ANTHROPOGENIC IMPACT ON MEIOFAUNA IN MYRTLE BEACH AREA ESTUARIES

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Abstract

The population of South Carolina has been steadily increasing for years, especially in coastal areas. In fact, Horry County, which contains Myrtle Beach, has shown a population increase of 37% in the last decade. With significant population increase comes a proportional increase in urbanization, defined by more industries, more buildings, and more natural areas encroached upon. Not only does urbanization physically impact the natural environment, there are also chemical impacts through the release of anthropogenic waste and chemicals. Through runoff and direct input, these chemicals can eventually reach the estuaries and may cause some changes in those communities. For this study, samples were obtained from the high and low marsh of four separate estuary locations, two anthropogenically impacted locations and two relatively pristine locations. These samples were then analyzed to obtain the abundances of the meiofauna groups that make up each community and compared to observe differences in community structure. It has been previously suggested that meiofauna can be used as environmental indicators of the pollution and overall health of an area, and it was expected that significant differences would be seen between the impacted and non-impacted locations. The results showed significant differences in community structure when non-impacted locations were compared to the impacted locations. Specifically, the most significant differences were seen with higher nematode abundance and lower copepod abundance in the impacted sites. Due to this difference, there was a higher nematode to copepod ratio in the impacted sites, which has been suggested to indicate a response to an anthropogenic impact. As nematodes are more resilient to chemical changes, they are able to increase in abundance while the copepods reproduction is negatively impacted by the pollution. With these results, it is apparent that more

research must be done to see if another factor is influencing the meiofauna communities and, if not, what pollutants and what concentrations are causing the differences in the communities.

Introduction

How does urbanization affect the meiofauna of South Carolina estuaries? Meiofauna are defined as those organisms which are larger than microfauna, but smaller than macrofauna. While the exact size range of these organisms varies, these organisms are approximately smaller than 1mm and larger than 45µm. Permanent meiofauna are the animals who are within the meiofaunal size category throughout their entire life cycle, while temporary meiofauna are animals who are considered meiofauna during their early life stages but grow past that size range throughout their life, becoming small macrofauna. All of these organisms are normally found within the benthos, normally living in the upper 2cm of sediment, but their distributions throughout an estuary can be varied based on species. The two most abundant types of meiofauna are copepods and nematodes. Copepods have a high dispersal rate, meaning that they spread out throughout the sediment, and meiofauna in general are motile organisms that can move within the sediment (Commito, et al., 2002). Meiofauna are a food source for various macrofauna and normally feed on detritus, diatoms and algal mats (Kennedy, et al., 1999). Also, they have multiple generations per year which allows for faster detection of pollutant effects on growth rate, longevity, and fecundity of the meiofauna (Coull, et al., 1992). Because of their sensitivity to the effects of urbanization, meiofauna will show the effects of pollution faster and at lower concentrations than most other organisms, so they are good indicators for the chemical pollution. Also due to the different feeding strategies between species, information about the type and strength of pollutants can be obtained by determining the differences between species in a given area.

Urbanization is the growth of an urban area, which can be seen by the building of more housing, growth of industries, and increased human waste. Within the past decade, the population of South Carolina has increased by 15.3% and the population of the coastal Horry County has grown by 37%, which has increased the anthropogenic impacts on the environment (US Census, 2010). While urbanization has not occurred along all stretches of the coast, many coastal areas have already been disrupted, and possibly changed, by the urbanization. Van Dolah, et al. specifically looked at this possibility and found that the areas with increased urban influence showed a decrease in biological production. The study also suggested that, with all of the pesticides entering the system, humans' use of the resources may also be limited soon (2008).

