FEEDING ECOLOGY OF JUVENILE CHINOOK SALMON EMIGRATING THROUGH THE LOWER COLUMBIA RIVER AND ESTUARY

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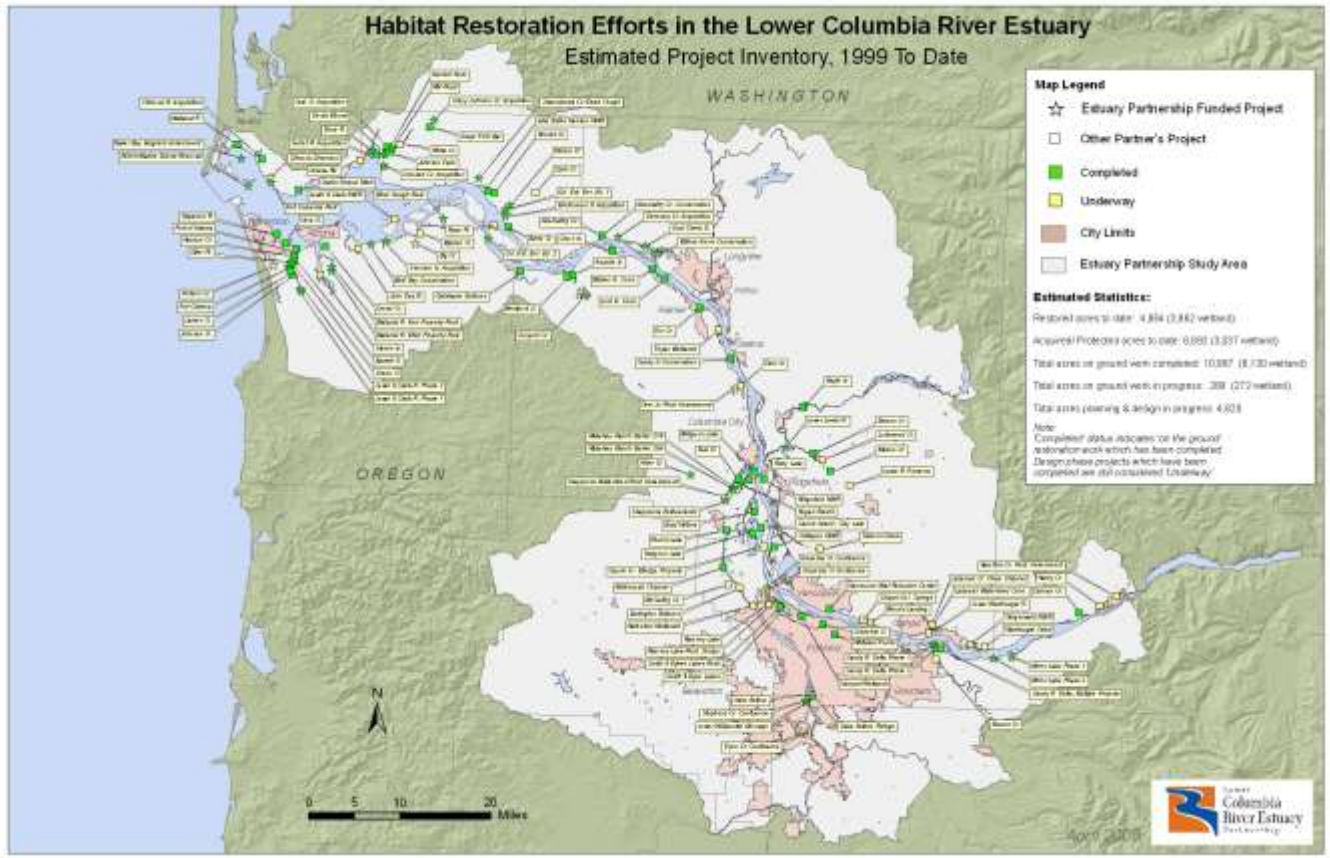
BACKGROUND- SALMON RECOVERY



- Over 90% of land in the lower Columbia River and estuary has been developed
- Focus on restoring estuarine habitats
- Currently, the Lower Columbia Estuary Partnership has restored/protected over 22,000 with the goal of 25,000 wetland acres by 2025
- Breaching levees and dikes to restore wetlands
- Improving salmonid habitat (rearing, spawning, feeding)

WHICH SPECIES IS THE ESTUARY BEING RESTORED FOR?

- **Lower Columbia River estuary is an important habitat for many juvenile salmonid stocks**
- **Duration in estuary can differ by stock during emigration**
- **Most research is focused on shallow water habitat and wetland use**
- **Less is known about habitat use by threatened interior spring stocks**

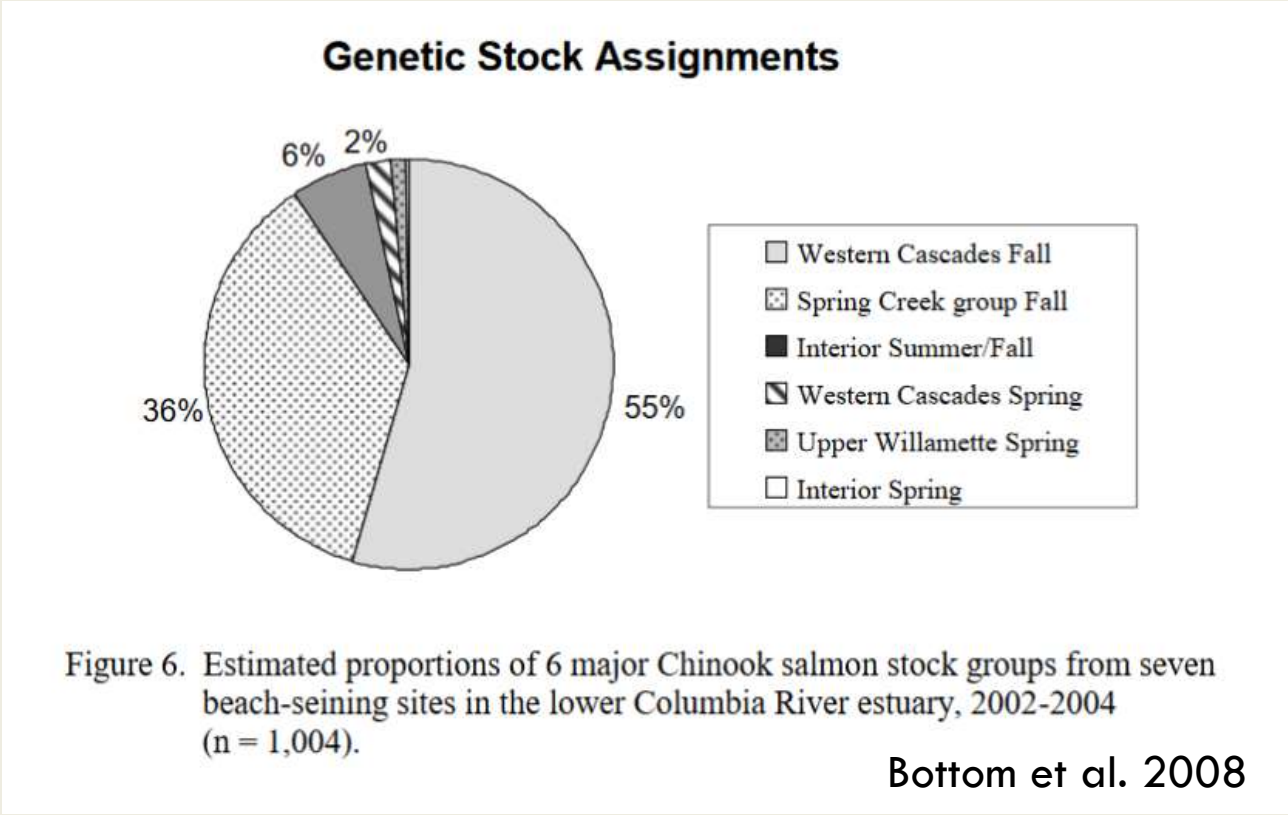
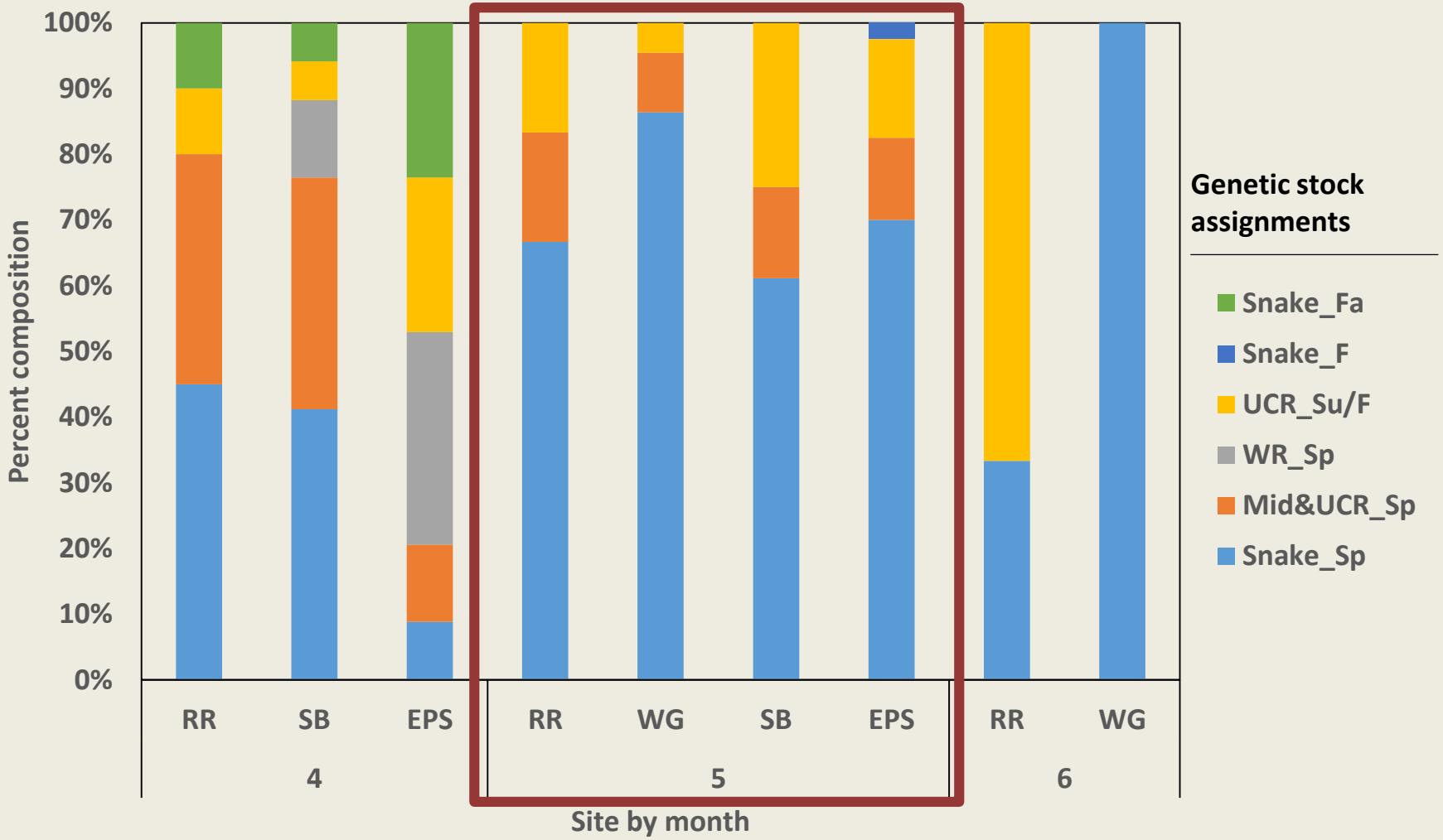


Figure 6. Estimated proportions of 6 major Chinook salmon stock groups from seven beach-seining sites in the lower Columbia River estuary, 2002-2004 (n = 1,004).

