ISSN:1984-2295

Revista Brasileira de Geografia Física

Homepage:https://periodicos.ufpe.br/revistas/rbgfe

A textural-based sectorization of the sandy beaches of Santa Catarina Island, SC, Brazil

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Artigo recebido em 10/02/2021 e aceito em 04/08/2021

A B S T R A C T

The collection of 192 sediment samples in the sandy beaches of the Santa Catarina Island (SCI) and subsequent laboratory analyses allowed to identify the main granulometric characteristics of the island's beach. According precedent criterion of distinction on sectors, the coasts were characterized as: in the Northwest coast, oriented to the North bay, present dominant texture of coarse sand, moderately sorted, approximately symmetric and mesokurtic; in the North coast, the beaches within Jurerê, Canasvieiras and Ingleses bays, present predominantly fine sand, well sorted, approximately symmetric and mesokurtic; in the Northeast coast, the beaches oriented to Atlantic ocean, present dominant texture of medium sand, well sorted, approximately symmetric and mesokurtic; in the Southeast coast, the beaches oriented to the ocean present dominant texture of medium sand, moderately sorted, negative asymmetry and mesokurtic; in the South coast, the beaches within the Pântano do Sul bay present dominant texture of fine sand, well sorted, approximately symmetric and mesokurtic; the Southwest coast, oriented to the South bay, present dominant texture of coarse sand, moderately sorted, approximately symmetric and mesokurtic. The beaches were arranged in four distinctive domains: Eastern domain, of high wave energy, alloying of Northeast and Southeast coasts; Western domain, comprehending protected beaches of the Northwest and Southwest coasts; Northern and Southern domain comprehending semi-protected beaches of the North and South coasts, located around Canasvieiras/Jurerê and Pântano do Sul bay, respectively. The granulometric characteristics of the SCI beaches are conditioned mainly by hydrodynamic agents associated with beach patterns and proximity of the source area.

Keywords: sediment; textural facies; hidrodynamics.

Setorização baseada nas texturas das praias arenosas da Ilha de Santa Catarina, SC, Brasil

R E S U M O

A coleta de 192 amostras de sedimentos em praias arenosas da ilha de Santa Catarina (ISC) e as análises laboratoriais subsequentes possibilitaram identificar as principais características granulométricas das praias da ilha. Conforme o critério prévio de distinção de setores pôde-se caracterizar que: a costa Noroeste, voltada para a baía Norte, apresentam textura predominante areia grossa, moderadamente selecionada, aproximadamente simétrica e mesocúrtica; na costa Norte, as praias nas enseadas de Jurerê, Canasvieiras e Ingleses apresentam textura dominante areia fina, bem selecionada, aproximadamente simétrica e mesocúrtica; na costa Nordeste, as praias voltadas para o oceano apresentam textura predominante areia média, bem selecionada, aproximadamente simétrica e mesocúrtica; na costa Sudeste, as praias voltadas para o oceano apresentam textura predominante areia média, moderadamente selecionada, assimetria negativa e mesocúrtica; na costa Sul, as praias da enseada do Pântano do Sul apresentam textura predominante areia fina, bem selecionada, aproximadamente simétrica e mesocúrtica e a costa Sudoeste, voltada para baía Sul, apresenta textura predominante areia grossa, moderadamente selecionada, aproximadamente simétrica e mesocúrtica. Puderam-se agrupar estas praias em quatro domínios distintos: domínio Oriental, de alta energia de onda, abrangendo as costas Nordeste e Sudeste; domínio Ocidental, compreendendo praias protegidas das costas Noroeste e Sudoeste; domínios Setentrional e Meridional abrangendo praias das costas Norte e Sul, semi-expostas da energia das ondas, situadas no entorno das enseadas de Canasvieiras/Jurerê e Pântano do Sul, respectivamente. As características granulométricas das praias da ISC são condicionadas principalmente pelos agentes hidrodinâmicos associados ao tipo de praia e à proximidade da área fonte.

Palavras-chave: sedimento; fácies texturais; hidrodinâmica.

Introduction

Coastal regions around the world, especially in countries with long coastlines, are generally sectored based on their physiographic characteristics, which are, on this scale, conditioned by tectonic-structural and oceanographic factors. Examples are cited in Australia (Harry et al., 2002), Brazil (Muehe, 1998; Dominguez, 2009; Klein e Short, 2016; Fernandez et al., 2019), and Mexico (Rivera-Arriaga e Villalobos, 2001), among others.

Despite this regional sectorization, locally, the most common coastal features - the beaches - usually have great morphological and sedimentary variability, such as the Santa Catarina island, located in the Southern region of Brazil, displaying, over a perimeter of 174.3 km, a diversity of coastal ecosystems, highlighting the 117 sandy beaches, representing 50% of the perimeter, besides dunes, lagoons, rocky coasts, and mangroves.

The socioeconomic importance of such sandy beaches, mainly as recreational areas, as well as their high morphological and sedimentary dynamics, has motivated several studies seeking a better understanding, rational use, and/or preservation of these environments. The first characterization of sandy beaches of the Santa Catarina island from the sedimentological point of view were developed by Martins et al. (1970) and Cruz (1998), describing the geomorphological aspects of the island beaches and the near mainland. Horn Filho et al. (1999, 2014a, 2014b) conducted a morphosedimentary study of the beaches, and Miot da Silva (2002) reported the granulometric characteristics of the beaches and their plan shape. More recently, Horn Filho et al. (2014a, 2014b) made a textural classification of 117 sandy beaches of the ISC and several studies based on remote sensing techniques, numerical modelling and spatial analysis, such as Bonetti et al. (2018), Serafim et al. (2019) Silveira and Bonetti (2019), Bonetti and Pereira (2020), Lima et al. (2020). Finally, Heidrich et al. (2020) monitored the annual granulometric variation in beaches belonging to all coastal sectors of the ISC.

This robust database is a favorable scenario for further investigations. Here, we present a detailed granulometric characterization of the sandy beaches on the Santa Catarina Island, taking into account the pre-existing sectorization of the coast, promoting the integrated knowledge of these coastal systems.

Textural variations along the beach with different orientations and degrees of exposure to waves provide valuable information on sandy beaches' main processes, whose understanding is fundamental for coastal management.

Materials and methods

Study Area

The Santa Catarina Island is in the Central coast of the state of Santa Catarina (Diehl e Horn Filho, 1996), between parallels of 27°22'45" and 27°50'10" south latitude and the meridians of 48°21'37" and 48°34'49" west longitude. The island is entirely bordered by the south Atlantic Ocean, separated from the mainland by the Florianópolis bay, individualizes in the North and South bays. It is presented as elongated towards the northeast-southwest with a total area of 399 km² (Figure 1).

It is characterized as a typical coastal island (Suguio, 1992). Its main physiographic and structural features are like those defined for the continental region, enabling us to state that the island and the near mainland were united when the sea level was lower.

The climate in the Santa Catarina Island is controlled by the action of the Maritime Polar and Marine Tropical Atlantic masses, inserted in a temperate climate region of the subsequent category (Nimer, 1989). The normal atmospheric circulation in the region is the domain of a semi-fixed high-pressure system with winds from the north/northeast, along with the local effect of the sea breeze. Periodically, the system is disturbed by the passage of cold fronts caused by the Mobile Polar Anticyclone migration over the region, from Southwest to Northeast (Trucollo, 1998; Mariotti e Franco, 2001). Prevailing winds are from the north/northeast, while south winds are more intense.

The geology of Santa Catarina Island consists of two main provinces: (1) the older crystalline basement, represented by the geological units of the Santa Catarina Shield and the Serra Geral Formation; and (2) most recent sedimentary deposits, represented by sediments of continental, transitional, and marine origin (Caruso Jr., 1993). The crystalline basement massifs present granites, rhyolites, and diabases as dominant rocks. Simultaneously, the sedimentary deposits are characterized by formations generated in beach marine, aeolian, lagoon, paludal, and colluvial sedimentation environments. Moreover, in the interface of crystalline hillslopes and coastal plain are located slope deposits.

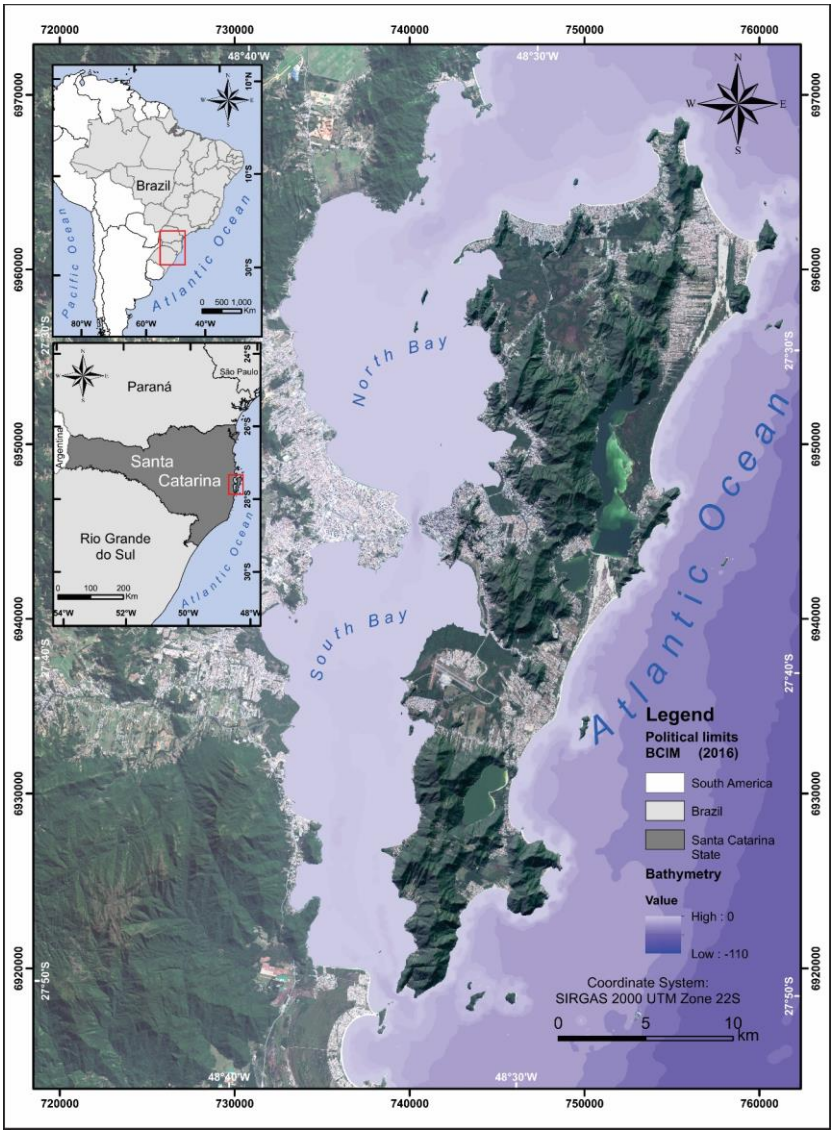

Figure 1. Location of Santa Catarina island in the Central coast of the state of Santa Catarina, Brazil.

The landscape is strongly marked by the two main geomorphological domains: (1) Complex Basement and (2) Recent Accumulations (Herrmann e Rosa, 1991). The first comprises the geomorphological unit of East Santa Catarina Belts or Coastal Crystalline Belts (Monteiro, 1958), and the second, the geomorphological unit Coastal Plains. The East Santa Catarina Belts unit constituting the highlands of the island is a sequence of elevations arranged in a subparallel direction, oriented toward the northeast - southwest. Their altitudes range from 75 to 532 m, with average values of 290 m. The Coastal Plains unit, which represents the island's lowlands, consists of a complex of continental-marine forms derived from erosion and/or accumulation (Bortoluzzi, 1987).

The drainage network in the Santa Catarina Island can be represented by four distinct sectors corresponding to the East, West, North, and South sectors. In the East, rivers and streams are born in the basement, not directly reaching the ocean. The West rivers flow directly into the North and South bays, while those in the North and South sides are also directed to the Atlantic Ocean. The island also has a system of coastal lagoons, highlighting the Conceição and Peri lagoons.

