Spatial relationships between sediment composition and freshwater mussel distribution in the tidal Delaware River: *Preliminary Findings*

Lance Butler[1], Jim D'Agostino[1], Danielle Kreeger[2,3], Priscilla Cole[2], Melanie Mills[3], Roger Thomas[3]

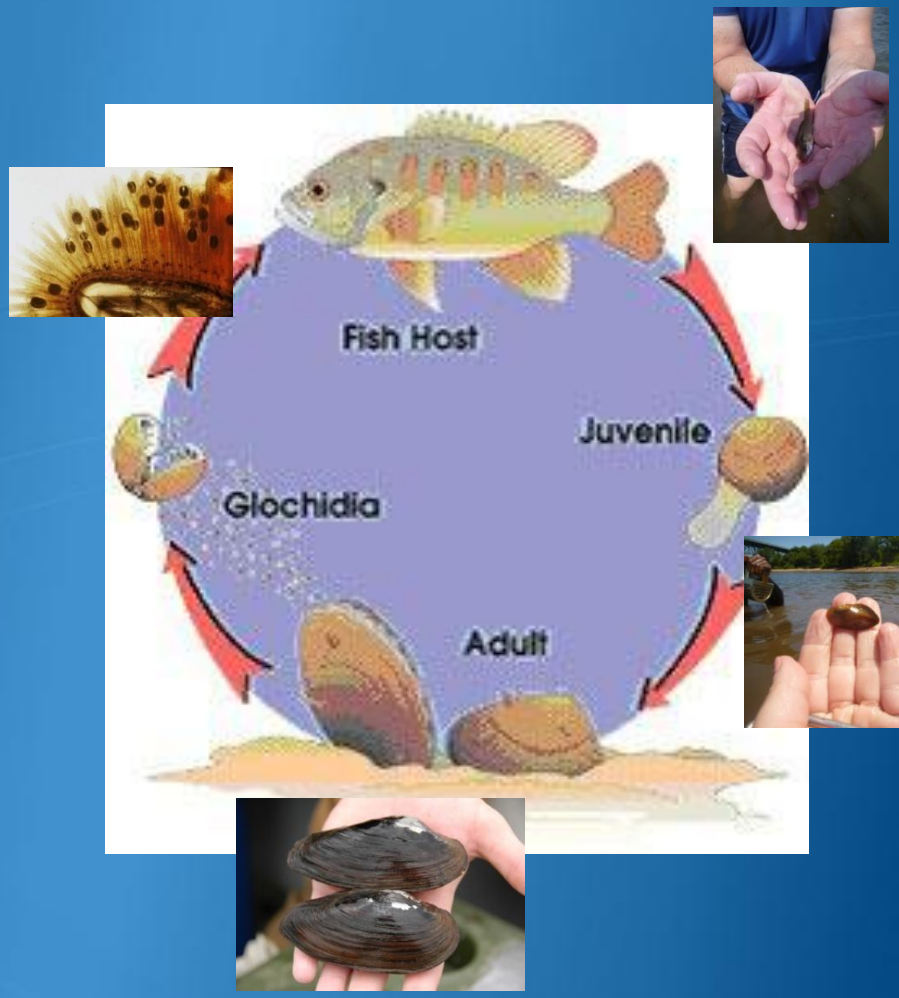
[1]Philadelphia Water Department, 1101 Market Street, Philadelphia, PA 19107

[2]Partnership for the Delaware Estuary, One Riverwalk Plaza, Suite 202, Wilmington, DE 19801

[3]The Academy of Natural Sciences of Drexel University, Patrick Center for Environmental Research, 19th and Ben Franklin Parkway, Philadelphia, PA 19103

Overview

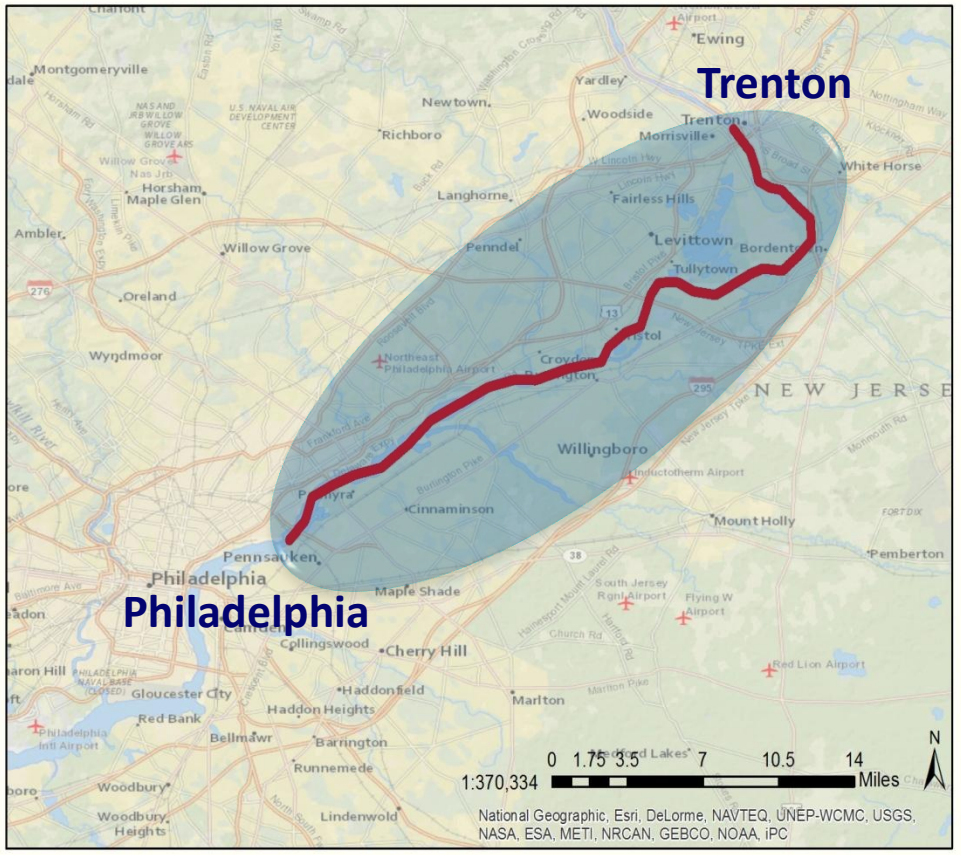
- Global decline in numbers and diversity
- Ecosystem services
  - Habitat
  - Water quality
  - Biological indicators
- Complex life cycles
  - Ecological linkages
- Under-represented
  - Monitoring
  - Management paradigms



