MOLLUSCAN COMMUNITY RESPONSE TO PULSED AND NATURAL FRESHWATER INFLUX IN HENDERSON AND BLACKWATER ESTUARIES, FLORIDA

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INTRODUCTION

Estuarine areas are important ecological and geological systems worldwide. Estuaries store and provide nutrients for a diverse coastal ecosystem, naturally treat waters and sediments, and remove pollutants and toxins through biological, physical, and chemical processes (Clark and Sarokwash, 1978). Their sheltered and navigable waters, along with a unique setting, make estuarine areas an attractive place for development by humans. Landscape alteration associated with development is the most common stress on estuarine systems and has led to contamination and pollution of many estuaries in the United States (Sklar and Browder, 1998). One area in which extreme urbanization has had deleterious effects on estuaries is southwest Florida, one of the fastest growing areas in the country (Shirley et al, 1997).

Rapid urban and suburban growth in southwest Florida has stressed the water supply and altered the natural drainage of the land as water is diverted to prevent flooding of newly urbanized areas (Tedesco, 1999). By altering natural conditions and water quality within estuaries, humans may be altering the ecosystems they support. Here I determine the effects of pulsed release of freshwater on molluscan community composition by sampling infaunal mollusks in both Henderson (pulsed release) and Blackwater Bays (natural influx), near Naples, Florida.

Samples of the molluscan benthic community present in both sandy and muddy substrates near salinity monitors in both estuaries were analyzed to compare and contrast gradients in community composition between estuaries. Although changes in the community are expected along salinity gradients within each estuary, examination of between-estuary patterns should determine if pulsed freshwater influx has a significant effect on mollusk communities. If the pulsed freshwater influx does affect mollusk communities, one would expect the community composition would be different between Henderson and Blackwater Bays due to the extreme rate of salinity change from the freshwater pulses controlled by the weir in Henderson Bay. If the pulsed freshwater flow does not affect mollusk communities, one would expect a similar pattern of community structure in both Henderson and Blackwater estuaries in response to salinity. Results indicate that molluscan communities are responding to pulsed freshwater influx in the estuary.

MATERIALS AND METHODS

Samples were taken from two estuarine locations in the Rookery Bay National Estuarine Research Reserve and Ten Thousand Islands area in southwest Florida. A South Florida Water Management District (SFWMD) weir near the head of the creek controls Henderson Creek estuary's freshwater influx. Blackwater River estuary's freshwater influx is viewed as natural and unaffected, although caution must be exercised in using this assumption too widely (Tedesco, 1999).

The two estuaries are similar in structure and physiography and eventually connect to the Gulf of Mexico. Five homologues, points of approximately equal salinity conditions and geomorphologic positions, have been assigned to each estuary by Savarese (1999) to establish points for various comparisons between them. Homologous stations are similar in terms of their position with respect to the estuary salinity gradient, distance from freshwater source, substrate type, and physical features. Substrate type was also a factor in sampling. Two locations, one with a sandy substrate and one with a muddy substrate, were chosen for each homologue sampled to assess variation of mollusk communities related to substrate preference.

Field Methods. Four sites in each estuary, Henderson and Blackwater, were chosen near homologues 1 through 5 in the vicinity of YSI Datasondes (salinity monitors). Four replicate samples were taken, in sandy and muddy substrates, for a total of 8 samples at each site, a total of 32 samples were obtained from each estuary. Sediment was collected within a 1 m radius of the site, shoveled into a 5-gallon bucket, and sieved through a 2 mm mesh in the water to isolate gastropods and bivalves. One sediment sample from each site was also obtained.