The analysis of data from an oceanographic buoy anchored in deep waters of the Santa Catarina Island, Araújo et al. (2003) identified that throughout the year prevail the swell from the South with a period around 12 s and East seas with a period of 8 s. During autumn and winter, the ripples of the waves prevail over east waves; in the summer, there is a balance between them and in the spring, east waves prevail. High wave energy conditions generally come from south and southeast swell with waves bigger than 4m in deep water, which can be found in all seasons. Tides are

of the micro tide type (< 2 m) with a semi-daily regime and maximum amplitudes of 1.4 m to the port of Florianópolis (DHN, 2020).

Procedures

Previous data on the beaches of the Santa Catarina Island were initially compiled. Next, field visits were made to all the 117 sandy beaches of the island, and 192 beach sediment samples were collected in the backshore sector (Figure 2), and their geographical coordinates were registered with a GPS.

For the granulometric analysis of sandy sediments, the sieving method was used based on Wentworth's (1922) (mm unit) and Krumbein's (1934) (*Ø unit*) granulometric scale, whose analysis was performed according to ¼ Ø ranges for higher fidelity in the expression of different grain sizes.

The data obtained from granulometric analyses were statistically treated using the parameters of Folk e Ward (1957) (average grain diameter, standard deviation, asymmetry, and kurtosis) through the application of the software PANCOM by Toldo Jr. e Medeiros (1986).

Results are presented considering the coastline sectors of the Santa Catarina Island proposed by Horn Filho et al. (1999). Under this classification, the coastline of the island can be subdivided into six coasts, called: (1) Northwest coast, (2) North coast, (3) Northeast coast, (4) Southeast coast, (5) South coast, and (6) Southwest coast. This subdivision was based on geological and geomorphological characteristics of the coast and mainly on the distinguishing features of the beaches.

Considering the 117 sandy beaches on the Santa Catarina island indexed in this study, 30 beaches belong to the Northwest coast, 21 beaches to the North coast, eight beaches to the Northeast coast, eight beaches to the Southeast coast, five beaches to the South coast and 45 to the Southwest coast. Clockwise, taking as a basis the Hercílio Luz Bridge, the following sandy beaches are identified on Santa Catarina Island (Table 1).

In the Northwest are mapped 30 sandy beaches (1 to 30), and 34 sediment samples (1 to 34) were collected (Figure 3). The average width, slope, and length are 7.36 m, 8.33°, and 297.3 m. On this coast outcrop, the crystalline massifs by the North bay, besides colluvial, lagoon, and paludal deposits.

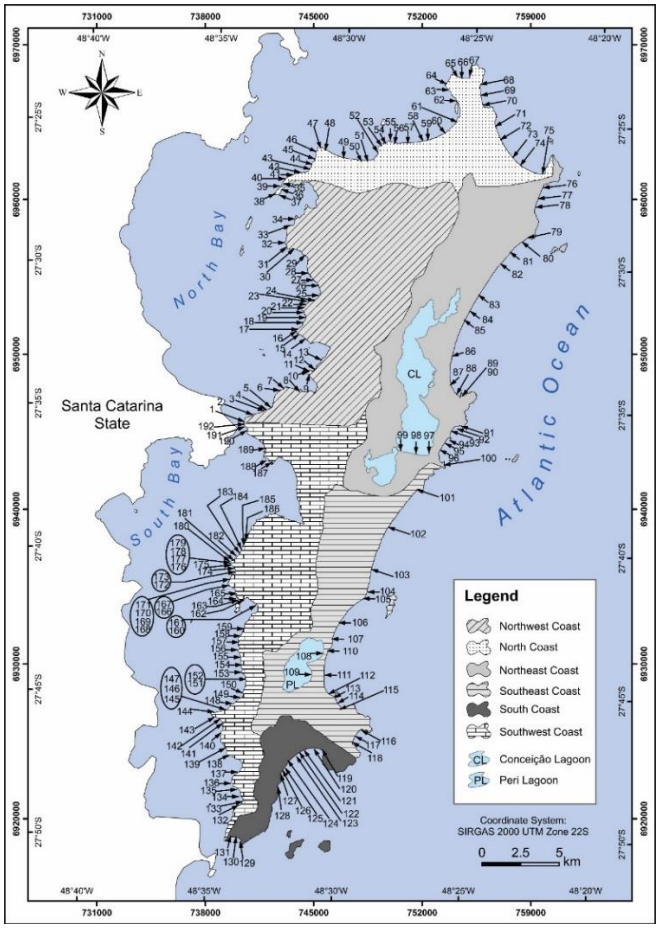

Figure 2. Geographic location of 192 sampling points along with the six geological-geomorphological coastal sectors of the Santa Catarina Island.

Table 1. Sandy beaches of the Santa Catarina Island.

Coast	Beach
Northwest	(1) Arataca, (2) Namorados, (3) São Luiz, (4) Ponta do Recife, (5) Coral Leste, (6) Lessa, (7) Goulart Sul, (8) Goulart Central, (9) Goulart Norte, (10) Saco Grande, (11) Maria do Mar, (12) Cacupé Grande, (13) Prainha do Cacupé, (14) Ponta do Cacupé, (15) Sossego, (16) Esperança, (17) Nogueira, (18) Amores, (19) Lage, (20) José da Benta, (21) Gaúchos, (22) Comprida, (23) Igreja, (24) Santo Antônio de Lisboa, (25) Sambaqui, (26) Condomínio Sambaqui, (27) Ponta do Sambaqui, (28) Toló, (29) Raulino, (30) Rola
North	(31) Pontal de Dentro, (32) Pontal de Fora, (33) Daniela, (34) Vavá, (35) Chico Pinhão, (36) Forte Sul, (37) Forte, (38) Dona Chica, (39) Jurerê Internacional, (40) Jurerê, (41) Croa, (42) Canajurê, (43) Morretes, (44) Francês, (45) Canasvieiras, (46) Cachoeira do Bom Jesus, (47) Ponta das Canas, (48) Prainha de Ponta das Canas, (49) Lagoinha, (50) Brava, (51) Ingleses
Northeast	(52) Santinho, (53) Moçambique, (54) Barra da Lagoa, (55) Prainha da Barra da Lagoa, (56) Galheta, (57) Mole, (58) Rendeiras, (59) Gravatá
Southeast	(60) Joaquina, (61) Campeche, (62) Morro das Pedras, (63) Peri Norte, (64) Peri Sul, (65) Armação, (66) Matadeiro, (67) Lagoinha do Leste
South	(68) Pântano do Sul, (69) Açores, (70) Solidão, (71) Saquinho, (72) Naufragados
Southwest	(73) Defunto, (74) Caieiras da Barra do Sul, (75) Prainha da Caieira da Barra do Sul, (76) Grande, (77) Ponta do Sinal, (78) Taperinha, (79) Tapera da Barra Sul, (80) Sinhá, (81) Caiacangaçu, (82) Fora, (83) Ponta, (84) Pracinha do Ribeirão, (85) Marcelino, (86) Três Patos, (87) Garapuvu, (88) Itaqui, (89) Doutor Ivo, (90) Recanto, (91) Ascan, (92) Ribeirão Sul, (93) Ribeirão Norte, (94) Freguesia do Ribeirão, (95) Bambuzal, (96) Saco, (97) Croa da Ilha, (98) Prainha da Ilha, (99) Flechas, (100) Garcia, (101) Pedra Grande, (102) Laranjeiras, (103) Tapera Sul, (104) Tapera, (105) Albatroz, (106) Pelicano, (107) Vila Sul, (108) Vila Norte, (109) Base Aérea, (110) Prainha da Caiacanga-Mirim, (111) Aeroporto, (112) Curtume, (113) José Mendes, (114) Iate Clube, (115) Remo, (116) Scuna, (117) Ponte

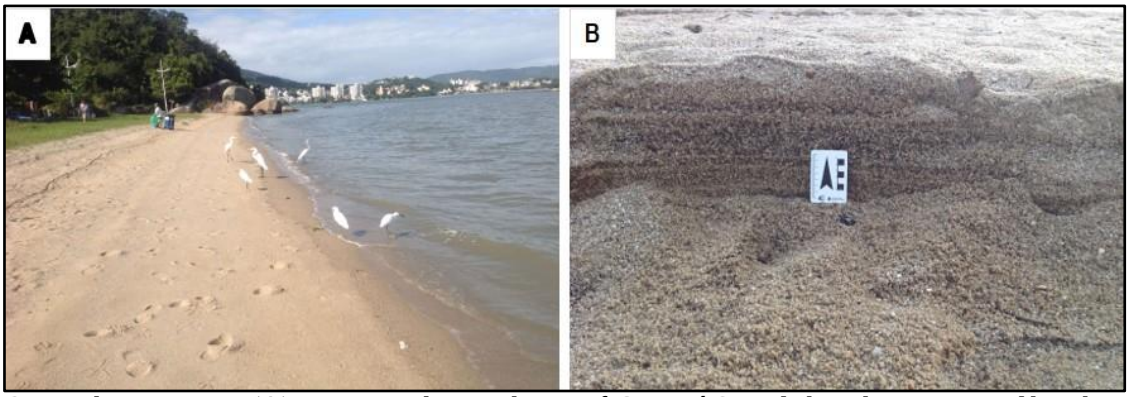

Figure 3. Northwest coast: (A) a view to the southeast of Cacupé Grande beach, a protected bay beach; and (B) Detail of the stratified, siliciclastic (quartz and feldspar) beach deposit, consisting of coarse sand.

The North coast is characterized by beach ridges on the coastal plain beyond the formation of sandy *spits*. The 21 beaches (31 to 51) oriented predominantly towards the north have an average width of 20.38 m and slope and length of 4.79° and 1.139 m, respectively (Figure 4). Forty sediment samples were collected (35 to 75) on this coast.

On the Northeast coast, the eight beaches (52 to 59) have an average width of 32.12 m, an average slope of 5.5°, and an average length of 2.313 m. Highlights of this sector are the Conceição Lagoon, rocky promontories, and eolic, marine and lagoon deposits. A total of 25 sediment samples (76 to 100) were collected on the eight beaches (Figure 5). Of these beaches, Rendeiras beach, on the shore of the Conceição Lagoon, is considered a beach representative of this coast, although not constituting an environment exposed

or semi-exposed to the ocean or a hydrodynamic bay, respectively.

The Southeast coast presents rocky promontories of granite and rhyolite, besides Quaternary marine and eolic deposits. The eight beaches (60 to 67) have average width, slope, and length of 30.87 m, 7º, and 2.415 m, respectively. A total of 18 sediment samples (101 to 118) were collected on this coast (Figure 6). The Peri lagoon beach is considered representative of this coast.

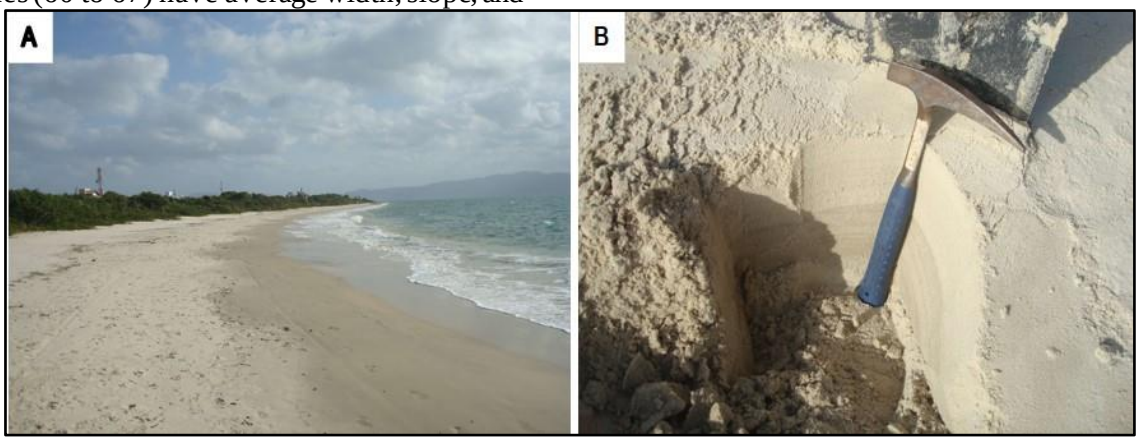

Figure 4. North coast: (A) a view to the Southwest of Daniela beach, a semi-protected bay beach; and (B) detail of the stratified, siliciclastic (quartz) beach deposit, consisting of fine sand.

