Feeding ecology of blue (flathead) catfish in VA's tidal rivers

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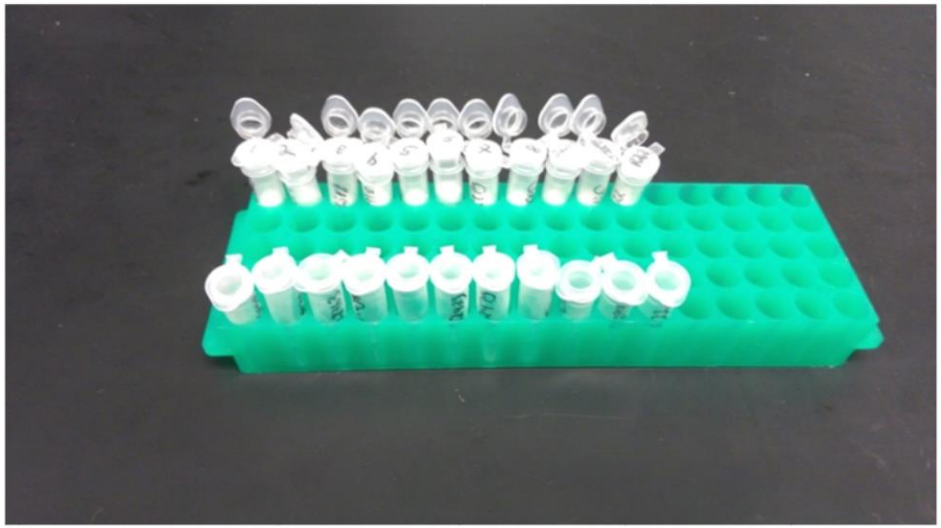
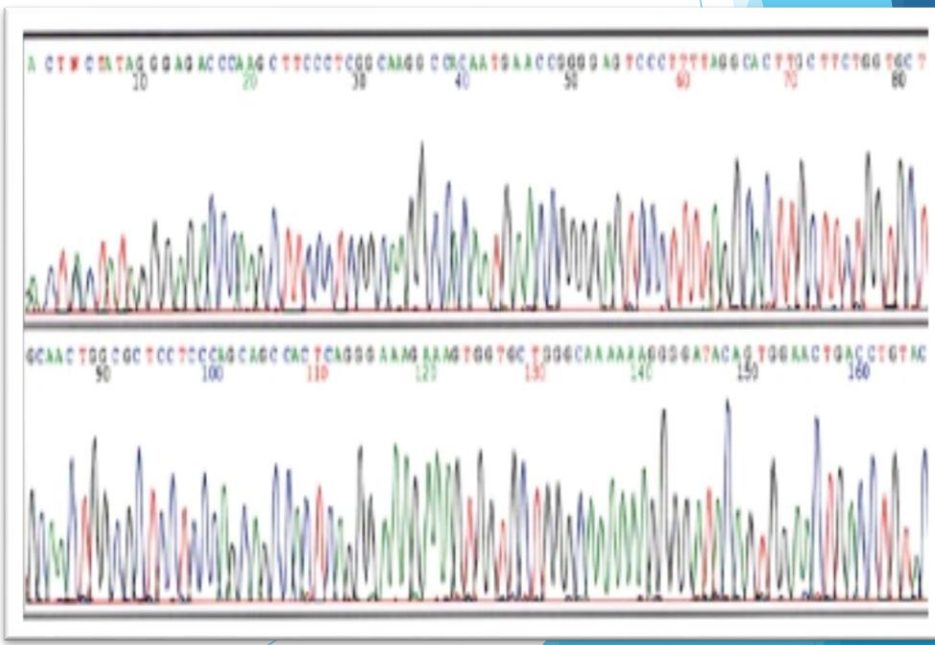
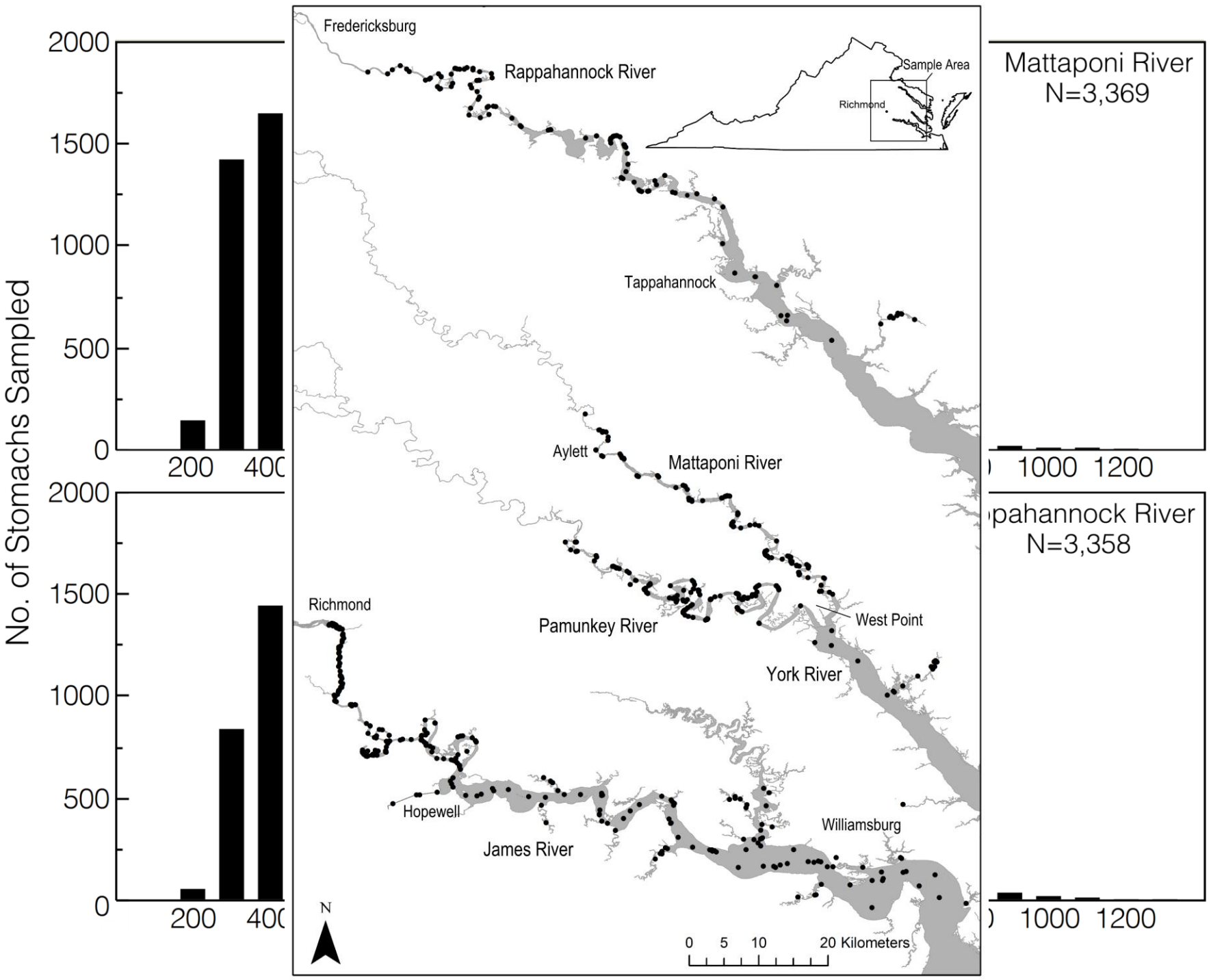
1. Overall diet, trophic position, and feeding ecology
2. Major drivers of diet, modeling consumption of species of concern
3. Spring predation of *Alosa* species
4. Lab and field estimates of consumption rates

