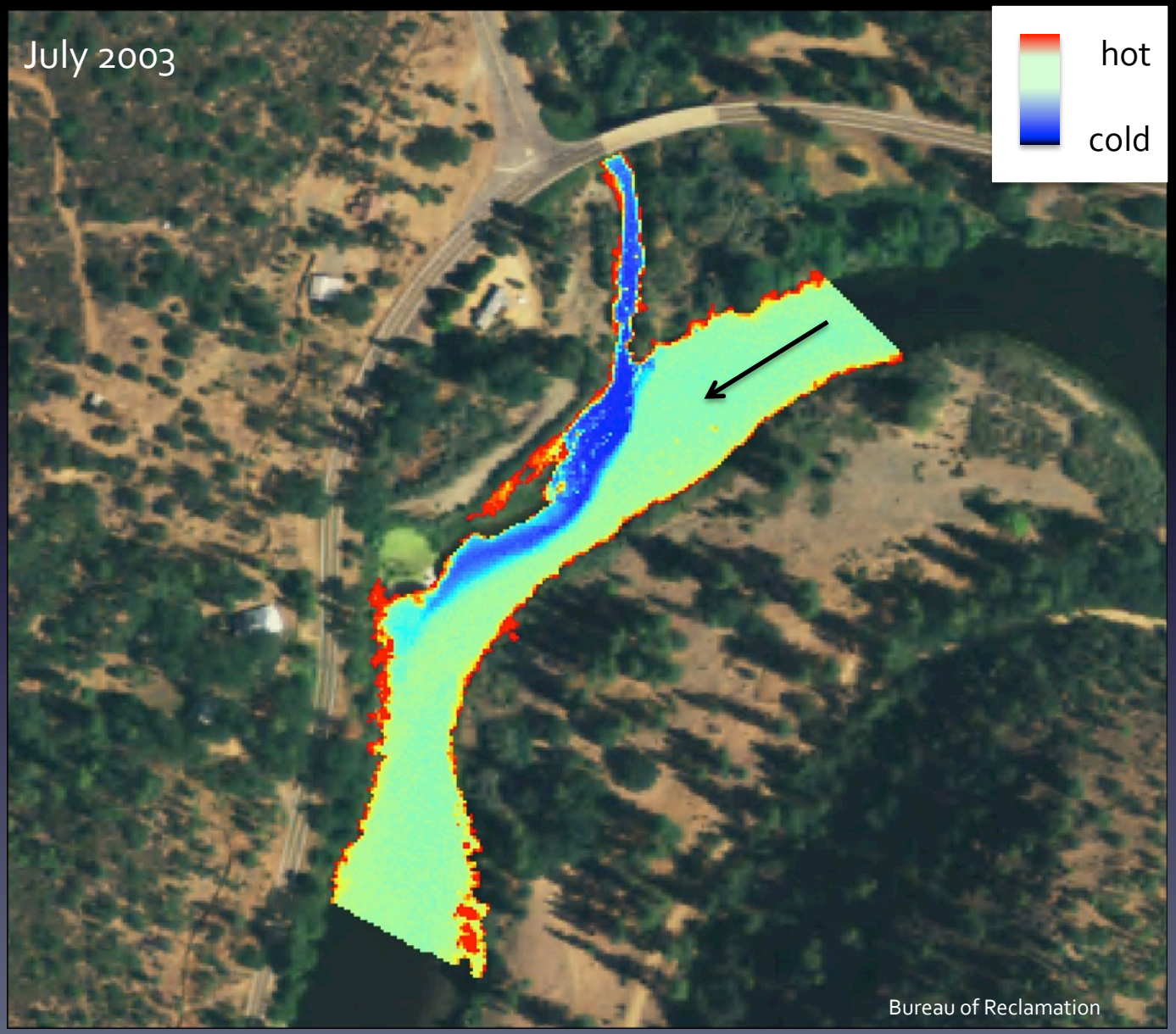
Combining stable isotope analysis with telemetry to identify trade-offs between thermal and trophic resources for fish in thermal refugia

Kim Brewitt

University of California Santa Cruz

Thermal Infrared Images of Beaver Creek joining the Klamath River



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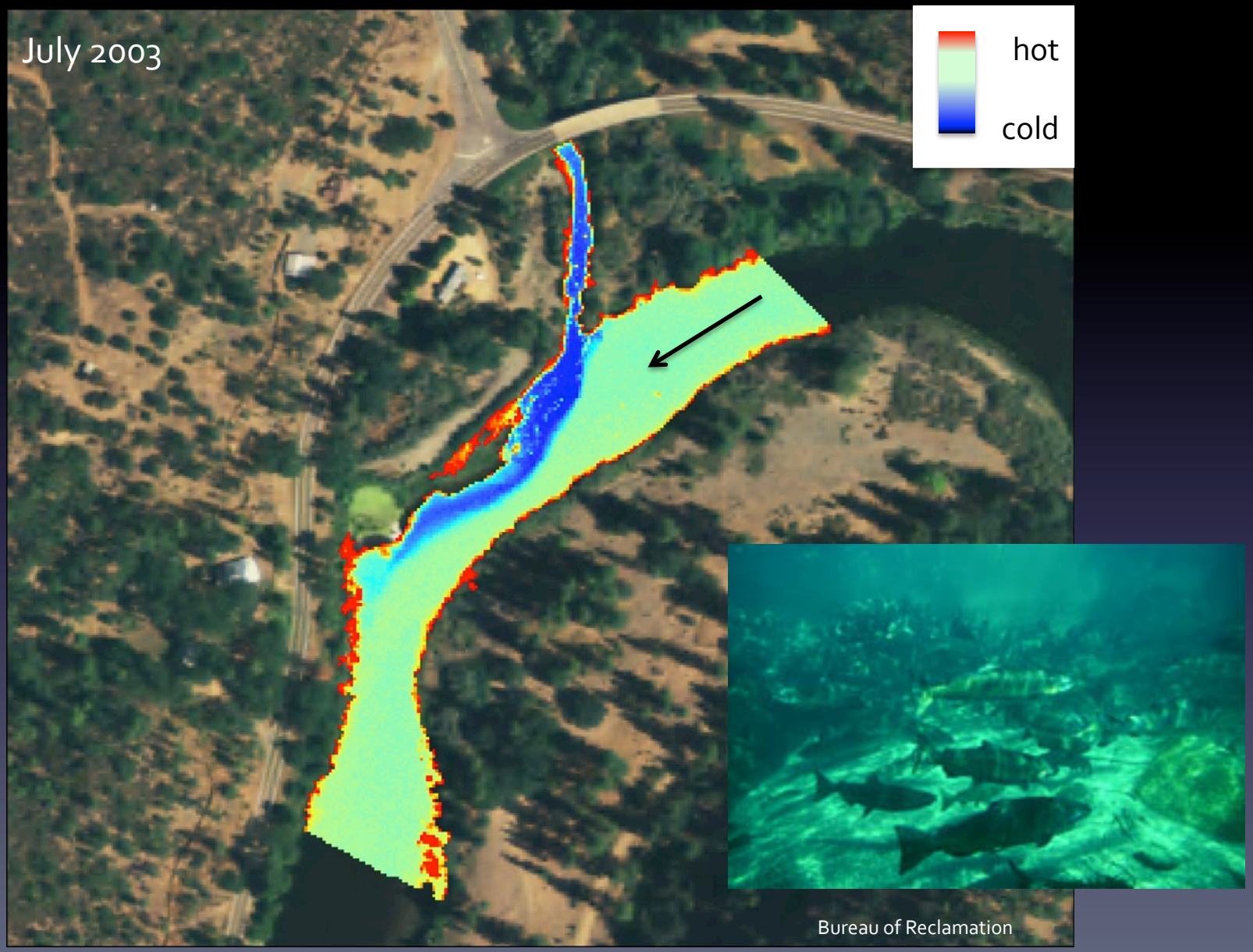
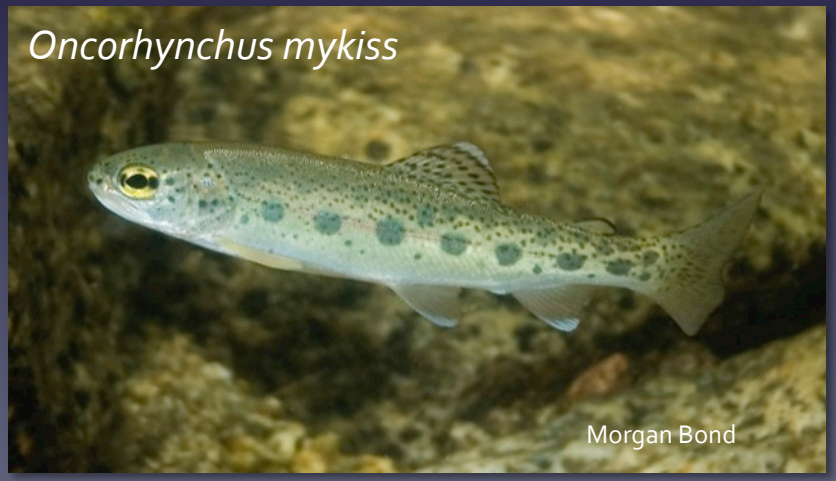
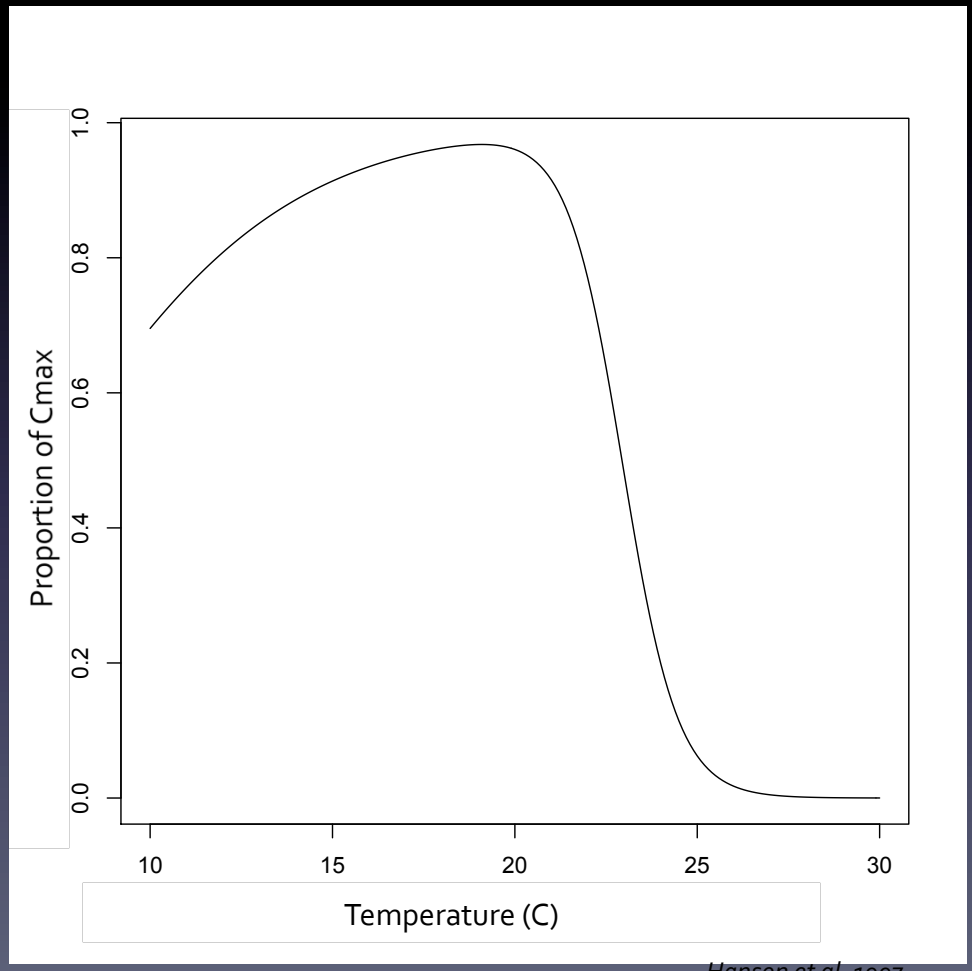


