Spatial Patterns of Bacterial Abundance in a Seagrass Restoration Site on the Eastern Shore of Virginia (USA)

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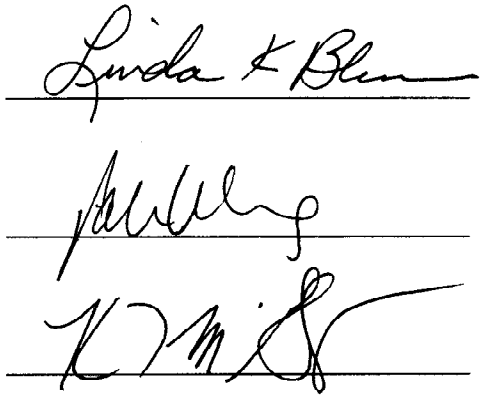

ABSTRACT

Establishing monitoring efforts of (and then subsequently tracking) spatial distribution patterns of microorganisms and sediment properties in restored seagrass meadows is crucial to understanding the redevelopment and reestablishment of ecosystem processes and function of these systems. In this study, spatial distribution patterns of bacterial abundance and selected sediment properties were examined in a restored *Zostera marina* seagrass bed in South Bay at the Virginia Coast Reserve – Long Term Ecological Research site. Two twelve-meter-long transects were established within a restored seagrass bed such that three vegetation zones were captured by each transect: a vegetated zone, an unvegetated zone, and a zone where vegetated sediment transitions into vegetated sediment. Small sediment cores (approximately 6 – 8 $cm^3$with a depth of approximately 7-8 cm) and water column samples (approximately 40 ml) were taken at 0.25 m intervals along the length of each transect in November 2007 and again in June 2008. Acridine Organic Direct Counting (AODC) was done to enumerate the bacterial communities in each sample, and the sediments were also analyzed for organic content, moisture content, and carbon-to-nitrogen ratio. These data were subjected to geostatistical analyses to determine bacterial community patch size and to check for possible correlations between patch size and the spatial distribution of sediment properties. Statistical analysis was used to compare data from differing vegetation zones. The results of these analyses suggested that there was no spatial pattern in bacterial abundance in the water column for either transect in November 2007 or June 2008 at the scale at which sampling was conducted – likely, a result of the shallow, well-mixed water column in South Bay. In the sediment, abundance generally increased from unvegetated to vegetated areas. The sediment variograms showed 2 different correlation length scales which corresponded to a bacterial community patch size in the sediment of 2-3 m and another of 6-7 m. This suggests that the presence/absence of vegetation

influences the spatial distribution of microorganisms in the sediment. Community patch size in the sediment was similar in the fall and the summer; however, in Transect 2 in June the community patch size appeared to be considerably larger (> 8 m) than it was for the same transect in November. This suggests that some seasonal change in the sediment of this location was influencing the abundance of bacteria in this transect. Sediment properties such as organic content, moisture content, and percent total carbon varied throughout each transect with no detectible spatial patterns in either month. The correlation length scales for the sediment properties measured in this study did not match up with the patch sizes seen for the bacteria in the sediment, suggesting that some other sediment properties are exerting the main structuring influence on bacterial communities in these areas, and other sediment properties (e.g. oxygen content, DOC, pH, and concentrations of compounds such as iron and sulfates) should be examined in the future.

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ACKNOWLEDGEMENTS

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"The past was yours,
But the future's mine.
You're all out of time…"

-The Stone Roses

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Chapter 1: Introduction

1.1 The significance of microorganisms in the rhizosphere

Microorganisms play vital roles in ecosystems all over the planet by decomposing organic matter, cycling nutrients like carbon and nitrogen, and playing critical roles in detrital food webs. One place, in particular, where all of these processes occur with regularity is the rhizosphere, the small area of sediment or soil that directly surrounds plant roots and rhizomes. This area is a site of intense biological and chemical activity between plant roots, soil & sediment, and microorganisms (Curl 1986). The term and concept of the "rhizosphere" is certainly not new. It was first introduced over a hundred years ago in 1904 by German scientist Lorenz Hiltner, and in addition to introducing the concept, his work then pointed out that the activity of microorganisms in the rhizosphere is of crucial importance to nutrient cycling and overall plant health. Since Hiltner's seminal work, and throughout recent decades, a massive number of articles have appeared in scientific journals discussing the topic of the rhizosphere – a few relevant examples of these papers from the past 30 years include: Ames et al 1984; Anderson et al 1993; Barber & Lynch 1977; Blum 1993; Blum et al. 2004; Cheng et al. 1993; Grayston et al 1998; Jensen et al. 1998; Jones 1998; Kent & Triplett 2002; Kraffczyk et al 1984; McGlathery et al. 1994; McGlathery et al. 1998; McGlathery et al. 2001; Meyer & Linderman 1986; Parkinson & Coleman 1991; Raven & Edwards 2001; Smalla et al. 2001; Tester & Leigh 2001; and Whipps 2001.

This study focused on spatial patterns of bacteria in a vegetated ecosystem because (as mentioned above) these organisms respond to the presence of plants, and in turn affect ecosystem functioning - largely though their interaction with roots in the sediment. Bacteria have long been known to be more abundant and active near plant roots in comparison to bulk

soils (Stotzky & Burns 1982; Graysten et al. 1998). This effect also has been documented in many types of vegetated sediments. In soils and sediments, bacterial cell numbers can reach $10^9 – 10^{12}$ per gram of soil, a number which is at least an order of magnitude greater than in surrounding unvegetated bulk soils (Lynch & Whipps 1990), and growth rates of bacteria are 2-3 times greater in the rhizosphere than in non-rhizosphere soil (Soderberg and Baath, 1998). That the activity of bacteria in the rhizosphere has a significant impact on nutrient supply to the plant by mediating mineralization of organic compounds also has been known for around half a century (Alexander 1961; Krasilnikov 1954).

Increased abundance and higher growth rates of bacteria in vegetated areas can generally be attributed to additional organic content in the sediment resulting from root turnover processes (root growth, root death, and root decay), and the presence of dead and decomposing organisms. Differences in parameters like sediment/soil moisture, pH, and nutrient and oxygen availability also may exert influences on bacteria community characteristics. Thus, the intense biochemical interactions between microbes and plants in the rhizosphere tend to be quite complex. These interactions can be beneficial to plants and microbes, neutral, potentially harmful, or some combination thereof depending upon the specific microorganisms present in the rhizosphere (Barber and Lynch 1977; Blum et al. 1988; Blum & Mills 1991; Kraffczyk et al 1984; Cheng 1993; Grayston et al. 1998; Jones 1998; Tester & Leigh 2001; Whipps 2001).

The spatial extent of the rhizosphere is difficult to quantify (Campbell & Greaves 1990); however, the effect of plant roots on bacteria can be observed up to 1-2mm from the root (Roose et al. 2001; Viebahn et al. 2003). In recently restored seagrass beds (like the one where this study was conducted) roots are relatively far apart, and therefore, their influence on

microbes and their activities should likewise be patchy and limited, reflecting the patterns of root distribution. As seagrass beds mature, root mass increases and the patchiness that once existed concomitantly decreases (Di Carlo & Kenworthy 2008). As root biomass increases, so too does the spatial extent of the rhizosphere and its effect on bacteria. If, for example, restoration of belowground biomass in seagrass beds takes as long as a century as suggested by Mateo et al (1997), then understanding the distribution of bacteria in sediments may provide insight into the spatial patterns of active carbon and nitrogen mineralization and the progress in recovering these critical ecosystem functions (Kusel & Trinkwalter 2006). Additionally, Jensen and Kuhl (2007) showed that roots appear to have distinct bacterial communities in *Z. marina* inhabited sediments, and other studies have demonstrated that dissolved organic carbon (DOC) exuded from seagrass roots in the rhizosphere can be used by bacteria to drive other biochemical processes such as sulfate reduction and nitrogen fixation (Pollard & Moriarty 1996; Isaksen & Fenster 1996; Welsh 1996). Peduzzi & Hundl (1991) as well as Danovaro (1996) suggested that microorganisms play a vital role in the trophic chain of Mediterranean seagrass systems. Clearly, the presence of vegetation plays critical roles in determining microbial activity in and over seagrass beds and processes that microbes are involved in within these ecosystems are quite complex and important to these ecosystems as a whole.

In addition to the rhizosphere work, numerous studies have sought to demonstrate the potential effects of a variety of environmental gradients (both biotic and abiotic) on microbial abundance and community composition. For example, spatial variations in substrate and oxygen (O_2) availability (Bossio & Scow 1998), soil properties of agricultural zones (Ibkewe et al. 2002; Wieland et al. 2001), estuarine gradients (Crump et al. 2004; Lowit 2006), horizontal variations in elevation (Franklin et al. 2002), and vegetation gradients (Brodie et al. 2002; Burke et al. 2002; Grayston et al. 2001; Floyd 2007) have all been studied. Heterogeneity of physical,

chemical, and biotic components of natural ecosystems is the rule in both space and time (Larkin et al. 2008). As early as 1976, Levin hypothesized that spatial heterogeneity gives rise to a variety of stable communities within a given location. More recently, Tessier et al. (2002) provide evidence that heterogeneity promotes diversity by maintaining habitats in non-equilibrium states. Theory relating spatial heterogeneity to ecosystem structure and function derives primarily from research on habitat diversity. The application of these ideas to ecological restoration stems from an interest in restoring ecosystem function and structure, including diversity of the restored ecosystem.

This study focused specifically on the role that the seagrass species *Zostera marina* (eelgrass) plays on structuring microbial communities in the rhizosphere, in directly adjacent unvegetated sediments, as well as in the overlying water column in a recently restored seagrass ecosystem. One of the most challenging aspects of restoring ecosystem functioning (including seagrass beds) is understanding which spatial and temporal patterns facilitate reestablishment and persistence of ecosystem function and structure (Larkin et al. 2008; Cardinale et al. 2002). However, even in light of all the effort that has been dedicated to these areas of research, interactions between microbes and plants (at the microscopic level) remains an area that is not adequately understood. Properly understanding these small-scale interactions can then allow us to use mathematical modeling to scale-up our understanding to larger levels allowing us to gain a better understanding entire of plant communities.

The objective of this study was to determine microbial community abundance and to estimate, through geostatistical analysis, the physical extent (in the horizontal direction) of these communities based on differences in abundance within sediment and in the water column overlying a seagrass bed. Additional objectives included characterization the horizontal spatial

distribution of sediment properties such as organic matter, moisture content, and carbon to nitrogen ratio in vegetated and adjacent unvegetated areas. Specifically some of the questions addressed in this study include: 1) How large is microbial community patch size in vegetated and unvegetated areas? 2) Is microbial community patch size different between vegetated and unvegetated sediments? 3) Is microbial community patch size in the water column overlying the vegetated and unvegetated patches different? 4) Are microbial communities different sizes when sampled in the winter and summer? 5) Are any differences observed in the sediment microbial communities correlated with differences in sediment organic matter content and/or C:N ratio?

1.2 The Relationship of This Study to the Overarching VCR-LTER Research Objectives

The seagrass species *Z. marina* is the dominant form of submerged aquatic vegetation (SAV) in the lower portion of the Chesapeake Bay. These plants perform critical ecosystem functions that exert an influence on the overall functioning of the coastal system as a whole. For example, seagrasses provide food, habitat, and nursery areas for local fauna such as fish, shellfish, and a multitude of invertebrates. They support vibrant fisheries (which can provide support for local economies), dissipate wave energy and stabilize sediment (which reduces erosion and enhances water clarity), and are important indicators of water quality (Anesio et al 2002; Gacia & Duarte 2001; Hendricks et al. 2008; Herbert 1999; McGlathery 1995; McGlathery et al. 2007; Orth et al. 1984). However, for a variety of reasons, seagrass populations the world over have experienced a dramatic decline in previous decades, and recent efforts have focused on restoring these important plant communities (Short & Wyllie-Echeverria 1996).

Historically *Z. marina* was present throughout the network of coastal lagoons and bays off the coast of the Eastern Shore of Virginia and the Delmarva Peninsula (Moore et al. 1996). However, in the 1930s a combination of events (hurricanes and a slime mold epidemic) worked in concert to drive seagrass populations in Virginia coastal lagoons into extinction. The decimated coastal areas of the Delmarva peninsula remained devoid of any significant *Z. marina* regrowth or restoration efforts for decades. Spurred by the discovery of a small patch of naturally occurring seagrass in the late 1990's, large-scale restoration efforts have been successful in recolonizing over 1400 acres of seagrass in the Virginia coastal lagoons. Beginning in 2000 seeding efforts were conducted within South Bay, and since then the bay has been observed to have been successfully recolonized by *Z. marina* (Orth et al. 2006) - see Figure 1 below.

This study aimed to be an important first step toward more fully understanding the microbial ecology of these recovering seagrass ecosystems. Advancing the knowledge base regarding microorganisms in the seagrass beds is important to the restoration effort as a whole because the wide variety of processes that microbes are involved in have widespread ramifications on things like sediment and water quality. Maintaining high water quality is an important issue as changes in water quality can affect seagrass establishment and growth. First and foremost it is important that we start to gain an understanding of how bacteria are distributed in these shallow coastal bays before we can begin to understand all of the complexities regarding microbial processes in these ecosystems. The results of this study will lay a foundation for addressing more specific questions regarding how microbes function in relation to seagrass restoration on the Eastern Shore of Virginia.

As illustrated in South Bay, the extensive loss of seagrass habitat occurring in recent decades has lead to efforts in these systems to recover important ecosystem functions and services that seagrasses provide. Most efforts have focused on identification of areas suitable for seagrass restoration (e.g. Duarte et al. 2007) or methods to maximize the spatial extent of areas supporting survival and growth of grasses after seed broadcasting or transplanting. Fewer studies examine recovery of restored seagrass meadow functioning, particularity with respect to spatial patterns. The goal of this project was to identify spatial patterns of microbial abundance in a recently restored seagrass bed at the Virginia Coast Reserve – Long Term Ecological Research (VCR-LTER) site and compare patterns within the seagrass beds to those in bare sediments as well as in the overlying water column. Understanding these patterns will provide information necessary to establish monitoring efforts that track recovery of the ecosystem's functioning. Without this type of information, appropriate spatial distribution of these monitoring efforts will be, at best, only haphazard.

Chapter 2: Site Description & Selection

2.1 Site Description

The location selected for this study is South Bay (Figure 1), a shallow coastal bay located near the southern end of the Delmarva peninsula and off the coast of the Eastern Shore of Virginia (37º 15'13.86"N, 75º 48'43.70"W). South Bay is located within the Virginia Coast Reserve and is part of the Long Term Ecological Research worldwide network of research sites. This bay is a tidal system with an average water depth of about 1 meter at low tide, and is connected to a network of other bays and lagoons within the VCR-LTER and to the Atlantic Ocean by coastal inlets to the north and south. In 2003, Orth et al. reported that sediment in South Bay consisted of 83% sand, 9.8% silt, and 7.5% clay. The average grain size in Hog Island Bay (a bay connected to South Bay to the north through Cobb Bay) was reported as 0.125mm to 0.250mm (Lawson 2004).

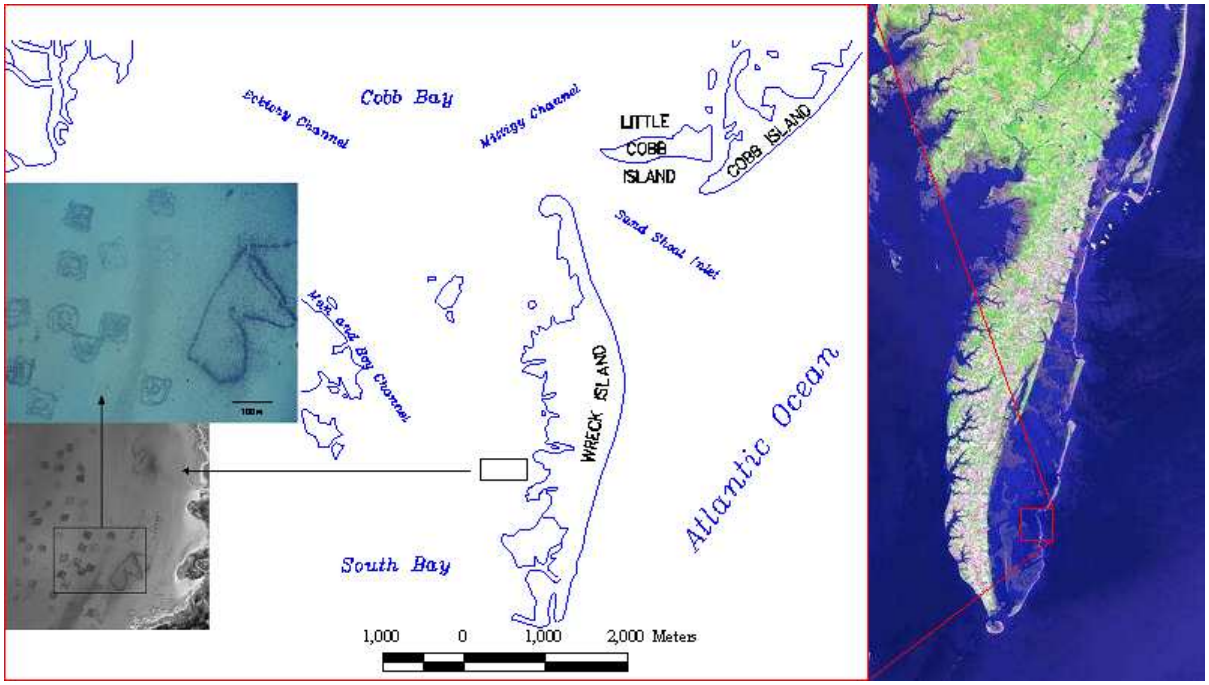


Figure 1: On the right is a satellite image showing the location of South Bay off the coast of the Delmarva Peninsula. The lower left image is two aerial photos of seagrass restoration efforts in 2001 and 2002 within the bay - these images were taken in 2004 (Orth et al. 2006). The middle image shows the approximate location of this study within South Bay of study site in relation to Wreck Island (Virginia Institute of Marine Science website).

2.2 Site Selection

South Bay was deemed to be a sufficient location to conduct this study for the following reasons:

- In comparison to other lagoons/bays within the VCR-LTER where other seagrass restoration efforts have been undertaken within the past couple of years (Hog Island Bay for example) , the *Z. marina* beds located in South Bay are relatively well established in comparison to the more recently established plots elsewhere on the Eastern Shore of Virginia. This results in a locality where a restored seagrass bed exists, yet this bed is old enough to provide a location with seagrass growth similar to natural

populations. The average shoot density is 410-530m^2 in this area (personal communication, MaGathery 2009). The type of growth in this area helps when making comparisons of data from unvegetated and vegetated areas in and around the bed.

- For this project it was important that a study site was chosen where a sharp boundary exists between unvegetated areas of sediment and the seagrass bed. This helped to make any potential changes in bacterial abundance and sediment properties more evident than in a location with a diffuse boundary between unvegetated and vegetated sediment. A suitable location was found in South Bay that met these criteria. Two bare patches of sediment of approximately the same size within the restored South Bay seagrass meadow were chosen as locations for this study.

- A number of other studies have been, or are currently being, conducted by other graduate students within the restored *Z. marina* bed in South Bay. The specific location for this study (within the larger framework of South Bay) was chosen with this in mind, as the site was chosen is in close vicinity to many of the locations of these other projects. In establishing this site in proximity to the others, the potential for direct cross-study exchange is fostered.

- Additionally, at low tide the bay is shallow enough to allow for sampling without the use of SCUBA diving.

Chapter 3: Field and Laboratory Methods

3.1 Experimental Design

Three zones with different sediment vegetation conditions within South Bay were identified based on visual inspection of the above ground seagrass community. These three zones are: 1) vegetated 2) unvegetated and 3) transitional zones. Sediment with no seagrass growth is referred to as the "unvegetated zone," sediment within the seagrass bed is referred to as the "vegetated zone," and the boundary area between the unvegetated zone and the vegetated zone will be referred to as the "transition zone," as this area marked the transition from bare sediment to the seagrass bed proper. It should be noted that the unvegetated zones are areas in that *Z. marina* appears to be growing into, as opposed to areas where the grass was once present but has since died off. Additionally, the water column overlying each of these zones is referred to with the same three terms mentioned above, and is based upon the directly underlying vegetation conditions in the sediment.

For sample collection, two independent, replicate 12-meter transects were established as described below for the collection of both sediment and water column samples which were all taken at 25cm (horizontal) intervals (Figure 2).

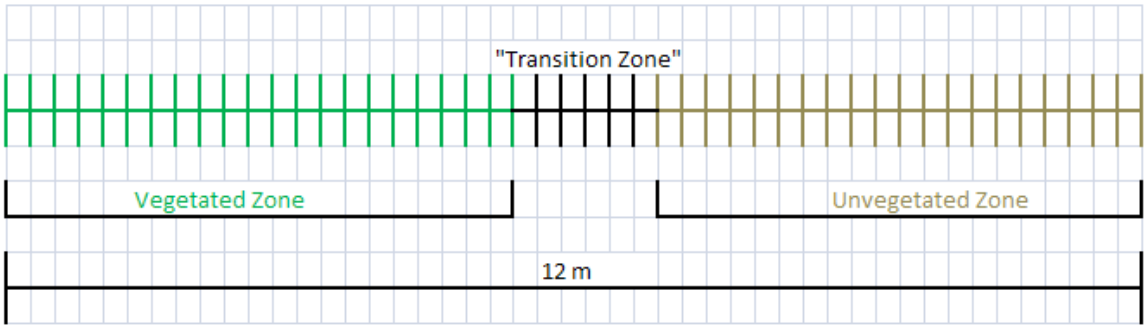


Figure 2: An idealized depiction of the way the sampling points were set up along each transect. There are 48 vertical hash marks along the horizontal transect above, and each hash mark is intended to represent one sampling location. The sample locations were spaced at 25cm (horizontal) intervals along each transect. A sample of each type (water and sediment) was taken at every sampling point along each transect, which results in both transects each being a total of 12 meters in length. "Sample 1" for both sediment and water column would be located at one end of the above figure and the sample number increases all the way to 48 on the other end of the transect. The three vegetation zones depicted in the figure are given to help the reader become familiar with how the zones are delineated along a transect and are not actually meant to necessarily convey any specific information regarding the actual length of the 3 zones for either transect during either sampling event.

Both transects were sampled twice. The first sampling event took place on November 8, 2007 when water temperature in South Bay was observed to be around 12^{o}C. The extent of the three zones was determined by visual inspection at the time of each sampling event. A second, nearly identical, sampling even was completed on June 17, 2008 when the water temperature was 28^{o} C, and the seagrass bed was more dense and vibrant in comparison to the November sampling event. Using similar sampling regimes in different seasons allowed for comparison of the combined effect of temperature and plant phenology on microbial community abundance. The variables collected from both sampling events include those items listed in Table 1.

