FINAL REPORT

South Carolina State Wildlife Grant SC-T-F19AF00750

South Carolina Department of Natural Resources

October 1, 2019 – March 31, 2021

Project Title: Ecology of Estuarine Sensitive Infauna Along a Stress Gradient

Objective: Quantify community composition, abundance, and biomass of Estuarine Sensitive Taxa along a stress gradient at four sites within each system and compare these between four Charleston-area tidal creeks representing a range of development intensities.

Accomplishments: Four tidal creek systems in coastal South Carolina, specifically in and around the City of Charleston, were selected using a stakeholder-driven process for further study. These allowed for a comparison between highly developed, moderately developed, and sparsely developed tidal creek watersheds and associated proportional levels of stormwater impact. These included Dupont-Wappoo (Du-Wap) Creek, Seaside Creek, Guerin Creek, and Toomer Creek **(**Figure 1**)**. Four sampling sites were located throughout each system to cover a range of habitats and stress gradients, from variable headwaters to the more environmentally stable downstream portion. These sites were also utilized for a concurrent project that allowed for the pairing of detailed salinity data to each benthic sample.

One sediment composition sample was collected at each site, for a total of 16 samples, by collecting surficial sediments (upper 2 cm) of four separate grab samples, homogenizing the sediment on-site in a stainless-steel bowl, then separating a portion of the sample into a Ziploc bag for processing at the lab. Sediment composition samples were analyzed to determine the percentage by weight of silt, clay, and sand using procedures described in Folk (1980) and Pequegnat *et al*. (1981).

Two benthic community samples were collected at each site for a total of 30 benthic samples (Figure 2). Samples were collected using a stainless steel 0.044 m^2 Van Veen grab deployed by a biologist from a dock or in the creek itself and repositioned between samples, and samples were collected in close proximity and at comparable depths to the water quality stations. Samples were brought back to the lab where they were rinsed through a 0.5 mm mesh sieve. The organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin containing rose Bengal stain. Benthic organisms were sorted from the retained material under a magnifying loupe and each individual specimen was identified to the lowest possible taxonomic level and enumerated by experienced taxonomists. To aid in biomass processing, after identification, taxonomists sorted the organisms into separate vials representing one of major taxonomic groupings: crustacean, mollusk, oligochaete, polychaete, and other.

Ninety-five taxa were observed across all study sites. Response screening analysis was performed across all taxa as well as a suite of community metrics to identify what was most correlated to salinity regime and other development metrics. Overall, several taxa were identified that may serve as indicators of degraded conditions, although some of these were observed in low abundances in general. *Mediomastus* sp., a capitellid polychaete, was the most sensitive of all species observed, although at low abundances throughout, and was significantly inversely correlated to salinity drop, impervious cover % as well as total pesticide concentrations (Figure 5). Other taxa indicating similar relationships were *Cassidinidea ovalis, Paraprionospio pinnata, Cyathura burbancki,* and the polychaete family Spionidae. Annelids, both polychaetes and oligochaetes, generally showed the strongest relationship to development and position within creek (i.e. headwater or downstream), with the lowest abundances occurring at high development and/or headwater sites. There were some exceptions, however, particularly at TC2, which also had a high prevalence of live subtidal oysters. Species richness (number of species) was also negatively correlated to salinity drop and total pesticide concentrations. The polychaete worm *Streblospio benedicti*, traditionally considered a stress sensitive species, was nearly significantly related to impervious cover and was observed in the greatest abundances overall ($p = 0.07$). Similarly, *Monopylephorous ruboniveus*, often considered a stress tolerant species, was not significantly correlated to any single metric, but after accounting for substrate type (silt/clay %, $p = 0.004$), its abundance was significantly positively correlated to percent impervious cover ($p = 0.125$). Overall species richness was most strongly inversely correlated to the total relative pesticide concentration, indicating fewer species at higher concentrations ($p = 0.04$). Overall organism abundance was not significantly related to development or stress metrics, but all high development sites (Du-Wap Creek) exhibited abundances less than 3,000 individuals per square meter, whereas forested and suburban sites exceeded this threshold at 41% of sites.

