Rapid Assessment of Anthropogenic Impacts on Exposed Sandy Beaches in Ghana using Ghost Crabs (*Ocypode* spp.) as Ecological Indicators

Denis Worlanyo Aheto[1]*, Cephas Asare[2], Emmanuel Abeashi Mensah[3] and Joseph Aggrey-Fynn[4]

[1,4]Department of Fisheries and Aquatic Sciences, School of Biological Sciences, University of Cape Coast (UCC), Ghana (*daheto@ucc.edu.gh)

[2]Coastal Resources Center (CRC), Adiembra – Sekondi-Takoradi, Ghana

[3]Department of Geography and Regional Planning, University of Cape Coast (UCC), Ghana

ABSTRACT

We applied a rapid assessment methodology to estimate the degree of human impact on exposed sandy beaches in Ghana using ghost crabs as ecological indicators. The use of ghost crab burrow density and size ranges of the burrows as ecological indicators to assess extent of anthropogenic impacts on beaches was explored in this study. For each site, three transects were laid perpendicular to the shoreline over a 100 meter distance at 50 m intervals, i.e., at reference points 0, 50 and 100 meter points. Sampling locations were randomly selected along the three transects using a 1 m x 1 m quadrat. Measurements were done twice weekly for a period of four weeks. The results showed that even though the moderately disturbed beach had higher burrow density than the disturbed beach on the average, the difference is not statistically significant (t-test; $p > 0.01$). However, the mean burrow diameter at the moderately disturbed site was significantly larger than for the disturbed site (t-test; $p < 0.01$). We conclude that ghost crab burrow sizes is a better estimator of human impacts on exposed sandy beaches and could be employed as a rapid tool for monitoring the quality of beaches.

Keywords: Ghost crab (*Ocypode* spp.), Beach habitat modification, Ecological monitoring

1. INTRODUCTION

In coastal areas, sandy beaches are the most intensively used by humans with a significant part of many coastal economies relying on the ecosystem services they provide. Most significant is their role as prime areas for recreation and tourism (Barros, 2001; Schlacher and Lucrezi, 2009). Human population growth in coastal areas is significantly higher than elsewhere, and shorelines are sites for rapid development especially as sites for industries and housing (Schlacher et al., 2006) resulting in significant alteration of the flora and fauna occurring in this environment (Steiner and Leatherman, 1981; Barros, 2001). Despite this situation, traditional management of beaches has almost exclusively focused on the maintenance and restoration of sand budgets with limited consideration of the ecological importance of beaches (Nordstrom, 2001; Schlacher et al., 2008). Some efforts have been made to use biota to verify anthropogenic impacts on aquatic habitats but these have focused on freshwater environments (Chessman, 1995; Wright, 1995). On a wider scale, efforts are being made to find suitable tools to identify the impacts of population growth and human

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influence in coastal regions (Defeo and De Alava, 1995; Jaramillo et al., 1996; Barros, 2001; Neves and Bemvenuti, 2006; Magalhães et al., 2009).

Ghost crabs (Genus *Ocypode*) offer practical advantages for estimating health status or level of anthropogenic impacts on beaches because of their occurrence and abundance on many beaches and their densities can be estimated relatively quickly by counting burrow openings which can be achieved within a narrow timeline. Neves and Bemvenuti (2006) indicated that the use of ghost crabs as ecological indicators is of great value to beach conservation owing to their global distribution and habit of living in conspicuous burrows along the supralittoral zone of sandy beaches. It has been further shown that burrows of the genera *Ocypode* spp. serve as a good estimator of their density, and a strong correlation between the number of burrows and the number of crabs of the Ocypodidae has long been established (Warren, 1990). The method has been applied to urban beaches with the result of the studies showing a reduction in the population densities of crabs in disturbed regions (Barros, 2001; Neves and Bemvenuti, 2006; Magalhães et al., 2009).

Worldwide, there are about 20 species of ghost crabs of which two namely *Ocypode africana* and *Ocypode cursor* have been identified in Ghana. These two species have been found to occur in the beaches along the 550 km coastline from Denu in the Volta Region to Half Assini in the Western Region (Gauld and Buchanan, 1956). Sandy beaches in Ghana are used extensively as recreational and fish landing sites; sand winning is also common. In some cases, beach sand dunes have been removed and replaced with sea defense walls or groins to combat coastal erosion and flooding especially in areas of key livelihood and economic interests. The objective of this study was to determine the density of the ghost crab burrows along the beaches, estimate the relative sizes of burrows, and address the feasibility of the use of ghost crabs for verifying anthropogenic impacts on beaches.

