Study of the Relationship between Seagrass and Sea Turtle

A Study of Nesting Sites Selection of Loggerhead Sea Turtle In Crete Island, Greece

Daniel G. Louhenapessy

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by

Daniel G. Louhenapessy

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Thesis Assessment Board

Chair	: Dr. A.G.Toxopeus , NRS Department, ITC, The Netherlands
External Examiner	: Dr. P. Lymberakis, Department of Zoology, University of Crete, Greece
Supervisor	: Mr. Valentijn Venus, NRS Department, ITC, Netherlands

Supervisors

Mr. Valentijn Venus (1^{st} Supervisor), NRS Department, ITC, The Netherlands
Dr. A.G.Toxopeus (2^{nd} Supervisor), NRS Department, ITC, The Netherlands

INTERNATIONAL INSTITUTE FOR GEO-INFORMATION SCIENCE AND EARTH OBSERVATION
ENSCHEDE, THE NETHERLANDS

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Abstract

Sea turtles nest on a variety of beach types, however it is still not really clear why they choose one beach and ignore others in order to deposit their eggs. This study was to investigate the beach sand characteristics and seagrass presence focusing in nest site selection by Loggerhead sea turtles in Crete, Greece. To detect presence and absence of seagrass, underwater photo imaging was used. The statistical test was using in this research namely using independent t-test, chi-square significant tests and Wilcoxon signed ranks test. The result of beach sand characteristics shown that grain shape and grain cleanliness is significant different between nesting and non-nesting beaches. In addition, sea grass presence is almost in nesting beaches. It can be sign as a preference of this animal to choose that beach as a nesting site.

Keywords : *Loggerhead sea turtle, Beach sand characteristics, Seagrass.*

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Table of contents

List of figures

List of tables and appendices

List of abbreviations

CL = Carapace length

CCL = Curved carapace length

ITC = International institute for Geo-information science and Earth Observations

IUCN = International Union for the Conservation of Nature and natural resources

ppm = part per million

SCL = Straight carapace length

1. Introduction

1.1. Background

Sea turtles are distributed throughout the tropical and subtropical seas. They have a complex history, with juveniles and immature stages shifting foraging habitats and adult females performing long distance breeding migrations (Mazaris et al., 2008). In coastal and marine ecosystem, sea turtles have as important role as a keystone species that transfer nutrient and energy from the ocean to the land at nesting beaches when they deposit their eggs, and they affect the structure and functioning of foraging habitats such as coral reefs, seagrass meadows, algal beds, and soft substrate sea bottom (SWOT, 2006).

Sea turtles select a nest site by deciding where to emerge from the surf and where on the beach to put their eggs (Witherington and Marti, 1996). However, this is still speculative in order to choose to nest on some beaches and not others (Van Meter, 1992). For instance, In Japan, an analysis of nesting beaches revealed that factors affecting beach selection by turtles included softness of the sand and beach length (Kikukawa et al., 1999), while in the Mediterranean Loggerhead sea turtle emerge primarily on beaches that are fronted by predominantly sandy areas (Le Vin et al., 1998). Other factors that influence nesting site selection by sea turtle are vegetation cover, distance to vegetation, humidity, temperature of the sand, and distance to high tide line (Kamel and Mrosovsky, 2004; Karavas et al., 2005; Mazaris et al., 2006; Pike, 2008).

Seagrass is one of the most widespread coastal vegetation types in the world. It protects shorelines against erosion in the middle and lower intertidal and sub tidal zones, because of their gregarious growth and dense root systems (Dahdouh-Guebas et al., 2006). They are also known to accumulate and stabilize sediments from the surrounding environment (Fry et al., 1983). Seagrass beds are also important because they provide breeding and development grounds for many species of fish, shelfish and crustaceans (Cccturtle.org, 2009), foraging ground for herbivores (Musick and Limpus, 1997), and attachment sites to small macroalgae and epiphytic organisms such as sponges, bryozoans, forams, and other taxa that use seagrasses as habitat (SMS.si.edu, 2009)

So far, there is no research has been done to see what is the relationship occurred between the Loggerhead sea turtle and presence of seagrass. This could be an interesting question to answer the curiosity of researcher about nesting behaviour of this species.

1.1.1. Distribution and Nesting Ecology

Loggerhead sea turtles are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (NOAA-Fisheries., 2009). They are also highly migratory, capable of travelling hundreds to thousands of kilometres between foraging and breeding areas. Female Loggerhead does not appear to migrate to just one foraging area. Rather, they move continuously and thus appear to forage at a series of coastal areas. Moreover, females migrate to nest at their natal beaches about every 3 years (Plotkin, 1997)

In Mediterranean, the important nesting sites of Loggerhead sea turtles are found in Greece, Turkey and Cyprus, while others nesting sites with lower density are found in Egypt, Italy, Syria, Lebanon, Israel, Tunisia, and Spain (Kasparek, 1995; Kuller, 1999; Margaritoulis et al., 2003). For Greece, nesting Loggerheads are significantly smaller that those other parts of the world. Following nesting data from several seasons, Margaritoulis (2000) classified nesting areas in Greece as "major" or "moderate". "Major" nesting areas are those hosting on average more than 100 nests/season and over 6 nests/km/season. Only five areas in Greece fulfil the requirements for "major" areas, there are: Laganas Bay (Zakynthos island), Kyparissia Bay (western Peloponnesus), Rethymno (Crete), Lakonikos Bay (Southern Peloponnesus) and the Bay of Chania (Crete island) (Margaritoulis, 2000).

Loggerhead nesting in Greece is highly seasonal. The nesting season usually extends from end of May to late August (Margaritoulis and Rees, 2001). Nesting success varied from area to area, generally caused by diversity of nesting habitat (Table 1-1).

Table 1-1. The main nesting areas monitored during 2002 in Greece

Nesting Area	Beach length (km)	Number of emergences	Number of nest	Overall nesting success (%)	Nesting Density (nest/km)
Laganas Bay (Zakynthos)	5.5	5123	1175	22.9	213.6
Southern Kyparissia Bay	9.5	1784	593	33.2	62.4
Rethymno	10.8	1347	325	24.1	30.1
Lakonikos Bay	23.5	888	187	21.1	8.0
Bay of Chania	13.1	433	100	23.1	7.6
Bay of Messara	8.1	227	61	26.9	7.5
Koroni	2.7	189	55	29.1	20.4
Total	73.2	9991	2496	25	34.1

Sources : Margaritoulis and Rees (2003)

1.1.2. Feeding and Diving Behaviour

Loggerhead sea turtles are known as a carnivorous, foraging primarily on benthic invertebrates throughout their distribution range. Loggerhead populations from different geographic locations forage on different types of prey, and the list of the types of prey eaten by Loggerhead in the wild is extensive. The high diversity in the types of their prey demonstrates versatility in foraging behaviour, suggesting that the Loggerhead is a generalist (Plotkin et al., 1993)

Dodd(1988) stated that this species eats a variety of foods for each stage. Juvenile Loggerhead particularly feed on coelenterates while sub adult and adult feed on jelly fish but they are primarily feeder on benthic invertebrates. He also mentioned that Loggerhead take alga occasionally, perhaps ingesting it while feeding invertebrates. Table 1-2 shows diet preference of Loggerhead sea turtles.

Table 1-2. Diet preference Loggerhead sea turtles (*Carreta carreta*)

Size	Diet	Location
4.0 – 5.6 cm (SCL)	Cnidaria, Tar, Synthetics, *Sargassum*, Crustacean, Hydrozoans, Insects, Gastropods, Plant Material	Atlantic, off at sea
4.5 -4.7 cm (CL)	*Sargassum* , Plant material (Alga fragments), Insects , Crustacean, Cnidaria, Tar, Fish eggs, Plastics/synthetics	Atlantic Ocean
4.1 – 7.8 cm (SCL)	*Sargassum,* Plant Material (seagrasses, Algae), Cnidaria, Copepods, Insects, Plastics & Tar, Polycheates, Bryozoan	Atlantic Ocean
Hatchling	*Sargassum,* Gastropods, Crustacean	Florida, stranded
13.5 – 74.0 cm (CCL)	Gastropods, Cephalopods, Crustaceans, Cnidaria, rochordata, Fish, Annelids, Algae	Pacific Ocean
Mean 61.4 cm (SCL)	*Pleuroncodes planipes* – Pelagic crab	Pacific Ocean
4.6 – 10.6 cm (CCL)	Synthetics, Cnidaria, Crustacea, Gastropods, Plant Material (seed pods and spores)	Pacific Ocean

From various sources. Summarized by Boyle and Limpus (2008)

Diving plays a central role in the lives of all air-breathing marine vertebrates, including sea turtle (Rice and Balazs, 2008) and it is influenced by body size (Schreer and Kovacs, 1997). Salmon (2004) reported that the younger of Chelonian mydas (8-10 weeks of development period) dives were usually shallow (≤ 6 m) and consisted of three (V, S, U) profiles. The older can dives only slightly deeper than the younger. In contrast, adult can dive in excess of 100 - 135 m (Rice and Balazs, 2008).

Oceanic Loggerhead spend 75 % of the time in the top of water column; 80% of dives are 2-5 meter, and reminder of the dives are distributed throughout the top 100 m. Occasionally this species can dive greater than 200 m (Bolton and Rieward, unpubl.data). In general, small size should limit diving depth and duration because of volume of tissue to store oxygen is lower and mass specific metabolic rates of smaller animal are higher (Schmidt-Nielsen, 1997).

1.2. Research Problem

The most important nesting sites of the Loggerhead in the Mediterranean are located in Greece. The sites are dispersed along Greece's western and southern coast line and on Crete Island. However, the population of the Loggerhead in Greece declined rapidly in the last decade. Human activities such as fishing pressure, coastal development, extensive urban expansion for tourism and recreation, are the most factors that influencing in decreasing of number of this species (Arianoutsou, 1988; Margaritoulis et al., 2003).

