

A Historical view on Coastal Erosion. The case of Furadouro (Portugal)

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Abstract

The village of Furadouro, in the Northwestern coast of Portugal, is emblematic of current problems of coastal management. The purpose of this article is to analyze the interaction between the human communities and the coast in Furadouro, in order to understand how practices and arrangements have contributed to potentiate coastal erosion effects in the last century. The conceptual tools of “socio-natural sites”; “co-evolution”; and “socio-natural sites as nexus of practices and arrangements” guide this investigation. The methodology adopted is a socio-ecological long-term research. Data used comes mainly from primary historical sources (church registers, minutes of local authorities' meetings and newspapers) and secondary literature (local writers and monographies). Historical information was cross-referenced with geomorphological data to allow for a more global approach to the coastal erosion phenomenon.

The analysis of the evolution of Furadouro shows that human activities were determinant to the increase of coastal erosion problems, not only by contributing to the decrease of sand in the beach, but also by destroying its natural protection structures - the dunes. The reconstruction of past coastal landscapes and human intervention allows us to have a better understanding of the complex and intertwined history of this socio-ecological site, offering as well a model of analysis and interpretation that can be applied to other cases around the world.

Key-words: Socio-natural Site, Long-term Research, Coastal Erosion, Furadouro, Portugal

Introduction

Coastal erosion is the process of wearing away material from a coastal profile due to imbalance in the supply and export of material from a certain section. It takes place mainly during strong winds, high waves and high tides, and storm surge conditions, and results in coastline retreat. Erosion is a natural phenomenon of coastal dynamic processes, but it becomes a problem – especially in areas where built heritage exists - since it causes damage or even loss of property located on the top of cliffs and dunes, loss of land with economic value, flooding of the hinterland and salinization of

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agricultural land³. Coastal erosion is already a big concern all over the world and it is believed that it will grow worse in the future. The Intergovernmental Panel on Climate Change (IPCC) has estimated that sea level - due to thermal expansion of the ocean and the melting of mountain glaciers and the polar caps - will rise between 0.26–0.55m and 0.45–0.82m, depending on the chosen scenario, by the end of the 21st century⁴. On the other hand, over the last century, human activity in most of the catchment areas and in the coastal zones has had a great impact, directly or indirectly, on natural coastal systems. Damming, dredging, inert extraction, fluvial and maritime engineering works, agricultural and forestry activity and the urbanization of coastal zones have all caused profound imbalances in the natural systems. Amongst other things, these imbalances have led to the reduction of the amount of sediments arriving to the littoral, contributing to the degradation of coastal ecosystems and the diminishing of their resilience in the case of extreme weather events⁵. The combination of these factors could lead to catastrophic consequences across the whole world.

Matters relating to natural phenomena and their impact on the planet and its populations have traditionally fallen mainly within the scope of the natural sciences. In the last decades, multidisciplinary teams of geologists, climatologists, geophysicists and others have worked together to analyze the causes of coastal erosion. However, many of the questions posed by scientists about the state of the coastlines cannot be explained simply as a result of physical conditions or of recent human impact, as many of ‘those ‘why’ questions are rooted in culture’⁶. The present situation of the world's coastlines is influenced by a combination of both Nature and Culture, so it is absolutely necessary to make integral and global studies of the coasts, taking in both natural and human factors, to achieve a holistic understanding of coastal systems. Despite this, it’s not very common to find works on Social Sciences / History about erosion and other hazards on coastal zones. There are exceptions, like some articles published in *Environment and History* and its special issue on Flooding; the French works - motivated by the Cynthia storm - about flooding and tsunamis in the French coasts since the Middle Ages and the Dutch and German historiographies on coastal hazards⁷. Nevertheless, these are still a

³ Marcel Marchand (ed.), *Concepts and Science for Coastal Erosion Management. Concise report for policy makers* (Delft: Deltares, 2010), 6.

⁴ IPCC, Summary for Policymakers, in T.F.Stocker, D. Qin et al. (eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge and New York: Cambridge University Press, 2013), 23, 25.

⁵ R.J. Nicholls et al., ‘Coastal systems and low-lying areas’, in M. Parry, O.F. Canziani et al. (eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, pp. 315-356 (Cambridge: Cambridge University Press, 2007).

⁶ D. Worster, ‘The Two Cultures Revisited: Environmental History and the Environmental Sciences’, *Environment and History*, 2-1 (1996): 12.

⁷ For example: M. Elvin and S. Ninghu, ‘Man against the Sea: Natural and Anthropogenic Factors in the Changing Morphology of Harnghzhou Bay, circa 1000-1800’, *Environment and History*, 1-1 (1995): 3-54; G. Bankoff, ‘The ‘English Lowlands’ and the North Sea basin system: A History of shared risk’, *Environment and History* 19-1 (2003): 3-37; M. Danaher, ‘Reconciling Foreshore Development and Dune Erosion on Three Queensland Beaches: An Historical Perspective’, *Environment and History* 11-4 (2005): 447-474; *Environment and History*, Special Issue on Flooding, 19-2 (2013); E. Chaumillon, E. Garnier et al. (eds.), *Les littoraux à heure du changement climatique* (Paris: Les Indes Savantes, 2014); E. Garnier and F. Surville (eds.), *La tempête Xynthia face à l'histoire. Submersions et tsunamis sur les littoraux français du Moyen Age à nos jours* (Saintes: Le Croît Vif, 2010); M.K.E. Gottschalk, *Storm Surges and River Floods in the Netherlands* (Assen: Van Gorcum, 1971–1977) 3 vols; F. Mauelshagen, ‘Flood disasters and political culture at the German North Sea coast: a long term historical perspective’, *Historical Social Research* 32 (2007): 133–44; A. Kraker, ‘Two Floods Compared. Perception of and

minority in Environmental History especially when compared to the number of works about agriculture and forests, aquifers, rivers, droughts and river flooding, pollution, mining and industrial issues.

This work, within the frame of Environmental History, analyzes the case of Furadouro, a village located in the Northwestern coast of Portugal, affected by erosion since the 19th century. Furadouro offers an excellent example of historical coastal hazards and current problems of coastal management. Coastal erosion is well studied in this area. Scientists have determined a mean retreat rate of 2,8 meters/year between 1954-1990 and 8 meters/year between 1984-1990⁸. They attribute coastal erosion to a reduction in sedimentary supply to the coast, due to dams, fluvial and maritime engineering works, and urbanization. In the 1970s, the village had to be protected by hard engineering structures – groynes and a rip-rap seawall – which are recurrently damaged by the sea and have to be rebuilt and reinforced at high financial cost. These structures do not obviously solve coastal erosion; they just ‘hold the line’ to ensure the village's maintenance, transferring the problem downdrift. Coastal erosion in Furadouro, however, started much earlier, in the second half of the 19th century, before the major human interventions in the coast and river basins, and this has never been properly studied.

The case of Furadouro allows us to observe the antecedents of coastal erosion, the beginning of the phenomenon and the motivations beyond the activities that explain the increase of the present problems. The American geologist Orrin Pilkey defended, in 1979, that ‘no erosion problems exist until people lay out property lines and build’. The beaches are moving environments; any building on or near them normally increases the rate of erosion, since structures and their foundations reduce the flexibility of natural systems to respond to the changes in their dynamic equilibrium. Later, Pilkey synthesized his ideas in just a few words: ‘No people, no problem’⁹. Based on this core principle, a main theory is tested in this case-study: in the 20th century two opposing realities joined to potentiate the effects of erosion - urban growth in risk areas and sediment supply reduction to the coast.

The purpose of our study is therefore to analyze the interactions between human communities and the coast, understanding how practices and arrangements contributed to the transformation of a specific coastal site and how this led to unexpected side effects, unintended consequences that were not, or could not be, foreseen. This requires monitoring change over time, recognizing natural and human dynamics, determining the impacts of transitions and identifying actors and intentions, in order to have a complete perspective of these complex phenomena. Thereunto, we analyze the consequences of the settlement in Furadouro and its passage from fishing village into touristic place. We also compare the natural behaviour of this coastal system with the consequences of human intervention on the catchment areas of the supplier rivers and the coast itself. The goal is to understand the legacy of past actions on present and future decisions and to build the bases to extrapolate this particular case to other coasts around the world.

Response to the 1682 and 1715. Flooding Disasters in the Low Countries’, in K. Pfeifer (ed.) *Forces of Nature and Cultural Responses*, pp. 287–302 (Dordrecht, Heidelberg, London, New York: Springer, 2013).

⁸ C. Ângelo, ‘Taxas de variação do litoral oeste: uma avaliação temporal e espacial’, *Proceedings do Seminário A Zona Costeira e os Problemas Ambientais*, pp. 109-120 (Aveiro: EUROCOAST, 1991); J.A. Dias, O. Ferreira and A.R. Pereira, *Estudo sintético de diagnóstico da Geomorfologia e da Dinâmica Sedimentar dos troços costeiros entre Espinho e Nazaré* (Lisboa: ESAMIN, 1994), 62.

⁹ W. Kaufman and O. Pilkey, *The beaches are moving. The drowning of America's shoreline* (Garden City / New York: Anchor Press / Doubleday, 1979), 191; O. Pilkey and K. Dixon, *The Corps and the Shore* (Washington D.C.: Island Press, 1996), 34.

Materials and Methods

Winiwarter *et al.* wrote that interdisciplinary, long-term studies are still a novelty. The joint work of scholars with different disciplinary backgrounds imposes challenges concerning communication and understanding of data, notions, methods, theories and forms of presentation between them. Facing this challenge, a team of historians and natural scientists working on a long-term study of the evolution of the Viennese Danube defined a conceptual basis that they applied to the analysis of the riverine landscape. Since these concepts proved to be useful tools, we decided to apply them to coastal landscapes.

So, in this case-study, Furadouro: (a) is considered a ‘socio-natural site’: a place created by both human action and biophysical phenomena; (b) its transformation is interpreted as a ‘co-evolution’: a product of human and nature interactions as a process between two structurally coupled systems; (c) as a socio-natural site it is the spatial ‘nexus of practices and arrangements’, ‘practices’ being understood as a routinized type of behavior, a combination of perceptions, motivations and knowledge inherent to human action, ‘arrangements’ the material precipitates and the prerequisites of practices; (d) both practices and arrangements are understood as socio-natural hybrids and are transformative of each other, since human ideas and activities cannot be separated from the environment where they emerge and at the same time that environment is transformed by those ideas and activities; (e) human ‘actors’, individuals or groups, and nonhuman elements are considered as driving forces in the making of this coast; (f) ‘legacy’ is the idea that its current situation is dependent on a material and immaterial inheritance. As a working methodology we adopted a socio-ecological long term research, as described by Haberl *et al.*, focusing in the three core themes: socio-ecological metabolism, land use and landscapes, governance and decision making¹⁰.