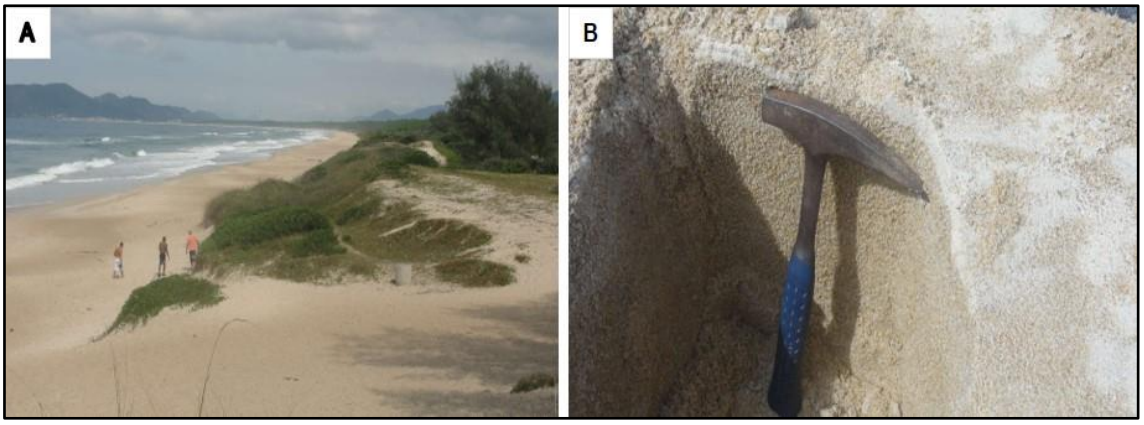

Figure 5. Northeast coast: (A) a view to the Southwest of Moçambique beach, an exposed beach; and (B) detail of the stratified, siliciclastic (quartz) beach deposit, consisting of medium sand.

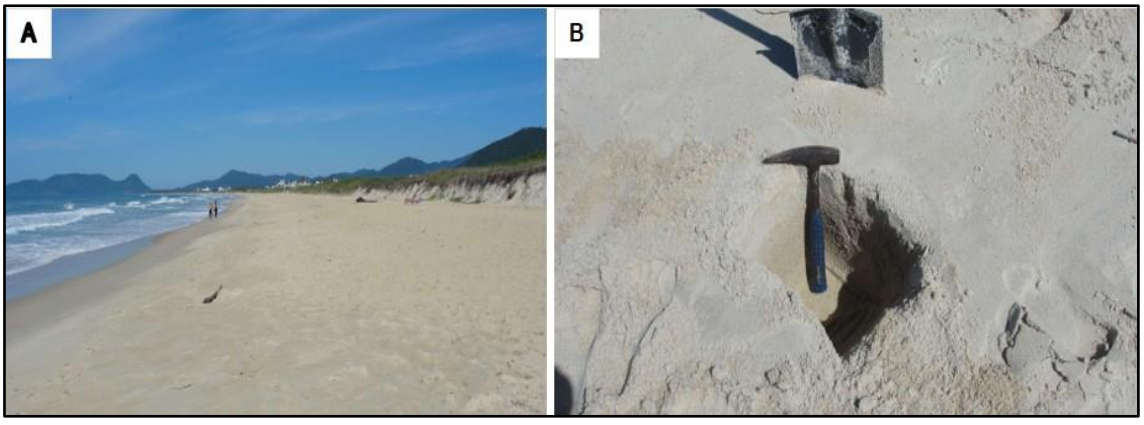

Figure 6. Southeast coast: (A) a view to the south of Campeche beach, an exposed oceanic beach; and (B) detail of the stratified, siliciclastic (quartz) beach deposit, consisting of medium sand.

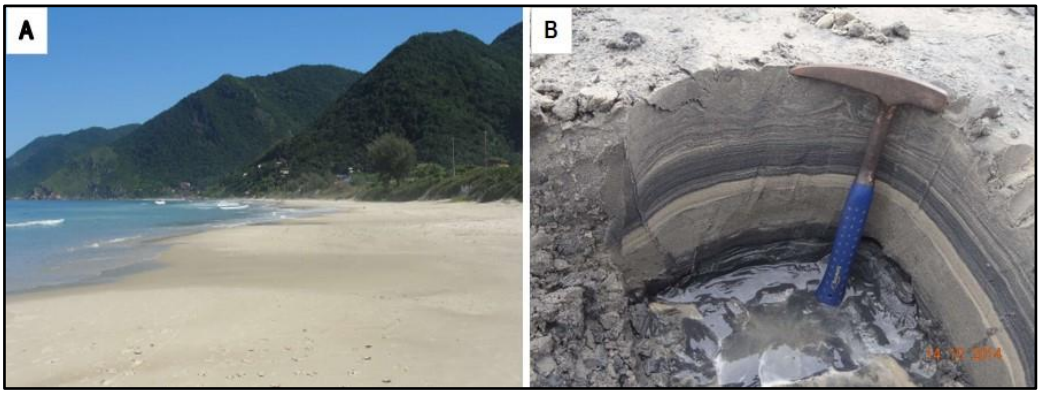

Figure 7. South coast: (A) a view to the southwest of Pântano do Sul beach, a semi-exposed parabolic beach; and (B) detail of the stratified, siliciclastic (quartz) beach deposit, consisting of fine sand.

Figure 8. Southwest coast: (A) a view to the northwest of Fora beach, a protected bay beach; and (B) detail of the bio siliciclastic beach deposit, consisting of coarse sand.

On the South coast, the five beaches (68 to 72) (Figure 7) are wide (average 37.6 m), low slope (average 4.6°), and have an average length of 1.180 m. A total of 13 sediment samples (119 to 131) were collected on the five beaches of the South coast.

On the Southwest coast, 45 beaches (73 to 117) were registered, presenting an average width of 8.48m, an average slope of 7.35°, and a mean length of 267.6m, being usually undeveloped or small beaches. The crystalline massifs appear close to the coast, in addition to the occurrence of lagoonal and paludal (mangrove of the Tavares river) deposits. A total of 61 sediment samples (132 to 192) were collected on the 45 beaches of the Southwest coast (Figure 8).

Results

Coast to coast

Northwest coast

As for the mean grain diameter (Table 2, columns A and B), 25 samples were classified as coarse sand (CS); six samples as medium sand (MS); two samples as fine sand (FS), and one sample as very coarse sand (VCS). The values ranged from 0.00 Ø (VCS), on the Santo Antônio de Lisboa beach (point No. 24, sample No. 28) to 2.31 Ø (FS) on the Rola beach (point No. 30, sample No. 34). The average value of the mean grain diameter was 0.78 Ø (CS) (Figure 9), taking the Cacupé Grande beach as an example of this coast.

As for the standard deviation (Table 2, columns C and D), the values ranged from 0.49 Ø (WS), on the José da Benta beach (point No. 20, sample No. 22) to 1.44 Ø (PS), on the Goulart Sul beach (point No. 7, sample No. 9). The average value of the standard deviation was 0.84 Ø (MS). Of the total samples, 14 samples were classified as moderately sorted (MS); 10 samples as moderately well sorted (MWS), nine samples as poorly sorted (PS), and one sample as well sorted (WS).

Concerning the asymmetry (Table 2, columns E and F, the values ranged from -0.40 (VN) on the Esperança beach (point No. 16, sample No. 18) to 0.22 (P), on the Igreja beach (point No. 23, sample No. 27). Of the total samples, 15 samples were classified as approximately symmetric (AS); 11 samples as negative (N), six samples as positive (P), and two samples as very

negative (VN).

As for the kurtosis (Table 2, columns G and H), the values ranged from 0.75 (P), on the Maria do Mar beach (point No. 11, sample No. 13) to 2.03 (VP) on Amores beach (point No. 18, sample No. 20). The average value of the kurtosis was 0.97 (M). Of the total samples, 16 samples were classified as mesokurtic (M); 13 samples as platykurtic (P); three samples as leptokurtic (L), and two samples as very leptokurtic (VL). These average values corroborate the work of Heidrich (2011).

Table 2. Granulometric data of 34 samples from 30 beaches on the Northwest coast of the Santa Catarina Island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
1	Arataca	35'32,4"	33'46,8"	0.40	CS	1.15	PS	-0.26	N	0.77	P
2	Namorados	35'09,1"	33'09,5"	0.49	CS	0.65	MWS	-0.14	N	1.02	M
3	São Luiz (1)	35'00,5"	32'54,3"	0.15	CS	1.07	PS	-0.17	N	0.77	P
3	São Luiz (2)	34'59,5"	32'47,4"	0.60	CS	0.94	MS	0.19	P	0.96	M
3	São Luiz (3)	34'52,8"	32'41,9"	0.48	CS	1.04	PS	0.07	AS	0.92	M
4	Ponta do Recife	34'18,1"	32'19,2"	0.83	CS	0.66	MWS	-0.04	N	1.10	M
5	Coral Leste	34'13,0"	32'07,9"	0.52	CS	0.56	MWS	-0.00	AS	0.76	P
6	Lessa	34'19,5"	31'39,0"	0.57	CS	1.20	PS	-0.30	N	0.83	P
7	Goulart Sul	33'46,8"	31'15,6"	1.45	MS	1.44	PS	-0.15	N	0.83	P
8	Goulart Central	33'38,4"	31'17,1"	0.57	CS	0.97	MS	-0.07	AS	1.19	L
9	Goulart Norte	33'40,2"	31'12,9"	2.03	FS	1.17	PS	-0.33	VN	0.91	M
10	Saco Grande	33'37,1"	31'03,0"	0.38	CS	0.91	MS	0.01	AS	1.01	M
11	Maria do Mar	33'16,4"	30'47,7"	0.05	CS	1.02	PS	0.10	AS	0.75	P
12	Cacupé Grande	32'32,0"	31'27,1"	0.82	CS	0.93	MS	0.20	P	1.04	M
13	Prainha do Cacupé	32'19,5"	31'45,2"	0.14	CS	0.93	MS	0.07	AS	1.00	M
14	Ponta do Cacupé	32'15,2"	31'49,6"	0.70	CS	0.58	MWS	-0.01	AS	0.92	M
15	Sossego	32'10,9"	31'43,6"	1.35	MS	0.51	MWS	0.16	P	1.10	M
16	Esperança	31'55,5"	31'26,6"	0.60	CS	0.74	MS	-0.40	VN	1.19	L
17	Nogueira	31'43,2"	31'23,9"	0.90	CS	0.57	MWS	0.11	P	0.93	M
18	Amores	31'35,3"	31'30,3"	1.32	MS	0.81	MS	-0.25	N	2.03	VL
19	Lage	31'28,2"	31'26,1"	0.40	CS	0.60	MWS	-0.28	N	1.17	L
20	José da Benta	31'17,9"	31'20,4"	0.43	CS	0.49	WS	-0.10	AS	0.97	M
21	Gaúchos	31'13,6"	31'17,0"	0.57	CS	0.84	MS	0.06	AS	0.77	P
22	Comprida (1)	31'10,1"	31'01,2"	0.66	CS	0.75	MS	0.06	AS	0.84	P
22	Comprida (2)	30'57,4"	30'54,1"	1.07	MS	0.71	MS	0.16	P	0.97	M
22	Comprida (3)	30'39,1"	31'04,2"	0.70	CS	0.72	MS	-0.05	AS	0.93	M
23	Igreja	30'25,9"	31'07,3"	0.34	CS	1.19	PS	0.22	P	0.81	P
24	Santo Antônio de Lisboa	30°20,2"	31°19,8"	0.00	VCS	0.9	MS	-0.01	AS	0.93	M
25	Sambaqui	29'40,3"	31'31,1"	0.86	CS	0.52	MWS	-0.14	N	0.79	P
26	Condomínio Sambaqui	29'24,0"	31'57,5"	0.48	CS	0.93	MS	-0.26	N	0.81	P
27	Ponta do Sambaqui	29'19,4"	32'13,9"	0.45	CS	1.04	PS	-0.03	AS	0.76	P
28	Toló	29'07,3"	32'16,3"	1.28	MS	0.86	MS	0.06	AS	1.51	VL
29	Raulino	28'32,2"	32'00,3"	1.80	MS	0.58	MWS	0.09	AS	0.81	P
30	Rola	28'17.3"	31'51.8"	2.31	FS	0.56	MWS	-0.20	N	0.92	M