	Type of Sample	
Type of Analysis	**Water Column**	**Sediment**
Microbial Abundance	X	X
Organic Content		X
Mineral Content		X
Moisture Content		X
Sediment Density		X
C:N		X

Table 1: The two types of samples taken and the laboratory procedures performed on each. An "X" indicates that a particular analysis was performed on that sample type.

All variables were subjected to geostatistical analysis and the characteristics of the resulting plots were compared. Additionally, unpaired t-tests at $\alpha = 0.05$ were performed to test the effect of various groupings (i.e. the sample location: "vegetated" vs. "unvegetated"; and the sample type: water column vs. sediment), on bacterial abundance. These analyses allowed the consideration of the following questions. 1) What is the effect of vegetation on bacterial community size in sediment at the meso-scale (i.e. ~ 1-8 meters in length)? 2) Does the presence or absence of vegetation have a detectable effect on microbial populations in the overlying water column? 3) How do the patch sizes of microbial communities in the water column and sediment compare to one another? 4) Is microbial abundance correlated with measurable sediment characteristics (e.g. organic content and carbon to nitrogen ratio)?

3.2 Field Methods

All sampling events were conducted around low tide to facilitate the ease and efficiency of collecting samples – particularly extracting sediment cores - and also to help ensure that the seagrass bed was under a similar tidal influence at both events. All samples (sediment and water column) were taken at 25 cm (horizontal) intervals along each transect. As described above, the two transects were set up in the following manner: one end is located in an area of un-vegetated sediment area while the other end of the transect is located within a seagrass bed. This orientation maximized the potential of capturing changes in microbial community abundance and sediment properties along a vegetated to un-vegetated gradient.

3.3 Sediment Sampling

Sediment cores of approximately 6 to 8 cm^3 were taken at each sampling position (every 25 cm in the horizontal direction) along each transect. The cores were extracted using a 10 cm^3 de-tipped syringe. The depth and volume of each core varied slightly; however, only the top of each core was analyzed. The top 5cm^3 section of each core was homogenized in the lab by extruding the core from the sample container onto a new, clean plastic tray and mixed thoroughly with a metal rod that was flamed and rinsed with filter sterilized deionized water before any mixing work began and before changing to work with a different sample. This procedure was followed throughout the mixing process. Then the samples were used for analysis. This size sample provided enough sediment to complete all of the above analyses and, in the case of the samples taken from the vegetated zones, captured the rhizophere in the vertical direction. A total of 48 cores were taken along the length of each transect, and each core was characterized for moisture content, organic matter content, and carbon to nitrogen

ratio (C:N) – this allows for the determination of any changes in these relative to sampling position as it moves from the vegetated to the unvegetated zone(s).

3.4 Water Column Sampling

In addition to the sediment cores, a water column sample was taken at each sampling position (again, at horizontal intervals of 25 cm) within each transect. The water samples were collected using a Plexiglas sediment core tube. The tube was placed in the water column and then capped on the lower end and the sample was then transferred to a 50 ml centrifuge tube (for storage). This method of sampling was intended to isolate an unmixed segment of the water column in a way that would not be possible by collecting a grab sample of the surface water. Water column samples were taken at 25 cm intervals along each transect. A total of 48water samples were taken per transect. All sediment and water samples were immediately stored on ice and returned to the lab where they were moved to a -80^{o}C freezer until analysis.

3.5 Laboratory Methods

Bacterial Community Analysis

The changes in both water column and sediment microbial abundance was determined by counting cells via Acridine Orange Direct Counts (AODC) following the methods in Hobbie et al. 1977 and Kepner & Pratt 1994. AODC was performed on both the water column samples and the sediment samples, and bacterial cell numbers are expressed (as is standard practice for environmental samples of these types) as number of cells ml $^{-1}$ of water for the samples that came from the water column and as number of cells g $^{-1}$ of sediment for the sediment samples.

Equation 1 was used to compute the total number of bacterial cells ml $^{-1}$ of water in the original sample:

(1) Cells /ml = [(total area)/(area/field)*(cells/field)] / (volume filtered × dilution factor)

Where:

- total area = total area of stained filter = 314 mm^2
- area/field = area of one field as defined by the eyepiece micrometer = 0.009409 mm^2
- cells/field = number of cells counted averaged over the number of fields counted
- volume filtered = amount of sample filtered onto filter

Each sample was removed from storage in a -80^{o}C freezer and allowed to thaw. Thawed water samples were mixed on a vortex mixer for 30 seconds each and a 2.0 ml aliquot was removed from the sample and preserved in 8.0 ml of 20% filter sterilized formaldehyde solution until the AODC analysis was performed. The microscope used was a Carl Ziess Axio Imager A1 with an X-Cite Series 120 laser.

Sediment samples were allowed to thaw and only the top 5 cm of each sample was used for analysis. What little surplus remained was discarded. Upon thawing, each sample was extruded into a container and homogenized, as mentioned above. The resulting mixture was then divided into four aliquots for a) AODC analysis b) DNA extraction (for preservation) c) moisture and organic content analysis and d) carbon-to-nitrogen ratio analysis. For AODC analysis 0.1 ml of sediment was taken and added to 9.9 ml of a 20% filter-sterilized formaldehyde solution. From that mixture 2.0 ml was removed and subjected to AODC analysis (Hobbie et al. 1977). The number of cells g $^{-1}$ of sediment in the original sample was determined using Equation 1, substituting units of mass (g) of sample filtered for the volume (ml) of sample filtered term.

Each sample from both months was counted via AODC only once. To determine variance in bacterial abundance at any given sampling position along the transect, randomly selected November samples were counted three different times and the results of the three counts were subjected to statistical analysis. The results of this analysis showed that there was no significant statistical difference among the replicates (at $\alpha = 0.05$). For more information on each of these tests see the appendix. The results of this analysis demonstrated that counting all samples from a transect, rather than counting the bacteria in every sample 3 (or more) times, provided denser (finer) coverage of abundance differences along the transects for the same investment of time and lab supplies. Denser sampling along the transect allows more meaningful geostatistical analysis. It is believed that the results of these statistical tests give legitimacy to this practice and that the data that are reported herein are, in fact, statistically representative of the sample from which they came.

		Sample	AODC Count # (cells/ml and cells/g)		
Sample Type	**Transect**	**Number**	**1**	**2**	**3**
Water	1	12	3730000	4110000	3910000
Water	2	27	5760000	6450000	7010000
Water	1	43	6510000	4460000	5050000
Sediment	2	4	94100000	98700000	83200000
Sediment	1	27	127000000	141000000	152000000
Sediment	2	40	231000000	246000000	258000000

Table 2: The results of the triplicate bacterial counts for six samples taken in November 2007. The differences in the counts for all samples were not statistically significant at $\alpha = 0.05$.

Sediment Analyses

In addition to the AODC analysis, additional analyses were performed to determine soil parameters such as organic content, moisture content, and carbon-to-nitrogen ratio. The techniques used were virtually identical to those already used in other work at the VCR-LTER.

For the C:N analysis a portion of each homogenized sediment sample was dried in an oven for 24 at 150^{o} C. The dried sample was then ground using a mortar and pestle and analyzed to determine the carbon to nitrogen ratio of each sample using a Carlo Erba Elemental Analyzer. These data were reported as percentage of carbon and percentage of nitrogen present in each sample.

For the moisture and organic content analysis, a portion of each homogenized wet sample was placed in a pre-ashed, pre-weighed container, the mass of the container and wet sample was recorded, and the sample was dried for 24 hours at 150^{o} C. The sample was then weighed again and the difference in the wet weight and dry weight was used to determine the mass of water originally in the sample. This was then used to determine the moisture content of each sample. The sample was then placed in a muffle furnace at 450^{o} C for 24 hours to burn off organic matter. The organic content was determined by the mass difference in the sample before and after placement in the furnace (adapted from Murdoch & McKnight 1991). The equations used to determine moisture content (equation 2) and organic content (equation 3), respectively, are:

(2) % moisture = [(wet mass (g) – dry mass (g)) / dry mass (g)] *100
(3) % organic = [(dry mass (g) – ashed mass (g)) / dry mass (g)] *100

3.6 Statistical Analyses

An alpha value of 0.05 was used in a series of unpaired t-tests for each set of data for each month. For example, for the water column bacterial abundance data in both transects during November 2007, 5 unpaired t-tests were conducted. The data groupings compared (for each parameter that data was collected for) were: 1) data from the unvegetated area to data from

the vegetated area of Transect 1, 2) data from the unvegetated to data from the unvegetated area of Transect 2, 3) Data from the transition zone of Transect 1 to data from the transition zone of Transect 2, 4) data from the unvegetated zone of Transect 1 to data from the unvegetated zone of Transect 2, and 5) data from the vegetated zone of Transect 1 to data from the vegetated zone of Transect 2. Each of these five comparisons were done for all of the data collected - i.e. bacterial abundance (in the water column and in the sediment), sediment organic content, moisture content, and carbon content from both months. The Bonferroni correction was used for each set of t-tests conducted to account for the issues resulting from conducting multiple statistical comparisons within the same set of data. In this method all tests are conducted at a significance level of (α/n), where *n* is the number of tests performed on a data set (Legendre and Legendre 1998). For all the tests conducted in this study, n = 5. Therefore, in this study, α/n = 0.01, and this value will be referred to as *α'*. A summary table for all t-tests performed is given at the end of the data presentation for each month.

3.7 Variogram Construction and Analysis

The terms "semi-variogram" and "variogram" are synonymous and may be used interchangeably (Legendre and Legendre 1998). To construct a semi-variogram, data points are placed on a Cartesian plot where sample separation distance located on the x-axis and the sample variance parameter on the y-axis (Figure 3). Throughout this study, the variance parameter used is semi-variance, which can be calculated with Equation 4 (Franklin and Mills 2007).

$$\textbf{(4)} \qquad \gamma(d) = (1/2n_d)\ \Sigma\ [y_{(i+d)} - y_{(i)}]^2$$

Here $\gamma(d)$ is the semi-variance, y is the observed values (e.g. bacterial abundance or sediment organic matter content etc.), n_d is the number of pairs of points located at distance, d, from one another. In Figure 3, variability among the samples increases as sample separation distance increases over the range, the point at which samples cease to be autocorrelated. At separation distances less than, and up to, the range all of the samples are considered to be autocorrelated, and at separation distances greater than the range samples are not correlated. The dashed lines within Figure 3 (as well as those in the variograms presented throughout the results and discussion section) are present merely as a visual aid to enable the viewer to more easily gain a sense of where, numerically, the sill and the range fall.

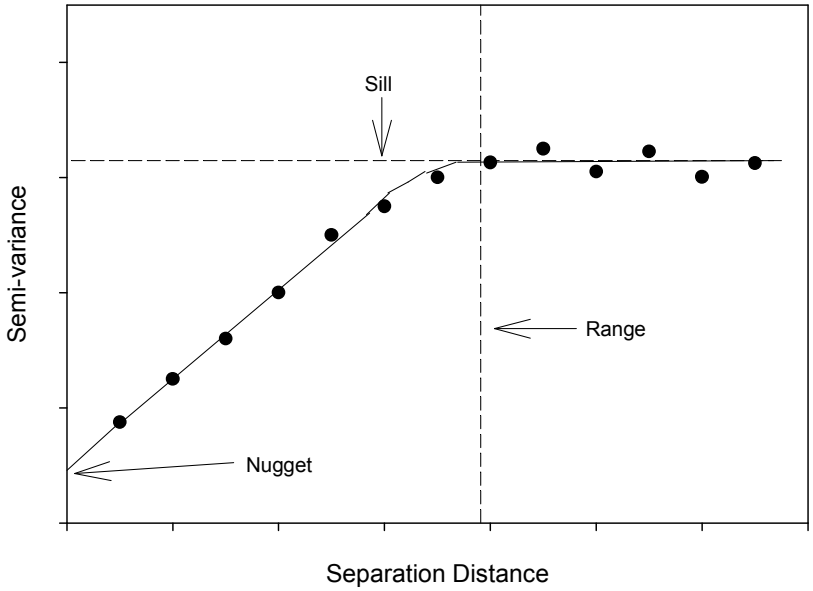
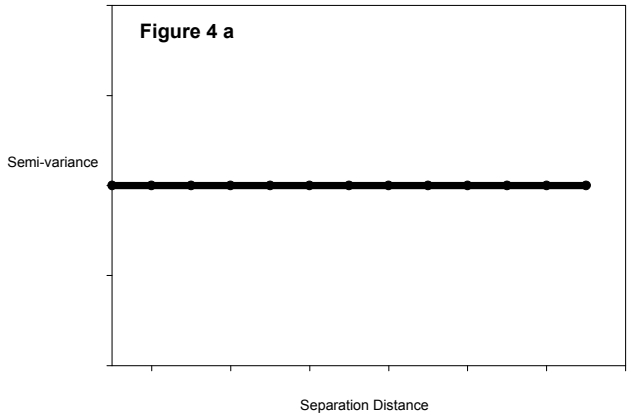
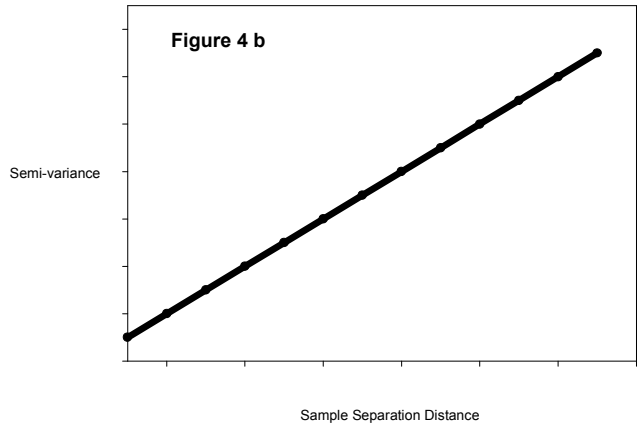


Figure 3: A theoretical variogram model showing the main components of these types of figures.

The three basic forms that an experimental variogram will take are a) nugget/flat b) linear, or c) linear-sill (Figures 4a, 4b, and 4c below). The basic shape of each of these forms is illustrated in the figures below (Franklin & Mills 2007).





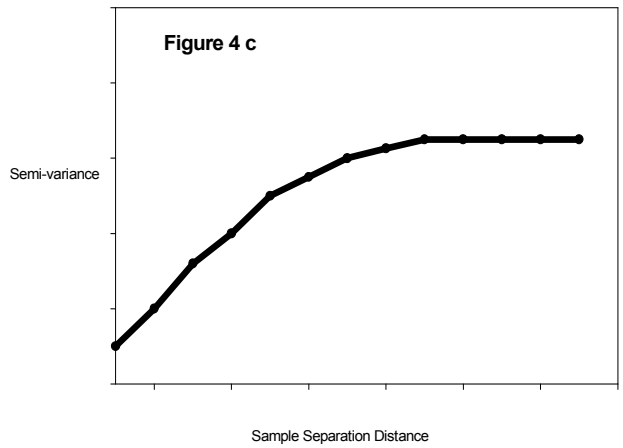


Figure 4: The three most common data patterns seen in experimental variograms. 14a: flat, 14b: linear, and 14c: linear-sill.

These generalized shapes can be modeled mathematically with a variety of equations (e.g. linear, spherical, exponential, and Gaussian). The pattern presented in Figure 4a represents a “pure nugget” result. This pattern indicates that no spatial structure exists in the data over the separation distance analyzed. When data are positively autocorrelated the semi-variance will increase with increasing sample separation distance. This is tied to the idea that samples separated by smaller distances will be more similar to one another than samples separated by larger distances. Figure 4b above represents a linear pattern. This pattern occurs when spatial autocorrelation is present throughout all separation distances over which samples are analyzed. In this situation, samples become more different from one another as separation distance becomes greater; however the maximum difference has yet to be reached. In data sets where samples are positively autocorrelated in space but the maximum difference is reached, spatial autocorrelation ceases and a linear- sill pattern is seen (Figure 4c). The sample separation distance at which the sill occurs is known as the correlation length scale. The value of the correlation length scale was used in this study to determine bacterial community patch size.

The separation distance over which the semi-variance increasing and then reaches a leveling off point is called the range (Figure 3). Moving beyond the range, the semi-variance will fluctuate around the sill. This value is roughly equal to the total sample variance. The nugget is the interpolated semi-variance when sample separation distance equals zero. In practice semi-variance at the nugget rarely equals zero (this would be the origin on the x-y coordinate plane), and the reasons for this are 1) the nugget values accounts for spatial variability when sample separation distance is very small (smaller than the shortest sampling distance) and 2) variability present due to sampling or measurement error.

The ratio of the nugget to the sill provides an estimate of the amount of total variance that cannot be accounted for by spatial variation alone. Finally, when analyzing a data set in this way, it is customary to exclude the final third of separation distances, over which samples are the most far apart. The reason these values are excluded customarily is due to the fact that when samples near the very extremity of the transect, there are simply fewer data values to compare with one another at these larger distances when compared to samples taken from smaller separation distances (Franklin & Mills 2007). For that reason, this convention was used in all the variograms presented in the results section. In this study, separation distances from 0.25 m to 8 m where used for variogram analyses despite the total length of each transect being 12 m.

Chapter 4: Results and Discussion

4.1 November 2007 Results

All figures depicting transect data (for both months) are divided into three sections delineated by differences in shading. The shaded area on the left represents sampling points taken from areas of unvegetated sediment and these same locations in the overlying water column, the unshaded area near the middle represents the transition zone from the unvegetated areas to the seagrass bed proper, and the shaded area on the right denotes the area on which the seagrass bed was located. The length of each transect is presented on the x-axis.

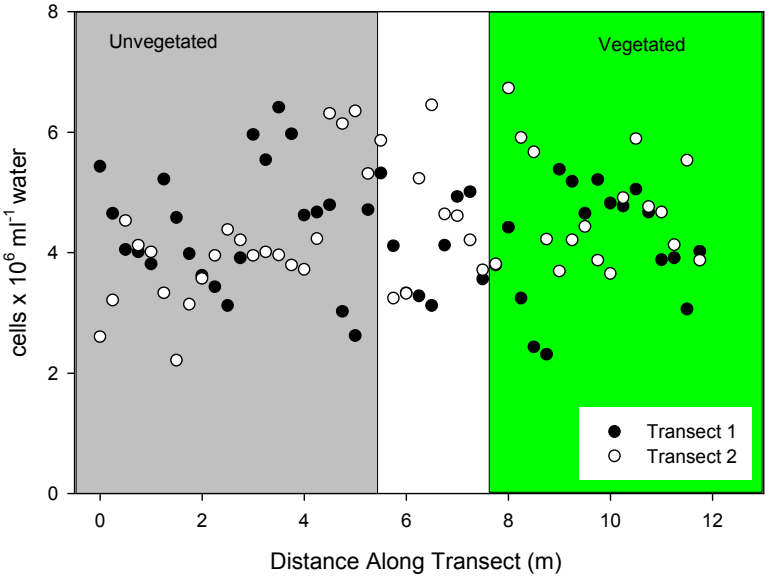


Figure 5: November 2007 water column bacterial abundance. This figure shows the number of bacterial cells per milliliter of water for each sampling point along each transect. Each data point represents one sample along the transect with bacterial abundance counted one time via AODC for that sample.

Water column bacterial abundance in November 2007 ranged from over 2 x 10^6 cells ml^{-1} to just under 7 x 10^6 cells ml^{-1} (Figure 5). These values are quite typical of estuarine water columns as seen in other studies (Lowit 2006). The data in Figure 5 show no clear patterns or trends in abundance in either transect regardless of the underlying vegetation conditions, but rather appear as scattered points that vary along the two transects. This result is not surprising because these samples were taken from a well-mixed tidal system with a shallow water column (Lawson et al. 2007). Daily tidal ebb and flow should result in a well-mixed water column, and no significant changes in heavily structuring influences (e.g. large changes in nutrient or oxygen concentrations) over the spatial scale sampled would likely exist. The lack of a discernable pattern at this spatial scale does not rule out the potential for either smaller or larger scale patterns of bacterial abundance (e.g. Lowit 2006). There were no statistically significant differences (at $\alpha = 0.05$ Bonferroni corrected to $\alpha' = 0.01$) in bacterial abundance between any of the 3 vegetation zones either within a transect or when comparing the same vegetation zone between the two transects, further suggesting a lack of spatial structure at this scale.

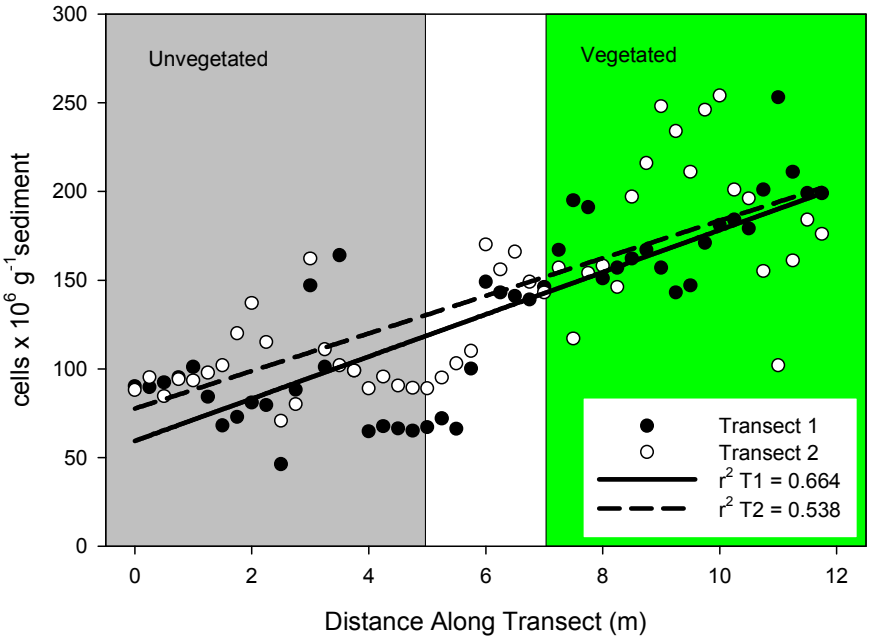


Figure 6: November 2007 sediment bacterial abundance. This figure shows sediments bacterial abundance across the length of each transect given in units of number of cells per gram of sediment. Each data point represents a single sample counted once via AODC.