Furadouro started as a seasonal fishing camp dependent on a nearby village called Ovar, later becoming a seaside resort of regional relevancy. This evolution followed a process common to other human settlements in European coastal areas; a development based in new ideas and perceptions about the beach, which were the motor of the creation of a novel urban form – the seaside resort. It can be defined as an urban area, near the sea, organized in direct connection to a beach, characterized by an innovative maritime architecture and specific infrastructures. A leisure destination, where most economic activities are seasonal with a summer predominance. Iconic European seaside towns - like Brighton (UK), Scheveningen (Holland), Biarritz (France) and San Sebastian (Spain) - defined urban models that were copied and adapted to other countries and regions, according to historical periods, culture, habits, uses, climate and specific environment of the implantation sites. Despite local differences there is a set of elements shared by most seaside resorts: location, basic structures, infrastructures, public spaces and transports. Much literature has been produced about seaside resorts;

¹⁰ V. Winiwarter, M. Schmid and G. Dressel, ‘Looking at half a millennium of co-existence: the Danube in Vienna as a socio-natural site’, *Water History* (2013): 108-110; V. Winiwarter, M. Schmid, S. Hohensinner *et al.*, ‘The Environmental History of the Danube River Basin as an Issue of Long-Term Socio- Ecological Research’, in S. Singh, H. Haberl *et al.* (eds.), *Long Term Socio-Ecological Research. Studies in Society-Nature Interactions across Spatial and Temporal Scales*, pp. 103-122 (Netherlands: Springer, 2013); H. Haberl, V. Winiwarter *et al.*, ‘From LTER to LTSER: conceptualizing the socioeconomic dimension of long-term socioecological research’, *Ecology and Society*, 11 (2): 13 (2006).

we used the works of Justome, Clairay, Lemos and Gray¹¹ to characterize the urban evolution of Furadouro and its socio-economic effects.

This paper draws on substantial primary historical sources, such as church records (1758) and regional descriptions (1801); the minutes of the meetings of the Ovar Township Assembly and the local Tourism Commission; the newspapers *Ovarense* (1888-1921), *Povo d'Ovar* (1929-1942) and *Notícias d'Ovar* (1954-1994); the urbanization plans of Furadouro (1950, 1961, 1968, 1981); and the coastal erosion defense plans organized by the National Hydraulic Services¹². As secondary literature we reference the works of several local writers who wrote about Furadouro, the consequences of sea invasions, the way of life of the inhabitants and the development of the village¹³. The most relevant information missing is the fishermen's perceptions of coastal erosion events. Fishermen and their families were the first and the majority of the inhabitants of Furadouro, but because of their illiteracy there aren't any written sources produced by them. And, as Favier and Granet-Abisset¹⁴ have noticed, it is very difficult to find popular knowledge in administrative archives.

Finally, historical information was cross-referenced with geomorphological data and some studies about the coastal erosion phenomenon at Furadouro¹⁵ allowing us to do a long term research of the co-evolution of this socio-natural site.

Furadouro: co-evolution of a socio-natural coast

1. Characterization of the conditions of this coast

¹¹ E. Justome, 'Du village maritime à la ville balnéaire: l'exemple des stations balnéaires de la Côte Picarde', in Y. Perret-Gentil, A. Lottin and J.P. Poussou (eds.), *Les villes balnéaires d'Europe occidentale du XVIIIe siècle à nos jours*, pp. 193-204 (Paris: PUPS, 2008); P. Clairay, 'Le développement balnéaire breton', in Perret-Gentil, Lottin and Poussou (eds.), *Les villes balnéaires d'Europe...*, 206; M. Lemos, *Models in the formation of coastal urban spa towns in Portugal against the background of European design in the nineteenth and early twentieth centuries*, (PhD diss. Wroclam University of Technology, 2006); F. Gray, *Designing the Seaside* (London: Reaktion Books Ltd., 2006).

¹² E. Costa, 'Memórias Paroquiais do Século XVIII', *Arquivo do Distrito de Aveiro*, XXXIV-135 (1968): 204-214; I. Amorim, 'Descrição da Comarca da Feira - 1801 - feita pelo Desembargador / Corregedor Columbano Pinto Ribeiro de Castro', *Revista da Faculdade de Letras: História*, II, 11 (1994): 227-286; M. Rezende, Antepiano de Urbanização da Praia do Furadouro (1950); J. Gigante, Plano de Urbanização da Zona Norte do Furadouro (1961); R. Barroca and M. Cerveira, Antepiano Director do Cordão Litoral Norte da Ria de Aveiro (1968); CEAPE, Plano Geral de Urbanização do Cordão Litoral Norte da Ria de Aveiro - Ovar (1981); Conselho Superior de Obras Públicas, Parecer n.º 3801. Projecto de obras de defesa da praia do Furadouro (1971), Biblioteca e Arquivo das Obras Públicas (BAHOP).

¹³ M. L. Marques, *Pescadores do Furadouro* (Ovar: Museu de Ovar, 1991 [1955]); E. Lamy Laranjeira, *O Furadouro. O Povoado, o Homem e o Mar* (Ovar: C.M. Ovar, 1984); A.S. Lamy and A. Rodrigues, *Furadouro uma terra com passado e com futuro...* (Comissão de Melhoramentos do Furadouro, 2001).

¹⁴ R. Favier and A.M. Granet-Abisset, 'Society and Nature Risks in France, 1500-2000. Changing Historical Perspectives', in C. Mauch and C. Pfister (eds.), *Natural Disasters, Cultural Responses. Case Studies towards a Global Environmental History* (Plymouth: Lexington Books, 2009), 125.

¹⁵ Ângelo, 'Taxas de variação do litoral oeste...'; Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*; O. Ferreira and J.A. Dias, 'Evolução recente de alguns troços do litoral entre Espinho e o Cabo Mondego', *Actas do 2.º Simpósio sobre a Protecção e Revalorização da Faixa Costeira do Minho ao Liz*, pp. 85-95 (Porto, 1991); S. Costa and C. Coelho, 'Northwest coast of Portugal - Past behaviour and future coastal defense options', *Journal of Coastal Research*, SI 65 (2013): 921-926; C. Pereira, C. Coelho et al., 'Numerical modelling of shoreline evolution in the Aveiro coast, Portugal - climate change scenarios', *Journal of Coastal Research*, SI 65 (2013): 2161-2166.

Figure 1. Location of Furadouro, Ovar, Espinho, Aveiro Lagoon and Douro River (Google Maps, 2015)

The coast of Furadouro, located in the Northwest of Portugal, facing the North Atlantic, presents a NNE-SSW orientation and a straight profile (Figure 1). It's a low-laying sandy area, subject to severe wave conditions and a mesotidal range. The wave height is superior to 1 meter in 85% of the year and to 4 meters during 5% to 2%. The waves of the 10-year return period storms can reach 10 meters and more¹⁶. Furadouro is situated in the medium part of the sand barrier that separates the Aveiro Lagoon from the ocean. All this coastline is geologically very recent, as the sand barrier, formed by dunes, grew between the 10th and the 19th centuries, due to high sedimentary deposition. When the mean sea level reached its current level, about 5000 to 3000 years ago, this coast was an open bay exposed to the high energetic waves of the Atlantic. At the end of the first millennium, demographic factors and new political and economic conditions, namely the growth of the population in the North of the country (Minho), the development of agriculture (favored by the Little Climatic Optimum) and the Christian conquest of the region between Minho and Douro to the moors, led to a major increase in the sediment supply to the coast. Sediments carried by rivers to the ocean, especially the Douro River, were transported by longshore currents, running North to South, feeding the beaches along this coastal stretch. Due to the NW dominant orientation of the waves a sandy spit was formed towards SSW, converting the open bay into a coastal lagoon¹⁷. The coast of Furadouro was formed during this process.

The Portuguese coast in the East margin of the North Atlantic Ocean is subject to extreme weather conditions. The energy of the big storms of North Atlantic, fed by a fetch of thousands of kilometers, often dissipates in the Portuguese coast. This is therefore a very energetic coastline. On the other hand, the Portuguese territory is frequently affected by the passage of low pressure atmospheric systems that generate storm surges. When the two types of waves occur together, the energy dissipated in the coast is very high, assuming catastrophic proportions. Coastal erosion can reach its maximum amplitude in these occasions with significant coastline retreat. Several works also show that storm strength is greater in the North than in the South coast of Portugal, the stretch between Espinho and Nazaré (where Furadouro is included) being one of the hardest hit¹⁸.

¹⁶ Instituto Hidrográfico, *Tabela de Marés 2011*, vol. I (Lisboa: Instituto Hidrográfico, 2010); H.N.O. Pires, 'Alguns aspectos do clima de agitação marítima de interesse para a navegação na costa de Portugal', *O Clima de Portugal*, fasc. XXXVII, vol. 2 (Lisboa: Inst. Nac. Meteo. Geofísica, 1989); M. Carvalho, *Valores extremos da agitação marítima, Figueira da Foz: tratamento local dos dados existentes* (Lisboa: Instituto Hidrográfico e LNEC, 1992).

¹⁷ J.A. Dias, 'Registos da migração da linha de costa nos últimos 18 000 na Plataforma Continental Portuguesa Setentrional', *Actas da 1.ª reunião do Quaternário Ibérico*, pp. 281-295 (Lisboa, 1985); Lucci, *Alterações litorais. A ria de Aveiro* (Lisboa: Typographia do Anuario Commercial, 1918); A.A. Girão, *Bacia do Vouga. Estudo Geográfico* (Coimbra, Imprensa da Universidade, 1922); J.A. Dias, M.R. Bastos, C. Bernardes, J.G. Freitas et al., 'Interação homem-meio em zonas costeiras: o caso de Aveiro, Portugal', in M.A. Rodrigues, S.D. Pereira, S.B. Santos (eds.), *Baía de Sepetiba: Estado da Arte* (Rio de Janeiro: Corbã, 2012), 216, 221-224.

¹⁸ J.J.R. Carvalho and J.P. Barceló, *Agitação marítima na costa Oeste de Portugal Metropolitano - Contribuição para o seu estudo* (Lisboa: LNEC, 1966); H.N.O. Pires and L.E. Pessanha, 'Estima da distribuição de probabilidade dos valores extremos utilizando séries climatológicas curtas', *Revista do INMG* (Lisboa, 1986); H.N.O. Pires and L.E. Pessanha, 'Wave Power Climate of Portugal', in D. Evans and A.F. Falcão (eds.) *Hydrodynamics of the Ocean Wave-Energy Utilization*, pp. 157-167 (Berlin-Heidelberg: Springer, 1986); R. Taborda and J.A. Dias, 'Análise da sobrelevação do nível do mar de origem meteorológica durante os temporais de Fevereiro/Março de 1978 e Dezembro de 1981', *Geonovas* (1992): 89-97; Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*, 134-136.

2. Human and Natural factors: coastal erosion problems

Socio-natural sites – like coasts - are nexus of practices and arrangements. Human needs for food, water, housing, energy, transport, raw materials, security, pleasure or leisure determine practices. But these needs do not emerge in a vacuum; in many ways they depend on natural conditions societies have to face. To fulfill these social metabolic needs, arrangements like dams, ports, roads, buildings, factories and groynes are built using the natural resources available and causing simultaneously deep impacts on ecosystems. The hybridity in all this is the result of an indistinguishable blend of social and natural elements and processes. This is what Winiwarter *et al.* tried to explain in their studies on the environmental history of the Danube; this is what we are interested in doing about Furadouro. In other words, our purpose is to identify practices and arrangements, human and non-human forces, explaining how they acted and evolved over time in this specific site, forging it and leaving as a legacy the current erosion problems. *Grosso modo* we identified four different stages in human-environment relations in Furadouro.

a) First period: an almost empty place

Geologically very recent, the coast where Furadouro is located is a hybrid product of both nature and humans: as mentioned, the sand spit that originated all this coastal area was due to nature's driving forces, but also to the increase of activities such as agriculture and deforestation in the basins of the nearby rivers (like Douro), the main sediment suppliers to this littoral. The sand spit in front of Ovar (town located at a distance of 4,5 kilometers from the coast) was formed between the 11th and the 12th centuries and the first reference to Furadouro in the medieval documents dates from 1354. As the sand spit consolidated and turned stable, the local county rented this area to private or religious institutions for grazing cattle. Later, in the 14th century, it became a common space where the people of Ovar raised their cattle¹⁹. Until the 19th century, all this sandy barren land, belonging to the township of Ovar, was considered useless and without economic value.