Loggerhead sea turtles (*Caretta caretta*) have defined as endanger species in the world By IUCN. Therefore, many international treaties and agreement have been set up to protect the existence of this species (NOAA-Fisheries., 2009). Many studies have been done in order to understand nesting habitat suitability criteria, but they are rarely reach consolidation (Miller et al., 2003) and mainly focused on the nesting beaches, and take less attention on non nesting beaches that are relative nearby. Knowing that sea turtle spend most of their life in the marine environment, understanding how they interact in their environment is one of important factor for assessing habitat suitability and can lead to enhance successful of management decision and conservation strategies.

1.3. Research Objectives

1.3.1. General Objective

The main objective of this study is to investigate the relationship between seagrass and nesting sites selection by Loggerhead sea turtles (*Caretta caretta*) in Crete, Greece.

1.3.2. Specific Objective

To characterize percentage cover of seagrass as a parameter to determine the suitability for nesting site selection by Loggerhead sea turtles (*Caretta caretta*).

1.4. Research Questions

1. a. What are the differences between beach sand characteristics in nesting and non-nesting beaches?
   b. Which are the beach sand characteristics that are more correlated with the nesting habitat of the Loggerhead sea turtle?

2. Can presence of seagrass be confirmed as an indicator to determine sea turtle nesting site selection?

1.5. Research Hypothesis

1. H_0: The beach sand characteristics are not statistically significant ($p \geq 0.05$) between nesting and non-nesting beaches

$$H_0 : \mu 1 = \mu 2$$

H_1: The beach sand characteristics are significantly differs between nesting and non-nesting beaches.

$$H_1: \mu 1 \geq \mu 2$$

2. H_0: The grain size is not statistically significant ($p \geq 0.05$) than the other factor of beach sand characteristics to determine nesting habitat of Loggerhead sea turtle.

$$H_0 : \mu 1 = \mu 2$$

H_1: The grain size is more important factor than the other to determine nesting habitat of Loggerhead sea turtle.

$$H_1: \mu 1 \geq \mu 2$$

3. H_0: There is not statistically significant ($p \geq 0.05$) between presence of seagrass and the number of nests.

$$H_0 : \mu 1 = \mu 2$$

H_1: There has a significant relationship between presence of seagrass and the number of nests.

$$H_1: \mu 1 \geq \mu 2$$

2. Material and Methods

2.1. Study Area

Crete is the largest island in Greece and the second biggest (after Cyprus) of the east Mediterranean (Figure 2-1). It lies at the southern Aegean Sea (23°31' to 26°18' E and from 34°55' to 35°41'N) and at the crossroads of three continents Europe, Asia and Africa. Crete covers an area of 8,336 km2, with a length of 260 km, and a width that from 12 to 60 km. The total length of the Cretan coastline is 1046 km and consists of both sandy beaches and rocky shores (West-Crete, 2008).

Figure 2-1 Map of Crete Island, Greece.

Administratively, Crete is one of the 13 regions of Greece and is divided to four prefectures (Hania, Rethymnon, Heraklion and Lassithi) and 70 municipalities. The population of the island is approximately 630.000 (2005), and over a third of it is found in the three major cities, Iraklion (~150.000), Hania(~50.000) and Rethymnon (~30.000) located on the north coast of the island (Interkriti.org, 2009).

Crete was chosen as a study area because of this island has been categorized as one of important nesting sites for Loggerhead sea turtle in the Mediterranean. There are 3 areas that were indicated as main nesting sites in Crete i.e Rethimnon, Hania and Messara .

In the Mediterranean Sea, *Posidonia oceanica* is the dominant endemic seagrass and its meadows are considered as one of the most important and productive ecosystems in coastal waters. It covering the sea bed from the surface down to about 40 m (Montefalcone et al., 2008).

2.2. Research Scheme

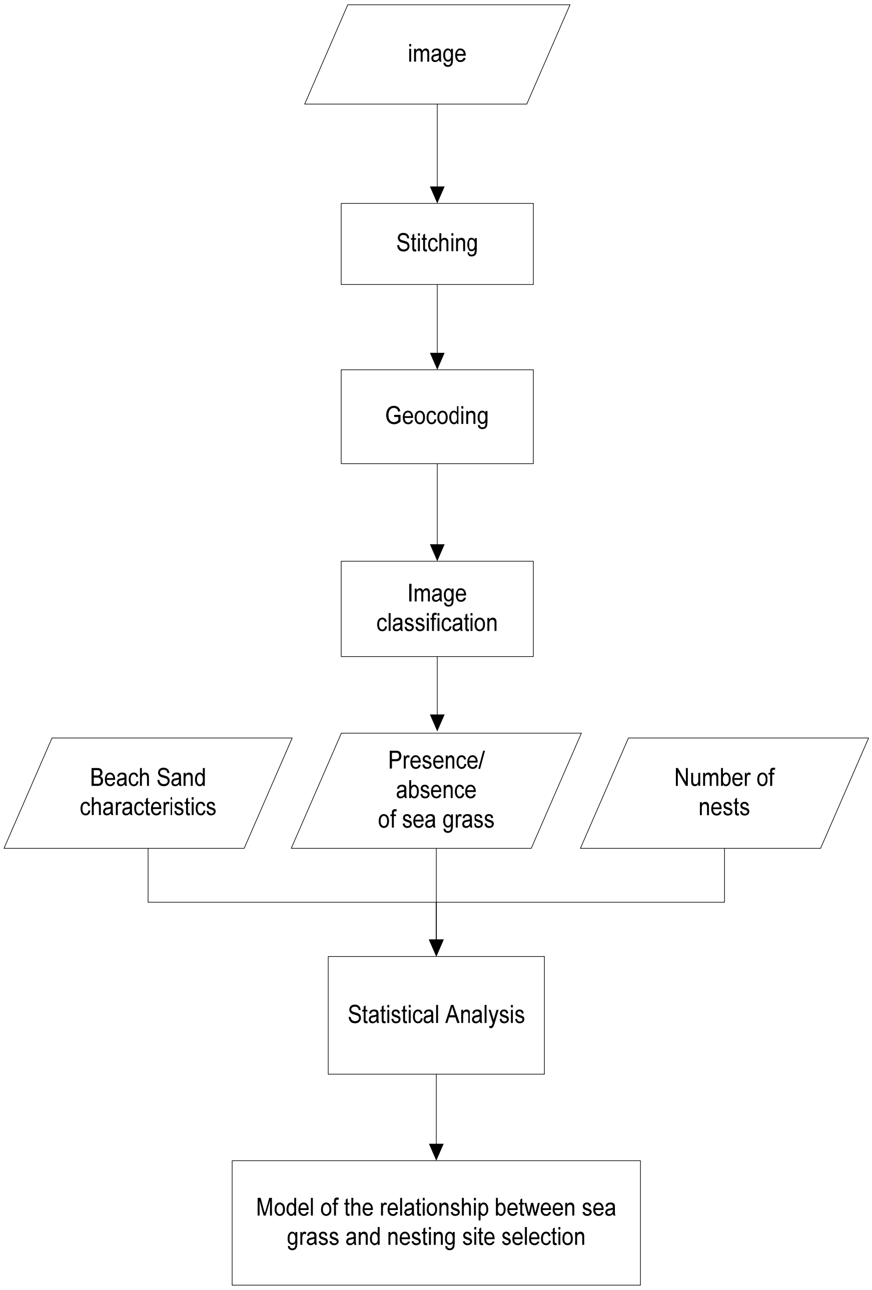


Figure 2-2. Research Scheme

2.3. Data Collection

2.3.1. In situ data collection

Fieldwork was carried out from September 28th to October 18th. The data were collected includes the information about nesting beaches, non nesting beaches, and presence or absence of seagrass. Most of the beaches was been visited in this study are based on the data from the previous study (Asaad, 2009) and combined with the data from Margatoulis and Dretakis (1991).

There are three additional sample points that have been added in this study i.e Vai, Itanos, Trachilos. All of point observations are presented in Table 2-1. Sand sample were collected for those new additional nesting and non-nesting beaches. The methods that are used to collect the sand samples are based on Asaad, (2009)

Table 2-1. Point of Observations

Location	Nesting Status*	Presence or Absence of Seagrass **
Paleohora	Non-nestng	Absence
Frangocastelo	Non-nestng	Absence
Koutsunary	Non-nestng	Absence
Ierapetra	Non-nestng	Absence
Trachilos	Non-nestng	Absence
Falasarna	Nesting	Presence
Iraklion	Nesting	Presence
Rethimnon	Nesting	Presence
Hania	Nesting	Presence
Messara	Nesting	Absence
Itanos	Nesting	Presence
Vai	Nesting	Presence
Georgioupoli	Nesting	Presence
Xerokampos	Nesting	Presence

Source: * : Margatoulis and Dretakis (1991), ** : Field observation.

Data from Natura 2000 were utilized to locate seagrass presence. There are 6 areas covered by Natura 2000 project in Crete i.e Setia, Zakros, Rethimnon bay, Kissamos, Paleohora, and

Elafonissos (see Figure 2-2). However, not all observations points were corresponded with the data from Natura 2000. Therefore, the seagrass data was collected based on information from local people and visual observation. Due to whether condition, the visual observation was helpful. It was done by detecting seagrass presence through litter found along the beach.

Presence or absence of seagrass were identified based on images taken along the seagrass area using transect sampling method. The photos were captured using an underwater camera, Olympus ST 8000 at 4 minutes interval from zodiac boat along the transect line. The camera and GPS were attached to the measuring frame. A leveller was used to keep the position of the camera horizontal when submerged. The time stamp of the GPS position and still images allowed the geolocation of each photo.

