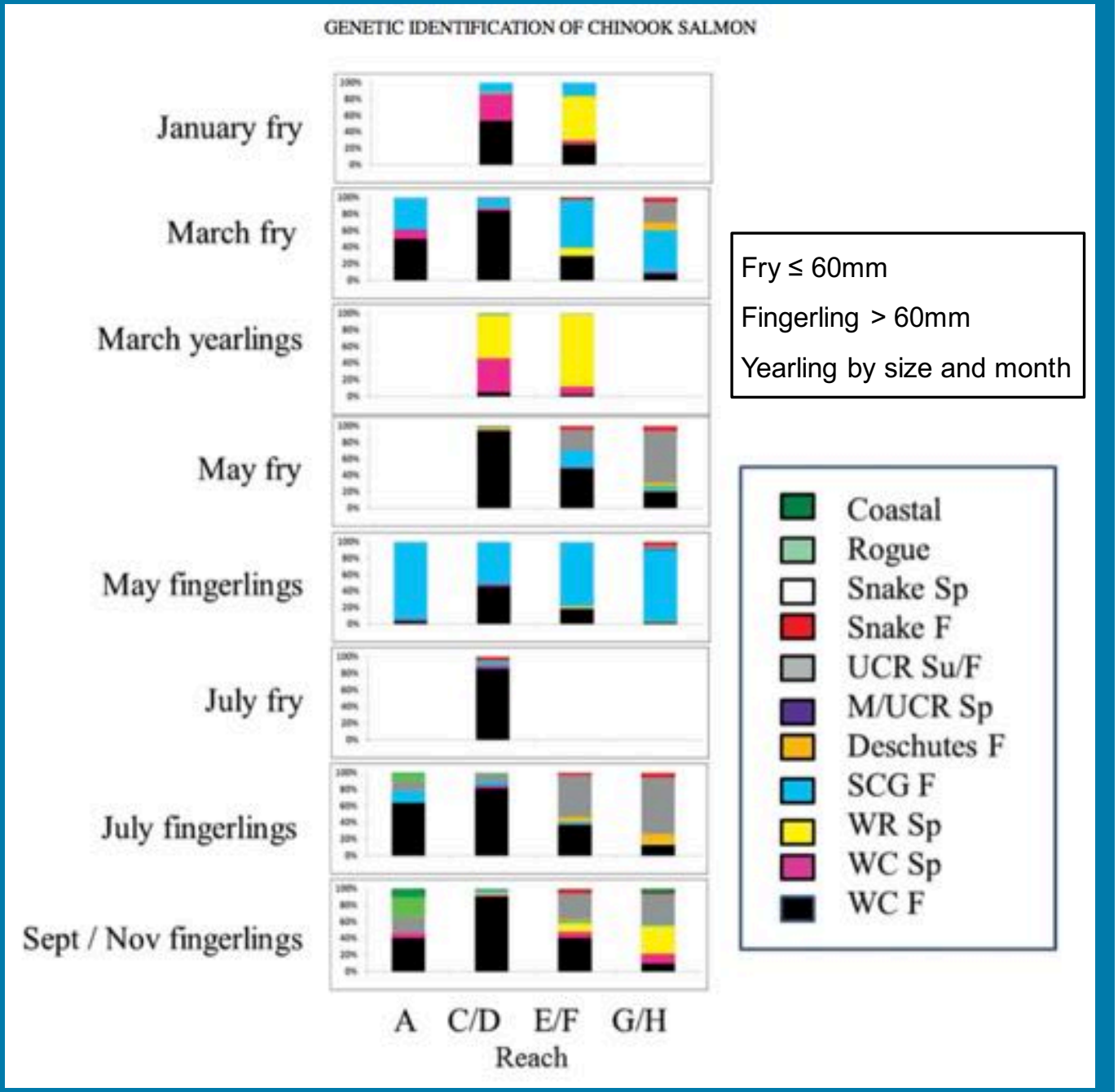
Prey composition (Index of Relative Importance) of juvenile Chinook salmon 2002-05 (n = 1,554)



