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

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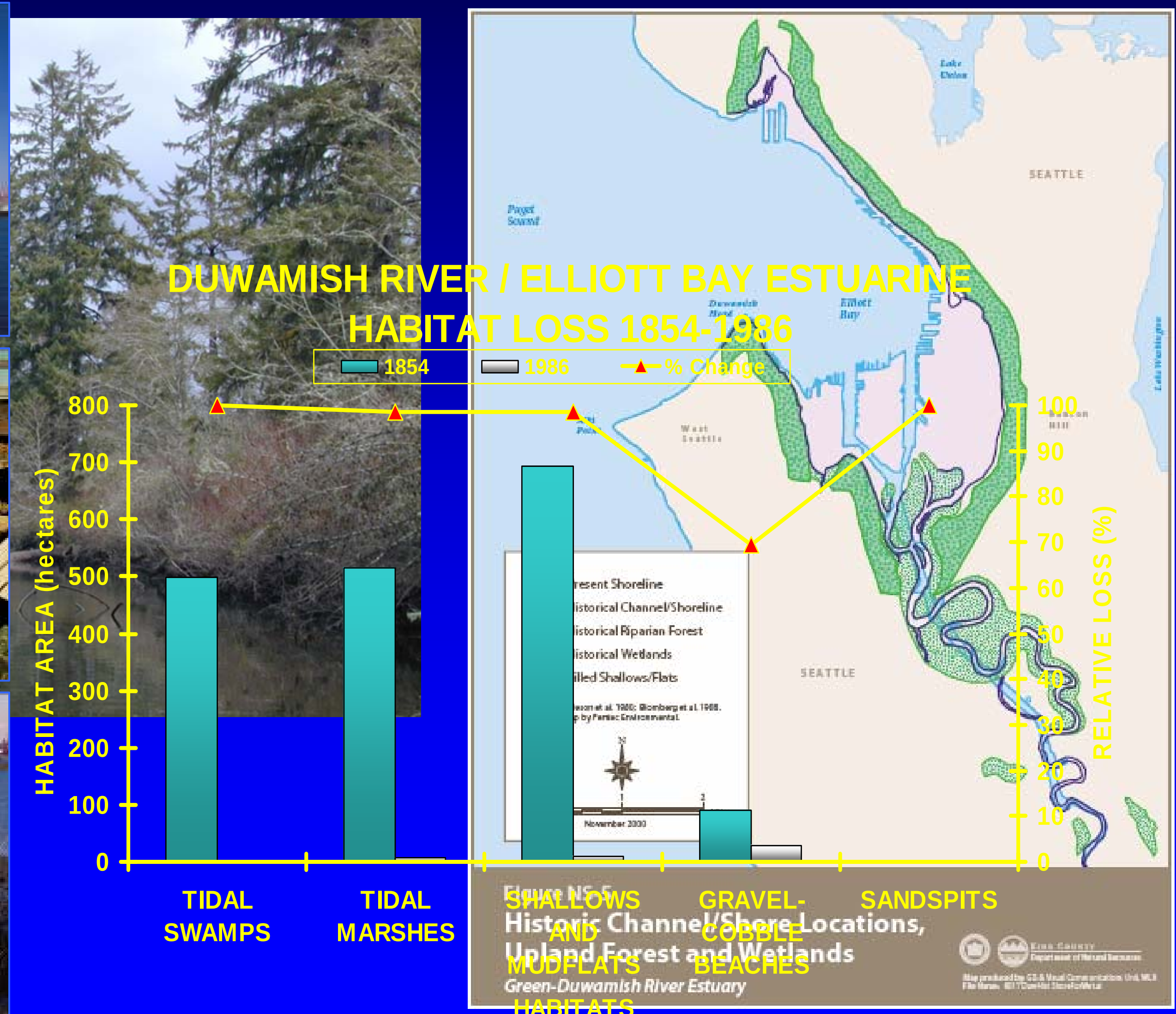
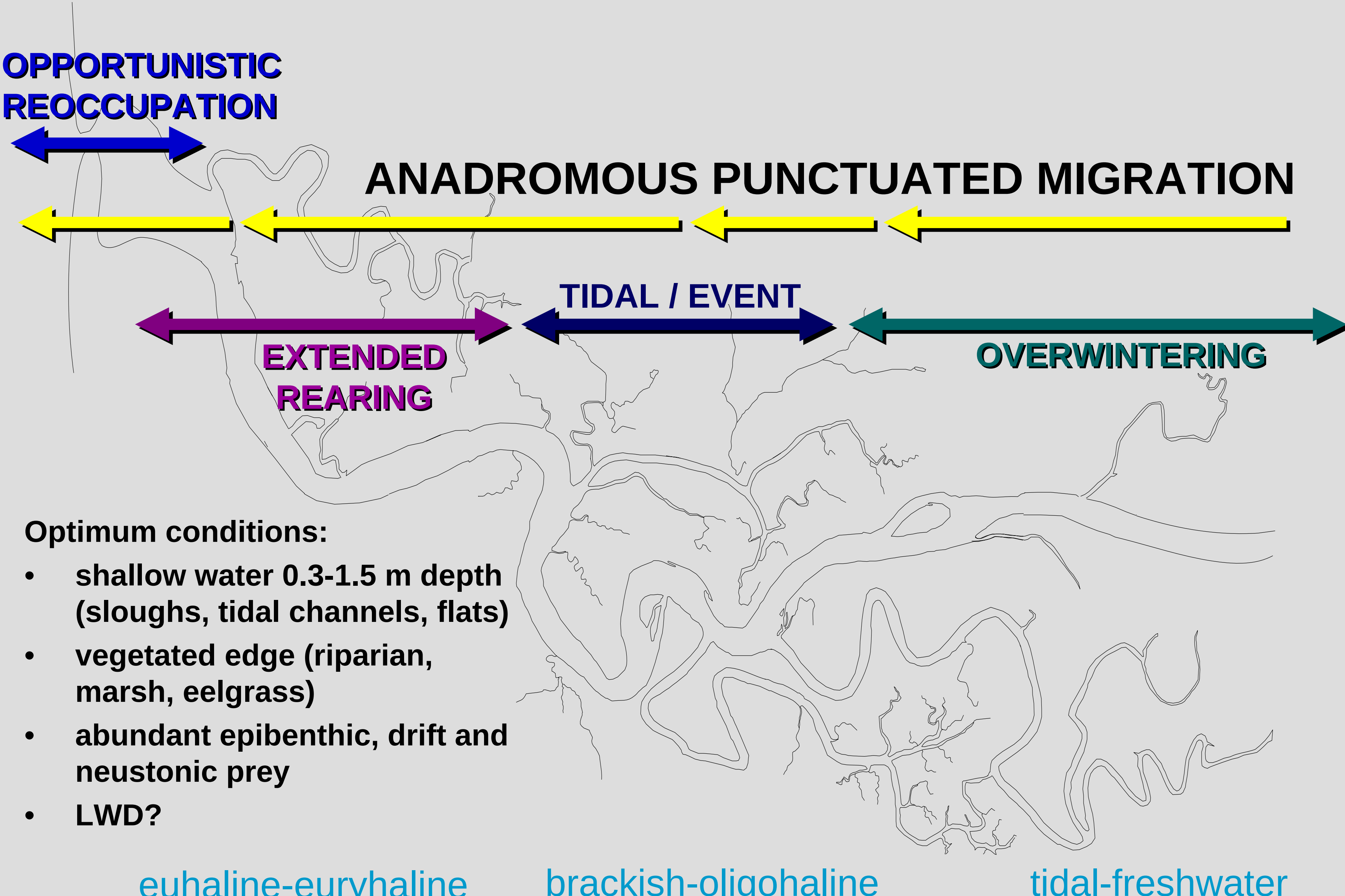
TIDAL FRESHWATER ECOSYSTEMS: The estuarine ‘bridge” between fluvial and land-margin ecosystems

- 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"



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?**

<u>Perspective</u>: On-Going Studies of Estuarine Influence on Recovery and Resilience of Salmon Populations in the Columbia River

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David Jay, Principle Investigator
Tobias Kukulka

Salmon at River's End:

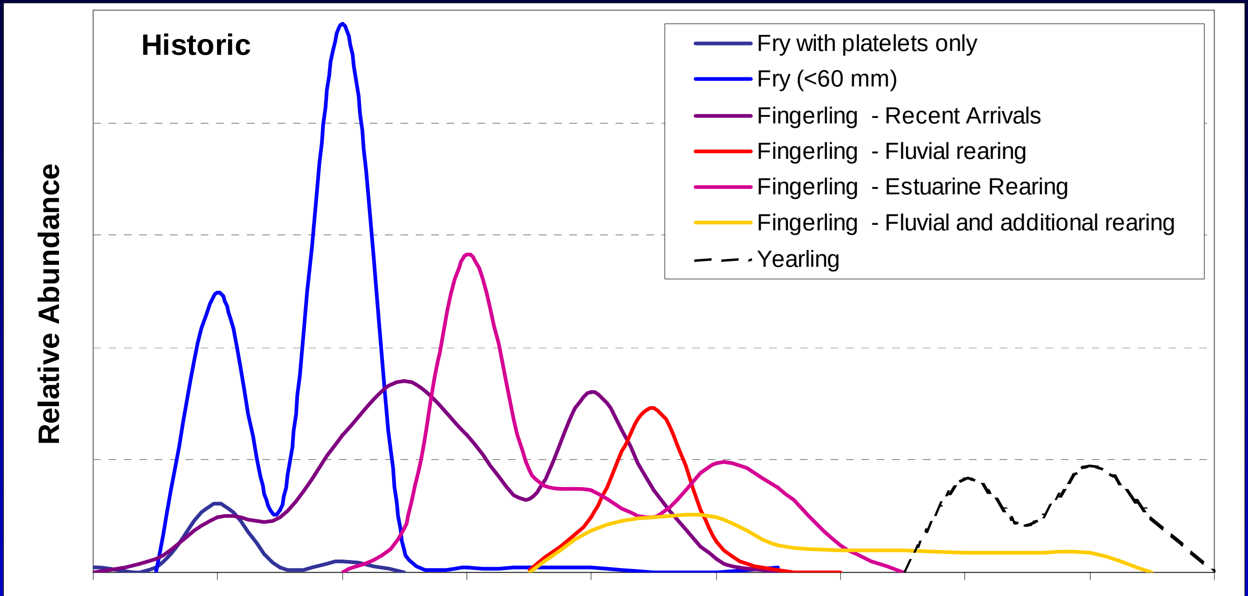
The Role of the Estuary in the Decline and Recovery of Columbia River Salmon

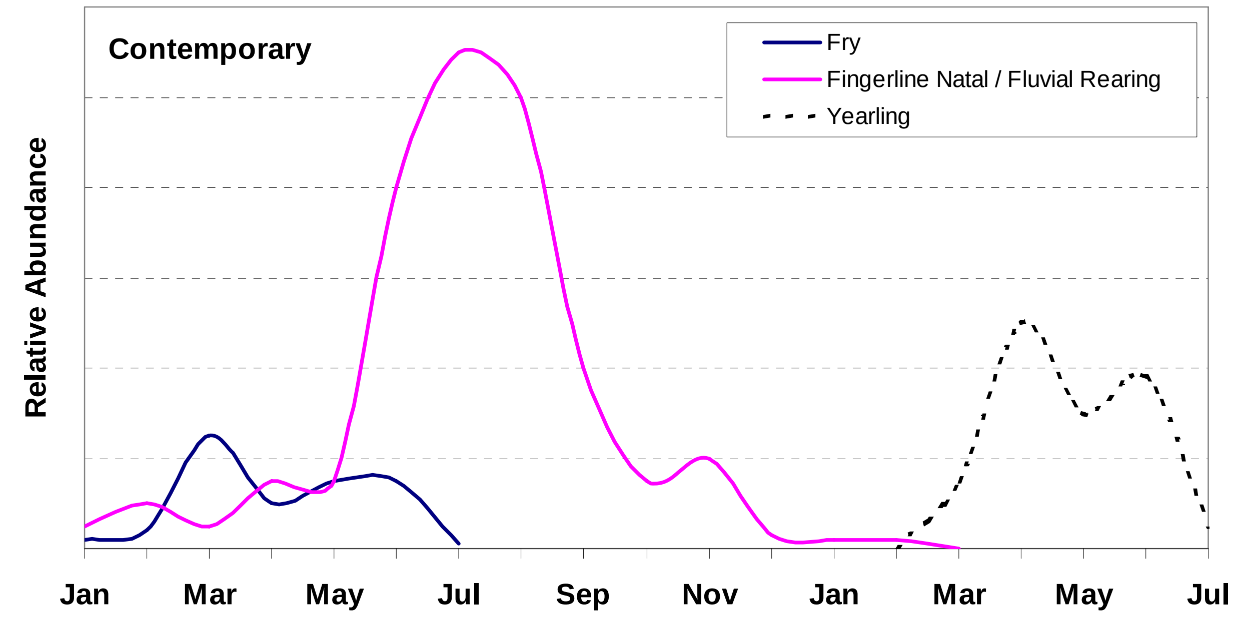
2006
U.S. National Marine Fisheries Service
Seattle

