Revista de Gestão Costeira Integrada - Journal of Integrated Coastal Zone Management
E-ISSN: 1646-8872
fpinto@fe.up.pt
Associação Portuguesa dos Recursos Hídricos

Souza Vieira, Laysa Raisa; Castro Manso, Cynthia Lara
Textural and compositional variations in beach sands along south Alagoas coast, Brazil
Revista de Gestão Costeira Integrada - Journal of Integrated Coastal Zone Management, vol. 17, núm. 2, diciembre, 2017, pp. 139-149
Associação Portuguesa dos Recursos Hídricos
Lisboa, Portugal

Journal of Integrated Coastal Zone Management / Revista da Gestão Costeira Integrada 17(2):139-149 (2017)
http://www.aprh.pt/rgci/pdf/rgci-n99_Vieira.pdf | DOI:10.5894/rgci-n99

GESTÃO COSTEIRA INTEGRADA
Journal of Integrated Coastal Zone Management

Textural and compositional variations in beach sands along south Alagoas coast, Brazil

Variação textural e composicional em areias de praias do litoral sul de Alagoas, Brasil

Laysa Raisa Souza Vieira[1], Cynthia Lara Castro Manso[1]

[1] *Programa de Pós-Graduação em Geociências e Análise de Bacias - Universidade Federal de Sergipe; Email: laysavieira.geo@gmail.com, cynthialaramanso@gmail.com*

ABSTRACT: Coastal and shallow marine sediments are usually of heterogeneous nature, composed of variable mixtures of siliciclastic and bioclastic particles. The comprehension of sedimentation dynamics in these environments is rendered problematic by their variable compositional and physical properties. Surface samples collected in the beach face from eighteen stations in southern Alagoas were analyzed. Grain size parameters were determined through the SYSGRAN package and 300 grains were identified for each grain size class coarser than 0.125 mm. Grain size distribution ranged from very fine sand to medium sand with dominance of the former, mostly classified as moderately sorted. Beach sediments are essentially siliciclastic and quartz is the major component. Pontal do Peba beach concentrates the highest content of bioclastic grains and northwards from it bioclastic grains content gradually diminishes. The main bioclastic grains are mollusc shells, red algae, and Halimeda fragments. Echinoderm spines and fragments, bryozoans and foraminifera tests also contribute significantly to beach deposit. Grain size and sorting patterns shows a correspondence with coastal plain width and the proximity of carbonate grains source. The sediment distribution pattern suggests that in addition to the grains originated from the hinterland, the continental shelf constitutes an important sediment source for the beaches.

Keywords: Beach sands, Sediment composition, Bioclastic grains.

ASSOCIAÇÃO PORTUGUESA DOS RECURSOS HÍDRICOS · UNIVALI · CIMA · UFRN · U.PORTO FEUP · IMPRENSA DA UNIVERSIDADE DE COIMBRA

** Submission: 09 MAR 2017; Peer review: 07 JUN 2017; Revised: 27 JAN 2018; Accepted: 28 JAN 2018; Available on-line: 11 ABR 2018*

RESUMO: Os sedimentos costeiros e marinhos rasos são geralmente de natureza heterogênea, compostos por misturas variáveis de partículas siliciclásticas e bioclásticas. A diversidade composicional torna complexa a compreensão da dinâmica de sedimentação nesses ambientes. Amostras superficiais coletadas na face de praia de dezoito estações do sul de Alagoas foram analisadas. Os parâmetros granulométricos do sedimento foram determinados por meio do Sistema de Análises Granulométricas (SYSGRAN) e 300 grãos de cada fração acima de 0.125mm foram identificados. A granulometria dos sedimentos variou de areia muito fina a areia média, com predomínio de areias muito finas, e são em sua maioria moderadamente selecionadas. As praias do sul de Alagoas são essencialmente siliciclásticas e o quartzo constitui o componente principal. A praia do Pontal do Peba concentra o maior conteúdo de grãos bioclásticos e a norte desta a proporção de bioclastos gradualmente diminui. Os principais componentes biogênicos são as conchas de moluscos e fragmentos de algas vermelhas e Halimeda. A granulometria e grau de seleção dos sedimentos mostram correlação com a variação da largura da planície costeira e com a proximidade de fontes de grãos carbonáticos. O padrão de distribuição do sedimento sugere que, além dos grãos oriundos do interior do continente, a plataforma continental constitui uma importante fonte de sedimentos para as praias.

Palavras-chave: Areia de praia, Composição do sedimento, Grãos bioclásticos.

1. INTRODUCTION

Ocean sandy beaches are among the most popular and attractive recreational venues for humans and underpin many coastal economies around the world (Davenport & Davenport, 2006). Beaches encompass a wide and unique range of ecosystem services to humankind (e.g. water filtration, provision of habitat and coastal protection), yet they are facing rapid degradation by both natural and anthropogenic pressures (Amaral *et al.*, 2000; Defeo *et al.*, 2009; Schlacher *et al.*, 2007).

Sandy shores are dynamic harsh environments, with interactions that makes them especially vulnerable to environmental changes (Brown & McLachlan, 2002; Perez *et al.*, 2009; MMA, 2010) and with biological communities that are primarily controlled by physical factors, such as wave energy, grain size, tidal regime and beach slope (Brazeiro, 1999; McLachlan & Dorvlo, 2005; Barboza & Defeo, 2015; Carcedo *et al.*, 2015). Textural character of beach sands may also influence nest site selection of sea turtles (Mortimer, 1990).

Composition and texture of beach sediments are largely dependent on the source material and the coastal processes (mainly waves, tides and currents) that modify the sediments over long periods of time (Bird, 2008; Stanica & Ungureanu, 2010). Several authors have stated the direct relationship of beach morphology as a result of hydrodynamic action and the type of sediment available (Wright *et al.*, 1979; Wright *et al.*, 1985; Calliari *et al.*, 2003; Tessler & Goya, 2005; Schlacher *et al.*, 2008; Reis & Gama, 2010; Scott *et al.*, 2011).

Coastal and shallow marine sediments are usually of heterogeneous nature, with variable mixtures of siliciclastic and bioclastic particles (Komar, 1998; Flemming, 2016). The behavior of calcareous bioclastic material subject to the hydraulic forces differs from that of siliciclastic material due to the great variety of shapes and densities of calcareous grains (Pilkey *et al.*, 1967; Prager *et al.*, 1996). Therefore, an adequate interpretation of hydrodynamic processes in mixed sand beaches is generally problematic (Pilkey *et al.*, 1967; Albino & Suguio, 2011).

The biogenic components of the sediment have been used in many studies, with different objectives such as: as natural tracers of sediment dispersion pathways (Gao & Collins, 1995; Benavente *et al.*, 2005), biological indicators of physical and ecological dynamics in modern and ancient environments (Kidwell, 2007). Rowland *et al.* (2000) and Fernandez-Fernandez *et al.* (2014) have also shown that mixed carbonate-siliciclastic sands favor oil degradation and thus can be used to complement bioremediation techniques during oil clean-up operations.

Despite of holding the Ecological Station of Pontal do Peba and being least urbanized stretch of the state, the southern coast of Alagoas holds some urban villages developing disorderly and suffer of local problems related with coastal erosion (Araújo *et al.*, 2006), overfishing (Correia & Sovierzoski, 2008), disposal of sewage and solid waste and occasional spills of oil from fishing boats (Lima *et al.*, 2003).