Chinook Genetic Stock Survey, 2010-12

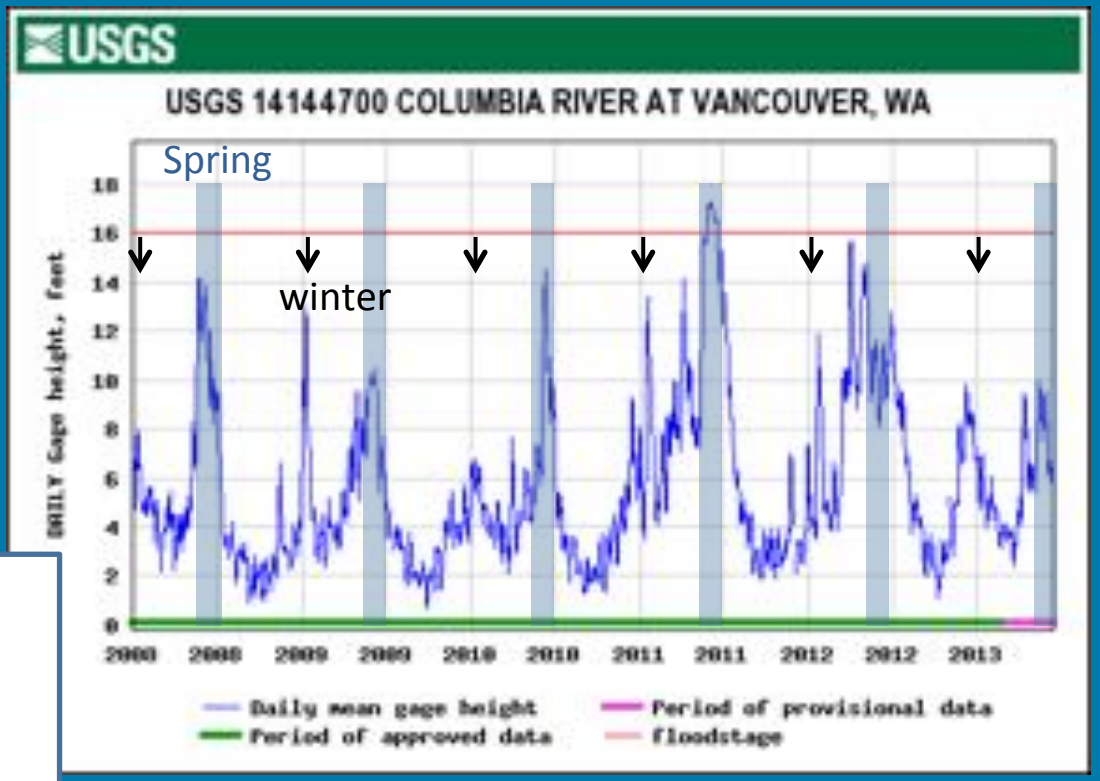


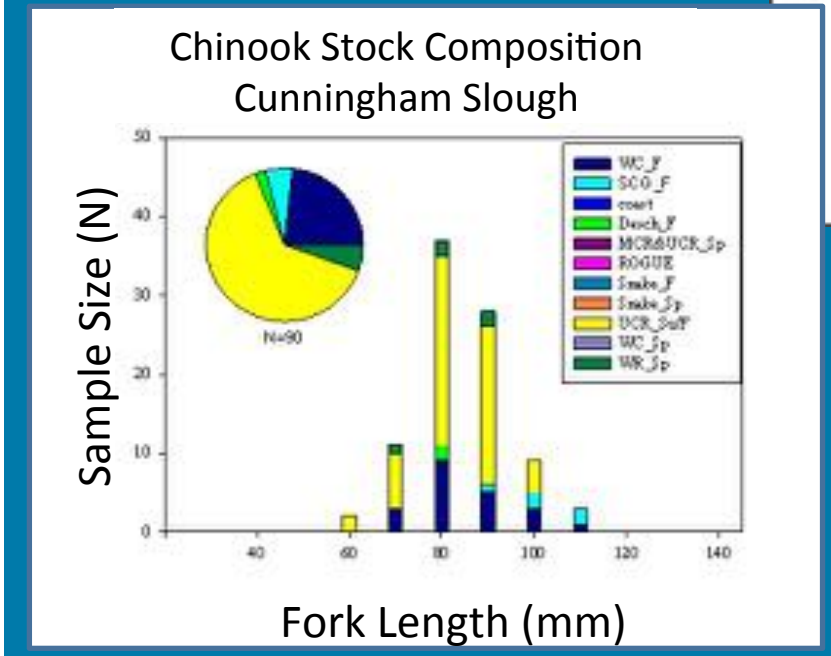
Diverse Chinook stocks and life history types frequent different habitats along the estuarine tidal gradient



from Teel et al. 2014

Fish access to upper-estuary tidal floodplains is seasonally intermittent (spring, occasionally winter)