HISTORIC AND CONTEMPORARY SALMON LIFE HISTORY CHRONOLOGIES

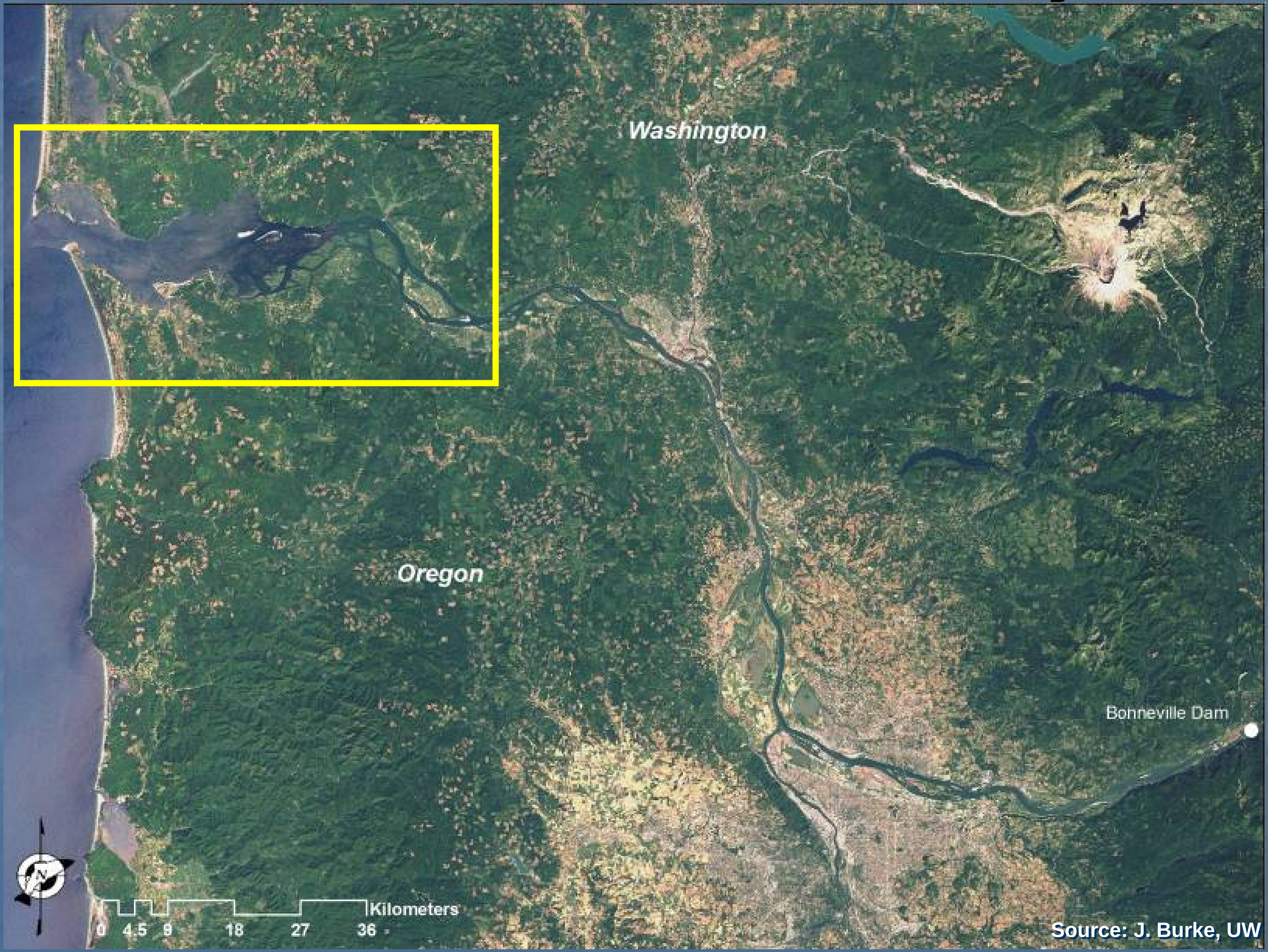
One brood year of chinook salmon in the Columbia River estuary

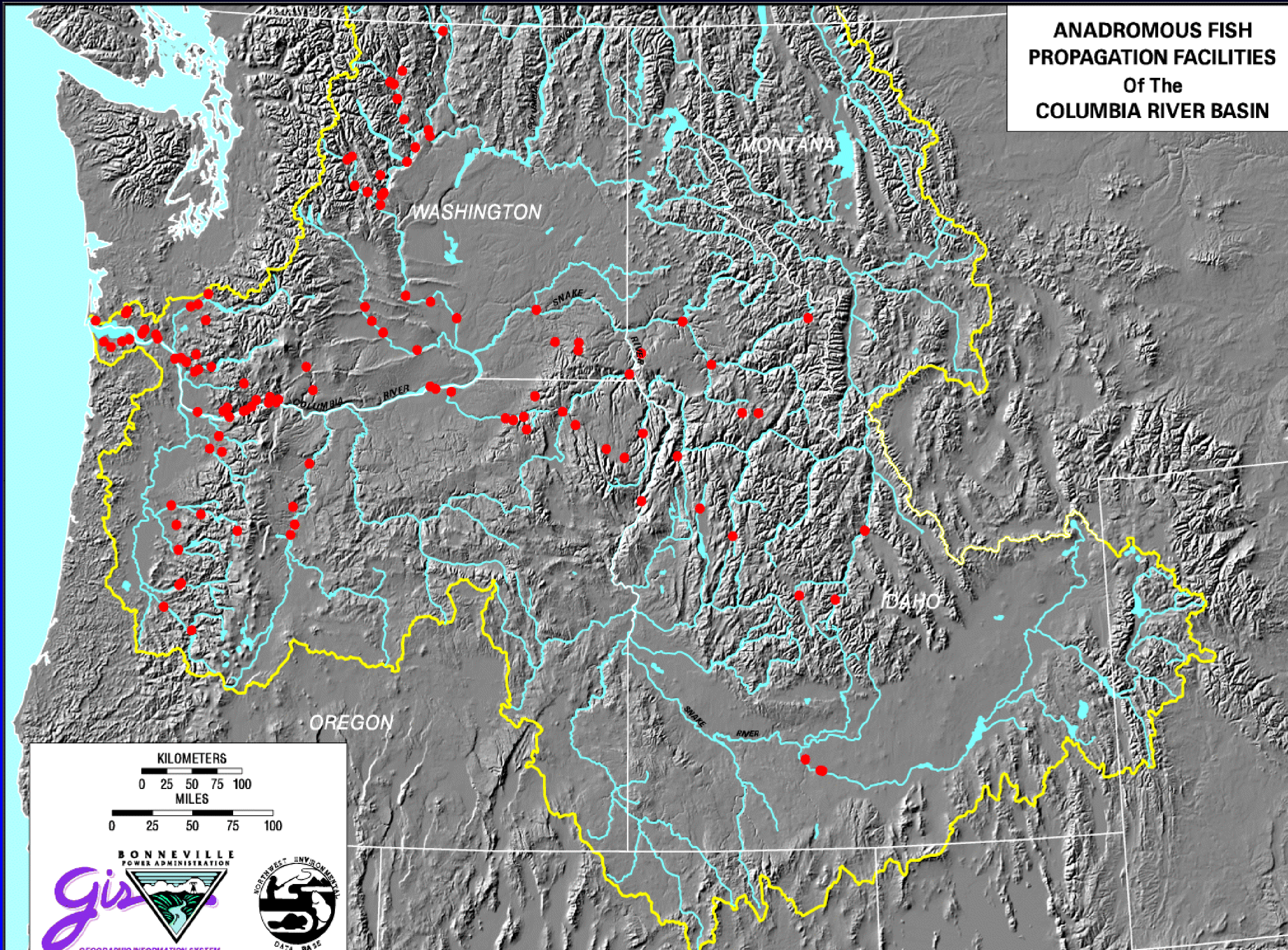
Source: J. Burke (2004), based on data from Rich (1920) & Dawley et al. (1985)





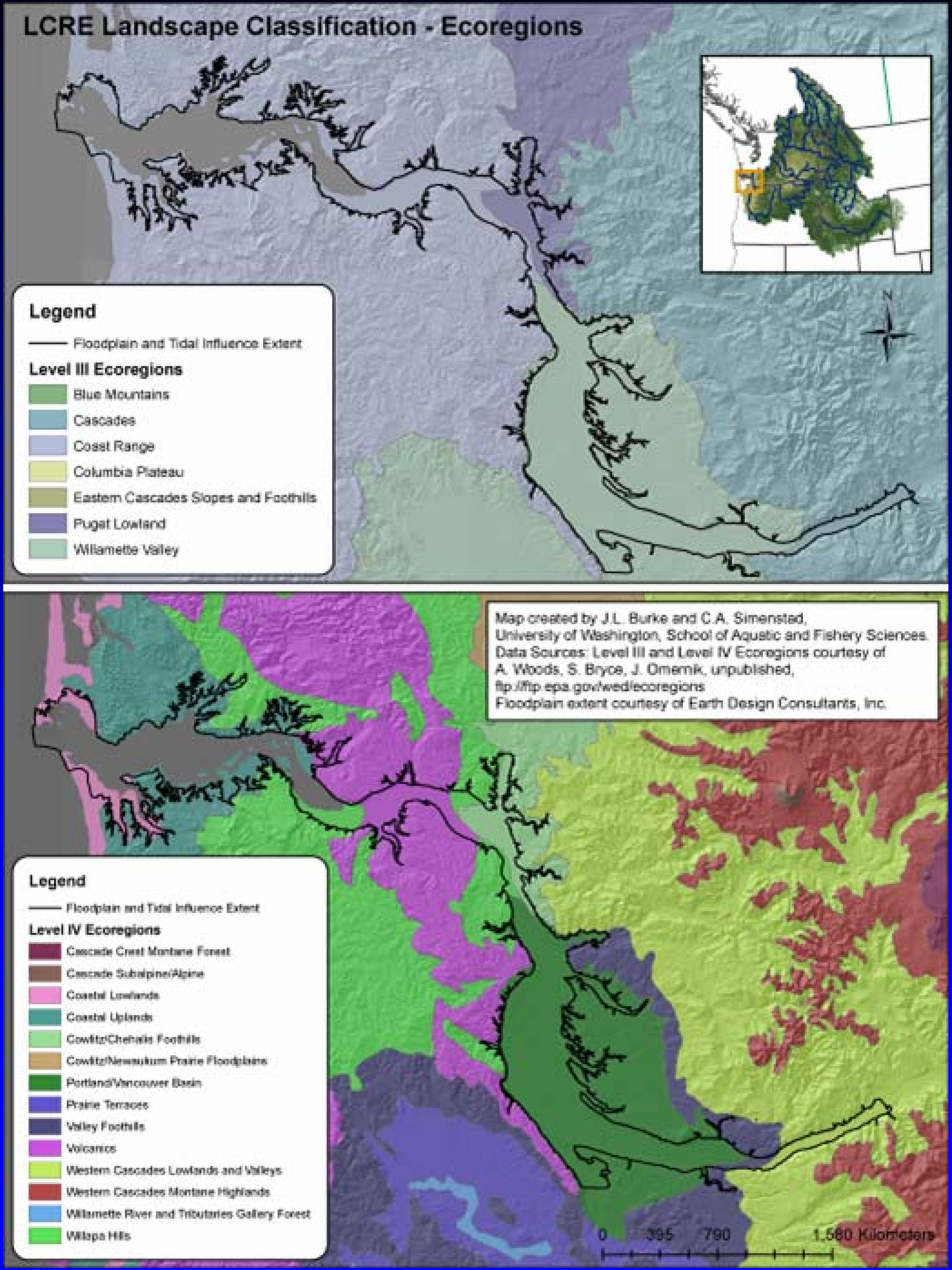
Columbia River estuary



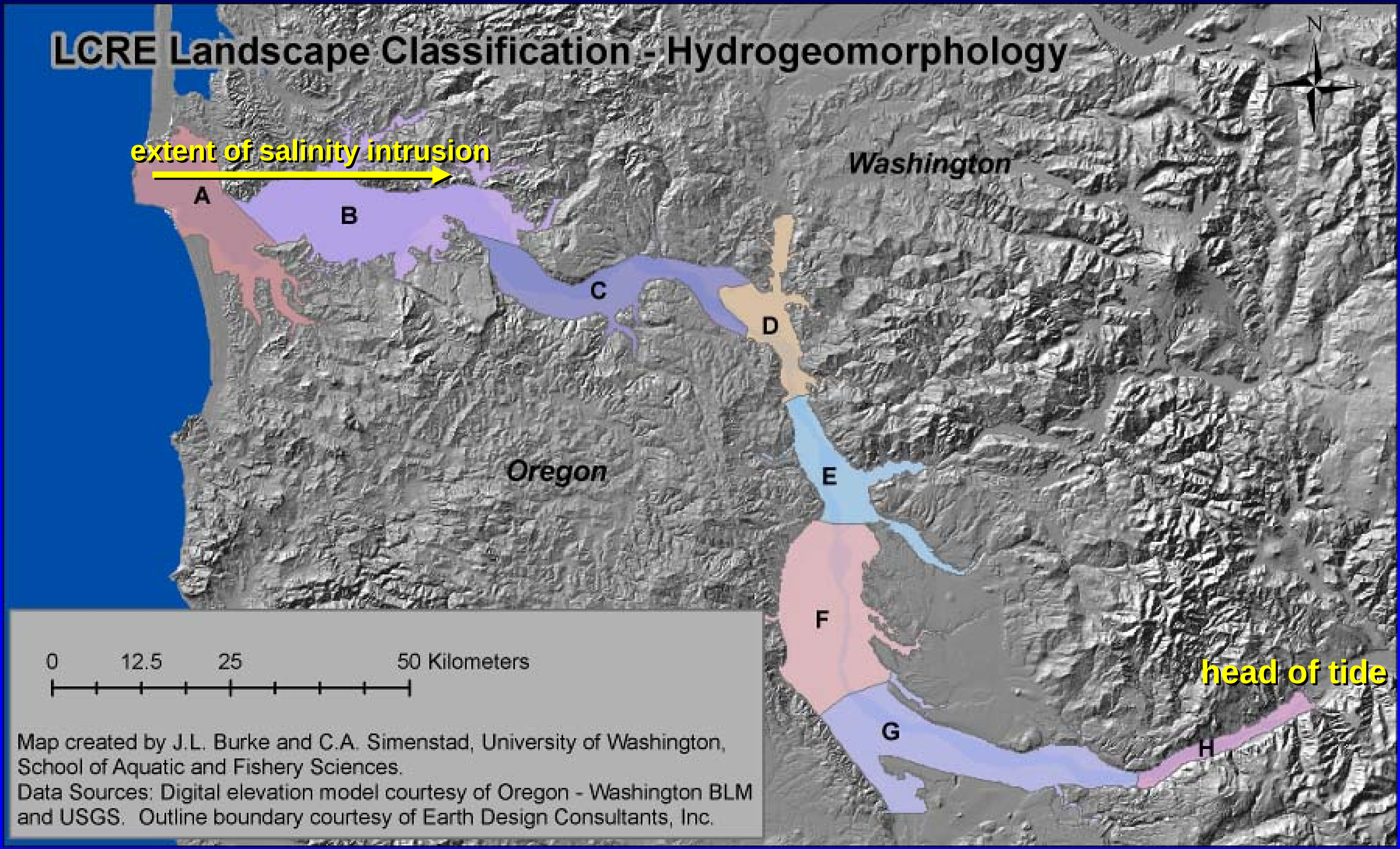

ANADROMOUS FISH PROPAGATION FACILITIES Of The COLUMBIA RIVER BASIN
WASHINGTON
MONTANA
OREGON
IDAHO
SNAKE
RIVER
COLUMBIA
RIVER
SNAKE RIVER
KILOMETERS
0 25 50 75 100
MILES
0 25 50 75 100
BONNEVILLE POWER ADMINISTRATION
GIS
GEOGRAPHIC INFORMATION SYSTEM
NORTHWEST ENVIRONMENTAL DATA BASE