Forward stepwise regression was used to explore how various groups of species were correlated to salinity variability, and whether they were positively or negatively related (i.e. stress tolerant = positive correlation, stress sensitive = inverse correlation). Salinity variability integrates the two primary stress metrics position within creek (more stressful towards headwater) and development intensity (percent impervious cover). In this model, species were included as independent variables and salinity variability was included as the dependent variable. This allowed the selection of a suite of species that best relates to salinity drop overall (Figure 6). Species were added until no longer significant, resulting in a suite of six taxa: Ampharetidae (sens), *Capitella capitata* (tol), *Cassidinidea ovalis* (tol), *Laeonereis culveri* (tol), *Mediomastus* sp. (sens), and Melitidae (tol). The parameter estimates for this model are shown in Table 1. Total benthic infauna abundance was lowest in the urban watershed and greatest in the forested watershed, with suburban sites generally falling in between (Figure 7). This pattern was similar to the trend for pollution sensitive species identified in previous research, and opposite but noisier for the suite of pollution tolerant species (Figure 7).

Benthic infaunal biomass was only significantly correlated to stress metrics for oligochaetes, and no relationships were identified for the other taxa crustacean, mollusk, polychaete, other, or total biomass. Oligochaete biomass was significantly lower at high impervious cover sites and occurred at approximately 20% of the levels of the forested watershed sites, but this trend follows differences in abundance as well and is therefore less likely driven by differences in individual biomass. Oligochaete biomass was also low at all suburban sites except for one site along Toomer Creek that was characterized by an abundance of subtidal live oyster bottom.

Future analyses should include similar assessments utilizing relative abundance of benthic infauna, further exploration and comparison to the suite of sensitive species identified in previous research efforts, community analysis using PRIMER, and further exploration of potential body size differences from the biomass analysis.

<u>Significant deviations:</u> None.

Objective: Conduct spatial and statistical analysis to identify linkages between land cover characteristics, rainfall events, and data generated in Objective 1, and apply these to other Charleston-area watersheds to predict benthic communities and abundances in these systems.

Accomplishments: Environmental data (total precipitation, salinity, dissolved oxygen, sediment chemical contamination) collected in each creek for a separate project was utilized as well (Charleston Salinity Project funded by the South Carolina Sea Grant Consortium (SCSGC)). It permitted an in-depth characterization of salinity fluctuations from both coastal development and natural landscape features, as well as additional environmental variables and landscape features associated with coastal development and stormwater inputs. Having access to this environmental data provided an additional layer of information that would otherwise have been unavailable and allowed for analysis between site characteristics and benthic sediment and community compositions. Spatial data was also compiled, and these datasets were also included in the analysis. Due to the patchy nature of less frequent species, only taxa or other metrics with higher abundances that also exhibited a development-related trend across headwater sites were utilized for this analysis. Biomass was variable and was not included here. Species included were *Steblospio benedicti* and *Tubificoides heterochaetus*, as well as total organism abundance. Watershed-scale metrics included system geomorphology (width at mouth, length), development levels (impervious cover, developed classes), stormwater pond prevalence, landscape types (e.g., marsh, swamp, forest), and soil type (percent poor and percent well-draining soils).

With a limited sample size for headwater sites ($n = 4$), the analysis focused on the strongest relationships and metrics with greater abundances. All dependent variables were log transformed to scale the highest abundances and ensure a linear fit is appropriate. The abundance of the stress sensitive species *Tubificoides heterochaetus* was significantly inversely correlated to percent developed (high + medium + low classes, $r^2 = 0.95$, $F(1,2) = 39$, $p = 0.02$). Predicted values scaled proportionately, with the highest predicted values occurring in more rural Abbapoola and Rantowles Creeks ($>175 / m^2$ for both), both rural watersheds. The lowest predicted values occurred for urban watersheds on the Charleston peninsula, on Vardell and Newmarket Creeks ($< 2 / m^2$ for both). *Steblospio benedicti*, another stress sensitive species, was significantly positively correlated to the prevalence of both marsh and forested uplands, and exhibited similar predicted relationships to rural and urban areas.

Significant deviations: None.