For this study, the locations being researched are South Carolina estuaries, more specifically those within the Myrtle Beach area. An estuary is considered to be where a river empties into the sea/where a river and the sea mix. These areas can have many various characteristics as they are not only affected by ocean processes such as tides and waves, but are also affected by freshwater runoff and sediment input from the terrestrial area. Because of this, estuaries are very biologically productive and can support many various species, especially meiofauna. While the terrestrial runoff can provide necessary nutrients to the meiofauna species, an increase in urbanization could also increase the amount of nutrients entering the system so much so that the estuary undergoes eutrophication. These effects can usually be seen more significantly when there is rainfall as it increases the amount of runoff entering the system within a shorter time frame (White, et al., 2004). Urbanization may also cause changes in sedimentation and may introduce dangerous compounds to the system like pesticides.

Studies of urbanization effects in various locations have previously been performed. One such study that assessed the toxicity of sediments in South Carolina using a copepod species showed that many copepods were able to survive significant chemical exposure. However, reproduction ability of these species was decreased (Bejarano, et al., 2004). This would suggest that, in this study, there would be a decrease in copepod abundance within the impacted sites as there was a decrease in reproduction due to chemical impacts. Also, a separate study found that increases in carbon, lead, and zinc lead to a decrease in the population of meiofaunal nematodes (Gyedu-Ababio, et al., 2006). If there is a significant increase in any of these compounds due to urbanization in the locations chosen, the meiofaunal community may show the impact of these changes. However, another study found that contamination and pollution relates to a higher abundance of meiofauna (Hewitt, et al., 2004). So unless the estuary is affected by one of the contaminants that appears to be detrimental, the urbanized estuary should show a greater amount of meiofauna than the pristine estuary. The purpose of this study is to observe meiofaunal community structure in four Myrtle Beach area estuaries to assess the possible anthropogenic impact. In general, it is expected that the more anthropogenically impacted estuaries will show a change in the community structure, with an increase in total meiofauna but a decrease in copepod and nematode abundances.

Methods

First, four separate sites must be identified, two that were relatively pristine and undeveloped and two that were developed. To assist in this identification, aerial maps of locations were consulted to identify areas of very high and very low development that are relatively close to each other (Fig. 1). The low-impact areas that were chosen for this study were

Waties Island and Huntington Beach State Park; the high-impact areas were Hog Inlet and Garden City.

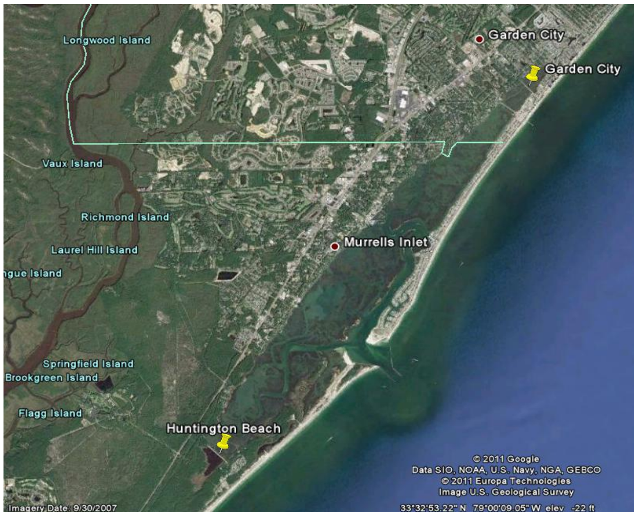

Figure 1a: Aerial image of Huntington Beach State Park and Garden City sites.

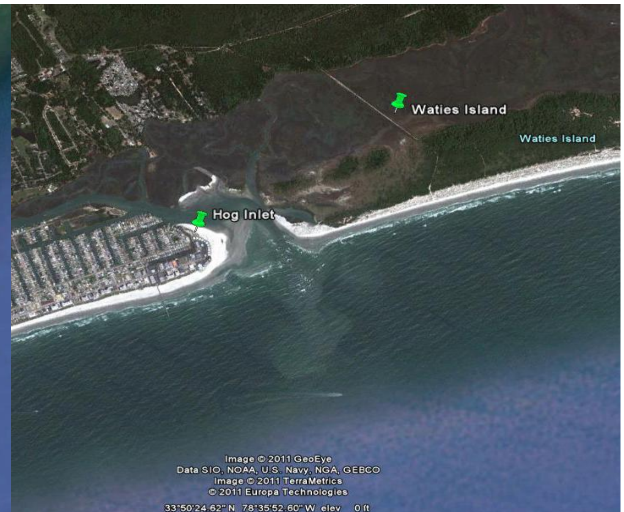

Figure 1b: Aerial image of Waties Island and Hog Inlet sites.