Bottom et al. 2008

MAINSTEM CATCH DATA (2016)



WETLAND RESTORATION-INDIRECT BENEFITS

Yearling migration rates: 30-60 km/day

BIG QUESTION

- Are the estuary habitat restoration actions achieving expected biological and environmental benefits?
  - Specifically for interior stocks of Chinook salmon

Is restoration working and can we detect it?

River **Floodplain**

Photo credit: Jeff Operman, UC Davis Watershed Sciences

RESEARCH OBJECTIVES

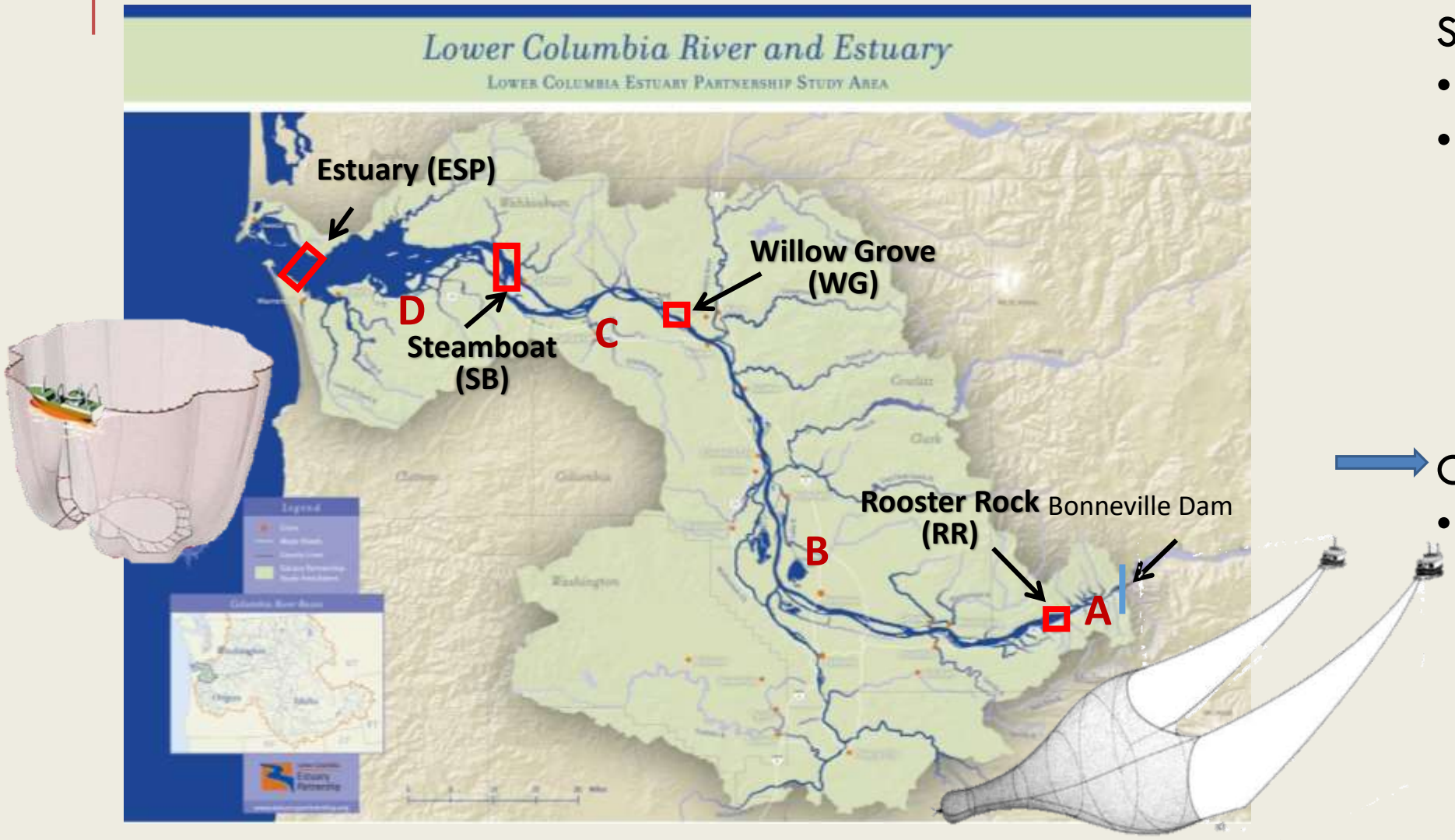
Goal: Evaluate the ecological benefits of restoration actions for yearling salmon in the lower Columbia River and estuary

OBJECTIVES:

1) *Characterize food habits of emigrating yearling Chinook in the LCR&E*
   - Determine diet composition and stomach fullness trends along the longitudinal continuum

2) *Identify if we can detect changes in food sources (stable isotope signatures) supporting emigrating yearlings*
   - *If so, can we provide any information on those changes*

METHODS: FIELD COLLECTIONS (2016-2017)



2017 only

- McCall Hatchery Sampling
  - 50 fish
  - 5 tissue types:
    - Caudal fin
    - Muscle
    - Liver
    - Plasma
    - Red blood cells
- Ocean (BPA)
  - 24 fish

ANALYSES

Diet analysis (<30hrs)

- **Presence/absence of insects**

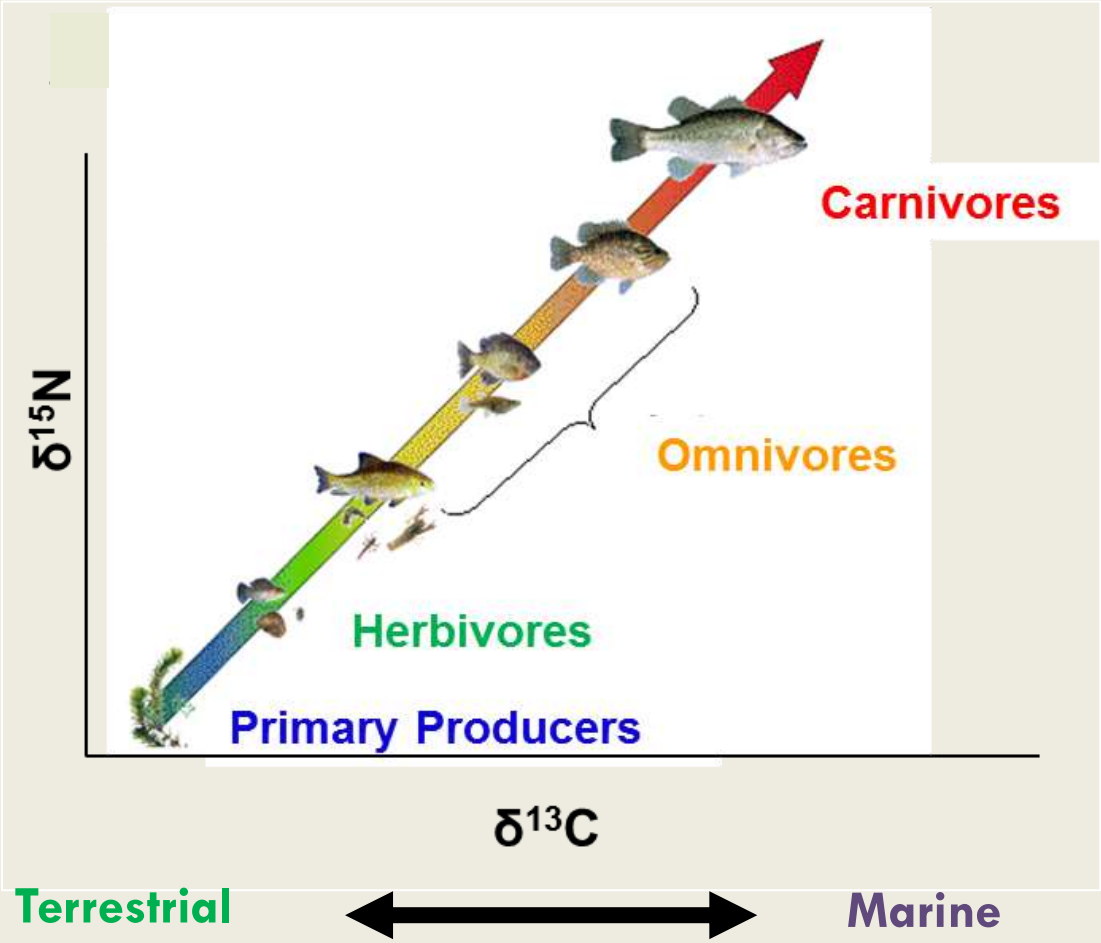
Stable isotope analysis

- **Tissue (Fin and Muscle) - recent food source switches**
- **Prey in stomach – stable isotope signatures of prey consumed**

For 2016

STABLE ISOTOPE ANALYSIS (SIA)

- **Powerful tool in diet and food web studies**
  - **"You are what you eat!"**
- **Measured as a ratio of heavy to light isotope**
- **Carbon** – Primary producers (carbon sources)
- **Nitrogen** - Trophic position
  ~3.5% enrichment for each trophic position



