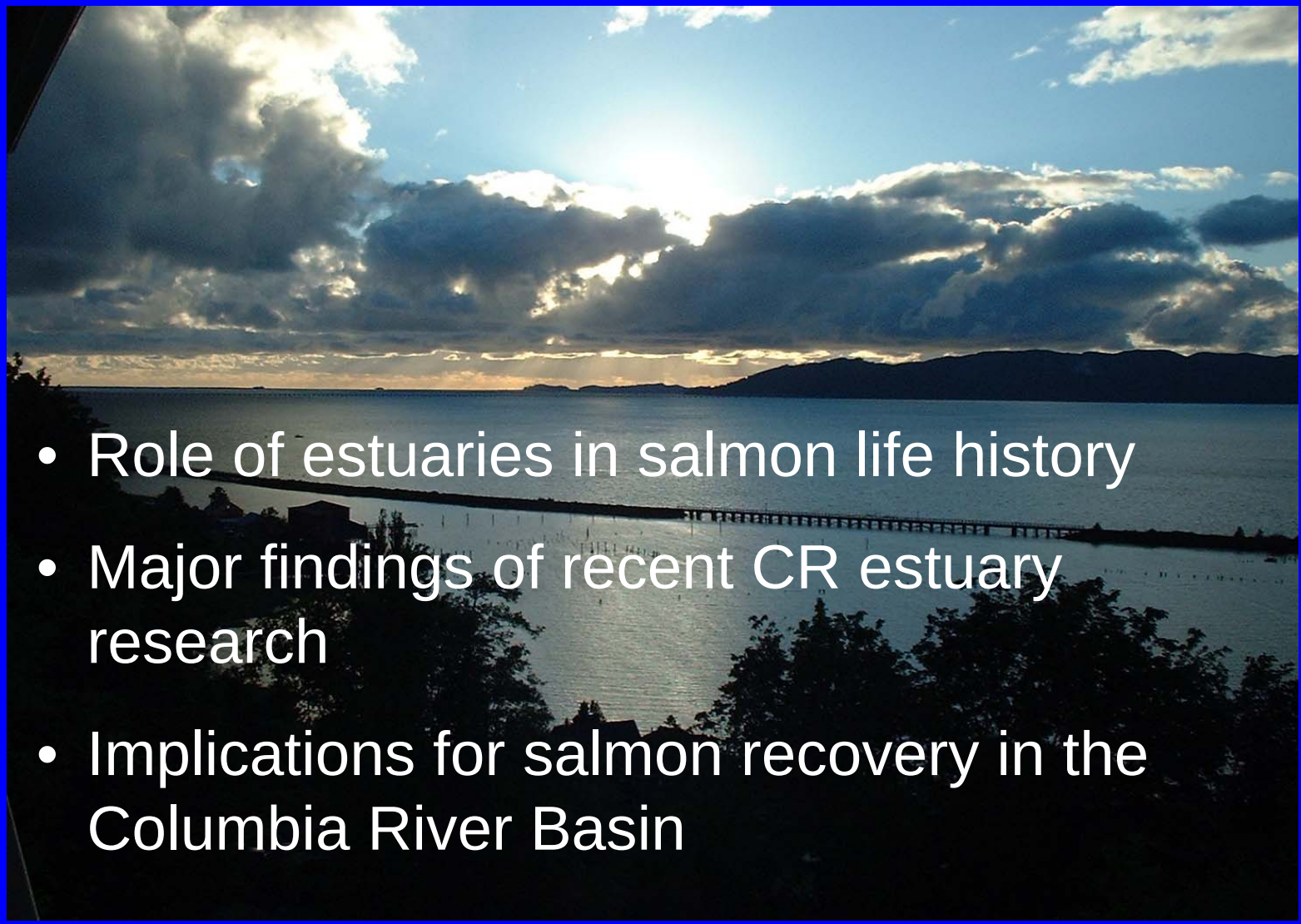
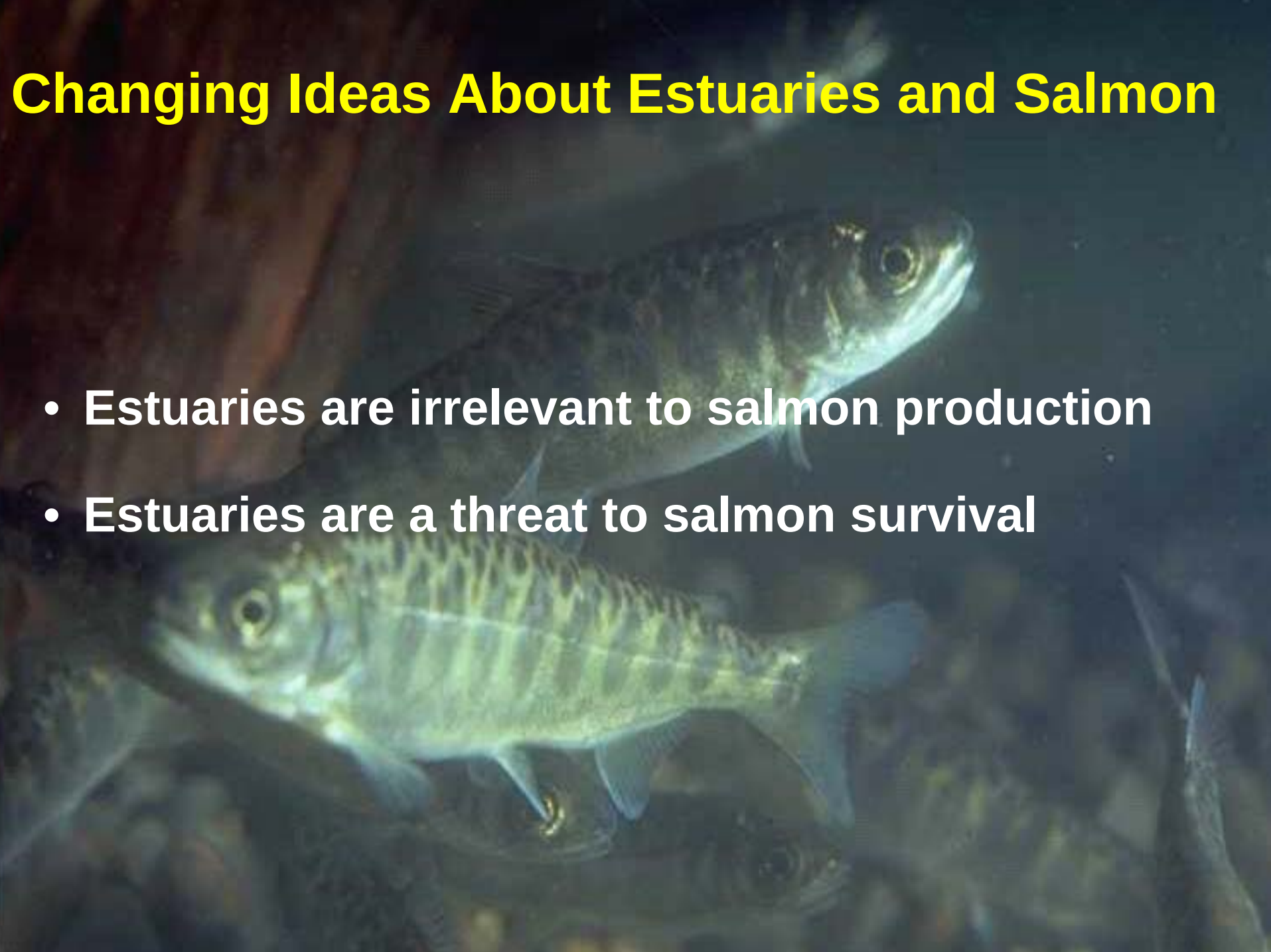
# Salmon Life Histories, Habitats, and Food Webs in the Columbia River Estuary



- Role of estuaries in salmon life history
- Major findings of recent CR estuary research
- Implications for salmon recovery in the Columbia River Basin

# Changing Ideas About Estuaries and Salmon



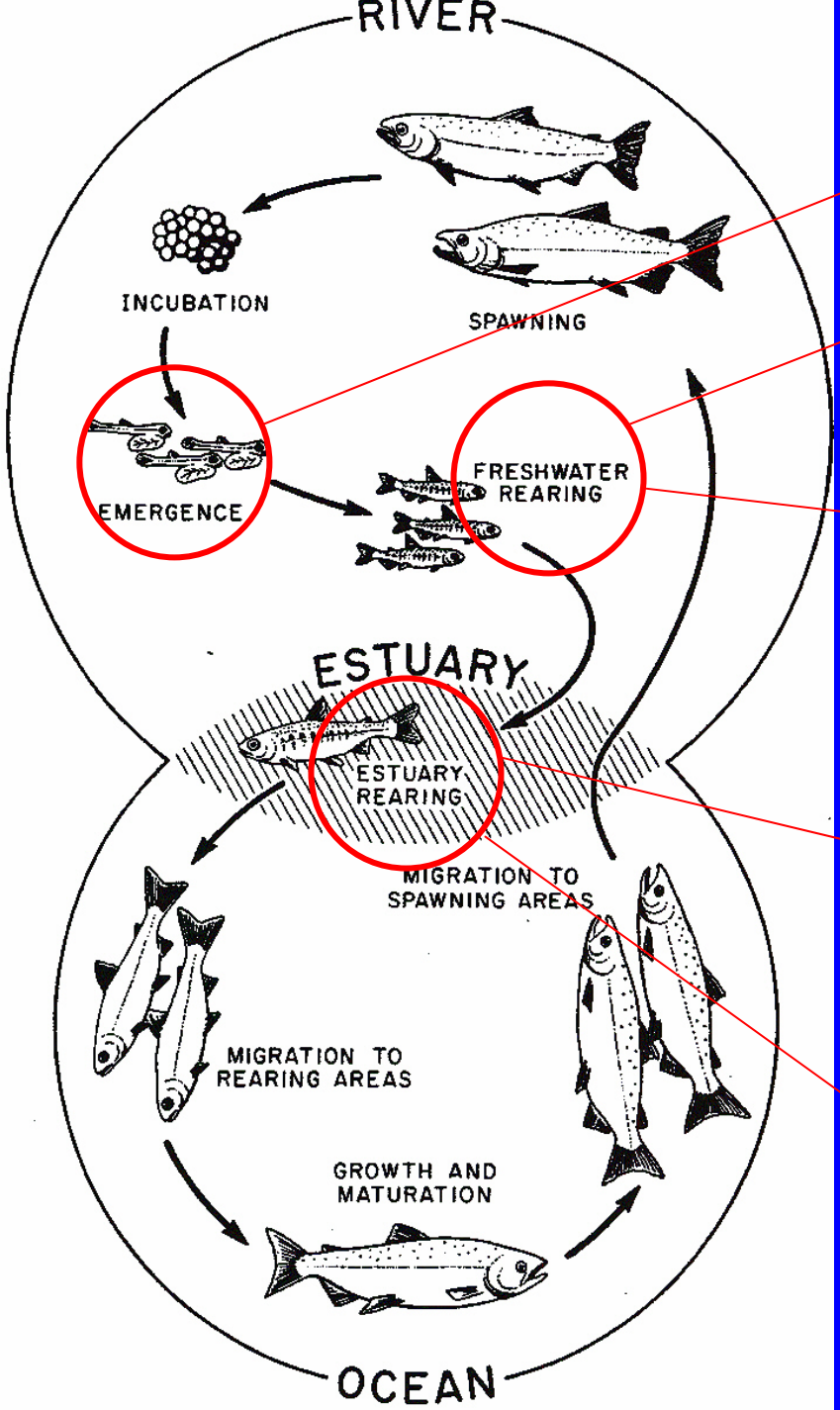
- Estuaries are irrelevant to salmon production
- Estuaries are a threat to salmon survival

