The Aquatic Food Web and Foraging Ecology of Juvenile Chinook Salmon on Restored Floodplains

Carlos M. Polivka, Stine Griep, Keith van den Broek, Matt Holland, Sarah Schwarz, Conor Leahy, Shannon Claeson

Key questions for food web monitoring...

- Are key fish prey items/food resources distributed according to habitats within restored floodplains?
- Does food web complexity vary according to habitat type?
- Is fish density associated with food web structure or productivity?
- Do fish select foraging habitat based on food availability?

Image: Matt Holland

How does food web monitoring address UC data gaps?...

- Tier 1: Effectiveness of habitat projects incorporating spatial and temporal influences on results and at the appropriate scale (e.g., project, reach, assessment unit, population).

- Tier 2: Certain project types are missing robust effectiveness monitoring (e.g., floodplain, off-channel, riparian, upland water storage, beaver reintroduction, BDAs).

- Tier 1: Habitat requirements and limiting factors by life stage.

Hypotheses

- Habitats on floodplains will differ in invertebrate composition and overall diversity
- Food web productivity will predict fish foraging opportunities - some variation by habitat type
- Food web structure will drive consumption by Chinook fry
- Diet preferences will differ among habitats
- Trends in foraging behavior will reflect patterns in overall density of invertebrates and availability of primary prey

Gray F

Stormy B

Merritt Oxbow

Nason Oxbow

Images: Matt Holland

Habitat types

- ELJs - pools created by engineered log jams
- NLJs - natural log jams
- Open areas - inundated floodplain with no structural features
- Riffles - faster flowing areas in the active channel
- “Vegetation” - habitats with submerged aquatic and/or terrestrial vegetation

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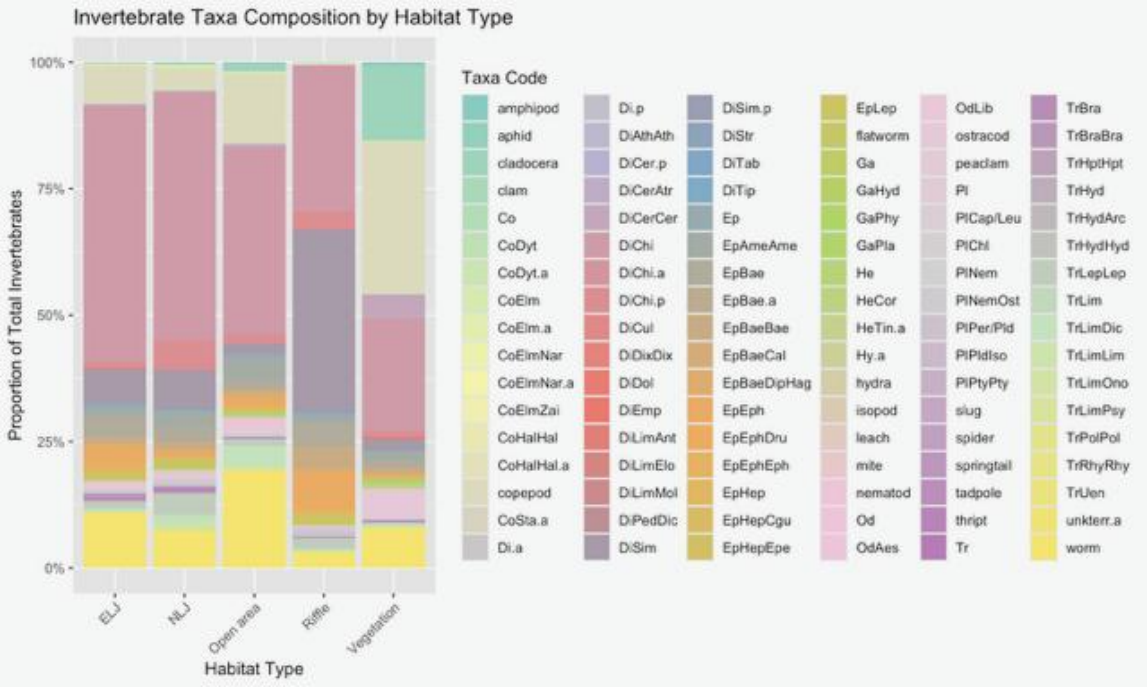
Results

Hyp: Habitats on floodplains will differ in invertebrate composition and overall diversity