	Km downstream from station 1	
Station #	Blackwater River	Henderson Creek
0	N/A	above weir
1	boat basin	below weir
2	1.05	1.16
3	2.39	*
4	3.24	1.58
5	4.15	2.60
6	5.03	3.17
7	9.71	3.80
8	12.52	5.06
9	16.38	6.51
10	17.90	7.56
11	19.59	8.90
12	21.59	10.73
13	N/A	13.08

*Station 3 is located 0.2 km up the Manatee Basin tributary of Henderson Creek

Fig. 1: Station locations

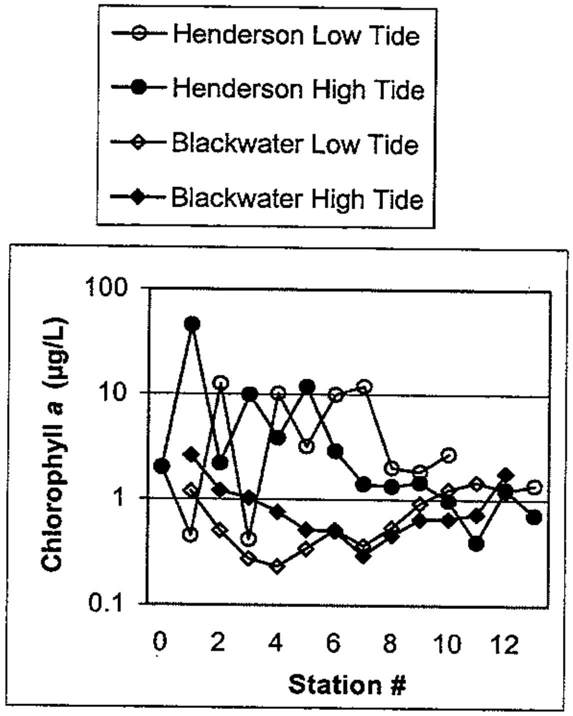


Fig. 2: Chlorophyll *a* concentration

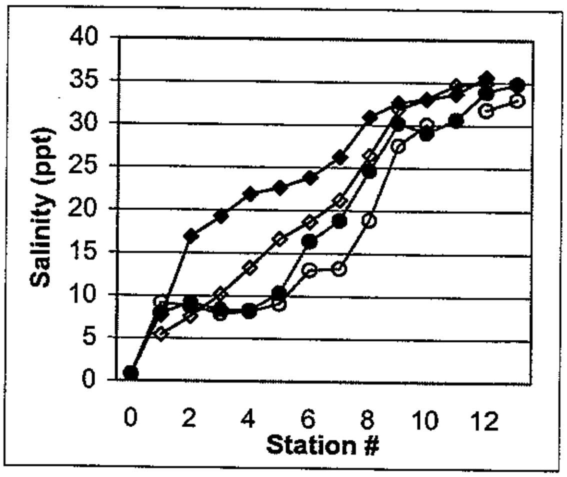


Fig. 3: Surface salinity

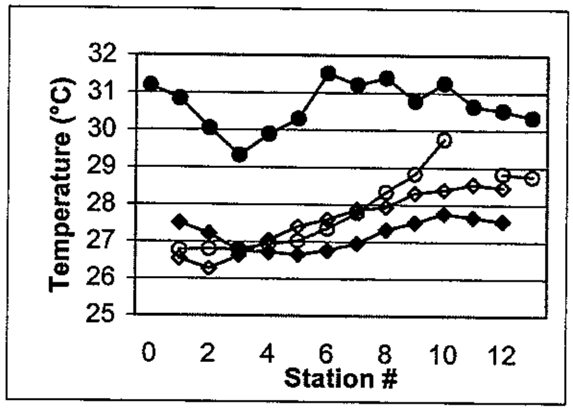


Fig. 4: Surface temperature

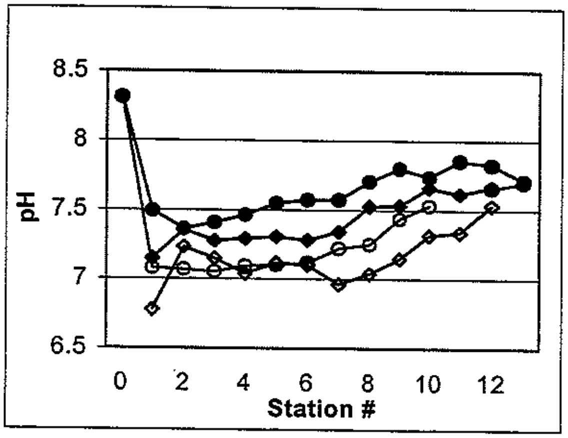


Fig. 5: Average of surface and bottom pH

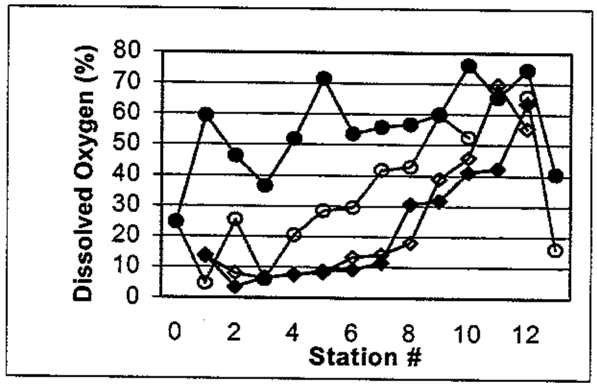


Fig. 6: Average of surface and bottom dissolved oxygen

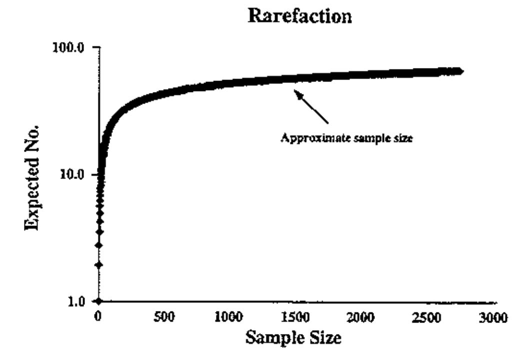
Lab Methods. In the lab, live and dead mollusks were separated and live specimens were preserved in isopropyl alcohol. All specimens were identified using Abbott (1995) and Andrews (1994), and classified based on preservation, predation, and valve presence.