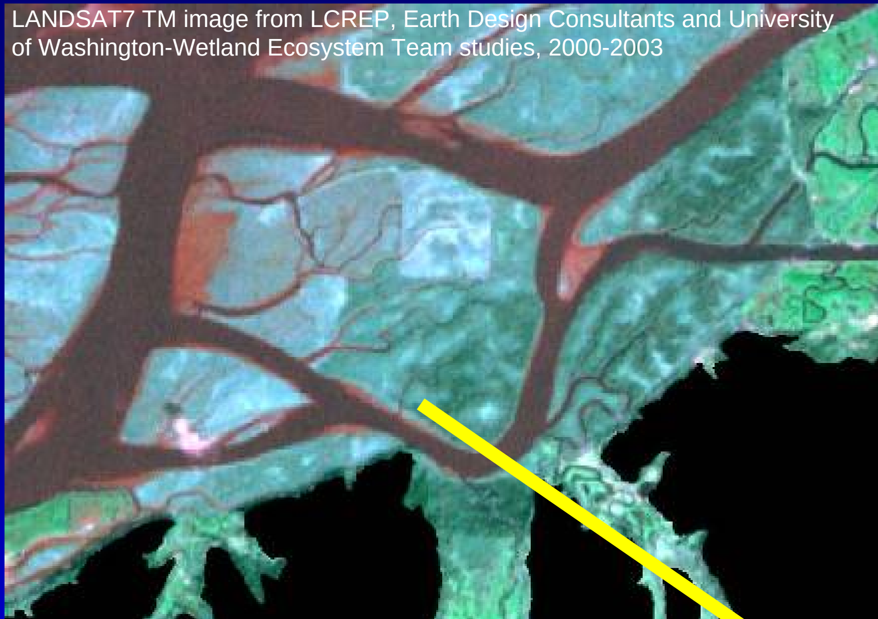
Streamnet

EPA Ecoregion Levels III and IV used to develop <u>Ecoregion</u> Level 2 (top) and <u>Hydrogeomorphic Reach</u> Level 3 (bottom) of Hierarchical Columbia River Ecosystem Classification



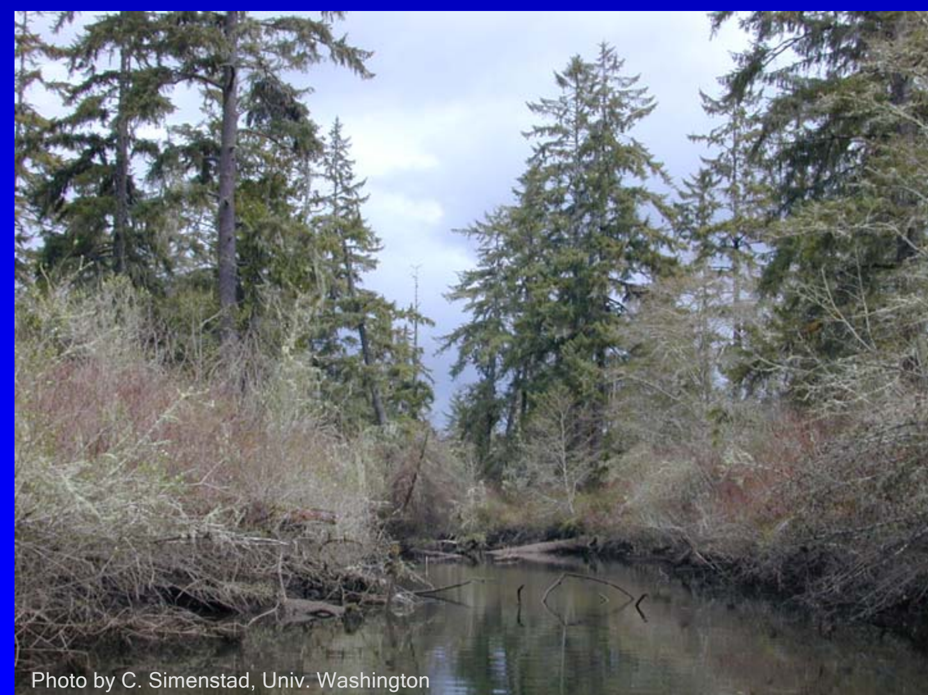
Hydrogeomorphic Reach
Level 3 of Hierarchical Columbia River Ecosystem Classification

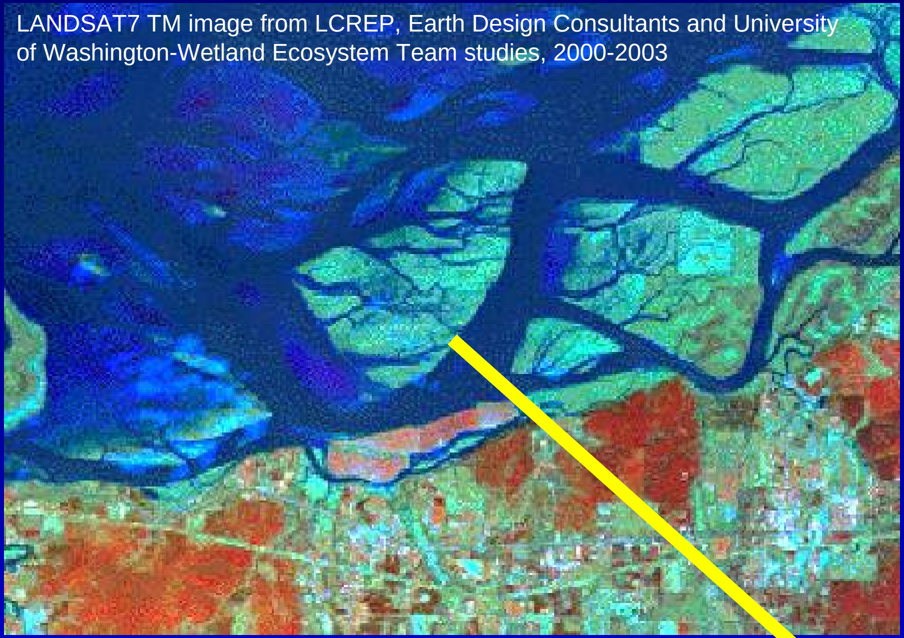




TIDAL SWAMPS

Karlson Island Tidal Freshwater Wetland Slough, Cathlamet Bay, Columbia River Estuary

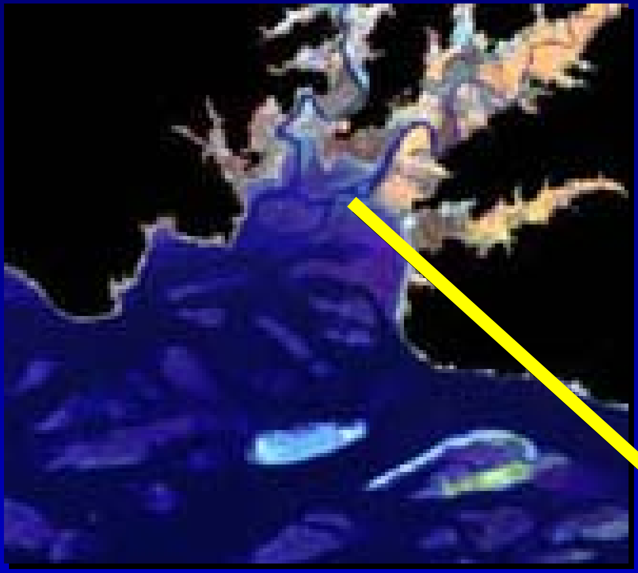




TIDAL MARSHES

Russian Island Marsh, Cathlamet Bay, Columbia River Estuary

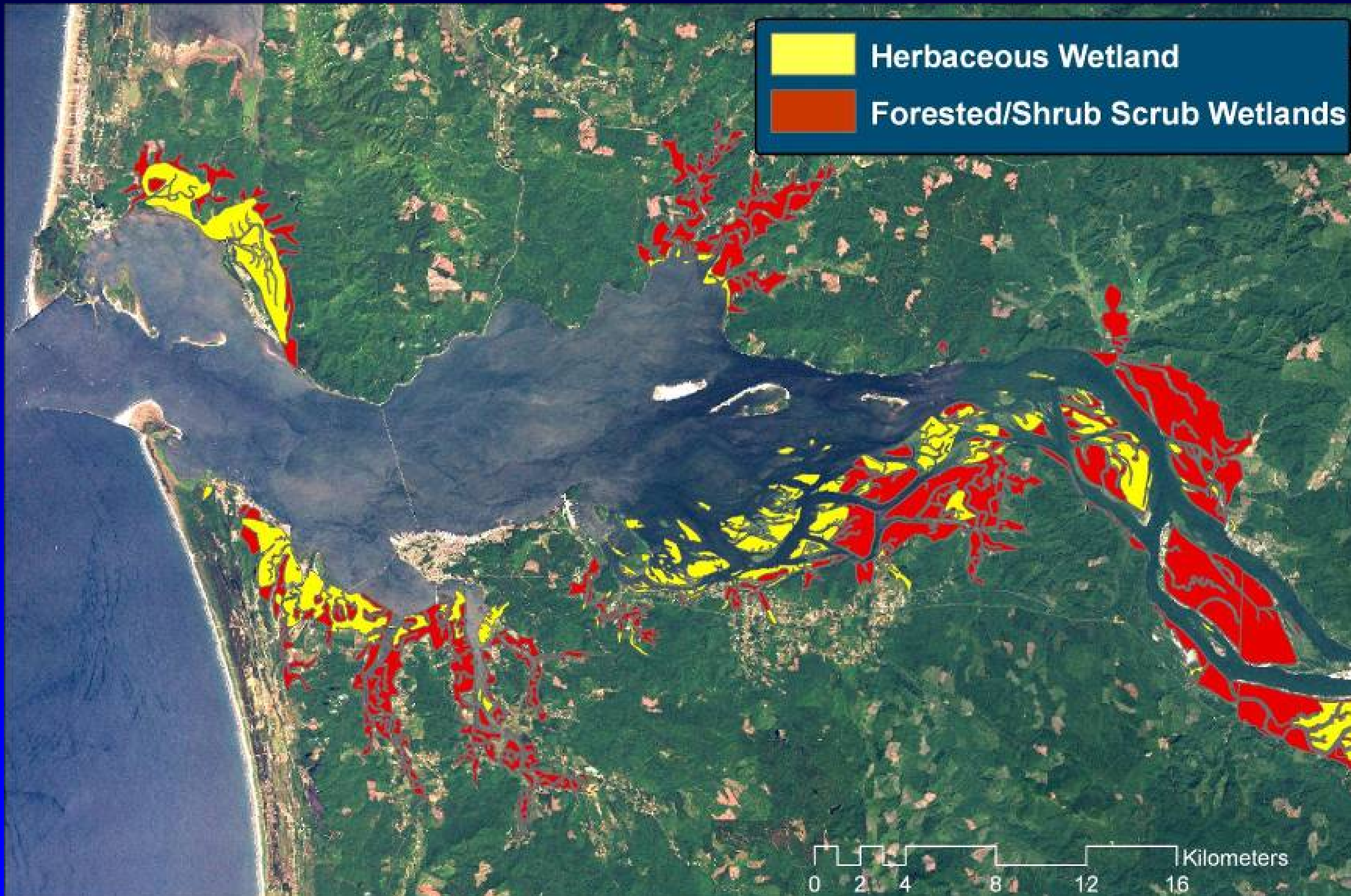
LANDSAT7 TM image from LCREP, Earth Design Consultants and University of Washington-Wetland Ecosystem Team studies, 2000-2003