Picture: North Carolina Wildlife Resources Commission

Monitoring Locations

- Urban corridor between Philadelphia and Trenton
- Approximately 28 river miles (47 km)
- 4 Monitoring stations
  - 3 on Pennsylvania side
  - 1 on New Jersey side
- 7-9 transects
- 3 different depth regimes
  - 0-2 ft
  - 2-4 ft
  - 4+ ft



2012 Freshwater Mussel Sampling Efforts in the Delaware River

2012 Survey Reach

Effort lead by Partnership for the Delaware Estuary, Academy of Natural Sciences of Drexel University, and the Philadelphia Water Department. By Priscilla Cole, Jan. 22, 2013.

Sampling Methods

- 1 m^2 quadrats for mussel surveys placed at the 3 depth regimes (see Kreeger *et al*)
- Cylindrical core sampler (150 in^3 ~2.5 L)
- Core depth approximately 4 inches
- Capped and placed in 2 gallon plastic bags
- Iced and transferred to PWD Bureau of Laboratory Services (BLS)
- Semi-quantitative surveys of submergent vegetative cover (percent & species composition)

Laboratory Analyses

Soil composition

- Standard methods for sieve analysis were performed
  - ASTM C-117
  - ASTM C-136
  - ASTM D-422
- Soil composition based on three size distributions
  - **Gravel** (4.75mm-75mm)
  - **Sand** (0.075mm-4.75mm)
  - **Fines** (smaller than 0.075 mm)
    - Silt
    - Clay

Laboratory Analyses

Physio-chemical properties

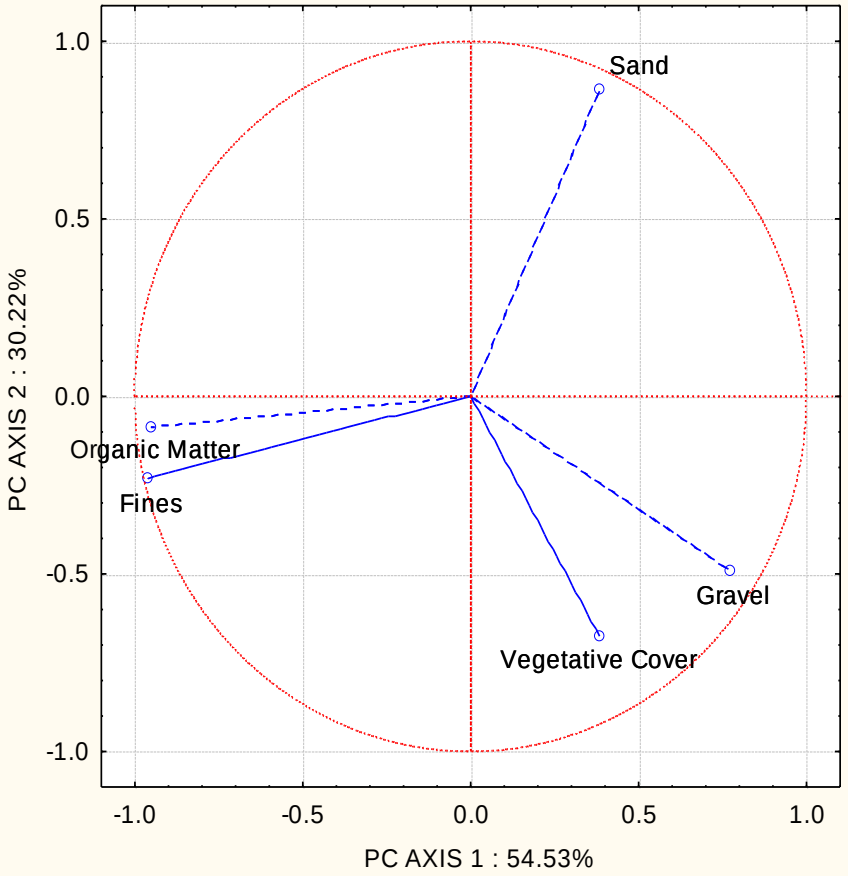
- Standard methods for physical and chemical properties were performed
  - ASHTO methods
  - ASTM methods
- Analytes
  - Organic matter (%)
  - pH
  - Aluminum (%/wt)
  - Calcium (%/wt)
  - Magnesium (%/wt)
  - Iron (%/wt)
  - Phosphorus (%/wt)
  - Nitrogen (%/wt)
  - Silica (%/wt)

PRINCIPAL COMPONENTS ANALYSIS (PCA)