Pacific salmonids and thermal refugia

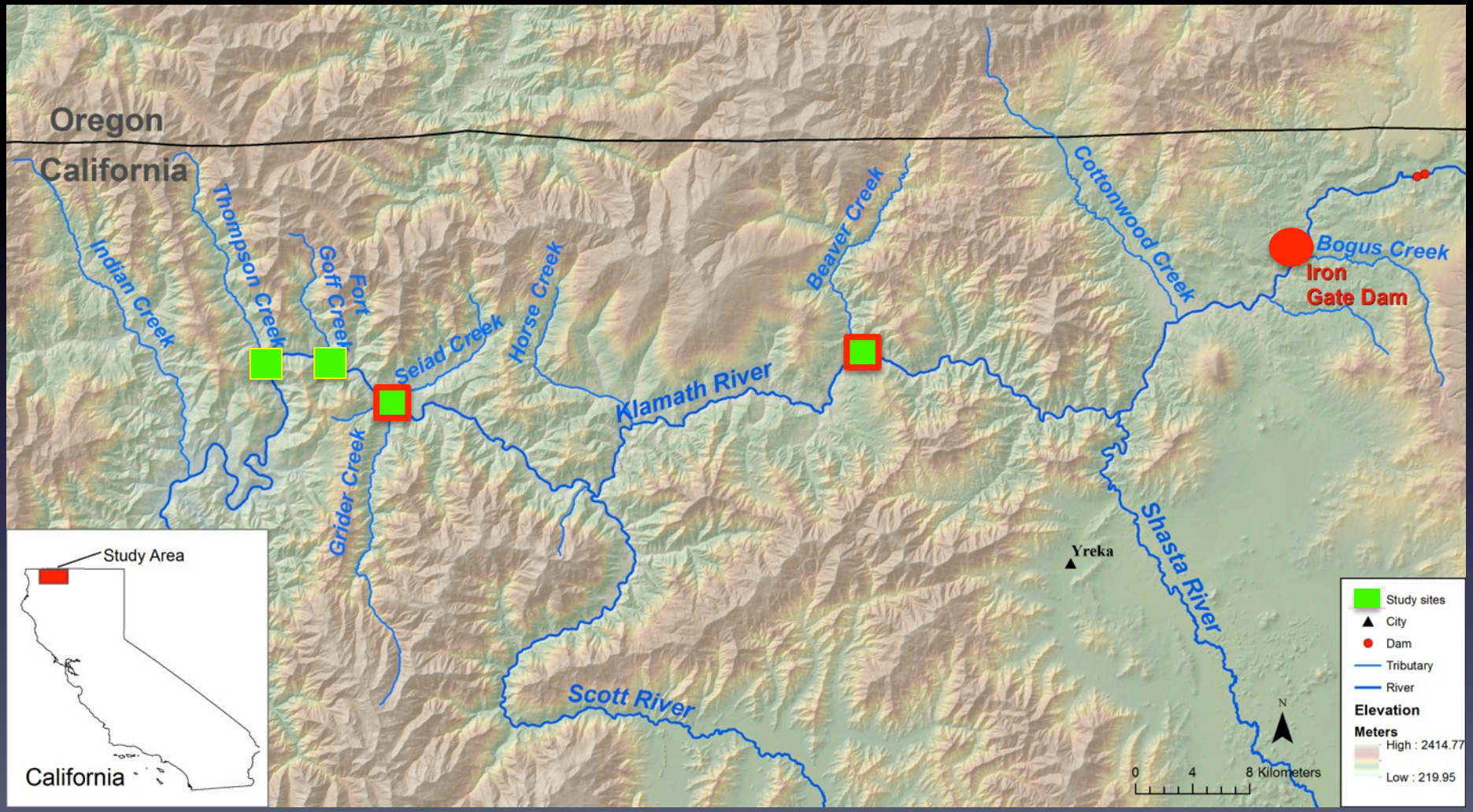
- Coldwater fish with specific thermal tolerance
- Thermal refugia important to salmonids for over-summer survival





Hanson et al. 1997

Study system: Klamath River



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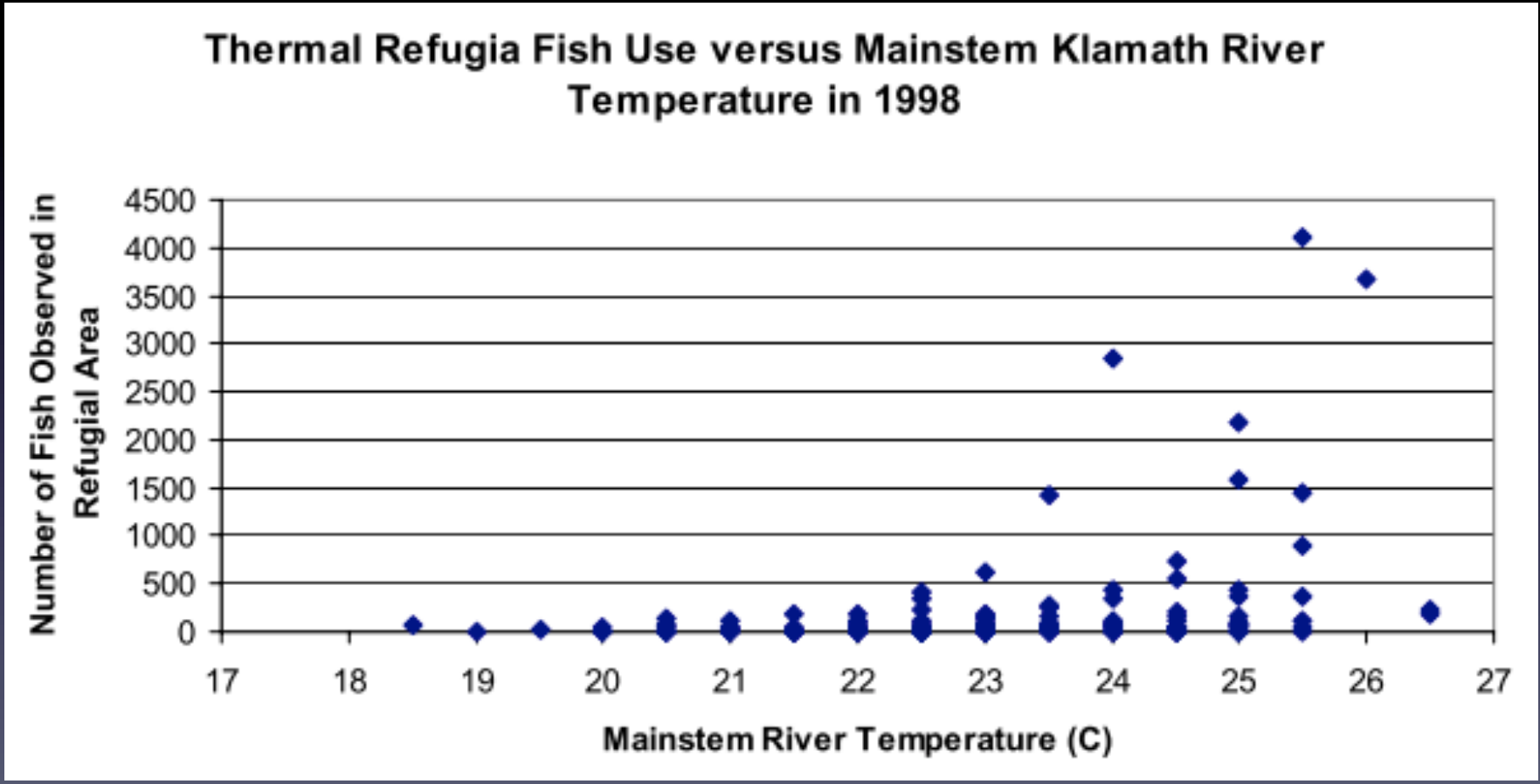

Belchik 2003

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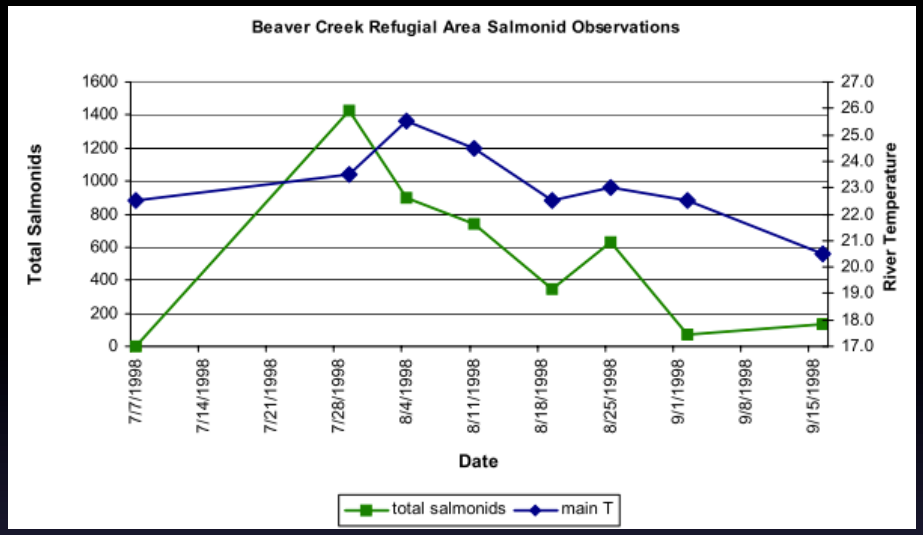

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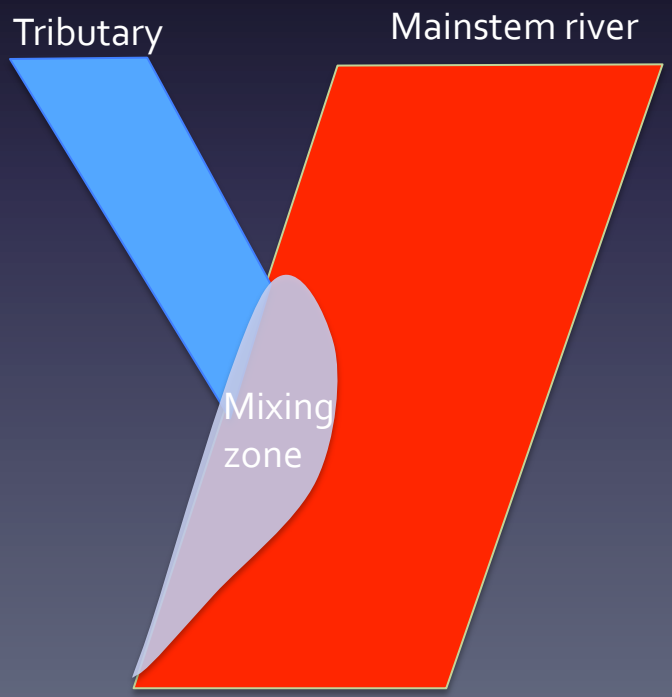

Studies on thermal refugia with observed foraying behavior:
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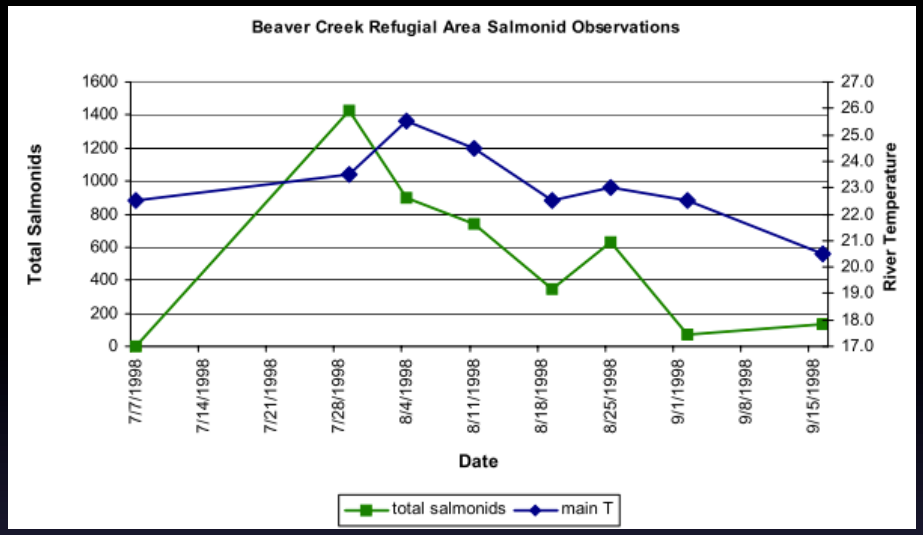