The southern coast of Alagoas is a region of high ecological relevance, with an urbanization process that is still recent and lacking scientific works on a detailed scale. The physical characterization of the environment is one of the primordial stages for the foundation of applied works and in the decision-making process for an effective coastal management, either for preservation or recovery. The present contribution describes the spatial variation of grain size trends and composition of beach sands along a coastline stretch of southern Alagoas State in Brazil, also discriminating the nature of the bioclastic grains.

2. STUDY AREA

The study area comprises the sandy beaches located between Pontal do Peba and Pontal do Coruripe, consisting in a coastal stretch with about 36 km of extension in the southeast of the state of Alagoas (Figure 1). The quaternary coastal plain of Alagoas is characterized by incipient development, with wider extension southwards, next to São Francisco river estuary. Northwards, the coastal plain is generally narrower or even non-existent and the beaches are limited by the sea cliffs of the Cenozoic Barreiras Formation or the Mesozoic formations of the sub-basin of Alagoas (Muehe, 1998; Araújo *et al.*, 2006).

The area is characterized by an As-climate in the sense of Koppen's classification, which means a tropical climate with precipitation in winter (Alvares *et al.*, 2013). The study area has a semidiurnal micro-meso-tidal regime, with a maximum range of 2.38 m (Dominguez *et al.*, 2016). Because of the constancy of the trade winds and the geographic location of the east coast of Brazil lying entirely within the trade wind belt, waves generated by SE-trade type winds strongly influence the coastal processes in this section of Brazilian coast (Dominguez *et al.*, 1992; Cavalcanti *et al.*, 1966; Barros *et al.*, 2012).

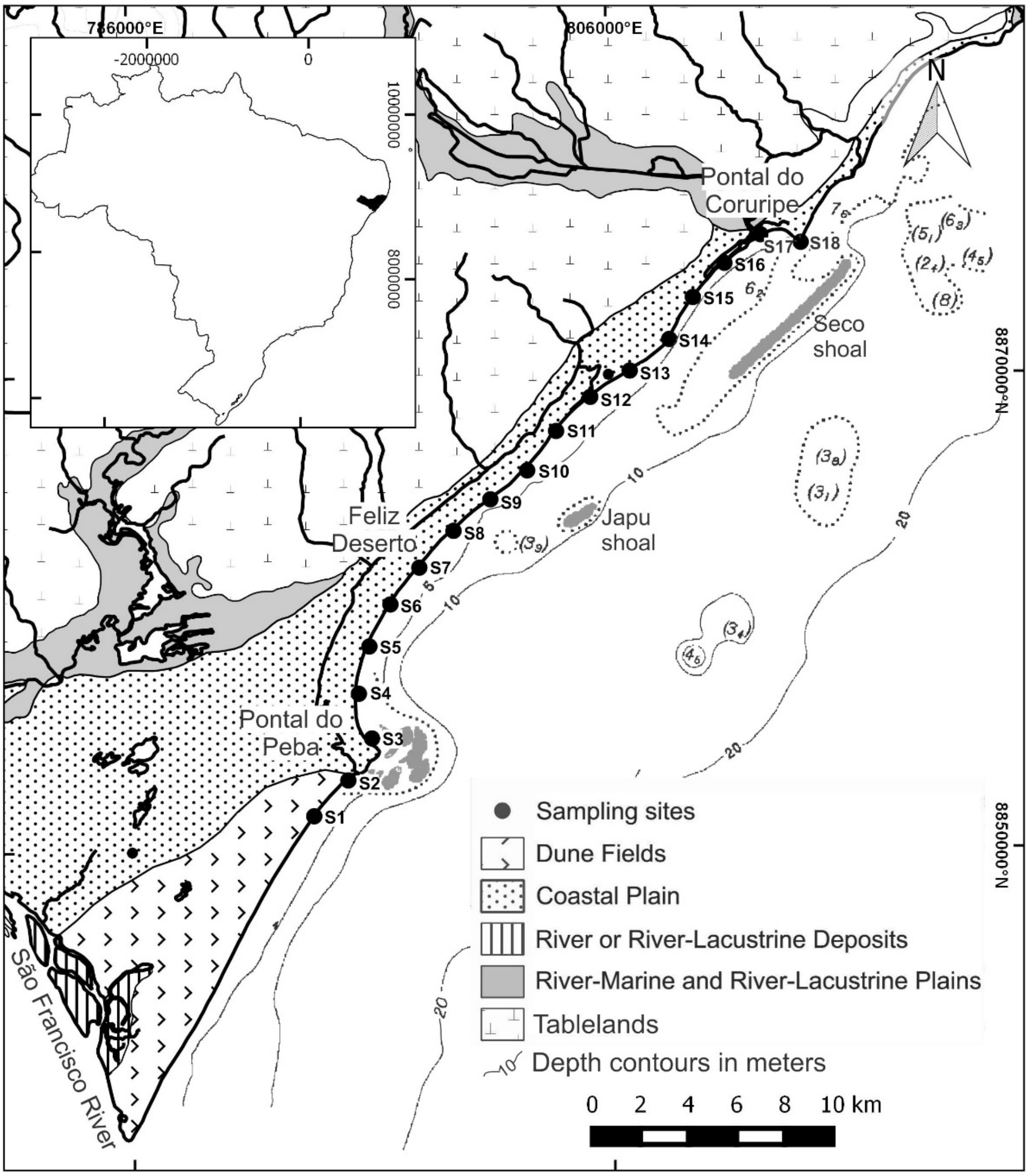

Figure 1 - Geological setting of the southern Alagoas coastal zone with depth contours extracted from nautical chart number 22300 of DHN (2016).

According to Pianca *et al.* (2010), E/SE waves, mainly generated by trade winds, are dominant in the area, though during the fall and winter, waves from the S are also noticeably present, showing that cold fronts can affect the wave climate of this area too. The modal height-period combination (period and height of major incidence) is for waves with height ranging from 1.0 to 2.0 m and periods of 6 to 8 s. The frequency tables of wave parameters are available at the Oceanographic Institute of the University of São Paulo (IO/USP) Coastal Dynamics Lab. website (http://ldc.io.usp.br/waves).

The preferential direction of the longshore drift transport depends on the approaching angle of the wave front relative to initial shoreline orientation and the wave high. Based on numerical modeling made on wave refraction diagrams along the northeast Brazilian coastline, Bittencourt *et al.* (2002, 2005) presented a schematic picture of the sediment dispersal patterns along the coast. Two large coastal segments were identified, starting at a nodal divergence point in the direction of longshore drift located at Japaratinga, near the border between the States of Alagoas and Pernambuco. These two segments present opposite drift directions with a longshore drift directed to the north above the nodal point and to the south below the nodal point (Bittencourt *et al.*, 2005).

Dominguez *et al.* (2016) however, state that north of the São Francisco river mouth there is an effective longshore transport tendency to northeast. Guimarães & Dominguez (2005) observed that north of the Pontal do Peba the coastline retreat is larger than in southwest, this point acts as an obstacle to longshore drift, inducing erosion downdrift of the obstacle which indicates that the longshore drift has a direction from SW-NE. Alagoas' coastline shows a reduced delivery of fluvial sediments which makes it highly vulnerable to erosion (Dominguez & Bittencourt, 1996; Araújo *et al.*, 2006; Muehe, 2010).