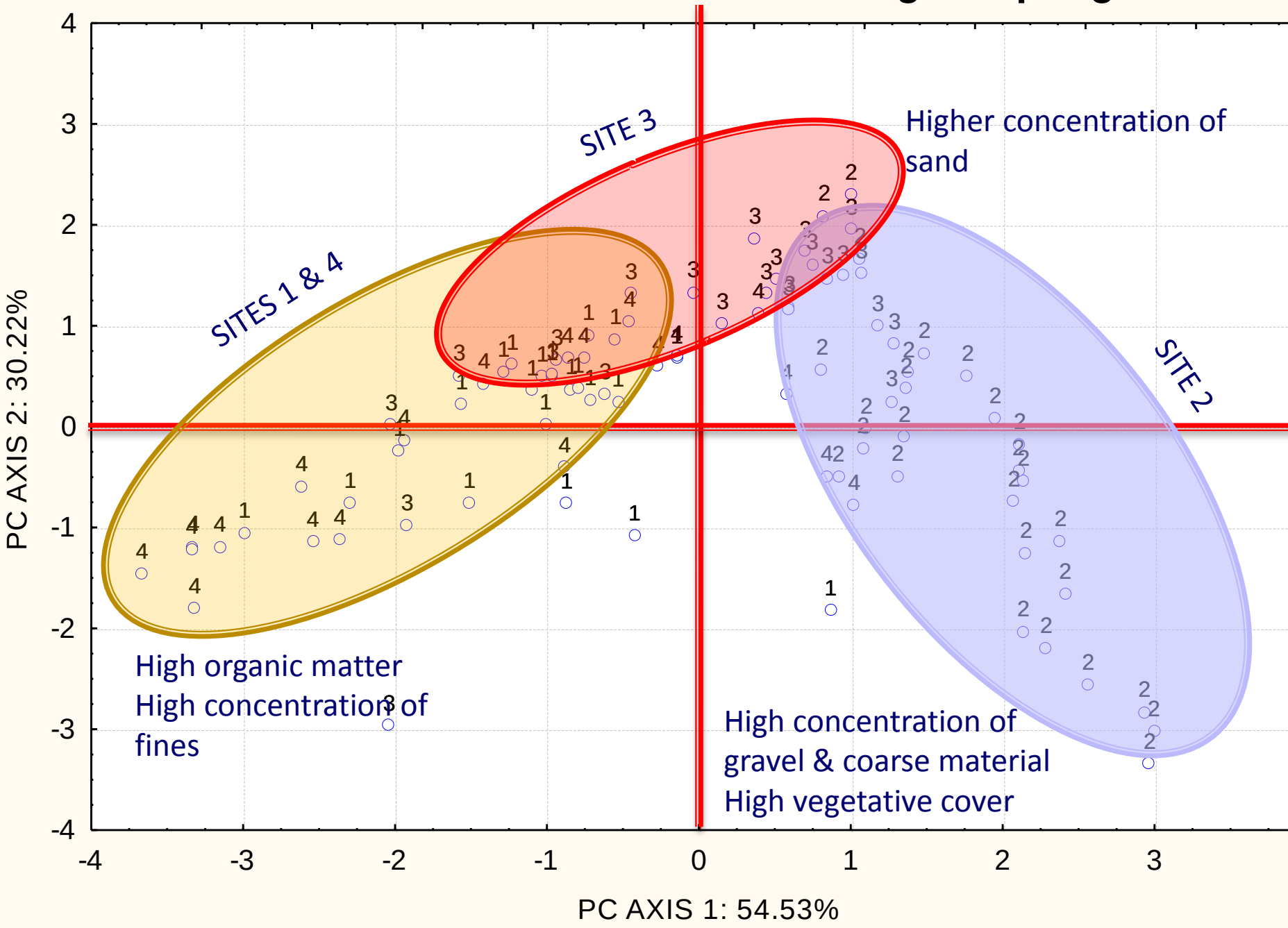
- 84.7% of the variation among sampling sites explained by first two principal components axes
- **Gravel** showed a strong positive correlation with PCA 1, while **Organic Matter** and **Fines** showed a strong negative correlation
- PCA 2 was most influenced by **Sand** and showed a negative correlation with **Vegetative Cover**

Factor coordinates of the variables (Loading Coefficients)

	Factor 1	Factor 2
Gravel	**0.774661**	-0.490406
Sand	0.385678	**0.867186**
Fines	**-0.961078**	-0.231290
Organic Matter	**-0.952300**	-0.086642
Vegetative Cover	0.383521	**-0.676243**

