



Confins

Revue franco-brésilienne de géographie / Revista franco-brasileira de geografia

39 | 2019
Número 39

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Edição electrónica

URL: <http://journals.openedition.org/confins/18175>

DOI: 10.4000/confins.18175

ISSN: 1958-9212

Editora

Hervé Théry

Refêrencia eletrónica

Flavia Moraes Lins-de-Barros, Thierry Sauzeau e Josefa Varela Guerra, « Historical evolution of seafront occupation in France (Bay of Biscay) and Brazil (Rio de Janeiro) face to coastal erosion vulnerability and risks (19th - 21th centuries) », *Confins* [Online], 39 | 2019, posto online no dia 24 março 2019, consultado o 02 maio 2019. URL : <http://journals.openedition.org/confins/18175> ; DOI : 10.4000/confins.18175

Este documento foi criado de forma automática no dia 2 Maio 2019.



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- 1 Although large-scale direct anthropic intervention on the coastline started centuries ago, it became stronger in the 19th century, with the need to accommodate increasingly larger ships, and the diffusion of the value of beaches as places for sea and sunbathing. However, it is only from the mid-twentieth century on, when tourism activities and urban growth expanded towards the coast, that more significant transformations occur. In



France as in Brazil, beaches have a major value for the coastal societies. The historical

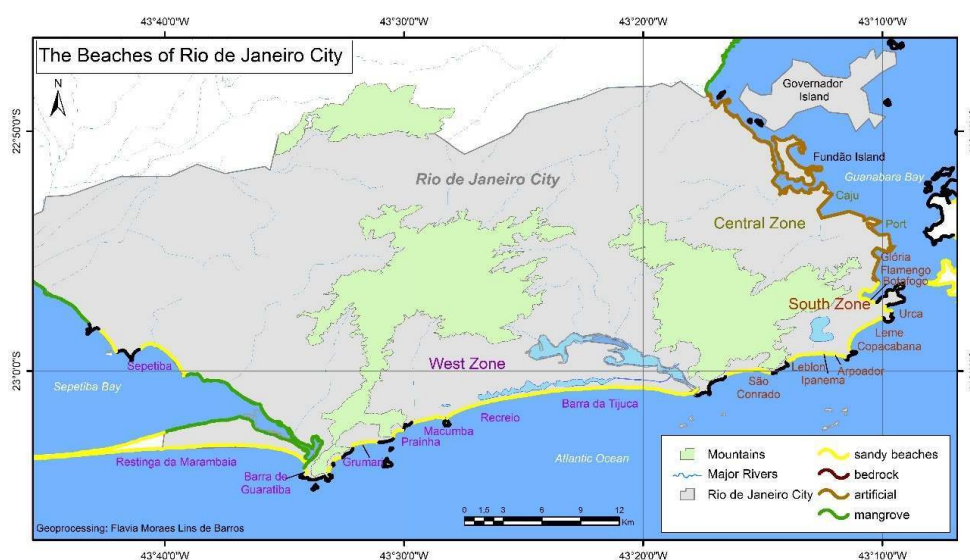
evolution of waterfront occupation of Rio de Janeiro city, in Brazil, and of the Gulf of Biscay, in France, can be compared. First, most of their coastline is made up of sand; second, both areas followed a similar path of transformation of their natural spaces according with the needs created by their occupation. Nowadays, people visiting French or Brazilian waterfronts come from everywhere and, to welcome them, coasts were transformed by a series of interventions that led to the acceleration of beach and dune erosion. Although erosion had always been a natural phenomenon, the growth of beach resorts and of urbanization, created a new reality. Because beaches and dunes constitute a natural system where both elements feed each other with sand, as coastlines became increasingly artificial, coastal erosion and environmental degradation grew substantially.

- In this scenario, the major aim of this article is to propose a reflection on the historical model of seafront occupation and its influence on the construction of vulnerability to coastal erosion by comparing two case studies: the urban beaches of Rio de Janeiro (Brazil) and the Bay of Biscay (France). It will be presented a historical periodization of important moments and events that help to understand the relationship between the culture of sea bathing and the transformations experienced by the coastal landscape from the beginning of the 19th century until nowadays. The focus of this periodization is the connection between both, balnearization and beach value, with the growing artificialization of the coast, the destruction of the native ecosystems and the subsequent construction of vulnerability and risk to erosion in Rio de Janeiro (Brazil) and Gulf of Biscay (France).

Study area: Rio de Janeiro City (Brazil) and Bay of Biscay (France)

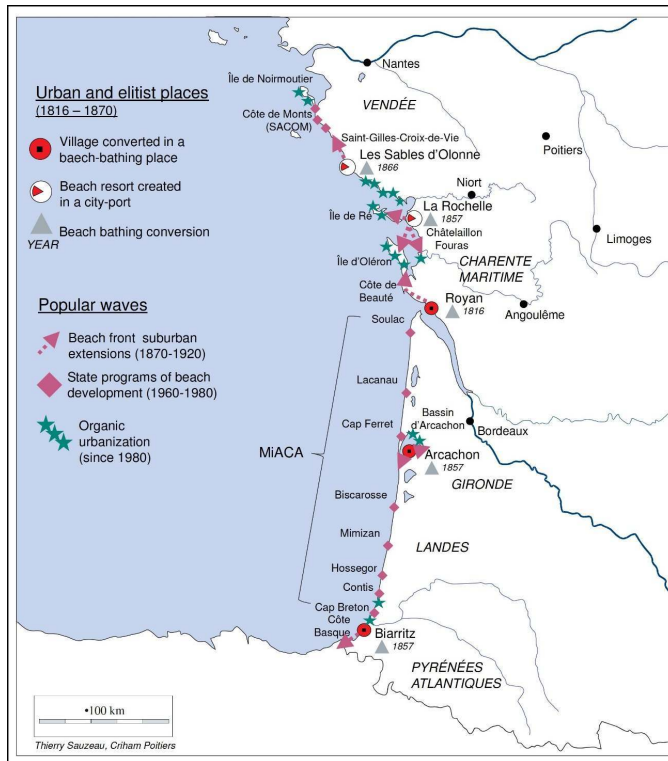
- In Rio de Janeiro, the study area covers beaches located between the city center (the Central Zone, inside Guanabara Bay) and Macumba, an open coast beach on the western limit of the city (Map 1).

Map 1 – Location of Rio de Janeiro beaches between the Central and the West Zones.



- 4 A few beaches were not included in the present work: 1) those located around islands; 2) Grumari, Prainha (two environmentally protected beaches) and Marambaia barrier island (a military area) because they have no significant urban structures; 3) Barra de Guaratiba, a small pocket beach; 4) three beaches located inside Sepetiba bay.
- 5 In Biscay Bay the study covers the coastline from Nantes to the Spanish border. (Map 2).

Map 2 – Historical construction of a seaside coastline: Biscay bay (France, 1815-2010)



- 6 Distinctly from many coastal towns, Rio de Janeiro's economy does not rely exclusively on tourism, being a metropolis with about 6.3 million inhabitants (IBGE, 2010). Compared to Rio de Janeiro city, Biscay bay is less urbanized, but its population is similar: the French region of Nouvelle-Aquitaine has about 6 million inhabitants.
- 7 The two study areas have a long history of occupation, albeit with particular economic and political aspects. The first evidence of human occupation in Rio de Janeiro and its surroundings goes back to prehistoric times, between approximately 4000 and 1800 years A.P., when fishermen-collectors lived on the coast and built shell middens (e. g. Gaspar *et al.*, 2013). This first occupation was followed by the arrival of indigenous groups that populated the region until the arrival of Europeans in the 16th century. But it is only in the nineteenth century, and especially after the arrival of the Portuguese Royal Family in 1808, that the city of Rio de Janeiro begins to transform more significantly its urban and social structure, until then a merchant city whose majority of the population was slave (Abreu, 2013). Throughout the nineteenth century the growth of the coffee and manufacturing industries made the city expand and increase the number of free workers, both domestic and foreign. In 1821 the total population was of approximately 110,000 inhabitants, reaching more than 230,000 inhabitants in 1870. Rio de Janeiro was Brazil's capital from colonial times (1763) until 1960¹.