Legend for tables 2, 3, 4, 5, 6 and 7: No. - Sequential number, 27° - South latitude, 48° - West longitude; A - Average grain diameter (Mz) in Ø ; B - Classification by average diameter: G (gravel); VCS (very coarse sand), CS (coarse sand); MS (medium sand); FS (fine sand); VFS (very fine sand) C - Standard deviation in Ø; D - Classification by degree of selection: VWS (very well sorted); WS (well sorted); MWS (moderately well sorted); MS (moderately sorted); PS (poorly sorted); VPS (very poorly sorted), EPS (extremely poorly sorted); E - Asymmetry; F - Classification by asymmetry: VN (very negative); N (negative): AS (approximately symmetric): P (positive); VP (very positive); G - Kurtosis; H - Classification by kurtosis: VP (very platykurtic); P (platykurtic); M (mesokurtic); L (leptokurtic); VL (very leptokurtic); EL (extremely leptokurtic). Highlighted in red and blue are the highest and lowest values, respectively.

North Coast

As for the mean grain diameter (Table 3, columns A and B), 41 samples (45 to 75) were classified as fine sand (100%). The values ranged from 2.08 Ø (FS) on the Pontal de Dentro beach (point No. 31, sample No. 1) to 2.69 Ø (FS) on the Chico Pinhão beach (point No. 35, sample No. 44). The average value of the mean grain diameter was 2.38 Ø (FS) (Figure 10), taking the Daniela beach as an example of this coast.

As for the standard deviation (Table 3, columns C and D), the values ranged from 0.30 Ø (VWS), on the Brava beach (point No. 20, sample No. 3) to 0.50 Ø (WS), on the Francês beach (point No. 44, sample No. 55). The average value of the standard deviation was 0.37 Ø (WS). Of the total samples, 28 samples were classified as well sorted (WS) and 13 samples as very well sorted (VWS).

As for the asymmetry (Table 3, columns E and F), the values ranged from -0.17 (N) on the Vavá beach (point No. 34, sample No. 43) to 0.24 (P), on the Brava beach (point No. 50, sample No. 70) and Ingleses beach (point No. 51, sample No. 72). Of the total samples, 29 samples were classified as approximately symmetric (AS); eight samples as negative (N), and four samples as positive (P).

As for the kurtosis (Table 3, columns G and H), the values ranged from 0.75 (P), on the Forte beach (point No. 37, sample No. 46) and Cachoeira do Bom Jesus (point No. 46, sample No. 61) to 1.35 (L), on the Morretes beach (point No. 43, sample No. 54). The average value of the kurtosis was 0.97 (M). Of the total samples, 20 samples were classified as platykurtic (P); 11 samples as mesokurtic (M), and 10 samples as leptokurtic (L).

The results of this sector are in line with those obtained by Silva et al. (2016) Silva (2017) e Pereira (2018).

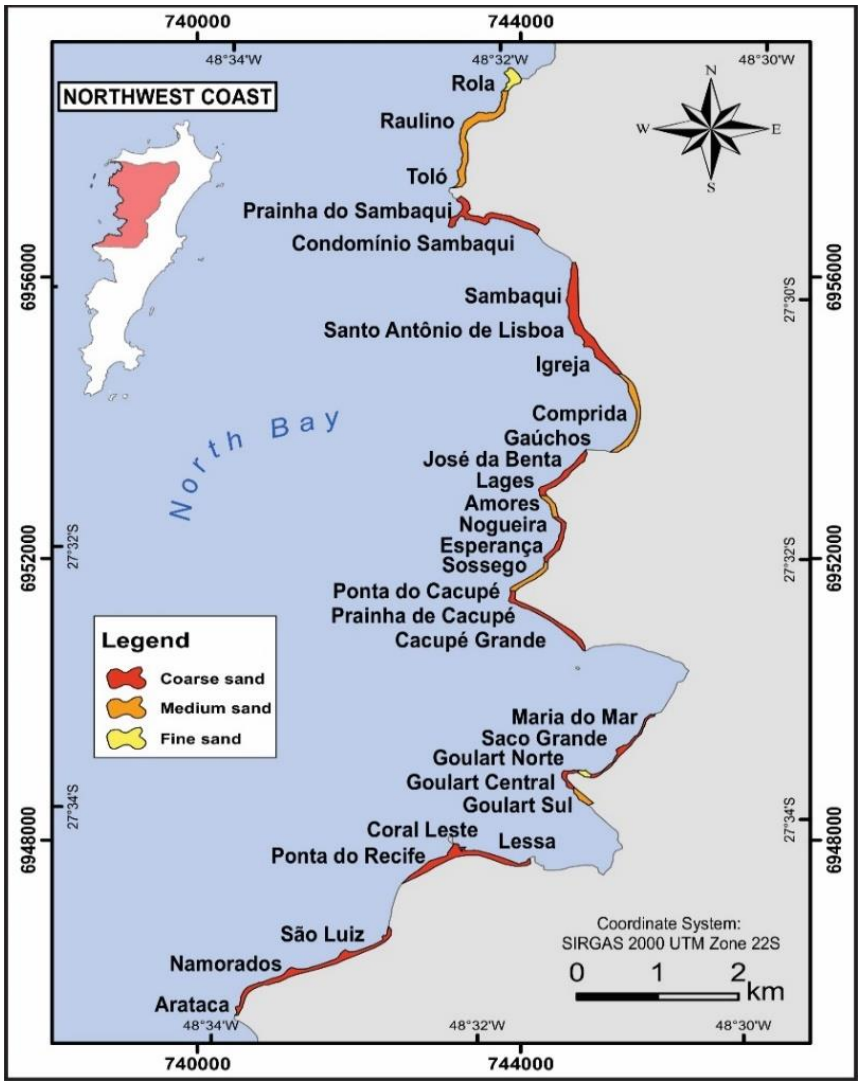

Figure 9. Geographic location and texture of the 30 sandy beaches of the Northwest coast.

Table 3. Granulometric data of 41 samples from 21 beaches on the North coast of the Santa Catarina island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
31	Pontal de Dentro (1)	27'19,1"	32'33,2"	2.08	FS	0.41	WS	0.07	AS	0.88	P
31	Pontal de Dentro (2)	27'29,5"	32'39,2"	2.21	FS	0.37	WS	-0.03	AS	1.20	L
31	Pontal de Dentro (3)	27'30,7"	32'450"	2.58	FS	0.35	VWS	-0.08	AS	0.83	P
32	Pontal de Fora (1)	27'23,8"	32'42,0"	2.41	FS	0.39	WS	-0.01	AS	0.90	P
32	Pontal de Fora (2)	32'20,5"	27'09,3"	2.61	FS	0.34	VWS	-0.12	N	0.86	P
33	Daniela (1)	26'58,0"	32'20,5"	2.49	FS	0.36	WS	-0.03	AS	0.83	P
33	Daniela (2)	31'57,9"	32'07,9"	2.48	FS	0.37	WS	-0.05	AS	0.86	P
33	Daniela (3)	26'40,0"	31'29,2"	2.42	FS	0.38	WS	0.00	AS	0.89	P
34	Vavá	26'33,9"	31'22,5"	2.55	FS	0.35	VWS	-0.17	N	0.82	P
35	Chico Pinhão	26'28,2"	31'20,2"	2.69	FS	0.35	VWS	-0.10	N	1.20	L
36	Forte Sul	26'16,9"	31'10,6"	2.44	FS	0.36	WS	-0.01	AS	0.85	P
37	Forte	26°00,4"	31°09,8"	2.57	FS	0.32	VWS	-0.13	N	0.75	P
38	Dona Chica	25'52,3"	30'58,7"	2.33	FS	0.44	WS	-0.06	AS	0.94	M
39	Jurerê Internacional (1)	25'54,7"	30'47,6"	2.29	FS	0.40	WS	0.03	AS	1.09	M
39	Jurerê Internacional (2)	26'10,7"	30'03,4"	2.38	FS	0.36	WS	0.05	AS	0.91	M
40	Jurerê (1)	26'14,8"	29'26,1"	2.26	FS	0.48	WS	-0.08	AS	1.22	L
40	Jurerê (2)	26'13,8"	28'58,1"	2.29	FS	0.42	WS	-0.01	AS	1.10	M
41	Croa	25'57,7"	28'43,2"	2.38	FS	0.45	WS	-0.12	N	0.99	M
42	Canajurê	25'42,7"	28'36,6"	2.40	FS	0.39	WS	-0.00	AS	0.91	M
43	Morretes	25'39,3"	28'34,0"	2.26	FS	0.32	VWS	0.05	AS	1.35	L
44	Francês	25'36,5"	28'26,4"	2.21	FS	0.50	WS	-0.15	N	1.20	L
45	Canasvieiras (1)	25'34,7"	28'16,3"	2.39	FS	0.32	VWS	0.18	P	0.78	P
45	Canasvieiras (2)	25'36,0"	27'33,8"	2.30	FS	0.38	WS	0.07	AS	1.10	M
45	Canasvieiras (3)	25'33,8"	26'59,7"	2.52	FS	0.39	WS	-0.01	AS	0.90	P
46	Cachoeira do Bom Jesus (1)	25'30,4"	26'48,2"	2.36	FS	0.39	WS	0.00	AS	0.95	M
46	Cachoeira do Bom Jesus (2)	25'13,8"	26'03,6"	2.46	FS	0.38	WS	-0.10	N	0.88	P
46	Cachoeira do Bom Jesus (3)	24°50,2"	25°43,7"	2.52	FS	0.34	VWS	-0.08	AS	0.75	P
47	Ponta das Canas (1)	24'08,1"	25'46,4"	2.31	FS	0.39	WS	0.04	AS	1.05	M
47	Ponta das Canas (2)	23'42,0"	26'00,6"	2.49	FS	0.38	WS	-0.13	N	0.89	P
48	Prainha de Ponta das Canas	23'33,1"	26'07,4"	2.41	FS	0.39	WS	-0.07	AS	0.93	M
49	Lagoinha (1)	23'16,0"	25'42,2"	2.40	FS	0.37	WS	0.03	AS	0.90	P
49	Lagoinha (2)	23'19,0"	25'27,9"	2.47	FS	0.38	WS	-0.09	AS	0.89	P
49	Lagoinha (3)	23'18,1"	25'13,8"	2.41	FS	0.35	VWS	0.08	AS	0.84	P
50	Brava (1)	23'34,3"	24'50,6"	2.27	FS	0.36	WS	0.04	AS	1.23	L
50	Brava (2)	23'54,6"	24'48,2"	2.29	FS	0.35	VWS	0.08	AS	1.20	L
50	Brava (3)	24'16,3"	24'40,0"	2.33	FS	0.30	VWS	0.24	P	0.93	M
51	Ingleses (1)	24'59,7"	24'11,2"	2.31	FS	0.31	VWS	0.16	P	1.15	L
51	Ingleses (2)	25'28,0"	23'59,1"	2.42	FS	0.37	WS	0.24	P	0.87	P
51	Ingleses (3)	26'05,6"	23'27,0"	2.30	FS	0.36	WS	0.08	AS	1.21	L
51	Ingleses (4)	26'20,9"	23'08,4"	2.31	FS	0.36	WS	0.07	AS	1.06	L
51	Ingleses (5)	26'38,5"	22'14,2"	2.38	FS	0.35	VWS	0.07	AS	0.89	P

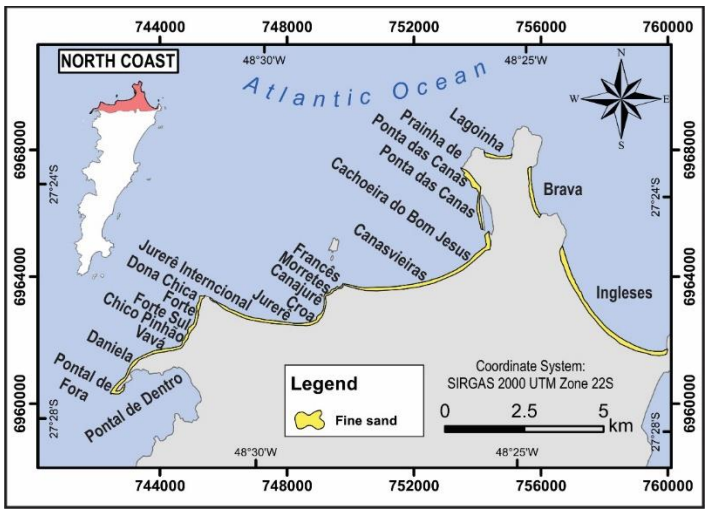

Figure 10. Geographic location and texture of the 21 sandy beaches of the North coast.