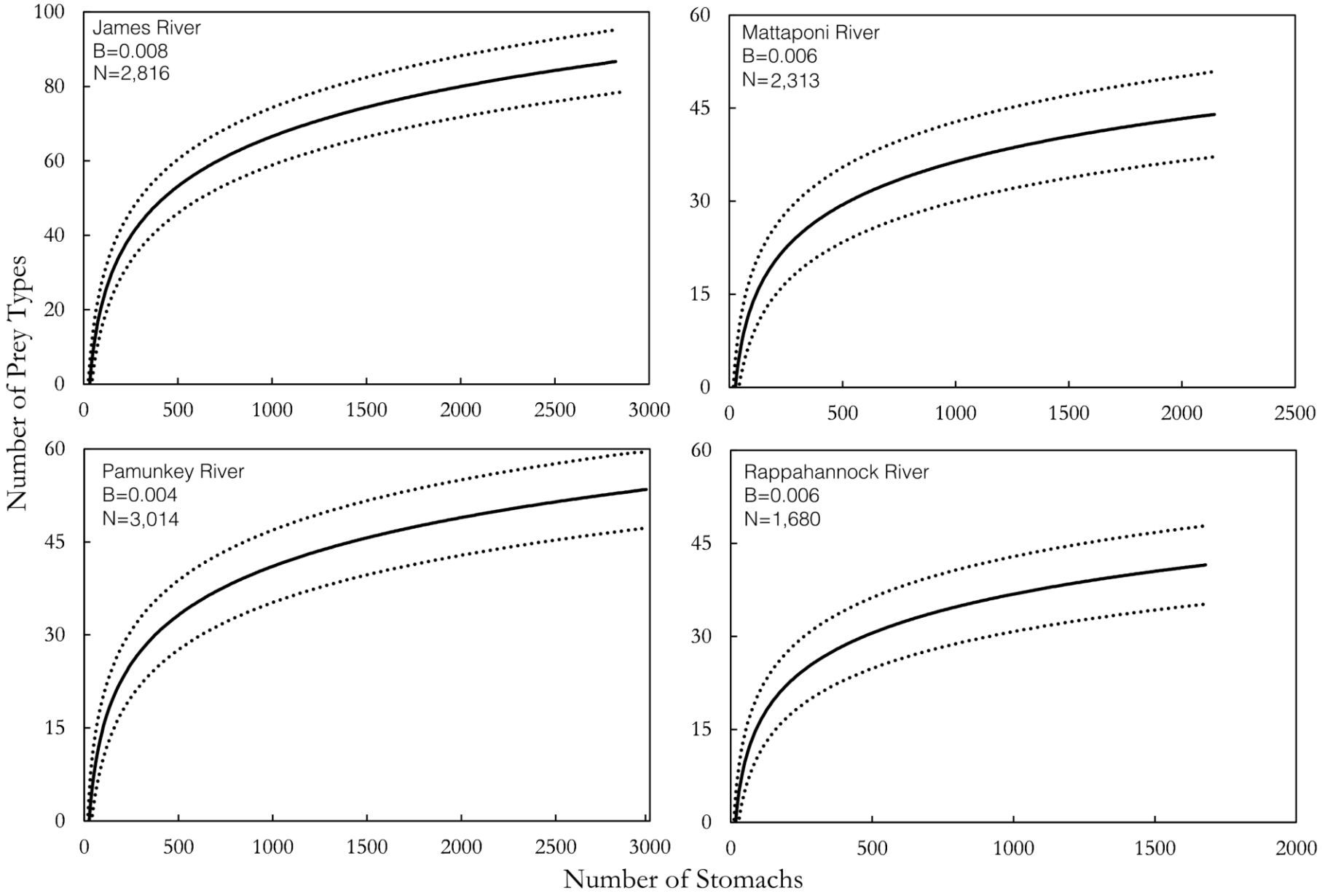
Major Diet Study

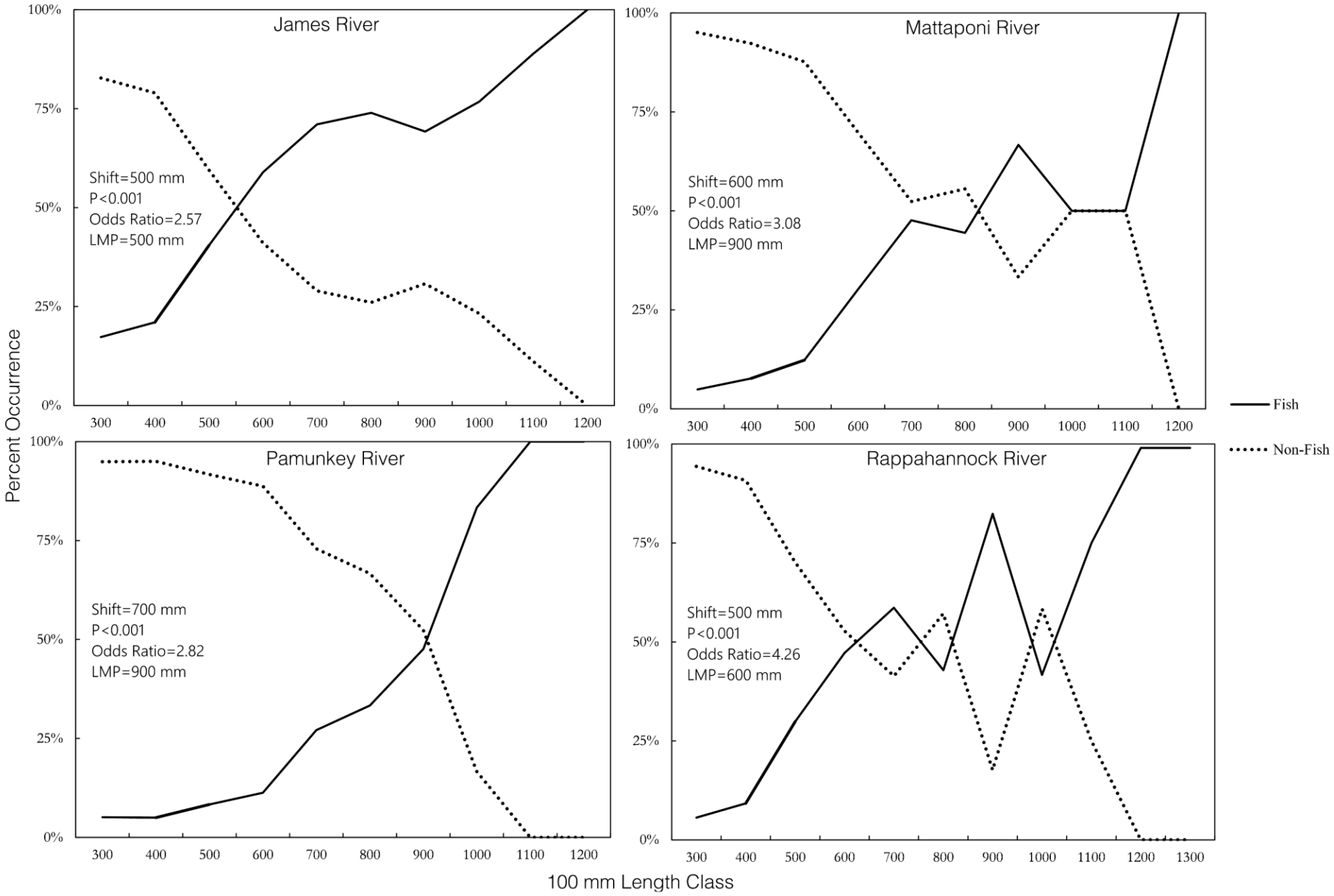
- Stratified Random Sampling April – October
- Decreased efficiency high salinity areas
- Winter sampling on James/York



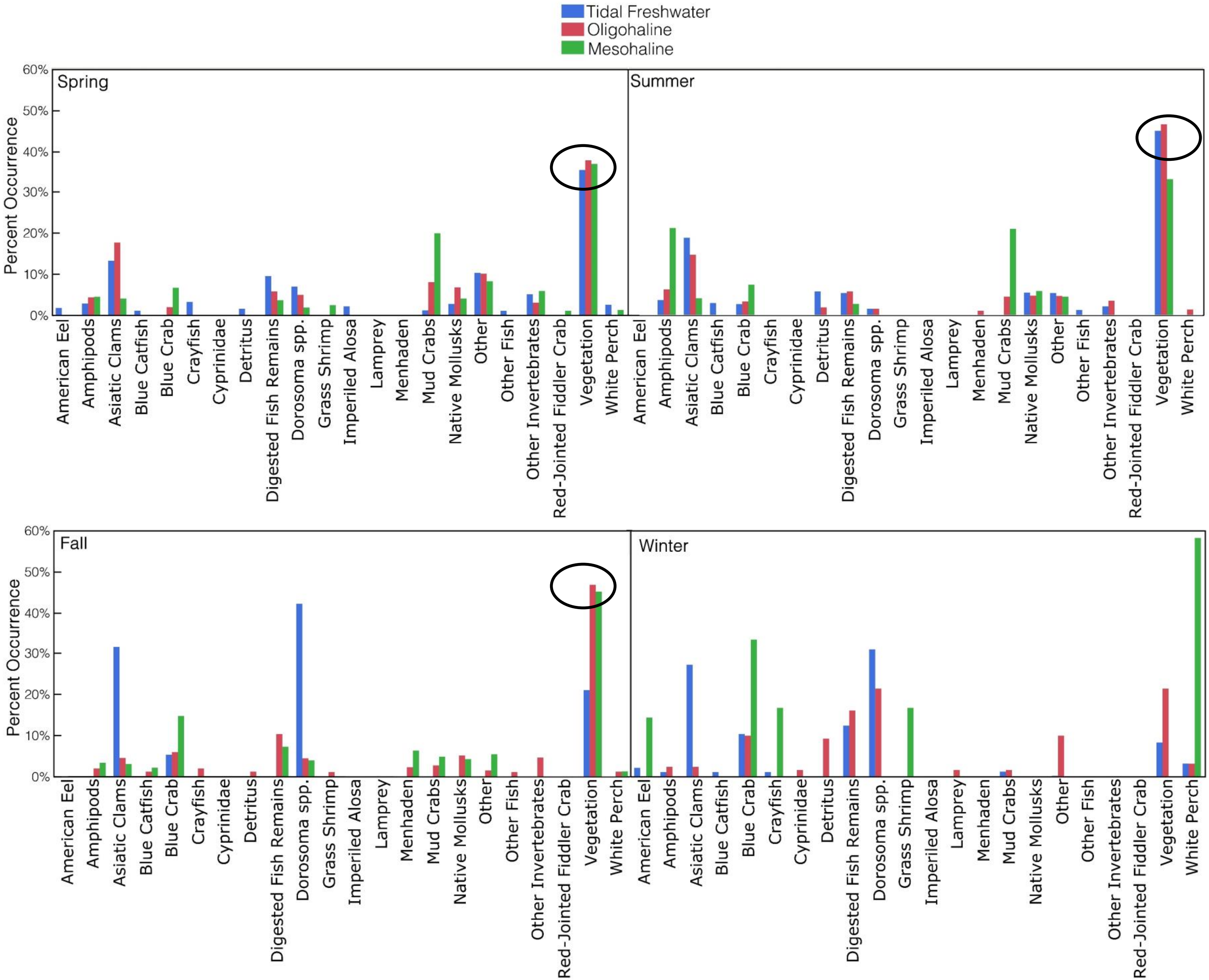



No. of Stomachs Sampled
2000
1500
1000
500
0
200
400
Fredericksburg
Rappahannock River
Sample Area
Richmond
Tappahannock
Aylett
Mattaponi River
Mattaponi River
N=3,369
1000
1200
Richmond
Pamunkey River
West Point
York River
pahannock River
N=3,358
Hopewell
James River
Williamsburg
N
0
5
10
20 Kilometers


