# Landscape Features and Density Dependence in Tidal Delta Habitats: Juvenile Chinook in Four Puget Sound Estuaries

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# Acknowledgements


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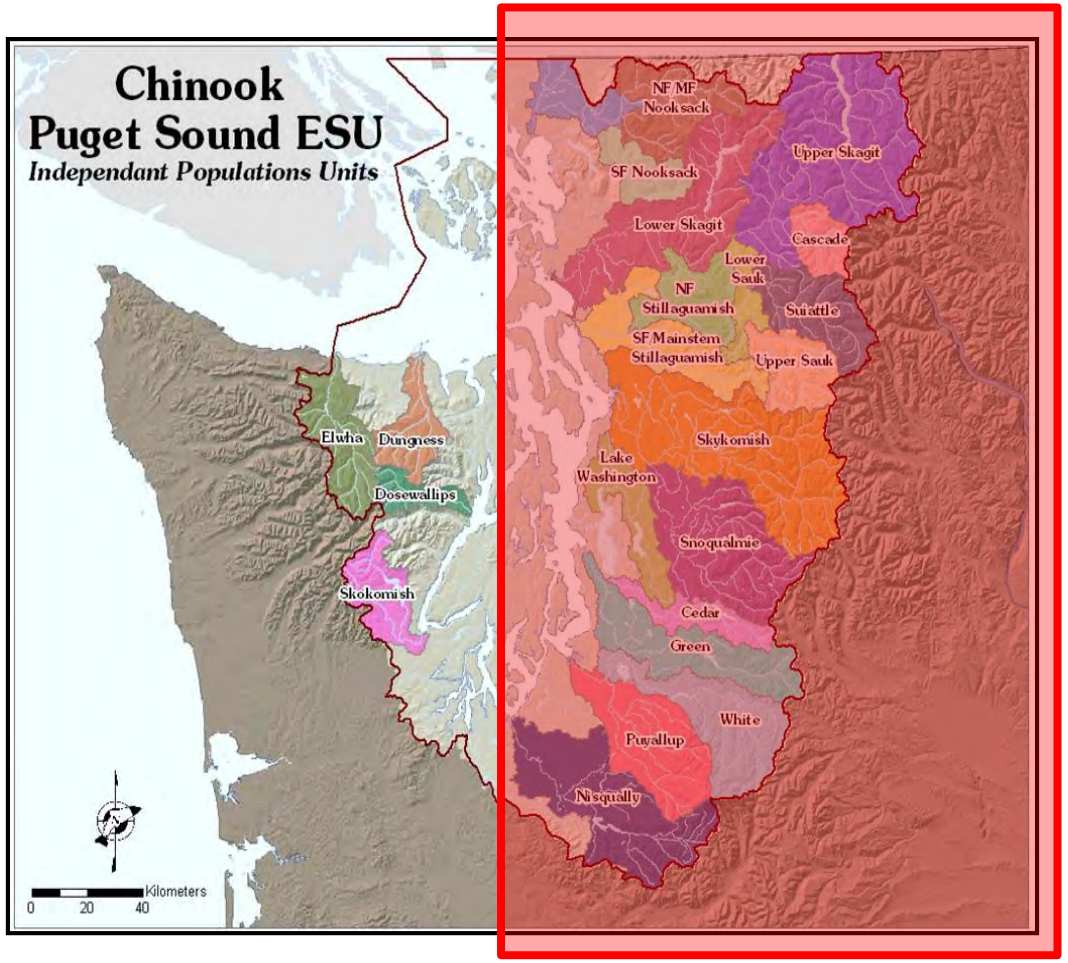
Long Live the Kings

# Estuaries and Chinook salmon

Cultural, recreational,
Commercial icon

ESA listed

Extensive use of estuaries
by juveniles




Current area = 1-55% of historical
(PSNERP Change Analysis 2011)

# Questions

- What estuarine landscape features are most important for juvenile Chinook?

- Are estuary habitats limiting salmon populations?

