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Abundance of Macro-organisms on Pneumatophores at Matapouri Estuary

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Abstract

Mangrove forests are important and productive ecosystems that exist only in certain climates. One mangrove system in particular, Matapouri Estuary, provides a great study site due to the easy accessibility of the estuary. It is unique in the fact that there are multiple habitats formed within the estuary which include mangrove forests, pneumatophore zones, and seagrass beds. In previous studies at Matapouri Estuary, pneumatophore areas have shown high epifaunal biodiversity (Alfaro, 2006; Morrisey et al., 2007). To quantify differences in macro-organism abundance, pneumatophore samples were collected from three different locations within the estuary and three main species—*Chamaesipho* spp., *Xenostrobus pulex*, *Saccostrea glomerata*—were identified and counted. From observation and lab work it was shown that zonation of organisms on the pneumatophores exists, but there is no clear reason as to why. The results of the study show that the location first location studied had higher abundances of all species.

Introduction

Mangrove forests are important and productive ecosystems that continue to remain poorly understood. These forests grow only in tropical and subtropical climates and are located within estuary systems near the sea (Kathiresan and Bingham, 2001). Mangrove trees have adapted to estuarine conditions of brackish water and anoxic soil. The roots of mangrove trees have adapted to these conditions by growing upward. These upright aerial roots, called pneumatophores, extend above the mud at low tide allowing the plant to obtain oxygen (Hogarth, 2007; Kathiresan and Bingham, 2001). In New Zealand, in particular, mangroves create issues with local residents because they tend to overgrow and take over the beautiful sandy beaches, replacing the sand with muddy mangrove forests. It is important to learn more about mangroves and the habitats they create in order to know how best to deal with these issues (i.e. should mangrove forests be cut back, or should we leave them to overtake the beaches?).

The study site, Matapouri Estuary, is located on the North Island of New Zealand. This study site contains multiple habitats in which many different species live. Within the estuary there are not only habitats created by the mangrove trees, but also seagrass, sand flat, pneumatophore, and channel habitats which surround the river that runs through the estuary. Previous studies such as Alfaro (2006) show that some zones are more abundant or productive than other zones, such as pneumatophore zones. This study focuses on the abundance of species within those pneumatophore zones. Pneumatophore samples were collected and species abundance was quantified. Zonation patterns of organisms on the pneumatophores was also noted.

By studying one of the more abundant zones within the estuary, especially one which is directly related to the growth of mangrove trees like pneumatophores, it will further understanding of mangrove systems. This can then be applied to the social and scientific issue of what to do with overgrown mangrove forests in New Zealand.

Background

Mangrove systems are important in enriching coastal waters because of the leaf litter. As mangrove leaves die they begin to decompose, releasing nutrients into the surrounding habitats, mainly the mud and water. This can lead to high biological productivity. In lower latitudes there are higher amounts of nutrients because the rate of decomposition of mangrove litter is accelerated (Kathiresan and Bingham, 2001). Not only does the leaf litter provide nutrients to the estuary, but the surrounding zones (i.e. pneumatophores, sand flats, etc.—see Figure 1) also provide great habitats for a variety of organisms. For example, pneumatophores have a film of diatoms and algae that grow, but larger organisms such as barnacles, gastropods, and bivalve mollusks, including mussels and oysters, can be attached to the pneumatophore as well (Hogarth, 2007).

