Stable Isotopes Inform Stock-Specific Marine Life History and Energy Accumulation in Chinook Salmon

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Chinook Salmon, *Oncorhynchus tshawytscha*

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Dwindling returns

- Canada: 28 populations assessed by COSEWIC, only 2 “not threatened”
- USA: 9 of 17 ESUs in lower 48 listed as ‘endangered’ or ‘threatened’

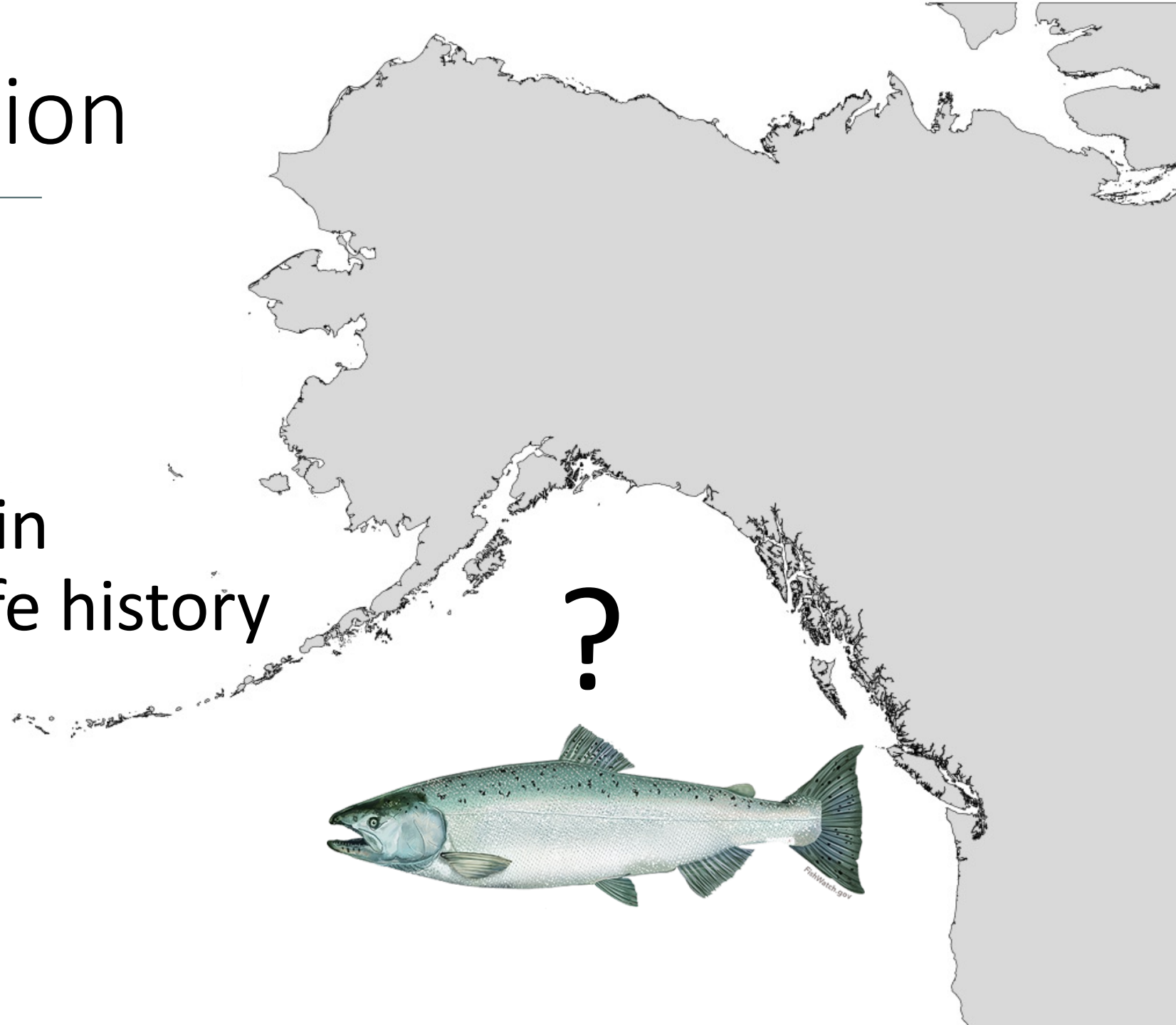
Synchronous declines across the coast

Threatens:

- Indigenous communities
- Economies
- Endangered species

The Big Question

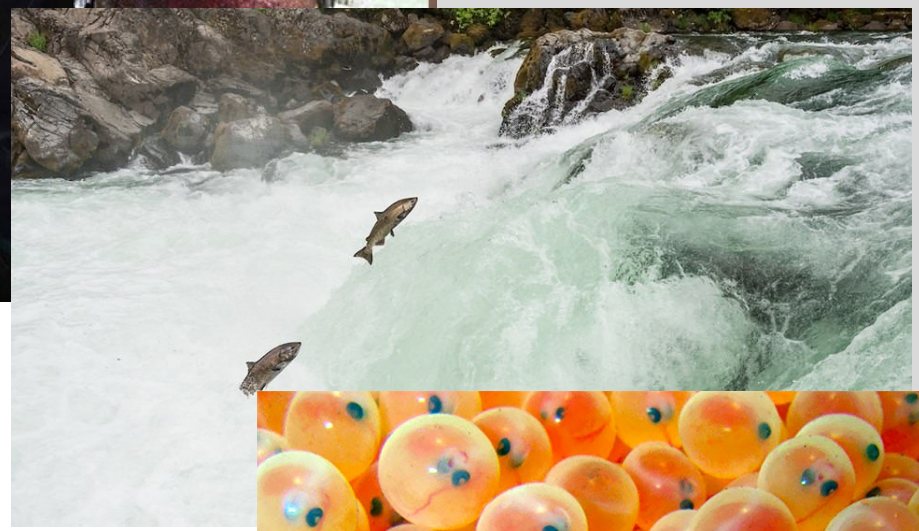
What is happening in Chinook's marine life history stage?



Marine Life History

Accumulate majority of their energy and vitamins / nutrients

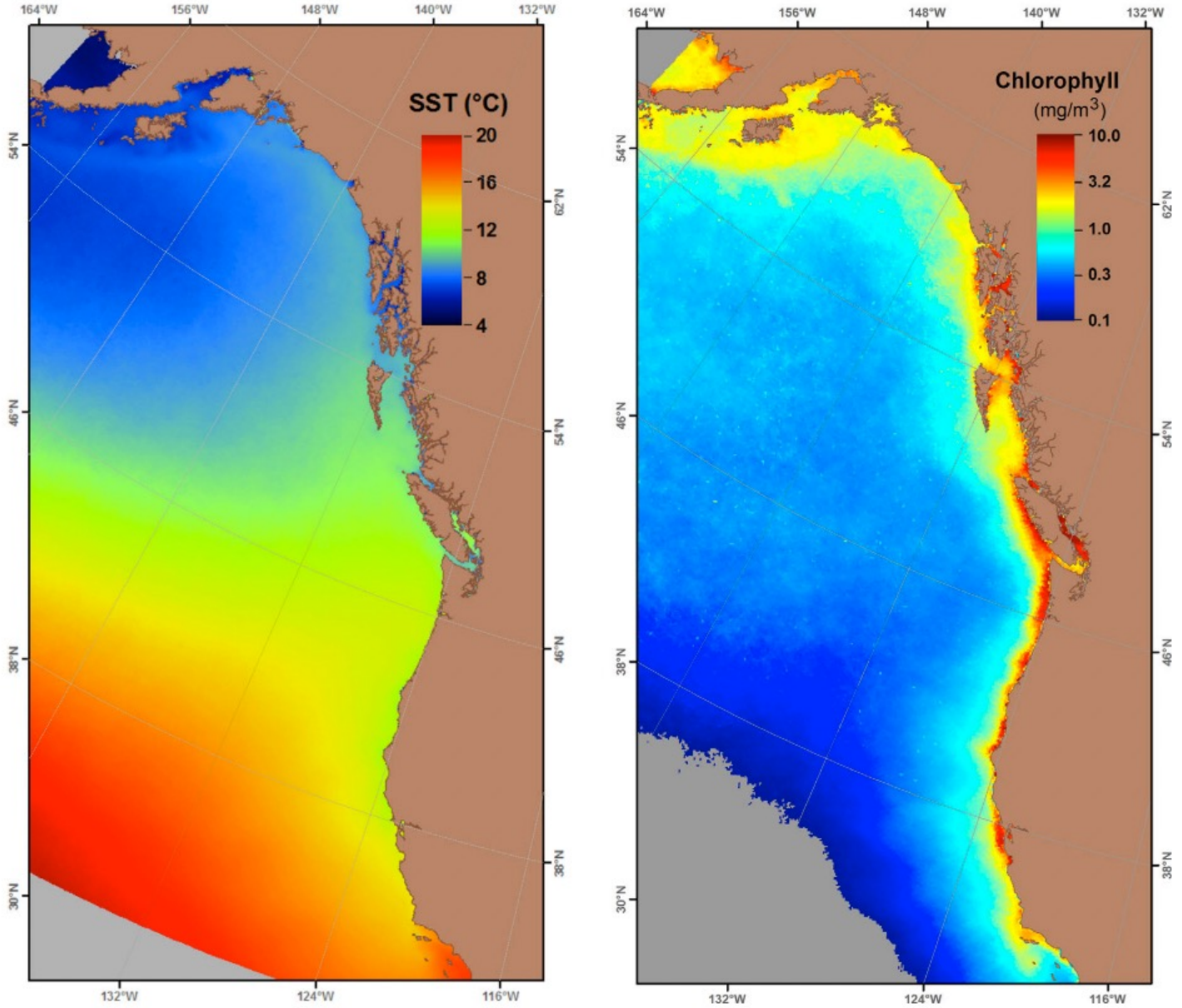
- Growth
- Migration
- Successful spawning/maternal effects



Marine Life History

Ocean conditions are heterogeneous

- Temperature
- Productivity
- Species assemblages

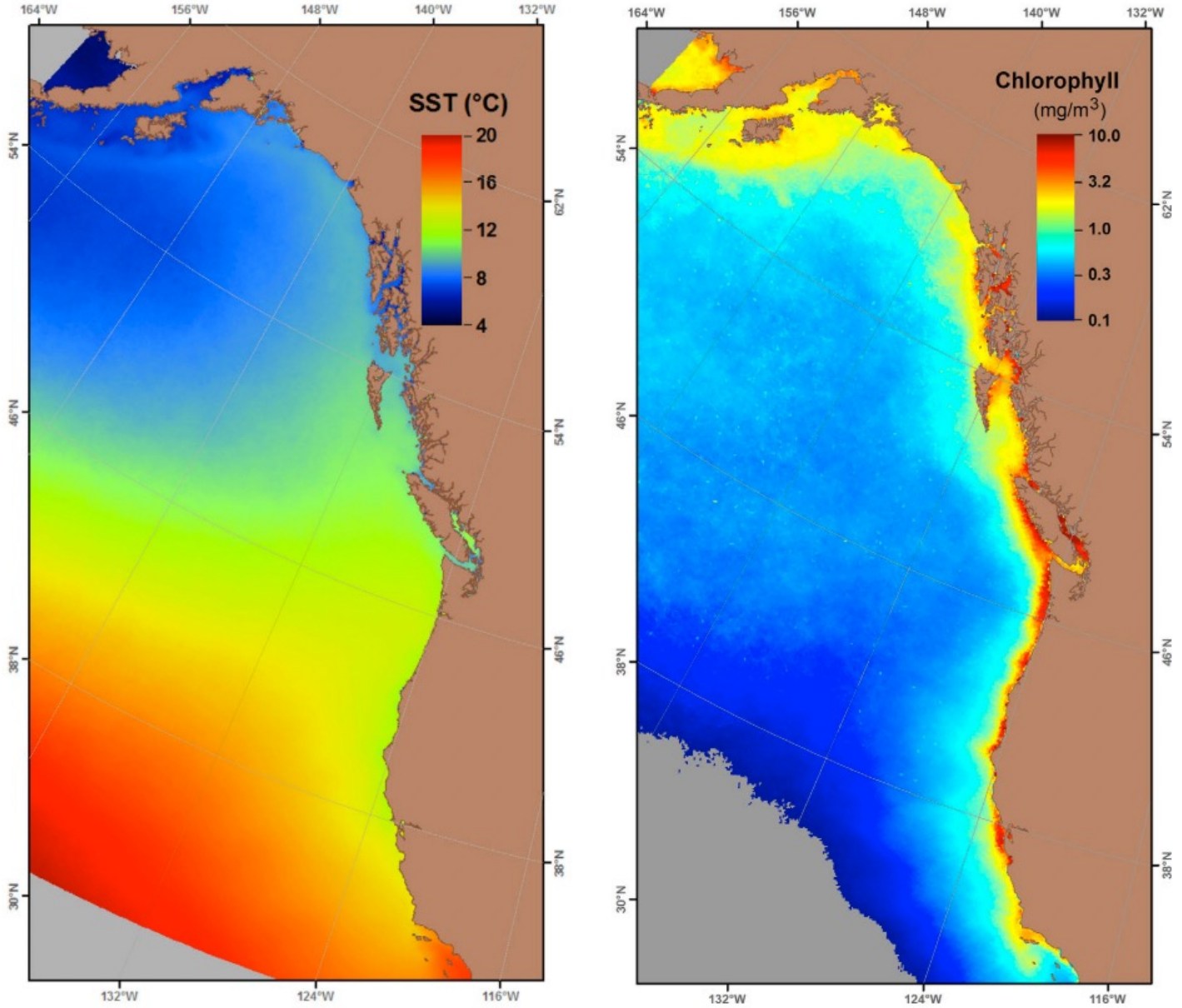


Average satellite-derived SST (calculated from 1985–2008) and chlorophyll concentration (calculated from 1997–2010) in log-transformed units. (From Jackson *et al.*, 2015)

Marine Life History

Chinook stocks distribute differently along the coast

Marine experience of individual salmon populations will be determined by where they go



Average satellite-derived SST (calculated from 1985–2008) and chlorophyll concentration (calculated from 1997–2010) in log-transformed units. (From Jackson *et al.*, 2015)

Questions

1. How do different Chinook stocks distribute along the coast?

2. Do Chinook stocks exhibit different marine foraging behaviors?

3. How does this impact Chinook energy accumulation?

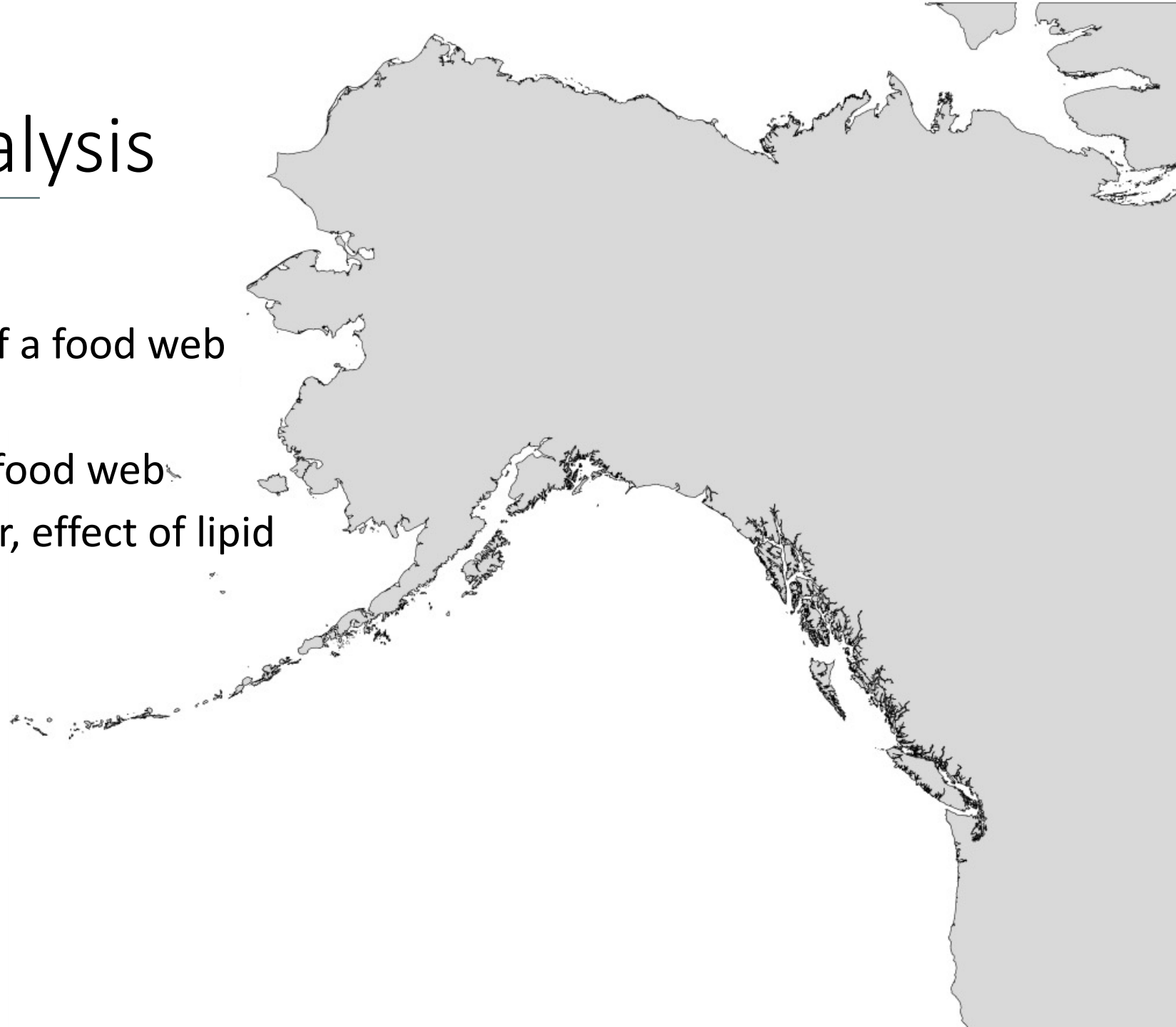
Stable Isotope Analysis

Chemical Tracers

Signatures set at the bottom of a food web

Change predictably through a food web

(e.g., trophic enrichment factor, effect of lipid content on isotope value)



