

GEOSPATIAL VARIATION OF RIBBED MUSSEL (*GEUKENSIA DEMISSA*) ECOSYSTEM SERVICES ACROSS THE SALT MARSH LANDSCAPE



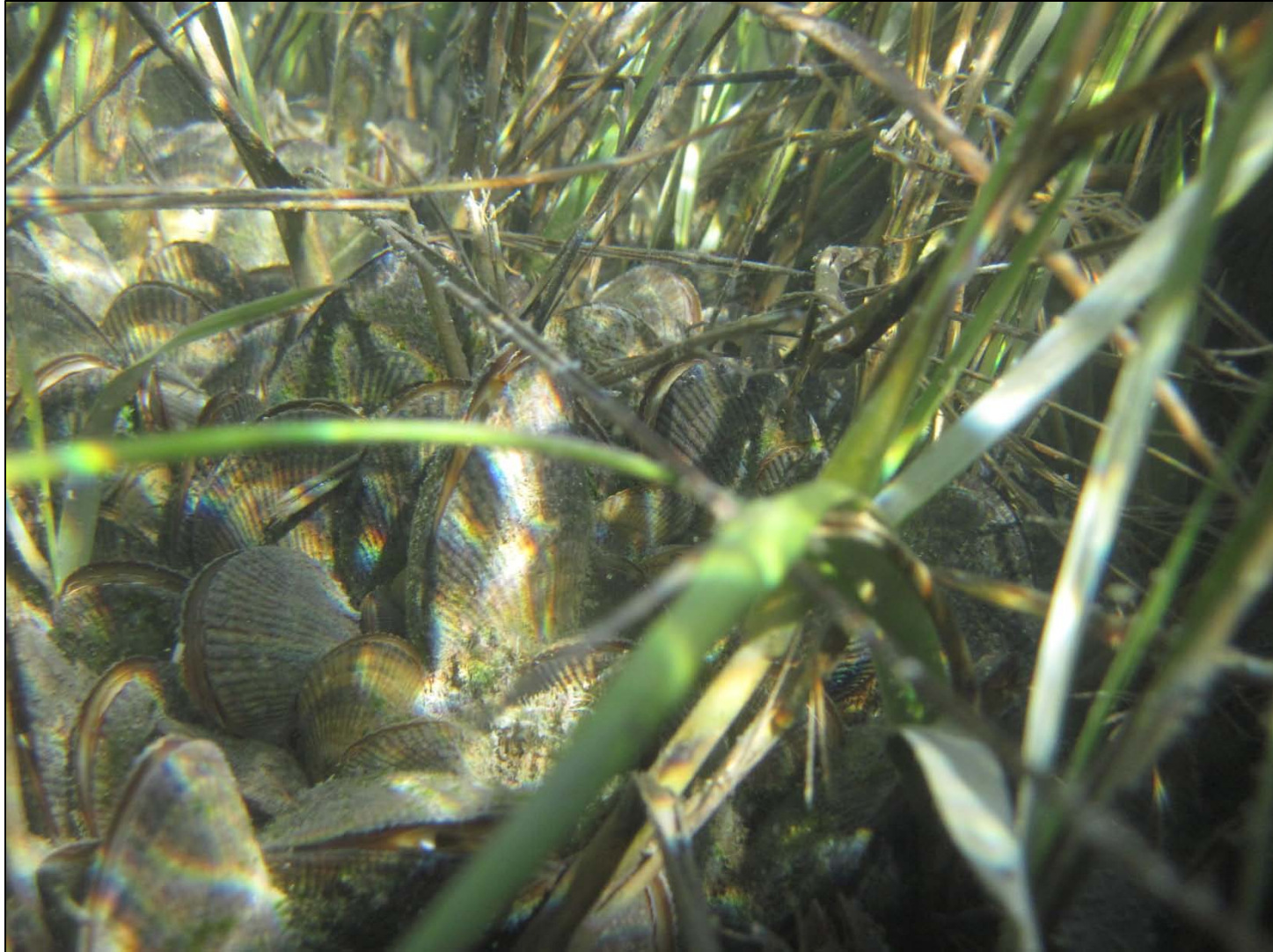
Joshua Moody, Danielle Kreeger and Elizabeth Watson

Partnership for the Delaware Estuary 2015 Science Summit
Balancing Progress & Protection – 10 Years of Science in Action
January 25-28, 2015
Cape May, NJ



Ribbed Mussels: Functionally Dominant Bivalve of Eastern US Salt Marshes

(Kuenzler 1961; Lent 1969; Jordan and Valiela 1982)

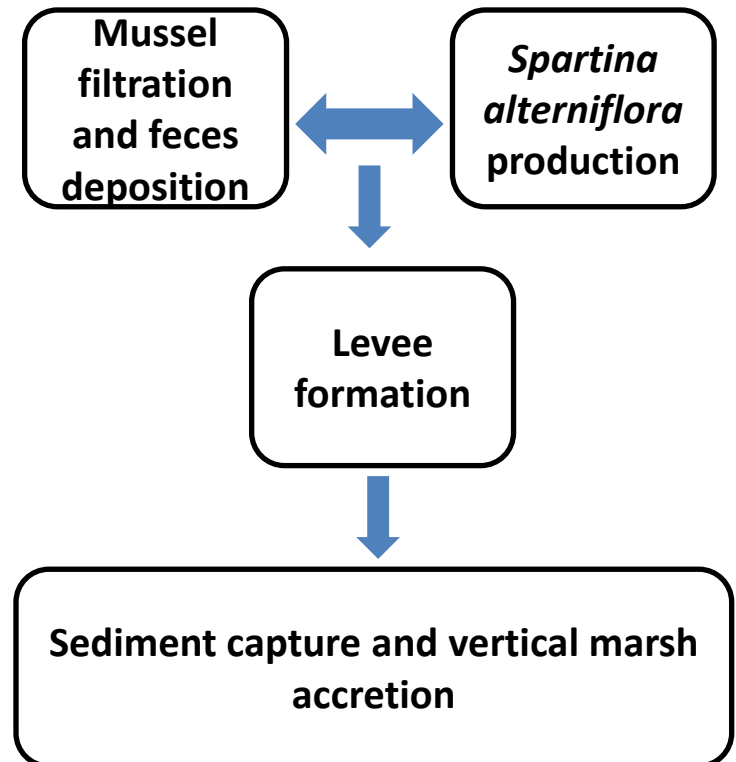


Ecosystem Services: Nutrient Uptake and Marsh Surface Accretion

Nutrient Input to Estuarine Waters



Vertical Growth and Levee Building



What is Spatial Distribution of Particle Removal Services?

1. Spatial distribution of water processing to meet nutritional demands (Clearance Rate)
2. Spatial distribution of TSS removal (Filtration Rate)
3. Does mussel biomass differ across marshes and habitat?
4. How does spatial variation of habitat size within marshes concentrate ecosystem services?

Study Design

↑
**Dividing
Creek**

↗
**Maurice
River**

↗
**Dennis
Creek**

**Delaware
Bay**

United
States

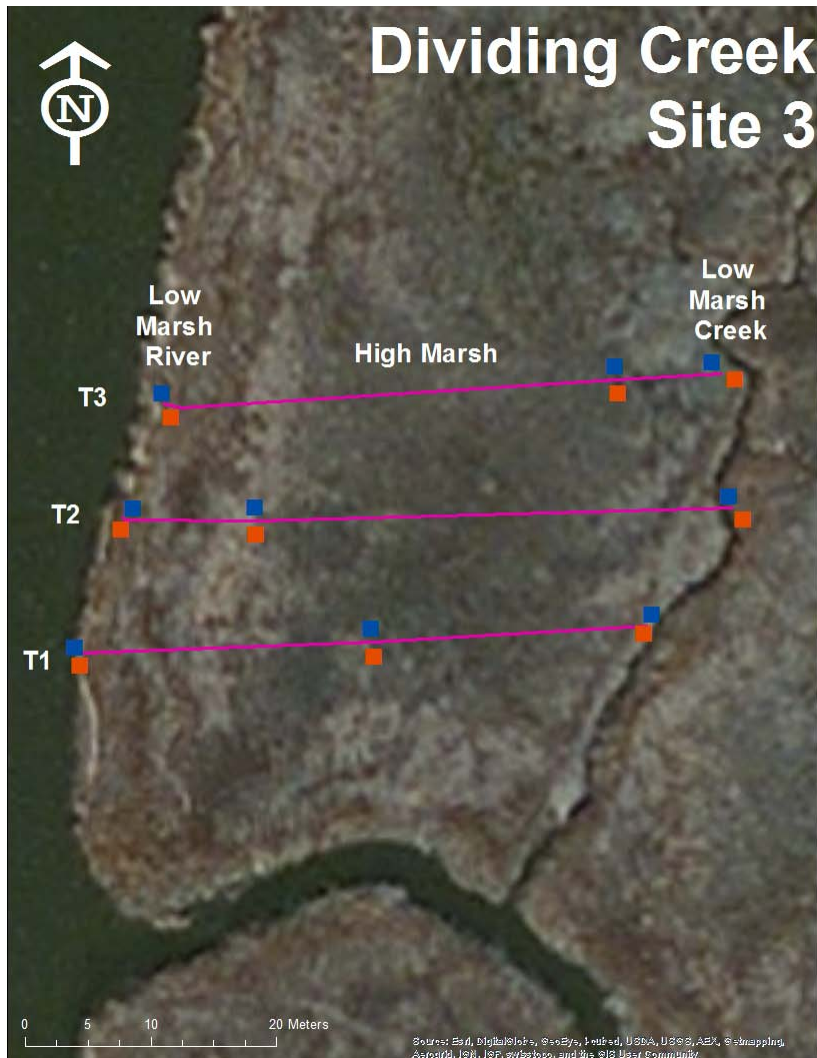


Atlantic
Ocean





Study Design



- Three transects ~10m apart
 - Low Marsh River
 - High Marsh
 - Low Marsh Creek

Mussel Density

- 6 quads/habitat/site
- Allometric relationships: Shell length:DTW

What is Spatial Distribution of Particle Removal Services?

1. Spatial distribution of water processing to meet nutritional demands (Clearance Rate)
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Physiology by River and Habitat

Mussels by Habitat/Season (n=8)