James River
B=0.008
N=2,816
Mattaponi River
B=0.006
N=2,313
Pamunkey River
B=0.004
N=3,014
Rappahannock River
B=0.006
N=1,680
Number of Prey Types
Number of Stomachs



GLM with logit link and binomial dist. 1=fish, 0=non-fish



Tidal Freshwater
Oligohaline
Mesohaline
Spring
Summer
Fall
Winter
Percent Occurrence
0%
10%
20%
30%
40%
50%
60%
American Eel
Amphipods
Asiatic Clams
Blue Catfish
Blue Crab
Crayfish
Cyprinidae
Detritus
Digested Fish Remains
Dorosoma spp.
Grass Shrimp
Imperiled Alosa
Lamprey
Menhaden
Mud Crabs
Native Mollusks
Other
Other Fish
Other Invertebrates
Red-Jointed Fiddler Crab
Vegetation
White Perch

Trophic Level, Diet Breadth, Omnivory Index

$$\mathrm{TROPH}_i = 1 + \sum_{j=1}^{G} \mathrm{DC}_{ij} \times \mathrm{TROPH}_j$$

$$B_i = \left(\frac{1}{n-1}\right)\left(\left(\frac{1}{\sum_{i,j=1}^{n} P_{ij}^2}\right) - 1\right)$$

$$\mathrm{OI}_i = \sum_{j=1}^{n} \left[\mathrm{TL}_j - (\mathrm{TL}_i - 1)\right]^2 \cdot \mathrm{DC}_{ij}$$

Trophic level = **2.90** (2.72 – 3.55)

Omnivory

Diet Bread

*Hajisamae et al. 2003; Akin and Winemiller 2006

Blue catfish not apex predators

-Even large fish =3.55 TL

-Flatheads *are* apex

Eat primarily vegetation, Asian clams, and benthic invertebrates

High diet breadth

Blue crab consumption

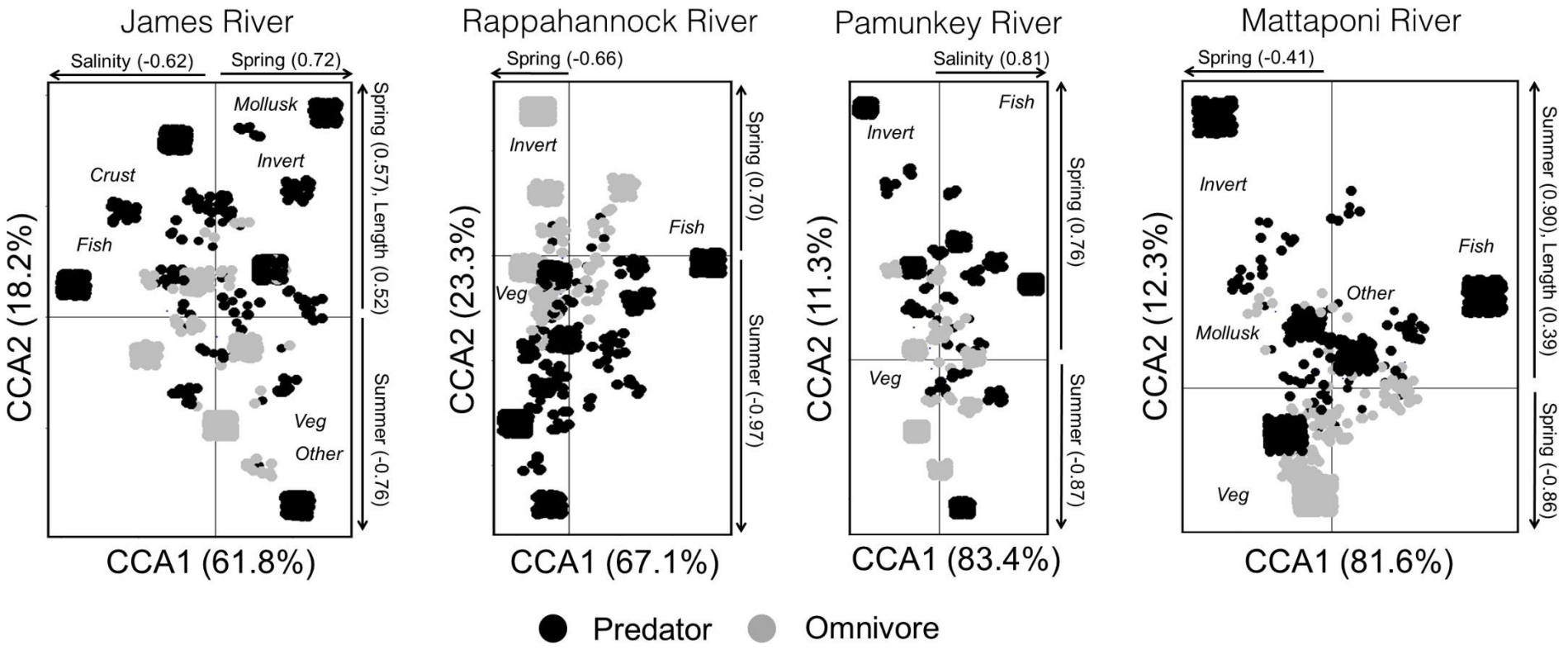
Major Drivers of Diet and Modeling Consumption of Species of Concern

CCA used to determine major drivers of diet

- A matrix of response variables constrained (regressed) against matrix of predictor variables
- Used to determine the major drivers of the BCF diet in VA's tidal rivers

Eigen equation: $(\mathbf{Z}^T\mathbf{Y}\,(\mathbf{D}_c^{-1})\,\mathbf{Y}^T\mathbf{Z} - \lambda\mathbf{Z}^T\mathbf{D}_r\mathbf{Z})\mathbf{b} = \mathbf{0}$ with

$\mathbf{D}_c = \mathrm{diag}(y_{+1}, \ldots, y_{+m})$, $\mathbf{D}_r = \mathrm{diag}(y_{1+}, \ldots, y_{n+})$



	James			Rappahannock			Pamunkey			Mattaponi		
	df	*F*	p	df	*F*	p	df	*F*	p	df	*F*	p
Global model	**4**	**17.9**	**<0.0001**	**4**	**21.6**	**<0.0001**	**4**	**21.7**	**<0.0001**	**4**	**14.9**	**<0.0001**
Salinity zone	1	32.7	<0.0001	1	11.8	<0.0001	1	46.7	<0.0001	1	1.9	0.0806
Season	3	21.6	<0.0001	2	49.2	<0.0001	2	13.3	<0.0001	2	43.1	<0.0001
Length category	1	8.9	<0.0001	1	7.6	<0.0001	1	7.8	<0.0001	1	11.3	<0.0001

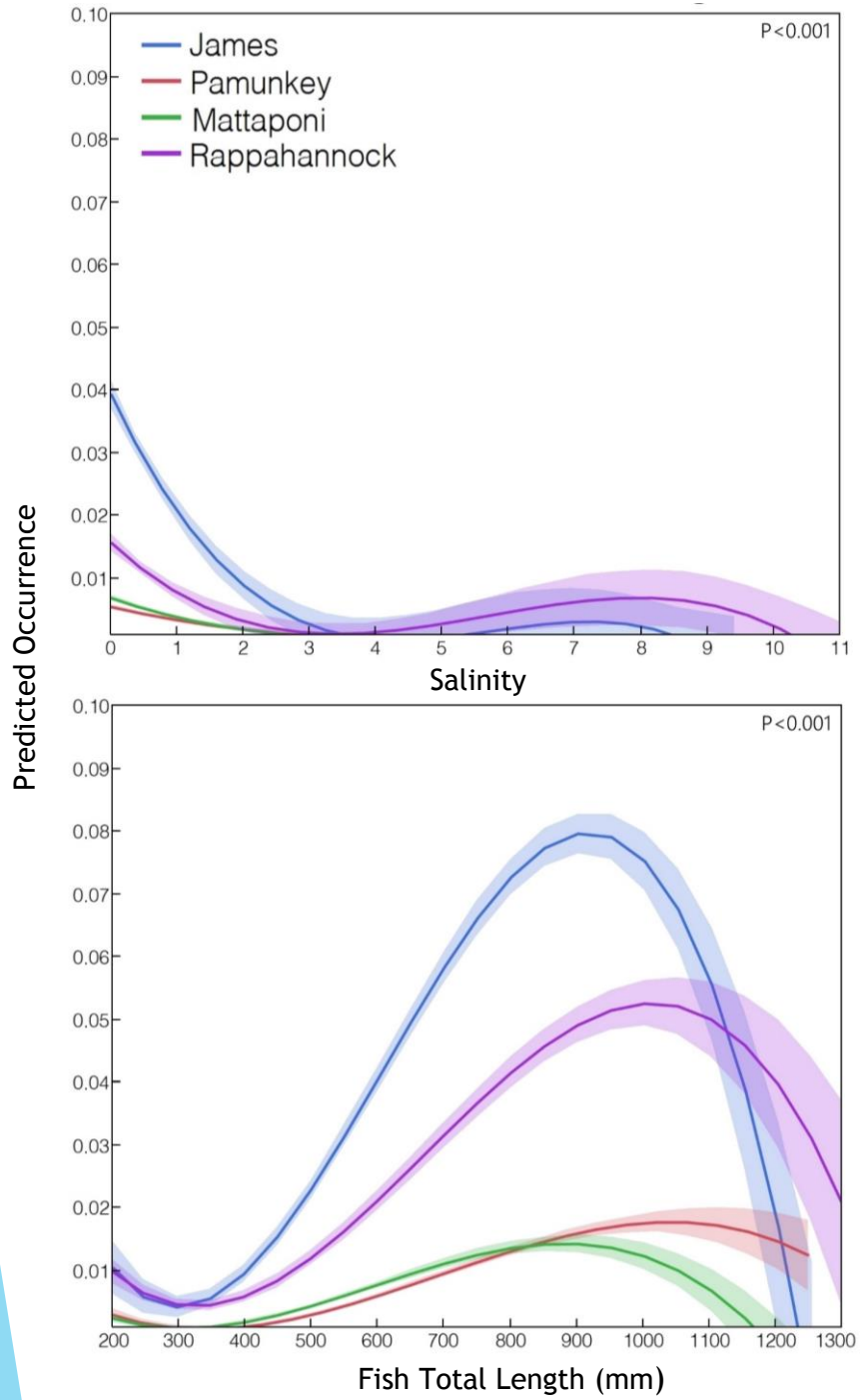
Season and salinity explain the most variation in the occurrence of different prey categories in the diet