In November 2007, sediment bacterial abundance ranged from around 50 x 10^6 cells g^{-1} sediment to around 250 x 10^6 cells g^{-1} sediment (Figure 6). Abundance increased along both transects moving from the unvegetated to vegetated areas suggesting a positive correlation between bacterial abundance and the presence of vegetation. Results of the t-test analysis ($\alpha' = 0.01$) showed that a significant increase in abundance was seen in Transect 1 in the vegetated zone (mean = 179.7 10^6 cells g^{-1}) as compared to the unvegetated zone (mean = 88.13 x 10^6 cells g^{-1}) of the transect ($p < 0.0001$, $t = -10.556$). Likewise, a similar statistically significant increase in bacterial abundance was observed in the vegetated (mean = 184.9 x 10^6 cells g^{-1})and unvegetated zones (mean = 100.8 x 10^6 cells g^{-1})of Transect 2 ($p < 0.0001$, $t = -7.651$). There

were no other significant differences found in bacterial abundance between the two transects. Greater bacterial abundance in vegetated areas could result from a rhizosphere effect or plant turnover processes (plant growth, plant death, and plant decay). These processes provide excellent substrate for bacterial growth and survival. Results of a regression analysis at 95% confidence on the data for each transect revealed an r^2 value of 0.664 and an F-statistic of 90.9 for Transect 1, which was a highly significant result. The same analysis done for Transect 2 gave an r2 value of 0.538 and an F-statistic of 53.65, which is also a highly significant result. These results help to illustrate that there is a significant difference in bacterial abundance in the sediments of differing vegetation types.

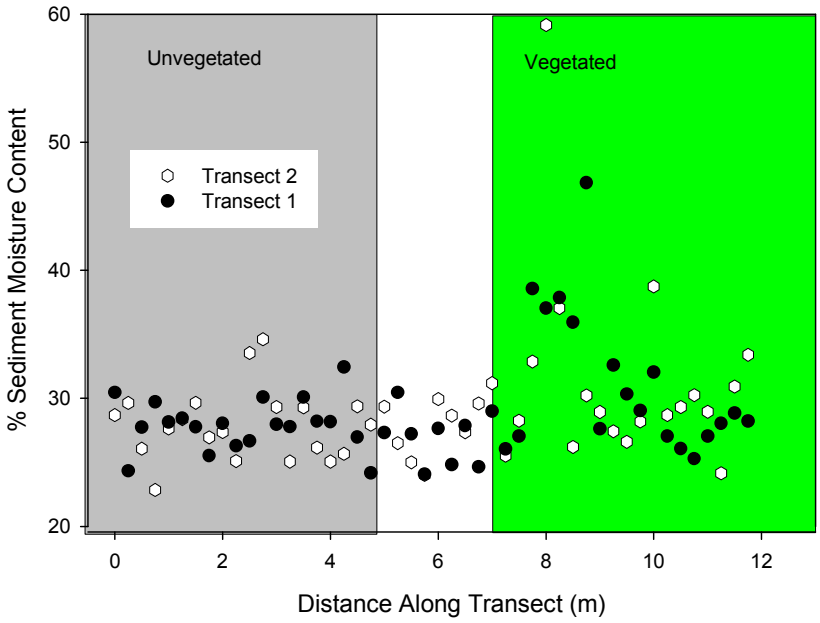


Figure 7: Sediment moisture content along transects 1 and 2 in November 2007. Moisture content is expressed as a percentage of the total wet mass of sample.

Moisture content of the vast majority of samples along both transects were in the 20% to 30% range with a few notably higher values occurring in the vegetated zone (Figure 7). The higher moisture values of a few samples might result from a higher porosity in the sediment in

this area. There is no definite trend in moisture content along either transect; however, and the high values in the vegetated areas may result from sampling from a location with roots or with animal burrows that might be more abundant in vegetated areas, thereby increasing sediment porosity. That the moisture content of vegetated sediments in Transect 2 appears greater than the unvegetated sediments of this transect is almost certainly due to a few extreme high values in the vegetated area of Transect 2. However the t-test analyses conducted at $\alpha' = 0.01$ showed that no significant differences in sediment moisture content existed either within the different vegetation zones of a given transect, nor were there any significant differences when comparing vegetation zones between the two transects.

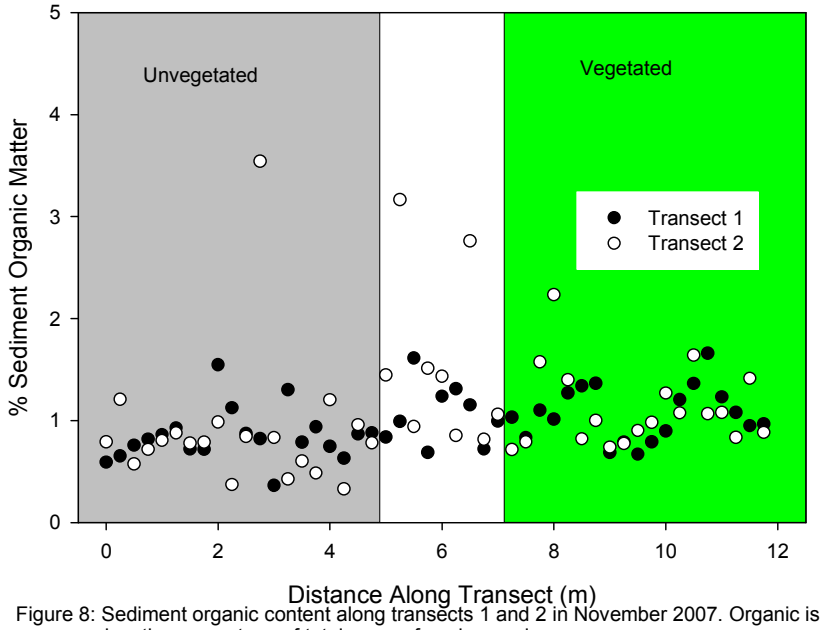


Figure 8: Sediment organic content along transects 1 and 2 in November 2007. Organic is expressed as the percentage of total mass of each sample.

The sediment organic matter data for each transect was typically between 0.5% to 1.5% for each sample (Figure 8). An expectation with these data was that organic matter would be higher in the vegetated area than the unvegetated area as a result of higher due to foliage input

and plant and root turnover. However, t-test analyses conducted with the Bonferroni corrected alpha level ($\alpha' = 0.01$) showed that no significant differences in organic content existed for the three different vegetation zones within either transect, nor were any statistically significant differences observed when comparing the same vegetation zone between transects. The organic matter in the vegetated zones may be slightly higher when compared with the unvegetated zones of each transects; however, if there is an increase in organic content it is not significant at this spatial scale. This seagrass bed is still relatively young (i.e. around 5 years old at the time of the last sampling conducted in this study) and full recovery of organic content in vegetated sediments probably has not had sufficient time to fully recover. As the bed matures, significant changes in sediment organic content could redevelop.

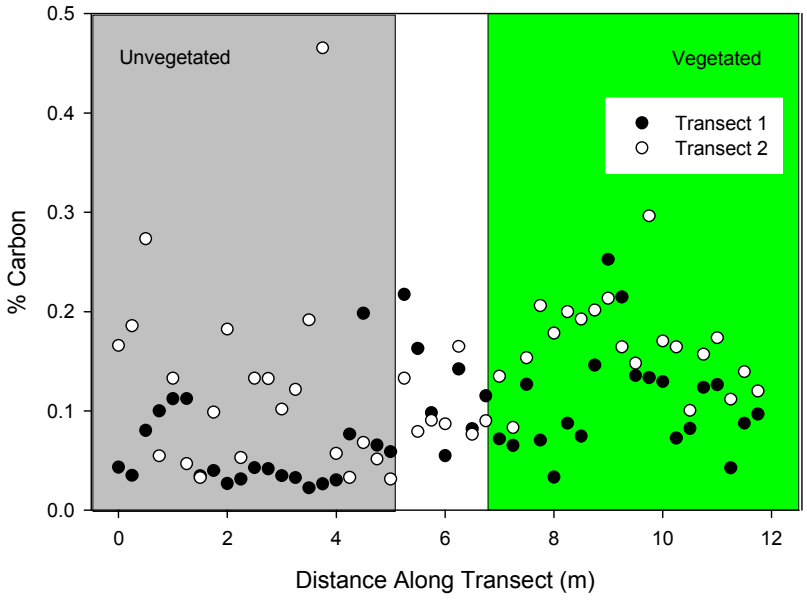


Figure 9: Sediment carbon content (based on C:N analysis) in November 2007.

Each of the sediment samples was analyzed to determine carbon to nitrogen content; however, the nitrogen content of all the samples was below the detection limits for nitrogen

(0.01%) of the analyzer. Therefore, only the percent carbon values of each sample are presented here (Figure 9). Carbon content of sediments along both transects was quite variable. T-test results ($\alpha' = 0.01$) suggested that there was a significant difference ($p = 0.0028$, $t = -3.228$) in the carbon content of the unvegetated and vegetated zones of Transect 1, as sediment carbon content increased from the unvegetated zone into the vegetated zone. Although the mean carbon content of the vegetated zone of Transect 2 was higher than in the unvegetated zone, this difference was not statistically significant (0.1289% vs. 0.1669%).

Another statistically significant difference that was observed was between the unvegetated zones of Transect 1 and Transect 2. Mean carbon content was higher in the unvegetated zone of Transect 2 (0.1289%) than in the same vegetation zone of Transect 1 (0.0954%), and at $\alpha' = 0.01$ this difference was significant ($p = 0.0094$, $t = -2.803$). The third statistically significant difference found in the carbon content data was in the higher mean of the vegetated zone of Transect 2 (0.1669%) than the vegetated zone of Transect 1 (0.1104%). At $\alpha' = 0.01$ this difference was statistically significant. These results suggest that carbon content was generally significantly higher across Transect 2 than across Transect 1. No other statistical tests completed show a significant difference in carbon content neither within the three zones of a transect nor is there a significant difference when one analyzes the data from each vegetation zone across the two transects.

Data Type	Group 1	Group 2	T-value	P-value	Significance
Water column bacterial abundance	T1 Unveg	T1 Veg	1.187	0.2433	Not
Water column bacterial abundance	T2 Unveg	T2 Veg	-2.183	0.0357	Not
Water column bacterial abundance	T1 Transition	T2 Transition	-2.12	0.0513	Not
Water column bacterial abundance	T1 Unveg	T2 Unveg	1.86	0.0706	Not
Water column bacterial abundance	T1 Veg	T2 Veg	-1.497	0.143	Not
Sediment bacterial abundance	T1 Unveg	T1 Veg	-10.556	P < 0.0001	Significant
Sediment bacterial abundance	T2 Unveg	T2 Veg	-7.651	P < 0.0001	Significant
Sediment bacterial abundance	T1 Transition	T2 Transition	-1.078	0.2971	Not
Sediment bacterial abundance	T1 Unveg	T2 Unveg	-1.652	0.1075	Not
Sediment bacterial abundance	T1 Veg	T2 Veg	-0.440	0.6626	Not
Sediment organic content	T1 Unveg	T1 Veg	-2.634	0.0122	Not
Sediment organic content	T2 Unveg	T2 Veg	-1.265	0.2153	Not
Sediment organic content	T1 Transition	T2 Transition	-1.651	0.1298	Not
Sediment organic content	T1 Unveg	T2 Unveg	-0.3049	0.7631	Not
Sediment organic content	T1 Veg	T2 Veg	-0.4622	0.6471	Not
Sediment moisture content	T1 Unveg	T1 Veg	-2.299	0.0314	Not
Sediment moisture content	T2 Unveg	T2 Veg	-1.810	0.0833	Not
Sediment moisture content	T1 Transition	T2 Transition	-0.010	0.9921	Not
Sediment moisture content	T1 Unveg	T2 Unveg	0.0367	0.9709	Not
Sediment moisture content	T1 Veg	T2 Veg	-0.0813	0.9357	Not
Sediment carbon content	T1 Unveg	T1 Veg	-3.228	0.0028	Significant
Sediment carbon content	T2 Unveg	T2 Veg	-1.496	0.1497	Not
Sediment carbon content	T1 Transition	T2 Transition	0.578	0.5716	Not
Sediment carbon content	T1 Unveg	T2 Unveg	-2.803	0.0094	Not
Sediment carbon content	T1 Veg	T2 Veg	-3.386	0.0017	Significant

Table 3: A summary of the t-tests performed on the November 2007 data. For more information on the results of the statistical analyses for each month see appendix A.

4.2 June 2008 Results

Bacterial abundance in the water column in June 2008 proved to be similar (in terms of both number of cells and the visible trends along the length of each transect) to the November 2007 results of the same type (Figure 10 and Figure 5). Water column bacterial abundance in June 2008 varied across both transects and no identifiable spatial trends can be observed – very similar to what was observed in November.

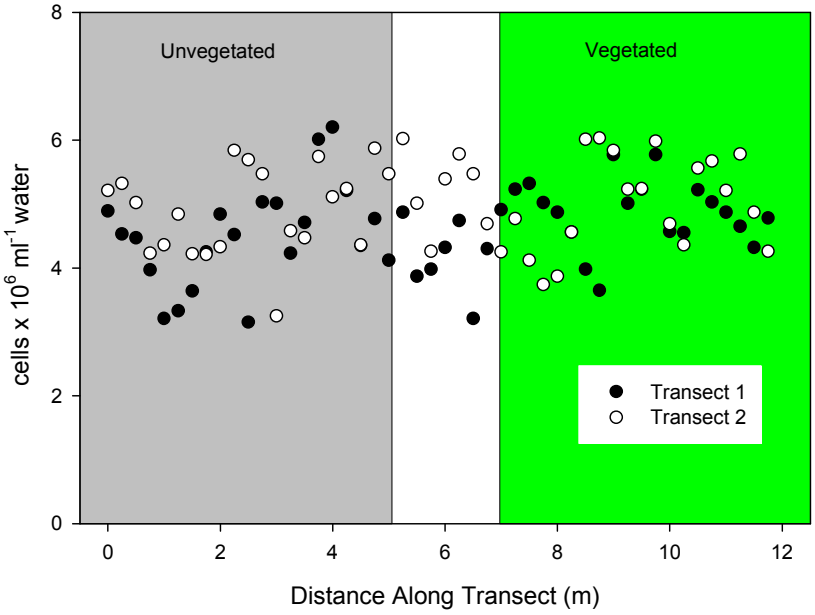


Figure 10: June 2008 water column bacterial abundance. This figure shows the number of bacterial cells per milliliter of water for each sampling point along each transect. Each data point represents one sample along the transect with bacterial abundance counted one time via AODC for that sample.

The only significant differences either within or between each transect was between the values in the transition zones of the two transects ($p = 0.0062$, $t = -3.315$). Abundance had a mean of 4.18×10^6 cells ml^{-1} in the transition zone of Transect 1 and a mean of 5.23×10^6 cells ml^{-1} in the transition zone of Transect 2. The higher abundances across the transition zone of Transect 2 was statistically significant at the Bonferroni corrected alpha level ($\alpha' = 0.01$). As with

the November water column results, the lack of any other definite visible trends, significant differences, or spatial structure suggests that the strongest influence on bacterial abundance was most likely the tidal mixing that is occurring in the water column in this area, and no spatial structure exists at this scale.

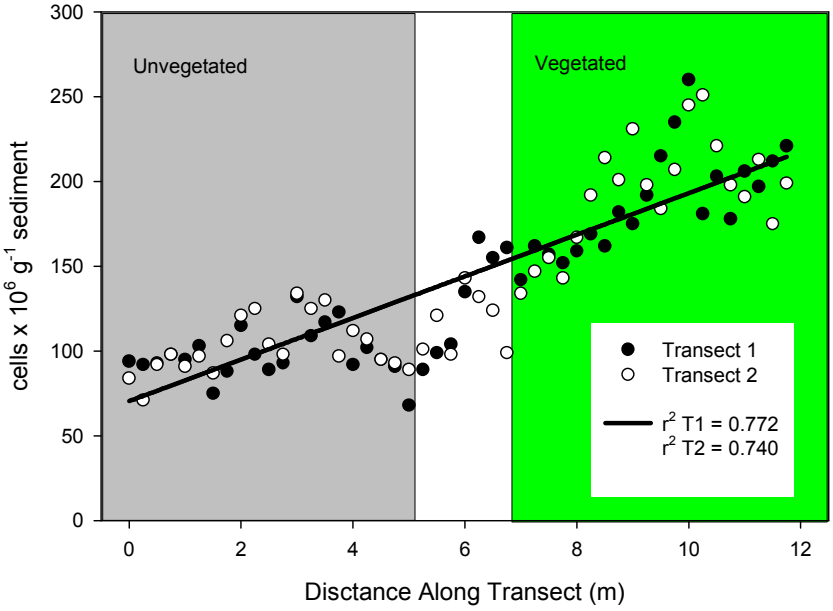
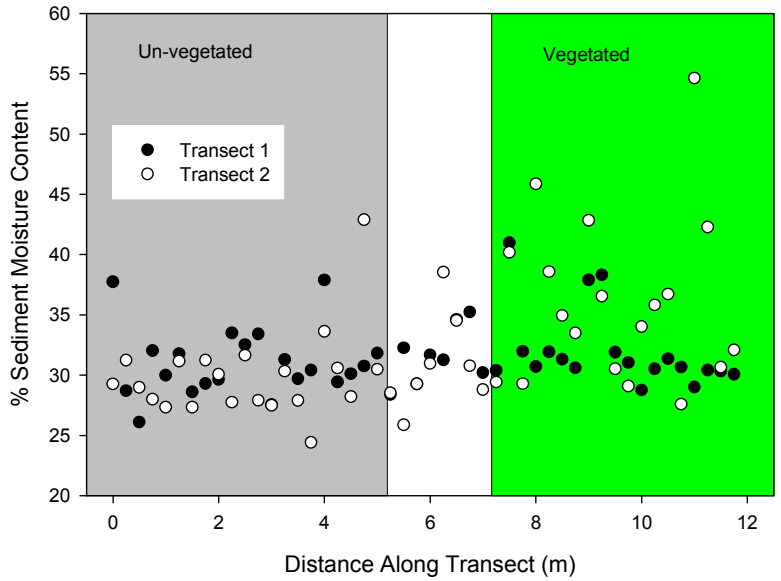


Figure 11: June 2008 sediment bacterial abundance. This figure shows sediments bacterial abundance across the length of each transect given in units of number of cells per gram of sediment. Each data point represents a single sample counted once via AODC. The r^2 values for both transects were so similar for both transects that the regression lines essentially overlap one another.

In contrast to the water column abundance data for both months, the June 2008 sediment bacterial abundance shows a noticeable trend; bacterial abundance increases from the unvegetated to the vegetated area of each transect (Figure 11). This could be due to greater organic matter input from plant foliage input and root turnover and the rhizosphere effect in vegetated areas, although based on the results of this study, this is not a certainty.

The t-test results (at $\alpha' = 0.01$) confirm that bacterial abundance is higher in the vegetated zones than in the unvegetated zones in both transects. Statistically comparing bacterial abundance in the unvegetated zone of Transect 1 (mean = 98.2 x 10^6 cells g^{-1}) to the vegetated zone (mean = 188.0 x 10^6 cells g^{-1}) suggest that the increase we see in abundance across this transect is significant. When comparing the unvegetated zone to the vegetated zone of Transect 2, a mean abundance value of 102.6 x 10^6 cells g^{-1} for the unvegetated zone, while a mean of 193.3 x 10^6 cells g^{-1} is obtained for the vegetated zone. The statistical analysis suggests that this increase in abundance from unvegetated to vegetated areas is significant ($p < 0.0001$, $t = -11.16$). These statistical results are comparable to what was seen in the November 2007 abundance data in the sediment of both transects. Results of a regression analysis at 95% confidence gave an r^2 value of 0.772 and an F-statistic of 155.88 for Transect 1 – this indicate a highly significant result. The same analysis done for Transect 2 gave an r^2 value of 0.740 (very similar to Transect 1) and an F-statistic of 131.12 – again, indicating a highly significant result. As was the case with the November sediment bacterial abundance data, these results help to illustrate the point that differing vegetation conditions are supporting significantly different numbers of microbes in the sediment of South Bay.



Figuire 12: Sediment moisture content along transects 1 and 2 in June 2008. Moisture content is expressed as a percentage of the total wet mass of sample.

Sediment moisture content in June 2008 was highly variable throughout the length of each transect; however, the majority of the values were between 25% to 35% water (Figure 12), and there is a visual suggestion of increasing moisture content where seagrass was growing. This observation was statistically confirmed ($\alpha' = 0.01$) for Transect 2, where there is a significant difference in moisture content between the unvegetated and vegetated values ($p = 0.0023$, $t = -3.341$). The mean moisture content in the unvegetated area of Transect 2 was 29.968% while the mean value in the vegetated zone was 35.661%. The significantly higher moisture content in the vegetated zone of Transect 2 suggests a possibility of higher porosity (due to the presence of vegetation, plant roots, and animal burrows) in the sediment in this area compared to other vegetation zones.

No other statistically significant differences were found in the data within the different vegetation zones of the two transects, nor were there any significant differences in moisture

content in the same vegetation zones between the two transects. The lack of much significant difference in the moisture data is consistent with the November 2007 data of the same type.

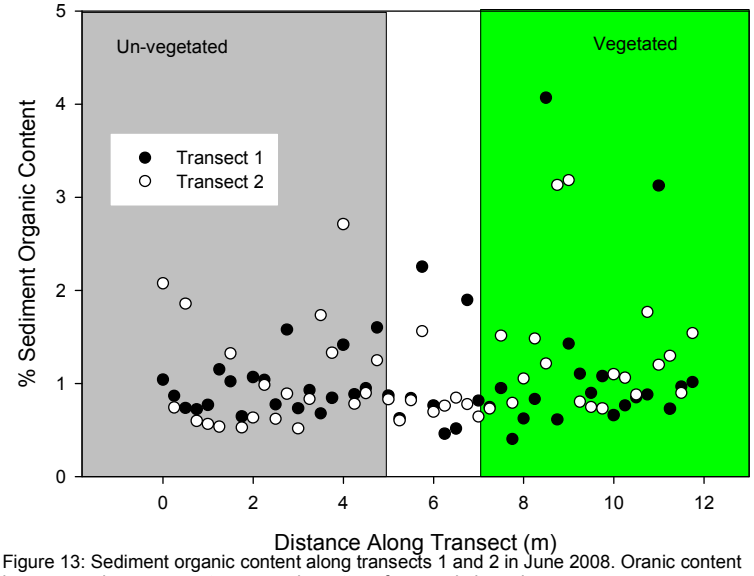


Figure 13: Sediment organic content along transects 1 and 2 in June 2008. Oranic content is expressed as a percentage organic matter of a sample based on mass.