Water from each River: TSS
and T_0 = Particulate N



Physiology and Physical Metrics

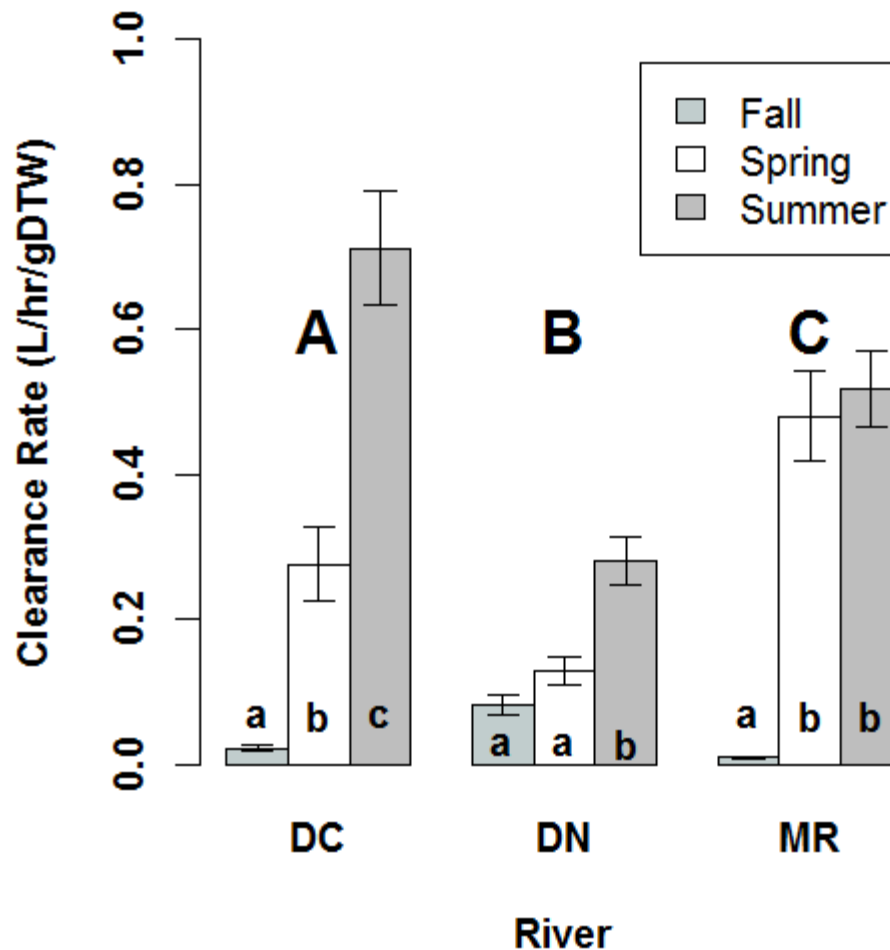
n=5 samples/animal, 2hrs

NH₃ and Feces

wet/dry wt, shell height



Clearance Rate Varies by River and Season



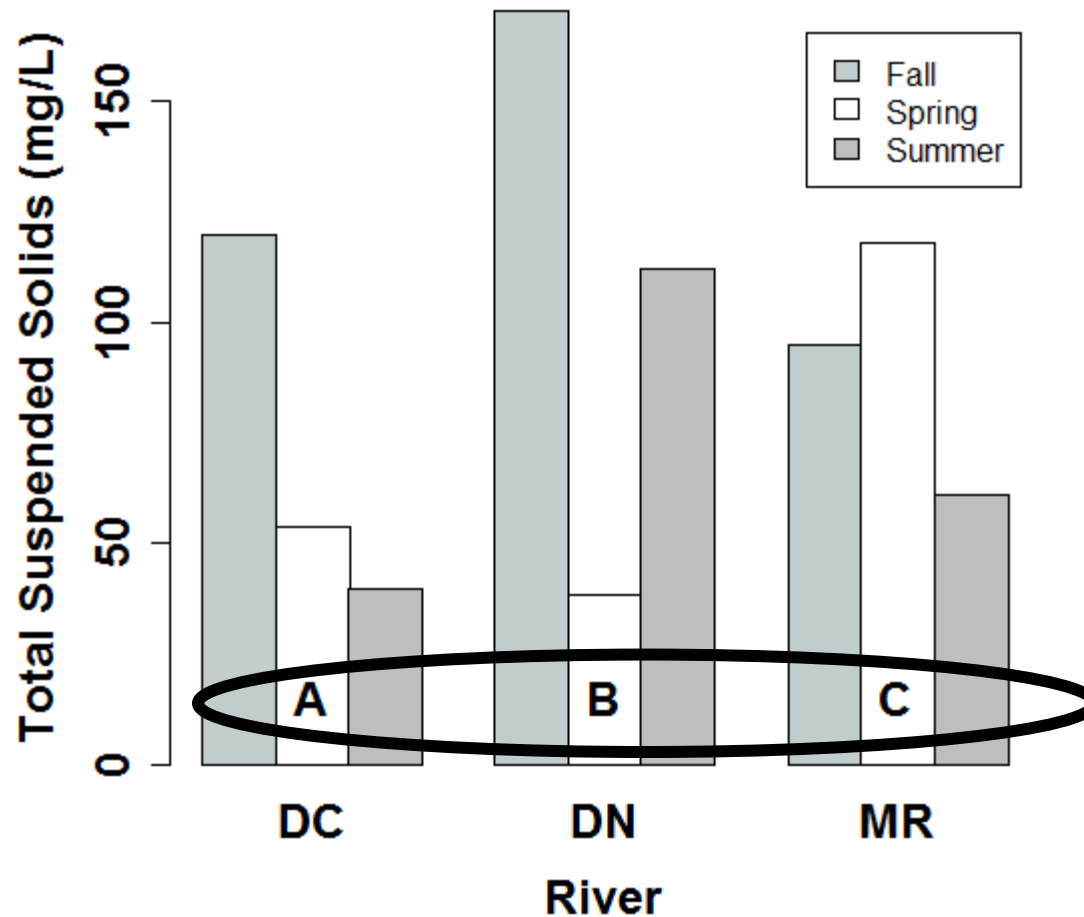
Literature:

Widdows and Bayne (1971)

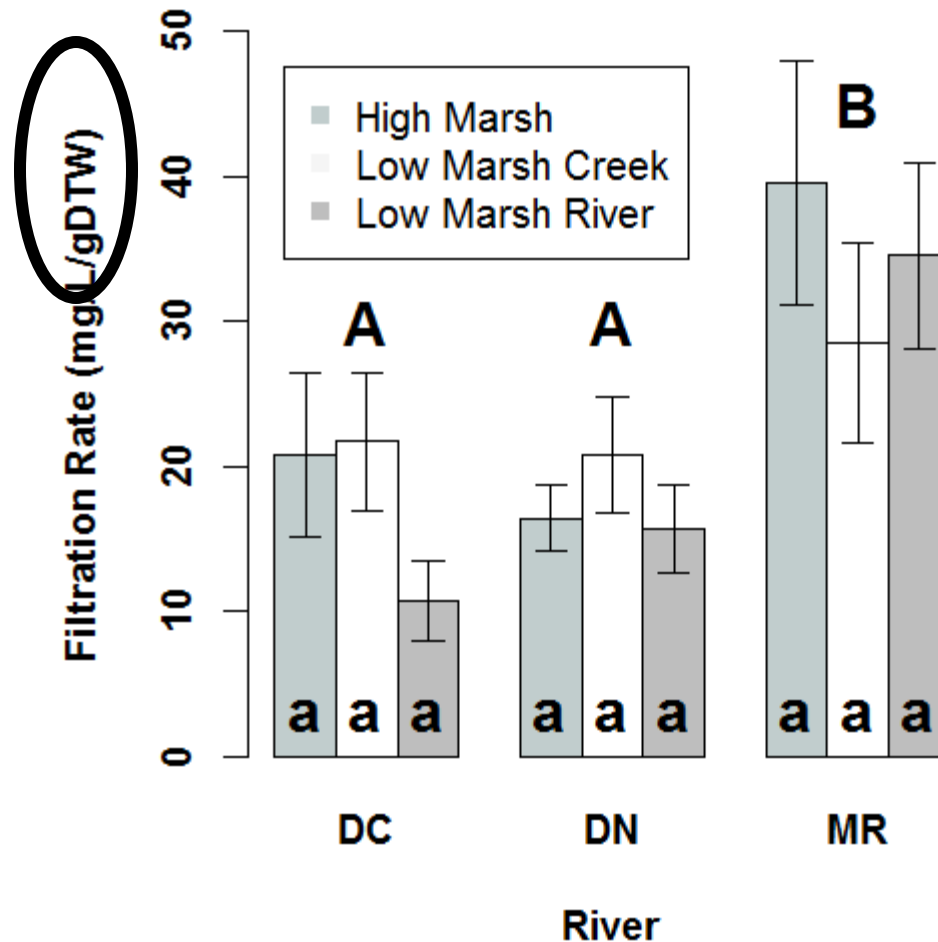
Widdows (1976)

Willows (1992)

TSS Varied by River and Season



Filtration Rate Similar Across Habitats

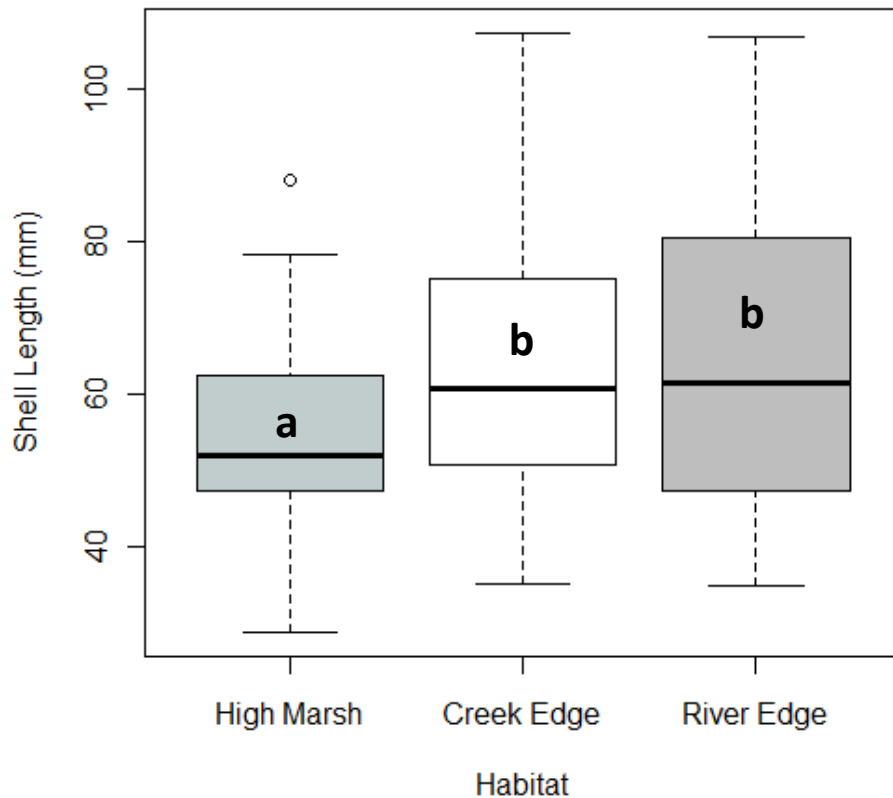


Mussel Size and Abundance Across Salt Marsh Habitats

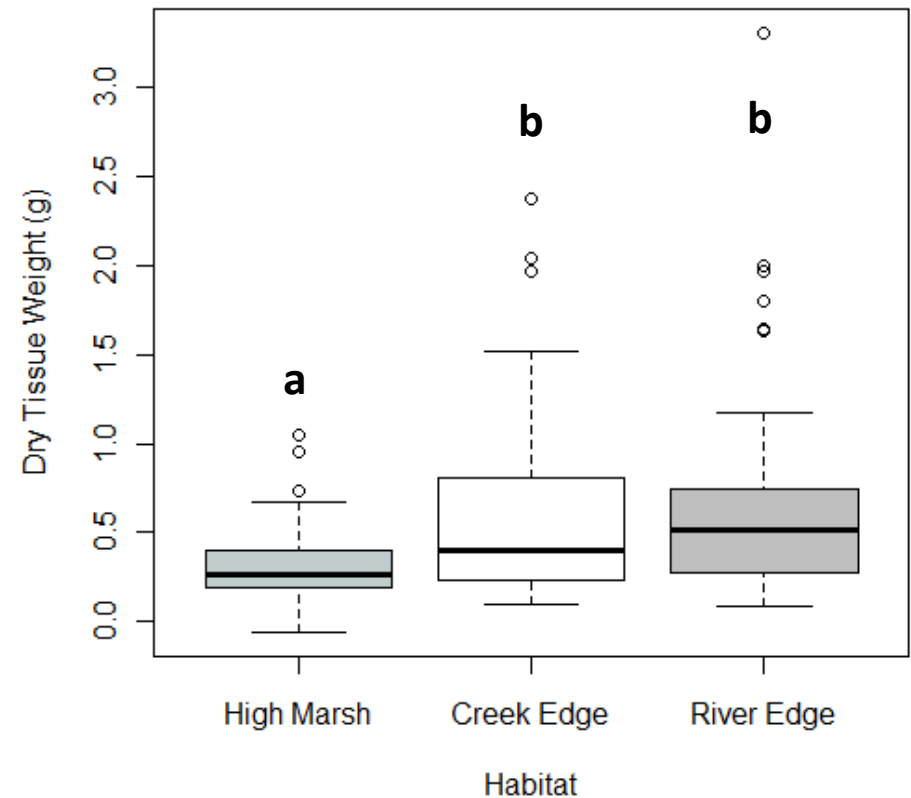
1. Clearance Rate dependent on Temperature and TSS
2. Filtration Rate similar across habitat is a river
3. Does mussel biomass differ across marshes and habitat?
4. How does spatial variation of habitat size within marshes concentrate ecosystem services?