It is probable that fishing activities in Furadouro have started earlier, but historical sources only mention them since 1501, stating that the fishermen of Ovar used to go there to fish sardines, on a seasonal basis. Because of the proximity of the Aveiro Lagoon, most of the fishing was done in that sheltered and plentiful estuarine environment. Fishing on the maritime coast, where there was no harbor or natural protection for the boats, was a dangerous activity, only possible in the summer, with good weather and calm seas²⁰. For a very long time, environmental conditions - exposure to extreme weather, large dunes, non-existence of proper soils for agriculture, scarcity of fresh water – and human factors – privateers and piracy, low technology, absence of roads and a general demographic deficit - have imposed restrictions to fishing and settling on the coast of Furadouro.

Since this coast is highly exposed to storms and is characterized by fast variations in width, it is probable that maritime overwashes occurred during major storms. However,

¹⁹ M.R. Bastos, O. Pereira, J.A. Dias, 'Em tempo de temporais: o caso do Furadouro (NW de Portugal) como exemplo de (in)gestão do litoral', in D. Paula and J.A. Dias (eds.), *Ressacas do Mar. Gestão Costeira* (Fortaleza: in press), 205, 208-209, 211.

²⁰ Costa, 'Memórias Paroquiais do século XVIII', 209-211; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 12.

because Furadouro was uninhabited for centuries and its first settlers were fishermen, who did not have written sources, we do not have historical information about previous occurrences up to the 19th century. There is one exception: according to oral tradition, at the occasion of the 1755 earthquake and the following tsunami, the sea invaded all this area, right down to Carregal (around 3km inland from Furadouro). No one was killed and damages were limited as no one lived in Furadouro at the time²¹.

In this first period, until the second half of the 18th century, the socio-economic needs of humans drove them seasonally (in the summer) to this coast looking for the acquisition of nutrients – through fishing – as a complement to rural activities and as an additional income to families' savings. Because of the temporary use of the land, the only structures there were *palheiros*, wooden houses with thatched roofs, built on the dunes. These precarious houses, typical of the sandy coasts of Portugal, were perfectly suited to this rough environment, as they were perishable (probably rebuilt or fixed every year) and mobile (shifting places according to coastline changes). Nevertheless we can say that, in this period, Furadouro was an “almost empty space”: ‘le territoire du vide’ according to Corbin’s concept about some coastal zones previous to the 19th century²², since only a few actors – the fishermen – used it for a short time and structures were temporary with almost no impact in the landscape. The governance of this area was weak as the land had no value and the existing impositions were mainly related to taxes on fishing²³.

b) Second period: a fishing camp

In *Memórias Paroquiais* (church records), in 1758, Furadouro is not mentioned, meaning that it was still unoccupied. As the years went by the situation slowly changed. A small chapel was built on the beach in 1759 and the activities of fishing and salting sardines increased. In 1763, estimates point to 480 to 640 men working in fishing companies; in 1801 they were 666 and in 1835, 1000. This development was due to the use of a fishing gear called *xávega* and to the establishment of a new method for salting sardines introduced in the Portuguese coast by the French Jean Mijouille, who opened an artisanal factory in the region. These technical improvements helped increase the catch and preservation of the fish, allowing for the expansion of its commerce and the growth of fishing revenues. The organization of fishing activities also changed, the old cooperative system of fishermen crews being replaced by enterprises run with a capitalist spirit. All this brought a significant growth to Furadouro, as warehouses, small factories and more houses appeared in the beach. In 1827, Furadouro had about 380 *palheiros*²⁴.

When the first fishermen settled here this was a large dune area. Maps and descriptions point to a coast in accretion²⁵. The beach profile was always changing, but

²¹ Ribeiro and Lirio (ed.), *Almanaque Ilustrado de Ovar* (1914): 203-204.

²² A. Corbin, *Le territoire du vide. L'Occident et le désir du rivage, 1750-1840* (Paris: Aubier, 1988).

²³ Amorim, ‘Descrição da Comarca da Feira -1801’, 233, 243.

²⁴ Costa, ‘Memórias Paroquiais do século XVIII’, 205, 212; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 12, 19-21; I. Amorim, ‘Relações de trabalho e gestão pesqueira nos séculos XVIII e XIX – a pesca da xávega na praia do Furadouro (Costa de Aveiro)’, *Revista de História Económica e Social*, 2-2 (2001); Amorim, ‘Descrição da Comarca da Feira -1801’, 244; Bastos, Pereira and Dias, ‘Em tempo de temporais: o caso do Furadouro’, 220-221; L. Laranjeira, *O Furadouro. O Povoado, o Homem e o Mar*, 68.

²⁵ *Mappa topografico da Barra, Rios e Esteios da Cidade de Aveiro com parte do Rio Vouga e de toda a Costa* [c. 1778], Instituto Geográfico Português; I.P. Pereira and M.S. Ramos, *Mappa topografico da Barra Rios e Esteios da Cidade de Aveiro* [c. 1781], Biblioteca Municipal do Porto; *Carta de Portugal*,

that wouldn't be a problem for them. Their wooden houses could be easily rebuilt and, based in historical reports from other places of the Portuguese coast, it is known that fishermen used to move their houses according to shifts in the coastline²⁶. In spite of the increasing activities in the beach the structures built – warehouses and factories – were made of wood and using the same local techniques. In fact they were just bigger *palheiros*, as these had several practical functions. Also the settlement was not permanent; in the winter people returned to Ovar or moved to other fishing places (mainly sheltered estuarine and river environments)²⁷.

In this second period, from the last quarter of the 18th century to the second half of the 19th century, the socio-economical use of this site was related to fishing and the small production of salted sardines. The use of the *xávega* and the improvements in the methods for salting sardines increased fishing incomes and made possible for more people to live off these activities. Men went to sea. Women worked in the factories and sold fish in the surrounding areas. New actors arrived to the beach as novel business opportunities appeared and the local economy became more complex. Entrepreneurs – the ones with the money – were responsible for the organization of fishing companies and small factories. The commerce of the salted sardines also implied the presence of tradesmen, taking care of the buying and shipping of the fish to other parts of the country. Governance of the beach – and along the coast – became more effective, as the authorities established regulations – in some cases based in old ones – to increase their control over the workers and the fishing companies, in order to enhance tax revenues²⁸. In this second stage, population and activities increased, but sociological metabolism needs and land use didn't change much. Practices connected with the demand for food, housing, small scale production, mooring of the boats and drying of fishing nets – were still based on the available local resources and their material arrangements still had little impact in the environment.

c) Third period: new people, new ideas, big transformations

In the 1850s and 1860s some wealthy families from the surrounding areas – Ovar, Oliveira de Azeméis, Vale de Cambra - started to go to Furadouro for beachgoing in the summer²⁹. Following a fashion already well-established in other European countries (England, France, Netherlands, Spain) the Portuguese elites went to the beach for therapeutic reasons³⁰. The railroad arrived at Ovar in 1865 and in 1870 a road was built linking Ovar to Carregal (that some years later arrived to Furadouro). Both events increased the affluence of people to the beach and contributed to the development of the salted sardine trade, facilitating the transportation to Ovar and to other parts of the country. Until then the communications between Furadouro and Ovar were done by foot

Direcção Geral dos Trabalhos Geodésicos, Filipe Folque, f. 10 (1870), Instituto Geográfico Português; J.S. Ferreira, 'A construção do porto de Leixões e a sua influência no litoral', *Arquivo do Distrito de Aveiro*, 130 (1967): 107-109; A. Lima, 'Espinho. Breves apontamentos para a sua história', *Espinho: Boletim Cultural*, 1, I, (1979 [1927]): 11-44.

²⁶ Rocha Peixoto, 'Habitação. Os palheiros do litoral', *Portugália. Materiais para o estudo do povo português* (Porto: Imprensa Moderna, 1899), 11, 16-17; E.V. Oliveira and F. Galhano, *Palheiros do Litoral Central português* (Lisboa: Centro de Estudos de Etnologia Peninsular, 1964), 11, 26, 28, 109.

²⁷ Lamy and Rodrigues, *Furadouro uma terra com passado...*, 33, 35.

²⁸ Amorim, 'Relações de trabalho e gestão pesqueira nos séculos XVIII e XIX'.

²⁹ R. Ortigão, *Praias de Portugal. Guia do banhista e do viajante* (Porto: Livraria Universal de Magalhães e Moniz Editores, 1876), 112.

³⁰ J.G. Freitas, 'Paisagens simbólicas do litoral: antigas leituras, novas tradições', in C. Sarmiento (ed), *Entre Margens e Centros: Textos e Práticas das novas Interculturas*, pp. 165-182 (Porto: Afrontamento, 2013).

or horseback, through a difficult path in the dunes. In 1884 animal-powered vehicles transported people and merchandise between the railroad station and the beach. An automobile daily service was established between the two places in 1912. In the first years, the newcomers rented fishermen's houses during their stay at the beach. Then, slowly, between the end of the 19th century and the first three decades of the 20th century, Furadouro started having small hotels, rental houses, cafes, billiards and a meeting place for social reunions, concerts and dances (Figure 2). A branch of a large sardine cannery settled there, in 1905, reflecting the flourishing state of fisheries. This industry had great development during World War I supplying Portuguese soldiers³¹.

According to historical sources the land – or better the sand dunes where Furadouro developed - belonged to the township of Ovar. In 1843 it was established that no one could build or rebuild a *palheiro* without a license from the township. From 1866 onwards the township started collecting taxes from the ones interested in building in the beach. A plant from 1904 (information from 1913 was later added to it) found in the Municipal Archive of Ovar shows the ownership of different land plots in Furadouro. In the North part – urbanized according to an orthogonal plan applied after 1881, when a fire destroyed most of the *palheiros* – land had been sold to private individuals at the end of the 19th century. The South part of the village was less occupied; near the coastline most of the land belonged to the township, which granted (in 1904) a large part of it for free to the enterprise that owned the cannery factory *A Varina*, for the installation of that industrial infrastructure³². In the year 1912 the sea destroyed about 20 *palheiros*. The sand where they used to stand disappeared or was covered by the water. To help the fishermen, the Township of Ovar decided to give them some land, to the South of Furadouro. Because that land was public, a special authorization had to be asked from Parliament so it could be sold directly to the victims. To the poorest the land was not sold but given. Also in 1912, the Township decided to divide and sell a part of its land in the south so private individuals could build on it³³.