Literature Cited:
Folk, R.L. 1980. Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, Texas. 185 pp.

Pequegnat, W.E., L.H. Pequegnat, B.M. James, E.A. Kennedy, R.R. Fay, and A.D. Fredericks. 1981. Procedural guide for designation surveys of ocean dredged material disposal sites. Final Report prepared by TerEce Corp. for U.S. Army Engineer Waterways Experiment Station, Technical Report EL-81-1, 268 pp.

Total Federal Cost: $48,080 (fully expended)

Recommendations: Close the grant.

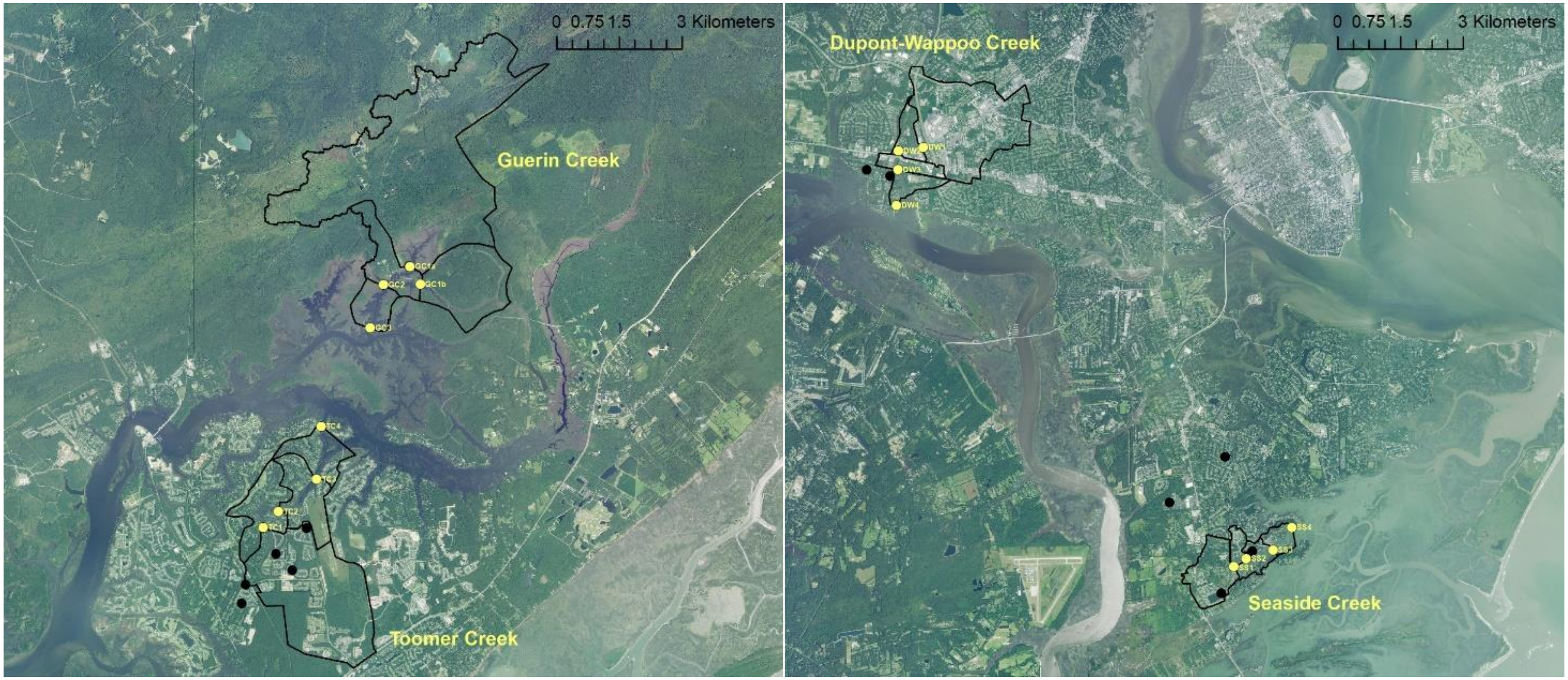


Figure 1. Map of study systems along the Wando River (left), and Ashley River and James Island (right) showing study sites (yellow dots) and weather stations (black dots). The weather station for Guerin Creek was located at site GC1a. Toomer Creek represents a moderately developed suburban watershed with a well-developed stormwater pond infrastructure. Guerin Creek represents a largely forested watershed. Dupont-Wappoo Creek represents a highly developed urban-suburban watershed largely developed before stormwater pond requirements were enacted. Seaside Creek represents a suburban watershed containing a mixture of pre-stormwater pond development as well as newer developments with stormwater ponds.

