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Fauna Census of Intertidal Cliffs, Mangapwani, Zanzibar

Emily Jankowski
SIT Study Abroad, jankem01@gettysburg.edu

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Emily Jankowski

Advisor: Dr. Saleh Yahya

Academic Director: Helen Peeks

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Abstract

Due to their extreme variations in condition over the course of a day, intertidal zones are challenging environments. Organisms that live there must be prepared to cope with both exposure and submersion, not to mention the temperature variations that accompany these conditions. The differing tolerances and adaptations of various organisms to these conditions generally cause patterns of vertical zonation to occur in the intertidal zone, especially when the shore is steep and rocky. Understanding the ecology of shore environments is important to future conservation and management efforts. This study was conducted on a beach in Mangapwani, Zanzibar at at 6˚ 9.874'S and 39˚ 11.281'E. In order to establish what organisms make use of steep, rocky, intertidal habitats in Zanzibar and establish a baseline understanding of the ecosystem with which to compare future changes, a census was taken of the animals living on the intertidal sections of cliffs and steep rock faces and data was analyzed for evidence of vertical zonation patterns. Informal observations of human activity were also made to gauge the likely level of anthropogenic impact already occurring at the site. From April 6 through April 23, organisms were identified and counted along 11 transects with between six and 11 replicates per transect location. Nineteen different kinds of organisms from three phyla (Chordata, Crustacea, Mollusca) were observed over the course of this study. The most numerous animals were acorn barnacles (*Chthamalus dentatus*), conical barnacles (*Tetraclita squamosal rufotincta*), limpets (Phylum Mollusca, Family Patellidae), and mussels (Phylum Mollusca, Family Mytilidae). These organisms were all very likely to exhibit distribution patterns along a transect that were found to be significantly inconsistent with random distribution.

Introduction

Coastal ecosystems are shaped by many physical and biological factors. One of the most prominent of these is the tide. Due to the effects of basin shape on amplifying and dispersing tidal movements, tidal patterns and ranges vary greatly by region. The most common tidal pattern is semi-diurnal, in which two high and two low tides of approximately equal height occur each day. Other areas have diurnal tides, in which only one high and one low tide occur per day, or mixed semi-diurnal tides, in which two high and two low tides occur daily, but they are unequal. In Zanzibar, the tide is semi-diurnal and the range is fairly high, averaging about 4m.

The area of shore that is exposed at low tide and submerged at high tide is the intertidal zone. Intertidal zones are challenging habitats because of their fluctuating conditions. Organisms living within these zones must be able to tolerate submersion and exposure, as well as the wide range in temperatures that accompany these disparate conditions. Temperature is a well-known factor that affects organism distribution, and acute heat stress events may be more damaging than sustained heat to some organisms (Lathlean, Ayre, and Minchinton 2014). As a result of this difficult environment, many organisms are highly specialized within the intertidal zone, resulting in vertical zonation. Vertical zonation describes distribution patterns in which certain species dominate particular elevations. On cliffs and rocky shores, this can result in stacked, visually distinct bands inhabited by different organisms. Patterns of vertical zonation are formed by a combination of many factors, but often the upper limit of a species range is set by abiotic factors such as temperature while the lower limit is set by biotic factors such as predation (McNeill 2010). Zonation on open rock face is traditionally considered to be primarily caused by the degree of exposure to the interrelated factors of dessication, heat, and light combined with the degree of exposure to wave action (Stephenson 1942). However, the reality is much more complicated as physical factors can sometimes alter the results of community interactions, which can in turn alter the community structure and zonation patterns. Intertidal zonation patterns are not truly descriptive of an inherent coastal community structure, but instead represent a "snapshot" of a dynamic community structure at a particular place and time (Benson 2002). For example, Gestoso, Arenas, and Olabarria (2015) found that environmental stress in the form of increased temperature and lower pH differentially affected the susceptibility of two mussel species to predation by dogwhelks, causing one mussel species to be consumed far more than the other in laboratory experiments. Whatever the combination of causes, vertical zonation is often much less pronounced on sandy and muddy shores. This is partially because the slope of the beach is often more gentle, resulting in a more gradual change in physical parameters (Sawicki 2000). Additionally, many organisms live interstitially on sandy and muddy beaches and are simply more difficult to observe than the encrusting organisms that often live on rock faces. It is important to note, however, that vertical zonation is not directly related to biodiversity. Both sand-free and sand-covered rocky areas have been found to have similar levels of species richness and a tendency to be dominated by relatively few species (Díaz-Tapia, Bárbara, and Díez, 2013).

Human activities can also have a large impact on the ecology of the intertidal zone, especially in areas where people collect organisms for food. Castilla et al. (2014) studied the exploitation of an invasive tunicate in Chile. The tunicate had previously displaced native mussels in the intertidal zone, but in areas where the tunicate was harvested extensively by the local population its numbers had declined sharply and the local mussels and barnacles were reclaiming the mid-intertidal zone . Even tourism can have adverse effects however, as some organisms may get trampled or otherwise disturbed. Pour, Shokri, and Abtahi (2013) found a significant difference in taxonomic richness, density, and assemblage structure of macroinvertebrates living in the intertidal zones of heavily trafficked tourist beaches as compared to those of pristine beaches. Similar results have been obtained experimentally for intertidal algal cover, which was found to decrease up to 20% with human interference (Kimura et al. 2014).

Although much is already known about rocky intertidal zones in general, relatively little study has been done on the ecology of rocky intertidal zones in Zanzibar. The community of one intertidal region cannot be predicted by another, as combinations of many small biotic and abiotic factors shape the community. Relatively close sites, even on the same island, can have very different community structures despite sharing similar tides, currents, and substrate (Cox et al. 2013). In order to understand Zanzibar-specific community structures of the intertidal zone, studies must be conducted in Zanzibar. With tourism increasing, it is important to establish a baseline understanding of this habitat in an area of low human impact for comparison to tourist areas and to gauge future changes. Better knowledge of the structure of the local ecosystem can lead to better conservation and management plans in the future. The purpose of this study was to conduct a census of the fauna living on the cliffs of Mangapwani, Zanzibar and look for evidence of vertical zonation patterns.

Study Area

Tanzania is a country located on the eastern coast of Africa, bordered to the north by Kenya and to the south by Mozambique. The country has approximately 1,424 km of coastline on the Indian Ocean and includes the Zanzibar archipelago, which consists of many small islands and two large ones: Unguja and Pemba (Figure 1). Unguja Island is 1,658 km² and is home to Stone Town, the historic center of the capital of Zanzibar. It is considered the main island of the archipelago and is separated from the mainland by Zanzibar Channel. The channel is relatively shallow at approximately 40m maximum depth and it is about 40km wide. Unguja is located six degrees south of the equator and has a tropical climate that remains between about 22˚C and 32˚C year-round. Precipitation, however, varies greatly by season. Due to the monsoon wind patterns in the Indian Ocean region, Zanzibar experiences two rainy seasons every year. The shorter one runs from November to December, and the longer one begins at the end of summer in mid to late March and lasts through May.