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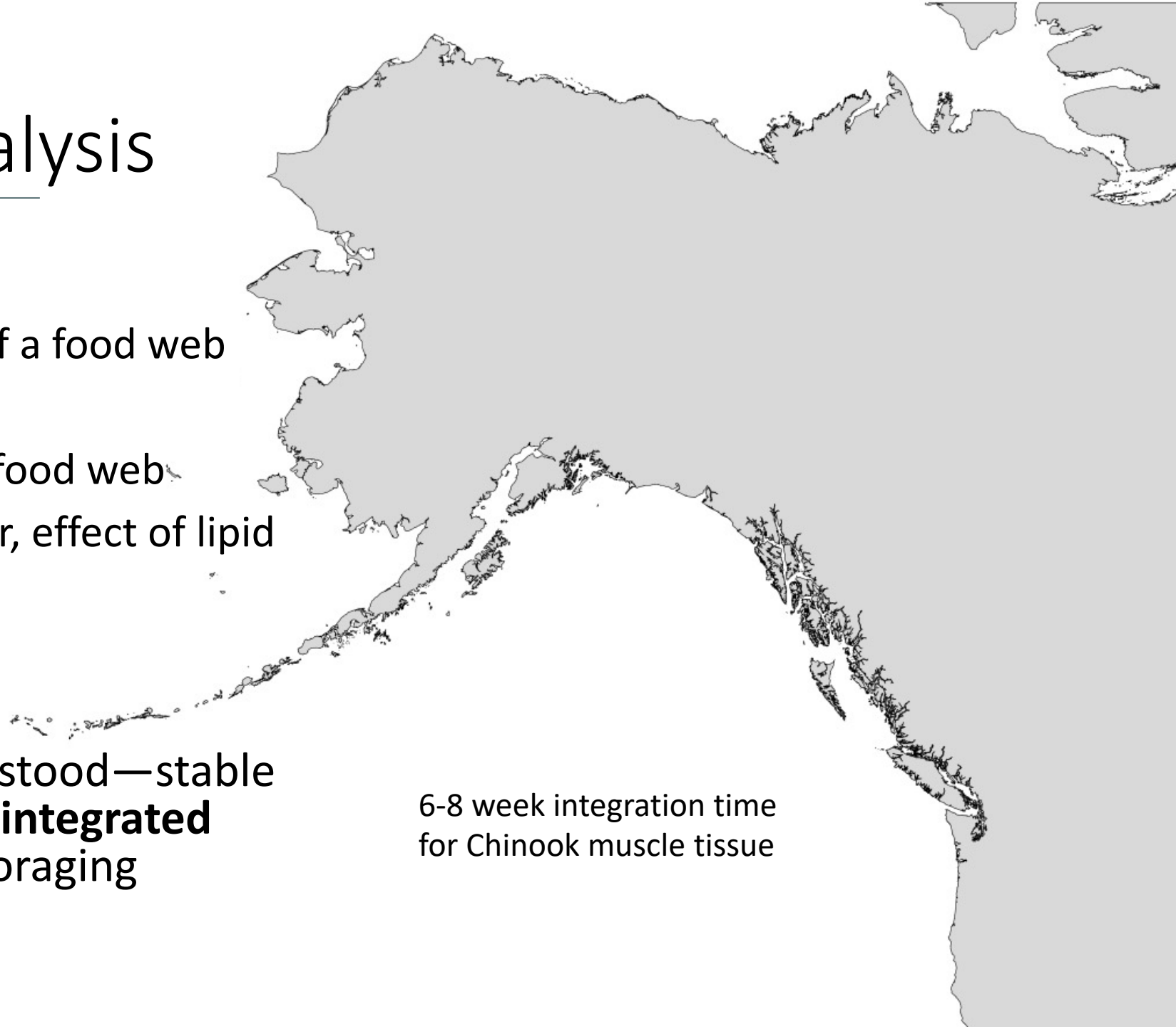
If predictions are well understood—stable isotopes can provide a **time integrated** signature of an organisms' foraging behavior and distribution



6-8 week integration time for Chinook muscle tissue

Methods: Sampling

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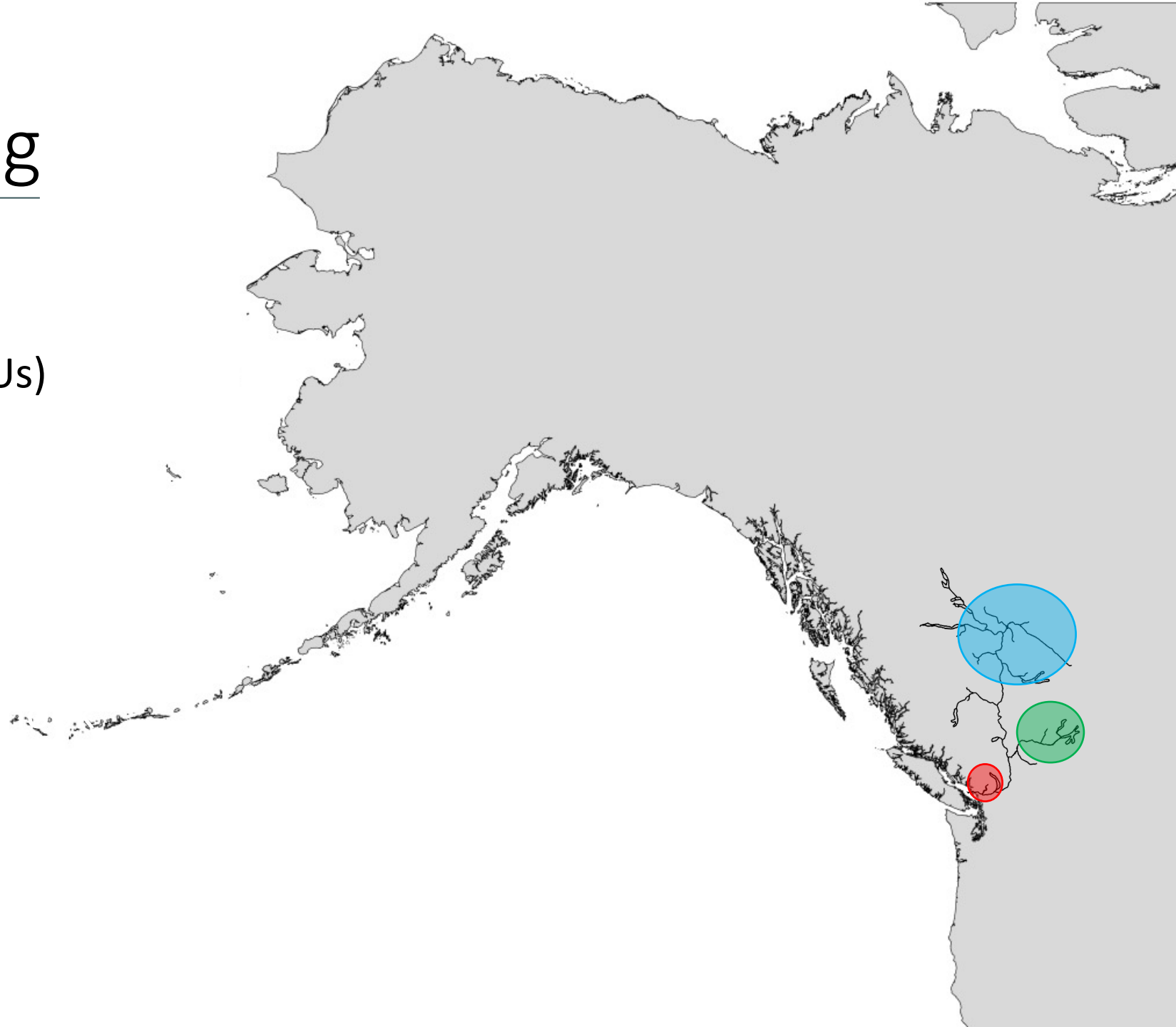
Three Management Units (MUs)

- Fraser Fall 0.3
- Fraser Summer 0.3
- Fraser Spring 1.3



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Sampled Chinook at freshwater entry—Albion Test Fishery

- Weight/length/sex
- Genetic stock identification
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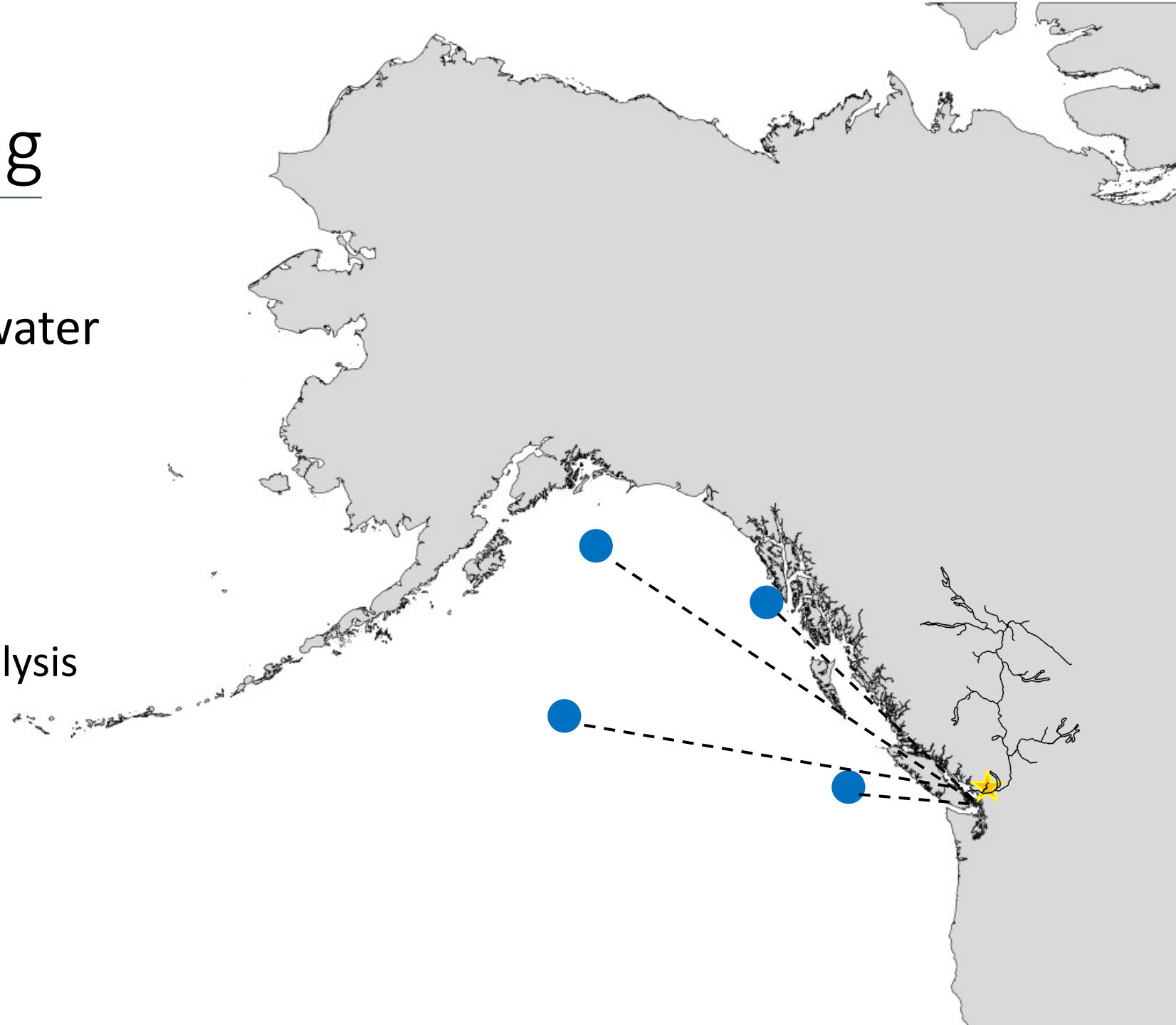

Questions

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2. Do Chinook stocks exhibit different marine foraging behaviors?

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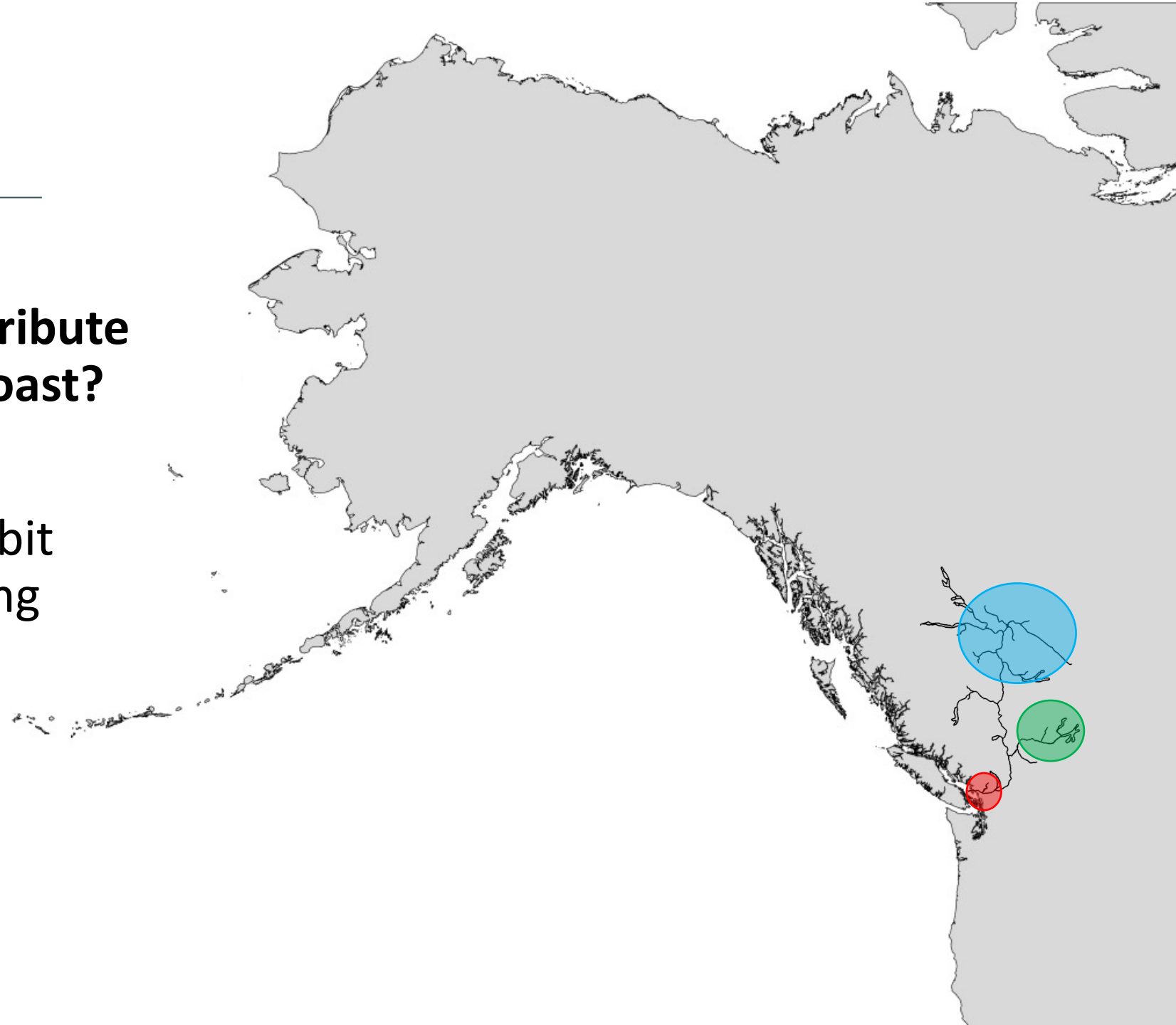
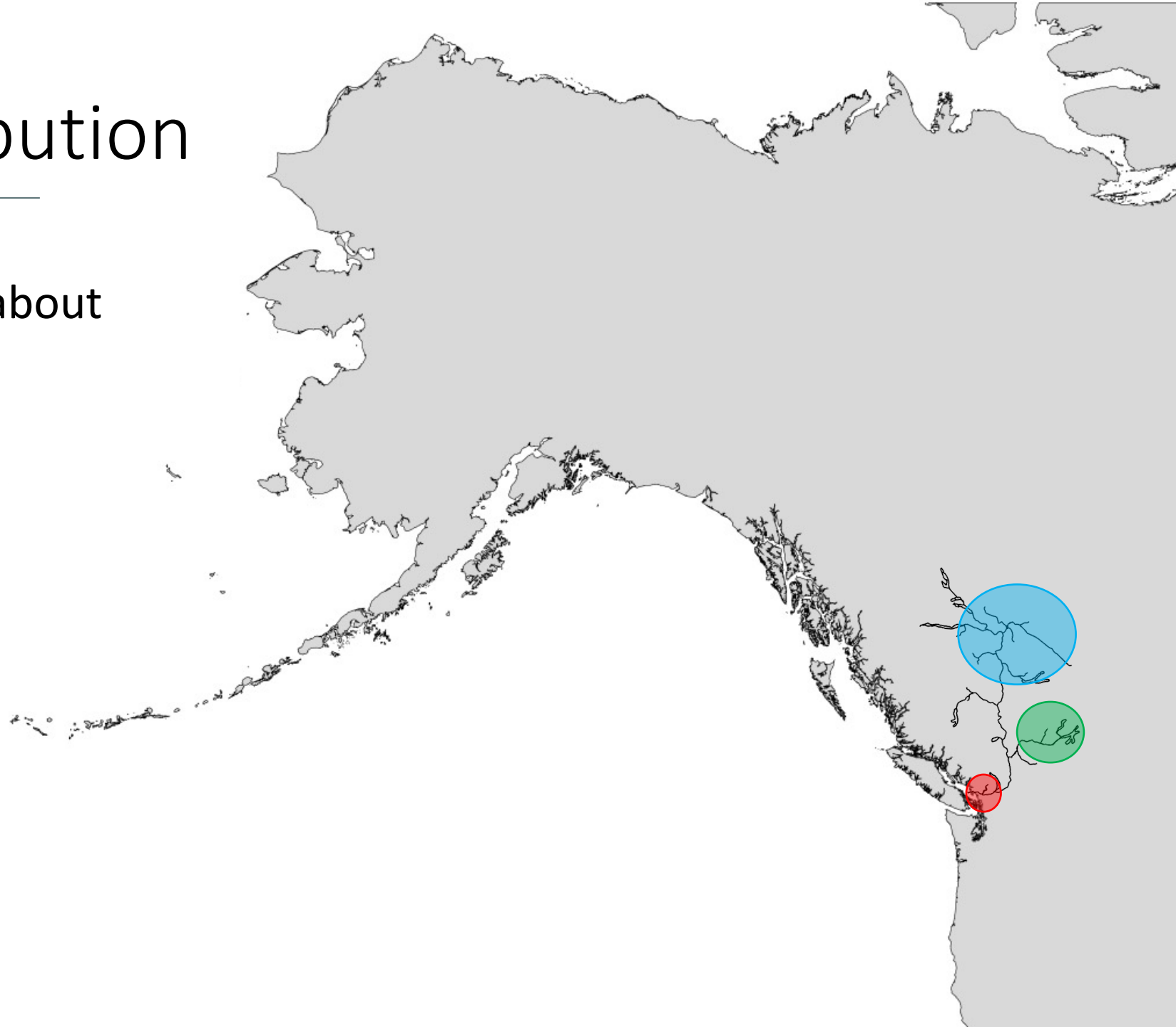


Q1: Marine Distribution

What do we already know about distribution?