Figure 2. Biologist lowering grab sampler at a site along Toomer Creek, a moderately developed suburban creek system.

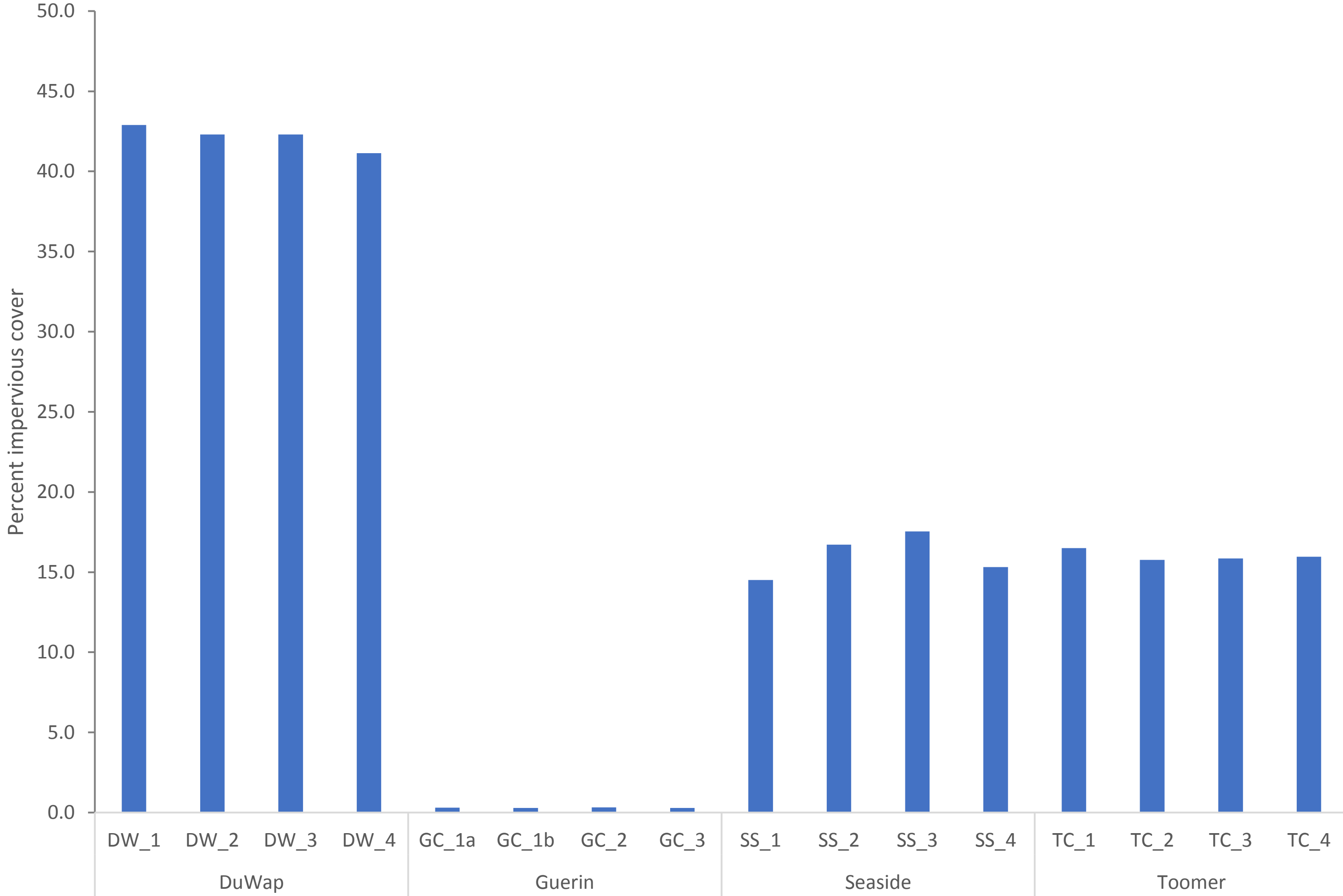


Figure 3. Percent impervious cover, a metric representative of the degree of development, at each study site.