The Brazilian tropical northeast continental shelf is narrow and exhibits a shallow depth. With low rates of terrigenous sedimentation, Alagoas shelf is a huge reef environment where *Halimeda* dominates the most sheltered places and *Lithothamnium* covers the flat surfaces of the reefs (Coutinho, 1981). Carannante *et al.*, (1988) proposed a zonation of the Brazilian continental shelf based on the distribution of the biogenic associations present in the carbonate facies. Alagoas continental shelf is inserted in the Tropical Zone A, where calcareous green algae (*Halimeda*) and branching coralline algae predominate followed by *Amphistegina* (a benthic foraminifer). According to Figueiredo *et al.*, (2011) even in the inner shelf, although wave energy may hinder the organic growth, there are carbonate spots ranging from the coast to the outer shelf where tablelands of the Barreiras Formation are present.

Beach sandstones arranged parallel to the coast, at about 3 km, between Pontal do Coruripe and Miaí, as well as reefs around 4 km from the coast in front of the Pontal do Coruripe are registered in the area (Correia & Sovierzoski, 2005). In Pontal do Peba an emerged reef bank occurs, bordering the beach, giving rise to a small promontory covered by an algal crust and a tidal creek with mangrove development (Barbosa *et al.*, 2003). Southwards of this reef, the shoreline is bordered by the active coastal dune field of Piaçabuçu (Barbosa & Dominguez, 2004).

3. MATERIALS AND METHODS

Surface samples were collected from eighteen stations, numbered from south to north, distributed along 36 km of coastline in southern Alagoas in October 2015. Samples with approximately 200 g of sand were collected from the uppermost centimeter of the beachface at 2 km intervals during the spring tide and at the lower tide level. One extra sample was collected in Pontal do Peba for a better insight (Station 2B, Figure 5). Samples were repeatedly washed with distilled water in order to remove soluble salts, oven-dried at 60 ºC and submitted to dry sieving in 1Φ (phi) intervals according to the methodological procedures described by Briggs (1977). The calculation of textural grain-size parameters followed the percentile statistical method proposed by Folk & Ward (1957) using the SYSGRAN software package (Camargo, 2006).

Compositional analysis was carried out only on grain size fractions above fine sand (0.125 mm). The identification and frequency of each constituent was determined through the observation of 300 random grains from each fraction under a binocular microscope. Some grain size fractions have not contained 300 grains and in this case all available grains were identified. The relative frequency of sediment grains was determined taking into account the weight of each grain size fraction. Siliciclastic constituents were grouped as quartz, mica, rock fragments and other minerals.

The identification criteria of biogenic fragments are those described in Tinoco (1989). Some grains did not exhibit enough attributes for the identification and were then counted on a separated group named "Unidentified" while those present in insignificant numbers in the samples were grouped as "Others". Distribution charts were elaborated for bioclast groups that accounted for at least 2% of the total bioclastic grains content in each sample. Additionally, small samples from Pontal do Peba reef bank and Pontal do Coruripe beachrock were collected for comparison of their community composition with the nature of the bioclastic content observed in the adjacent beaches.

4. RESULTS

The grain size distribution (Figure 2) shows the dominance of very fine sands and the mean size values ranged from 1.35 Φ to 3.48 Φ (very fine sand to medium sand). In what concerns standard deviation, samples emerge as very well sorted (< 0.35 Φ) to poorly sorted (1.0 Φ - 2.0 Φ), most of them classified as moderately sorted (0.5 Φ -1.0 Φ), Figure 2.

More than seventeen thousand grains were counted in this work for the compositional analysis. Beach sediments show an overall predominance of siliciclastic grains (77% on total), mainly quartz, which makes up almost the totality of these grains (98%). Regarding the nature of the bioclastic grains, we have distinguished the main taxonomic groups (Figures 3 and 4). The most frequent bioclastic components are molluscs shells (mainly bivalve and gastropod shells), *Halimeda*, coralline algae and echinoderm shell fragments and echinoderm spines.

Molluscs, coralline algae and *Halimeda*, bryozoans and vermetid tubes are abundant in Pontal do Peba reef bank

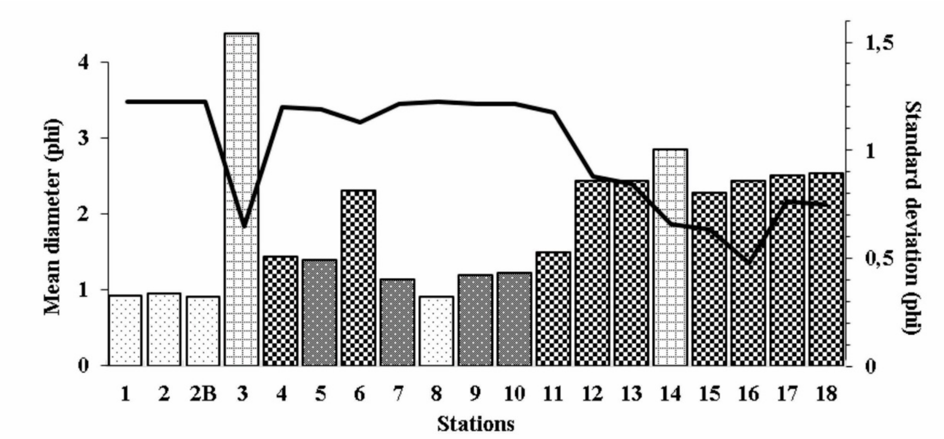

Figure 2 - Statistics of the samples: mean diameter (black line) and standard deviation in phi (Φ) units.

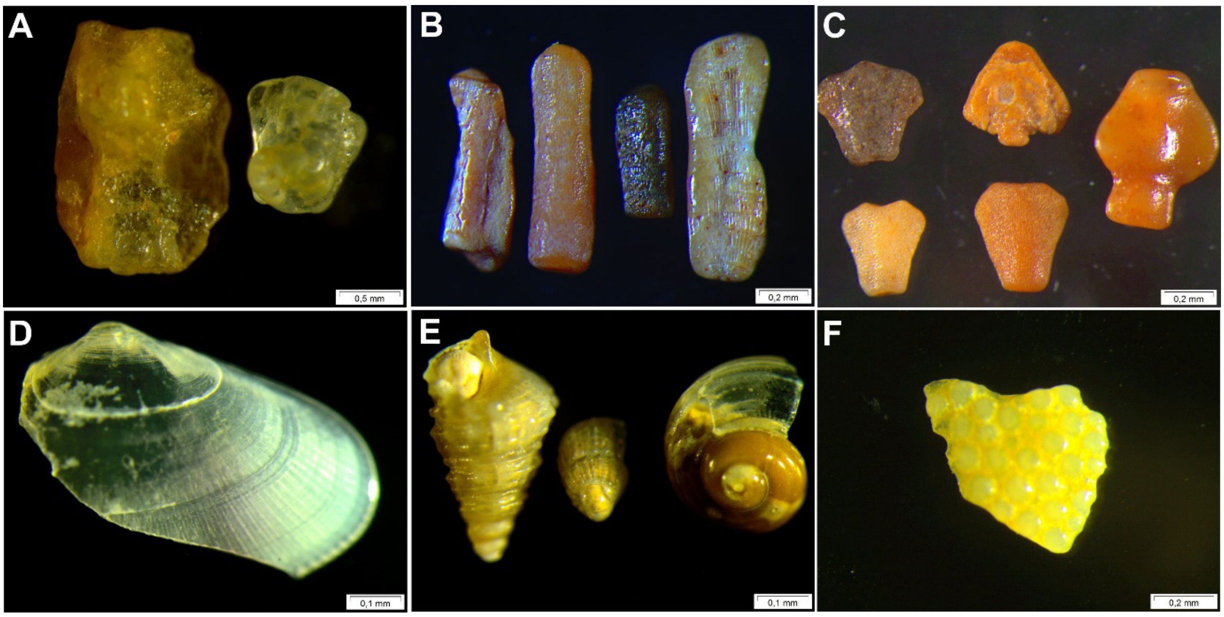

Figure 3 - Main components identified in samples of the study area. (A) Quartz; (B) Coralline algae; (C) Halimeda; (D) Bivalve shell fragment; (E) Gastropod; (F) Echinoderm fragment.