- Fraser Fall 0.3
- Fraser Summer 0.3
- Fraser Spring 1.3



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- Fraser Summer 0.3
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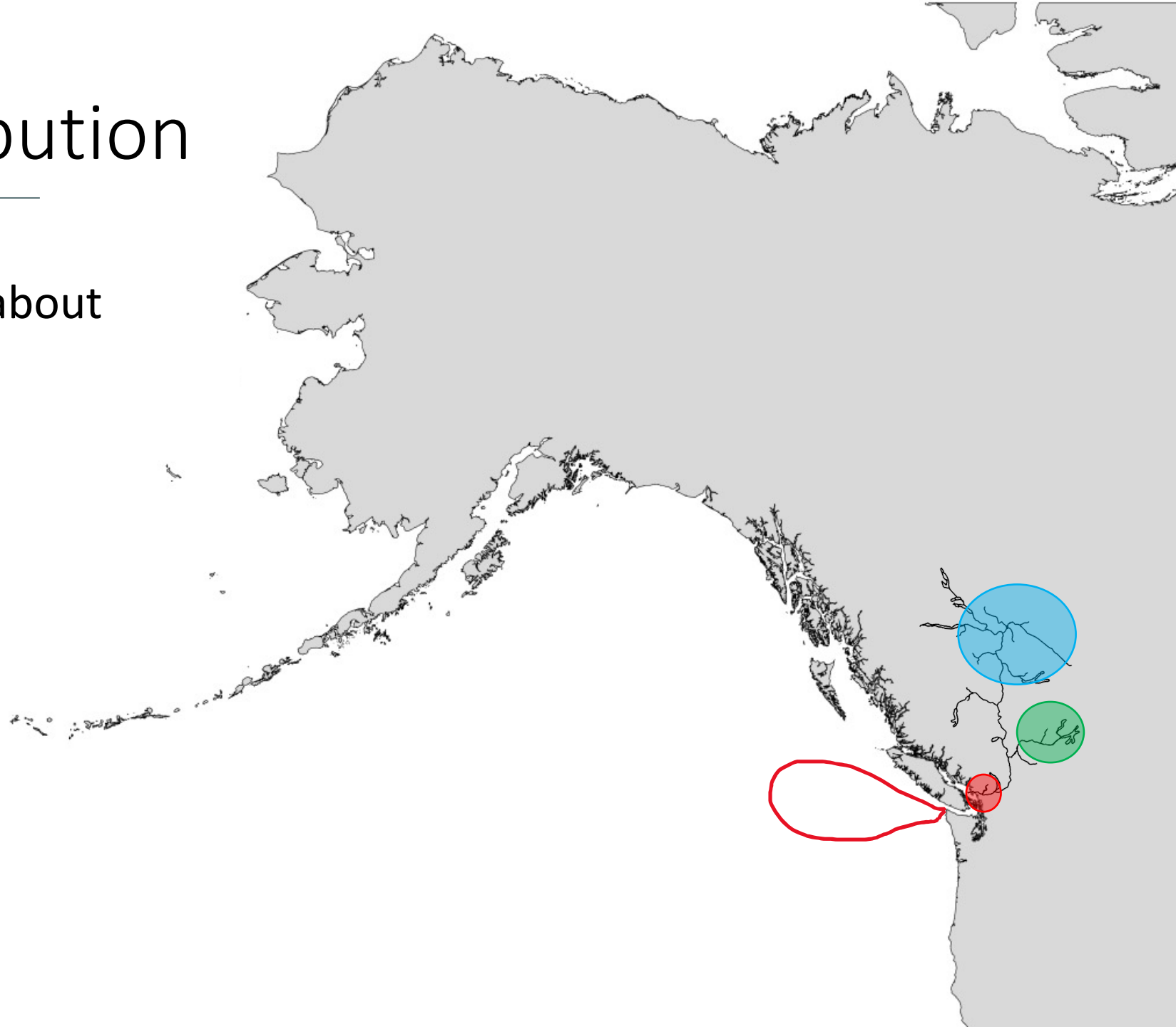

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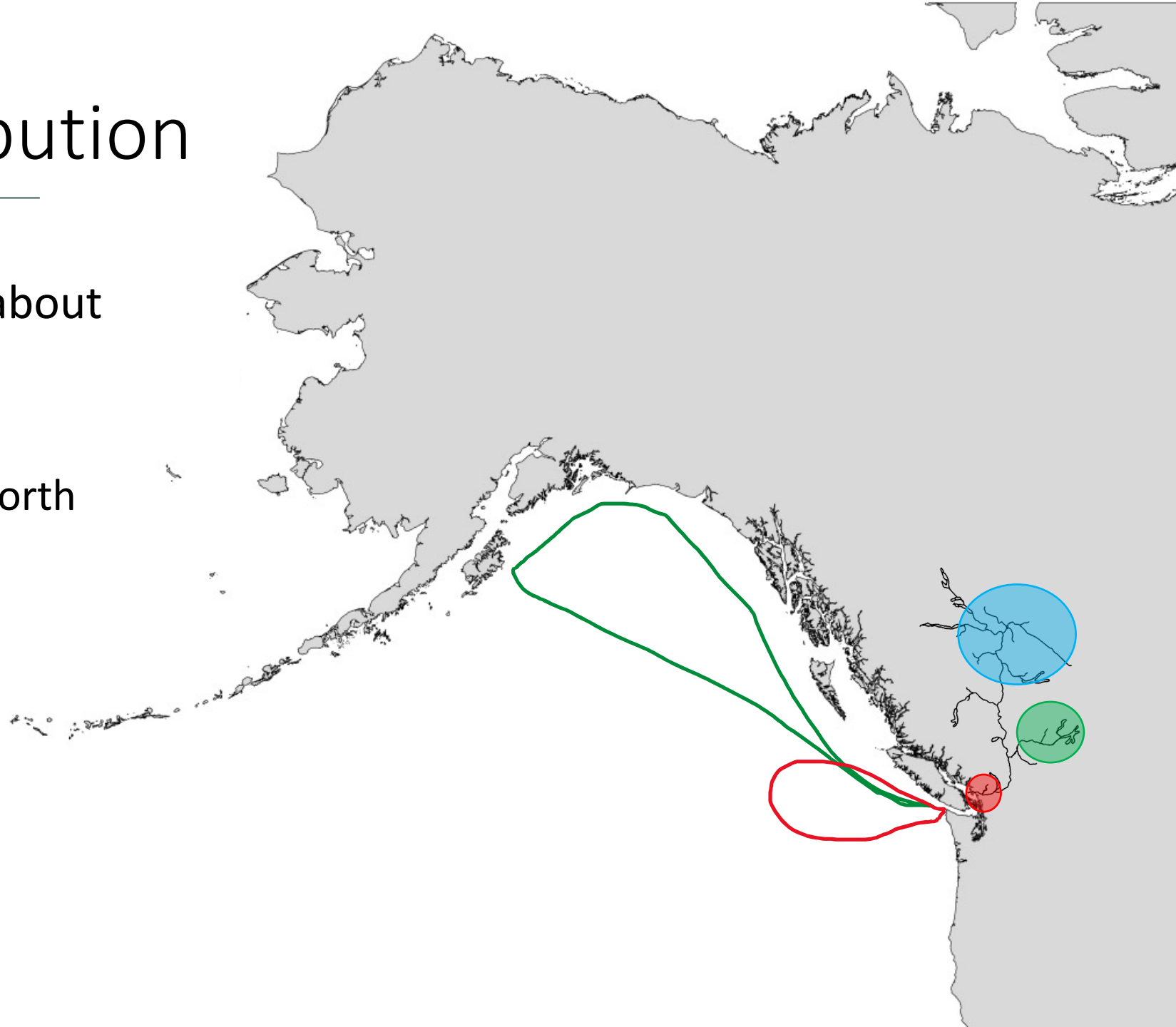
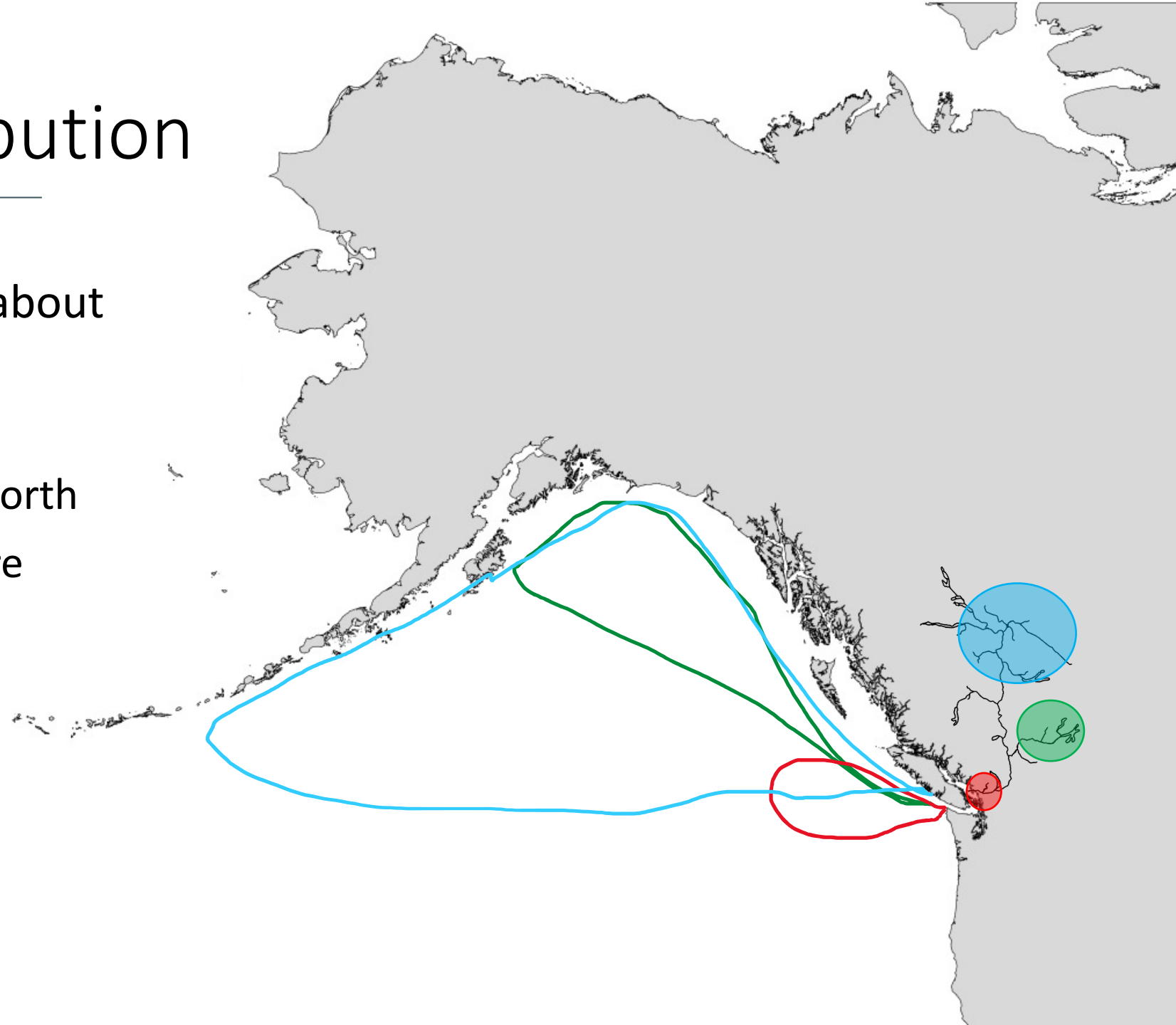
- Fraser Summer 0.3—Far North
- Fraser Spring 1.3



Q1: Marine Distribution

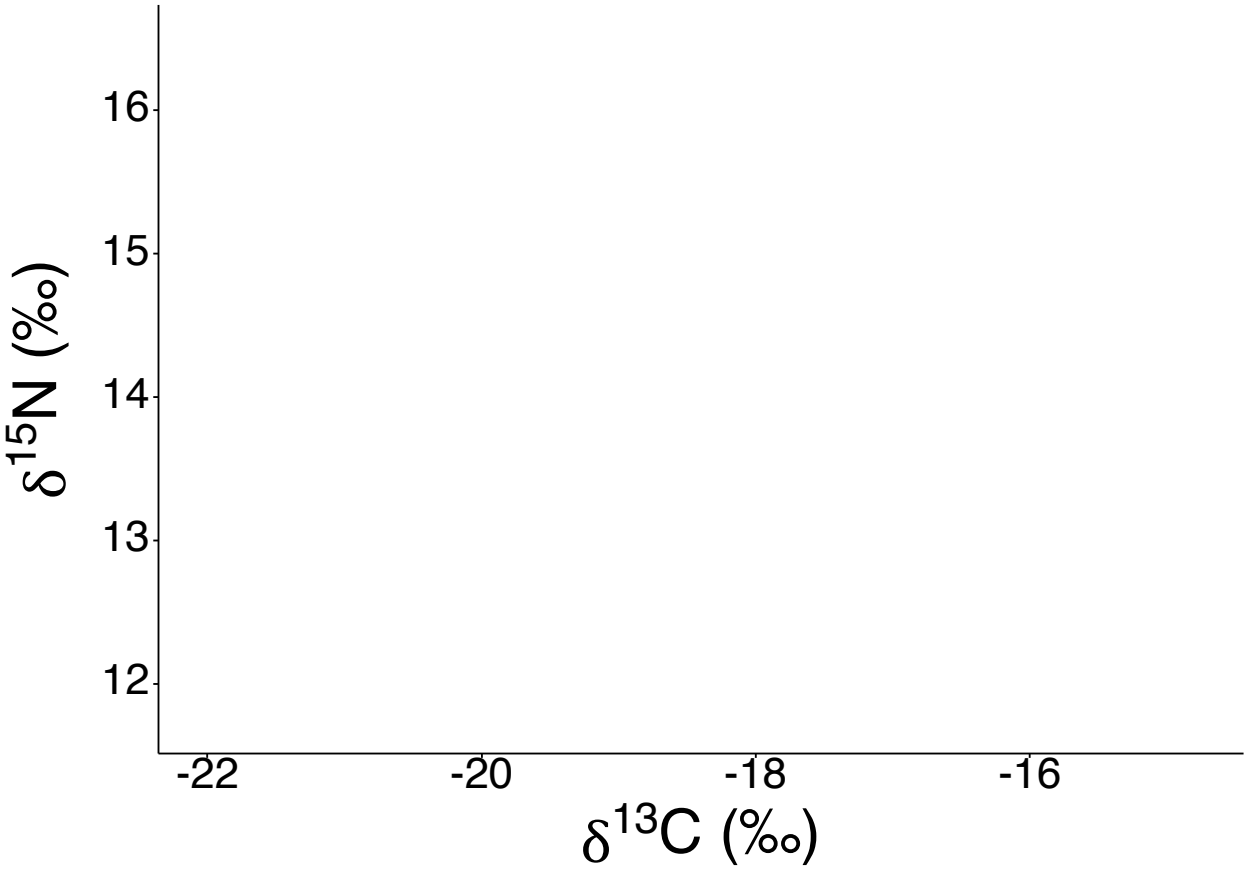
What do we already know about distribution?