Mussels Size: Smaller in High Marsh

Shell Length by Habitat

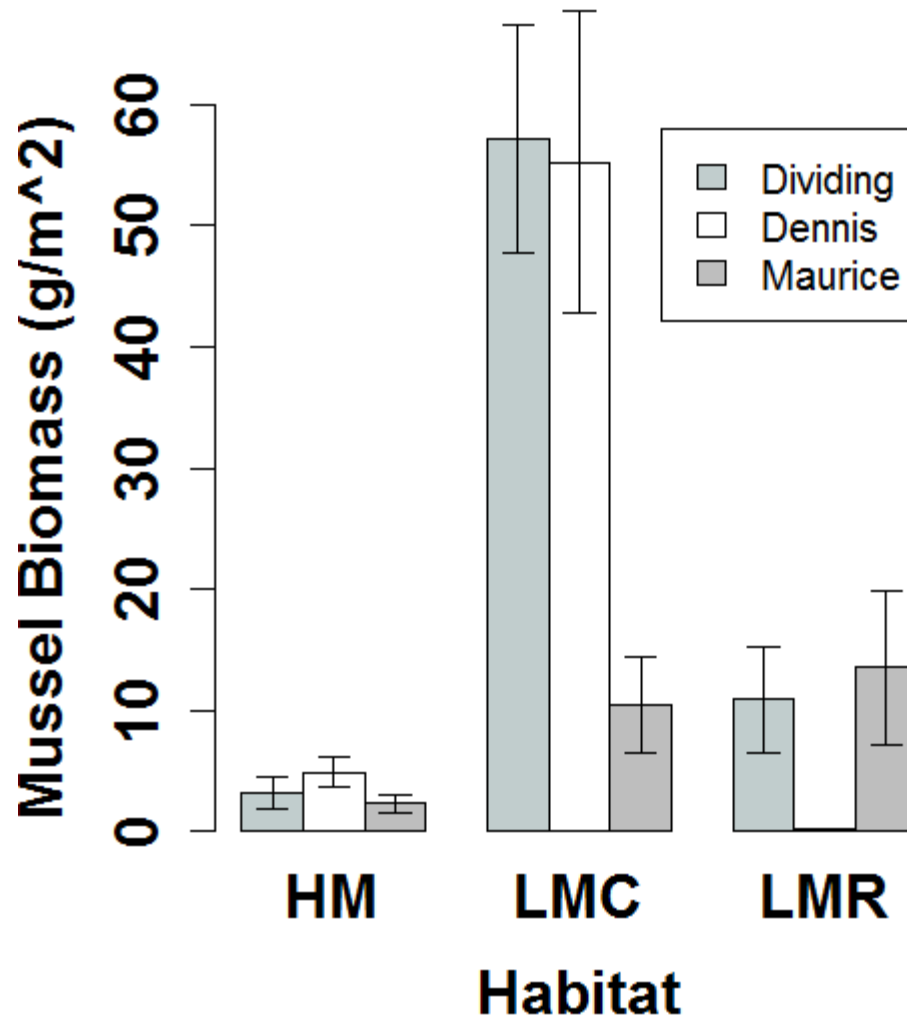


Dry Tissue Weight by Habitat



Literature: Bertness and Grosholz (1985); Stiven & Garder (1992); Franz (1993)

Mussel Abundance: Biomass Concentrated in Creeks



Spatial Variability of Salt Marsh Habitats

1. Clearance Rate dependent on Temperature and TSS
2. Filtration Rate similar across habitat is a river
3. Mussel biomass differs across habitats
4. How does spatial variation of habitat size within marshes concentrate ecosystem services?

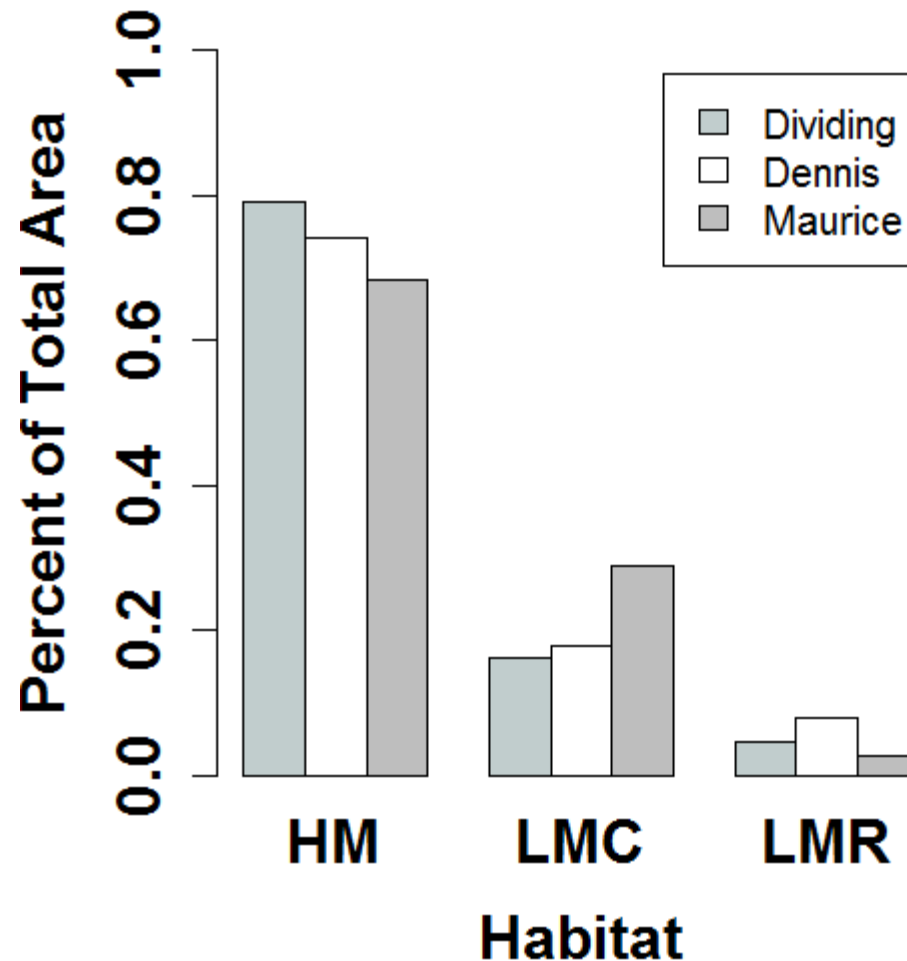
Mapping Ecosystem Services



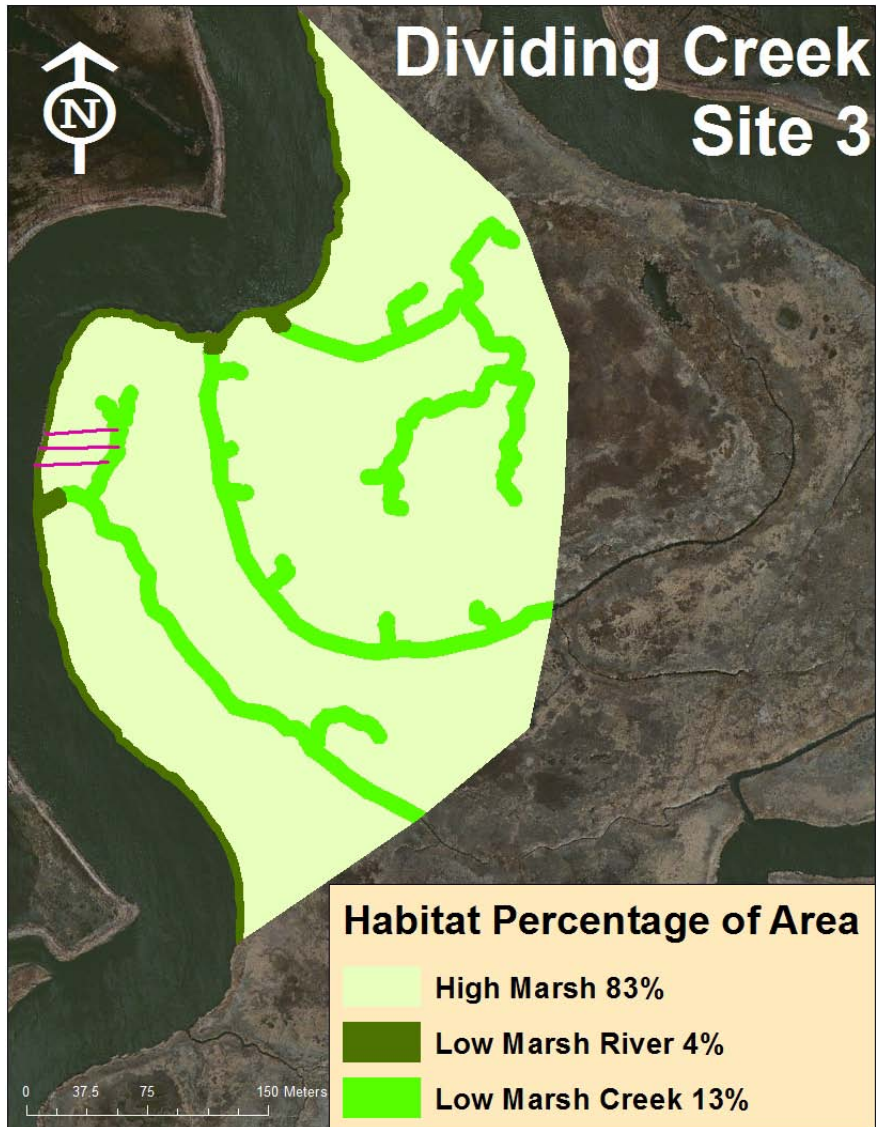
- 1. 300m Buffer
Centered on Middle
Transect**
 - Not crossing main channel
- 2. Spatial Variability
of Habitats**
 - Digitized edge/creeks
IKONOS 2014 (1:300)
 - LMC/LMR 5m buffer on
digitized edge/channel*
- 3. Mussel Biomass**
- 4. Filtration Rate**

