Testing ghost crab density as a useful indicator of human impacts on exposed sandy beaches.

A Conservation Research Report

by

A Rocha Kenya

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Testing ghost crab density as a useful indicator of human impacts on exposed sandy beaches.

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Introduction

Ghost crabs (*Brachyura, Ocypodidae*, *Ocypode*) are circumglobal across the tropics and subtropics (Barros, 2001). They are generally nocturnal; living in up to 1m deep burrows during the day and feeding at night in the intertidal zone (Jackson, Smale and Berry, 1991; Moss and McPhee, 2006). Various aspects of the ecology of *Ocypode* have been studied previously, these include: burrows and burrowing (Barrass, 1963); ecology and behaviour (Jones, 1972) and biological cycle, feeding and predation (Vannini, 1976). Jones (1972) found that different species were observed on different beaches depending on the shelter or exposure.

Jones (1972) and Vannini (1976) both noted that there is no relationship between the size of a ghost crab burrow and the distance to the ocean. Vannini (1976) adds that there is also no relationship between the size of an individual crab and distance to the ocean. Furthermore, Wolcott and Wolcott (1984) state that burrow size is a reflection of crab size.


Figure 1. *Ocypode ceratophthalmus*.
Photo: H Hereward, 2014


Figure 2. *Ocypode ryderi*.
Photo: H Hereward, 2013

Previous papers recorded three species of *Ocypode* on Watamu beach (*Ocypode ceratophthalmus, O. Kuhlii and O. ryderi*). Jones (1972) recorded *O. ceratophthalmus* (Figure 1) and *O. kuhlii* on Watamu beach, Kenya. However Richmond (2011) states that *O. Kuhlii* is restricted to the Western Pacific Ocean, consequently previous recordings of this species are actually *O. ryderi*

(Figure 2). Hereward and Hereward (2002 unpub.) recorded *O. ryderi* on Watamu beach. *O. cordimanus* (Figure 3) has been recorded in South Somalia (Vannini, 1976), in Kilifi creek as a preserved specimen (Discoverlife, 2013) and in Gazi, Kenya by Ruwa (1989), however it has not been previously recorded in scientific literature on Watamu beach. Ruwa (1989) also recorded *O. ceratophthalmus* in Kenya.

Figure 3. Ocypode cordimanus.
Source: H Hereward, 2013

Several investigations into the impact of human activity on beaches in relation to ghost crab density have been conducted (eg. Wolcott and Wolcott, 1984; Barros, 2001; Moss and McPhee, 2006; Schlacher and Lucrezi, 2010). All determined that ghost crab density is higher on non-urban beaches compared to urban. Furthermore, all conclude that the density of *Ocypode* burrows could be a useful indicator for assessing the environmental condition of the beach.

The goal of this study was to test the hypothesis that Ocypode density can be used as an indicator of impact of human activities on an exposed sandy beach. In order to test this hypothesis, we compared ghost crab burrow density between sites with on-beach hotels to those with residential housing and coastal scrub along the exposed sandy beach of Watamu Marine National Park (WMNP), Kenya.

Methods

Field work was conducted between September and November 2013. Four sites were chosen along the exposed sandy beach of WMNP, Turtle Bay (TB), Mwamba (MB), Plot 34 (34) and Garoda (GD) (figure 4-8). TB is in front of Turtle Bay Hotel and has much human activity such as football matches, exercise groups and beach market stalls. Turtle Bay hotel has built up to the edge of the sand dune area. Between the beach and the sea there are intertidal rock pools of around 40m in width. MB is in front of Mwamba, A Rocha Kenya's field study centre and small guest house. It has extended sand dunes between the centre and the beach with minimal human activity on the beach. Site 34 is in front of

Plot 34 which has limited human activity and has around 65m of intertidal rock pools between the end of the beach and the sea. These are only exposed at extreme lows tides, below 0.5m. Site GD is in front of Garoda Hotel which has less human activity than TB but it is more concentrated than MB or 34. GD has on-beach stalls, beach volleyball as well as general human activity. The sand is also raked. GD is slightly up from the beach and has retained more sand dunes with additional rocky outcrops, compared to TB. The length of the beach between the furthest sites is 4.34km. At spring low tides, the width of the beach at Plot 34 reached 78m whereas Turtle Bay was 66m wide. Beach profiles were taken at each site using Andrade and Ferreira's (2006) method (Figure 8). The direction of the wave action is the same at each site, however the direction changes seasonally.

