Coastal risks : how to better understand and face them

Atlantic Network for Coastal Risks Management

ANCORIM

ATLANTIC NETWORK FOR COASTAL RISKS MANAGEMENT

CONTENTS

Pyla, Aquitaine (France)

INTRODUCTION

This guide is an educational tool. Its objective is enabling a better knowledge of coastal risks in the regions of the European Atlantic Area. The document is part of the ANCORIM (Atlantic Network for Coastal Risk Management) – Interreg IVB "Atlantic Area" project (URL http://ancorim.aquitaine.fr) co-funded by the European Regional Development Fund (ERDF). The Ancorim project's objective is helping to prevent and manage coastal risks affecting the European Atlantic coast.

The aim of this document is to inform and raise awareness of coastal risks' issues among coastal governance decision makers and technical staff, as well as maritime professionals and other interested parties. It is about promoting a new territorial culture and realizing the necessity of appropriate governance of coastal risks.

The ancorim project also has developed some other more detailed complementary tools; "overview of soft coastal protection solutions" and "governance and integration of coastal risks issues in land planning processes". They can also be consulted on the project website.

During recent decades, there has been an increase in the impact of coastal risks due to the littoralization process. This process means that there are more people, activities and goods exposed to hazards resulting from the action of phenomena related to the specificity of coastal territories.
Public authorities in every European country should advice interested parties in order to protect their stakes, and minimize their vulnerability to coastal hazards. They have to face an increasing number and a complex combination of factors that threaten the coastline and the coastal activities. Those factors should be carefully studied.
This guide is a generic and comprehensive document. It intends to be a representative guide to the European coastal Atlantic area, as well as being the basis to elaborate different guides adapted to each area, developing the contents and going deeper into those factors affecting each of the 33 regions of the European Atlantic Coast, with the support of the attached "User guide".

Petite Mer de Gâvres. Brittany (France)

The contents of this guide show include in a descriptive way:

- The specificity of the European Atlantic Coast.
- Definition of coastal risk.
- The hazards causing coastal risks.
- The sensitivity of our coasts.
- Goods and stakes at risk.
- Coastal natural regeneration capability and vulnerability.
- Governance of coastal risk and technical solutions.

Lacanau, Aquitaine (France)

For further information, the project website ANCORIM shows more specific details, examples, proposals and tools about the topics included in this document.

The coastal area is the area where land and sea interact. It is normally a profitable area in aesthetic and resources terms, as well as in leisure industry, tourism, fishing or transportation terms.

The coastal areas are constantly changing due to the dynamics produced by the interaction between sea and coast. The waves and the wind are probably the most important elements, since they generate erosion and sediment dynamics in a changeable way during every day, season, tide or climatic event.

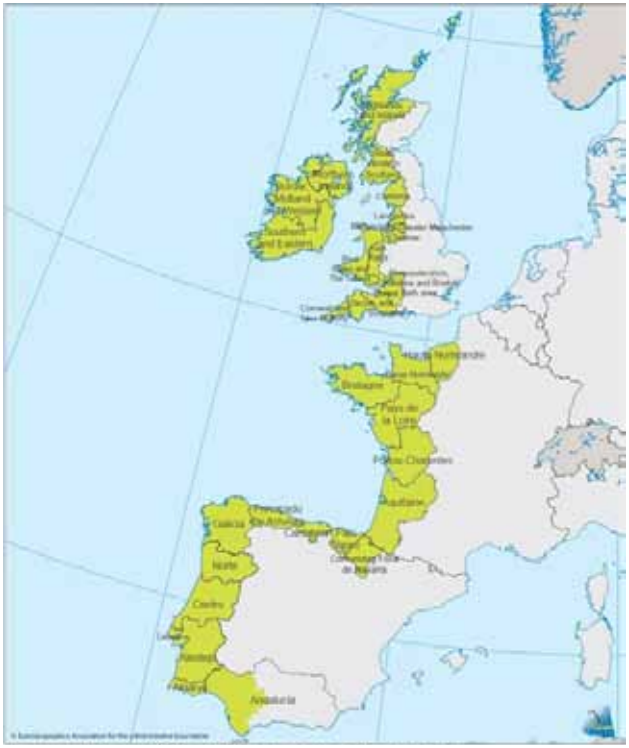
The European Atlantic Area is made up of 33 regions of Spain, France, Ireland, Portugal and the United Kingdom, covering a coastline of 2,500 km, where 70 million inhabitants live.

Characteristics of the European Atlantic coastal area :

- Oceanic climate: in this region, the oceanic climate extends many kilometres inland. It features mild winters and cool summers. It is also characterized by the predominance of westerly winds and moderate rain throughout the year.

- Different landscapes: we can find in these coasts a heterogeneous landscape with cliffs, rocky capes and narrow estuaries, as well as long sandy beaches, sheltered bays and vast marshes. Furthermore, there are vast estuaries with high socio-economic and natural value. They are mainly formed at the mouths of rivers of great importance.

- Biodiversity: although the level of biodiversity is not as high as in other regions in the world, these regions stand out for the abundance of animal and plant species. The strong power of the tides, the wind and the swell can be considered the main causes of such varied, dynamic and rich habitats and species in the coastal zone. The mobility of a high number of migratory birds stands out in the characterization of its fauna.



Member regions of the european atlantic area

We can also find abundant sea life in its waters. Throughout the year, the Gulf Stream moves a great mass of hot water and a rich nutrient supply from the Caribbean to the west coast of Europe. In shallow waters, these conditions provide a special nutrient richness (phytoplankton) that feeds a high range of sea organisms, such as plankton, crustaceans, bivalve molluscs and fish. They are also the food of sea birds and mammals that are on the top of the food chain.

• Human presence: nowadays, the landscape of the European Atlantic coast is mainly a farming landscape, with some heavily built-up areas. About 16% of European population lives in coastal areas, and this is increasing. As a result, the natural and semi-natural habitats are nowadays scattered among artificial landscapes in a fragmented way. Economic activities settled in and dependant on coastal areas have increased in the past decades (leisure and tourism activities, aquaculture and fishing, urbanization and related economic activities etc.).