- Fraser Fall 0.3—Local
- Fraser Summer 0.3—Far North
- Fraser Spring 1.3—Offshore



Q1: Marine Distribution

Position Chinook stocks in North Pacific isotopic space using known isotope values



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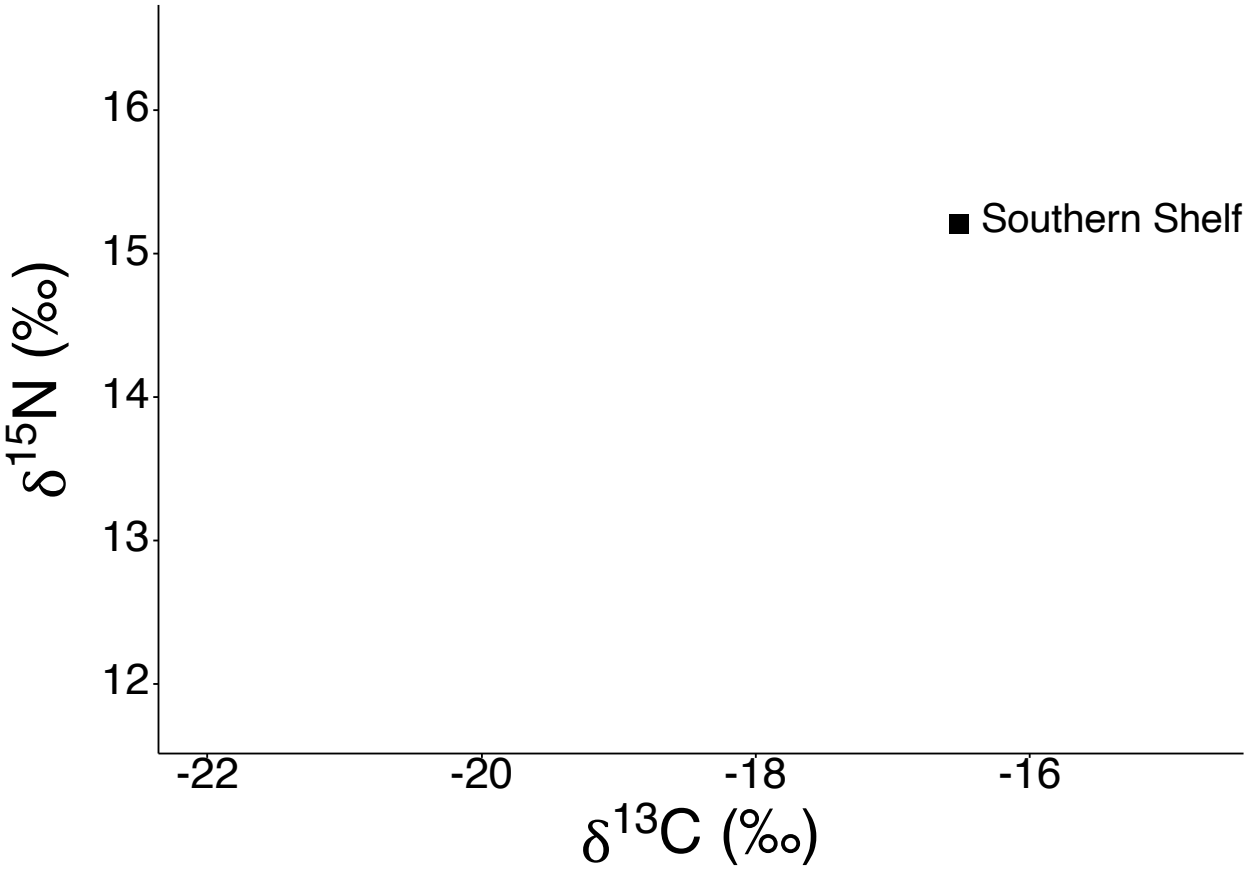
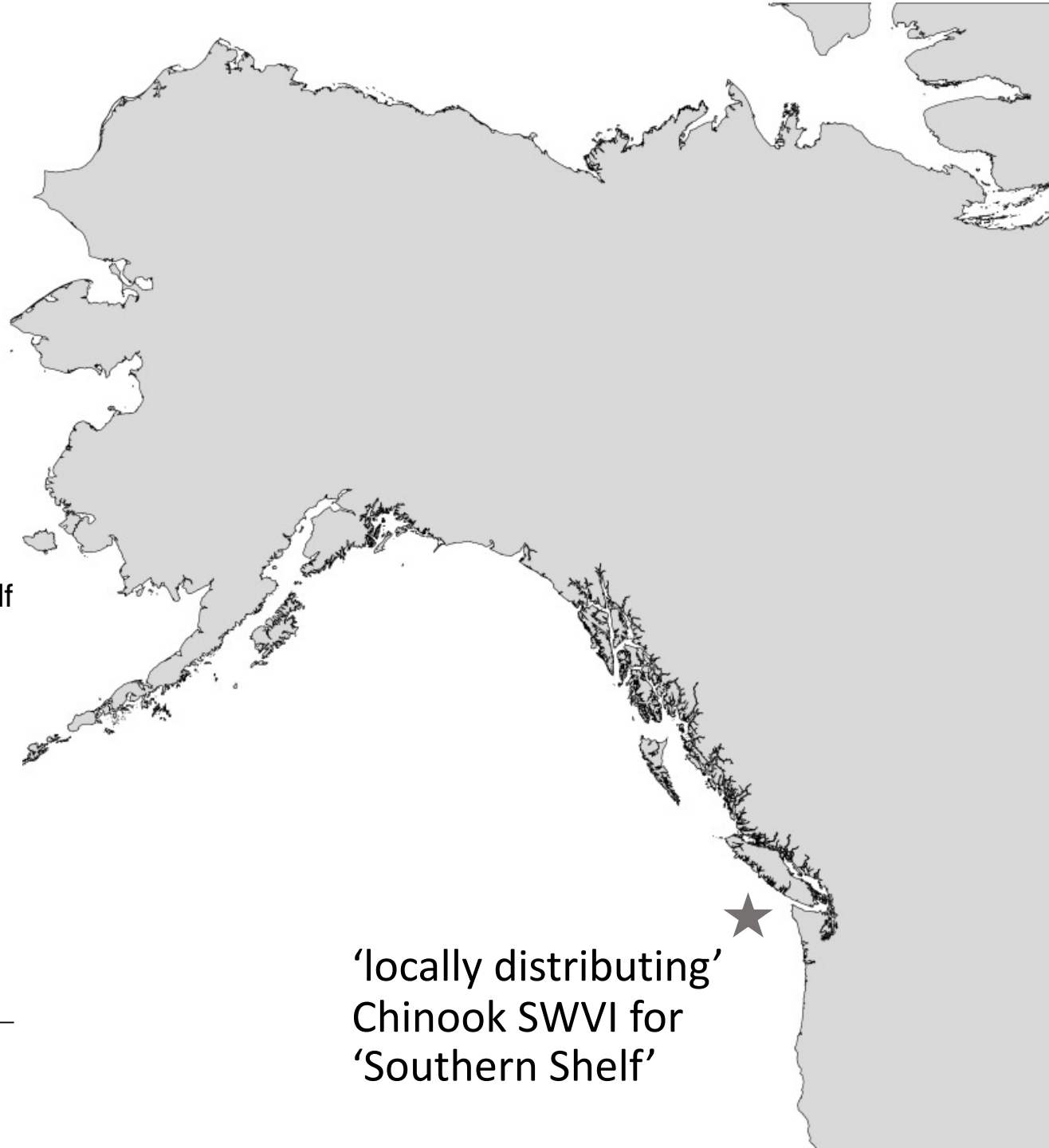
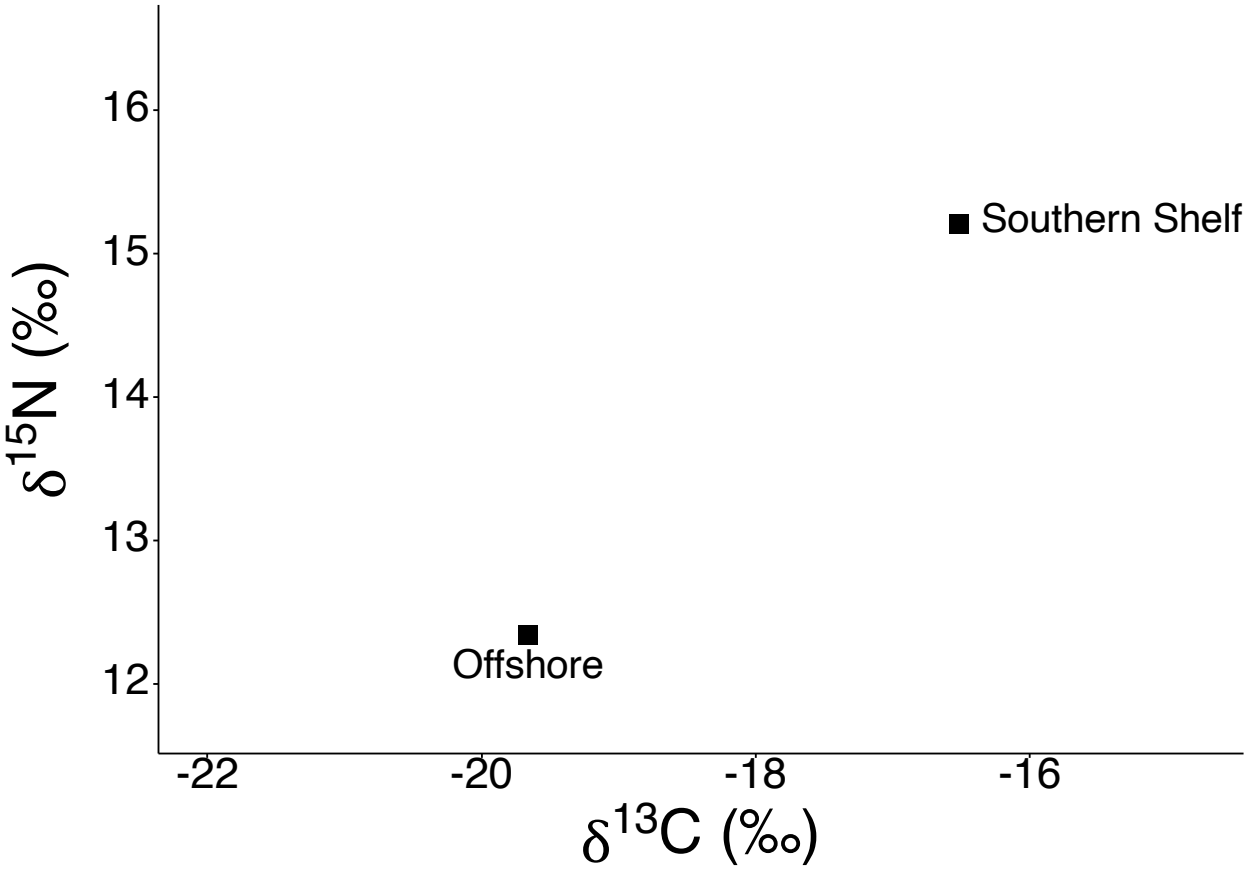




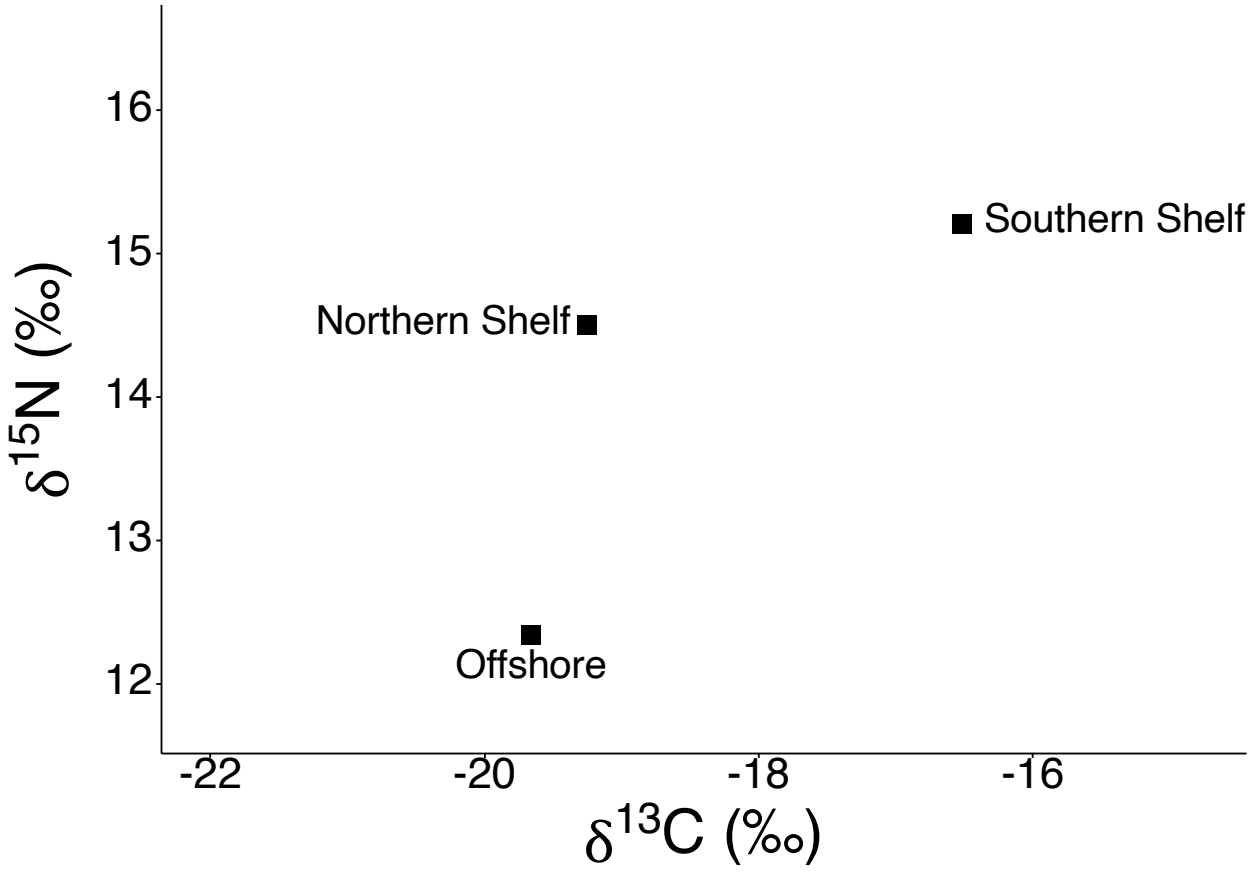
‘locally distributing’ Chinook SWVI for ‘Southern Shelf’

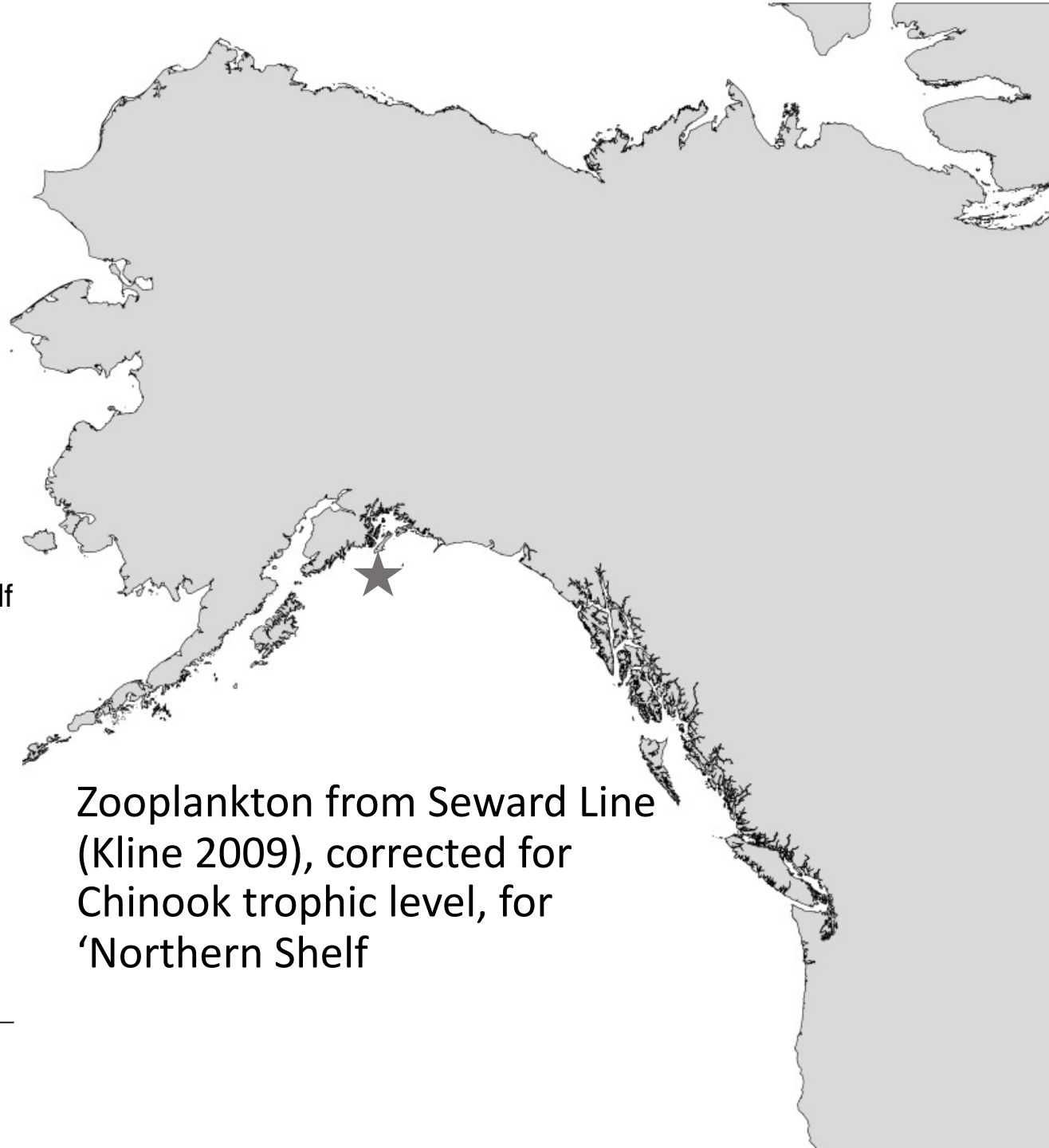
Q1: Marine Distribution



Chinook from Gulf of Alaska for ‘offshore’ isotopic signature

Q1: Marine Distribution





Zooplankton from Seward Line (Kline 2009), corrected for Chinook trophic level, for ‘Northern Shelf