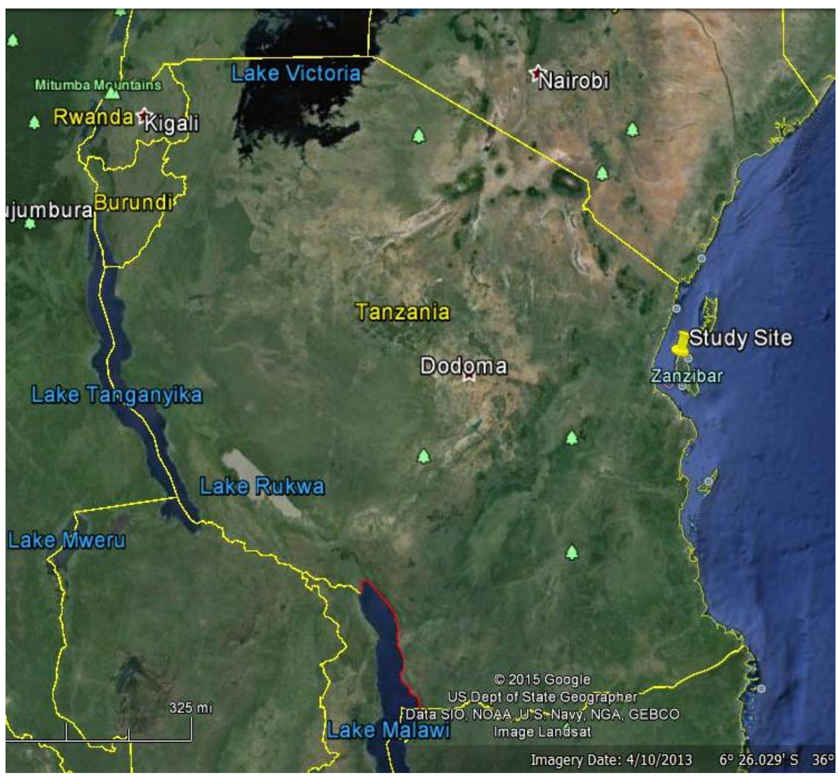

Figure 1. A map of Tanzania and Zanzibar(source: Google Earth).

Mangapwani is a small fishing village on the west coast of Unguja Island, about 20km north of Stone Town. The beach surveyed is found at 6˚ 9.874’S and 39˚ 11.281’E and is accessed by a staircase near the Slave

Chambers historic site or by walking from adjacent beaches when the tide is low (Figure 2). The beach is approximately 200m long and sandy, although there are many rocky outcrops and a section of cliffs. These rocks and cliffs are made of the ancient coral rock which makes up the vast majority of Unguja. Today, their intertidal location and numerous nooks and crannies make these rocks an important habitat for many organisms. Similar rocks and cliffs are located in other regions of Unguja, but Mangapwani's small size has shielded its shores from overdevelopment and excessive tourism. Additionally, although Mangapwani is a fishing village, this beach is too small with not enough large sandy areas to be used as a landing site for fishermen. These factors make this beach an ideal site for an ecological study with relatively low interference from human activity.

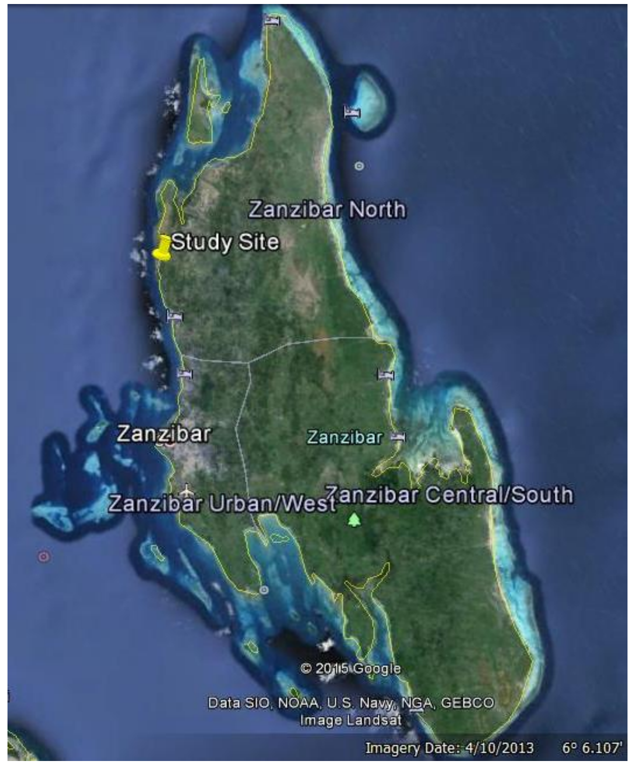

Figure 2. A map of Unguja (courtesy of Google Earth) showing the position of the study site in Mangapwani with a yellow pin.

Methodology

A GPS was used to record the location of the specific beach studied in Mangapwani. Individual transect coordinates were not recorded as the beach was too small for the GPS to register a difference between many of the transects. Twelve vertical transect locations were randomly selected from among the accessible rocky outcrops and cliff faces on the beach. Transects were measured from where the base of the rock met the sand, as it was the only consistently accessible point. A $0.25m^2$ quadrat was placed adjacent to the measuring tape and all animals within the quadrat were recorded by transect number and quadrat location they were found in. The quadrat was placed every half meter, forming a continuous sample area one half meter wide and the length of the transect. To improve accuracy, the height of each transect was limited to the height at which the researcher felt comfortable making accurate counts and usually amounted to 1.5 vertical meters. Transects were measured from the base of the rock and quadrats were numbered such that quadrat number increased with height.

Transects were conducted in the four hours surrounding low tide from April 6 through April 23, 2015 with some days skipped due to weather or the timing of low tide for the day. Transect 1 was discarded after one sample and was not further analyzed as it was all supralittoral habitat, but all other transects were conducted between six and eleven total times in this period.

Organisms were identified primarily using A Field Guide to the Seashores of Eastern Africa and the Western Indian Ocean Islands (Richmond 2011) as well as other field guides and internet sources as required. Organisms were identified in the field or photographed or described for later identification.