2. METHODOLOGY

2.1 Study area

The density and size distribution of ghost crab (*Ocypode* spp.) burrows along the Cape Coast (5°06′06.76″ N; 1°15′15.96″ W) and Elmina (5°05′33.69″N; 1°20′17.88″W) beaches of Ghana (Fig. 1) was studied twice weekly over a period of one month (February 13-March 13, 2010).

The disturbed beach was sited at Elmina in comparison to a moderately disturbed beach in Cape Coast. Measures for the identification of, and distinction between the disturbed and moderately disturbed sites were based on qualitative assessment of beach conditions. The disturbed beach was characterized by the presence of seawall that interrupts water flow and limits the movement of sediments. Widespread beach trampling and high levels of pollutants mainly inorganic waste products such as plastic or polythene materials were also considered in this context. The moderately disturbed beach served as a reference site/ control experiment serving as best case scenario, and was characterized by the absence of seawalls, and generally low levels of beach trampling. This beach was also characterized by the limited presence of inorganic pollutants mainly plastic and polythene materials.

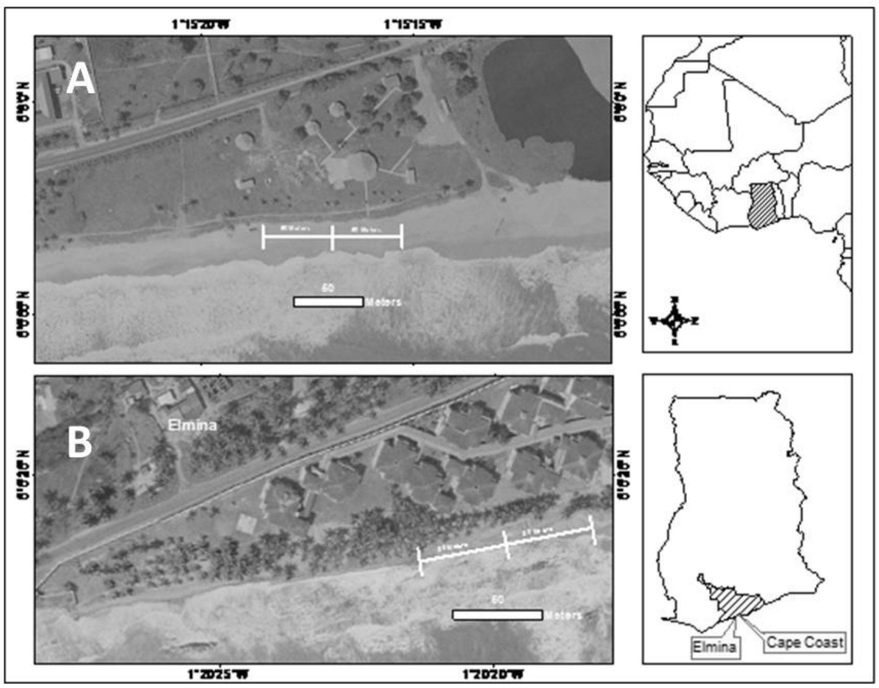

Figure 1: Aerial photograph (A) Cape Coast (B) Elmina beaches in Ghana

2.2 Determination of burrow density and size distribution

Three transects were laid within the study areas measuring 100 m in length. The three transects were laid perpendicular to the shoreline over a distance of 100 m at 50 m intervals i.e. at reference points 0, 50 and 100 meters intervals (Fig. 2). A surveyor's tape was used for measuring of the transect distances. The measurements were done during low tide periods using standard tide tables (GHAPOHA, 2010). Sampling locations were randomly selected along each of the perpendicular transects using a 1 m x 1m quadrat. Count of number of ghost crab burrows was made and recorded per quadrat. The diameter of the burrows in each quadrant was also measured using venier calipers. The specific locations of each transect were determined using a GARMAIN eTREX Global Positioning System (GPS).