The coastal areas of the European Atlantic Area are important in supporting population, productive activities, biological diversity and as sources of resources for all the Member States. However, those stakes are threatened by natural and/or human hazards, leading to the need to take the concept of coastal risks into consideration.


Cliff in St. Jean de Luz de La Corniche (France)


Estuary of Laita in Guidel, Brittany (France)


Sea flora


Northern gannet in Cies Islands (Spain)

• Coasts typology: There are several ways of classifying coasts. The most suitable classification for the territory with which this guide is concerned divides the natural coastal areas as follows.

Eroding Coasts

Cliffs, platforms and rock formations

The hardest formations create craggy coasts, while the softest ones erode fast and create coasts with gradual slopes. Their morphology also depends on tectonic disturbances which have occurred. There is a difference between eroding cliffs (unstable), with a terraced appearance, stable cliffs and dead cliffs (the ones out of the reach of the sea). The cliffs can be unstable due to phenomena in their bases caused by the sea in an underwater level (foreshore or atmospheric level), or due to the impact of the waves above the tidal level. There are also land processes that cause instability of cliffs, such as the wind, the rain, infiltrations, salinity.

Capes and bays

The alternation of harder and softer rocks creates headlands and more enclosed areas thanks to the sea force. It is highly characteristic of the european atlantic coast due to the geological formations perpendicular to the coast. This creates the necessary alternation for the formation of capes and bays.

Ría de Arousa, Galicia (Spain)

Cliffs in Brittany, Groix (France)

Sedimentary or sandy coasts

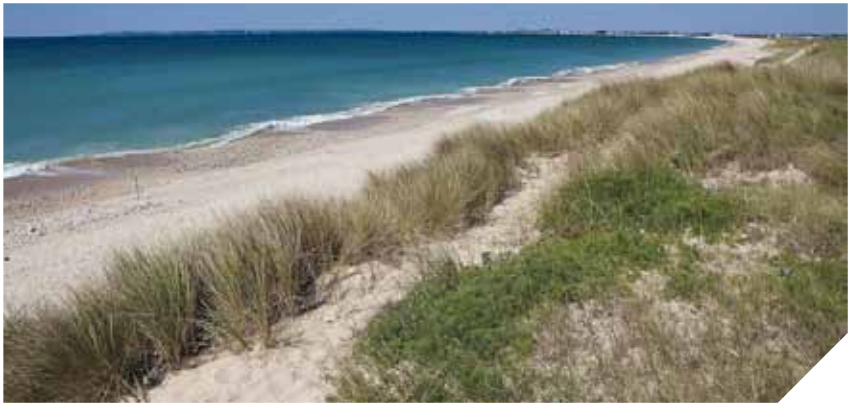
Beaches

They are created from eroded material that has been transported and deposited by the waves, wind or tides. Constructive waves help with creating beaches. Beaches are normally made of sand, with a soft slope and a sandy ridge on its top, even though some of them are craggy and made with pebbles. Some other sand formations have more accidental shapes, spreading sandy bars out to sea or joining a continental area together with an island. These formations can be due to natural or artificial causes. The main cause is the similar angle the dominant wind and the currents have.

Dunes

Dunes need appropriate wind dynamics, a source of sediments and specific vegetation in order to exist. Dunes are sand reserves, and they allow beaches to feed from them when they lose sediments due to the action of the waves. Dunes alternate the area of sediment exchange with the beach (the mobile part) and the areas of permanent vegetation. They offer a variety of landscapes, biodiversity and contribute to the conservation of beaches. They are also natural infrastructures which may protect inland areas from sea flooding.

Ossoda, Baleia, Leiria (Portugal)

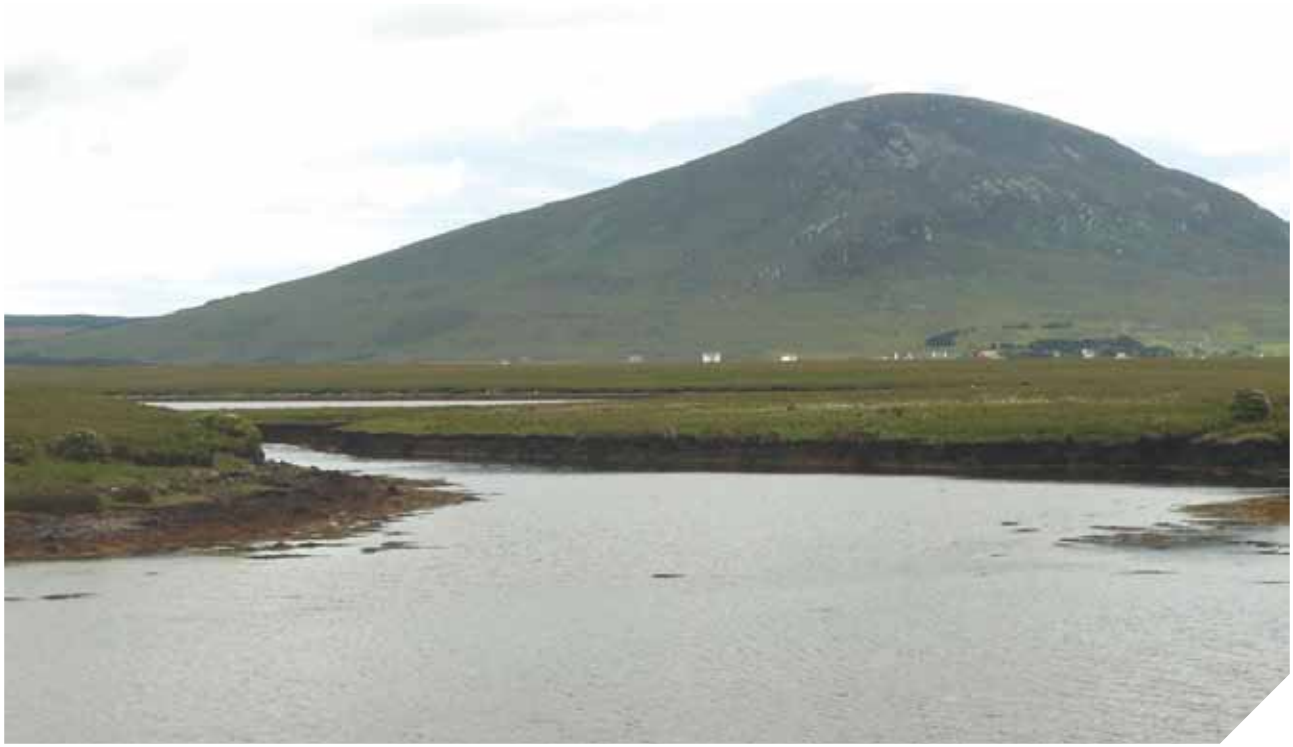


Galivel, Cordon Dunaire, Brittany (France)