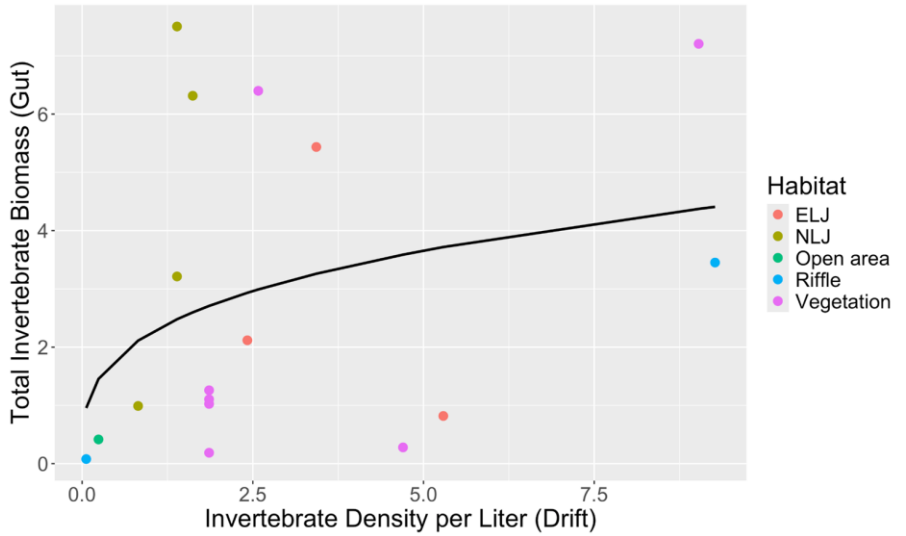
- Dominant species tend to be chironomid (midges) larvae
- In vegetated habitats, copepods (small crustaceans).

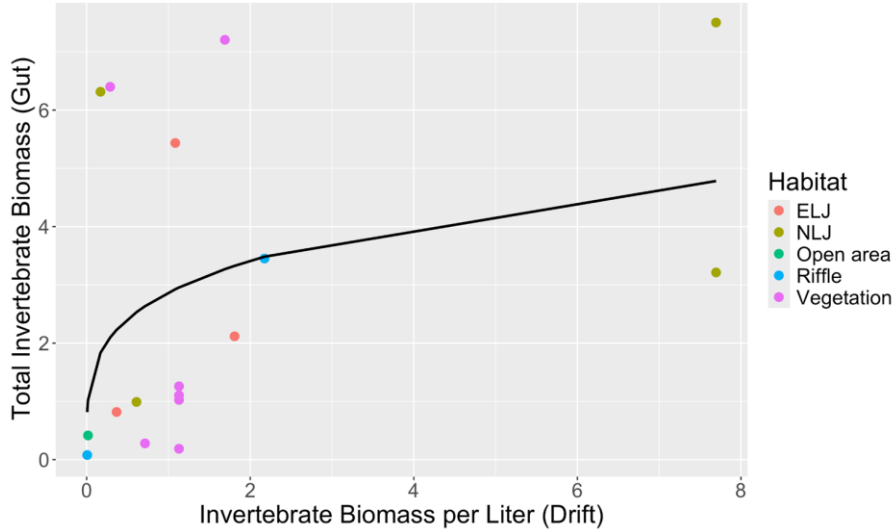


Results

Hyp: Food web productivity will predict fish foraging opportunities - some variation by habitat type

- More available food in the drift does predict food biomass in gut samples (consumption) - not surprising
- No obvious separation by habitat
- Type II functional response fits the foraging rate data.