Although there are many different mangrove species, only one of those species, *Avicennia marina* var. *australasica*, grows in New Zealand. Mangrove forests are primarily located on the top of the North Island in New Zealand, where the forests grow larger toward the top of the island. One mangrove system in particular provides a great study site—Matapouri Estuary. Matapouri Estuary, mapped out in Figure 1, is located on the top of the North Island of New Zealand. This estuary is fairly shallow, contains many different habitats beside the mangrove forest, and is perfect for study because the bend in the river creates a place for replicate studies. The different habitats that have been studied thoroughly within the estuary include mangroves, pneumatophores, seagrass beds, channels, banks, and sand flats, as indicated in Figure 1. In previous studies at Matapouri Estuary, pneumatophore areas have shown high epifaunal biodiversity (Alfaro, 2006; Morrisey et al., 2007). Epifaunal biodiversity refers to the variety of animals living on the surface of a particular substrate, such as the surface of the pneumatophore. Pneumatophores often have mussels, barnacles, oysters, and filamentous seaweeds attached to them and can be zonated according to the tidal levels. A zonation pattern, for purposes of

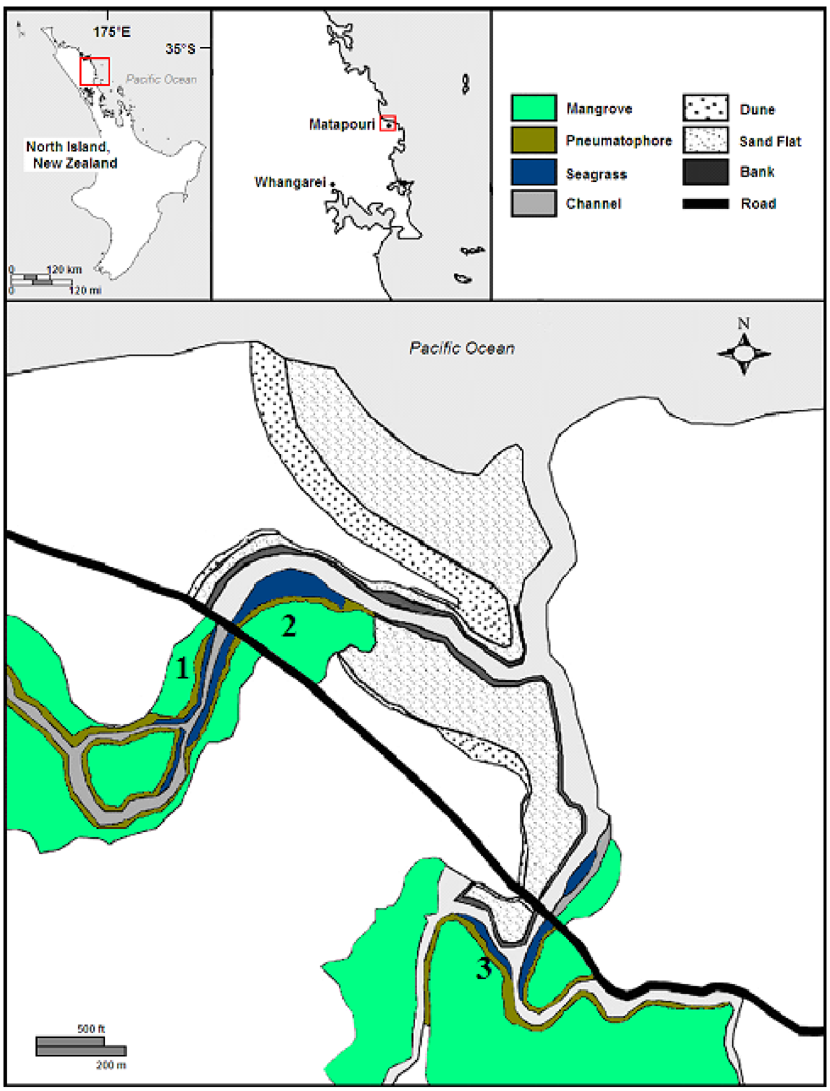

Figure 1. Map of study site at Matapouri Estuary, North Island, New Zealand. Numbers 1, 2, and 3 signify general area of sampling locations. Modified from Alfaro, 2006.

this research, will be any observation that shows a certain organism living in one specific area as opposed to another (i.e. mussels which only live on the top of the short pneumatophores which do not get fully immersed even at high tide). This research is to see if there is higher abundance, i.e. a larger amount, of certain organisms in one location in the estuary than the others.