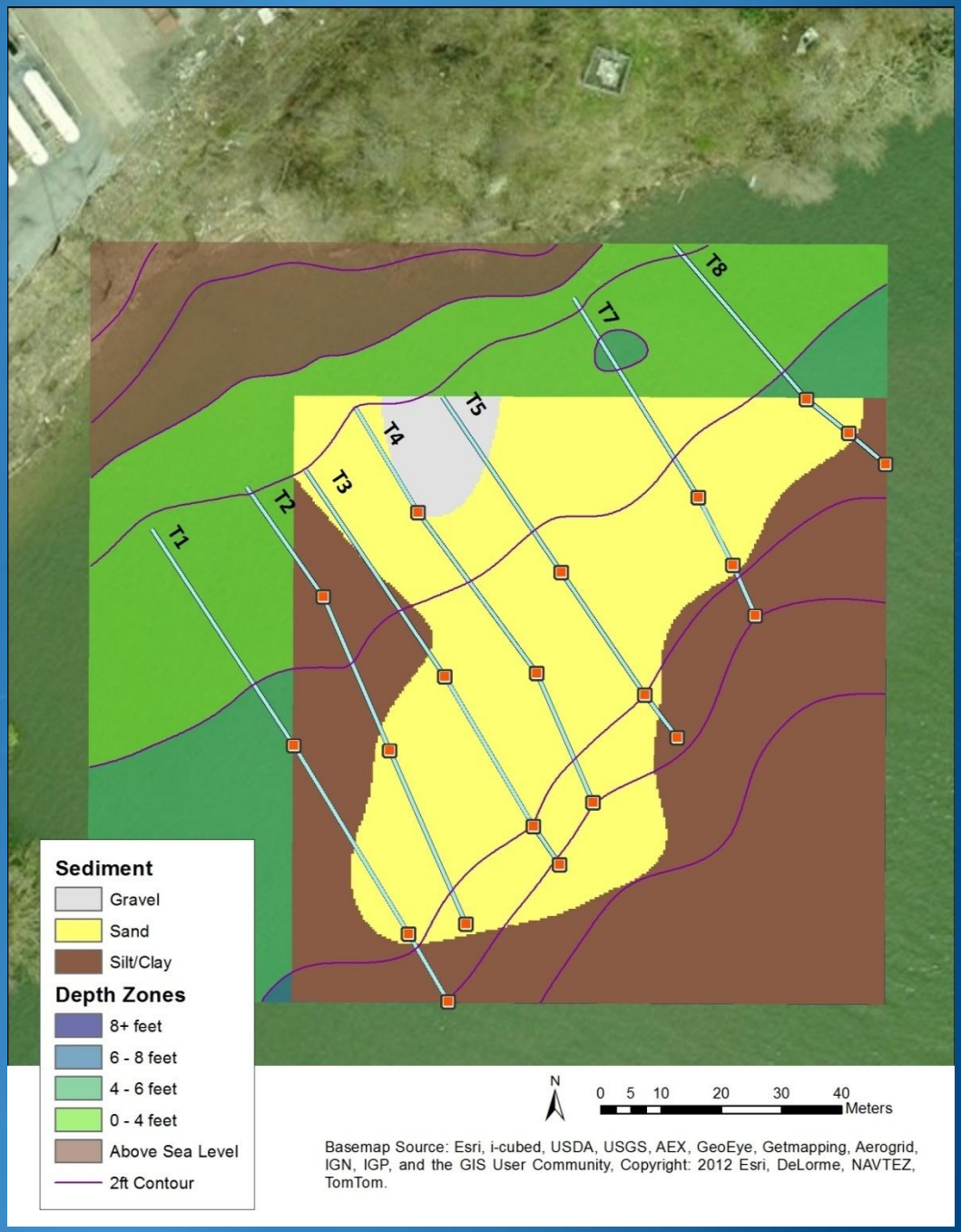


Variation In Sediment Characteristics Among Sampling Location



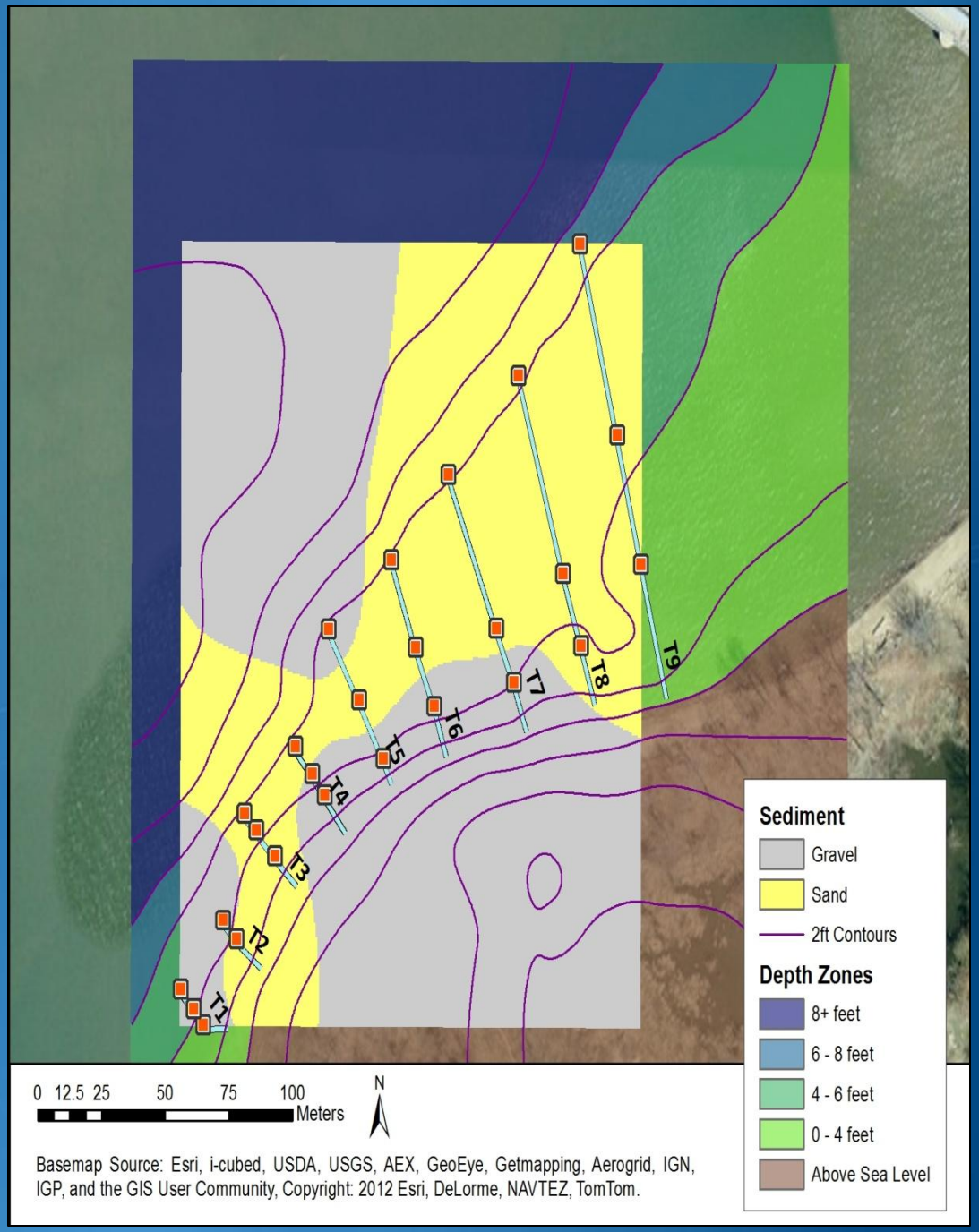
Site 1

- Sediment Characterization
  - 7.5% Gravel
  - 56.6% Sand
  - 35.9% Fines
  - **4.7% Organic Matter**
  - **No emergent vegetation**