PRELIMINARY RESULTS

			RR	WG	SB	EPS
Insecta						
	Coleoptera	Coleoptera	4	4	4	4
		Coccinellidae	2	2		
		Dytiscid			1	
		Elmidae		1		
		Staphylinidae	1			
	Diptera	Diptera	4	4	4	4
		Cecidomyiidae			1	
		Ceratopogonidae			2	2
		Chironomidae	4	4	4	4
		Simuliidae		1		
	Diptera-Brachycera	Muscidae			1	
	Ephemeroptera	Ephemeroptera	3	3	3	
	Hemiptera	Hemipteran	2		2	
		Aphididae	3		3	3
		Cicadellidae	1			
		Psyllidae			1	
		Tingidae		1		
	Hymenoptera	Hymenoptera	4	4	4	4
		Formicidae		1		
	Odonata	Anisoptera		1		
		Coenagrionidae		1		
		Zygoptera	2		2	
	Plecoptera	Plecoptera	1			
	Trichoptera	Trichoptera case	2			2
	Insect	Insect	4	4	4	4
Other arthropoda						
		Acari				1
		Araneae	3	3	3	
Crustacea						
	Amphipod	Amphipod	4	4	4	4
	Corophiidae	Americorophium	4	4	4	4
		A. salmonis		2	2	
		A. spinicornis		2	2	
	Gammaridae	Gammaridae	4	4	4	4
		Orange gammarus	3	3	3	
		G. lacustris	3	3	3	
	Cladocera	Daphnia sp			2	2
	Other crustacea	Crustacean parts	3	3		3
		Cirripedia	2			2
		Mysidae	1			
Other						
		Bivalve	3		3	3
		Fish scale	4	4	4	4
		Nematoda		3	3	3
		Rocks/seeds/plants	4	4	4	4
		Plastic		2	2	
		Unidentified matter	4	4	4	4

PRELIMINARY RESULTS

Hymenopteran

Americorophium

			RR	WG	SB	EPS
Insecta						
	Coleoptera	Coleoptera	4	4	4	4
		Coccinellidae	2	2		
		Dytiscid			1	
		Elmidae		1		
		Staphylinidae	1			
	Diptera	Diptera	4	4	4	4
		Cecidomyiidae			1	
		Ceratopogonidae			2	2
		Chironomidae	4	4	4	4
		Simuliidae		1		
	Diptera-Brachycera	Muscidae			1	
	Ephemeroptera	Ephemeroptera	3	3	3	
	Hemiptera	Hemipteran	2		2	
		Aphididae	3		3	3
		Cicadellidae	1			
		Psyllidae			1	
		Tingidae		1		
	Hymenoptera	Hymenoptera	4	4	4	4
		Formicidae		1		
	Odonata	Anisoptera		1		
		Coenagrionidae		1		
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	Cladocera	Daphnia sp			2	2
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		Cirripedia	2			2
		Mysidae	1			
Other						
		Bivalve	3		3	3
		Fish scale	4	4	4	4
		Nematoda		3	3	3
		Rocks/seeds/plants	4	4	4	4
		Plastic		2	2	
		Unidentified matter	4	4	4	4

PRELIMINARY RESULTS

Odonata: Coenagrionidae

			RR	WG	SB	EPS
Insecta						
	Coleoptera	Coleoptera	4	4	4	4
		Coccinellidae	2	2		
		Dytiscid			1	
		Elmidae		1		
		Staphylinidae	1			
	Diptera	Diptera	4	4	4	4
		Cecidomyiidae			1	
		Ceratopogonidae			2	2
		Chironomidae	4	4	4	4
		Simuliidae		1		
	Diptera-Brachycera	Muscidae			1	
	Ephemeroptera	Ephemeroptera	3	3	3	
	Hemiptera	Hemipteran	2		2	
		Aphididae	3		3	3
		Cicadellidae	1			
		Psyllidae			1	
		Tingidae		1		
	Hymenoptera	Hymenoptera	4	4	4	4
		Formicidae		1		
	Odonata	Anisoptera		1		
		Coenagrionidae		1		
		Zygoptera	2		2	
	Plecoptera	Plecoptera	1			
	Trichoptera	Trichoptera case	2			2
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	Corophiidae	Americorophium	4	4	4	4
		A. salmonis		2	2	
		A. spinicornis		2	2	
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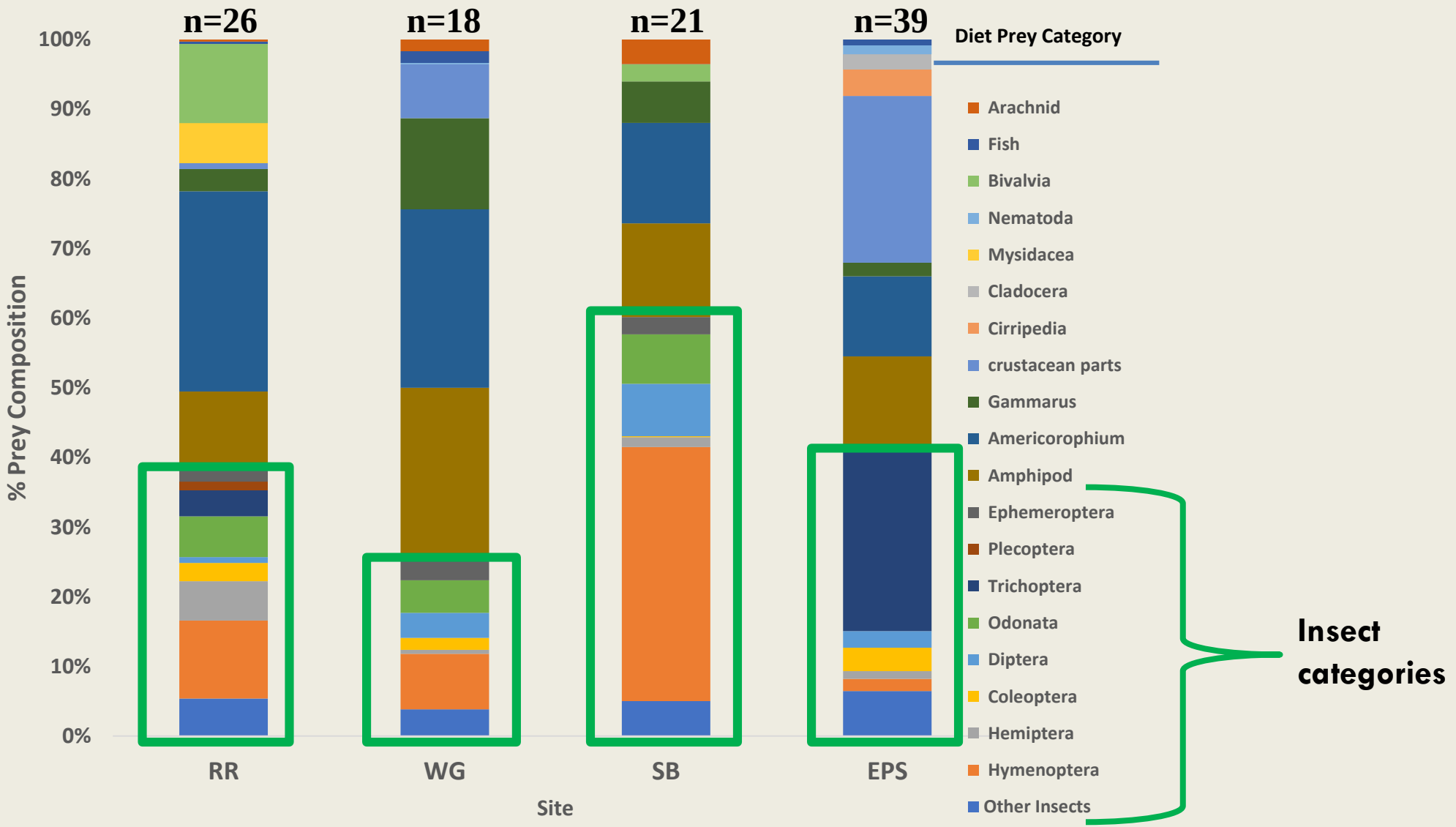
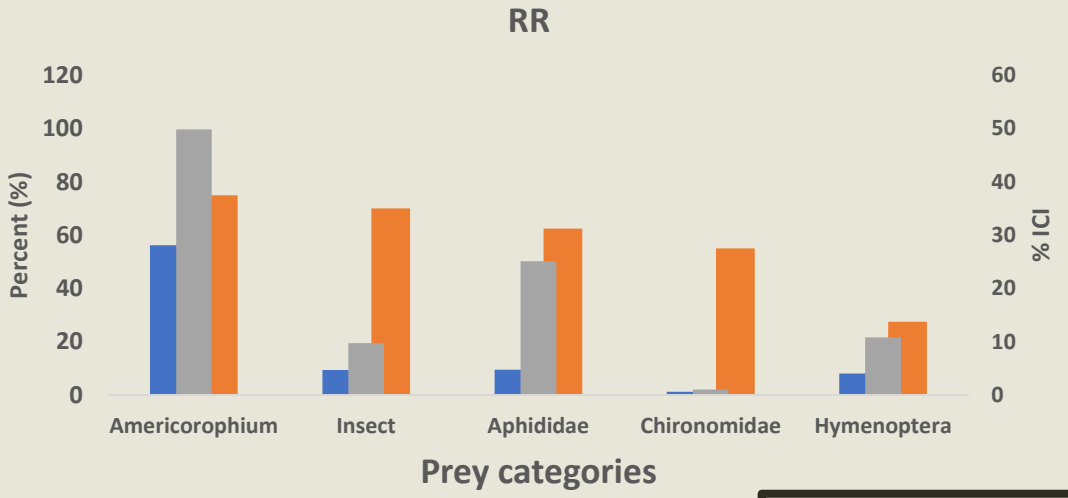
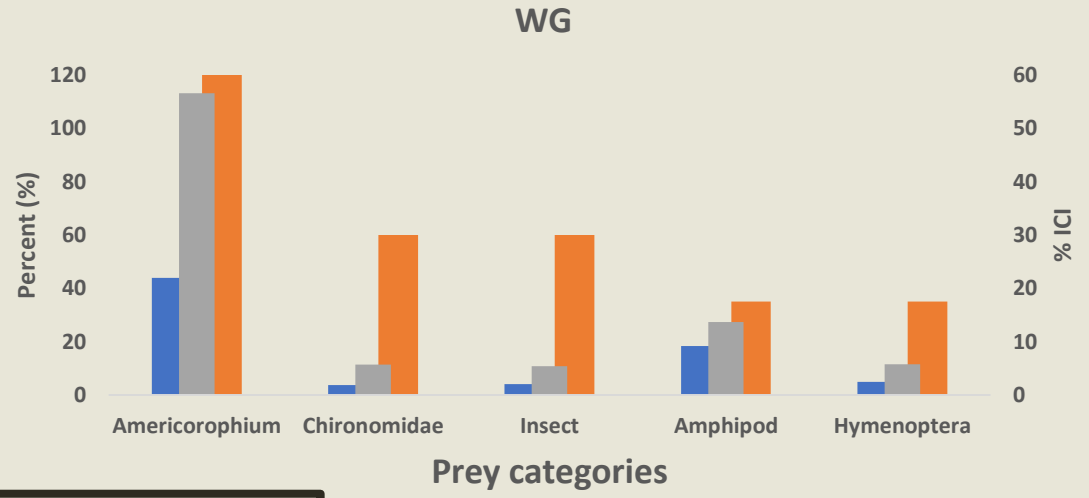
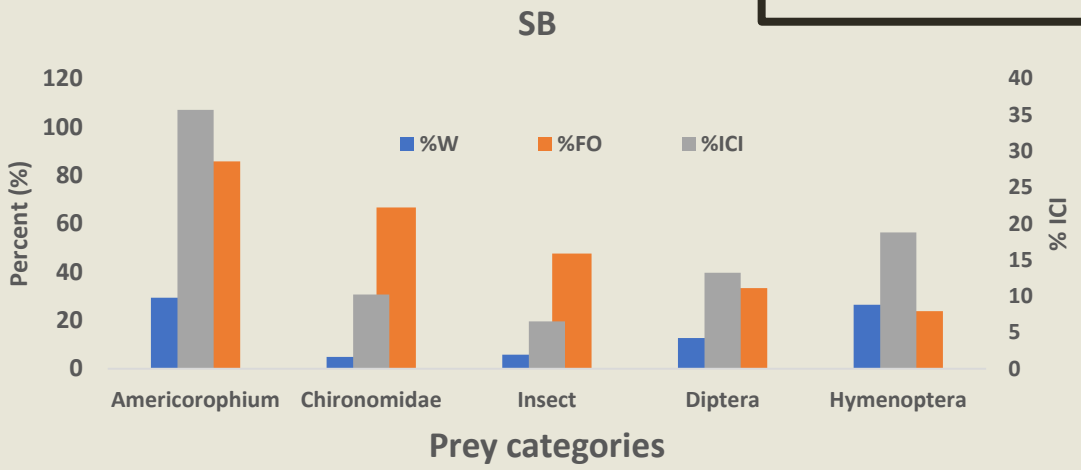
		Bivalve	3		3	3
		Fish scale	4	4	4	4
		Nematoda		3	3	3
		Rocks/seeds/plants	4	4	4	4
		Plastic		2	2	
		Unidentified matter	4	4	4	4