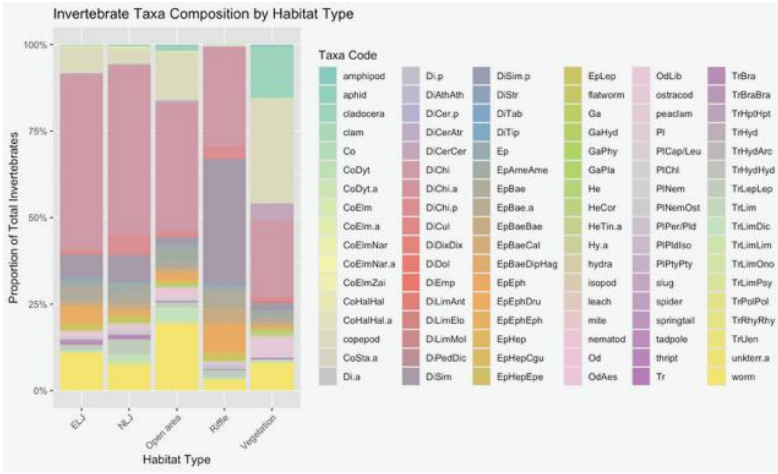


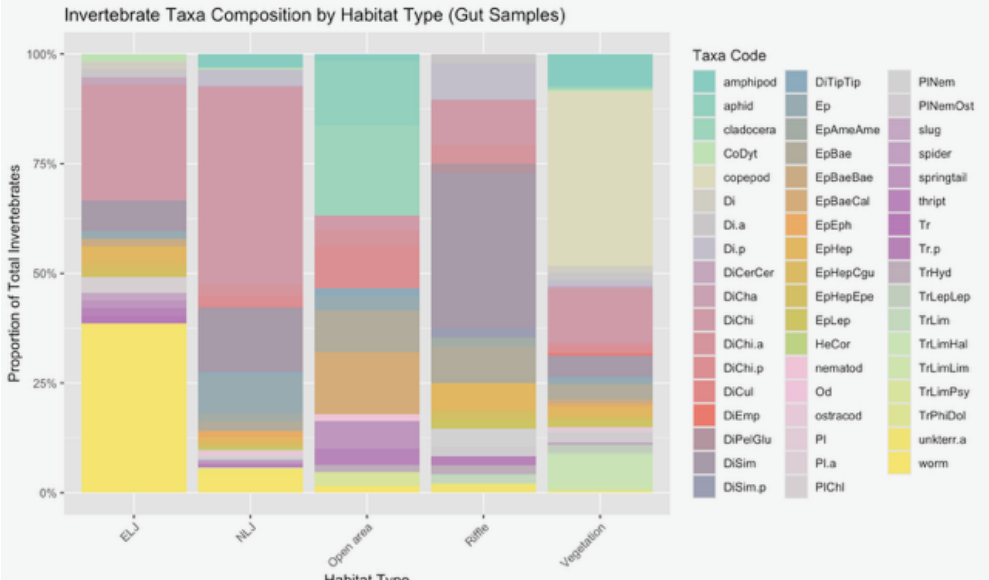


Results

Hyp: Food web structure will drive consumption by Chinook fry; Diet preferences will differ among habitats

- Chironomids are a primary prey category in fry gut samples
- Aquatic vegetation: copepods (small crustaceans) abundant in the diets
- Open areas: amphipods (small crustaceans) and cladocerans (water fleas/*Daphnia*) were present in high numbers.
- Prey switching due to habitat features?

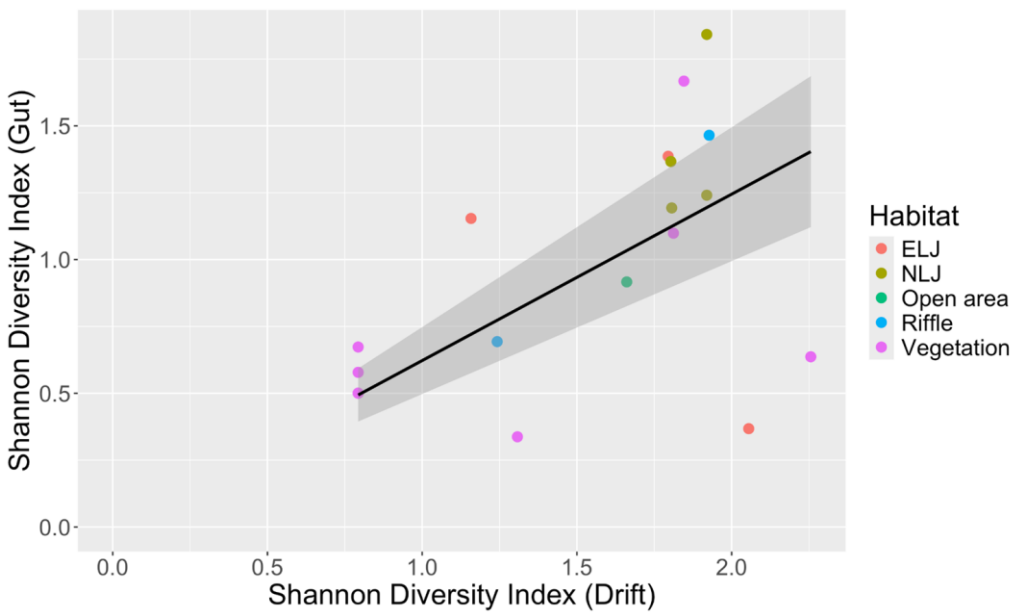




Results

Hyp: Food web structure will drive consumption by Chinook fry

- Fish track overall diversity - Increasing diversity in the diet with increasing diversity available in the drift.
- Suggests that food web complexity drives foraging opportunities to some extent