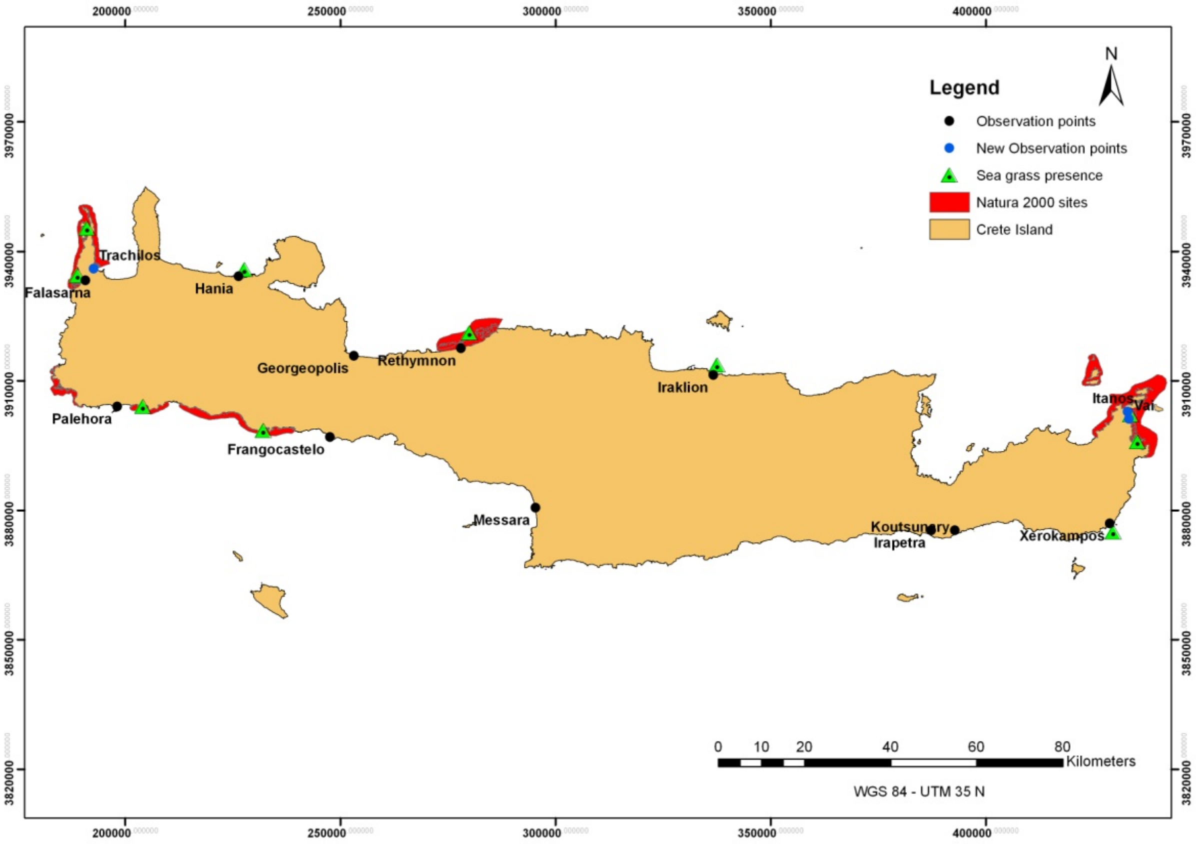


Figure 2-3. Map of observation points in Crete Island, Greece

2.4. Data Analysis

2.4.1. Sand Samples Analysis

Sand samples were analysed at ITC laboratory for 6 parameters of beach sand characteristics i.e. pH, conductivity content, grain shape, grain cleanliness, Sodium Chloride (NaCl) content, and grain size. The methods for analysis followed those outlined methods which is done by Assad, (2009).

2.4.2. Presence and absence of seagrass

An imaging approach was taken to identify the presence and absence of seagrass. Most approaches to image stitching require nearly exact overlaps between images and identical exposures to produce seamless results. It is also known as mosaicing (M. Brown *et al.*, 2003). These photos were analysed using autostich panorama software. Image stitching or photo stitching is a technique of combining numerous images with overlapping fields of view to produce a segmented panorama or high-resolution image (Wikipedia, 2009). This software identified overlapping photos using algorithm for feature matching abilities that takes into consideration the camera properties parameter and make necessary adjustment to ensure fast computation and a precise blending for the photograph inputted in the stitching model. These connected photographs are called panoramas.

2.4.3. Statistical Analysis

The statistical analyses were used are focusing on determine the difference in value of the beach sand characteristics in both nesting and non-nesting, the identification of the relationship between presence or absence of seagrass and nesting occurrence (number of nests and number of emergences), to determine the parameters that are correlated with nesting activity,. All of the analyses were done using SPSS 16.

Each parameter was tested using independent t-test and chi-square significant tests. The relationship between presence of seagrass and number of nest was tested using a correlation test. The independent t-test was used to see the significant difference between the means of continuous variable of two groups on some independent variable where those two groups are independent of one another. Nesting and non-nesting beaches are independent variables of two groups while the other independent variables are pH, conductivity, NaCl content, and number of nest. The rest of variables, sand grain shape and sand cleanliness are tested using a chi square test.

Highly correlated factor with suitable nesting beaches were tested using logistic regression with backward stepwise likelihood method. To determine whether the beach sand characteristics are influenced to accessibility of se grass, a multiple linear regression was used and normalized in order to delineate the influences of the said parameters thus the increasing the variability of the accessibility of seagrass using Multiple Linear regression.

3. Result

3.1. Beach Sand Characteristics

A total of 6 parameters were analysed for sand characteristics in ITC laboratory i.e pH, conductivity content, grain shape, grain cleanliness, Sodium Chloride (NaCl) content, and grain size. All of this data are presented in Appendix.

3.1.1. pH

The pH value shows a slightly different between nesting and non-nesting beaches in this study. The minimum pH value in nesting beaches is 8.89 and the maximum value is 9.34. For non-nesting beaches, the minimum value is 8.75 and the maximum value is 9.33.

Based on the statistical test (independent t-test), the result shows that there is not a significant difference in pH value between nesting and non-nesting beaches for both study and combined study ((**a**), t = -1.470, df = 21.543, p = 0.156; (**b**), t = -1.879, df = 42.486, p = 0.067; (**c**), t = -1.470, df = 21.543, p = 0.156).

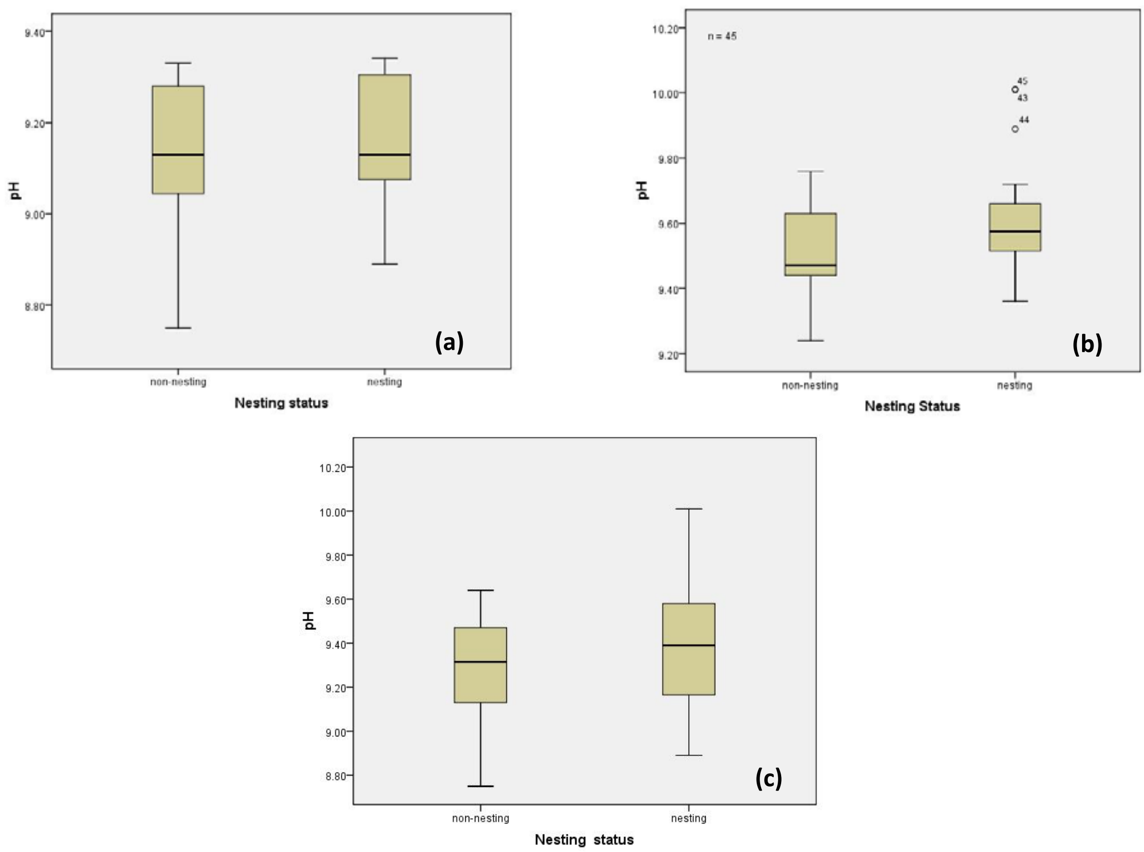


Figure 3-1. Comparison of pH variations of the sand in non-nesting and nesting beaches.
A. This study, B. Asaad (2009), and C. Combined

3.1.2. Conductivity

The conductivity value was measured using Hach-multimeter HQ 40d. The result for this study shows that in nesting beaches, the minimum value is 104 µS/cm and the maximum value is 1,026 µS/cm. While in non-nesting beaches, the minimum value is 101.90 µS/cm and the maximum value is 1,240 µS/cm. There is one one sample in nesting beaches that has a very high value and is consider as outlier. This sample was taken at Itanos.