# Estuaries are nursery areas for juvenile salmon

- Transition to salt water
- Productive feeding area
- Refuge from predators

# Chinook Life-History Diversity

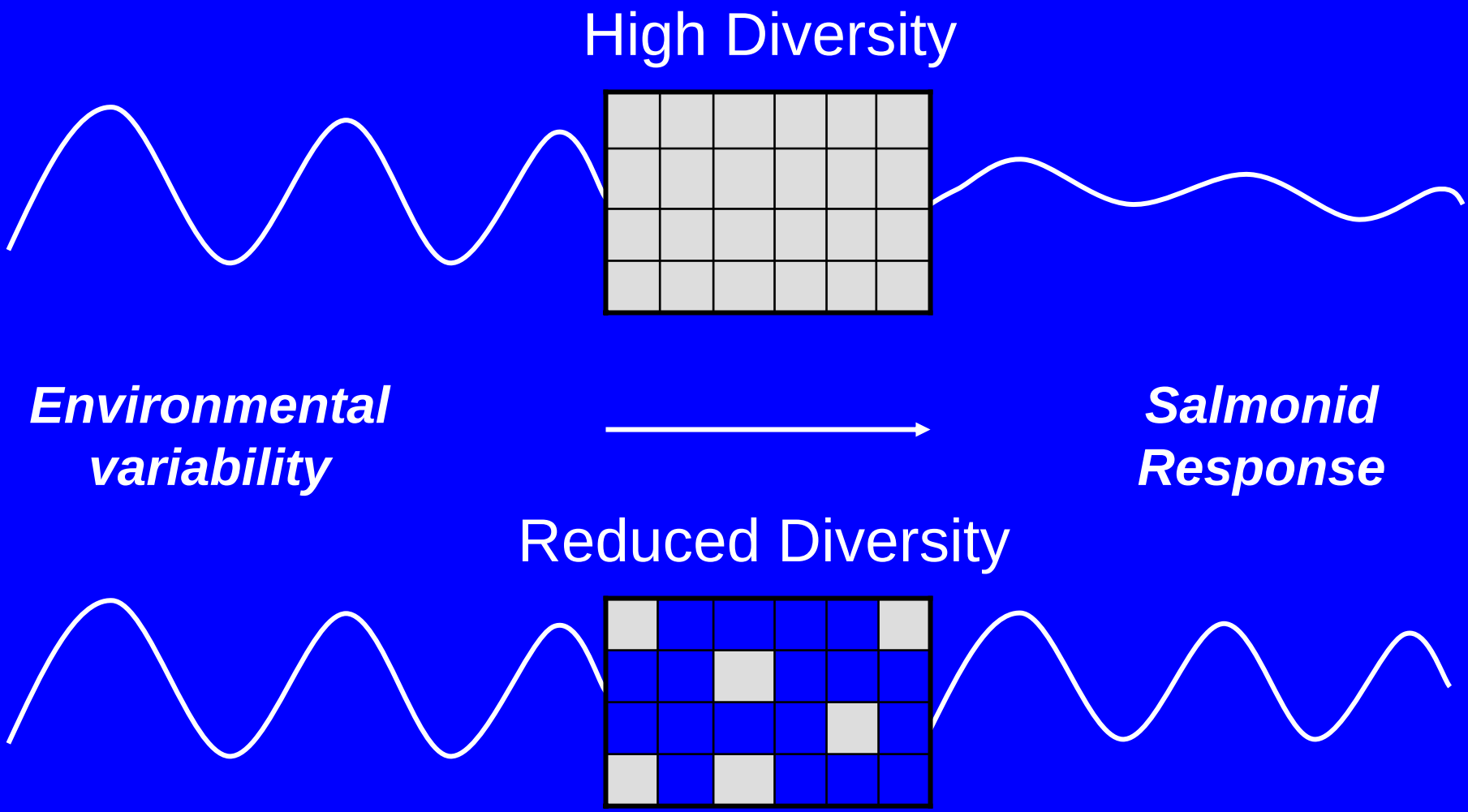
Estuaries are one of many alternative rearing habitats for juvenile salmon




- Fry migrants
- Subyearling migrants
- Yearling migrants
- Subyearling migrants (mid summer)
- Subyearling migrants (late summer/fall)

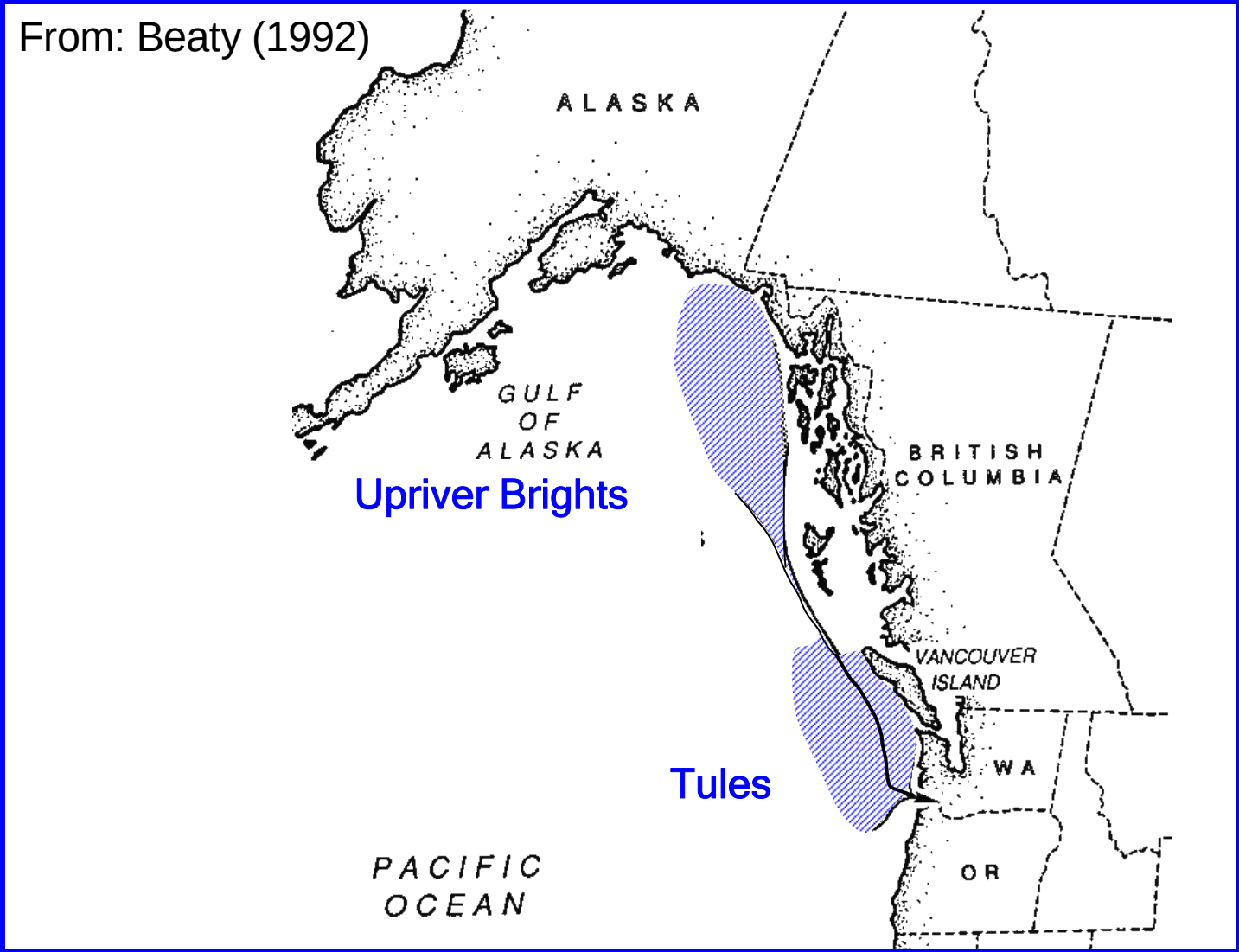
From Reimers 1973

# Diverse life histories promote resilience of salmon populations



# Ocean Distribution of Columbia River Fall Chinook

From: Beaty (1992)



# Estuarine Research Team

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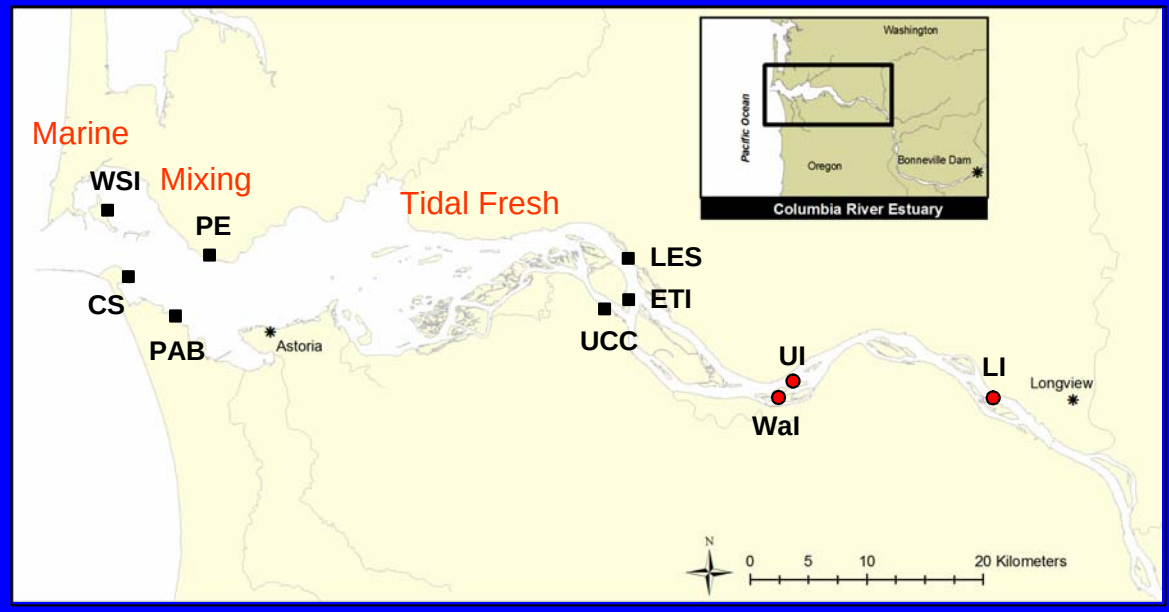
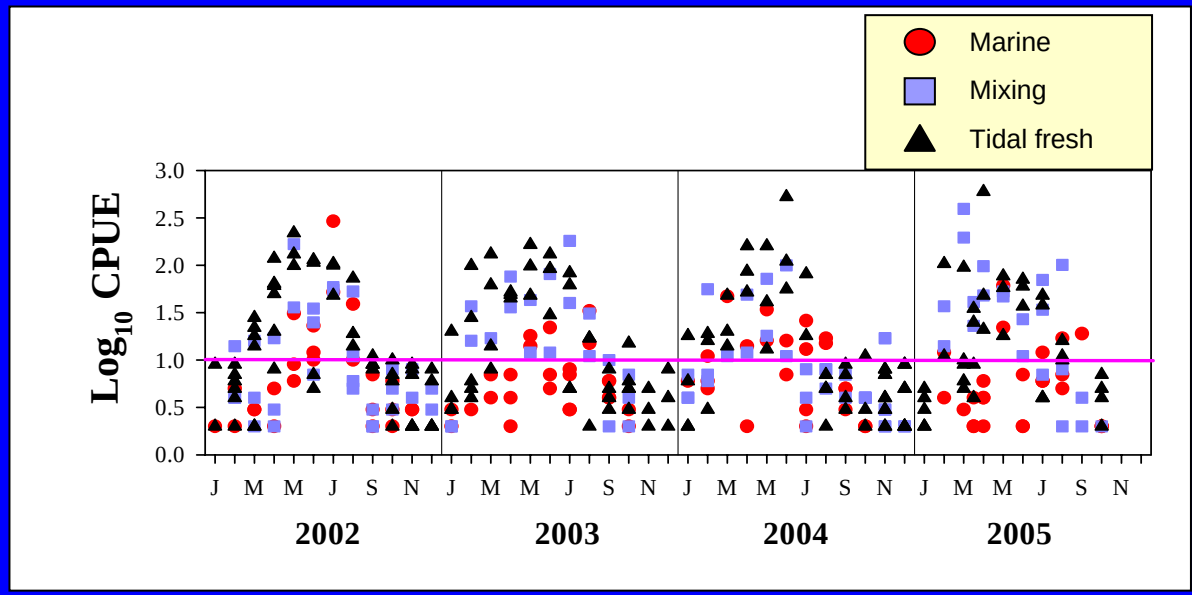
# Four Conclusions

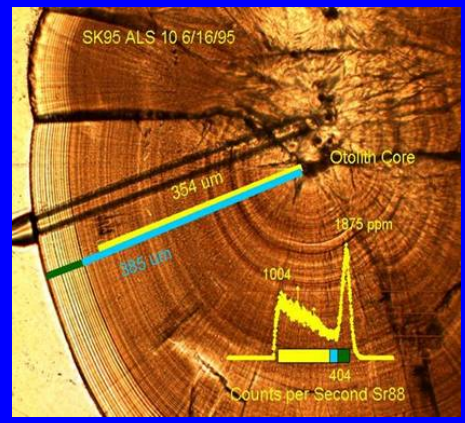
1. Habitat opportunities in the estuary contribute to salmon life history diversity and resilience

# Juvenile Chinook salmon occupy the CR estuary throughout the year



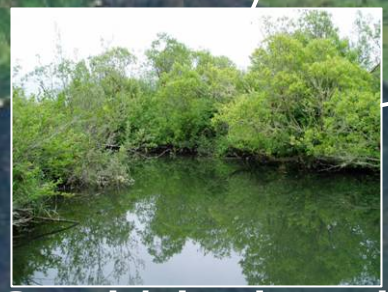
# Many individuals remain in the estuary for weeks to months




2004 Otolith Analysis

- 41% of 94 Chinook sampled near the river mouth had resided in salt water before capture
- Mean estuarine residency 73 days (range: 10 - 219)
- 46% entered the estuary < 60 mm, 11% < 40 mm.
- Estuarine residency was probably much longer since the method cannot detect use of tidal fresh habitats