Because there was no way to measure true elevation, each transect was analyzed individually for evidence of zonation. Total counts across all days for each species were divided by specific quadrat along the transect and a Chi square goodness of fit test was performed on each to compare the distribution of each species to a random or uniform distribution which would indicate no preference or zonation. For each transect, this was done for every species with a sufficient sample size. The minimum sample size was set at least 10n observations total, where n is the transect length in meters. The mean numbers of each of these species observed per quadrat per day were also graphed to help visualize trends.

During the course of field work, some informal observations were also recorded on human activities on the beach in order to estimate the level of human impact on the ecosystem.

Results

Across all transects and all sample days, animals belonging to three phyla; Mollusca, Crustacea, and Chordata; were identified. The molluscs included chitons (*Acanthopleura gemmate*), periwinkles (*Littoria glabrata*), nerites (*Nerita undata*), rock shells (*Morula granulate*), limpets (Family Patellidae), slugs (*Onchidium* sp.), mussels (Family Mytilidae), and two unidentified snail species (Gastropoda).The crustaceans included acorn barnacles (*Chthamalus dentatus*), conical barnacles (*Tetraclita squamosal rufotincta*), hermit crabs (Superfamily Paguroidea), pebble crabs (*Eriphia smithi*), striped pebble crabs (*Lydia annulipes*), shore crabs (*Macrophthalmus boscii*), small crabs (Family Grapsidae, most likely *Pachygrapsus plicatus* and/or *P. minutus*), and two unidentified crab species. The only chordate observed was the African striped skink (*Trachylepis striata*).

Transects varied in the abundance of organisms as well as which organisms were present (see Appendix I). Each transect had anywhere from four to 11 different kinds of organisms. Organisms found on the most transects include limpets, mussels, and chitons. The rarest organism was the African striped skink, with only one observation in a transect across the duration of the study. Skinks were frequently observed on the rocks, but fled quickly at the researcher's approach. Mussels, acorn barnacles, white barnacles, and limpets were the most numerous organisms, appearing in very high densities in certain locations (Appendix II).

In transects 2 and 11, very few organisms were counted and the sample sizes were too small for effective analysis. In transect 3, Chi-square goodness of fit analysis determined that the distribution of acorn barnacles, chitons, limpets, and mussels were all significantly different from a random distribution across quadrats ($p<0.0001$, all Chi-square results in Appendix III). Acorn barnacles. mussels, and limpets each peaked in the second quadrat, while chitons increased in each quadrat, peaking in the final one (Figure 3).

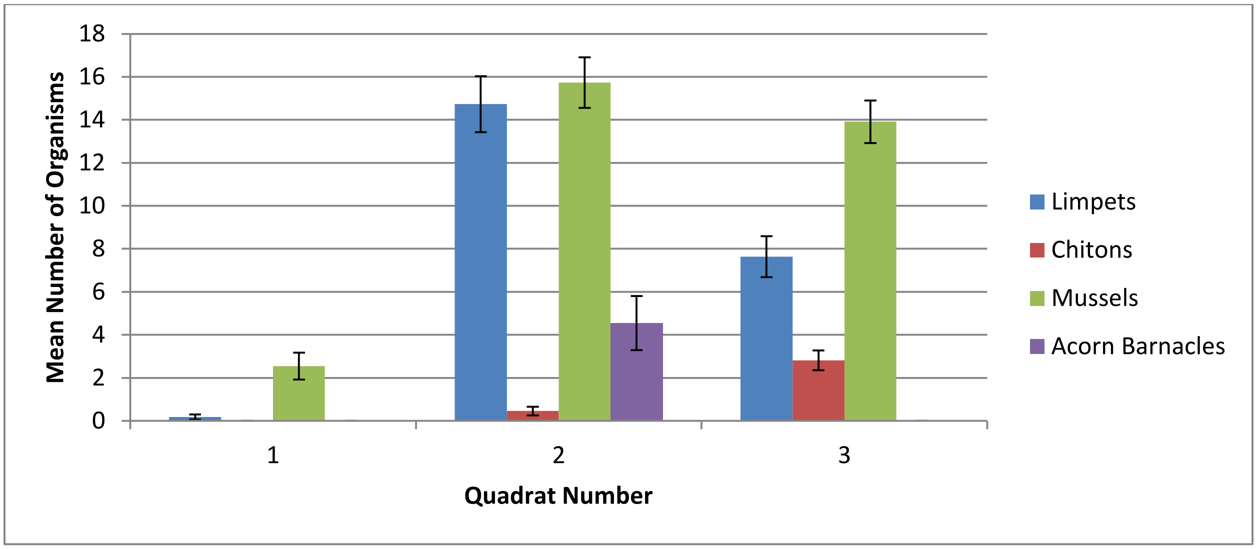

Figure 3. Mean numbers of selected species observed in transect 3 by quadrat. Error bars show ±standard error.

In transect 4, only limpets and rock shells had a sufficient sample size to analyze distribution. The distribution of limpets was found to be statistically significantly different from a random distribution ($p=0.0316$), but for rock shells the difference was non-significant ($p=0.1345$). Limpets tended to increase in abundance with distance, while rock shells and the next most numerous organisms were seen in roughly equal numbers throughout (Figure 4).

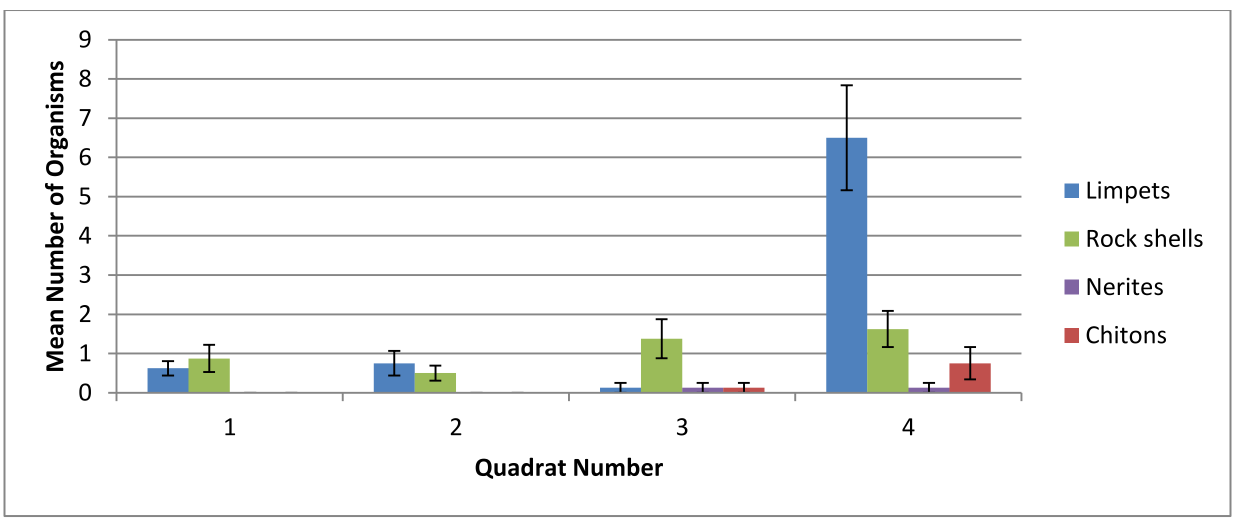

Figure 4. Mean numbers of selected species observed in transect 4 by quadrat. Error bars show ± standard error.