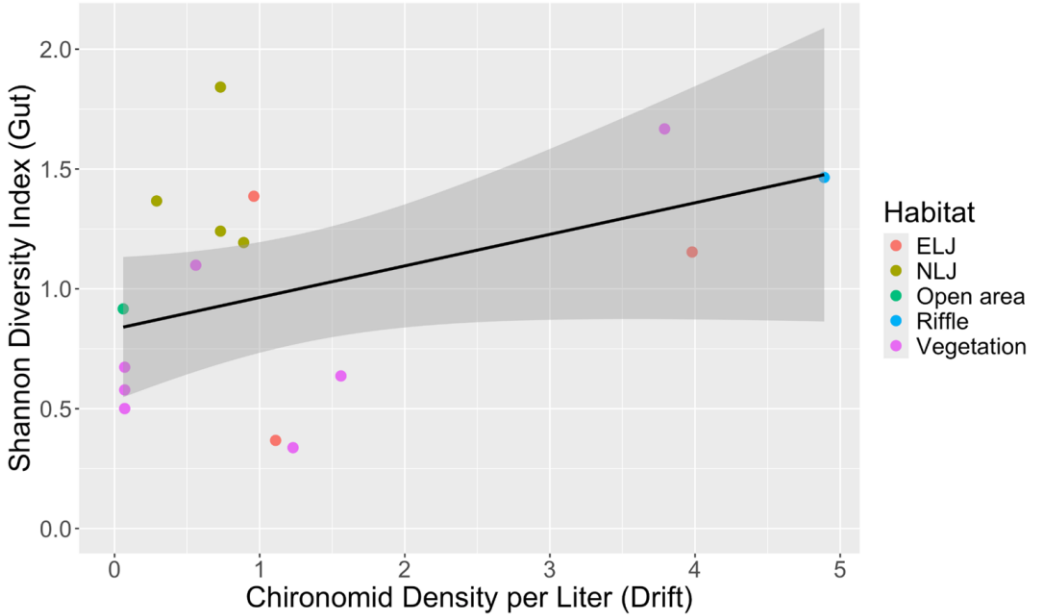


$p << 0.0001$

Results

Hyp: Food web structure will drive consumption by Chinook fry

- However, when more chironomids are more available (higher density), we do not see an increase in diversity of food items selected
- In other words, they don't shop around as much when more chironomids are available.
- Supports a trend in preference for chironomids.

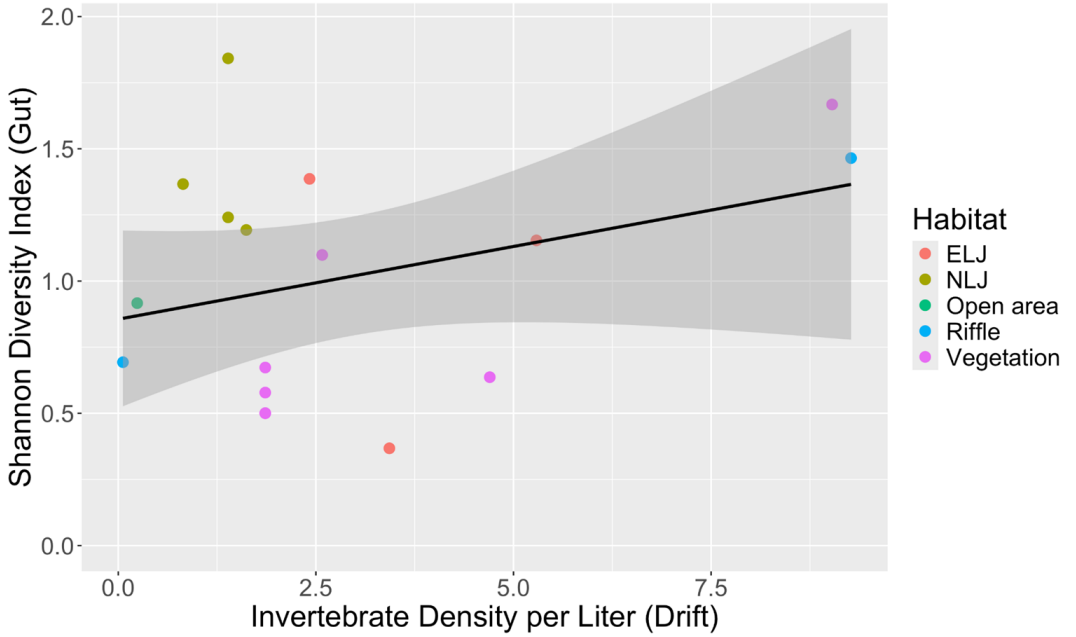


p = 0.09

Results

Hyp: Trends in foraging behavior will reflect patterns in overall density of invertebrates and availability of primary prey

- Chinook fry are selective foragers (vs. opportunistic)
- When *total* density of the food web components increases, diversity in the gut samples does not