# Salmon with subyearling life histories use all wetland types along the tidal gradient

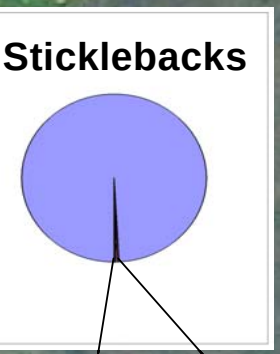


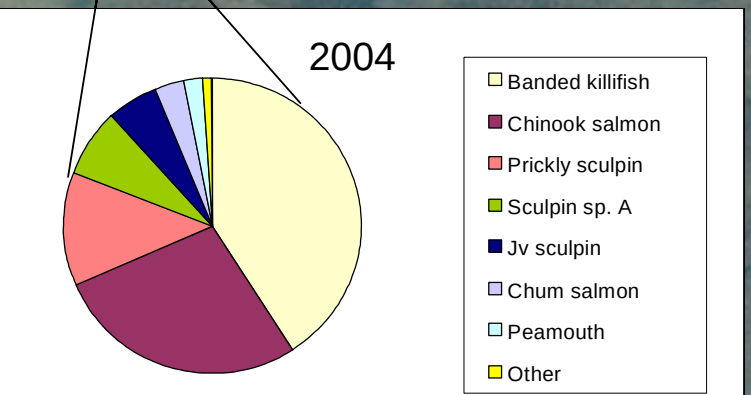
Scrub/shrub wetlands

Forested swamps

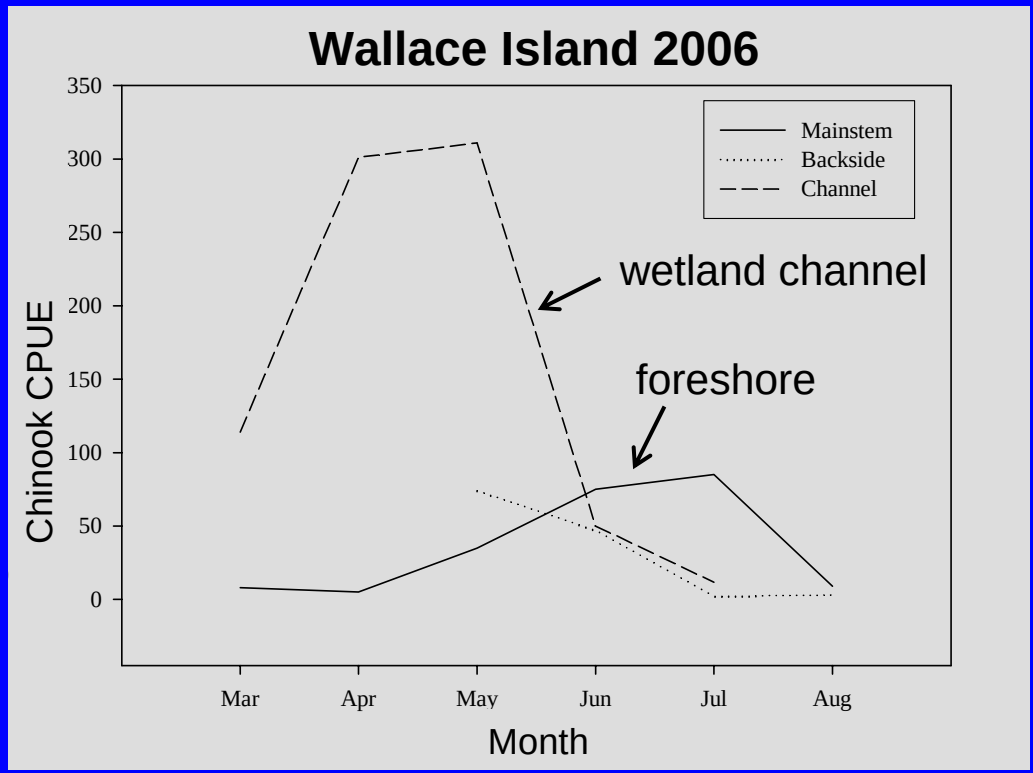
Emergent wetlands

Fish species composition of lower CR estuarine wetlands



# Juvenile salmon are abundant at emergent/scrub-shrub marshes throughout the tidal-freshwater zone

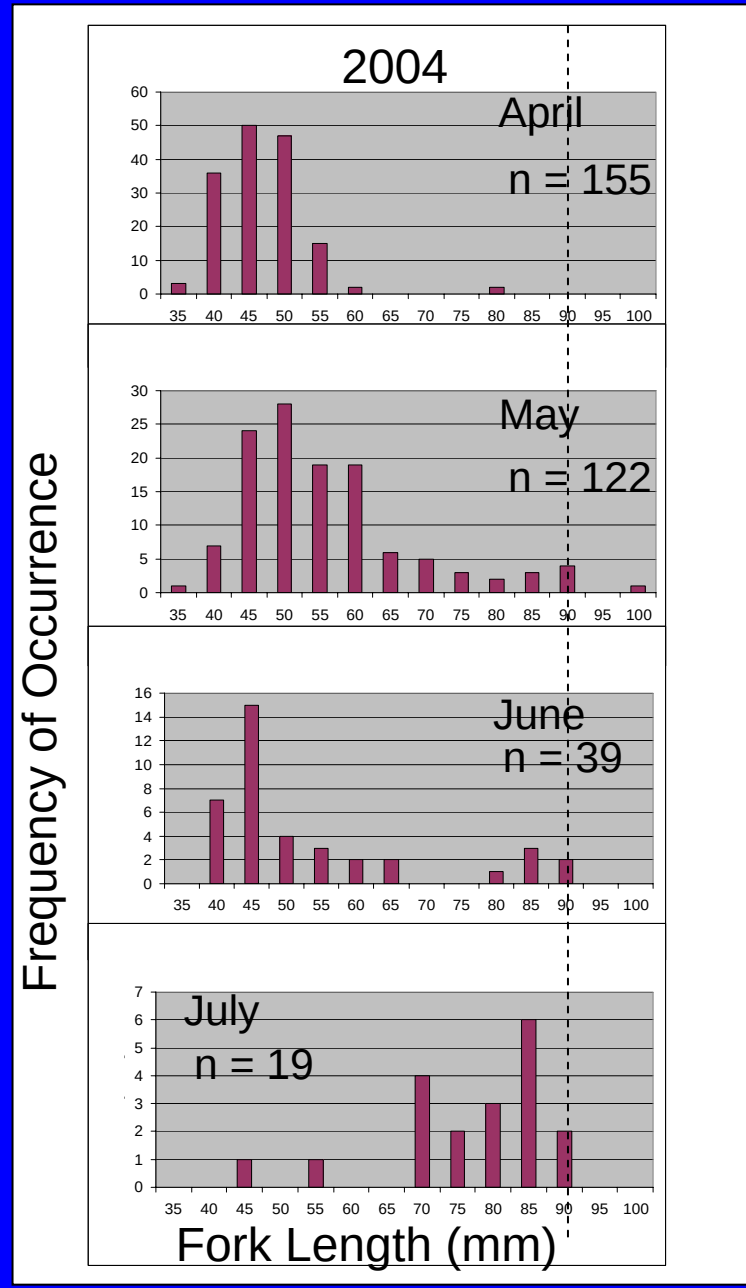




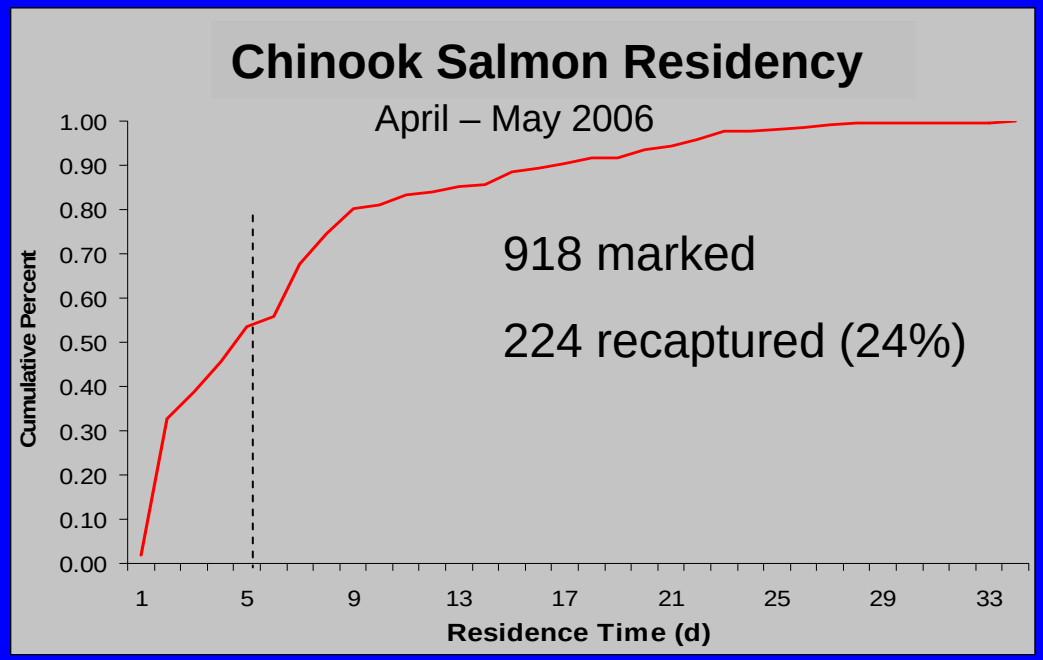
# Habitat use by salmon is size-related


- Small size classes frequent shallow, nearshore and wetland habitats
- Few juveniles > 90 mm enter or remain in interior marsh channels

## Chinook Length Frequency in Wetland Channels



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

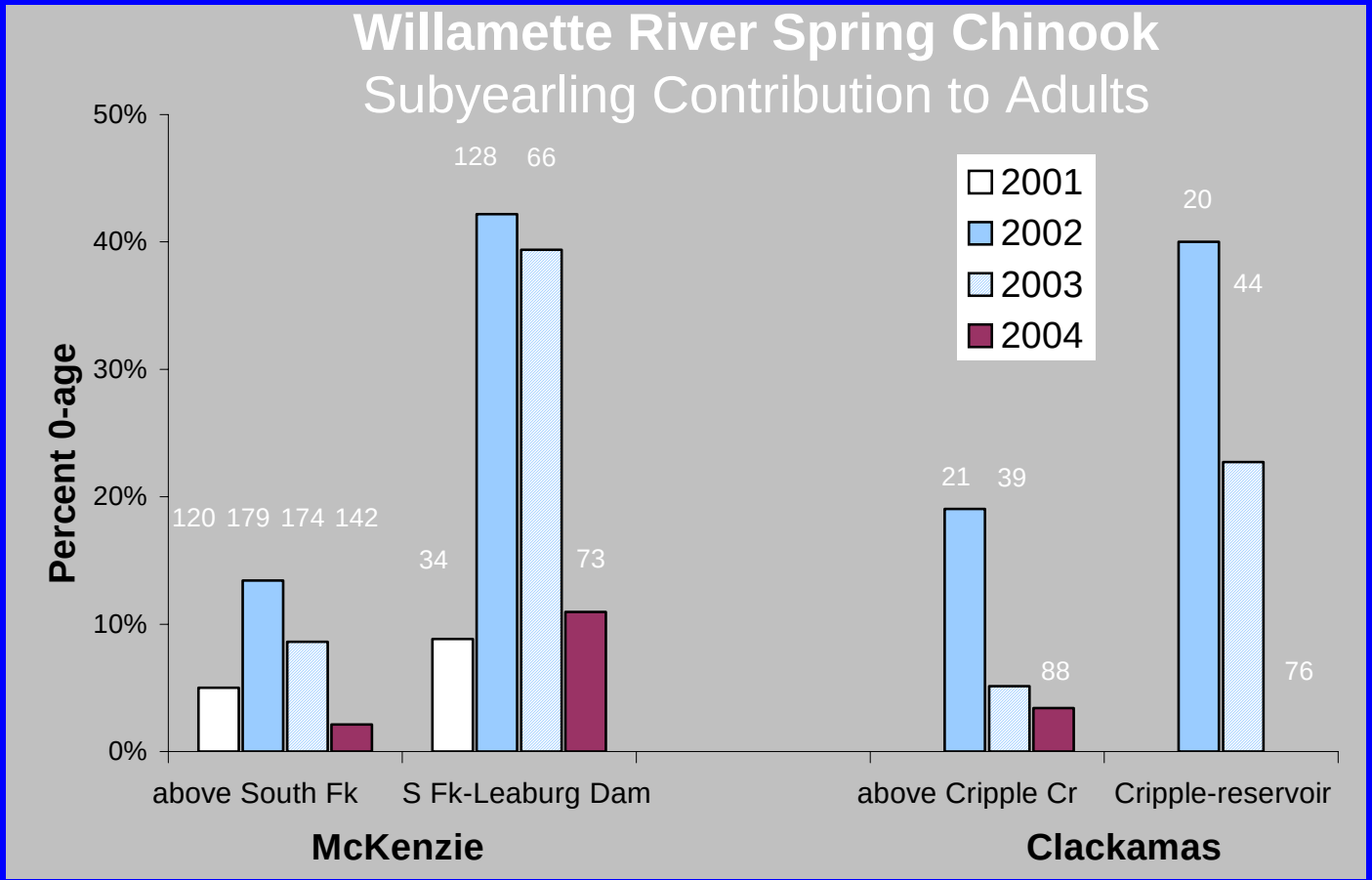



- Median residency ~5 days, 14% > 2 weeks,
- Maximum 34 days

# Diverse juvenile life histories contribute to adult returns

- Each ESU is composed of diverse juvenile life histories
- The relative contribution of each life history type to the returning adult population varies with location and year