A Statistical test, independent t-test, for this study and combined data revealed that there is no significant difference between conductivity content in nesting and non-nesting beaches (t-test(a), $t = -0.555$, $df = 28.021$, $p = 0.583$; t-test(c), $t = 1.435$, $df = 62.291$, $p = 0.156$). In contrast, Asaad (2009) found that that there is significant between conductivity content in nesting and non-nesting beaches,

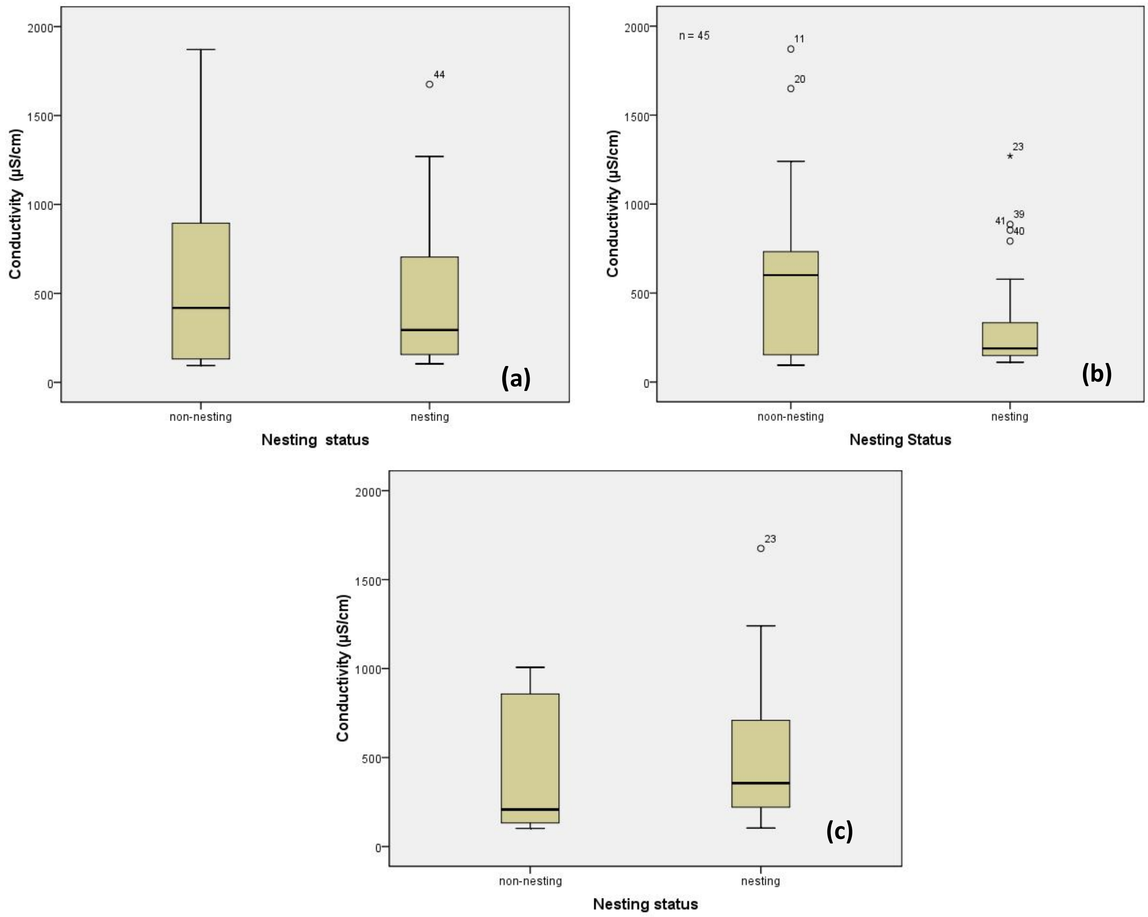


Figure 3-2. Comparison of conductivity variations (µS/cm) of the sand in non-nesting and nesting beaches. A. This study, B. Asaad (2009), and C. Combined

3.1.3. NaCl content

The result of the AAS (atomic absorption spectrometer) revealed that the minimum value of NaCl content in nesting beaches is 21 ppm and the maximum value is 519 ppm. In non-nesting beaches, the minimum value of NaCl is 18 ppm and the maximum value is 607 ppm. There are two samples that have excessive values. These samples were taken from Itanos (nesting beach) and Vai Palm Beach (non-nesting beach) and are considered as an outlier. These excessive values might be due to the geomorphology of the beaches that are relative close to the sea water.

A statistical analysis using independent t-test for this study shows that there is no significant difference between NaCl content in nesting and non-nesting beaches (t-test, $t = -0.175$, $df = 25.219$, $p = 0.862$). The same result also was found for the combined data (t-test, $t = 0.570$, $df = 73.300$, $p = 0.570$).

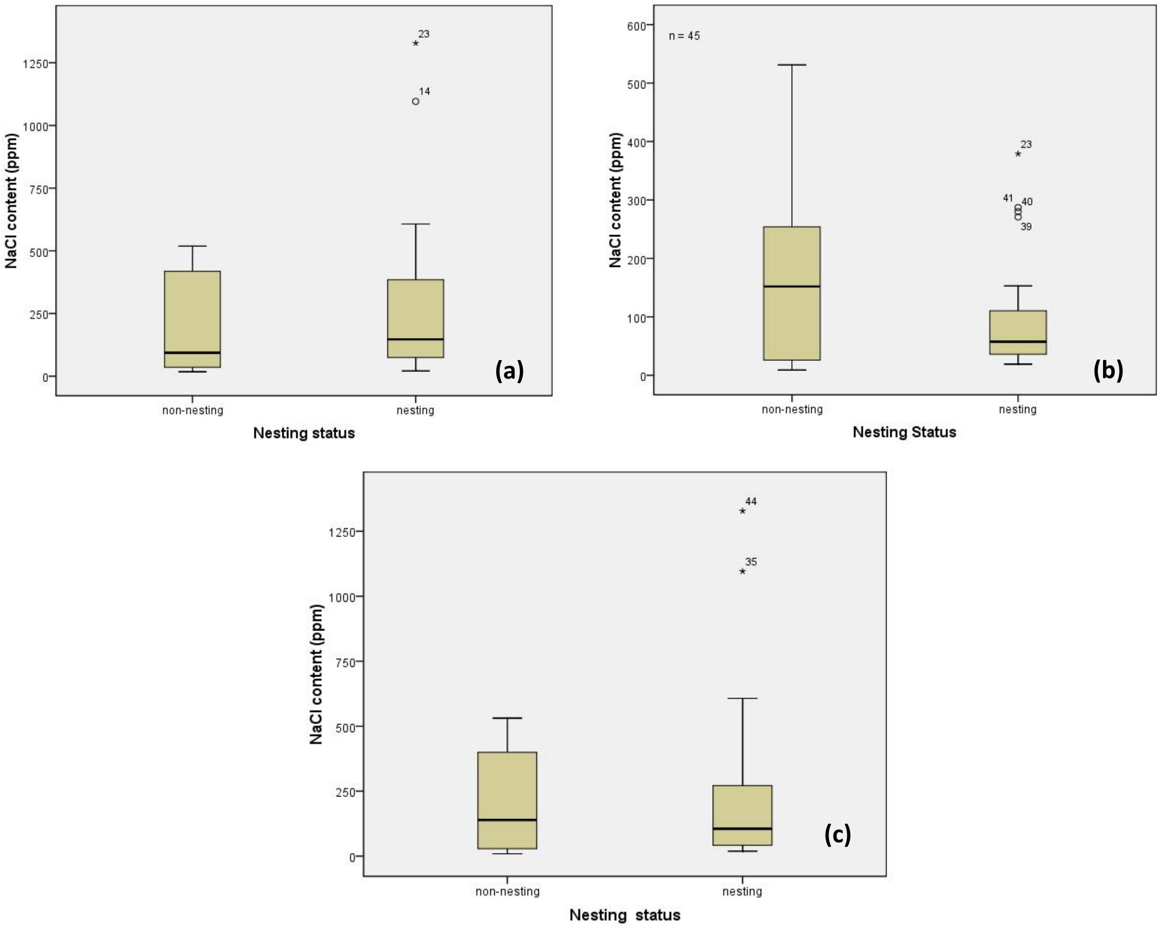
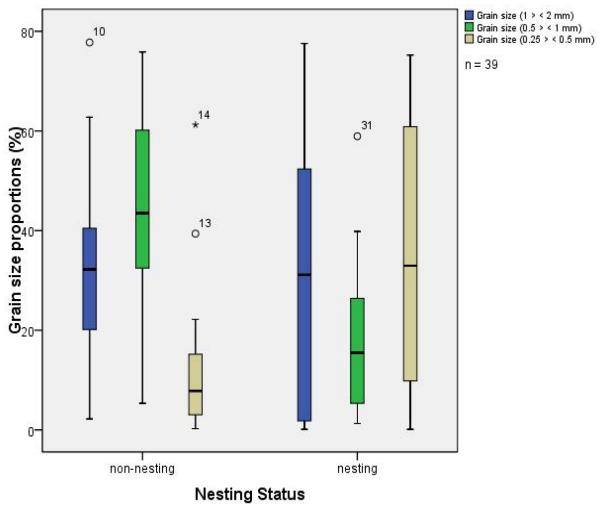


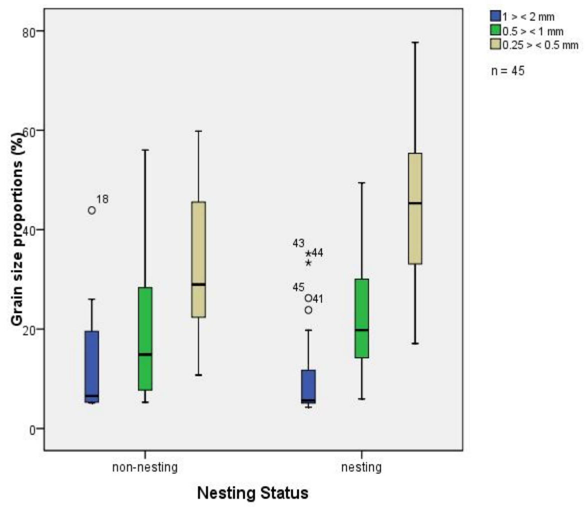
Figure 3-3. Comparison of NaCl content variations (ppm) of the sand in non-nesting and nesting beaches. A. This study, B. Asaad (2009), and C. Combined