The June sediment organic matter content varied across the length of the two transects and ranged from around 0.4% to just over 4% along both transects. However, several much higher values were observed (Figure 13). A possible explanation for this result is the inclusion of plant matter or small organisms that were caught up in the sediment sample. This would have artificially heightened the organic content of a sample. Despite these higher values, no statistically significant difference (at $\alpha' = 0.01$) was seen to exist either within or between either transect, mirroring what was seen for these transects in November 2007.

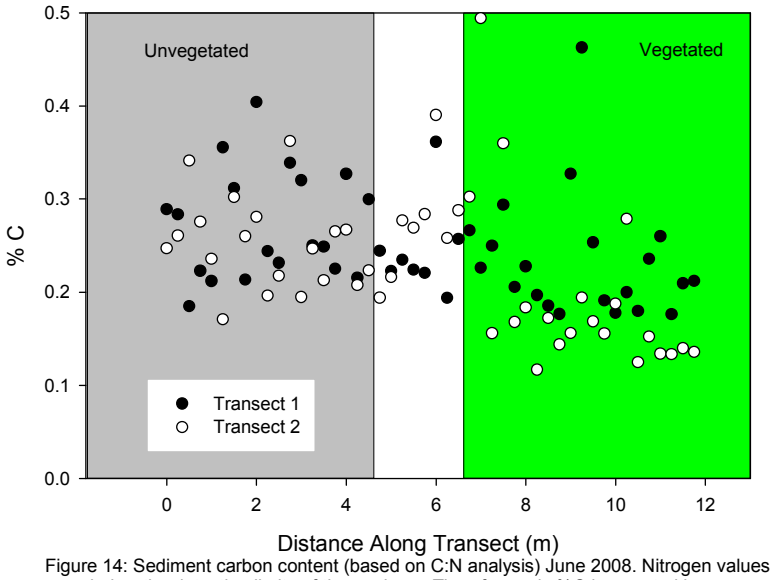


Figure 14: Sediment carbon content (based on C:N analysis) June 2008. Nitrogen values were below the detection limits of the analyzer. Therefore only %C is reported here.

No differences in sediment carbon content were detected between Transect 1 and Transect 2 for June 2008. The data were highly variable throughout each transect. However, visual inspection suggests a potential decreasing in carbon content along the length of each transect (particularly in Transect 2). The results of t-tests at $\alpha' = 0.01$ show there is a significant difference between the unvegetated and vegetated areas of Transect 2. No statically significant differences in the data either within a transect (in different vegetation zones) or between the two transects (in the same vegetation zones) is completely consistent with what was observed for the November 2007 data of the same type.

Data Type	Group 1	Group 2	T-value	P-value	Significance
Water column bacterial abundance	T1 Unveg	T1 Veg	-1.754	0.0882	Not
Water column bacterial abundance	T2 Unveg	T2 Veg	-0.465	0.6441	Not
Water column bacterial abundance	T1 Transition	T2 Transition	-3.315	0.0062	Significant
Water column bacterial abundance	T1 Unveg	T2 Unveg	-1.732	0.0912	Not
Water column bacterial abundance	T1 Veg	T2 Veg	-0.665	0.5108	Not
Sediment bacterial abundance	T1 Unveg	T1 Veg	-11.88	< 0.0001	Significant
Sediment bacterial abundance	T2 Unveg	T2 Veg	-11.16	< 0.0001	Significant
Sediment bacterial abundance	T1 Transition	T2 Transition	0.94	0.3716	Not
Sediment bacterial abundance	T1 Unveg	T2 Unveg	-0.92	0.3616	Not
Sediment bacterial abundance	T1 Veg	T2 Veg	-0.531	0.5983	Not
Sediment organic content	T1 Unveg	T1 Veg	-0.774	0.4473	Not
Sediment organic content	T2 Unveg	T2 Veg	-1.120	0.2699	Not
Sediment organic content	T1 Transition	T2 Transition	0.621	0.5518	Not
Sediment organic content	T1 Unveg	T2 Unveg	-0.637	0.5295	Not
Sediment organic content	T1 Veg	T2 Veg	-0.634	0.53	Not
Sediment moisture content	T1 Unveg	T1 Veg	-0.890	0.3788	Not
Sediment moisture content	T2 Unveg	T2 Veg	-3.341	0.0023	Significant
Sediment moisture content	T1 Transition	T2 Transition	-0.328	0.7495	Not
Sediment moisture content	T1 Unveg	T2 Unveg	1.153	0.2561	Not
Sediment moisture content	T1 Veg	T2 Veg	-2.208	0.0359	Not
Sediment carbon content	T1 Unveg	T1 Veg	1.852	0.072	Not
Sediment carbon content	T2 Unveg	T2 Veg	2.552	0.0162	Not
Sediment carbon content	T1 Transition	T2 Transition	-1.679	0.1189	Not
Sediment carbon content	T1 Unveg	T2 Unveg	1.354	0.1832	Not
Sediment carbon content	T1 Veg	T2 Veg	-1753	0.088	Not

Table 4. A summary of all of the t-test results for the June 2008 data. For more detailed information regarding the results of each test, see appendix B.

4.3 Variogram Analyses

The semi-variograms generated for the data in this study are presented in this section. When fitting mathematical models to the data in these figures, differing arguments (many of them valid) could be made regarding which model(s) would constitute a "good fit" for the data over a given distance in a given figure; however, after trying to fit a variety of different models (exponential, linear, quadratic, cubic, sigmoidal, hyperbola, power function, and Gaussian) to the various visual patterns in each figure, the decision was made (by the author) that models which produced an r^2 value below 0.80 would not be considered to adequately fit the data over the given separation distance tested with that model. Therefore, the reader should note that all of the above mentioned models were fitted to the visual patterns in the data in each figure, and in figures where data is described as displaying a "pure nugget" effect, all of these models yielded an r^2 value of less than 0.80. The decision to use this convention is particularly important when one considers that for the data ranges in which models were fit and are presented as such, r^2 values of 0.97+ are obtained.

After a literature and text book search, it became apparent that no definite rules exist that are widely accepted regarding what r^2 values constitute a good fit, a fair fit, or a poor fit etc. - particularly on the subject of fitting mathematical models to semi-variogram data. The above convention has therefore been adopted for this study since the difference between, for example, an r^2 value of 0.98 and an r^2 of 0.78 is quite striking.

It is important to note that the models applied in the semi-variogram figures presented below are not intended to allow the reader to project data beyond what is presented or extrapolate further data points as is sometimes the case with mathematical models applied to other types of figures. These models applied herein are actually visual guideposts that aid in

determining what the range is and where sill might occur on a given figure, and these in turn, help to quantitatively determine correlation length scales and bacterial community patch size. These are the objectives of the mathematical modeling throughout this section. The decision regarding which data points to use when fitting a model is based entirely on visual inspection of noticeable shapes and patterns in the variogram data.

4.4 AODC Bacteria Community Patch Size in the Water Column

The results of the geostatistical analyses done for the water column bacterial abundance in transect one during November 2007 and June 2008 are shown in Figures 15 and 16. From the figures is it apparent that abundance at spatial separation scales from 0.25 m to 8 m was more variable in November than in June. The pattern displayed by the November data is more "noisy" than the June data. After consulting historical weather records for Melfa, VA (one of the nearest location to South Bay where this type of data was readily available) it became apparent that the area experienced differing wind conditions prior to each sampling event. For the two days preceding the November 8, 2007 sampling, the recorded wind speeds were as follows: on November 6, 2007 average wind speed was 7 mph with gusts up to a maximum of 34 mph; on November 7, 2008 average wind speed was 14 mph with gusts up to a maximum of 26 mph (Weather Underground website). For the two days preceding the June 17, 2008 sampling, the recorded wind speeds were as follows: on June 15, 2008 averaged wind speed was 2 mph with gusts up to a maximum of 17 mph; on June 16, 2008 wind speeds averaged 4 mph with maximum gusts up to 17 mph (Weather Underground website). Clearly, the wind conditions on the two days prior to the November sampling were higher than the two days preceding the June sampling event. Higher winds in the area combined with the observation of a less dense/vibrant seagrass bed in November could have a significant effect on the higher scatter of the November

data. Higher winds coupled with a (relatively) lessened stabilizing influence of the seagrass bed in November could quite easily result in particulate matter being entrained into the water column much more freely than might happen in June. This would cause issues during the sampling of the water column as the ability to capture only free living bacteria (in the water column) versus particle attached bacteria (stirred up from the sediment) would be hampered. Unavoidable "noise" might occur as sediment dwelling bacteria could more easily be captured in the water column, which could account for higher variance in data from November.

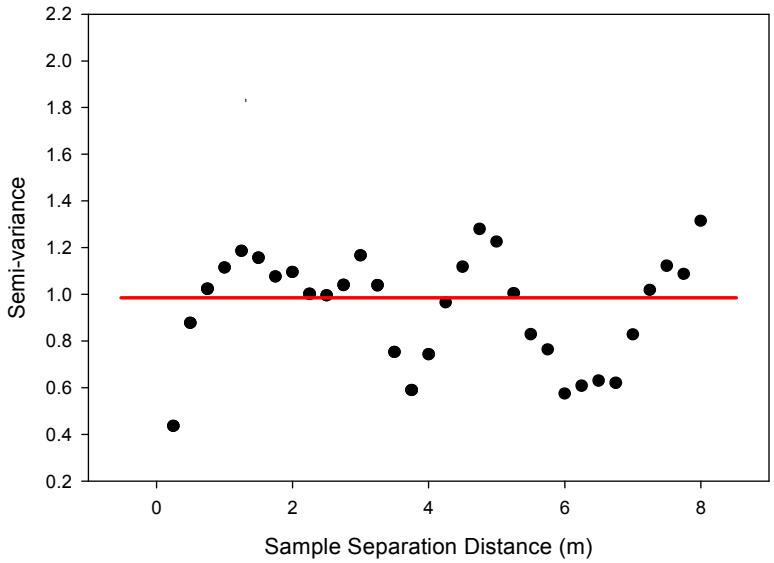


Figure 15: Semi-variogram of bacterial abundance in Transect 1 in November 2007. Data were variable; however, no mathmatical models adequately fit the patterns seen. Therefore spatial autocorrelation is present throught the distance examined and the data exhibit a pure nugget effect.

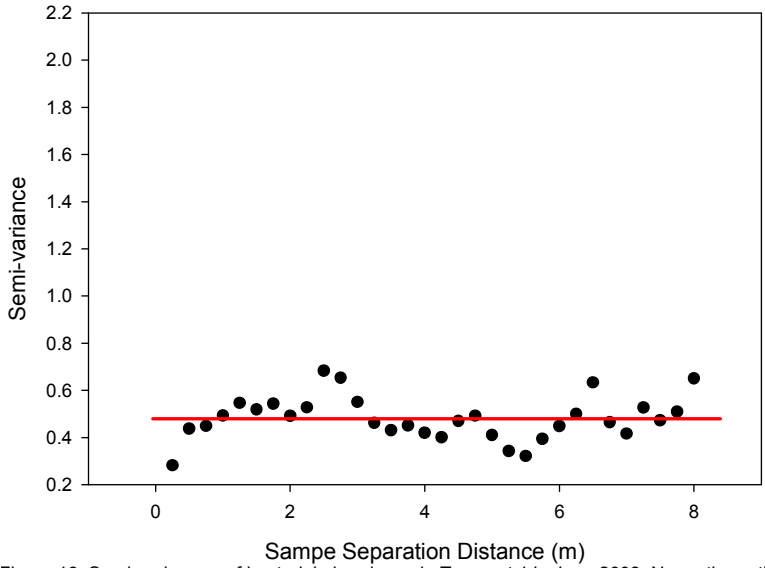


Figure 16: Semi-variogram of bacterial abundance in Transect 1 in June 2008. No mathematical models applied adequately fit the data. Therefore a pure nugget effect is observed.

An alternating pattern was seen for the water column bacterial abundance variograms for Transect 1 in both months(Figures 15 and 16). However, application of mathematical models yielded no fit higher than an r^2 of 0.80, so based on the criteria set forth here the data were deemed to show a "pure nugget" effect for this transect in both months. That is, no detectable spatial structure exists for these data at the scale on which sampling was conducted, and autocorrelation is not present throughout these distances. Sampling was conducted at either too small or too large a scale in the water column to capture a demonstrable spatial structure. The spatial scale sampled was too large to account for potential differences in bacterial abundance associated with free living cells vs. bacterial communities attached to particulates in the water column. Likewise, the spatial scale sampled was likely too small to account for the scale at which tidal mixing of the water column in South Bay occurs. The same can be said for the June water column data for Transect 1, as the data in Figure 16 above illustrate a pure nugget effect, as no spatial structure is present regarding bacterial abundance in this month at

this spatial scale. A likely explanation for this is that the tidal mixing occurring in the shallow water column helps to homogenize bacterial community abundance in the water column at the spatial scale examined here. This is not unexpected given the shallow water column and wind-driven nature of the lagoon system.

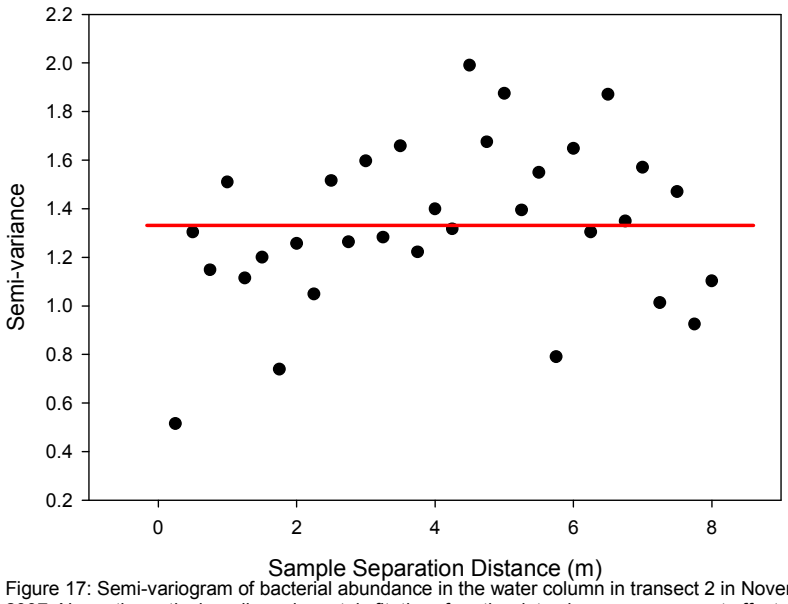


Figure 17: Semi-variogram of bacterial abundance in the water column in transect 2 in November 2007. No mathematical modles adequately fit, therefore the data show a pure nugget effect.

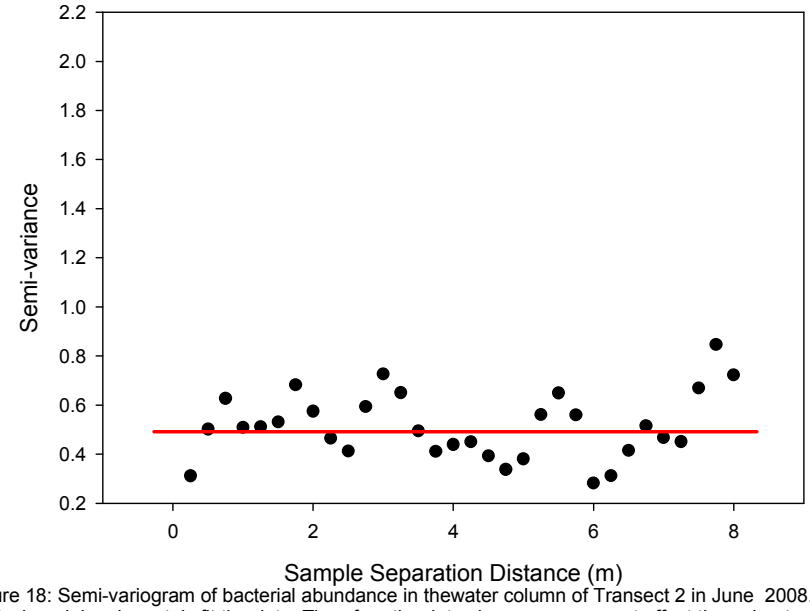


Figure 18: Semi-variogram of bacterial abundance in thewater column of Transect 2 in June 2008. No ma matical models adequately fit the data. Therefore the data show a pure nugget effect throughout.

The results of the geostatistical analyses for bacterial abundance in water column in Transect 2 in November 2007 and June 2008 are shown in Figures 17 and 18. These figures show a very similar result to those seen above for Transect 1 in Figures 15 and 16. Again, the variance in bacterial abundance is slightly higher in November than June, possibly due to the differences in weather and vegetation conditions at the sampling event. The r^2 values for all mathematical models applied did not approach the 0.80 mark, suggesting that both months show a pure nugget effect with no spatial autocorrelation occurring at these spatial scales. These results indicate that no spatial structure exists for bacterial abundance in the water column in either month for Transect 2 at the spatial scale used here.

4.5 AODC Bacteria Community Patch Size

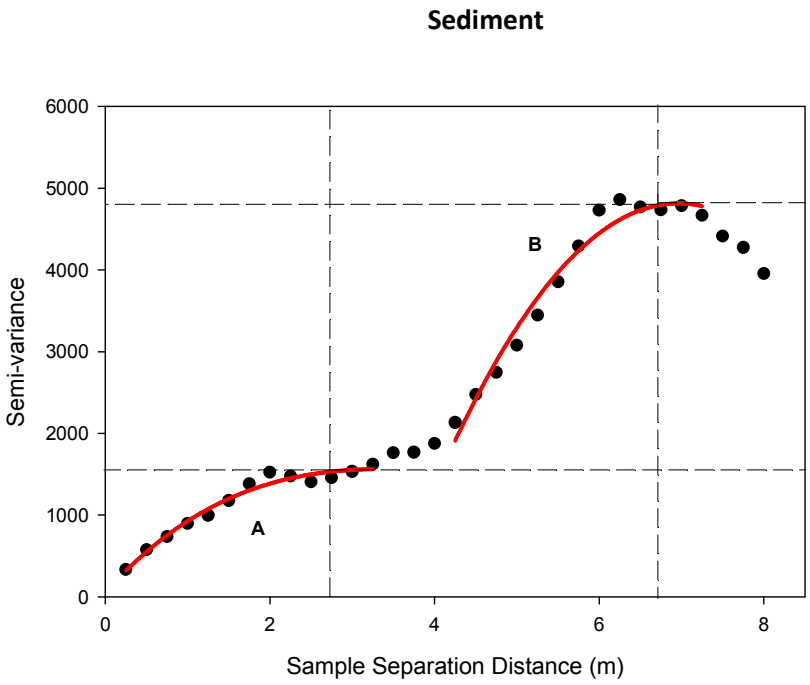


Figure 19: Semi-variogram of bacterial abundance in sedimet of 1 in November 2007. Two mathematical models were fitted to this data. The models show sills occurring at semi-variances around 1450 and 4800, with a range of 2.5 meters and 6.5 meters respectively. This indicates that bacterial abundance in the samples ceased to be autocorrelated on two different spatial scales within the transect.

Sediment bacterial abundance was correlated over two spatial scales in Transect 1 in November 2007 (Figure 19). The first correlation length scale (= patch size) occurs at a sample separation distance between 2 and 3 m, while the second occurs between 6 and 7 m. Some details of the two mathematical models fitted to the data are given in Table 3 below.

Date	Model	Equation Type	y^o	a	b	r^2
November, 2007	A	Cubic	57.741	1113.0335	-263.3677	0.9973
November, 2007	B	Quadratic	-14333.71	5502.17	-395.28	0.9984

Table 5: The model output data for the two equations fitted to the data in Figure 19 are given here. For the first model, A, a cubic equation was used. For the second model, B, a quadratic equation was used.

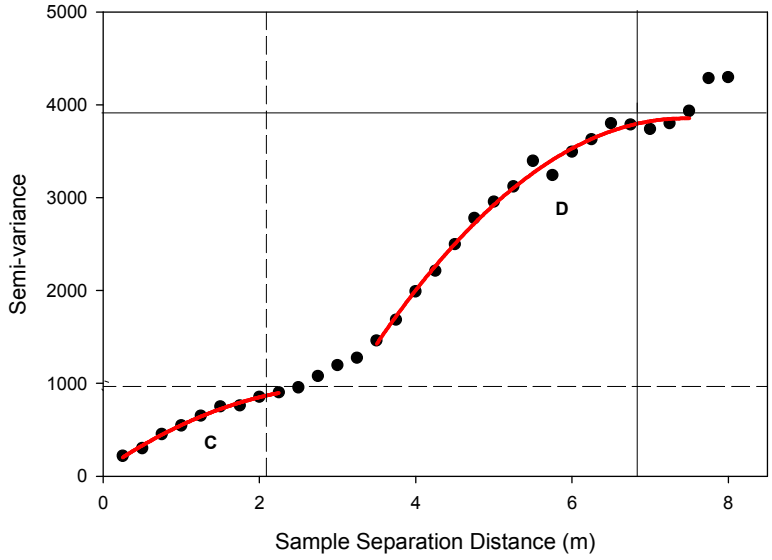


Figure 20: Semi-variogram of bacterial abundance in sediments in transect 1 in June 2008. Two mathematical models we fitted to this data. The models show sills occurring at semi-variances around 950 and 3780, with a range of 2.25 meters and 6.8 meters respectively. This indicates that bacterial abundance in the samples ceased to be autocorrelated on two different spatial scales within the transect.

As was the case in November 2007, bacterial abundance in June 2008 was correlated over two different spatial scales in Transect 1 in June 2008 (Figure 20). The first correlation length scale (= patch size) occurred at a sample separation distance just beyond 2 m, a slightly smaller distance than in the November 2007 results. The results from the models applied to the data in this figure are given in Table 3 below. The second correlation length scale occurred around a sample separation distance of 7 m. Regardless of the month in which the samples were taken the correlation length scales were very similar for Transect 1.

Date	Model	Equation Type	y^o	a	b	r^2
November, 2001	C	Quadratic	64.0337	577.8276	-92.4236	0.9992
November, 2007	D	Quadratic	-4802.6451	2326.4444	-156.3169	0.9995

Table 6: The model output data for the two equations fitted to the data in Figure 20 are given here. For the first model, C, a cubic equation was used. For the second model, D, a quadratic equation was used.