- 8 The current occupation of the coasts of Biscay Bay began during the Antiquity. The inhabitants were involved in the exchanges of tin between Britain and the Roman Empire (Laporte, 2009). After the tin period, the salt economy was the second stage of the internationalization of the Biscay coastal societies and reached its peak in modern times (Hocquet and Sarrazin, 2006). Around the French revolution the density of people in some areas of Biscay bay was one of the largest of Europe, about 100 inhabitants per km². After the Napoleonic wars (1792-1815) the weakness of the French war fleet, unable to protect fishermen on the banks of Newfoundland, stopped the cod fishing activity in Les Sables d'Olonne, Bayonne and Saint-Jean de Luz, also affecting the salt economy. On the other hand, during modern times, the monopoly of sugar cane plantation gave huge profits to the merchants of Nantes, Bordeaux and La Rochelle (Poussou, Bonnichon and Huetz de Lemps, 1998). But, after 1815, the prohibition of the slave trade and the loss of Saint-Domingue (nowadays Haïti) stopped that economy.
- 9 It is mainly in the second decade of the 19th century that these coastal areas come to experience the English fashion of sea-bathing (Corbin, 1988; Vincent, 2007). For the Bay of Biscay, the arrival of this culture meant a solution that enabled the littoral societies to maintain their historical business. This new habit did not care about marshes or mangroves, but it was interested in wide and natural areas, made of beaches and dunes. Fortunately for touristic and urban development, that kind of landscape was common, both in Biscay bay and Rio de Janeiro.
- 10 Before 1815, Biscay Bay had always been viewed as no man's land, due to the mobility of the shorelines and the risk brought by the sand. Then, since 1815, the growing fashion of sea bathing transformed those areas. The building of estates and waterfronts, the transformation of the shorelines in order to defend them against the sea and finally, the vulnerability of the societies, never stopped to increase. Rio de Janeiro coastline is nowadays largely occupied by high-rises, concentrating the most valuable real estate of the city. Copacabana Beach, for instance, receives near 2 million people for New Year's celebrations. Thus, Rio de Janeiro beaches exhibit both tourism and urban occupation, presenting enormous economic and social value. The coastline went through huge transformations what, combined with frequent sea storms, created new problems related to coastal erosion and vulnerability.

Historical periods of coastline development and related geomorphological changes (1814 - present).

Rio de Janeiro City

- 11 Aiming at presenting a brief history of beach use in Rio de Janeiro, the period between 1814 and the present time was segmented into six historical phases that were associated with a myriad of types of geomorphological changes induced by anthropic interventions.

The first hotels and houses for sea bathing (1814 - 1905)

- 12 The practice of sea bathing started in the early 19th century and, in Rio de Janeiro, it began to be widely diffused after the arrival of the Royal Family in 1808. At first, it was practiced in places where today lie the port area and reclaimed land, such as Caju beach, where the first royal beach hotel was installed, and Santa Luzia beach, attended by

different social classes. In 1814 a Hotel in French style, considered the first Brazilian hotel (Hotel Pharoux), was built in the region where Praça XV is currently located. During the colonial period and extending until the beginning of the 19th century, there was the dock of Valongo, a warehouse of slaves and salt, a place that came to be known as Pedra do Sal (Gerson, 2000).

- 13 In Caju beach, a beautiful bathhouse, nowadays listed as a historical heritage site, was built at the beginning of the 19th century to serve Prince D. João VI, whose doctor recommended sea baths for the healing of wounds caused by tick bites (Gerson, 2000). Santa Luzia beach, from the 18th century until the mid-19th century, was a devaluated and derelict area due to the presence, in its vicinity, of a slaughterhouse, of the gallows of the city and of the cemetery of the of Santa Casa homeless (Gerson, 2000). By 1852 the Santa Luzia area began to be valued with the inauguration of a hospital and the transfer of the cemetery to the district of Caju. In 1859, the German Gymnastics Society was founded on the beach of Santa Luzia and shortly thereafter, the region became the favorite place for regatta clubs and for sea baths (Gerson, 2000; Figure 3). Other bathhouses were built, such as the Deordeu, that in 1900 had 400 rooms, and in 1904 the Fluminense, with 120 rooms (Gaspar, 2004). It is also worth noting that although the central region was the most used for bathing, at the end of the 19th century there were also hotels in the Botafogo embayment that were advertised to travelers seeking bathing services (O'Donnell, 2013), highlighting the touristic function of this region. Flamengo beach was also very popular for bathing. In a report from 1851, American travelers Daniel Parish Kidder and James Cooley Fletcher (Bandeira and Andrade, 1965) describe that even before sunrise a line of men, women, and children arrived at this beach to take a bath and point out that the inhabitants of Rio have a passion for bathing.

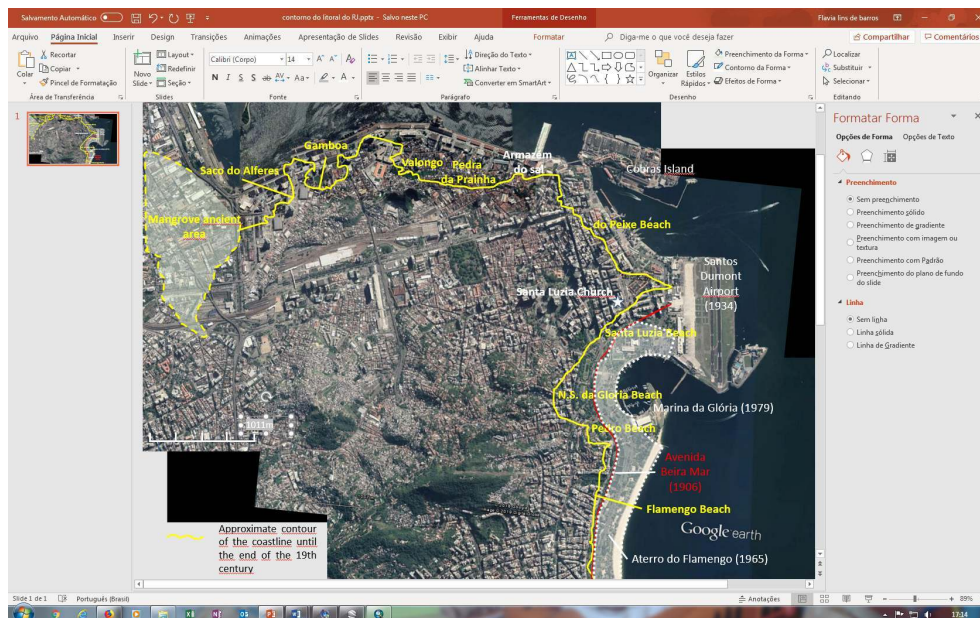
Image 1 - Bathhouse in Santa Luzia beach. Picture taken in the 1910's by Augusto Malta.



Source: Ermakoff (2009).

- 14 The coastline of the Central Zone, comprised between the present city center and the Botafogo embayment (Figure 2), was deeply modified at the beginning of the 20th century. Some of the beaches were extinct due to land reclamation, while others had their contours entirely modified. Sea storms and damages observed in some beaches, as Saúde (Gerson, 2000) and at the shore of Glória beach, encouraged works in the coastline (Adbelhay, 2011).