Then, general sample locations within each site were chosen. In both locations, four samples were taken at various sites which are considered low marsh and high marsh, based on distance from the water. To collect samples, cores with diameter 2.2cm were used to pick up approximately 1-2cm depth of sediment, with four cores making up one total sample. All samples were collected on October 15 and were kept in a refrigerator overnight to preserve the living organisms until processing in the lab the following day. To prepare the samples for analysis, a solution of 10% Formalin and 1% Rose Bengal was measured out to match the volume of sample, which was 22.8mL. This solution allowed for preservation of the meiofaunal structures and staining of those structures for later viewing. To analyze the samples, the samples were split into smaller portions to allow for ease of counting with smaller volumes of organisms. These portions were each filtered with deionized water in a 63μm sieve, which was considered to be the lower size limit of meiofauna for the purposes of this study. When there was no longer any material falling through the sieve, the floating material was poured into a Petri dish, leaving sand, plant material, and other large particles in the sieve. This procedure was used because of the fact that the meiofauna are less dense than the sand and plant materials and so they could be rinsed off the top of that material and poured out with the water. As this is not an exact form of separation, the remaining sieve material was kept and later run through the sieve again in an attempt to make sure that all present meiofauna were collected in the Petri dishes. One study points out that there are some difficulties in working with meiofauna, particularly their small size as it is sometimes hard to obtain accurate measurements, but working carefully and precisely should have eliminated those concerns (Kennedy, et al., 1999). An Olympus transmitted light microscope was used initially at 40x magnification to identify organism structures and groups and 10x magnification afterwards for the counting of the meiofauna groups. The data for each sample was recorded for further analysis using community structure comparison, ANOVA, and the nematode to copepod ratio.

Results

Community Structure

To compare the community structure for each site, the total abundance for each site was calculated and then that value was broken up in percentages of the different organism groups. For all locations, nematodes accounted for the greatest percentage of the community structure, ranging from 60-96% of the total meiofauna abundance. More specifically, the percentage of nematodes was higher in the impacted sites than in the relatively undisturbed sites in both the high and low marsh locations; however, there were also a higher percentages of nematodes in both the high and low marsh of Huntington Beach when compared to the Waties locations (Fig.2,3).

Inversely to the difference in percent of nematodes, the percentages of copepods, forams, turbellarians, and ostracoda were lower in the disturbed locations than in the relatively pristine locations for all sites. Of these groups, copepods showed the most distinct difference as the Waties low marsh location had a percentage of 19% while its paired disturbed location had only 3% copepods; whereas the ostracoda showed the least significant change. The oligochaetes and polychaete percentages were variable and did not follow any apparent trends between the disturbed and undisturbed locations(Fig.2,3).