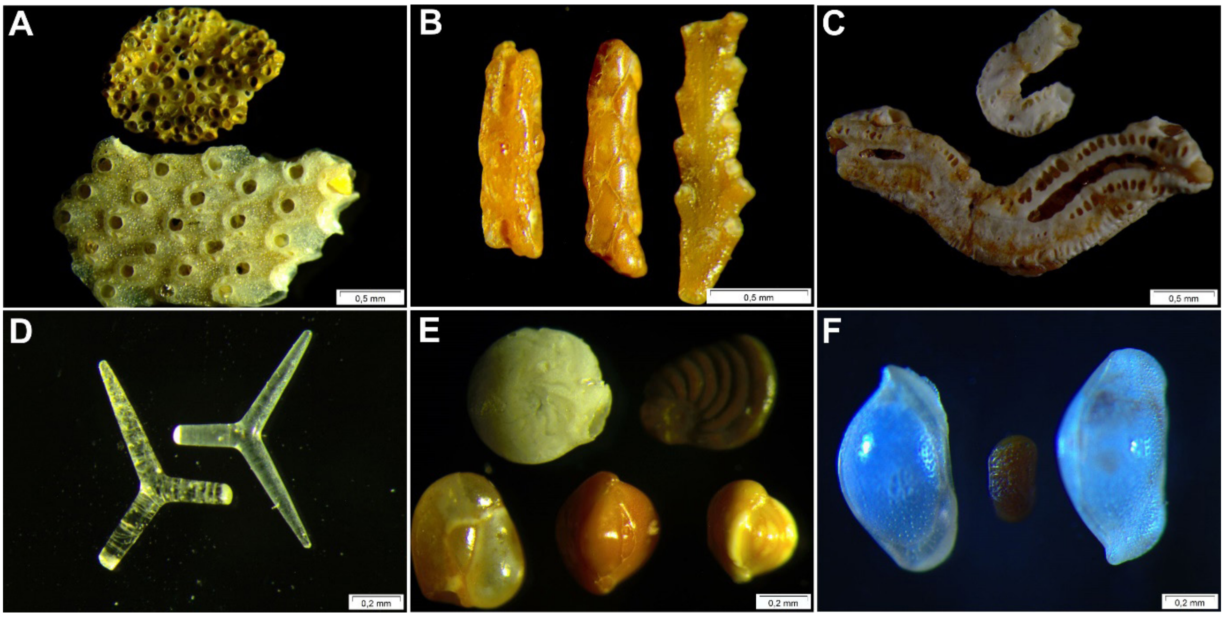

Figure 4 - Other components identified in samples of the study area.
(A) and (B) Bryozoans; (C) Worm tubes; (D) Porifera spicules; (E) Foraminifera; (F) Ostracoda.

while Pontal do Coruripe beachrock shows molluscs, foraminifers, bryozoans, echinoderms and barnacles as main components. In the light of the content of bioclastic grains in the samples, that ranged from 2.5% to 42%, four coastline sectors were distinguished. The distinct concentrations and associations of bioclastic components as well as textural properties of the sediments in each of these sectors are described below.

4.1 Sector I

This sector encompasses beach sands close to the Piaçabuçu coastal dune field and in the south portion of the Pontal do Peba (Stations 1, 2 and 2B). Siliciclastic grains compose herein, in average, 95% of the grains counted with quartz representing 92% of them. The mean grain size is very fine sand and the sediments are very well sorted. Biogenic grains are almost inexpressive, with most of their diagnostic features obliterated and represented basically by a few identifiable mollusc shells, foraminifers and coralline algae (Figure 5). Station 2 has about 25% of unidentified grains due to the lack of diagnostic features. The amount of mica (3.2%) and rock fragments (2.6%) found in Station 2 stands out when compared to the other sectors that added up to 1.1%.

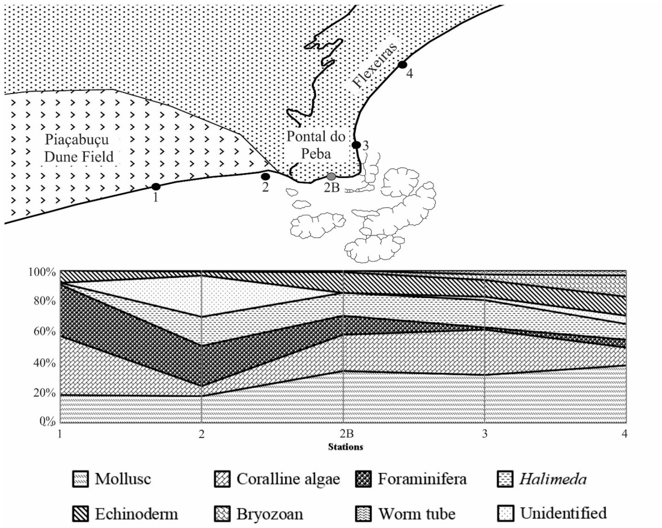

Figure 5 - Distribution of bioclastic grains in Sector I (Stations 1, 2 and 2B) and Sector II (Stations 3 and 4).

4.2 Sector II

Continuing northwards, near the border between the municipalities of Feliz Deserto and Piaçabuçu, the highest bioclastic grain contents of the studied area were found. The sector encompasses merely two samples in Pontal do Peba and Flexeiras beaches (Stations 3 and 4) distinguished from the others by the content of bioclastic grains around 35%. The medium and poorly sorted sands of Station 3, near Pontal do Peba reef bank, have the highest bioclastic grains content (utmost at 42%) of the whole area and a strongly bimodal grain size distribution in response to an addition of coarser sands.

On the other hand, Fleixeiras beach encompasses very fine and moderately sorted sands with 37% of the grains of biogenic nature.

Regarding the bioclasts, mollusc shells are the main bliocastic grains in both stations. In Peba beach (Station 3), molluscs predominate followed by coralline algae and *Halimeda* (Figure 5) while in Flexeiras (Station 4), molluscs predominate followed by bryozoans, echinoderms and coralline algae.

4.3 Sector III

This sector was delimited by the ranges of 10 to 30% of bioclastic grains, although one sample (Station 7) has concentrated only 6% of bioclasts, and comprises solely samples granulometrically classified as very fine sands. Except for the stations 6 and 11 that are moderately sorted, all the others are well or very well sorted. Encompasses Miaí de Baixo, Japu and Toco beaches and in spite of the decrease of bioclastic grains proportion, this area shows a significant diversity of these grains and all taxonomic groups identified in the whole area were found in this stretch.

Molluscs, echinoderm fragments, bryozoans and *Halimeda* predominate followed by foraminifers and coralline algae. Southern samples tend to show more expressive contributions of molluscs and *Halimeda* fragments (Figure 6). Some centimeter aggregations of unattached, non-geniculate coralline algae (rhodolith) attached to foliose algae were found in Japu beach, near Station 10.

4.4 Sector IV

This sector encompasses the Pontal do Coruripe beach, samples on both sides of the Coruripe river mouth as well as Barreiras and Miaí de Cima beaches. Essentially siliciclastic (91 to 98% of the total sample), this sector is composed by fine sands in the outermost samples (Stations 12, 13, 17 and 18) and by medium sands in its inner portion (Stations 14, 15 and 16). There is a coarsening trend of beach sands to the north until the Coruripe river mouth (Figure 2).