Methods

Pneumatophore samples were collected from locations 1, 2, and 3 (Figure 1) on April 4, 2009. Pneumatophore zones were located on the edges of the mangroves closest to the water (Figure 1). Each sample was taken at low tide in order to identify zonation patterns amongst the larger organisms on the pneumatophores. The pneumatophore roots themselves were classified as short or long based on observation. Short pneumatophores ranged between 9 cm and 16.5 cm (with one outlier, see Appendix), and long ranged between 16.5 cm and 24 cm. All samples were given a label based on this length classification and field observations of the predominant type of organism living on the pneumatophore, such as mussels, barnacle, mixed community or seaweed covered. At each location 10 pneumatophores per classification were collected, approximately 100 in total.

Two pneumatophores per classification type and location were analyzed in the lab, in total: 20. Each root was stripped of all visible organisms and the length of the root was measured to ensure similar surface area for all pneumatophores investigated. Visible organisms that were stripped from the pneumatophores were then identified as mussel, barnacle, oyster, or other, and counted. Zonation of organisms was noted before organisms were stripped from pneumatophores. Mussels, barnacles, and oysters were then identified at the species level as *Xenostrobus pulex*, *Chamaesipho* spp. (both *C. columna* and *C. brunnea* were present but not distinguished during organism counts), and *Saccostrea glomerata*. Abundance was quantified and compared for each location based on this data. To see if the qualitative results observed in the field were consistent with the results obtained from lab work, graphs showing abundance were made.

Results

In the field it was noted that the pneumatophore zones in each location varied in size. Locations 1 and 3, which were replicate locations, both had pneumatophore zones on the western edge of the river. Location 2 had a small pneumatophore zone located on the eastern edge of the river as well as some on the southern side of the bend. Pneumatophore zones only appear in location 2 on the northern side of the bridge (Figure 1). Also it was noted that the pneumatophore coverage grew denser farther from the road, which was landward.

Other field observations noted that organisms on pneumatophores were zonated in relation to water levels. In general, pneumatophores identified as mussel dominant and mixed community (mussel and barnacle) were located above the low tide water level, closer to the trees. Barnacles could be found in and out of the water during low tide, and pneumatophores with seaweed were generally located nearer to the water. Mussel and barnacle dominant pneumatophores were seen in all locations, whereas mixed and seaweed pneumatophores were not seen, though oysters were observed in location 2.

The total abundance of barnacles was the greatest, with mussels being second greatest, ‘Other’ third, and oysters being the least (Figure 2). Location 1 had the highest abundance of all species and location 2 had the