Figure 4. Map of crab transects and beach profiles.

Figure 5. Turtle Bay (TB) Photos: H Hereward, 2013.

Key: green line = example transect line.

Figure 6. Mwamba (MB) Photos: H Hereward, 2013.

Key: green line = example transect line.

Figure 7. Plot 34 (34) Photos: H Hereward, 2013.

Key: green line = example transect line.

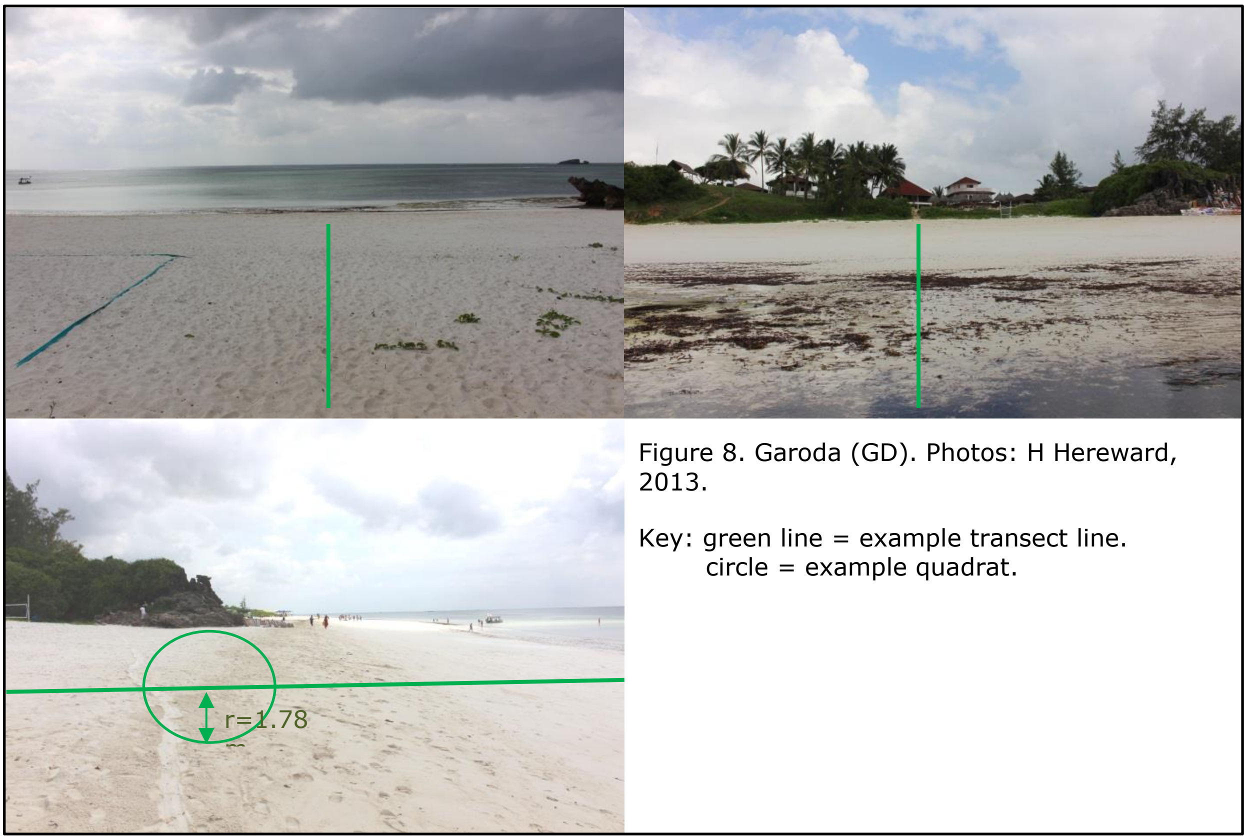

Figure 8. Garoda (GD). Photos: H Hereward, 2013.

Key: green line = example transect line.
circle = example quadrat.

Observations were made at each site to identify which species of *Ocypode* were utilising the beach habitat using Richmond (2011) for identification. Photos were taken and referred to in the laboratory when necessary. Five transects were lain at each site in order to quantify ghost crab burrow density. Barrass (1963) and Jackson (1991) assumed that the number of burrows directly relates to the number of ghost crabs found on the beach. We similarly assumed that there was a direct relationship between the number of burrows and the number of crabs.