Coastal Marshes

Coastal marshes are wet areas with a high sea influence. They are created when salt and fresh water mix in areas quite protected from swell. Marshes are naturally subjected to sediment accretion. At present, it is rare that they are covered with salt water, due to human action to delimit and refill (polders). They can be highly beneficial since they can stop river floods as well as sea flooding and retain much sediment. They have three different parts. The higher one is filled with water only in the event of strong spring tides, and has plenty vegetation, mainly herbaceous, that is able to mitigate currents, retain suspended sediment particles and fix them on the bottom. The intertidal zone consists of flat areas with strong sand sedimentation, silt and tangue, with calcareous composition and remains of mollusk broken up shells.

Those areas are natural barriers (flat intertidal zones). They minimize water speed and force during sea and river storms. They also filter river water, so they prevent the modification of water quality. They are really rich ecosystems.



Castle Hill (Ireland)

Most regions along the European Atlantic coast have examples of full variety of natural areas described.
This document shows how each type of coast is exposed to different risks, and the protecting measures that can be put in place.

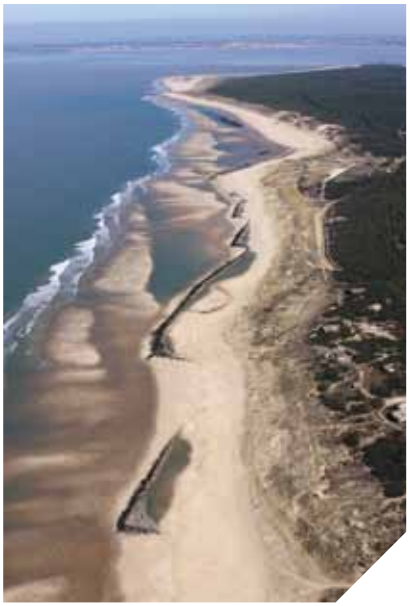
2 - DEFINITION OF COASTAL RISK

Living in a coastal area puts people at risk of suffering natural phenomena. The environmental impact of human activities should be also considered.

Coastal risk is defined as the expected loss (of lifes, physical and economic damage, environmental degradation) that certain natural or human hazards may cause in a coastal area for a specific period. The severity of these potential risks basically depends on the stakes that can be affected, on the level of vulnerability and exposure to the hazard.

According to the Plan Nacional de Adaptación al Cambio Climático, (Oficina Española del Cambio climatic, 2006) a risk is a combination of the probability of the occurrence of a given event and the magnitude of its consequences. The risk considers the frequency of some states of events and the magnitude of the probable consequences related to the exposure to those states or events of goods, people, ecosystems or activities developed in the area.

Thus, risk is the assesment of possible damages and their impacts.
These risks or losses are caused by different kinds of **hazards** (chapter 3).

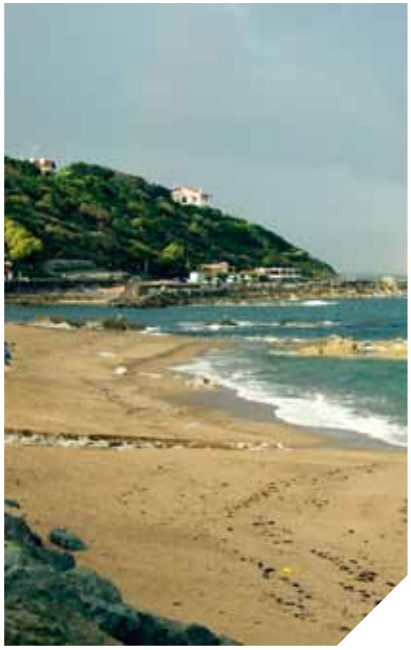


Soulac, Aquitaine (France)

The main **natural hazards** in the areas of concern are the following :

- Coastal erosion: It is mainly caused by strong winds, big waves and intense tides and storms. It can cause coastline retreat and damage to infrastructure.
- Coastal floods: The breaking or overcoming of natural or artificial protection means by rivers, storms or tides cause coastal floods.
- Climate change: Climate has an influence on the ecosystems, and it can mean important risks threatening basic elements for living, such as water supply, agricultural production, health or safety.
- Sea level rise: The causes can be mainly human. This phenomenon can cause floods and erosion, causing coastline variations.
- Wind: coastal infrastructures are exposed to strong winds.
- Tsunami: Is a giant wave caused by an earthquake, volcanic eruption or landslides. These events are not really frequent in Europe, nevertheless, there have been some throughout history.

Human activities in the coastal area can have an influence in coastal processes, **increasing the coastal risk.** The activities that can cause risks, or can be exposed to risks due to coastal processes include:



Bidart, Aquitaine (France)

- Coastal development: Increasing tourist pressure, infrastructures, goods and people in general.
- Coastal industry and harbours: Many companies have been attracted by the facilities of transportation by the sea. Some of them are potential sources of pollution. Furthermore, harbour extensions for economic or leisure facilities can invade areas of great environmental value, as well as segment interdependent systems.
- Agriculture: Intensive agriculture can reduce habitats, minimize biodiversity and modify water composition, through the use of pesticides, for instance.
- Tourism and leisure: Increases the pressure in areas of ecological interest, and they can lead to intensive use of resources.
- Fishing, industry and aquaculture: Overfishing has often been a source of controversy. Aquaculture can modify coastal habitats.
- Offshore activities: These activities, such as oil or gas extraction, aggregate extraction or offshore wind farms, modify the habitat and can be the source of pollution and spills.
- Change in water quality: This is adversely affected by industrial or domestic sewage dumping. Water coming from agriculture or changes in the patterns of rivers can affect water quality.