Grain size distribution shows a remarkable tendency of mixed grain size populations with an increment of medium and coarse siliciclastic grains, mostly on the central area of the sector. The majority of the samples show uniformity in grain sorting, classified as moderately sorted with only one sample poorly sorted.

Bioclasts content continues the trend of northwards decrease and the dominant overall bioclastic grains are coralline algae, *Halimeda* and foraminifers (Figure 7). Molluscs, bryozoans and spines and fragments of echinoderms are also significantly present. *Halimeda* tends to be more expressive in the southern samples of the sector while bryozoans are more expressive in Pontal do Coruripe beach.

5. DISCUSSION AND CONCLUSION

The overall scenario of the study area exhibits the predominance of siliciclastic grains in all the samples, essentially quartz grains. For the southern sector is noteworthy the tendency of most fluvial sediments from the São Francisco river being transported to the southwest while north of the river mouth beaches are primarily nourished by the wave generated longshore drift (Dominguez *et al.*, 2016; Bittencourt *et al.*, 2007).

In fact, the very fine and very well sorted beach sands of Sector I corroborate the reduced extent to the north of the area nourished with medium sands from the São Francisco river. Nevertheless, the amount of mica and rock fragments slightly higher than in the other

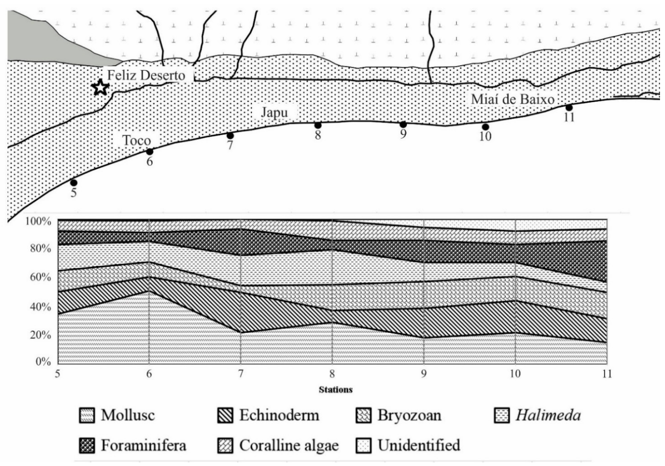

Figure. 6 - Distribution of the bioclastic grains in Sector III.

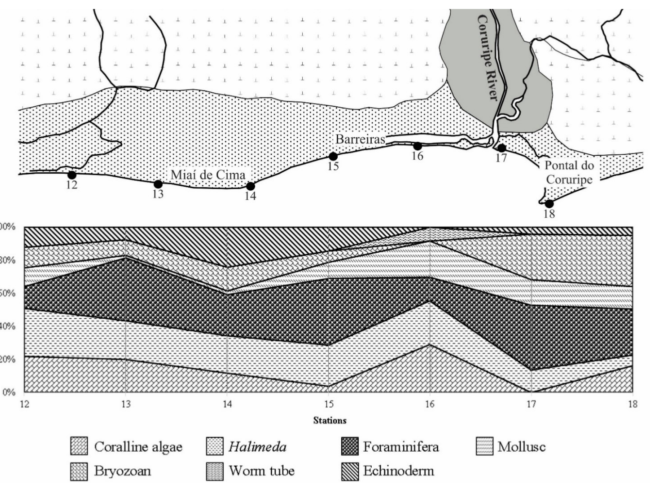

Figure. 7 - Distribution of the bioclastic grains in Sector IV.

samples suggests perhaps a contribution of recent fluvial sediments. Sector I do not share textural and compositional similarities with the samples neighboring to the north. Although this sector is located in the vicinities of the Pontal do Peba, which represents a near source of bioclastic material, this reef bank does not nourish expressively southern beaches.

Bioclastic grains give its biggest contribution to beach sands in the north vicinities of the Pontal do Peba reef bank and its proportion gradually diminishes northwards from this point. The amount of mollusk, and algae, main components of Peba reef bank, also decreases is the same direction. Although worm tubes are constant elements in this reef bank, they are sparsely found in beach sands in the study area. Lisco *et al.* (2017) describes sabellariid worm reefs at southern Italy coast and demonstrated that degradation phases seem to be related only to the action of storm waves, when broken fragments were recognized at surrounding beaches. However, the lack of taxonomic identification papers on the bio-constructing species of the Peba reef and reef structure makes it difficult to evaluate the explanation for the scarcity of worm tubes as bioclastic grains.

The great compositional discrepancy between samples immediately south and north from Peba reef bank evidences not only its contribution as a source of bioclastic grains but also corroborates the effective northeast longshore transport. In what concerns grain size distribution, the addition of coarser elements from Peba reef seems to have a very local influence since immediately north of Peba beaches are composed of very fine sands. Chave (1960) noted that abrasion of coarse calcareous skeletal materials produced large quantities of fines with a general lack of intermediate sized abrasion products. In spite of the decrease in the content of bioclasts in Miaí de Baixo, Japu and Toco beaches (Sector III) relatively to Sector II, they show a great diversity of bioclastic grains.

In Brazil, foliose algae (*Sargassum* spp. and others) are commonly found attached to rhodoliths and can act as a sail under the action of currents. In times of higher currents intensity these algae can be transported to the beaches, producing the so-called phenomenon of “arribada”, very common on the beaches adjacent to the banks of algae (Dias, 2000).

Rhodoliths found in Japu beach indicates an episodic local increase in wave energy, perhaps associated with the influence of the Baixo do Japu shoal (Figure 1) on wave refraction behavior. A number of studies have examined this interaction of waves across reef surfaces and demonstrated that they can induce the formation of distinctive wave convergence zones (Lee & Black, 1978; Young, 1989; Gourlay, 1994; Brander *et al.*, 2004; Kench *et al.*, 2009; Mandlier & Kench, 2012) and the transmission of this energy is greatest at higher water stages (Kench *et al.*, 2009).

Bioclastic grains in Miaí de Cima, Barreiras and Pontal do Coruripe beaches (Sector IV) are very sparse, maintaining the tendency of decreasing northwards. The riverborne sediments delivered by the Coruripe River may also contribute to the dilution of the bioclastic components. Differently from Sector II, where coarser grains are related to the carbonate fraction, in Sector IV the coarser sediment is essentially siliciclastic. The shallow beachrock (beach sandstone) present near the coast does not seem to act as an influent source of biogenic grains but potentially affect the wave regime in these beaches through wave refraction.

Although the evaluation of the coastal erosion is not the scope of this paper, during field data collection it was observed that besides being a narrow width and steeper beach, with coarser sands than the surrounding beaches, Barreiras beach also exhibits tree stumps exposed. These features added up to the proximity of a river mouth (Coruripe River), are considered by Bush *et al.* (1999) as potential geoindicators of coastal-hazard risk. Steep beaches allow wave energy to be absorbed over a relatively narrow zone, with both the swash and backwash velocities higher than for gently sloping beaches and they are, therefore, more mobile than flat beaches (King, 1972; Davidson-Arnott, 2010).

There is a preference, in the analyzed littoral, for fine and very fine sand and most sands are concentrated in the range of moderately sorted to very well sorted. In general, the sands from the wider coastal plains have, in average, finer grain sizes and are better sorted, because the detritus have longer periods of abrasion, whereas the narrower coastal plains have a tendency for coarser and worse sorted beach sands (Edwards, 2001) and this tendency was also observed in the study area.