Image 2 –Composition of the approximate contour of the late 19th century coastline



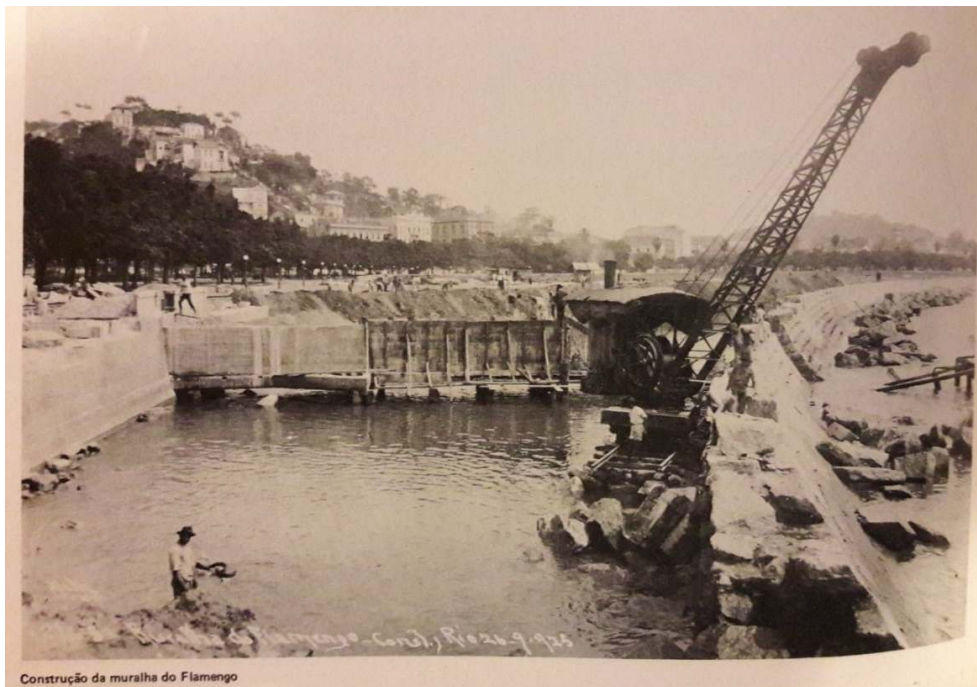
Drawn from a city plan from 1867 and bibliographic sources over a recent satellite image.

Source: Prepared by the authors. Image: Google Earth (2019).

Coastline rectification and land reclamation: the new contour of the sheltered beaches of Guanabara Bay (1906-1922)

- 15 In the first decades of the 20th century, the sinuous contour of the coast between the entrance of Guanabara Bay and Botafogo beach, with small gulfs and pocket beaches, was replaced by a rectified and walled coastline, leaving no room for a strip of sand and the practice of sea bathing. This transformation was carried out for the renovation of the port area and the construction of Avenida Beira Mar, that begun in 1906. These works were part of an enterprise conceived by Mayor Pereira Passos, the *Pereira Passos Reform*. During this time, it was put through the first major land reclamation project using, in part, land taken from the dismantling of Senado and Castelo hills, completed in 1922, as well as the building of the first embankment and a seawall at Flamengo beach (Image 3). During the period of *Pereira Passos Reform*, the first sea storms were documented by photography at Flamengo beach and the Avenida Beira-Mar (Image 4).

Image 3 - Construction of a seawall in Flamengo beach, 1925. Photo: Augusto Malta.



Source: Prefeitura do Rio de Janeiro (1979)

Image 4 – The great sea storm of 1906 at Flamengo Beach (A) and Beira Mar avenue at 1913 (B).



Photos: (1906 and 1913) Source: Ermakoff (2009) and Institute Moreira Salles collection.

- 16 Another major transformation of the coastline was the construction of a new neighborhood, called Urca, located next to the Sugar Loaf (Image 5). This new neighborhood was entirely made by landfill using Guanabara Bay's sand that was thrown upon the cliffs (Image 6). This massive work was important, not only due to its size, or for taking place close to one of the morphological symbols of Rio de Janeiro, the Sugar Loaf, but mainly because it established a new trend of expansion to the south, towards the open coast (Andreatta *et al.*, 2009).

Image 5 – Vermelha beach with Pão de Açúcar, before the Urca landfill (1893).



Photo: Gutierrez, 1893. Source: http://rio-curioso.blogspot.com/2007/08/bairro-da-urca_15.html

Image 6 – Landfill that created the Urca neighborhood (1927).



Source: http://rio-curioso.blogspot.com/2007/08/bairro-da-urca_15.html

The expansion of urbanization to the oceanic beaches (1923-1960)

- 17 In 1923, the Copacabana Palace Hotel was open roughly in the center of the Leme-Copacabana beach, consolidating the idea of urban expansion towards the oceanic beaches, a trend that was followed by the development of the Arpoador-Leblon area (Map 1). From a geomorphological point of view, as well as from that of use and urban

occupation, Copacabana was quite different from the beaches located at the entrance of Guanabara Bay. Only at the end of the 19th century did the city begin to spread towards Copacabana with the construction of a tunnel (known as the Old Tunnel) in 1892, connecting the Botafogo and Copacabana neighborhoods. With the Pereira Passos Reform the open beaches of the city located at South Zone became more accessible and the sea bath of city center zone have become unfeasible to carry out due to the incorporation of the beaches to the port area (O'Donell, 2013). In some photographs it is possible to note that the newly developed area was occupied by fishermen and formed by dune fields that covered the entire coastal plain behind the sandy beaches (Images 7 and 8). On the beach itself, there were foredunes and the sand strip was not very wide. Houses were built close to the beach, resulting in the first known cases of damage to urban structures related to the attack of waves during sea storms (Image 9).

Image 7 – Copacabana Beach at the beginning of 20th century with some boats where there is still a fishermen community.