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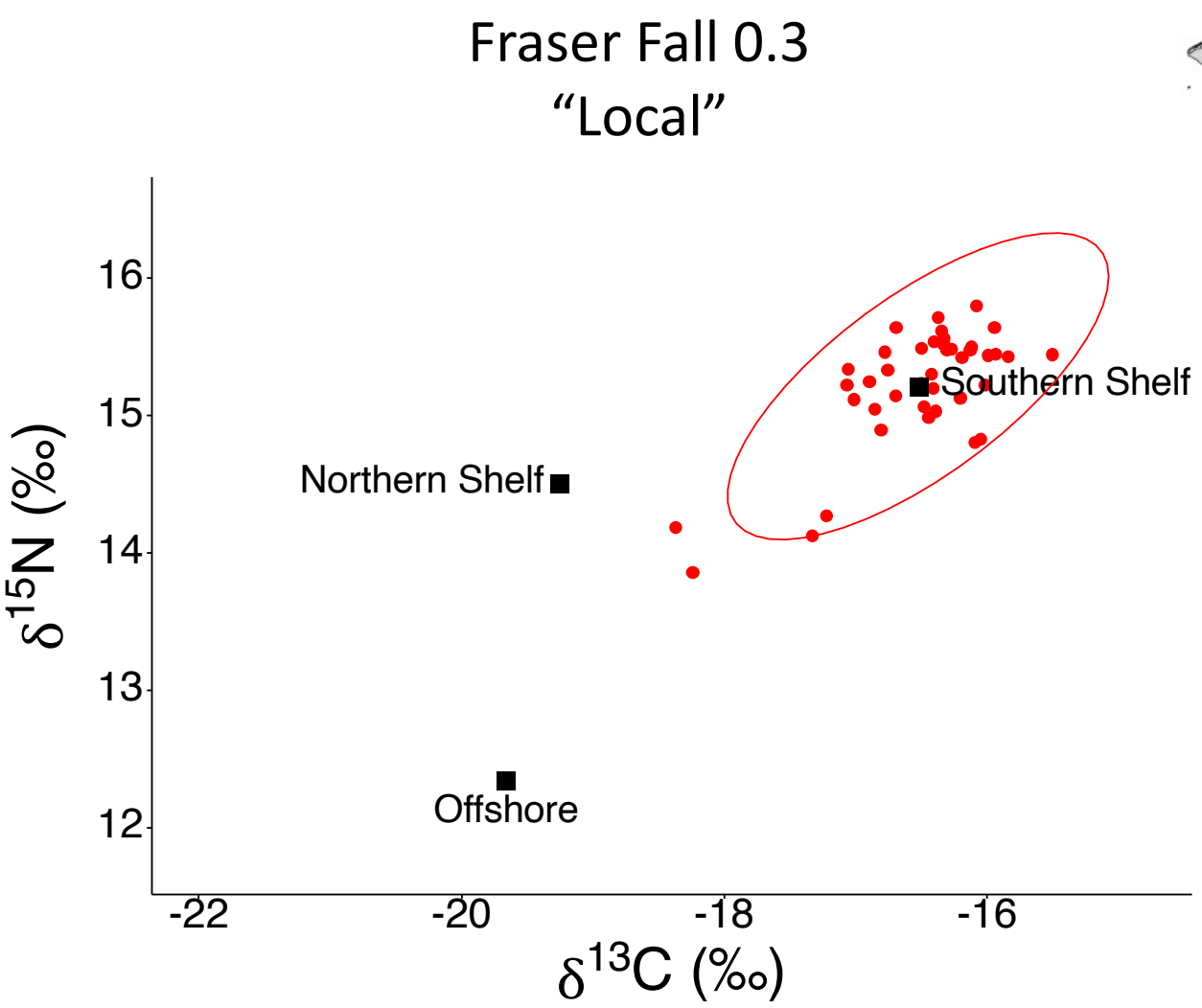

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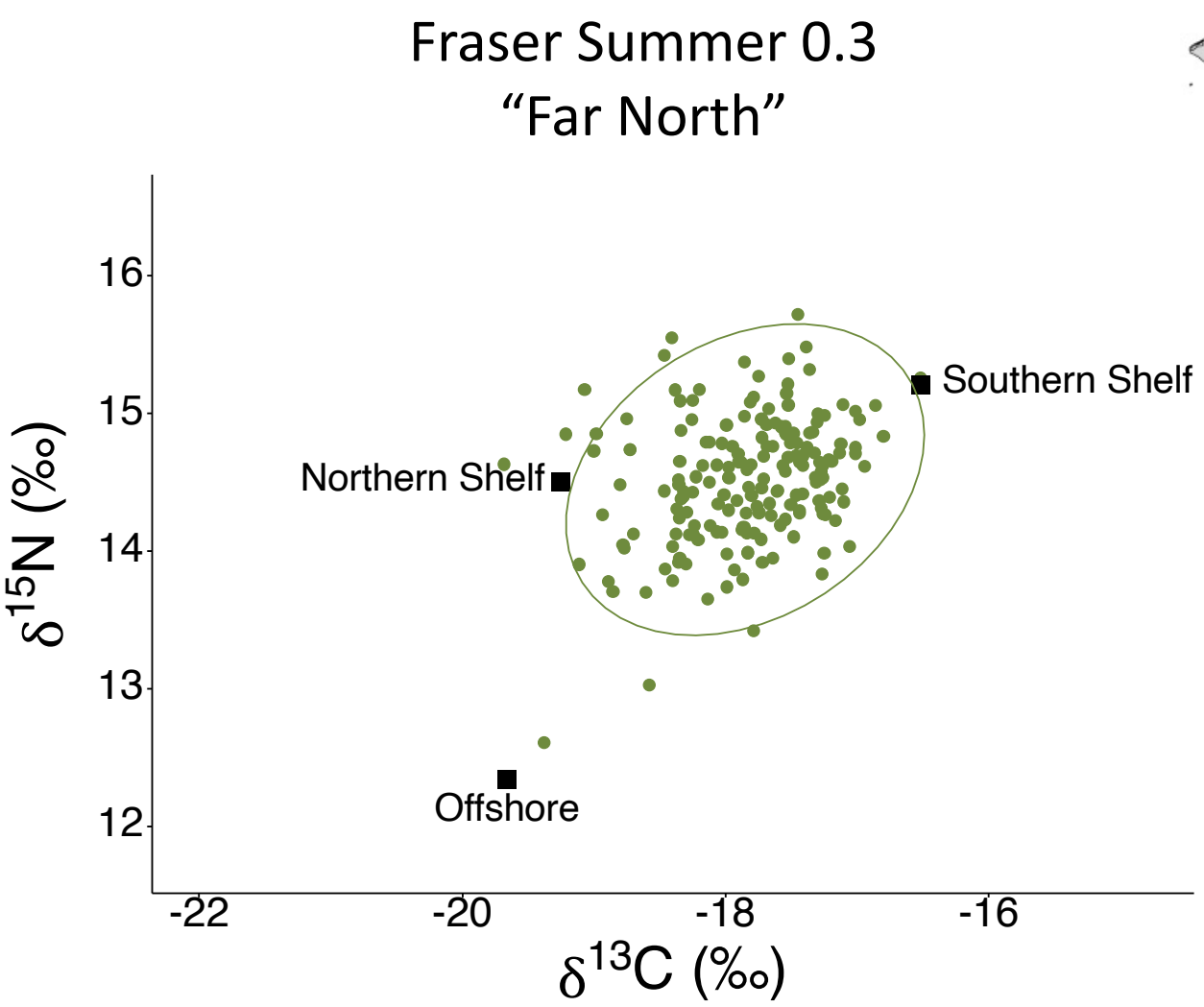
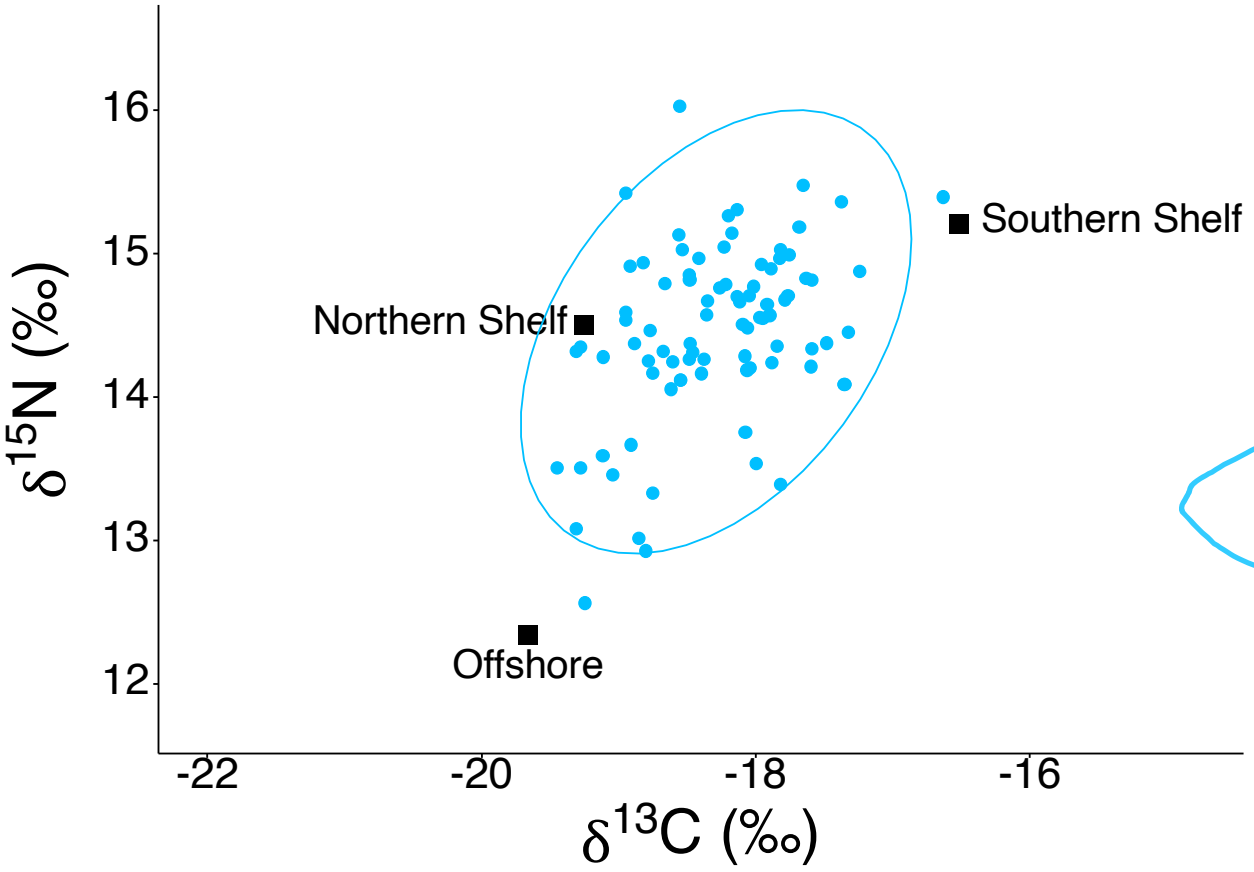
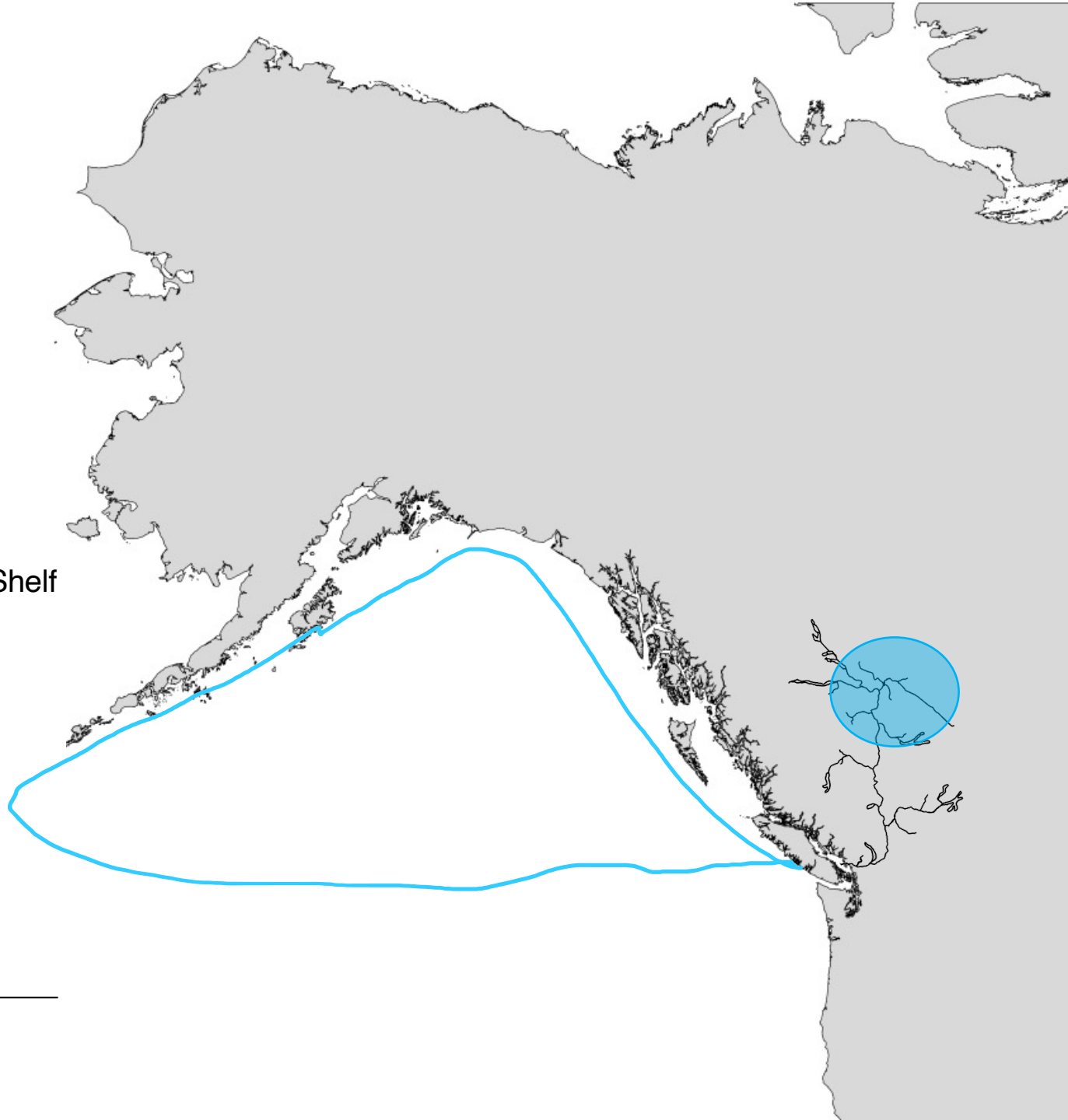


Q1: Marine Distribution

Fraser Spring 1.3
"Offshore"