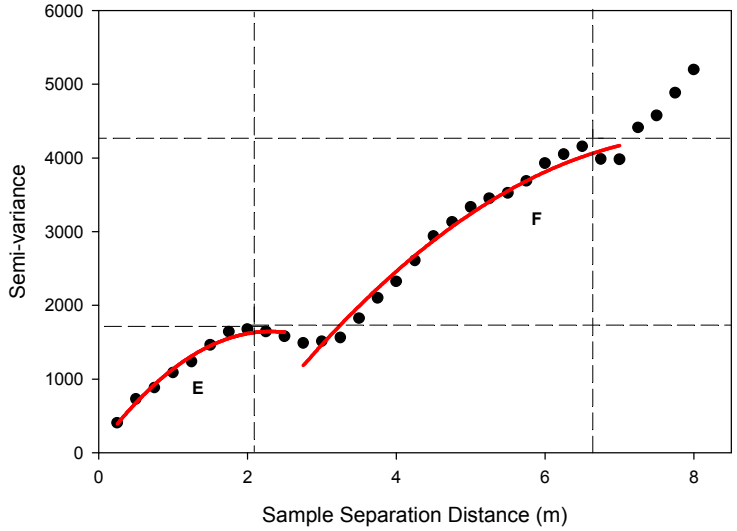


Figure 21: Semi-variogram of bacterial abundance in sediments in transect 2 in November 2007.Two mathematic models were fitted to this data. The models show sills occurring at semi-variances around 1600 and 4100, with a range of 2.25 meters and 6.5 meters respectively. This indicates that bacterial abundance in the samples cease to be autocorrelated on two different spatial scales within the transect.

Similar to the Transect 1 results, there were two correlation length scales in November 2007 for transect 2 (Figure 21). The first correlation length scale (= patch size) occurred at a sample separation distance just beyond 2 m. The second correlation length scale occurred at a separation distance of around 6.5 to 7 m. The results from the models applied to the data in this figure are given in Table 5 below.

Date	Model	Equation Type	y^o	a	b	r^2
June, 2008	E	Quadratic	66.8167	1365.8422	-295.423	0.9983
June, 2008	F	Quadratic	-2796.0267	1739.8187	-106.4396	0.9982

Table 7: The model output data for the two equations fitted to the data in Figure 21 are given here. For the first model, E, a cubic equation was used. For the second model, F, a quadratic equation was used.

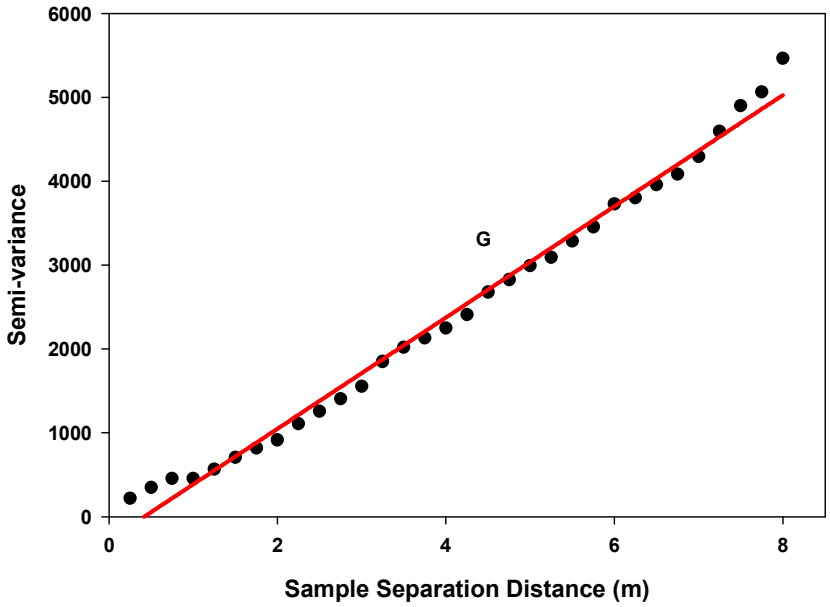


Figure 22: Semi-variogram of bacterial abundance in sediments in transect 2 in June 2008. A linear mathematicalmodel was fitted to this data, which shows spatial autocorrelation of bacterial abundance occurring throughout the entirety of the transect, indicating that samples were taken on either too large or too small a scale to fully capture the entirety of bacterial community size.

A linear model gave the highest r^2 (0.99) for bacterial abundance along Transect 2 for the June 2008 data (Figure 22). This result, quite different from the other sediment abundance results from either month, indicates that spatial autocorrelation is present throughout the entirety of the transect. In this situation the bacterial abundance became more different as the separation distance between samples was increased; however, the data have not yet reached their maximum difference. This result also suggests that sampling scales would need to be greater than 12 m in order to obtain the distance at which the bacterial abundance ceases to be autocorrelated. The mathematical model information for this figure is given in Table 6 below. This result (Figure 22) does not imply a lack of spatial structure at smaller scales, only that when samples are collected 0.25 m apart the bacterial communities are autocorrelated over a distance of at least 8 m. Extending the sample separation distance to the limits of the total sampling interval (12 m) suggests that there may be a sill occurring in the data around a distance of about 10.5 m; however, it is important to note that due to the relatively few pairs of data

compared at these larger separation distances, this result is somewhat questionable at best. Though it does lend credence to the idea that the bacterial community patch size for this transect in this month was likely greater than the 8 meter separation distance presented in Figure 22.

Date	Model	Equation Type	y^o	a	b	r^2
June, 2008	G	Linear	-277.2259	663.092	n/a	0.9973

Table 6: The model output data for the equation fitted to the data in Figure 22 is given here. A linear model was used in this instance.

When comparing the results of the sediment bacterial community patch size to the results from the water column variograms we see that that community size in the water column exists on a much larger spatial scale than in the sediment. Patch size was generally around 2 m and 7m in the sediment, while in the water column, results suggest that patch size is much different – either much smaller or much larger.

4.6 Geostatistical Analysis of Sediment Characteristics

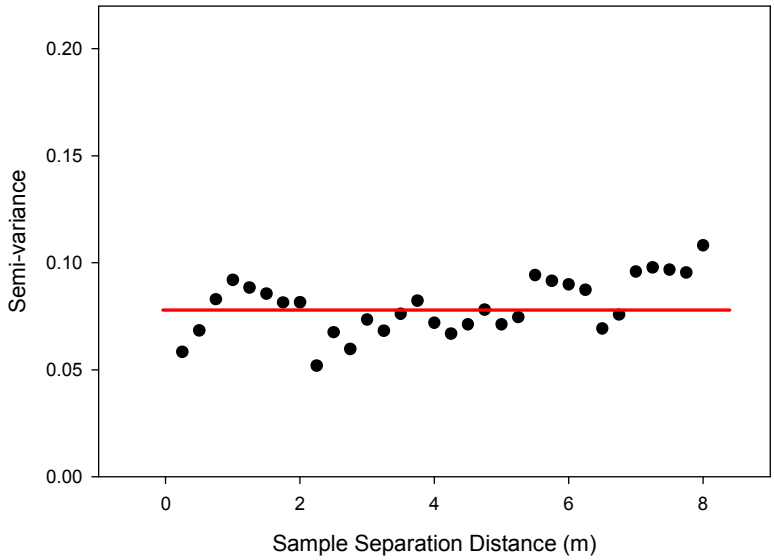


Figure 23: Semi-variogram depicting spatial variation in sediment organic content in transect 1 in November 2007. No mathematical models fit the data suitably indicating that the data display a "pure nugget" effect. This means that spatial autocorrelation exists over the entire sampling distance. The samples were taken at either too small or too large a scale to capture significant differences in sediment organic content in this transect.

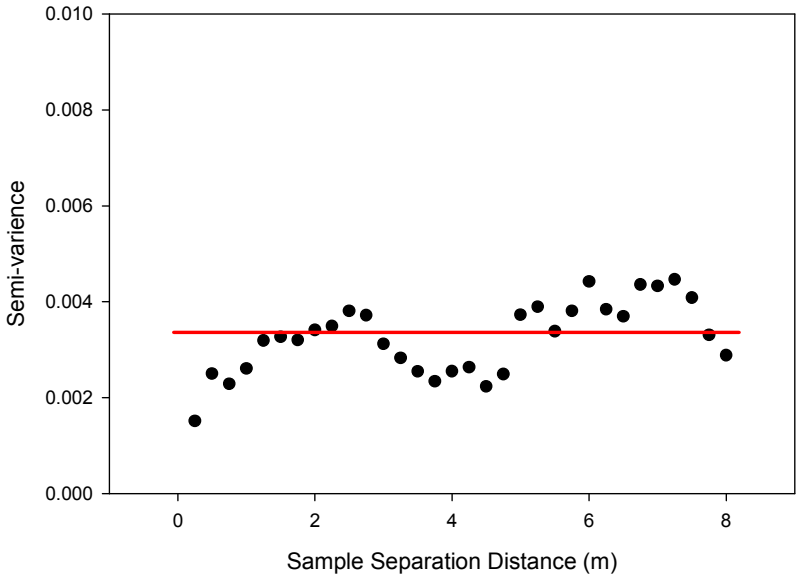


Figure 24: Semi-variogram of percent organic content in Transect 1 in June 2008. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefore, spatial autocorrelation exists over the entire distance examined. The samples were taken at too large or too small a separation distance to capture significant differences in organic content in this transect.

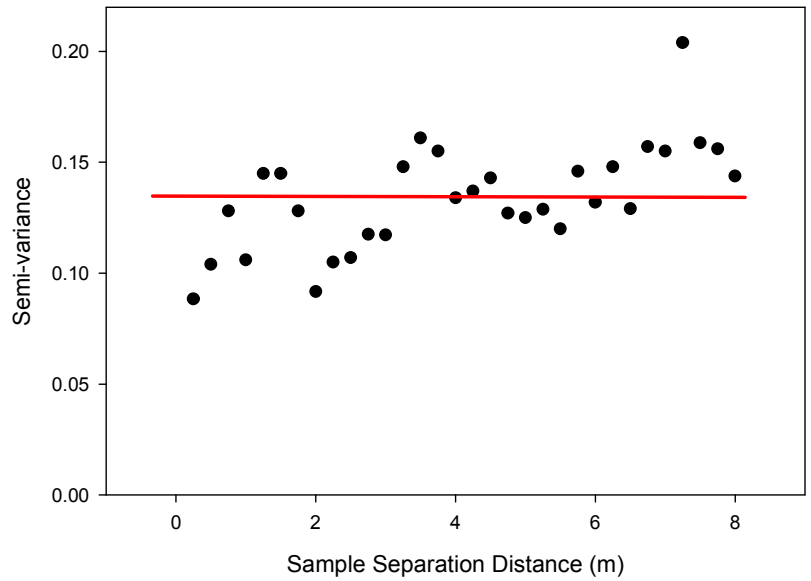


Figure 25: Semi-variogram of percent organic content in Transect 2 in November 2007. No mathe-maticalmodels adequately fit the data, indicating a "pure nugget" effect. Therefore, spatialautocorrelation exists over the entire distance examined. The samples were taken at too large or too smalla separation distance to capture significant differences in organic content in this transect.

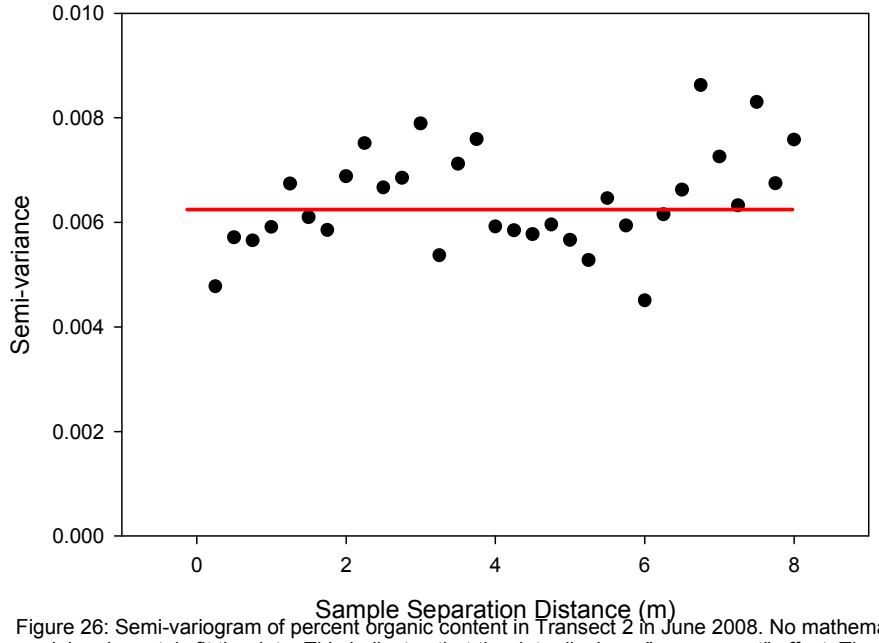


Figure 26: Semi-variogram of percent organic content in Transect 2 in June 2008. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefore, spatial auto correlation exists over the entire distance examined.

No mathematical models met the minimum criteria ($r^2 > 0.80$) for the results of the geostatistical analyses for the organic matter data for both transects during both months of sampling (Figures 23, 24, 25, and 26). Therefore, it was determined that each of these figures displays a pure nugget effect indicating that no definite spatial structure was present in either transect in either month at the spatial scale examined here. This means that the spatial scale sampled was not sufficient to capture the scale at which organic content is structured in the study area, and future sampling should be done on a much smaller or larger scale than what was done in this instance.

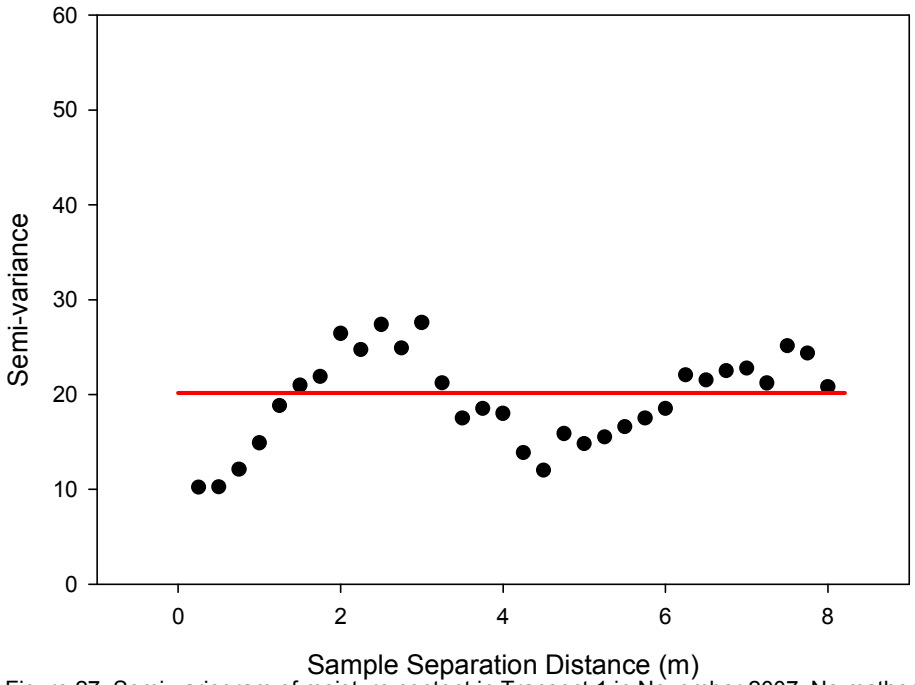


Figure 27: Semi-variogram of moisture content in Transect 1 in November 2007. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefore,spatial auto correlation exists over the entire distance examined.

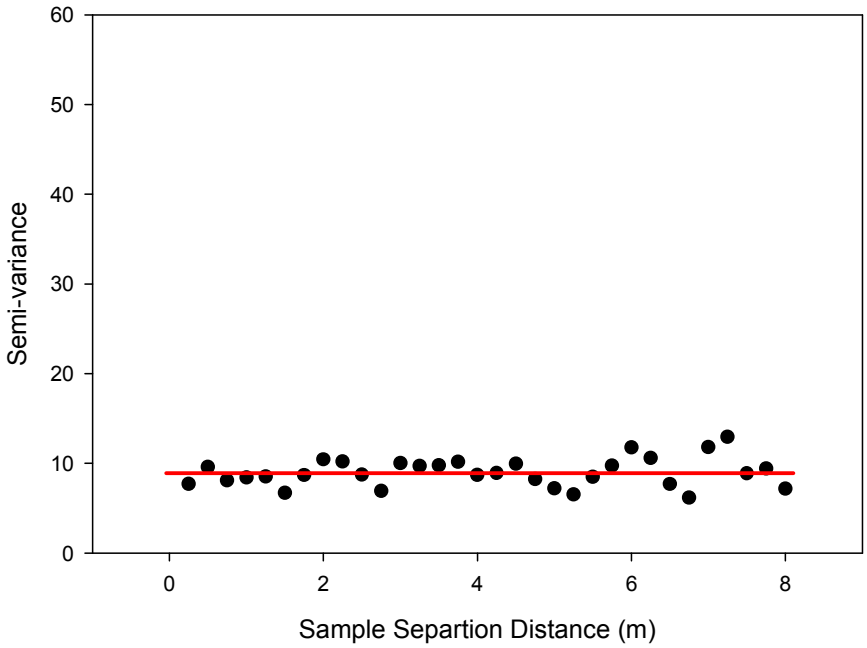


Figure 28: Semi-variogram of moisture content in Transect 1 in June 2008. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefo spatial auto correlation exists over the entire distance examined.

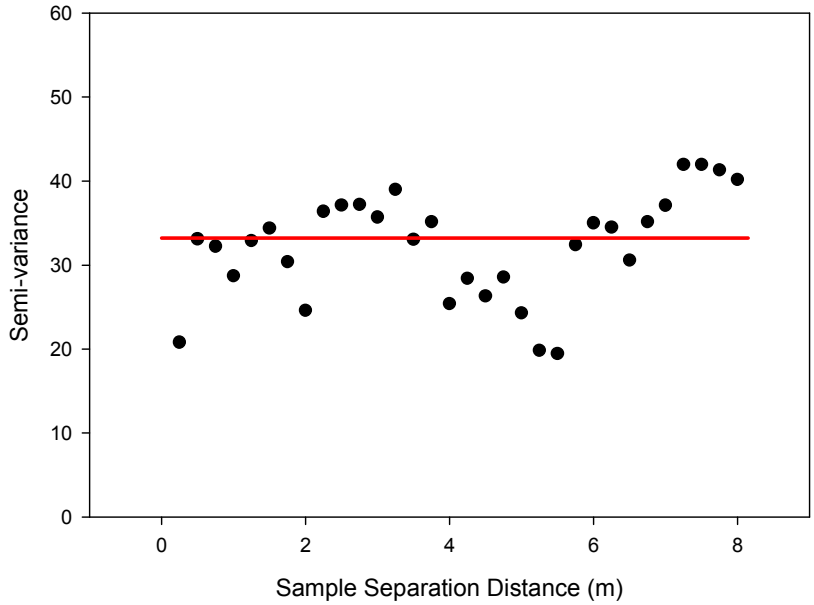


Figure 29: Semi-variogram of moisture content in Transect 2 in November 2007. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefore, spatial auto correlation exists over the entire distance examined.

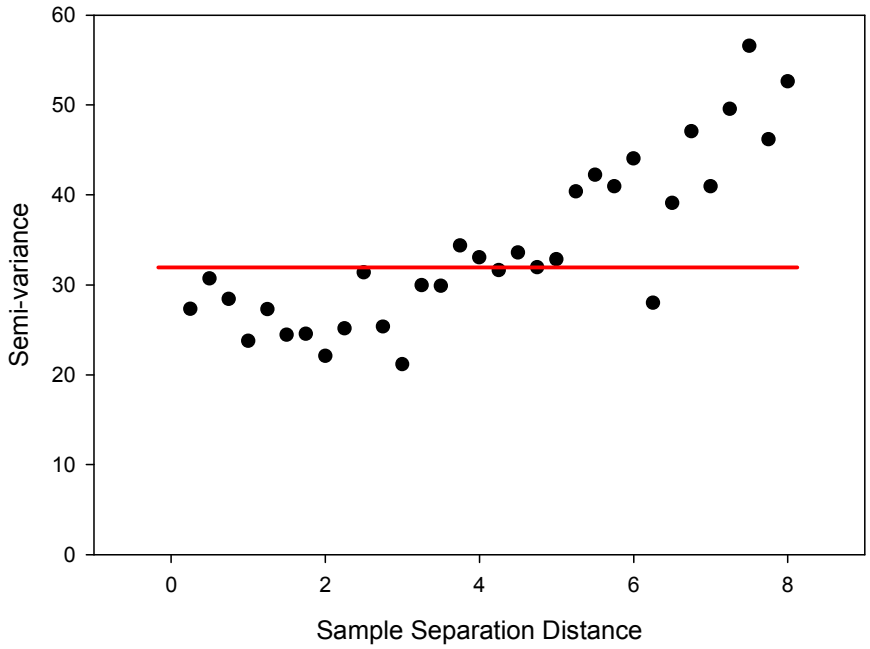


Figure 30: Semi-variogram of moisture content in Transect 2 in June 2008. No mathematical models adequately fit the data. This indicates that the data display a "pure nugget" effect. Therefore, spatial auto correlation exists over the entire distance examined.

No mathematical models applied to the data produced a high enough r^2 value to be considered anything other than displaying a pure nugget for the getostatistical analysis of sediment moisture content in either transect in either month (Figures 27, 28, 29, 30). Moisture content was therefore not spatially structured at the length scale sampled in this study, nor does it explain the spatial structure of bacterial abundance. These results might not be unexpected because the sediment along the length of each transect is completely inundated with water 24 hours a day. The potentially higher porosity of the vegetated sediments may play a minor role in controlling moisture content in certain areas of each transect, and account for the higher variance at greater separation distances (e.g. samples in vegetated zones vs. unvegetated zones of Transect2). The overriding influence on sediment moisture content appears to the constant inundation with bay water over the length of each transect regardless of season.

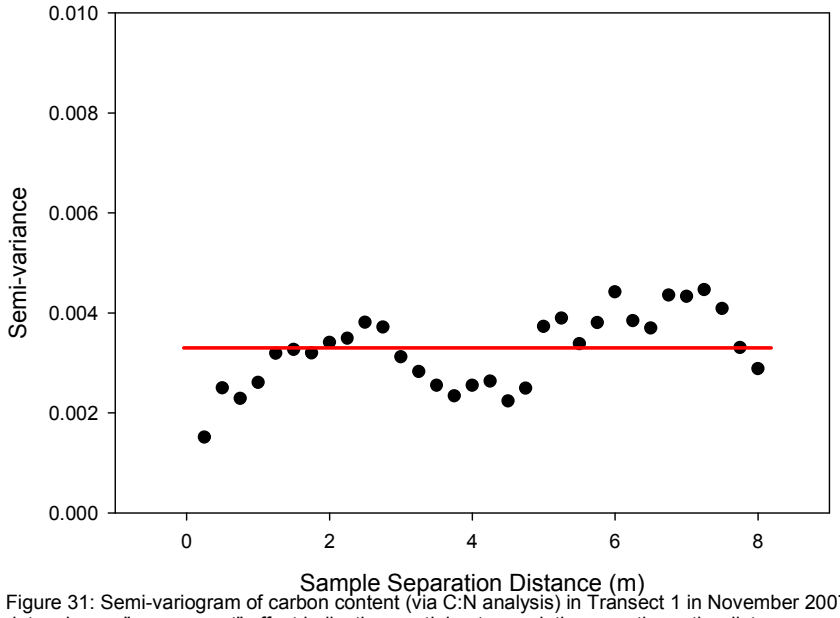


Figure 31: Semi-variogram of carbon content (via C:N analysis) in Transect 1 in November 2007. The data, show a "pure nugget" effect indicating spatial autocorrelation over the entire distance examined.