Figure 2. Furadouro beach and the Old Chapel in the 1930s (Foto by Mário de Almeida, Arquivo Municipal de Ovar)

The first known information about 'sea invasions' – the name overwashes were given then - is from this third period of human-environment relations in Furadouro. It is almost from the same time as beachgoers' in that beach. In February 1841 some fishermen are said to have been killed by the sea and in January 1857 15 *palheiros* were destroyed³⁴. One of the first descriptions of an overwash at Furadouro, in 1863, is from an eyewitness, a bather, spending some days at the beach. According to him, 'the sea invaded the coast, ruining 22 *palheiros*. The sea that during syzygy tides was 40 meters away from the *palheiros*, or even more, in seven days washed them up (...). This was something never seen before'. The event caused 'profound terror' in the families

³¹ Laranjeira, *O Furadouro. O Povoado, o Homem e o Mar*, 21; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 35-36, 38-39, 41-42; Ribeiro and Lirio (ed.), *Almanaque Ilustrado de Ovar* (1913): 181-182.

³² Rezende, *Anteplano de Urbanização da Praia do Furadouro*, 4; *Planta da Concessão de terreno de areia, na Costa do Furadouro de Ovar*, Novembro de 1904; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 37, 41-42.

³³ *Diário da Câmara dos Senhores Deputados*, 29 Feb. 1912, 4; Idem, 4 Mar. 1912, 3; Câmara Municipal de Ovar (hereafter CMO), *Livro de Actas*, n.º 40, 31 Dec. 1910 to 4 Nov. 1912, fl. 117, 120, 143.

³⁴ *Diário do Governo*, 15 Feb. 1841, 179; Laranjeira, *O Furadouro. O Povoado, o Homem e o Mar*, 174;

bathing at Furadouro and many returned home with fear³⁵. Only fishermen were not surprised, as they were used to changes to the coastline.

The third phase of Furadouro must be divided in two: the first half of the 20th century, that we already characterized, and the 1950s-1960s. Both were driven by the arrival of new people to the beach, its growth and progressive urbanization. However, these phenomena were particularly pronounced in the second one.

Furadouro was never an elite beach. It was a modest place frequented by people from the surrounding areas³⁶. Nevertheless the economic relevance of the tourism phenomenon determined the intentional organization of the urban space, especially from the 1950s onwards. In Furadouro it is possible to find a set of equipments and infrastructures that are common to many other seaside resorts and even the rearrangement of the village followed a specific organization, according to the aesthetic and functional concepts current at the time³⁷. The transformation of Furadouro was done in different phases. Following the arrival of the sunbathers, a set of seasonal businesses were installed: hotels, rental houses, restaurants, cafes and shops. Meanwhile a new neighborhood was created separated from the pre-existing one. The big fire of 1881 destroyed most of the *palheiros* of the North part of the village. The later reconstruction allowed the realignment of streets and buildings according to an orthogonal plan³⁸. In time this became the best part of the village, where summer visitors settled; simultaneously, fishing and industrial activities were pushed to the South, creating two different neighborhoods.

In 1950, integrated in a national campaign for the modernization and embellishment of coastal towns, Furadouro had its first urbanization plan. The village had then about 100 families, corresponding to 500 inhabitants, most of them fishermen, living in extreme poverty. In the South part of the village, where the *palheiros* were standing, the plan provided for the replacement of these old houses with homes with better living conditions. In the North part a new residential area would be built for touristic proposes. Some new basic infrastructures - sewages, a market, a school, a church, hotels, restaurants and a theater/town hall – were also planned³⁹. Other plans were designed in 1961 and 1968, but as most of the urbanization projects made in the 1950s and 1960s in Portugal, they were never implemented or only a part of them was put into practice. As Furadouro kept attracting people during the summer and the existing urban regulations were not enough, the site grew in an unordered way, with uncharacteristic buildings and houses, of all sizes and shapes⁴⁰.

During all this time the Ovar Township and the Tourism Commission tried hard to improve the village, creating rules to define the condition of the houses rented to tourists, forbidding the existence of pigs outdoors, ordering the demolishing of *palheiros* in ruins, repairing the streets, supporting private initiatives for the construction of sporting fields, playgrounds and a camping park. In order to follow the model of other seaside resorts, the great ambition of these two institutions was the construction of the *Esplanada*, a kind of boardwalk and balcony, parallel to the beach,

³⁵ *Comércio do Porto*, 28 Sep. 1863, 2.

³⁶ S. Dionísio, *Guia de Portugal*, III (Lisboa: Fundação Calouste Gulbenkian, 1993 [1940]), 512, 555.

³⁷ Lemos, *Models in the formation of coastal urban ...*; Clairay, 'Le développement balnéaire breton'.

³⁸ Lamy and Rodrigues, *Furadouro uma terra com passado...*, 37.

³⁹ Rezende, Antepiano de Urbanização da Praia do Furadouro, 14-34.

⁴⁰ Gigante, Plano de Urbanização da Zona Norte do Furadouro, 2-3; Barroca and Cerveira, Antepiano Director do Cordão Litoral Norte da Ria de Aveiro, 49-50; CEAPE, Plano Geral de Urbanização do Cordão Litoral Norte da Ria de Aveiro – Ovar, 18.

delimitating the maritime and urban areas, that would be the center of social life during the summer⁴¹. An enterprise that became much more difficult than expected as the sea was constantly changing the maritime front of Furadouro.

According to historical information, maritime overwashes occurred in 1841, 1857, 1863, 1868, 1887, 1888, 1889, 1905, 1912, 1938, 1939, 1940, 1946, 1957, 1958, 1960, 1964, 1965, 1969 and 1971⁴². Lamy and Rodrigues say that 106 *palheiros* and other buildings were destroyed between 1857 and 1969. Some 'sea invasion' events had more impact on local community than others, for instance, the chapels' destruction in 1939 and 1957; and the disappearance of Chalet Matos in 1969. The first chapel of Furadouro was built in 1766, in front of the ocean, and was destroyed by the sea in 1939 (Figure 3). It was a shock for the population. Although the chapel had been repeatedly at risk, people never expected it to be destroyed. There was a popular belief that the sea would respect that sacred place. In 1887, a new chapel was built in Furadouro, because the old one was considered too small and inadequate for a developing seaside resort. The New Chapel only lasted 68 years; it was ruined by the sea in 1957 and afterwards demolished by the local authorities. The Chalet Matos was the biggest *palheiro* of Furadouro; it was built between the end of the 19th century and the beginning of the 20th century. Its owners were influential people in the region and the house became an iconic building of that beach. The sea destroyed it partially in 1964-1965 and then in December 1969 it disappeared, taken by the waves⁴³.

Figure 3. Destruction of the Old Chapel in 1939 (Photo from Arquivo Municipal de Ovar)

For a long time there wasn't much that local authorities and population could do about overwashes. Furadouro was a small fishing village, so its defense was not a priority. In the beginning of the 20th century, Portugal faced a political, social and financial crisis and resources were scarce. Also, unlike the town of Espinho, a seaside resort nearby, with national projection and frequented by the upper class, Furadouro did not have enough social and economic relevance to convince the government to spend a large amount of money to build hard defense structures to protect it from the sea. In the 1930s, after an interruption of almost 20 years, when the sea started to cause damages again, local authorities asked the government for some protective measures. But their

⁴¹ CMO, *Livro de Actas*, n.º 53, 5 Apr. 1949 to 7 Jun. 1952, fl. 51v, 57, 64; *Livro de Actas* n.º 56, 19 Set. 1956 to 1 Oct. 1958, fl. 120v; Junta de Turismo do Furadouro, *Livro de Actas*, 18 Mar. 1947 to 7 Set. 1950, fl. 54v-55; *Livro de Actas*, 6 Mar. 1950 to 30 Dec. 1953, fl. 32, 52, 63v-64, 76v-77, 100; *Livro de Actas*, 4 Jun. 1956 to 31 Dec. 1958, fl. 1v, 28-28v, 43v, 67v; *Livro de Actas*, 31 Dec. 1958 to 4 Feb. 1961, fl. 27v-29v, 42v, 46v, 62v, 83v-84; *Livro de Actas*, 4 Feb. 1961 to 2 Aug. 1963, fl. 3v-7v; *Livro de Actas*, 6 Set. 1963 to 2 Jul. 1965, fl. 60-60v; *Livro de Actas*, 6 Aug. 1965 to 4 Oct. 1967, fl. 93v-94.

⁴² *Diário do Governo*, 15 Feb. 1841; *Comércio do Porto*, 28 Sep. 1863; *Diário de Notícias*, 15 Mar. 1868; *O Ovarense*, 1 Apr. 1888; *Diário de Notícias*, 31 Oct. 1905; *Diário da Câmara dos Senhores Deputados*, 4 Mar. 1912; *Notícias de Ovar*, 19 Dec. 1957; *Notícias de Ovar*, 17 Mar. 1960; Laranjeira, *O Furadouro. O Povoado, o Homem e o Mar*, 174; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 57-58.

⁴³ Lamy and Rodrigues, *Furadouro uma terra com passado...*, 19, 40, 53, 57, 59; *Povo de Ovar*, 3 Mar. 1939 and 5 May 1939; *Notícias de Ovar*, 19 Dec. 1957.

request was not answered. It would take 20 more years for national authorities to act in defense of the village⁴⁴.

In 1958, the sea destroyed part of the *Esplanada*. The National Maritime Services made then an emergency intervention placing a rip-rap coating in front of Furadouro. But this was not enough; the stone wall was too short in length to protect all the urban area, and after some years the sea took most of the stones, spreading them on the beach and ruining the wall. On April 7, 1960, after a severe winter, the journal *Notícias de Ovar* asked for 'stone, more stone' to protect the village and the new *Esplanada* that was being built to replace the previous one. Because the Maritime Services were not acting fast enough, the Ovar Township was forced to take measures to protect the *Esplanada*. Tons of stone – carried by trucks – were then dropped into the beach⁴⁵. According to records, between 1958 and 1970, in front of the village, overwashes were responsible for a coastline retreat of 50 to 100 meters⁴⁶.

From the second half of the 19th century onwards, but especially in the 20th century, new practices and their material implications - arrangements - changed human-environment relations in Furadouro. 'Changes in societies are closely intertwined with ecological transformations': many factors - shifts from agriculture to industrial economies and from biomass to fossil fuel use, societal modifications as institutional and regime change or new legal frameworks, fashions and patterns of consumption - can disrupt or modify socioecological dynamics⁴⁷. That is to say, people have the ability to act intentionally to shape their world, but the 'so-called human agency cannot be separated from the environment in which that agency emerges'⁴⁸. In the third phase of the evolution of the socio-ecological site of Furadouro, new ideas, uses and activities changed the beach and at the same time were conditioned by a changing littoral, in a complex puzzle of human and nature features, with consequences turning into causes and vice-versa. We will see this better later, when explaining the causes for coastal erosion problems.