Northeast coast

As for the mean grain diameter (Table 4, columns A and B), 14 samples were classified as fine sand (FS); nine samples as medium sand (MS) and two samples as coarse sand (CS). The values

ranged from 0.38 Ø (VCS), on the Moçambique beach (point No. 53, sample No. 79) to 2.90 Ø (FS) at the Barra da Lagoa beach (point No. 54, sample No. 87). The average value of the mean grain diameter was 1.98 Ø (MS) (Figure 11), taking the Moçambique beach (point No. 53, sample No. 84) as an example of this coast.

As for the standard deviation (Table 4, columns C and D), the values ranged from 0.30 Ø (VWS), at the Rendeiras beach (point No. 58, sample No. 99) to 1.13 phi (PS), on the Gravatá beach (point No. 59, sample No. 100). The average value of the standard deviation was 0.47 Ø (WS). Of the total samples, nine samples were classified as very well sorted (VWS); eight samples as well sorted (WS); five samples as moderately well sorted (MWS); two samples as moderately sorted (MS) and one sample as poorly sorted (PS).

Table 4. Granulometric data of 25 samples from eight beaches on the Northeast coast of the Santa Catarina island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
52	Santinho (1)	27'05,2"	22'18,8"	2.40	FS	0.34	VWS	0.06	AS	0.85	P
52	Santinho (2)	27'26,9"	22'30,0"	2.36	FS	0.35	VWS	0.08	AS	0.95	M
52	Santinho (3)	27'45,0"	22'34,9"	2.71	FS	0.31	VWS	-0.09	AS	1.29	L
53	Moçambique (1)	28'47,9"	22'54,3"	0.38	CS	0.65	MWS	0.31	VP	1.24	L
53	Moçambique (2)	28'57,1"	23'02,1"	1.30	MS	0.69	MWS	-0.05	AS	1.00	M
53	Moçambique (3)	29'16,0"	23'35,0"	1.74	MS	0.58	MWS	-0.15	N	0.89	P
53	Moçambique (4)	29'43,9"	23'50,4"	1.44	MS	0.78	MS	-0.11	N	0.76	P
53	Moçambique (5)	30'50,3"	24'41,1"	1.32	MS	0.74	MS	-0.10	N	0.82	P
53	Moçambique (6)	31'21,5"	25'01,6"	1.79	MS	0.50	WS	-0.06	AS	0.73	P
53	Moçambique (7)	31'45,7"	25'13,7"	2.27	FS	0.32	VWS	0.05	AS	1.33	L
53	Moçambique (8)	33'04,1"	25'45,3"	2.39	FS	0.32	VWS	0.14	P	0.80	P
54	Barra da Lagoa (1)	34'08,2"	25'45,3"	2.90	FS	0.37	WS	0.04	AS	1.21	L
54	Barra da Lagoa (2)	34'26,0"	25'26,7"	2.49	FS	0.42	WS	-0.17	N	1.02	M
54	Barra da Lagoa (3)	34'27,9"	25'15,0"	2.62	FS	0.37	WS	-0.07	AS	0.94	M
55	Prainha da Barra da Lagoa	34'26,8"	25'14,8"	2.48	FS	0.38	WS	-0.07	AS	0.86	P
56	Galheta (1)	35'26,9"	25'20,2"	2.61	FS	0.35	VWS	-0.27	N	0.88	P
56	Galheta (2)	35'30,0"	25'29,3"	2.58	FS	0.32	VWS	-0.18	N	0.77	P
56	Galheta (3)	35'35,5"	25'36,3"	2.40	FS	0.37	WS	-0.02	AS	0.92	M
57	Mole (1)	35'56,5"	25'46,3"	0.87	CS	0.39	WS	0.00	AS	0.93	M
57	Mole (2)	36'03,8"	25'54,1"	1.13	MS	0.37	WS	-0.14	N	1.00	M
57	Mole (3)	36'18,2"	26'03,6"	1.37	MS	0.55	MWS	0.12	P	1.07	M
58	Rendeiras (1)	36'29,5"	26'30,5"	1.32	MS	0.56	MWS	0.10	P	1.04	M
58	Rendeiras (2)	36'33,1"	26'59,4"	2.55	FS	0.35	VWS	-0.25	N	0.92	M
58	Rendeiras (3)	36'20,8"	27'44.5"	2.54	FS	0.30	VWS	-0.16	N	0.75	P
59	Gravatá	36'49,7"	25'56,5"	1.64	MS	1.13	PS	-0.23	N	0.69	P

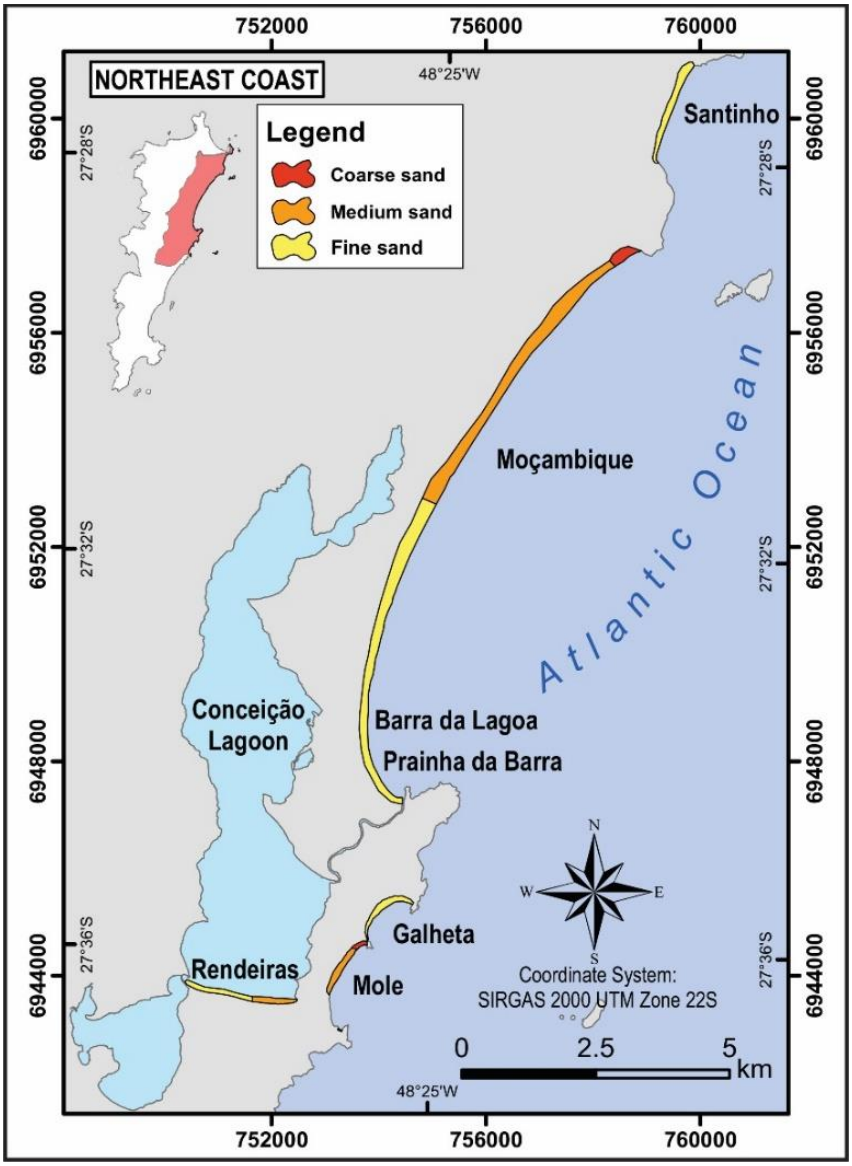

Figure 11. Geographic location and granulometry of the eight sandy beaches of the Northeast coast.

As for the asymmetry (Table 4, columns E and F), the values ranged from -0.27 (N) on the Galheta beach (point No. 56, sample No. 91) to 0.31 (VP), on the Moçambique beach (point No. 53, sample No. 79). Of the total samples, 11 were classified as approximately symmetrical (AS); 10 samples as negative (N); three samples as positive (P), and one sample as very positive (VP).

As for the kurtosis (Table 4, columns G and H), the values ranged from 0.69 (P), on the Gravatá beach (point No. 59, sample No. 100) to 1.33 (L) on the Moçambique beach (point No. 53, sample No. 85). The average value of the kurtosis was 0.94 (M). Of the total samples, 11 samples were classified as platykurtic (P); 10 samples as mesokurtik (M), and four samples as leptokurtic (L). These results are related to the literature (Miot Da Silva et al., 2008; Heidrich, 2011).

Southeast coast

As for the mean grain diameter (Table 5, columns A and B), seven samples were classified as fine sand (FS); seven samples as medium sand (MS), and four samples as coarse sand (CS). The values ranged from 0.13 Ø (CS), on the Armação beach (point No. 65, sample No. 110) to 2.67 Ø (FS) at the Matadeiro beach (point No. 66, sample No. 115). The average value of the mean grain diameter was 1.64 Ø (MS) (Figure 12), taking the Campeche beach (point No. 61, sample No. 104) as an example of this coast.