Foraminifer’s tests are constant in most of the samples and are the predominant bioclastic grains in Barreiras and Miaí de Cima. The wall structure of most benthonic foraminifers is compact and relatively resistant to breakage, so skeletons are commonly preserved (Scoffin, 1986) therefore this constancy may be related not only to an offshore source of these foraminifer’s tests but also to their resistance that permits its permanence in the beach deposit.

The major bioclastic grain types are mollusk shells and fragments of coralline algae and *Halimeda*. Molluscs are one of the largest and most diverse groups in the animal kingdom, in general widespread and often abundant in marine environments (Gosling, 2003), and are indeed the most abundant biogenic constituent of beach sands. Coralline algae and *Halimeda* were indicated by Carannante *et al.* (1988) as main constituents of the continental shelf carbonate facies in the area.

This sedimentological approach on beach sands texture and composition proved to be a useful, simple and inexpensive tool in evaluating longshore drift trends in a local context. Monitoring the contribution of bioclastic components to beach sands can also act as an index of communities' health, since the natural bioclastic supply to the beach depends on the health state of these environments (Moretti *et al.*, 2016).

The sediment distribution pattern shows that besides the siliciclastic grains originated from the hinterland, the Pontal do Peba shallow reef clearly constitutes an important sediment source of bioclastic grains for the beaches. Likewise the works of Ginsburg & Lowenstam (1958), Tinoco (1989), Rebouças *et al.* (2011), Moraes (2001), Santos *et al.* (2011), Machado & Araújo (2012) among many others, in addition to siliciclastic fraction of beach sands, the distribution of the biogenic components of the sediment provided here important information about the coastal dynamics.

ACKNOWLEDGMENTS

The authors thank the postgraduate program in Geosciences and Basin Analysis (PGAB-UFS) and Paleontology laboratory (Biology Department-UFS) for institutional support and infrastructure. Laysa Vieira acknowledges the scholarship provided by CAPES (Coordination for the Improvement of Higher Education Personnel) and Prof. Ana Claudia da S. Andrade (PGAB-UFS) for the prolific discussions.

REFERENCES

Albino, J.; Suguio, K. (2011) - The influence of sediment grain size and composition on the morphodynamic state of mixed siliciclastic and bioclastic sand beaches in Espirito Santo State, Brazil. *Revista Brasileira de Geomorfologia*, 12:81-92. DOI: 10.20502/rbgv12i2.237

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M.; Sparovek, G. (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22: 711-728. DOI: 10.1127/0941-2948/2013/0507

Amaral, A.C.Z.; Morgado, E.H.; Gianuca, N.M. (2000) - *Avaliação e ações prioritárias para a conservação da biodiversidade da zona costeira e marinha: Diagnóstico sobre praias arenosas*. 56p., MMA/SBF, Brasília.

Araújo, T.C.M.; Santos, R.C.A.; Seoane, J.C.S.; Manso, V.A.V. (2006) - Erosão e Progradação do Litoral Brasileiro - Alagoas. In: Muehe D. (Org.). *Erosão e Progradação do Litoral Brasileiro*. Brasília, Ministério do Meio Ambiente, p.197-212. Available on-line at: http://www.mma.gov.br/publicacoes/gestao-territorial/category/80-gestao-costeira-g-erosao-e-progradacao [Accessed 10 Aug. 2017]

Barbosa, L.M.; Lima, C.C.U.; Santos, R.C.L.; Carvalho, J.B.; Santos, C.F.; Albuquerque, A.L. (2003) - As variações morfológicas do campo de dunas ativas entre Pontal do Peba e a foz do Rio São Francisco. *Anais do IX Congresso da Associação Brasileira de Estudos do Quaternário*, Recife, Brasil.

Barbosa, L.M.; Dominguez, J.M.L. (2004) - Coastal dune fields at the São Francisco river strandplain, northeastern Brazil: morphology and environmental controls. *Earth Surface Processes and Landforms*, 29:443–456. DOI: 10.1002/esp.1040

Barboza, F. R.; Defeo, O. (2015) Global diversity patterns in sandy beach macrofauna: a biogeographic analysis. *Scientific Reports* , 5:14515.

Barros, A.H.C.; Araújo, J.C.; Silva, A.B.; Santiago, G.A.C.F. (2012) *Climatologia do Estado de Alagoas*. 32p., Emprapa Solos, Recife. Available on-line at https://ainfo.cnptia.embrapa.br/digital/bitstream/item/103956/1/BPD-211-Climatologia-Alagoas.pdf

Benavente, J.; Gracia, F.J.; Anfuso, G.; Lopez-Aguayo, F. (2005). Temporal assessment of sediment transport from beach nourishments by using foraminifera as a natural tracer. *Coastal Engineering*, 52: 205-219.

Bird, E.C. (2008) Coastal geomorphology: an introduction. New York, John Wiley & Sons, 436 p.

Bittencourt, A.C.S.P.; Martin, L.; Dominguez, J.M.L.; Silva, I.R.; Souza, D.L.A. (2002) - A significant longshore transport divergence zone at the Northeastern Brazilian coast: implications on coastal quaternary evolution. *Anais da Academia Brasileira de Ciências*, 74:505-518.

Bittencourt, A. C. S. P.; Dominguez, J. M. L.; Martin, L.; Silva, I. R. (2005) Longshore transport on the northeastern Brazilian coast and implications to the location of large scale accumulative and erosive zones: an overview. *Marine Geology*, 219: 219-234.

Bittencourt, A.C.S.P.; Dominguez, J.M.L.; Fontes, L.C.S.; Sousa, D.L.; Silva, I.R.; Da Silva, F.R. (2007) - Wave refraction, river damming, and episodes of severe shoreline erosion: The São Francisco River mouth, northeastern Brazil. *Journal of Coastal Research*, 23(4):930–938. DOI: 10.2112/05-0600.1

Brander, R.W.; Kench, P.S.; Hart, D.E. (2004) - Spatial and temporal variations in wave characteristics across a reef platform, Warraber Island, Torres Strait, Australia. *Marine Geology*, 207:169–184. DOI: 10.1016/j.margeo.2004.03.014

Brazeiro, A. (1999) Community patterns in s andy beaches of Chile: richness, composition, distribution and abundance of species. *Revista Chilena de Historia Natural,* 72: 93-105

Briggs, D (1977): *Particle size analysis, Sources and methods in geography: Sediments*, Butterworth, 55-110.

Brown, A.C.; McLachlan, A. (2002) Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. *Environmental Conservation* 29: 62–77.

Bush, D.M.; Neal, W.J.; Young, R.S.; Pilkey, O.H. (1999) - Utilization of geoindicators for rapid assessment of coastal-hazard risk and mitigation. *Ocean and Coastal Management*, 42(8):647-670. DOI: 10.1016/S0964-5691(99)00027-7

Calliari, L.J.; Muehe, D.; Hoefel, F.G.; Toldo, J.E. (2003) - Morfodinâmica praial: uma breve revisão. *Revista Brasileira de Oceanografia*, 51: 63-78. DOI: 10.1590/S1679-87592003000100007

Camargo, M.G. (2006) - Sysgran: um sistema de código aberto para análises granulométricas de sedimentos. *Revista Brasileira de*

Geociências, 36(2):371-378. Available on-line at http://www.ppegeo.igc.usp.br/index.php/rbg/article/view/9346/ 9288

Carannante, G.; Esteban, H.; Milliman, J.D.; Simone, L. (1988) - Carbonate lithofacies as paleolatitude indicators: problems and limitations. *Sedimentary Geology*, 60:333-346. DOI: 10.1016/0037-0738(88)90128-5

Carcedo, M.C.; Fiori, S.M.; Piccolo, M.C.; López Abbate, M.C., and Bremec, C.S., 2015. Variations in macrobenthic community structure in relation to changing environmental conditions in sandy beaches of Argentina. *Estuarine, Coastal and Shelf Science*, 166ª: 56–64.