Salinity data were obtained from past and current records of the YSI Datasondes located at stations in both estuaries. These data were analyzed for salinity gradients within the estuaries.

Sedimentological data were obtained by cleaning the sediments with bleach and 30% H_2O_2 following the methods of Royse (1970). The grain size, sorting, and constituent particle information from the sediment samples and the salinity information were used as subsidiary data in the analyses.

A rarefaction curve (Fig.1) was used to legitimize the reduction of three large samples. If one assumes the relative proportions of taxa in one sample are constant in samples of various sizes at the same location, a rarefaction curve can be constructed.

Figure 1 - Rarefaction curve compensating for differences in sample sizes by graphically determining diversity for a given sample if smaller sample sizes had been collected (Dodd and Stanton, 1981). Approximate sample size from curve, 1550.

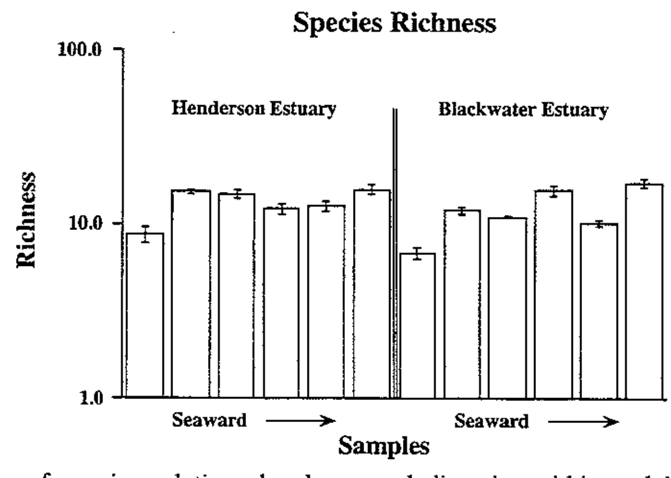


Species richness is the simplest measure of diversity. Richness is the number of species present in the sample standardized for sample size.