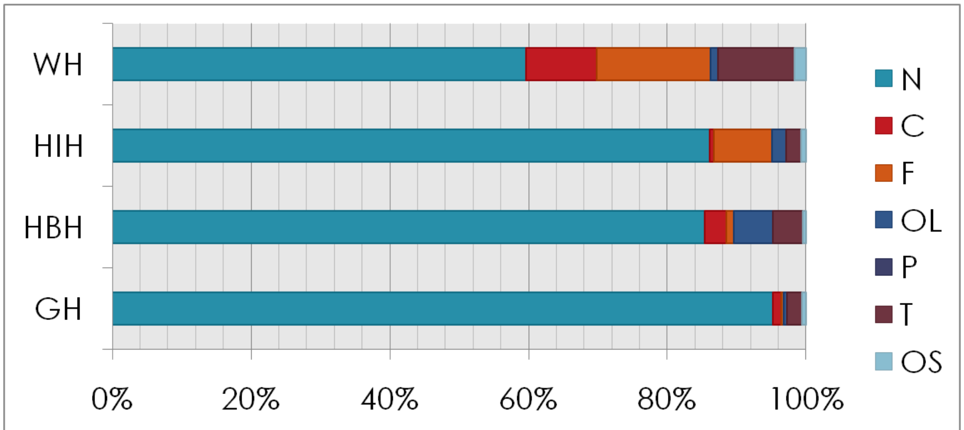

Fig. 2: Community structure graph showing the percentages of each group (N-nematode, C-copepod, F-foraminifera, OL-oligochaete, P-polychaete, T-turbellaria, OS-ostracoda) of the total sample for high marsh locations of all sites (WH-Waties Island, HIH-Hog Inlet, HBH-Huntington Beach, GH-Garden City).

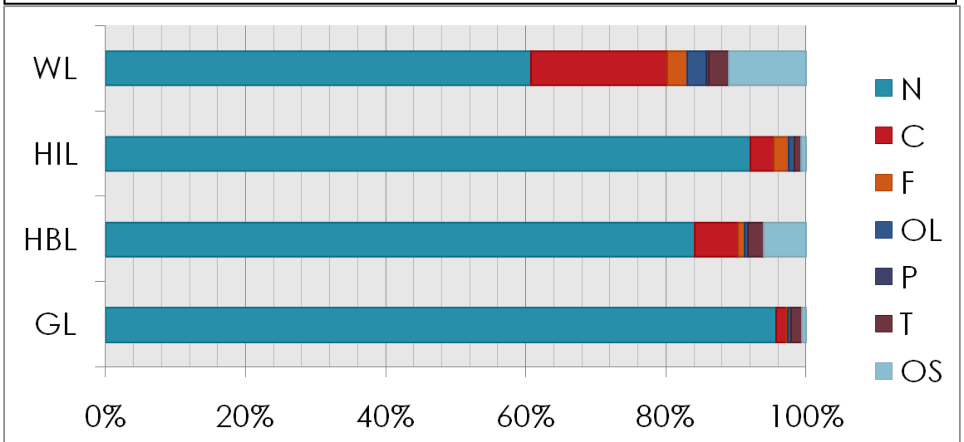

Fig. 3: Community structure graph showing the percentages of each group (N-nematode, C-copepod, F-foraminifera, OL-oligochaete, P-polychaete, T-turbellaria, OS-ostracoda) of the total sample for low marsh locations of all sites (WH-Waties Island, HIH-Hog Inlet, HBH-Huntington Beach, GH-Garden City).

Nematodes & Copepods

Both nematodes and copepods showed the most significant differences between the pristine and urbanized locations. The two-way ANOVA results showed that there was convincing evidence of differences both between sites ($p=0.004$) and between elevations ($p=0.01$). In Waties Island, nematode abundance was 477/22.8cm^3 in the low marsh and 213/22.8cm^3 in the high marsh; whereas, in Hog Inlet the nematode abundance was 3602/22.8cm^3 for the low marsh and 428/22.8cm^3 for the high marsh. Both the high and low marsh nematode abundances at Huntington Beach were higher than those of Waties Island, with a concentration of 2735/22.8cm^3 for the low marsh and 1142/22.8cm^3 for the high marsh. In contrast, the Garden City site showed the highest nematode abundances for both the high and low marsh sites with 4923/22.8cm^3 in the low marsh and 3140/22.8cm^3 in the high marsh (Fig.4).