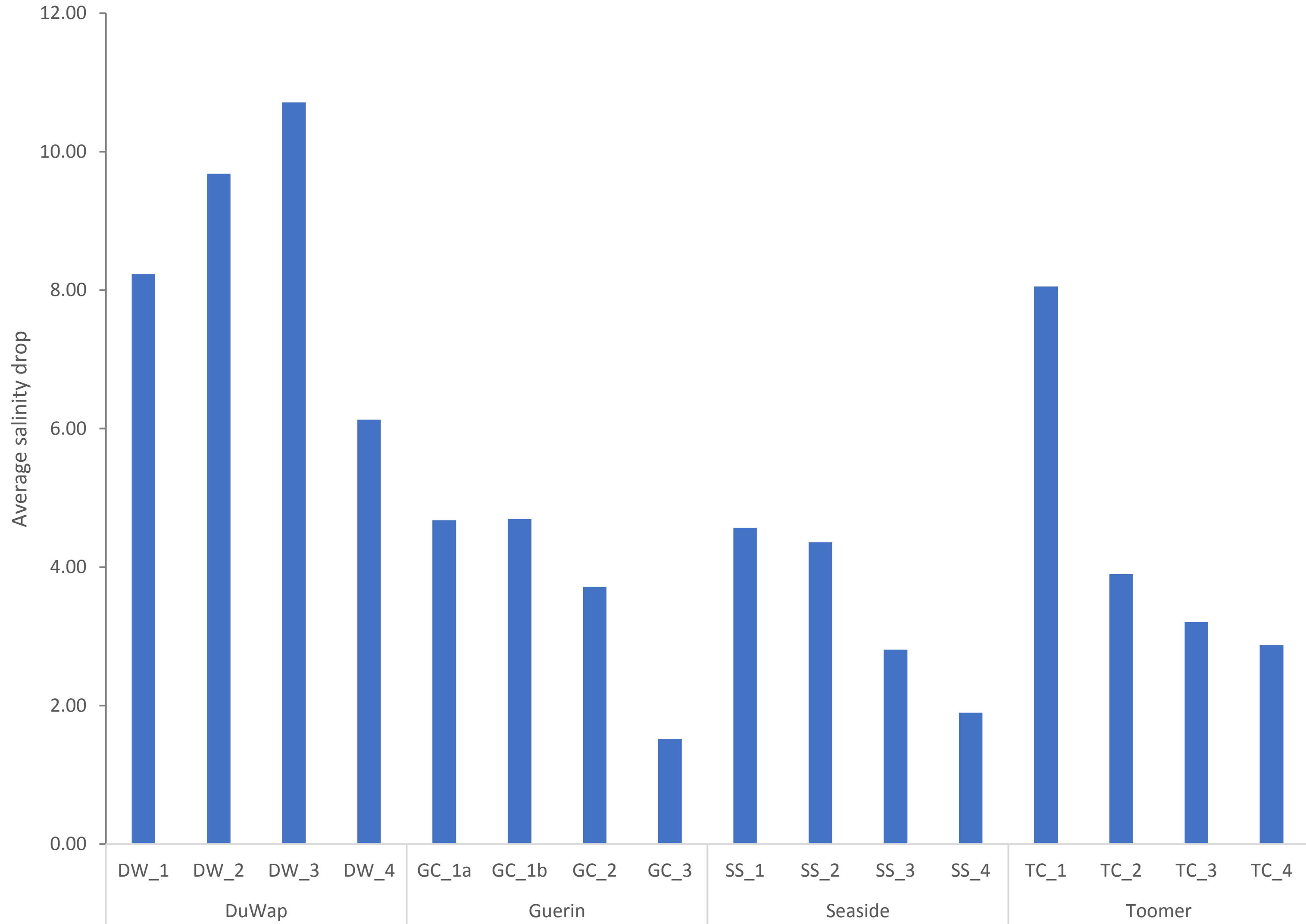


Figure 4. Average salinity drop recorded at each site. Greater salinity drops generally correspond to two factors: proximity to headwaters and development influence, with both factors resulting in a more dynamic and variable salinity regime.