Site 2

- Sediment Characterization
  - **40.8% Gravel**
  - 54.4% Sand
  - 4.6% Fines
  - **1.0% Organic Matter**
  - **18.0% Vegetative Cover**

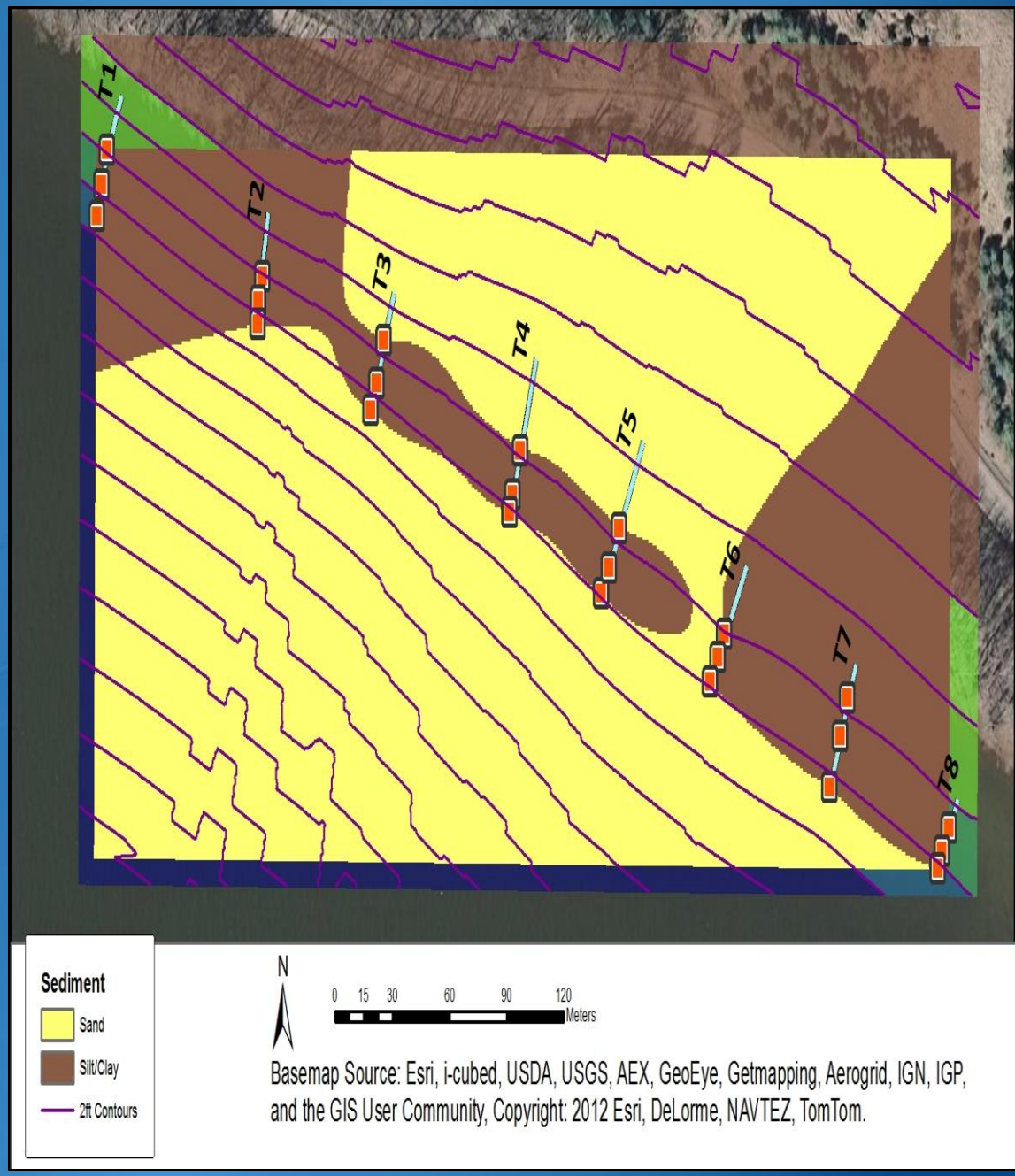


Site 3

- Sediment Characterization
  - 5.4% Gravel
  - **83.2% Sand**
  - 11.3% Fines
  - 2.3% Organic Matter
  - 2.3% Vegetative Cover

Site 4

- Sediment Characterization
  - **4.6% Gravel**
  - 49.1% Sand
  - **46.3 % Fines**
  - **4.9% Organic Matter**
  - 7.7% Vegetative Cover