Multidimensional scaling (MDS) was used to evaluate differences in taxonomic composition between assemblages. Results are graphically depicted and can be assessed visually to determine dissimilarity in composition between samples.

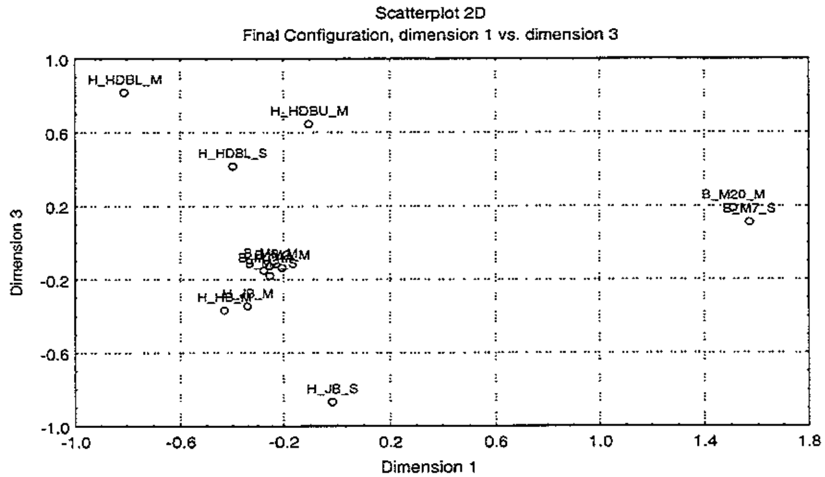
RESULTS

Figure 2 - Richness is significantly different between sites within both estuaries, Blackwater ($F_{\alpha .05, 3, 20}$ =17.374) and Henderson ($F_{\alpha .05, 3, 20}$ =22.604). However, between-estuary species richness is not significantly different ($F_{\alpha .05, 1, 10}$ =1.112). Error bars are standard errors.



Gradients in Community. Patterns of species relative abundance and diversity within and between Blackwater and Henderson estuaries were explored using multidimensional scaling. The pooled raw count of samples result in clear and understandable graphic depiction (Figure 3). The 3D depiction of the data shows a clustering of Blackwater samples, while Henderson samples are spread along dimension 3.

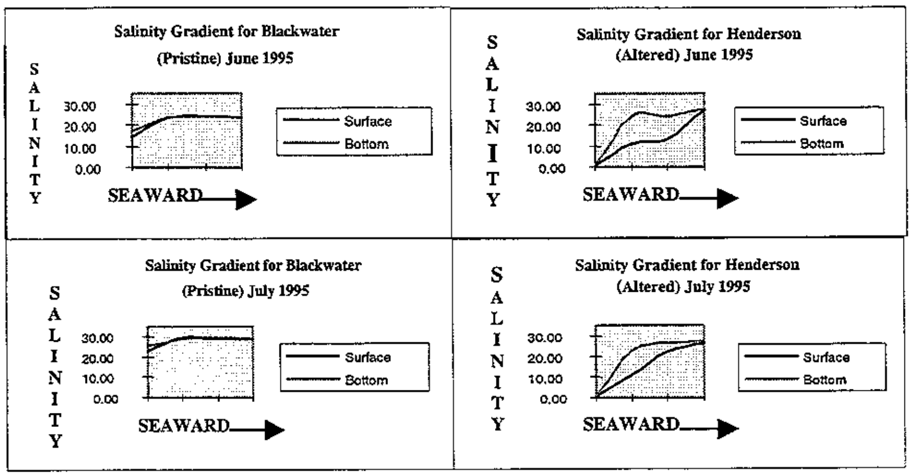
Figure 3 - A depiction (stress =0.028) of dimension 1 vs. 3 depicts Henderson samples grading from up-estuary to down-estuary along dimension 3. There is also a very slight and similar pattern in the Blackwater samples, although the majority of the samples are clustered together. The gradient from upstream to downstream suggests that dimension 3 is dependent on salinity.