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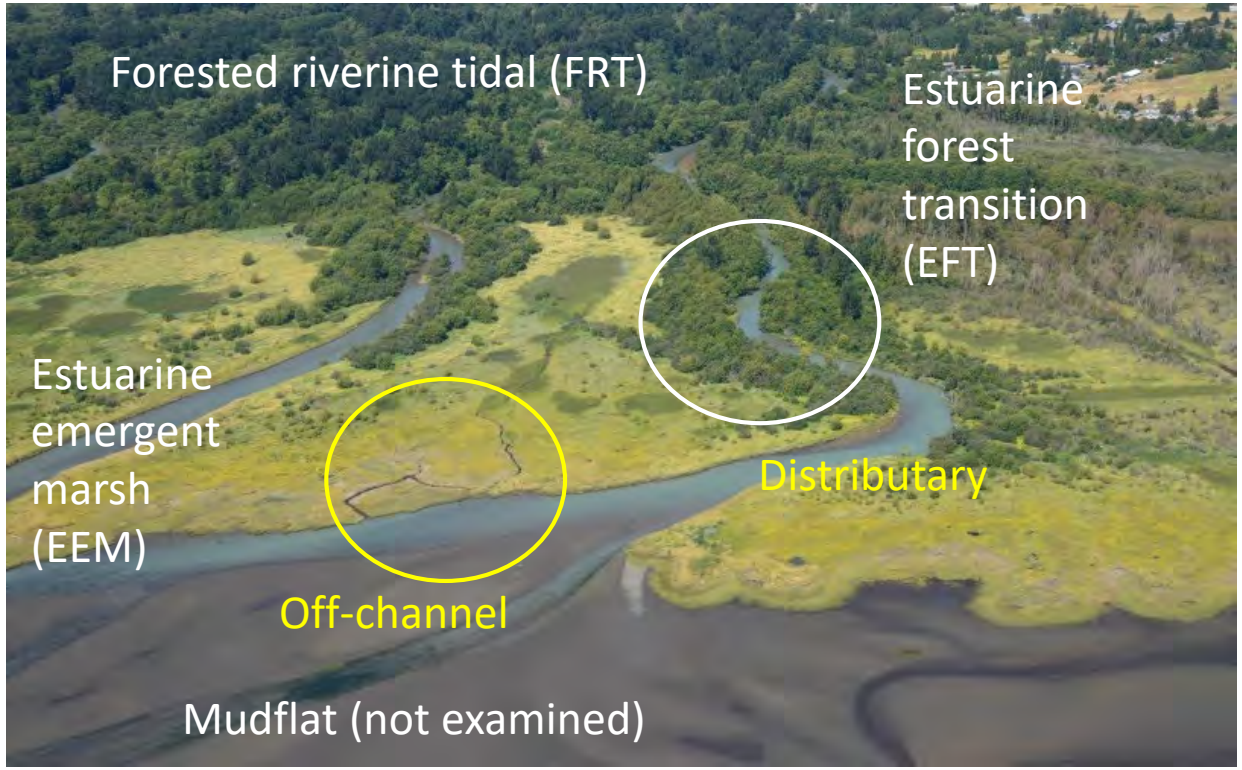
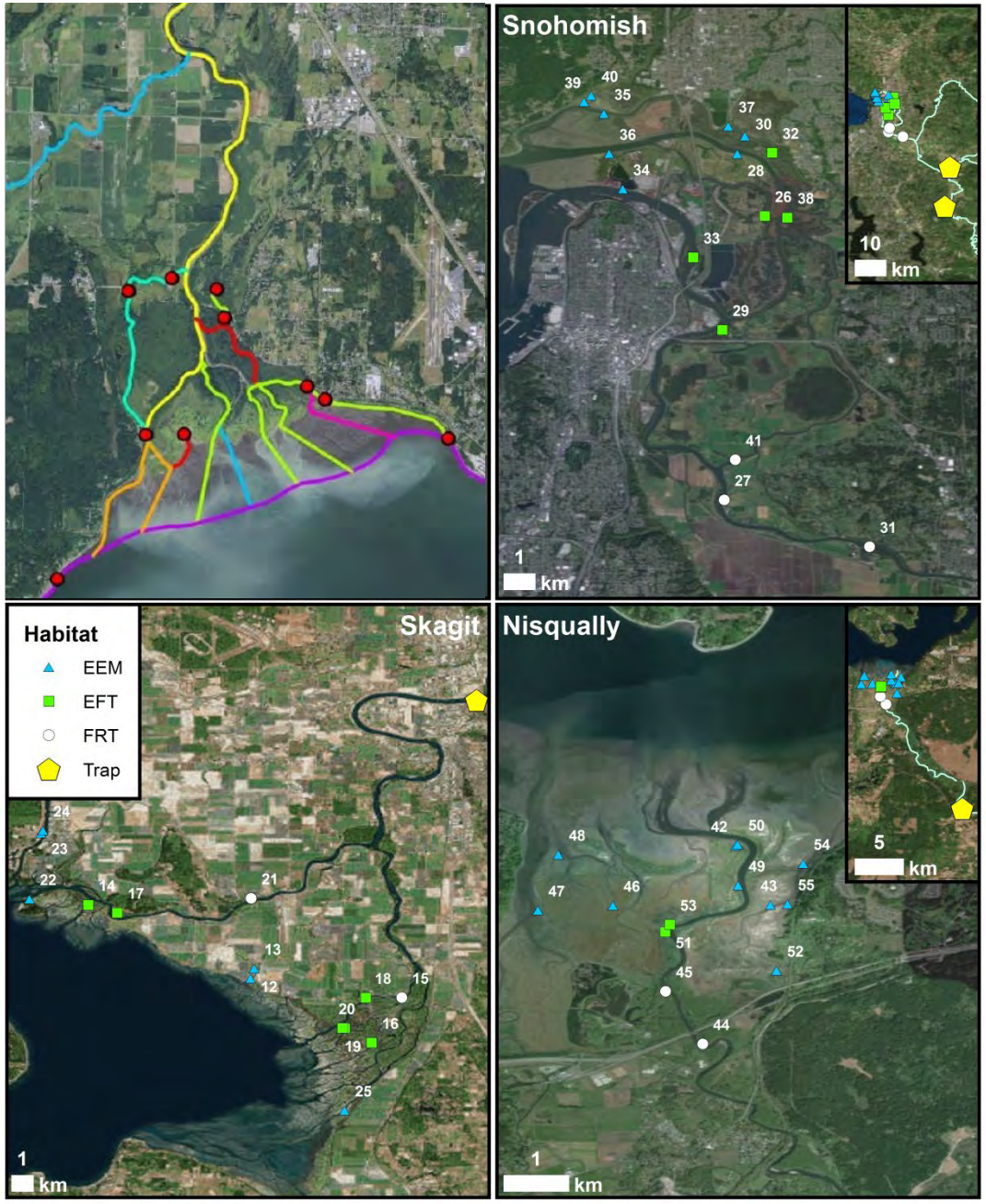
- What estuarine landscape features are most important for juvenile Chinook?
  - Examine densities of salmon in context of
    - Estuary system (different watersheds)
    - Connectivity (distance from upstream source)
    - Wetland type (Forested, Scrub, Estuarine emergent)
    - Channel type (Distributary or Off-channel)
- Are estuary habitats limiting salmon populations?
  - Examine densities of salmon in context of freshwater outmigrants