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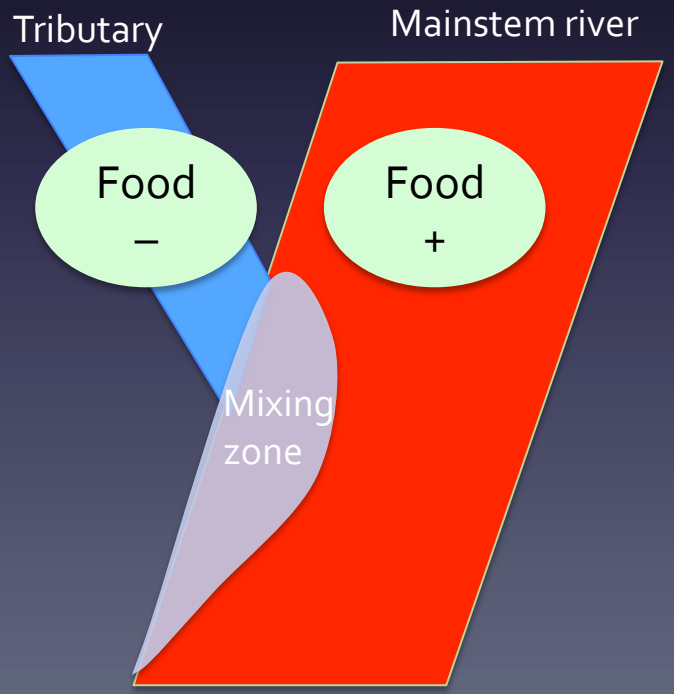

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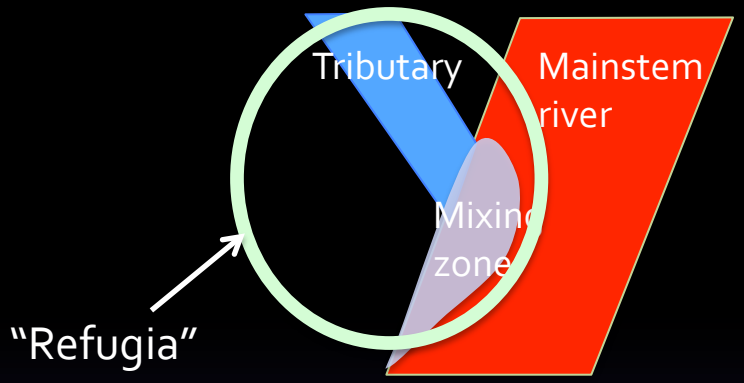
Pacific salmonids and thermal refugia

- Radio tagging study (2010-2012)
- n = 185 fish (~130,000 observations)



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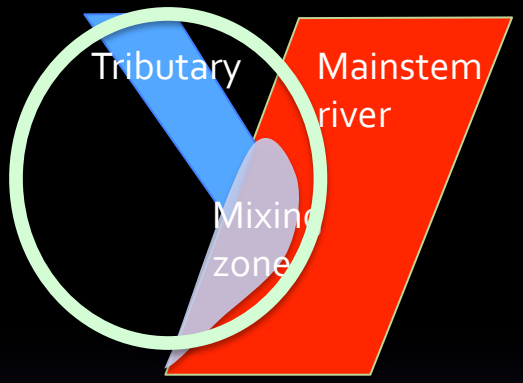

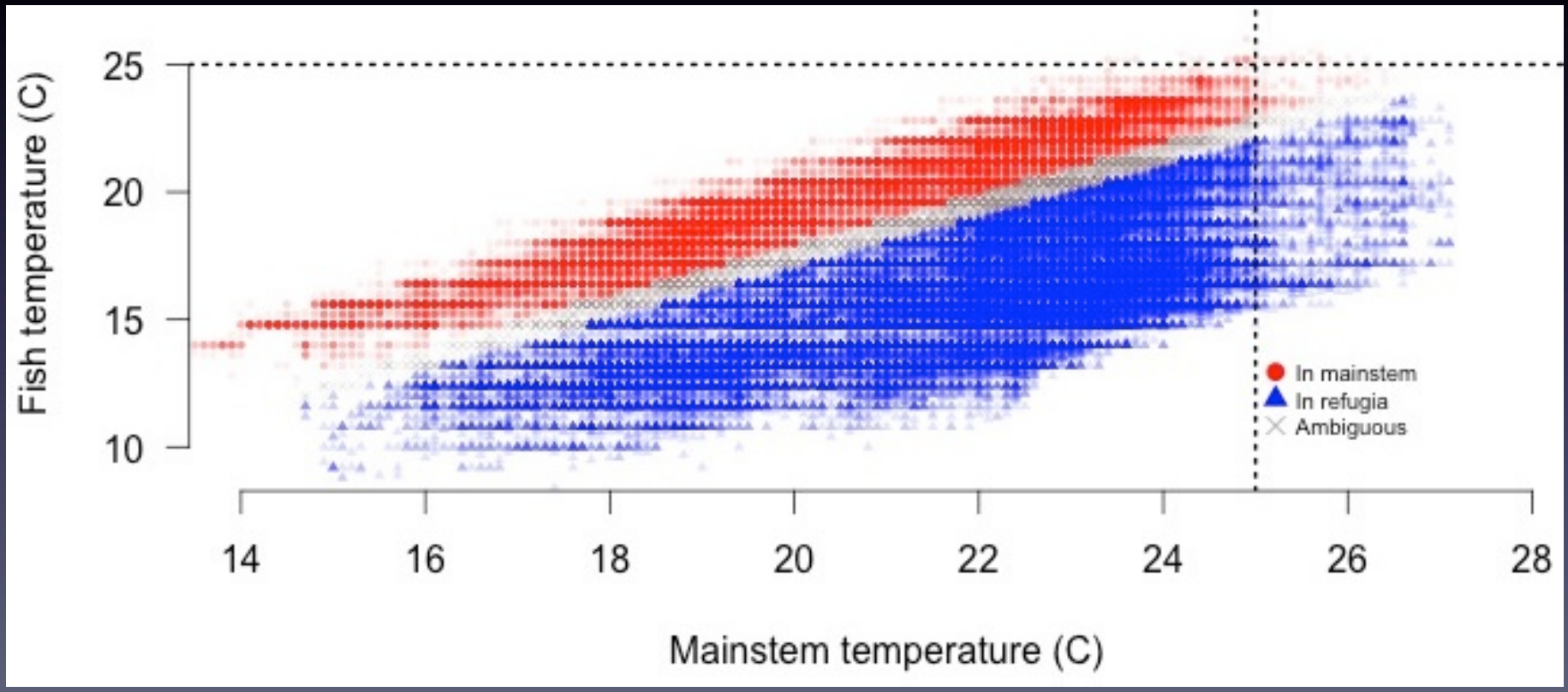

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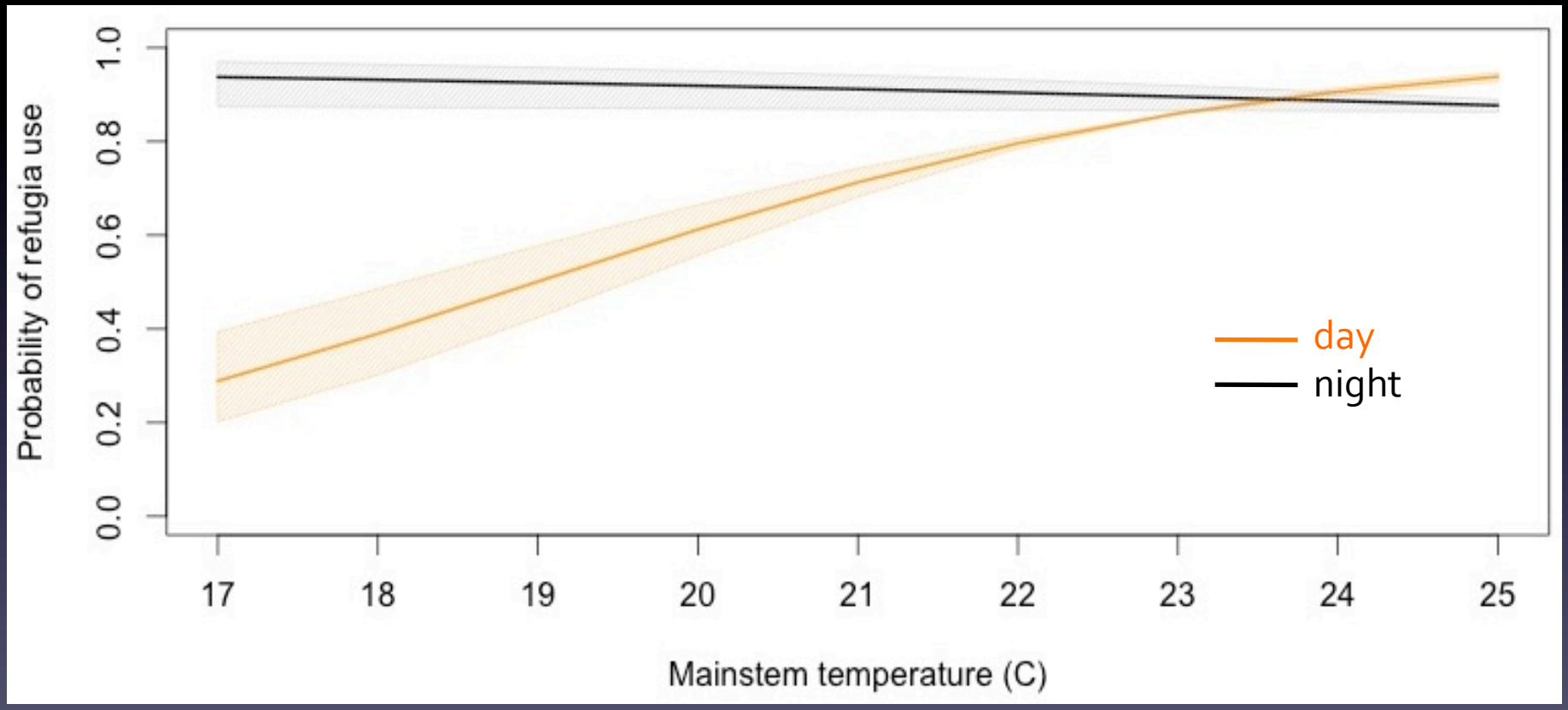

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Questions

1. What are possible mechanisms of food limitation in refugia?
    i. Is **food availability** lower in tributaries than in the mainstem river?
    ii. Are **fish densities** higher in refugia than adjacent mainstem habitat?

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2. What proportion of their diet are fish obtaining from the mainstem versus tributary?