***Deegan, 2012; PDE MACWA Report, 2014**

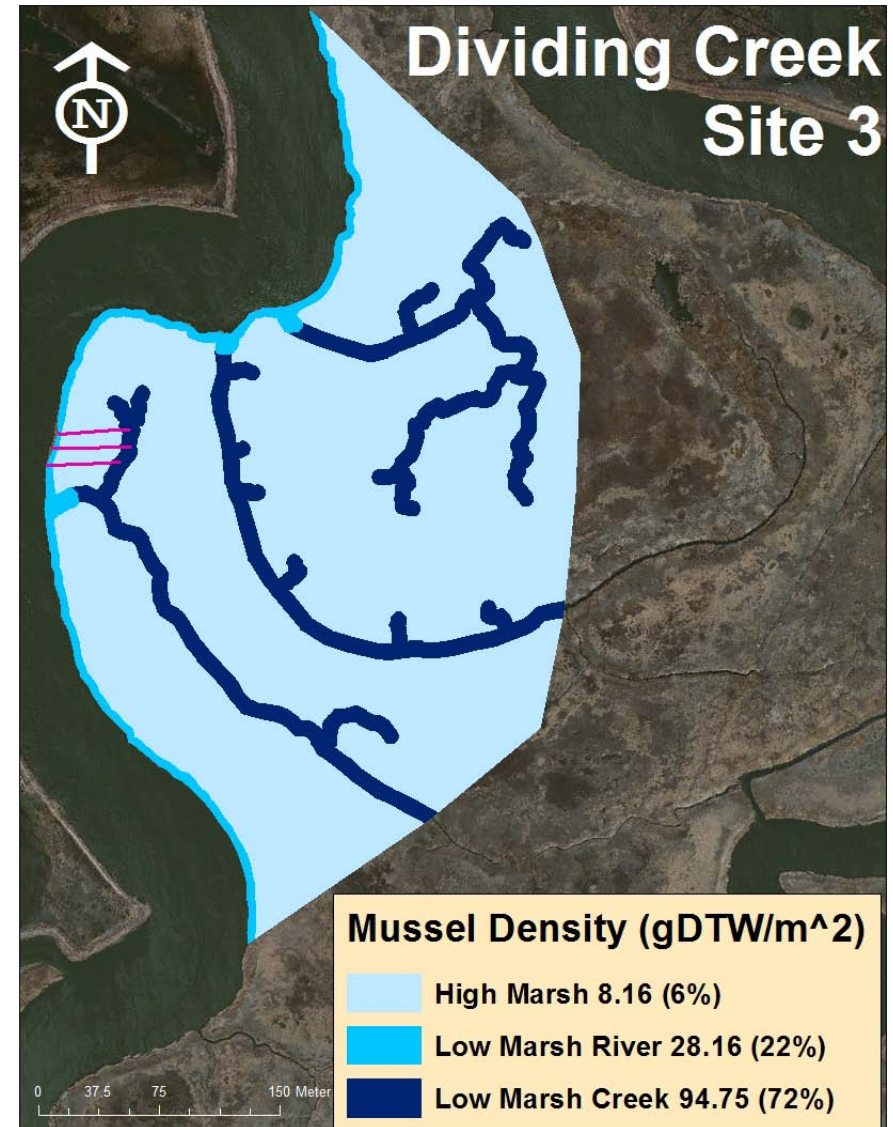
High Marsh is Significantly Larger



Habitat Variability



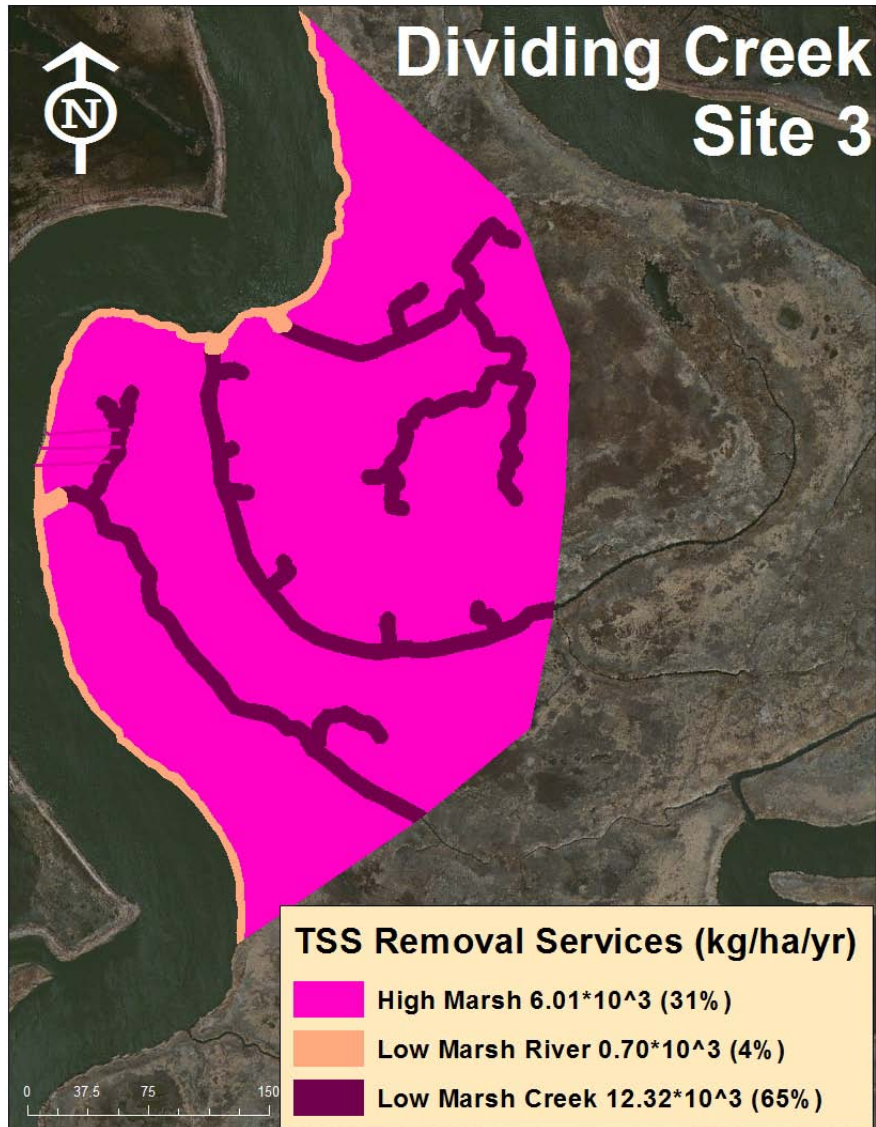
Mussel Variability



Calculation: Ribbed Mussel TSS Removal by Habitat Dividing Creek 3

| | | Low Marsh River | High Marsh | Low Marsh Creek |
|---|---|-----------------------|----------------------|-----------------------|
| 1 | Mussel Biomass (g DTW m ⁻²) | 28.16 | 8.16 | 94.75 |
| 2 | Clearance Rate (L hr ⁻¹ g DTW ⁻¹) | 0.20 | 0.28 | 0.32 |
| 3 | Daily Clearance Rate (L d ⁻¹ g DTW ⁻¹) (assuming 12hr immersion; correct with hydroperiod data) | 2.40 | 3.41 | 3.85 |
| 4 | Clearance Rate/Area (L d ⁻¹ m ⁻²) (1 & 3) | 67.48 | 27.81 | 364.47 |
| 5 | [TSS] (mg L ⁻¹) | 71.26 | 71.26 | 71.26 |
| 6 | TSS Removal Services (mg d ⁻¹ m ⁻²) (4 & 5) | 4.81*10 ³ | 1.98*10 ³ | 25.97*10 ³ |
| 7 | Area Percentage (ha) | 0.04 | 0.83 | 0.13 |
| 8 | Area Wide TSS Removal Services by Habitat (Kg ha ⁻¹ yr ⁻¹) (6 & 7) | 0.7*10 ³ | 6.01*10 ³ | 12.32*10 ³ |

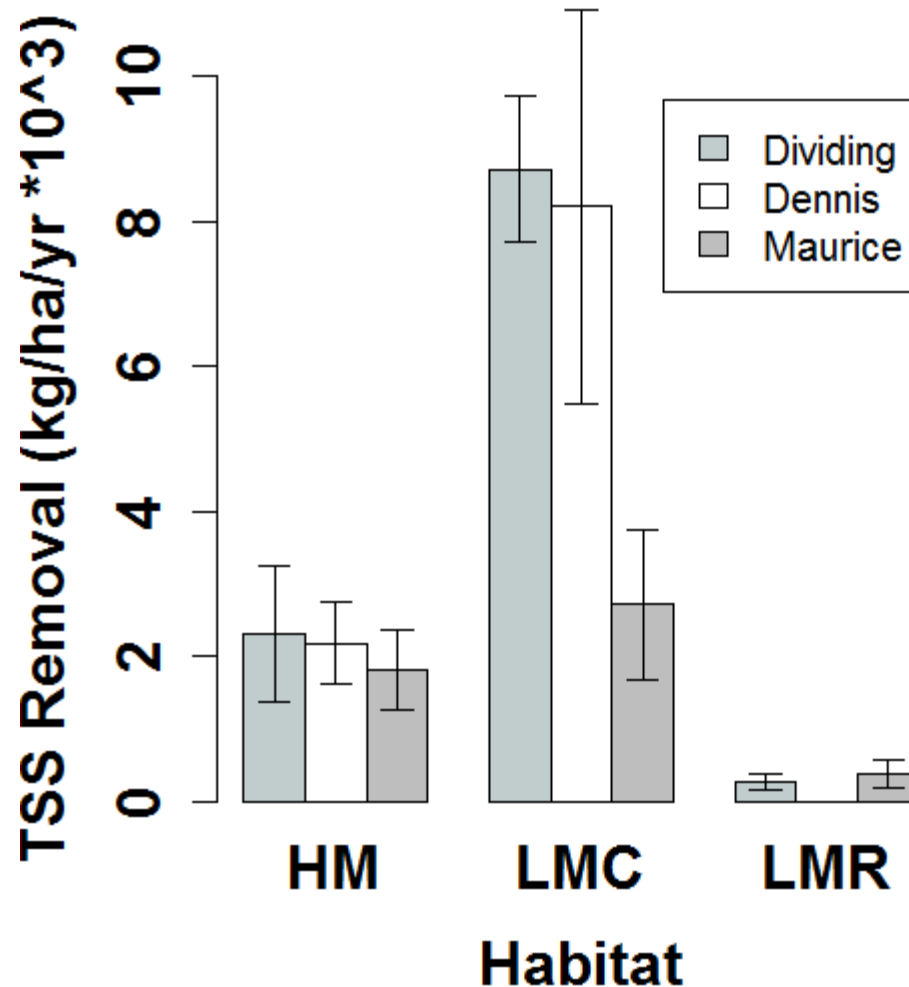
TSS Removal



Next Steps

1. Nutrient composition of TSS
2. Net Absorption Efficiencies: nutrients removed from system
3. Correct for Hydroperiod
4. Calculate habitat specific particulate nutrient removal services by system

TSS Removal Highest In Creeks



Conclusions

Currently:

- Mussels remove particulates across marsh platform
- Concentrated in Low Marsh Creeks
- Highlighting relative importance of creeks
- Low mussel density along similar habitat at the marsh edge

Future:

- Potential increase in services along river edge through mussel enhancement during restoration projects

At one representative Site: **19 Metric Tons TSS removed/ha/yr**

Thank You

- **EPA R2**
- **EPA ORD Narragansett**
 - Elizabeth Watson
 - Marty Chintala
 - Suzanne Ayvazian
- **Rutgers Haskin Shellfish Research Laboratory**
 - David Bushek
 - Jenny Paterno
- **Partnership for the Delaware Estuary**
 - Kurt Cheng
 - Priscilla Cole
 - LeeAnn Haaf
 - Jessie Buckner
- **The many people who have contributed to field efforts!!!!**



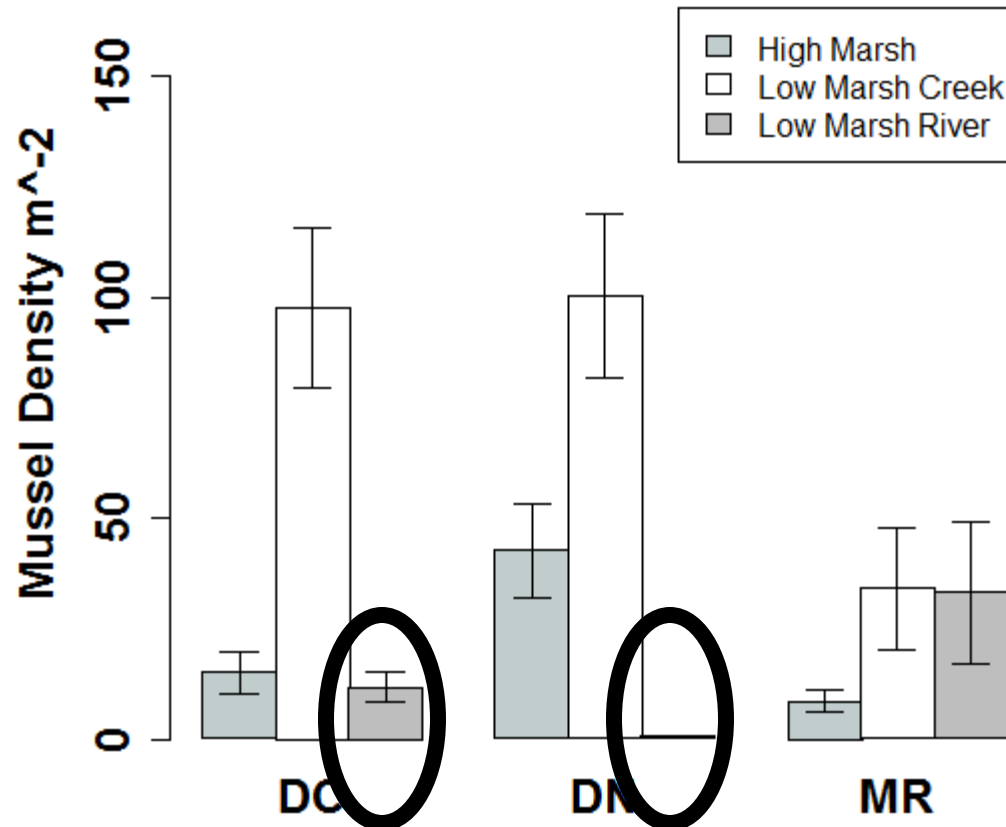
Dividing Creek Site 3



Habitat Area

- RTK GPS: accuracy 3mm
- Delineated habitat based on dominant vegetation zonation
- Low Marsh
 - Tall form
Spartina alterniflora
- High Marsh
 - Short form *S. alterniflora*, *S. patens*, *D. spicata*, *Salicornia*