# Landscape features

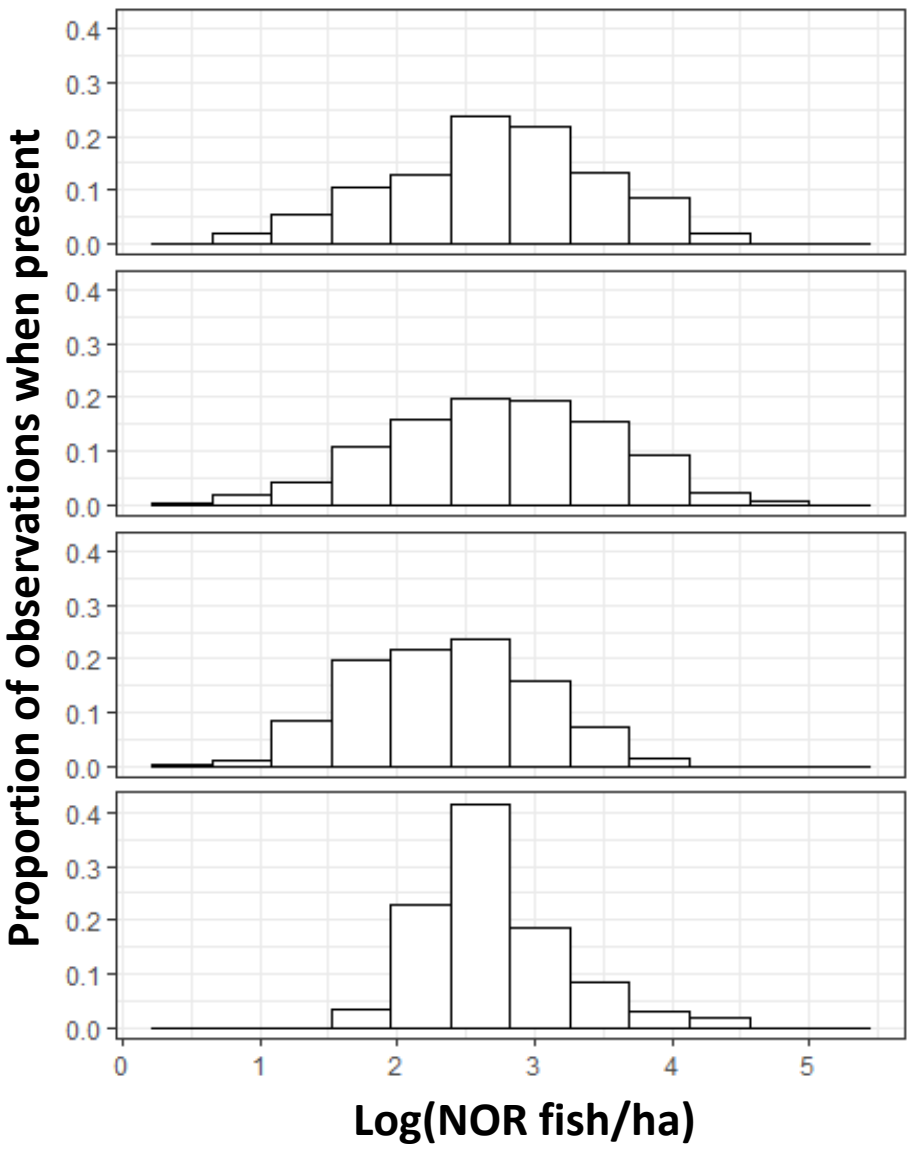


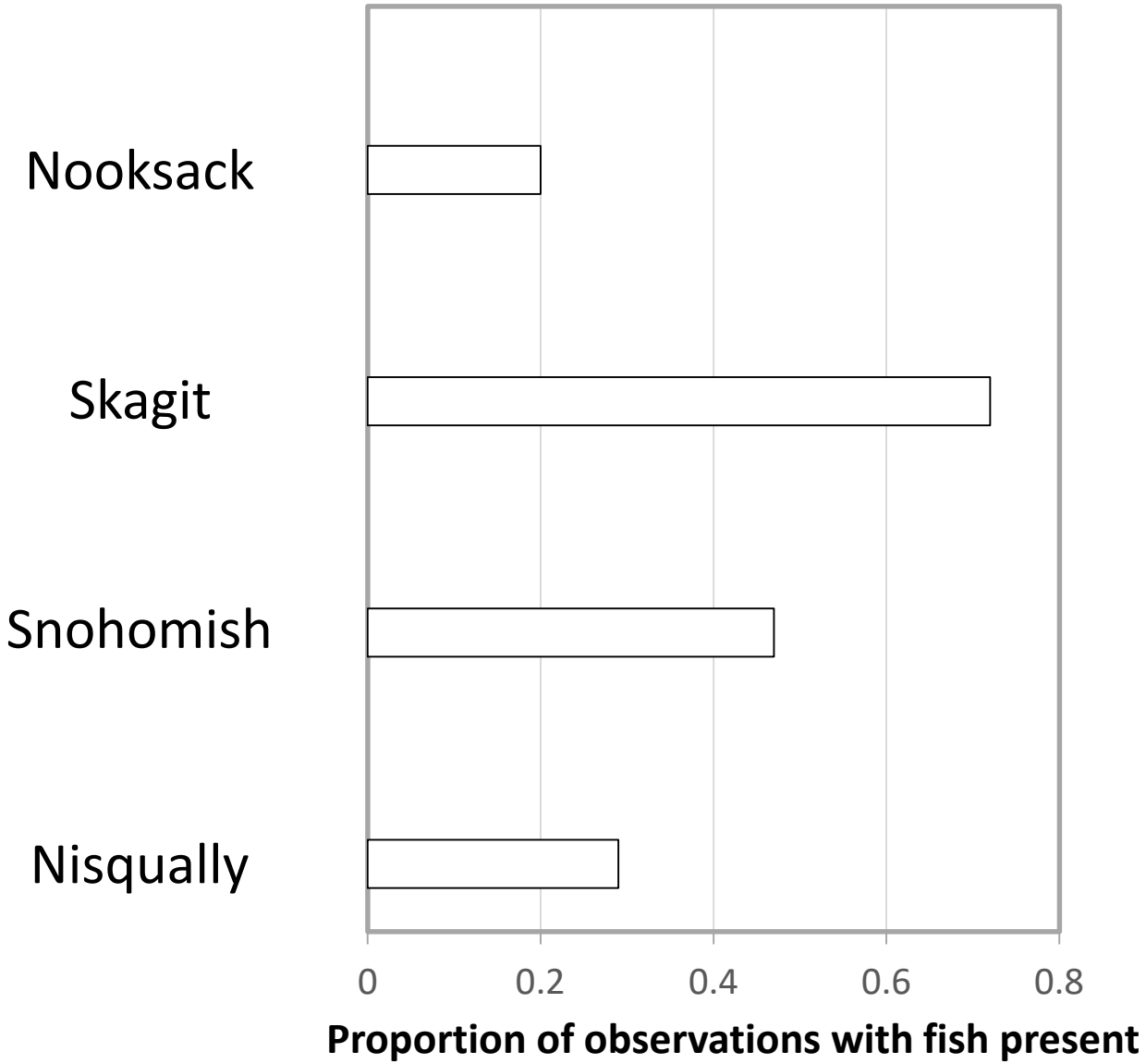



# Sampling

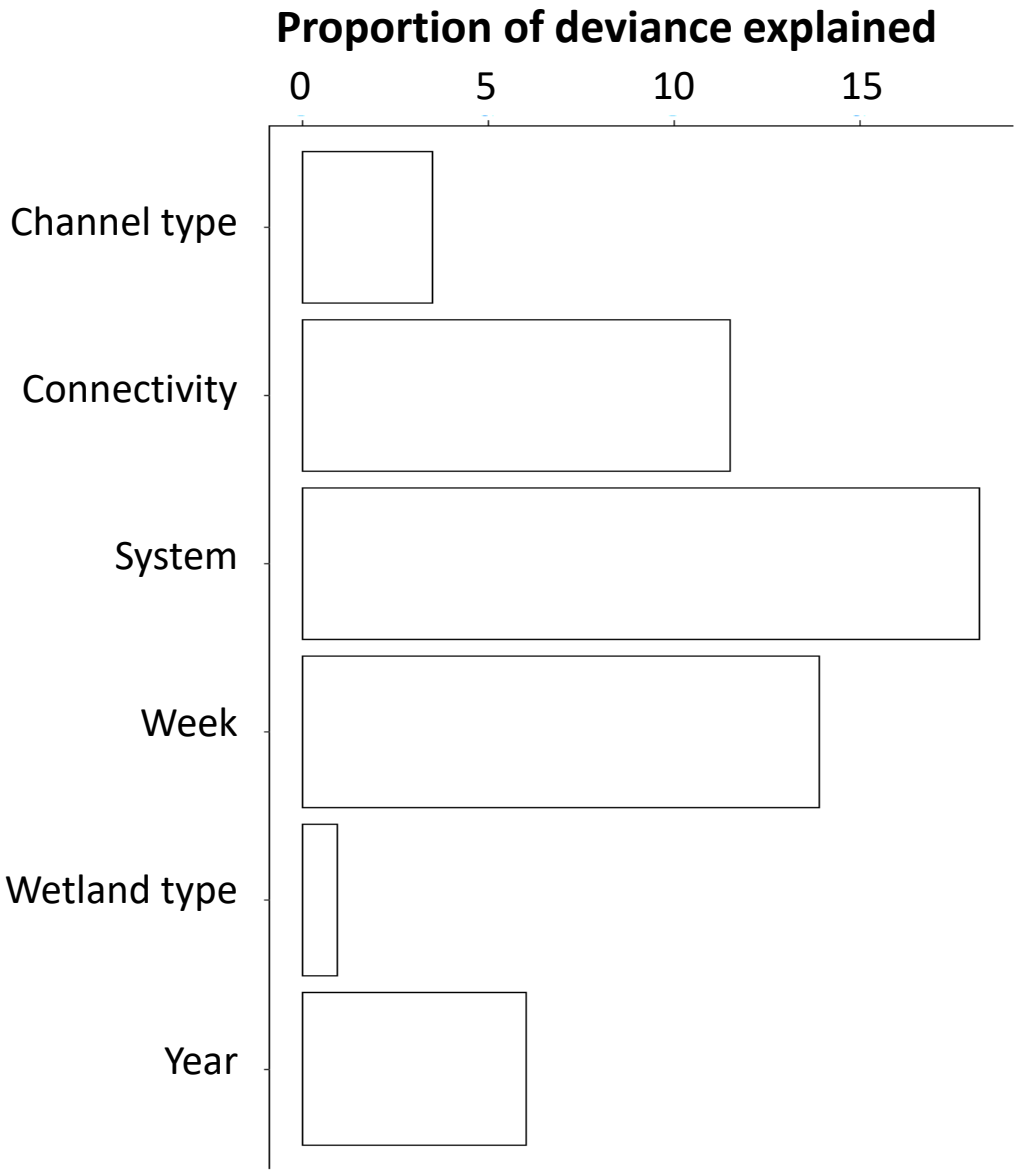
- Fyke trap and beach seine data
  - Abundance converted to densities
- 1997-2017
- 10-16 index sites in each system
- Monitored 3-28 times each year
- 7227 total observations of density
- Focus: Unmarked (NOR) juveniles