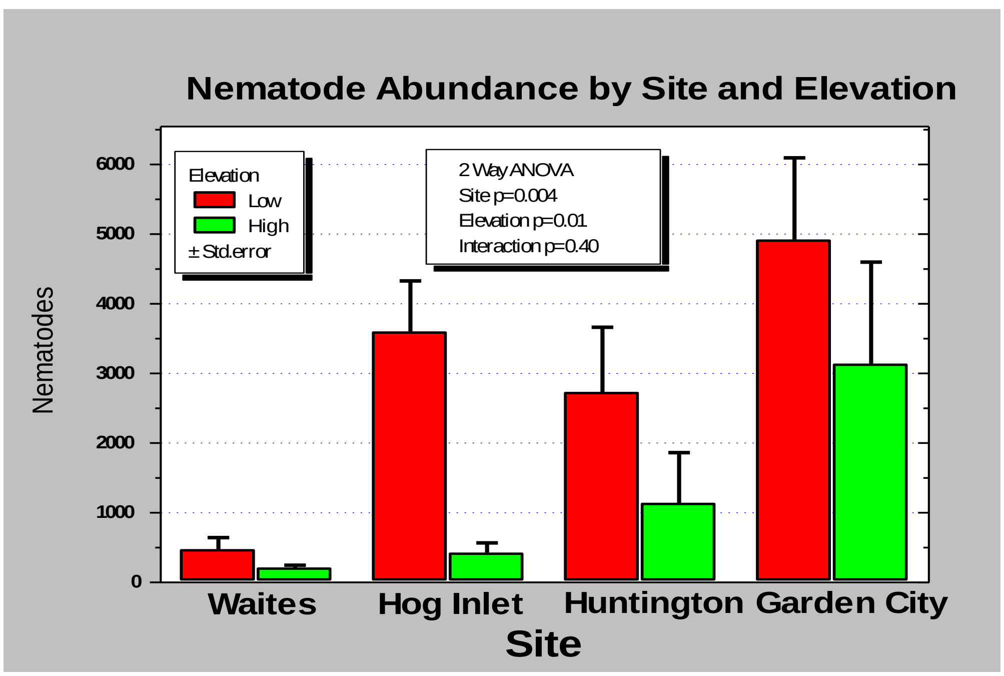

Fig. 4: Average nematode abundance per sample of 22.8cm^3 by site (Waties Island, Hog Inlet, Huntington Beach, and Garden City) and elevation (low and high).

For the copepod abundances, the two-way ANOVA results showed no convincing evidence of a difference between sites (p=0.23), but convincing evidence of a difference by elevation (p=0.0002). For Waties Island, copepod abundance was 153/22.8cm^3 in the low marsh and 36/22.8cm^3 in the high marsh; whereas, in Hog Inlet the copepod abundance was 126/22.8cm^3 for the low marsh and 3/22.8cm^3 for the high marsh. Huntington Beach abundances were 202/22.8cm^3 for the low marsh and 41/22.8cm^3 for the high marsh. Lastly, Garden City abundances of copepods showed 74/22.8cm^3 in the low marsh and 40/22.8cm^3 in the high marsh (Fig.5).