In this period, leisure and pleasure practices determined arrangements and the transformation of Furadouro. Beachgoing habits were introduced in Portugal at the end of the 18th century. They spread slowly from the upper to the lower classes of society, during all the 19th and the 20th centuries. Empty or scarcely populated coasts like Furadouro, until then working and living places for some marginal communities, turned into attractive and desired spaces. As new people arrived to the seashore, new socio-economical demands emerged: lodging, food supplies, transports, communications, energy, basic infrastructures and entertainment. Arrangements reflected these needs: houses, hotels, railroads, roads, telegraph, telephone, postal services, electricity, water and sewage; cafes, restaurants, meeting places, cinemas, sporting fields, seaside boardwalks. Land use changed significantly as the *palheiros* were gradually replaced by masonry buildings. There was also a shift in settlement patterns: the urbanized area grew and spread along the coast and inland. Authorities' role increased and became

⁴⁴ D. Pinto, *O turismo em Ovar entre 1945 e 1960*, Master Thesis (Porto: University of Porto, 2011), 20; CMO, *Livro de Actas* n° 51, 28 Mar. 1936 to 7 Oct. 1939, fl. 166-166v; *Livro de Actas* n° 56, 19 Set. 1956 to 1 Oct. 1958, fl. 187, 196v-197.

⁴⁵ *Notícias de Ovar*, 2 and 9 Oct. 1958; 18 Dec. 1958; 21 Jan. 1960; 17 Mar. 1960; 14 and 21 Apr. 1960; 23 Jun. 1960; Junta de Turismo do Furadouro, *Livro de Actas*, 31 Dec. 1958 to 4 Feb. 1961, fl. 28-29.

⁴⁶ Conselho Superior de Obras Públicas, Parecer n.º 3801, fl. 2-3.

⁴⁷ Haberl, Winiwarter, Andersson et al., 'From LTER to LTSER'.

⁴⁸ L. Nash, 'The Agency of Nature or the Nature of Agency?', *Environmental History*, 10-1 (2010): 20.

more effective as all these people and activities needed more regulation, supervision and financial support.

Public (and previously wasted) land near the sea, belonging to the township, became valuable and was sold to the highest bid – or given away according to different interests – to increase the township revenues. As Bavel and Thoen put it, the issue around property rights is not about their nature, but who or which social groups possess them and what are the objectives and economic strategies of those who hold these rights. The functions, uses and interests concerning the land influence the management, the decision-making processes and the adopted coping strategies related to that environment⁴⁹. In Furadouro, as more people arrived to the beach, more actors participated in the transformation of that site: fishermen, beachgoers, builders, traders, local and national authorities' representatives. But not everybody had the same power and influence; in this process there was one crucial group - the builders – who created and manipulated the village's new image and the associated built environment. According to Gray, 'the builders include professional architects and designers and engineers, surveyors and constructors, but also extend to the individual, communal, government and corporate owners, developers and authorities making a direct contribution to building and rebuilding' a specific area. 'Apart from making a physical artifact, the builders of seaside resorts also envisage and enact a particular view of their work and its purpose and future use'⁵⁰. In the case of Furadouro, the Township of Ovar and the Tourism Commission – influenced by national policies concerning coastal areas – were its main builders. Their objective was to create a modern urban area – based on the idea of bringing progress and civilization to a marginal territory -, developing it as a seaside resort, like the neighboring town of Espinho, calling more visitors to Furadouro, increasing local economy revenues and improving its inhabitants' living standards. The members of both institutions were mainly influential men from Ovar, from powerful local families, with business and other investments in Furadouro, where they also went as sunbathers. So there was a mix of political, economic, social and even moral and philanthropic interests in their intervention on that beach⁵¹.

As new actors were taking control of this territory, traditional populations - fishermen - were losing it. Their ways of life, type of houses, uses, traditions and knowledge changed or disappeared. As fishing turned into a secondary activity and tourism developed in the village, the fishing communities were progressively moved to the peripheries so that the central area of the beach could be used by the beachgoers. Settled here when the use of the land was free, building their *palheiros* where they understood best, these communities were pushed both by nature (sea invasions) and by political, economic and social constraints to specific areas. Their typical houses – associated with misery and old traditions – disappeared as new neighborhoods were built by local authorities and the government according to the (social, hygienic and control) policies of *Estado Novo* (the dictatorship that ruled Portugal between 1933 and 1974).

Unlike the previous stages in which national government influence in this marginal area was weak, in this period central governance decisions had a relevant role in at least

⁴⁹ B. Bavel and E. Thoen, 'Rural history and the environment. A survey of the relationship between property rights, social structure and sustainability of land use', in B. Bavel and E. Thoens (eds.), *Rural Societies and Environmental Risks. Ecology, Property Rights and Social Organisation in Fragile Areas (Middle Ages – Twentieth Century)*, (Turnhout: Brepols Publisher, 2013), 32-33.

⁵⁰ Gray, *Designing the Seaside*, 10.

⁵¹ Junta de Turismo do Furadouro, *Livro de Actas*, 31 Dec. 1958 to 4 Feb. 1961, fl. 83-84; Idem, *Livro de Actas*, 6 Set. 1963 to 2 Jul. 1965, fl. 33, 60; Pinto, *O turismo em Ovar entre 1945 e 1960*, 13-14, 16; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 37-38, 40, 48, 53, 63.

one major issue: the protection of Furadouro. The high cost of hard engineering protection structures could only be supported by the state, but national authorities did nothing to protect the village until the end of the 1950s. Three reasons explained this late intervention. First, in this decade – for causes that we will see ahead – coastal erosion problems increased, significantly putting the village in great danger. Second, when the sea was only destroying *palheiros* it was considered that Furadouro wasn't worth – economically and socially speaking – the investment in defensive structures. Third, in the 1940s and 1950s, with the urban development of the beach, the increasing number of beachgoers and the interests of the local elites at stake, there was much more to lose. When the land and the buildings on it became valuable, a citizens petition, articles in newspapers and the intercession of influential people close to ministers obtained from the government the much desired protection of Furadouro⁵².

Knowing that urban growth was taking place at the same time that Furadouro was being destroyed by overwashes one has to ask: didn't the people and the government realize the risks of building in such an exposed area? Historical data shows that they did, but they kept building anyway. For instance, a technical report from the Urban Services of Aveiro (the district capital), clearly against the building of the Esplanada because the enterprise was condemned to failure, was ignored and put aside as 'inopportune' by the Tourism Commission⁵³. We attribute this attitude to the general lack of knowledge about natural processes and the causes of coastal erosion and to an overconfidence in hard engineering structures as being capable of solving the problem. This last reason is particularly evident in the next phase.

d) Fourth period: challenges of coastal management

The 1970s onwards represent a new period in the life of Furadouro. In the 1960s fishing activities were still the major occupation of its inhabitants. But the *xávega* was in decay, as more modern and profitable techniques were developed⁵⁴. The absence of a harbor and the necessity of mooring the boats in the beach – which was getting smaller and rocky because of the rip-rap and the groynes⁵⁵ – made impossible the adoption of new boats and other improvements. So in the 1980s the tertiary sector linked to tourism and summer business had become the main motor of the local economy⁵⁶. Along the years, many fishermen migrated to other places (Tejo and Matosinhos), to other types of fishing (mainly to trawlers and Terra Nova cod fishing) or even to other countries to work on building. In 2005 there were only three *xávega* fishing crews in Furadouro, employing 43 workers⁵⁷. Nevertheless, in the last decade of the 20th century the village had a significant population and urban increase, as it turned into a dormitory for people working in Ovar and a second home area. The 2001 national statistics (Censos) pointed to the existence of 2057 inhabitants and 2631 homes, of which 28,84% primary

⁵² *Notícias de Ovar*, 16 May and 18 Jun. 1958.

⁵³ Junta de Turismo do Furadouro, *Livro de Actas*, 31 Dec. 1958 to 4 Feb. 1961, fl. 28-29v, 42v.

⁵⁴ Barroca and Cerveira, Antepiano Director do Cordão Litoral Norte da Ria de Aveiro, 17, 20.

⁵⁵ H. Souto, *Comunidades de pesca artesanal na costa portuguesa na última década do século XX* (Lisboa: Academia da Marinha, 2007), 91-92, 99-100, 110.

⁵⁶ CEAPE, Plano Geral de Urbanização do Cordão Litoral Norte da Ria de Aveiro – Ovar, 11, 18.

⁵⁷ Lamy and Rodrigues, *Furadouro uma terra com passado...*, 42; T. Pires (coord.), *Diagnóstico Social do Concelho de Ovar* (Câmara Municipal de Ovar, 2009), 162, 240.

residencies and 71,16% second homes. According to a recent study, 61,44% of Furadouro' buildings are in a risk area⁵⁸.

In fact, in the winter of 1971, despite the measures of the Township of Ovar, the sea had again damaged part of the Marginal Avenue and some buildings nearby. In Parliament, a deputy asked for government intervention in the case of Furadouro: it was necessary to do something that could effectively protect that village and its population. The cost of protection was considered a price to pay for progress. By then, the Maritime Services had prepared a project for a major engineering intervention at Furadouro: a 1275-meter seawall along the front of the urban area and three groynes with 200 meters each. The works had the double purpose of protecting the seafront of the village and enlarging the beach in order to allow its touristic use for bathing. The project was approved by higher authorities based on the justification that coastal erosion had done significant damage in Furadouro and has seriously threatening that seaside resort. The works took place between 1971 and 1974⁵⁹. But, since the sea keeps damaging heavily these structures, over the years they had to be rebuilt and reinforced several times, at high public financial cost.

Scientific studies on erosion in the coastal stretch between Douro and Aveiro have shown a mean retreat rate of 0,6 meters/year, between 1947 and 1958, in a 12 km area around Furadouro. In the period of 1958-1980 the mean retreat rate reached 2,1 meters/year, but this value should be analyzed carefully because it was influenced by the construction of the hard engineering works in front of the village in 1972/1973. In fact, aerial photography analysis has shown some accretion (1,3m/y) at the north of the groynes and a retreat rate of 4,8m/y to the south of those structures (in this coast littoral drift runs North to South)⁶⁰. In a more localized analysis, Ângelo determined mean retreat rates of 3,6 and 2,6 meters/year, between 1947-1954 and 1954-1990, in the North of Furadouro; 2,8 and 8 meters/year, between 1954-1990 and 1984-1990, at Furadouro beach (in front of the village); and 4 meters/year, between 1984-1990, to the South⁶¹. All these data point to an increase of coastal erosion during the 20th century and its propagation downdrift, that is to the South, especially after the construction of the coastal defenses of Furadouro in 1958 and 1971s⁶². Between 1994 and 2011, despite the longitudinal rip-rap, the number of overtopping events rose. Emergency interventions are usual in this stretch, which means that this is still a highly vulnerable beach. In the winters of 2010 and 2014 storms caused significant damage in the front area of the village⁶³ (Figures 4 and 5). 'Considering the expected modifications of the coastal erosion drivers induced by climate changes', a study was made, in 2013, 'to define their

⁵⁸ INE, Censos 2001 – XIV Recenseamento Geral da População. IV Recenseamento Geral da Habitação apud L. Pinho, H. Albuquerque and F. Martins, 'Vozes do mar não chegam a terra – segunda residência em áreas de risco', *Estudos Regionais*, 17 (2008): 86-87, 88.

⁵⁹ *Diário das Sessões da Assembleia Nacional*, 21 Jan. 1971, 1520; Conselho Superior de Obras Públicas, Parecer n.º 3801, 10-11; Lamy and Rodrigues, *Furadouro uma terra com passado...*, 57.

⁶⁰ Ó. Ferreira and J.A. Dias, 'Evolução recente de alguns troços do litoral entre Espinho e o Cabo Mondego', 91.