Another important concept related to coastal risks is **vulnerability** (chapter 6). It is the exposure level of every stake in every territory combined with the capability to cope with the hazards.

Resilience (chapter 6) is the capability of a system, community or society exposed to hazards, to cope with, absorb, adapt and recover from the effects of a hazard in an efficient way. This concept includes the protection and/or restoration of infrastructures and functions that existed prior to the hazard impacts.

The **stakes** (Chapter 5) existing in the given area will determine whether the above hazards may potentially generate a risk for the territory.
For instance, there is no coastal risk if there is a flood plain, as that flood does not cause any negative consequence to people, activities or ecosystems, since the system is able to recover its natural state without affecting biodiversity, infrastructures, or people.

So, the assessment of existing stakes (goods,a economic activities, infrastructures, natural ecosystems etc.) is fundamental to assessing the seriousness of potential risks.

If the stakes are assessed as being of high vlaue and if the vulnerability of the environment doesn't allow it to cope with the hazards through its own resources, then it is important to adopt solutions in order to prevent and/or minimize negative impacts. Governance of coastal risks is therefore a fundamental issue, as is assessment of the most appropriate technical responses (Chapter 7).

In the regions of the European Atlantic Area, there are different risks due to natural causes. It means a challenge for the coastal decision makers. Wind force, waves, currents, tides or soil composition are natural factors linked to the coast that can be a hazard.

Some of the risks of natural origin could be aggravated by climate change.

Other artificial factors that can increase the risks are linked to human activities like urban planning, activities to be developed near the coast, coastal resources exploitation and infrastructures.
The main hazards of our coasts are described below. Every involved party should assess the hazards which characterize their own local context and the stakes exposed to them (Chapter 5). If there is no vulnerability, there is no risk, or potential damage.

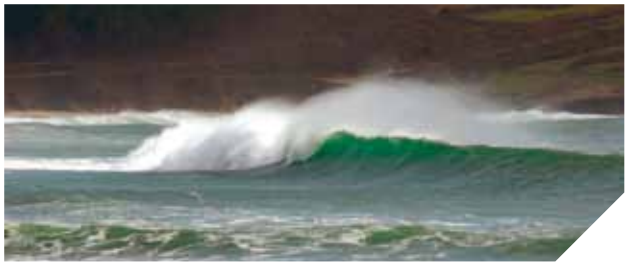
Raxó, Poio, Galicia (Spain)

Natural and anthropogenic hazards

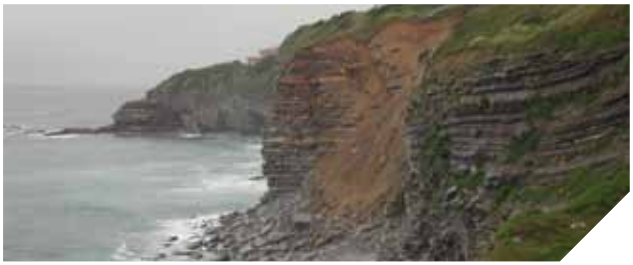
> Littoral erosion and shoreline mobility

The main causes of natural origin erosion are waves and tides, as well as the strength and frequency of weather events such as storms, wind, etc. Furthermore, sea level changes that modify the area where these phenomena act, often multiply his effects. Littoral currents, which are generated by winds, waves and tides, move the sediment around, and contribute to erosion or sediment accretion depending on local factors. If sediment exchange areas get isolated, there can be dramatic and permanent changes to the coastline and to the vulnerability of its richness. The effect of waves and tides is stronger in low and sandy coasts than in high and rocky coasts. In the same way, low coasts present a higher human occupation, therefore, more risk situations are associated with them.
In wide areas, storms are considered mainly responsible for coastal erosion. Erosion depends on the incident energy, expressed through models such as Vellinga's (1982), and the rise of swell action level. Bruun's (1954) model is one of the most important ones relating to the latter factor. It calculates the recession of a beach line due to the overtopping of the sea level during those storms, although it is also used to estimate the coastal recession caused by the eustatic sea level rise.

In addition to the natural causes, there is also an important series of human-induced causes relating to the origin of these hazards, such as chaotic construction or uncontrolled execution of certain human activities.



Swell in the beach Nemiña, Muxía, Galicia (Spain)



St Jean-de-Luz, Sainte-Barbe, Aquitaine (France)

> Floods

The main natural causes of floods are heavy storms/gales . The action of storms causes the rise of sea level above normal tide level. This process, joined to the swell strength, can cause an extreme overtopping, causing the overflowing of dune chains and coastal defences, especially when the storms occur at the same time as spring high tides.

In february 2010 the storm called xynthia caused huge damage in france and portugal, and caused 50 deaths in france through flooding.

Gâvres area, Brittany (France)

Heavy storms are the primary cause of death due to natural disasters in Spain (132 people died in 1989, 13 in 1990 and 86 in 1991).

On the other hand, some of those semi-enclosed areas can suffer reflection phenomena of the tidal wave, generating what is called "bore". It causes a rapid increase of the water level (more than 4 metres in some cases), at a velocity of even 30 km/h. This process should be taken into account, since it can cause flooding problems in human settlements near the estuaries.
Furthermore, an increase in wave height is another concurrent factor during storms. This increase causes sea level rise in the wave surf zone ("wave setup"), together with an increase in the wave run-up.

Finally, the strong rains that go together with heavy storms should also be taken into account. In fact, these precipitations become an "ally" of the storm, and they help in the process of coastal water level rise.

> Changes in water quality

Although many of the causes of changes in water quality are of human origin, some other causes of natural origin, such as and the impact of climate change are relevant. It is important to highlight the impact caused to water composition due to the supply of fertilizers, pesticides, herbicides and other chemical agents used in agriculture, since they modify its properties and suitability for some ecosystems and species.