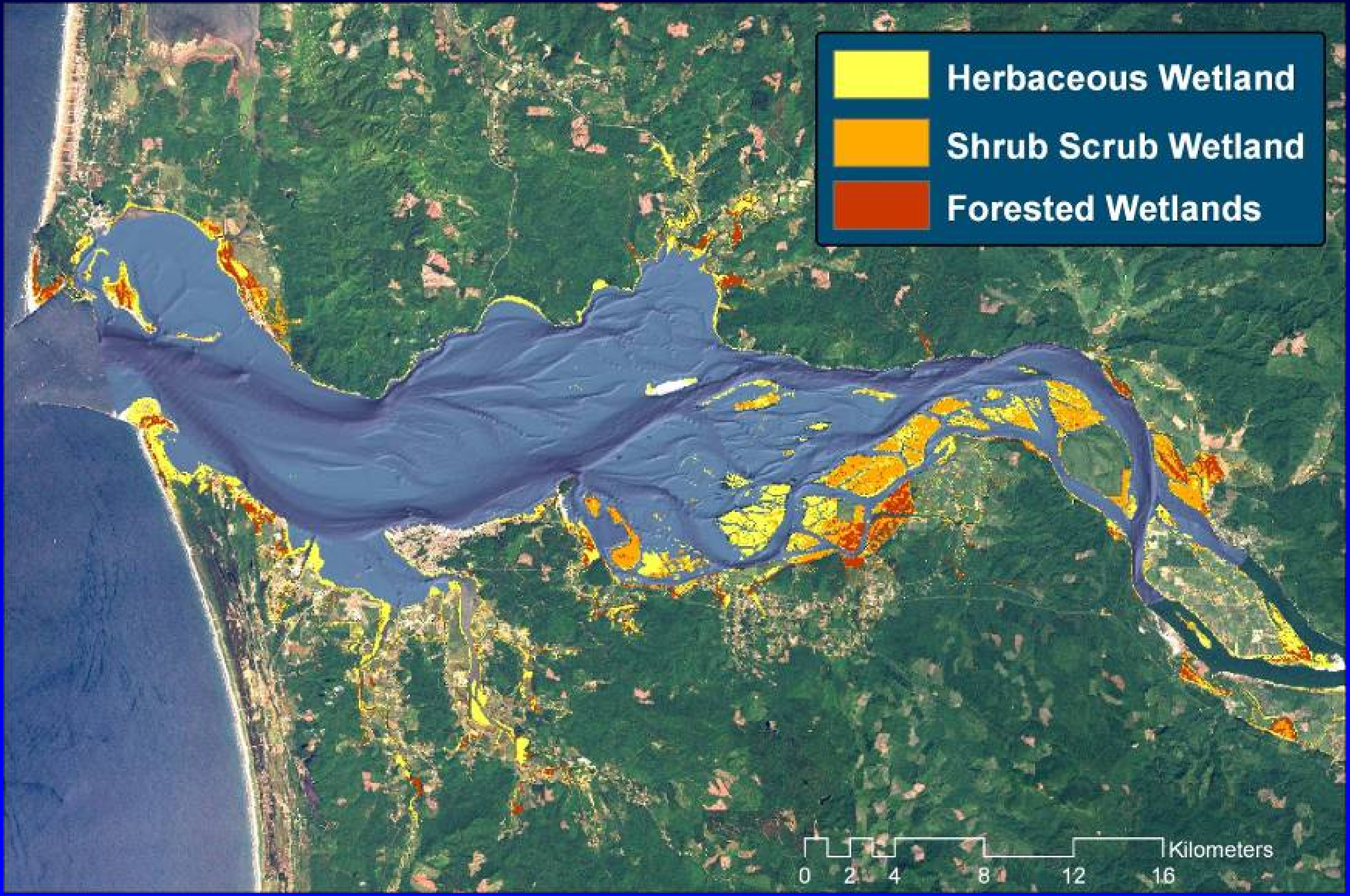


TIDAL FLATS AND OPEN WATER

Grays Bay (foreground), and Columbia River Estuary

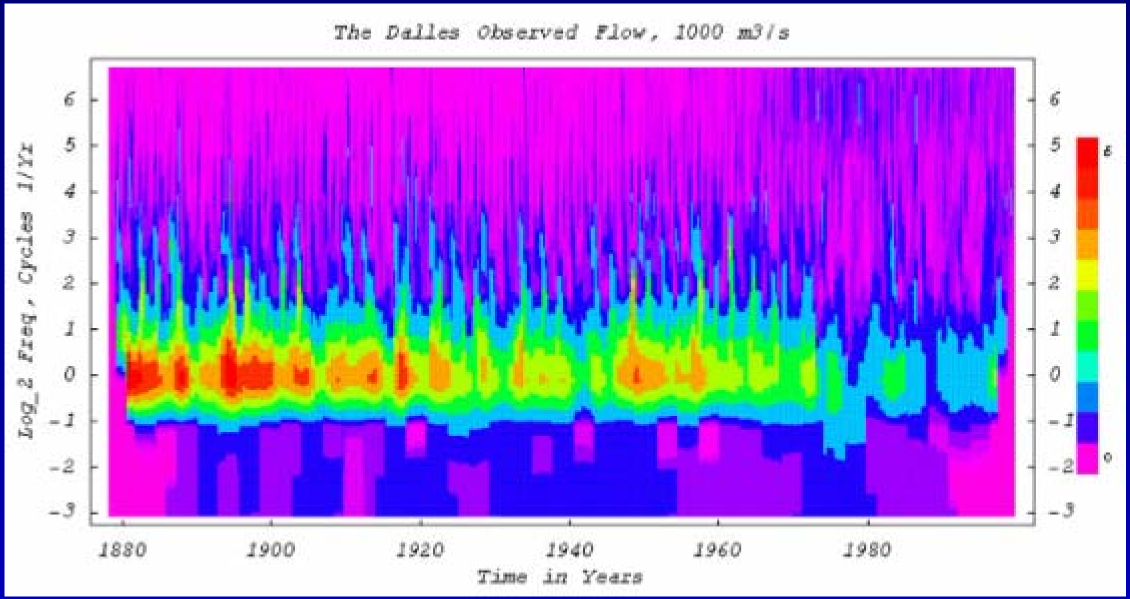
Photo by R. Emmett, NMFS


Herbaceous Wetland
Forested/Shrub Scrub Wetlands
Kilometers
0
2
4
8
12
16

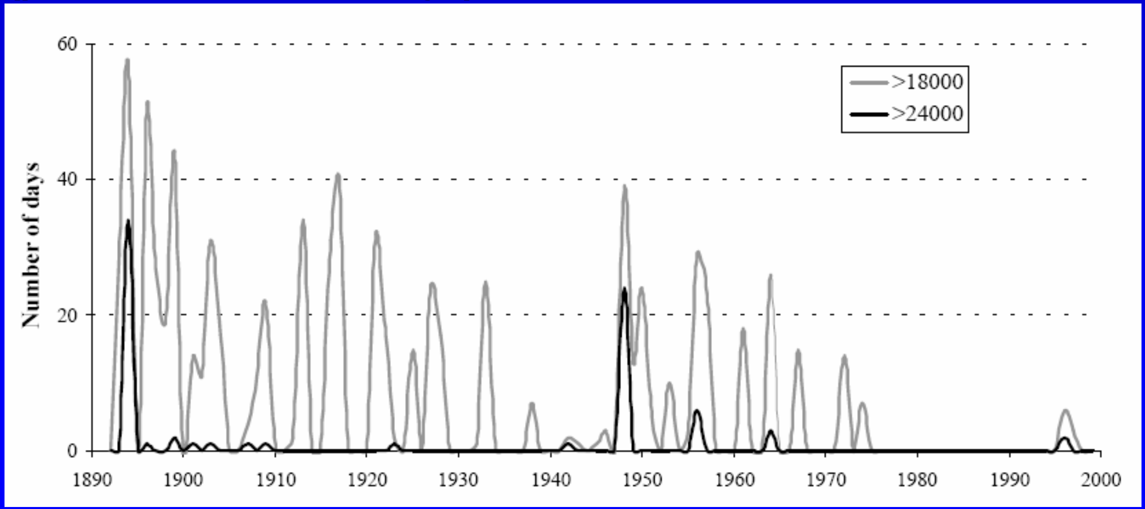


Herbaceous Wetland
Shrub Scrub Wetland
Forested Wetlands
Kilometers
0
2
4
8
12
16

FREQUENCY AND INTENSITY OF DISTURBANCE IN THE COLUMBIA RIVER ESTUARY DUE TO CHANGES IN RIVER FLOW

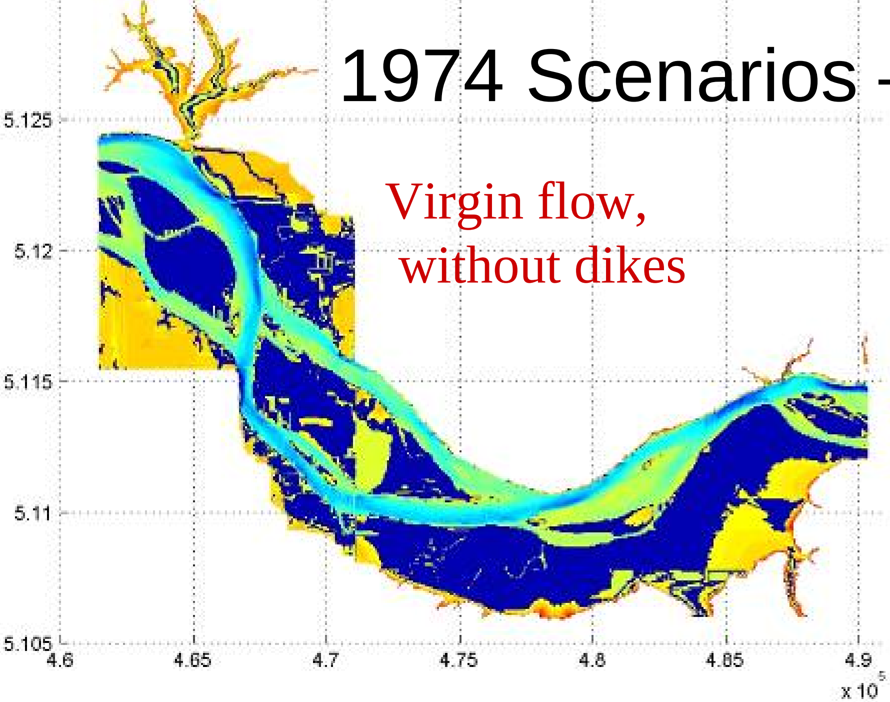


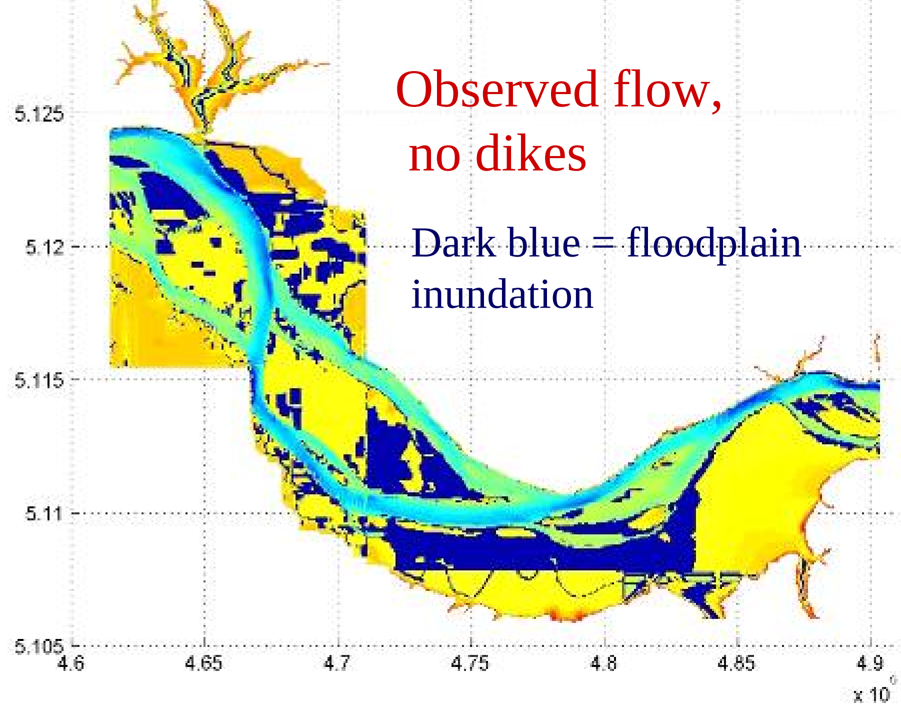
Scaleogram of observed flow at The Dalles, showing periods of 8 years (bottom) to 3.5 days (top). Irrigation depletion begins to affect freshet strength and the annual flow cycle noticeably after 1920. Flow regulation effects are evident in the 1960s and dominant after 1970. High-frequency power peaking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