p = 0.19

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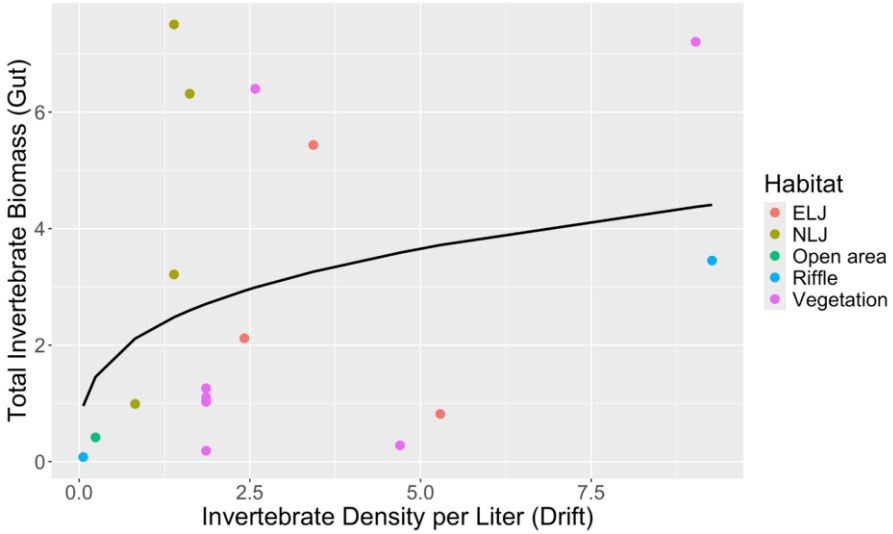
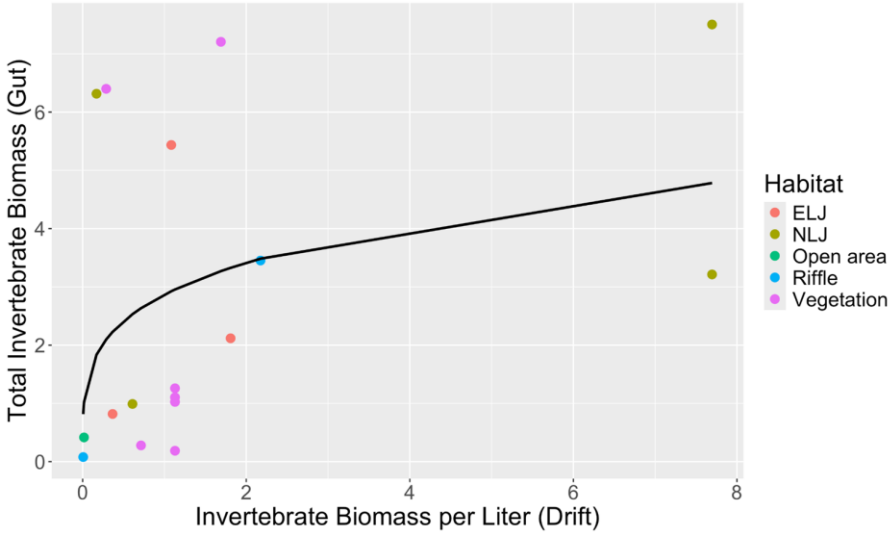
- Foraging depends upon food availability





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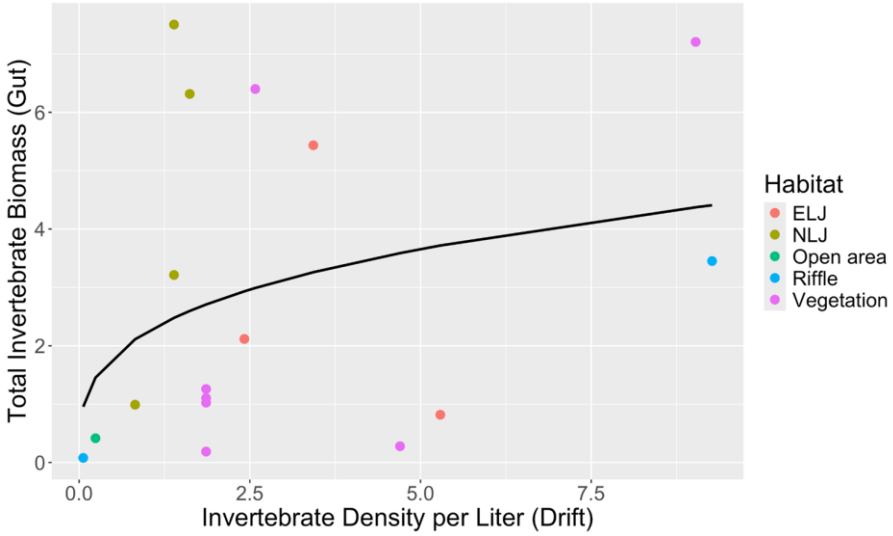
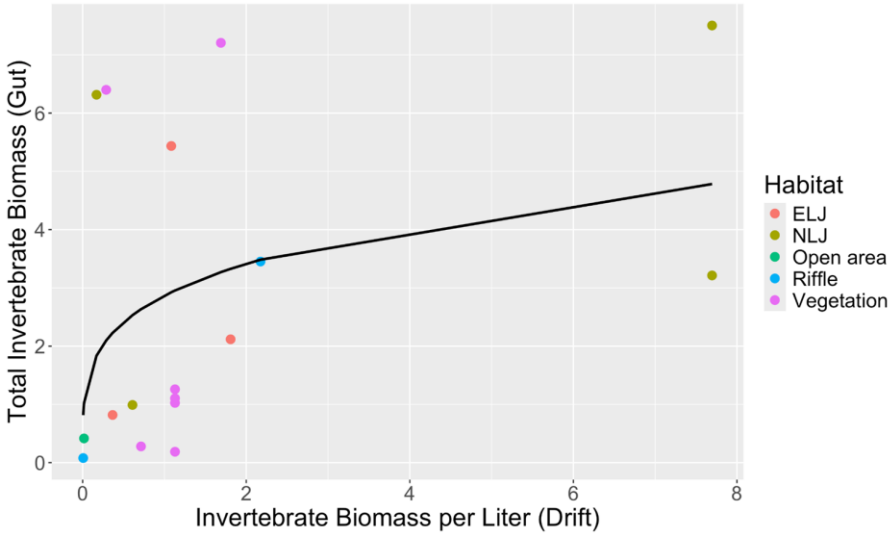
- Foraging depends upon food availability
- Foraging theory predicts forager will quit foraging when food obtained no longer exceeds the costs of foraging