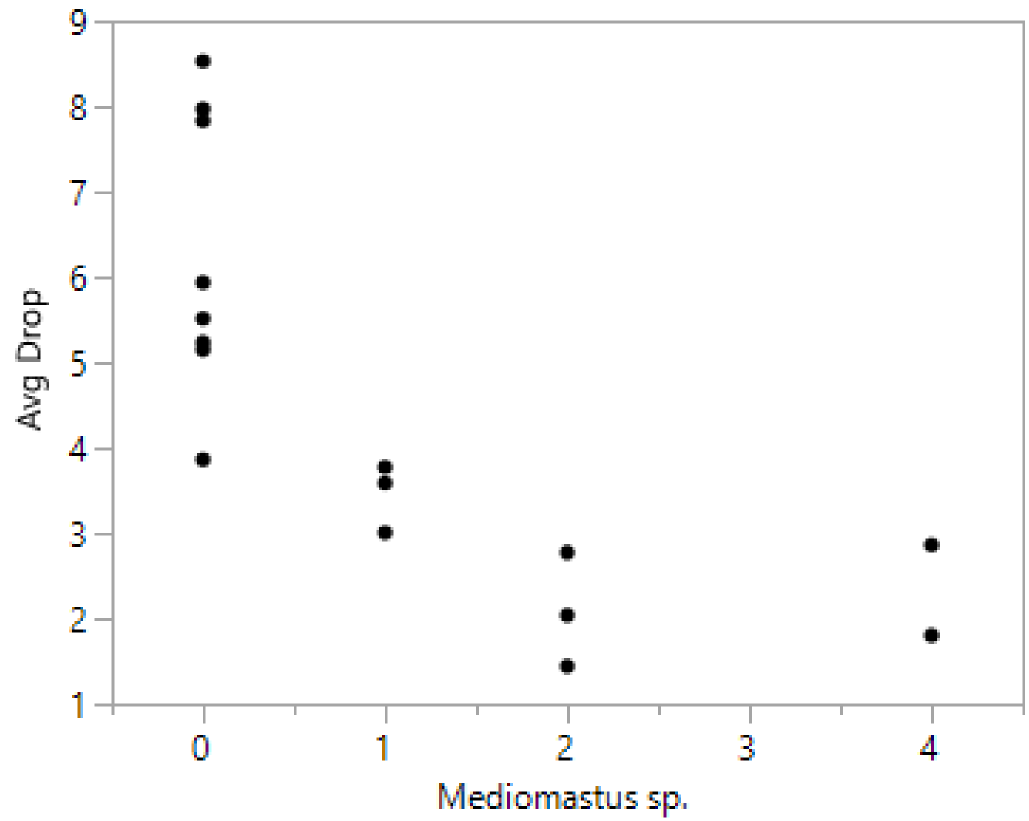


Figure 5. Example of species abundance comparison to average salinity drop. Although abundances of this taxa were low overall, the correlation to salinity variability was the strongest across all taxa and stress metrics.