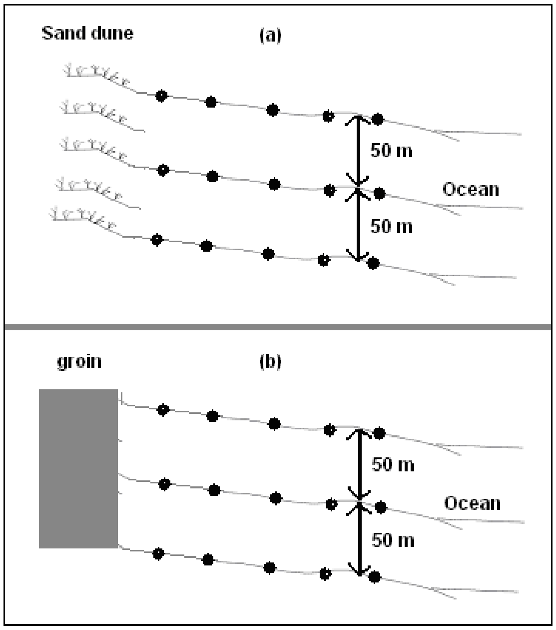

Figure 2. Schematic diagram showing sampling sites and transects on the (a) moderately disturbed beach (Cape Coast) and (b) disturbed beach (Elmina).

2.3 Data analysis

The mean burrow diameter and burrow density were estimated and compared for both beaches with calculations done according to standard methods (Warren, 1990; Barros, 2001; and Magalhães et.al., 2009). The t-test was done using Minitab 15 to compare the differences between burrow densities and burrow diameter at both sites and MS Excel 2007 was used to plot and calculate the distribution pattern at the study sites.

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3. RESULTS

3.1. Burrow density

A mean density of 94.3±69.9 m^{-2} was recorded at the Cape Coast beach with the maximum burrow density estimated to be 347 m^{-2} (see Table 1). Burrow density at the Elmina beach ranged from $0m^{-2}$ to 214 m^{-2} (mean = 50.1±62.6). The Cape Coast beach therefore had a higher burrow density than the Elmina beach though the difference is not statistically significant (t-test, P> 0.01). Figure 3 presents the weekly burrow density estimates over the sampling period. The data indicate a generally variable distribution pattern of the ghost crab burrows.

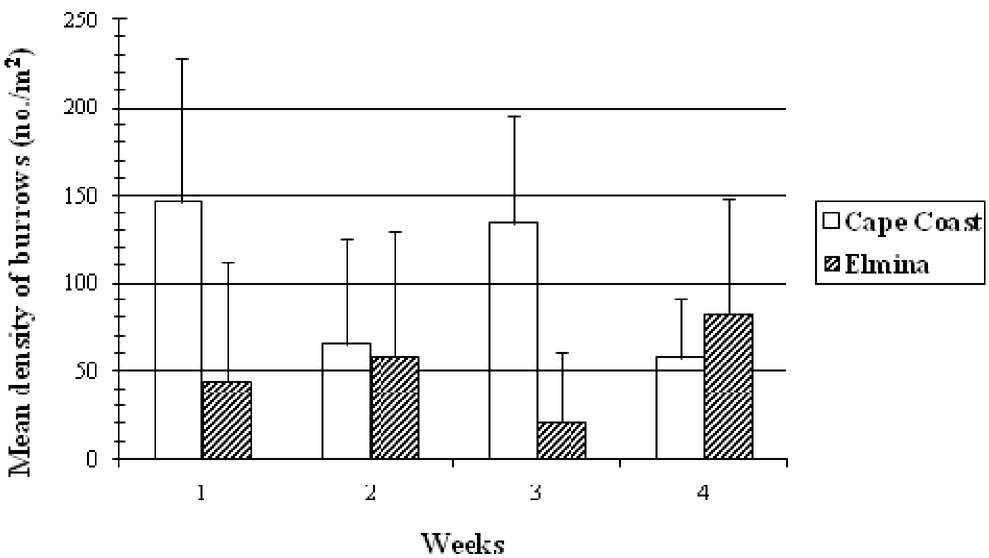

Figure 3: Density of burrows at the study sites (vertical bars represent Standard Deviation)

Table 1: Pooled data on density of ghost crab burrows at Cape Coast and Elmina beaches (Cape Coast; n=60 quadrats) and (Elmina; n=60 quadrats).