Cavalcanti, L.B.; Coelho, P.A.; Kempf, M.; Mabesoone, J.M.; Silva, O.C. (1966) - Shelf off Alagoas and Sergipe (Northeastern Brazil). I. Introduction. *Trabalhos do Instituto de Oceanografia da Universidade Federal de Pernambuco*, 7/8:137-150.

Chave, K.E. (1960) - Carbonate skeletons to limestones: problems. *Transactions of the New York Academy of Sciences*, 23:14–24.

Correia, M.D.; Sovierzoski, H.H. (2005) - Ecossistemas Marinhos: Recifes, Praias e Manguezais. *Série Conversando sobre Ciências em Alagoas*. 59p., EDUFAL, Maceió.

Correia, M.D.; Sovierzoski, H.H. (2008) - Gestão e Desenvolvimento Sustentável da Zona Costeira do Estado de Alagoas, Brasil. *Revista da Gestão Costeira Integrada*, 8(2):25-45. Available on-line at http://www.aprh.pt/rgci/pdf/rgci-146_Correia.pdf

Coutinho, P.N. (1981) - Sedimentação na Plataforma continental Alagoas-Sergipe. *Arquivos de Ciências do Mar* (ISSN: 0374-5685), 21:1-18, Fortaleza, CE, Brazil.

Davenport, J. & Davenport, J.L. (2006). The impact of tourism and personal leisure transport on coastal environments A review. Estuarine, Coastal and Shelf Science 67 280-292.

Davidson-Arnott, R.G.D., 2010. *Introduction to Coastal Processes and Geomorphology.* Cambridge University Press, Cambridge, England. 442pp.

Defeo, O.; McLachlan, A.; Schoeman, D.S; Schlacher, T.A.; Dugan, J.; Jones, A.; Lastra, M.; Scapini, F. (2009) Threats to sandy beach ecosystems: A review. *Estuarine, Coastal and Shelf Science,* 81: 1–12.

DHN. Diretoria de Hidrografia da Marinha. (2016) - *Carta da série Internacional Brasil – Costa Leste, de Maceió a Aracaju* (nº 22300). Available On-line at http://www.mar.mil.br/dhn/chm/box-cartas-raster/raster_disponiveis.html

Dias, G.T.M. (2000) - Marine bioclasts: calcareous algae. *Revista Brasileira de Geofisica*, 18(3): 307-318. DOI: 10.1590/S0102-261X2000000300008

Dominguez, J.M.L.; Bittencourt, A.C.S.P.; Santos, A.N.; Nascimento, L. (2016) The Sandy Beaches of the States of Sergipe-Alagoas. *In*: Short A.D., Klein A.H.F. (Orgs.). *Brazilian Beach Systems*. 1ed. Switzerland, Springer International Publishing, 17:281-305.

Dominguez, J.M.L.; Bittencourt, A.C.S.P.; Martin, L. (1992) - Controls on Quaternary coastal evolution of the east-northeastern coast of Brazil: roles of sea-level history, trade winds and climate. *Sedimentary Geology*, 80:213-232. DOI: 10.1016/0037-0738(92)90042-P

Dominguez, J.M.L.; Bittencourt, A.C.S.P. (1996) Regional Assessment of Long-term trends of coastal erosion in northeastern Brazil. *Anais da Academia Brasileira de Ciências*, 68:355-371. DOI 10.1590/S0001-37652002000300012

Dominguez, J.M.L.; Bittencourt, A.C.S.P.; Santos, A.N.; Nascimento, L. (2016) - The Sandy Beaches of the States of Sergipe-Alagoas. In: Short, A.D.; Klein, A.H.F. (Orgs.). *Brazilian Beach Systems*, Springer International Publishing, Switzerland, pp.281-305.

Edwards, A.C. (2001) - Grain Size and Sorting in Modern Beach Sands. *Journal of Coastal Research* (ISSN: 0749-0208), 17(1):38-52. Available on-line at http://journals.fcla.edu/jcr/article/view/81197/78345

Fernández-Fernández, S., Bernabeu, A. M., Rey, D., Mucha, A.P., Almeida, C.M.R., Bouchette, F. (2014). The effect of sand composition in the oil buried degradation. *Marine Pollution Bulletin,* 86: 391-401.

Figueiredo Jr., A.G.; Fontes, L.C.S.; Santos, L.A.; Mendonca, J.B.S. (2011) - Geomorfologia da plataforma continental da bacia Sergipe-Alagoas. *Anais do XIII Congresso da Associação Brasileira de Estudos do Quaternário*.

Flemming, B.W. (2016) - Particle shape-controlled sorting and transport behavior of mixed siliciclastic bioclastic sediments in a mesotidal lagoon, South Africa. *Geo-Marine Letters*, 36:1-14. DOI: 10.1007/s00367-016-0457-3

Folk, R.; Ward, W. (1957) - Brazos river bar: A study on the significance of grain size parameters. *Journal of Sedimentary Petrology*, 27: 3-26. DOI: 10.1306/74D70646-2B21-11D7-8648000102C1865D

Gao, S.; Collins, M. (1995). Net sand transport direction in a tidal inlet, using foraminiferal tests as natural tracers. *Estuarine, Coastal and Shelf Science*, 40, 681-697.

Ginsburg, R. N.; Lowenstam, H.A. (1958) - The influence of marine bottom communities on the depositional environment of sediments. *Journal of Geology*, 66:310–318.

Gosling, E.M. (2003) - Bivalve molluscs: Biology, Ecology and Culture. 443p., Blackwell Publishing, Oxford.

Gourlay, M.R. (1994) - Wave transformation on a coral reef. *Coastal Engineering*, 23:17–42. DOI: 10.1016/0378-3839(94)90013-2

Guimarães, J.K.; Dominguez, J.M.L. (2005) - Relação Morfodinâmica entre Orientação da Linha de Costa e Deriva Litorânea na Evolução do Delta do Rio São Francisco. In: *Anais do X Congresso da Associação Brasileira de Estudos do Quaternário*, 1:1-8.

Kench, P.S.; Brander, R.W.; Parnell, K.E.; O'callaghan, J.M. (2009) - Seasonal variations in wave characteristics around a coral reef island, South Maalhosmadulu atoll, Maldives. *Marine Geology*, 262:116–129. DOI: 10.1016/j.margeo.2009.03.018

Kidwell, S.M. (2007) Discordance between living and death assemblages as evidence for anthropogenic ecological change. *Proceedings of the National Academy of Sciences of the United States of America*, 104:17701-17706. DOI: 10.1073/pnas.0707194104

King, C.A.M. (1972) *Beaches and coasts*. London: Edward Arnold, 570 p

Komar, P. D. (1998) - *Beaches processes and sedimentation*. 544p., Prentice Hall Inc, New Jersey.

Lee, T.T.; Black, K.P. (1978) - The energy spectra of surf waves on a coral reef. *Proceedings of the. XVI International Conference on Coastal Engineering*, ASCE, p. 588–608.

Lima, R.C.A.; Barbosa, L.M.; Albuquerque, A.L.S. (2003) - Morfologia, Uso e Riscos de Ocupação no Litoral Sul Alagoano - Implicações ao Gerenciamento Costeiro. *Anais do IX Congresso da Associação Brasileira de Estudos do Quaternário,* p.1-3, Recife, Brasil.