Table 5. Granulometric data of 18 samples from eight beaches on the Southeast coast of the Santa Catarina Island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
60	Joaquina (1)	37'44,7"	26'54,6"	2.35	FS	0.34	VWS	0.11	P	0.95	M
60	Joaquina (2)	39'04,4"	28'02,0"	1.30	MS	0.92	MS	0.40	VP	0.64	VP
61	Campeche (1)	40'32,9"	28'42,8"	1.90	MS	0.48	WS	-0.15	N	0.77	P
61	Campeche (2)	41'20,6"	28'51,2"	1.37	MS	0.68	MWS	0.01	AS	0.89	P
62	Morro das Pedras (1)	41'33,5"	28'56,3"	2.50	FS	0.32	VWS	-0.01	AS	0.73	P
62	Morro das Pedras (2)	42'23,7"	29'51,5"	0.31	CS	0.60	MWS	0.18	P	0.99	M
62	Morro das Pedras (3)	43'00,8"	30'10,7"	0.67	CS	0.63	MWS	0.13	P	0.89	P
63	Peri Norte	43'31,5"	30'29,8"	1.75	MS	0.50	MS	-0.11	N	0.85	P
64	Peri Sul	44'17,0"	30'58,1"	1.61	MS	0.65	MWS	-0.12	N	0.91	M
65	Armação (1)	43'25,4"	30'18,6"	0.13	FS	0.58	MWS	-0.07	AS	1.17	L
65	Armação (2)	44'17,3"	30'27,4"	0.22	MS	0.63	MWS	0.11	P	1.09	M
65	Armação (3)	44'58,4"	30'08,9"	2.07	CS	0.74	MS	-0.36	VN	1.18	L
66	Matadeiro (1)	45'05,3"	30'03,5"	2.56	CS	0.34	VWS	-0.06	AS	0.79	P
66	Matadeiro (2)	45'17,2"	29'53,2"	2.60	FS	0.38	WS	-0.12	N	0.95	M
66	Matadeiro (3)	45'23,5"	29'48,2"	2.67	FS	0.35	VWS	-0.08	AS	1.07	M
67	Lagoinha do Leste (1)	46'09,2"	28'57,5"	2.13	FS	0.48	WS	-0.29	N	1.09	M
67	Lagoinha do Leste (2)	46'27,4"	29'06,1"	1.77	MS	0.52	MWS	-0.12	N	0.80	P
67	Lagoinha do Leste (3)	46'32,3"	29'15,6"	1.63	MS	0.62	MWS	-0.10	N	0.89	P

As for the standard deviation (Table 5, columns C and D), the values ranged from 0.32 Ø (VWS), at the Morro das Pedras beach (point No. 62, sample No. 105) to 0.92 Ø (MS), on the Joaquina beach (point No. 60, sample No. 102). The average value of the standard deviation was 0.54 Ø (MWS). Of the total samples, eight samples were classified as moderately well sorted (WS); four samples as very well sorted (VWS); three samples as moderately sorted (MS), and three samples as well sorted (WS).

As for the asymmetry (Table 5, columns E and F), the values ranged from -0.36 (VN) on the Armação beach (point No. 65, sample No. 112) to 0.40 (VP) on the Joaquina beach (point No. 60, sample No. 102). Of the total samples, seven were classified as negative (N); five samples as approximately symmetric (AS); four samples as positive (P); one sample as very positive (VP), and one sample as very negative (VN).

As for the kurtosis (Table 5, columns G and H), the values ranged from 0.73 (P), on the Morro das Pedras beach (point No. 62, sample No. 105) to 1.18 (L) on the Armação beach (point No. 65, sample No. 112). The average value of the kurtosis was 0.94 (M). Of the total samples, eight samples were classified as platykurtic (P); seven samples as mesokurtik (M); two samples as leptokurtic (L), and one sample as very platykurtic (VP). These average values corroborate the work of Broggio (2015), Ferreira (2019) e Gomes (2020).

South coast

As for the mean grain diameter (Table 6, columns A and B), all 13 samples were classified as fine sand (FS). The values ranged from 2.12 Ø (FS), on the Saquinho beach (point No. 71, sample No. 128) to 2.89 Ø (FS) at the Pântano do Sul beach (point No. 68, sample No. 119). The average value of the mean grain diameter was 2.39 Ø (FS) (Figure 13), taking the Pântano do Sul beach (point No. 68, sample No. 119) as an example of this coast.

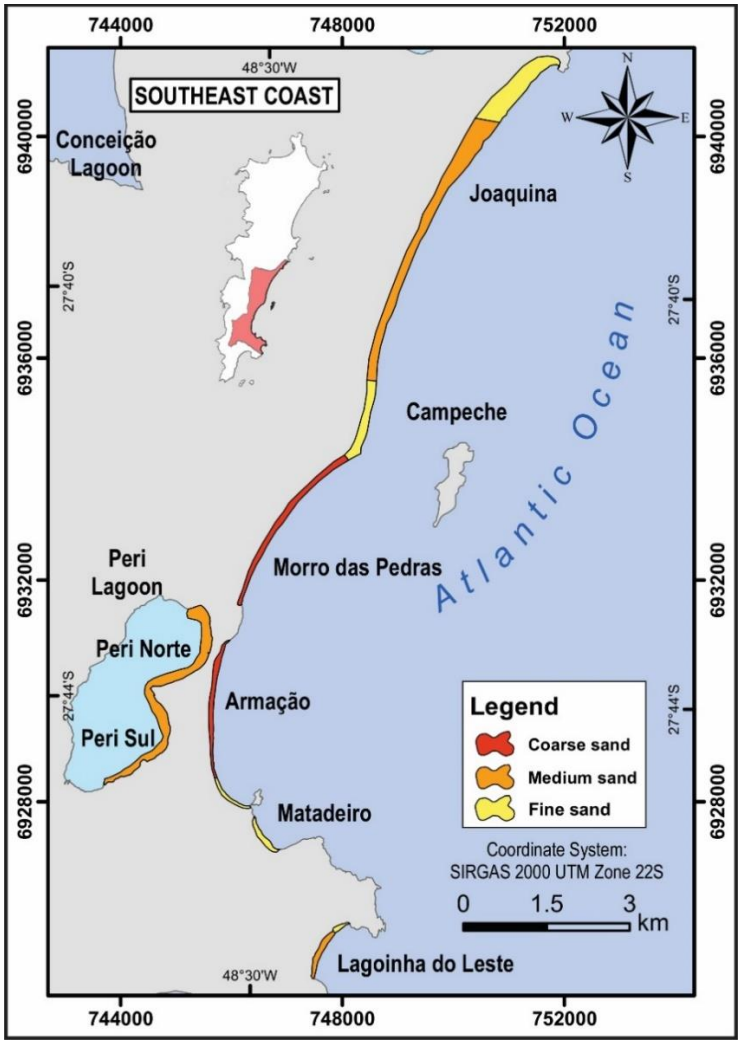

Figure 12. Geographic location and granulometry of the eight sandy beaches of the Southeast coast.

Table 6. Granulometric data of 13 samples from five beaches on the South coast of the Santa Catarina island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
68	Pântano do Sul (1)	46'46,8"	30'29,2"	2.89	FS	0.52	MWS	0.06	AS	0.95	M
68	Pântano do Sul (2)	46'49,3"	30'47,7"	2.38	FS	0.36	WS	0.09	AS	0.91	M
68	Pântano do Sul (3)	46'53,1"	31'11,9"	2.25	FS	0.32	VWS	0.04	AS	1.34	L
69	Açores (1)	46'55,1"	31'17,4"	2.20	FS	0.38	WS	-0.06	AS	1.13	L
69	Açores (2)	47'05,0"	31'30,1"	2.25	FS	0.31	VWS	0.04	AS	1.37	L
69	Açores (3)	47'19,1"	31'45,7"	2.23	FS	0.33	VWS	-0.03	AS	1.35	L
70	Solidão (1)	47'31,5"	31'55,7"	2.18	FS	0.43	WS	-0.04	AS	1.01	M
70	Solidão (2)	47'35,6"	31'59,5"	2.37	FS	0.42	WS	-0.05	AS	0.93	M
70	Solidão (3)	47'43,0"	32'04,8"	2.40	FS	0.40	WS	-0.03	AS	0.93	M
71	Saquinho	48'11,0"	32'06,9"	2.12	FS	0.54	MWS	-0.07	AS	1.02	M
72	Naufragados (1)	50'06,8"	33'35,8"	2.68	FS	0.33	VWS	-0.13	N	1.27	L
72	Naufragados (2)	49'57,9"	33'54,6"	2.48	FS	0.32	VWS	0.03	AS	0.93	M
72	Naufragados (3)	49'59,3"	33'45,7"	2.64	FS	0.31	VWS	-0.28	N	0.92	M

As for the standard deviation (Table 6, columns C and D), the values ranged from 0.31 Ø (VWS), at the Açores beach (point No. 69, sample No. 123) and Naufragados beach (point No. 72, sample No. 131) to 0.54 Ø (MWS), on the Saquinho beach (point No. 71, sample No. 128). The average value of the standard deviation was 0.38 Ø (WS). Of the total samples, six samples were classified as very well sorted (VWS); five samples as well sorted (WS), and two samples as moderately sorted (MS).

As for the asymmetry (Table 6, columns E and F), the values ranged from -0.28 (N) on the Naufragados beach (point No. 72, sample No. 131) to 0.09 (AS) on the Pântano do Sul beach (point No. 68, sample No. 120). Of the total samples, 11 samples were classified as approximately symmetrical (AS) and two samples as negative (N).

As for the kurtosis (Table 6, columns G and H), the values ranged from 0.91 (M), on the Pântano do Sul beach (point No. 68, sample No. 120) to 1.37 (L) on the Açores beach (point No. 69, sample No. 123). The average value of the kurtosis was 0.97 (M). Of the total samples, eight samples were classified as mesokurtik (M) and five samples as leptokurtic (L). These average values corroborate the work of Broggio (2015), Ferreira (2019) e Gomes (2020).

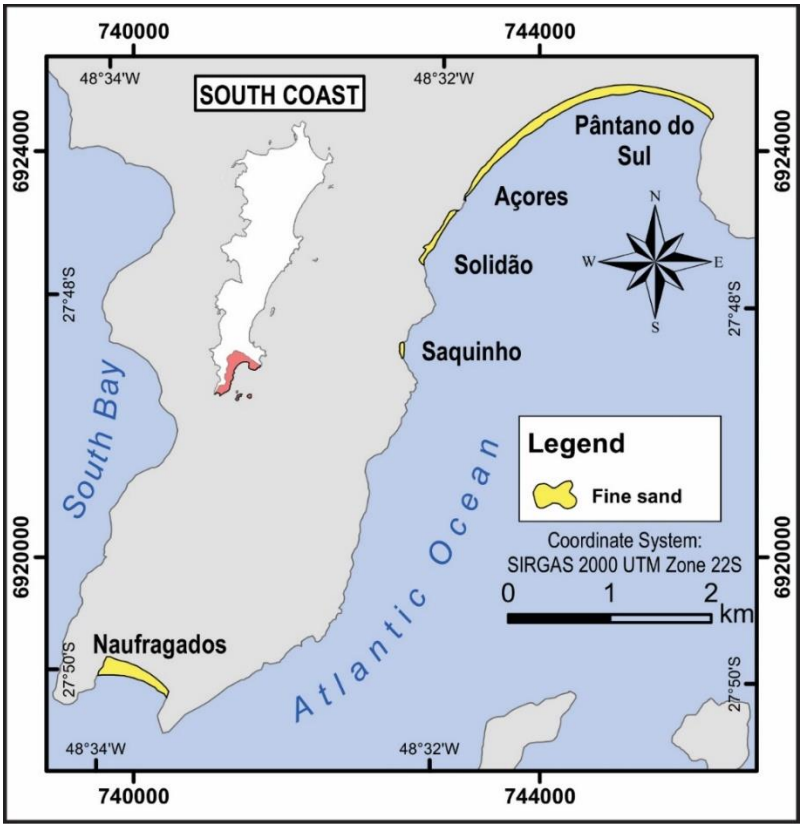

Figure 13. Geographic location and granulometry of the five sandy beaches of the South coast.

Southwest coast

As for the mean grain diameter (Table 7, columns A and B), the values ranged from 0.01 Ø (CS) on the Laranjeiras beach (point No. 102, sample No. 167) to 2.63 Ø (FS) at the Taperinha beach (point No. 78, sample No. 137). The average value of the mean grain diameter was 0.96 Ø (CS), taking the Fora beach (point No. 82, sample No. 142) as an example of this coast (Figure 14). Of the total samples, 37 samples were classified as coarse sand (CS); 16 samples as medium sand (MS), and eight samples as fine sand (FS),

As for the standard deviation (Table 7, columns C and D), the values ranged from 0.36 Ø (WS), at the Taperinha beach (point No. 78, sample No. 137) to 1.61 Ø (PS), on the Pedra Grande beach (point No. 101, sample No. 166). The average value of the standard deviation was 0.94 Ø (MS). Of the total samples, 26 samples were classified as poorly sorted (PS); 15 samples as moderately sorted (MS); 15 samples as moderately well sorted (MWS) and five samples as well sorted (WS).