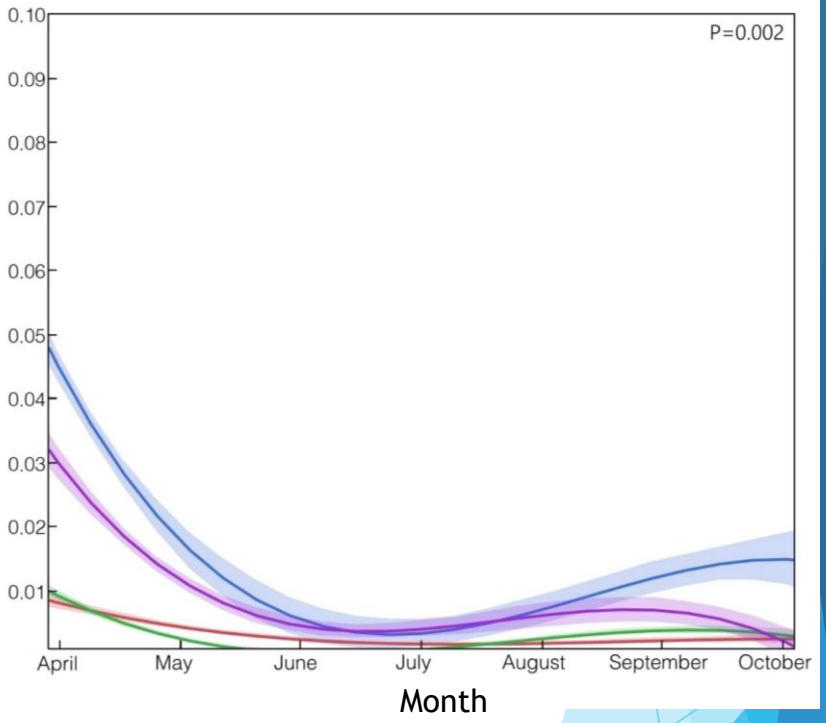
Generalized Additive Models (GAMs)

- Spatiotemporal patterns
- Size-based variation

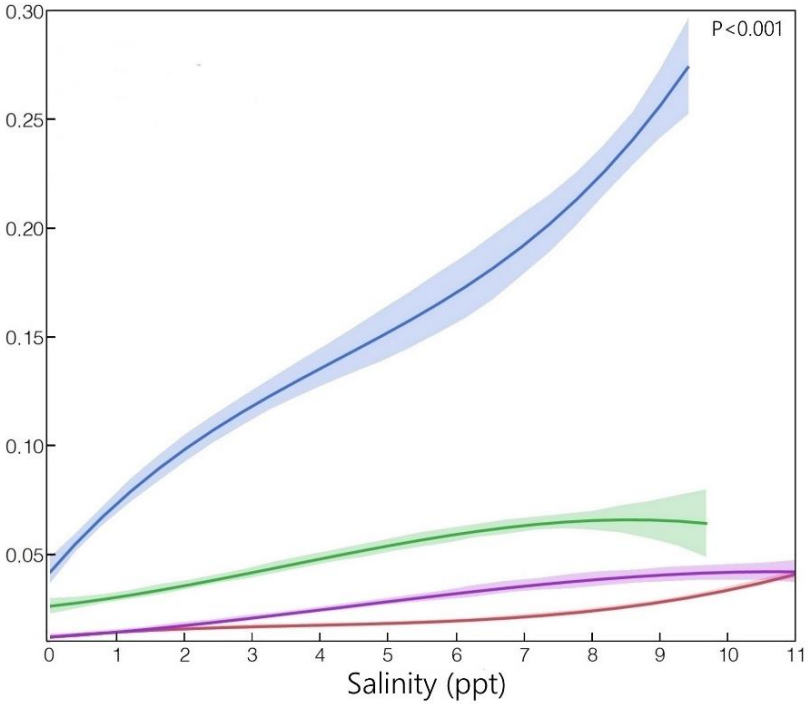
$$\text{logit}(p) = \beta_0 + f_1(\text{predator length}) + f_2(\text{salinity}) + f_3(\text{month}) + f_4(\text{river})$$