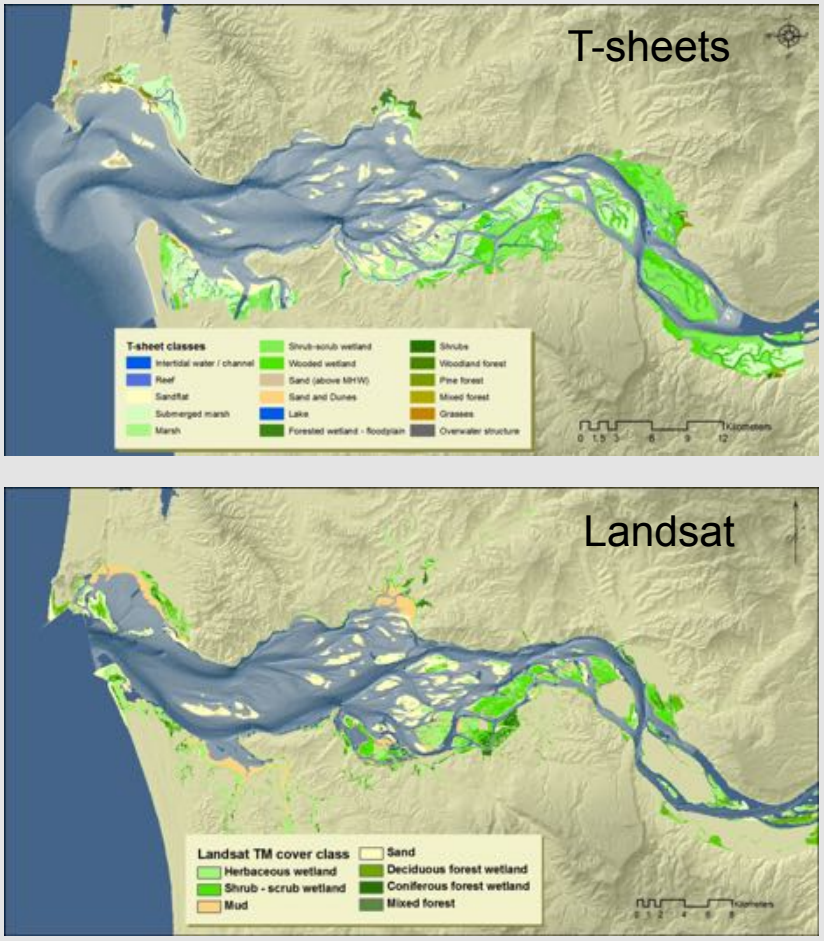




Most historical rearing habitat has been lost from the Columbia River estuary

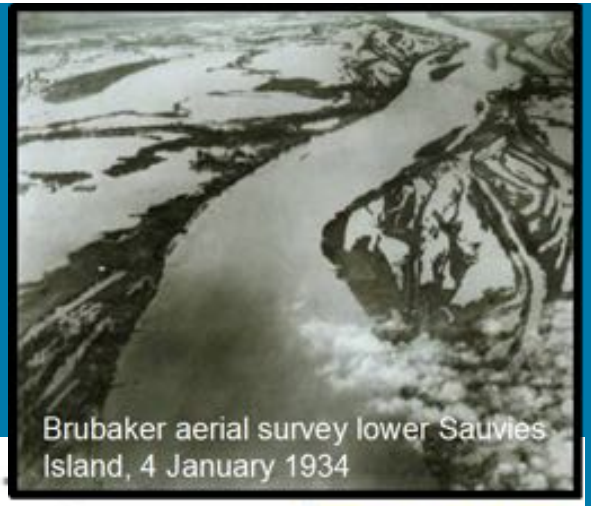
- Historical floodplain habitat (mouth – Bonneville) ~1468 km^2
- 68% to 70% of tidal wetlands lost to diking, filling, etc. (Marcoe and Pilson, 2013)