Q1: Main Takeaways

1) Isotopes used to validate Chinook marine distribution

2) Heavy use of southern shelf
Fraser Fall 0.3

3) Limited use of offshore habitat for Fraser Spring 1.3 populations

Questions

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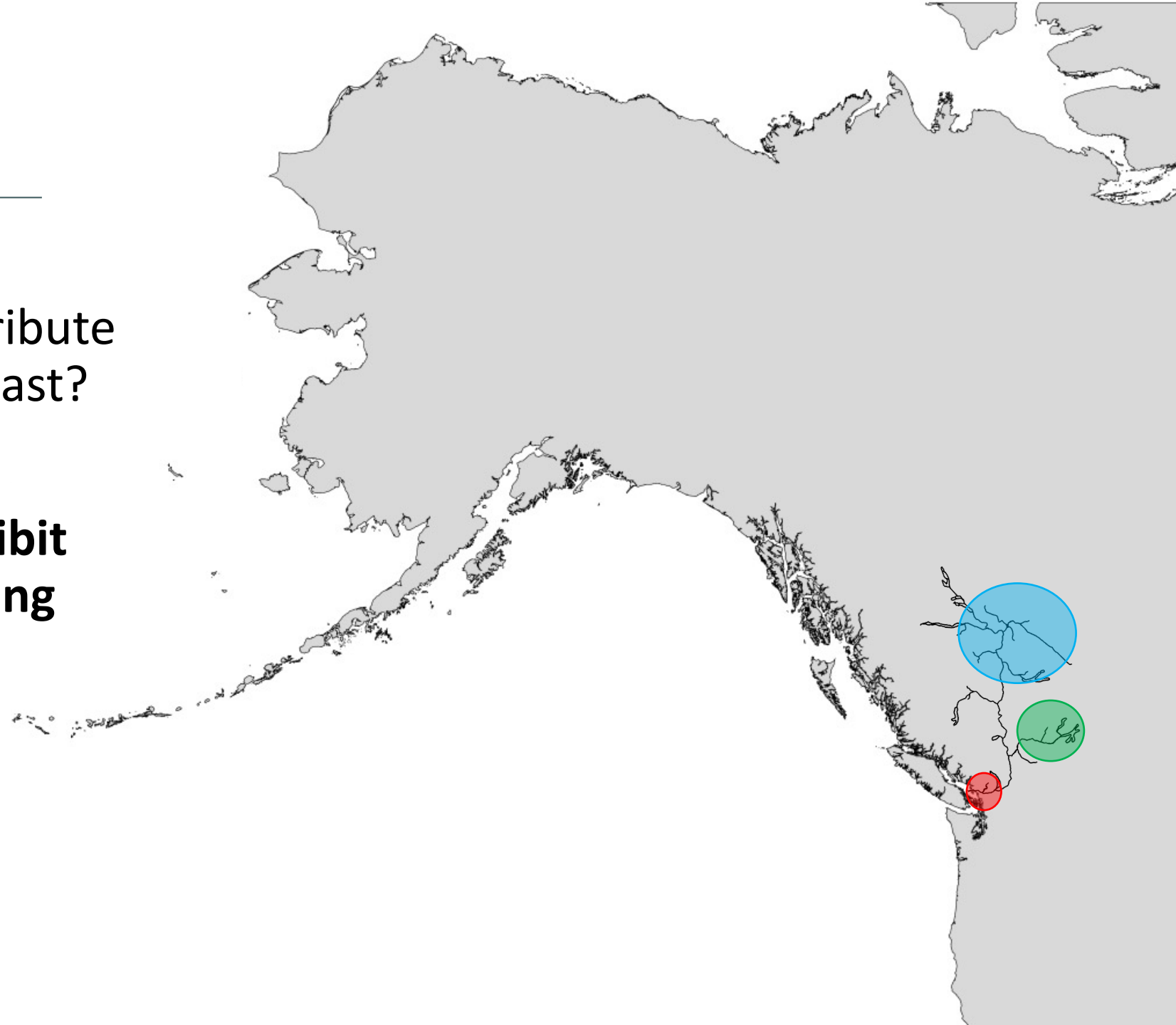
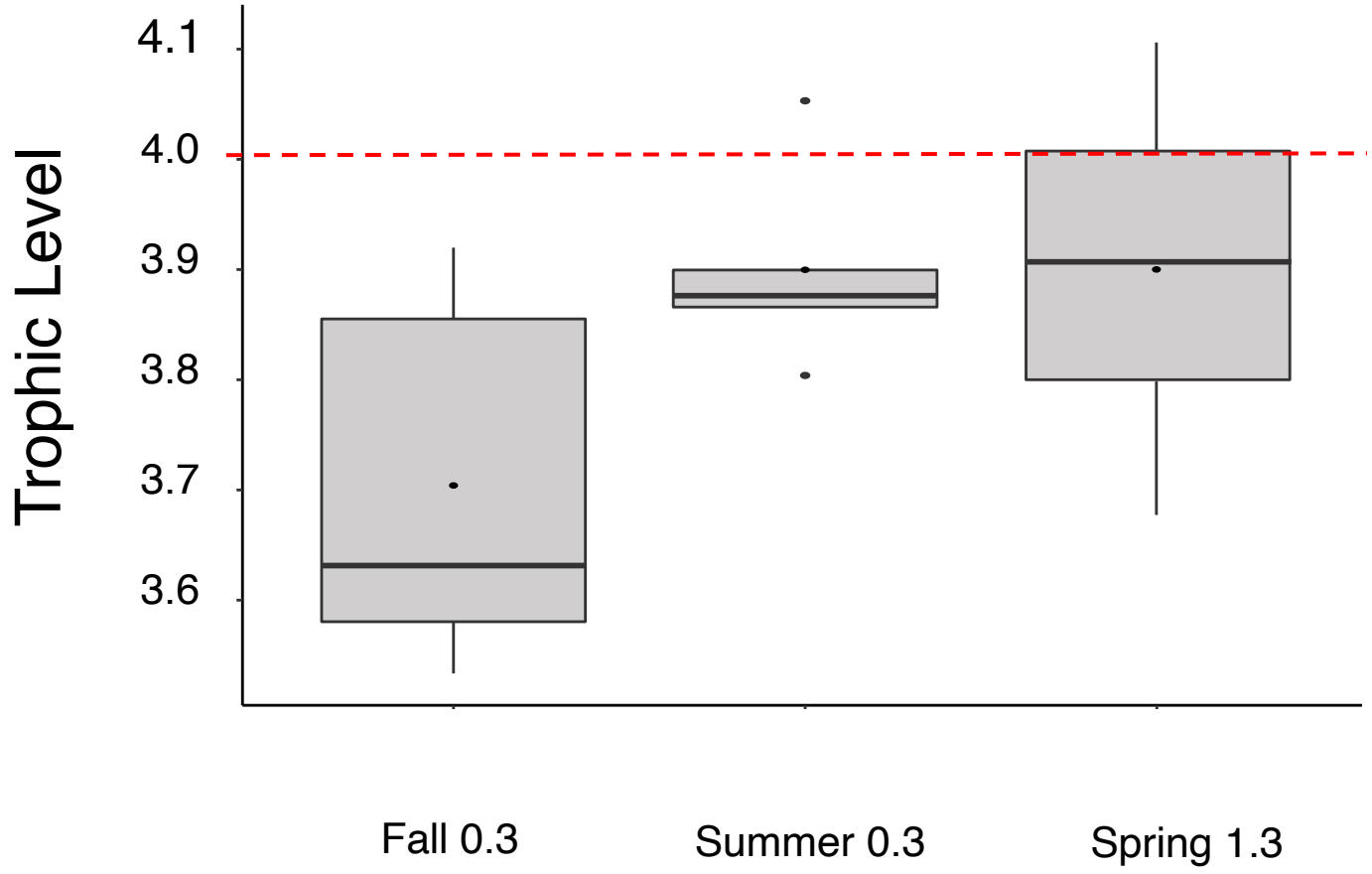
2. **Do Chinook stocks exhibit different marine foraging behaviors?**

3. How does this impact Chinook energy accumulation?



Q2: Marine Foraging

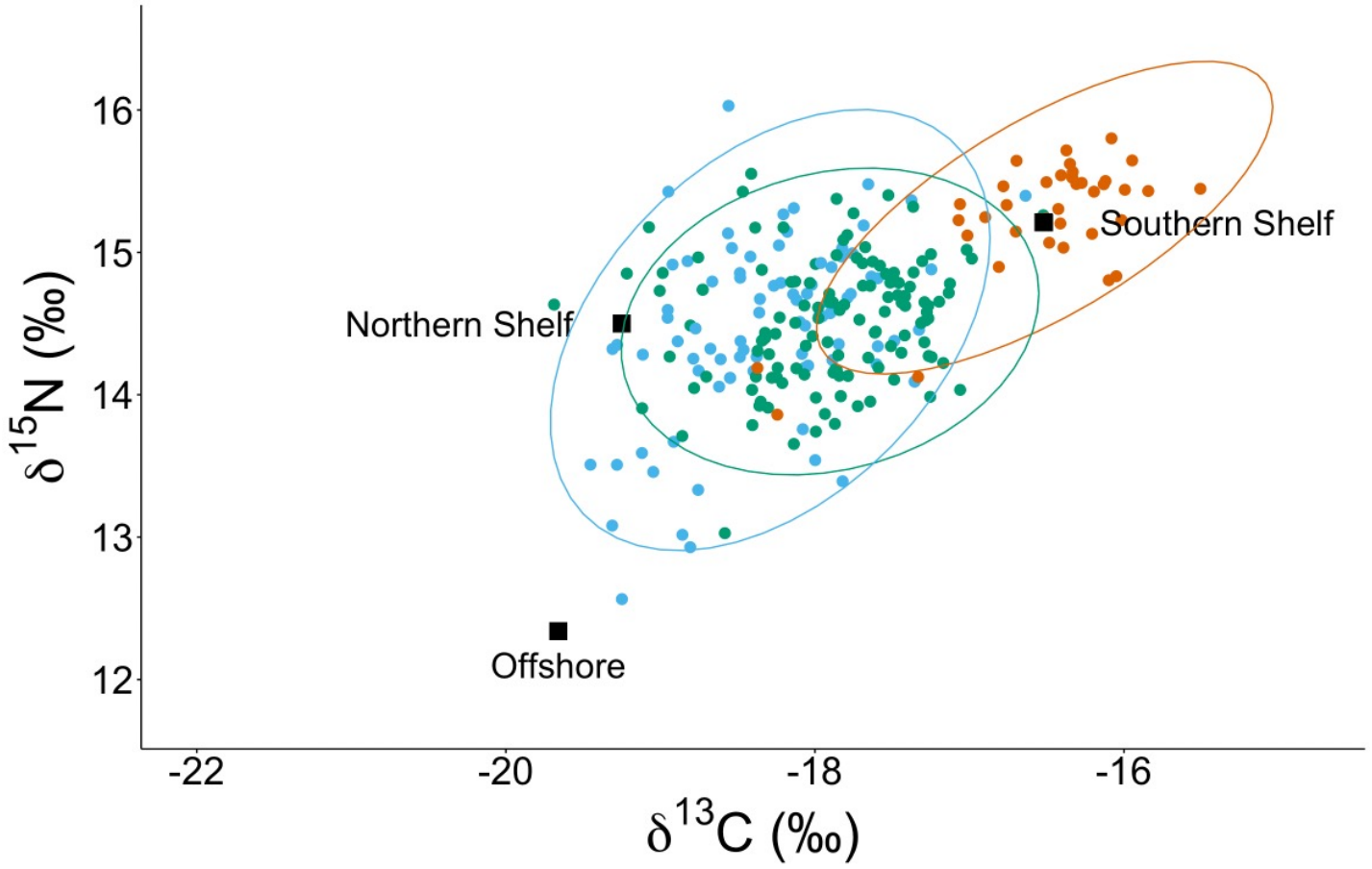


Q2: Marine Foraging

What do the size of the ellipses themselves tell us?

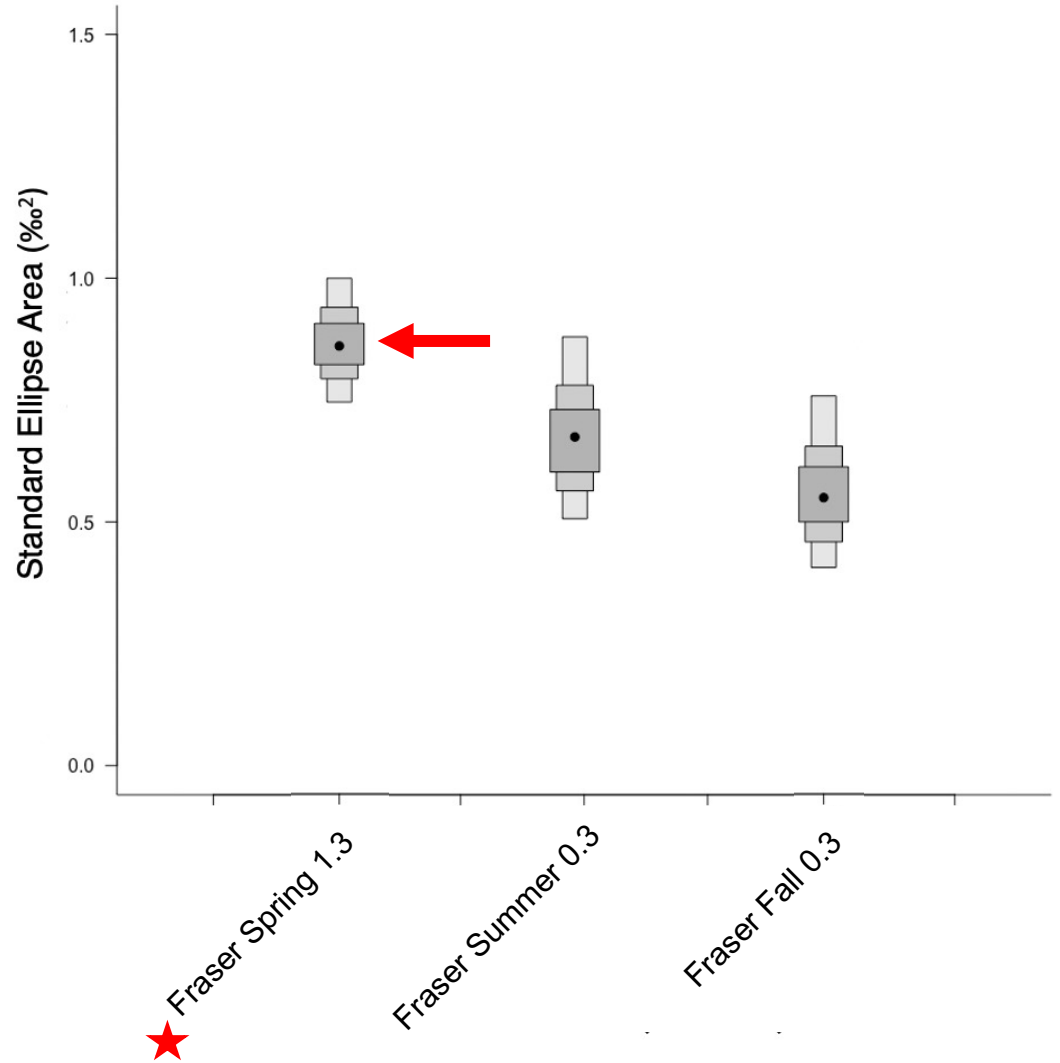
Ellipse = isotopic niche

Large niche = Large habitat diversity



Q2: Marine Foraging

Significant differences in a population's niche size



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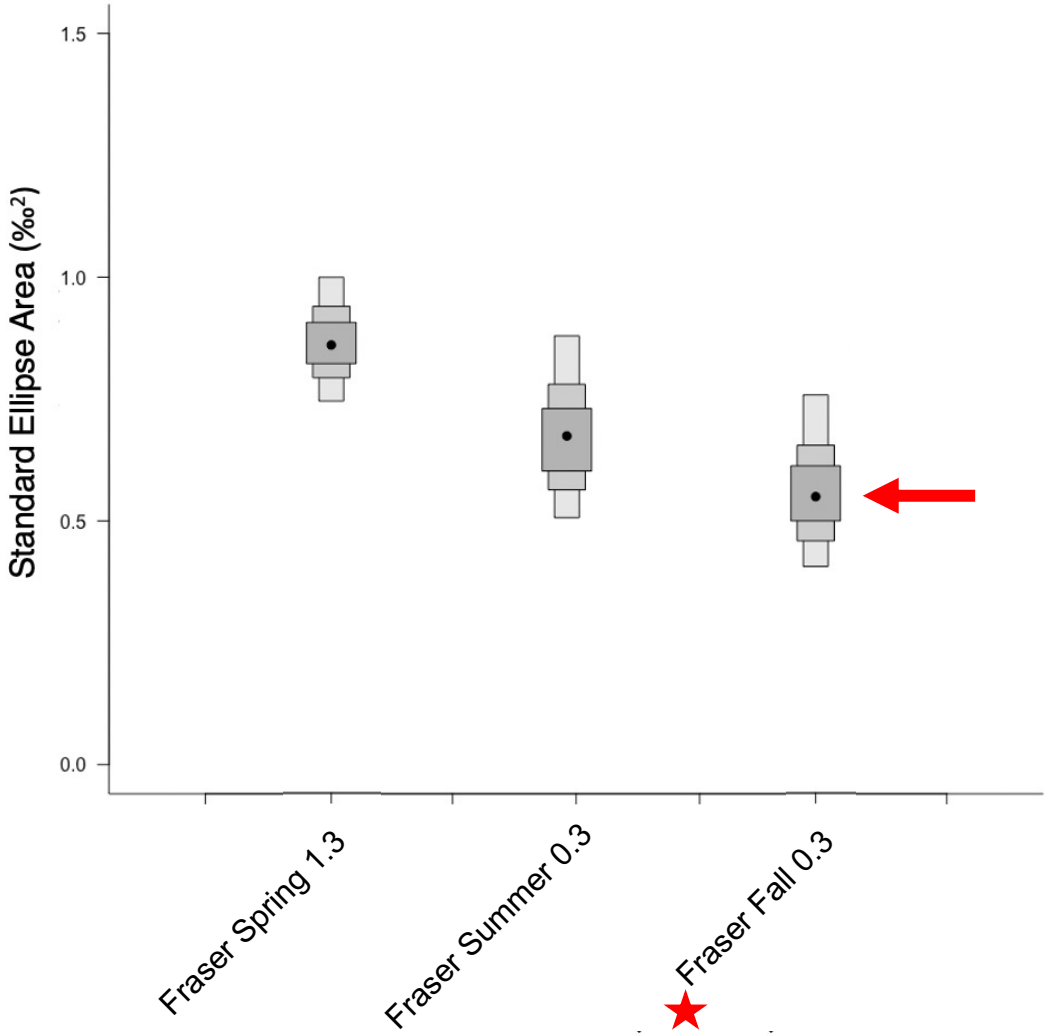
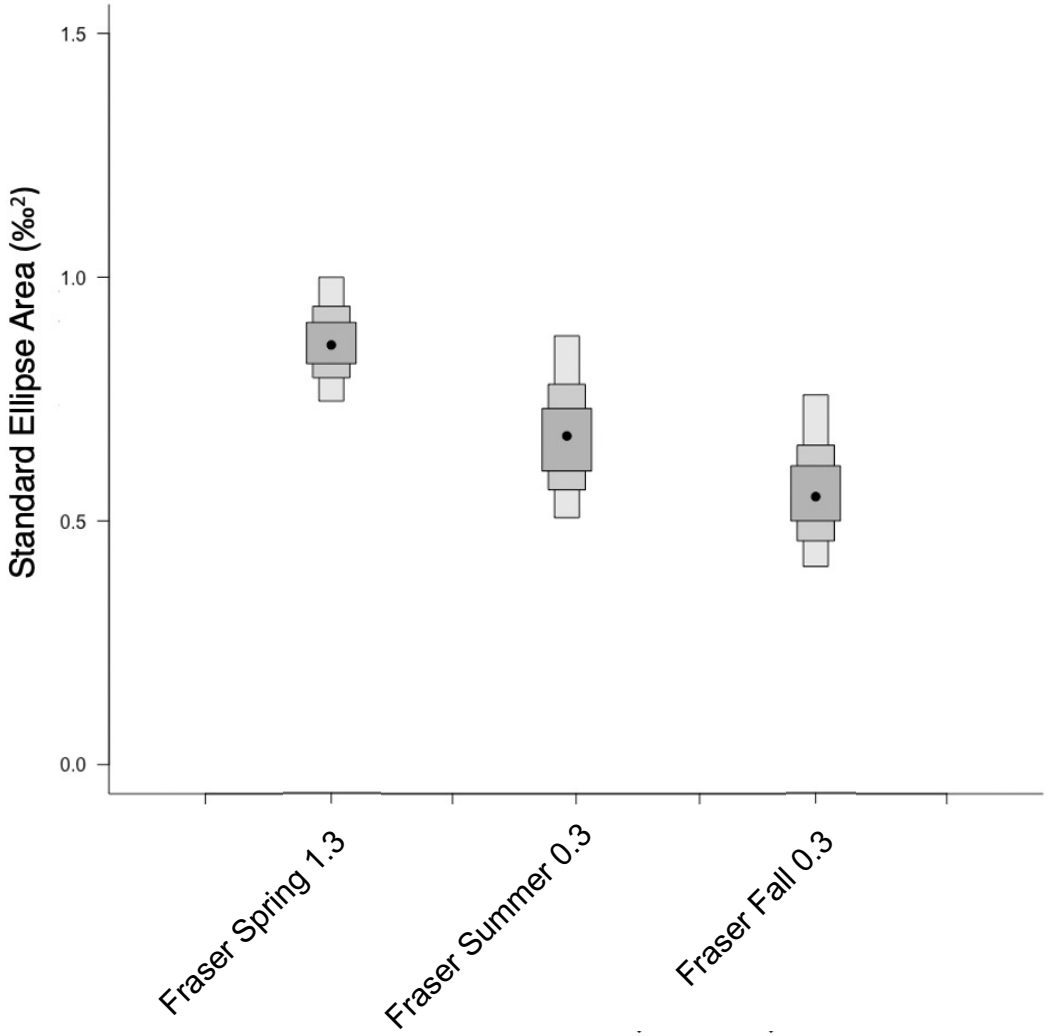