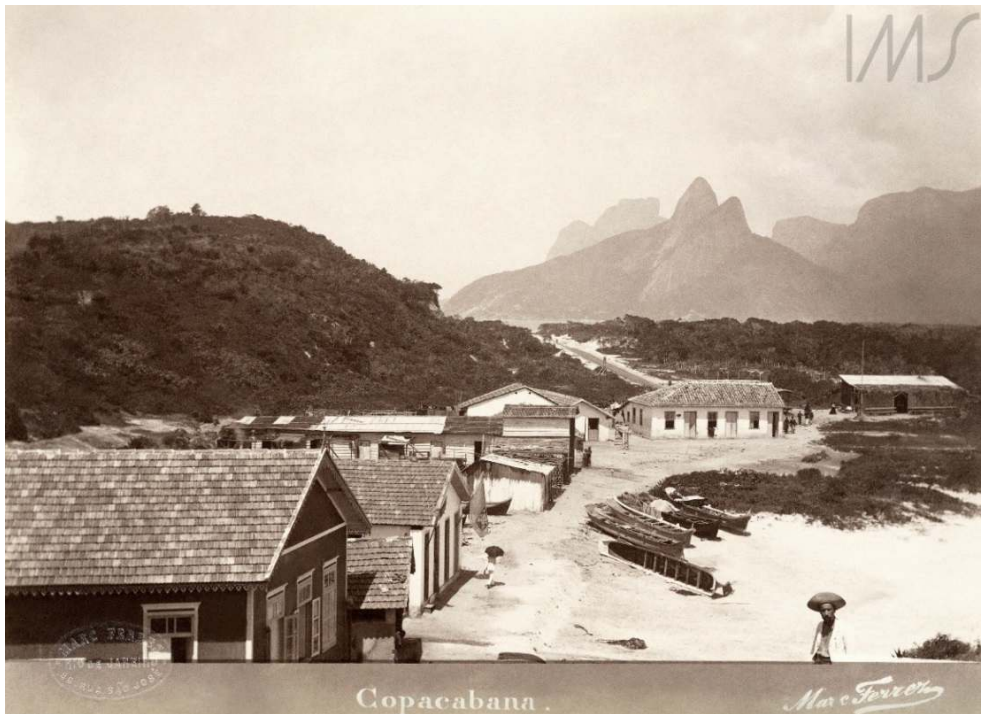
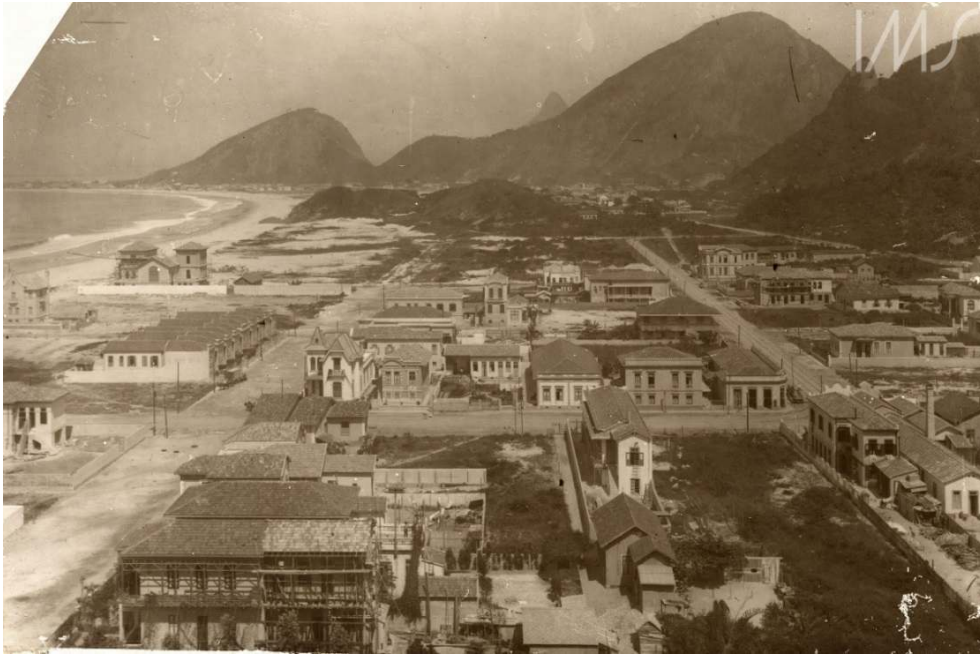


Photo: Marc Ferrez. Source: Instituto Moreira Salles collection.

Image 8 - Copacabana Beach at the beginning of the 20th century



Source: Instituto Moreira Salles collection.

Image 9 – Copacabana beach during a storm with damages and houses at risk. Photo: Augusto Malta (~1920).



Source: Ermakoff (2009).

- 18 In the first two decades of the 20th century, there was still a rarefied urban occupation in Leblon and most of the foredunes were preserved (Image 10). But, by the end of the 1930's Ipanema and Leblon were already developed and land reclamation of Rodrigo de Freitas lagoon had begun (Image 11). Still in the 1930's, a stair-like wall, yet in place, was constructed on the western corner of Leblon beach on top of the strip of sand (Image 12). By this time, there were almost no foredunes or restinga vegetation² in this sector, contrarily to the observed in the remaining of the beach (Image 13).

Image 10 – Leblon beach in 1919. Photo by Augusto Malta.



Source: Ermakoff (2009)

Image 11 – Leblon and Ipanema beaches with Rodrigo de Freitas lagoon in the background (1938).



Source: Collection of the Aerospace Museum.

Image 12: Leblon beach in the 1930's during the construction of the masonry staircase

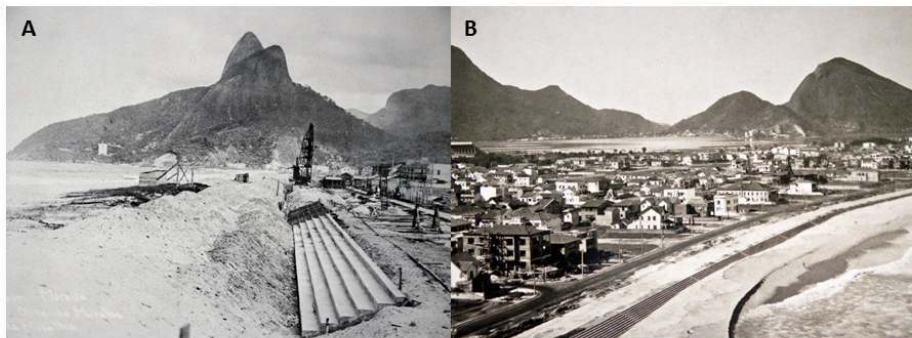


Photo: Augusto Malta (A) and in the 1940's after completion Unknown photographer. (B).
 Source: Prefeitura do Rio de Janeiro (1979) – (A) and Ermarkof (2008) – (B)

Image 13 – Leblon Beach, 1937. Sandy foredunes and typical vegetation still observed.



Photo: Peter Fuss. Source: Ermakoff (2008).

Artificial nourishment of Copacabana beach and the Flamengo landfill (1964-1972)

- 19 This period is marked by two major projects that deeply altered the original layout of the coast. The first project was the construction of Flamengo Park (*Aterro do Flamengo*), a $1,200,000 \text{ m}^2$ landfill created on the edge of Guanabara Bay, between Santos Dumont Airport and Botafogo Creek (Images 2 and 14). The material for the landfill came mostly from the dismantling of a nearby hill and the inauguration of the park occurred in 1965.

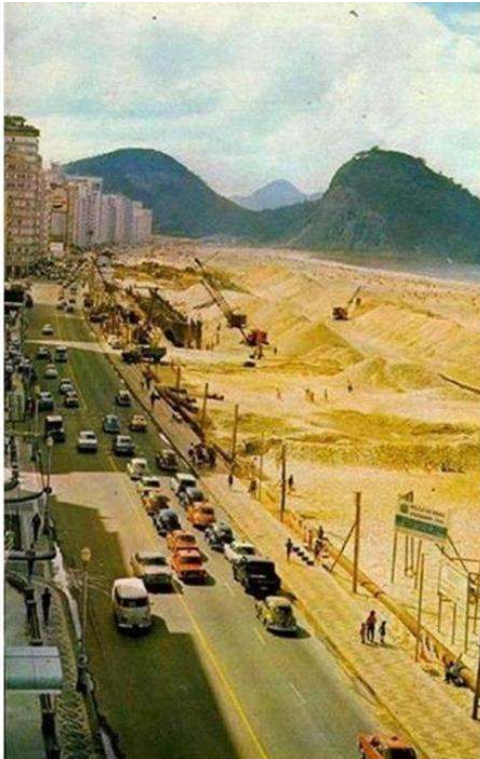
Image 14- Flamengo park construction (1965).



Source: *O Globo* archives - <https://oglobo.globo.com/rio/a-construcao-do-parque-do-flamengo-17736982>.

- 20 The second project was the artificial nourishment of Copacabana beach, initiated in 1970 and concluded two years later (Image 15). The main goal of this project was to ensure the safety of the buildings (Image 16) and of the shore-parallel avenue (Avenida Atlântica), which was duplicated. Approximately 5 million tons of sand was discharged from the Botafogo embayment and from the nearby shelf. After the artificial feeding, beach width increased from an average of 55 m to 90 m (Vera-Cruz, 1972; Image 17). Despite its success, the artificial nourishment did not prevent the occurrence of erosion on the western end of the beach (Image 18).