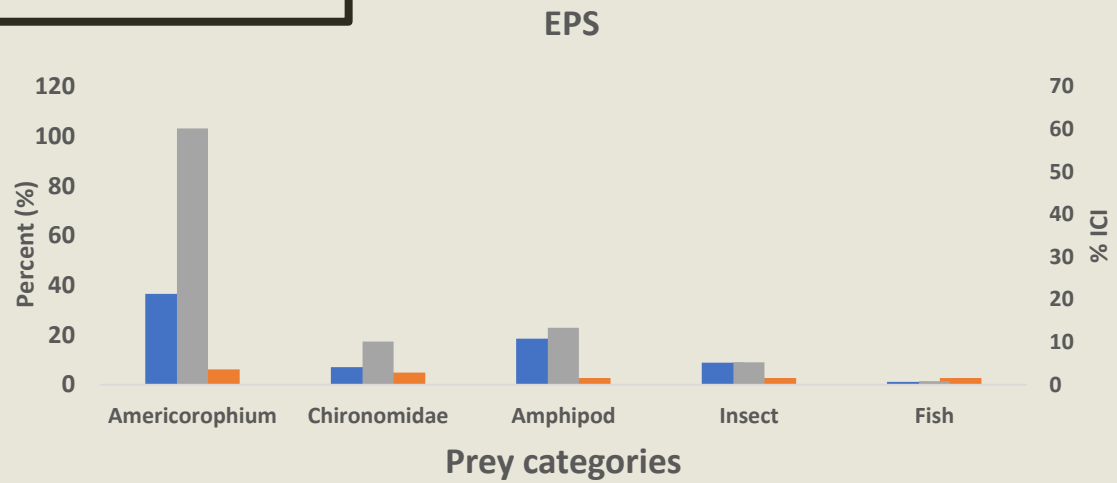
DIET COMPOSITION





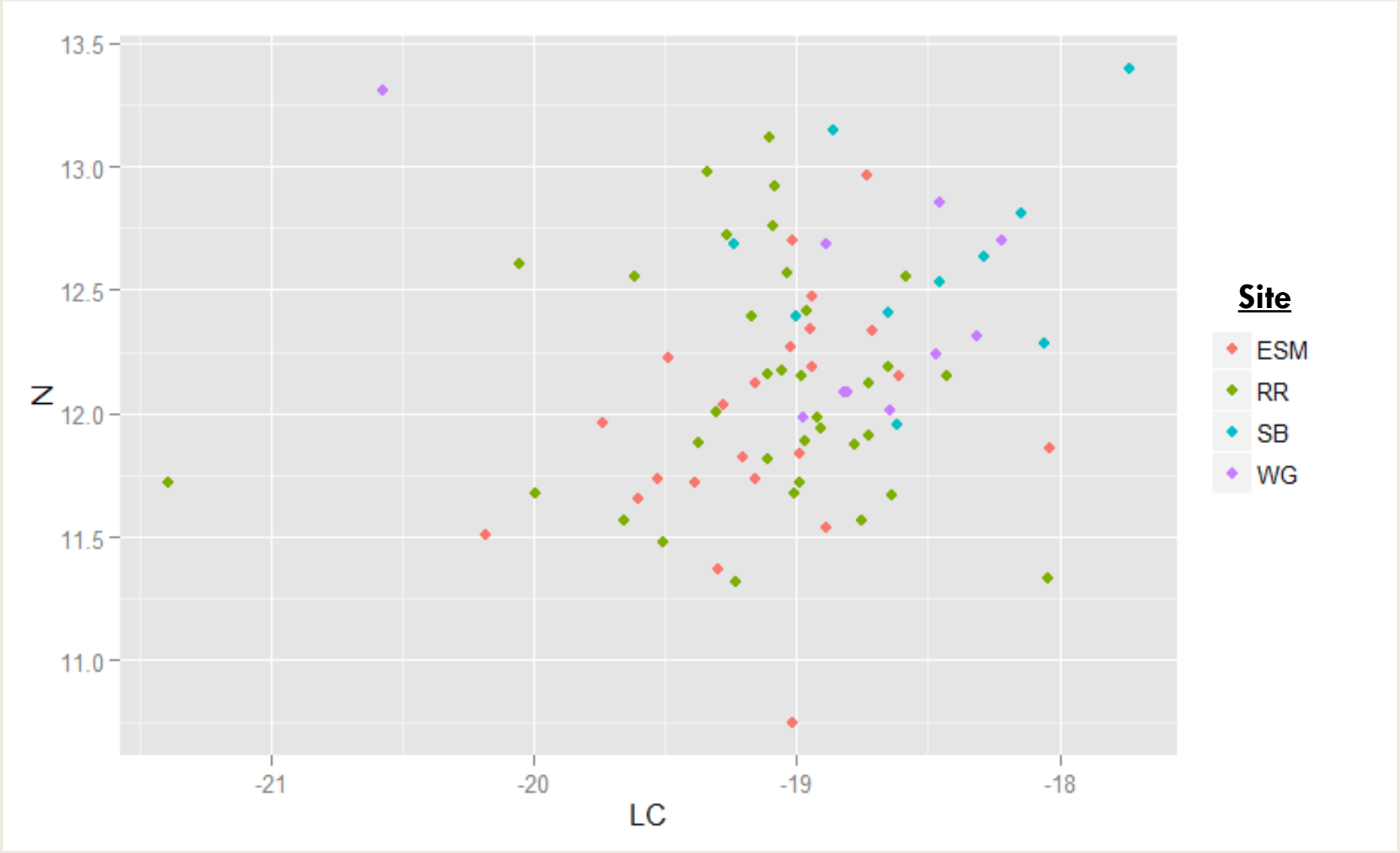




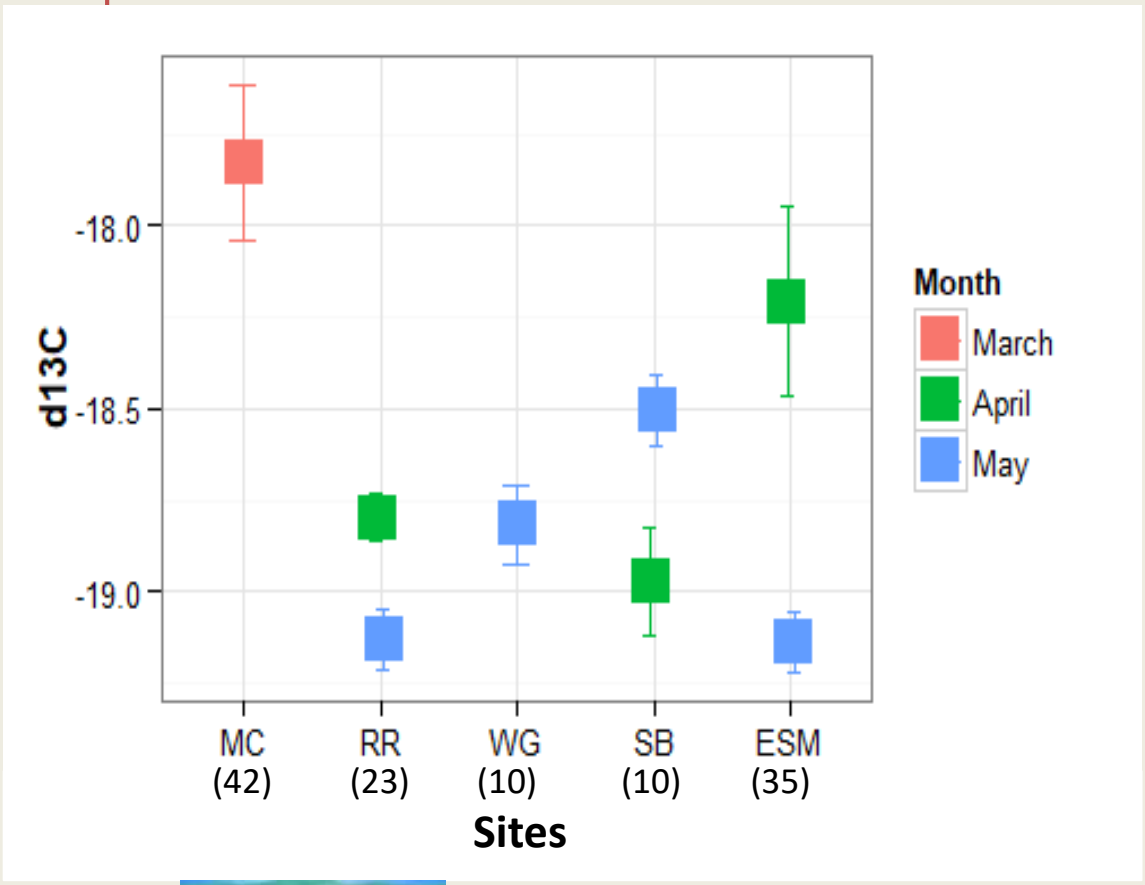


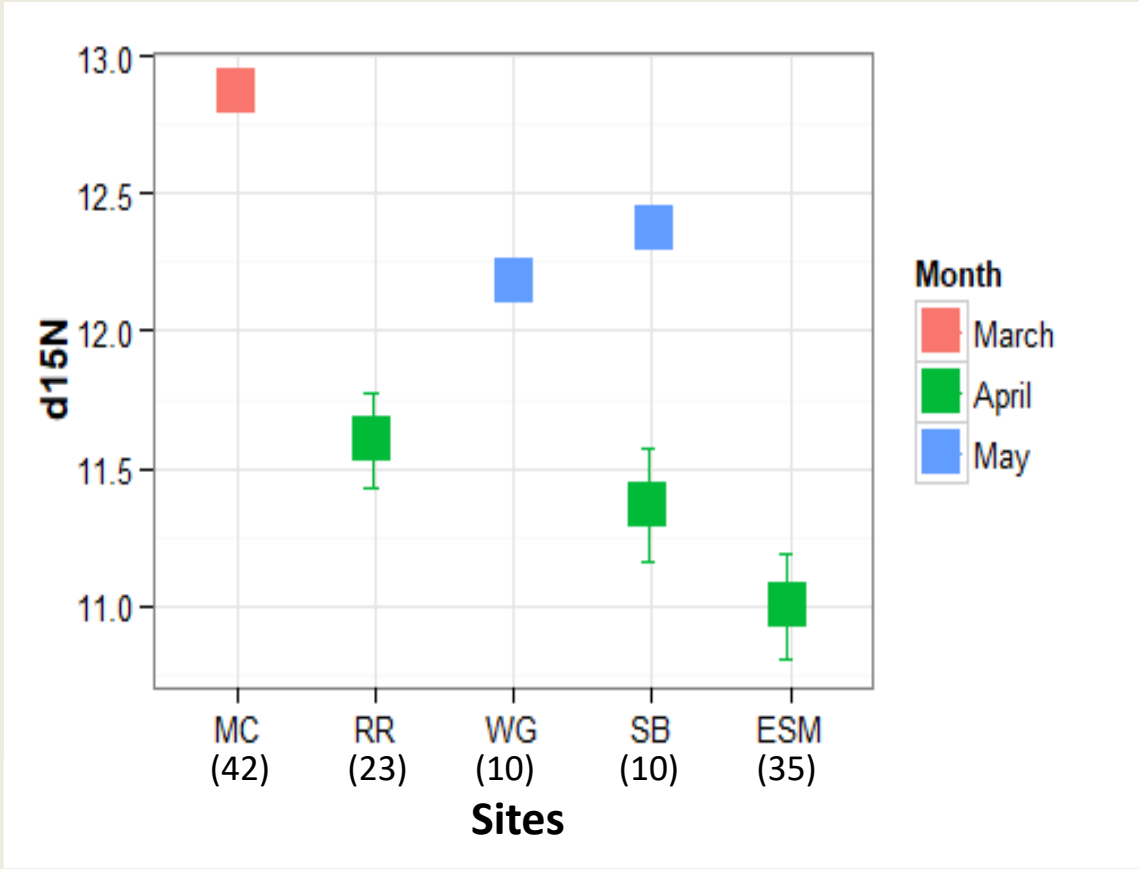
IMPORTANT PREY BY SITE

FIN SAMPLES (MAY 2016)



FIN STABLE ISOTOPE (MAY 2016)





Dam

Ocean

SIGNIFICANCE: MAINSTEM SPRING CHINOOK SIA

Carbon (d13C)

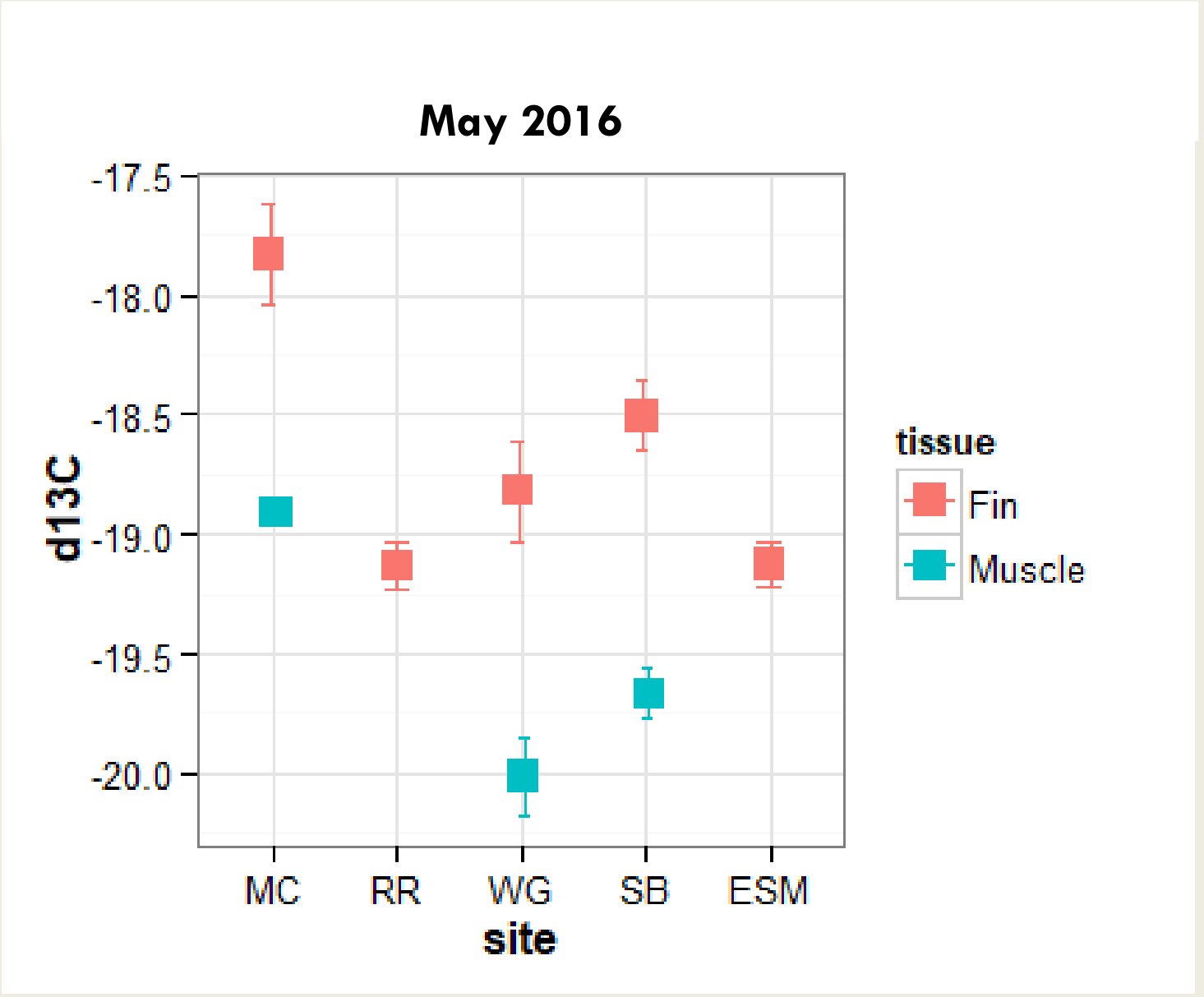
- SB and RR ($p<0.05$)
- SB and ESP ($p<0.05$)
- McCall is significantly different from all sites except SB

Nitrogen (d15N)

- SB and RR ($p<0.05$)
- SB and ESP ($p<0.05$)
- WG and ESP (<0.05)
- McCall is significantly from ESP and RR

STABLE ISOTOPE SIGNATURE BY TISSUE TYPE

- Mean shift in muscle and fin stable isotope signatures ~1unit
- Smaller sample size for muscle
- No samples collected from RR and ESM



WHAT IS NEXT?

- Using McCall samples and possibly prey and primary source data from monitoring sites in the LCR&E to aid in interpretation of field samples
- Stable isotope analysis on most common prey items from yearling stomach contents
- Determine if there is variability within the caudal fin tissue
  - Split fin into thirds
- 2017 AEMR samples + BPA Ocean samples
- Compare yearling Chinook data to steelhead and sub-yearling fin data (2017)