In transect 5, chiton, conical barnacle, limpet, mussel, and rock shell distribution were all significantly different than random distributions ($p<0.0001$). Of these, mussels and limpets tend to increase with increased height. Conical barnacles are not found at all before the seventh quadrat and peak sharply in the ninth quadrat (Figure 5).

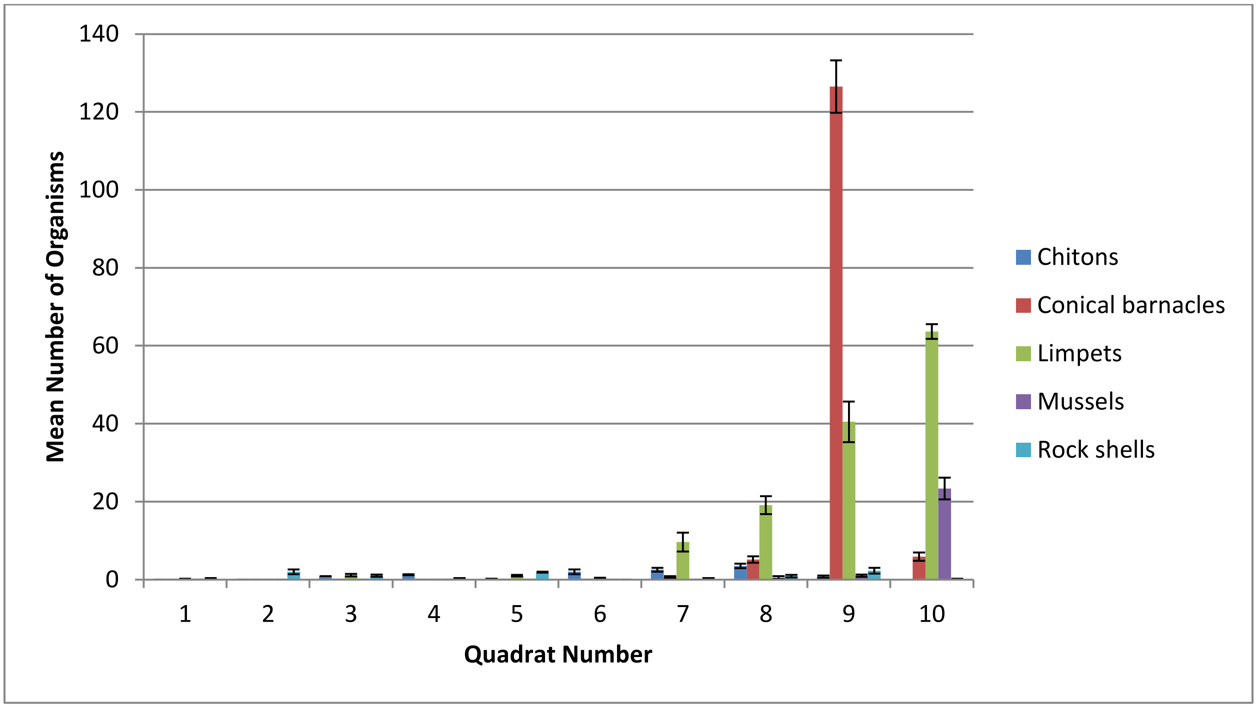

Figure 5. Mean numbers of selected species observed in transect 5 by quadrat. Error bars show ± standard error.

Conical barnacle, limpet, and rock shell distributions all varied significantly from a random distribution in transect 6 ($p<0.0001$). Limpets showed a clear trend with height however, tending to increase in abundance as height increased. Conical barnacles were only present in quadrats 4, 6, 7, and 8, with a clear peak in quadrat 7. Rock shells had a small peak in abundance in quadrat 6 (Figure 6).

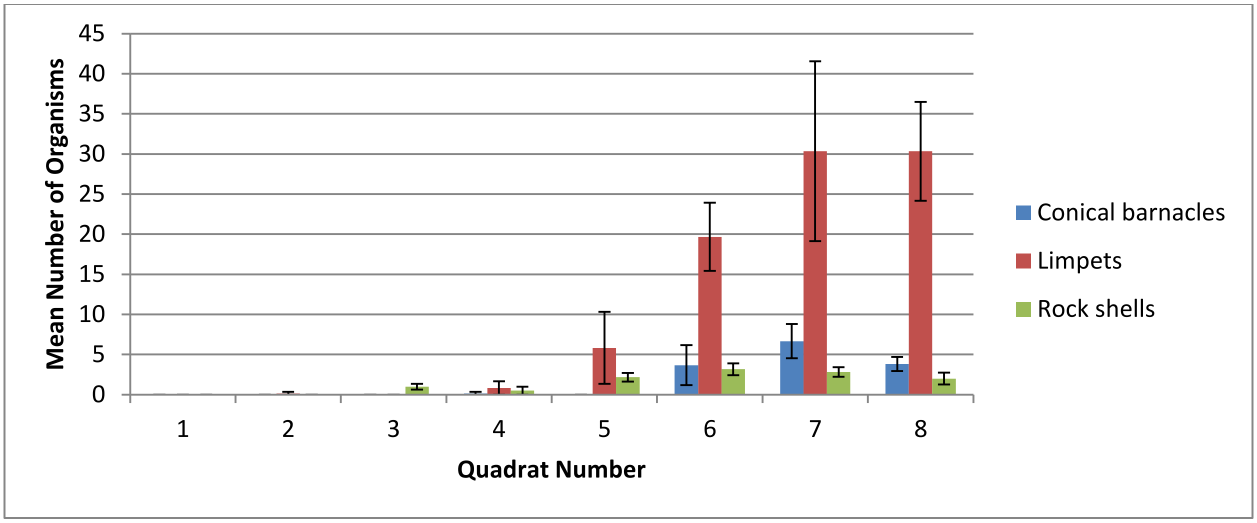

Figure 6. Mean numbers of selected species observed in transect 6 by quadrat. Error bars show ± standard error.