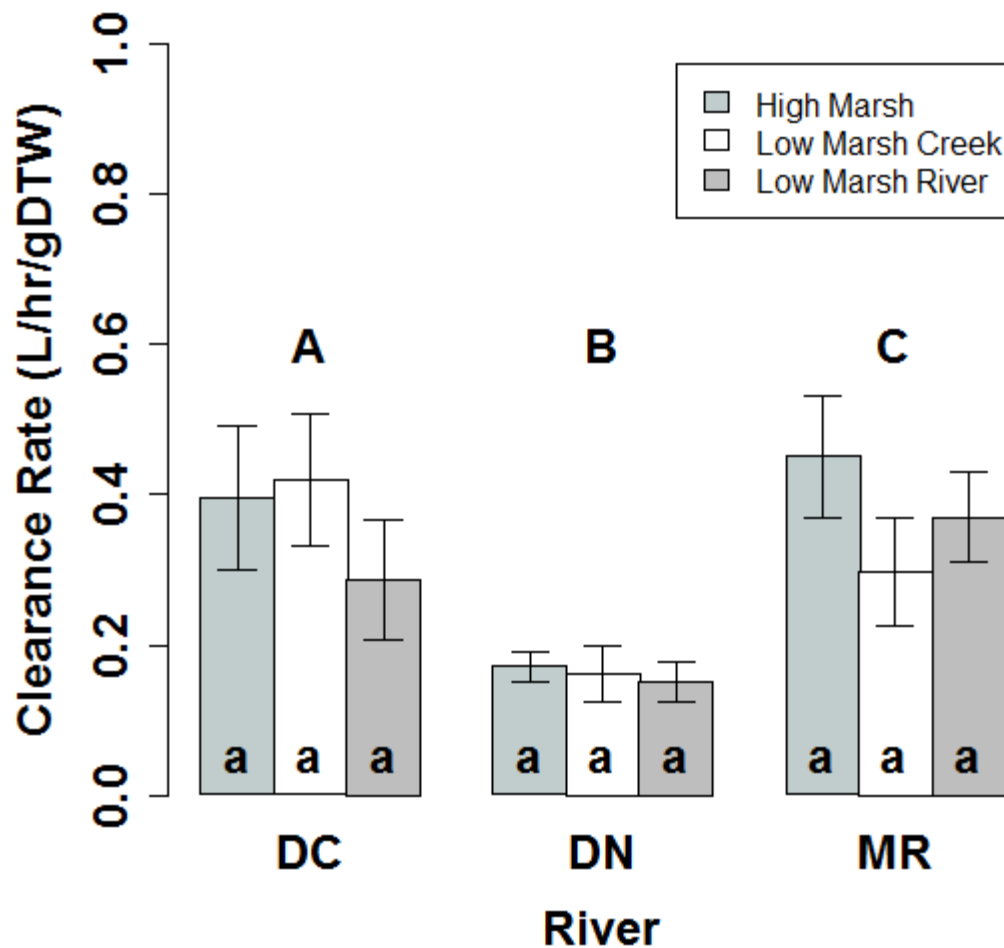
Mussels Density Differs by Habitat



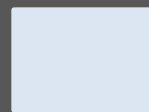
Literature: Stivin and Gardner (1992)

River

Clearance Rate Does Not Vary by Habitat



Maurice River

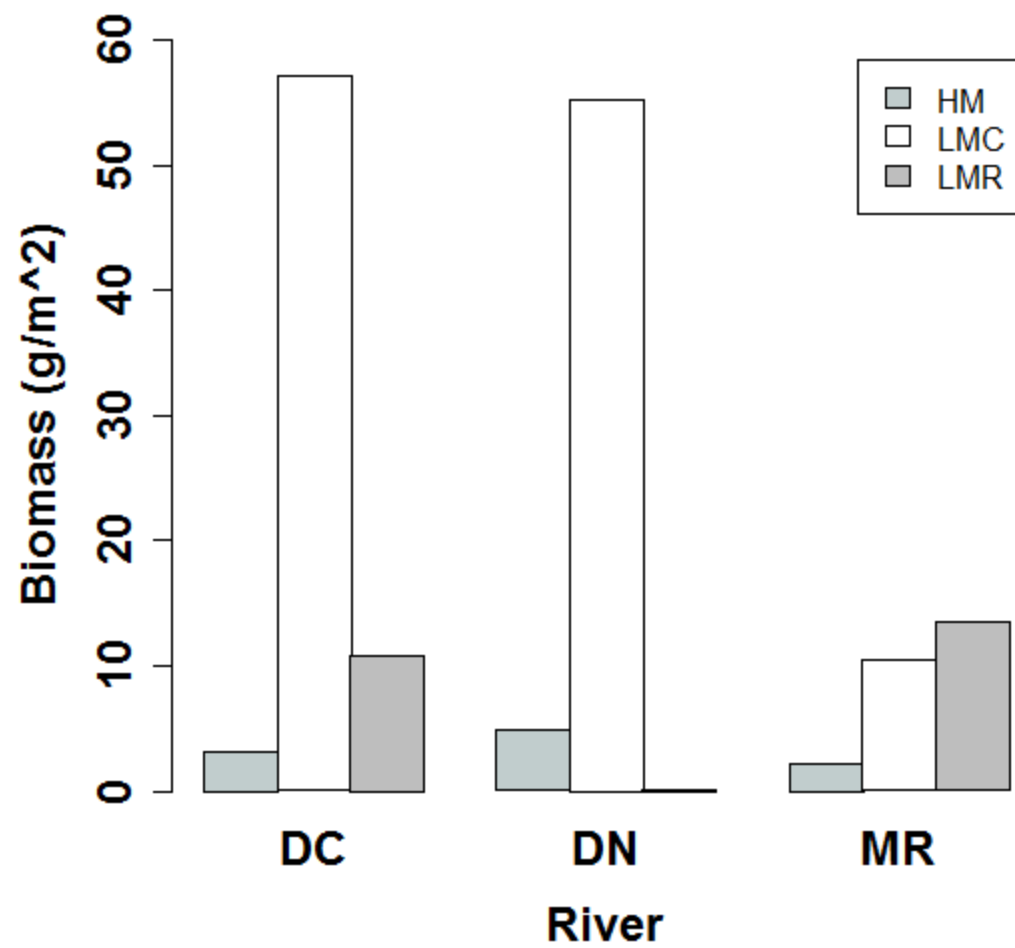


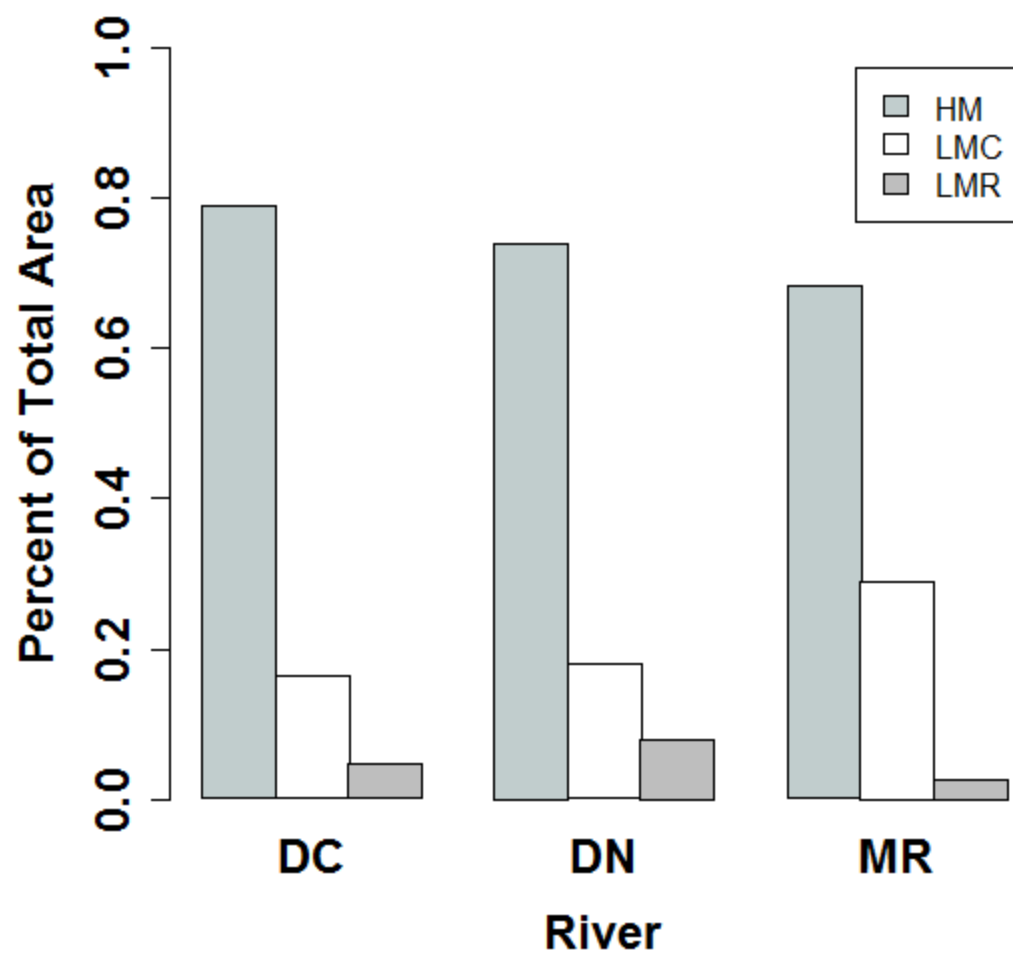
Low Concentration of
Ecosystem Services

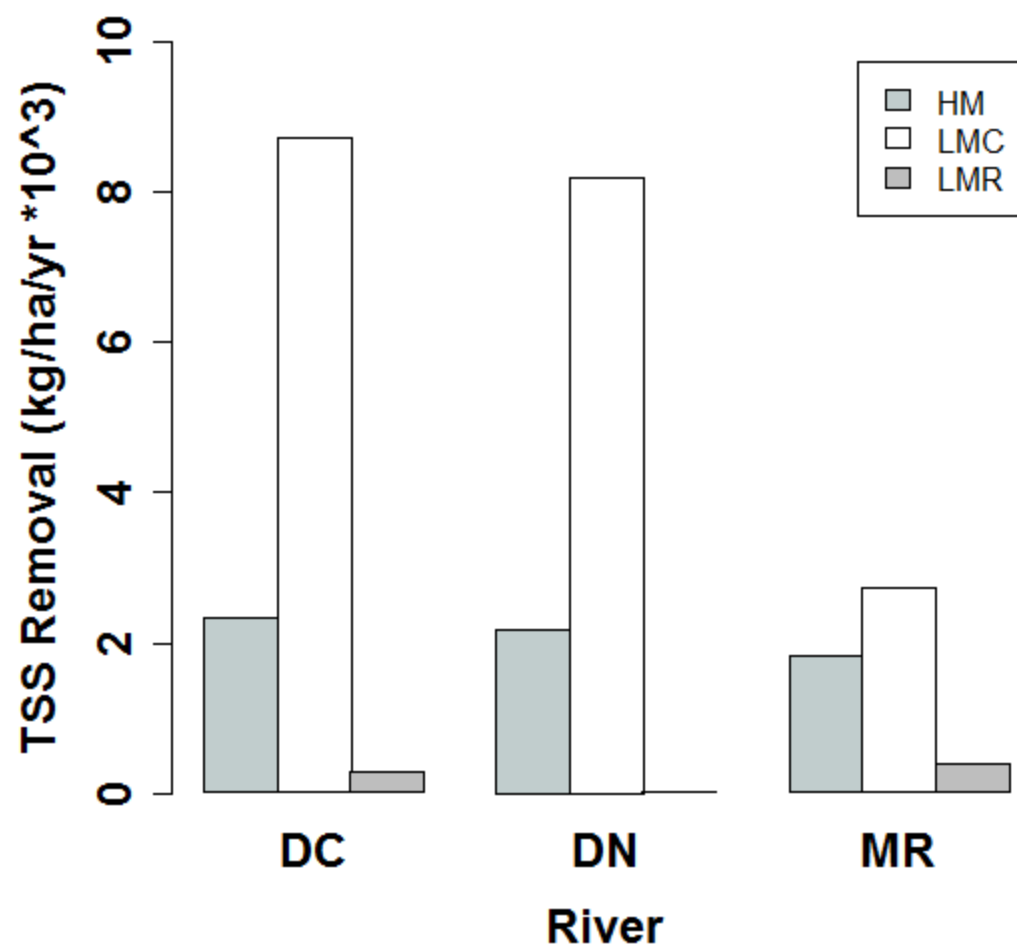


High Concentration of
Ecosystem Services









- **Filtration Rate Responds to Temp**

- Widdows and Bayne (1971)
- Widdows (1976)
- Willows (1992)