For the full moon data, transects were lain from sand dune to the water's edge, each separated by 10m. For the new moon data, transects at MB were separated by 5m. At 34 and TB transects one and two were separated by 5m and the other three were separated by 10m and at GD all transects were separated by 10m. Along each transect seven 10m^2 circular quadrats were drawn out using a 1.78m long piece of string centred on the transect tape every 8m starting at 1.78m (Figure 8). Within each quadrat the size and number of all the burrows were noted as was the total length of the transect. Each site was surveyed on days with low tides between 8am-10am; this was to allow the longest time possible for night time burrowing activities across the whole beach and to assure the least amount of burrow disturbance due to humans using the beach. Where possible transects were conducted with the same tide cycle in order to avoid tidal movement variation.

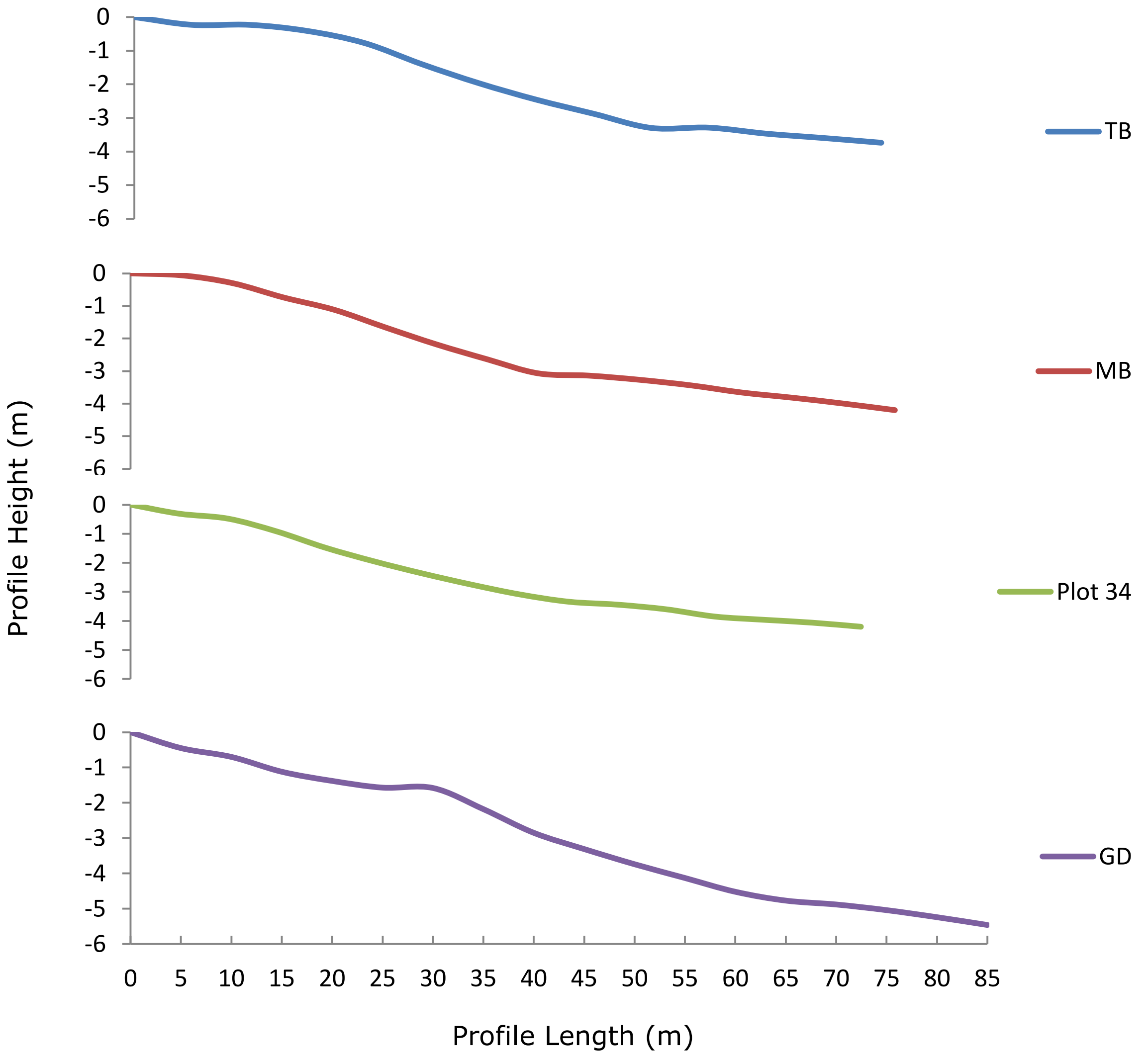

Figure 8. Beach profiles for each site.