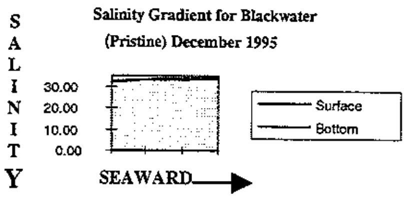
From the MDS plot, x-, y-, and z-coordinates were obtained for each sample. Average salinity for one year was also assigned to each sample based on records from the salinity monitors near the sample sites. The z-coordinate from the MDS plot (dimension 3) was plotted against the salinity of the sample resulting in a plot that reveals a significant (α=0.05) negative correlation of -0.7283.

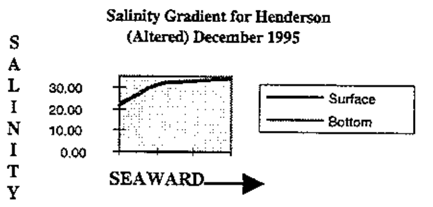
Salinity. Surface and bottom salinity differs throughout an estuary due to a saline tidal prism. Fresh groundwater influx lies on top of this tidal prism creating stratification unless mixing occurs (Sklar and Browder, 1998). Because of this phenomenon, salinity data are obtained from both the surface and bottom of the estuary. The salinity readings each month for a number of years in both Henderson and Blackwater estuaries resulted in different patterns of stratification (Figs. 4-9). The year 1995 will be used as an example. The summer months in Florida are considered the rainy season and it is at this time the Henderson weir is most often in use. There is little to no stratification in the "pristine" Blackwater estuary, suggesting that fresh and salt waters are mixed as water enters the estuary through sheetflow. Henderson, on the other hand has extreme stratification during the summer months possibly due to the weir openings and the influx of extreme amounts of freshwater at a given time. To test that this stratification is not present due to factors other than the weir, salinity readings for the "dry" winter months were also studied (Figs. 8-9). Also noted is that the yearly average salinity readings have different ranges in the estuaries. For the area studied in Blackwater salinity ranges from 25.83 at the uppermost station to 28.31 at the lowermost station, while Henderson ranges from 19.25 to 31.0.

Figures 4-7 - Surface and bottom salinity graphs during the months of June-July 1995 show a difference in salinity stratification of the estuaries at this time.



Figures 8-9 – Lack of salinity stratification during January 1995





DISCUSSION AND CONCLUSIONS

The difference in the gradients in communities along dimension 3 in the MDS plot suggests that molluscan communities are responding to the alteration of the Henderson estuary. Although it is common for communities to pattern themselves relating to substrate because species distributions are strongly influenced by sediment composition (Lyons, 1989), these samples are structured differently, suggesting that another condition is producing a more powerful signal than substrate. The data suggest that sample structure resulting from MDS is responding to the stratification and range of salinity present in the estuaries. The Henderson samples are widely distributed along the z-axis, which has a negative correlation in salinity. Blackwater samples are also distributed along this axis, but they are more clumped. The stratification and salinity range signals in these estuaries may be responsible for producing these different patterns. Stratification in the Henderson estuary is extreme during the wet season, suggesting the pulsed release of freshwater from the weir is a factor. The freshwater forms a lens over the tidal prism, which not only increases stratification, but also the salinity range from up- to down-estuary. These two factors appear to be present in the MDS plot of Henderson samples along dimension 3, depicting a headwaters to mouth gradient in the composition of the samples. Blackwater estuary lacks stratification during the wet season and has a narrow range of salinity. The Blackwater communities have only a slight gradient along dimension 3, responding to the lack of stratification and also narrower range of salinity, producing the clumping of communities. Further cluster analysis of the estuaries suggested substrate may be a secondary condition in community structure, especially in Blackwater. Also, the composition of the organisms producing a change in community structure is different between the estuaries, although species richness is the same.

The results of this study can be used to establish baseline data for estuary restoration and management. In this case, mollusk communities are responding to the presence or absence of salinity stratification and the breadth of the salinity range in the estuary.