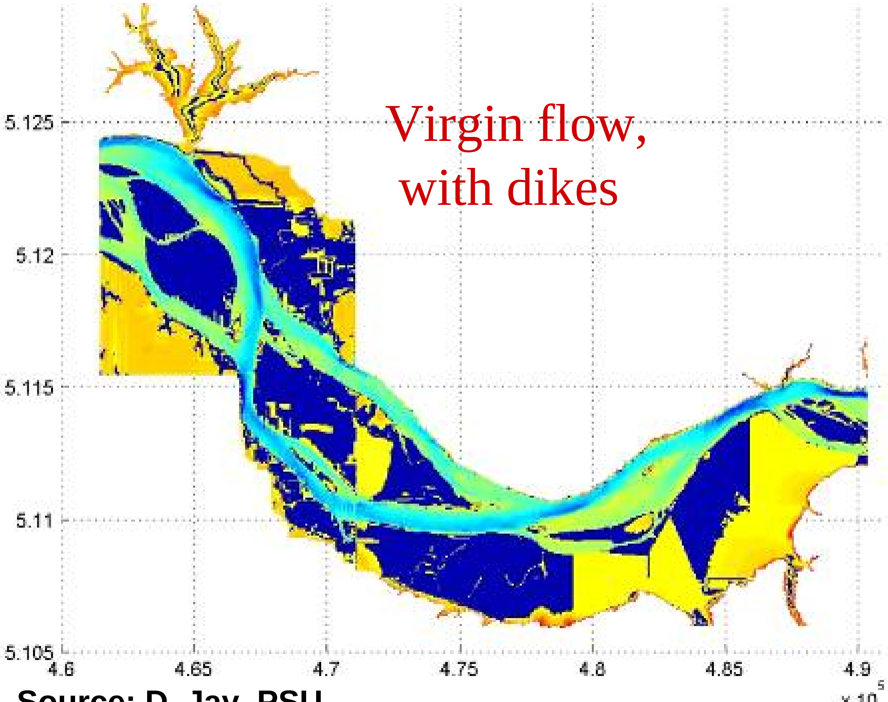


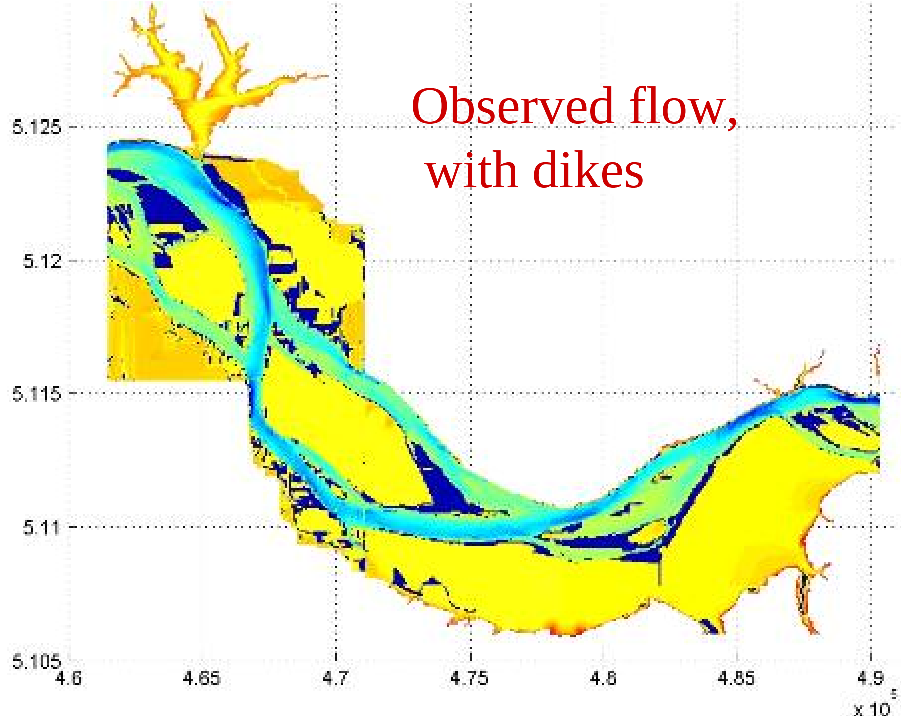
The incidence of flows above 18,000 m^3s^{-1} (the pre-1900 estimated bankfull flow level) and above 24,000 m^3s^{-1} (the present bankfull flow level). The present bankfull flow level has only been exceeded in four years since 1948. Source: Bottom et al. (2005)