- **Selective Feeding Occurs**

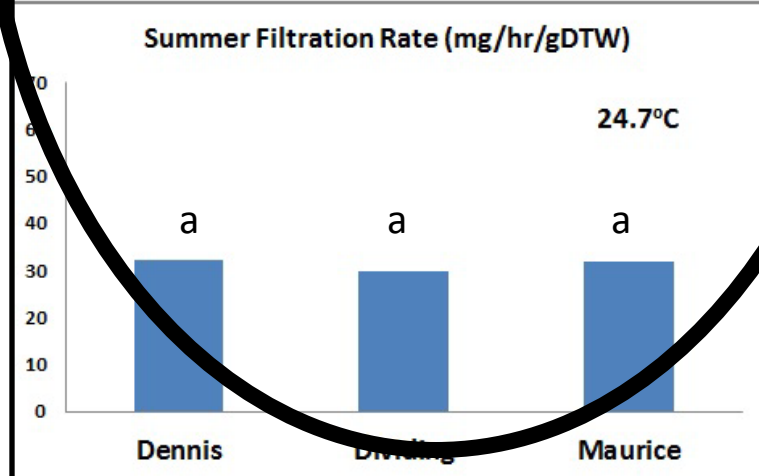
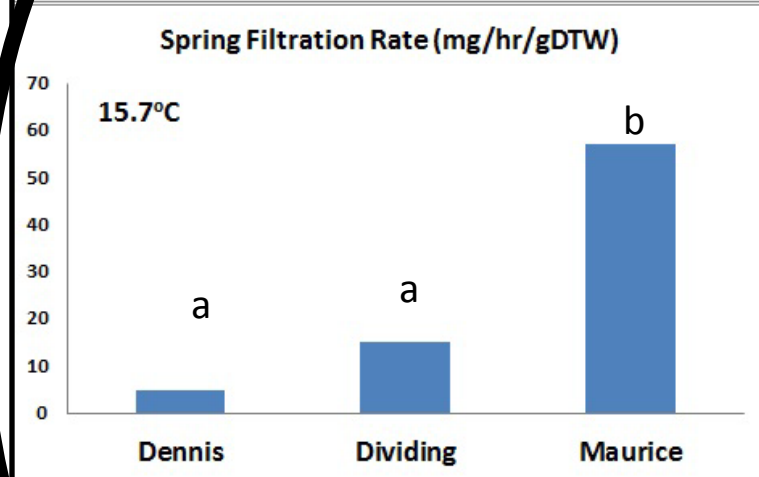
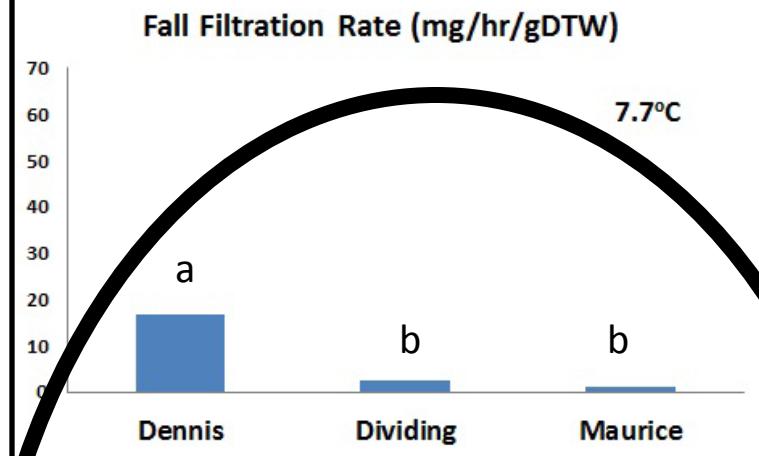
- Grave (1916)
- Morse (1944)

- **Seasonal Variation in Diet**

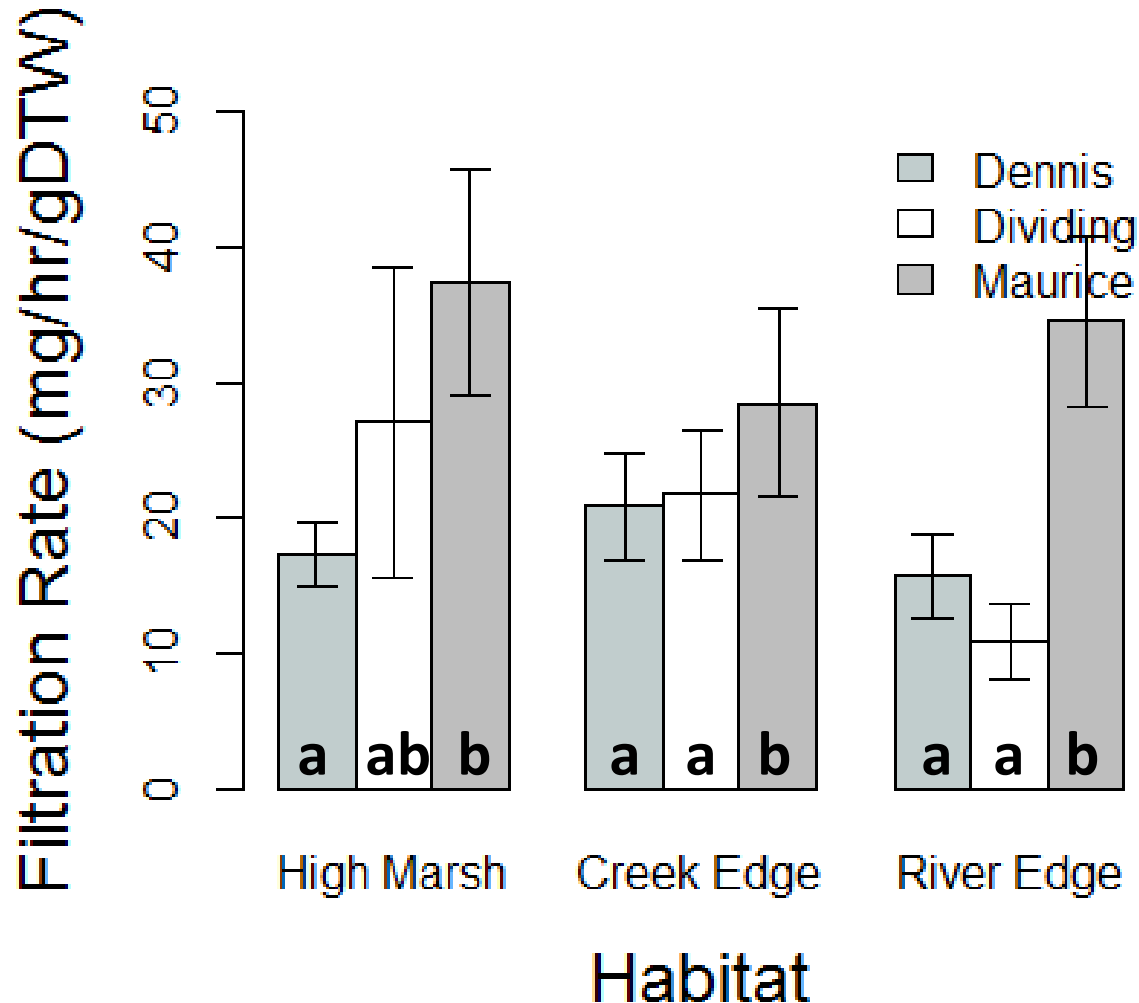
- Kreeger and Newell (2001)

- **Food Quality Info May Explain Variation**

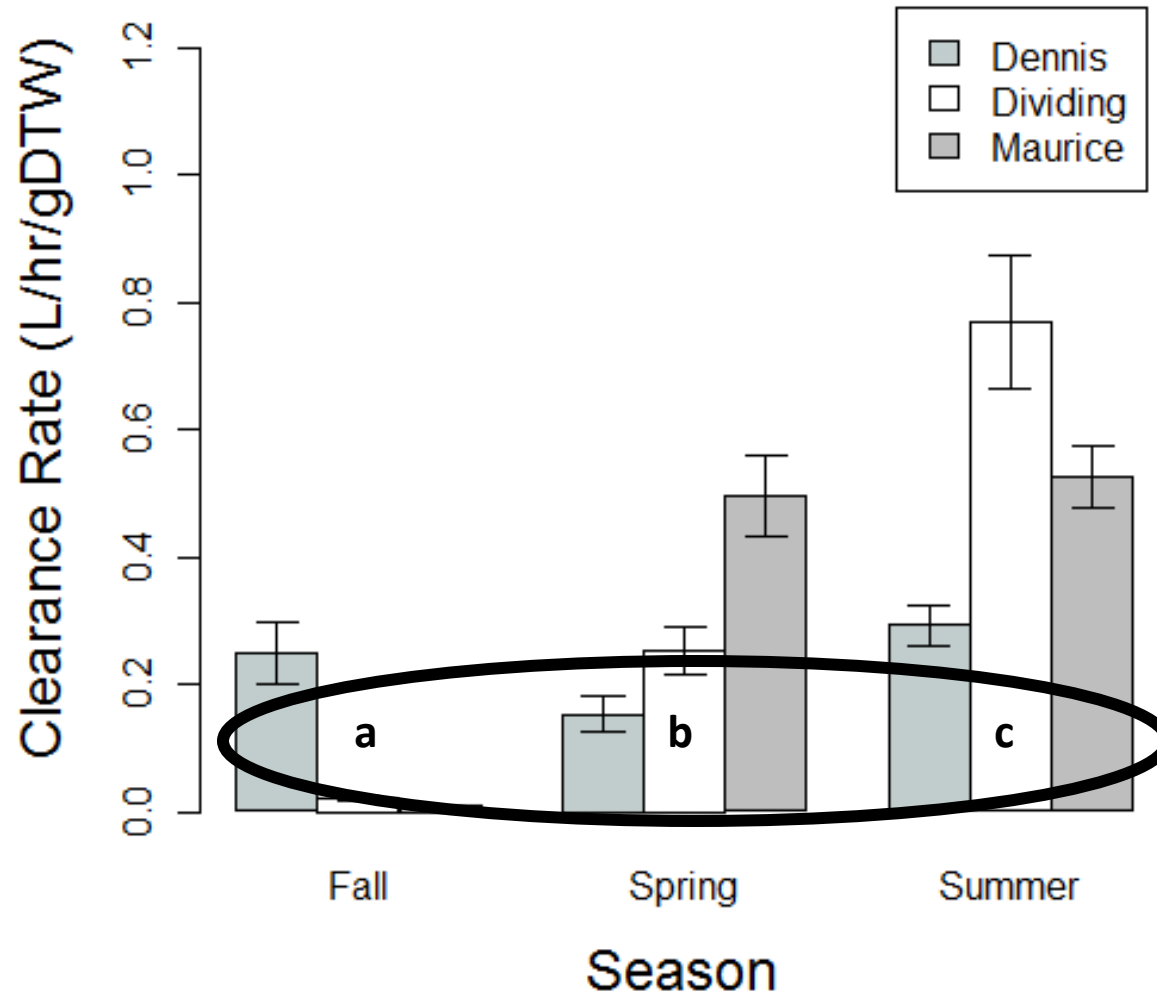
- **There are Variations Among Rivers**



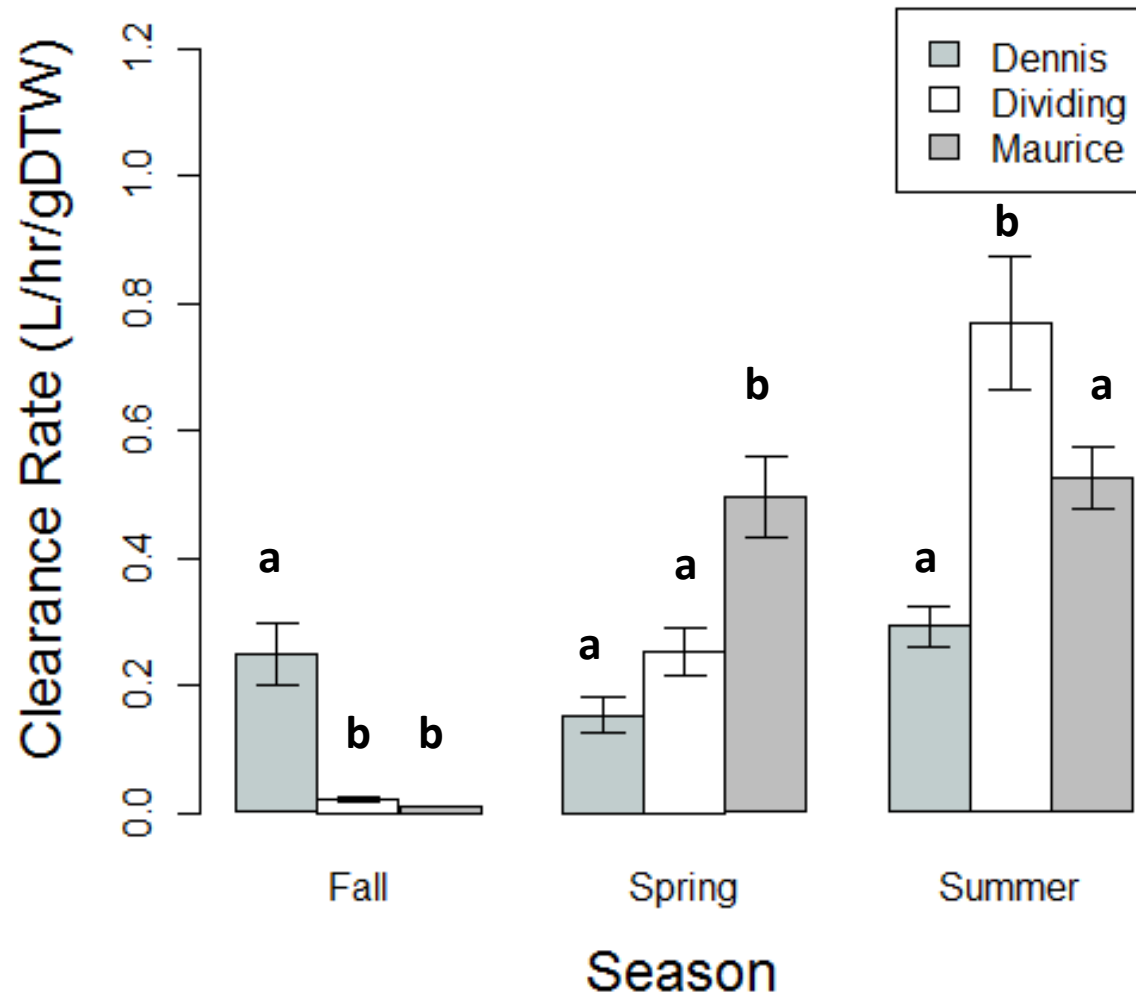
Filtration Rate Within a Habitat Different Among Rivers