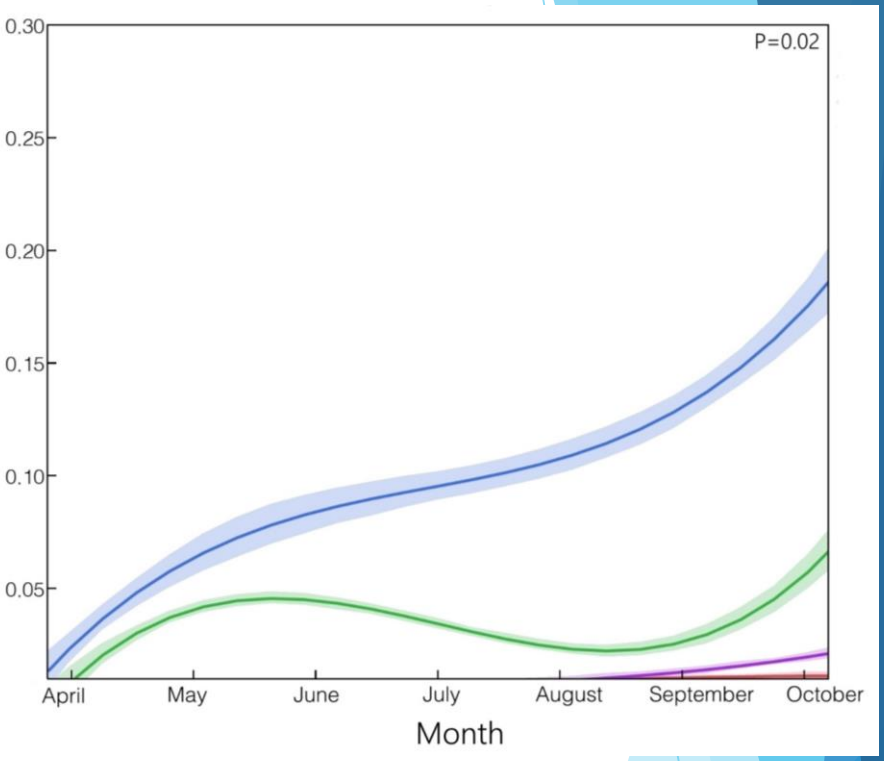
American Shad and River Herring

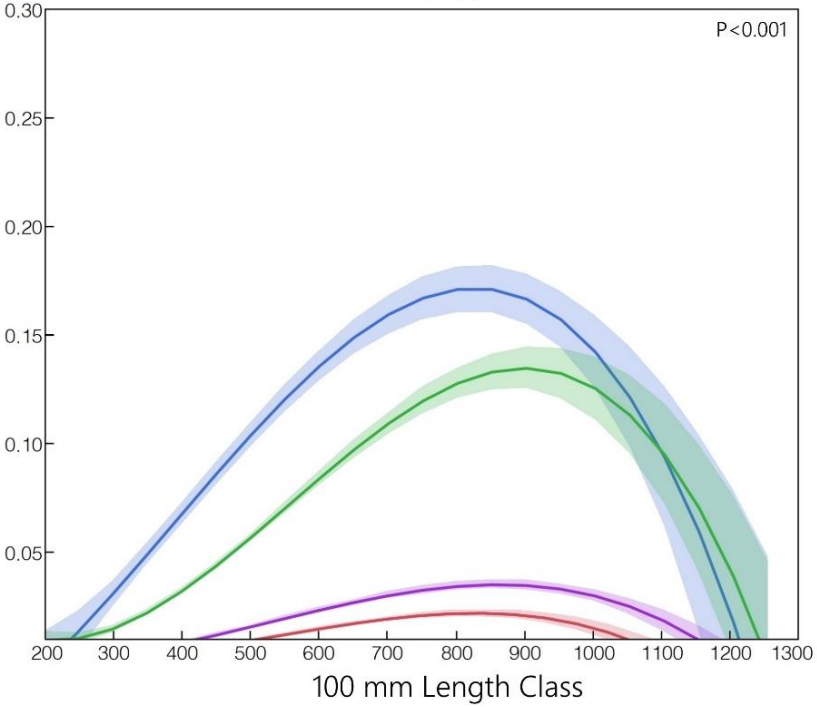




Blue Crab

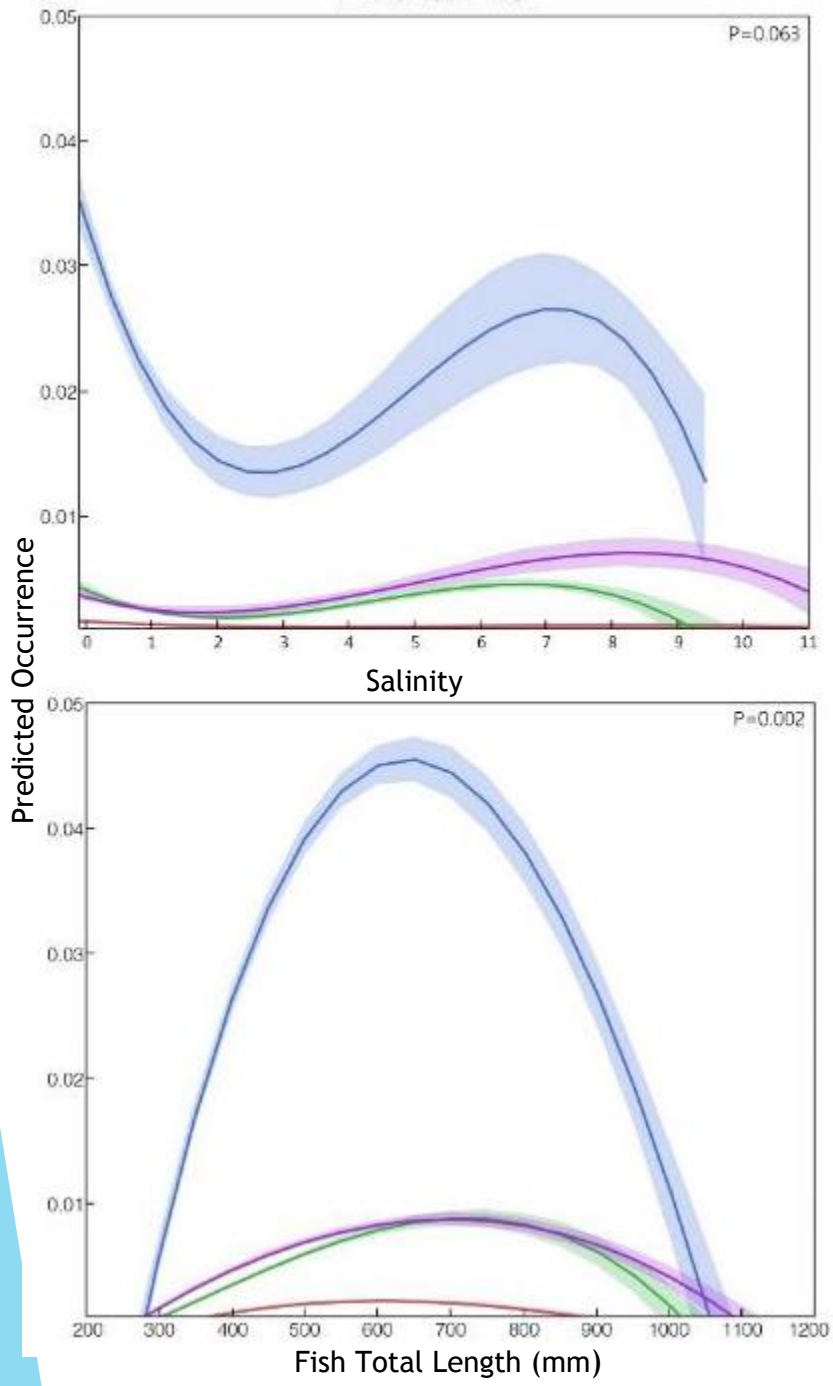

P<0.001
0.30
0.25
0.20
0.15
0.10
0.05
0 1 2 3 4 5 6 7 8 9 10 11
Salinity (ppt)

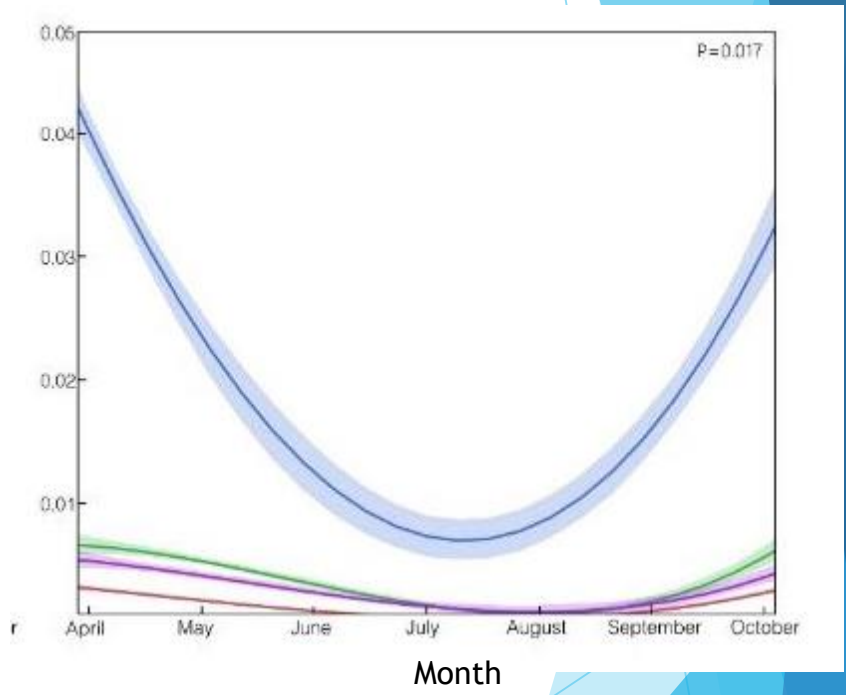

P=0.02
0.30
0.25
0.20
0.15
0.10
0.05
April May June July August September October
Month


P<0.001
0.30
0.25
0.20
0.15
0.10
0.05
200 300 400 500 600 700 800 900 1000 1100 1200 1300
100 mm Length Class


Date:
Contents:
E&S
BCR

American Eel





Predation of eels, Am. shad, And r. herring relatively low

- *Alosa* highest in spring in fresh areas
- Eels highest during spring and fall, not affected by salinity

Predation of blue crab fairly high

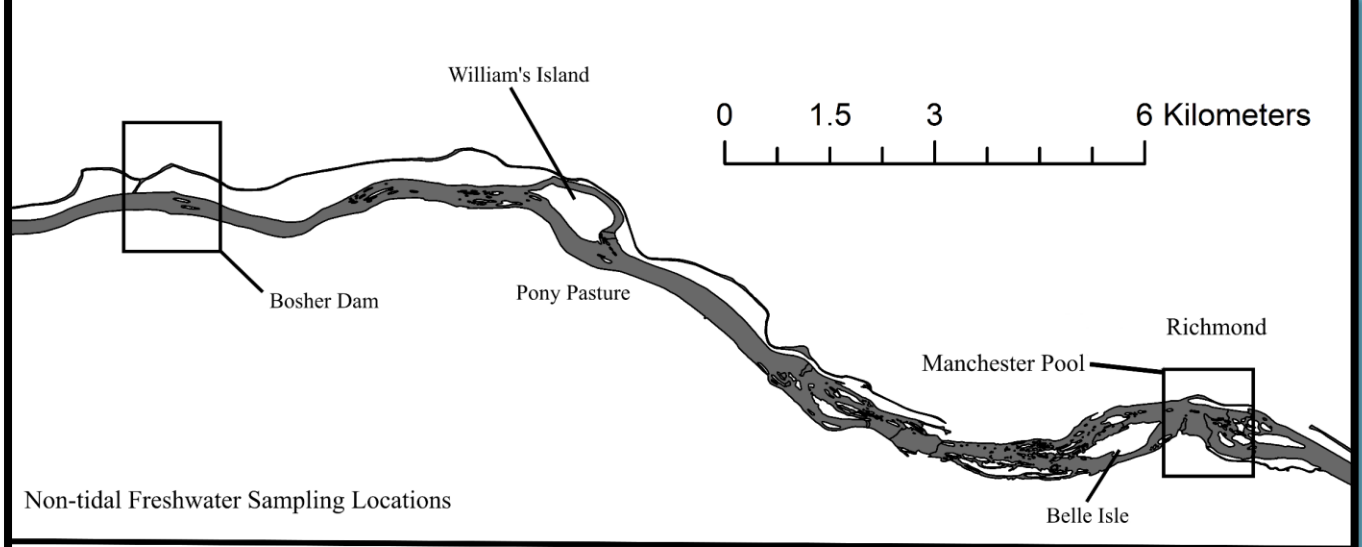
- Increases w/ salinity
- Increases during fall