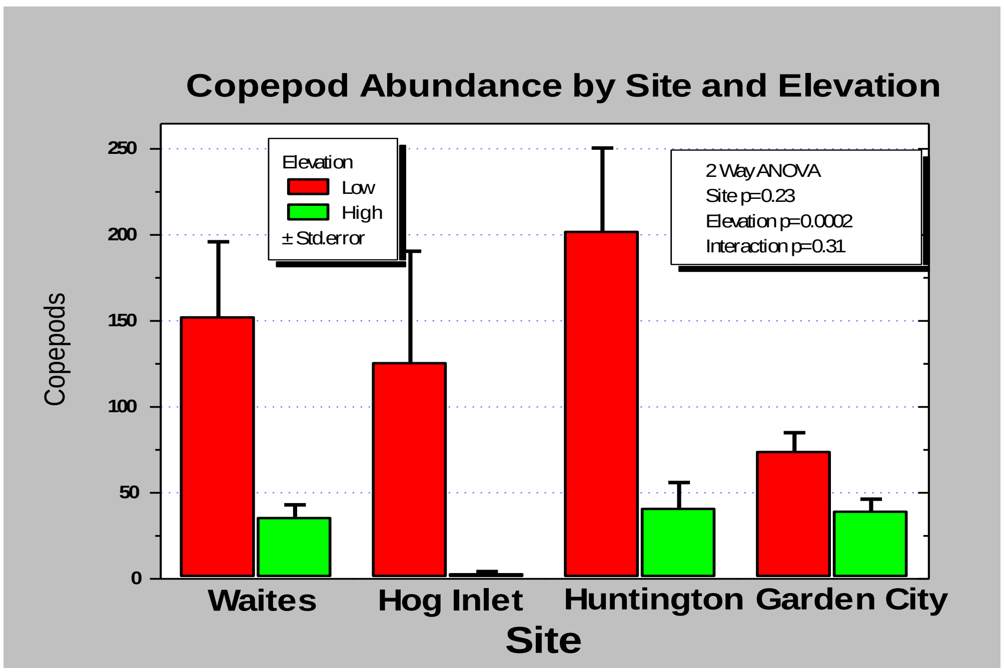

Fig. 5: Average copepod abundance per sample of 22.8cm^3 by site (Waties Island, Hog Inlet, Huntington Beach, and Garden City) and elevation (low and high).

When the nematode to copepod ratio was calculated for the average values of each 22.8cm^3 sample and tested with a two-way ANOVA, there was convincing evidence of a difference between sites (p=0.005), but no evidence of a difference between elevations (p=0.10).

The lowest ratios were seen in Waties Island within both the high and low marsh. The Huntington Beach ratios in both the high and low marsh were also low, but both were higher than the Waties ratios. The low marsh location in Hog Inlet showed the lower of the two ratios for the impacted sites, but it showed a higher ratio for the two impacted sites in the high marsh. Both impacted sites showed higher ratios of nematodes to copepods than the more pristine sites (Fig. 6).

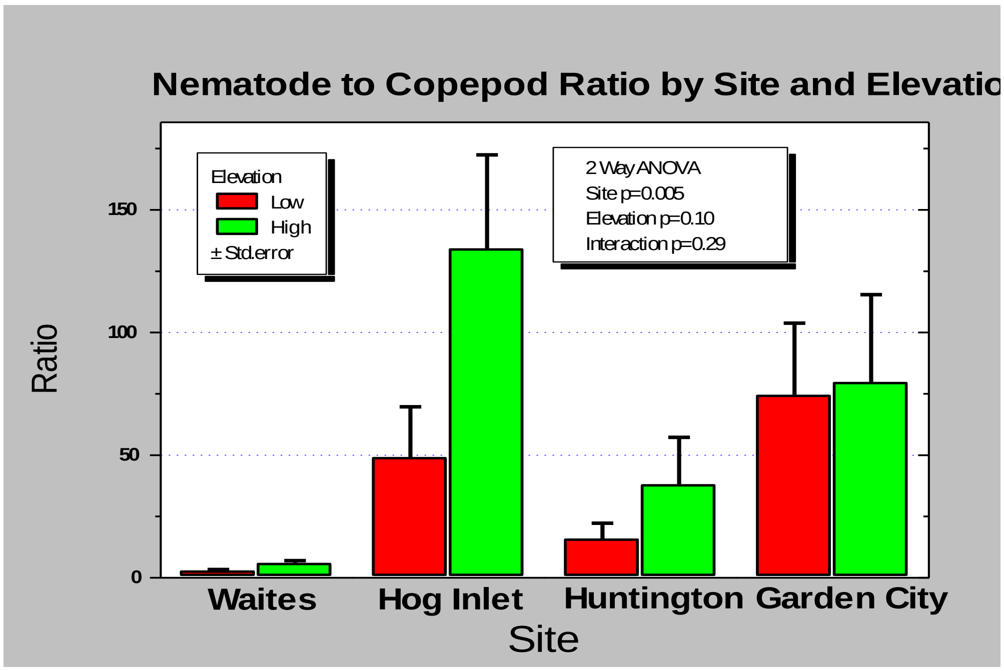

Fig. 6: Nematode to copepod ratio per sample of $22.8cm^3$ by site (Waties Island, Hog Inlet, Huntington Beach, and Garden City) and elevation (low and high).