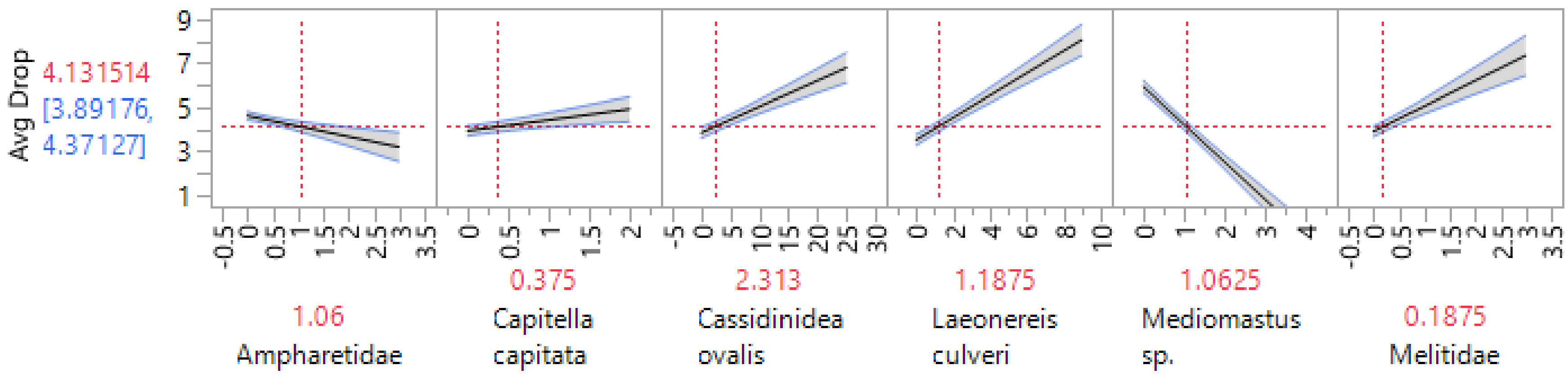
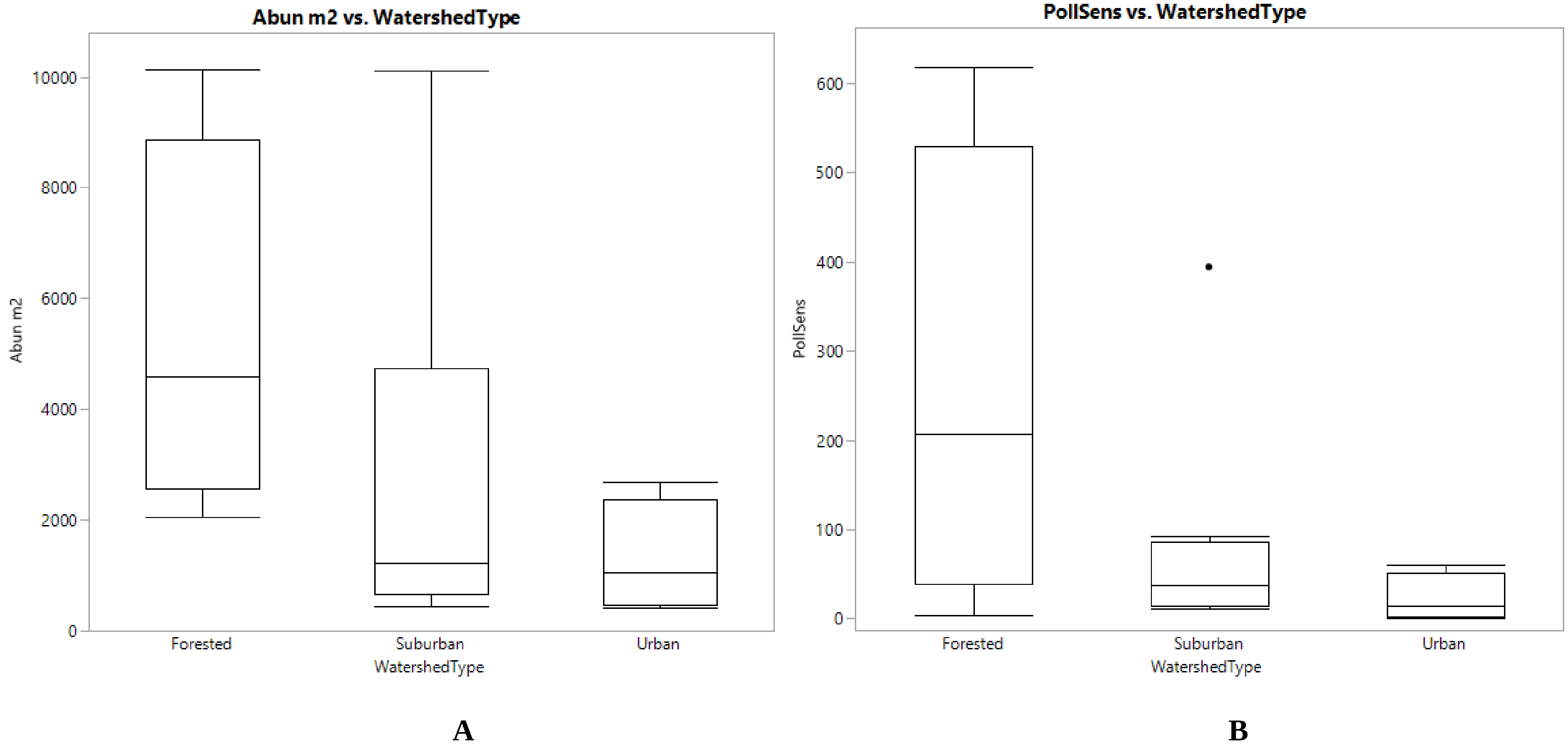