⁶¹ Ângelo, 'Taxas de variação do litoral oeste: uma avaliação temporal e espacial'.

⁶² Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*, 58; F. Veloso Gomes, F. Taveira Pinto, L. das Neves, J. Pais Barbosa, *EUrosion: Pilot site of River Douro – Cape Mondego and case studies of Estela, Aveiro, Caparica, Vale de Lobo and Azores* (Porto: IHRH/ FEUP, 2006); T. Ramos, *Estudo de reabilitação de estruturas de defesa costeira. Casos de estudo do Mindelo, Norte do Furadouro e Torreira* (Master diss, University of Porto, 2011), 57.

⁶³ Costa and Coelho, 'Northwest coast of Portugal...', 923-924; Ramos, *Estudo de reabilitação de estruturas de defesa costeira*, 57-58.

potential effects, trying to anticipate hydro/morphodynamics changes in coastal areas'⁶⁴. According to it, sea-level rise, the increase of storminess and rotations in the wave regime 'will increase coastal flooding of low-plains, houses and infrastructures, causing economic damage and eventual patrimonial, cultural and ecological losses'. The study mentioned 'applies numerical models to predict shoreline evolution, in a medium-long term perspective, contributing to establish trends and foresee shoreline position scenarios'. These projections, up to 2040, 2070 and 2100, point to an erosion trend with heavy loss of territory in the stretch Esmoriz-Mira (where Furadouro is included), in all the considered scenarios.

Figure 4. Furadouro's Avenue and coastal protections - seawall and groyne – in 2014
(Photo by Joana Gaspar de Freitas)

Figure 5. Furadouro's seawall damaged by 2014's winter storms (Photo by Joana Gaspar de Freitas)

In the years that followed the end of the dictatorship and the establishment of the democratic regime (April 1974) Portuguese society changed much. The regulation of workers' rights allowed them to have more free time and paid vacations. The development of national economy improved citizens' living conditions; better roads and transports made some areas more accessible; and a significant part of the population moved to coastal zones. Urbanization spread and grew all along the Portuguese coast, in many cases, due to the second home phenomena. Furadouro was no exception. This is why nowadays two thirds of its buildings are second homes, empty for most of the year. People's metabolic needs also changed. Fishing is not relevant any more. Pleasure and rest during the summer holidays are the reasons that drive people to this beach. Its inhabitants work mainly in the service sector or in the nearby city, Ovar. Since many of these new actors came from other regions they did not know the characteristics of the territory where they settled. They were unaware of its risks. In the same way, local authorities with planning responsibilities, as well as property developers, thinking only of profit, acted as if the coastline was stable, and allowed urban growth in a danger area. The groynes built in the 1970s made them believe they were safe. Urban land use increased, contributing significantly to coastal artificialization and to the growth of its vulnerability to extreme weather events.

Today, the maritime front of the village is still its hot spot. The seaside esplanade and avenue is Furadouro's postcard view, the place where all visitors go. Local authorities keep investing in the aesthetic and functional aspects of this particular area. However, the main concern about this avenue is still its protection. Hard engineering structures are there to 'hold the line' and keep the sea away. Nevertheless, during the winter, waves frequently cause them severe damages. For the inhabitants of Furadouro – especially the ones living there all year – coastline changes are now impossible to ignore. In a survey made in 2006, most of them said they would accept to be relocated in case of danger, but the majority also said they feel secure near the sea, because of the defensive structures. The 150 interviewed were mainly the retired, housewives and the unemployed. The ones who did work were civil, commercial and other service workers. Only 8 were fishermen or were connected to fishing activities. 81% of the total said

⁶⁴ Pereira, Coelho, Ribeiro et al., 'Numerical modelling of shoreline evolution...', 2161, 2164.

they were available to participate in the decision-making process concerning coastal management, but just 40% knew about the existence of a Management Plan for this coast. The interviewees justified their previous non-participation with the lack of information about the public consultation period⁶⁵.

In Portugal – in reminiscence of several decades of dictatorship maybe – state administration is still very centralized and hierarchic, so there are many (formal and informal) barriers to public participation and decisions are made based in general convictions and specific interests more than in scientific studies and in open dialogue with social groups. In many cases, public consultation is done solely because of the legal obligation to do so, since decisions have already been taken and public opinion has little or no consequence. Citizens' participation is also hampered because many are not familiar with coastal management issues. Others, like fishermen, have a deep knowledge about the sea and the coast, but are put aside. Recent studies show that they are conscious (they always were) about coastline shifts, identifying easily both natural and human causes of coastal erosion. However, fishermen are hardly ever heard in the process of decision-making about coastal management. The low income of their activity, their low position in the social scale and their empirical knowledge (in contrast to the technical and formal knowledge of engineers) explain why their opinions are usually neglected in the decision process⁶⁶.

In recent years, the protection of Furadouro has been prevalent in local governance issues, determining the relationship between the population and the authorities and between authorities themselves. The timings, the cost of rebuilding and reinforcing the engineering structures and the uncertainties about this strategy have been the cause of a certain friction between local and central powers. Meanwhile, other voices say that the hard structures solution is obsolete and call for the adoption of other measures⁶⁷.

The fourth phase of the socio-ecological evolution of Furadouro is determined by national political, social and economic events. Rural exodus, better living conditions, profit revenues from real estate construction and the firm belief in defensive hard engineering structures explained the growth of Furadouro's urban area and the second-home phenomenon. Practices concerning housing, communications, transports, basic sanitation, business activities and sea protection are the reason for arrangements like buildings, roads, car parking lots, water and sewage infrastructures, groynes and seawalls. Human and natural features are highly connected as one transformed the other and vice-versa. For instance, the need for protection and its material consequence, groynes, are only there because more people settled in this beach, craving to be close to the sea. But by putting houses so close to the coastline they caused profound changes to it, building a new hybrid environment, where human and nature sit side by side, raising unwelcome side-effects that make people fear the ocean and build protections against it, accelerating and taking coastal erosion problems down-drift to other coastal villages to the south and leaving a heavy burden legacy to future generations. Old actors – like fishermen – disappeared as new ones took their places. Retired people and workers from Ovar are now the inhabitants of Furadouro, but most of its houses are empty for a

⁶⁵ Pinho, Albuquerque and Martins, 'Vozes do mar não chegam a terra...', 88-92.

⁶⁶ A. Delicado, L. Schmidt et al., 'Fishermen, local knowledge and coastal change on the Portuguese coastline', *Journal of Integrated Coastal Zone Management*, 12-4 (2012): 447-448; C.P. Silva, 'Landscape perception and coastal management: a methodology to encourage public participation', *Journal of Coastal Research*, SI 39 (2004).

⁶⁷ J. Lopes, 'Combate à erosão costeira transforma Furadouro (Ovar) em praia de...pedra', *Etc. e Tal Jornal*, 01 Jan. 2014.

large part of the year. Township and state governance face serious challenges concerning coastal management and have hard decisions to make. On the one hand, the desire to develop Furadouro, to improve its living and touristic conditions, to answer its inhabitants' expectations about the future of their property, jobs and ways of life. On the other, the situation of this specific site – a coast in erosion; the increasing risks upon this vulnerable area - a consequence of the last decades' urban growth; the pressure to protect people and estate from the ocean and the real knowledge that this may not be possible in the long-run since the available financial resources may not be enough to keep the sea away.

Furadouro's coastal problems: searching for explanations

We have seen previously that erosion is a natural phenomenon. But in the case of Furadouro several local and non-local human activities have contributed to its increase.

The biggest sediment supplier to the Furadouro coastal stretch is the Douro River. Until the end of the 18th century, few works had been done in the mouth of this river. After this period, the necessity of improving the navigation channel to facilitate transport and commercial activities was responsible for several arrangements. In 1790, almost at the same time as Furadouro was developing as a fishing camp, a guidance wall began to be built between Cantareira and the Felgueiras rocks. The purpose was the regularization of the right margin of Douro, the reducing of the sand split at its mouth, the improving of the navigation channel and the deepening of the river bottom. In 1821 another wall started to be built in the left margin. These works were interrupted several times: the invasion of Napoleon's troops, institutional and financial crises and a civil war postponed their conclusion until the second half of the 19th century. Between 1860 and 1869 many underwater rocks in the mouth of the river, considered a danger to navigation, were destroyed. The right bank has finally regularized and dredging was done between 1886 and 1904 to reduce the silting of the river bar⁶⁸ (Figure 5). The first “sea invasions” at Espinho and Furadouro occurred while these works were being carried out so there is a strong hypothesis of correlation between the two events.

Figure 6. Detail of the mouth of the Douro River and some of the correction made (A. Loureiro, *Os portos marítimos de Portugal e ilhas adjacentes. Atlas* (Lisboa: Imprensa Nacional, 1904-1909)

Until the 20th century, almost all the transportation of people and goods was done by sea. The two main Portuguese harbors were Lisbon and Oporto, but this last one – located in the mouth of the Douro River – had natural characteristics that jeopardized maritime and commercial traffic. Given the relevance of the town of Oporto for the national economy some improvement works were done – as we have seen - at its harbor, but they were not enough. Traffic increase and the growth of ships' tonnage made necessary for harbors to have specific physical characteristics and equipments. After some studies, it became clear that the harbor at the Douro River mouth didn't have the conditions to ensure safe navigation and ship docking. The alternative was to build a new harbor nearby, at Leixões. This artificial port was a major arrangement at the time it was built, from 1884 to 1895. Two big jetties were built to create a sheltered

⁶⁸ A.N. Soares, *Revista de Obras Públicas e Minas* (Lisboa: 1871): 23-35; A. Loureiro, *Os portos marítimos de Portugal e ilhas adjacentes*, I (Lisboa: Imprensa Nacional, 1904), 353-356.

bay in the exposed Northwestern coast of Portugal. It is believed that the works in the estuary of Douro and the port of Leixões jetties (blocking the passage of the sand carried by the rivers to the north of Douro) have caused the diminishing of sediments entering the littoral drift and feeding beaches to the South⁶⁹. This theory has been debated since the construction of the port of Leixões and throughout the 20th century. According to the ones who considered human intervention at Douro and Leixões responsible for the erosion at Espinho and Furadouro, it was common for the sea in this coastal stretch to cause significant coastline retreat in some occasions. But this was temporary, as the sea returned the sand after a while. Before the construction of the Leixões harbor the sea brought more sand to the beach than the amount it used to carry away. Afterwards, the situation changed and the tendency was for the beach to have less sand than before. Current knowledge about the negative effects of jetties make us believe that this theory is correct⁷⁰. It is probable that the external jetties of the harbor were responsible for the change of the longshore currents, causing the loss into deep ocean of part of the sediments that used to feed the beaches down the coast to Aveiro (Figure 7). For instance, the Leixões jetties were expanded in the 1930s, in that same decade coastal erosion increased in Espinho and Furadouro.