Density (Number of burrows/m^2)					
Cape Coast Beach (Moderately disturbed)			Elmina beach (Disturbed)		
Mean (SD)	Min	Max	Mean (SD)	Min	Max
94.3±69.9	0	347	50.1±62.6	0	214

3.2. Burrow size distribution

The maximum burrow diameter recorded in Cape Coast was 11.3 mm while the maximum burrow diameter at Elmina was 12.4 mm. The smallest burrow size recorded for both study sites was 0.2 mm. On average, burrow diameter was significantly larger on Cape Coast beach compared to Elmina ($P< 0.01$) where mean burrow sizes of 1.34 mm ±0.63 and 1.29 mm ±0.7 respectively were computed. Fig. 4 shows the weekly mean burrow diameter recorded over the study period. The data indicate a fairly stable diameter range of burrows during the study period.

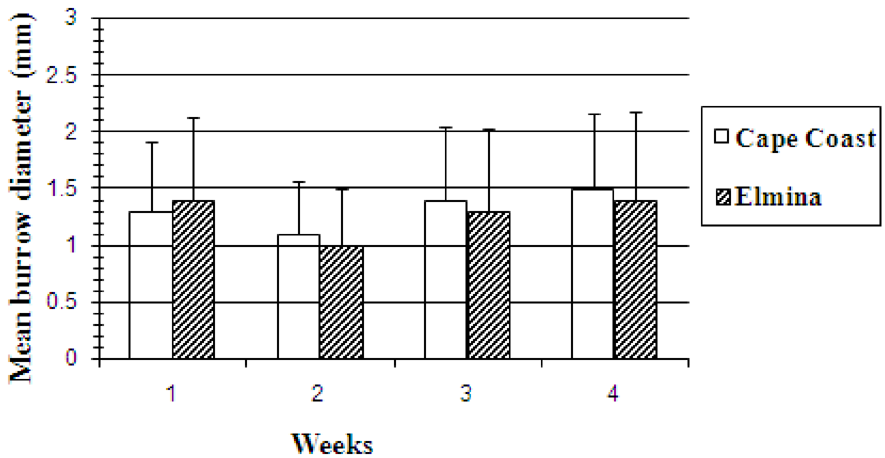

Figure 4: Mean burrow diameter at the Cape Coast and Elmina beaches

Table 2: Burrow diameter at the beaches during the study period (n = number of burrows).

Burrow diameter (mm)					
Cape Coast Beach (Moderately disturbed)			Elmina beach (Disturbed)		
Mean (SD)	Min	Max	Mean (SD)	Min	Max
1.34 ±0.63 (n = 6,068)	0.2	11.3	1.29 ±0.7 (n = 3,101)	0.2	12.4

These results shown in Table 2 indicate that the disturbed beach (Elmina) had a significantly smaller burrow diameter compared to the moderately disturbed beach (Cape Coast) (t-test; $P<0.01$). The Elmina beach generally had higher number of locations with no record of ghost crabs found within the quadrates as compared to those found for the Cape Coast beach. Generally, ghost crabs burrows were absent in 38% of the 60 quadrats of Elmina while in Cape Coast, only 8% of the 60 quadrats were without burrows (see Figs. 5 and 6).