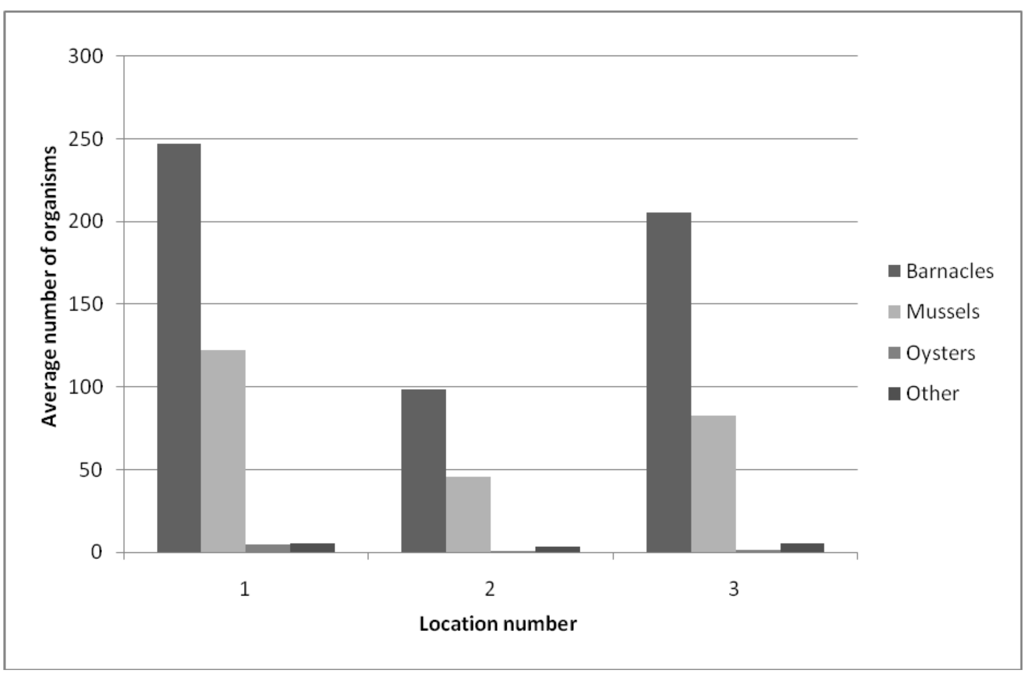

Figure 2. Total abundance using average amounts of *Chamaesipho* spp., *X. pulex*, and *S. glomerata* per location at Matapouri Estuary.

lowest abundance of all species. Locations 1 and 3 show abundances very close to one another, but overall abundance is slightly higher at location 1 than location 3 (Figure 3). At location 1 the relative abundance of mussels compared to barnacles is higher due to the presence of many juveniles found mixed in with the adults. Also, all mussels found on barnacle dominated pneumatophores were juveniles, which means that location 1 has more juvenile mussels than location 3. Both graphs show a general trend of barnacles being the most abundant species on all types of pneumatophores except for the short pneumatophore with mussels as a predominant feature. Long pneumatophores with mixed communities showed that although barnacles dominated over mussels, the amount of each on any particular pneumatophore would be close to the same.