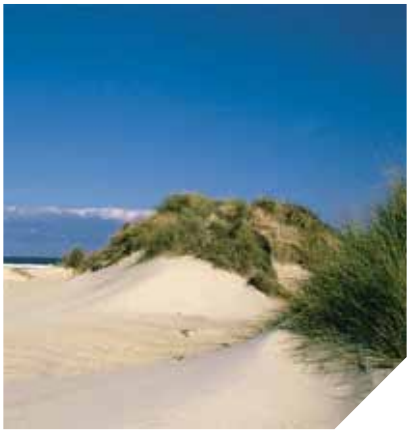
Other sources of water pollution are maritime transport, urban and industrial waste disposal, discharge of ballast water and introduction of marine pests, etc.

These kinds of changes range from water temperature variation, water salinity and pH changes to increase of harmful algae (i.e. green algae in Brittany).

> Loss and transformation of beaches and dune systems

Urban development, tourism and sand extraction and dredging activities are also other human causes of erosion and littoral mobility, affecting both beaches and dune systems.

Well developed dune systems balance the erosive event occurring throughout the coast during heavy storms. On the one hand, these dunes return part of the sand received during good weather conditions. On the other hand, they absorb the effect of the incident swell, since they are more porous and have less slope than a breakwater. At the same time, subtidal forms create sand bars, sparking off the swell energy, so the biggest waves break off the dry beach.

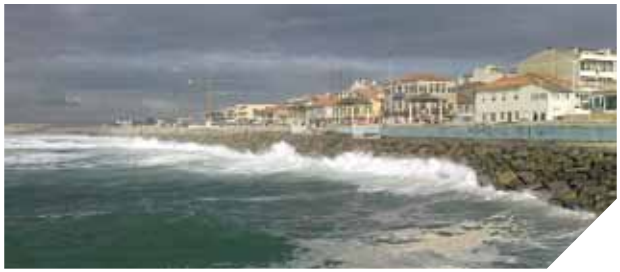


Dunes of Corrubedo, Ribeira, Galicia (Spain)

That's why sand extraction or occupation and transformation of beaches and dunes for the installation of communication routes or promenades, for urban, tourist or leisure purposes (such as golf courses) trigger erosion and deterioration processes on these environments; sometimes, these processes are irreversible.

On the other hand, coastal defence works also affect beach stability. Docks, breakwaters and some other harbour works interrupt the longitudinal transportation of sediment. This creates deposit areas upstream, and erosion subjected areas downstream. It sometimes changes coastal morphology by modifying the swell impact angle.

Artificial breakwaters in San Vicente, Galicia (Spain)



Artificial breakwaters in Porto, (Portugal)

> Watercourse change

River-mouth area, estuaries in Ramallosa, Vigo, Galicia (Spain)

Water courses are the main source of sediment supply for the coast, where the littoral current distribute them. That means that any change in rivers or their recipient basins can cause modifications in the amount of supplies.

Basin deforestation and clearing for agricultural purposes speed up soil erosion, which products are carried towards the coast. This is how progradation and sedimentation occurs in deltas, estuaries, beaches, etc.

Since the XX century, construction of big dams in basins and diversions for irrigation purposes caused a sedimentary shortage in the coast, and significant erosion of sandy littorals.

> Pollution from accidents

Concentration of activity along the coast or offshore makes necessary the evaluation and protection against risks due to accidents and their possible consequences. The sinking of the oil tanker Prestige (2002) along the Galician coast, or the sinking of the Erika in Brittany (1999) are just two examples of the huge amount of traffic to which this area is subjected. The spilling accidents can also come from economical activities located on the coast to avail of communication facilities. Some of the most important ones are refineries, chemical industries and gas or oil extraction.

The coast is full of industries; that is why it is important to control possible spilling risks and to lay down protection and reaction means against accidents.

> Pollution from industrial activities and urban waste disposal

Pollution from industrial and urban activities, agricultural and forest pollution and inadequate governance of urban waste are also responsible for coastal pollution, as well as pollution of water (pH, salinity…), where many different flora and fauna species live. That also adversely affects activities related to the sea, such as aquacultures, inshore fishing and leisure and tourism activities.

> Strong winds and storms

The prevalence of periods with strong winds and storms is highly worrying in some areas, where they frequently cause damage to infrastructure and industries. Coastal infrastructures are more exposed to strong winds due to their location. Those are some factors to take into account when laying down constructive laws for street furniture or warning systems before extreme events. In Ireland, for instance, this hazard may be particularly serious.

Nowadays, the possible influence of climate change in increasing of the prevalence of those phenomena is been studied. Potential impacts may be seen in cases such as Hurricane Katrina (2005), Hurricane Gordon (2006), or the hurricane that lashed Europe in 1987, when more than 30 people died.

Climate change: could it affect coastal risks?

> Factors of the climate

The climate of the Earth depends on many factors, such as the atmospheric concentration of aerosol and greenhouse gases, the amount of energy from the sun, or the properties of earth's surface. When those factors change, because of natural processes, they cause planetary warming or cooling, since they modify the proportion of solar energy absorbed or returned out to space. Human activities have intensified these phenomena especially since the end of the XIXth century.

> Possible climate change influences on coastal risks

The annual average atmospheric temperature has increased between 0.3 and 0.6 ºC[1] since 1900. Some of the possible consequences brought by temperature variation are sea level rise and stronger and more frequent storms[2], floods and droughts, as well as an increase in water temperature, which impacts water quality and wildlife changes.
According to the I.P.C.C. *(Intergovernmental Panel for Climate Change)*, the sea level rise will cause a great impact on the environment and coastal infrastructures, even in the best case scenario. Some of the impacts include coastal erosion, floods, aquifer and soil salinization, loss of habitats.