Image 15 - Copacabana beach during the nourishment carried out between 1970 and 1972.



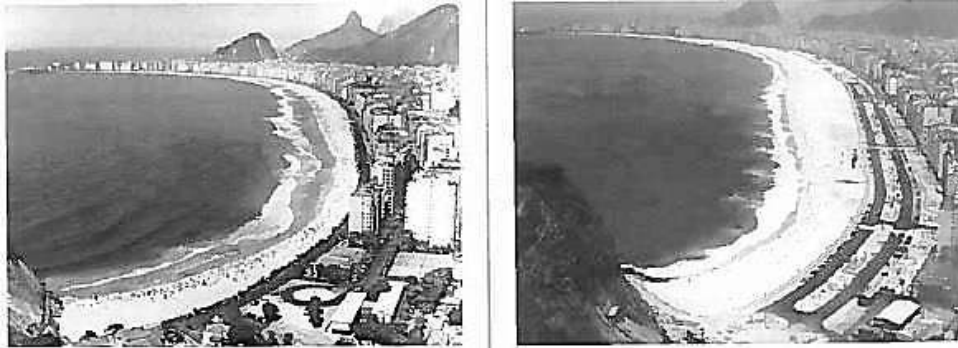
Source: <http://gilfuentes.com.br/novo/wp-content/uploads/2012/11/aterro-copa2.jpg>.

Image 16 - Destruction caused by a sea storm in front of the Copacabana Palace hotel (1920's)



Source: Instituto Moreira Salles.

Image 17 - Copacabana beach before (left) and after (right) artificial nourishment.



Source: Vera-Cruz, 1972.

Image 18 – Western limit (Posto 6) of Copacabana beach and damaged kiosks (2016).

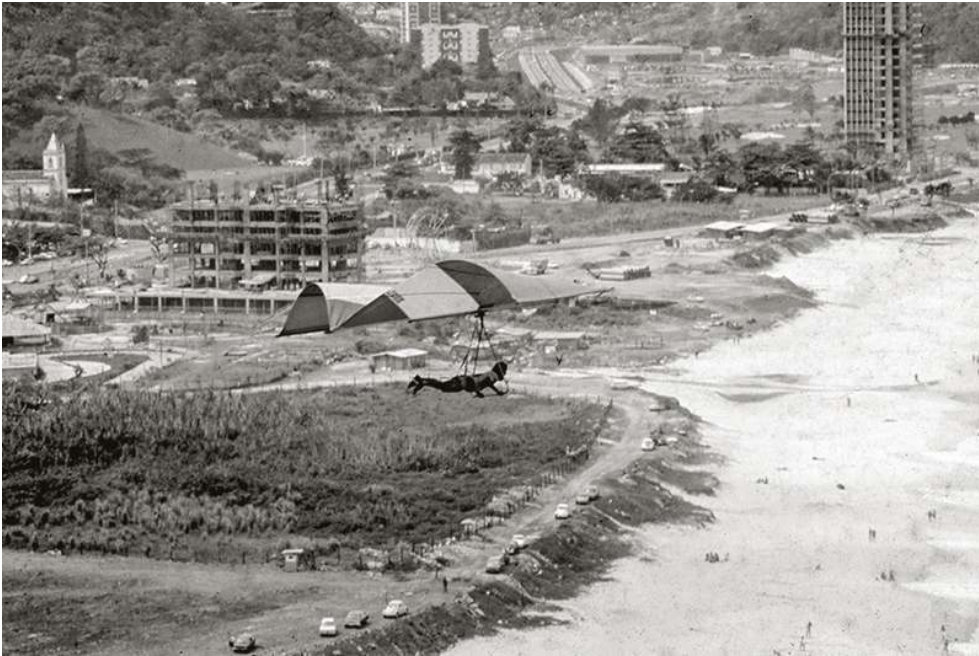


Source: Flavia Lins de Barros – 12/06/2016

Accelerated urban expansion to the South and West zones (1970 - 2000)

- 21 Throughout the 1960s and 1970s the practice of underwater fishing and diving as well as of surfing began at Pedra do Arpoador. In the 1970s, beaches of the South Zone were already undergoing intense urban densification. In contrast, at the western limit of the South Zone, São Conrado beach was the only beach that had not yet been developed due to its inaccessibility³. It began to be occupied for residential purposes after the opening of Lagoa-Barra highway and its tunnels in 1971 (Image 19).

Image 19 – São Conrado beach in the 1970's where the practice of paragliding started in Brazil



Source: <https://vejario.abril.com.br/cultura-lazer/documentario-conta-a-historia-do-primeiro-praticante-de-voo-livre/>

- 22 The expansion of urbanization towards the West Zone will start only in the 1970s, when it was still a well preserved coastal plain formed by sand ridges, swamps, mangroves and lagoons (Images 20).

Image 20 - Barra da Tijuca with Lucio Costa Avenue partly constructed. Photo from the 1950's.



Source: <https://peregrinomutante.wordpress.com/2012/03/08/barra-da-tijuca-primordios/>

- 23 In 1969 the architect Lucio Costa was invited by the State Government to prepare a plan for the development of the Baixada de Jacarepaguá area, where the beaches of Barra da Tijuca, Recreio and Macumba are located (Map 1). Although he had previously recommended that nothing should be done, he understood that the development of this region was inevitable since it was the area to where the city could grow. In 1971, the Zuzu Angel and Elevado do Joá tunnels were inaugurated, connecting the South Zone to São Conrado and Barra da Tijuca, accelerating their urbanization. Although largely undeveloped, most of Baixada de Jacarepaguá land belonged to only four landowners, what paved the way for the occupation model foreseen by the Lucio Costa Plan (Menezes, 2012). Nowadays, most of the Baixada and the Barra da Tijuca beach are densely occupied (Image 21) except in areas where condominiums with individual households and townhouses were built (Image 22).

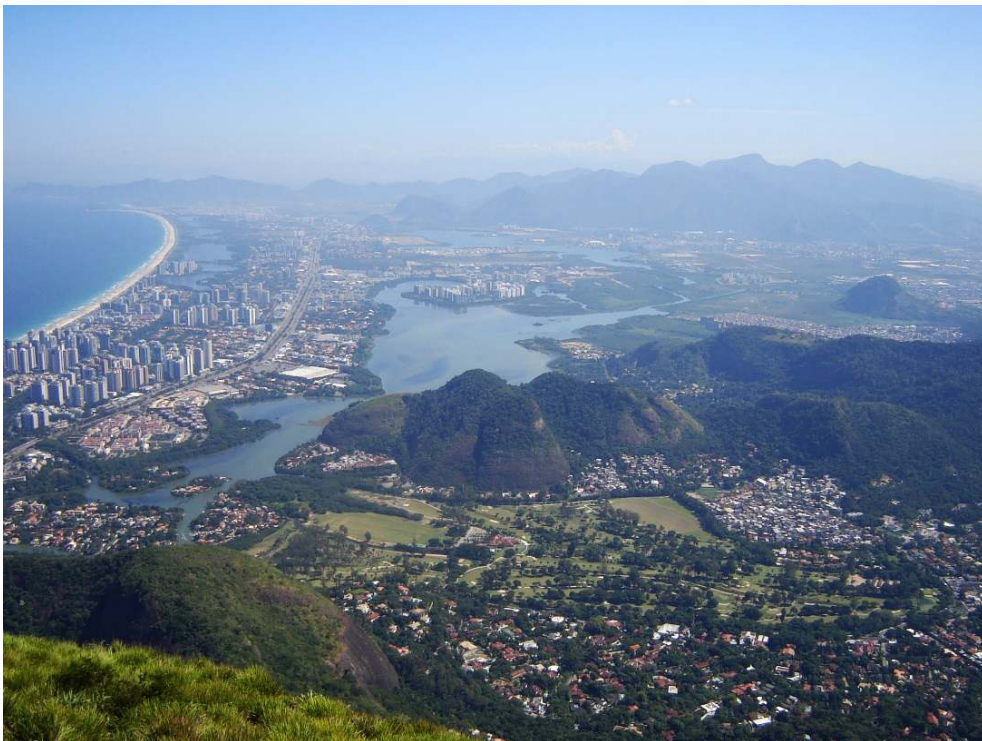
Image 21 - Barra da Tijuca beach in 2014, with high-rise buildings close to the shore.