In transect 7 acorn barnacle, conical barnacle, limpet, and mussel distributions were all statistically significantly distinct from a random distribution (p<0.0001). Acorn barnacle and mussel abundance increased with increasing height while conical barnacles peaked in the second quadrat. Limpet abundance was roughly equal in quadrats 2 and 3, but this was clearly higher than in quadrat 1 (Figure 7).

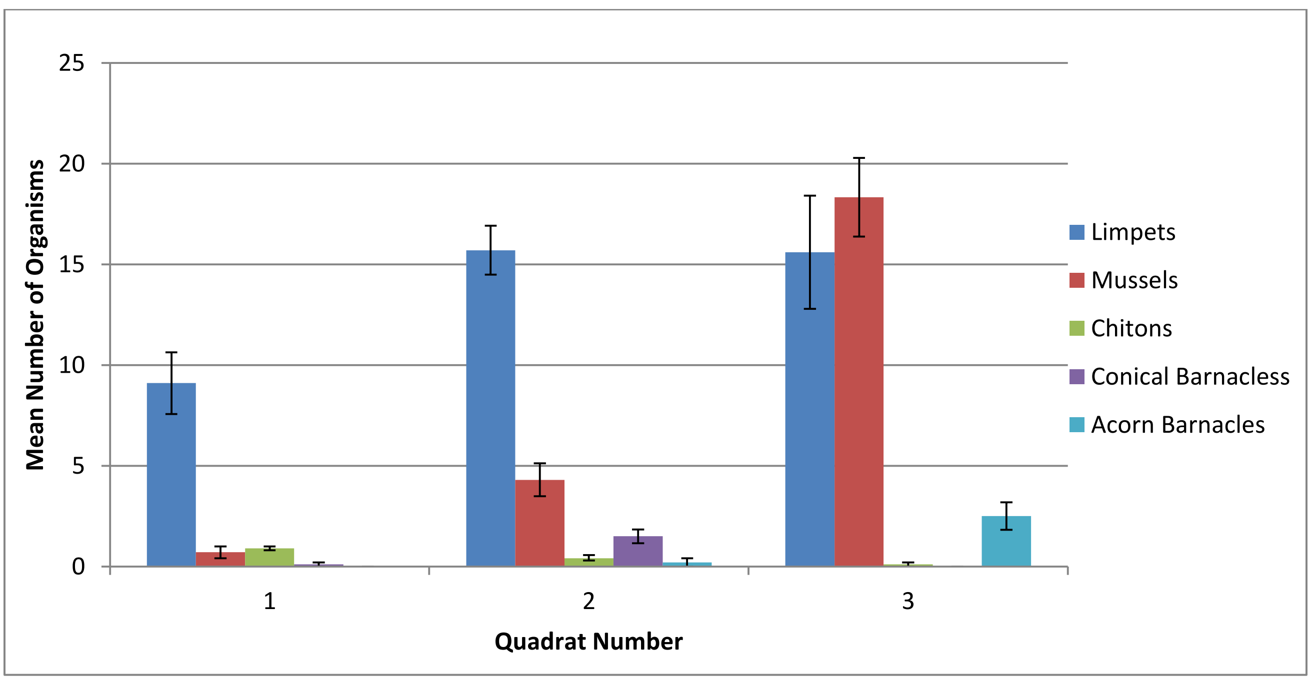

Figure 7. Mean numbers of selected species observed in transect 7 by quadrat. Error bars show ±standard error.

The distributions of limpets and mussels in transect 8 were statistically very distinct from a random distribution ($p<0.0001$). Acorn barnacle distribution was also significantly non-random ($p=0.0017$), but chiton distribution was not significantly different from random distribution ($p=0.2879$). Mussel abundance increased with increasing height, while acorn barnacle and limpet abundances peaked in quadrat 2. Chiton abundance showed a non-significant decrease with increasing height (Figure 8).

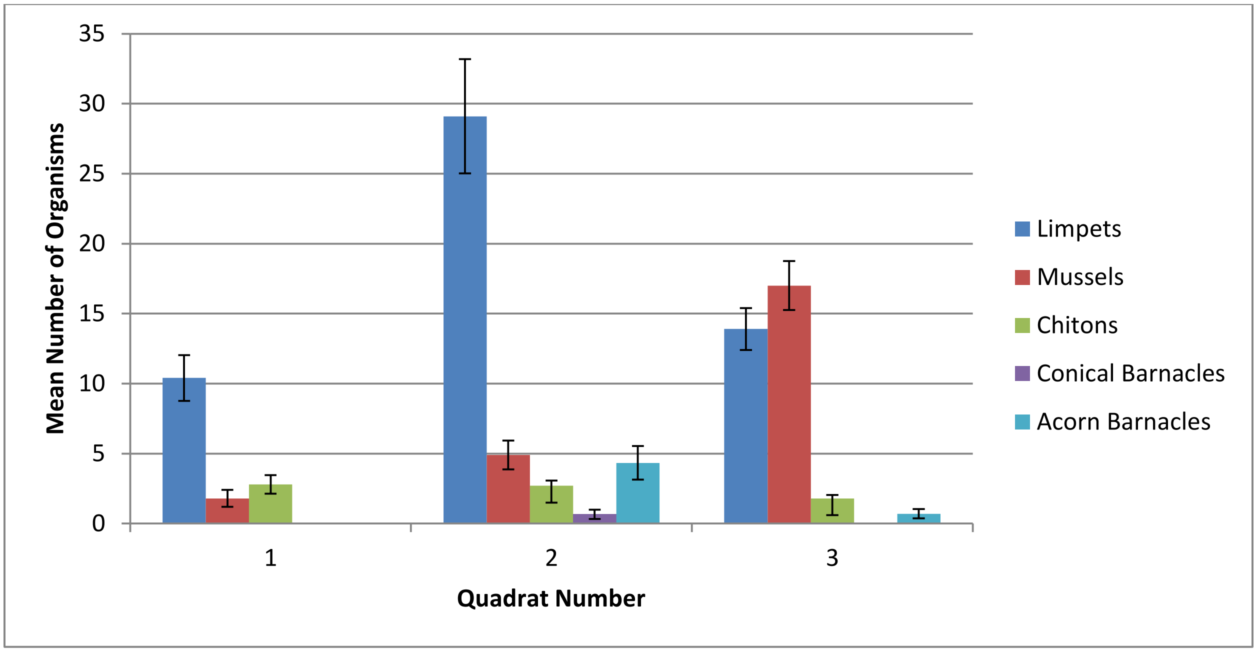

Figure 8. Mean numbers of selected species observed in transect 8 by quadrat. Error bars show ± standard error.