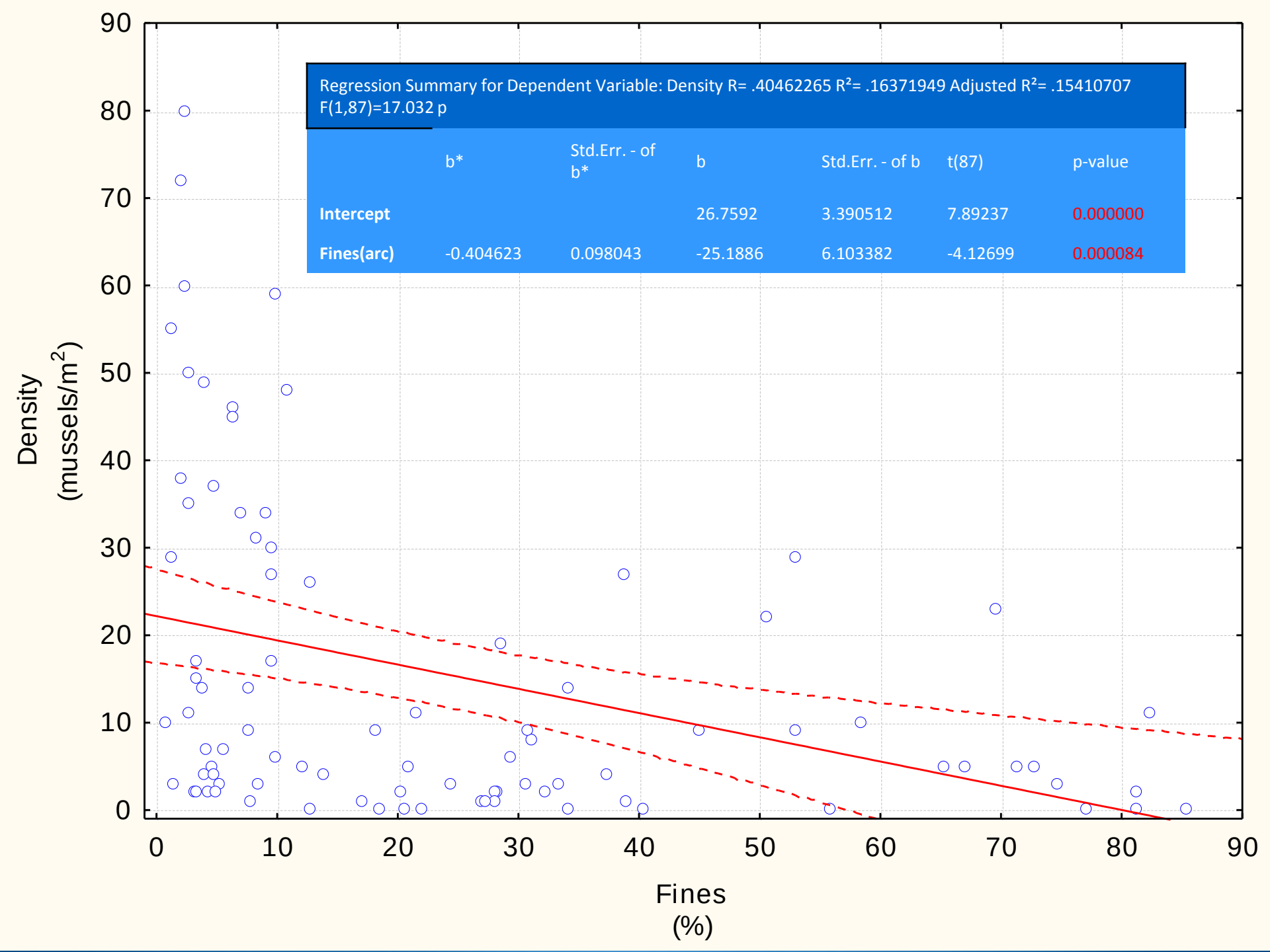


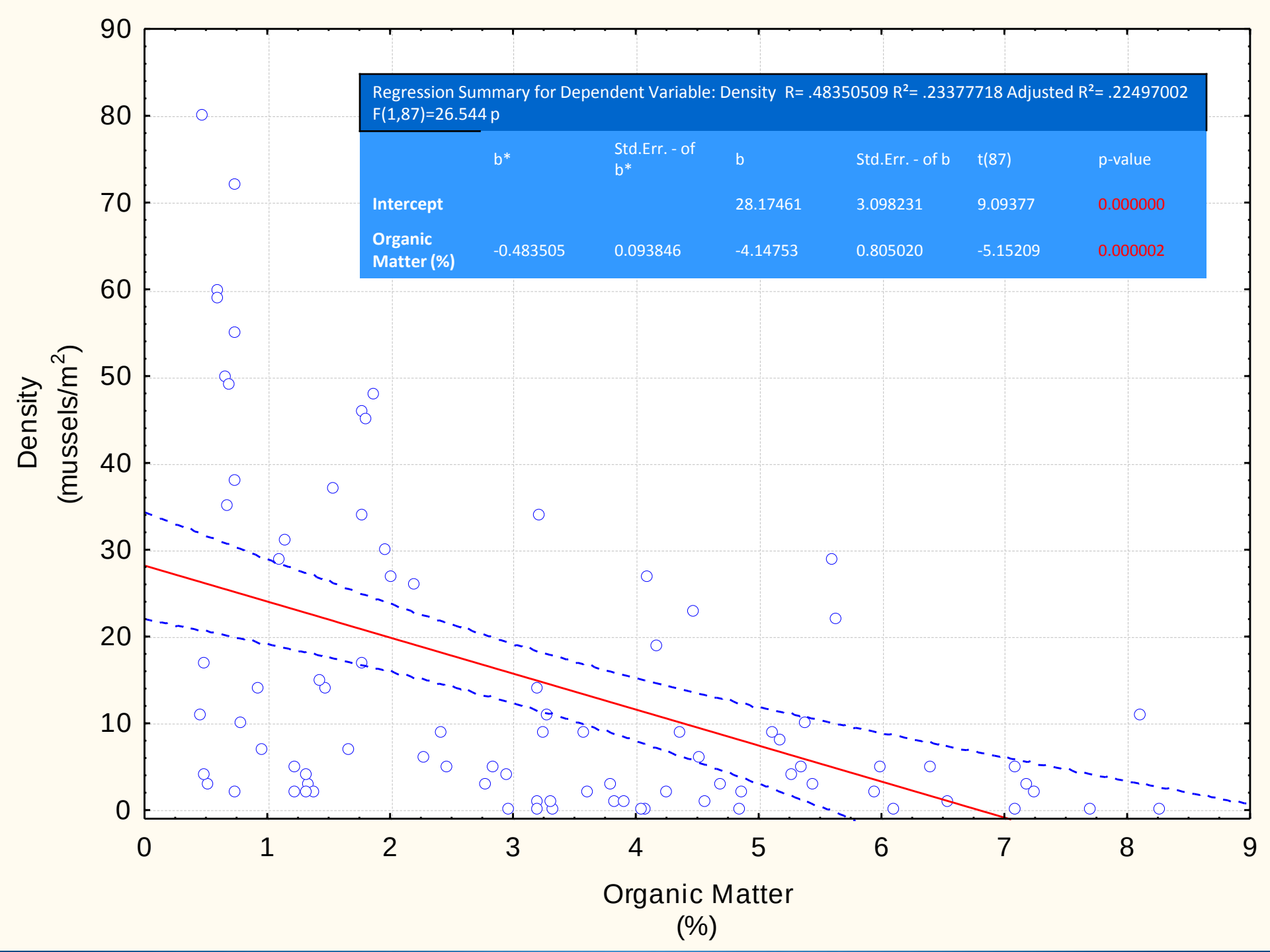
Statistical Analysis