Both subyearling and yearling life histories contribute to returns of Willamette R. Spring Chinook



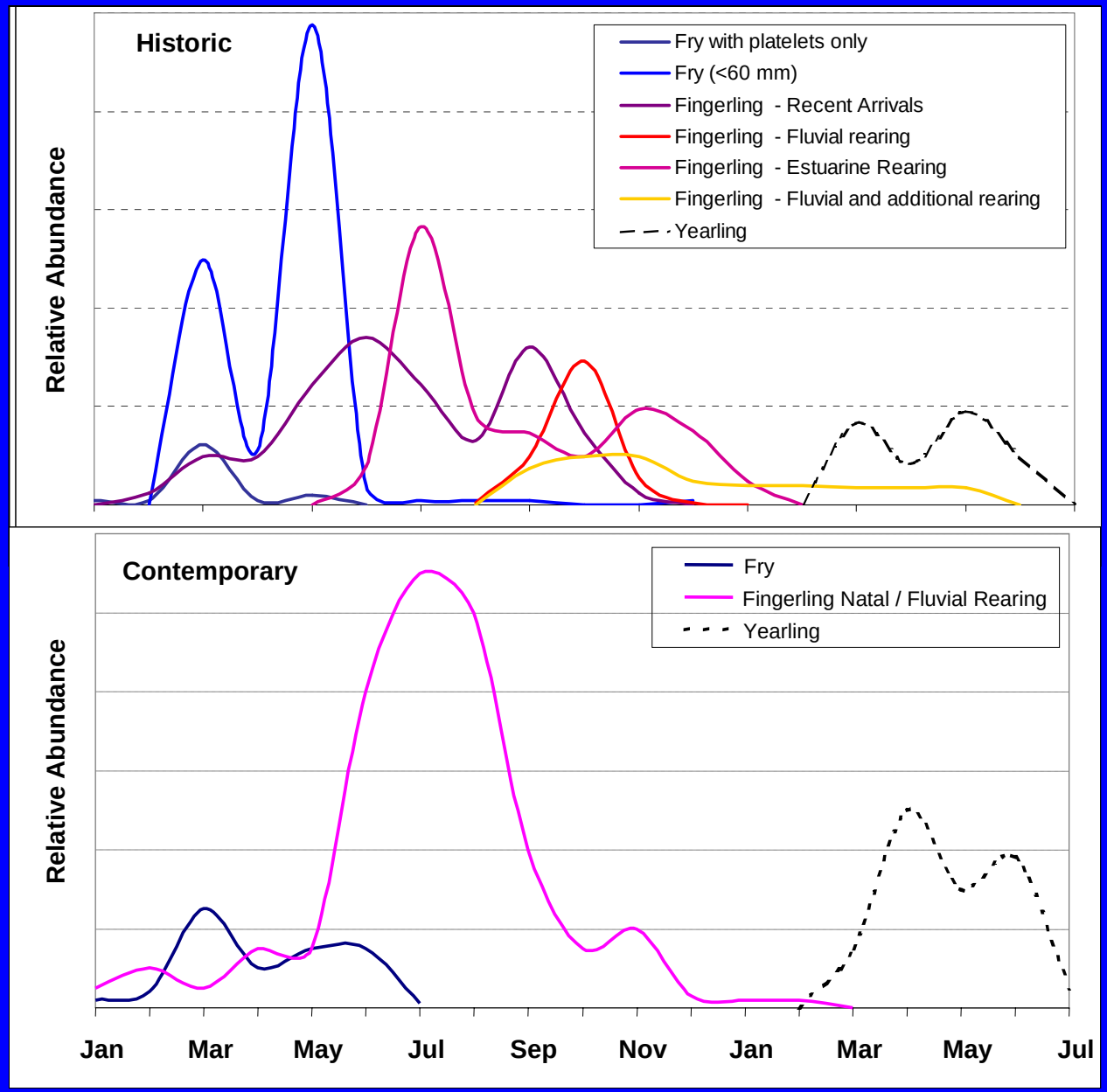

From Kirk Schroeder, ODFW

# Four Conclusions

1. Estuarine habitat opportunities contribute to salmon life history diversity and resilience
2. Changes upriver and in the estuary have reduced salmon life history diversity

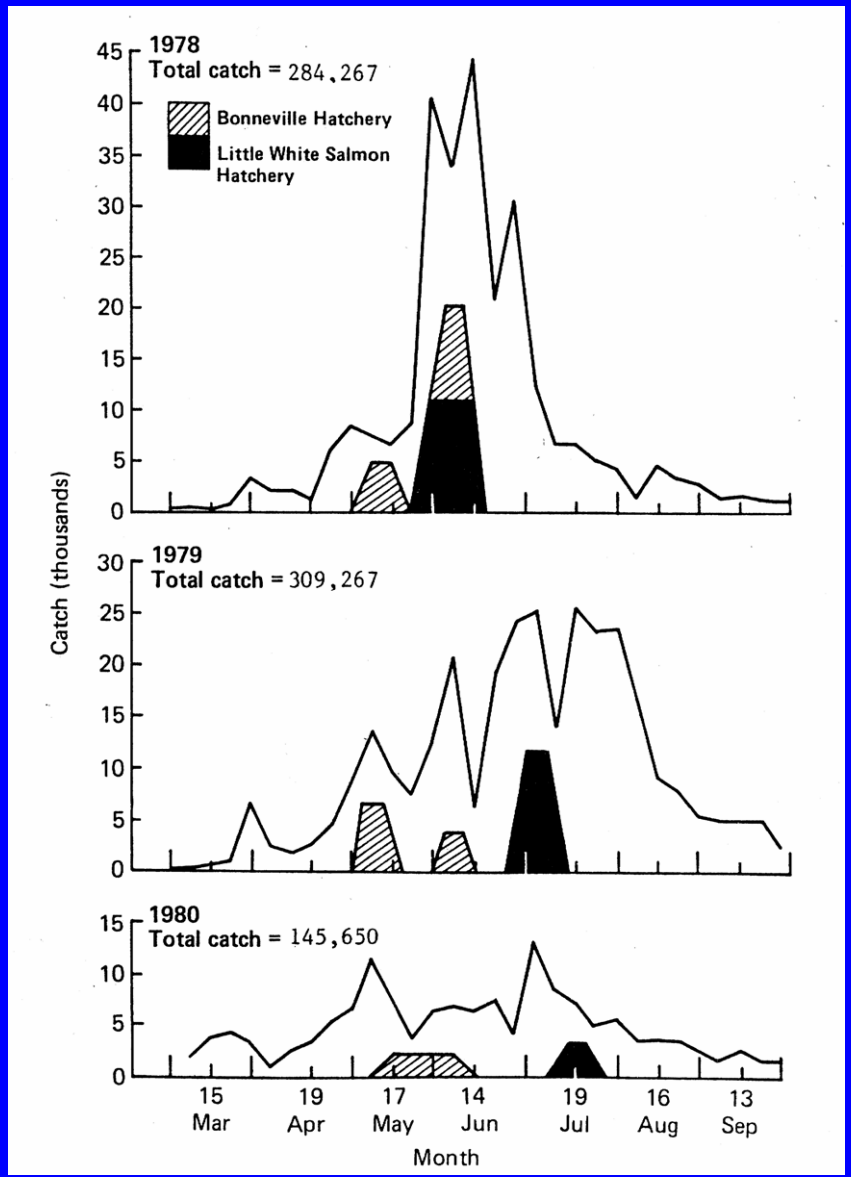
# Chinook salmon life histories have been simplified

Estimated proportions of juvenile salmon life histories from historic and contemporary surveys




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

# Patterns of estuary use by salmon are now hatchery-driven




Juvenile chinook timing, stock composition, and duration in the Columbia River estuary are now largely influenced by hatchery releases

Reproduced from Dawley et al. (1986)

# Habitat Change in the lower Columbia River Estuary

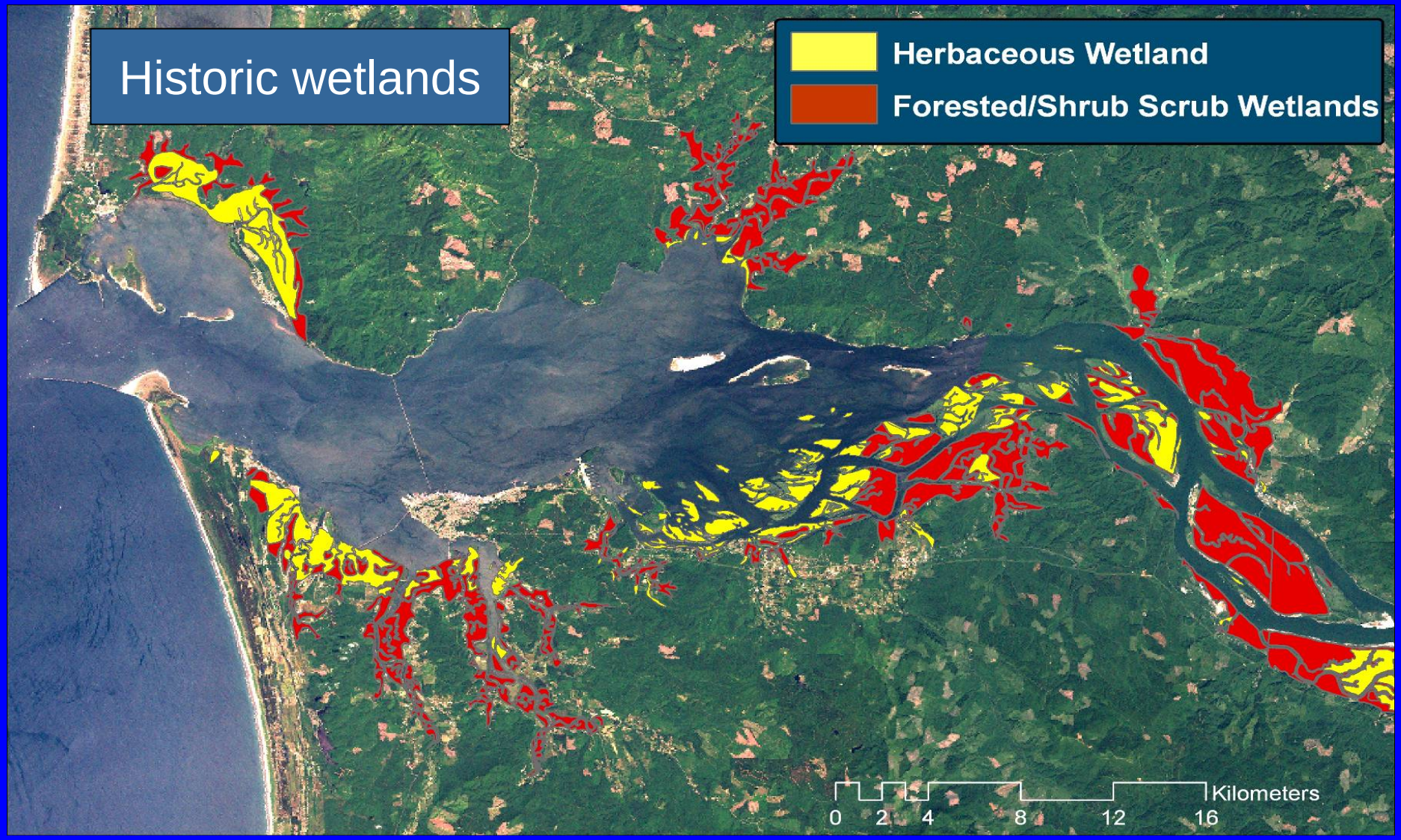



Image by: Jennifer Burke, UW; Historical data from Thomas (1983)