In transect 9, acorn barnacles, chitons, conical barnacles, limpets, and mussels all had significantly nonrandom distribution patterns ($p<0.001$). Mussel abundance increased with height, while chiton, conical barnacle, and limpet abundances all decreased. Acorn barnacle abundance peaked in the second quadrat (Figure 9).

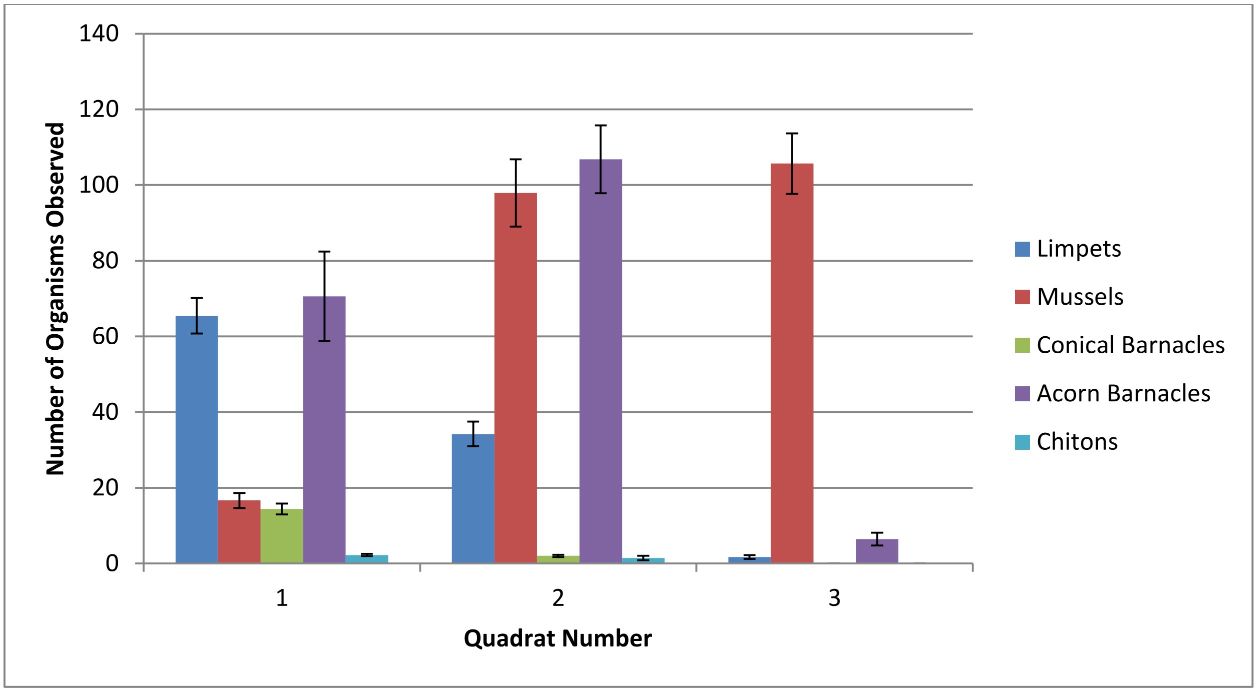

Figure 9. Mean numbers of selected species observed in transect 9 by quadrat. Error bars show ±1 standard deviation.

In transect 10, acorn barnacle, limpet, and mussel distributions were all significantly nonrandom ($p<0.0001$). Limpet and acorn barnacle abundance decreased with increasing height while mussel abundance peaked in quadrat 2 (Figure 10).

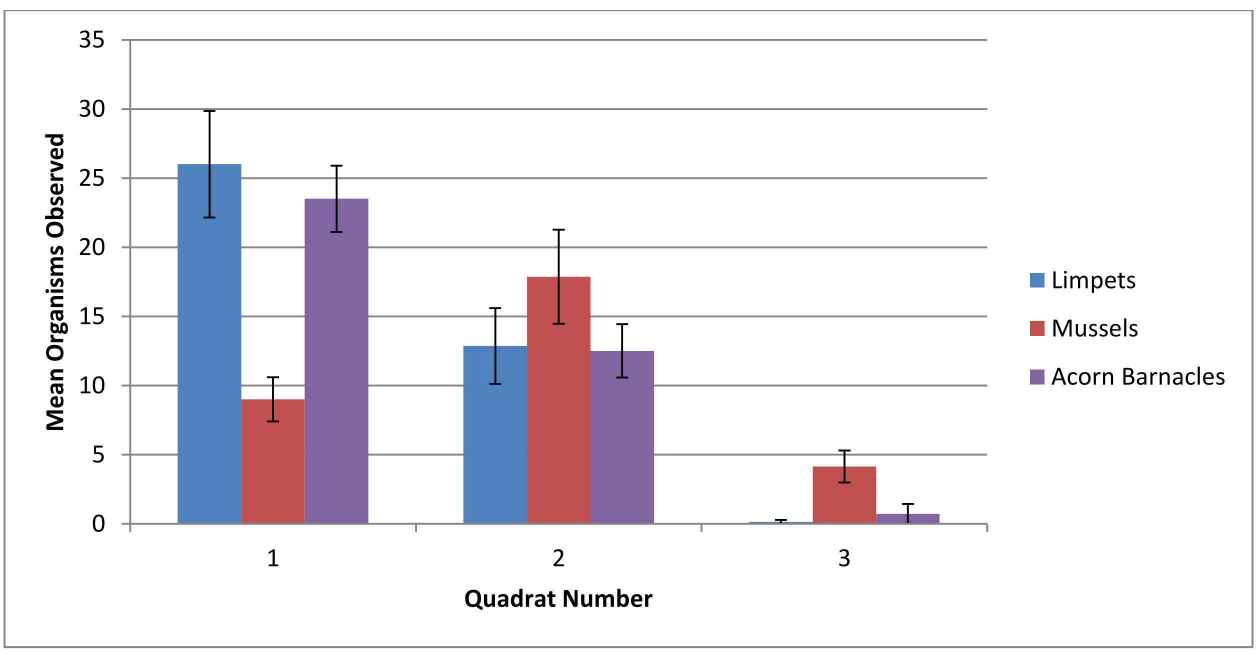

Figure 10. Mean numbers of selected species observed in transect 10 by quadrat. Error bars show ± standard error.

Transect 12 showed significantly nonrandom distributions of acorn barnacles, conical barnacles, limpets, and mussels ($p<0.0001$), but chiton distribution was nonsignificantly distinct from a random distribution ($p=0.0743$). In this transect, mussel abundance increased with height while limpet distribution decreased. Conical and acorn barnacles both peaked in the second quadrat (Figure 11).