Figure 7. The Douro River, the city of Oporto and the Leixões harbor (Loureiro, *Os portos marítimos de Portugal e ilhas adjacentes...*)

In the 19th century, commerce and maritime transportation justified the first big arrangements in this coastal area: port infrastructure and river regularization. In the 20th century, society's metabolic needs for energy and water supply were responsible for the constructions of dams which reduced significantly the sediment input from rivers. Until the 1930s electric power production was small and restricted to local consumption: minor power plants, industries and mills. During the Second World War, because of the scarcity of imported fuel, Portuguese authorities sought alternative sources. The 1944 law established the basis of national electricity production, its transport and distribution. The construction of big hydroelectric infrastructures began soon after the end of the conflict. In the following years several dams were built in the Portuguese rivers, including the Douro and its tributaries: Picote (1958), Miranda (1960), Bemposta (1964), Vilar-Tabuaço (1965), Carrapatelo (1971), Régua (1972), Valeira (1975), Crestuma-Lever (1985). Since the Douro is an international river shared by Spain and Portugal, Spanish arrangements also have to be considered. In Spain, between 1955 and 1975, big dams were built to produce energy, irrigate farmland, provide water to the population and control floods⁷¹. These major arrangements are responsible for the

⁶⁹ Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*, 169; J.G. Freitas, *O litoral português na época contemporânea: representações, práticas e consequências. Os casos de Espinho e do Algarve* (PhD diss., Universidade de Lisboa, 2011), 87, 152; J.G. Freitas and J.A. Dias, 'O caso de Espinho (Portugal): um exemplo das consequências das acções antrópicas nas zonas costeiras', in M.A. Rodrigues and S.D. Pereira (eds.), *Interações Homem-Meio nas zonas costeiras Brasil/Portugal* (Rio de Janeiro: Corbã, 2013), 131-132.

⁷⁰ *Gazeta de Espinho*, 2 Feb. 1908; *Diário de Notícias*, 6 Jun. 1908; 7 and 9 Jun. 1909; A. Lima, 'As invasões do mar em Espinho', *Espinho. Boletim Cultural*, IV, 15/16 (1982 [1931]): 334; M.A. Eça, 'Espinho e o Mar', *Arquivo do Distrito de Aveiro*, 43 (1945): 235-238; Ferreira, 'A construção do porto de Leixões...', 106; Kaufman and Pilkey, *The beaches are moving*, 193-196; J.A. Dias, 'Evolução da zona costeira portuguesa: forçamentos antrópicos e naturais', *Revista Encontros Científicos – Turismo, Gestão Fiscalidade*, 1 (2005): 19-20.

⁷¹ Madureira and C. Baptista, *Hidroelectricidade em Portugal. Memória e Desafio* (Lisboa: REN. Rede Eléctrica Nacional S.A, 2002), 12-14; F. Rollo, 'Hulha branca: uma história de triunfos, impasses e

retention of the sediments carried by rivers and for significant changes in the regime of floods reducing drastically the amount of sediment that reaches the coast. For instance, the Douro River in natural conditions used to carry to the sea a sediment load of $1,8 \times 10^6 \text{ m}^3/\text{year}$; this amount was reduced to $0,25 \times 10^6 \text{ m}^3/\text{year}$ after the construction of dams and other river works⁷².

There are also the impacts of dredging and sand extraction. In the second half of the 20th century harbor conditions had to be further improved to allow the access and navigation of big ships. The mouth of rivers and the navigation channels are currently dredged to prevent silting. In addition, the development of construction (houses, roads, infrastructures) increased the need for sand as a raw material. Inert materials extraction from rivers and beaches is a lucrative business and many excesses are committed. For 40 years, near the Leixões port a sediment load of $1,5 \times 10^5 \text{ m}^3$ was dredged every year. In Douro River, in the beginning of the 1990s, dredging was taking an amount of about $1,5 \times 10^6 \text{ m}^3$ of sediments per year⁷³. In 1930-1950 there was also a change in land use in this region due to the afforestation of a part of the mountain area of the Douro catchment area. These works were part of a bigger campaign – the National Afforestation Plan - to develop the forest area in Portugal. Control of soil erosion was one of its main purposes. The idea was not new, but in this period the state had something that it didn't have before: human and financial resources and the power to impose its will against those who opposed the project⁷⁴. All these factors contributed to a drastic decrease in the amount of available sand to feed the beaches of that coastal stretch. Other circumstances may have played a role too – like storm activity and floods -, but there are not enough quantitative and qualitative data to draw conclusions. Erosion in Furadouro is always connected to big storms – this is a very energetic coast -, however the available information does not allow us to connect them to specific periods of climatic instability.

Previous studies⁷⁵ about this coast connect all these socio-ecological factors to coastal erosion in Espinho, a town situated around 15 km north of Furadouro. Espinho, such as Furadouro, started having problems of coastal erosion in the mid-19th century. But in Espinho the situation was much worse. In 1912, the engineer responsible for the construction of the defense system of the town calculated that between the first 'sea invasions' in 1869 and 1912, coastline retreat had reached an average of 8 meters /year. 350 meters of land were lost. In fact, part of the old Espinho is under water hundreds of meters away from the present coastline. The consequences were significant since Espinho was an important fishing and canning industry town and a famous seaside resort. The first defensive system was built in 1909 and rebuilt in 1912. Between 1913 and 1930 decade there were no 'sea invasions'⁷⁶. But the problems returned (probably

renovados desafios', Revista *Ingenium*, II, 88 (2005); Madureira and Baptista, *Hidroeletricidade em Portugal*, 15-26; L.B. Casafont, 'Presas e embalses en la España del siglo XX', *Revista de Obras Publicas*, 3488 (2003).

⁷² I.B. Mota Oliveira, A.J. Valle and F.C. Miranda, 'Littoral Problems in the Portuguese West Coast', *Coastal Engineering*, 3 (1982): 1950-1969; Dias, 'Evolução da zona costeira portuguesa...', 16.

⁷³ F. Abecasis, M.F. Matias et al., 'Methods of determining sand-and-silt movement along the Coast, in Rivers and in Maritime Rivers', *Technical Paper 186* (Lisboa: LNEC, 1962); Oliveira, Valle and Miranda, 'Littoral Problems in the Portuguese West Coast'; Dias, 'Evolução da zona costeira portuguesa...', 18-19.

⁷⁴ M.C. Radich and A.A.M. Alves, *Dois séculos da floresta em Portugal* (Lisboa: CELPA – Associação da Indústria Papeleira, 2000), 138-139.

⁷⁵ Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*, 18, 60, 62; Freitas and Dias, 'O caso de Espinho (Portugal)...'.

⁷⁶ M. Faria e Maia, *Memória sobre as obras de defesa da povoação de Espinho* (Lisboa: Typographia de António Maria Antunes, 1912); F. Perdigoão, 'Defesa da costa marítima de Espinho', *I Congresso*

because of the extended jetties of Leixões) and in the 1940s a new defensive structure was built. It consisted of a longitudinal wall and three groynes. In 1980s another protection system was implemented and more groynes were built to the South of Espinho⁷⁷.

As referred above, coastal erosion problems in Furadouro became more serious in the 1950s. A wall of rip-rap stone blocks had to be built to protect the village and later a major defensive system was erected. It has been long known that groynes trap ‘sand that is moving somewhere’. ‘Interruptions that build one section of beach erode another’. Human arrangements like groynes and jetties ‘can affect beaches for miles along the coast’⁷⁸. Scientists believe that coastal erosion in Espinho and Furadouro have the same causes, but Furadouro’s situation got worse in the mid-20th century because of the construction of Espinho defensive system located updrift. Espinho was well protected, but its groynes were responsible for beach starvation downdrift, that is, in Furadouro and other villages to the South⁷⁹.

Coastal erosion at Furadouro, however, does not depend exclusively from external causes. Human intervention in that area is also responsible for the increasing of risks and vulnerabilities, by causing the decrease of sand in the beach and the destruction of its natural protection structures. In fact we can say that the third period of settlement in Furadouro represented a turning point between sustainability and vulnerability in human-nature relations on that beach. Fishermen and their families knew the shifts of that coastline and its susceptibility to storms; that is why they did not live there permanently, only settling in during the summer when storms are less probable and the coast is relatively stable. Further, they built temporary houses sheltered by the dunes, they used perishable and easy to find materials collected in the surrounding areas. The *palheiros* were moveable, changing place according to a shifting environment of sand and tides. Also they were easily rebuilt when destroyed by the sea.

The fishermen’s coping strategies were based in the acceptance of the inevitability of coastline mobility and also in avoiding danger instead of facing it. This is not new; past communities survived many natural challenges with simple solutions. As Mauch wrote their ‘motto was “be prepared”, but more often it was “stay away from...”!’⁸⁰. This way of life disappeared slowly with the arrival of newcomers and the introduction of new practices and arrangements at the beach. As the land became valuable and regulations and interests started defining and ruling its occupancy, fishermen could no long move the *palheiros* as they pleased, according to their knowledge of that changing environment. In some cases – like in 1912 – they were given a specific place to stay and to build their houses. With time, long proved sustainable building techniques – the *palheiros* – were replaced by masonry houses. It was the beginning of a fixed settlement in the beach, since masonry houses and building cannot be moved. Also, the constructions of their foundations – as well as the installation of other modern commodities like water and sewage systems – implied the dislocation of large masses of sand and interfered with its natural movements. Fire, sea water and people destroyed the last remains of the typical houses of the sandy coasts of Portugal.

Nacional de Engenharia (Porto: Oficinas do Comércio do Porto, 1931), 17-28; A. Teixeira, ‘As invasões do mar em Espinho através dos tempos’, *Espinho. Boletim Cultural*, III, 7 (1980): 236-246.

⁷⁷ I.B.M. Oliveira and L. Martins, ‘Obras de defesa e reconstrução das praias de Espinho’, *Recursos Hídricos*, 12 (1991): 71-76.

⁷⁸ Kaufman and Pilkey, *The beaches are moving*, 194-195.

⁷⁹ Dias, Ferreira and Pereira, *Estudo sintético de diagnóstico...*, 58-62.

⁸⁰ C. Mauch, *Notes from Greenhouse. Making the case for Environmental History* (Munich: RCC, 2013), 25.

There is more: between 1946 and 1969, authorities allowed the extraction of sand from the beach to be sold for construction. Although in some years the sea took large amounts of sand, in others it brought so much that it turned into a problem. There were complaints about sand invading the seaside avenue, hindering car traffic and the access to the nearby hotel⁸¹. The sand extraction work was done by fishermen, their wives and children, the dunes were removed with shovels, the sand was put into wooden boxes and carried to trucks. The work was hard, but it represented an extra income for these families' economies⁸². The role of sand and dunes in natural beach dynamics was not known then; sand dune mining was a legal activity, as sand was considered a resource that people could use or ignore. In 1956, the Tourism Commission ordered the removal of the remains of the dune in the North part of the village, near the hotel, with the excuse that the dune prevented visitors from seeing the sea views⁸³. To build the *Esplanada* all the maritime front of the village was leveled and the dunes razed. This interrupted and destroyed the natural defensive system of the beach - dune-beach-dune transfer of sediments - against overwashes and coastal erosion. Also, the sand that was taken and sold as a commodity left this littoral cell system and was lost to it. Over the years human practices and arrangements in Furadouro defined a fixed line – the avenue, the *Esplanada*, a row of buildings – in front of the sea separating the urbanized area from the natural one. People did this without understanding that that line was an artificial creation that could not last long in such a high dynamic environment like a beach.