# Habitat Change in the lower Columbia River Estuary

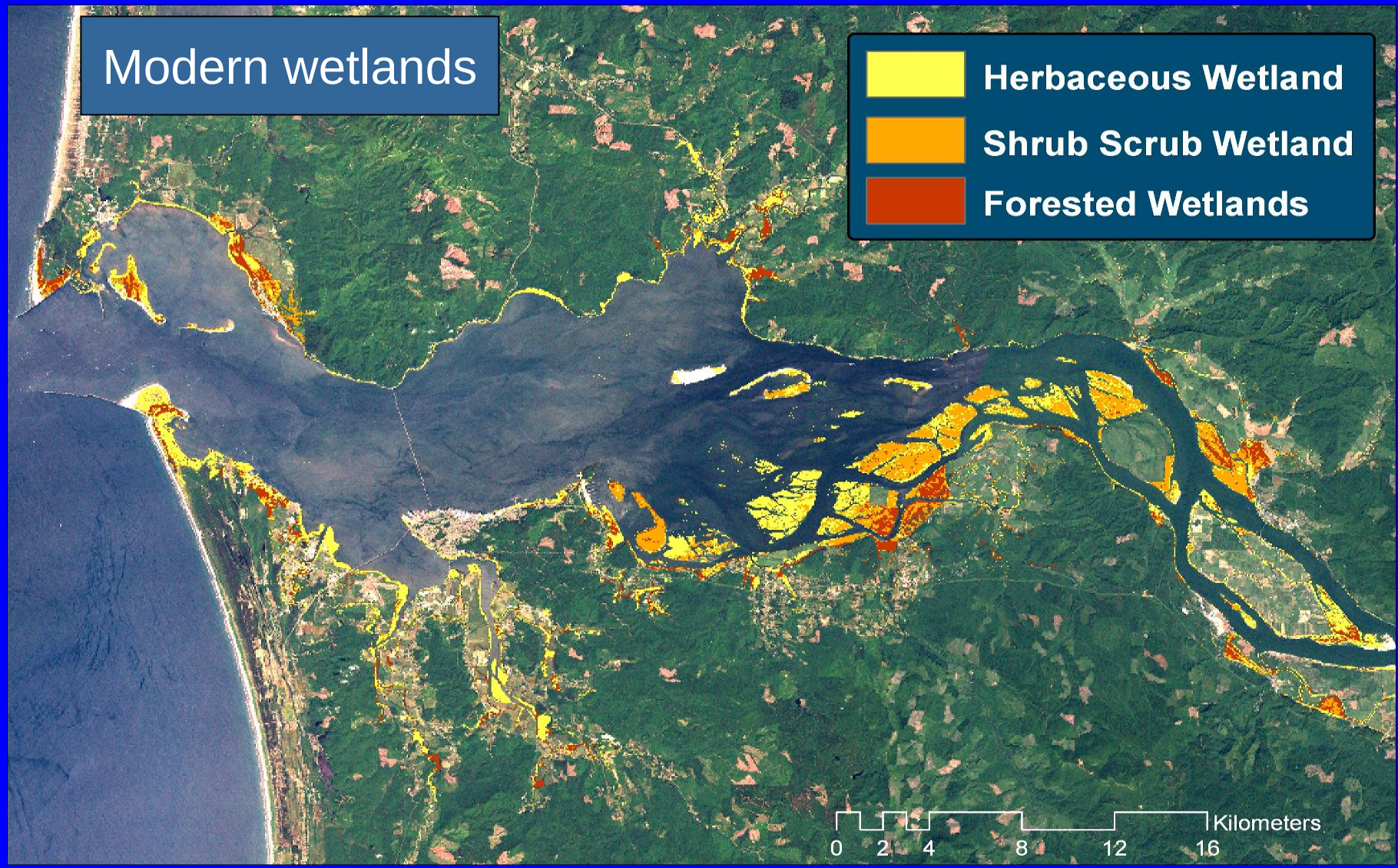
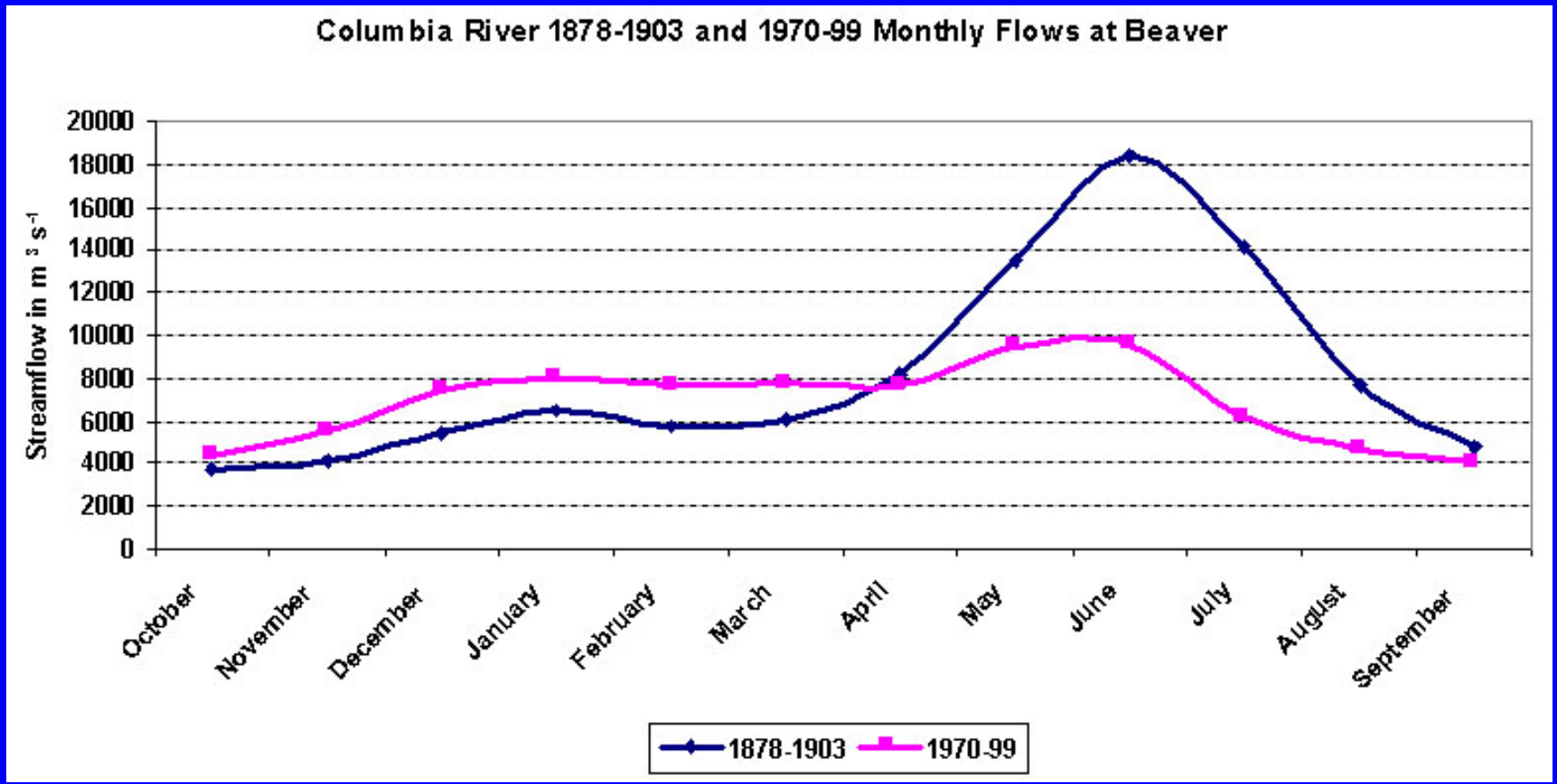



Image by: Jennifer Burke, UW

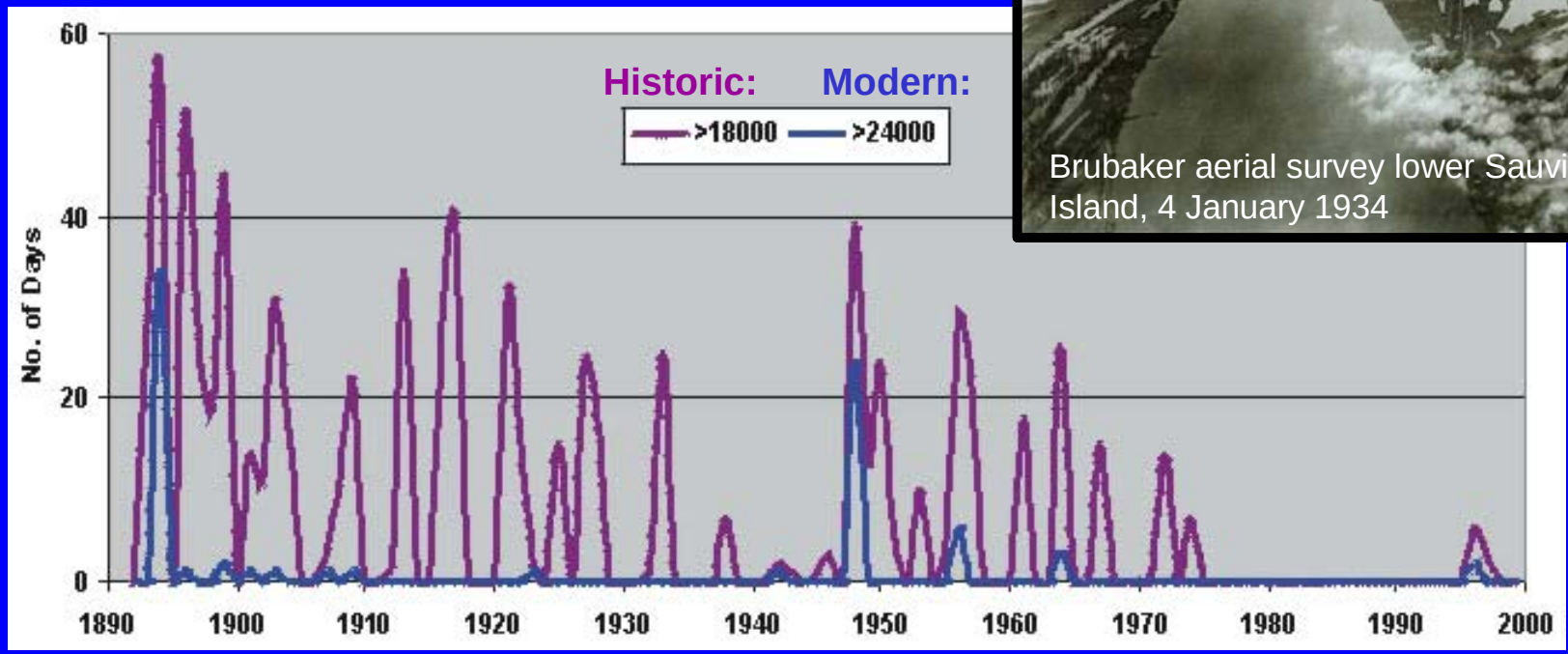
# Changes in Flow




- Annual flow cycle of Columbia River at Beaver, 1878-1903 (some data missing) vs. 1970-99.

# The tidal river has been disconnected from its floodplain

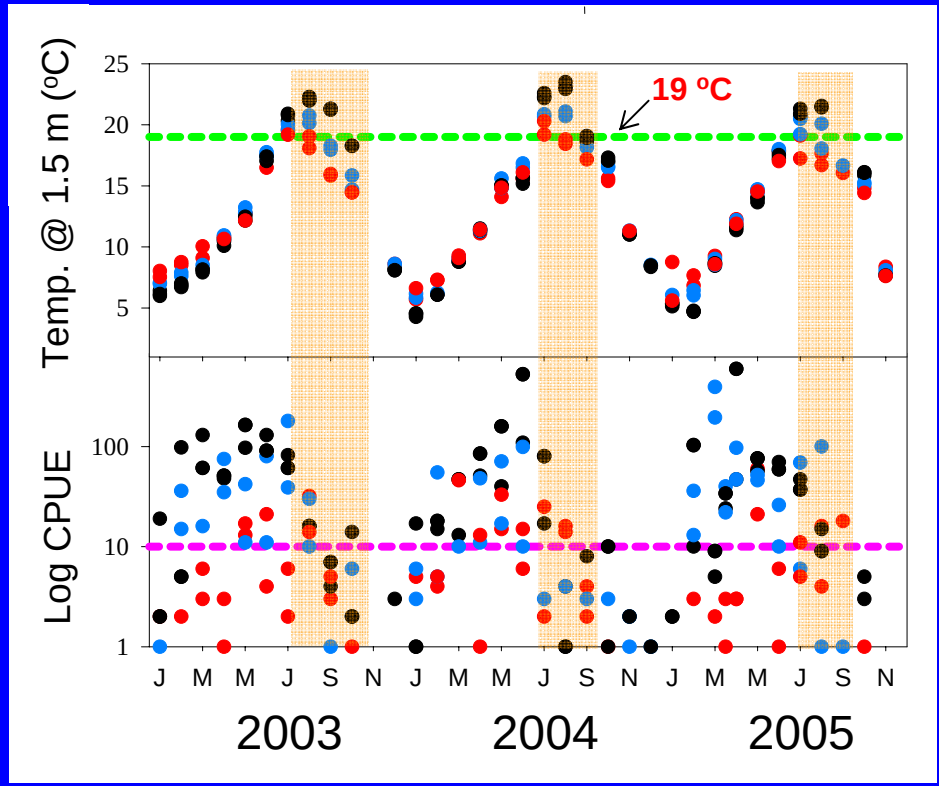

Brubaker aerial survey lower Sauvies Island, 4 January 1934




- Overbank flows now rare and floodplain inaccessible to fish
- Reduced delivery of nutrients, organic matter, salmon prey, and structure (large wood)
- Impact on food webs