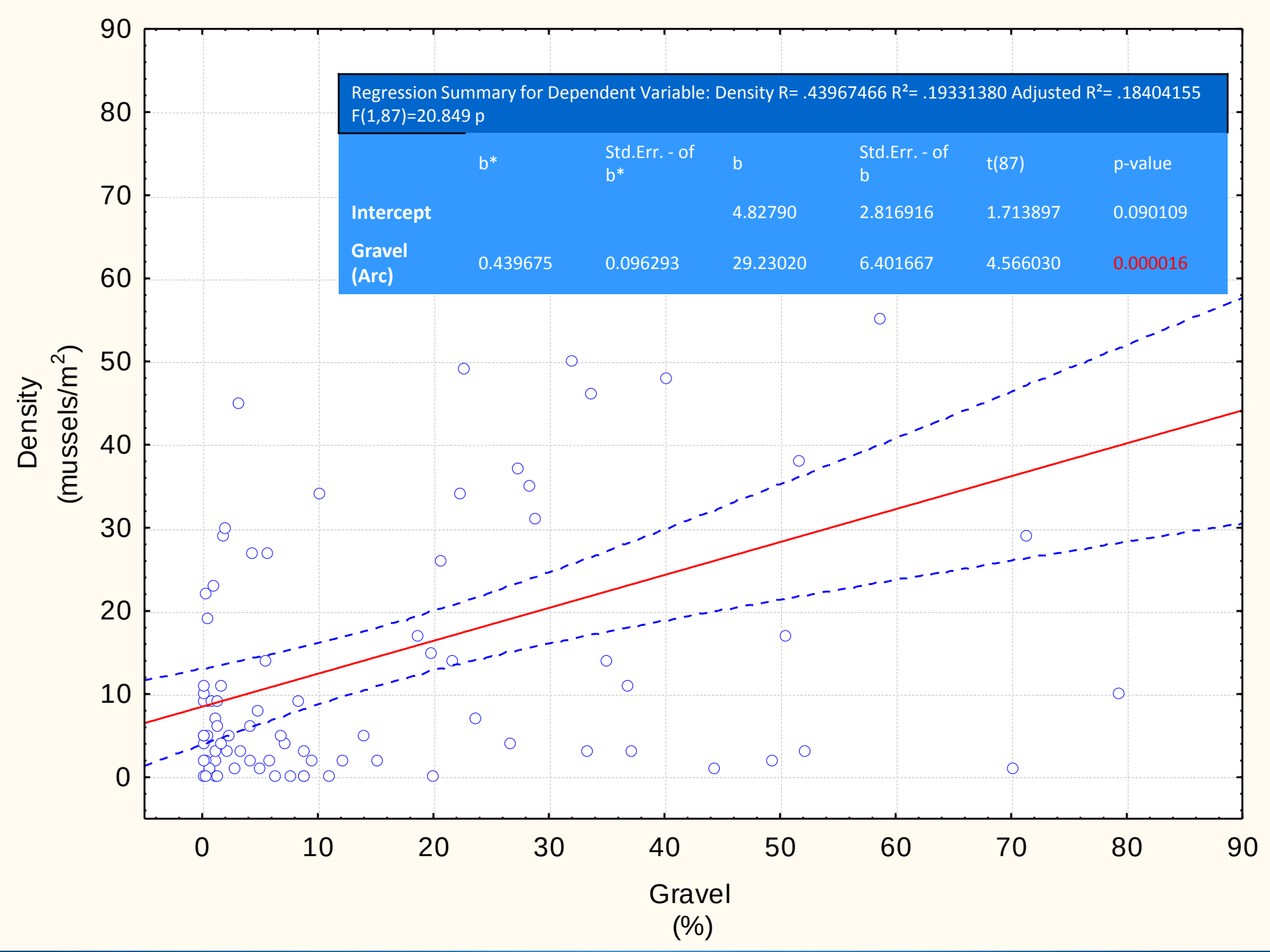
Sediment Composition vs. Fresh Water Mussel Density