3. Is there a mismatch between fish thermal habitat use and fish diet?

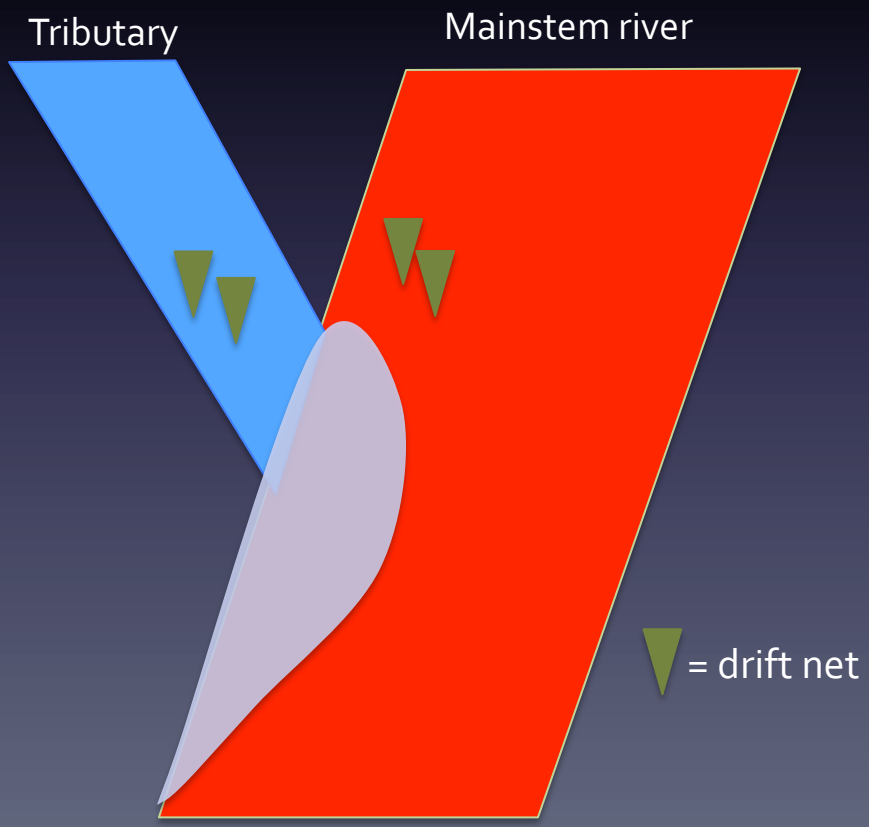
Methods: prey availability

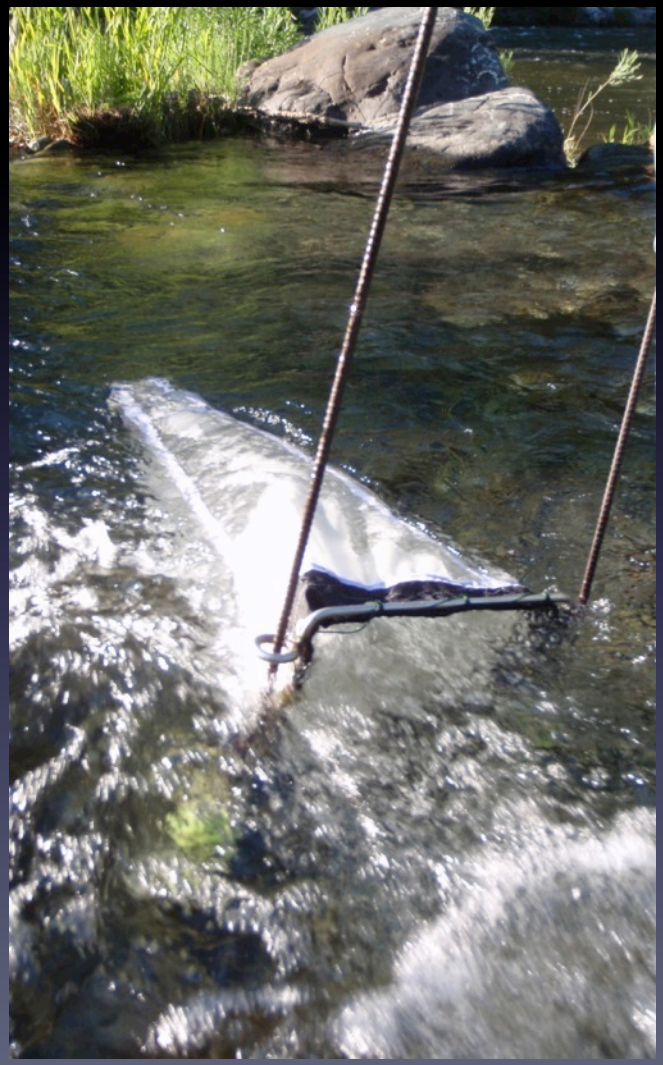
*Is **food availability** lower in tributaries than in the mainstem river?*

Drift sampling

Summer 2010 – monthly samples; 4 sites

Summer 2011– weekly samples; 1 site



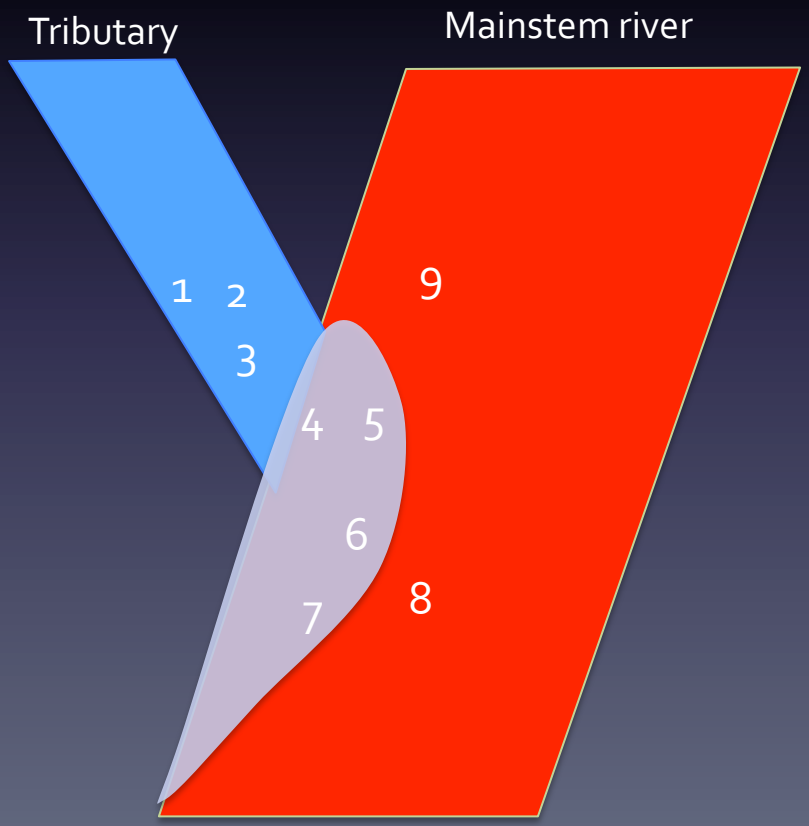


Methods: fish density

*Are **fish densities** higher in refugia than adjacent mainstem habitat?*

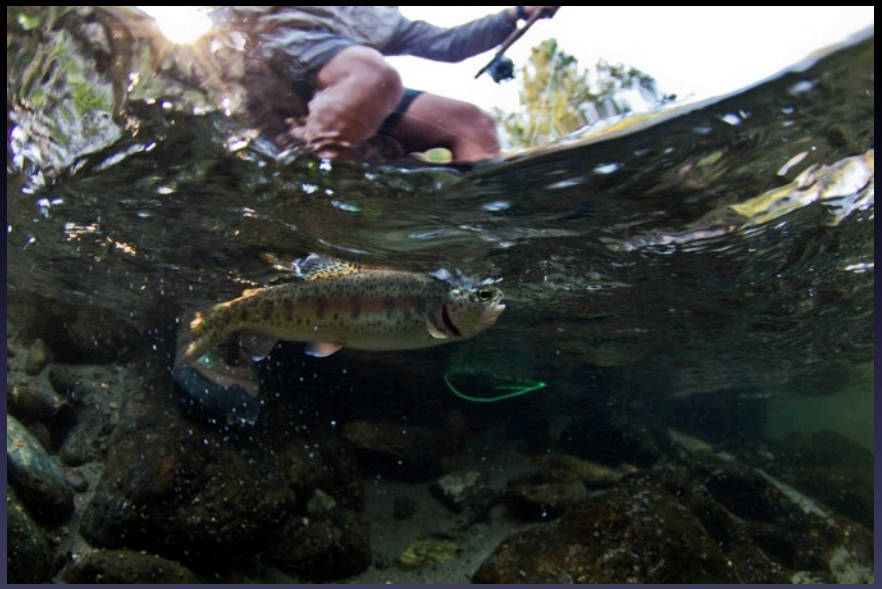
Snorkel surveys

- August 2012 at Beaver Creek
- weekly observations
- 3x daily (9am; noon; 4pm)



Methods: isotopic analysis to assess fish diet

Proportion of fish diet derived from mainstem versus tributary?



Prey: benthic sample collection

- From tributary and mainstem
- 2x during the 2 week period prior to fish sampling periods
- 4-7 point locations

Fish sample collection

- 2 sites
- Early July and late August
- Caught within 50m of confluence

Analyses

- Samples analyzed for $\delta^{15}N$ and $\delta^{13}C$
- MixSIAR (Bayesian mixing model)

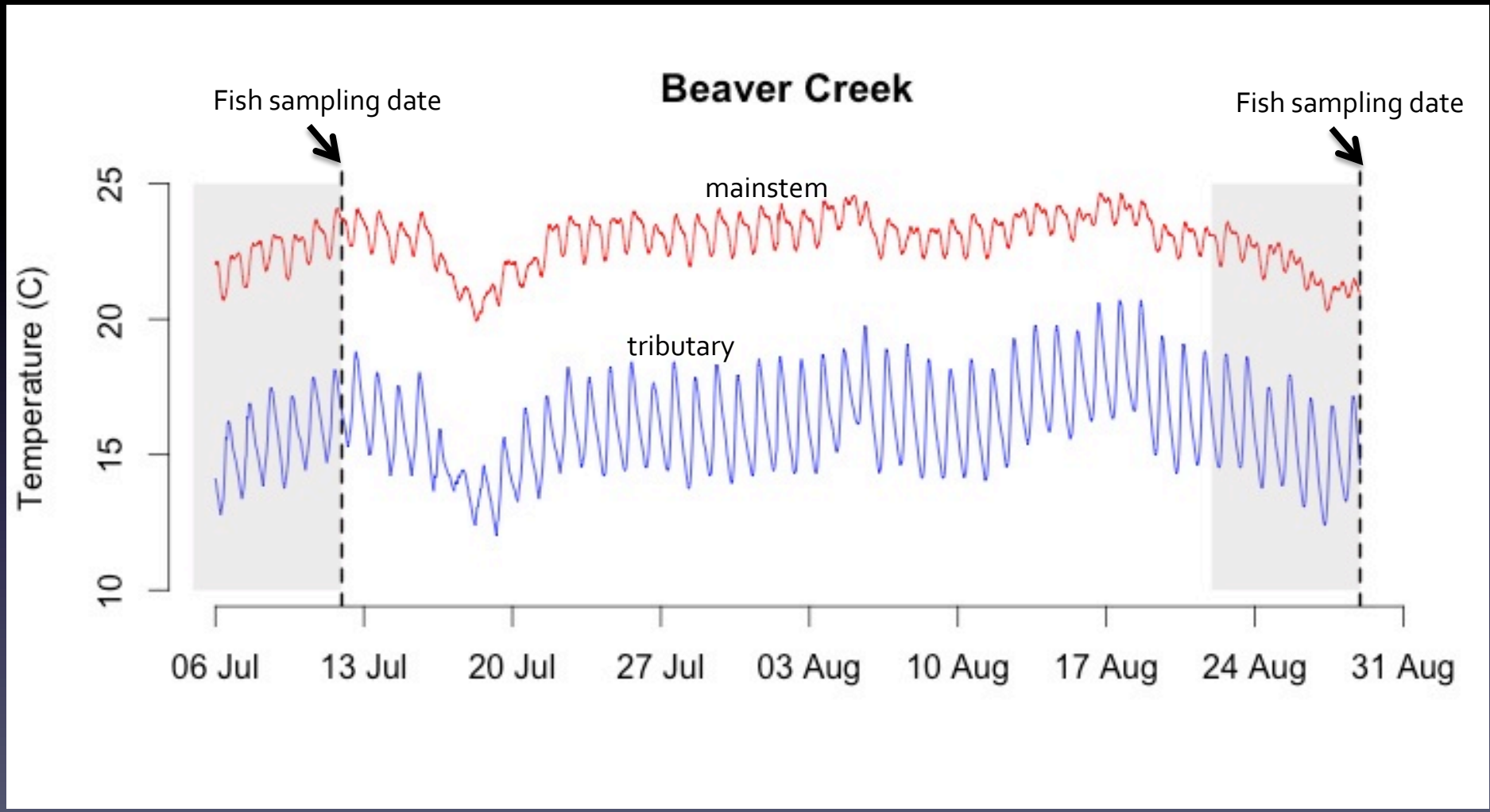
Methods: radio tagging

Is there a mismatch between fish thermal habitat use and fish diet?