# Densities in different estuaries



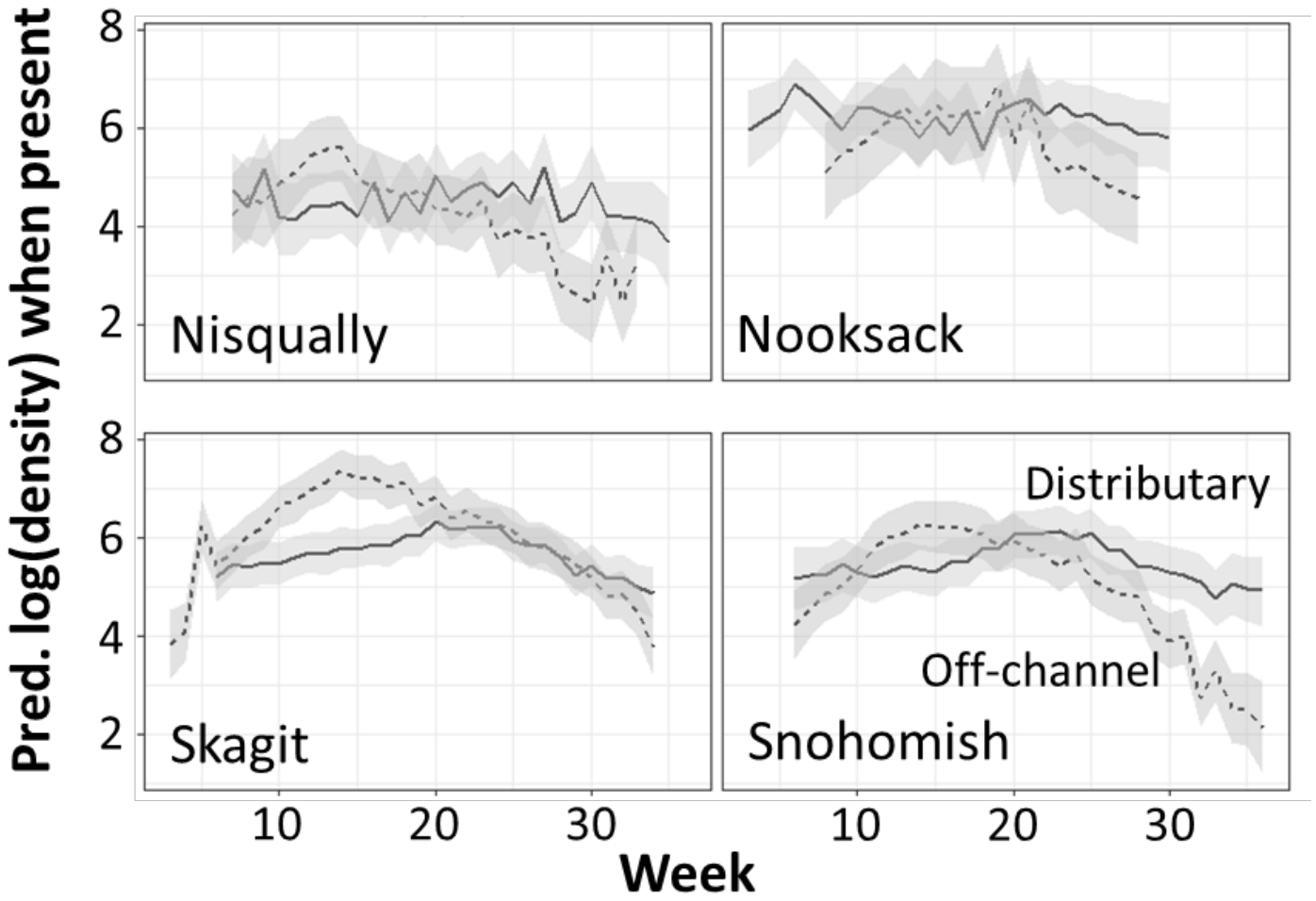



# Results of general additive modeling (GAMs)




| Terms | F | p-value |
|---|---|---|
| **Week** | **0.000** | **0.001** |
| System | 0.000 | 0.159 |
| **Year** | **6.535** | **0.000** |
| **Connectivity** | **0.028** | **0.003** |
| Wetland type | 0.000 | 0.420 |
| Channel type | 0.000 | 0.483 |
| **Connectivity x system** | **6.090** | **0.000** |
| **Wetland type x week** | **0.951** | **0.000** |
| **Channel type x week** | **11.427** | **0.000** |
| **System x week** | **0.482** | **0.001** |
| **Channel type x system: Nisqually** | **2.560** | **0.012** |
| Channel type x system: Nooksack | 0.000 | 0.294 |
| Channel type x system: Skagit | 0.000 | 0.361 |
| Channel type x system: Snohomish | 0.000 | 0.835 |