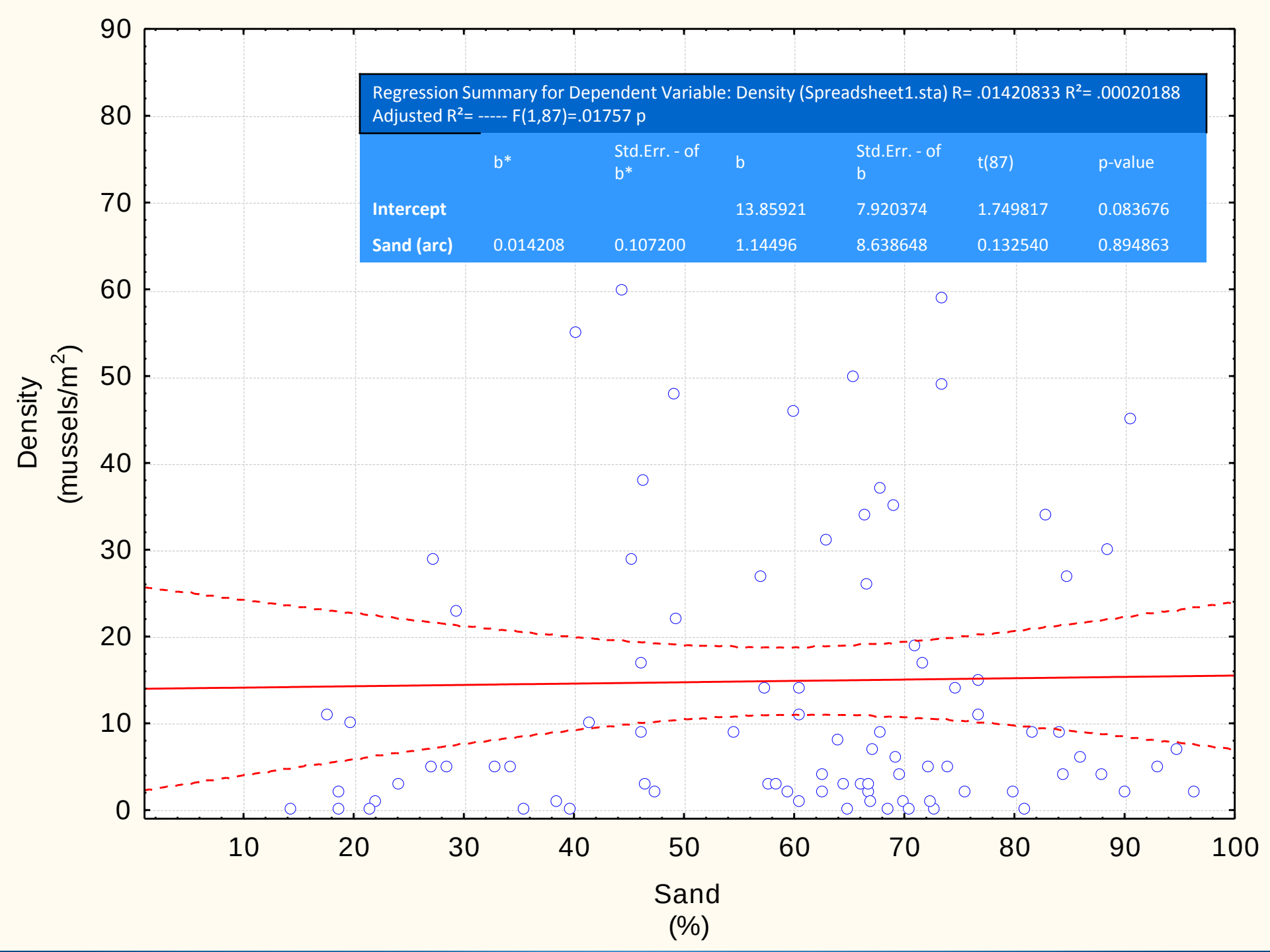
Questions:

- Are there relationships between the physio-chemical properties of the sediment and mussel abundance?
- What analytes (if any) show positive or negative relationships with mussel density?
- How strong are these relationships?


Regression Summary for Dependent Variable: Density R= .40462265 R²= .16371949 Adjusted R²= .15410707 F(1,87)=17.032 p
b* Std.Err. - of b* b Std.Err. - of b t(87) p-value
Intercept 26.7592 3.390512 7.89237 0.000000
Fines(arc) -0.404623 0.098043 -25.1886 6.103382 -4.12699 0.000084
Density (mussels/m2)
Fines (%)
0 10 20 30 40 50 60 70 80 90


Regression Summary for Dependent Variable: Density R= .48350509 R²= .23377718 Adjusted R²= .22497002 F(1,87)=26.544 p
b* Std.Err. - of b* b Std.Err. - of b t(87) p-value
Intercept 28.17461 3.098231 9.09377 0.000000
Organic Matter (%) -0.483505 0.093846 -4.14753 0.805020 -5.15209 0.000002
Density (mussels/m2)
Organic Matter (%)
0 10 20 30 40 50 60 70 80 90
0 1 2 3 4 5 6 7 8 9


Regression Summary for Dependent Variable: Density R= .43967466 R²= .19331380 Adjusted R²= .18404155 F(1,87)=20.849 p
b*
Std.Err. - of b*
b
Std.Err. - of b
t(87)
p-value
Intercept
4.82790
2.816916
1.713897
0.090109
Gravel (Arc)
0.439675
0.096293
29.23020
6.401667
4.566030
0.000016
Density (mussels/m2)
Gravel (%)
0
10
20
30
40
50
60
70
80
90


Regression Summary for Dependent Variable: Density (Spreadsheet1.sta) R= .01420833 R²= .00020188
Adjusted R²= ----- F(1,87)=.01757 p
b* Std.Err. - of b* b Std.Err. - of b t(87) p-value
Intercept 13.85921 7.920374 1.749817 0.083676
Sand (arc) 0.014208 0.107200 1.14496 8.638648 0.132540 0.894863
Density (mussels/m²)
Sand (%)
0 10 20 30 40 50 60 70 80 90
10 20 30 40 50 60 70 80 90 100

Conclusions

- Quantitative surveys during summer 2012 revealed high variability in sediment composition among sites and along individual transects.
- Preliminary findings suggest that their exists a relationship between sediment composition and mussel density.
- Concurrent studies suggests that other physical and/or chemical properties may also govern spatial variability of mussel density (*see Thomas et al., 2013)*.
- More research is needed. . . . .

Future Research

- Continued community-level surveys
  - Identifying downstream boundary
  - Strengthen biomass estimates
  - Major tributary studies
- Physiological rate process studies
  - Species specific
  - Seasonal studies
- Identification of key habitat requirements
  - Sediment chemistry
  - Species-specific
  - Bed stability
- Restoration studies
  - Urban freshwater mussel hatchery?
  - Reintroduction?
  - Bioindicators for stream and wetland restoration projects?

Acknowledgements

- PA Coastal Zone Management
- PWD-Bureau of Laboratory Services
- Drexel University Co-Operative Program
- Millersville University Summer Internship Program

Questions