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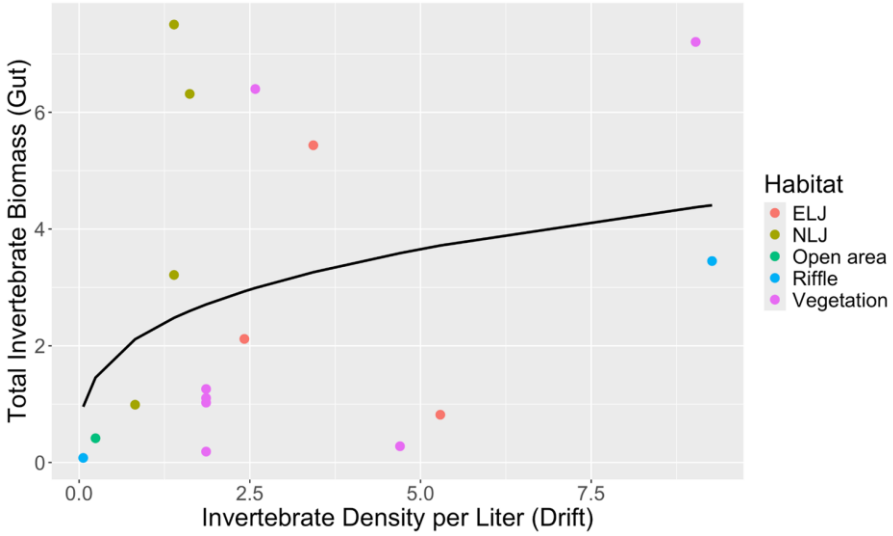
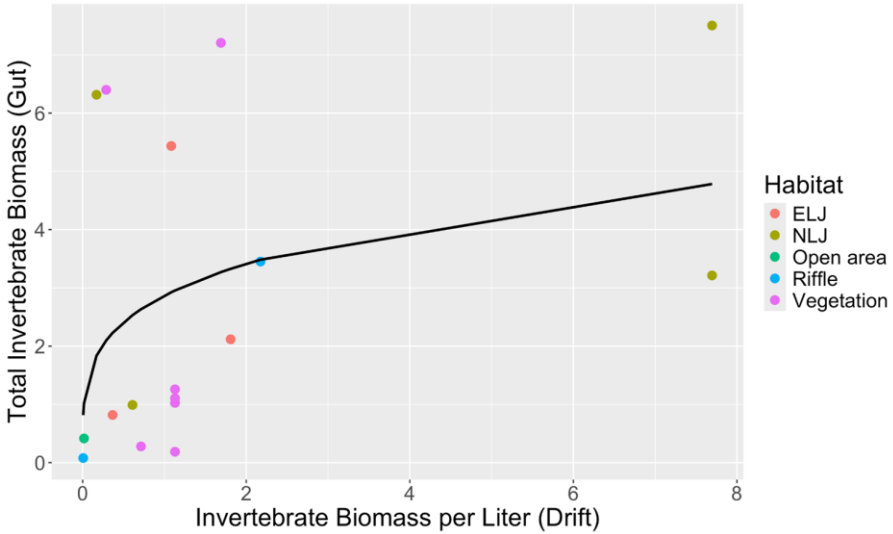
- Food remaining at the patch after forager quits = “Giving-up Density” (aka, GUD)