Q2: Marine Foraging

Marine portfolio effect

- More diverse marine habitat = larger niche size
- May buffer populations from effects of changing ocean conditions



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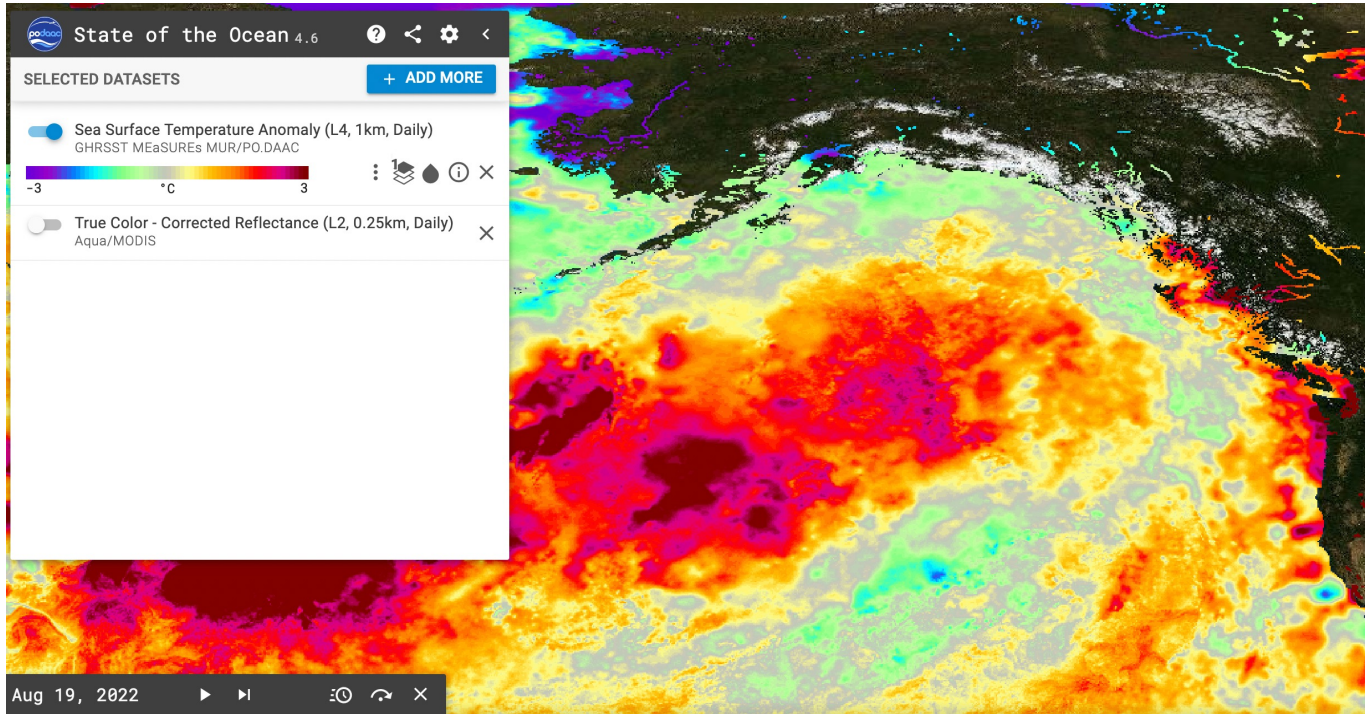

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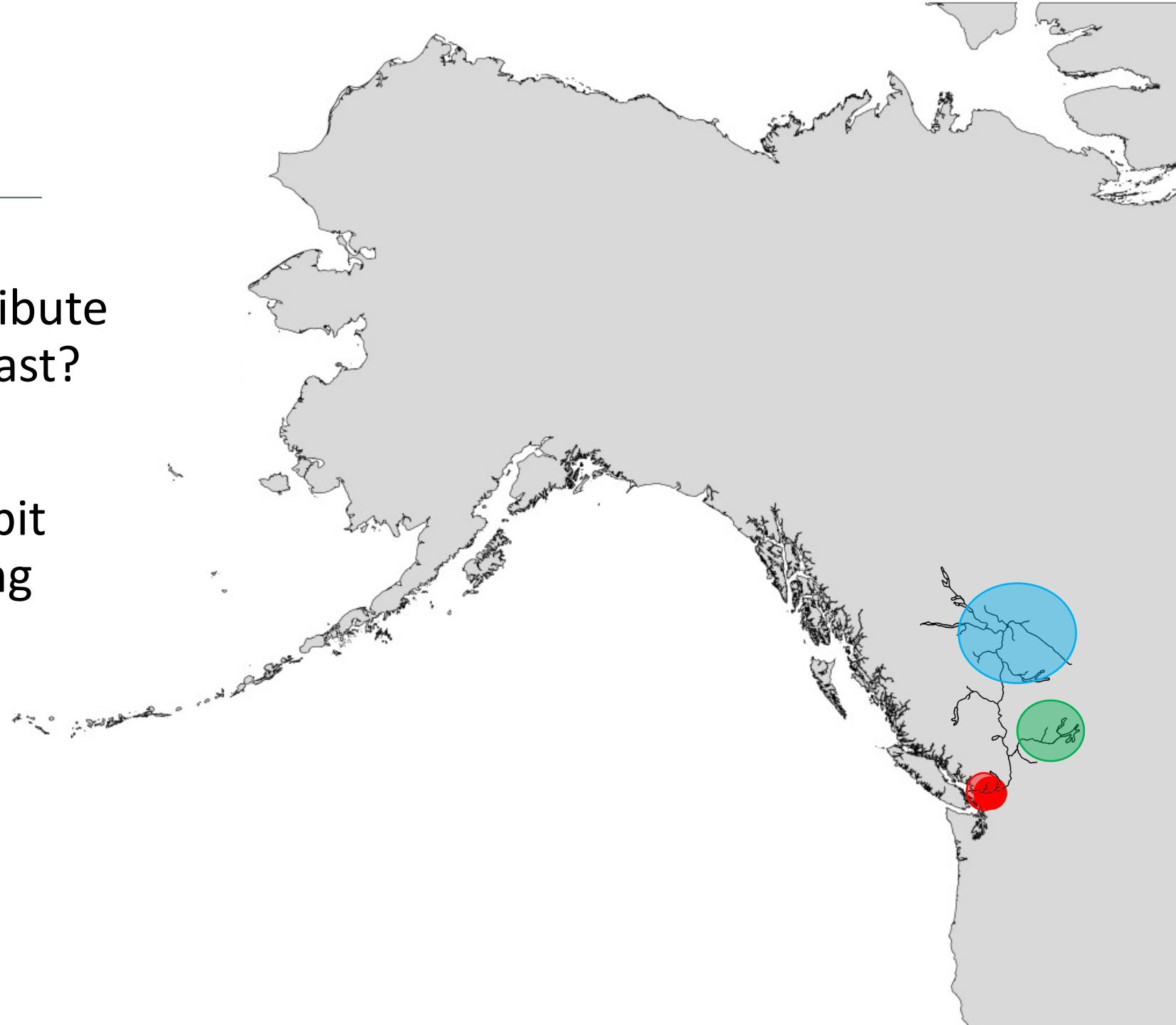
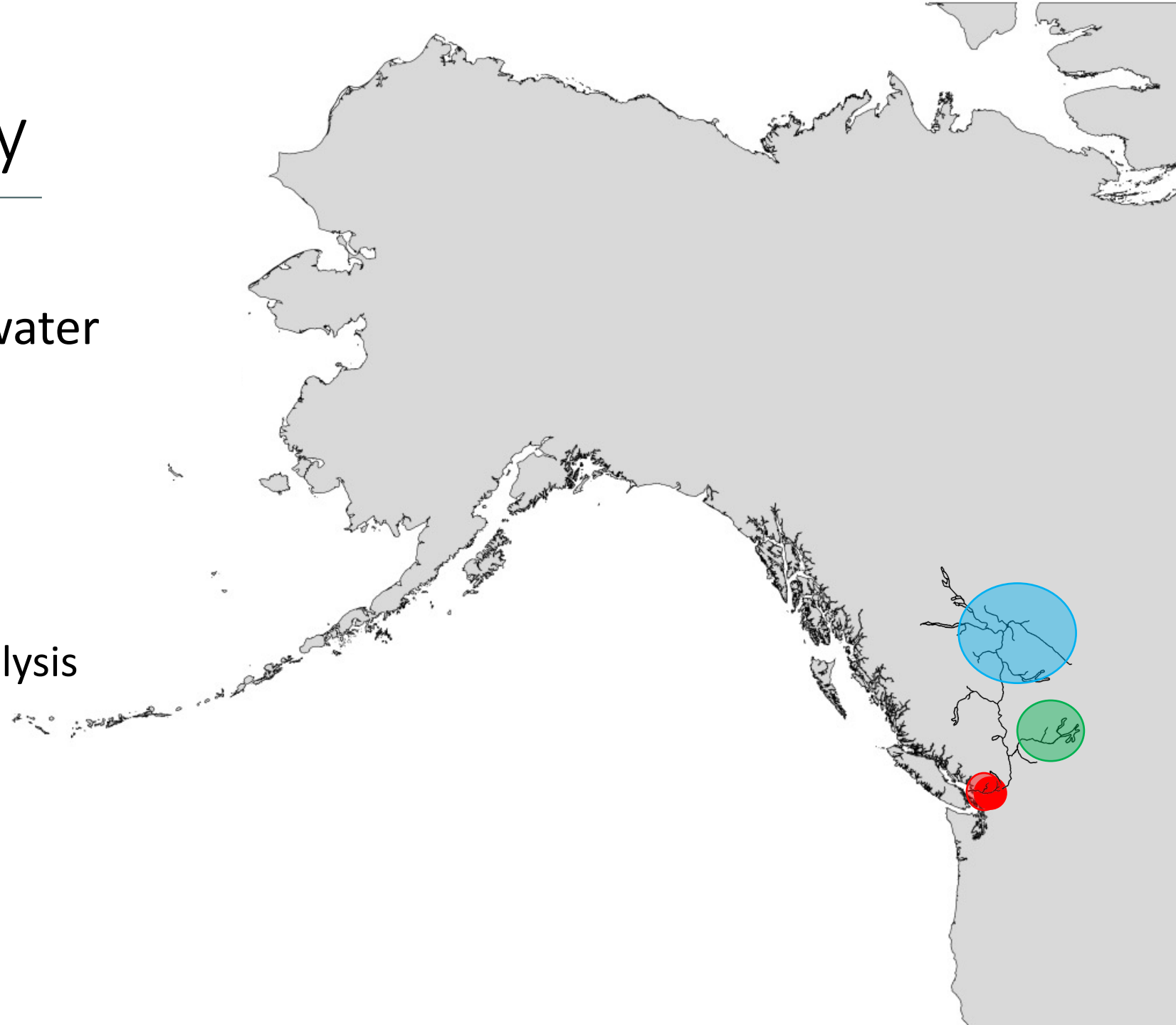


Q3: Marine Energy

Sampled Chinook at freshwater entry—Albion Test Fishery

- Weight/length/sex
- Genetic stock identification
- Energy-lipid content
- Muscle for stable isotope analysis



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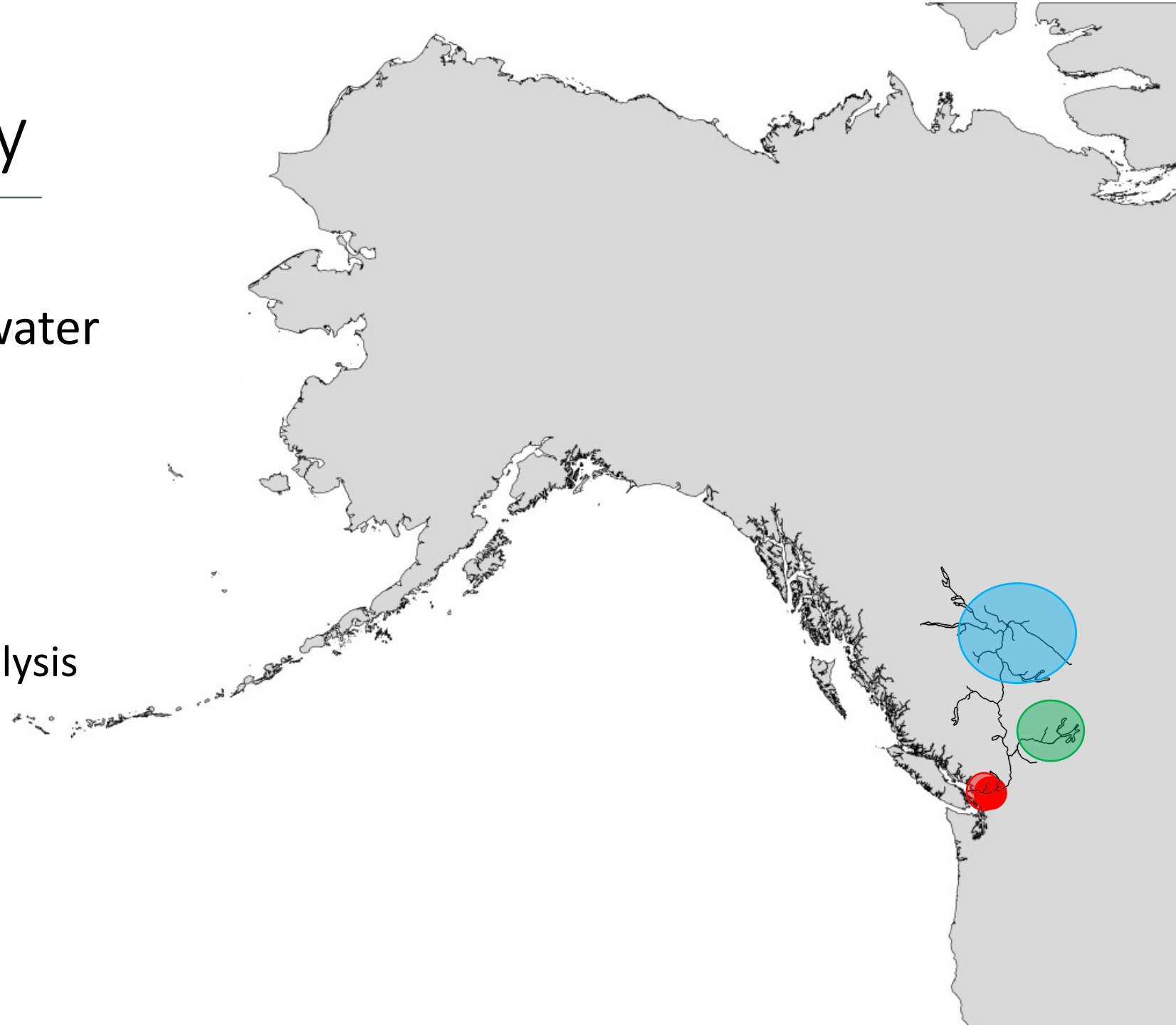

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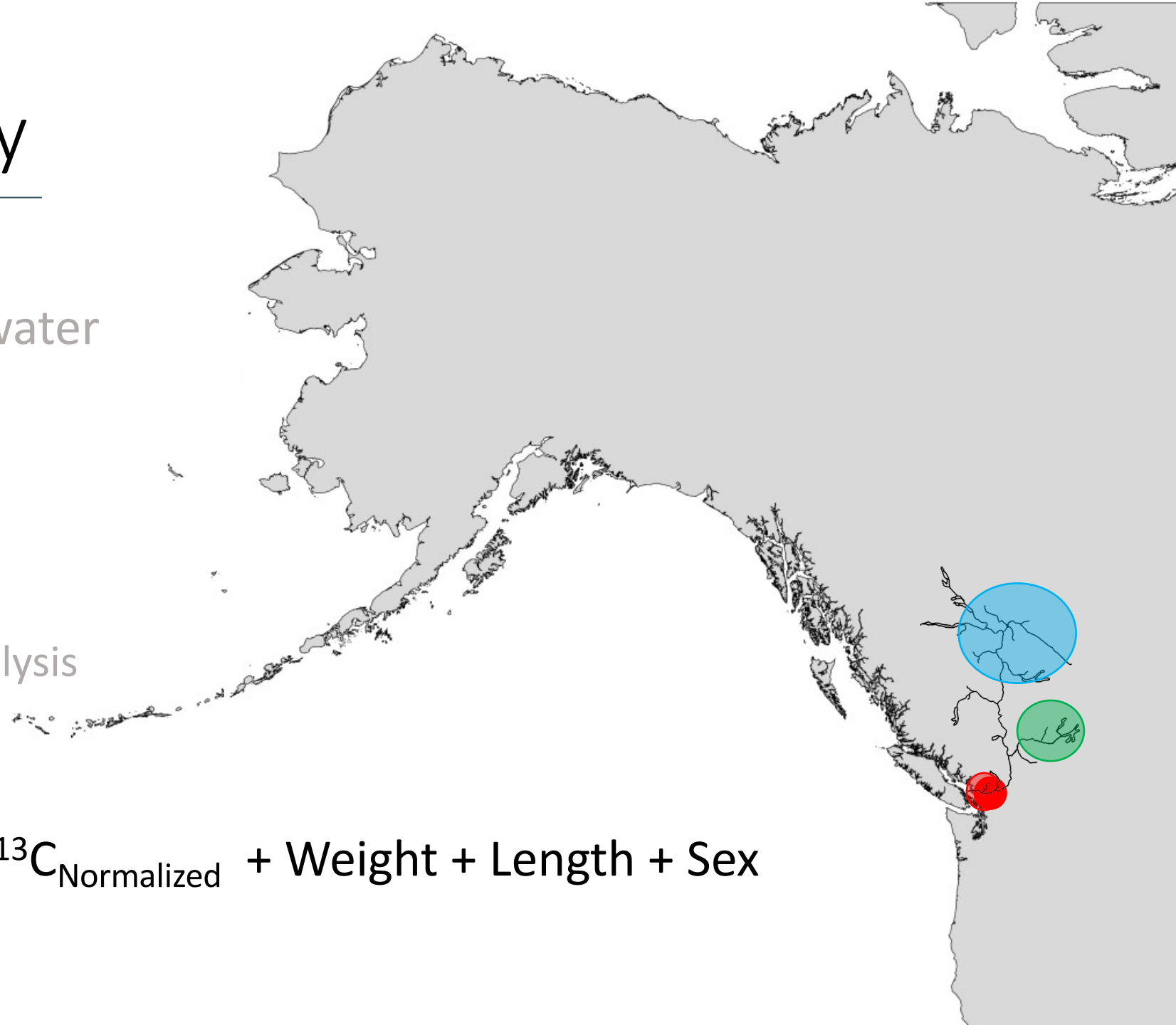