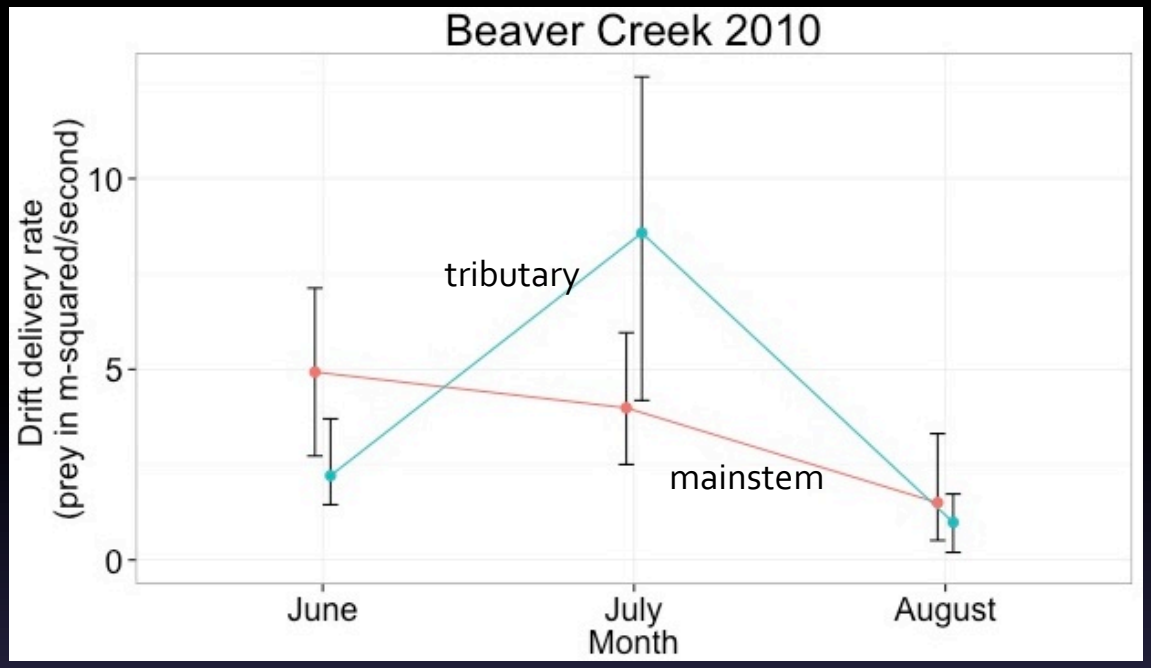
Monitoring fish body temperatures as a proxy for habitat use (2010-2012):

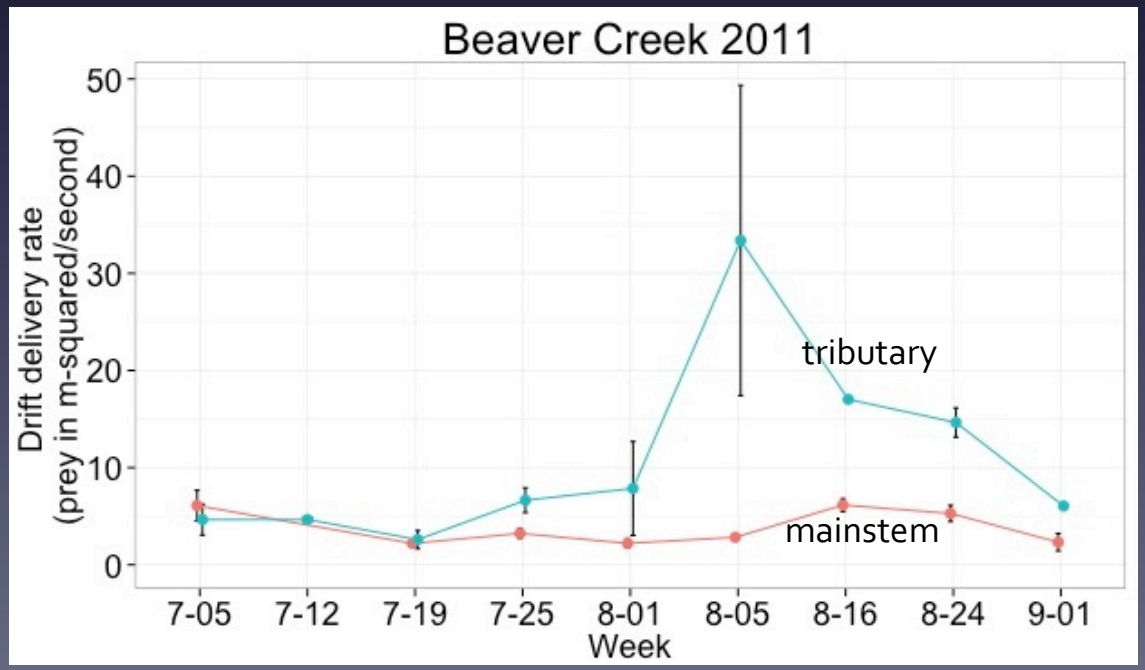
- N = 185 radio tagged juvenile steelhead (>30g) using Lotek temperature-sensitive tags
- 20 fish per site across 1-4 sites

Water temperatures in 2012



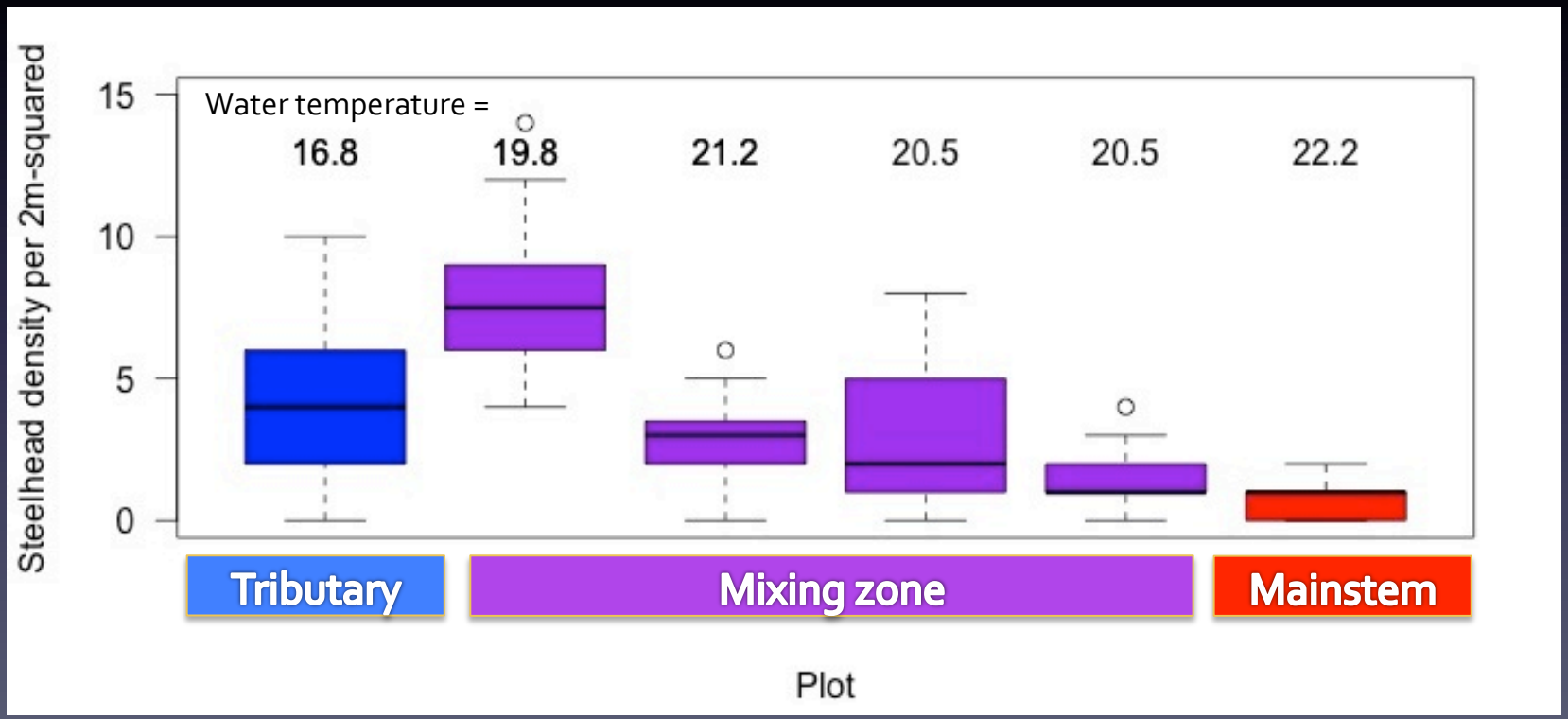
Is prey availability a mechanism of food limitation?





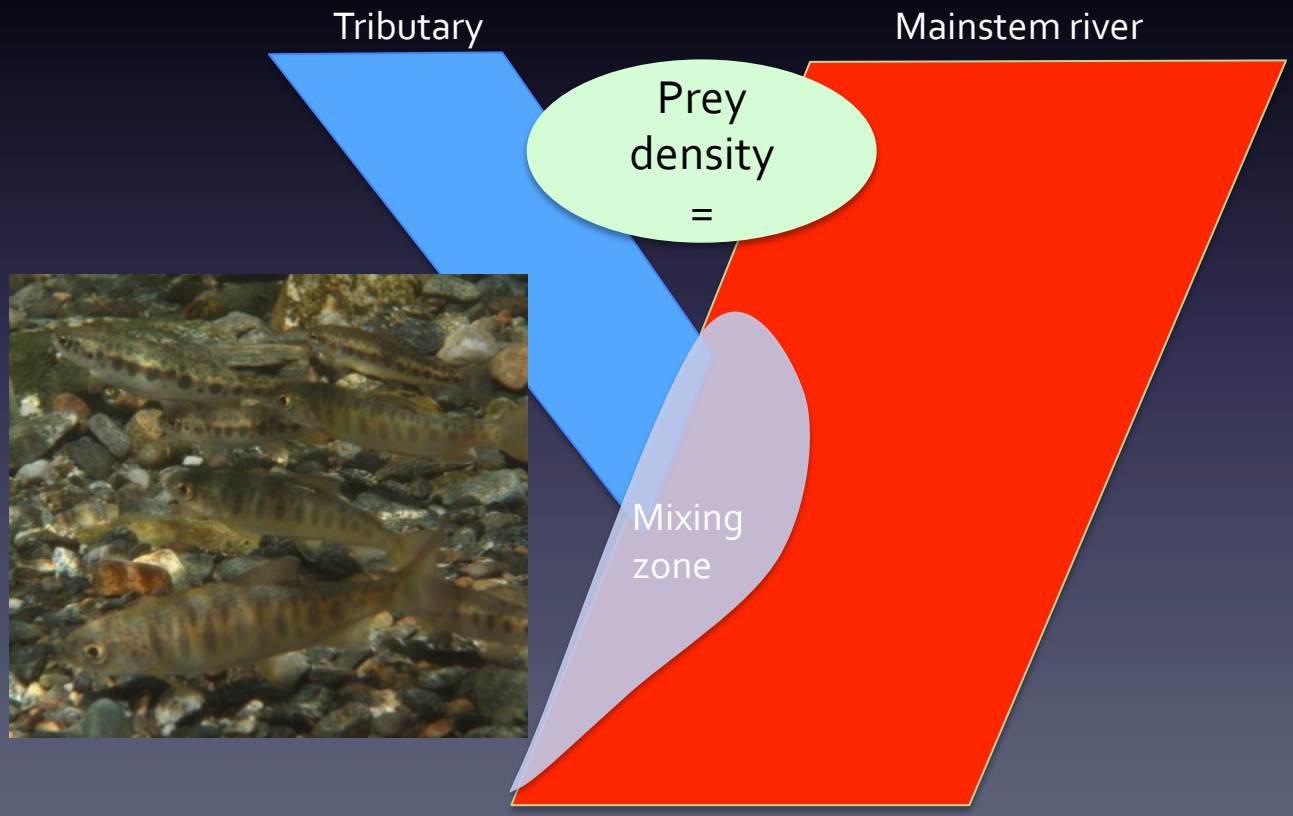
Is fish density a mechanism of food limitation?