Predation of ALL species highest in James and highest in large fish

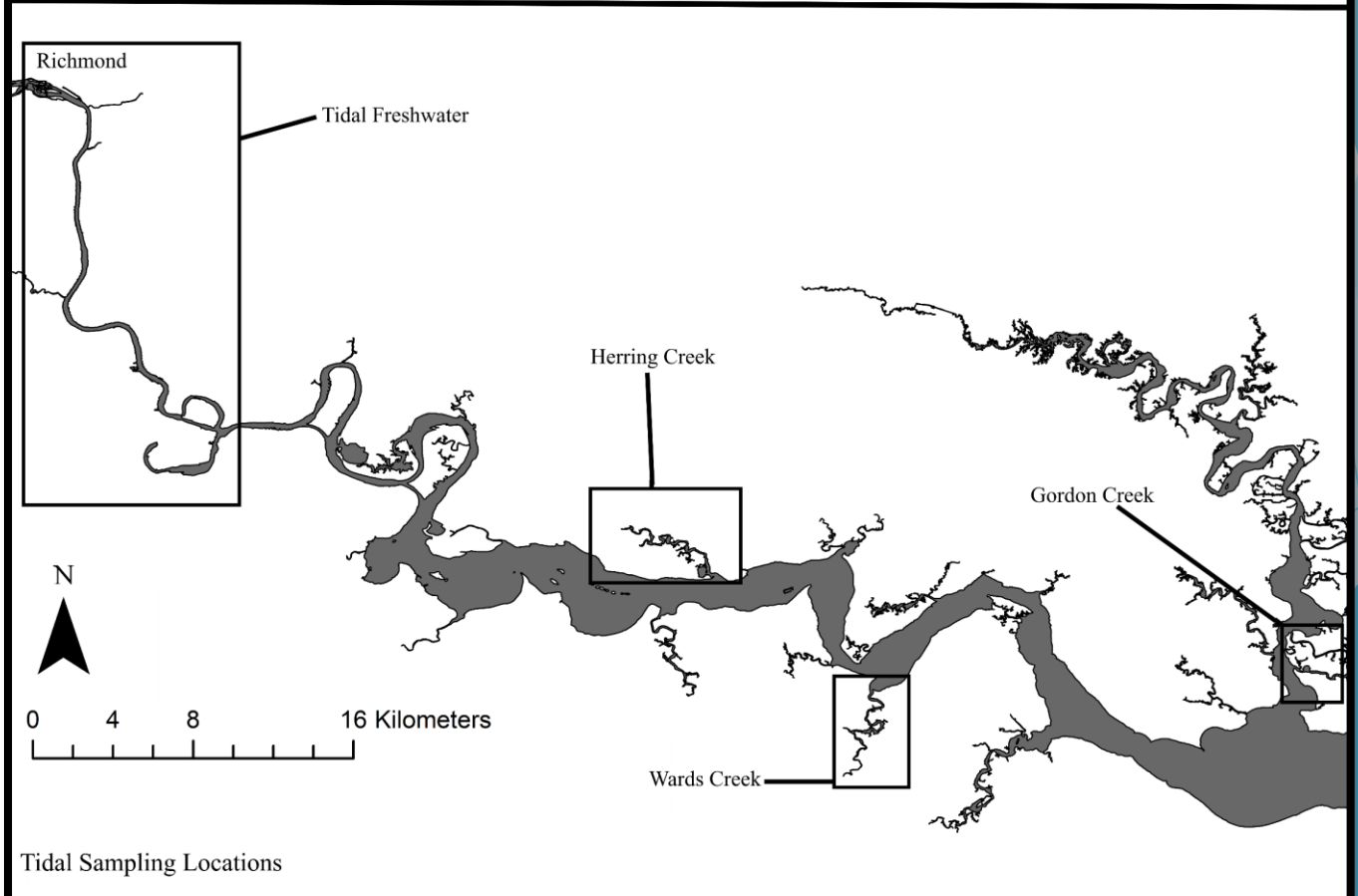
- James HAS large fish

Summary

- Blue crabs = main management concern
- Other species rare in diet, but impacts possible due to high population densities
- Season, salinity, and fish size influence occurrence in the diet
- Large fish in the James River have biggest impact (600 – 900 mm TL)



Non-tidal Freshwater Sampling Locations



Tidal Sampling Locations

Results

Stomachs collected from:

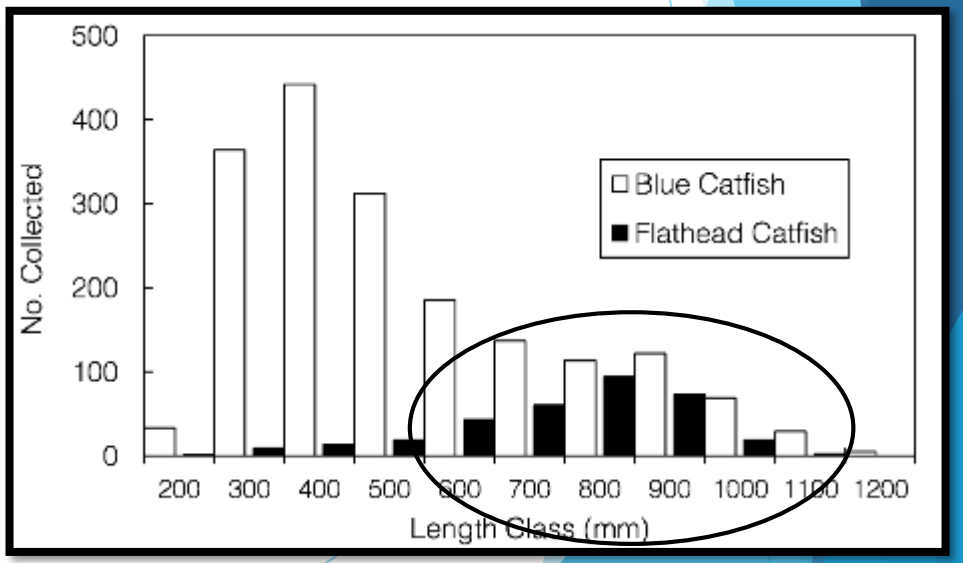
331 Flathead Catfish

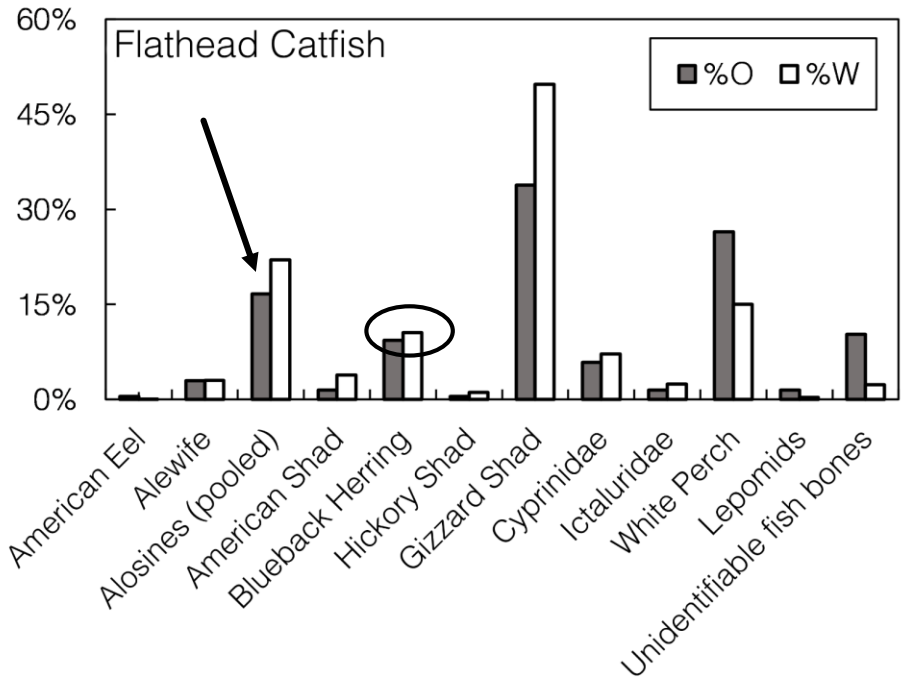
2,164 Blue Catfish

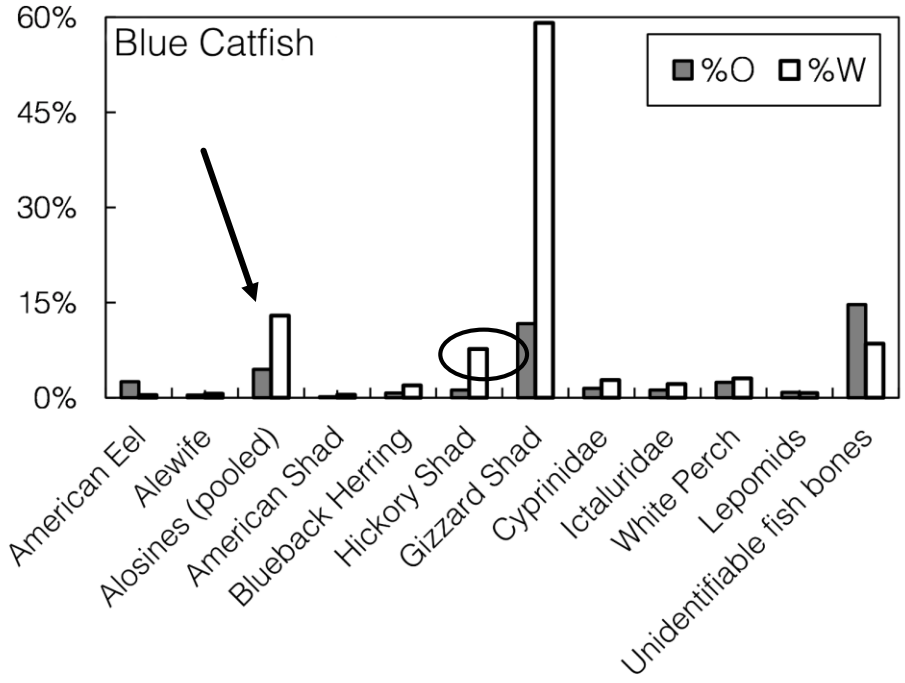
FCF exclusively piscivorous

BCF piscivorous >500 mm TL

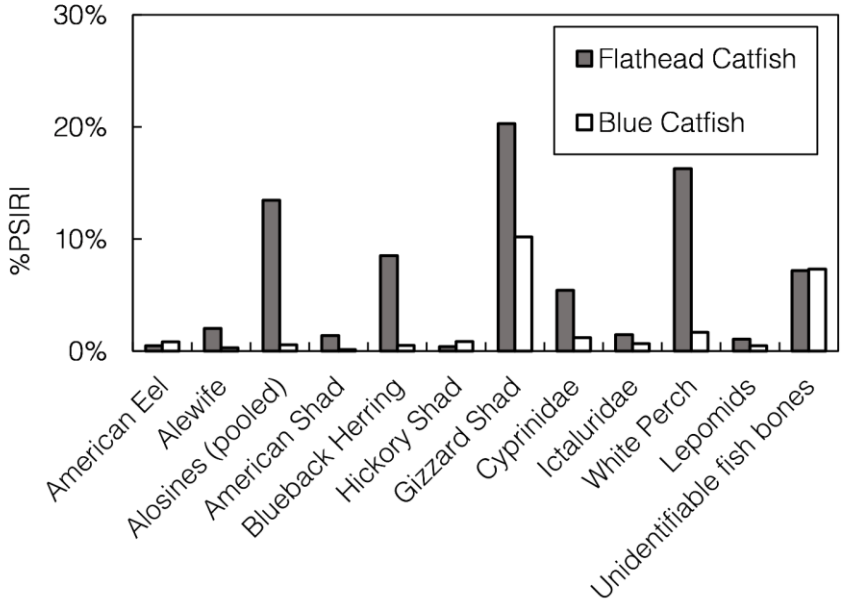
Piscivorous BCF vs. FCF similar

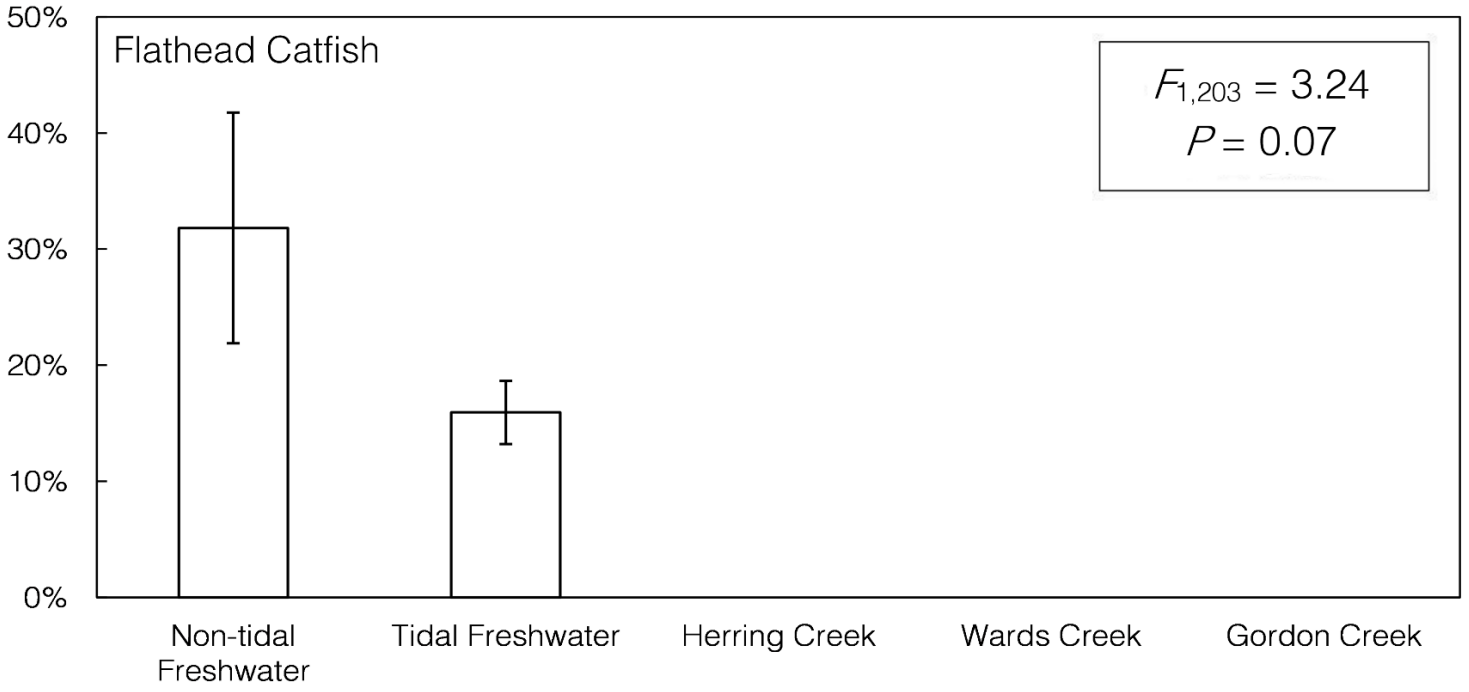


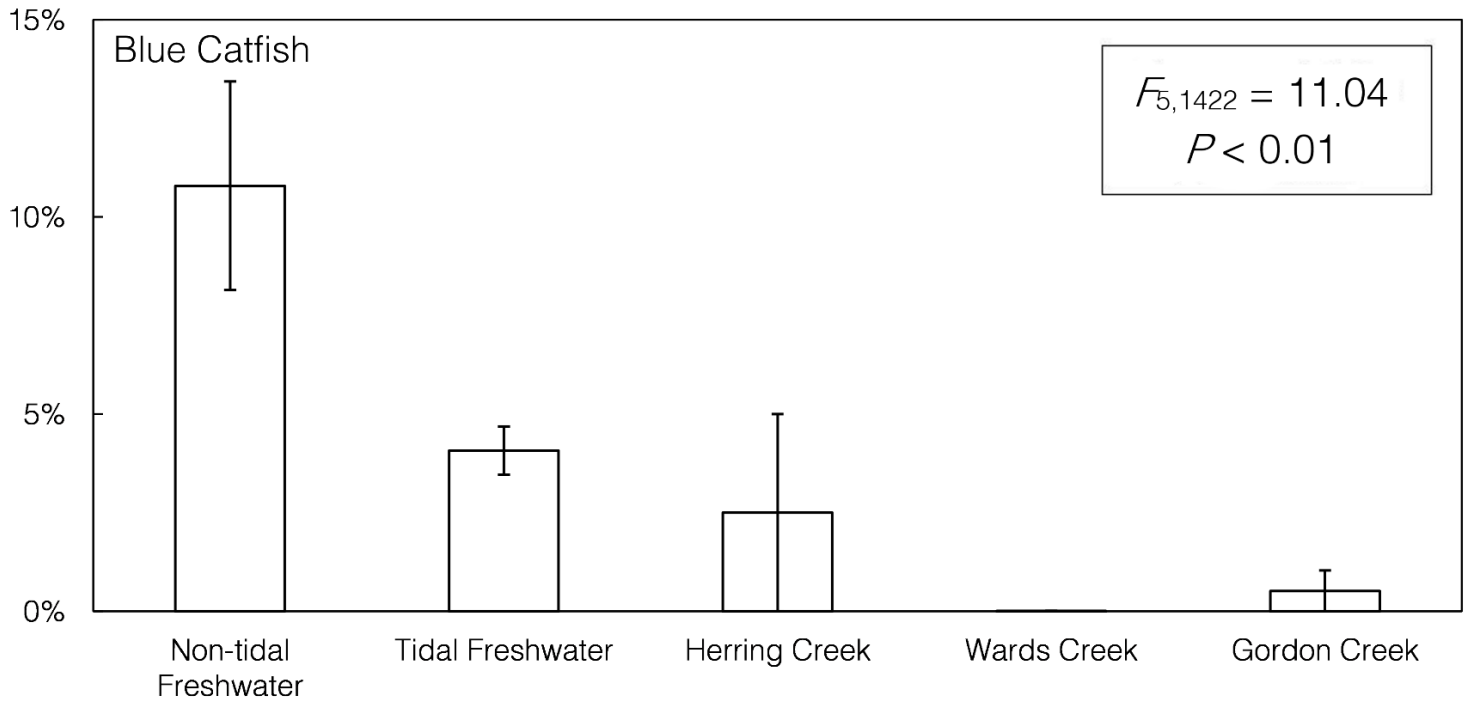




Alosa species found in 17% of FCF and 4% of BCF




Flathead Catfish
$F_{1,203} = 3.24$
$P = 0.07$
50%
40%
30%
20%
10%
0%
Non-tidal Freshwater
Tidal Freshwater
Herring Creek
Wards Creek
Gordon Creek


Blue Catfish
$F_{5,1422} = 11.04$
$P < 0.01$
15%
10%
5%
0%
Non-tidal Freshwater
Tidal Freshwater
Herring Creek
Wards Creek
Gordon Creek