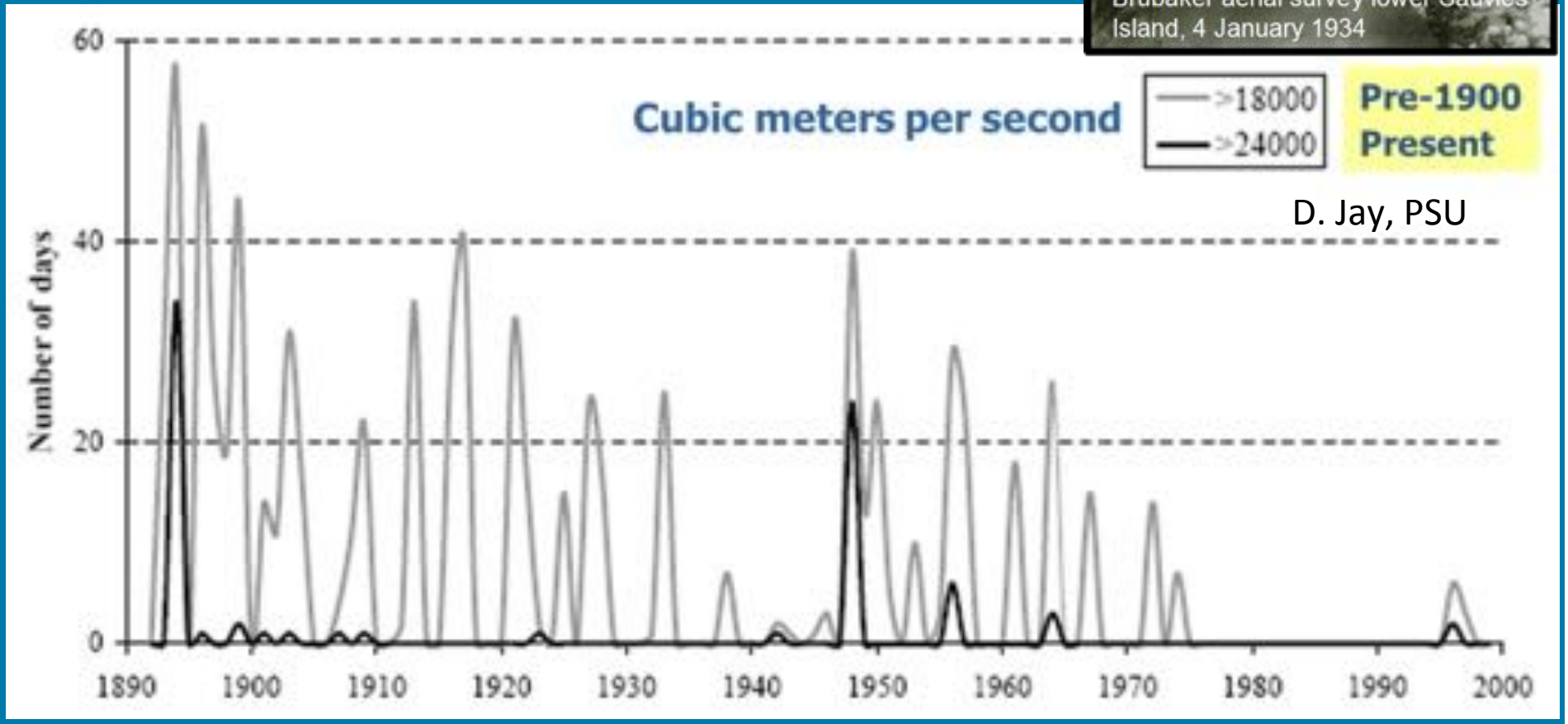
Wetland Habitat Change Lower Estuary



from Jennifer Burke

Flow regulation and diking have reduced overbank flow and connectivity to tidal floodplains