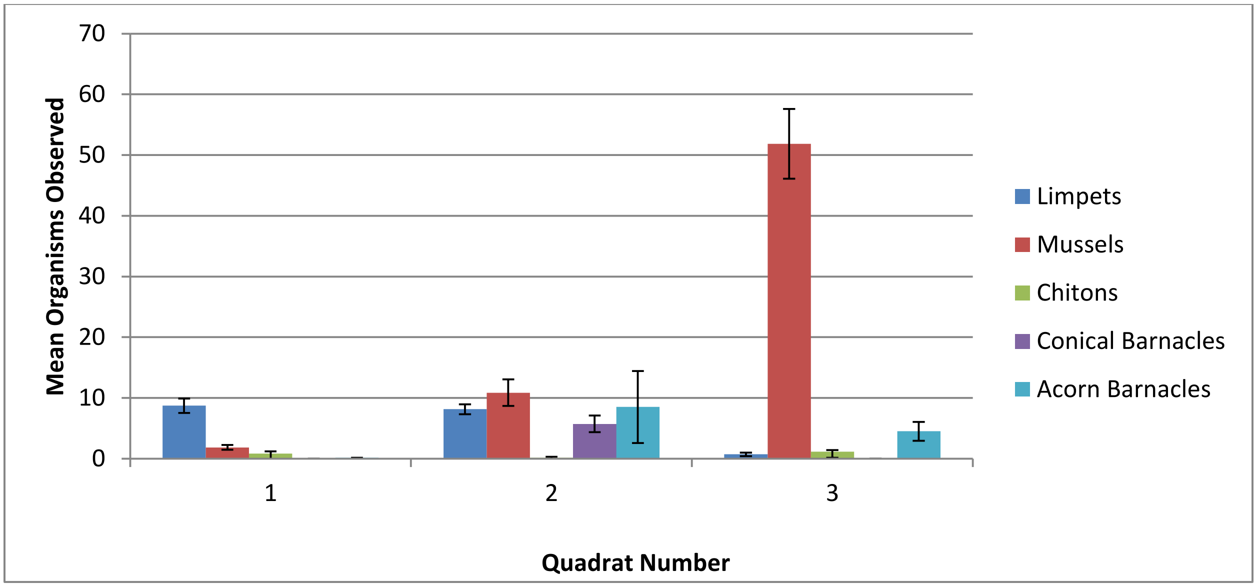

Figure 11. Mean numbers of selected species observed in transect 12 by quadrat. Error bars show ±1 standard deviation.

Informal observations recorded a low level of human activity on the beach in this study. It was not uncommon to see fewer than four people on the beach across three hours of study time. Two fishermen were observed on multiple occasions setting and checking dema traps during low tide. A few people were seen engaging in other fishing activities in the subtidal fringe as well and although fishing boats were seen nearby, none landed on this beach. Periodically, people would walk from one end of the beach to the other, apparently passing through en route to another destination. The beach was also used recreationally by locals as on April 10, when a large group of school children came to swim. However, no other large groups of people were seen on the beach during the course of this study.

Discussion

Due to the limited sample size and time scope of this study, it is highly likely that the 19 kinds of organisms found do not represent the full range of animals living in the study habitat. Most sessile and slow moving animals were probably observed in approximately their true densities, but motile organisms are likely underrepresented. Skinks and crabs tended to flee as the researcher approached, leaving the transect area before counting began. This flight response of the animals also inhibited identification efforts, as the crabs that remained within the transect were usually hiding in small crevices in the rock. This extremely restricted visibility necessitated attempted identification based on very few features, preventing species level identification of a few organisms and increasing the likelihood of mistakes with the others. It is also possible that some organisms inhabit the area seasonally and were not observed during this period for that reason. Despite these limitations, it is clear that the intertidal rock faces of Mangapwani are a rich habitat for many kinds of animals. The harsh conditions of the intertidal zone represent a challenge that organisms are well adapted to cope with, and diversity of the intertidal zone appears high.

Most transects showed some evidence of vertical zonation in the distribution patterns of the animals found there. Mussels and limpets tended to be present across much of a transect, but have a peak in numbers or an increasing or decreasing overall trend. Both acorn and conical barnacles, however, generally peaked very sharply and were present in only a small portion of a transect, possibly indicating that the barnacles have a very small tolerance. The most extreme example is in transect 5, where over 100 conical barnacles could be found in the ninth quadrat, but the quadrats on either side had fewer than 10 conical barnacles each and they were not found at all before quadrat seven. While such trends in individual transects are interesting, comparison across transects would help to resolve whether the nonrandom distribution is truly vertical zonation or due to other factors. Unfortunately, no objective measurement of elevation could be made so the different transects could not be directly compared. Direct comparison would help to resolve whether the nonrandom distributions were due to vertical zonation or individual transect factors.

None of the highly motile organisms were observed in sufficient numbers for distribution analysis. However, this is not a serious problem as such organisms are unlikely to be strongly zoned because they are able to move easily to whichever part of the habitat suits them at a given time. This mobility also accounts for the presence of the terrestrial skink, which likely comes to the rocks primarily to sun.

The beach appears to be under a relatively low level of human impact. Although fishing activities occur at this site, they are limited to a few traps and hand collection in the subtidal fringe. No one was observed collecting organisms off of the rock faces or otherwise directly interfering with the specific section of habitat covered in this study. Locals do walk along the beach, including on at least one rocky section at the base of the cliffs, but foot traffic is not particularly common. While fishing boats were a common sight in nearby waters, none landed on this beach. In many other area beaches which are landing sites for fishermen, there is extremely high traffic from the resulting commercial activity, a sharp contrast to the state of the study site. Additionally, while the beach studied is used recreationally, it is not commonly visited by tourists and has no associated restaurant, hotel, or other structures. It appears that there are far fewer anthropogenic impacts on this beach than on many nearby ones. Therefore, it is unlikely that differences observed in this study are being driven by human activities.

Conclusions

The community structure of the intertidal cliffs of Mangapwani consists of at least 19 distinct groups of organisms from 3 phyla, and likely several more that were unobserved or unidentified during this time period. Despite the relatively small sample size of this study, it appears that many of the sessile and slow-moving animals living on the cliffs and rock faces of the Mangapwani beach studied have vertically zoned distribution patterns. Human activity seems comparatively low on this beach and is unlikely to have a major effect on the distribution of these organisms.

Recommendations

Further study on the ecology of the rocky intertidal zone of Zanzibar could be extremely useful, especially if conducted over a longer period of time and with a larger sample size. Studies conducted in different areas could be compared to analyze regional distribution of different organisms and variations in the community structure as a whole. Additionally, comparisons between areas with similar physical habitats but different levels of human interference and development could give insight into the anthropogenic impacts on the coast and the current state of the environment in specific locations. Additionally, dedicated experimental studies of the impact of different kinds and levels of human activity on the ecology of the rocky intertidal zone could further clarify the role of human activities in shaping this habitat. This could enable the development and execution of effective conservation and management plans. Finally, it could be useful to analyze the relationship organisms have with the physical habitat to determine what variations in structure are most conducive to hosting life.