Discussion

Urbanization of coastal environments will impact that environment in various ways, but those impacts will not necessarily have a negative result. For this study, there was an apparent shift in community structure between the developed and relatively pristine sites. There were significant differences in both pairs with a higher proportion of the community made up of nematodes and a lower proportion of copepods in the more developed sites. The proportion of forams, turbellarians, and ostracoda, like the copepods, made up a lower proportion of the community within the impacted sites. This suggests that the urbanization of the location may be associated with a shift in the community structure, where nematodes are able to become slightly more dominant and other species are reduced in their abundances. Throughout all of the sites, there were low abundances for both oligochaetes and polycheates, which is probably due to their more temporary meiofauna status causing them to be left behind in the sieving process if their size was too large. It is also possible that the oligochaetes and polycheates were out-competed in these communities and so made up a smaller proportion.

When the average nematode abundances were considered on their own, it was seen that there is a significant difference between both the sites and the elevations. The differences between elevations can be explained by the nematodes preference to be in more saline environments, hence their greater abundances in the low marsh locations. For the between site differences, it is clear that the more pristine sites had a lower abundance than the developed sites at both elevations. This suggests that estuaries with near-by development may be experiencing some change in nutrients, volume of runoff, or some other anthropogenically-caused shift in their environment that allows for a higher nematode abundance. It was expected that the results would show lower abundances of all organisms in the more impacted locations; however the nematodes have significantly higher numbers. This suggests that the nematodes are not being impacted by limiting pollutants such as lead and zinc, but rather are thriving and producing with resilience to the present pollutants. This result is similar to what was seen in an experiment on nematodes which showed that when nematodes are exposed to various common chemicals of pollutants, they will only show impact when exposed to specific elements such as lead and zinc (Gyedu-Ababio, et al., 2006).

The copepod abundances showed that there was a significant difference between the high and low marsh elevations, but no significant difference between the sites. Like the nematodes, copepods preferentially inhabit areas of higher salinity, usually having higher abundances within the low marsh. While there is no significant difference between the sites, there is a slight indication of some differences between the pristine and urbanized locations. Waties Island and Huntington Beach, for both elevations, showed higher copepod abundances than the Hog Inlet and Garden City sites. With this result, it is possible that the development of the coastal habitat is related to a slight decrease in the abundance of copepods. Previous studies have shown that copepod populations do not experience direct mortality due to changes in their environment, but rather experience a decrease in their reproductive success due to changes in concentrations of metals such as Ni, Cu, and Zn (Mohammed, et al., 2010). If this is the case, it is possible that within the impacted locations of this study, the copepods have undergone multiple generation cycles since first being impacted and have decreased in their overall abundance in these sites because of smaller, less successful generations of offspring.

The nematode to copepod ratio is a commonly used ratio to analyze the possible impact of pollutants and environmental changes on a community. While this method is not perfect, it does allow for a more concise comparison of proportional changes in nematodes and copepods. Waties Island and Huntington Beach had the smallest ratios, with both elevations of Waties reaching a ratio of nearly one. While the Huntington Beach ratios were higher than those of Waties Island, the ratios of Hog Inlet and Garden City were significantly higher, with similar trends in both the high and low marsh. Nematodes are a much more resilient group to environmental, specifically chemical, changes; whereas, copepods can be negatively impacted reproductively by similar changes. If an environment is being changed by anthropogenic pollutants, the reproduction of the copepods would decrease, which would lead to a decrease of their abundance within that environment. Conversely, the more resilient nematodes can withstand most anthropogenic pollutants with no significant mortality or change in their reproductive ability. With the decrease in the copepods, which are the nematodes' main competitor for resources, the nematodes are able to increase in abundance and make up a higher proportion of the community, causing a much higher nematode to copepod ratio. Lower nematode to copepod ratios are suggested to indicate a more healthy, stable environment. The results apparently go along with this fact, as Waties and Huntington have the lowest ratios.