O. Pilkey wrote 'to know the beaches is to know the beaches are moving. We ignore this when we build motels, pavilions, boardwalks and even whole towns on the edge of the ocean. In our business hats we do not recognize any real estate as moveable'. According to him this problem is affecting coasts all over the world⁸⁴. A beach is a system subject to different natural forces like the wind and the waves. During storms the beach works as a buffer zone, the big and strong waves carry away the sand and reaching the dunes they take some of its sand, too. When there are buildings on the beach or in the dunes, the sediment transfer between the dune and beach is disturbed and the capability of the beach to recover after a storm decreases, turning it more vulnerable to other storms. Over time the beach becomes narrower, jammed up against these buildings, offering no protection against sea waves, which eventually overtop the remaining sand and destroy whatever humans have built.

So in the second half of the 20th century, Furadouro's inhabitants became more vulnerable to coastal erosion. First, human activities – locally or far away – had interfere with natural systems potentiating the risks. Second, with the growth of the urban area, the permanent settling and the increase in the number of inhabitants the exposure to danger is bigger and much more is there to lose. Furthermore, frequently people who invest in coastal real estate do not want to hear about its vulnerability. They build seawalls to reassure themselves and keep the *status quo* postponing the problems (in fact, increasing and spreading them). As long-term analysis show, despite sea encroachment of the urban area, the trend was always for its reconstruction and growth.

⁸¹ Junta de Turismo do Furadouro, *Livro de Actas*, 7 Jan. 1954 to 17 May 1956, fl. 52; *Livro de Actas*, 4 Jun. 1956 to 31 Dec. 1958, fl. 10, 16; *Livro de Actas*, 6 Aug. 1965 to 4 Oct. 1967, fl. 95-95v.

⁸² Lamy and Rodrigues, *Furadouro uma terra com passado...*, 55; M. Ribeiro, 'Recolha de areia. Elementos para o estudo da Ergologia e Tecno-economia do Litoral Português', *Arquivo do Distrito de Aveiro*, 132 (1967): 283-292; Marques, *Pescadores do Furadouro*, 28-29.

⁸³ Junta de Turismo do Furadouro, *Livro de Actas*, 4 Jun. 1956 to 31 Dec. 1958, fl. 16.

⁸⁴ Kaufman and Pilkey, *The beaches are moving*, 13; Pilkey and Dixon, *The Corps and the Shore*, 34.

The legacy of human interventions: past, present and future

In the 20th century human activities have led to two opposing realities: urban growth in risk areas and the decrease of the sediment supply to the coast. Their impacts on the environment had an unwanted side-effect, the enhancement of coastal erosion. Arrangements like dams and harbor jetties are not going to disappear. They ensure energy, water supply and maritime transports to society. Cities, towns and villages all around the world were built near the water and people do not want to leave them to the sea. So during the last century the main strategy against sea encroachment was armoring the coastline (e.g. Fortaleza, in Brazil, and New Jersey barrier islands, in the USA). But this has unwanted side effects too. Groynes cause coastal erosion to migrate downdrift; seawalls destroy the beach where they are implanted. Moreover, ‘impacts in the adjacent shorelines inevitably lead to demands for more armoring’. In a long-term perspective, building, maintaining, repairing and reinforcing these structures can cost more than the worth of the property that they are protecting⁸⁵. After the Second World War in the USA, later in other countries, new methods of solving coastal erosion problems were tried. Beach nourishment and dune replacement are now seen as “soft measures” based on the principles of “building with Nature” instead of fighting it. But these are also very expensive solutions and have to be regularly replaced.

Winiwarter *et al.* wrote that we are bound to the maintenance of our arrangements. In many places, like Furadouro, the inherited arrangements (groynes and seawalls) still determine the present scope of options when dealing with coastal zones management. Hard defensive structures are being maintained and reinforced whenever needed to “hold the line”, to protect recent second homes, empty for most part of the year. One thing the combined reconstruction of past landscapes and human intervention allow us is ‘to appreciate the complex, intertwined history of effects turning into causes and vice versa, and the long-term legacies of prior interventions’⁸⁶. One lesson that stands out from this integrated history of a socio-ecological site is that if the option is to keep Furadouro (and many other towns) safe there will never be an end to human regulation, as the sea’s energy cannot be fully controlled, especially with climatic change and the rise of the sea mean level. But does that mean that we are bound to hold on to a strategy that we already know that is not a good one?

New strategies are needed for Furadouro and other urban areas in the same situation. In a recent report (2014) of a technical working group created by the Portuguese government several solutions are pinpointed to mitigate the problems of the sandy West coast of Portugal. The most relevant is the recommendation to improve regulation (that already exists) on riverine and estuarine dredging and to promote the integration of the dredged sediments in littoral drift (by placing them in the submerge or the emerged parts of the beaches) to feed the littoral cells and solve the chronic lack of sand. The other proposed strategies (that are not new and have been developed in other countries too) deal with human settlement and are based in three key-ideas: adaptation, protection and relocation. Their implementation depends on multi-criteria analysis like case-based conditions and cost-benefit assessment. In some cases, where the risks are big and the urban area is small - like Esmoriz and Cortegaça, located between Espinho and Furadouro - it is suggested that the best solution is the relocation or the planned retreat of people and property to safe areas. That’s not the case of Furadouro where protection seems to be the main option on the table. However, according to what is already being

⁸⁵ Pilkey and Dixon, *The Corps and the Shore*, 51-53.

⁸⁶ Winiwarter, Schmid and Dressel, ‘Looking at half a millennium of co-existence...’, 115, 114.

done, this solution is supported by both “hard” and “soft” protection measures: the maintenance of the seawall and the reinforcement of the dunes in the north, central and south part of the village. Also, if the repositioning of the sediment cycle advised by the working group is put forward in the next years, Furadouro will benefit a lot from it. Last, in the report, some suggestions are made concerning adaptation in order to increase the resilience of urban centers in vulnerable areas. It is said that urban (and architectonic) solutions based in mobility, seasonality and perishable materials are the best for a changing territory. Houses on wooden pilings, light and removable homes or structures on floaters are recommended. In fact, *palheiros* are presented as good examples of past societies adaptation to their environment!⁸⁷

The working group recommendations are only guidance measures for a future public strategy concerning coastal management. Their application depends on next government’s policy, interest, strategic vision and financial resources. Taking into account the challenges concerning the future of the coasts, public participation in the decision making process is the best way to guarantee the practical implementation of adopted measures.

Conclusion

Using the words of Winiwarter *et al.*, ‘an environmental history of the kind we aimed to write requires two quite different sets of skills’⁸⁸. One set comprises the historian’s craft, the other the geomorphologist’s work. The product of this combined work is the long-term history of a socio-natural site, Furadouro. Actors, perceptions, motivations, behaviours, groynes, dams, ports, sediments, currents, waves, dunes are put together to explain impacts, reactions and transformations as consequences of the intertwined history of the human and the environment. This analysis of coastal erosion problems in a long-term perspective – monitoring change over time and identifying dynamics and transitions – can be useful for a sustainability science. The knowledge of past decisions and especially of the unintended consequences of human actions can help guide future options based on that previous experience⁸⁹.

Furadouro is an example of a general pattern of unsustainable coastal land-use. Its coastal erosion problems are very similar to many others in the Portuguese sandy West coast and along the Atlantic high energetic sandy coasts of Europe. Generally, these are villages or towns with a recent settlement, that started slowly in the end of the 18th century and reached great progress in the second half of the 20th century. Some began as fishing camps, however beachgoing and tourism were the main motor of their growth. Their development in instable coastal areas triggered the intensification of unwanted natural side-effects causing the known problems. But Furadouro’s history also shows that this area is the result of a mix of environmental and social conditions which are largely site-specific. In fact, social conditions seem to be the main factor contributing to the specificity of the evolution of this space, since humans’ reaction to disaster is different from one place to another. For instance, Furadouro and Espinho have many

⁸⁷ Grupo de Trabalho do Litoral, *Gestão da Zona Costeira. O Desafio da Mudança* (2014), 68, 123-125, 127, 138-139 http://sniamb.apambiente.pt/infos/geoportaldocs/docs/Relatorio_Final_GTL2015.pdf; Agência Portuguesa do Ambiente, *Protecção do litoral: intervenções concluídas e em execução* (2015). http://www.apambiente.pt/zdata/DESTAQUES/2015/Intervencoes_Concluidas_Execucao_05.06.2015.pdf

⁸⁸ Winiwarter, Schmid and Dressel, ‘Looking at half a millennium of co-existence...’, 115.

⁸⁹ Haberl, Winiwarter, Andersson, Ayres et al., ‘From LTER to LTSER’.

aspects in common (location, origin as fishing camps, transformation into seaside resorts, coastal erosion and hard engineering structures), but the way society – public opinion, press and authorities – faced their problem was not the same.

In our analysis, we considered four stages in human / environment relations in Furadouro. The first was the period of absence of settlement in this area, with the exception of some seasonal presence during the summer for fishing purposes. For centuries there were no coastal erosion problems. The beach would change often in width because that is its nature, but that would not be an issue since nobody was living there.

The second stage was when the fisherman started coming on a regular basis, settling temporary fishing camps. Their houses – the *palheiros* – were perfectly suited to a moveable territory as they were also moveable.

The third stage began in the second half of the 19th century when sea bathing habits spread between the Portuguese elites converting the beaches into attractive places. In the same period were gathered the conditions – political will, economical resources and technical capacity – to improve the navigation access in the Douro river's mouth and to build the Leixões harbour. The arrival of the newcomers to Furadouro changed the relation of its inhabitants with their environment. The sands once worthless become desirable and have been given a price. Land parcels were defined. Regulations set the organization of the place. New buildings appeared. The fishermen could no longer move their homes according to coastline variations. A fixed settlement replaced a moving way of life. Over the years a stationary line (a fictitious one) was established between the beach and the urban area. Coastal erosion problems started then, when the sea disrespected the boundaries created by humans and they felt the need to fight back to regain a place they thought belonged to them, but in fact had never been theirs. Armouring the coast was the strategy adopted.

The fourth stage, from the last decades of the 20th century till today, has been marked by coastal management problems caused by last century human arrangements and their unwanted side-effects. Dams, harbour jetties, dredging, inert extraction and flood control works are responsible for the decrease in sediment supply to this coast. At the same time the growth of cities and villages – like Espinho and Furadouro - in high risk coastal areas and the construction of hard engineering structures to protect them have contributed to the spread of erosion to other regions. Their legacy is a heavy issue. In fact, erosion is now a bigger problem than in the nineteenth century or the beginning of the twentieth century. As people believed to be protected by seawalls and groynes, they built even closer to the sea. The increasing exposure – more houses, more people - to coastal risks made these communities more vulnerable than before.

Furadouro is a good example of Pilkey's principle about coastal erosion: 'no people, no problems'. We have presented the working hypothesis that in the 20th century two opposing realities joined to potentiate the effects of erosion: urban growth in risk areas and sediment supply reduction to the coast. Furadouro's case prove it. Historical and geomorphological data crossing allow to build the contexts of human interactions with the ecosystems and to have a long-term perspective of the effects of those interactions.

Acknowledgements

Joana Gaspar de Freitas's research is supported by National Funds through FCT, Science and Technology Foundation, under the project PEst-OE/ELT/UI0657/2015 and the Post-Doctoral Fellowship, SFRH/BPD/70384/2010.