ACKNOWLEDGEMENTS

Laurie Weitkemp

Jessica Miller

Interns

Sawyer Finley, Elle Bowman

Field Crew and Boat Operators

Jake Biron, Wayne Haines, Lance Renoux, Brian Kelly, Kaya Johnson

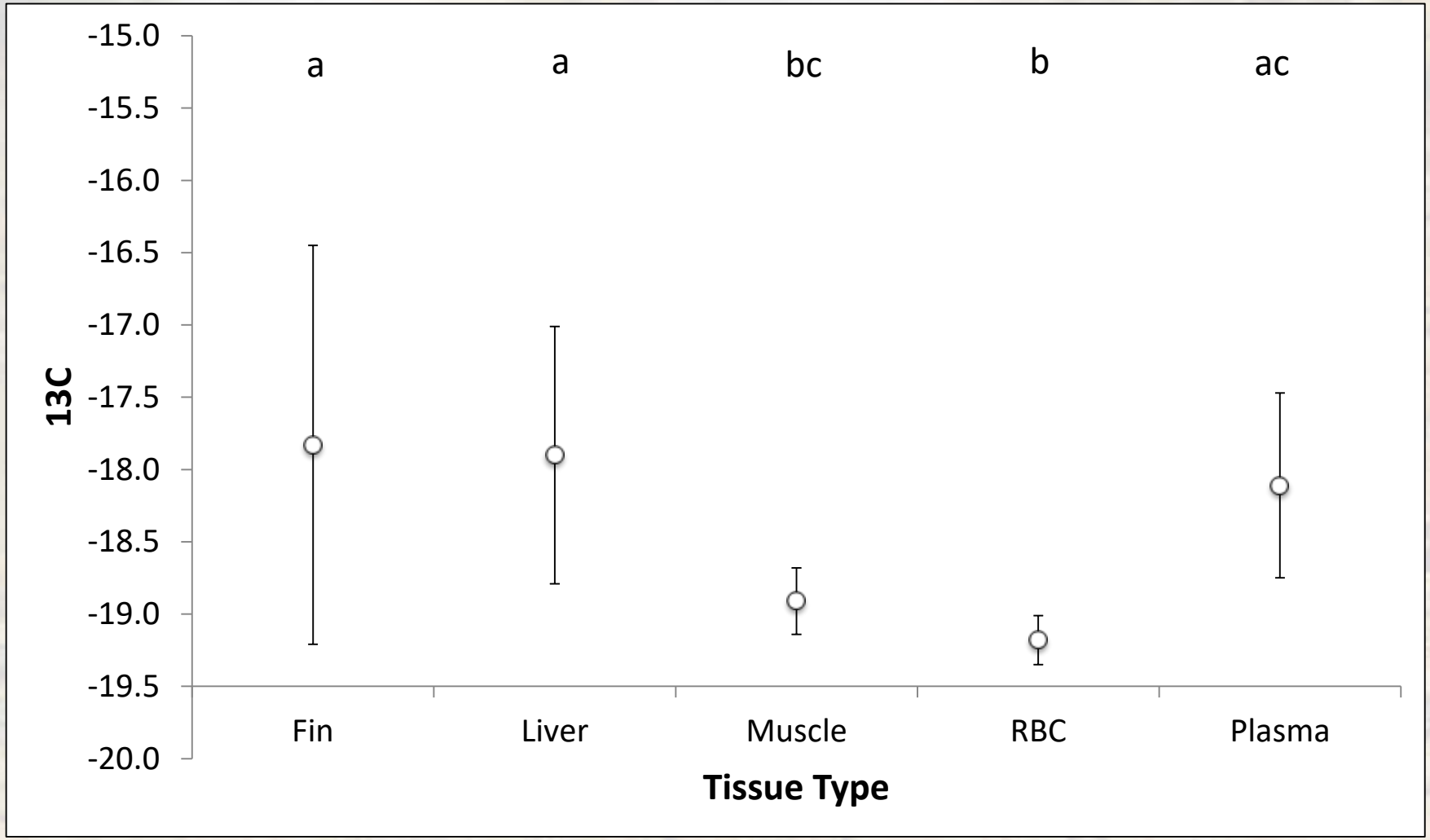
McCall Collections

Beckman Lab, Peik Anderesen

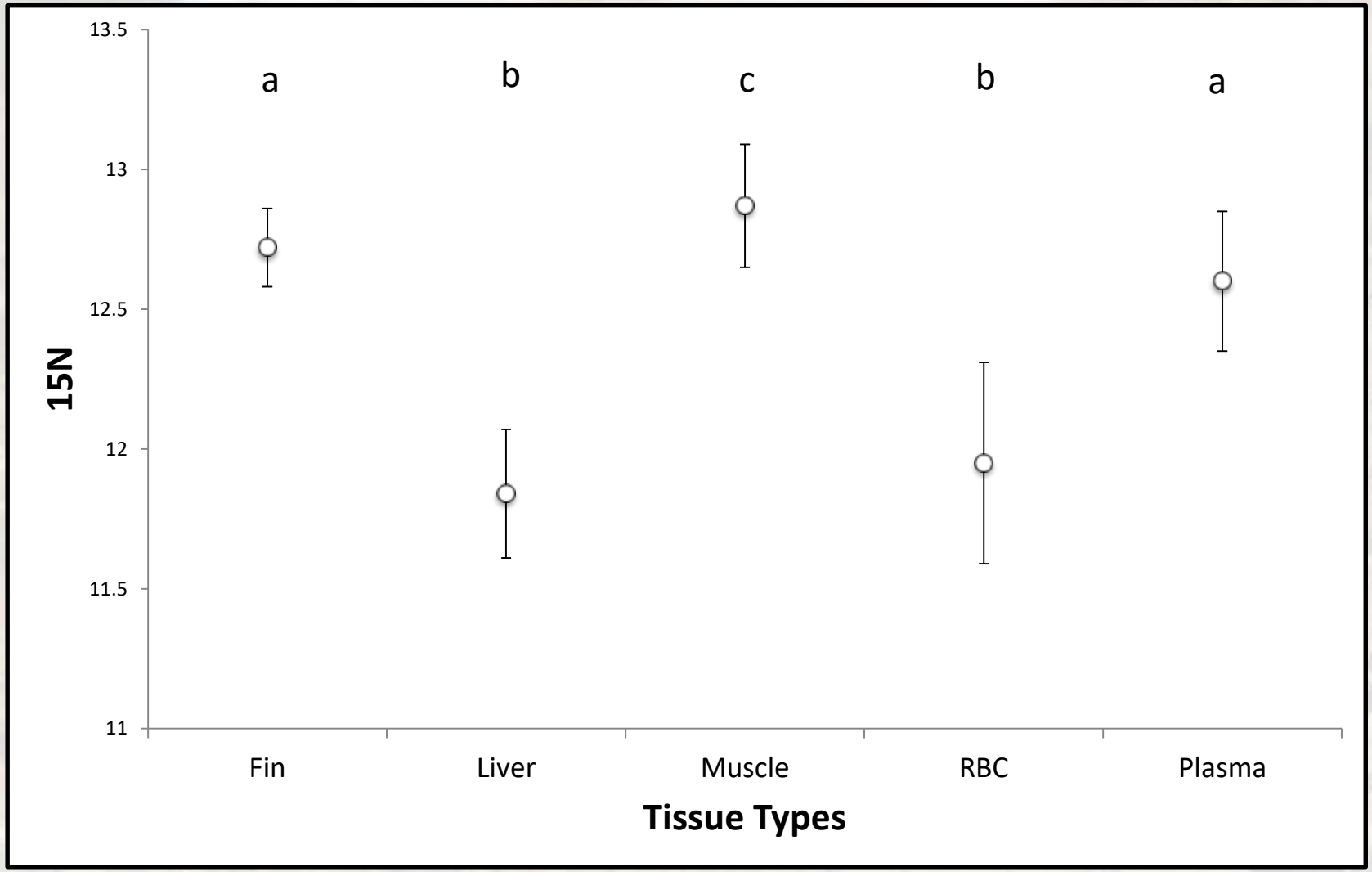
Funding

NOAA LMRCSC and EPP, Mamie Markham Research Award

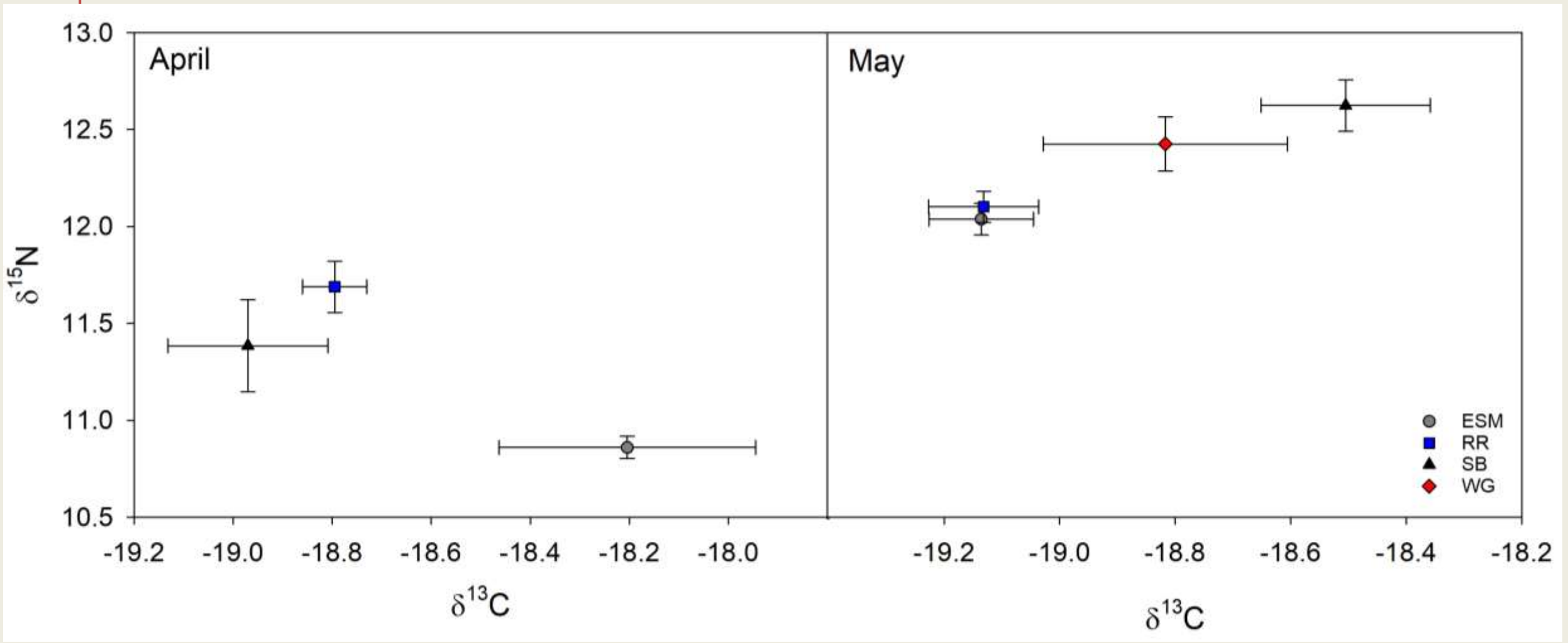
Lipid corrected $\delta^{13}C$ values differed significantly between tissue types