# Water temperatures in the estuary may limit salmon rearing opportunities during summer and fall

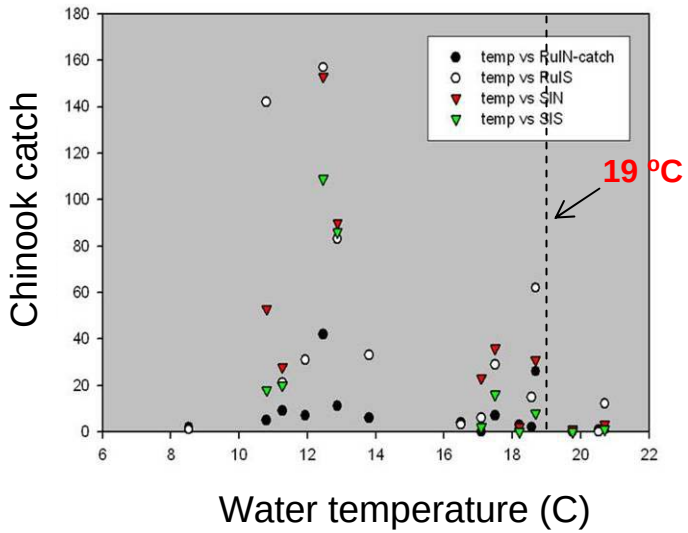
Estuary-wide Beach Seine



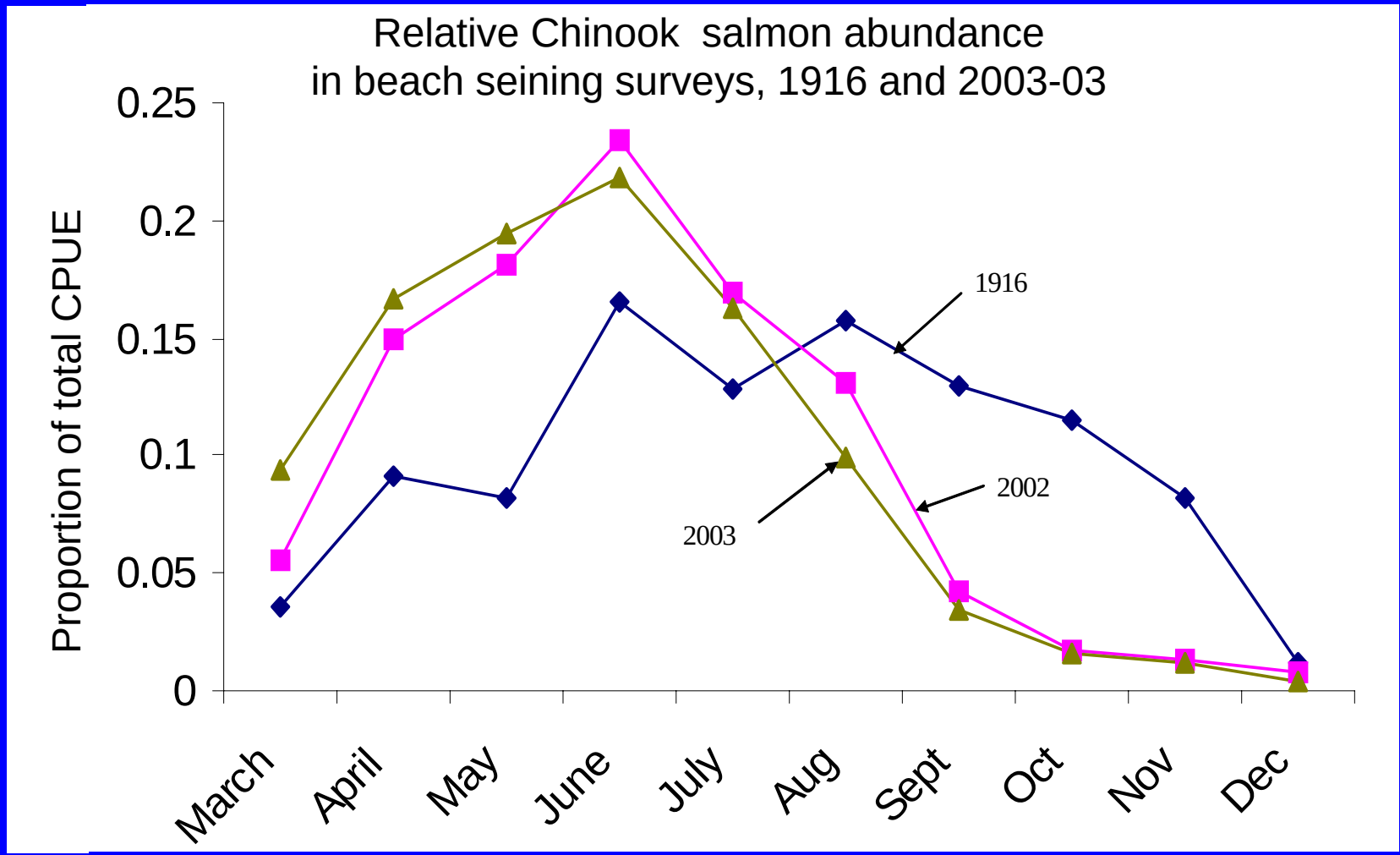

Wetland Surveys

**Abundance and Water Temperature**

Russian & Seal Island Marshes



# Recent survey results support the hypothesis that life history diversity has declined

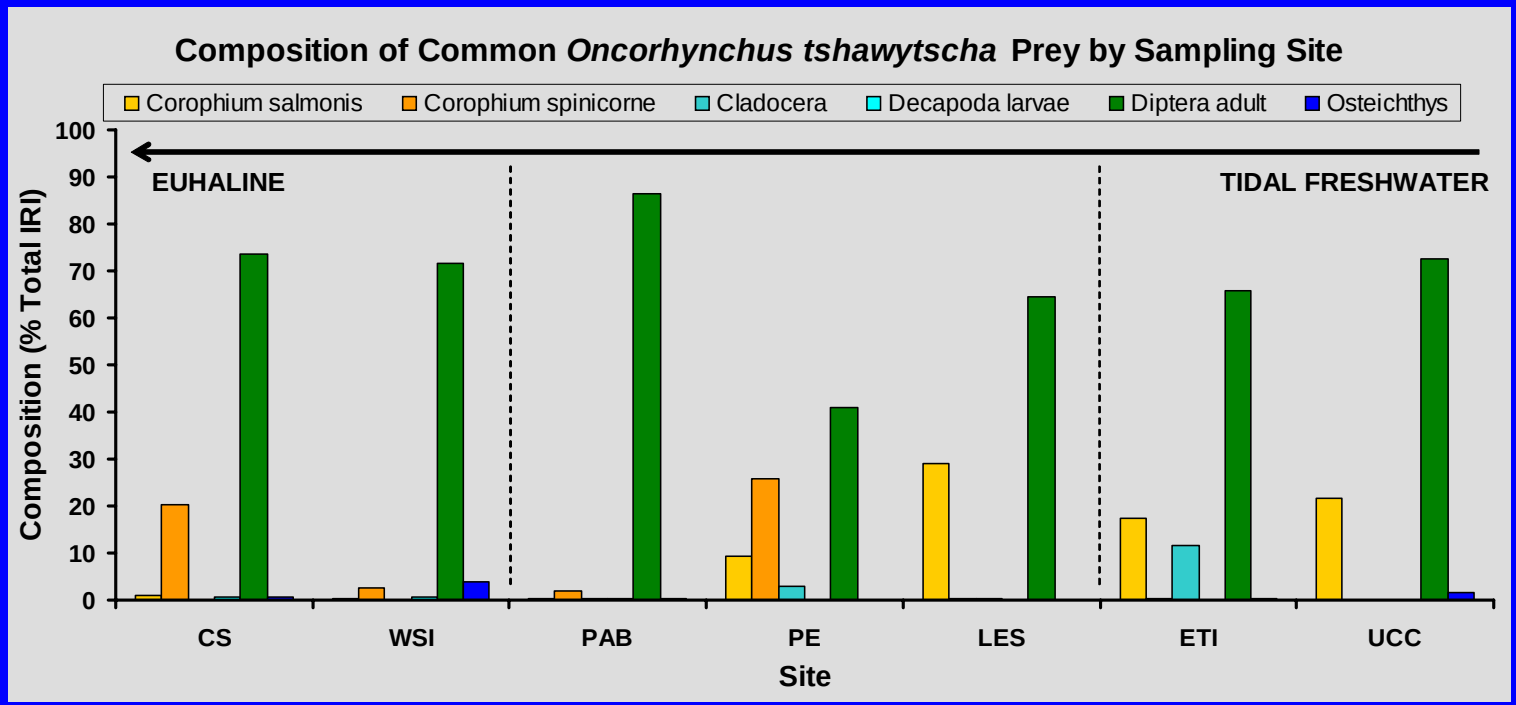


# Four Conclusions

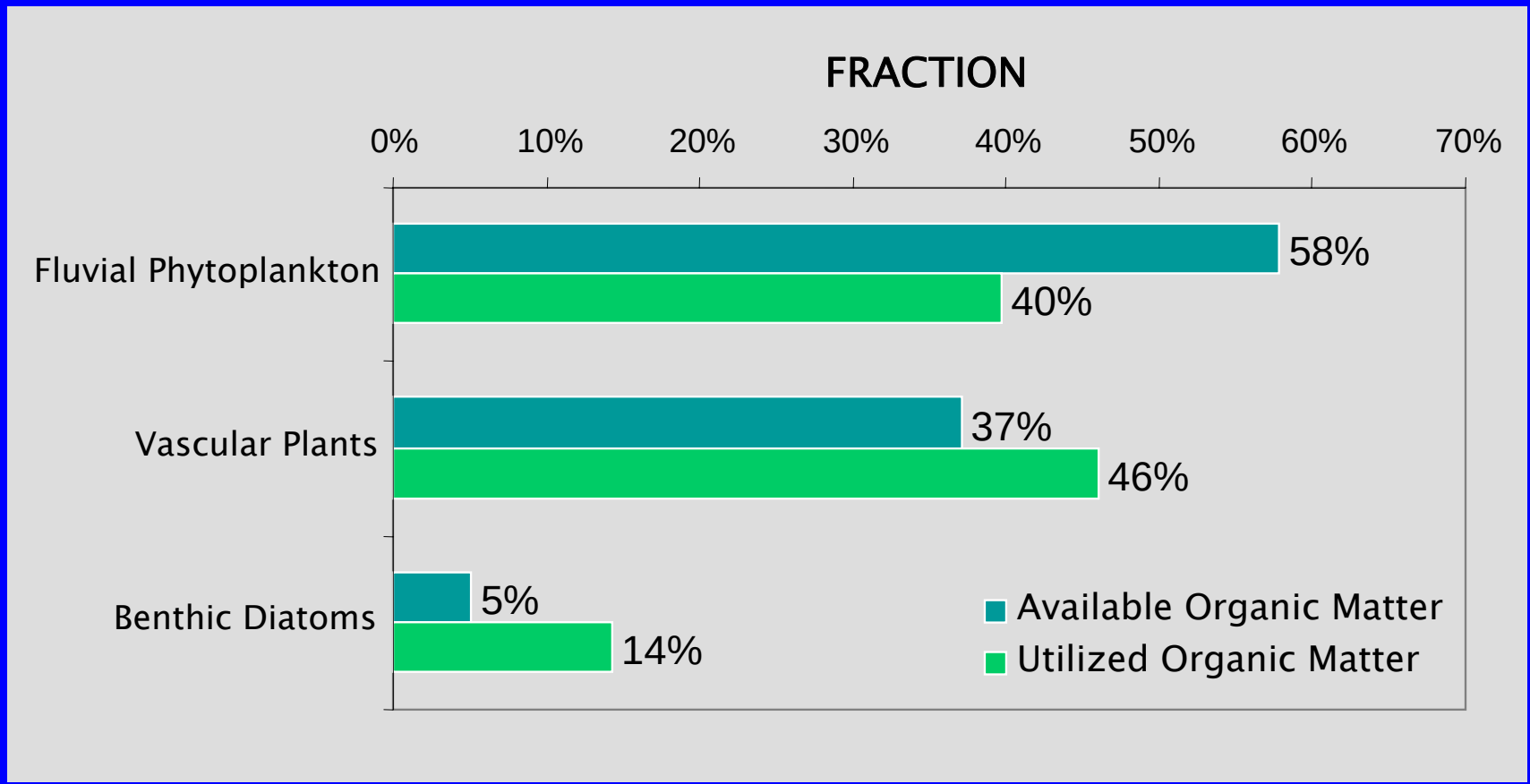
1. Estuarine habitat opportunities contribute to salmon life history diversity and resilience
2. Changes upriver and in the estuary have reduced salmon life history diversity
3. Energy flow to salmon in the estuary is through wetland and other shallow habitats