However, the nematode to copepod ratio of Huntington Beach in both the high and low marsh is higher than that of Waties, but both sites are considered to be relatively pristine when compared to their developed counterpart. A possible reason for this apparent difference in these locations is that, when the aerial maps are re-analyzed, Waties Island is a good distance away from any form of significant development in the form of large housing areas, highways, or commercial business. In contrast, the Huntington Beach State Park, while undeveloped and pristine within its borders, is significantly closer to some mid-size developments, highways, and a largely developed area North of the Park. This suggests the possibility that, not only does urbanization affect the nearest estuary system through direct input of pollutants, runoff, and physical changes, it is also a possibility that these affects can be observed at some distance from the anthropogenic input through indirect travel of runoff and pollutants into non-adjacent estuary systems. Lee, et al. showed, in a similar study performed in Chile, that the ratio was not a good indicator for the concentration of metals; however, the abundance of copepods alone was able to provide more information (2001). For this study, while the nematode to copepod ratio will not provide direct information about the amount or type of pollution, it does show a more concise view of the trend by which the copepod abundance was lower when the nematode abundance was higher.

The results of this study show that the urbanization of the Myrtle Beach area may be impacting the near-by estuaries through input of pollutants to the systems. While some organisms are resilient and can resist the effects of these changes, other organisms do not have the same adaptations and can be significantly impacted both directly and reproductively, causing a decrease in their success. In this study, species-level identification could not be completed due to lack of knowledge in that area; however, studying more specific changes within the species of a certain group may allow for better analysis of the possible impacts. Previous studies have even suggested that species-level studies of nematodes could show the amount and type of pollutants within a system based on the different feeding preferences and styles of the various species. Due to the restraints of this study and the subject matter, it is impossible to conclude that there has been a definite shift in the communities due to the anthropogenic impacts on the estuaries because there is no way to obtain measurements from before the estuaries were impacted to compare the changes within one estuary. It is possible to make more connections by collecting some other such as analyzing different grain sizes in different locations and sites to see if that physical change is causing a shift in communities based on preference, pH of the soil to determine if the pollutants or runoff was causing a change in the pH such that certain species were being stressed to the point of mortality, and testing the muds for various chemicals and cross-referencing with common pollutants of the urbanized areas to see if there is truly a significant input of non-natural chemical substances into the estuaries. A previous study in the UK has shown that changes in species and community composition over various locations could be explained by concentrations of metals in the system and sediment grain size (Schratzberger, et al., 2000). Exploring the changes in specific sites as they become more anthropogenically impacted is the next step, and for this study, monitoring Huntington Beach as the urbanization continues to move closer to that location would be one way to see if there is a true shift due to those changes.

Conclusion

This study shows that there is an apparent shift in meiofauna community structure, which may be caused by the increased urbanization which has an anthropogenic impact on the estuaries. Specifically, the high nematode to copepod ratio in the more developed areas seems to be an indicator of increased pollution to those systems. The structure and ratio of the Huntington Beach State Park site also may indicate that, while this area is relatively pristine when compared to Garden City, it is still being impacted slightly by an increase in population. The results of this study indicate a need for further research to show if the differences in the meiofauna populations are due to an increase in exposure to toxins or by another environmental or anthropogenic change such as sediment type, volume of runoff, or soil pH. If it is found that these changes are due to an anthropogenic impact, a species-level identification of the meiofauna, specifically the nematodes, could be necessary to determine the effect of the toxins or differences in species composition.

Resources

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