# Effects of channel type and week

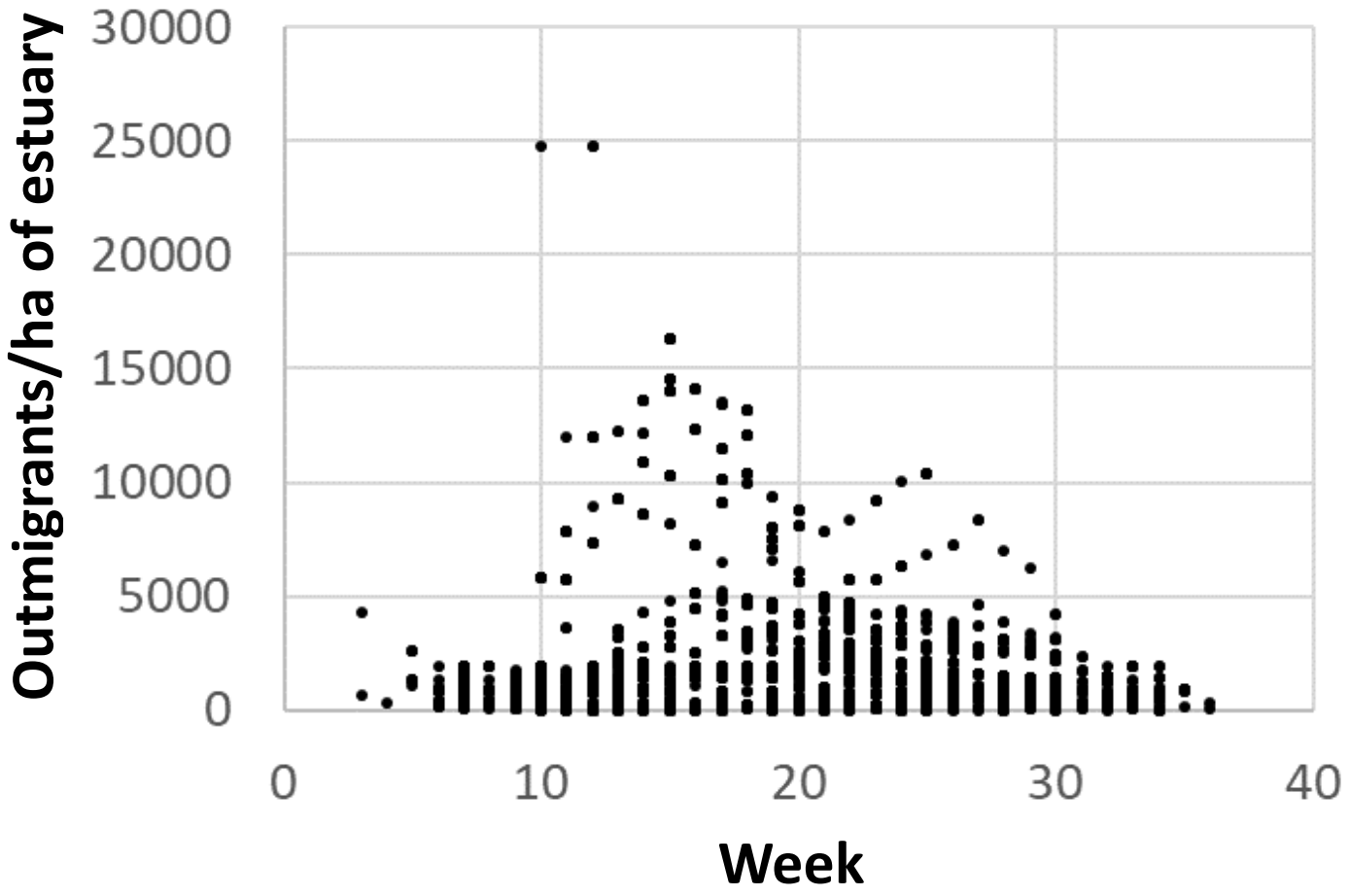



Higher densities in off-channel habitats early in season when fish are small (< 50 mm)

Higher densities in distributaries later in season when fish are larger (> 50 mm)

# Are estuaries limiting populations?

## Is there evidence of density dependence?



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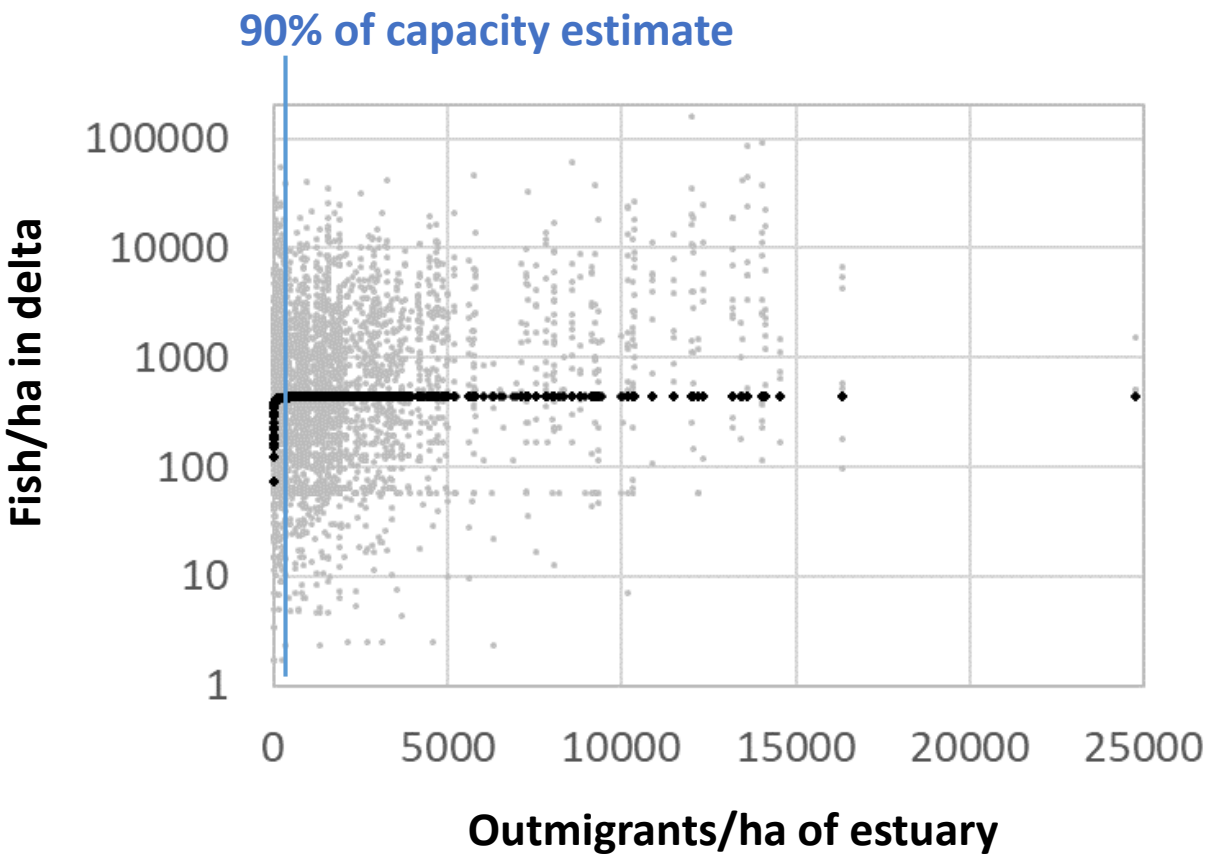