3.1.4. Grain Size

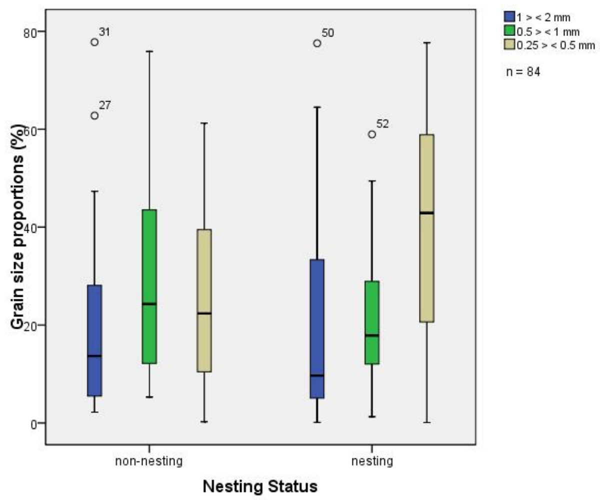
The sand samples were analysed and divided into six grain size fractions in order to determine their particles size proportions. There are three major sand size grades that contributed to the main proportion of sand particles i.e. very coarse sand (1> < 2 mm), coarse sand (0.5> <1.0 mm), and medium sand (0.25 > < 0.5).



(a)

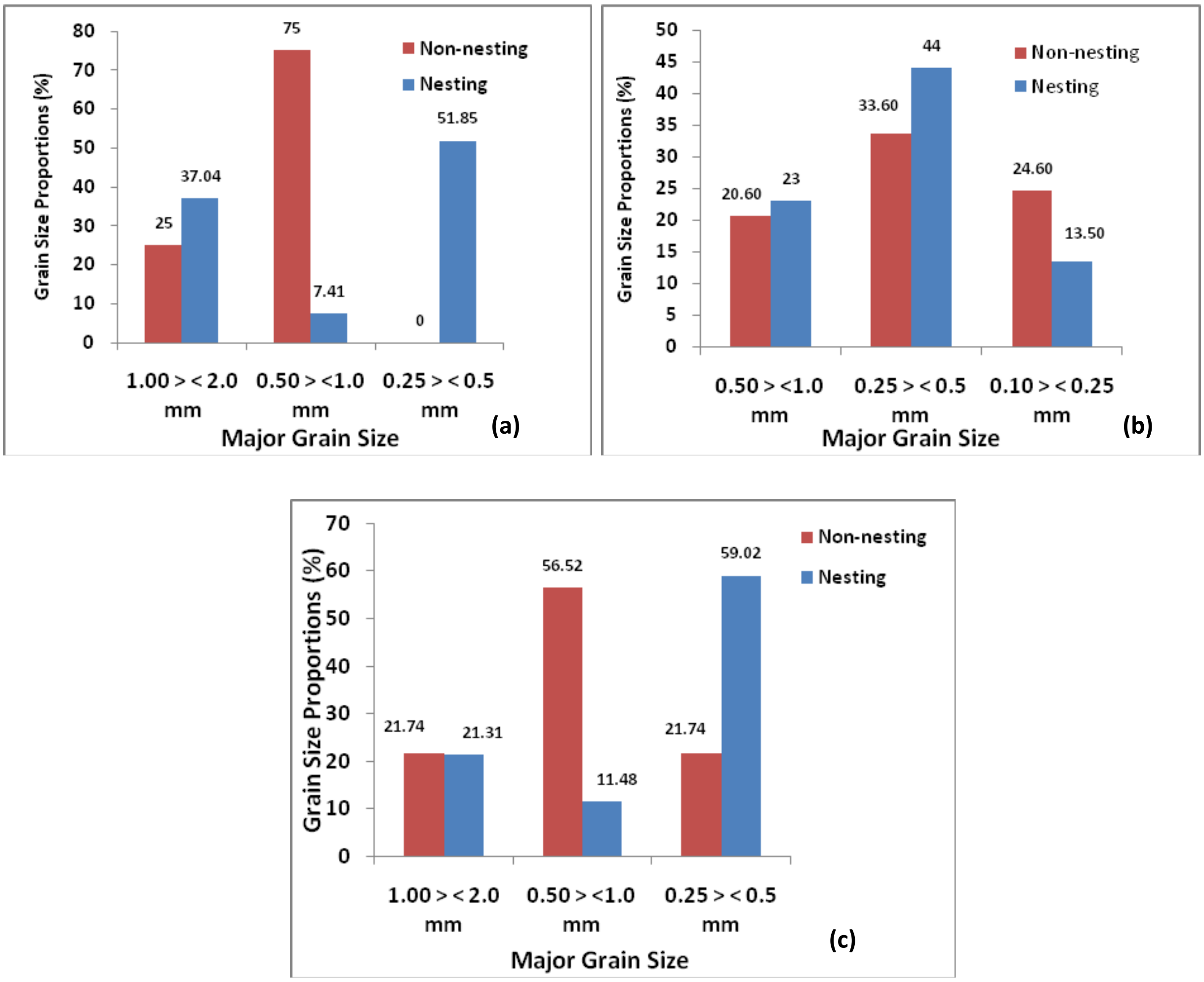


(b)



(c)

Figure 3-4a. Comparison of three major grain size proportion of the sand in non-nesting and nesting beaches. A. This study, B. Asaad, (2009), and C. All



3.1.5. Grain shape

The grain shape was done using visual microscopic analysis. The grain was divided into 3 different classes i.e. rounded shape, mixture shape (mixture of rounded and angular shape), and angular shape. The result revealed that a mixture shape contributed to the majority of grain shape proportion in nesting and non-nesting beaches by 79% and 68%, respectively (see Figure 3.1-5.a)

This result is different from the previous study by Asaad, (2009) whereas in his result, nesting beaches are dominated by 75% of angular grain shape proportions and non-nesting beaches are dominated by 54.55% of rounded grain shape proportion. For the combined study, the result shows a slightly different in proportion of grain shape for both nesting and non-nesting beaches. The mixture grain shape contributed 50% of grain shape proportion in nesting beaches while the angular grain shape contributed 53.06% of grain shape proportion in non-nesting beaches.

The statistical analysis (chi-square test) for all studies shown that there is significant different between grain shape in nesting and non-nesting beaches (p = 0.011).

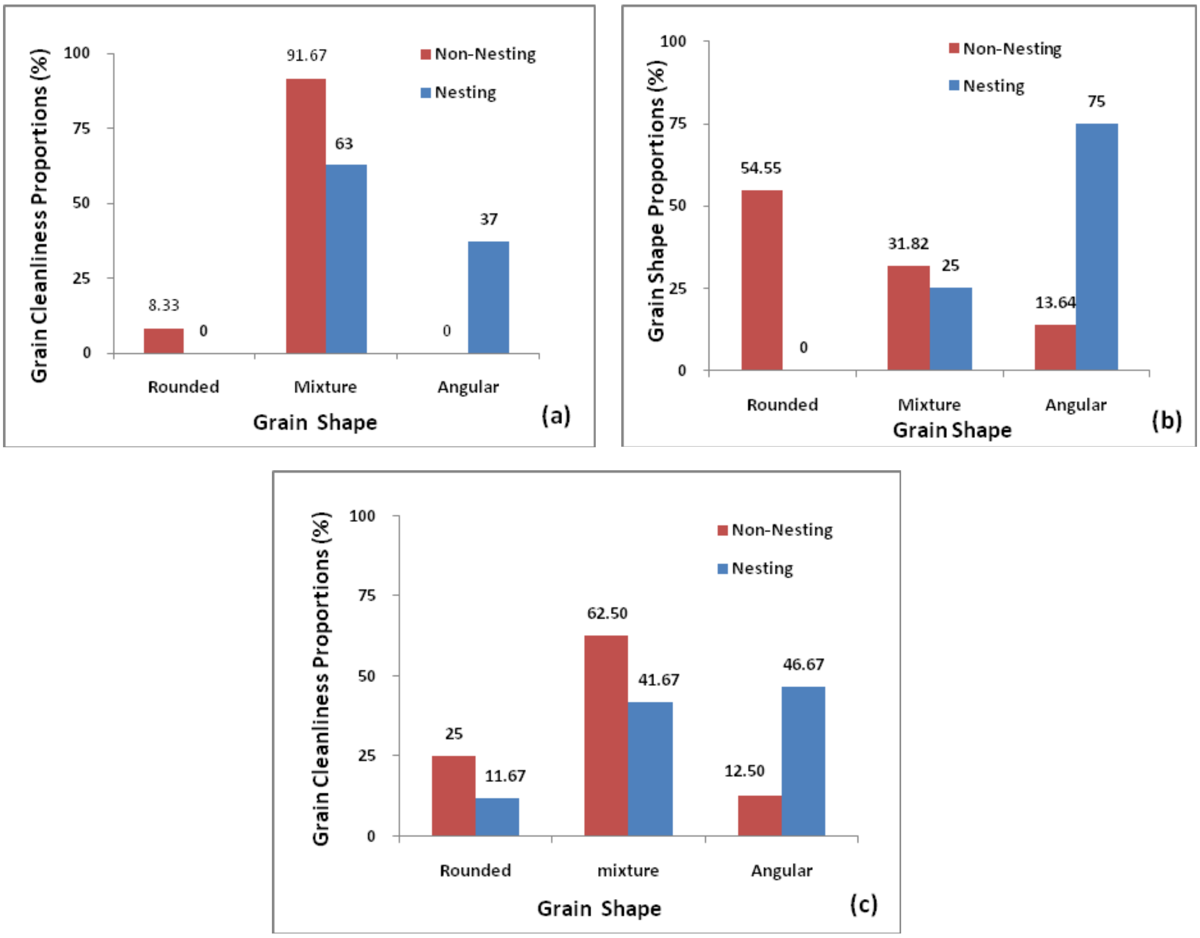


Figure 3-5. Comparison of grain shape proportion of the sand in non-nesting and nesting beaches. A. This study, B. Asaad (2009), and C. Combined.