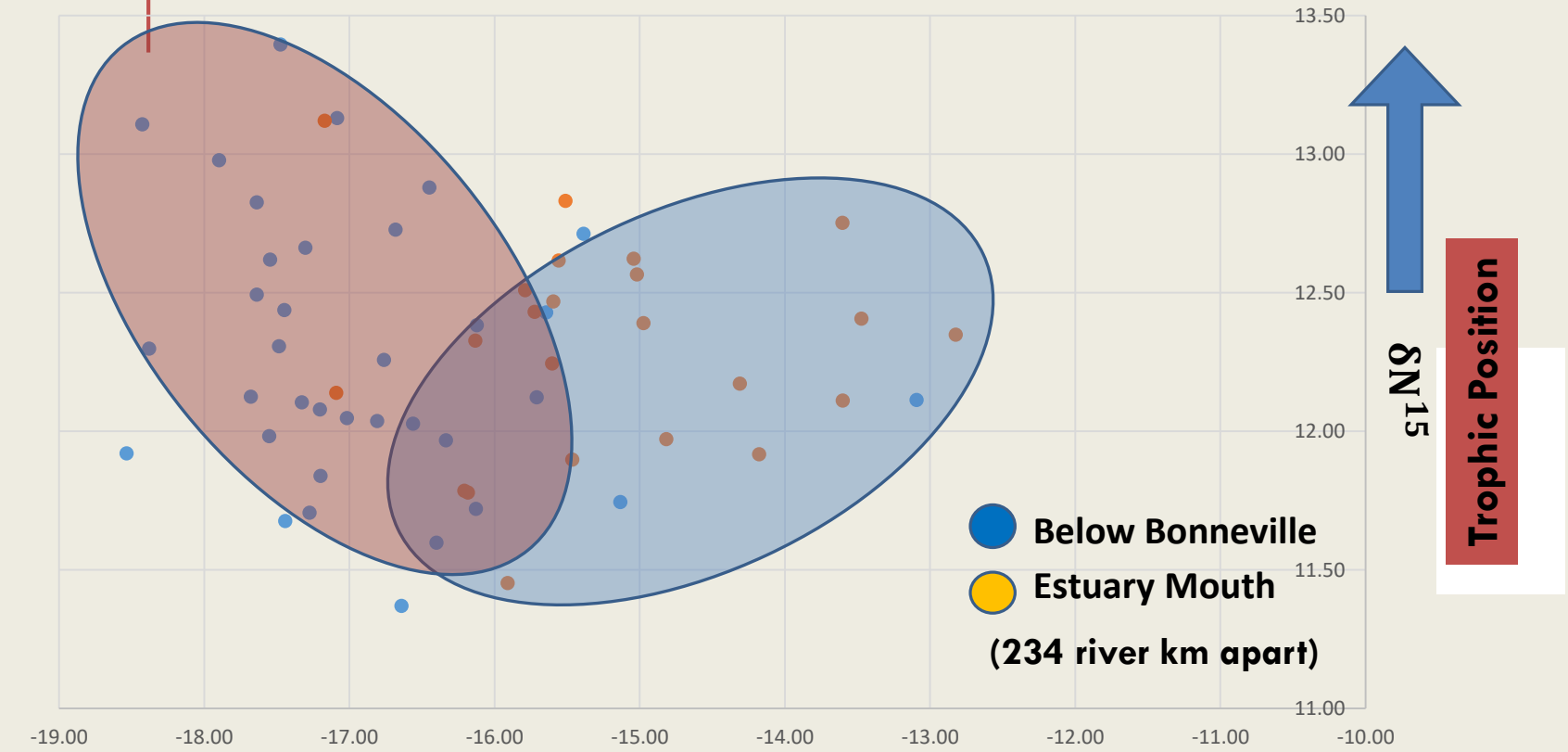
$\delta^{15}N$ rates were different between most tissue types



Fin Tissue


April
May
13.0
12.5
12.0
11.5
11.0
10.5
$\delta^{15}N$
-19.2
-19.0
-18.8
-18.6
-18.4
-18.2
-18.0
$\delta^{13}C$
ESM
RR
SB
WG

PRELIMINARY: SIA FIN TISSUE



Dam

Ocean

- Snake Spring Chinook salmon collected in May
- Variable migration rates and food sources seen in overlap
- Moving away from hatchery signal (decrease in N)
- Diet switches occurring during emigration
- Middle sites and April samples yet to be analyzed

	P-value
C:N	< 0.01
dN15	0.88
dC13	<0.01

CHALLENGES AND LIMITATIONS

- Will fin tissue have a fast enough turnover rate that I can identify shifts in food sources during their emigration through the LCR&E?
- How well am I going to be able to translate my stable isotope signatures into actual sources?

METHODS: DIET ANALYSIS

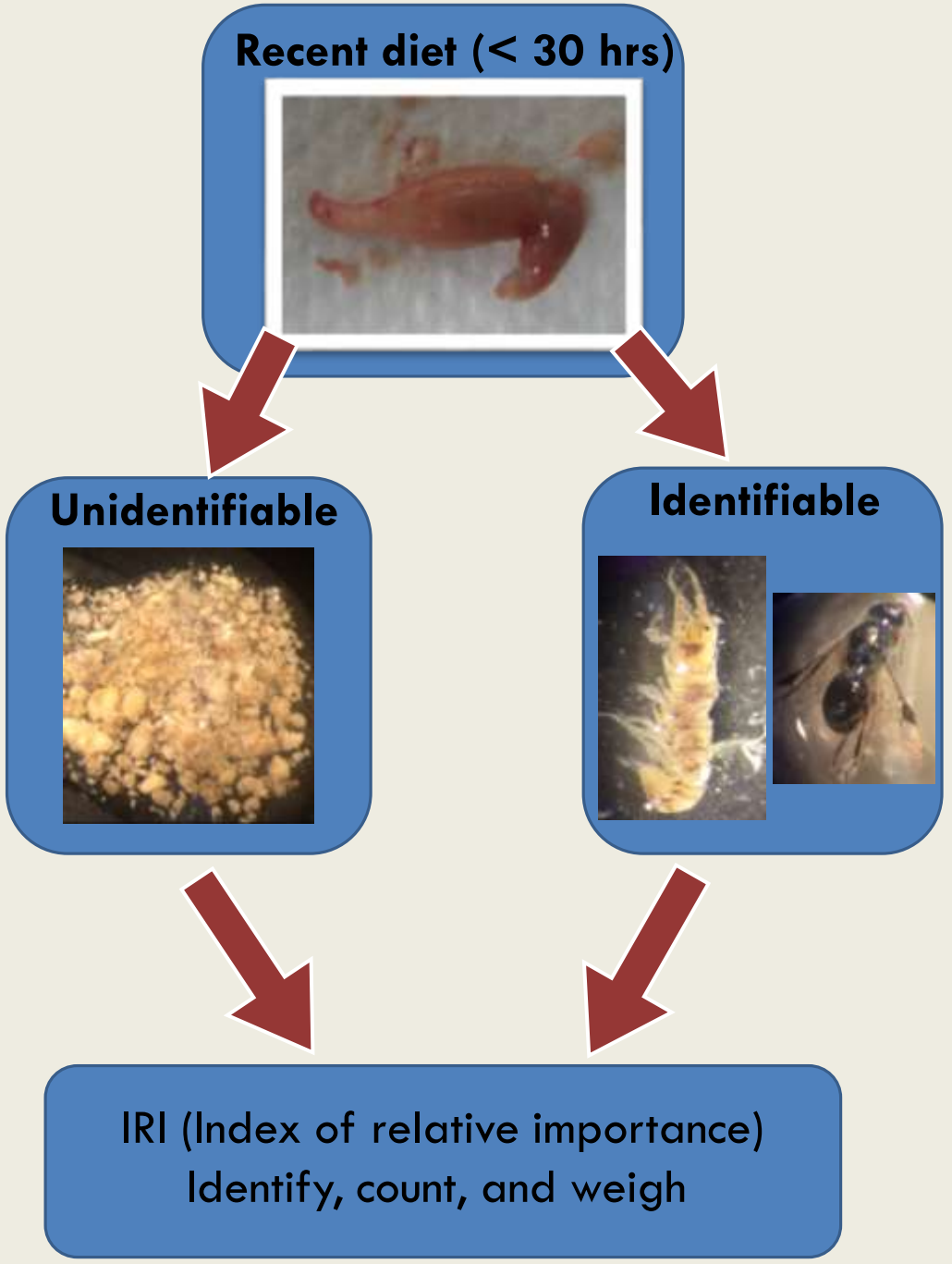
Analysis:

Diet composition

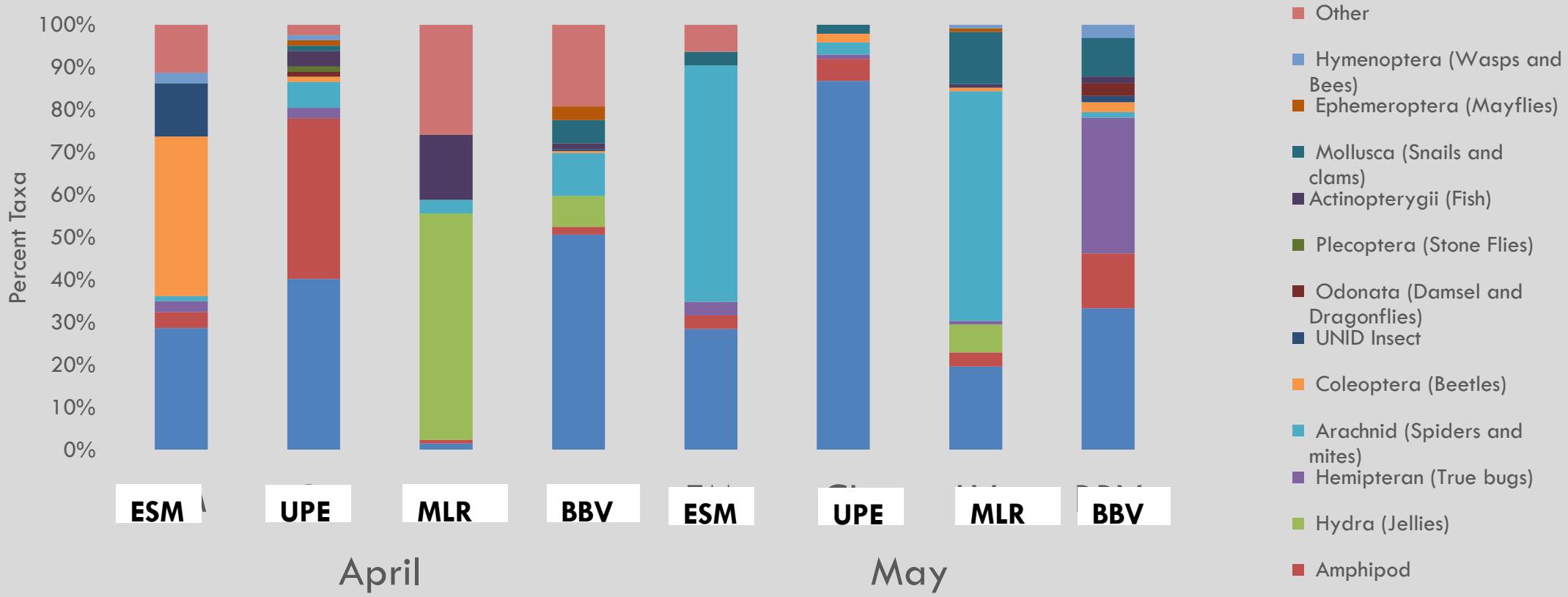
- % similarity indices (between sites)
- NMDS (Environmental variables, site, year, month)