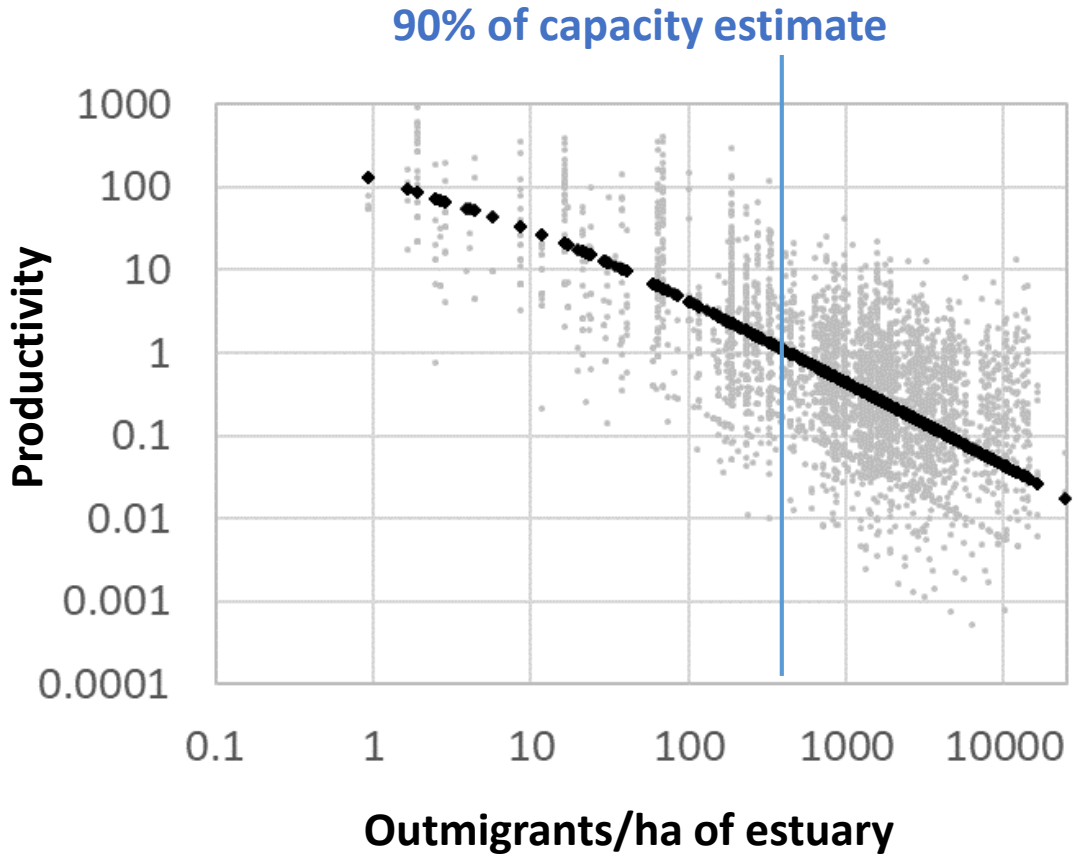

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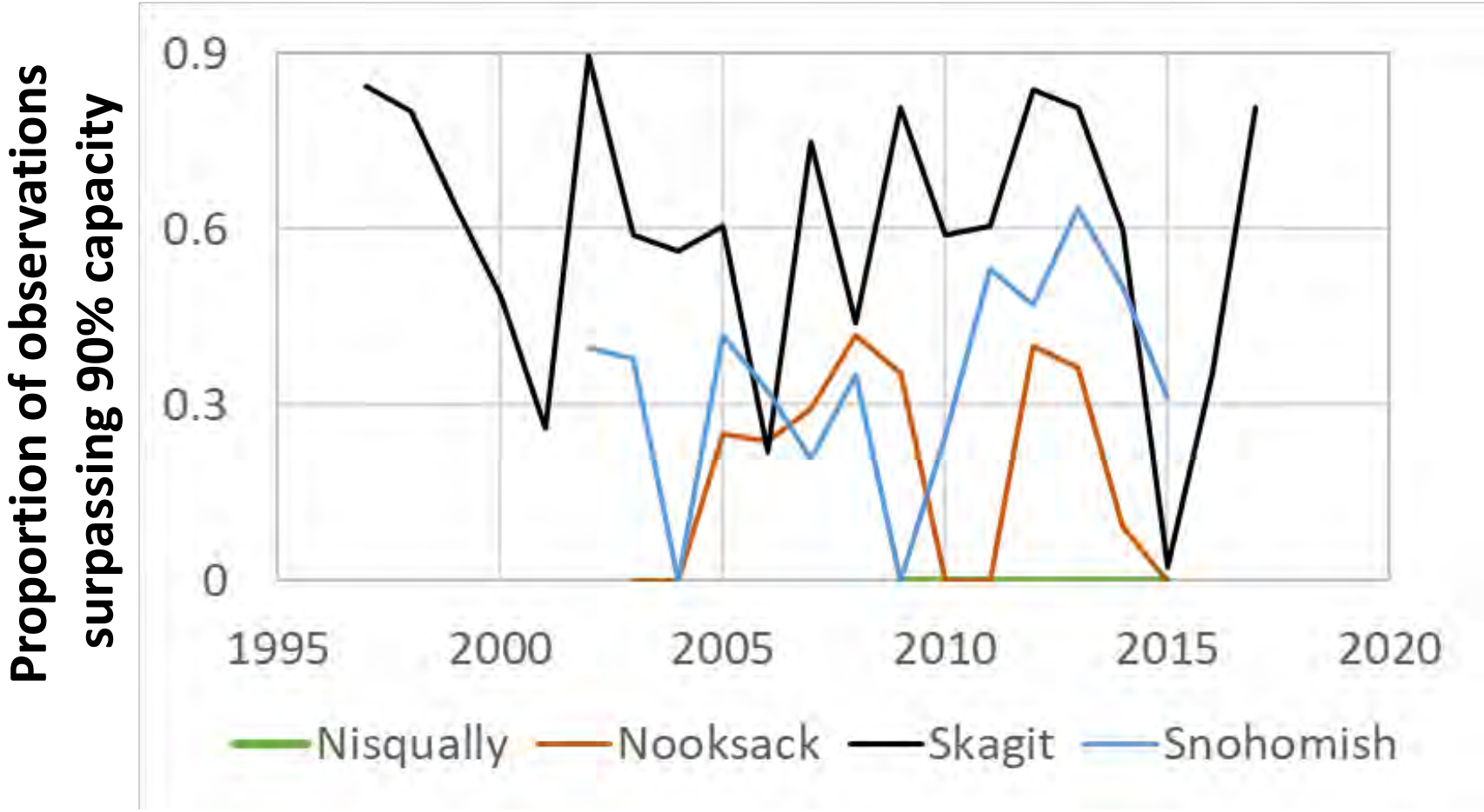