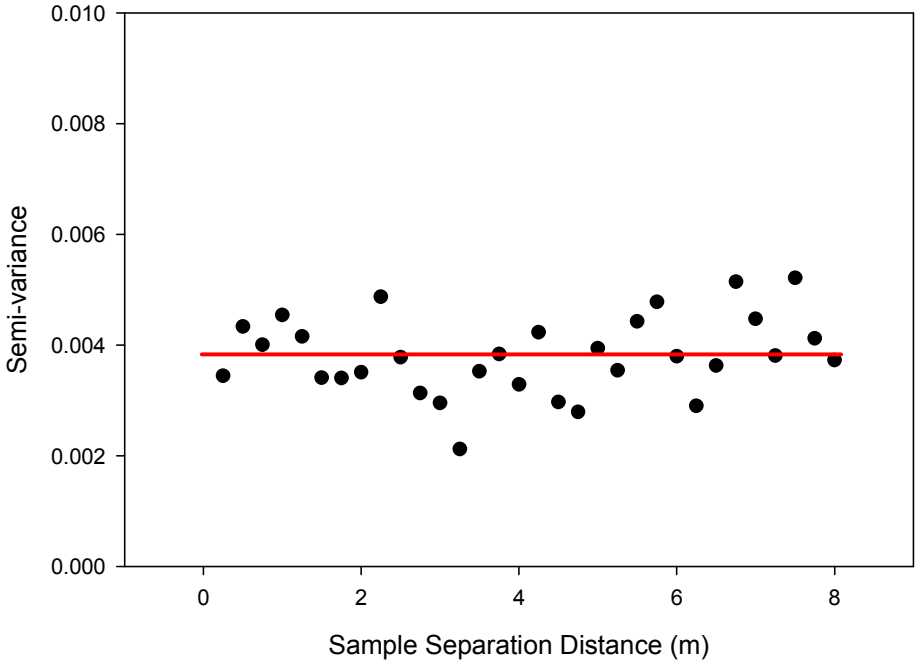


Figure 32: Semi-variogram of carbon content (via C:N analysis) in Transect 1 in June 2008. The data, show a "pure nugget" effect indicating spatial autocorrelation over the entire distance examined.

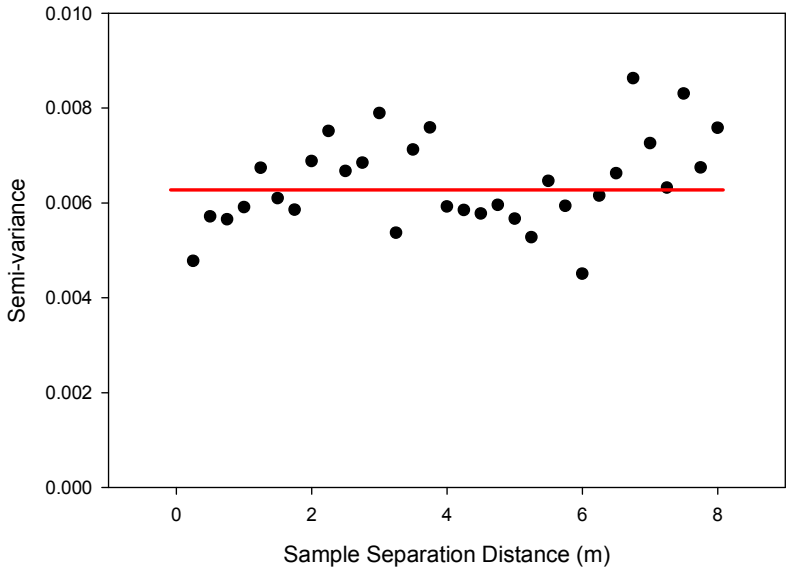


Figure 33: Semi-variogram of carbon content (via C:N analysis) in Transect 2 in November 2007. The data, show a "pure nugget" effect indicating spatial autocorrelation over the entire distance examined.

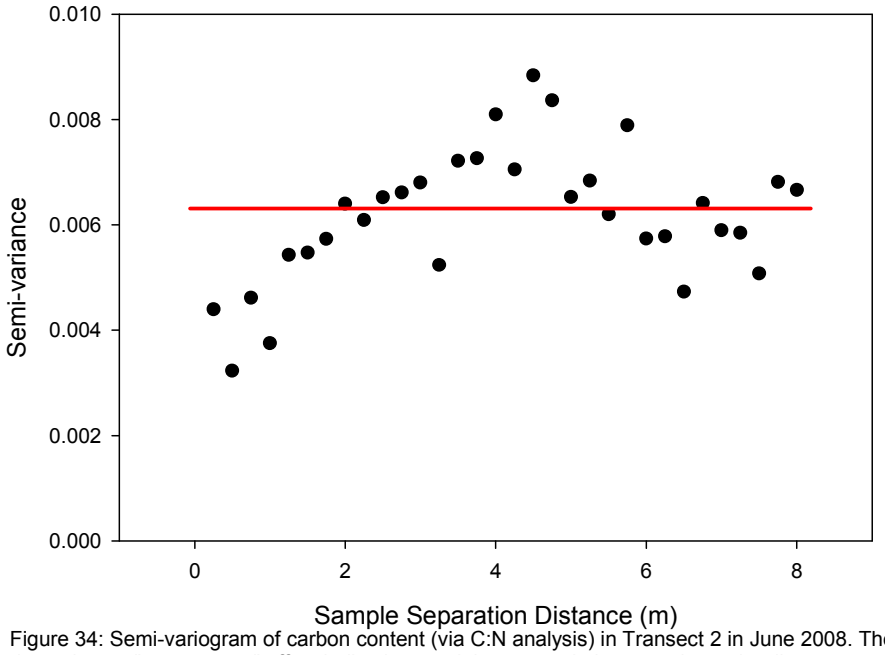


Figure 34: Semi-variogram of carbon content (via C:N analysis) in Transect 2 in June 2008. The data, show a "pure nugget" effect indicating spatial autocorrelation over the entire distance examined

The results for the geostatistical analyses for the carbon content (from carbon to nitrogen ratio analysis) along each transect were determined to be pure nugget throughout each transect in both months (Figures 31, 32, 33, and 34). This indicates that at the spatial scale sampled, no spatial structure exists in for any of the measured sediment properties. Sampling on a larger spatial scale will probably help to elucidate the heterogeneity in this environment; however, the question remains: how large or small does that spatial scale have to be? It should be noted that the results of the geostatistical analyses for the sediment parameters displays a lack of correlation with sediment bacterial community patterns. This is somewhat puzzling as it would suggest that these factors are not the determining influence on bacterial spatial structure in the sediments of this area. In the future, other parameters (e.g. sediment oxygen concentrations) should be examined. Another influencing factor could be the release of DOC from seagrass roots, which could fuel bacterial metabolism. This labile carbon pool is not reflected in the sampling and analyses conducted in this study.

Chapter 5: Concluding Remarks

There was no spatial pattern in bacterial abundance in the water column between the two transects or across vegetation zones in either November 2007 or June 2008. All of the bacteria abundance variograms for the water column conformed to a linear model with a slope of 0. This means that there was no spatial autocorrelation as well as a lack of spatial structure to bacterial community abundance in the water column at the scale sampled. This could most likely be attributed to the near constant tidal mixing in the shallow water column of South Bay. In order to capture the spatial structure of bacterial community abundance in future efforts, sampling should probably be conducted on a much larger or smaller scale than what was attempted here. However, extremely small spatial scales (i.e. much less than 0.25m) cannot be completely ruled out either.

Bacterial abundance in the sediment was orders of magnitude higher than in the water column, and abundance generally increased from unvegetated to vegetated areas as would be expected due to the rhizosphere effect and organic matter cycling. The sediment variograms generally showed 2 correlation length scales and a patch size of 2-3 m and another of 6-7 m. One explanation for this is that changing vegetation conditions exert an influence on these length scales, as samples around 5-7 m (a typical correlation length scale found here) is a result of each 12 m transect being approximately half vegetated. This would mean that, at this separation distance, samples are more likely to come from different vegetation zones. Community patch size in the sediment was similar in the fall and the summer; however in Transect 2 in June the community patch size appeared to be larger than it was for the same transect in November, suggesting that some seasonal change might be influencing the numbers of bacteria in this transect in differing seasons of the year .

Sediment properties such as organic content, moisture content, and percent carbon generally fluctuated throughout each transect with no detectible spatial patterns in either month. The correlation length scales for the sediment properties measured did not match up with the patch sizes seen for the bacteria in the sediment. This suggests that some other properties are structuring bacteria in these areas. What these influencing factors are is yet to be determined, but could include things like spatial differences in sediment pH, DOC concentrations, sediment oxygen content, and spatially differing concentrations of other compounds such as iron oxides and sulfate (Fru 2009; Lauber et al. 2008). These parameters should be among those considered during future work in this area.

Appendix

VI. Appendix A

Microbial DNA Extraction and Preservation for Future Analyses

Microbial DNA was extracted from all samples (sediment and water) using MoBio Power Clean Soil DNA ® kits. These kits have been successfully used in other studies at the VCR-LTER (Franklin et al. 2002 & 2003; Floyd 2007). Due to the fact that these extraction kits are designed for soils, a slight modification of the protocol will be used that involves filtering a known volume of 30 ml from each water sample through a 0.2um polycarbonate filter (Franklin et al. 2000). For the sediment samples, the factory provided protocol was followed.

These kits yield DNA of high purity for sediments and water and they reduce the amount of PCR inhibition by nucleic acids in samples. Following this study, the DNA will be used in the bacterial community fingerprinting technique DGGE, which will add another dimension to the information gained from this study. This technique (DGGE) has been used in numerous other studies similar to this one (Crump et al. 2003; Crump et al. 2004; Floyd 2007; Duineveld et al. 2001; Ibekew et al. 2002; Lovell et al. 2000; Muyzer et al. 1993; Muyzer & Smalla 1998; Piceno & Lovell 2000; Smalla et al. 2001). (Crump et al., 2004; Crump et al., 2003; Holmer et al. 2004; Kaldy et al. 2006; Ibekwe et al., 2002; Smalla et al., 2001). After completing all the analyses for this study, any remaining DNA can be frozen and preserved and archived for future analysis.

November 2007 Data

Table A1: Bacterial Abundance November 2007

Water Column

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
1	5.43	2.60
2	4.65	3.21
3	4.05	4.53
4	4.01	4.12
5	3.81	4.01
6	5.22	3.33
7	4.58	2.21
8	3.98	3.14
9	3.62	3.57
10	3.43	3.95
11	3.12	4.38
12	3.91	4.21
13	5.96	3.95
14	5.54	4.01
15	6.41	3.96
16	5.97	3.79
17	4.62	3.72
18	4.67	4.23
19	4.79	6.31
20	3.02	6.14
21	2.62	6.35
22	4.71	5.31
23	5.32	5.86
24	4.11	3.24
25	3.33	3.32
26	3.28	5.23
27	3.12	6.45
28	4.12	4.64
29	4.93	4.61
30	5.01	4.21
31	3.56	3.71
32	3.79	3.81
33	4.42	6.73
34	3.24	5.91
35	2.43	5.67
36	2.31	4.22

November 2007
Water Column (Continued)

Sample Position	**10^6 cells/ml Transect 1**	**10^6 cells/ml Transect 2**
37	5.38	3.69
38	5.18	4.21
39	4.65	4.43
40	5.21	3.87
41	4.82	3.65
42	4.77	4.91
43	5.05	5.89
44	4.67	4.76
45	3.88	4.67
46	3.91	4.13
47	3.06	5.53
48	4.02	3.87

Table A2: Bacterial Abundance November 2007

Sediment

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
1	90.1	88.1
2	89.6	95.2
3	92.3	84.5
4	95.2	94.1
5	101.0	93.4
6	84.1	97.8
7	68.0	102.0
8	72.8	120.0
9	81.0	137.0
10	79.5	115.0
11	46.2	70.6
12	88.2	80.0
13	147.0	162.0
14	101.0	111.0
15	164.0	102.0
16	99.0	99.0
17	64.7	88.9
18	67.6	95.5
19	66.3	90.5
20	65.0	89.2
21	67.1	88.9
22	72.0	95.0
23	66.1	103.0
24	100.0	110.0
25	149.0	170.0
26	143.0	156.0
27	141.0	166.0
28	139.0	149.0
29	146.0	143.0
30	167.0	157.0
31	195.0	117.0
32	191.0	154.0
33	151.0	158.0
34	157.0	146.0
35	162.0	197.0
36	167.0	216.0

November 2007
Sediment (Continued)

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
37	157.0	248.0
38	143.0	234.0
39	147.0	211.0
40	171.0	246.0
41	181.0	254.0
42	184.0	201.0
43	179.0	196.0
44	201.0	155.0
45	253.0	102.0
46	211.0	161.0
47	199.0	184.0
48	199.0	176.0

Table A3: Sediment Data

November 2007
% Organic Content

Sample Position	Transect 1	Transect 2
1	0.5904	0.7895
2	0.6506	1.2084
3	0.7564	0.5736
4	0.8171	0.7166
5	0.8602	0.8033
6	0.9264	0.8784
7	0.7188	0.7785
8	0.7165	0.7866
9	1.5446	0.9844
10	1.1242	0.3705
11	0.8717	0.8436
12	0.8228	3.5422
13	0.3640	0.8324
14	1.3003	0.4258
15	0.7868	0.6001
16	0.9376	0.4831
17	0.7464	1.2016
18	0.6291	0.3294
19	0.8668	0.9573
20	0.8796	0.7802
21	0.8358	1.4463
22	0.9913	3.1656
23	1.6102	0.9410
24	0.6871	1.5123
25	1.2364	1.4325
26	1.3107	0.8536
27	1.1518	2.7607
28	0.7188	0.8144
29	0.9937	1.0596
30	1.0316	0.7141
31	0.8324	0.7914
32	1.1004	1.5750
33	1.0133	2.2317
34	1.2705	1.3978
35	1.3392	0.8199
36	1.3657	1.0002

November 2007
% Organic Content (Continued)

Sample Position	Transect 1	Transect 2
37	0.6853	0.7377
38	0.7878	0.7744
39	0.6686	0.9010
40	0.7889	0.9823
41	0.8964	1.2685
42	1.2037	1.0735
43	1.3627	1.6410
44	1.6596	1.0649
45	1.2307	1.0799
46	1.0789	0.8331
47	0.9481	1.4116
48	0.9645	0.8820

Table A4: Sediment Data

November 2007
% Moisture

Sample Position	Transect 1	Transect 2
1	30.4485	28.6900
2	24.3228	29.6357
3	27.7440	26.0661
4	29.7216	22.8373
5	28.1460	27.6441
6	28.4392	28.3861
7	27.7566	29.6464
8	25.5033	26.9569
9	28.0238	27.3690
10	26.2879	25.1080
11	26.6677	33.5332
12	30.1012	34.6059
13	27.9569	29.3164
14	27.7717	25.0552
15	30.0891	29.2875
16	28.2041	26.1536
17	28.1608	25.0539
18	32.4286	25.6656
19	26.9683	29.3747
20	24.1557	27.9407
21	27.3142	29.3546
22	30.4482	26.4936
23	27.2214	4.9303
24	12.2950	24.0148
25	27.6322	29.9377
26	24.8114	28.6489
27	27.8732	27.3599
28	24.6452	29.5924
29	28.9832	31.1836
30	26.0367	25.5177
31	27.0369	28.2502
32	38.5643	32.8770
33	37.0359	59.1544
34	37.8708	37.0428
35	35.9500	26.1999
36	46.8306	30.2204

November 2007
% Moisture (Continued)

Sample Position	Transect 1	Transect 2
37	27.6026	28.9257
38	32.5860	27.4272
39	30.3242	26.5974
40	29.0327	28.1899
41	32.0327	38.7394
42	27.0369	28.6959
43	26.0630	29.3199
44	25.2742	30.2469
45	27.0366	28.9528
46	28.0365	24.1404
47	28.8426	30.9166
48	28.2270	33.3954

Table A5: Sediment Data

November 2007
C:N Analysis

	Transect 1		Transect 2	
Sample Position	**% C**	**% N**	**% C**	**% N**
1	0.0432	0.0000	0.1658	0.0000
2	0.0350	0.0000	0.1856	0.0000
3	0.8023	0.0000	0.2732	0.0000
4	0.0999	0.0000	0.0547	0.0000
5	0.1121	0.0000	0.1327	0.0000
6	0.1122	0.0000	0.0466	0.0000
7	0.0346	0.0000	0.0326	0.0000
8	0.0398	0.0000	0.0987	0.0000
9	0.0269	0.0000	0.1822	0.0000
10	0.0312	0.0000	0.0530	0.0000
11	0.0426	0.0000	0.1326	0.0000
12	0.0415	0.0000	0.1325	0.0000
13	0.0347	0.0000	0.1016	0.0000
14	0.0327	0.0000	0.1214	0.0000
15	0.0224	0.0000	0.1915	0.0000
16	0.0265	0.0000	0.4653	0.0000
17	0.0301	0.0000	0.0569	0.0000
18	0.0765	0.0000	0.0329	0.0000
19	0.1982	0.0000	0.0681	0.0000
20	0.0654	0.0000	0.0513	0.0000
21	0.0588	0.0000	0.0312	0.0000
22	0.2170	0.0000	0.1327	0.0000
23	0.1626	0.0000	0.0790	0.0000
24	0.0979	0.0000	0.0903	0.0000
25	0.0548	0.0000	0.0867	0.0000
26	0.1420	0.0000	0.1647	0.0000
27	0.0818	0.0000	0.0763	0.0000
28	0.1150	0.0000	0.0898	0.0000
29	0.0717	0.0000	0.1347	0.0000
30	0.0651	0.0000	0.0832	0.0000
31	0.1265	0.0000	0.1534	0.0000
32	0.0704	0.0000	0.2058	0.0000
33	0.0331	0.0000	0.1780	0.0000
34	0.0875	0.0000	0.1996	0.0000
35	0.0745	0.0000	0.1922	0.0000

November 2007
C:N Analysis(Continued)

	Transect 1		Transect 2	
Sample Position	**% C**	**% N**	**% C**	**% N**
36	0.1459	0.0000	0.2013	0.0000
37	0.2523	0.0000	0.2132	0.0000
38	0.2146	0.0000	0.1644	0.0000
39	0.1355	0.0000	0.1479	0.0000
40	0.1333	0.0000	0.2963	0.0000
41	0.1294	0.0000	0.1702	0.0000
42	0.0725	0.0000	0.1644	0.0000
43	0.0821	0.0000	0.1004	0.0000
44	0.1235	0.0000	0.1567	0.0000
45	0.1262	0.0000	0.1735	0.0000
46	0.0426	0.0000	0.1117	0.0000
47	0.0875	0.0000	0.1394	0.0000
48	0.0966	0.0000	0.1199	0.0000

Table A6: Variogram Data November 2007

AODC Patch Size - Water Column

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.4355	0.5153
0.50	0.8775	1.3030
0.75	1.0231	1.1478
1.00	1.1139	1.5090
1.25	1.1853	1.1147
1.50	1.1559	1.1990
1.75	1.0759	0.7385
2.00	1.0953	1.2570
2.25	1.0008	1.0479
2.50	0.9946	1.5150
2.75	1.0396	1.2632
3.00	1.1663	1.5960
3.25	1.0380	1.2817
3.50	0.7520	1.6580
3.75	0.5897	1.2212
4.00	0.7427	1.3990
4.25	0.9650	1.3164
4.50	1.1173	1.9900
4.75	1.2793	1.6746
5.00	1.2247	1.8740
5.25	1.0049	1.3940
5.50	0.8283	1.5490
5.75	0.7636	0.7893
6.00	0.5745	1.6470
6.25	0.6076	1.3038
6.50	0.6302	1.8700
6.75	0.6202	1.3488
7.00	0.8278	1.5700
7.25	1.0179	1.0131
7.50	1.1212	1.4700
7.75	1.0870	0.9251
8.00	1.3142	1.1020

Table A7: AODC Patch Size

November 2007 – Sediment

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	332.62	405.66
0.50	574.99	728.58
0.75	736.34	882.37
1.00	896.29	1086.10
1.25	996.43	1234.35
1.50	1177.44	1463.25
1.75	1382.75	1641.01
2.00	1525.56	1674.90
2.25	1476.01	1644.64
2.50	1405.06	1579.02
2.75	1456.73	1486.74
3.00	1533.96	1510.88
3.25	1622.51	1561.10
3.50	1761.19	1824.43
3.75	1768.88	2100.35
4.00	1873.91	2324.57
4.25	2132.18	2607.93
4.50	2474.63	2938.94
4.75	2743.43	3131.10
5.00	3075.44	3332.87
5.25	3444.34	3450.97
5.50	3851.45	3524.79
5.75	4290.31	3688.06
6.00	4730.29	3928.91
6.25	4859.64	4049.75
6.50	4767.79	4156.64
6.75	4733.67	3985.63
7.00	4786.23	3980.98
7.25	4667.82	4413.01
7.50	4412.83	4577.00
7.75	4273.57	4883.00
8.00	3956.10	5199.00

Table A8: *Sediment Organic Content*

November 2007

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.0582	0.0884
0.50	0.0683	0.1040
0.75	0.0829	0.1280
1.00	0.0919	0.1060
1.25	0.0883	0.1450
1.50	0.0855	0.1450
1.75	0.0814	0.1280
2.00	0.0815	0.0917
2.25	0.0519	0.1050
2.50	0.0675	0.1070
2.75	0.0596	0.1176
3.00	0.0734	0.1172
3.25	0.0682	0.1480
3.50	0.0760	0.1610
3.75	0.0822	0.1550
4.00	0.0719	0.1340
4.25	0.0668	0.1370
4.50	0.0711	0.1430
4.75	0.0780	0.1270
5.00	0.0712	0.1250
5.25	0.0745	0.1288
5.50	0.0942	0.1200
5.75	0.0915	0.1460
6.00	0.0898	0.1320
6.25	0.0873	0.1480
6.50	0.0692	0.1290
6.75	0.0757	0.1570
7.00	0.0958	0.1550
7.25	0.0977	0.2040
7.50	0.0967	0.1588
7.75	0.0953	0.1560
8.00	0.1080	0.1438