Note the presence of small, vegetated foredunes. Photo by Sandro Gomes.

Source: <https://loucosporpraia.com.br/barra-da-tijuca-rio-de-janeiro/>

Image 22 - Baixada de Jacarepaguá and Barra da Tijuca seen from Pedra da Gávea (2011).



Source: Flavia Lins de Barros.

The last frontier of urban occupation (2000 to 2019).

- 24 The most recent urban expansion along the Rio de Janeiro coast is occurring towards Recreio and Macumba beaches, in the West Zone (Map 1). At the same time, the sand strip of the beaches is increasingly taken by sidewalks and kiosks, a reproduction of a model where no special attention is paid to the seafront, following the pattern adopted in the South Zone beaches. Macumba beach, the westernmost beach of Baixada de Jacarepaguá, is an emblematic example of this pattern. This beach, until 2000 barely occupied, began to receive small multifamily condominiums and hotels. To increase its real estate value, in 2004 the local government carried out a project called *Eco Orla*; a seaside road and a recreational area were built on top of the beach sand strip (Images 23 and 24).

Image 23 – Macumba beach before (1990`s) (A) and during (B) the implementation of the *Eco Orla* project (2004).



Source: <https://ricosurf.com.br/noticias/meio-ambiente/erosao-praia-macumba-tragedia-anunciada>

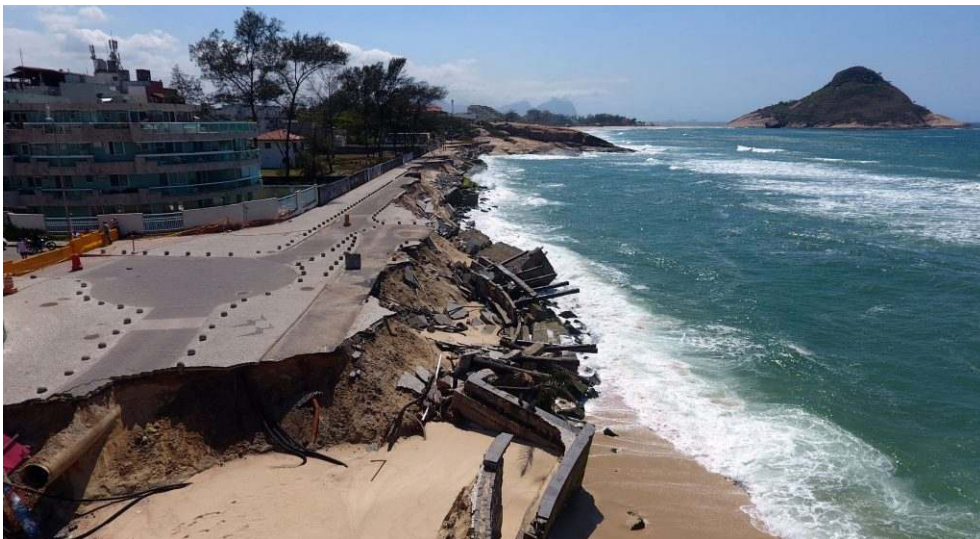
Image 24 – Macumba beach in 2015 after completion of the *Eco Orla* project.



Source: https://www.apontador.com.br/local/rj/rio_de_janeiro/praias/C4151530482F1C2F11/praiada_macumba.html

- 25 Since the completion of the project, storms caused severe damage to the structures more than six times. The last was in 2017 when the seaside road and sidewalk were almost destroyed, and the sea advanced over some waterfront properties (Image 25).

Image 25– Macumba beach after the October 2017 storm.



Source: <https://jovempan.uol.com.br/noticias/brasil/prefeitura-do-rj-deve-comecar-obras-emergenciais-de-contencao-do-calcadao-da-praia-da-macumba.html>

- 26 These events caused damages that cost millions of dollars to the taxpayers and will recur since rigid urban structures, as roads and sidewalks, are repeatedly built over the beach.

So far, no adequate action has been taken to effectively solve the problem and the shoreline was “rebuilt” following the same failed project (Image 26).

Image 26 – Reconstruction of the seaside road, bike path and sidewalk on top of the sand strip of Macumba beach after the storm of October 2017 destroyed most of it.



Source: Breylla Carvalho, 2018.

- 27 The presence of rigid structures over the sand strip of beaches is also noticeable in all beaches between Copacabana and Barra da Tijuca (Images 27, 28 and 29).

Image 27 – Kiosk being constructed on the sand strip of Ipanema. Photo from August 2017.



Source: Flavia Lins de Barros.

Image 28 – Kiosks from Copacabana beach reached by the sea during a storm 2011.



Source: Flavia Lins de Barros.

Image 29- Kiosk built in Leblon reached by a sea storm in 2013.



Source: <https://jovempan.uol.com.br/noticias/brasil/prefeitura-do-rj-deve-comecar-obras-emergenciais-de-contencao-do-calcadao-da-praia-da-macumba.html>

Biscay Bay

Royan and the first wave of beach tourism (Binot, 1994; Butaye, 2009)– urban and elitist customers (1815-1945)

- 28 In Biscay bay, the story began in Royan. As an outer harbor at the head of the Gironde estuary, the small city was linked to Bordeaux, that was the first French trade place before the Revolution. Before the beach-bathing revolution, the landscape was made of cliffs and coves, called locally “conches”. During the Bourbon Restoration (1814–1830), and especially during the Second Empire (1852–1870), the “grande conche” of Royan was transformed. The first investments were made in 1816 by the American consul in Bordeaux, who built a steamship to take the visitors to Royan in the summertime. Work to pave the town was completed in 1826. Each summer, mobile beach houses were installed on the sand, to welcome the tourists. In 1836, a staircase was cut out of the Foncillon cliff, to facilitate the landing of passengers from boats. By 1845, the engineer Botton incorporated the port to the city. In 1847, the first casino and the waterfront were built, beside a dike supposed to defend the city against storms and tide waves. When the city was connected by train to Bordeaux and Paris, in 1875, the beach touristic market of the south Atlantic French coast had become competitive: by the middle of the 19th century, Royan had lost its monopoly.

The extension of the beach tourism

- 29 Closer to Bordeaux, but less accessible than Royan, was a village stuck between the dunes and the Arcachon basin, whose inhabitants were fishermen, foresters and producers of pine resin. When the railway was extended by the rich brothers Pereire (in 1857), cutting the travel time from Bordeaux from 18 hours to 2 hours, the place became popular as a seaside resort for the wealthy of Bordeaux, as well as Paris. Arcachon officially became a town in 1857, by order of Napoleon III, who visited the place twice, adding to its reputation. As in Royan, a vast mass of dunes was quickly transformed into a settlement of elegant villas, connected to the beach by a waterfront. At the same time, the rich customers of Bordeaux could choose between Royan, Arcachon and Biarritz. Located close to the Spanish border, Biarritz was a village dedicated to whale hunting until Victor Hugo visited it in 1843. He wrote: “Friendly population and white cheerful houses, large dunes, fine sand, great caves and proud sea, Biarritz is amazing”. Thanks to that reputation, various hotels were built, as well as a municipal casino (1857), a salt-bath house (1893) and wonderful luxury houses. Biarritz became more renowned in 1854 when Empress Eugenie (the wife of Napoleon III) built a palace on the beach (now the Hôtel du Palais) where European state chiefs were frequent visitors (Image 30).