The difference between crab burrow density of on-beach hotel sites compared to the residential housing and coastal scrub sites was tested using a Two-Sample T-Test as the data was normally distributed (Minitab® Statistical Software[1]).

The difference in crab burrow density between each of the four sites was analysed using a one-way ANOVA due to the data being normally distributed (Minitab® Statistical Software). A Fisher's Least Significant Difference (LSD) test was conducted as the post-hoc test to determine which sites were significantly different from each other (Minitab® Statistical Software).

Results

Observations showed that *Ocypode ryderi* and *O. cordimanus* were found at all four sites. In addition, the general impression was that *O. ryderi* tended to have larger burrows and sand mounds than *O. cordimanus* (H. Hereward, personal observation). There was a marked change in burrow size when walking between sites 34 and Garoda. Prior to Garoda there were many larger burrows and sand mounds compared to the Garoda site which had a marked decrease in number. Personal observations of O. *cordimanus* showed that there are potentially a variety of colour morphs of the same species.

Crab burrow density at on-beach hotel sites was significantly lower compared to sites with coastal scrub and residential housing (t=-2.97, df=12, P=0.012) (Figure 10).

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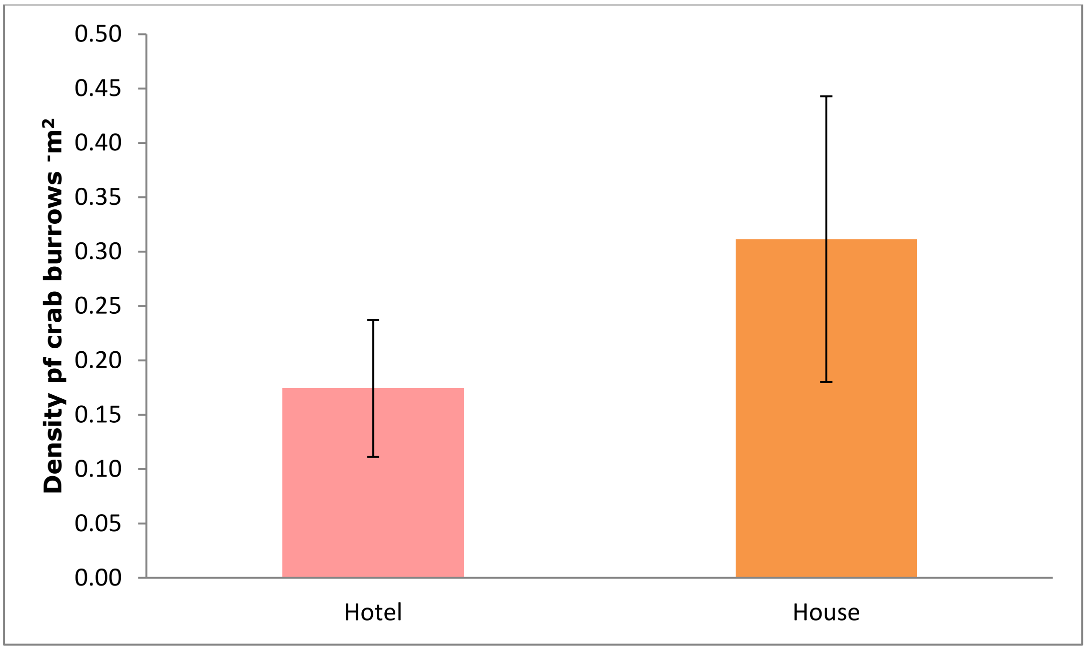

Figure 10. Mean density of crab burrows $^{-}$m^{2}, ± standard deviation, comparing on-beach hotels to coastal scrub and residential housing.

There were significant differences crab burrows density among sites around full moon ($F_{3,16}$=13.98, P<0.001). Post-hoc tests showed that only Garoda compared to Mwamba and Mwamba compared to Turtle Bay are not significantly different from each other.