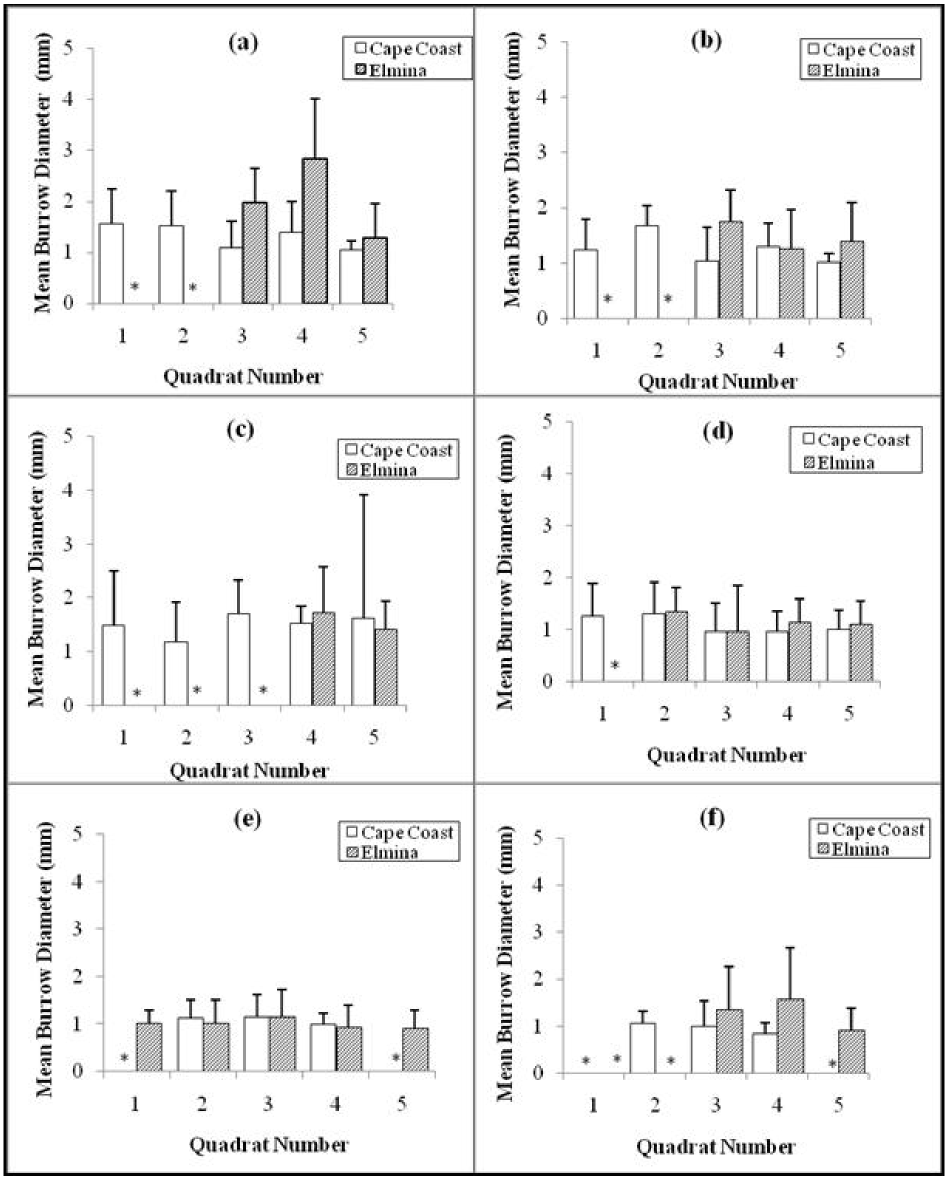

Figure 5: Mean ghost crab burrow diameter (+S.D) at the Cape Coast and Elmina beaches (a-f). (a-c) represents transect 1-3 for Week 1; and (d-f) represents transect 1-3 respectively for Week 2. [***Note***: *****-represent quadrat locations found without burrows for both Cape Coast and Elmina beaches. The locations were derived through random sampling along each of the three transects].