Table A9: Sediment Moisture Content

November 2007

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	10.225	20.810
0.50	10.267	33.120
0.75	12.120	32.240
1.00	14.890	28.700
1.25	18.820	32.890
1.50	20.960	34.400
1.75	21.900	30.380
2.00	26.420	24.600
2.25	24.710	36.390
2.50	27.370	37.140
2.75	24.900	37.200
3.00	27.580	35.700
3.25	21.210	39.000
3.50	17.490	33.050
3.75	18.510	35.140
4.00	17.999	25.390
4.25	13.855	28.410
4.50	11.988	26.310
4.75	15.870	28.570
5.00	14.800	24.298
5.25	15.520	19.834
5.50	16.610	19.450
5.75	17.520	32.430
6.00	18.520	35.020
6.25	22.050	34.500
6.50	21.510	30.570
6.75	22.480	35.130
7.00	22.760	37.110
7.25	21.205	41.950
7.50	25.130	41.960
7.75	24.350	41.330
8.00	20.820	40.180

Table A10: Sediment Carbon Content

(from C:N analyses) November 2007

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.00151	0.00477
0.50	0.00250	0.00571
0.75	0.00229	0.00565
1.00	0.00261	0.00591
1.25	0.00319	0.00674
1.50	0.00327	0.00609
1.75	0.00320	0.00585
2.00	0.00341	0.00688
2.25	0.00349	0.00751
2.50	0.00381	0.00667
2.75	0.00372	0.00685
3.00	0.00312	0.00789
3.25	0.00283	0.00537
3.50	0.00255	0.00712
3.75	0.00234	0.00759
4.00	0.00255	0.00592
4.25	0.00263	0.00584
4.50	0.00223	0.00577
4.75	0.00249	0.00595
5.00	0.00372	0.00566
5.25	0.00389	0.00528
5.50	0.00338	0.00646
5.75	0.00381	0.00594
6.00	0.00442	0.00450
6.25	0.00384	0.00615
6.50	0.00369	0.00662
6.75	0.00435	0.00862
7.00	0.00433	0.00726
7.25	0.00447	0.00632
7.50	0.00408	0.00830
7.75	0.00331	0.00675
8.00	0.00288	0.00758

Table A11: Triplicate AODC one-sample T-test Results

tests were performed at α = 0.05

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Water	1	12	3730000	4110000	3910000

sample mean = 3916666
the hypothesized mean = 3910000
standard deviation = 190087
sample size= 3

calculated t-value = 0.6

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Water	2	27	5760000	6450000	7010000

sample mean = 6406666
the hypothesized mean = 6450000
standard deviation = 626125
sample size= 3

calculated t-value = -0.12

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Water	1	43	6510000	4460000	5050000

sample mean = 5340000
the hypothesized mean = 5050000
standard deviation = 1055319
sample size= 3

calculated t-value = 0.48

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Sediment	2	4	94100000	98700000	83200000

sample mean = 92000000
the hypothesized mean = 94100000
standard deviation = 7960527
sample size= 3

calculated t-value = -0.46

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Sediment	1	27	127000000	141000000	152000000

sample mean = 140000000
the hypothesized mean = 141000000
standard deviation = 12529964
sample size= 3

calculated t-value = -0.14

Sample Type	Transect	Sample Number	AODC Count 1	2	3
Sediment	2	40	231000000	246000000	258000000

sample mean = 245000000
the hypothesized mean = 245000000
standard deviation = 13527749
sample size= 3

calculated t-value = 0

Table A12: Two Sample Within and Between Transects T-tests – November

All tests were performed at a Bonferroni corrected alpha level of 0.01

November	**2007**	**Transect 1**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Water Column		Vs.	Not Significant
P = 0.2433		Vegetated	
			T = 1.187
	Unvegetated	**Vegetated**	
Mean	4539500	4176842.11	
SD	975540.2	932297.36	
EM	218137.42	213883.68	
N	20	19	

November	**2007**	**Transect 2**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Water Column		Vs.	Not Significant
P = 0.0357		Vegetated	
			t = -2.183
	Unvegetated	**Vegetated**	
Mean	3968500	4624736.84	
SD	965822.67	911435.79	
SEM	215964.51	209097.71	
N	20	19	

November	**2007**	**Transition Zones**	**Statistical Significance**
Bacterial Abundance		Transition Zone T1	
Water Column		Vs.	Not Significant
P = 0.0513		Transition Zone T2	
			t = -2.12
	Transition T1	**Transition T2**	
Mean	3948888.89	5001111.11	
SD	919272.06	1173418.56	
SEM	306424.02	391139.52	
N	9	9	

November	**2007**	**Unveg Zones**	**Statistical Significance**
Bacterial Abundance		Unvegetated T1	
Water Column		Vs.	Not Significant
P = 0.0706		Unvegetated T2	
			t = 1.860
	Unveg T1	**Unveg T2**	
Mean	4539500	3968500	
SD	975540.2	965822.67	
SEM	218137.42	215964.51	
N	20	20	

November	**2007**	**Vegetated Zones**	**Statistical Significance**
Bacterial Abundance		Vegetated T1	
Water Column		Vs.	Not Significant
P = 0.1430		Vegetated T2	
			t = -1.497
	Veg T1	**Veg T2**	
Mean	4176842.11	4624736.84	
SD	932297.36	911435.79	
SEM	213883.68	209097.71	
N	19	19	

November	**2007**	**Transect 1**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Sediment		Vs.	Significant
P < 0.0001		Vegetated	
			t = -10.556
	Unvegetated	**Vegetated**	
Mean	88130000	179736842	
SD	27402153	26786900	
SEM	6127308	6145336	
N	20	19	

November	**2007**	**Transect 2**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Sediment		Vs.	Significant
P < 0.0001		Vegetated	
			t = -7.651
	Unvegetated	**Vegetated**	
Mean	100790000	184894737	
SD	20594248	43509762	
SEM	4605014	9981824	
N	20	19	

November	**2007**	**Transition Zones**	**Statistical Significance**
Bacterial Abundance		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.2971		Transition Zone T2	
			t = -1.078
	Transition T1	**Transition T2**	
Mean	124444444	115666667	
SD	35369871	19248377	
SEM	11789957	6416126	
N	9	9	

November	**2007**	**Unveg Zones**	**Statistical Significance**
Bacterial Abundance		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.1075		Unvegetated T2	
			T = -1.652
	Unveg T1	**Unveg T2**	
Mean	88130000	100790000	
SD	27402153	20594248	
SEM	6127308	4605014	
N	20	20	

November	**2007**	**Vegetated Zones**	**Statistical Significance**
Bacterial Abundance		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.6626		Vegetated T2	
			t = -0.440
	Veg T1	**Veg T2**	
Mean	179736842	184894737	
SD	26786900	43509762	
SEM	6145336	9981824	
N	19	19	

November	**2007**	**Transect 1**	**Statistical Significance**
Organic Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.0122		Vegetated	
			t = -2.634
	Unvegetated	**Vegetated**	
Mean	0.845515	1.064647	
SD	0.254202	0.264849	
SEM	0.056841	0.06076	
N	20	19	

November	**2007**	**Transect 2**	**Statistical Significance**
Organic Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.2153		Vegetated	
			t = -1.265
	Unvegetated	**Vegetated**	
Mean	0.894275	1.114737	
SD	0.668208	0.391116	
SEM	0.149416	0.089728	
N	20	19	

November	**2007**	**Transition Zones**	**Statistical Significance**
Organic Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.1298		Transition Zone T2	
			t = -1.651
	Transition T1	**Transition T2**	
Mean	1.059533	1.554	
SD	0.299993	0.846998	
SEM	0.099998	0.282333	
N	9	9	

November	**2007**	**Unveg Zones**	**Statistical Significance**
Organic Content		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.7631		Unvegetated T2	
			T= -0.3049
	Unveg T1	**Unveg T2**	
Mean	0.845515	0.894275	
SD	0.254202	0.668208	
SEM	0.056841	0.149416	
N	20	20	

November	**2007**	**Vegetated Zones**	**Statistical Significance**
Organic Content		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.6471		Vegetated T2	
			t = -0.4622
	Veg T1	**Veg T2**	
Mean	1.064647	1.114737	
SD	0.264849	0.391116	
SEM	0.06076	0.089728	
N	19	19	

November	**2007**	**Transect 1**	**Statistical Significance**
Moisture Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.0314		Vegetated	
			t = -2.299
	Unvegetated	**Vegetated**	
Mean	27.94489	31.127379	
SD	2.026871	5.701618	
SEM	0.453222	1.308041	
N	20	19	

November	**2007**	**Transect 2**	**Statistical Significance**
Moisture Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.0833		Vegetated	
			t = -1.810
	Unvegetated	**Vegetated**	
Mean	27.916315	31.305784	
SD	2.828328	7.681624	
SEM	0.632433	1.762285	
N	20	19	

November	**2007**	**Transition Zones**	**Statistical Significance**
Moisture Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.9921		Transition Zone T2	
			T = -0.010
	Transition T1	**Transition T2**	
Mean	25.691556	25.723978	
SD	5.342014	8.084175	
SEM	1.780671	2.694725	
N	9	9	

November	**2007**	**Unveg Zones**	**Statistical Significance**
Moisture Content		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.9709		Unvegetated T2	
			t = 0.0367
	Unveg T1	**Unveg T2**	
Mean	27.94489	27.916315	
SD	2.026871	2.828328	
SEM	0.453222	0.632433	
N	20	20	

November	**2007**	**Vegetated Zones**	**Statistical Significance**
Moisture Content		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.9357		Vegetated T2	
			t = -0.0813
	Veg T1	**Veg T2**	
Mean	31.127379	31.305784	
SD	5.701618	7.681624	
SEM	1.308041	1.762285	
N	19	19	

November	**2007**	**Transect 1**	**Statistical Significance**
Carbon Content		Unvegetated	
Sediment		Vs.	Significant
P = 0.0028		Vegetated	
			t = -3.228
	Unvegetated	**Vegetated**	
Mean	0.059285	0.110479	
SD	0.043635	0.054487	
SEM	0.009757	0.012500	
N	20	19	

November	**2007**	**Transect 2**	**Statistical Significance**
Carbon Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.1497		Vegetated	
			t = -1.496
	Unvegetated	**Vegetated**	
Mean	0.12896	0.166921	
SD	0.102215	0.048058	
SEM	0.022856	0.011025	
N	20	19	

November	**2007**	**Transition Zones**	**Statistical Significance**
Carbon Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.5716		Transition Zone T2	
			t = 0.578
	Transition T1	**Transition T2**	
Mean	0.111289	0.098378	
SD	0.053999	0.039603	
SEM	0.018	0.013201	
N	9	9	

November	**2007**	**Unveg Zones**	**Statistical Significance**
Carbon Content		Unvegetated T1	
Sediment		Vs.	Significant
P = 0.0094		Unvegetated T2	
			T = -2.803
	Unveg T1	**Unveg T2**	
Mean	0.09539	0.12896	
SD	0.171945	0.102215	
SEM	0.038448	0.022856	
N	20	20	

November	**2007**	**Vegetated Zones**	**Statistical Significance**
Carbon Content		Vegetated T1	
Sediment		Vs.	Significant
P = 0.0017		Vegetated T2	
			t = -3.386
	Veg T1	**Veg T2**	
Mean	0.110479	0.166921	
SD	0.054487	0.048058	
SEM	0.0125	0.011025	
N	19	19	

Sample Key Code

The sample key codes presented below are a guide to distinguishing sample labels on microbial DNA samples preserved at -80^0 C the Laboratory of Microbial Ecology, University of Virginia.

Table A13: Sample Key Code

November 2007
Water – Transect 1

Sample Position	Sample Label	Vegetation Conditions
1	12	Unvegetated
2	N4	Unvegetated
3	21	Unvegetated
4	N24	Unvegetated
5	10	Unvegetated
6	N3	Unvegetated
7	15	Unvegetated
8	N2	Unvegetated
9	17	Unvegetated
10	N8	Unvegetated
11	11	Unvegetated
12	N11	Unvegetated
13	14	Unvegetated
14	N6	Unvegetated
15	13	Unvegetated
16	N1	Unvegetated
17	16	Unvegetated
18	N9	Unvegetated
19	2	Unvegetated
20	N5	Unvegetated
21	20	Transition
22	N10	Transition
23	4	Transition
24	N7	Transition
25	23	Transition
26	N15	Transition
27	18	Transition
28	N12	Transition
29	24	Transition
30	N17	Vegetated
31	6	Vegetated
32	N22	Vegetated
33	22	Vegetated
34	N19	Vegetated
35	19	Vegetated
36	N18	Vegetated

November 2007
Water – Transect 1 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	8	Vegetated
38	N21	Vegetated
39	3	Vegetated
40	N13	Vegetated
41	7	Vegetated
42	N16	Vegetated
43	1	Vegetated
44	N20	Vegetated
45	5	Vegetated
46	N14	Vegetated
47	9	Vegetated
48	N23	Vegetated

Table A14: Sample Key Code

November 2007
Water – Transect 2

Sample Position	Sample Label	Vegetation Conditions
1	U	Unvegetated
2	NF	Unvegetated
3	K	Unvegetated
4	NX	Unvegetated
5	X	Unvegetated
6	NW	Unvegetated
7	S	Unvegetated
8	NH	Unvegetated
9	N	Unvegetated
10	NV	Unvegetated
11	W	Unvegetated
12	NQ	Unvegetated
13	P	Unvegetated
14	NG	Unvegetated
15	T	Unvegetated
16	NT	Unvegetated
17	M	Unvegetated
18	NO	Unvegetated
19	V	Unvegetated
20	NE	Unvegetated
21	C	Transition
22	NU	Transition
23	G	Transition
24	NN	Transition
25	B	Transition
26	NB	Transition
27	I	Transition
28	ND	Transition
29	D	Transition
30	NM	Vegetated
31	H	Vegetated
32	NP	Vegetated
33	F	Vegetated
34	NS	Vegetated
35	E	Vegetated
36	NA	Vegetated

November 2007
Water – Transect 2 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	R	Vegetated
38	NJ	Vegetated
39	J	Vegetated
40	NI	Vegetated
41	O	Vegetated
42	NC	Vegetated
43	A	Vegetated
44	NK	Vegetated
45	Q	Vegetated
46	NR	Vegetated
47	L	Vegetated
48	NL	Vegetated

Table A15: Sample Key Code

November 2007
Sediment – Transect 1

Sample Position	Sample Label	Vegetation Conditions
1	7	Unvegetated
2	34	Unvegetated
3	24	Unvegetated
4	21	Unvegetated
5	11	Unvegetated
6	22	Unvegetated
7	27	Unvegetated
8	6	Unvegetated
9	23	Unvegetated
10	28	Unvegetated
11	25	Unvegetated
12	12	Unvegetated
13	26	Unvegetated
14	29	Unvegetated
15	20	Unvegetated
16	31	Unvegetated
17	14	Unvegetated
18	30	Unvegetated
19	9	Unvegetated
20	36	Unvegetated
21	10	Transition
22	19	Transition
23	33	Transition
24	13	Transition
25	5	Transition
26	8	Transition
27	3	Transition
28	1	Transition
29	4	Transition
30	35	Vegetated
31	32	Vegetated
32	39	Vegetated
33	41	Vegetated
34	40	Vegetated
35	48	Vegetated
36	43	Vegetated

November 2007
Sediment – Transect 1 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	2	Vegetated
38	37	Vegetated
39	38	Vegetated
40	44	Vegetated
41	49	Vegetated
42	46	Vegetated
43	51	Vegetated
44	52	Vegetated
45	47	Vegetated
46	45	Vegetated
47	50	Vegetated
48	42	Vegetated

Table A16: Sample Key Code

November 2007
Sediment – Transect 2

Sample Position	Sample Label	Vegetation Conditions
1	AB	Unvegetated
2	AM	Unvegetated
3	C	Unvegetated
4	AK	Unvegetated
5	AY	Unvegetated
6	AV	Unvegetated
7	AP	Unvegetated
8	X	Unvegetated
9	I	Unvegetated
10	G	Unvegetated
11	AI	Unvegetated
12	AD	Unvegetated
13	AQ	Unvegetated
14	E	Unvegetated
15	AF	Unvegetated
16	AG	Unvegetated
17	AE	Unvegetated
18	H	Unvegetated
19	AC	Unvegetated
20	AN	Unvegetated
21	AO	Transition
22	AH	Transition
23	AJ	Transition
24	AL	Transition
25	Z	Transition
26	F	Transition
27	AW	Transition
28	AA	Transition
29	AU	Transition
30	AX	Vegetated
31	AR	Vegetated
32	K	Vegetated
33	N	Vegetated
34	U	Vegetated
35	D	Vegetated
36	AZ	Vegetated

November 2007
Sediment – Transect 2 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	Y	Vegetated
38	AT	Vegetated
39	S	Vegetated
40	L	Vegetated
41	T	Vegetated
42	AS	Vegetated
43	B	Vegetated
44	W	Vegetated
45	J	Vegetated
46	A	Vegetated
47	M	Vegetated
48	V	Vegetated

VII. Appendix B

June 2008 Data

Table B1: Bacterial Abundance June 2008

Water Column

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
1	4.89	5.21
2	4.53	5.32
3	4.47	5.02
4	3.97	4.23
5	3.21	4.36
6	3.33	4.84
7	3.64	4.22
8	4.25	4.21
9	4.84	4.33
10	4.52	5.84
11	3.15	5.69
12	5.03	5.47
13	5.01	3.25
14	4.23	4.58
15	4.71	4.47
16	6.01	5.74
17	6.20	5.11
18	5.21	5.24
19	4.35	4.36
20	4.77	5.87
21	4.12	5.47
22	4.87	6.02
23	3.87	5.01
24	3.98	4.26
25	4.32	5.39
26	4.74	5.78
27	3.21	5.47
28	4.30	4.69
29	4.91	4.25
30	5.23	4.77
31	5.32	4.12
32	5.02	3.74
33	4.87	3.87
34	4.56	4.56
35	3.98	6.01
36	3.65	6.03

June 2008
Water Column (Continued)

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
37	5.77	5.84
38	5.01	5.23
39	5.23	5.24
40	5.77	5.98
41	4.57	4.69
42	4.55	4.36
43	5.22	5.56
44	5.03	5.67
45	4.87	5.21
46	4.65	5.78
47	4.32	4.87
48	4.78	4.26

Table B2: Bacterial Abundance June 2008

Sediment

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
1	94.0	84.0
2	92.0	71.0
3	93.0	92.0
4	98.0	98.0
5	95.0	91.0
6	103.0	97.0
7	75.0	87.0
8	88.0	106.0
9	115.0	121.0
10	98.0	125.0
11	89.0	104.0
12	93.0	98.0
13	132.0	134.0
14	109.0	125.0
15	117.0	130.0
16	123.0	97.0
17	92.0	112.0
18	102.0	107.0
19	95.0	95.0
20	91.0	93.0
21	68.0	89.0
22	89.0	101.0
23	99.0	121.0
24	104.0	98.0
25	135.0	143.0
26	167.0	132.0
27	155.0	124.0
28	161.0	99.0
29	142.0	134.0
30	162.0	147.0
31	157.0	155.0
32	152.0	143.0
33	159.0	167.0
34	169.0	192.0
35	162.0	214.0
36	182.0	201.0

June 2008
Sediment (Continued)

Sample Position	10^6 cells/ml Transect 1	10^6 cells/ml Transect 2
37	175.0	231.0
38	192.0	198.0
39	215.0	184.0
40	235.0	207.0
41	260.0	245.0
42	181.0	251.0
43	203.0	221.0
44	178.0	198.0
45	206.0	191.0
46	197.0	213.0
47	212.0	175.0
48	221.0	199.0

Table B3: Sediment Data

June 2008
% Organic Content

Sample Position	Transect 1	Transect 2
1	1.0394	2.0741
2	0.8658	0.7410
3	0.7371	1.8548
4	0.7201	0.5959
5	0.7674	0.5632
6	1.1494	0.5348
7	1.0206	1.3205
8	0.6444	0.5263
9	1.0670	0.6318
10	1.0384	0.9822
11	0.7736	0.6174
12	1.5780	0.8885
13	0.7325	0.5147
14	0.9258	0.8326
15	0.6776	1.7313
16	0.8431	1.3276
17	1.4129	2.7099
18	0.8832	0.7808
19	0.9463	0.8954
20	1.5999	1.2482
21	0.8677	0.8283
22	0.6239	0.6015
23	0.8406	0.8184
24	2.2526	1.5599
25	0.7616	0.6945
26	0.4600	0.7588
27	0.5131	0.8460
28	1.8949	0.7759
29	0.8154	0.6427
30	0.7433	0.7282
31	0.9477	1.5125
32	0.4020	0.7914
33	0.6218	1.0510
34	0.8317	1.4811
35	4.0660	1.2116
36	0.6124	3.1306

June 2008
% Organic Content (Continued)

Sample Position	Transect 1	Transect 2
37	1.4255	3.1806
38	1.1032	0.8020
39	0.8973	0.7446
40	1.0784	0.7314
41	0.6577	1.0982
42	0.7634	1.0606
43	0.8482	0.8808
44	0.8796	1.7653
45	3.1233	1.1998
46	0.7260	1.2943
47	0.9655	0.8969
48	1.0137	1.5398

Table B4: Sediment Data

June 2008
% Moisture

Sample Position	Transect 1	Transect 2
1	37.7276	29.2462
2	28.6984	31.2387
3	26.1007	28.9771
4	32.0258	27.9934
5	29.9875	28.9361
6	31.7665	31.152
7	28.6044	27.3347
8	29.3028	31.241
9	29.6288	30.068
10	33.4916	27.7414
11	32.5245	31.6377
12	33.4159	27.9072
13	27.5465	27.4956
14	31.2865	30.3113
15	29.6966	27.8919
16	30.4131	24.4185
17	37.8833	33.6213
18	29.4201	30.58
19	30.1097	28.1984
20	30.7385	42.8692
21	31.8102	30.474
22	28.3819	28.5271
23	32.2571	25.8675
24	29.2693	29.274
25	31.669	30.9517
26	31.2461	38.5226
27	34.6073	34.5164
28	35.232	30.7728
29	30.1985	28.796
30	30.3779	29.411
31	40.9753	40.1813
32	31.9576	29.2814
33	30.6975	45.8446
34	31.9214	38.5628
35	31.3129	34.9309
36	30.5953	33.4903