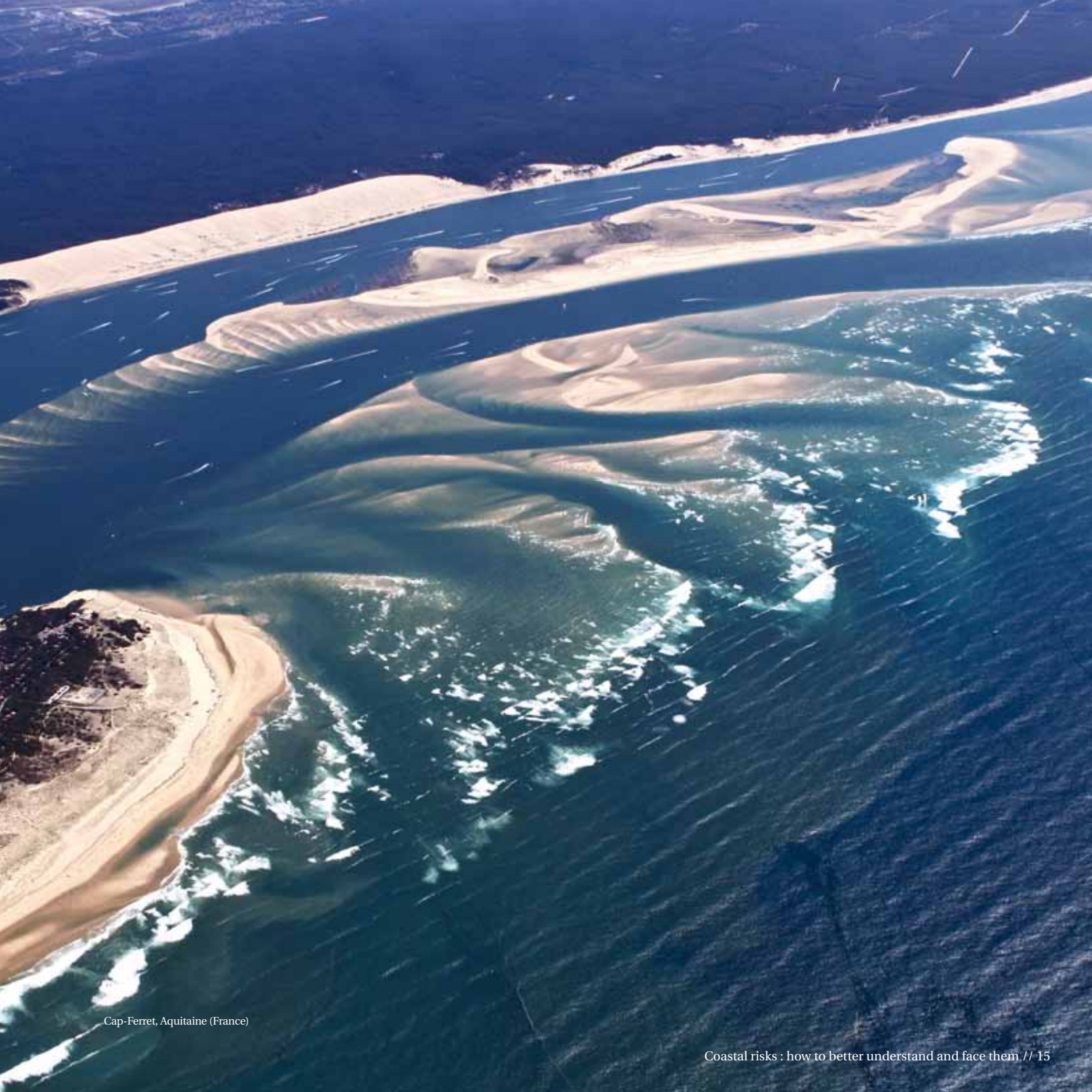
Both because of natural or artificial causes, it has been demonstrated that in the XX century the sea level rose about 1.5-2.0 mm/year[3], and it had an average increase of 3-1 mm/year in the first decade of the XXI century. In the low coasts, the rise of MSL could mean the flooding of deltas, coastal wet lands and agricultural or built-up areas around estuaries or coastal alluvial plains. The most vulnerable areas are deltas and confined beaches. The coastal area formed by resistant rock cliffs would not normally show any special problem. Nevertheless, there is a potential hazard of stability of the coasts formed by cliffs associated with cohesionless material.

The most important consequences of climate change are the sea level rise, and water and atmospheric temperature rise. these phenomena could also cause indirect changes in currents, water composition, erosion and wind and storm strength and frequency.

Many local and regional authorities already have put into force specific plans that take climate change into consideration in their policies. The Regional Council of Brittany adopted a plan called "Ambition and strategy to face with energetic and climatic challenge". As well, the Regional Council of Aquitaine promoted the strategy "Climate Plan for Aquitaine" for the period 2007-2013, with the aim of involving all the regional stakeholders in a commitment to concrete actions to mitigate climate change impacts on several socio-economic areas

Anyway, all the hazards that have been described have very different impacts depending on the vulnerability of each territory. Damage can be reduced and recovery can be faster and more complete with appropriate strategies when managing the territory. To do this, it's necessary to know the sensitivity and natural capability to recover each kind of coastal zone.

[1] This average is likely to increase in the future. [2]Especially on the summer tropical storms whereas extra tropical winter storms seem not to be directly linked to global warming. [3]This average is likely to increase in the future.



Cap-Ferret, Aquitaine (France)

4 - SENSITIVITY OF OUR COASTAL AREAS

Sensitivity can be defined as the degree a system is affected by the stimulus received, both negative and favorable. It can be a direct effect, such as damage after a storm, or an indirect effect, such as the future erosive consequences due to vegetation cover loss.
Sensitivity is the way the coast reacts to events, depending on their typology. If there is a negative transformation (resource loss, hazards to people and other living creatures…), where that stimulus can possibly occur, protection measures have not been set up and the system will not be able to recover from the negative impact, then we are facing a risk.

Coastal evolution can be reversible or irreversible, depending on external agents, either if they are natural or anthropogenic in several periods, areas and scales. Coastal natural balance is mainly due to sediment exchange and transportation between sea and land areas, or between different sea areas. From these dynamics and the different sensitivities they present, three types of shoreline can be considered in the European Atlantic coast: sandy coast, rocky coast and coastal marshes.