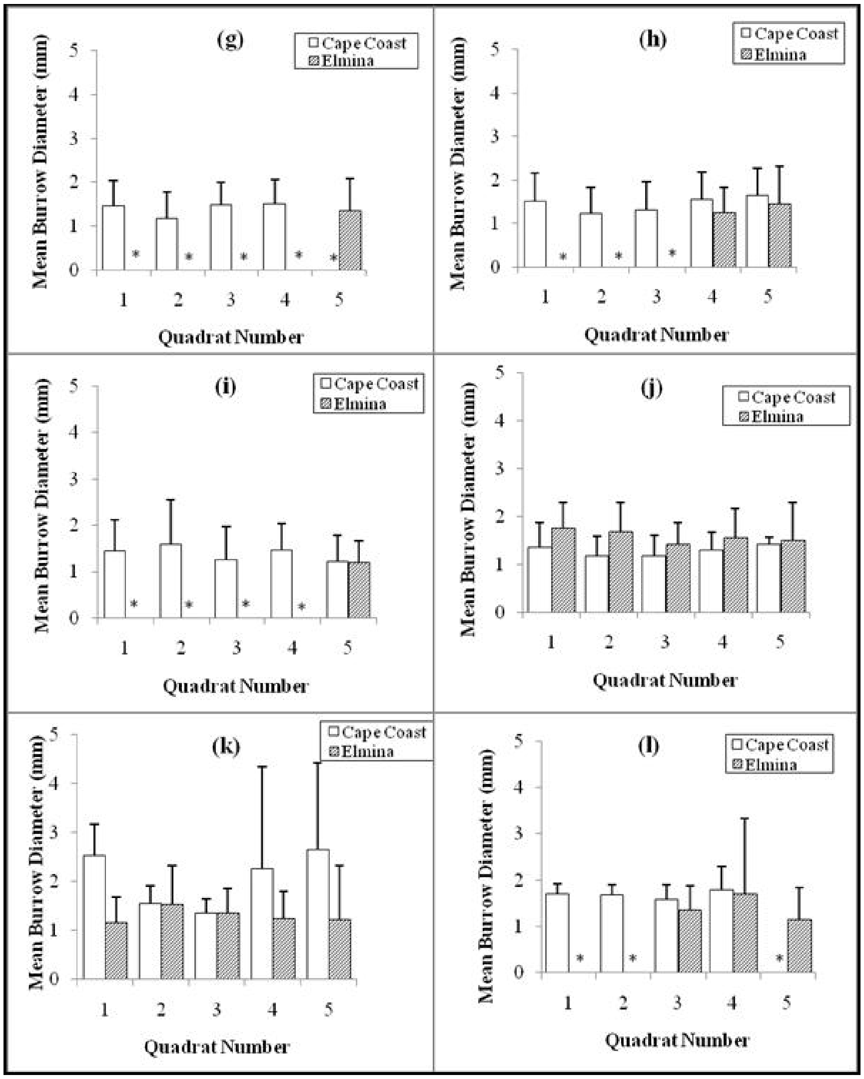

Figure 6: Mean ghost crab burrow diameter (+S.D) at the Cape Coast and Elmina beaches (g-l). (g-i) represents transect 1-3 respectively for Week 3; and (j-l) represents transect 1-3 respectively for Week 4. [***Note***: *****-represent quadrat locations found without burrows for both Cape Coast and Elmina beaches. The locations were derived through random sampling along each of the three transects].

4. DISCUSSION

4.1. Burrow density

Results of the present study show that the moderately disturbed beach had a higher ghost crab burrow density compared to the disturbed beach although there was no significant difference between the densities. Relative to human disturbances on beaches, it could be argued that higher human activity contributed to the lower ghost crab densities in the disturbed beach at Elmina. However, human activity *per se* may not be the only factor responsible for the lower densities of ghost crab burrows on the beach. Barros (2001) stated that if burrow density is not a good estimator of ghost crab abundance, at least it shows that crabs from both urban and non-urban beaches, referring to disturbed and non-disturbed beaches respectively exhibit some distinct behaviour as a result of human activity. In related studies, Strachan *et. al.* (1999), Barros (2001) and Neves & Bemvenuti (2006), found evidence suggesting significantly higher burrow density of ghost crabs in beaches with lower anthropogenic impact. These studies had focused on different species and within different environments. Strachan et al. (1999) worked in northern Cyprus on *Ocypode cursor* species and Barros (2001) on *Ocypode cordimana* species in New South Wales, Australia. Neves & Bemvenuti (2006) assessed the situation for *Ocypode quadrata* in Brazil. Therefore the issues of the different physiological adaptations and species behaviour should not be underestimated in such studies. Context specificity is also relevant in this regard.

4.2 Burrow size distribution

It is largely confirmed that ghost crab burrow diameter is a good estimator of ghost crabs size (Tureli et al., 2009). In the present study, ghost crabs were found to be randomly distributed within the study area. Generally, the mean burrow sizes of ghost crabs were higher in the moderately disturbed beach as compared to the disturbed beach. This difference was found to be statistically significant. This suggests that burrow sizes of ghost crabs are important indicators for estimating the impacts of human activity on beaches. Therefore, this data appears to confirm that the estimation of the diameter of burrows is a rapid tool for verifying the impacts of human activities on sandy beaches and for use in environmental monitoring programs. Based on the above findings, it could be concluded that burrow sizes is a good estimator that allows for verification of human impacts on exposed sandy beaches. It also confirms that burrow density even though an important factor, may not necessarily be a significant estimator of the impacts of human activity on beaches. The method could therefore serve as a useful tool for municipal or district governments and other stakeholders working in coastal programs such as beach environmental and biodiversity monitoring and could be deployed with minimal financial resources. However, owing to the short duration of the study, the tool may not be 100% reliable, and should therefore be applied with caution. It is highly recommended to replicate the study in other beaches in the country in order to establish the reliability of the method for assessing anthropogenic impacts on sandy beaches.

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