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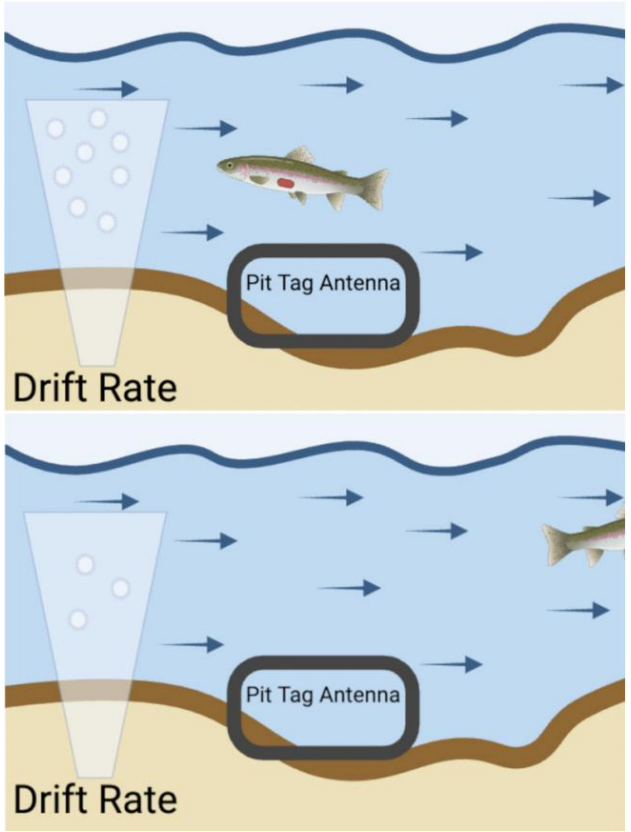
- GUD can indicate value of food which may vary across habitat types

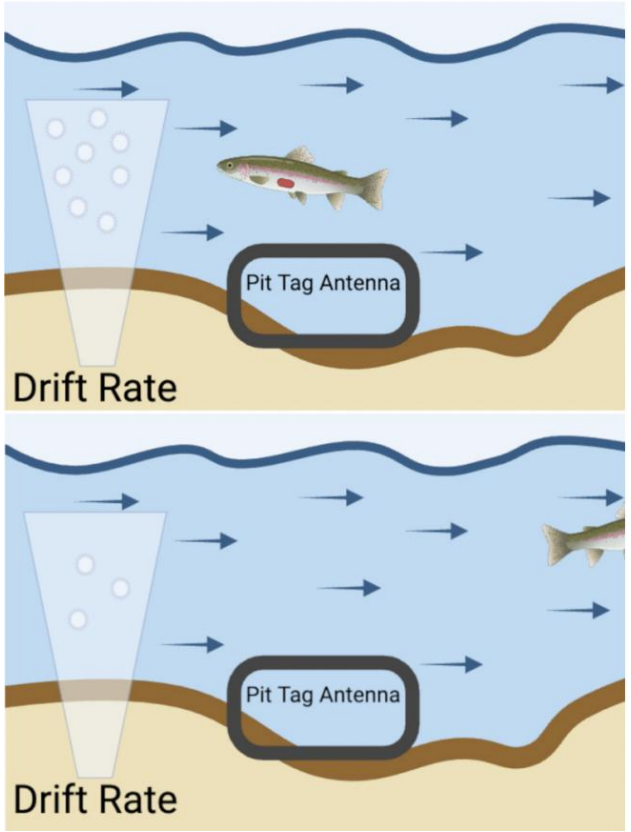


Malone et al. 2025

Results

Specific Hyp: Fish presence at a habitat will depend on delivery rate, suggesting that a GUD can be estimated

i.e., fish can tell us the value of food, which may vary across habitats.



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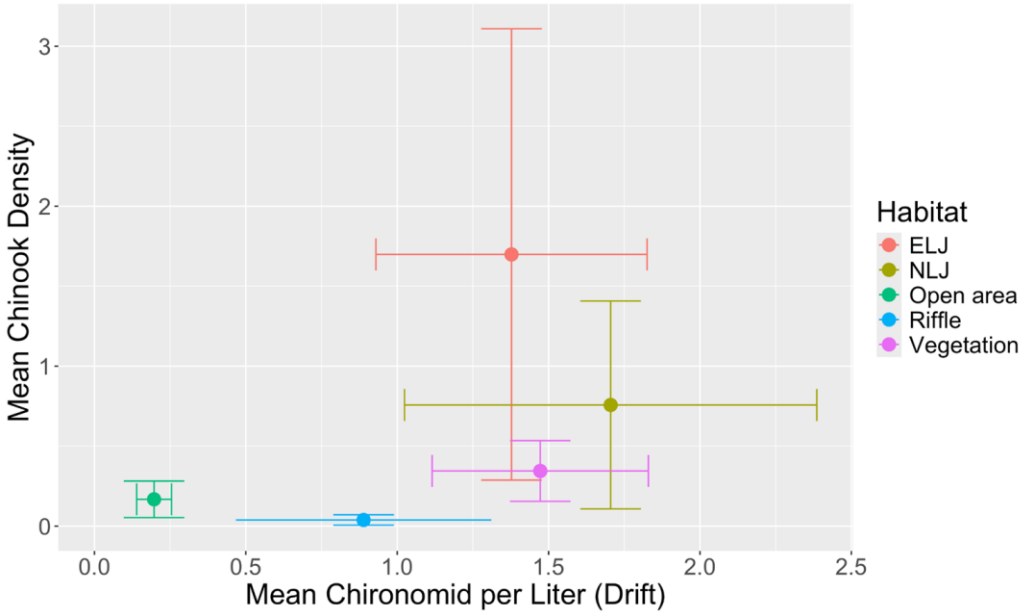
- Fish density approaches 0 at a drift delivery rate < 1.0-1.5 chironomids per liter in open areas, riffles, and possibly vegetated habitats. Similar food density may not be as close to GUD in ELJs/NLJs