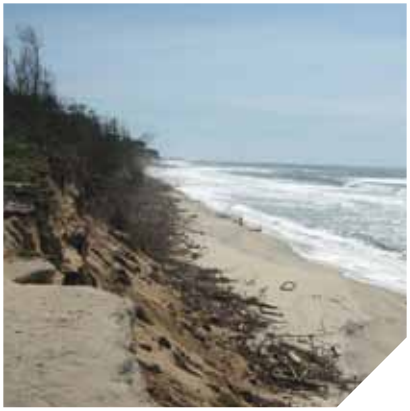
- Sandy coast, also known as mobile coast, features beaches and dune systems. There are also rock areas dividing the big Atlantic sandy shorelines. Erosion and accretion areas alternate throughout the shoreline. Nevertheless, the dominant general tendency is a decline in sandy coast due to sand shortage.

- Rocky coast. It has a compact nature, and it also copes with the impact of this shoreline erosion phenomenon (both land and sea origin causes). Cliff erosion (rocky coasts) feeds the surrounding coasts with sediments.

- Coastal marshes and estuaries : are also quite common along the Atlantic coast. They appear in some coastal sectors that are relatively protected from swell, and they are irrigated to a greater or lesser extent with the continental waters that feed them.

> Sandy coast sensitivity:

Beach outlines vary due to seasons, wave direction, kind of waves, winds or sediment supply. Beaches are not independent of their environments. They send and receive sediments from offshore bottoms and other beaches, so any change affecting any of them or the transportation channel can cause sudden changes in the beach morphology. The problem of building infrastructures that isolate interdependent system elements is a general tendency that is not easy to notice without the right technical advice.



Sandy coast, North Portugal

In the case of dunes, there is a continuous exchange between dunes and underwater areas, so any change in one of them affects the other one. Dunes are ecosystems by themselves and they are essential to the natural preservation of many beaches.
Countless human activities increase beach erosion: excessive cleaning works, sand extraction or circulation in some areas damaging the vegetation cover. An excess of artificial elements makes sediment exchange difficult and puts the elements that keep the balance at risk when diverting the current.

> Rocky coast sensitivity:

Rocky coasts are unstable due to the interaction of different factors. Sea processes at the cliff bottom cause its erosion. If there is a sea level rise, there will be an increase in its reach (height). This erosion could also cause other phenomena, such as landslides or slope decrease.

Generally, cliff and coastal rock erosion are also a positive source of sediments. This can be essential for the preservation of sandy coasts.

Blacksode

This kind of erosion increases due to some anthropogenic causes:

Urban development at the top of the cliff or construction of communication routes creates alterations in water seepage to the subsoil.

Pebble extraction at the cliff bottom also leaves it unprotected against the waves' impacts.

> Coastal marshes and estuaries sensitivity:

Marshes are flat areas protected from waves. They have some areas with vegetation cover, mainly herbaceous vegetation, and some other areas with sediments transported by rivers and tides. One of the main characteristics of coastal marshes is the change of its main component, since it changes from sea water to fresh water depending on tides and hydrological regime.

Marshes are considered essential ecosystems to preserve the life cycle of many kinds of fishes, amphibians, birds and insects.
These kinds of areas are subjected to anthropogenic impacts. These impacts can come from far inland, since they are very much affected by hydrography, precipitation and composition of the sediments swept away by rivers. These sediments can contain agricultural products (fertilizers, pesticides), waste (spills or untreated water), or swept elements from forest areas (deforestation increases erosion and the amount of sediments). All those phenomena change water quality and morphology of coastal marshes and estuaries.

Coastal marshes are also affected by urban development, agriculture, hunting, fishing, port activities and industrial activities.

Throughout the years, many docks or canals have been built for security reasons (flood hazard) or economic interests (reclamation of lands for agricultural or urban purposes), but this policy should be questioned and discussed. Water movement restriction impedes the flooding of the area with the tide, and it changes biological cycles. It can also modify the sediment transportation rhythm, and it can aggravate the risks it tries to prevent (floods). It is essential to decrease coastal risks such as erosion, floods and pollution in order to preserve coastal marshes.

At the same time, preserving coastal marshes may support the defense against flood hazard, and protect inland areas.

Arguin, Cap-Ferret, Aquitaine (France)

5 - EXPOSURE OF GOODS AND STAKES TO RISK

One of the most significant factors to determine, measure and plan the response to coastal risk is the analysis of goods and stakes threatened by those risks. There are different kinds of goods and stakes. Some of them can receive a direct or short-term impact, and some others can receive a long-term impact. Thus, the threatened stakes must be distinguished between the present and the future:

- The stakes exposed to risk in the present should be analyzed in order to take measures, such as prevention, security, hazard warning, access or circulation prohibition…
- Work should be done in order to avoid future stakes exposure to risk. To do this, the areas to be built up should be carefully studied, by considering the risks they are exposed to, and if they can affect the level of risk of other areas.

Vendays, Aquitaine (France)

what is threatened by coastal risks?

Depending on the vulnerability of coasts, coastal risks have specific impacts and consequences on human systems (human lives, economic sectors, activities and infrastructure) and natural systems.

	IMPACTS OF NATURAL RISKS AND RISKS FROM HUMAN ORIGIN
HUMAN SYSTEMS	• Impact on leisure and tourism activities (water activities, littoral routes and paths, beach disappearance …) • Impact on aquaculture and inshore fishing, on its development security and sustainability. • Impact on agriculture/forest. • Impact on built-up areas, hazards for people, goods and infrastructures.
NATURAL SYSTEMS	• Retreat of the sandy line and the rocky coast. • Impacts on swamps, disappearance or pollution of marshes and the species living in them. • Cliff instability. • Modification of dunes and the ecosystem they sustain. • Beach retreat. • Impact on habitats and natural species.

Tendencies of hazard exposure in the European Atlantic coast

Risk increases if more goods are exposed or if human activities cause or increase pressure in particular areas through the development of settlements, services and infrastructures.
Tendencies in human activities that constitute high stakes that need to be taken into consideration and are likely to affect coastal risks at a global level include:

- Human activities such as urbanization and littoralization: population and economic activity are concentrating in coastal areas as a result of urban growth, industrial activities, tourism and irrigation. There are also more risk activities in the sea, and those can result in spills and pollution. These tendencies are not likely to stop or decrease in the near future and may raise pressure on the coast, worsening coastal risks.
- Leisure and massive tourism activities: together with the creation of new infrastructures, urbanization by the shoreline, artificial infrastructures.
- Excessive exploitation of water resources: regarding fishing, aquaculture and mineral resources.
- Ecosystems and natural environment: these stakes are more and more taken into consideration in policies and their exposure to coastal risks doesn't seem to decrease.