Image 30 – High attendance at Biarritz Beach (1910's)



Source: postcard, Sauzeau's personal collection.

- 30 In the northern part of Biscay Bay, other beach baths appeared at the same time. In La Rochelle, where the train arrived in 1857, an elegant bath resort – *les Bains Richelieu* – with its promenade, *Le Mail*, were installed upon the cliff located near the north wall of the former fortress (Augeron and Gauriaud, 2006). Despite all, La Rochelle kept its identity of fishing and trading harbor. It was almost the same for Les Sables d'Olonne, which was a cod, tuna and sardine fishing place, up to the end of the 19th century. When the railroad arrived in the city, in 1866, it led to the development of a promenade, *Le Remblai*, along which beautiful villas were built on the dune (Retureau, 2013). Despite its dangers, the view of the ocean landscape took a value that fishermen, seamen and peasants had not noticed before (Image 31).

Image 31 – The high tide as a spectacle (Les Sables d'Olonne, 1910's)



Source: postcard, Sauzeau's personal collection.

The storm of January 1924 or the revelation of a renewed vulnerability

- 31 On the night of January 8-9, 1924, a tidal wave struck the Atlantic coast from England to Spain (Vincent, 2015). From a meteorological point of view, it was not an unknown event. Many archives attest that the 1924 storm reminded that from 1877 to the inhabitants of Biscay Bay (Garnier and Surville, 2010). Nevertheless, the consequences of both events were quite different. In the night of December 31, 1876 to the 1st of January 1877, material losses and human victims had been limited (9 deaths), mostly caused by professional occupations (peasants, seamen, customs).
- 32 In January 1924, the authorities listed 39 deaths and several million francs of damages (Image 32). Most of these losses were related to the coastal residential economy. However, the two storms appeared to be comparable, characterized by a very strong west-southwest wind, associated with storm surge and high swell waves. The main explanation for the contrast between 1877 and 1924 must be linked to the development of the beach tourism, which had consumed and occupied many parts of the coastal grounds that had never been constructed before and were flooded in 1924. In 1877, most of the victims were part of the rural society, but in 1924 the inhabitants who lost their properties and sometimes their lives, were urban people attracted by a new way of life still in evolution, without taking the memory of the local people into account. The storm of 1924 was also the first to receive intense media coverage: newspapers, postcards and numerous photographs broadcast the consequences of the event in Europe and even across the Atlantic.
- 33 Image 32 – The consequences of the 1924 storm in Royan



Source: postcard, Sauzeau's personal collection.

Three waves of popular customers: the growth of the mass tourism (since 1920's).

- 34 From the storm of 1924 onwards, authorities had to take coastal risk into account, by implementing policies of coastal defense. It was necessary because of the growth of the beach bathing fashion, caused by the progress of the transportation networks, that extended the coastal transformations out of the first cities, creating new and more popular places. After the Second World War, two successive waves of seaside development led to the urbanization of the coastal strip, even in rural areas, that had hitherto been left out.

A first popular wave (1920-1958): an extension of the suburbs (Lahondère, 1995).

- 35 The damages of the 1924 storm added to the nuisances that urbanization had created in the seaside resorts of the 19th century. These overcrowded places in the summer, were noisy and polluted, especially the freshwater. A new geography appeared then, with real touristic brands around new coastal appellations: the *Côte Basque*, the *Bassin d'Arcachon* (Image 33), the *Côte de Beauté*, the coasts of the Charente-maritime department and of Vendée department and the islands of Oléron, Ré and Noirmoutier.

Image 33 – The Bassin d’Arcachon (1930’s)



Source: postcard, Sauzeau's personal collection.

- 36 The progress of the railway network and of automobile technology made it possible to reach places not accessible before the First World War. In each place, including the smallest one, the trend of coastal transformations accelerated but the wave of touristic settlements was restricted to the safest zones, regarding the risk posed by storm surges. Despite all, the growing density of installations (roads, squares, seafronts, dikes and docks) gradually cut off beaches from their dunes, preventing the natural and reciprocal mechanism of sedimentary exchange. Urbanization and coastal transformations added to the trend of sediment shortage of the Quaternary period (Paskoff, 1993), leading to coastal erosion, to which the authorities reacted by building even more coastal installations, especially to trap sand that tended to become scarce. From the sedimentary point of view, it was the beginning of a vicious circle, whose consequences could not be foreseen. In the end, during the period 1920-1958, the long-term vulnerability had increased, but the short term seemed stable. For example, when a new storm surge arrived, in February 15th, 1957, it did not cause more damage than in 1924. Maybe it was limited by the safe location of the settlements? Three similar events (March 1937, November 1940 and February 1941) had happened shortly before. So, the memory of the risk had probably been kept in the minds of people who were not as mobile as nowadays (Péret and Sauzeau, 2014).

A second popular wave (1958-1980): State programs for desert coastlines

- 37 In 1958, General de Gaulle came to power with a project to modernize the country. Several major projects were launched in all areas: diplomacy, army, transport, European integration, economy. Coastal population was increasing in number but also in age. Each family then acquired a car and the mode of holiday to the sea became massive (Merkelbagh, 2009). That is why the government decided to create two major touristic complexes, in coastal areas that had previously remained out of major touristic movements. Since 1967, in the coast of the *Landes de Gascogne*, the MiACA (governmental

agency) decided to create 9 touristic units in order to modernize some old villages, which were located behind large dune massifs, away from their beaches. The new places were located close to the beaches and the dunes in Soulac, Lacanau (Image 34), Le Cap Ferret, Biscarosse, Mimizan, Contis les Bains, Moliets, Hossegor et Cap-Breton. At the same time, in the north shore of the Vendée, close to Nantes, la *Côte de Monts*, was transformed by the SACOM agency (Image 35).

Image 34 – The seaside resort of Lacanau (Landes, 1970's)



Source: postcard, Sauzeau's personal collection.

Image 35 – The construction of Saint-Jean-de-Monts (Vendée, 1970's)



Source: postcard, Sauzeau's personal collection.

- 38 Then, the population of those coastal communes recorded an increase of + 60% over the period 1960 – 2000. The new residents, who decided to buy an apartment in a waterfront building, or to buy a building land under the pines, probably trusted the developers. They did not know much about the dynamics of sandy coastlines (Merkelbagh, 2009). Unfortunately, the beach-dune system had always been mobile, and that is why it had remained uninhabited...

The last popular wave (since 1980): an organic urbanization of the beaches.

- 39 In 1981, François Mitterrand became president of the French republic and decided to decentralize decisions. Each little commune became free to decide which part of its ground could be developed. In the following years, the European, the local and regional authorities decided to intervene in decisions concerning the coastline, while the State was trying to protect it, by creating the *Conservatoire du Littoral* (1975) and passing the *Loi Littorale* (1986). During this period of confusion, and until the Xynthia storm surge (2010), large parts of the rural coasts were developed without caring either about the risk of erosion, which kept increasing, or about the risk of marine surge, that had been unknown since 1957. In the Charente-maritime and the Vendée departments, the marshes and the diked fields, located below sea level, had always been avoided by tourism. The main factor was probably the birth of the “silver economy”, which brought many retired people to the coast, in order to own their little house, close to the beach. All cautious habits were forgotten since 1957 and the new inhabitants did not know how high the risk was, because nobody took it seriously into account (Péret and Sauzeau, 2014). When the storm Xynthia happened, in the night of the 27th and 28th February 2010, it caused 53 deaths, flooded 6000 houses and made more than two billion euros of damages. The reaction of the French government – called the *Sarkozy doctrine* – clearly failed, unable to manage the tensions between local expertise and decision of the government, between economic

development and population security, between memory and forgetting. The storms of the 2013-2014 winter revealed for the authorities the real effects of coastal erosion and flooding. Each year, winter erosion of beach resorts built in the seventies impacts the dikes made of concrete and the buildings which are nowadays exposed to destruction, as *Le Signal* (Image 36) in Soulac (Gironde).