As for the asymmetry (Table 7, columns E and F), the values ranged from -0.72 (VN) on the Scuna beach (point No. 116, sample No. 191) to 0.51 (VP) on the Croa da Ilha beach (point No. 97, sample No. 162). Of the total samples, 20 samples were classified as approximately symmetric (AS); 17 samples as negative (N); 12 samples as positive (P); 10 samples as very negative (VN), and two samples as very positive (VP).

As for the kurtosis (Table 7, columns G and H), the values ranged from 0.62 (VP), on the Caieira da Barra do Sul beach (point No. 74, sample No. 133) to 1.74 (VL) on the Airport beach (point No. 111, sample No. 182). The average value of the kurtosis was 1.01 (M). Of the total samples, 21 samples were classified as platykurtic (P); 21 samples as mesokurtic (M); 10 samples as leptokurtic kurtosis (L); five samples as very leptokurtic (VL), and four samples as very platykurtic (VP). These results are related to the literature Theisges (2018) e Heidrich (2011).

Table 7. Granulometric data of 61 samples from 45 beaches on the South coast of the Santa Catarina Island.

NO.	Beach (sample)	27°	48°	A	B	C	D	E	F	G	H
73	Defunto	48'52,2"	33'35,1"	0.05	CS	1.05	PS	0.18	P	1.22	L
75	Prainha da Caieira	48'35,2"	33'34,3"	2.53	FS	0.46	WS	-0.16	N	1.04	M
76	Grande	48'19,6"	33'43,2"	1.81	MS	1.00	MS	-0.07	AS	0.67	VP
77	Ponta do Sinal	48'07,6"	33'56,5"	2.40	FS	0.43	WS	0.05	AS	0.98	M
79	Tapera da Barra Sul	47'04,6"	33'56,6"	2.14	FS	0.63	MWS	-0.16	N	0.82	P
80	Sinhá	46'54,2"	34'14,4"	0.99	CS	1.33	PS	-0.21	N	0.90	P
81	Caiacangaçú	46'17,6"	34'22,5"	0.48	CS	0.81	MS	-0.33	VN	1.09	M
82	Fora (1)	46'01,1"	34'23,7"	0.12	CS	0.77	MS	-0.18	N	0.83	P
82	Fora (2)	45'55,1"	34'01,1"	0.40	CS	1.46	PS	0.00	AS	0.79	P
82	Fora (3)	45'49,0"	34'44,7"	1.19	MS	0.88	MS	-0.19	N	1.58	VL
83	Ponta (1)	45'39,2"	34'38,5"	0.90	CS	0.66	MWS	0.14	P	0.96	M
83	Ponta (2)	45'36,6"	34'21,8"	0.64	CS	0.58	MWS	-0.12	N	1.12	L
83	Ponta (3)	45'33,6"	34'16,6"	2.61	FS	0.59	MWS	-0.39	VN	1.62	VL
83	Ponta (4)	45'31,1"	34'10,0"	0.26	CS	0.96	MS	0.04	AS	0.78	P
84	Pracinha do Ribeirão	45'19,4"	33'59,2"	0.21	CS	0.57	MWS	-0.13	N	1.09	M
85	Marcelino	45'06,8"	33'38,1"	0.45	CS	0.81	MS	-0.17	N	0.87	P
86	Três Patos	44'58,8"	33'32,4"	0.91	CS	0.61	MWS	-0.24	N	0.98	M
87	Garapuvu	44'29,8"	33'30,0"	1.64	MS	0.49	WS	0.18	P	0.92	M
88	Itaqui	44'24,5"	33'27,9"	0.52	CS	0.94	MS	-0.19	N	0.75	P
89	Doutor Ivo	44'10,1"	33'39,4"	0.66	CS	0.62	MWS	-0.21	N	1.17	L
90	Recanto	43'51,2"	33'42,9"	0.44	CS	0.79	MS	-0.28	N	1.43	L
91	Ascan	43'39,4"	33'47,4"	0.15	CS	0.75	MS	-0.02	AS	0.87	P
92	Ribeirão Sul	43'24,8"	33'46,7"	0.55	CS	0.48	WS	-0.03	AS	1.03	M
93	Ribeirão Norte	43'07,3"	33'49,6"	0.33	CS	0.65	MWS	-0.10	AS	0.88	P
94	Freguesia do Ribeirão	42'57,2"	33'45,7"	0.22	CS	0.68	MWS	-0.01	AS	0.97	M
95	Bambuzal	42'39.9"	33'35.6"	1.49	MS	0.84	MS	0.03	AS	0.95	M
96	Saco (1)	41'51,4"	33'09,1"	0.85	CS	1.43	PS	-0.16	N	0.66	VP
96	Saco (2)	41'38,6"	33'00,6"	1.33	MS	1.28	PS	-0.28	N	0.96	M
97	Croa da Ilha	41'47,5"	33'43,9"	0.95	CS	1.44	PS	0.51	VP	1.10	M
98	Prainha da Ilha	41'39,2"	33'53,4"	0.78	CS	1.48	PS	-0.03	AS	0.64	VP
99	Flechas	41'36,4"	33'54,6"	0.11	CS	1.54	PS	0.14	P	0.75	P
100	Garcia	41'32,7"	33'58,7"	0.42	CS	1.15	PS	-0.23	N	0.77	P
101	Pedra Grande	41'30,6"	34'01,0"	0.18	CS	1.61	PS	0.18	P	0.81	P
102	Laranjeiras	41'28,3"	34'00,9"	0.01	CS	0.95	MS	0.01	AS	0.87	P
103	Tapera Sul	41'24,8"	33'56,7"	0.51	CS	1.20	PS	-0.02	AS	1.06	M
104	Tapera (1)	41'21,7"	33'59,0"	0.47	CS	1.02	PS	0.18	P	1.10	M
104	Tapera (2)	41'16,5"	34'04,8"	1.04	MS	0.76	MS	0.34	VP	1.45	L
104	Tapera (3)	41'14,0"	34'11,0"	0.09	CS	1.03	PS	0.19	P	1.00	M
105	Albatroz	41'04,6"	34'17,4"	0.33	CS	0.95	MS	0.03	AS	0.83	P
106	Pelicano	40'56,3"	34'11,3"	0.44	CS	1.18	PS	0.26	P	0.82	P
107	Vila Sul	40'54,3"	34'09,2"	0.18	CS	1.30	PS	0.12	P	0.84	P
108	Vila Norte	40'53,0"	34'08,7"	0.30	CS	0.88	MS	-0.20	N	0.97	M
109	Base Aérea (1)	40'42,0"	33'59,5"	0.36	CS	1.11	PS	-0.01	AS	0.90	P
109	Base Aérea (2)	40'42,9"	33'58,8"	1.84	MS	0.68	MWS	-0.07	AS	0.86	P
109	Base Aérea (3)	40'32,1"	34'03,6"	1.21	MS	0.61	MWS	0.14	P	1.68	VL
109	Base Aérea (4)	40'28,5"	34'10,7"	0.28	CS	0.89	MS	-0.03	AS	0.87	P
110	Prainha da Caiacanga-Mirim	40'22,8"	34'11,3"	1.94	MS	0.53	MWS	-0.05	AS	1.21	L
111	Aeroporto (1)	40'21,7"	34'07,3"	1.69	MS	1.36	PS	-0.56	VN	1.02	M
111	Aeroporto (2)	40'10,6"	33'57,4"	1.88	MS	0.66	MWS	-0.19	N	1.74	VL
111	Aeroporto (3)	40'04,4"	33'50,7"	0.12	CS	1.38	PS	0.22	P	0.69	P
111	Aeroporto (4)	39'56,2"	33'45,8"	1.53	MS	1.18	PS	-0.36	VN	1.12	L
111	Aeroporto (5)	39'42,7"	33'40,2"	1.22	MS	1.55	PS	-0.34	VN	0.77	P
111	Aeroporto (6)	39'36,2"	33'39,3"	1.30	MS	1.06	PS	-0.31	VN	1.41	L
112	Curtume	36'49,4"	32'37,8"	0.69	CS	0.68	MWS	0.13	P	0.95	M
113	José Mendes	36'46,6"	32'48,3"	0.65	CS	1.11	PS	-0.01	AS	0.92	M
114	Iate Clube	36'23,4"	32'54,5"	1.09	MS	1.34	PS	-0.34	VN	0.92	M
115	Remo	35'44,1"	33'37,2"	2.20	FS	1.01	PS	-0.53	VN	1.61	VL
116	Scuna	35'37,4"	33'44,2"	2.57	FS	1.00	PS	-0.72	VN	1.44	L
117	Ponte	35'35,1"	33'44,3"	1.35	MS	0.60	MWS	0.07	AS	1.19	L

The coasts

Considering the standard deviation, of a total of 192 samples collected, 50 samples belong to the well-sorted (WS) class; 40 samples to the very well sorted (VWS) class. The average value of the standard deviation considering 192 samples was 0.58 Ø (MWS). The very poorly sorted (VPS) and extremely poorly sorted (EPS) classes were not mapped on the Santa Catarina Island. Of a total of 95 samples collected on the NW and SW coasts, facing the Florianópolis bay, 35 samples belong to the poorly sorted (PS) class; 29 samples to the moderately sorted (MS) class, 25 samples to the moderately well sorted (MWS) class and six

samples to the well-sorted (WS) class. The average value was 0.89 Ø (MS). Of a total of 43 samples collected on the NE and SE coasts, facing the Atlantic Ocean, 13 samples belong to the very well-sorted class (VWS); 13 samples to the moderately well sorted (MWS) class; 11 samples to the well-sorted (WS) class, five samples to the moderately sorted (MS) class and one sample to the poorly sorted (PS) class. The average value was 0.50 Ø (WS). Of a total of 54 samples collected on the N and S coasts, facing the Canasvieiras/Jurerê and Pântano do Sul bays, 33 samples belong to the well-sorted class (WS), 19 samples to the very well sorted (VWS) class, and two samples to the moderately well sorted (MWS) class. The average value was 0.37 Ø (VWS). The very poorly sorted (VPS) and extremely poorly sorted (EPS) classes were not mapped on the Santa Catarina Island.

Concerning the asymmetry, of a total of 192 samples collected, 91 samples belong to the approximately symmetrical (AS) class; 55 samples to the negative (N) class; 29 samples to the positive (P) class; 13 samples to the very negative (VN) class and four samples to the very positive (VP) class. Of a total of 95 samples collected on the NW and SW coasts, facing the Florianópolis bay, 35 samples belong to the approximately symmetrical (AS) class; 28 samples to the negative (N) class, 18 samples to the positive (P) class and two samples to the very positive (VP) class. Of a total of 43 samples collected on the NE and SE coasts, facing the Atlantic Ocean, 17 samples belong to the negative (N) class; 16 samples to the approximately symmetrical (AS) class; seven samples to the positive (P) class, two samples to the very positive (VP) class and one sample to the very negative (VN) class. Of a total of 54 samples collected on the N and S coasts, facing the Canasvieiras/Jurerê and Pântano do Sul bays, 40 samples belong to the approximately symmetrical (AS) class, ten samples to the negative (N) class, and four samples to the positive (P) class.

About the kurtosis, of a total of 192 samples collected, 73 samples belong to the platykurtic (P) class; 73 samples to the mesokurtic (M) class; 34 samples to the leptokurtic (L) class; seven samples to the very leptokurtic (VL) class and five samples to the very platykurtic (VP) class. The average value of the kurtosis considering 192 samples was 0.96 (M). The extremely leptokurtic (EL) class was not mapped on the Santa Catarina island. Of a total of 95 samples collected on the Campeche, Morro das Pedras, Peri Norte, Armação, Matadeiro, and Lagoinha do Leste, on NW and SW coasts, facing the Florianópolis bay, 37 samples belong to the mesokurtic (M) class; 34 samples to the platykurtic (P) class, 13 samples to the leptokurtic (L) class, seven samples to the very leptokurtic (VL) class, and four samples to the very platykurtic (VP) class. The average value was 0.99 (M). Of a total of 43 samples collected on the NE and SE coasts, facing the Atlantic Ocean, 19 samples belong to the platykurtic (P) class; 17 samples to the mesokurtic (M) class; six samples to the leptokurtic (L) class and one sample to the very platykurtic (VP) class. The average value was 0.93 (M). Of a total of 54 samples collected on the N and S coasts, facing the Canasvieiras/Jurerê and Pântano do Sul bays, 20 samples belong to the platykurtic (P) class, 19 samples to the mesokurtic (M) class, and 15 samples to the leptokurtic (L) class. The average value was 0.97 (M).