Figure 6. Relationships between the seven species most strongly correlated to salinity drop across the 16 sites. Positive slopes indicate pollution tolerant species and negative slopes indicate pollution sensitive species.


Abun m2 vs. WatershedType
Abun m2
10000
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6000
4000
2000
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Forested
Suburban
Urban
WatershedType
A
PollSens vs. WatershedType
PollSens
600
500
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Forested
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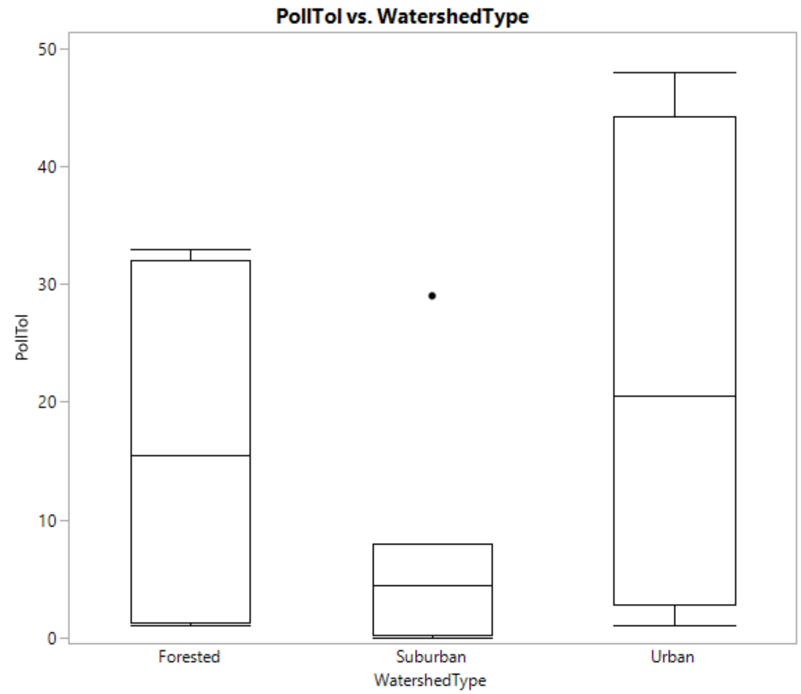

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Figure 7. Relationships between broad benthic infaunal groups and watershed type. Total organism abundance (A) and abundance of pollution sensitive species (B) are positively correlated to development intensity, whereas pollution tolerant species abundance is more variable but is also greatest in the urbanized watershed (C).

Table 1. Parameter estimates for the group of benthic infauna most strongly correlated to salinity variability, a metric that integrates natural physical stress (headwater or non-headwater) as well as development intensity.

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	5.1750301	0.147636	35.05	<.0001*
Ampharetidae	-0.47578	0.108408	-4.39	0.0017*
Capitella capitata	0.4929143	0.122913	4.01	0.0031*
Cassidinidea ovalis	0.1180086	0.012964	9.10	<.0001*
Laeonereis culveri	0.5048134	0.037861	13.33	<.0001*
Mediomastus sp.	-1.705486	0.086715	-19.67	<.0001*
Melitidae	1.1500053	0.139925	8.22	<.0001*