3.1.6. Grain Cleanliness

The same procedure as using in grain shape analysis was used to analyse the grain cleanliness. The grain cleanliness was analysed based on the amount of dust particles in the sample. Then, it was divided into three different classes i.e. dusts free, moderate, and high dust.

Figure 3.1-6 shows that in this study (a), nesting beaches is dominated by moderate sand while non-nesting beaches is dominated by dust free and moderate sand (48%) . For study (b) and (c), nesting and non-nesting beaches are dominated by dust free sand. The result of statistical test (chi-square test) shows that there is significant different between grain cleanliness proportions in nesting and non-nesting beaches (p = 0.009). In contrast, the grain cleanliness proportions doesn't show significant different in nesting and non-nesting beaches for combined (p = 0.144).

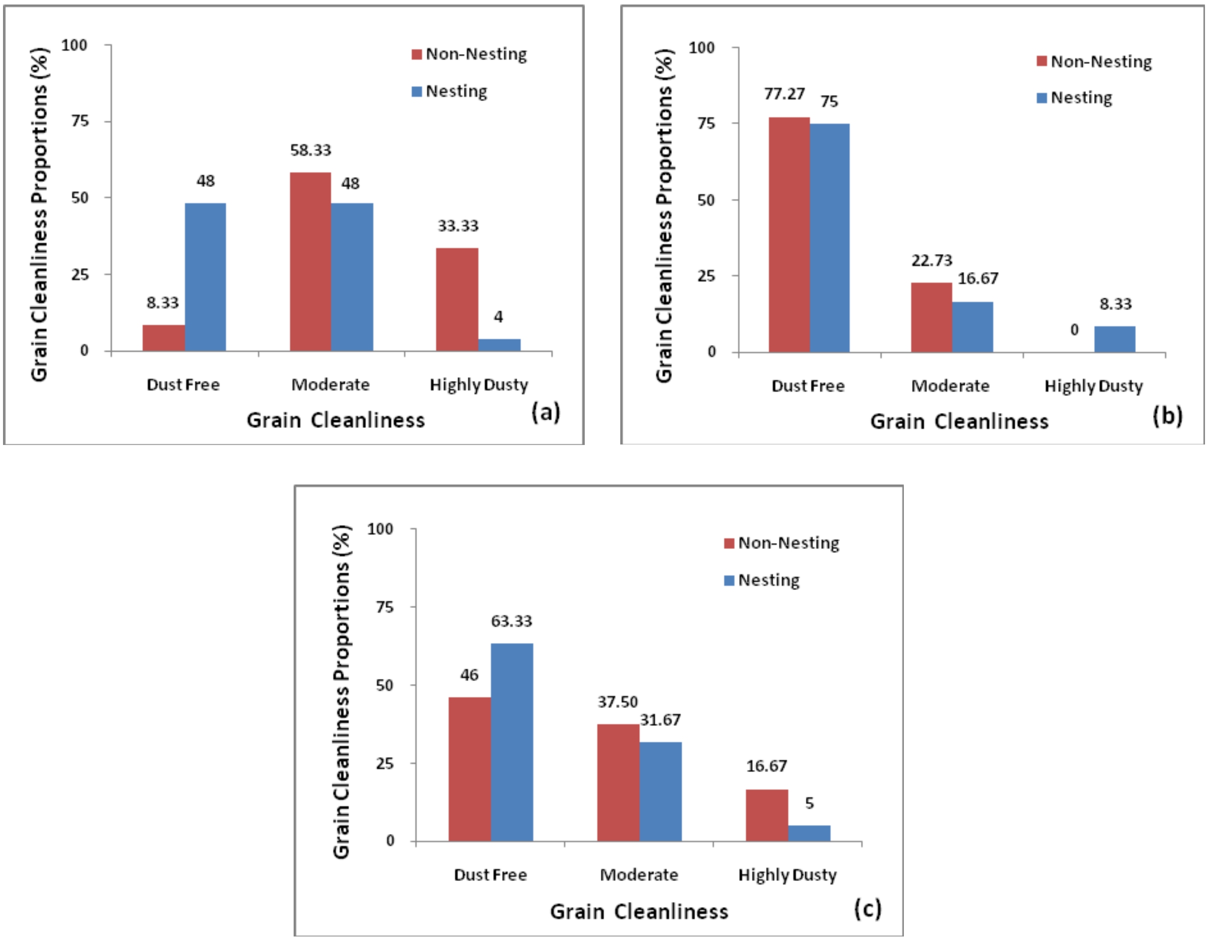


Figure 3-6. Comparison of grain cleanliness proportion of the sand in non-nesting and nesting beaches. A. This study, B. Asaad (2009), and C. Combined.

3.2. Seagrass presence and nesting attemp

Presence of seagrass was detected using underwater photo imaging. Figure 3-7 illustrates an example of the underwater image used to detect seagrass presence in Xerochampos. The map indicates the line transects and shows the sampling points of seagrass.

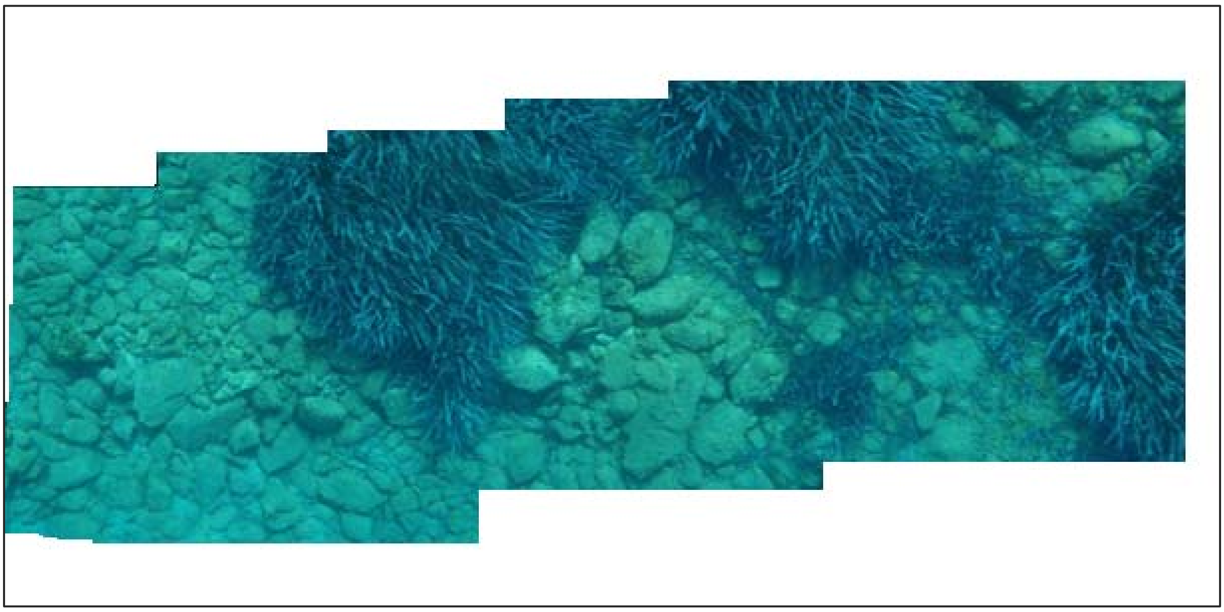


Figure.3-7. Autostitched image of seagrass from line transect.

The nesting data from Margatoulis and Dretakis (1991) and Margatoulis et al, (2005) were used in order to see the relationship between seagrass presence or absence with number of emergences and number of nest (see Table 3-1).

Table 3-1. The nesting area of Loggerhead sea turtles in Crete, Greece

No.	Location	Nesting Status	Presence or absence of Seagrass	Number of emergences	Number of nests
1	Paleohora	0	0	0	0
2	Frangocastelo	0	0	0	0
3	Koutsunary	0	0	0	0
4	Ierapetra	0	0	0	0
5	Trachilos	0	0	0	0
6	Georgioupoli	1	1	28	10
7	Rethimnon	1	1	1337	349.7
8	Hania	1	1	427	114.9
9	Messara	1	0	222	53.5
10	Vai	1	1	22	4
11	Xerokampos	1	1	2	3.5

The table shows that there are three locations that have large number of nests and emergences compared to others. These three locations are Rethimno, Chania and Messara and known as major nesting sites in Crete. However, the data was not completely recorded. There some data the number of number and number of emergences was missing. In order to avoid bias during the calculation, only available data was considered and taking into account.