1974 Scenarios –



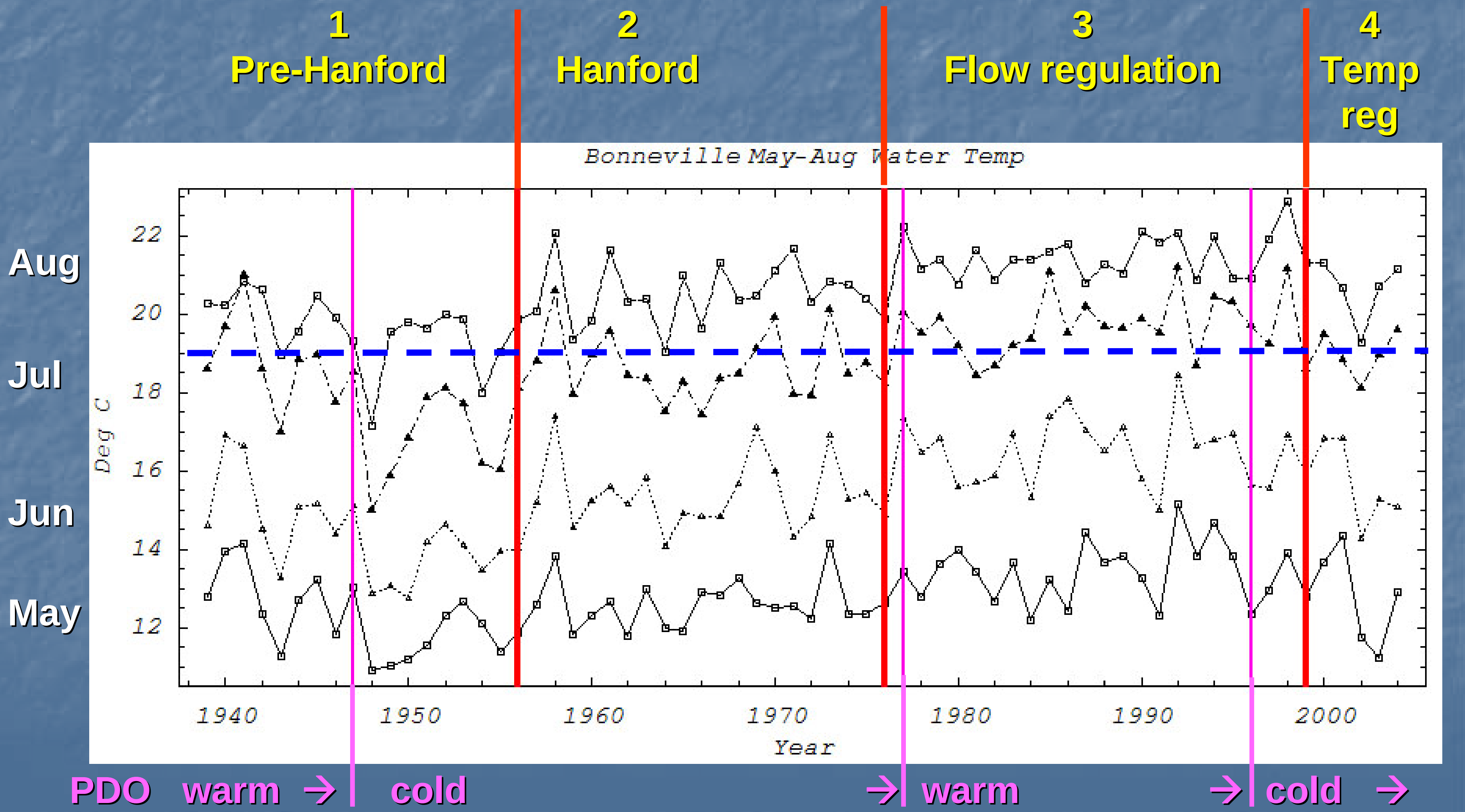






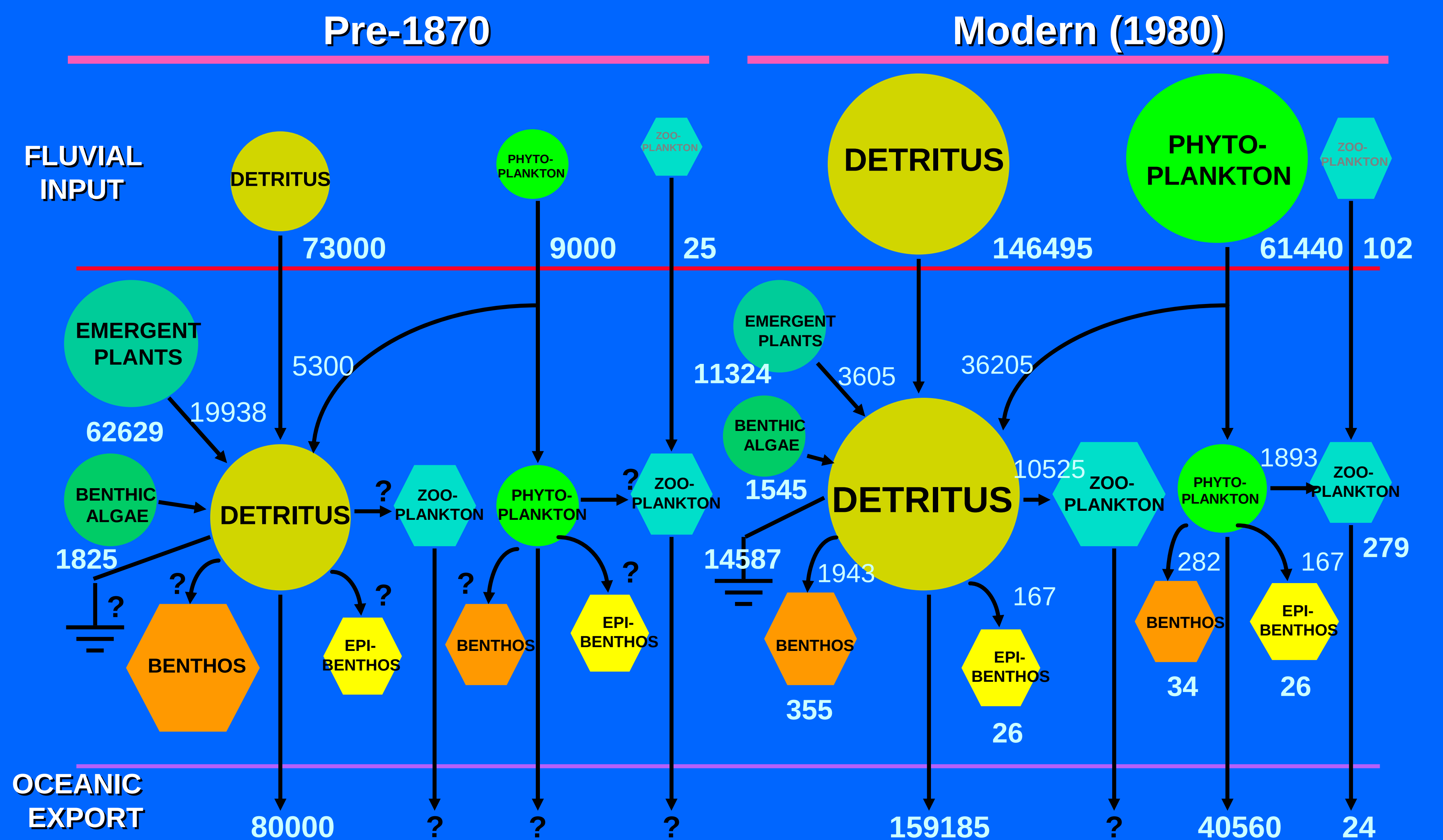
Source: D. Jay, PSU

Columbia River Temperature



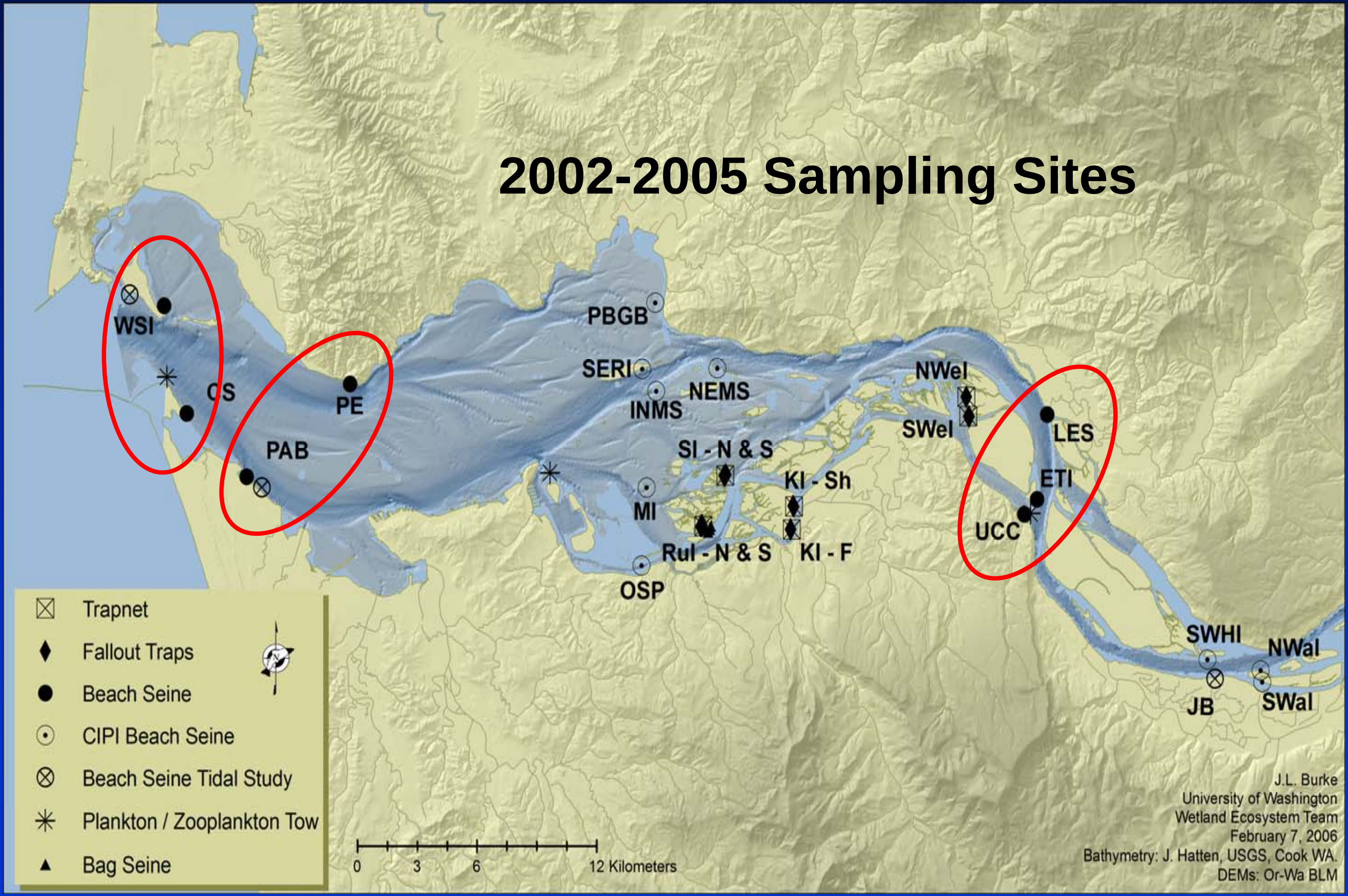
Source: D. Jay, PSU

HISTORIC AND MODERN COLUMBIA RIVER ESTUARY FOOD WEBS

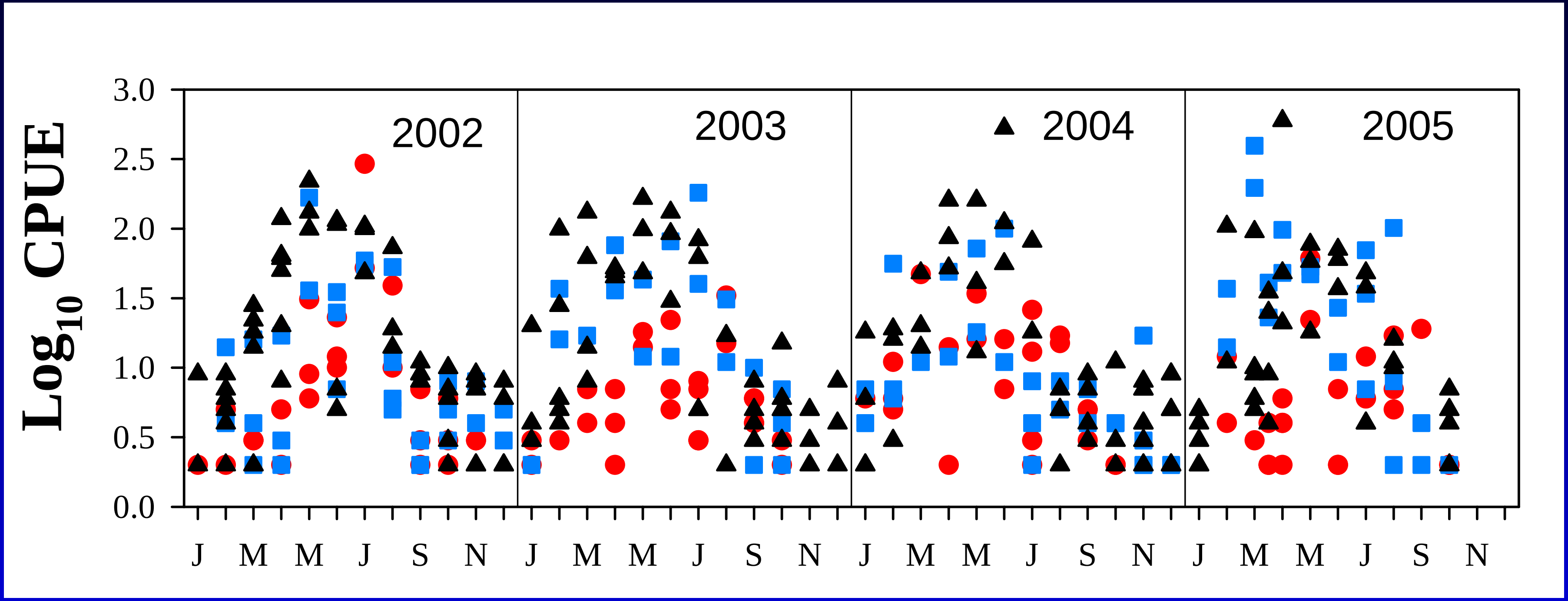


Source: 1978-1980 CREDDP investigations (Sherwood *et al.* 1984)

Capacity: <u>**Site**</u>, Seasonal and Fish Size Differences Along Estuarine Gradient



Chinook CPUE 2002-2005



Marine
Mixing
Tidal freshwater

- CPUE range: 0-550 ind / haul
- Spatial trend: FW>M>LE
- Annual trend: Broad peak (Feb-Jul), Sharp drop in Aug

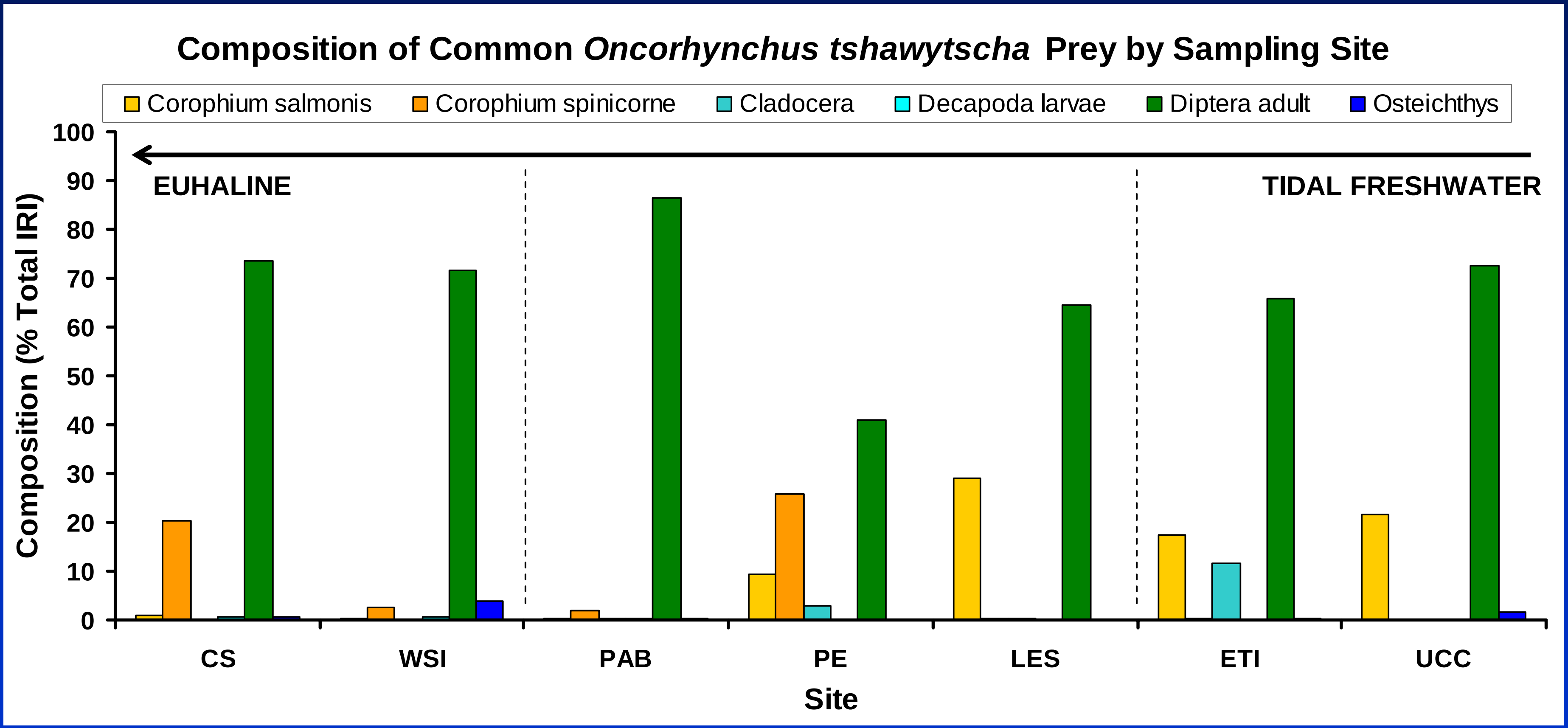
Interannual trend:

Subyearling Chinook found all year

Columbia River Estuary

Juvenile Salmon Habitat-Life History Relationships

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

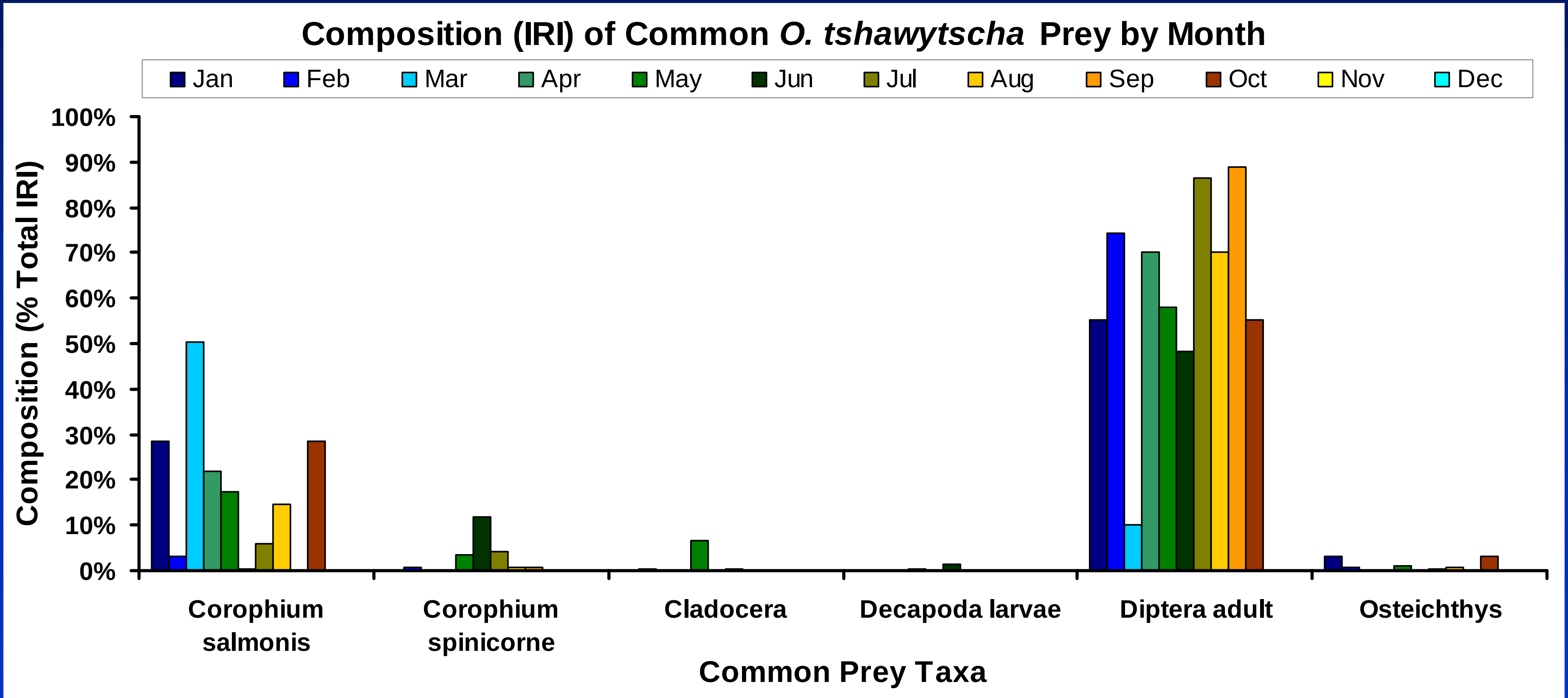


Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory

Columbia River Estuary

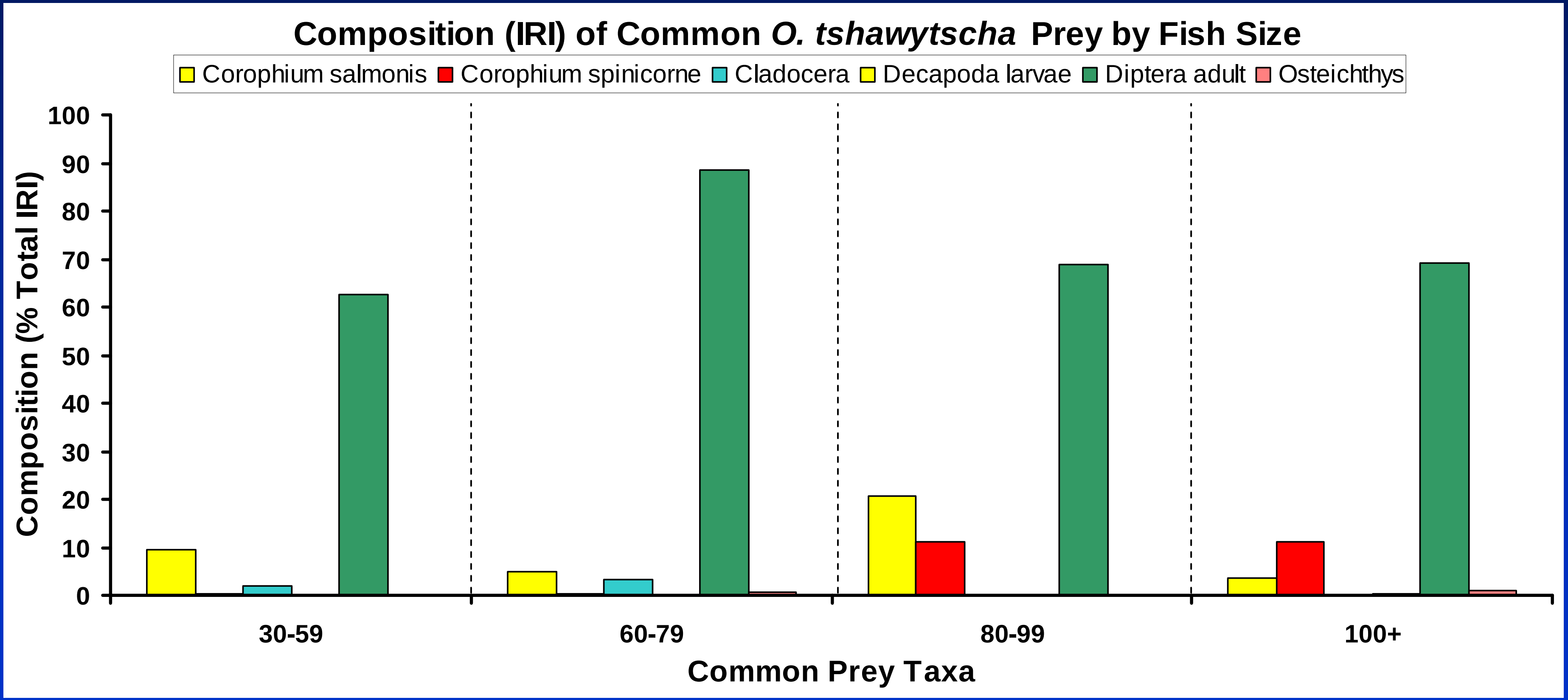
Juvenile Salmon Habitat-Life History Relationships