Steelhead densities in August 2012



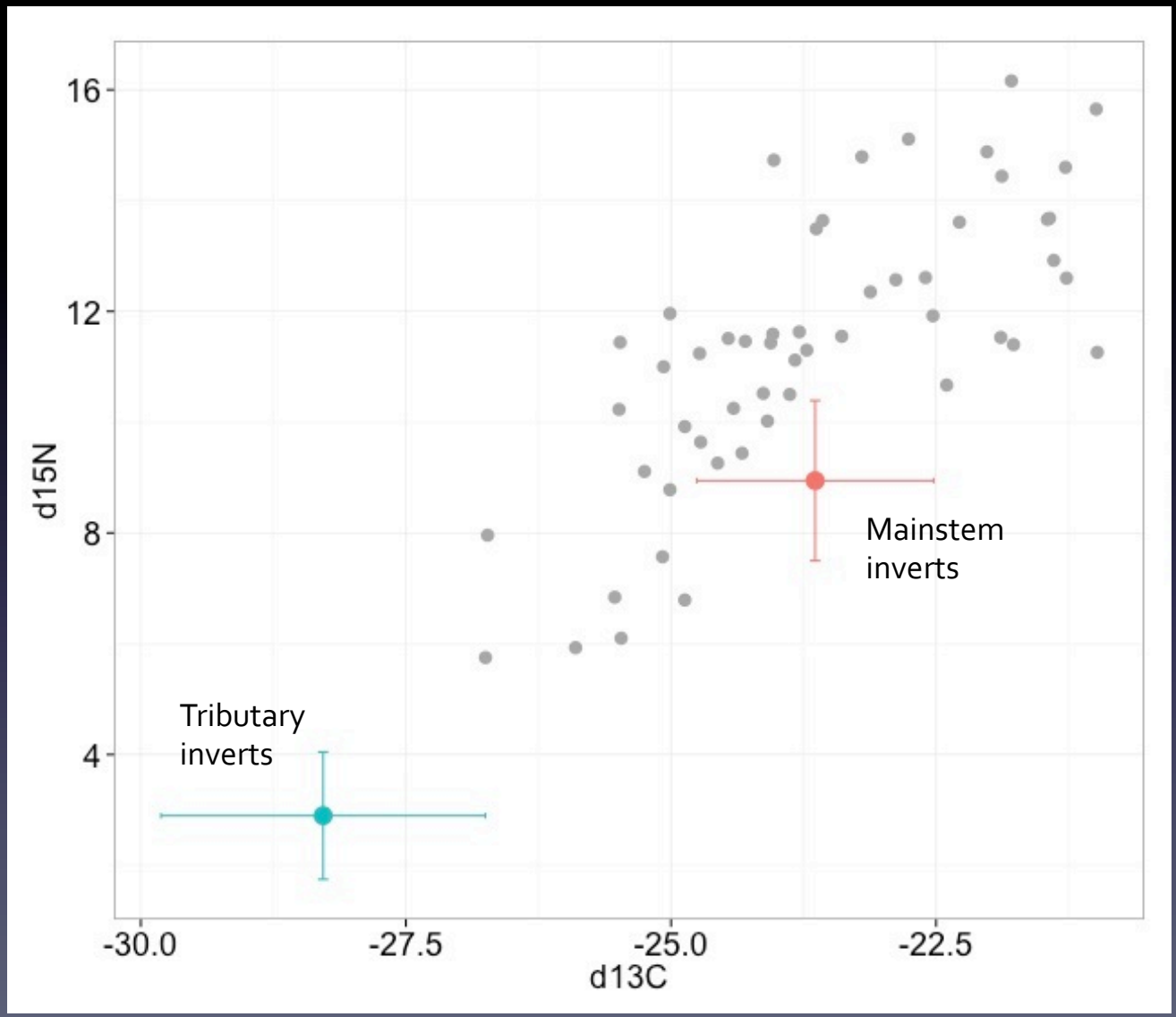
Mechanisms of food limitation in refugia?

1. Prey delivery rates in tributary NOT consistently lower than mainstem
2. Fish densities in refuge consistently higher than in mainstem



Proportion of fish diet from mainstem prey?

Beaver Creek steelhead



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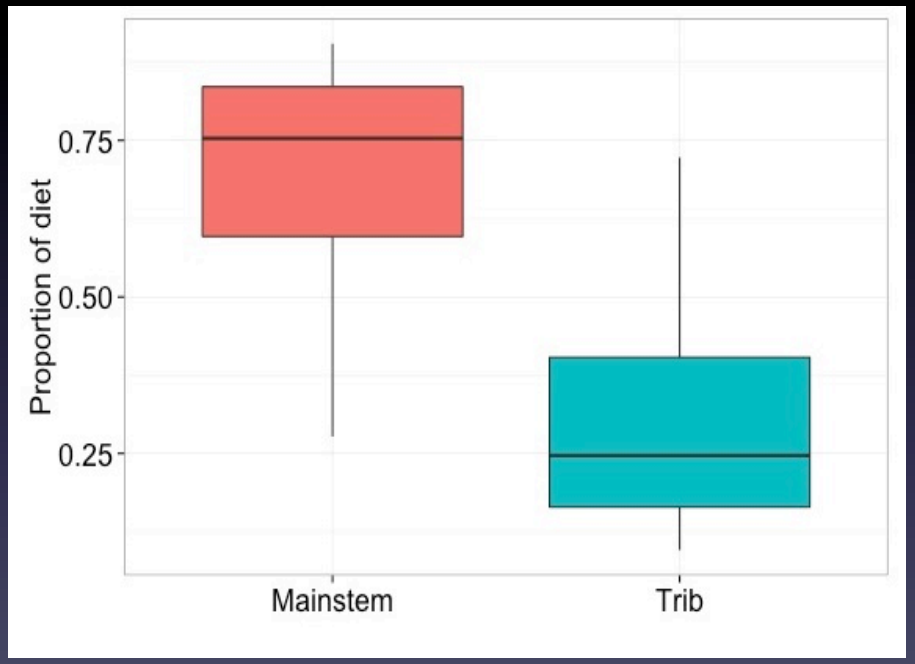
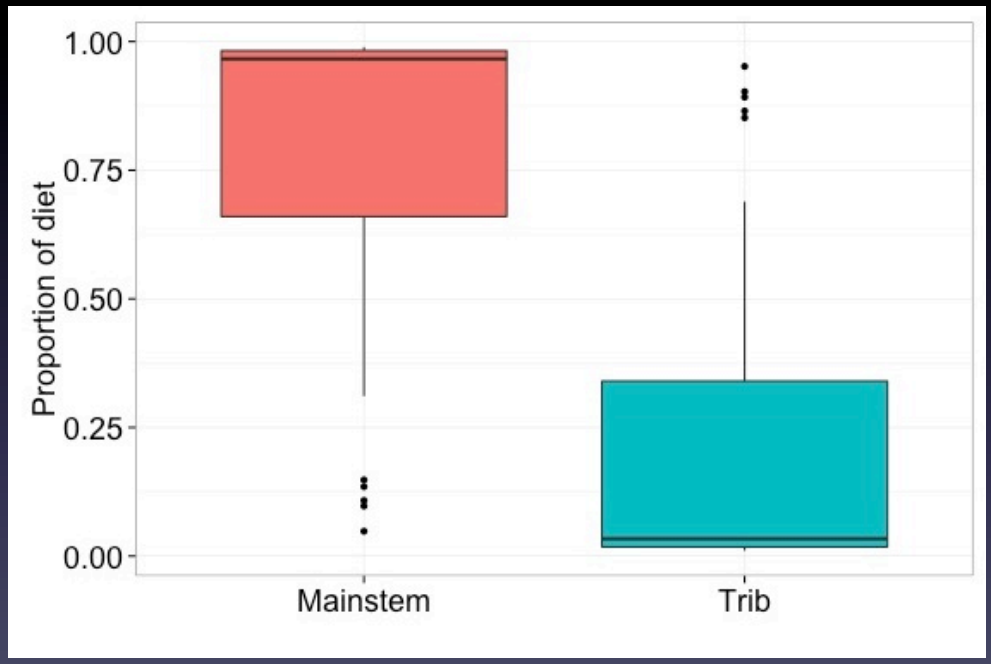
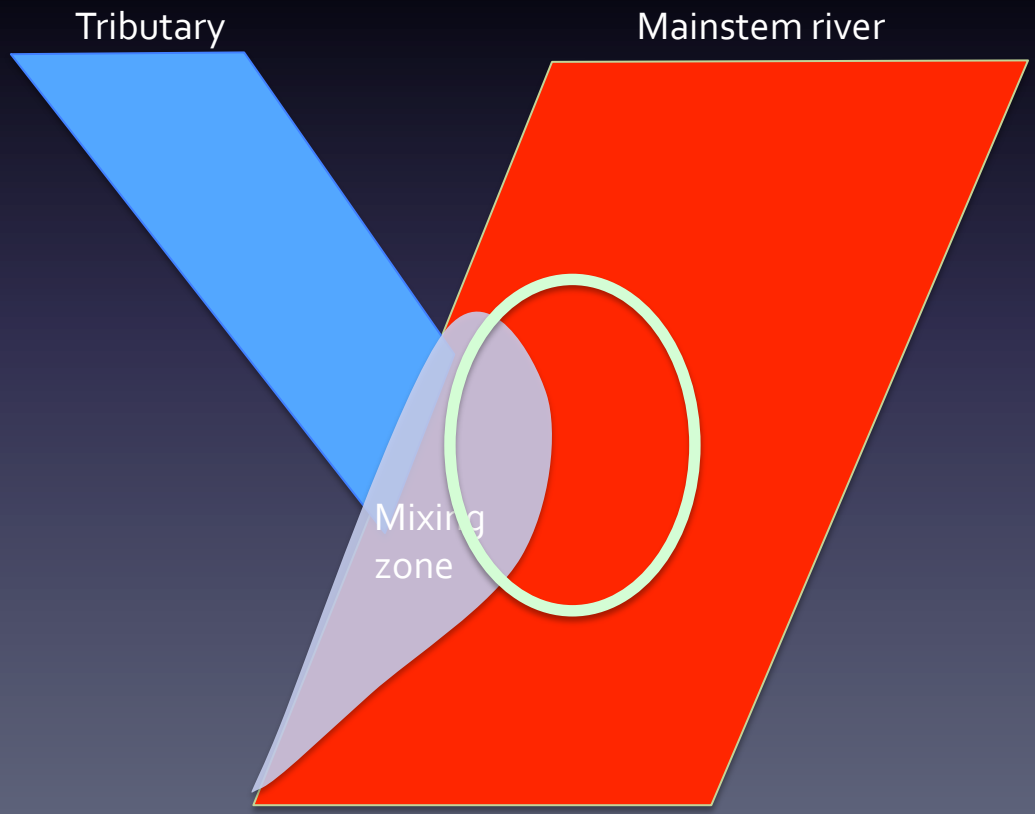


Grider Creek steelhead



What proportion of their diet are fish obtaining from the mainstem versus tributary?