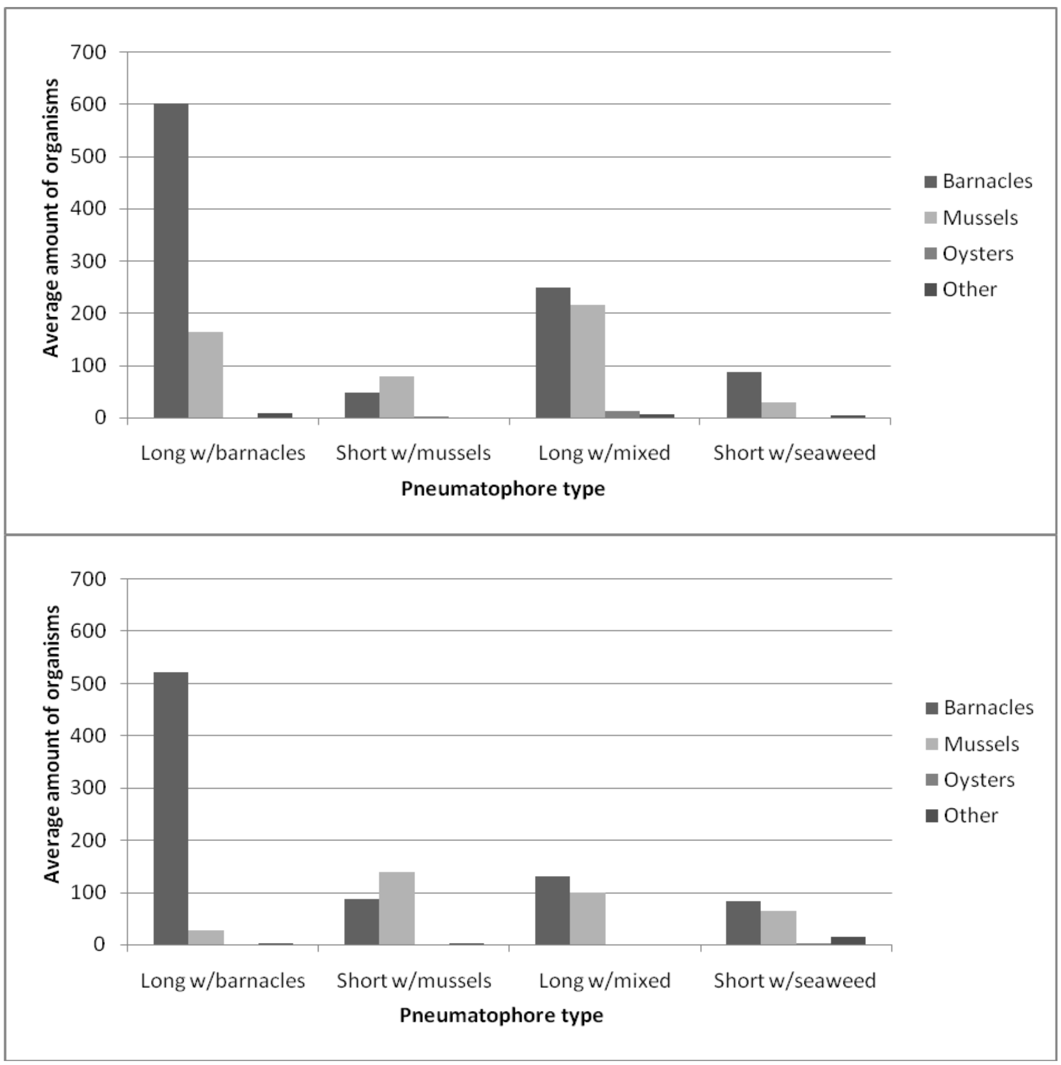

Figure 3. Top: abundance at location 1 at Matapouri Estuary using average amounts of *Chamaesipho* spp., *X. pulex*, and *S. glomerata* per pneumatophore type. Bottom: abundance at location 3 at Matapouri Estuary using average amounts of *Chamaesipho* spp., *X. pulex*, and *S. glomerata* per pneumatophore type.

Location 2 shows much different amounts of organisms than locations 1 or 3. The overall trend of the amount of barnacles being higher on barnacle dominant pneumatophores and the amount of mussels being higher on mussel dominant pneumatophores remains the same, but the amounts are much smaller than observed at the other locations (Figure 4). Oysters seem to be lacking altogether in location 2, although oysters were observed in the area during field observations. Both Figure 3 and Figure 4 confirm that field labeling of pneumatophore types correspond with actual dominant species.