Lipid Content ~ $\delta^{15}N + \delta^{13}C_{Normalized}$ + Weight + Length + Sex

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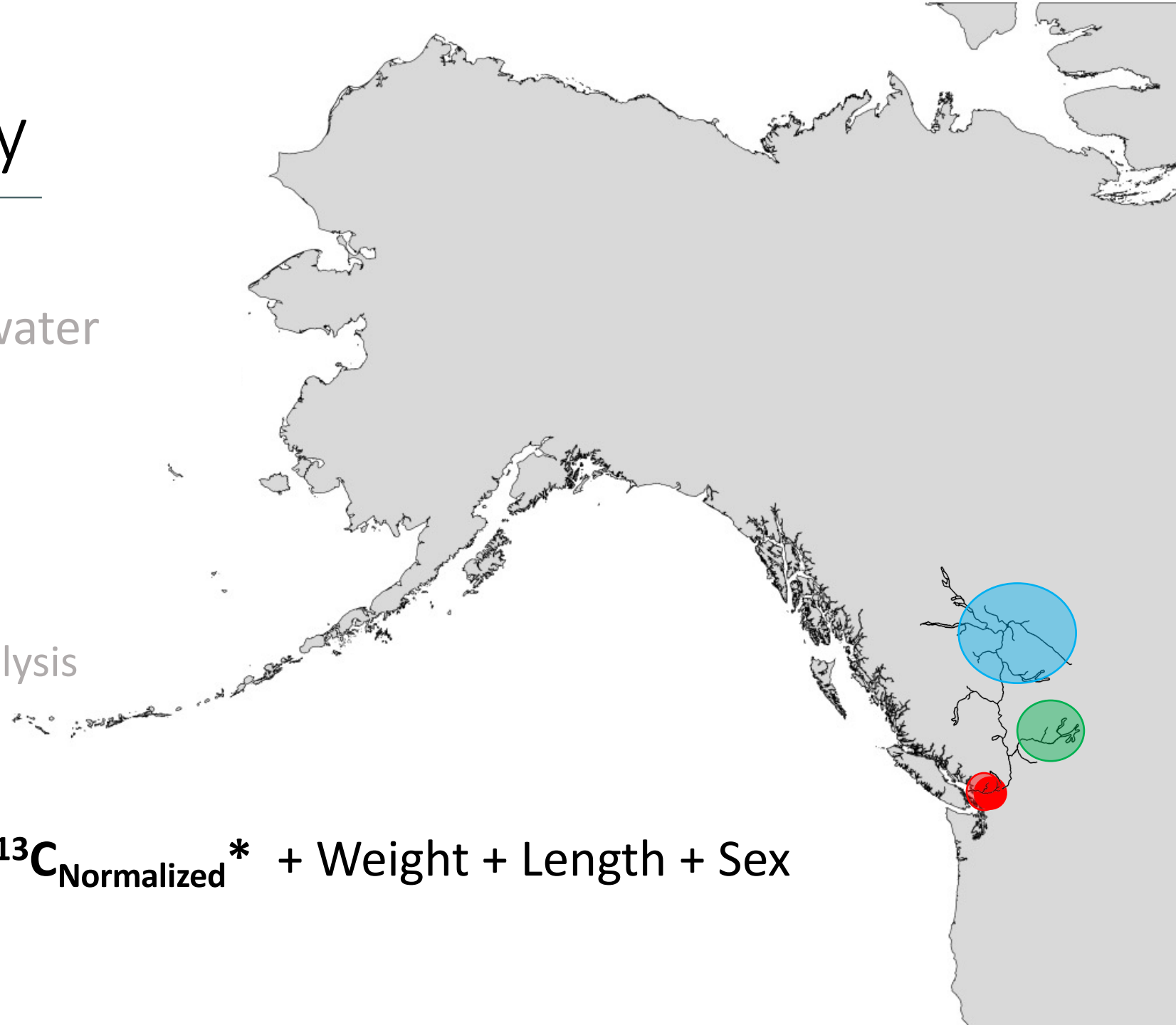

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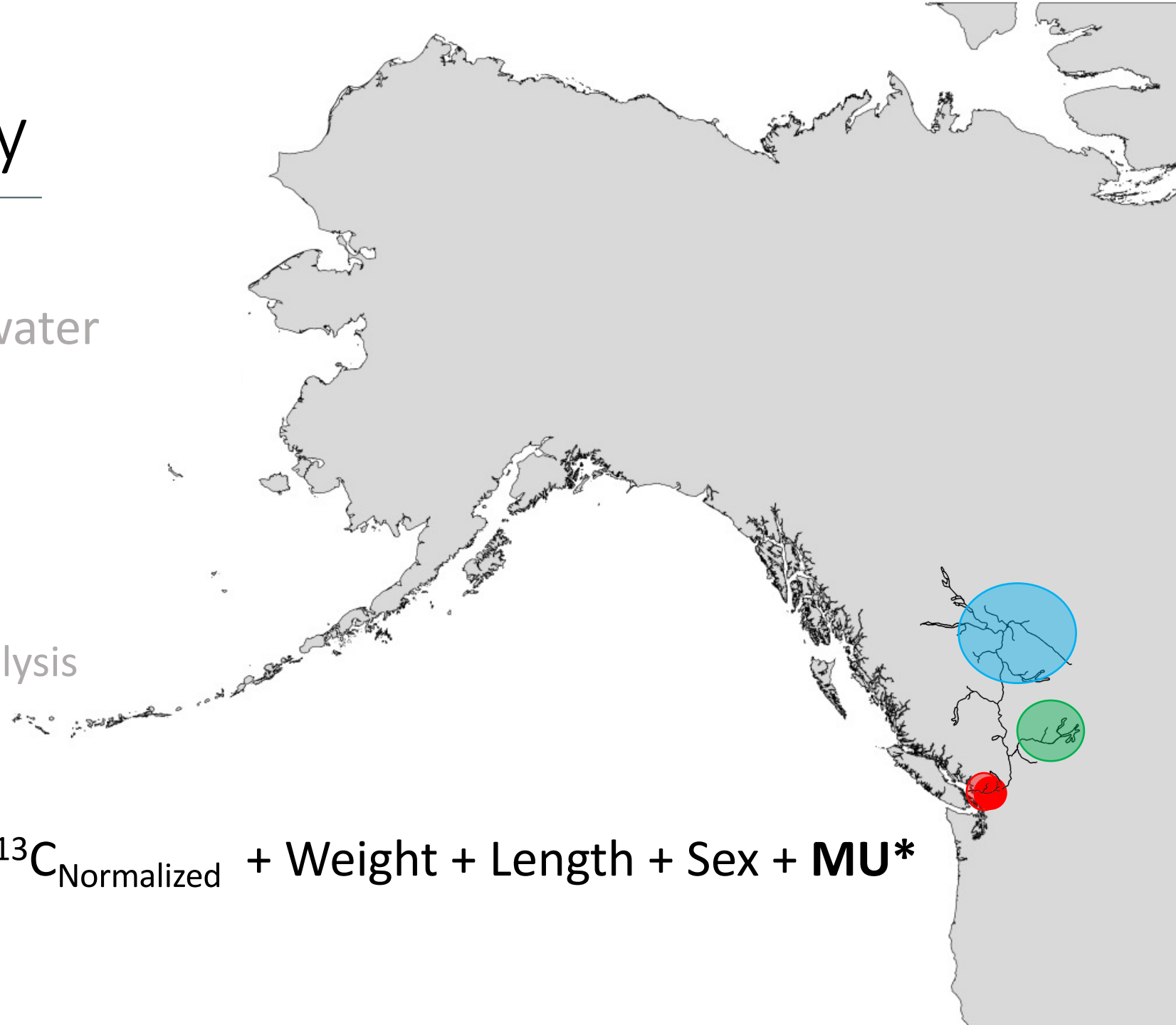


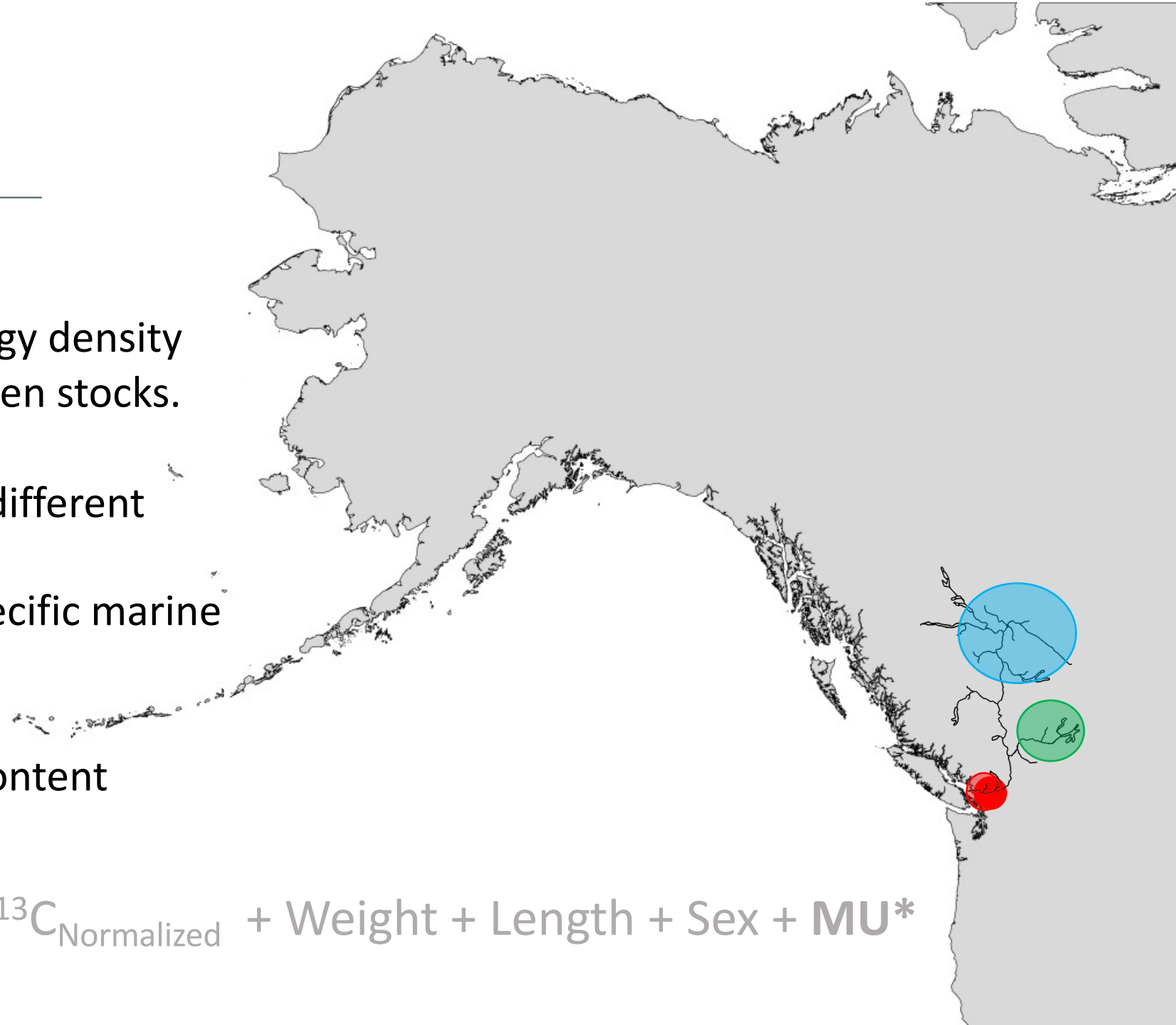
Lipid Content ~ $\delta^{15}N + \delta^{13}C_{Normalized}$ + Weight + Length + Sex + **MU***

Q3: Takeaways

1) Differences in Chinook energy density driven by differences between stocks.

2) Fattiest fish are foraging in different environments
   - May just reflect stock-specific marine distribution

3) No effect of $\delta^{15}N$ on lipid content



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   - Validate existing knowledge
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2) Indicate trophic ecology can vary between populations
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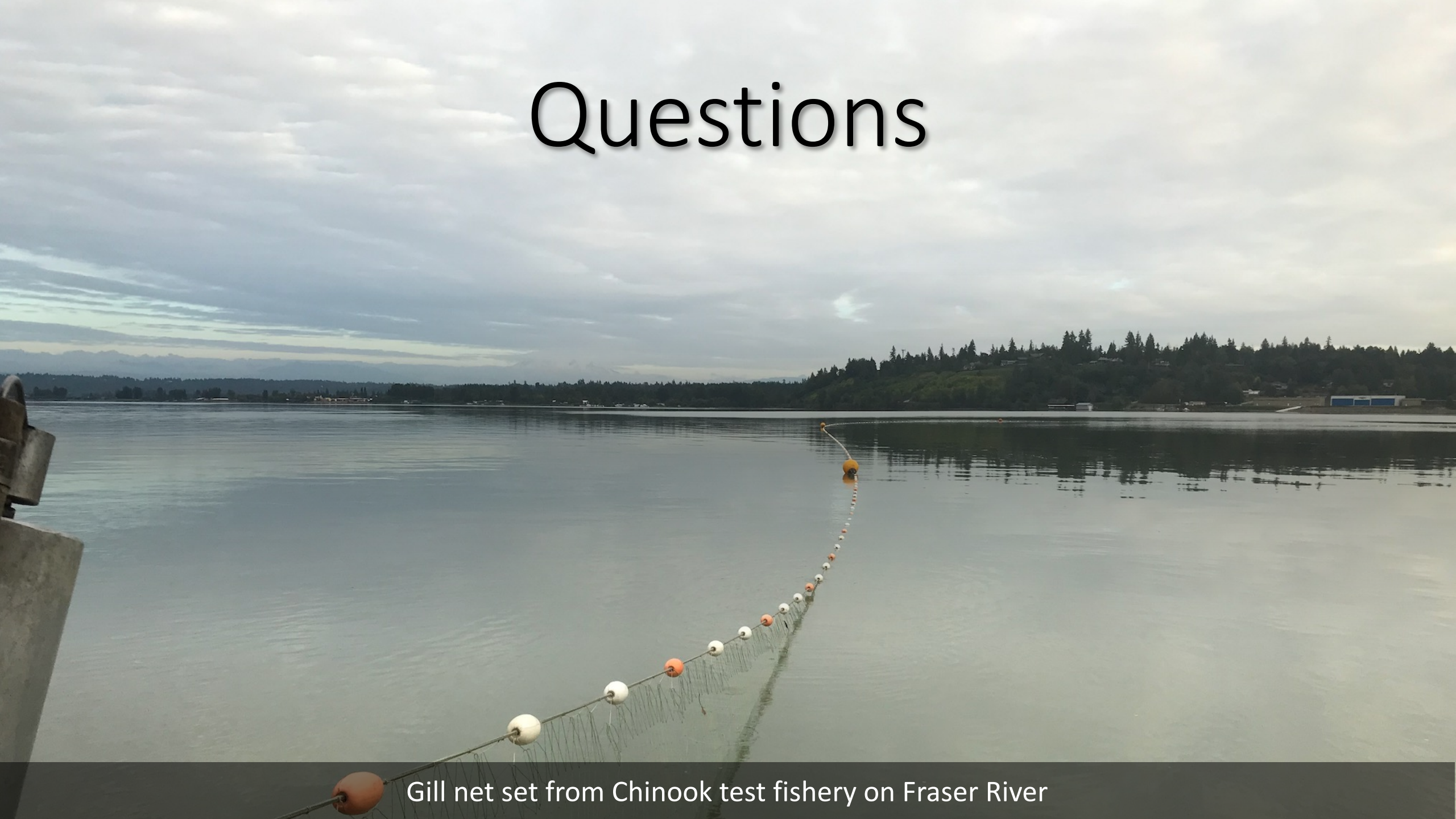
Stable isotopes:

1) Inform Chinook marine distributions
   - Validate existing knowledge
   - Inform knowledge gaps

2) Indicate trophic ecology can vary between populations
   - Reveal stock specific marine habitat diversity—marine portfolio effect

3) Fattiest fish are foraging in different environments - likely due to differences stock-specific marine distribution

Questions



Gill net set from Chinook test fishery on Fraser River