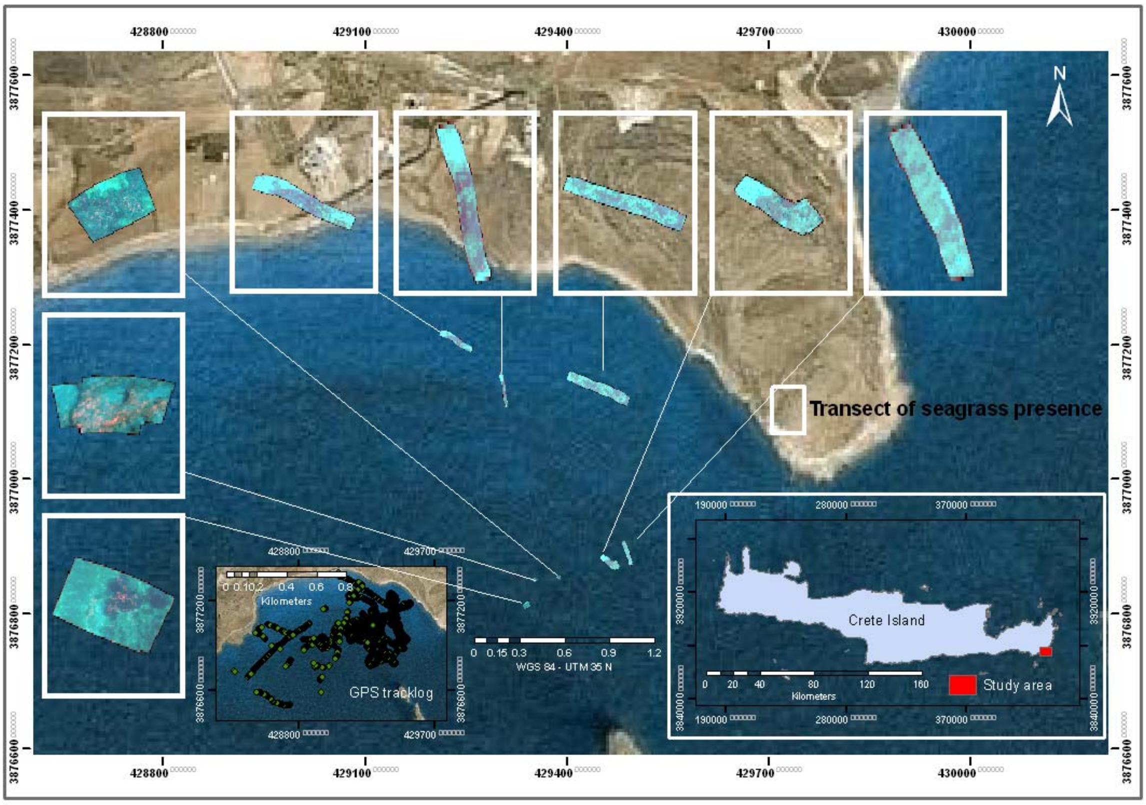


Figure 3-8. Underwater photos of seagrass presence tied to GPS locations in Xerochampos.

Emergences is defined as the number of hatchling that emerge (come up) from a nest. The parameters tested for nesting and non-nesting beaches are important as they determined the number of nest which is relative to the number of emergence from a nesting beach.

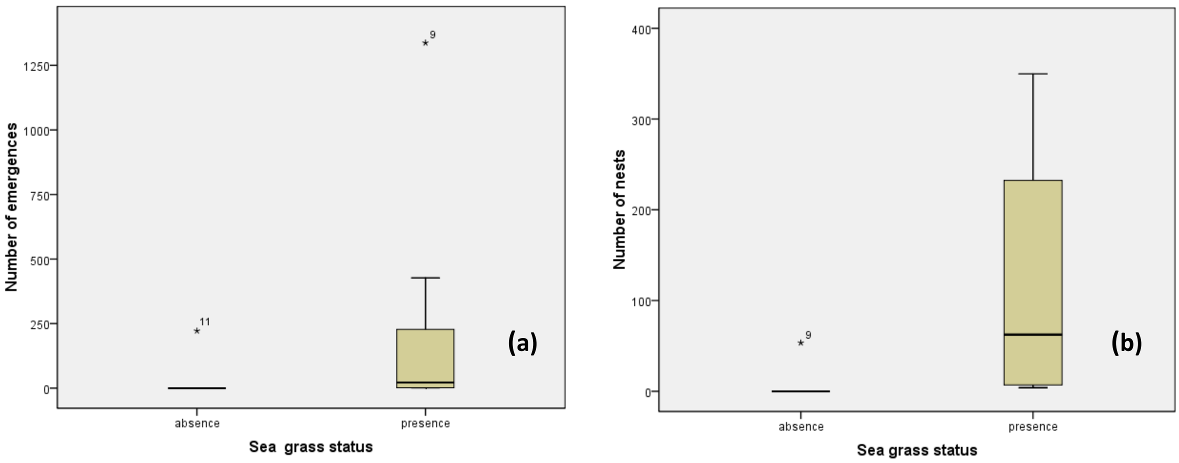


Figure 3-9. Comparison of nesting attempts between number of emergences (a), number of nests (b) and presence or absence of seagrass.

The Statistical test (Wilcoxon signed ranks test) was applied to see whether the relationship between seagrass presence and number of emergences is significant. The results show that there is a significantly importance of seagrass presence to the number of emergences and number of nests ($p = 0.022$, $n = 11$). As result of that result, I reject my null hypothesis.

4. Discussion

4.1. The beach sand characteristics

Terrestrial environmental plays an important role to the sea turtles. Wood and Bjorndal (2000) stated that nest site selection by sea turtles can be divided into three phases i.e. beach selection, emergence of the female, and nest placement. Beach selection and emergence probably depend largely on offshore cues and beach characteristics. Among others sand texture has been reported as important for the selection by sea turtles (Mortimer, 1990).

Sea turtles nest on a variety of beach types, however it is still not really clear why they choose one beach over another in order to deposit their eggs (Mortimer, 1995). In addition, she stated that the basic requirements to be a potential nesting beach are accessibility from the sea, the beach platform must also high enough to avoid the inundation by sea water and the beach sand should facilitate gas diffusion but moist enough and fine enough to prevent excessive slippage while the nest is being constructed. Typical loggerhead nesting beaches tend to be sandy, wide, open beaches backed by low dunes and fronted by a flat sandy approach from the sea (Miller et al., 2003).

This study investigated sandy beach characteristics (6 parameters) and tried to find out the correlations between those parameters and nesting and non-nesting beaches. The results then were combined and compared with the result from the previous study by Asaad (2009) in order to gain more understanding how it is different. In general, the result shown that most of the all parameters are not significant different between nesting and non-nesting beaches. There are two parameters of the beach sand characteristics that have significant i.e. grain shape and grain cleanliness.

Asaad (2009) stated that the beaches with angular sand have more advantages than rounded. The advantage of angular shapes is the surface of this particle has more possibility that interact with other particles. The more interaction occurs, the more cohesion force occurs. In addition, this process is needed to maintain the nest chamber from collapsing (Mortimer, 1995). Moreover, this kind of shape can give more space between particles in order to facilitate gas and water exchange which is important during embryo development (Asaad, 2009).

The result from this study confirmed what is shown by several studies namely Stancyk and Ross (1978) and Mortimer (1995) at Ascension beach. They found that there is no correlation between beach sand parameters i.e. calcium carbonat content, pH, conductivity, colour and particle size distribution to the site selection of sea turtle. In addition, for the Ascension beach, turtles lay eggs in many types of sand textures. It is ranging from dust to gravel. Therefore, factor other than physiognomy of sand on nesting beaches may be more important than the characteristics of the sand (Mortimer, 1995).

4.2. Presence of seagrass and nesting attemps

Seagrass is marine plant that has important function to the environment. The diversity and abundance of organisms that utilize in this area is high since they are known as habitats and nursery grounds.

The fact that more nesting activity occurred where there are a seagrass can be as a sign that this plant has more value to Loggerhead as a nesting site selection. Even though Loggerhead sea turtles are known as a carnivore, but this animal also found forage in seagrass bed (Houghton et al., 2000). Presence of seagrass also can be as a protection area for sea turtles from predator.

5. Conclusions and Recommendations

5.1. Conclusions

- The study shows that there are beach sand characteristics or parameters that might influence to the suitability of nesting site selection for Loggerhead sea turtles.
- The grain shape and the grain cleanliness are the two beach characteristics that significantly differ between in nesting and non-nesting beaches
- Seagrass presence can be confirmed as an indicator to determine Loggerhead sea turtles nesting sites selection.
- New beaches were tested to determined the characteristics as nesting and non-nesting beaches
- Underwater photograph are able to identify the presence of seagrass in nesting sites.

5.2. Recommendations

- More data are needed in order to improve the robustness of the nesting suitability assessment.

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Appendices

Appendices A. Data set of beach sand characteristics

Appendices A-1. In situ data set of beach sand characteristics in nesting and non-nesting beaches

Location	Nesting Status	pH	Conductivity	Na	Grain Cleanliness	Grain Shape
Trachilos	0	8.75	149.3	40	3	2
Trachilos	0	9.14	132.8	50	2	1
Trachilos	0	8.82	101.9	18	3	2
Trachilos	0	9.33	267	137	3	2
Trachilos	0	9.09	123.7	49	3	2
Trachilos	0	9.01	857	490	2	2
Trachilos	0	9.16	344	141	2	2
Trachilos	0	9.12	133.7	32	2	2
Trachilos	0	9.08	132.3	26	2	2
Trachilos	0	9.28	932	435	1	2
Trachilos	0	9.30	857	402	2	2
Trachilos	0	9.28	1007	519	2	2
Vai_palm beach	1	9.02	150.8	38	2	3
Vai_palm beach	1	8.94	1026	1096	2	3
Itanos	1	9.32	293	94	2	2
Itanos	1	9.33	266	272	2	2
Itanos	1	9.33	342	146	2	2
Itanos	1	9.31	129.5	48	2	2
Itanos	1	9.34	533	215	1	2
Itanos	1	9.30	176.4	66	1	2
Itanos	1	9.34	137.7	42	1	2
Itanos	1	9.28	360	122	1	2
Itanos	1	9.31	1675	1328	1	2
Itanos	1	8.95	1068	607	3	2
Vai	1	9.11	356	147	2	2
Vai	1	8.89	337	138	2	2
Vai	1	8.97	637	413	2	2
Vai	1	9.09	703	362	2	2
Vai	1	9.03	800	390	2	2
Vai	1	9.21	292	125	2	2
Vai	1	9.25	712	379	2	2
Xerocampos	1	9.11	115.1	28	1	3
Xerocampos	1	9.06	1094	557	1	3
Xerocampos	1	9.13	706	303	1	3
Xerocampos	1	9.10	283	83	1	3
Xerocampos	1	9.13	104	21	1	3
Xerocampos	1	9.14	134.1	34	1	3
Xerocampos	1	9.13	430	148	1	3
Xerocampos	1	9.19	1240	575	1	3