In short, the 117 beaches of the Santa Catarina island present the predominance of fine sand (FS), well-sorted (WS), approximately symmetrical (AS), platykurtic (P), and mesokurtic (M). The analysis of the main granulometric characteristics allowed the grouping of the six coasts into four distinct domains (Figure 15): (1) Eastern domain, of high wave energy, typical of Northeast and Southeast coasts; (2) Western domain, enclosing beaches protected from the wave energy, typical of Northwest and Southwest coasts; (3) Northern and Southern domains, enclosing beaches of the North and South coasts, semi-exposed to wave energy, situated in the vicinity of the Canasvieiras/Jurerê and Pântano do Sul bays, respectively.

The (1) Eastern domain represents the 16 beaches facing the Atlantic Ocean, highlighted by sediment supply to a well-developed coastal plain, represented by sediments of continental and transitional origin. These sediments were and are being deposited among rocky massifs and isolated nucleus of the crystalline basement. This domain has granulometric heterogeneity, with a predominance of medium sand (fine to coarse sand), in addition to variable slope, width, and length. Well-sorted to moderately sorted, approximately symmetrical to negative and mesokurtic sediments are predominant. Lagoon beaches on the shores of the Conceição Lagoon and Peri Lagoon are also present. The beaches that stand out in this domain are Santinho, Moçambique, Barra da Lagoa, Galheta, Mole and Rendeiras, on the Northeast coast, and Joaquina, the Southeast coast.

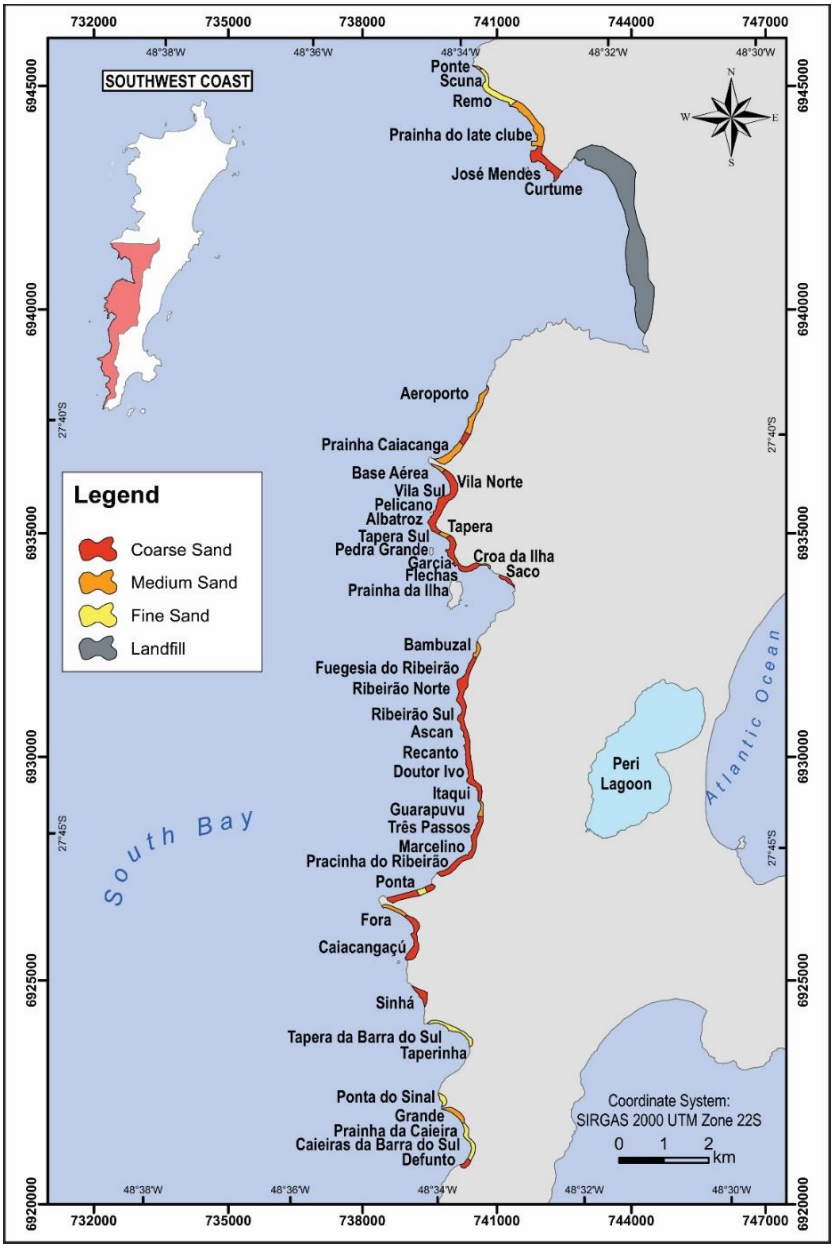

Figure 14. Geographic location and granulometry of the 45 sandy beaches of the Southwest coast.

The (2) Western domain represents the 75 beaches facing the Florianópolis bay on a rocky coast that borders the waters of the North and South bays, whose oceanographic agents (waves and currents) are typical of low-energy environments. This stretch is also characterized by beach marine deposits, narrow, adjacent at the rear, of the hillslopes with stretches quite deforested by the mangroves, also very changed. This domain presents a predominance of coarse sand, steep slopes, and small dimensions (width and length). Moderately sorted, approximately symmetrical, and mesokurtic sediments are predominant. The number of beaches (75 beaches) is higher when compared to other areas, although its dimensions are smaller. The main beaches that stand out in this domain are São Luiz, Cacupé Grande, Comprida, Santo Antônio de Lisboa and Sambaqui, on the Northwest coast, and Caieiras da Barra do Sul, Fora, Ponta, Ribeirão Sul, Ribeirão Norte, and Tapera, on the Southwest coast.

The (3) Northern and Southern domains represent two areas of transition between oceanic and protected beaches. These transitional stretches, one located north of the Santa Catarina island, facing the bays of Jurerê, Canasvieiras, and Ingleses, at the mouth of the North bay, and another in the south of the island, facing the bay of Pântano do Sul and its vicinity, at the mouth of the South bay, represent semi-exposed beaches. The beaches of the North coast are exposed to wave action from

the north and northeast quadrants, while in the South coast there is a predominance of wave action from the south and southeast quadrants. Localized stretches of these domains are subject to high wave energy. The beaches stand out for presenting a granulometric uniformity, with a predominance of fine sand and, therefore, a low slope. Predominant sediments are well to very well sorted, approximately symmetrical, ranging from mesokurtic to platykurtic. The main beaches that stand out in these domains are Daniela, Forte, Jurerê Internacional, Jurerê, Canasvieiras, Cachoeira do Bom Jesus, Ponta das Canas, Lagoinha, Brava and Ingleses, on the North coast, and Pântano do Sul, Açores, Solidão, and Naufragados, on the South coast.

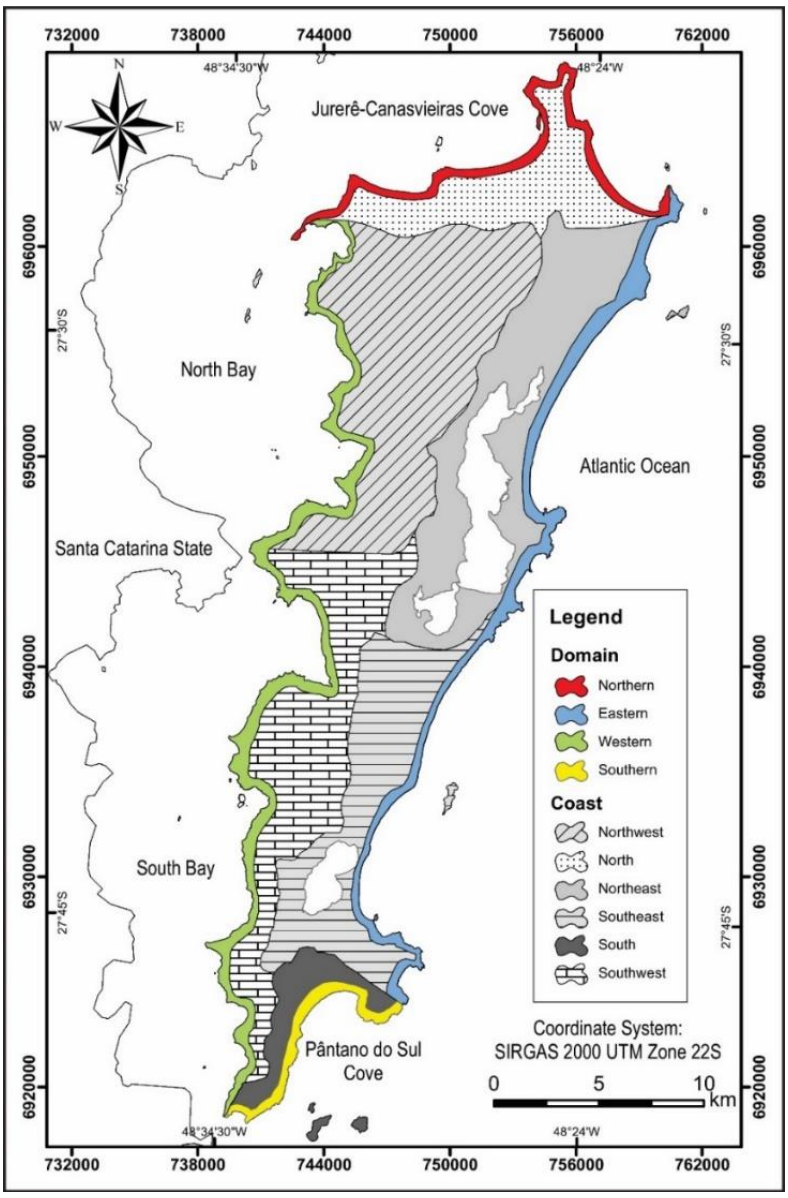

Figure 15. Coastal domains of the Santa Catarina Island based on granulometric parameters.

Conclusion

The collection of 192 samples of sediments along 88km of sandy beaches of the Santa Catarina Island and subsequent laboratory analysis enabled identifying the major granulometric characteristics of the beach sands of the island.

According to the previous criterion of distinction of sectors, in the 30 beaches of the Northwest coast predominates coarse sand, moderately sorted, approximately symmetric and mesokurtic. On the North coast the 21 beaches present dominant fine sand, well-sorted, approximately symmetric and mesokurtic. On the Northeast coast, the dominant textural facies of the eight beaches are medium sand, well-sorted,

approximately symmetric, and mesokurtic. On the Southeast coast, in the eight beaches facies predominates medium sand, well-sorted, negative asymmetry, and mesokurtic. On the South coast, the dominant textural facies of the five beaches, is fine sand, well-sorted, approximately symmetric, and mesokurtic. The 45 beaches present dominant coarse sand, moderately sorted, approximately symmetric, and mesokurtic on the Southwest coast.

The granulometric characteristics of the beaches on the Santa Catarina Island are conditioned mainly by the action of hydrodynamic agents associated with the type, orientation, and location of the beach and source area.

Acknowledgement

The authors thank the colleagues Paulo Cesar Leal and João Sérgio de Oliveira for monitoring the sediment collections, and Mr. Nivaldo Nunes and Prof. João Carlos Rocha Gré, Technician and Coordinator of the Sedimentology Laboratory, respectively, for the granulometric analyses performed.

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