Clearance Rate Varied by Season



Clearance Rate Varied by River



Conclusions

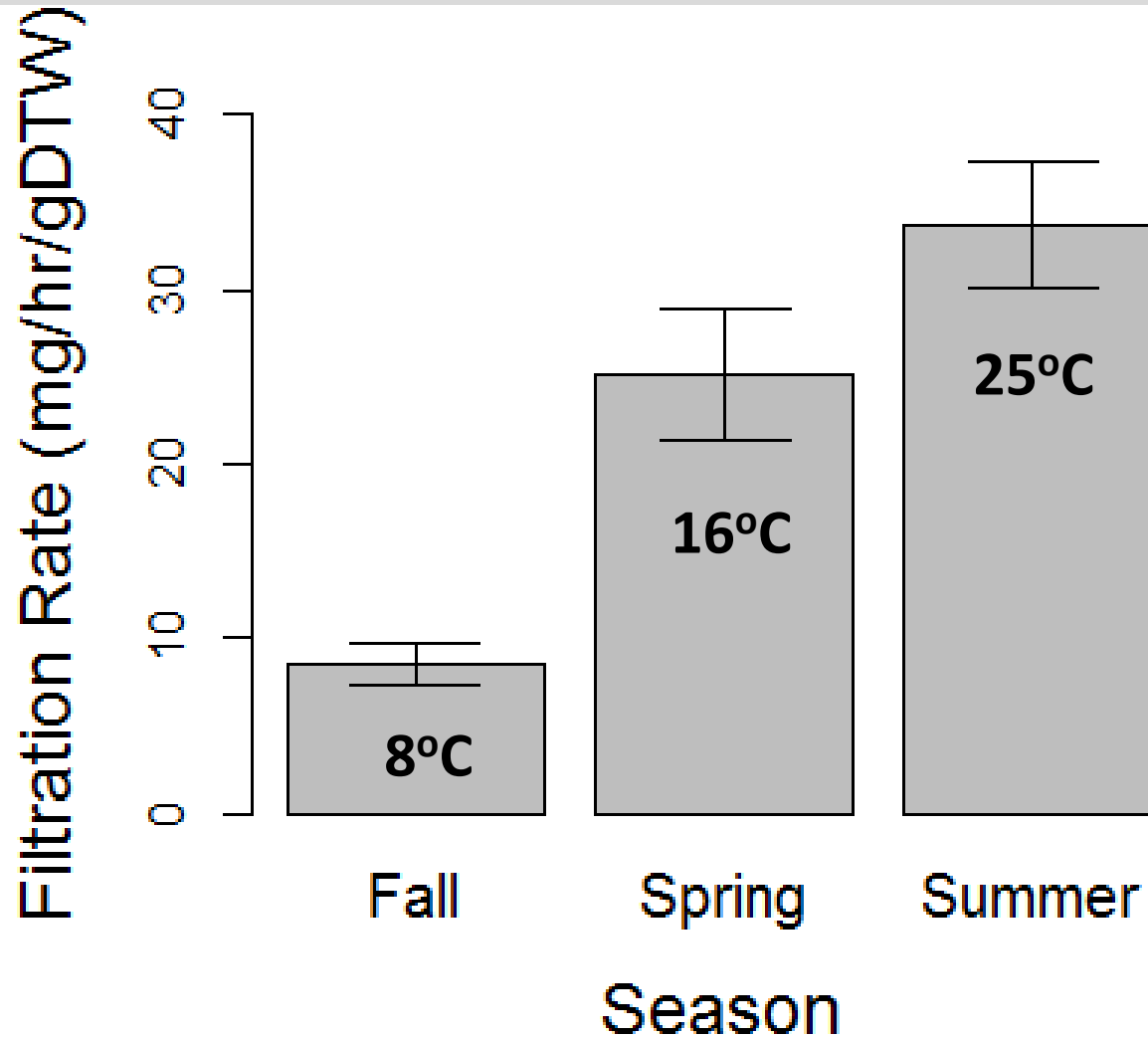
- TSS filtration rates were variable across Rivers and Seasons
- TSS filtration did not differ among habitats
 - suggests bivalves filter optimally at all times
- Potential to map mussel ecosystem services (TSS /Particulate N removal) based on Physiology, temperature, local TSS, and tissue biomass.

Ribbed Mussel, *Geukensia demissa*

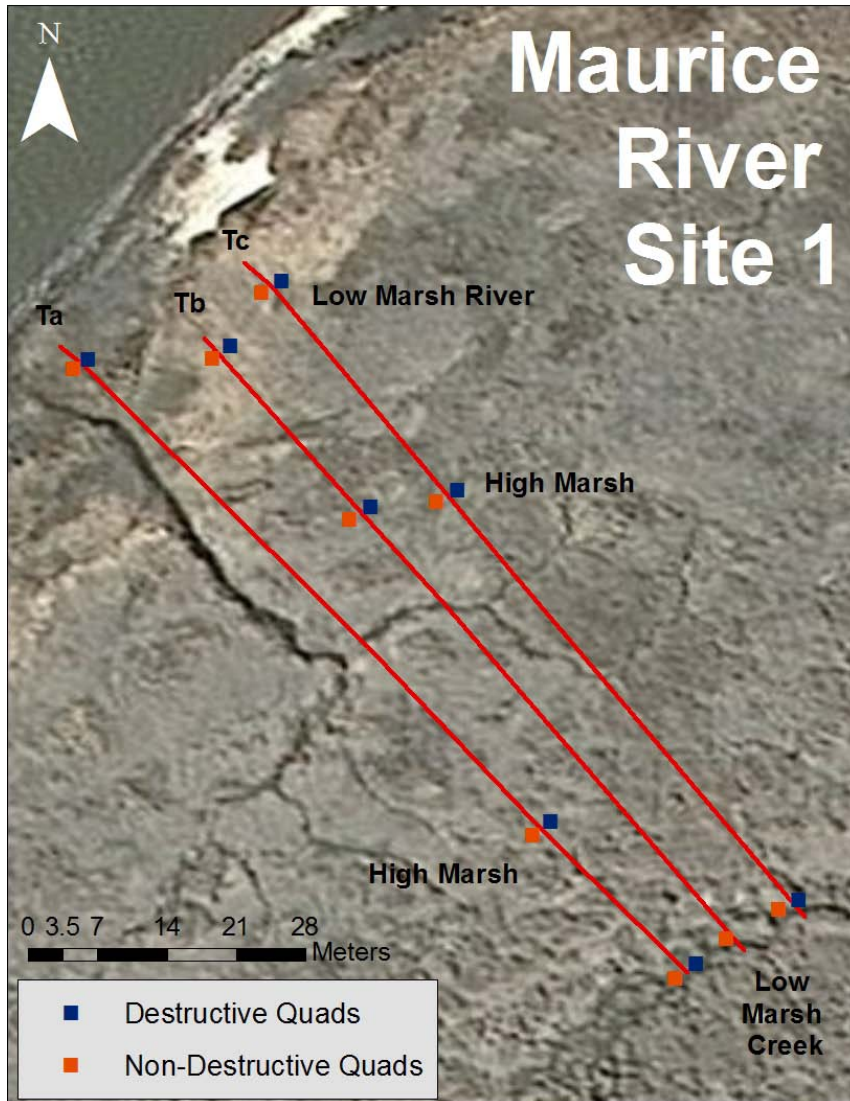
- Ubiquitous along Atlantic coast and Gulf of Mexico
- Coastal salt marsh
- Marsh edge, high marsh, creek networks (Kuenzler 1961; Bertness 1984)
- *Spartina alterniflora*



Filtration Rate Scaled with Temperature

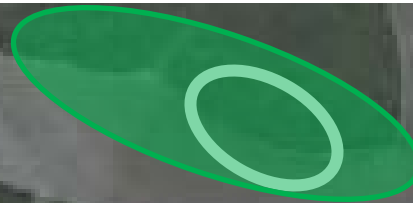
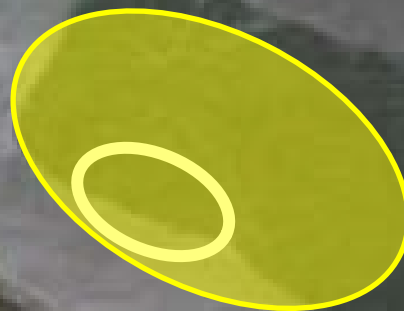


Quantify Mussel Density by Habitats

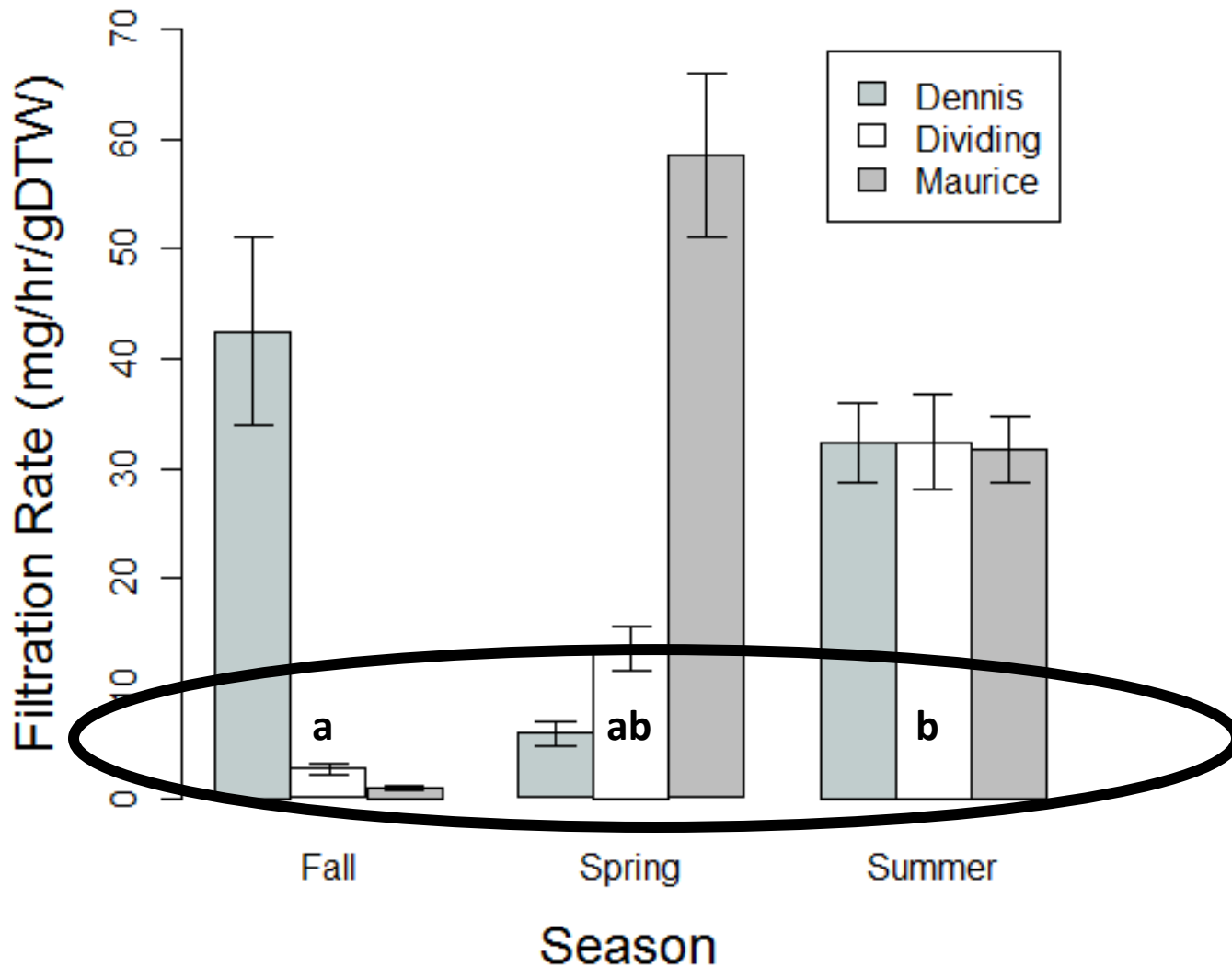


- 3 quads/habitat/site
- Allometric relationships: Shell length:DTW
- River Edge
 - 136.8 gDTW/m²
- High Marsh
 - 16.9 gDTW/m²
- Creek Edge
 - 61.8 gDTW/m²