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Appendices

Appendix I: Mean numbers of organisms observed by transect

Transect	Organism	Mean Number	Standard Error
2	Limpets	0.143	0.143
	Nerites	0.429	0.202
	Periwinkles	1.000	0.655
	Shore crab	0.286	0.184
3	Acorn Barnacles	4.545	1.260
	Chitons	3.273	0.449
	Limpets	22.545	1.615
	Mussels	32.182	1.848
	Nerites	0.182	0.122
	Periwinkles	0.182	0.122
	Shore Crabs	0.273	0.141
	Slugs	0.091	0.091
4	Chitons	0.875	0.479
	Limpets	8.000	1.150
	Nerites	0.250	0.164
	Rock shells	4.375	0.498
	Shore crabs	0.375	0.183
	Slugs	3.625	0.263
	Small crabs	0.375	0.133
	Striped pebble crabs	0.250	0.164
5	Chitons	10.875	1.025
	Conical barnacles	138.125	6.586
	Limpets	135.375	5.338
	Mussels	24.875	2.961
	Rock shells	8.875	1.202
	Shore crabs	1.000	0.327
	Slugs	0.375	0.183
	Small crabs	0.125	0.125
	Striped pebble crabs	0.750	0.313
	Unidentified crabs	0.500	0.327
	Unidentified snails	1.125	0.549
6	Chitons	6.000	1.438
	Conical barnacles	14.333	2.431
	Limpets	87.333	11.102
	Mussels	5.667	2.319
	Pebble crabs	0.167	0.167
	Periwinkles	0.167	0.167

	Rock shells	14.500	2.262
	Shore crabs	0.833	0.477
	Small crabs	1.167	0.601
	Unidentified crabs	0.167	0.167
	Unidentified snails	1.167	0.980
7	Acorn barnacles	2.700	0.817
	Chitons	1.400	0.221
	Conical barnacles	1.600	0.427
	Limpets	40.400	3.727
	Mussels	21.500	2.130
	Pebble crabs	0.100	0.100
	Rock shells	0.300	0.153
	Shore crabs	0.800	0.416
	Striped pebble crabs	0.100	0.100
	Unidentified crabs	0.100	0.100
8	Acorn barnacles	2.000	0.699
	Chitons	7.300	1.116
	Conical barnacles	0.667	0.183
	Limpets	53.400	5.350
	Mussels	23.700	2.324
	Rock shells	0.100	0.100
	Shore crabs	1.200	0.291
	Unidentified crabs	0.100	0.100
	Unidentified snails	1.700	0.790
9	Acorn barnacles	183.800	14.235
	Chitons	3.667	0.745
	Conical barnacles	16.400	1.121
	Hermit crabs	0.111	0.111
	Limpets	101.333	7.860
	Mussels	220.222	11.188
	Shore crabs	0.556	0.377
	Striped pebble crabs	0.111	0.111
	Unidentified crabs	0.111	0.111
10	Acorn barnacles	28.286	5.472
	Chitons	0.714	0.286
	Limpets	39.000	4.771
	Mussels	31.000	3.000
	Nerites	5.000	0.655
	Rock shells	0.286	0.184
	Shore crabs	0.286	0.184
	Striped pebble crab	0.429	0.202

	Unidentified crabs	0.714	0.421
	Unidentified snails	0.286	0.286
11	African striped skinks	0.143	0.143
	Chitons	0.143	0.143
	Mussels	0.143	0.143
	Nerites	0.143	0.143
	Pebble crabs	1.000	0.218
	Shore crabs	0.286	0.184
	Unidentified crabs	0.429	0.297
12	Acorn barnacles	13.000	4.557
	Chitons	2.143	0.340
	Conical barnacles	5.750	1.041
	Limpets	17.571	1.811
	Mussels	64.571	6.432
	Nerites	0.143	0.143
	Pebble crabs	0.857	0.143
	Rock shells	0.286	0.286
	Shore crabs	0.714	0.286
	Slugs	0.286	0.184
	Striped pebble crabs	0.143	0.143

Appendix II: Organism density across whole beach

Organism	Mean Number Present	Density (m^2)
Acorn barnacles	234.331	15.622
Chitons	36.389	2.426
Conical barnacles	176.875	11.792
Limpets	505.101	33.673
Mussels	423.860	28.257
Nerites	6.146	0.410
Pebble crabs	2.124	0.142
Periwinkles	1.348	0.090
Rock shells	28.621	1.908
Shore crabs	18.273	1.218
Slugs	4.377	0.292
Small crabs	1.667	0.111
Striped pebble crabs	1.783	0.119
Unidentified crabs	2.121	0.141
Unidentified snails	4.277	0.285

Appendix III: Chi-square goodness of fit test results

Transect	Organism	χ^2	df	p
3	Acorn barnacles	100	2	<.0001
	Chitons	46.17	2	<.0001
	Limpets	154.87	2	<.0001
	Mussels	104.66	2	<.0001
4	Limpets	8.83	3	0.0316
	Rock shells	5.57	3	0.1345
5	Chitons	62.43	7	<.0001
	Conical barnacles	6337.96	7	<.0001
	Limpets	1827.75	7	<.0001
	Mussels	1210.01	7	<.0001
	Rock shell	48.28	7	<.0001
6	Conical barn	157.16	7	<0.0001
	Limpets	722.48	7	<0.0001
	Rock shells	35.2	7	<0.0001
7	Acorn barnacles	42.89	2	<.0001
	Conical barn	26.38	2	<.0001
	Limpets	21.24	2	<.0001
	Mussels	191.37	2	<.0001
8	Acorn barnacles	12.7	2	0.0017
	Chitons	2.49	2	0.2879
	Limpets	111.04	2	<0.0001
	Mussels	163.32	2	<0.0001
9	Acorn barnacles	421.99	2	<0.0001
	Chitons	18.73	2	<0.0001
	Conical barnacles	111.32	2	<0.0001
	Limpets	541.98	2	<0.0001
	Mussels	595.79	2	<0.0001
10	Acorn barnacles	79.74	2	<0.0001
	Limpets	180.02	2	<0.0001
	Mussels	65.51	2	<0.0001
12	Acorn barnacles	33.38	2	<0.0001
	Chitons	5.2	2	0.0743
	Conical barnacles	46	2	<0.0001
	Limpets	47.61	2	<0.0001
	Mussels	462.03	2	<0.0001