June 2008
% Moisture (Continued)

Sample Position	Transect 1	Transect 2
37	37.8862	42.8342
38	38.302	36.5484
39	31.889	30.5097
40	31.0326	29.0832
41	28.7511	34.0176
42	30.5242	35.8134
43	31.3487	36.7185
44	30.6578	27.582
45	28.9971	54.6186
46	30.4214	42.2717
47	30.3124	30.6456
48	30.0635	32.0727

Table B5: Sediment Data

June 2008
C:N Analysis

	Transect 1		Transect 2	
Sample Position	**% C**	**% N**	**% C**	**% N**
1	0.2890	0.0000	0.2470	0.0000
2	0.2835	0.0000	0.2606	0.0000
3	0.1848	0.0000	0.3410	0.0000
4	0.2227	0.0000	0.2757	0.0000
5	0.2118	0.0000	0.2357	0.0000
6	0.3554	0.0000	0.1707	0.0000
7	0.3115	0.0000	0.3021	0.0000
8	0.2133	0.0000	0.2599	0.0000
9	0.4039	0.0000	0.2807	0.0000
10	0.2439	0.0000	0.1961	0.0000
11	0.2314	0.0000	0.2173	0.0000
12	0.3386	0.0000	0.3620	0.0000
13	0.3200	0.0000	0.1947	0.0000
14	0.2500	0.0000	0.2466	0.0000
15	0.2487	0.0000	0.2127	0.0000
16	0.2251	0.0000	0.2651	0.0000
17	0.3269	0.0000	0.2669	0.0000
18	0.2154	0.0000	0.2075	0.0000
19	0.2996	0.0000	0.2232	0.0000
20	0.2442	0.0000	0.1939	0.0000
21	0.2226	0.0000	0.2160	0.0000
22	0.2347	0.0000	0.2769	0.0000
23	0.2240	0.0000	0.2691	0.0000
24	0.2207	0.0000	0.2837	0.0000
25	0.3613	0.0000	0.3901	0.0000
26	0.1938	0.0000	0.2580	0.0000
27	0.2569	0.0000	0.2878	0.0000
28	0.2663	0.0000	0.3024	0.0000
29	0.2261	0.0000	0.4940	0.0000
30	0.2498	0.0000	0.1558	0.0000
31	0.2938	0.0000	0.3597	0.0000
32	0.2055	0.0000	0.1678	0.0000
33	0.2277	0.0000	0.1835	0.0000
34	0.1966	0.0000	0.1167	0.0000
35	0.1854	0.0000	0.1721	0.0000

June 2008
C:N Analysis (Continued)

	Transect 1		Transect 2	
Sample Position	**% C**	**% N**	**% C**	**% N**
36	0.1764	0.0000	0.1438	0.0000
37	0.3270	0.0000	0.1559	0.0000
38	1.3456	0.0000	0.1942	0.0000
39	0.2533	0.0000	0.1686	0.0000
40	0.1909	0.0000	0.1555	0.0000
41	0.1777	0.0000	0.1875	0.0000
42	0.1997	0.0000	0.2786	0.0000
43	0.1798	0.0000	0.1247	0.0000
44	0.2357	0.0000	0.1522	0.0000
45	0.2599	0.0000	0.1338	0.0000
46	0.1762	0.0000	0.1333	0.0000
47	0.2093	0.0000	0.1396	0.0000
48	0.2120	0.0000	0.1356	0.0000

Table B6: Variogram Data June 2008

AODC Patch Size - Water Column

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.2816	0.3110
0.50	0.4371	0.5013
0.75	0.4482	0.6268
1.00	0.4924	0.5091
1.25	0.5458	0.5112
1.50	0.5188	0.5305
1.75	0.5434	0.6819
2.00	0.4905	0.5745
2.25	0.5274	0.4644
2.50	0.6825	0.4125
2.75	0.6525	0.5933
3.00	0.5501	0.7268
3.25	0.4607	0.6498
3.50	0.4303	0.4938
3.75	0.4505	0.4113
4.00	0.4193	0.4391
4.25	0.4000	0.4501
4.50	0.4692	0.3928
4.75	0.4917	0.3377
5.00	0.4095	0.3803
5.25	0.3419	0.5609
5.50	0.3211	0.6488
5.75	0.3930	0.5599
6.00	0.4472	0.2818
6.25	0.4996	0.3122
6.50	0.6328	0.4147
6.75	0.4642	0.5150
7.00	0.4160	0.4673
7.25	0.5265	0.4504
7.50	0.4720	0.6692
7.75	0.5082	0.8466
8.00	0.6496	0.7224

Table B7: AODC Patch Size – Sediment

June 2008

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	218.39	216.54
0.50	307.60	346.64
0.75	452.32	454.87
1.00	545.42	455.24
1.25	650.51	564.07
1.50	750.83	705.07
1.75	758.63	818.12
2.00	853.38	914.89
2.25	900.03	1106.65
2.50	954.51	1255.13
2.75	1078.14	1405.51
3.00	1193.28	1554.51
3.25	1274.34	1849.11
3.50	1459.40	2020.84
3.75	1683.50	2129.50
4.00	1989.83	2248.86
4.25	2212.37	2408.45
4.50	2495.97	2676.63
4.75	2777.71	2825.41
5.00	2955.04	2991.13
5.25	3119.46	3090.69
5.50	3395.48	3285.00
5.75	3717.66	3455.10
6.00	4033.46	3729.75
6.25	4109.50	3798.93
6.50	4265.80	3955.77
6.75	4343.12	4085.12
7.00	4303.70	4293.18
7.25	4570.97	4592.95
7.50	4611.83	4897.83
7.75	4823.26	5063.00
8.00	4921.41	5462.41

Table B8: Sediment Organic Content

June 2008

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.8554	0.2988
0.50	0.7889	0.3827
0.75	1.0848	0.4096
1.00	0.7144	0.4604
1.25	0.7407	0.4401
1.50	0.7824	0.4543
1.75	0.9489	0.4166
2.00	0.8001	0.4537
2.25	0.9153	0.4660
2.50	0.8168	0.4884
2.75	0.5331	0.5198
3.00	0.6674	0.4410
3.25	0.7573	0.3550
3.50	0.7446	0.3044
3.75	0.5667	0.4349
4.00	0.5913	0.3156
4.25	0.5664	0.2666
4.50	0.7223	0.3695
4.75	0.7210	0.2631
5.00	0.7457	0.2048
5.25	0.6817	0.2922
5.50	0.7548	0.3953
5.75	0.6012	0.4940
6.00	0.5483	0.4442
6.25	0.7737	0.4946
6.50	0.7071	0.5385
6.75	0.6441	0.4511
7.00	0.7431	0.5376
7.25	0.7563	0.5161
7.50	0.8417	0.5271
7.75	0.9392	0.6777
8.00	0.7685	0.6712

Table B9: Variogram Data Sediment Moisture Content

June 2008

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	7.7097	27.3221
0.50	9.6154	30.7120
0.75	8.0852	28.4319
1.00	8.4099	23.7614
1.25	8.5285	27.2853
1.50	6.6951	24.4502
1.75	8.6829	24.5346
2.00	10.4263	22.0968
2.25	10.2111	25.1643
2.50	8.7308	31.3676
2.75	6.9273	25.3530
3.00	10.0392	21.1626
3.25	9.7142	29.9503
3.50	9.7744	29.8732
3.75	10.1702	34.3576
4.00	8.7176	33.0510
4.25	8.8972	31.6227
4.50	9.9574	33.5871
4.75	8.2432	31.9558
5.00	7.2011	32.8439
5.25	6.5159	40.3848
5.50	8.4723	42.2183
5.75	9.7325	40.9388
6.00	11.7685	44.0308
6.25	10.6036	28.0047
6.50	7.6876	39.1016
6.75	6.1606	47.0894
7.00	11.8248	40.9593
7.25	12.9591	49.5723
7.50	8.8724	56.5626
7.75	9.3986	46.1833
8.00	7.1820	52.6057

Table B10: Variogram Data Sediment Carbon Content

June 2008

Sample Separation Distance (m)	Transect 1 Semi-variance	Transect 2 Semi-variance
0.25	0.00344	0.00439
0.50	0.00434	0.00323
0.75	0.00400	0.00462
1.00	0.00454	0.00375
1.25	0.00416	0.00542
1.50	0.00341	0.00547
1.75	0.00340	0.00573
2.00	0.00351	0.00640
2.25	0.00487	0.00609
2.50	0.00378	0.00652
2.75	0.00313	0.00661
3.00	0.00295	0.00680
3.25	0.00212	0.00524
3.50	0.00353	0.00721
3.75	0.00383	0.00727
4.00	0.00329	0.00809
4.25	0.00423	0.00705
4.50	0.00297	0.00884
4.75	0.00279	0.00836
5.00	0.00395	0.00652
5.25	0.00354	0.00684
5.50	0.00442	0.00620
5.75	0.00478	0.00788
6.00	0.00380	0.00573
6.25	0.00290	0.00578
6.50	0.00363	0.00473
6.75	0.00514	0.00641
7.00	0.00447	0.00589
7.25	0.00381	0.00585
7.50	0.00521	0.00508
7.75	0.00412	0.00681
8.00	0.00373	0.00666

Table B11: Two Sample Within and Between Transects T-tests – June

All tests were performed at a Bonerroni corrected alpha level of 0.01

June	**2008**	**Transect 1**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Water Column		Vs.	Not Significant
P = 0.0882		Vegetated	
			t = -1.754
	Unvegetated	**Vegetated**	
Mean	4497143	4865650	
SD	799382	523477	
SEM	174439	117053	
N	21	20	

June	**2008**	**Transect 2**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Water Column		Vs.	Not Significant
P = 0.6441		Vegetated	
			t = -0.465
	Unvegetated	**Vegetated**	
Mean	4896667	5002000	
SD	691349	753606	
SEM	150865	168511	
N	21	20	

June	**2008**	**Transition Zones**	**Statistical Significance**
Bacterial Abundance		Transition Zone T1	
Water Column		Vs.	Significant
P = 0.0062		Transition Zone T2	
			t = -3.315
	Transition T1	**Transition T2**	
Mean	4184286	5231429	
SD	562816	617884	
SEM	212724	233538	
N	7	7	

June	**2008**	**Unveg Zones**	**Statistical Significance**
Bacterial Abundance		Unvegetated T1	
Water Column		Vs.	Not Significant
P = 0.0912		Unvegetated T2	
			t = -1.732
	Unveg T1	**Unveg T2**	
Mean	4497143	4896667	
SD	799382	691349	
SEM	174439	150865	
N	21	21	

June	**2008**	**Vegetated Zones**	**Statistical Significance**
Bacterial Abundance		Vegetated T1	
Water Column		Vs.	Not Significant
P = 0.5108		Vegetated T2	
			t = -0.665
	Veg T1	**Veg T2**	
Mean	4865650	5002000	
SD	523477	753606	
SEM	117053	168511	
N	20	20	

June	**2008**	**Transect 1**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Sediment		Vs.	Significant
P < 0.0001		Vegetated	
			t = -11.88
	Unvegetated	**Vegetated**	
Mean	98190476	188000000	
SD	14844592	30533847	
SEM	3239355	6827576	
N	21	20	

June	**2008**	**Transect 2**	**Statistical Significance**
Bacterial Abundance		Unvegetated	
Sediment		Vs.	Significant
P < 0.0001		Vegetated	
			t = -11.16
	Unvegetated	**Vegetated**	
Mean	102666667	193300000	
SD	16544888	32531928	
SEM	3610391	7274360	
N	21	20	

June	**2008**	**Transition Zones**	**Statistical Significance**
Bacterial Abundance		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.3716		Transition Zone T2	
			t = 0.94
	Transition T1	**Transition T2**	
Mean	124444444	115666667	
SD	35369871	19248377	
SEM	11789957	6416126	
N	9	9	

June	**2008**	**Unveg Zones**	**Statistical Significance**
Bacterial Abundance		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.3616		Unvegetated T2	
			t = -0.92
	Unveg T1	**Unveg T2**	
Mean	99700000	103350000	
SD	13475514	16667886	
SEM	3013217	3727053	
N	20	20	

June	**2008**	**Vegetated Zones**	**Statistical Significance**
Bacterial Abundance		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.5983		Vegetated T2	
			t = -0.531
	Veg T1	**Veg T2**	
Mean	190421053	196421053	
SD	29332037	30190719	
SEM	6729231	6926226	
N	19	19	

June	**2008**	**Transect 1**	**Statistical Significance**
Organic Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.4473		Vegetated	
			t = -0.774
	Unvegetated	**Vegetated**	
Mean	0.9662	1.126105	
SD	0.274559	0.88461	
SEM	0.059914	0.197805	
N	21	20	

June	**2008**	**Transect 2**	**Statistical Significance**
Organic Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.2699		Vegetated	
			t = -1.120
	Unvegetated	**Vegetated**	
Mean	1.05711	1.28717	
SD	0.593918	0.712668	
SEM	0.129604	0.159357	
N	21	20	

June	**2008**	**Transition Zones**	**Statistical Significance**
Organic Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.5518		Transition Zone T2	
			t = 0.621
	Transition T1	**Transition T2**	
Mean	1.049529	0.865	
SD	0.71938	0.317054	
SEM	0.2719	0.119835	
N	7	7	

June	**2008**	**Unveg Zones**	**Statistical Significance**
Organic Content		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.5295		Unvegetated T2	
			t = -0.637
	Unveg T1	**Unveg T2**	
Mean	0.9662	1.05711	
SD	0.274559	0.593918	
SEM	0.059914	0.129604	
N	21	21	

June	**2008**	**Vegetated Zones**	**Statistical Significance**
Organic Content		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.5300		Vegetated T2	
			t = -0.634
	Veg T1	**Veg T2**	
Mean	1.126105	1.28717	
SD	0.88461	0.712668	
SEM	0.197805	0.159357	
N	20	20	

June	**2008**	**Transect 1**	**Statistical Significance**
Moisture Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.3788		Vegetated	
			t = -0.890
	Unvegetated	**Vegetated**	
Mean	31.056143	31.91112	
SD	2.893731	3.234693	
SEM	0.631464	0.723299	
N	21	20	

June	**2008**	**Transect 2**	**Statistical Significance**
Moisture Content		Unvegetated	
Sediment		Vs.	Significant
P = 0.0023		Vegetated	
			t = -3.341
	Unvegetated	**Vegetated**	
Mean	29.968271	35.660695	
SD	3.57021	6.870894	
SEM	0.779084	1.536379	
N	21	20	

June	2008	Transition Zones	Statistical Significance
Moisture Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.7495		Transition Zone T2	
			t = -0.328
	Transition T1	**Transition T2**	
Mean	31.808957	31.204586	
SD	2.525858	4.166382	
SEM	0.954685	1.574744	
N	7	7	

June	2008	Unveg Zones	Statistical Significance
Moisture Content		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.2561		Unvegetated T2	
			t = 1.153
	Unveg T1	**Unveg T2**	
Mean	31.056143	29.968271	
SD	2.893731	3.57021	
SEM	0.631464	0.779084	
N	21	21	

June	2008	Vegetated Zones	Statistical Significance
Moisture Content		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.0359		Vegetated T2	
			t = -2.208
	Veg T1	**Veg T2**	
Mean	31.91112	35.660695	
SD	3.234693	6.870894	
SEM	0.723299	1.536379	
N	20	20	

June	**2008**	**Transect 1**	**Statistical Significance**
Carbon Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.0720		Vegetated	
			t = 1.852
	Unvegetated	**Vegetated**	
Mean	0.268681	0.27642	
SD	0.05736	0.254926	
SEM	0.012517	0.057003	
N	21	20	

June	**2008**	**Transect 2**	**Statistical Significance**
Carbon Content		Unvegetated	
Sediment		Vs.	Not Significant
P = 0.0162		Vegetated	
	Unvegetated	**Vegetated**	t = 2.552
Mean	0.246448	0.187645	
SD	0.048665	0.091446	
SEM	0.01062	0.020448	
N	21	20	

June	**2008**	**Transition Zones**	**Statistical Significance**
Carbon Content		Transition Zone T1	
Sediment		Vs.	Not Significant
P = 0.1189		Transition Zone T2	
			t = -1.679
	Transition T1	**Transition T2**	
Mean	0.2511	0.295429	
SD	0.05419	0.044054	
SEM	0.020482	0.016651	
N	7	7	

June	**2008**	**Unveg Zones**	**Statistical Significance**
Carbon Content		Unvegetated T1	
Sediment		Vs.	Not Significant
P = 0.1832		Unvegetated T2	
			t = 1.354
	Unveg T1	**Unveg T2**	
Mean	0.268681	0.246448	
SD	0.05736	0.048665	
SEM	0.012517	0.01062	
N	21	21	

June	**2008**	**Vegetated Zones**	**Statistical Significance**
Carbon Content		Vegetated T1	
Sediment		Vs.	Not Significant
P = 0.088		Vegetated T2	
			t = -1753
	Veg T1	**Veg T2**	
Mean	0.27642	0.187645	
SD	0.254926	0.091446	
SEM	0.057003	0.020448	
N	20	20	

Table B12: Sample Key Code

June 2008
Water – Transect 1

Sample Position	Sample Label	Vegetation Conditions
1	J20	Unvegetated
2	J23	Unvegetated
3	J21	Unvegetated
4	J10	Unvegetated
5	J24	Unvegetated
6	J7	Unvegetated
7	J19	Unvegetated
8	J17	Unvegetated
9	J22	Unvegetated
10	J14	Unvegetated
11	J18	Unvegetated
12	J12	Unvegetated
13	J13	Unvegetated
14	J11	Unvegetated
15	J9	Unvegetated
16	J2	Unvegetated
17	J5	Unvegetated
18	J8	Unvegetated
19	J4	Unvegetated
20	J1	Unvegetated
21	J15	Unvegetated
22	J16	Transition
23	J6	Transition
24	J3	Transition
25	13	Transition
26	3	Transition
27	6	Transition
28	15	Transition
29	5	Vegetated
30	20	Vegetated
31	7	Vegetated
32	22	Vegetated
33	10	Vegetated
34	23	Vegetated
35	8	Vegetated
36	1	Vegetated

June 2008
Water – Transect 1 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	18	Vegetated
38	14	Vegetated
39	19	Vegetated
40	4	Vegetated
41	11	Vegetated
42	17	Vegetated
43	24	Vegetated
44	16	Vegetated
45	21	Vegetated
46	12	Vegetated
47	2	Vegetated
48	9	Vegetated

Table B13: Sample Key Code

June 2008
Water – Transect 2

Sample Position	Sample Label	Vegetation Conditions
1	56	Unvegetated
2	70	Unvegetated
3	61	Unvegetated
4	71	Unvegetated
5	50	Unvegetated
6	47	Unvegetated
7	49	Unvegetated
8	66	Unvegetated
9	55	Unvegetated
10	52	Unvegetated
11	48	Unvegetated
12	64	Unvegetated
13	59	Unvegetated
14	69	Unvegetated
15	54	Unvegetated
16	51	Unvegetated
17	60	Unvegetated
18	58	Unvegetated
19	62	Unvegetated
20	67	Unvegetated
21	57	Unvegetated
22	63	Transition
23	65	Transition
24	53	Transition
25	34	Transition
26	29	Transition
27	35	Transition
28	41	Transition
29	45	Vegetated
30	40	Vegetated
31	32	Vegetated
32	36	Vegetated
33	33	Vegetated
34	37	Vegetated
35	39	Vegetated
36	31	Vegetated

June 2008
Water – Transect 1 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	68	Vegetated
38	28	Vegetated
39	44	Vegetated
40	30	Vegetated
41	26	Vegetated
42	42	Vegetated
43	46	Vegetated
44	27	Vegetated
45	24	Vegetated
46	25	Vegetated
47	43	Vegetated
48	38	Vegetated

Table B14: Sample Key Code

June 2008
Sediment – Transect 1

Sample Position	Sample Label	Vegetation Conditions
1	40	Unvegetated
2	43	Unvegetated
3	44	Unvegetated
4	18	Unvegetated
5	21	Unvegetated
6	38	Unvegetated
7	47	Unvegetated
8	41	Unvegetated
9	45	Unvegetated
10	19	Unvegetated
11	23	Unvegetated
12	48	Unvegetated
13	46	Unvegetated
14	37	Unvegetated
15	42	Unvegetated
16	15	Unvegetated
17	17	Unvegetated
18	22	Unvegetated
19	39	Unvegetated
20	20	Unvegetated
21	7	Unvegetated
22	3	Transition
23	16	Transition
24	4	Transition
25	34	Transition
26	30	Transition
27	35	Transition
28	29	Transition
29	27	Vegetated
30	36	Vegetated
31	28	Vegetated
32	32	Vegetated
33	33	Vegetated
34	26	Vegetated
35	1	Vegetated
36	14	Vegetated

June 2008
Sediment – Transect 1 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	25	Vegetated
38	24	Vegetated
39	13	Vegetated
40	5	Vegetated
41	6	Vegetated
42	2	Vegetated
43	10	Vegetated
44	11	Vegetated
45	9	Vegetated
46	31	Vegetated
47	8	Vegetated
48	12	Vegetated

Table B15: Sample Key Code

June 2008
Sediment – Transect 2

Sample Position	Sample Label	Vegetation Conditions
1	AM	Unvegetated
2	AC	Unvegetated
3	AN	Unvegetated
4	AB	Unvegetated
5	W	Unvegetated
6	AK	Unvegetated
7	AF	Unvegetated
8	AL	Unvegetated
9	K	Unvegetated
10	Y	Unvegetated
11	AD	Unvegetated
12	Z	Unvegetated
13	A	Unvegetated
14	J	Unvegetated
15	AA	Unvegetated
16	AG	Unvegetated
17	P	Unvegetated
18	N	Unvegetated
19	C	Unvegetated
20	L	Unvegetated
21	M	Unvegetated
22	AE	Transition
23	B	Transition
24	O	Transition
25	AQ	Transition
26	AR	Transition
27	AS	Transition
28	AP	Transition
29	AI	Vegetated
30	AV	Vegetated
31	AT	Vegetated
32	V	Vegetated
33	H	Vegetated
34	AU	Vegetated
35	D	Vegetated
36	R	Vegetated

June 2008
Sediment – Transect 2 (Continued)

Sample Position	Sample Label	Vegetation Conditions
37	T	Vegetated
38	I	Vegetated
39	F	Vegetated
40	E	Vegetated
41	AJ	Vegetated
42	U	Vegetated
43	AH	Vegetated
44	X	Vegetated
45	S	Vegetated
46	G	Vegetated
47	Q	Vegetated
48	AO	Vegetated

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