Maurice River

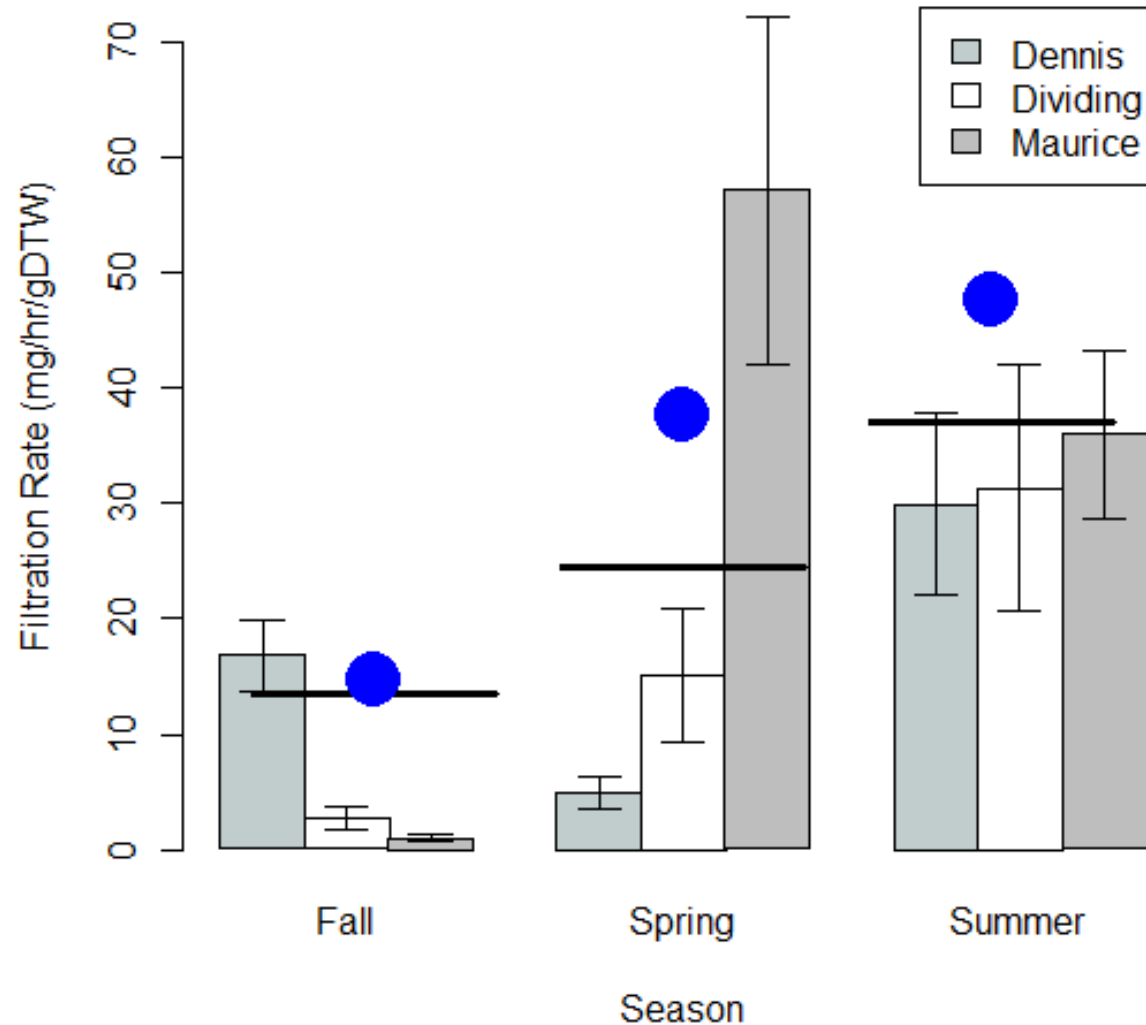


Filtration Rate Varied by Season

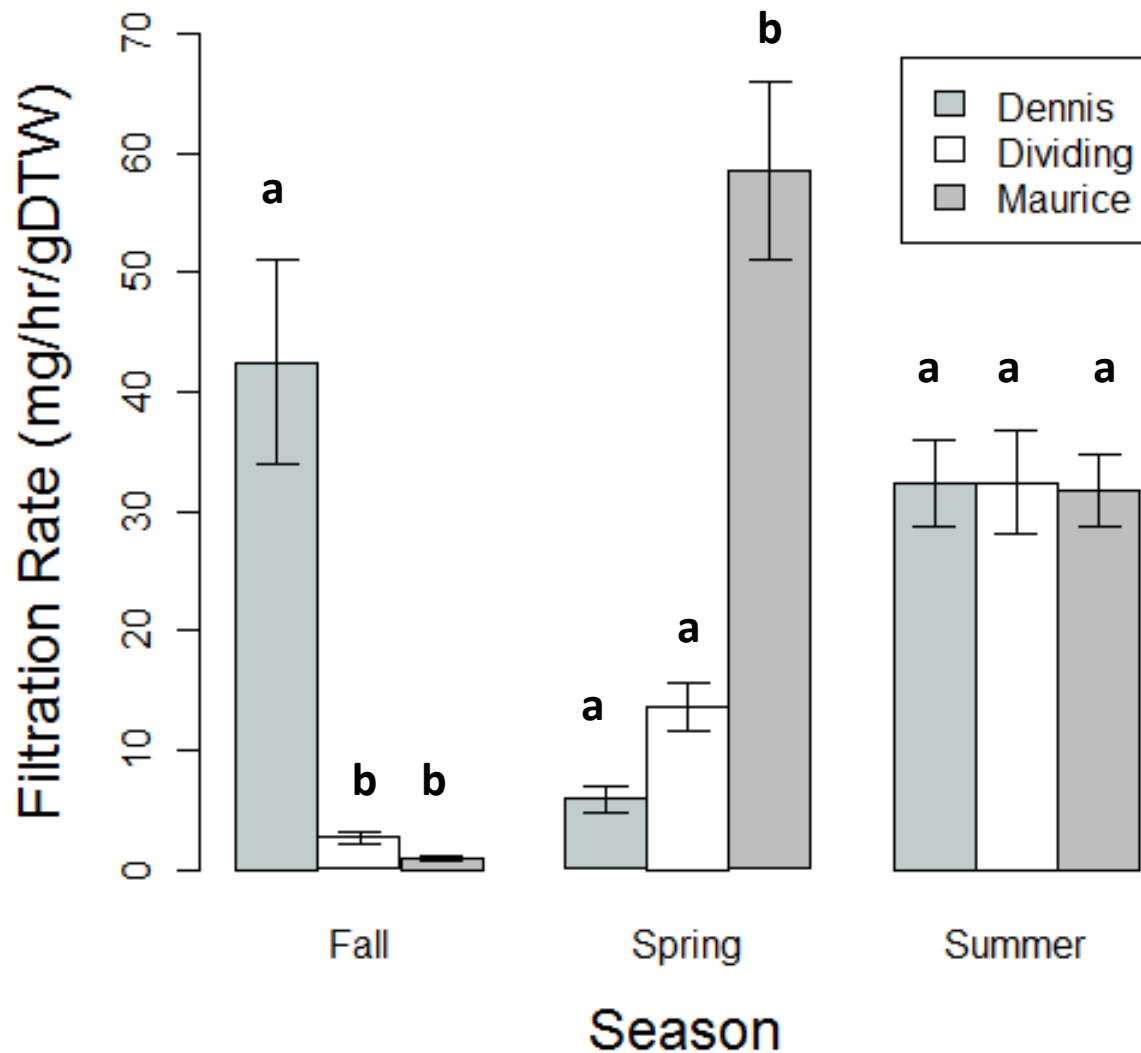


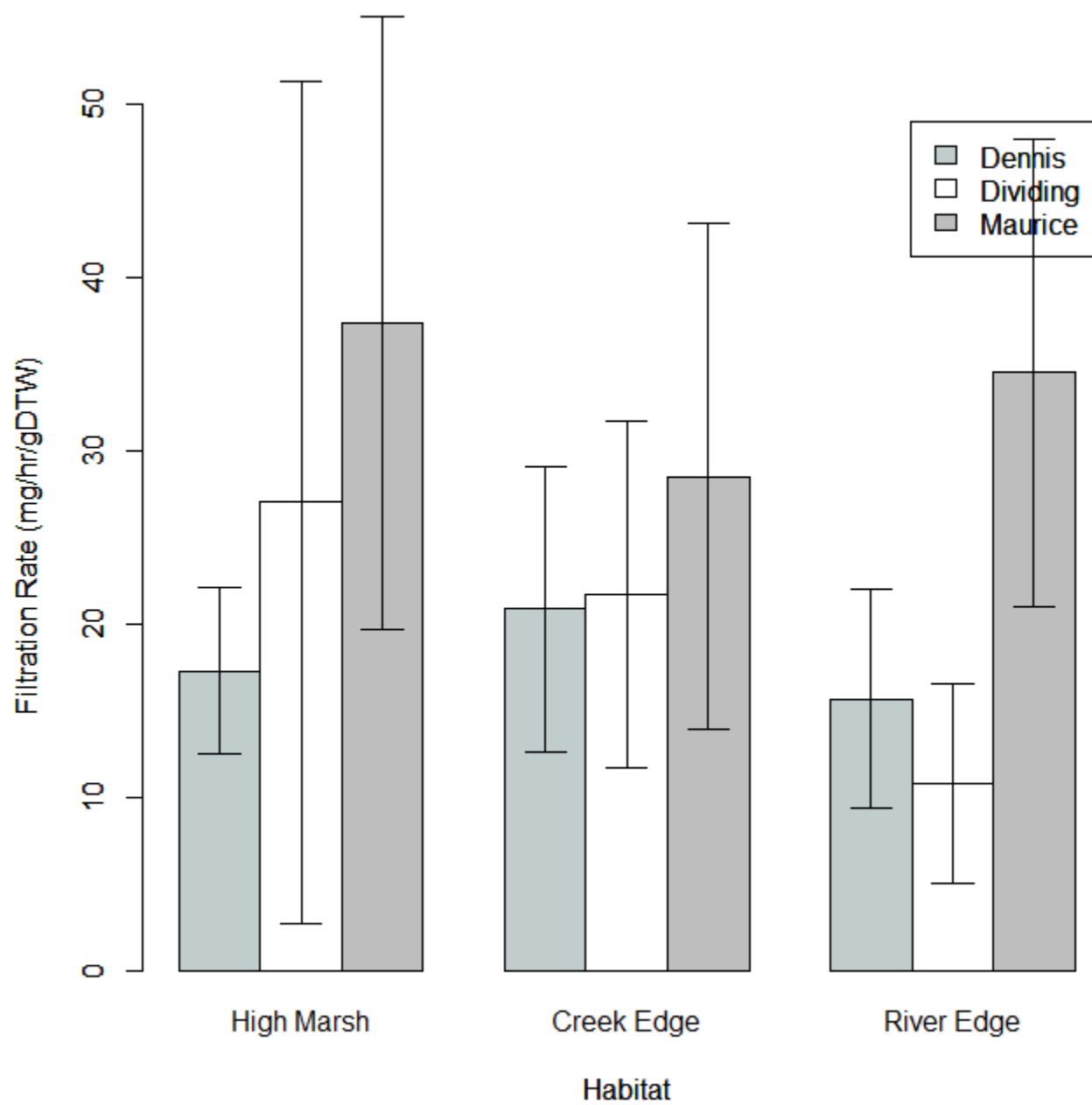
Water temp bars and FR means circles

Filtration Rate by Season



Filtration Rate Varied by River in Cooler Seasons





Cr with water temp add mean by band

Clearance Rate by River and Season