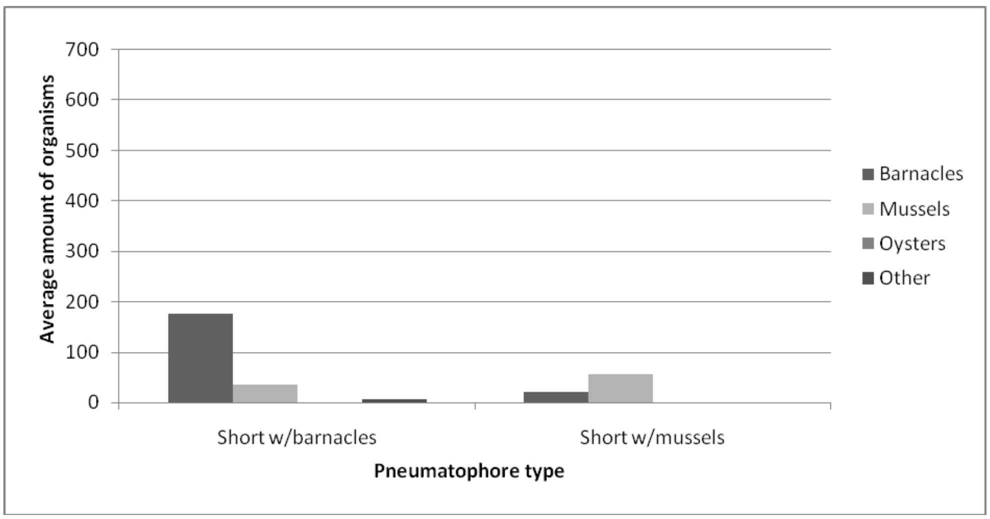

Figure 4. Abundance at location 2 at Matapouri Estuary using average amounts of *Chamaesipho* spp., *X. pulex*, and *S. glomerata* per

Discussion

The size and area of pneumatophore zones can be attributed to the location of each specific site within the estuary and the relative position of each with respect to the road which crosses both legs of the river. Both locations 1 and 3 are positioned on the southern side of the road where there is a larger amount of space and land. The mangrove forest is very large south of the road which means there is more potential for a greater amount of pneumatophores. There is very little land on the northern side of the bridge which is covered by mangrove trees compared to the southern side which would imply less pneumatophore growth.

On most pneumatophores the organisms chose to stay closer to the top, leaving a gap of exposed pneumatophore at the bottom near the mud. This zonation of organisms on the pneumatophores may be caused by several factors. Satumanatpan et al. (1999) suggests that zonation of barnacles on pneumatophores may be due to avoidance of disturbances such as ‘covering by drift seagrasses or algae, or smothering by sediment’. This could very well apply to other species such as the mussels and oysters studied. The only pneumatophores which exhibited less zonation patterns were the pneumatophores with seaweed coverage. This may be due to the fact that the pneumatophore and organisms had some protection from river-caused disturbances because of the seaweed coverage.

Barnacles on pneumatophores in Australian mangroves were found more toward the seaward zone of the estuary (Satumanatpan et al., 1999), which may explain the large abundance of barnacles at the locations studied at Matapouri seeing that these locations are very close to the tidal inlet and very much seaward. It is also noted that barnacles were the dominants species growing in these Australian estuaries (Satumanatpan et al., 1999), which, together with the fact that barnacles are less abundant landward, may show that temperate mangrove forests are dominated by barnacle species nearer to the ocean.

Analysis of locations 1 and 3 show that the abundance of organisms on pneumatophores is similar not only for total abundance (Figure 2) but also for the abundance on each type of pneumatophore (Figure 3). This is to be expected because location 1 and 3 are replicate sites. Locations 1 and 3 were replicates because of their locations within the estuary and likeness to each other in that they are both on the south side of the road and their pneumatophore zones are both located on the western side of the river. The difference in abundance between locations may be negligible, but the fact that location 1 had higher abundances of juveniles (implicated in higher abundance of mussels on barnacle dominated pneumatophores) may be of importance. This could be due to the location of the tidal inlet with respect to location 1.

Location 2 has a great difference in abundance when compared to other locations. There may be many reasons as to why certain aspects of the two other locations were diminished or missing from location 2, but without further research it would be hard to guess what caused these differences. For example, although there were no mixed community or seaweed dominated pneumatophores in location 2, oysters were found in the mud at that location at the time of field observations. This could be an error in sampling and in future studies more samples of pneumatophores of each type should be taken.

Oysters in this estuary should have larger settlements in areas of denser plant growth, such as locations 1 and 3 where there is more room for trees to grow. Oyster larvae feed on plant-cells and matured oysters also feed on plant matter (Yonge, 1960; Elliott, 1966), so where there is increased plant growth there should, theoretically, be a larger amount of oyster settlement. Location 2 does have potential to support oyster settlements because of the presence, though minute, of mangrove trees and a large bed of *Zostera*, or eel-grass. Oysters feed on nanoplankton, diatoms, flagellates (a type of cell), and plant particles (Elliott, 1966). Oyster spat have large settlements when eel-grass leaves are decaying because the flagellates feed on the bacteria produced by the decay of the leaves (Yonge, 1960). This could also be evidence that there were more oysters in location 2 than the samples showed, which, in the future, would require more samples to be processed to rule out sampling error.