Lisco, S.; Moretti, M.; Moretti, V.; Cardone, F.; Corriero, G.; Longo, C. (2017). Sedimentological features of Sabellaria spinulosa biocontructions. *Marine and Petroleum Geology*. DOI: 10.1016/j.marpetgeo.2017.06.013

Machado, A.J.; Araújo, H.A.B. (2012) - Relação entre a microfauna de foraminíferos e a granulometria do sedimento do Complexo Recifal de Abrolhos, Bahia, a partir de análises multivariadas. *Revista Brasileira de Geociências*, 42(3):547-562. DOI: 10.5327/Z0375-75362012000300009

Mandlier, P.G.; Kench, P.S. (2012) - Analytical modeling of wave refraction and convergence on coral reef platforms: Implications for island formation and stability. *Geomorphology*, 160:84-92. DOI: 10.1016/j.geomorph.2012.03.007

McLachlan, A., Dorvlo, A., 2005. Global patterns in sandy beach macrobenthic communities. *Journal of Coastal Research,* 21: 674–687

MMA Gerência de Biodiversidade Aquática e Recursos Pesqueiros. (2010) - *Panorama da conservação dos ecossistemas costeiros e marinhos no Brasil*, 148p., MMA/SBF/GBA, Brasília.

Moraes, S.S. (2001) - *Interpretações da hidrodinâmica e dos tipos de transporte a partir de análises sedimentológicas e do estudo dos foraminíferos recentes dos recifes costeiros da Praia do Forte e de Itacimirim, litoral norte do Estado da Bahia. Salvador*. Dissertação de Mestrado, Instituto de Geociências da Universidade Federal da Bahia, Salvador, BA, Brasil. *Unpublished*.

Mortimer, J. (1990) The influence of beach sand characteristics on the nesting behavior and clutch survival of green turtles (Chelonia mydas): *Copeia*, 3: 802-817.

Moretti, M.; Tropeano, M.; Van Loon, A.J.; Acquafredda, P.; Baldacconi, R.; Festa, V.; Lisco, S.; Mastronuzzi, G.; Moretti, V.; Scotti, R. (2016). Texture and composition of the Rosa Marina beach sands (Adriatic coast, southern Italy): a sedimentological/ecological approach. Geologos 22(2): 87–103 DOI: 10.1515/logos-2016-0011

Muehe, D. (1998) - O litoral brasileiro e a sua compartimentação. In: Guerra, A.J.T.; Cunha, S.B. (eds.), *Geomorfologia do Brasil*, Bertrand Brasil, Rio de Janeiro, pp.273-249.

Muehe, D. (2010) Brazilian coastal vulnerability to climate change. *Pan-American Journal of Aquatic Sciences*, 5:173-183. Available on-line at http://www.panamjas.org/pdf_artigos/PANAMJAS_5(2)_173-183.pdf

Perez, M.L.; Gonçalves, S.J.; Rosso, T.C. (2009) - Uma visão da implantação do Plano Nacional de Gerenciamento Costeiro no Brasil. *Rio's International Journal on Sciences of Industrial and Systems Engineering and Management*, 3:092-02. Available on-line at http://www.rij.eng.uerj.br/professional/2009/pe092-02.pdf

Pianca, C.; Mazzini, P.L.F.; Siegle, E. (2010) - Brazilian offshore wave climate based on NWW3 reanalysis. *Brazilian Journal of Oceanography*, 58:53-70. DOI: 10.1590/S1679-87592010000100006

Pilkey, O.H.; Morton, R.W.; Luternauer, J. (1967) - The carbonate fraction of beach and dune sands. *Sedimentology*, 8:311–327. DOI: 10.1111/j.1365-3091.1967.tb01330.x

Prager, E.J.; Southard, J.B.; Vivoni-Gallart, E.R. (1996) - Experiments on entrainment threshold of well-sorted and poorly sorted carbonate sands. *Sedimentology*, 43(1):33–40. DOI: 10.1111/j.1365-3091.1996.tb01457.x

Rebouças, R.C.; Dominguez, J.M.L.; Bittencourt, A.C.S.P. (2011) - Provenance, Transport and Composition of Dendê Coast Beach Sands in Bahia, Central Coast of Brazil. *Brazilian Journal of Oceanography*, 59 (4):339-347. DOI: 10.1590/S1679-87592011000400004

Reis, A.H.; Gama, C. (2010) - Sand size versus beachface slope: An explanation based on the constructal law. *Geomorphology*, 114(3): 276–283. DOI: 10.1016/j.geomorph.2009.07.008

Rowland A.P., Lindley D.K., Hall G.H., Rossall M.J., Wilson D.R., Benham D.G., Harrison A.F., Daniels R.E. (2000) Effects of beach sand properties, temperature and rainfall on the degradation rates of oil in buried oil/beach sand mixtures. *Environmental Pollution*, 109(1):109–118

Santos, M.V.P.; Campos, M.C.; Moraes, S.S. (2011) - Utilização dos componentes biogênicos recentes do sedimento na caracterização geoambiental da praia de Itapuã, Salvador, Bahia. *Anais do XIV Congresso latino-Americano de Ciências do Mar*, Balneário Camboriú, Santa Catarina.

Schlacher, T.A.; Schoeman, D.S.; Dugan, J.; Lastra, M.; Jones, A.; Scapini, F.; McLachlan, A. (2008) - Sandy beach ecosystems: key features, management challenges, climate change impacts, and sampling issues. *Marine Ecology*, 29:70-90. DOI: 10.1111/j.1439-0485.2007.00204.x

Schlacher,T.A; Dugan, J., Schoeman, D.S; Lastra, M., Jones, A., Scapini, F., McLachlan, A.; Defeo, O. (2007) Sandy beaches at the brink. *Diversity Distributions*, 13: 556–560.

Scoffin, T.P. (1986) - *An introduction to carbonate sediments and rocks*. 274p., Blackie, Glasgow.

Scott, T.; Masselink, G.; Russell, P. (2011) - Morphodynamic characteristics and classification of beaches in England and Wales. *Marine Geology*, 286:1-20. DOI: 10.1016/j.margeo.2011.04.004

Stanica, A.; Ungureanu, V.J. (2010) Understanding coastal morphology and sedimentology. *Terre et Environnement*, 88: 105–111

Tessler, M.G.; Goya, S.C. (2005) - Processos costeiros condicionantes do litoral brasileiro. *Revista do Departamento de Geografia (USP)*, 17: 11-23. DOI: 10.7154/RDG.2005.0017.0001

Tinoco, I.M. (1989) - *Introdução aos estudos dos componentes bióticos dos sedimentos marinhos recentes*. 221p, Editora Universitária da UFPE, Recife.

Wright, L.D.; Chappell, J.; Thorn, B.G.; Bradshaw, M. P.; Cowell, P. (1979) - Morphodynamics of refletive and dissipative beach and inshore systems: Southeastern Australia. *Marine Geology*, 32(2):105-140. DOI: 10.1016/0025-3227(79)90149-X

Wright, L.D.; Short, A.D.; Green, M.O. (1985) - Short term changes in the morphodynamic states of beaches and surf zones: an empirical predictive model. *Marine Geology*, 62(3-4): 339-364. DOI: 10.1016/0025-3227(85)90123-9

Young, I.R. (1989) - Wave transformation over coral reefs. *Journal of Geophysical Research*, 94:9779–9789. DOI: 10.1029/JC094iC07p09779