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Effects of water control structures on sediment characteristics and channel morphology in estuarine systems in Southwest Florida

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ABSTRACT

Water control structures are used to prevent salt-water intrusion and control flooding. They frequently result in pulsing of fresh water into estuarine systems. The purpose of this study is to determine if water control structures influence channel morphology and sediment characteristics. Channel morphologies have been measured along cross-channel transects in four estuaries in the southwest Florida area (Figure 1): Henderson Creek, Faka-Union Canal, Blackwater River, and Cocohatchee Canal. Henderson, Faka-Union, and Cocahatchee are each controlled by a different type of water control structure. Blackwater River has no water control structure and has been used as a control for comparison. In addition to testing the effect of water control structure versus no water control structure, channel morphology has been compared above and below each water control structure during the dry season in June and wet season in November. Sediment characteristics have been determined for each of the areas along transects and through time. These data are being used to determine how each type of water control structure affects the sedimentology within the channel, as well as how channel morphology responds to the presence of a structure.

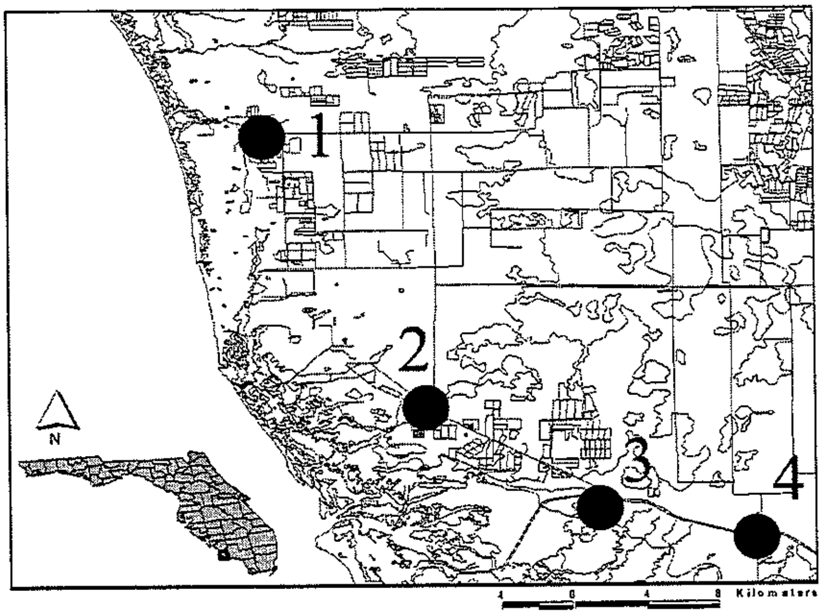

Figure 1: Map showing locations of 1) Cocohatchee Canal, 2) Henderson Creek, 3) Blackwater River, 4) Faka-Union Canal.

INTRODUCTION

The Southwest Florida estuarine system is the subject of this study. Freshwater is delivered to this estuarine system through a series of natural rivers and man-made channels. Many of these channels have a water control structure in place to prevent salt-water intrusion, control flooding and promote aquifer recharge. Freshwater release from these structures results in pulses of fresh water into the estuarine system. Henderson Creek, Faka-Union Canal, and Cocohatchee Canal are three such channels under study. Blackwater River has no water control and has been used as a control for comparison.

The purpose of this study is to determine if the presence of water control structures affects the sediment characteristics and channel morphology. This study compares the sediment characteristics and channel morphology above and below the water control structures of three channels with a river with no water control structure. A comparison is also made between the dry season in June and the wet season in November.

METHODS

Field Methods. Blackwater River was selected as a control as it has no water control structures. Cocohatchee Canal, Henderson Creek, and Faka-Union Canal each have a water control structure controlling the amount and timing of freshwater delivered to the estuarine system. Three transect stations were set across the channel both above and below each water control structure. For Blackwater River, four transect stations were set. Each transect