| | |
|---|---|
| Skagit: | 60% |
| Snohomish: | 34% |
| Nooksack: | 18% |
| Nisqually: | 0% |

# Conclusions

- Landscape features are important

    1) System: Understand the context of estuaries in your watershed

    2) Connectivity: More fish will use highly connected sites

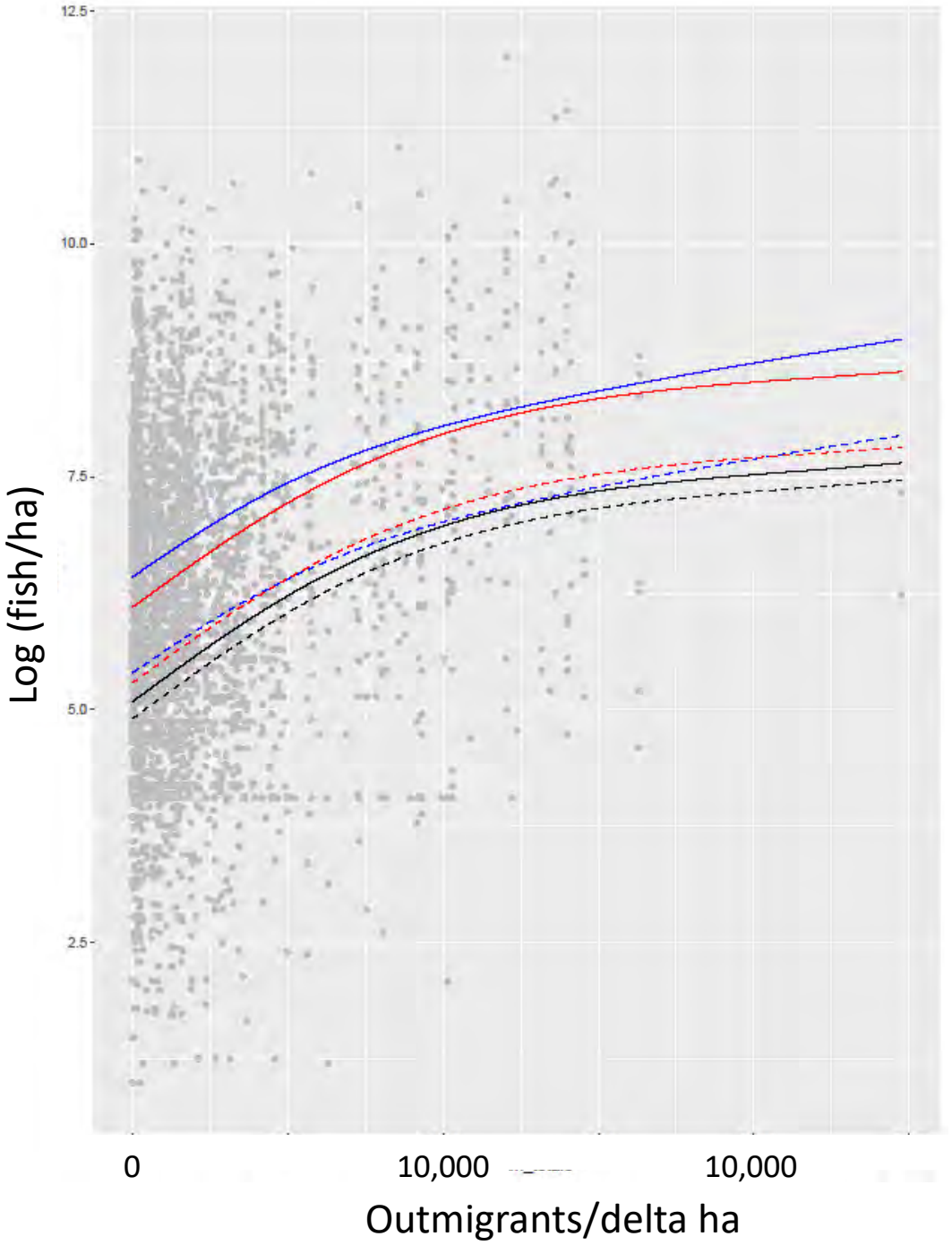
    3) Channel type: Off-channel habitats support fish likely to reside in the estuary

    4) Wetland type: FRT > EFT > EEM, but differences are pretty small

- Estuary habitat appears to be limiting in certain years in three of four systems
    - ➢ Identifying restoration success, in terms of improving capacity, may be system-specific

# Thanks!

# Wetland and channel type specific effects of density dependence



# Effect of wetland type vs channel type