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



Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory

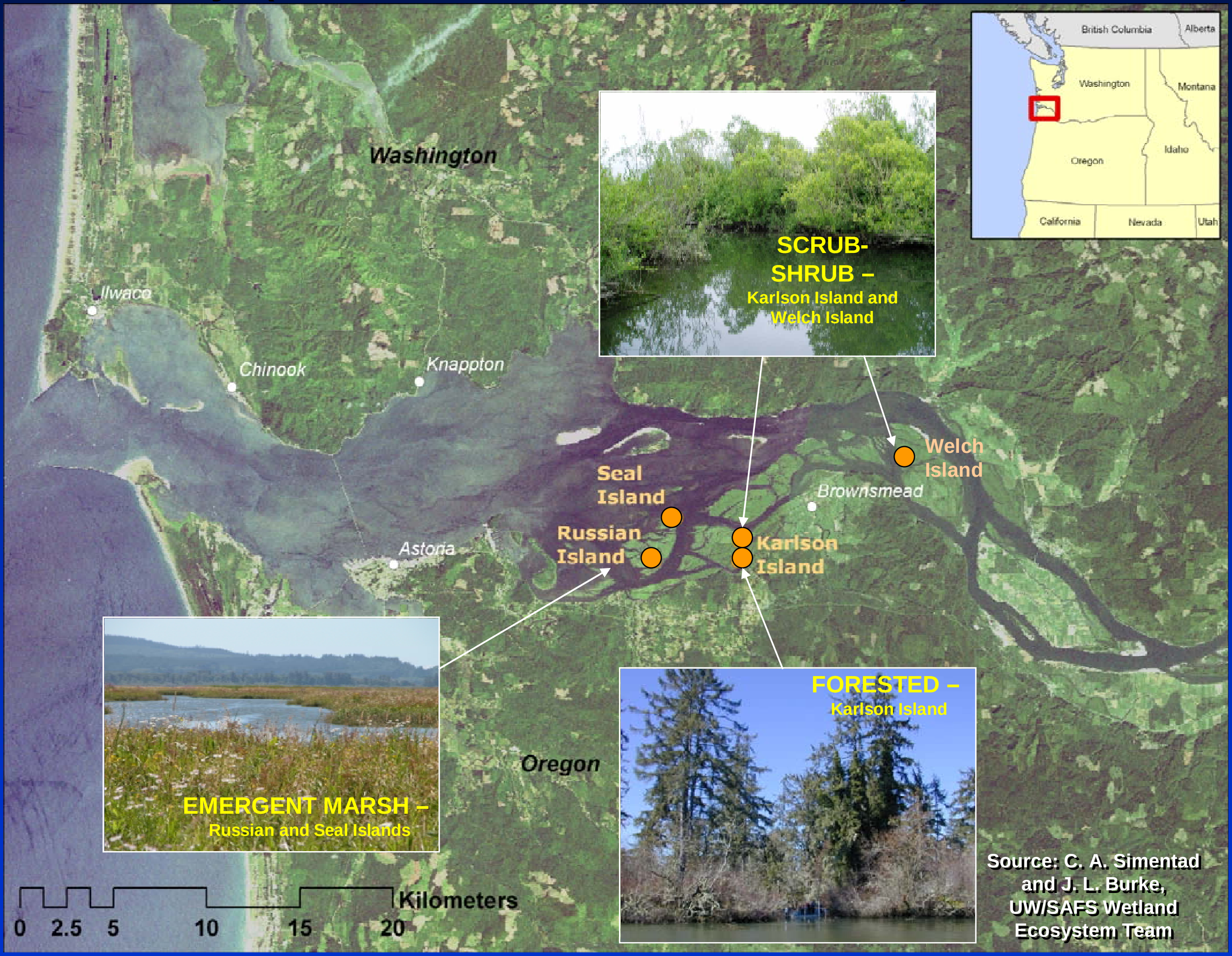
Capacity: Site, Seasonal and **Fish Size** Differences In Specific Wetland Habitats



Source: J. Zamon, NOAA-NWFSC, Pt. Adams Laboratory

Columbia River Estuary
Juvenile Salmon Habitat-Life History Relationships

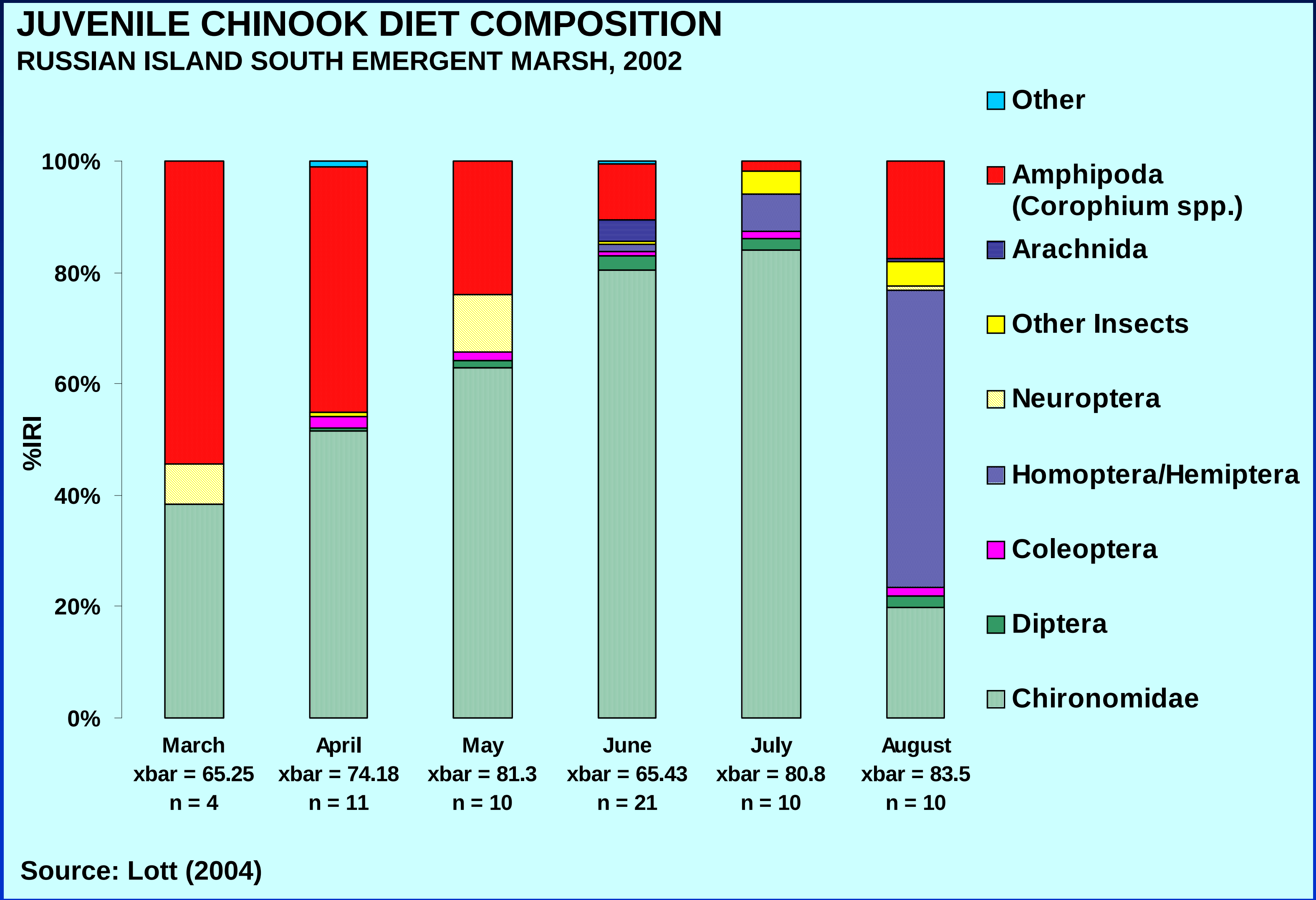
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Feeding selectivity (M.A. Lott & L. Stamatiou)