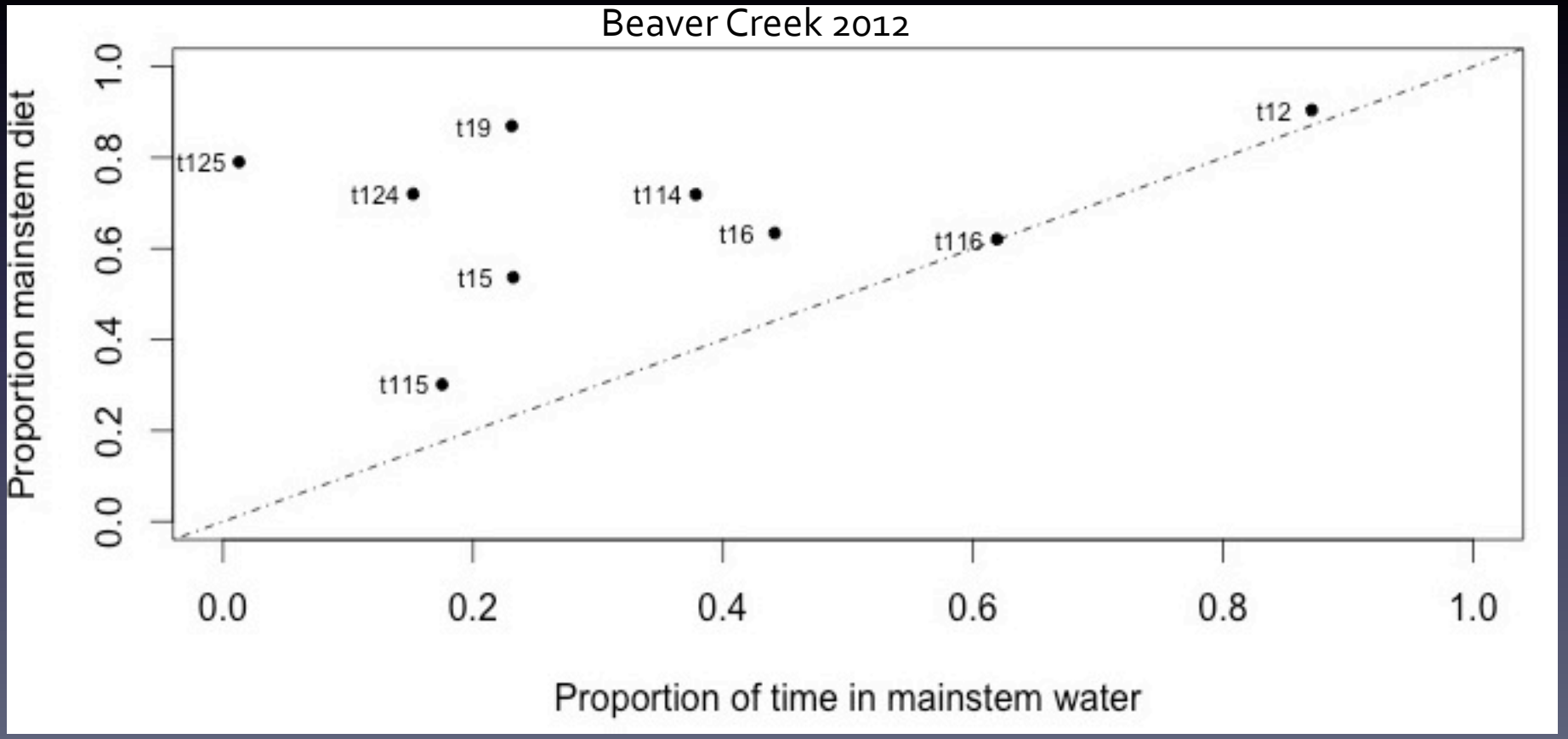
- ~75-100% of steelhead diets consist of mainstem prey



Mismatch between fish diet and temperature?

Tagged fish in 2012:

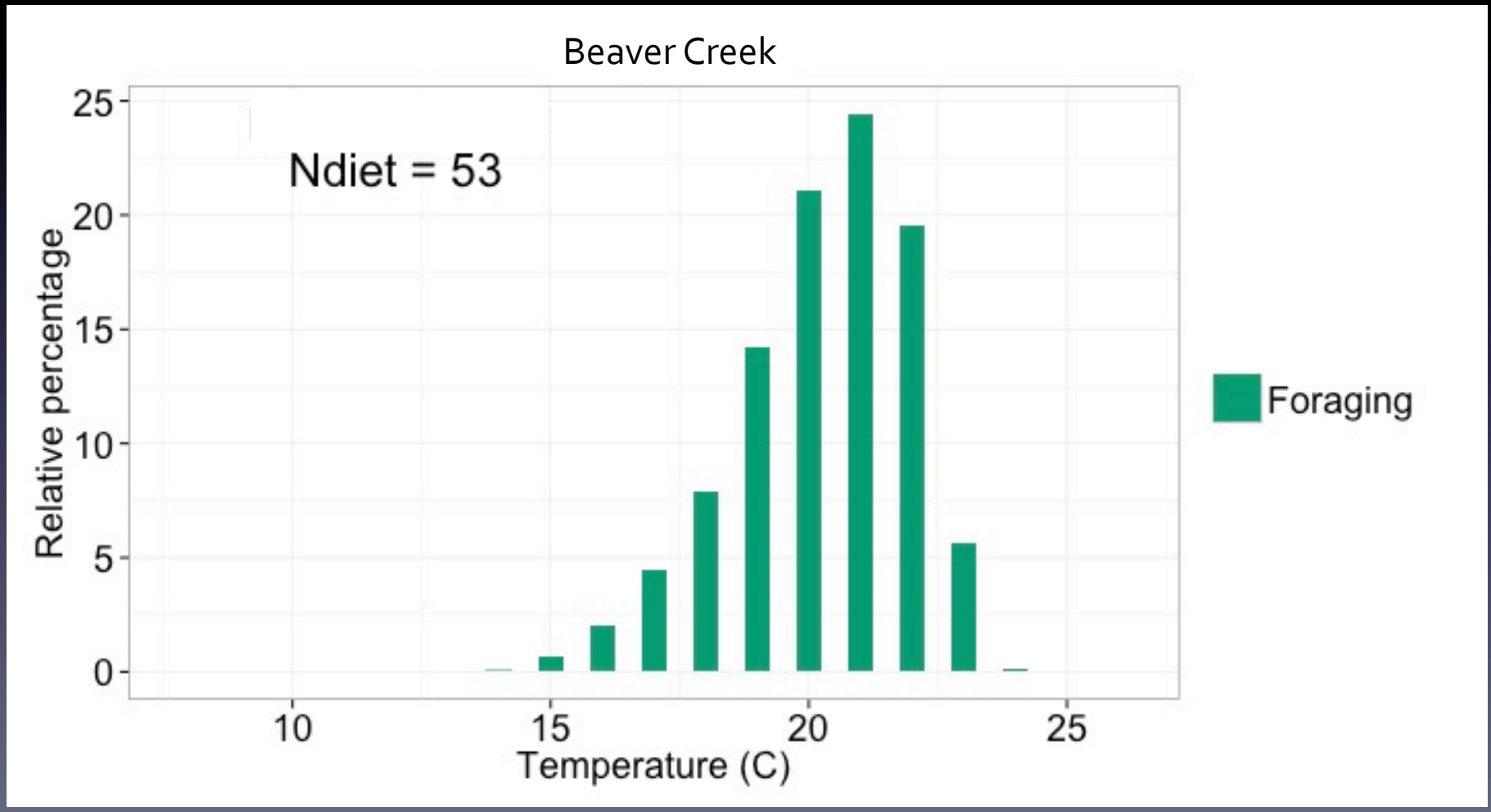
- Compare fish diet to fish temperature (n=9)
- Mass balance equation translating fish temperatures to proportion of time in mainstem water



Mismatch between fish diet and temperature?

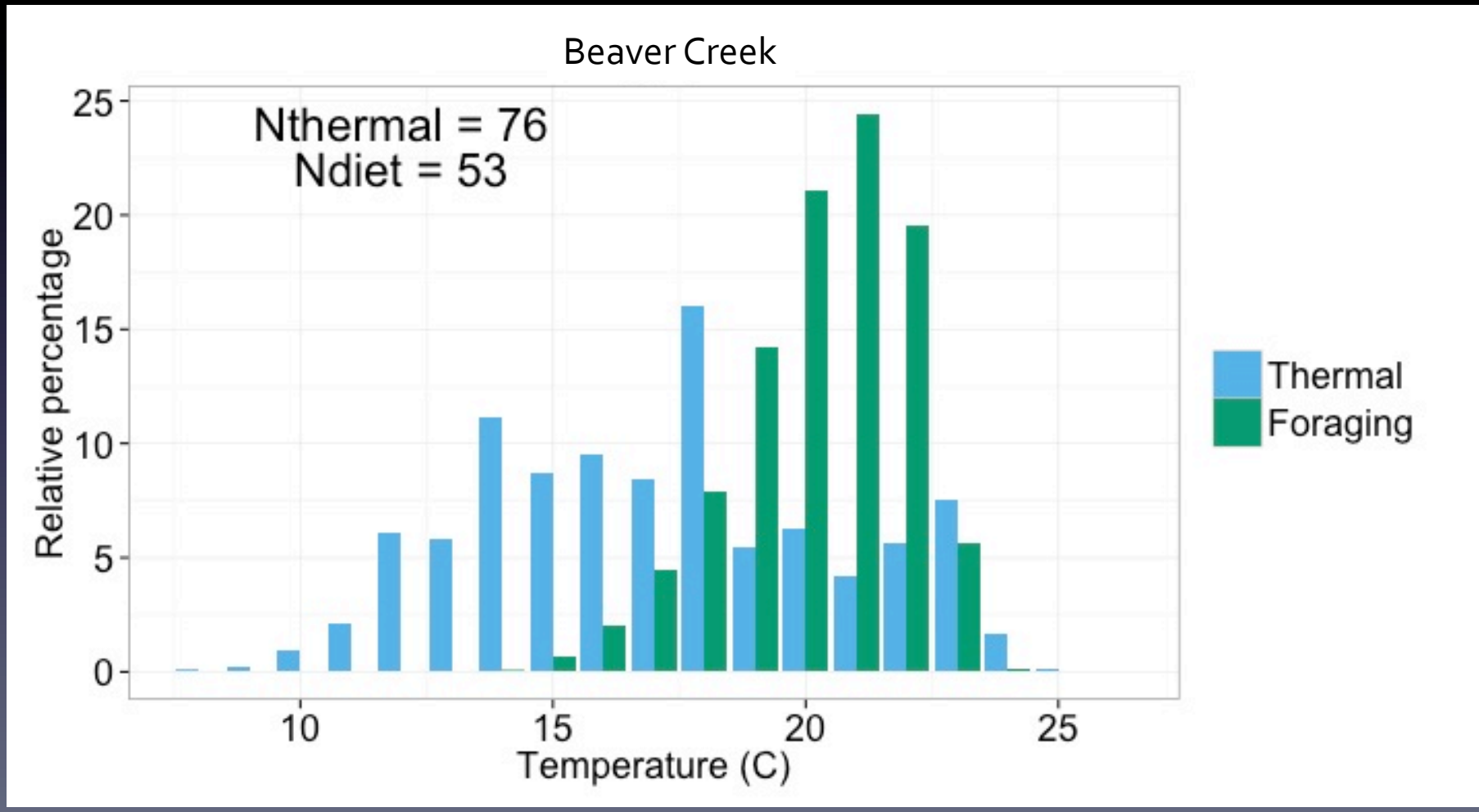
Transform fish diets into foraging water temperatures:

- Mass balance equation
- Water temperatures from 2 weeks prior to sampling



Mismatch between fish diet and temperature?