Image 36 – Building *Le Signal* in Soulac (Gironde, 2016)



Source: photography by Sauzeau.

When the local construction of vulnerability meets global changes...

- 40 From the beginning of the 19th century, the beach-bathing economy brought new stakes, which were taken in charge by new actors (investors, engineers and developers). Gradually, the memory of risk by marine flooding has declined. Nonetheless, the predicted sea-level rise, the worsening climate of storm surges in the North and South Atlantic, and the sedimentary shortage, created a new context. In one hand, for the climate change experts, storm surges are not supposed to be more frequent in Biscay bay, but stronger than those from the past. On the other hand, erosion is accelerating and the link with sea-level rise seems to be confirmed. In Rio de Janeiro, studies indicate that the coastline exhibits an erosive tendency, i.e., there are segments that show evidence of erosion, but no overall coastline retreat is observed yet (BRASIL, 2018). These segments are vulnerable areas that in the future could become erosive sectors depending on the effects of climate change or even of the anthropic interventions. Projections indicate that a sea-level rise of just 1 meter would be enough to advance the shoreline close to the waterfront buildings in Leblon, Ipanema and Copacabana (Lins-de-Barros and Parente-Ribeiro, 2018; Linhares, 2019).

- 41 Despite a real trend of “littoralization”, Biscay Bay was not as profoundly modified as its Carioca counterpart. However, consequences of climate change seem to be similar in the two study cases: beaches are currently vulnerable to erosive processes, which increases the strength of the storm surges, especially during winter storms. The phenomenon is well known but it requires different answers, linked to local considerations. The coast of the Landes, developed after the 1960s by the government and that is almost uninhabited in winter, prohibits massive investments to combat the effects of erosion. The situation seems to be the same in the oceanic coasts of the islands (Oléron, Ré, Noirmoutier). On the other hand, if the old seaside towns, as much as their urbanised waterfronts, appear less vulnerable to erosion, they are exposed to the risk of sea flooding, whose history is rich in examples. At the intersection of those two vulnerabilities (erosion and flooding), the most recently urbanised spaces are exposed to both risks because they used grounds of less quality (fields, marshes) for whom the seaside economy did not care about before.
- 42 The occupation model of the Carioca coastline was marked by intense modifications of the natural configuration of its geomorphology. In the sheltered or semi-sheltered beaches of Guanabara Bay, landfills were predominant in order to increase the area of the coastal plain and enable the city growth into the sea, rectifying the coast for port use and completely altering the natural landscape of its beaches. In contrast, on the open beaches of the South and West Zones of the city, the occupation model obeyed the logic of maximum economic exploitation of the coast based on real estate and commercial valuation, invading as much beach space as possible. With the destruction of the natural ecosystems and the modification of the sedimentary balance, beaches are currently more vulnerable to the erosive processes related to storm surges resulting in an increased risk of damages and losses. To solve this problem, it is necessary to go beyond the traditional engineering solutions, since there are worldwide examples of engineering works that have further aggravated the process of coastal erosion. The alternatives are “nature-based solutions” to coastal flooding and erosion, which work with natural processes to reduce risks and incorporate ecosystems into natural defense (Moller, 2019). In addition, one must finally seek a model of occupation that perceives the beach and the sea not as obstacles, as land for expansion of the city or just as spaces of economic use, but as an ecosystem and a landscape with important ecological functions and which must be integrated into the city.

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NOTAS

1. In 1815 Rio de Janeiro became the capital of the United Kingdom of Portugal and Algarve and, after Brazil's Independence in 1822, the capital of the Empire. Then, in 1889 it was proclaimed capital of the Republic, until 1960, when Brasília was founded
2. Herbaceous, shrub or tree vegetation very diversified in physiognomic terms that develops on coastal sandy deposits of varied origin.
3. There had already been a road linking Leblon to São Conrado since 1916 (Niemayer Avenue), but until the early 1950s there was no regular public transport service.

RESUMOS

Intervenções antrópicas na zona costeira ocorreram em larga escala a partir do século XIX em virtude da necessidade de se acomodar embarcações cada vez maiores nas áreas portuárias e da difusão do banho de mar nas praias como um valor social. A partir do século XX intensifica-se a urbanização das zonas costeiras onde hoje se situam algumas das mais populosas cidades do mundo, bem como importantes destinos turísticos, o que resulta em enorme fluxo de pessoas para estas áreas. No presente trabalho é apresentada a evolução histórica da ocupação do litoral na cidade do Rio de Janeiro (Brasil) e na Baía de Biscaia (França) apontando sua influência sobre as transformações da dinâmica natural das praias, a vulnerabilidade e os riscos à erosão costeira. O resgate histórico inicia-se no começo do século XIX e se estende até o momento atual, enfatizando as transformações promovidas pela ocupação urbana e o uso turístico, e sua relação com os eventos de ressaca.

Les interventions anthropiques de grande ampleur ont débuté au XIXe siècle sur les littoraux en raison de l'adaptation des ports au gabarit de navires de plus en plus grands mais aussi à cause de l'intérêt grandissant pour les plages et la mode balnéaire. Le XXe siècle a aussi connu une accélération de l'urbanisation littorale, si bien qu'aujourd'hui la plupart des plus grandes villes sont situées sur les côtes. La grande popularité des littoraux en tant que destinations touristiques est enfin à l'origine d'importants flux de populations. Cet article présente l'évolution historique de l'occupation des côtes de la ville de Rio de Janeiro (Brésil) et du golfe de Gascogne (France) en insistant sur les conséquences sur les dynamiques des littoraux sableux, sur leur vulnérabilité et sur les risques d'érosion. L'étude historique débute au XIXe siècle et s'étend jusqu'à nos jours, en insistant sur les transformations issues du développement urbain, et du tourisme qui lui est lié, sans oublier l'influence des événements extrêmes comme les tempêtes et les submersions marines.

Large-scale anthropic intervention in the coastal zone started mainly in the 19th century due to the need to accommodate increasingly larger ships in the port areas, and to the diffusion of the value of beaches as places for sea-bathing. Throughout the 20th century, urban growth of coastal areas increased, and it is where, nowadays, some of the largest cities in the world are established. Also, several popular tourist destinations are found in the coastal areas, creating a huge flux of people. In this work is presented the historic evolution of the coastal zone occupation in the city of Rio de Janeiro (Brazil) and in the Bay of Biscay (France) with emphasis on its influence on the natural dynamics of sandy beaches, and on their vulnerability and risks to coastal erosion. The historic review starts in the early 19th century and extends until our days, focusing on the transformations caused by the urban development and tourism-related activities, and their

ÍNDICE

Índice geográfico: Rio de Janeiro, Golfe de Gascogne

Keywords: tourism, urbanization, coastal erosion, climate change, Biscay Bay.

Palavras-chave: turismo, urbanização, erosão costeira, mudanças climáticas, baía de Biscaia.

Mots-clés: tourisme, urbanisation, érosion côtière, changements climatiques, golfe de Gascogne.

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