Response of high marsh benthic invertebrate assemblages to shoreline development in Murrells Inlet, South Carolina, USA

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Introduction

- Coastal zones across the southeastern United States are rapidly being developed. Although extensive research on freshwater wetland benthic invertebrates as indicators of anthropogenic activity exists, relatively little is known about the response of benthic organisms in salt marshes to increased anthropogenic activity.
- Potential changes in benthic invertebrate assemblages could be caused by land use induced changes in hydrology, increased nutrients and run-off, changes in soil particle size, soil chlorophyll *a* and salinity.
- Our goal was to examine the effects of development on the benthic invertebrate assemblage of the high marsh and potential abiotic mechanisms of change.

Objectives

- Compare differences in the benthic invertebrate assemblages among undeveloped, developed with riparian buffer and developed without riparian buffer sites in Murrells Inlet, SC (Fig. 1).
  - Development was based on percent impervious surface and lawn area digitized using GIS and aerial photography (2006).
- Examine the relationship between pore water chemistry, soil chlorophyll *a*, soil particle size and salinity with the benthic invertebrate assemblage and among treatments.

Figure 1. Aerial view of Murrells Inlet, SC (2006)

Figure 3. An example of undeveloped shoreline

Figure 2. Aerial view of the 50 x 100 m sites in Murrells Inlet, SC

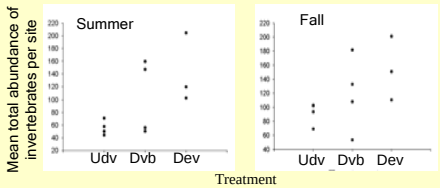
Figure 4. An example of a developed with riparian buffer shoreline

Methods

- Studies were conducted in the high salt marsh in Murrells Inlet, SC during summer and fall of 2007 (Fig. 1).
- We identified 11-50 x 100 m sites (4 undeveloped (UDV), 4 developed with riparian buffer (DVB) and 3 developed without riparian buffer (DEV)) (Figs 2, 3 & 4).
- Six benthic invertebrate cores and chlorophyll *a* were randomly sampled at each site along a 50-m transect located in the high marsh running parallel to the shoreline.
- Benthic invertebrates were preserved with 10% formaldehyde and rose bengal solution, sorted from debris and identified.
- Salinity, pore water chemistry and soil particle size were sampled once during each season and water levels were monitored at one site per treatment for two months using slotted PVC wells.
- Differences among treatments were assessed statistically using a one-way ANOVA for abiotic factors and overall mean taxa abundance with a significance of 0.1. Correlations between invertebrates, development and abiotic factors were done using a 2-tailed Spearman's rho. NMDS and MRPP along with Shannon-Weiner Diversity Index were used to analyze assemblage differences among treatments.

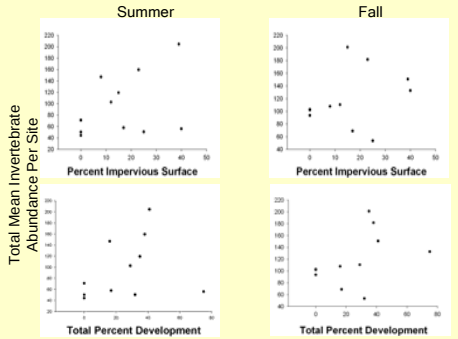
Results

Mean total invertebrate abundance



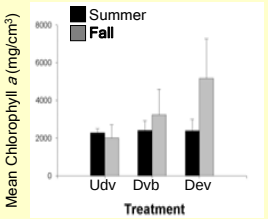
- Benthic invertebrates common to all sites were tanaids, oligochaetes, nematodes and copepods. Mean total invertebrate abundance was not significantly different during summer or fall. During summer there was a significant difference between undeveloped and developed without buffer ($df_{1,6}$, F = 8.854, p = 0.031). Tanaids were significantly different among treatments during summer ($df_{2,10}$, F = 3.580, p = 0.078), while bivalves were significantly different in fall ($df_{2,10}$, F = 3.880, p = 0.066).

Mean total invertebrate abundance compared to percent impervious surface and total development

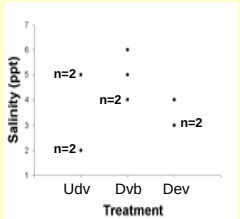


- A potential threshold exists for percent impervious surface and development at local spatial levels. Impervious surface appears to have a threshold of 20-25% while total percent development has a threshold of 40%.

Comparison of Chlorophyll *a* among treatment levels for summer and fall with standard error included



Comparison of salinity values among treatments for fall



- No significant differences were found among treatments during either sampling season for soil chlorophyll *a*, pore water chemistry, soil particle size or salinity.

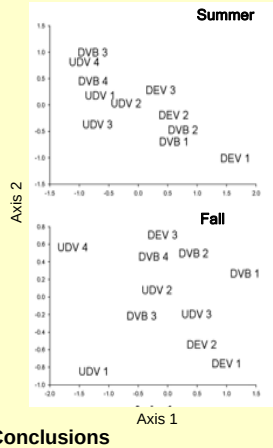
Taxa-development correlations

Taxa	Total development	Impervious surface	Lawn area
Crustacea			
Copepoda			
Harpacticoid			
Enhydrosoma			(F) **-0.704****
Paronychocamptus	(F) **0.537***		
Schizopera		(S) **-0.622***	
Annelida			
Polychaeta	(S) **0.604****	(S) **0.538***	
Mollusca			
Bivalve	(F) **0.697****	(F) **0.447***	(F) **0.582****

S = Summer, F = Fall; * < 0.10, ** < 0.05

- Taxa that were negatively or positively significantly correlated with impervious surface, development or lawn area are in bold. Several taxa of importance increased in abundance with development (e.g., bivalves and copepods)

NMDS ordination plots



- During summer and fall, variation could be explained by two axes, with several invertebrates positively correlated with axis 1 (e.g.,nematodes, ceratopogonids, copepods and oligochaetes).
- Cluster analysis revealed similar groupings for summer and fall, reinforcing NMDS results. Summer was most similar in results, grouping all undeveloped and two developed with buffer sites together and then another grouping of all developed without buffer and two developed with buffer sites together. Fall had several groupings that partially reinforced the NMDS results, with separate groupings of undeveloped sites 1 and 4 and developed with buffer site 1.

Conclusions

- Total invertebrate abundance was highest at developed without buffer sites and typically lowest at undeveloped sites.
- Several taxa were significantly correlated with percent total development and percent impervious surface (e.g., chironomids, oligochaetes) and are typically associated with increases in nutrients.
- Development at local spatial levels may be of importance to management.
- Mean invertebrate abundance increased with development and thresholds within the raw data for overall development are around 40% and 20-25% for impervious surface.
- Lack of significant differences among treatments may be partly explained by little precipitation and drought conditions. Increased precipitation in September may explain the increase in taxa and development correlations in the fall.
- Ecological responses to development within the entire Murrells Inlet watershed may hinder detection of ecological responses at more localized site levels.