Appendices A-2. In situ data set of beach sand characteristics in nesting and non-nesting beaches

Location	Grading Size / Sieve Fraction					
	> 2	1.00 > < 2.0	0.50 > <1.0	0.25 > < 0.5	0.10 > < 0.25	0.10 mm <
	%	%	%	%	%	%
Trachilos	7.07	47.33	41.92	3.63	0.06	0.00
Trachilos	7.40	40.49	43.97	6.77	0.89	0.49
Trachilos	7.56	39.72	40.28	10.19	1.23	1.03
Trachilos	4.48	28.79	43.06	22.19	1.25	0.23
Trachilos	3.02	27.42	60.15	8.88	0.28	0.24
Trachilos	17.48	62.76	18.59	1.16	0.00	0.00
Trachilos	0.18	13.66	70.71	15.19	0.23	0.02
Trachilos	0.62	37.17	59.09	3.04	0.08	0.00
Trachilos	0.04	20.15	67.19	12.35	0.23	0.03
Trachilos	3.71	77.78	18.27	0.25	0.00	0.00
Trachilos	1.77	35.66	57.00	4.68	0.65	0.24
Trachilos	0.06	21.90	75.88	2.11	0.05	0.00
Vai_palm beach	9.18	10.62	32.48	39.39	8.09	0.24
Vai_palm beach	4.95	2.21	5.35	61.25	26.13	0.13
Itanos	13.00	45.00	31.38	9.84	0.75	0.04
Itanos	7.67	31.13	39.83	20.63	0.72	0.02
Itanos	51.28	32.27	12.45	3.76	0.22	0.01
Itanos	12.10	55.79	15.48	14.78	1.75	0.09
Itanos	1.81	25.93	20.51	45.60	6.13	0.03
Itanos	1.83	51.18	22.30	20.00	4.58	0.12
Itanos	2.32	25.97	32.96	35.14	3.57	0.04
Itanos	2.30	19.57	26.06	42.88	9.15	0.04
Itanos	0.62	55.02	15.59	25.19	3.55	0.03
Itanos	4.65	13.48	13.58	59.45	8.80	0.05
Vai	6.85	64.48	22.41	5.66	0.56	0.04
Vai	3.01	52.37	33.83	9.87	0.86	0.06
Vai	39.99	57.65	2.26	0.10	0.00	0.00
Vai	2.56	36.59	26.40	32.95	1.47	0.02
Vai	10.09	77.55	12.35	0.01	0.00	0.00
Vai	4.77	53.81	28.46	9.35	3.62	0.00
Vai	0.84	34.28	58.94	5.65	0.29	0.00
Xerocampos	0.48	0.01	1.30	72.23	25.97	0.00
Xerocampos	0.02	0.12	1.59	67.07	31.19	0.01
Xerocampos	1.81	0.54	4.85	60.86	31.91	0.03
Xerocampos	0.06	0.05	1.28	75.25	23.29	0.08
Xerocampos	0.03	0.19	5.85	73.75	20.19	0.00
Xerocampos	0.47	1.81	12.77	68.89	16.06	0.00
Xerocampos	0.07	0.11	5.33	69.02	25.46	0.01
Xerocampos	1.83	0.29	1.48	59.28	37.11	0.01

Appendix B. Detail results of statistical analysis

Appendix B-1. Independent t-test of sand characteristics

a. Independent sample t-test of pH, conductivity, NaCl content, and three major grain size for this study

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
pH	Equal variances assumed	.362	.551	-.868	37	.391	-.04630	.05332	-.15434	.06174
	Equal variances not assumed			-.780	16.869	.446	-.04630	.05937	-.17163	.07904
Conductivity	Equal variances assumed	.000	.993	-.742	37	.463	-102.43611	137.97285	-381.99565	177.12343
	Equal variances not assumed			-.769	23.064	.450	-102.43611	133.15569	-377.84723	172.97500
NaCl	Equal variances assumed	.688	.412	-.922	37	.363	-93.12037	101.02756	-297.82165	111.58091
	Equal variances not assumed			-1.094	32.281	.282	-93.12037	85.12801	-266.46128	80.22054
1.00 > < 2.0	Equal variances assumed	3.869	.057	1.262	37	.215	10.03139	7.94751	-6.07179	26.13457
	Equal variances not assumed			1.416	28.180	.168	10.03139	7.08490	-4.47718	24.53995
0.50 > <1.0	Equal variances assumed	1.423	.241	5.757	37	.000	31.63620	5.49496	20.50236	42.77005
	Equal variances not assumed			5.201	17.059	.000	31.63620	6.08254	18.80655	44.46586
0.25 > < 0.5	Equal variances assumed	29.409	.000	-3.696	37	.001	-29.05037	7.85986	-44.97597	-13.12477
	Equal variances not assumed			-5.308	32.139	.000	-29.05037	5.47343	-40.19749	-17.90325

b. Independent sample t-test of pH, conductivity, NaCl content, and three major grain size for combined data.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pH	Equal variances assumed	.463	.498	-1.582	82	.117	-.09892	.06252	-.22328	.02545
	Equal variances not assumed			-1.639	45.819	.108	-.09892	.06034	-.22038	.02255
Conductivity	Equal variances assumed	6.338	.014	1.331	82	.187	133.07917	100.01739	-65.88729	332.04562
	Equal variances not assumed			1.140	32.172	.263	133.07917	116.76595	-104.71542	370.87376
NaCl	Equal variances assumed	.074	.786	.170	82	.865	9.46667	55.67649	-101.29161	120.22494
	Equal variances not assumed			.187	52.560	.853	9.46667	50.66901	-92.18237	111.11570
1.00 > < 2.0	Equal variances assumed	.130	.719	1.586	82	.117	7.50675	4.73213	-1.90696	16.92046
	Equal variances not assumed			1.596	42.962	.118	7.50675	4.70439	-1.98079	16.99429
0.50 > <1.0	Equal variances assumed	7.709	.007	4.099	82	.000	16.10342	3.92826	8.28885	23.91798
	Equal variances not assumed			3.484	31.796	.001	16.10342	4.62243	6.68547	25.52137
0.25 > < 0.5	Equal variances assumed	4.940	.029	-4.297	82	.000	-20.68083	4.81280	-30.25502	-11.10665
	Equal variances not assumed			-4.900	57.581	.000	-20.68083	4.22070	-29.13080	-12.23087

Appendix B-2. Independent t-test of number of nests with presence and absence of seagrass

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Number of Nests	Equal variances assumed	10.851	.006	-1.738	13	.106	-76.000	43.720	-170.451	18.451
	Equal variances not assumed			-1.205	4.094	.293	-76.000	63.082	-249.563	97.563

Appendix B-3. Chi-square t-test of beach sand characteristics

A. This study

a. Chi-square test of sand grain size

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.000[a]	38	.425
Likelihood Ratio	50.920	38	.078
Linear-by-Linear Association	6.541	1	.011
N of Valid Cases	39		

a. 78 cells (100.0%) have expected count less than 5. The minimum expected count is .36.

b. Chi-square test of sand grain shape

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.648[a]	2	.022
Likelihood Ratio	10.624	2	.005
Linear-by-Linear Association	7.283[c]	1	.007
N of Valid Cases	39		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is .31.
b. Cannot be computed because unable to open temporary file.
c. The standardized statistic is 2.699.

c. Chi-square test of sand grain cleanliness

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.526a	2	.009
Likelihood Ratio	10.038	2	.007
Linear-by-Linear Association	8.996c	1	.003
N of Valid Cases	39		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.54.
b. Cannot be computed because unable to open temporary file.
c. The standardized statistic is -2.999.

B. Combined study

a. Chi-square test of sand size 0.25 > <0.5 mm

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	84.000[a]	83	.449
Likelihood Ratio	114.104	83	.013
Linear-by-Linear Association	8.667	1	.003
N of Valid Cases	84		

a. 168 cells (100.0%) have expected count less than 5. The minimum expected count is .42.

b. Chi-square test of sand grain shape

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.954[a]	2	.011
Likelihood Ratio	9.927	2	.007
Linear-by-Linear Association	7.997	1	.005
N of Valid Cases	84		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.71.

c. Chi-square test of sand grain cleanliness

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.875[a]	2	.144
Likelihood Ratio	3.596	2	.166
Linear-by-Linear Association	3.458	1	.063
N of Valid Cases	84		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.00.

Appendix B-4. Wilcoxon Signed Ranks Test

a. Wilcoxon signed ranks test of the relationship between seagrass and number of emergences.

Ranks

		N	Mean Rank	Sum of Ranks
Number of emergences – Seagrass status	Negative Ranks	0[a]	.00	.00
	Positive Ranks	6[b]	3.50	21.00
	Ties	7[c]		
	Total	13		

a. Number of emergences < Sea_grass_status
b. Number of emergences > Sea_grass_status
c. Number of emergences = Sea_grass_status

Test Statistics[b]

	Number of emergences – Seagrass status
Z	-2.201a
Asymp. Sig. (2-tailed)	.028
Exact Sig. (2-tailed)	.031
Exact Sig. (1-tailed)	.016
Point Probability	.016

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

b. Wilcoxon signed ranks test of the relationship between presence of seagrass and number of nests.

Ranks

		N	Mean Rank	Sum of Ranks
Number of nests – Seagrass status	Negative Ranks	0[a]	.00	.00
	Positive Ranks	6[b]	3.50	21.00
	Ties	7[c]		
	Total	13		

a. Number_nests < Sea_grass_status
b. Number_nests > Sea_grass_status
c. Number_nests = Sea_grass_status

Test Statistics[b]

	Number of nests – Seagrass status
Z	-2.201a
Asymp. Sig. (2-tailed)	.028
Exact Sig. (2-tailed)	.031
Exact Sig. (1-tailed)	.016
Point Probability	.016

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Appendix C. Pictures of Nesting beach in Xerochampos