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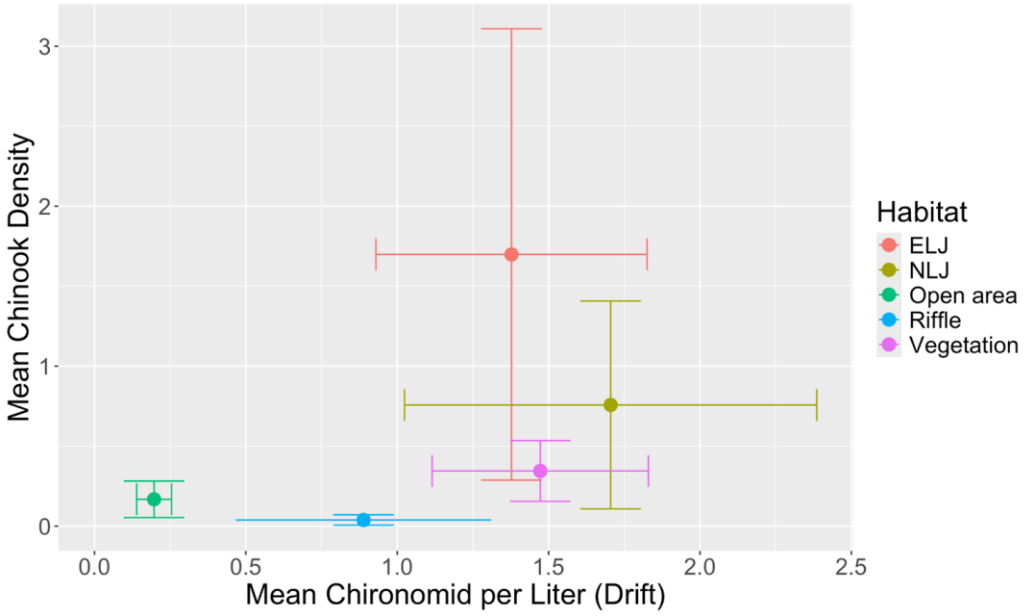
- Controlled experiments could generate GUDs much more accurately and precisely.



Summary

- Food web productivity drives total foraging on restored floodplains.
- Some differences among habitats in available prey species and consumption.
- Diversity of food items selected by Chinook fry depends on overall diversity available in the drift
- Management implications: Food matters! Because…
- Chinook appear to select chironomids preferentially in most habitats, alternate taxa in open areas and in aquatic vegetation.

More than a couple of caveats

- Relation between standing crop of food and foraging effort is not always mechanistic (i.e., drift could represent background resource availability different from specific delivery to a foraging fish)
- Some analyses considered chironomids only whereas there are other species to consider (especially copepods and amphipods in vegetated and open habitats, respectively)

More than a couple of caveats

- Relation between standing crop of food and foraging effort is not always mechanistic (i.e., drift could represent background resource availability different from specific delivery to a foraging fish)
- Some analyses considered chironomids only whereas there are other species to consider (especially copepods and amphipods in vegetated and open habitats, respectively)
- The only way to really estimate GUDs is through controlled feeding experiments (Malone et al. 2025) vs. basing conclusions on fish presence/absence.
- Some cases where fish may have foraged in a different place or at a different time - also digestion rates
- Bioenergetics analysis still pending

Shameless Plugs

Please read:

1) Malone, M. A. and C. M. Polivka. 2022. The behavioural ecology toolkit for fish management and conservation. *Fish and Fisheries* 23(6): 1485-1506

1) Malone, M. A., J. S. Brown, C. Whelan, and C. M. Polivka. 2025. How to feed a fish: Foraging theory and measurement of giving-up densities in marine and aquatic habitats. *Canadian Journal of Fisheries and Aquatic Sciences* 82: 1–17

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Questions / Discussion

Image: Matt Holland