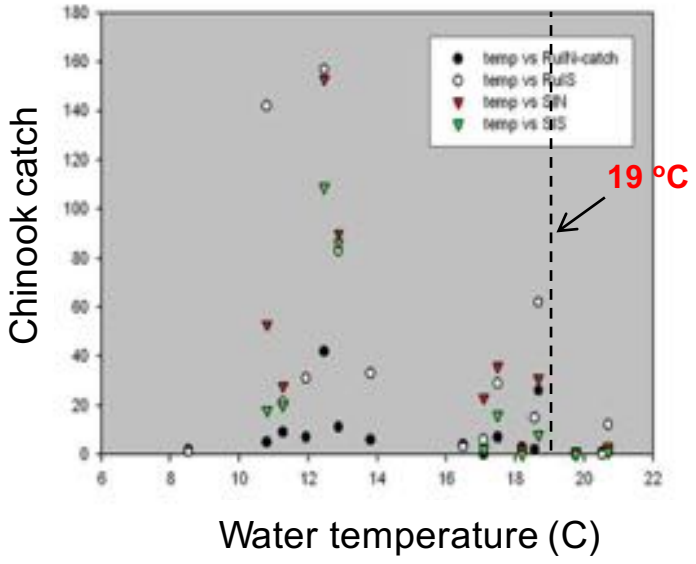


(From Bottom et al. 2005)

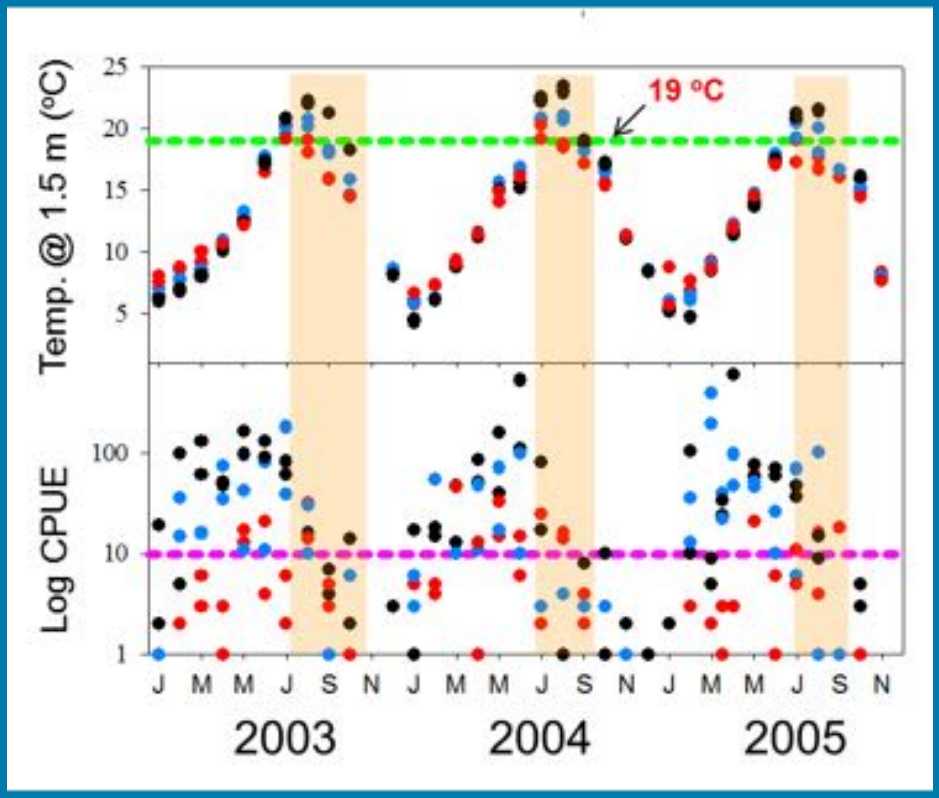
Increased summer/fall water temperatures may further reduce habitat opportunities in the estuary