- Foraging distribution from transformed fish diet
- Thermal distribution from fish body temperatures (2010-2012)



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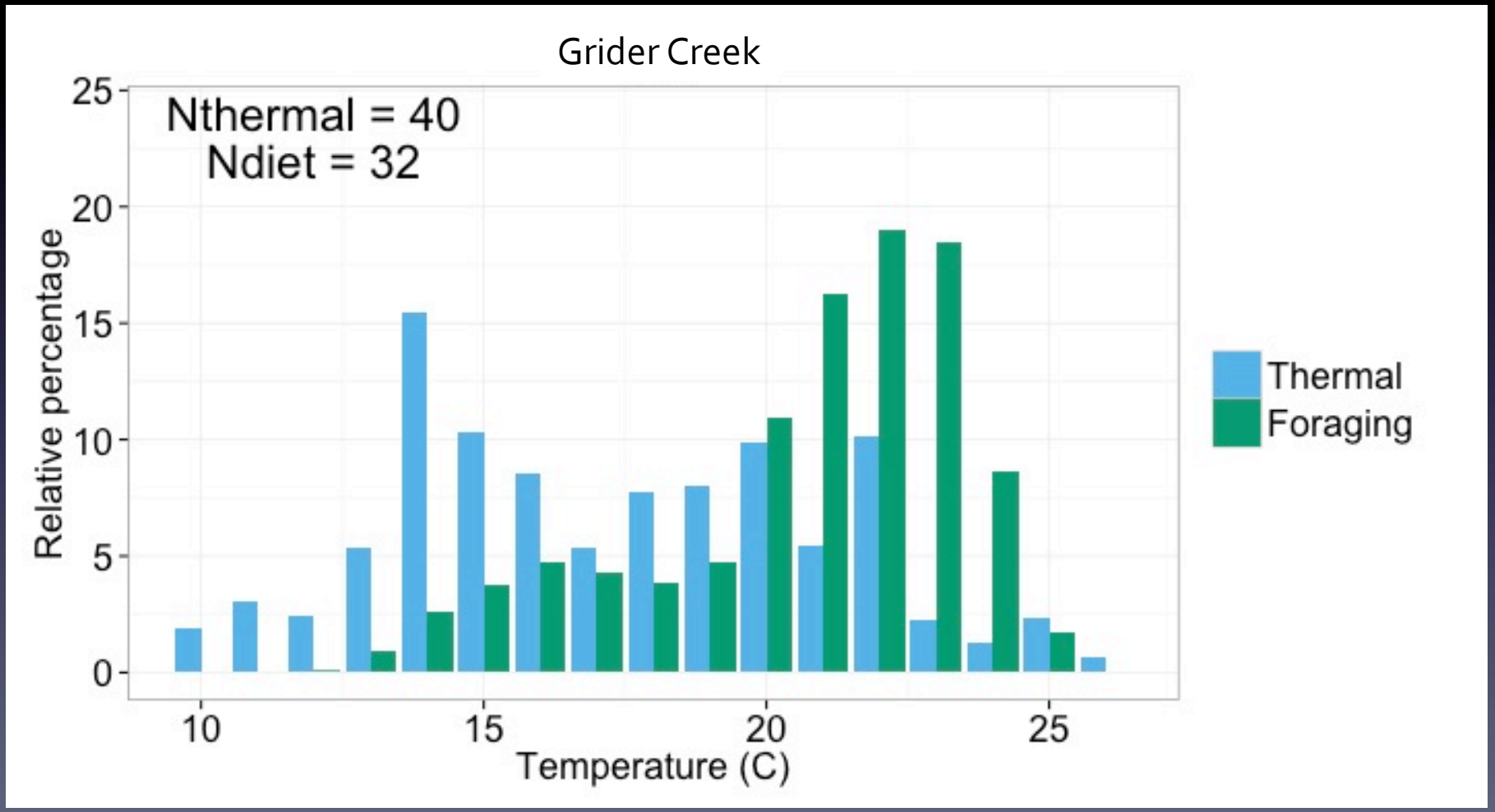
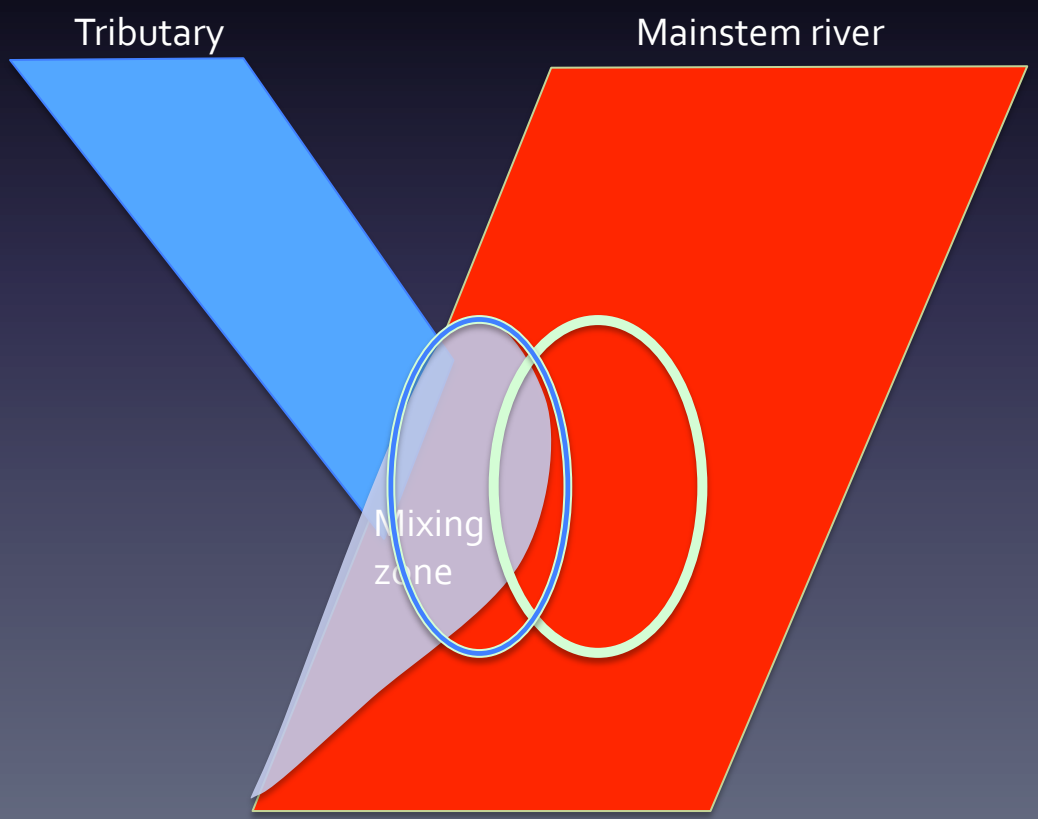


Is there a mismatch between fish thermal habitat use and fish diet?

- Thermal distribution centers around 18C
- Foraging distribution centers around 21-22C



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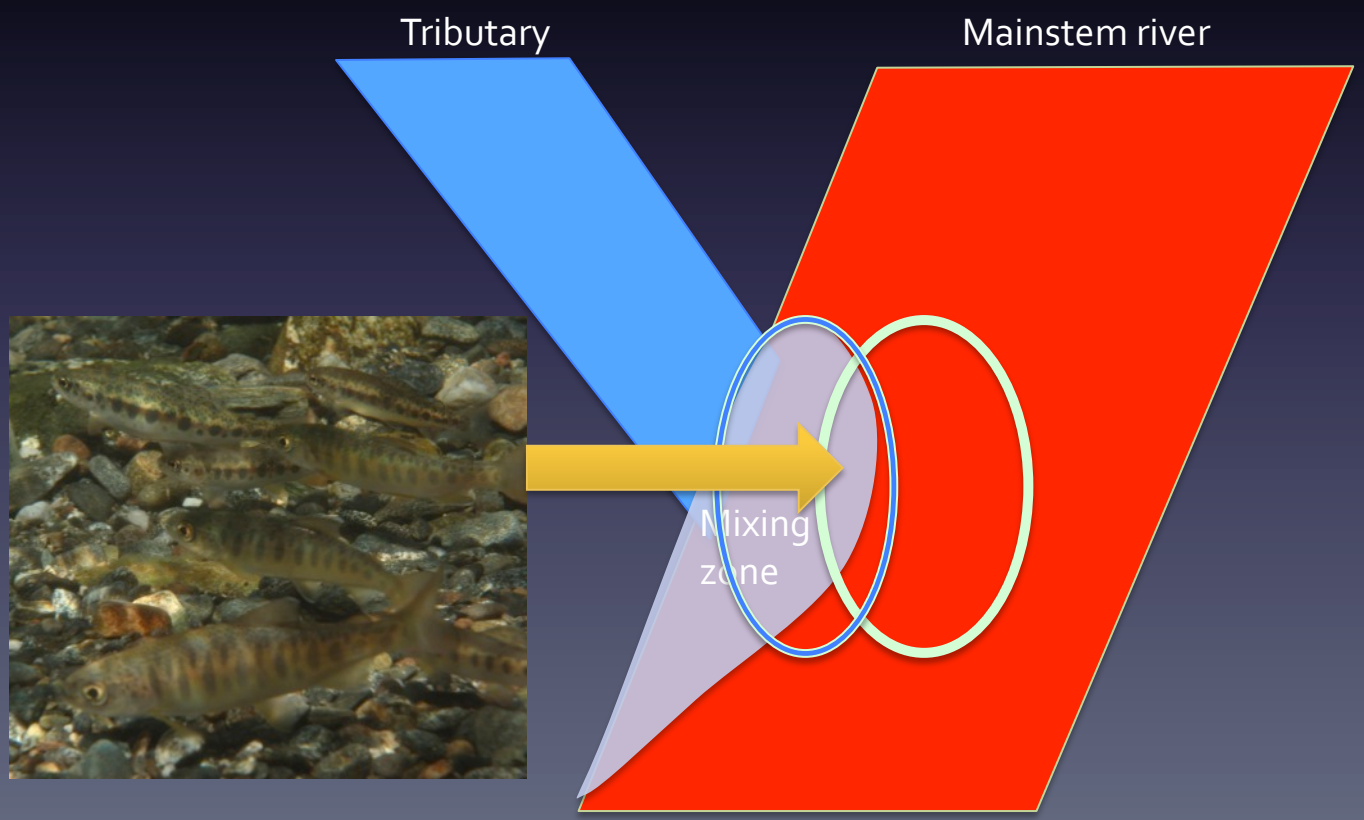

Conclusions

- Mainstem prey is the main food source for fish using refugia
- Mismatch between fish thermal and foraging distributions
  → Trade-off between thermal and trophic resources
- Likely due to fish densities in refugia rather than drift densities

Implications

1. Access to mainstem habitat important
   - Implications for carrying capacity of refugia

2. If fish density is driving resource-limitation…
   - Problems when mainstem temperature >25C

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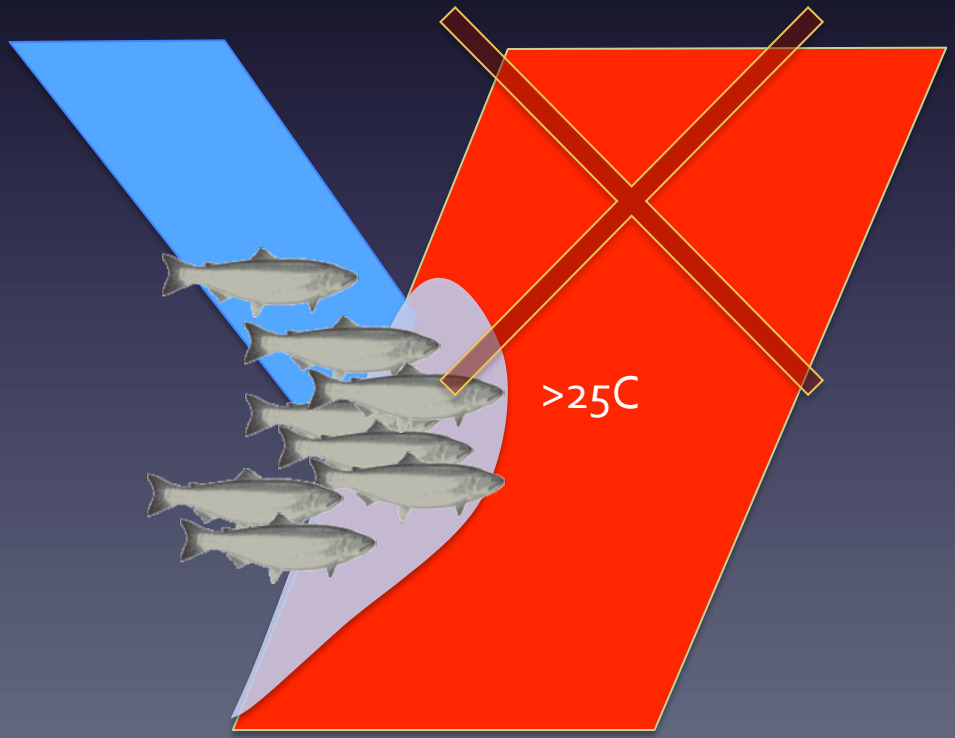
1. *Access* to mainstem habitat important
   - Implications for carrying capacity of refuge

2. IF fish density is driving resource-limitation…
   - Problems when mainstem temperature >25C

3. Future research on density-dependence and carrying capacity



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QUESTIONS?
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