# Tidal wetlands provide food and support growth of juvenile salmon

- Salmon feed in wetland habitats on insects and amphipods produced in these habitats
- Insects from wetlands and other shallow habitats are also a major food source of fish throughout the Col R. estuary
- Mean growth in emergent wetlands ~0.6 mm/day



# Salmon use wetland-derived food sources in greater proportion than their apparent abundance in the estuarine system



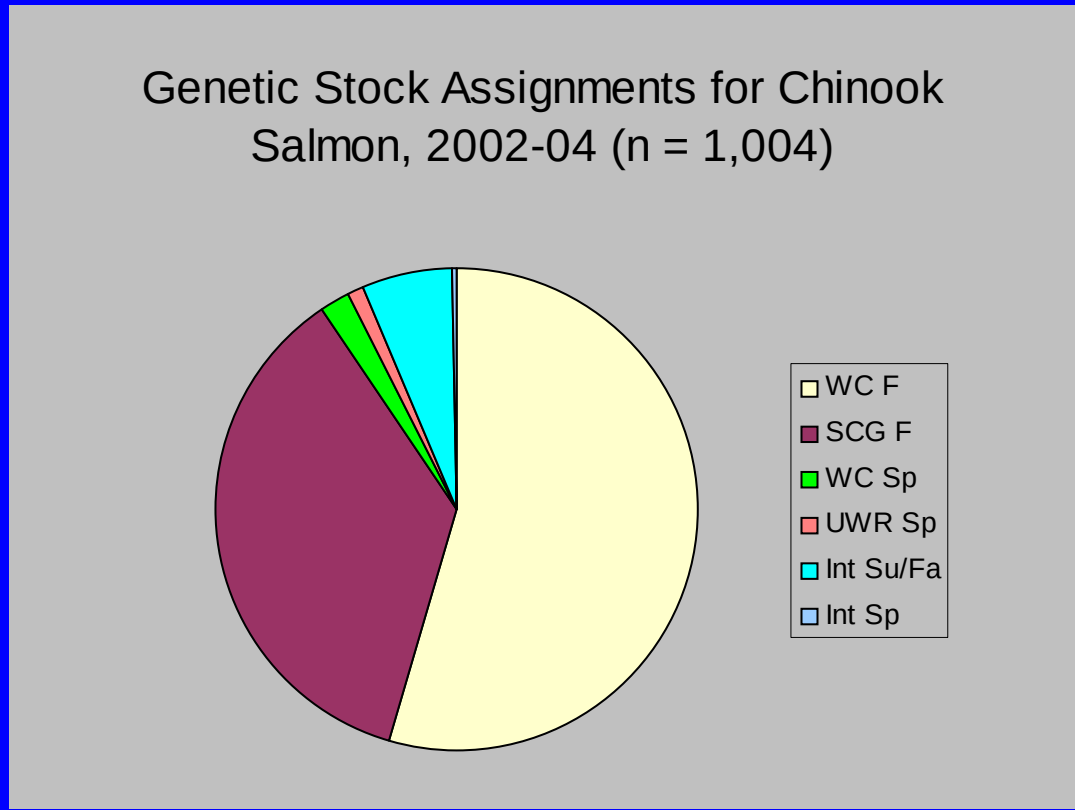

Available sources from Simenstad et al. (1990) and Sherwood et al. (1990). Utilized sources from Anderson (2006).

# Four Conclusions

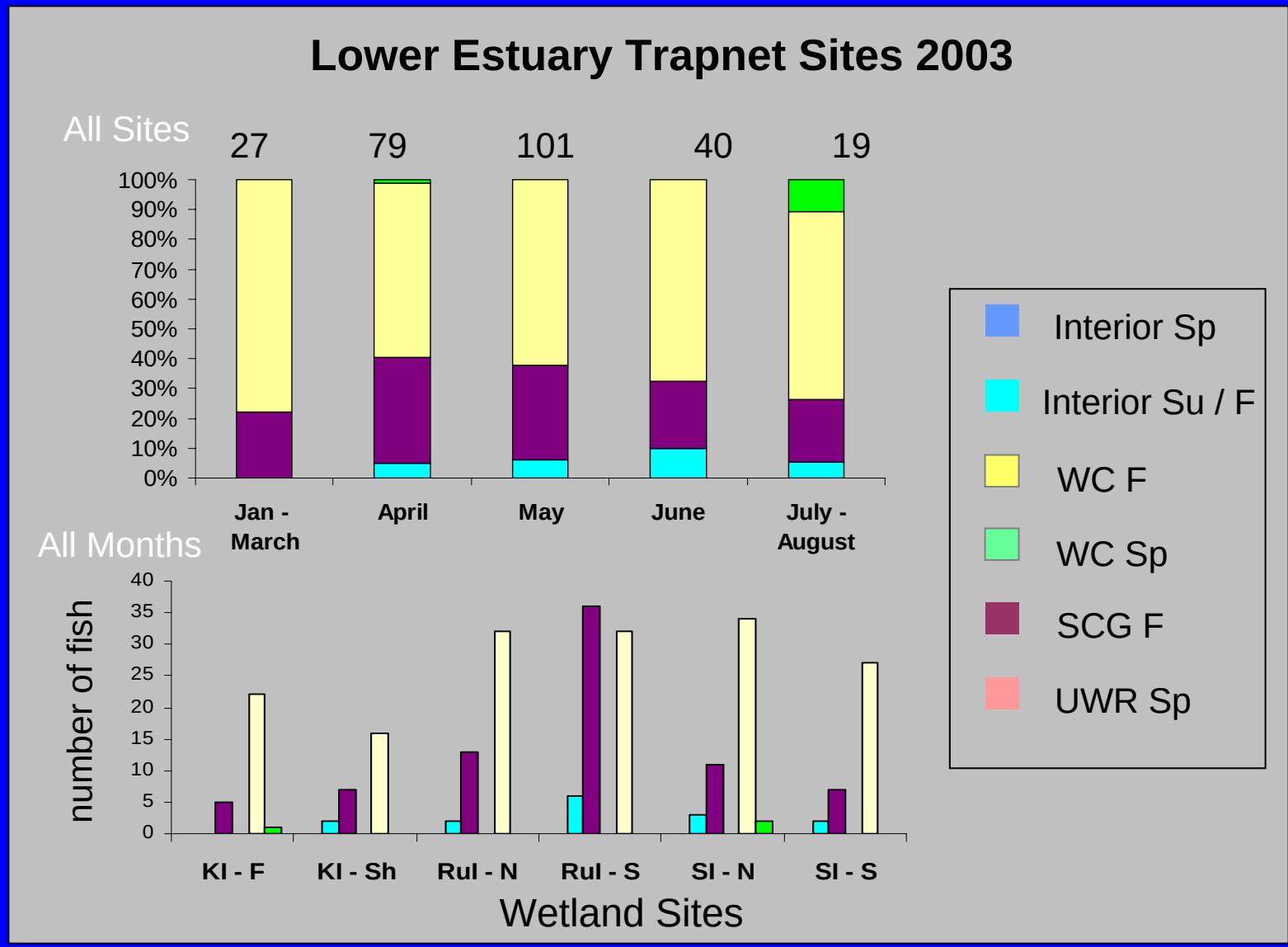
1. Estuarine habitat opportunities contribute to salmon life history diversity and resilience
2. Changes upriver and in the estuary have reduced salmon life history diversity
3. Energy flow to salmon in the estuary is through wetland and other shallow habitats
4. All Columbia River ESUs use estuarine habitats, and a diversity of genetic groups occupy all tidal wetland types

# Salmon samples collected throughout the estuary include individuals from a diversity of ESUs

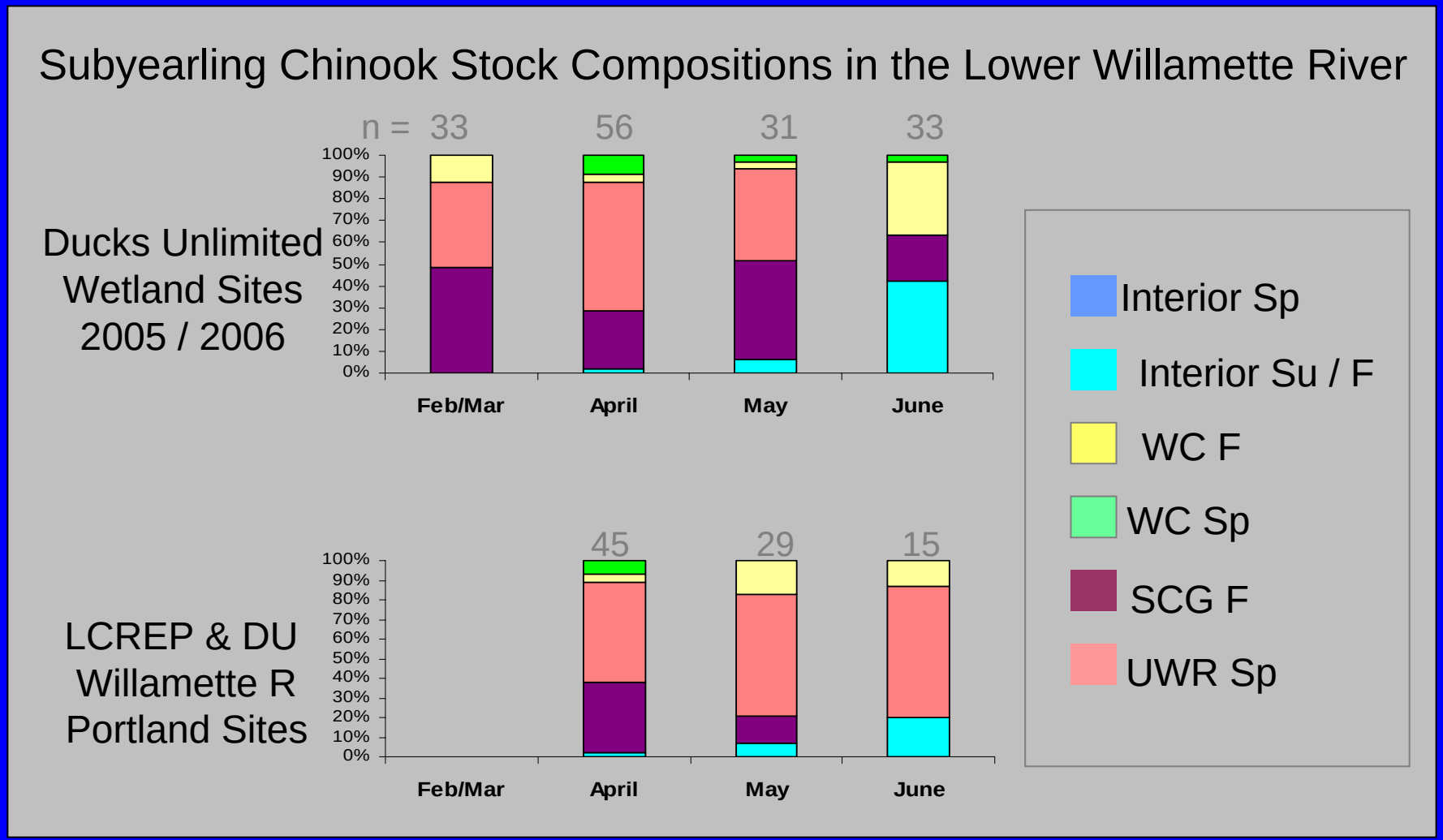
- 6 genetic stock groups identified using DNA markers from 36 CR populations
- All stock groups identified in estuary samples (evidence weak for 2 groups)



# Diverse stock groups, including interior summer/fall run groups, utilize wetland habitats



# Diverse stock groups utilize tidal wetlands and channels of estuarine tributaries




(Ducks Unlimited Samples From Cyndi Baker;
April Willamette R. sample includes DU and LCREP samples)