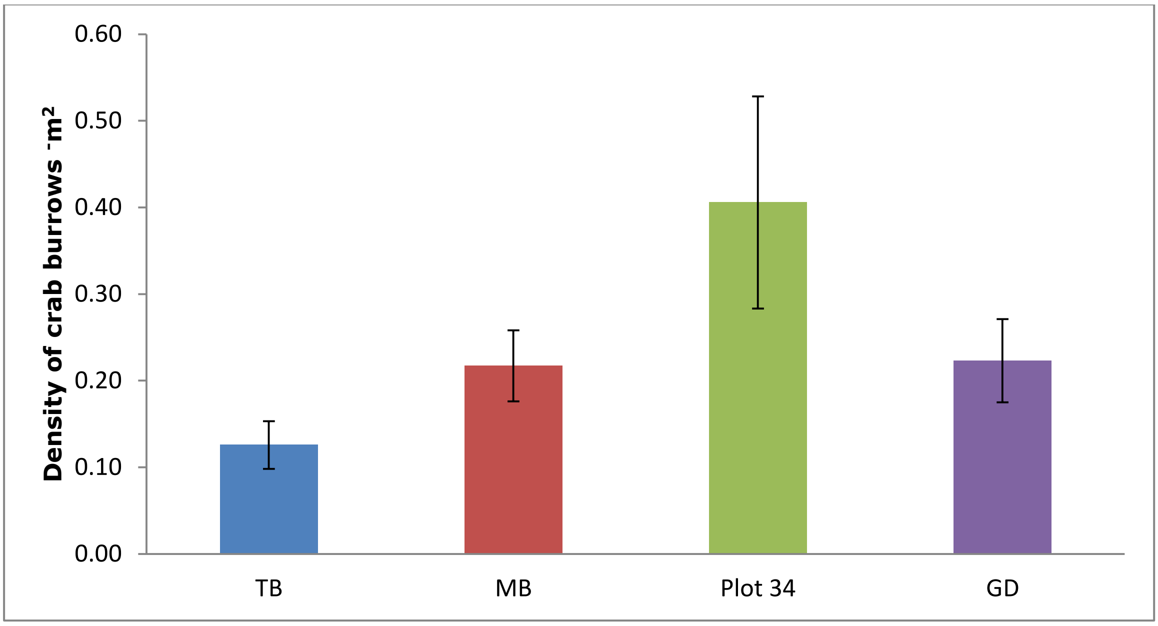

Figure 11. Mean crab burrow density around full moon $^{-}$m^{2}, ± standard deviation.

There were significant differences crab burrows density among sites around new moon ($F_{3,16}$=52.70, P<0.001). Post-hoc tests showed that all, except Garoda compared to Turtle Bay, were significantly different.