Stomach fullness

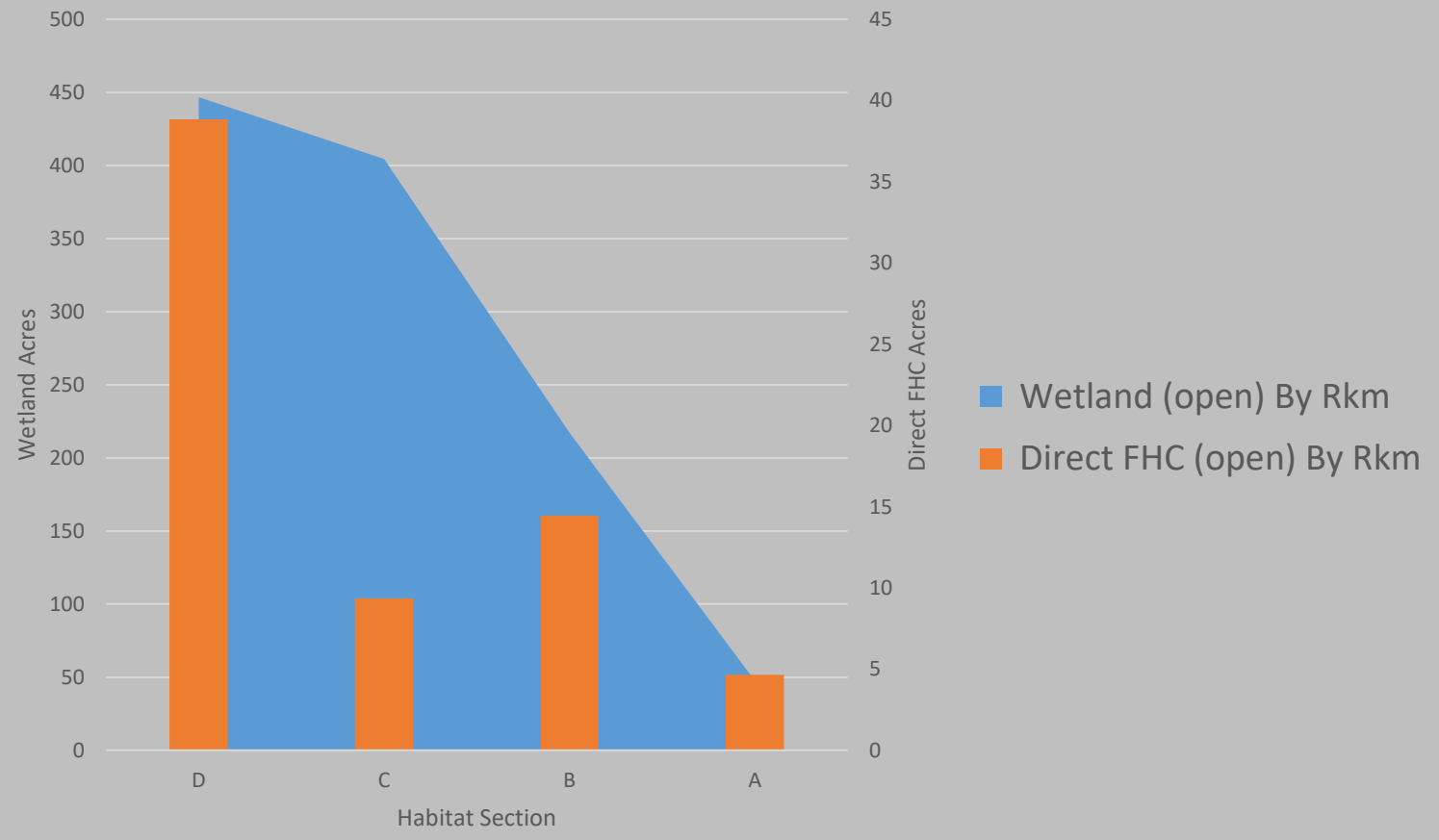
- Two-way ANOVA (between sites, months)



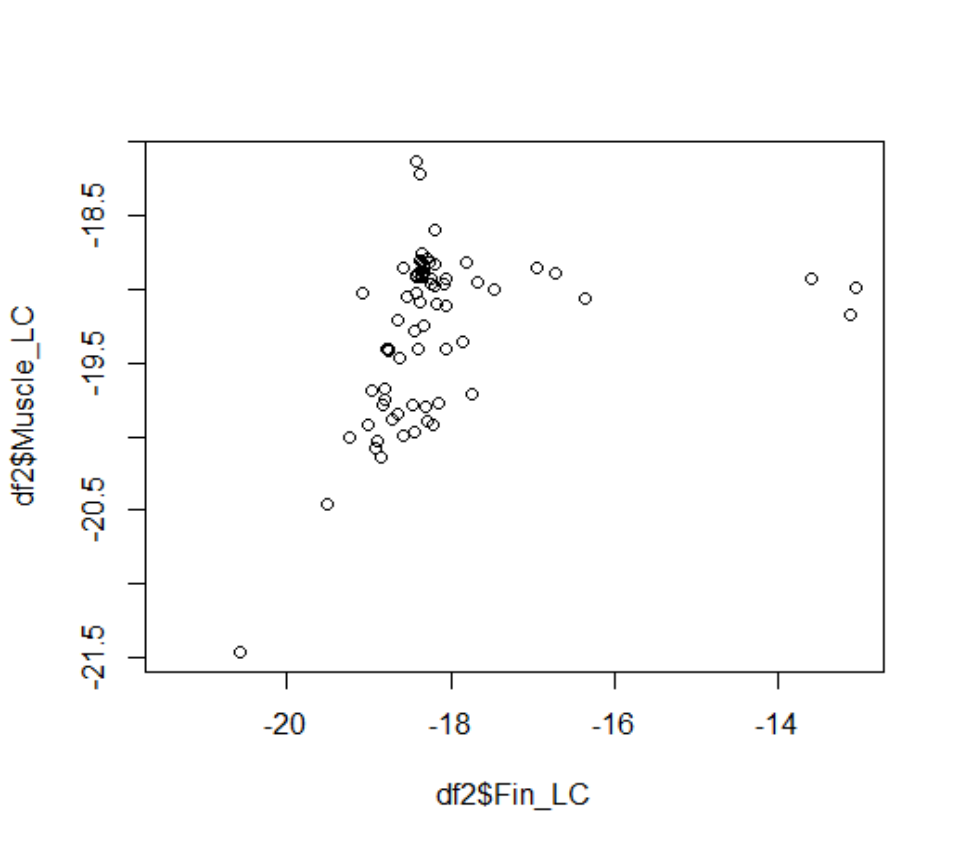
NEUSTON


Percent Taxa
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
ESM
UPE
MLR
BBV
ESM
UPE
MLR
BBV
April
May
Other
Hymenoptera (Wasps and Bees)
Ephemeroptera (Mayflies)
Mollusca (Snails and clams)
Actinopterygii (Fish)
Plecoptera (Stone Flies)
Odonata (Damsel and Dragonflies)
UNID Insect
Coleoptera (Beetles)
Arachnid (Spiders and mites)
Hemipteran (True bugs)
Hydra (Jellies)
Amphipod

WETLAND AND FISH HABITAT BY RKM



NEED TO ID



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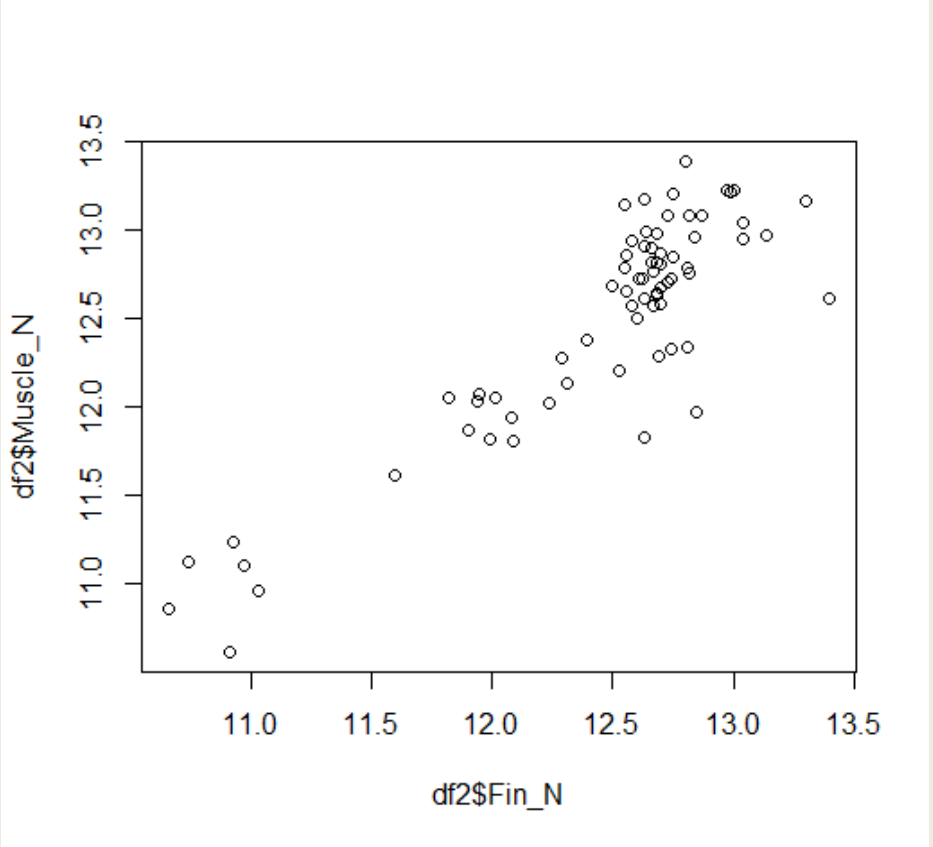

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