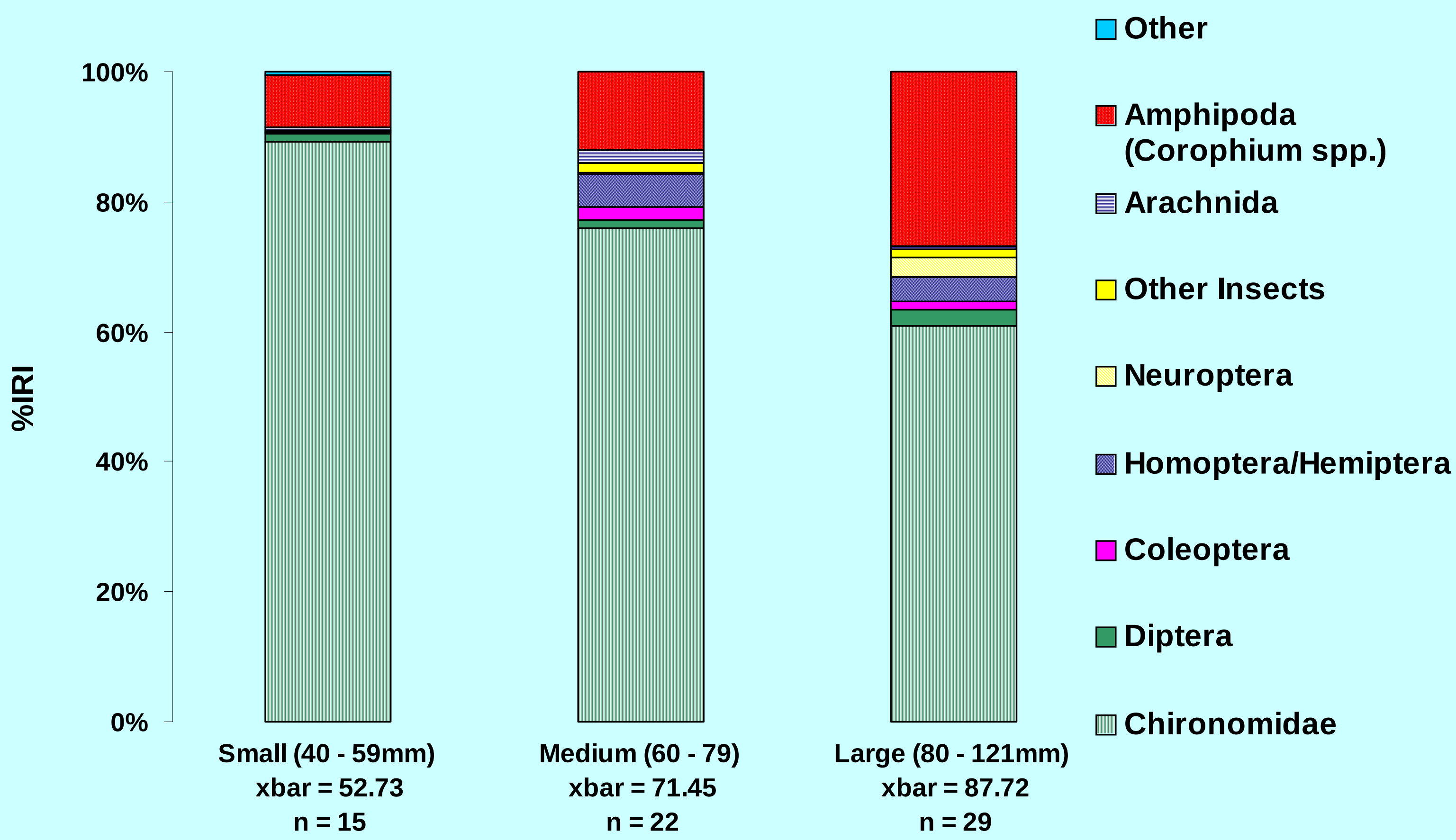
Columbia River Estuary

Juvenile Salmon Habitat-Life History Relationships

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



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

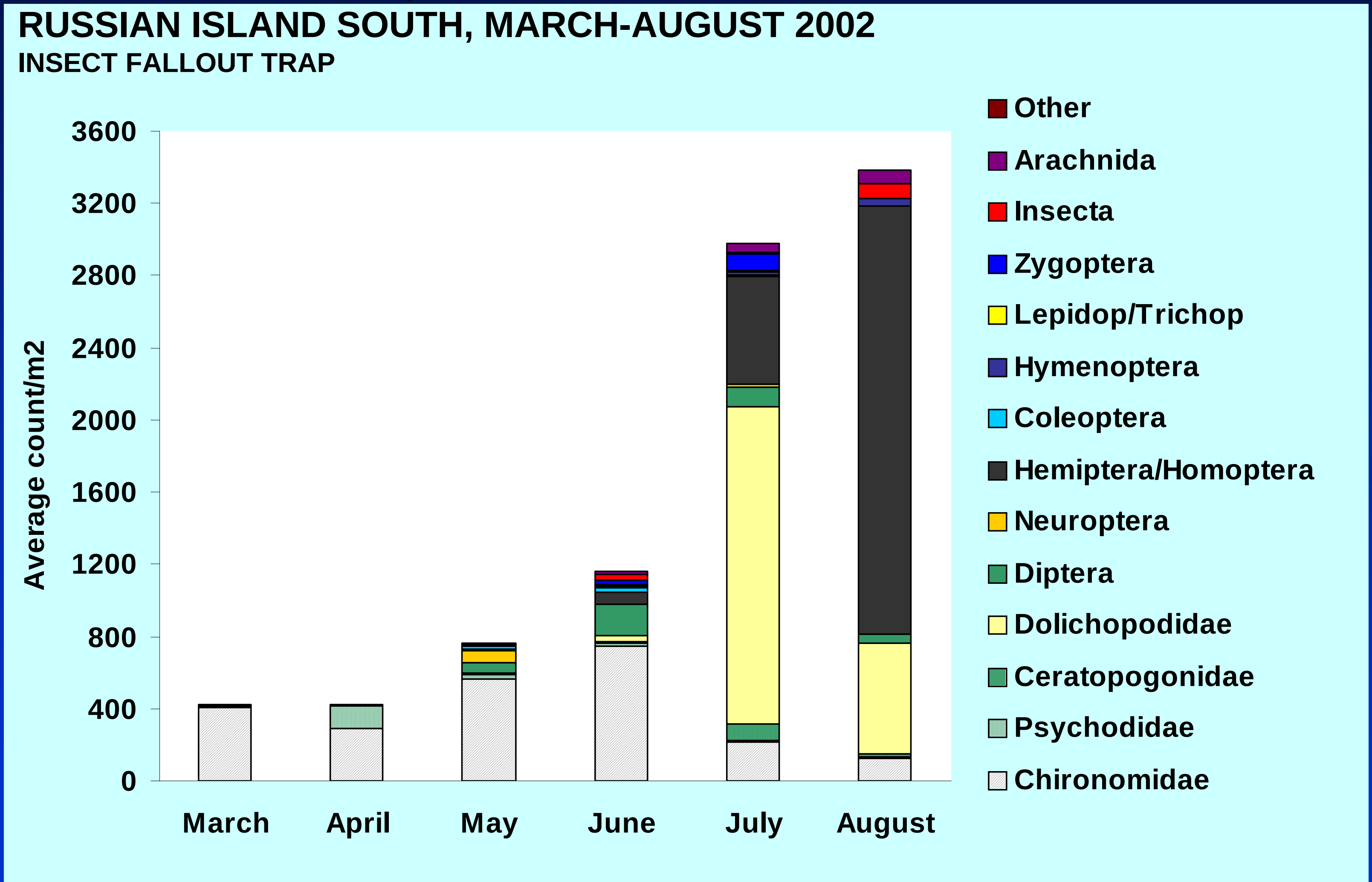


Source: Lott (2004)

Columbia River Estuary

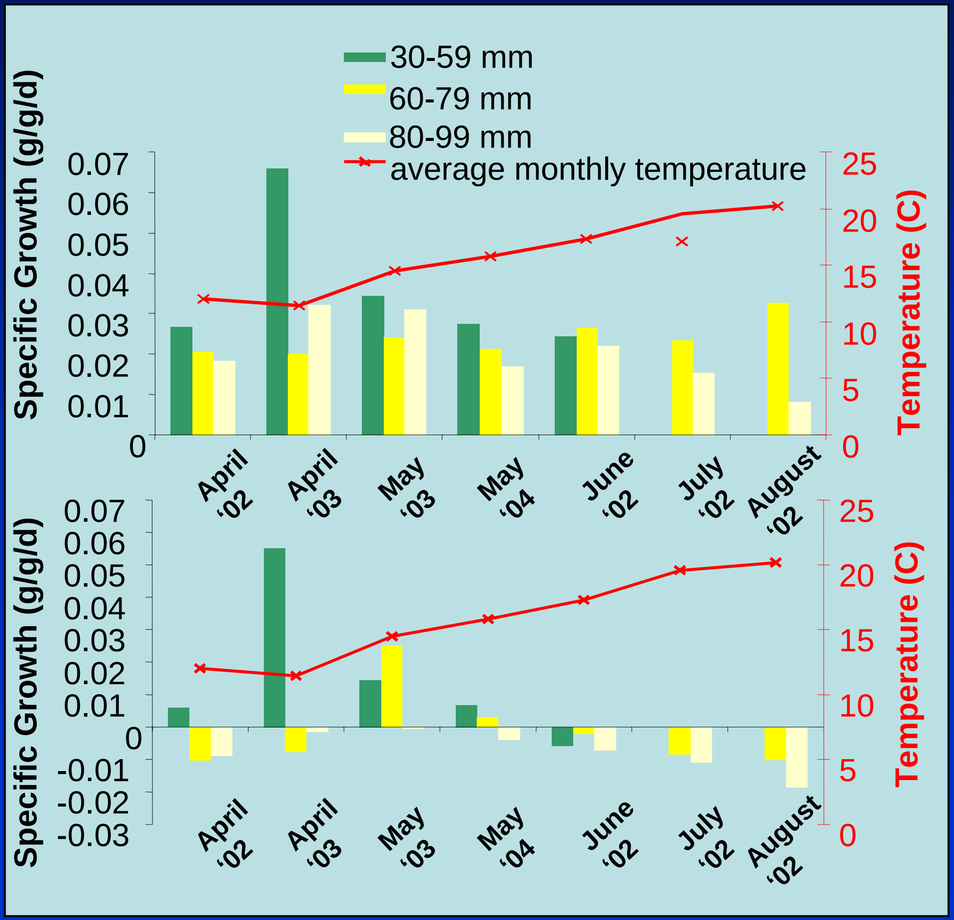
Juvenile Salmon Habitat-Life History Relationships

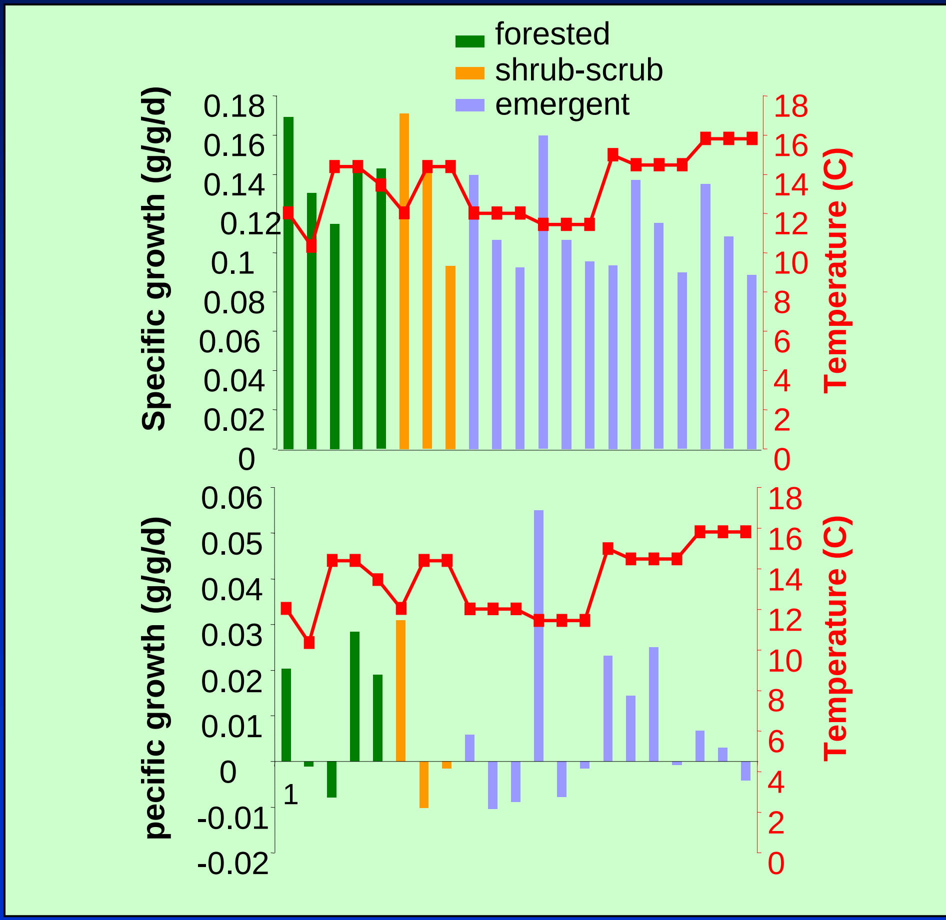
Capacity has changed at comprehensive and habitat-specific (emphasis) scales: Prey availability (M.A. Lott)



Source: Lott (2004)

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



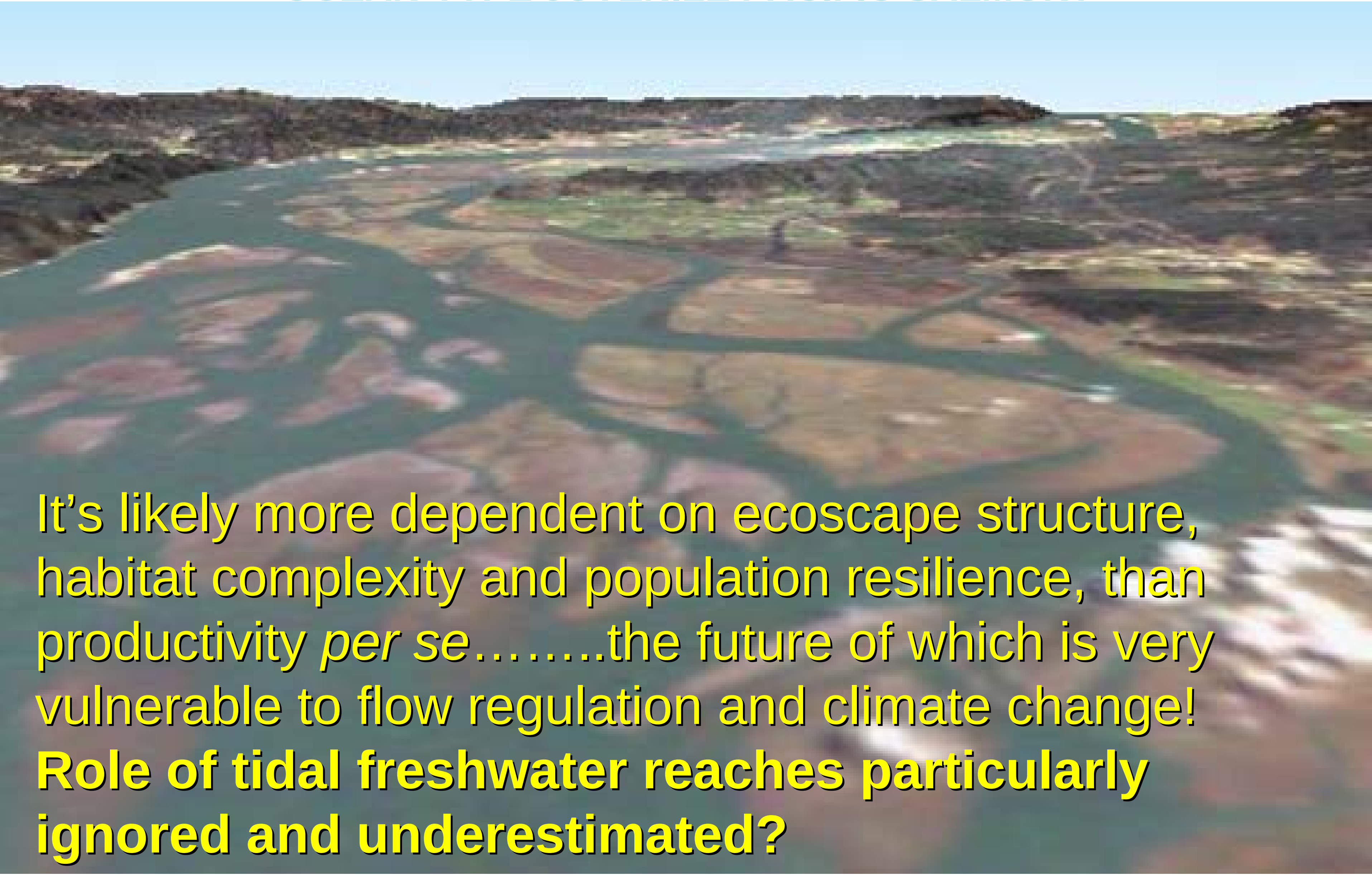


Source: Lott (2004) and A. Bieber, UW/SAFS Wetland Ecosystem Team

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?