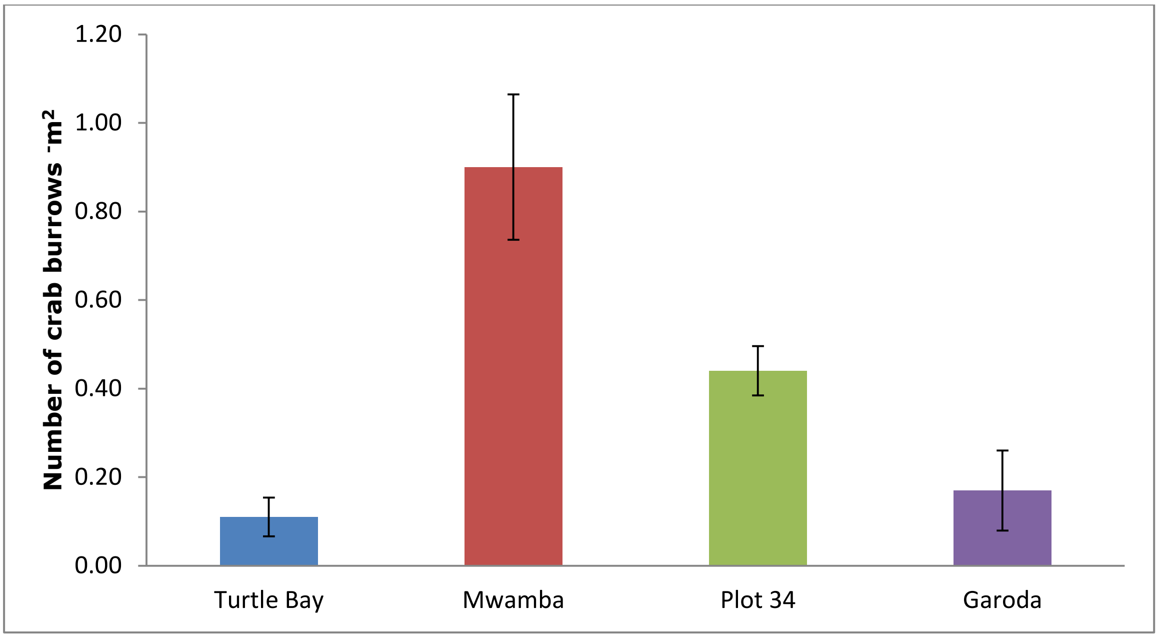

Figure 12. Mean crab burrow density around new moon $^{-}m^{2}$, ± standard deviation.

<u>Discussion</u>

The identification of the two *Ocypode* species by the current study highlighted that despite the previous research (Hughes, 1966; Jones, 1972) associating *Ocypode* species with various exposures, both *Ocypode ryderi* and *O. cordimanus* were found at all four sites. This could be due to little change in exposure along the study site. However further research on particle size is necessary to confirm this (Kings, 1966; Jones, 1972). Despite searching, the third species was not found within the study area. *O. ceratophthalmus* was previously found by Jones (1972) at sites outside of the WMNP and consequently not recorded in this study. Further observations at these other sites would be necessary to determine if they are still found there and to identify the difference(s) between the sites.

Ocypode cordimanus were found to have several colour morphs. This could be related to where they are most camouflaged to prevent predation (Palma and Steneck, 2001; Hemmi *et al*. 2006). Preliminary observations during the day showed that greener individuals were found on the tidal fringe on and around the washed in seagrass (*Thalassodendron ciliatum*) and the white-cream individuals were noted in the high tide zone. However, more detailed observations and specimen collection and dissections will be necessary to decipher if these colour morphs are truly this one species or if they are sub- or even new species.

Crab burrow density was significantly lower at on-beach hotel sites than coastal scrub and residential housing sites. This reflects studies in New South Wales, Australia (Barros, 2001) where some urban beaches had no crab burrows at all. In addition, Moss and McPhee (2006) also found that increased human activity was related to a decrease in crab density.

Mwamba's low density of crabs near the full moon is surprising, especially when compared to Plot 34. The beach profiles are similar across all the sites as is the wave action, so these are unlikely to be contributing factors. However, data was collected during the new moon had a marked increase in density. Jones (1972) comments that *Ocypode* distribution along the beach relate to the tides and the moon cycle (comparing neap to spring) and could explain the difference found at Mwamba between lunar cycles.

Turtle Bay had the lowest crab burrow density of all sites. There are various reasons that could be attributed to this, including, Turtle Bay having buildings built onto the sand dune, which could cause a similar reduction in crabs as Barros (2001) found on beaches with a concrete wall. In addition, TB has a higher level of activity with three additional hotel complexes surrounding it compared to Garoda which has one other nearby. In contrast, Mwamba and Plot 34 have houses inland and have dispersed human activity. The beach profile of both TB and MB are very similar, but TB has 40m of intertidal pools which MB does not have. Further studies into the exposure of each beach would help determine if the lack of intertidal rock pools affects the overall beach composition and consequently the crab populations (Kings, 1966). Other than this, human activity and placement of the hotel are the main differences between the sites and consequently likely reasons for this significant difference. This gives a strong possibility of crabs being a useful indicator for human activity impacts.

Further studies could include, determining particle size and variation across all four sites to determine the exposure (Kings, 1966). It would be interesting to identify if each species have specific zones as specified by Jones (1972) and Vannini (1976) and to discover if these change due to other *Ocypode* occupying the same area. Additional field work using Barros' (2001) method comparing on-beach hotel to residential and coastal scrub beaches would be interesting to determine if the density of the crab burrows changes with the position of the quadrat down the beach.

Conclusion

The field work detected two species of Ocypode, *Ocypode ryderi* and *O. cordimanus*. These were found at all four sites. There was a significant difference found between on-beach hotels and residential housing. These results suggest that Ocypode density can be used to determine the impact of human activity. However, differences in populations over lunar cycles may mask this value at medium levels of human impact.

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