- *Alosa* species consumed most frequently in tidal fresh/non-tidal fresh

-April

-*Alosa* species consumed more frequently by flathead catfish

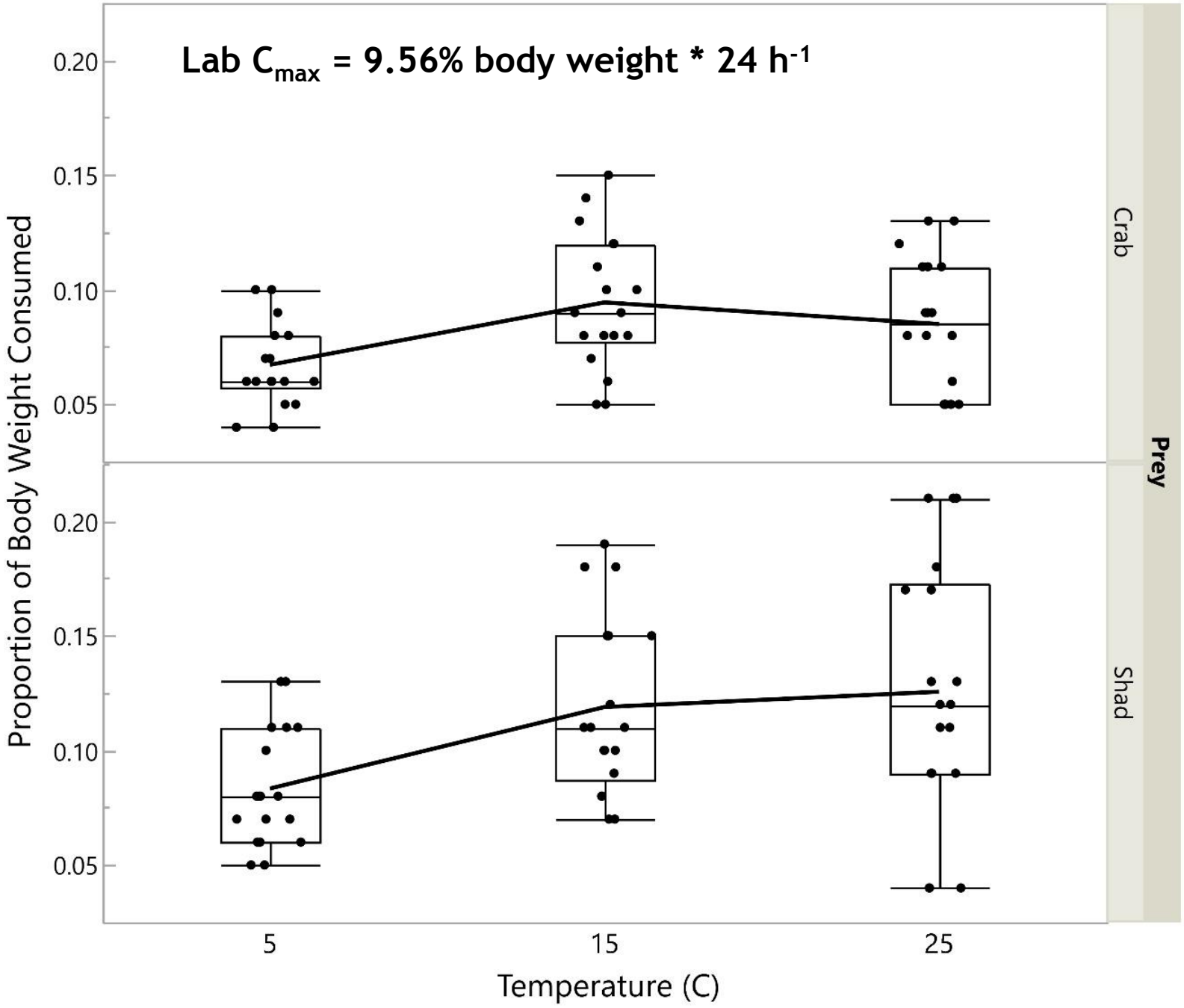
-Flatheads should not be ignored (York River)

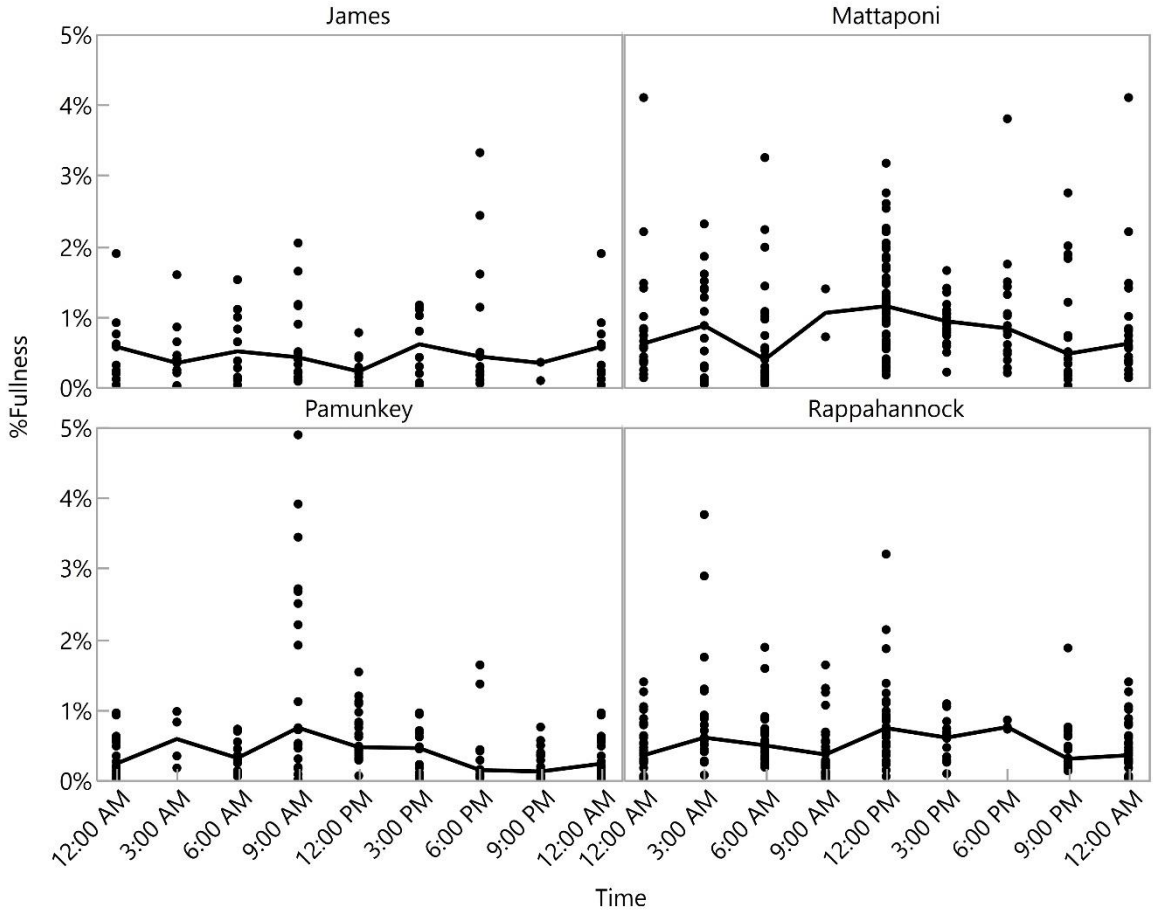
Consumption Rates

Combination of field and lab methods used to determine C_{24} (daily ration) and C_{max} (max daily ration)

Ad libitum feeding trials

- three temps (5,15,25 C)
- two prey types (blue crab, gizzard shad)
- catfish from 200 – 900 mm TL
- three replicates per treatment combination
- 24 h experiments with 3 h feeding intervals


Lab C_{max} = 9.56% body weight * 24 h^{-1}
Proportion of Body Weight Consumed
0.20
0.15
0.10
0.05
Crab
Shad
Prey
5
15
25
Temperature (C)



Lab Estimate of C_{max}: 9.56% bw/day

Field Estimate of C_{max}: 8.76% bw/day

$$F_t = \frac{W_t}{W_f} \times 100,$$

$$C_{24} = \sum_{t=1}^{p} \frac{(F_{t+1} - F_t e^{-Rt})RT}{(1 - e^{-RT})},$$

$$R = \frac{\log_e F_{(t+1)} - \log_e F_{(t)}}{T},$$

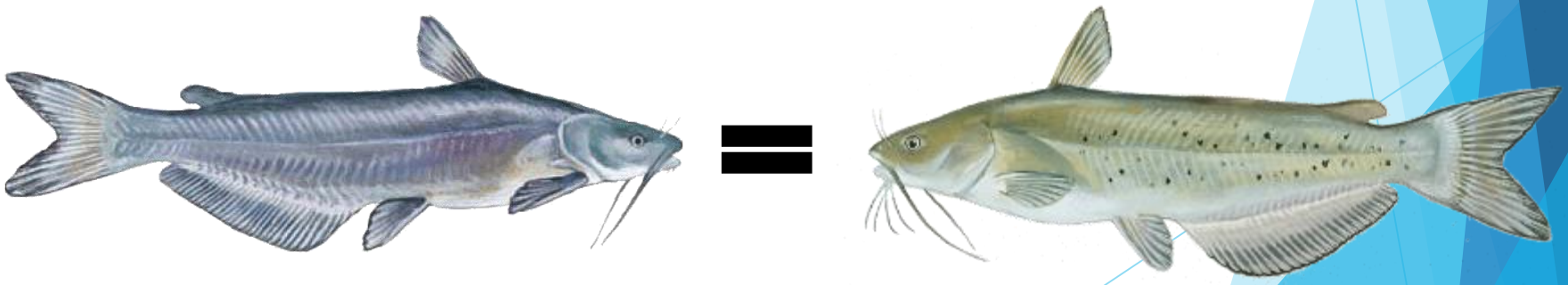
River	Daily Ration (C_{24})	Max Daily Ration (C_{max})	R(average)	R max
James	3.520%	10.320%	0.161	0.391
Mattaponi	2.270%	4.343%	0.064	0.084
Pamunkey	5.220%	15.004%	0.202	0.298
Rappahannock	3.390%	5.371%	0.134	0.152
All Rivers	3.600%	8.760%	0.140	0.231

BCF C_{max} = **5 - 15%** bw/day

- channel catfish **5 - 16%** bw/day (Vigg et al. 1991; Kwak et al. 1992)

BCF C_{24} = **2-5%** bw/day

- channel catfish **2-6%** bw/day (Andrews and Stickney 1972)



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