Conclusion

Location 1 had the highest abundance of all species. Location 3, although it is a replicate and should be very close to the same as location 1, had slight differences compared to location 1. Location 2 has a very low abundance of all species. Further research on each location should be done to better understand why there are differences between sites with respect to pneumatophore type and species abundance. Future studies should estimate the area of each location, the amount of pneumatophore coverage, the amount of long versus short pneumatophores, and the amount of coverage by each species on the pneumatophore itself. This would give a better estimate for the total species abundance on pneumatophores and help identify further differences between each location. To understand why there may be differences in abundance, measurements of temperature and salinity may be helpful. A better understanding of reproductive cycles of each species would help determine whether or not low abundance on pneumatophores is due to low productivity in the general area, or if it is due to the fact that organisms had not settled and matured on the pneumatophores yet. Gut content analysis of each species found in this study would help to see what their main food supply is. Further studies should go into where this food supply comes from. Also, zonation of organisms on pneumatophores does occur, especially with barnacles and mussels. In order to understand this better more studies, maybe direct observation, would be necessary to see why these patterns exist.

References

Alfaro, A.C., 2006. Benthic macro-invertebrate community composition within a mangrove/seagrass estuary in northern New Zealand. Estuarine, Coastal and Shelf Science 66, 97-110.

Elliot, H., 1966. Some Aspects of the *Crassostrea* Species in Australian and New Zealand Waters, With Special Reference to the New Zealand Northern Rock Oyster, *C. Glomerata*. New Zealand Marine Dept. Technical Fisheries Report No. 11.

Hogarth, P., 2007. The Biology of Mangroves and Seagrasses. 2nd ed. Oxford University Press, New York, USA.

Kathiresan, K., Bingham, B. L., 2001. Biology of Mangroves and Mangrove Ecosystems. Advances in Marine Biology 40, 81-251.

Morrisey, D., Beard, C., Morrison, M., Craggs, R., Lowe, M., 2007. The New Zealand mangrove: review of the current state of knowledge. Auckland Regional Council.

Satumanatpan, S., Keough, M.J., Watson, G.F., 1999. Role of settlement in determining the distribution and abundance of barnacles in a temperate mangrove forest. Journal of Experimental Marine Biology and Ecology 241, 45-66.

Yonge, C.M., 1960. Oysters. Collins Press, London, Great Britain.

Appendix

Table 1. Location, classification, length, and abundance of organisms for pneumatophore samples.

Location	Classification	Length (cm)	Barnacles	Mussels	Oysters	Other
1	Long w/barnacles	21.5	599	136	0	13
1	Long w/barnacles	20.3	606	191	0	6
1	Short w/mussels	11.8	36	90	2	0
1	Short w/mussels	11.8	61	69	6	1
1	Long w/mixed	24	152	262	20	6
1	Long w/mixed	20.2	348	170	5	6
1	Short w/seaweed	9	0	27	0	6
1	Short w/seaweed	11.6	176	31	2	5
2	Short w/mussels	15	0	58	1	0
2	Short w/mussels	18.3	43	55	0	0
2	Short w/barnacles	15.2	160	35	2	4
2	Short w/barnacles	16	191	35	0	8
5	Short w/mussels	14	141	162	0	4
5	Short w/mussels	15	31	117	1	0
5	Short w/seaweed	16.5	99	69	5	16
5	Short w/seaweed	13.5	68	60	2	13
5	Long w/barnacles	16.5	511	27	0	2
5	Long w/barnacles	17.1	533	28	0	5
5	Long w/mixed	-	198	80	0	1
5	Long w/mixed	17.4	65	119	0	0