# Four Conclusions

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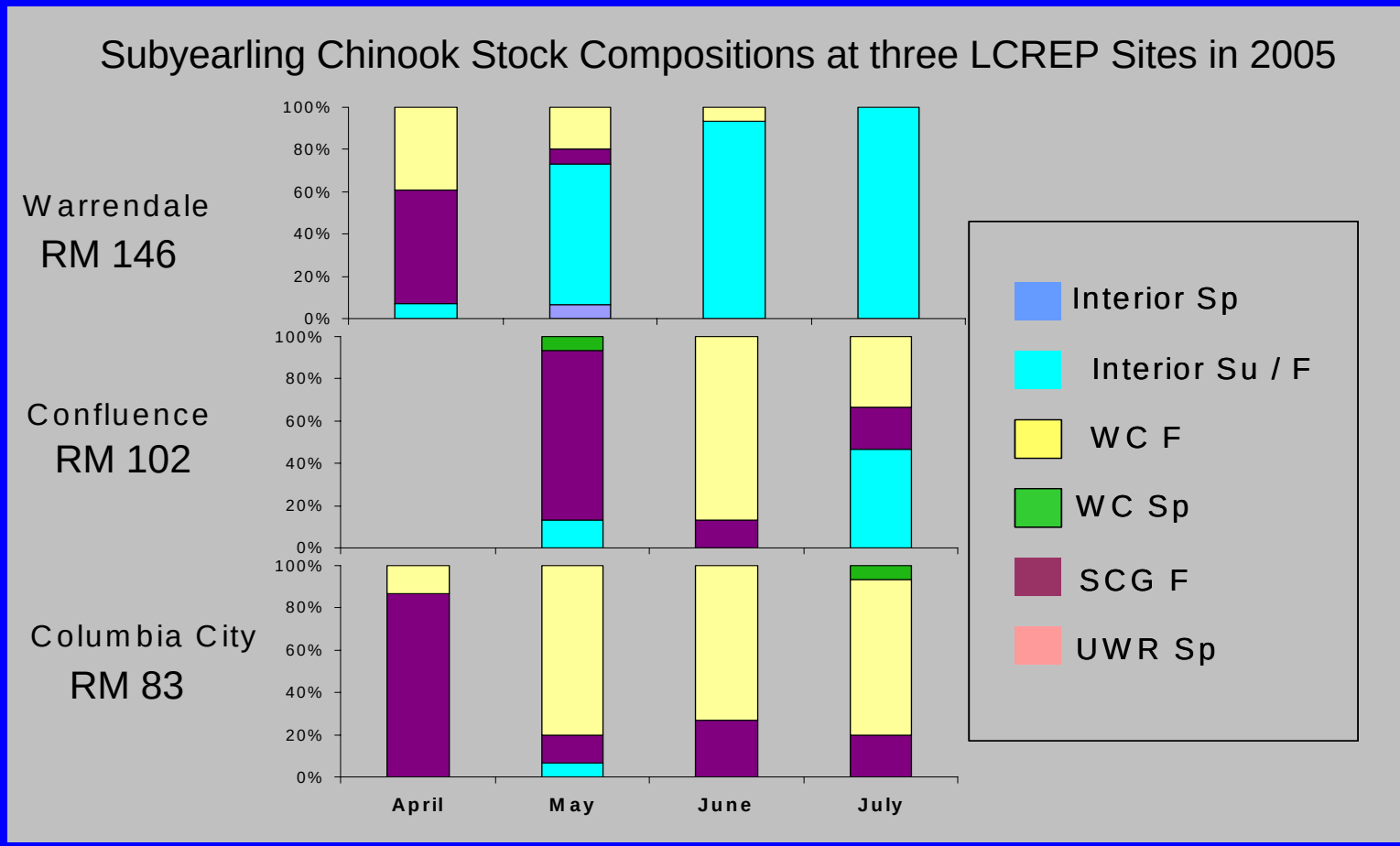
# Estuary Implications for Salmon Recovery

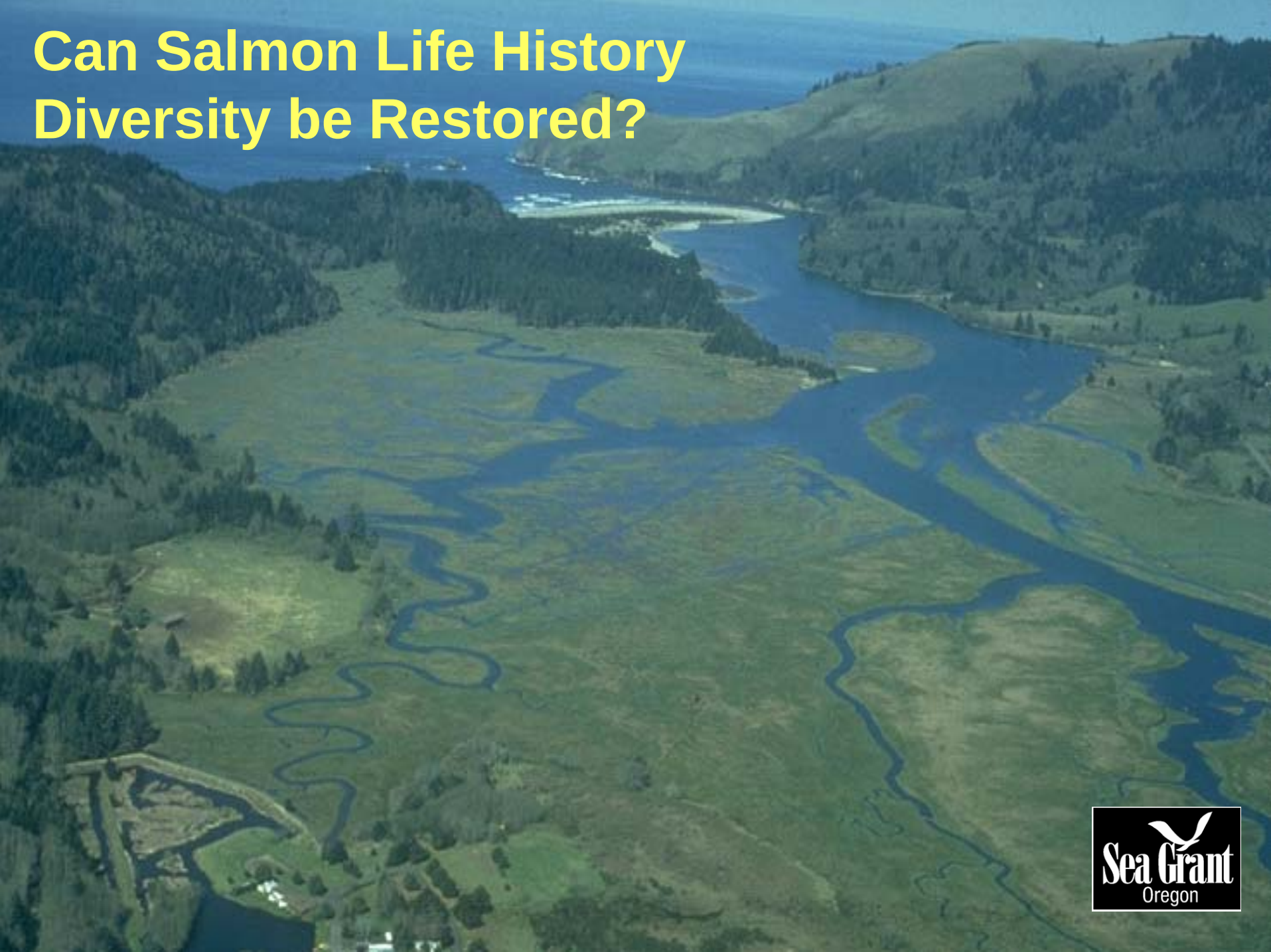
- The CR estuary is not a simple corridor but a critical transitional and rearing environment for young salmon
- Salmon recovery will require restoration of sufficient habitat opportunity in the estuary to accommodate the full diversity of CR stocks and life history types
- Principal restoration concerns include:
  - --Loss of peripheral wetlands & tidal floodplains
  - --Hatchery and flow regulation effects on life histories (i.e., migration patterns, residency, etc.)
  - --Potential effects of increasing river temperatures on estuarine rearing opportunities

# Estuary restoration should address the entire habitat continuum not just the lower 46 miles




- Temporal/spatial patterns of estuary use may vary among genetic stock groups
- Tributary channels are used by upper river stocks

# Can Salmon Life History Diversity be Restored?

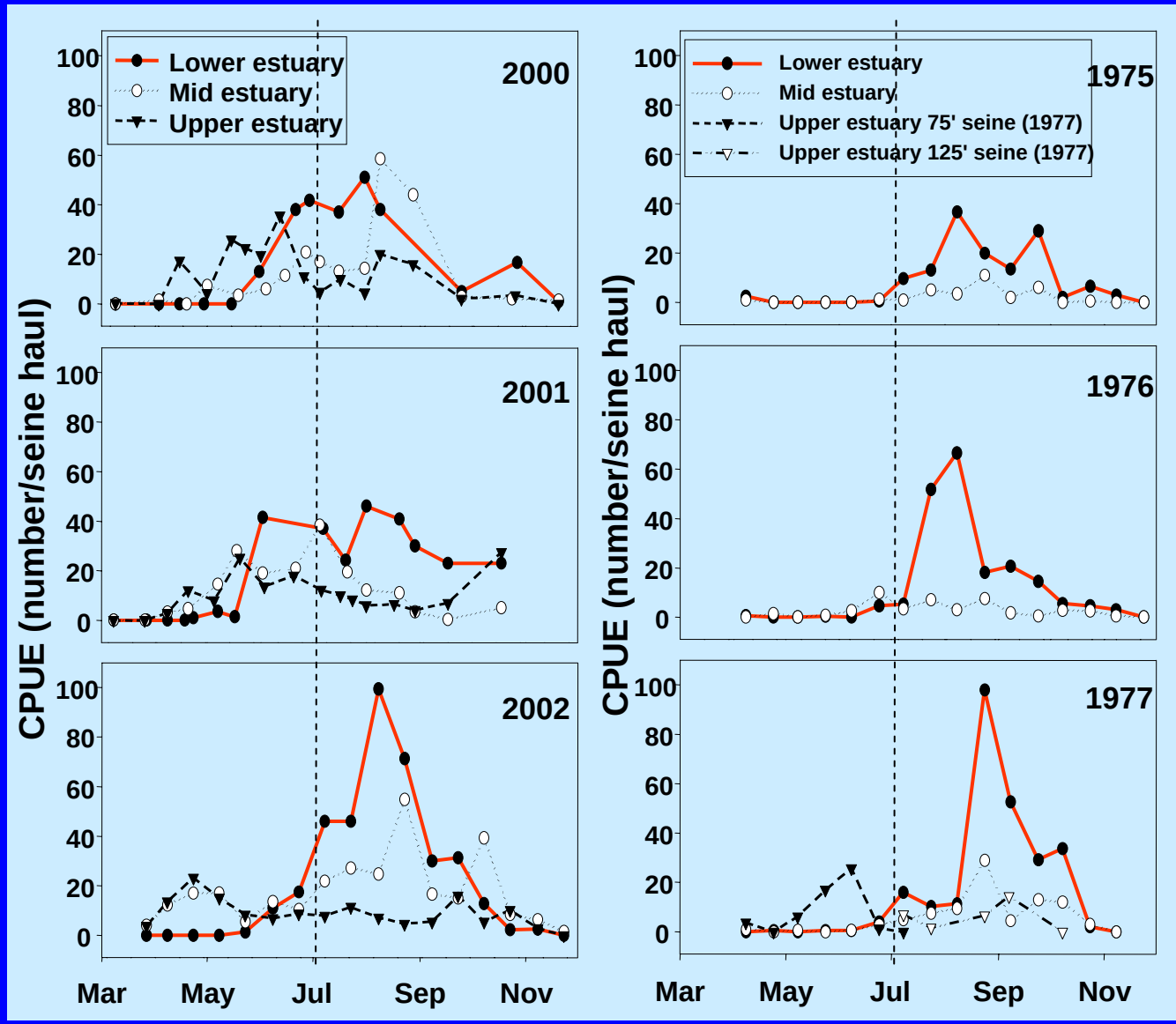


Sea Grant Oregon

# Can Life History Diversity be Restored?

## Chinook Catch Salmon River Estuary

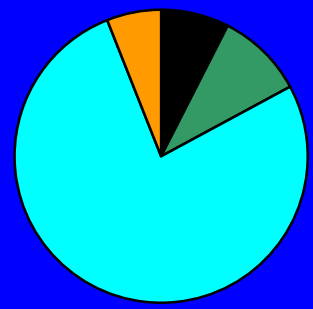
- Life history diversity has expanded with increased wetland opportunity



# Contribution of Diverse Juvenile Life Histories to Returning Adults at Salmon River

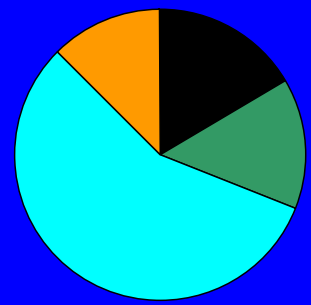
## Size at Estuary Entry for Juveniles at Mouth (BY 2001 & 02)

| | | |
|---|---|---|
| Emergent Fry | < 45mm | 7% |
| Spring (MAM) | 47 – 64 mm | 10% |
| Summer (JJA) | 55 – 96 mm | 77% |
| Fall (SON) | 97 – 109 mm | 6% |



## Size at Estuary Entry for Adults (2004 RY; n=145)

| | | |
|---|---|---|
| Emergent Fry | <45 mm | 17% |
| Spring (MAM) | 45-60 mm | 14% |
| Summer (JJA) | 61-95 mm | 57% |
| Fall (SON) | >95 mm | 12% |



# Management Questions

- Can the CR Fish and Wildlife Program achieve its recovery goals solely through mitigative actions in headwater or mainstem habitats above Bonneville?
- What, if any, changes are needed in the CR Fish and Wildlife Program to account for the estuarine habitat needs of Columbia River salmon?
- What restorative measures will most benefit estuarine rearing opportunities for juvenile salmon?
- What, if any, additional information is needed to support estuary restoration?