Abundance and Water Temperature

Russian & Seal Island Marshes



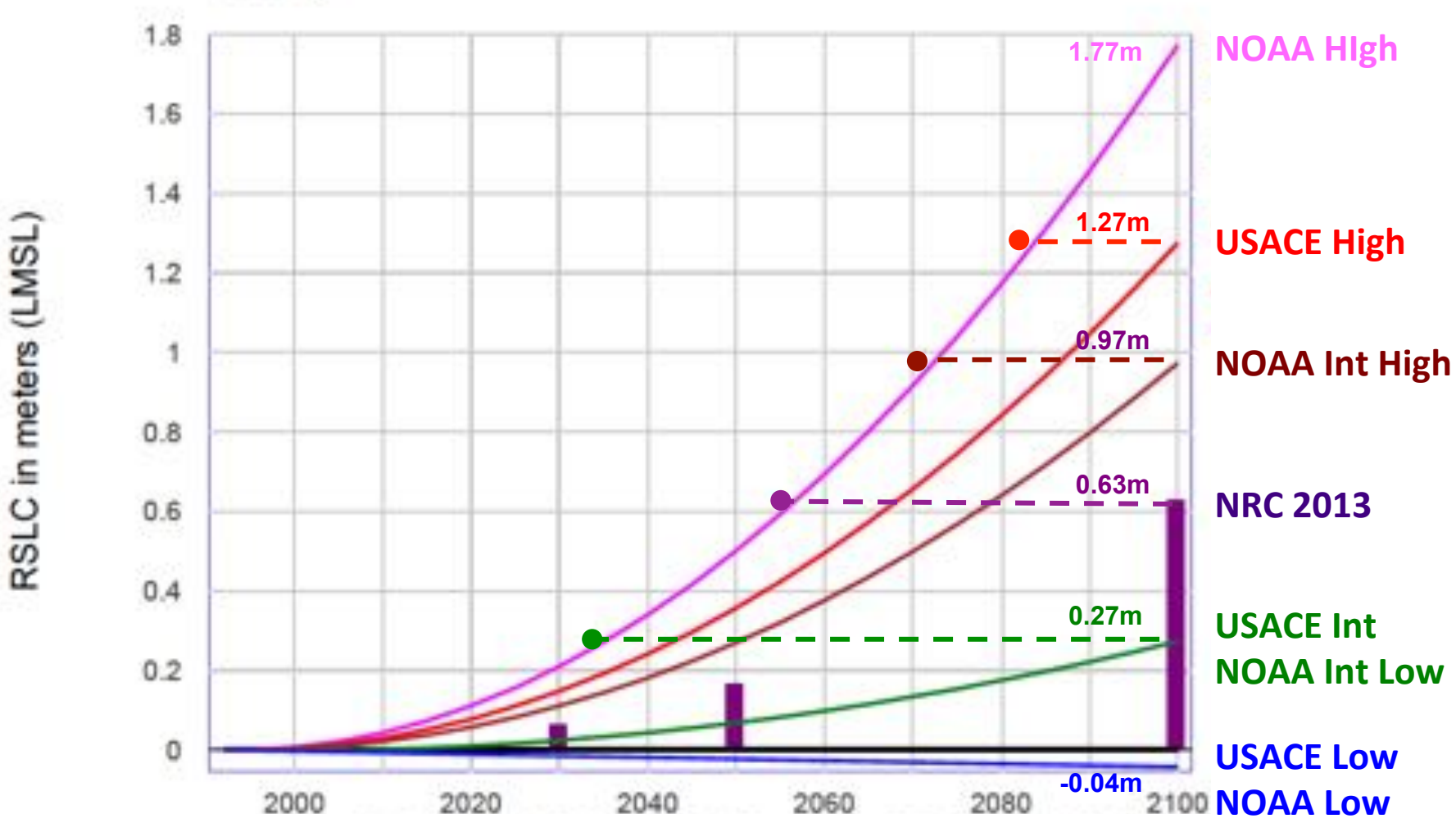
Estuary-wide Beach Seine



main-stem temps have increased ~2° to 3°C since 1890

Sea level rise scenarios

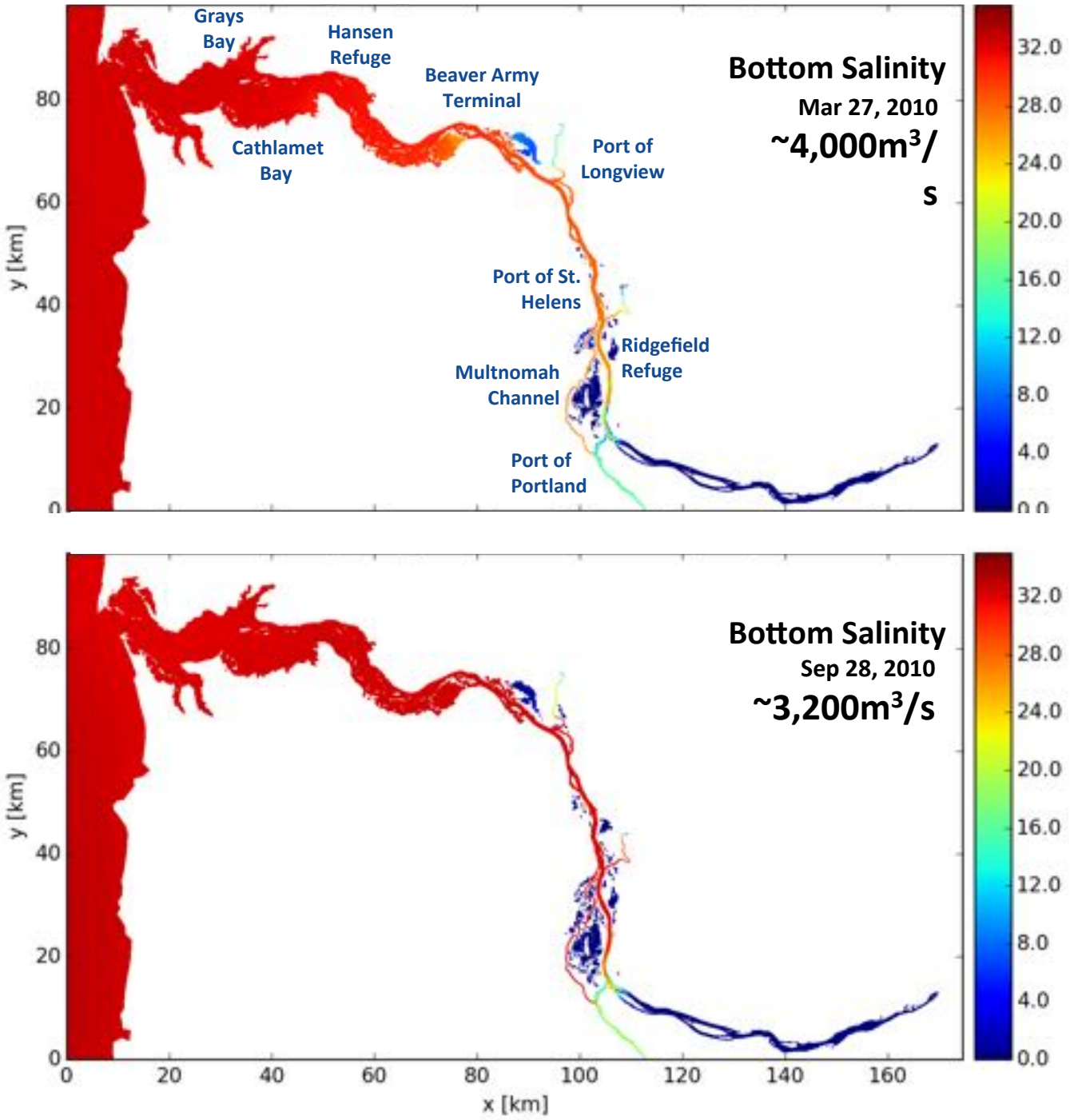
Courtesy Mojgan Rostaminia and Antonio Baptista, OHSU-CMOP



CMOP Center for Coastal Margin Observation & Prediction

Scenario generating tool courtesy USACE

OREGON HEALTH & SCIENCE UNIVERSITY OHSU



Year-long simulations with "2010" as reference

Current condition

SLR 0.27 m

SLR 0.63 m

SLR 0.97 m

SLR 1.27 m

SLR 1.77 m

Courtesy Mojgan Rostaminia and Antonio Baptista, OHSU-CMOP

Conclusions

- Diverse wetland and floodplain habitats afford a diversity of salmon rearing opportunities along the estuarine tidal gradient
- Much of the historical rearing habitat has been lost to diking, filling, and flow regulation
- Climate change may further limit rearing opportunities through increased summer/fall water temperatures and reduced river flow
- Sea level rise and salinity intrusion could fundamentally alter the processes that determine the availability, quality, and distribution of shallow rearing habitats
- Recent modeling raises concerns about estuary “tipping points” and whether these might exceed the adaptive capacities of wetland habitats and estuarine species, including salmon