Corniche basque, Aquitaine (France)

After assessing the relevance of coastal risks by evaluating hazards and stakes of a specific area, it is necessary to check the capacity of the environment to cope with the changes and damages that may occur (Chapter 6) or/and to implement solutions to better protect such areas (Chapter 7).

When handling the management of coastal risks, it is necessary to assess the capacity of the given environment to recover or adapt to the changes which occur. It is essential, indeed, to assess the vulnerability of the area. In addition, the approach should stress the value on the intrinsic resources of the natural environment and to support it with human interventions when necessary. Concepts of vulnerability, resilience and natural infrastructures are thus essential to understand.

Vulnerability and resilience

> Vulnerability

A phenomenon or hazard becomes a risk if it occurs in a vulnerable territory. For instance, a hazard such as heavy rains will cause flood risk if the territory is built-up wrongly, there are not enough channels and there is sediment sweeping reducing the course. Therefore, a coastal risk is a convergence of hazard (natural or artificial) and vulnerability. Another example would be the circulation of vessels with dangerous goods (hazard) together with the lack of measures against pollution, ports of refuge or inspections (vulnerability). This becomes a potential pollution risk.
System weakness affects vulnerability. The European Atlantic coast is weak due to the high and disorganized human presence, shortage and fragmentation of natural areas, economic exploitation and a growing record of spills, overuse and arid extraction. All those aspects make quite difficult its own recovery in a natural way from damages suffered due to an extreme event.

Vulnerability can be defined as the sensitivity of a population, system or place to suffer damages due to hazard exposure. vulnerability is directly defined by the capability to respond and recover from disasters and hazards.

VULNERABILITY:

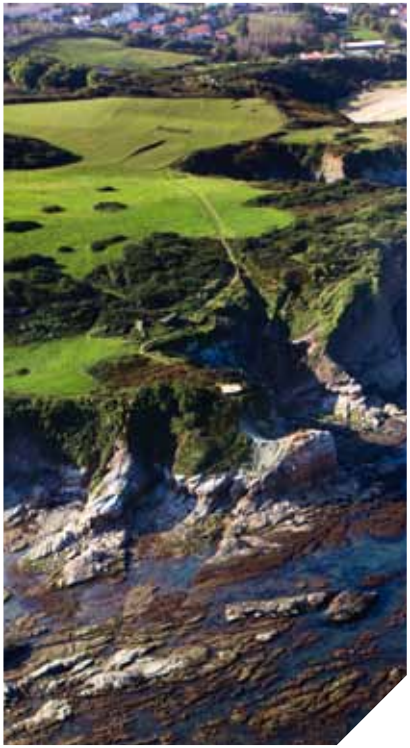
An area is more vulnerable if there are no resources to prevent the hazards affecting that area from causing more damages, or if it would be more difficult to recover from them.
A coast suffers more damage if it has more exposed stakes, if it suffers from more intense hazards, if it is poorly protected or if it has more difficulties to recover after the damage.

Praia Fig Foz (Portugal)

In the box below, there is a summary of the possible factors that makes an area more vulnerable to coastal hazards.

FACTORS THAT HAVE AN INFLUENCE ON VULNERABILITY

- Geological composition of the land that can expose it to erosion, landslides or habitat loss.
- Slope inland and existent vegetation cover.
- Kinds of stakes and town planning: existent economic activities, leisure areas, littoral population, and any kind of human presence. The planning levels of these activities, if they have been built up taking coastal risks' impacts into account.
- Natural systems: the fragility of each ecosystem can be different. Marshes and dunes are particularly fragile due to their changing nature throughout the year, as a result of the interaction of tides, currents, rains and winds. River systems are very sensitive to volume changes or spills, which are transported and distributed through wider areas.
- Vulnerability depends on the society capacity for protecting itself: creation of emergency plans, warning systems or good town planning. Education, awareness and communication are also basic tools to decrease vulnerability.



Bidart, St Jean-de-Luz, Aquitaine (France)

Once the factors affecting vulnerability are described, a methodology to measure it can be established as follows:

- Inventory of threatened goods: it should include ecosystems, human settlements and leisure or economic activities developed in the threatened areas.
- Importance of the threatened goods: the existence of protected natural areas, or those used as shelter. The existence of strategic economic activities is another factor to take into account. Of course, hazards to people turn some vulnerabilities into points of paramount importance.
- Existing protection measures of threatened goods: The third point of the vulnerability analysis will be focused on emergency plans, prevention or suitability of facilities to cope with the risk impact

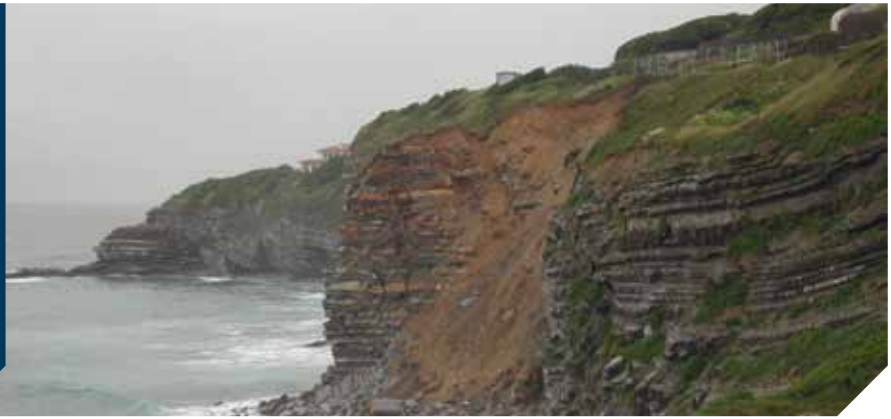
> Resilience

Vulnerability refers to the tendency of something to be damaged. The opposite of this is resilience, or the ability to resist and/or recover from damage. When we talk about vulnerability, we are automatically also talking about resilience because the two are opposite sides of a single coin. That is, something is vulnerable to the extent that it is not resilient, and visa versa[4].

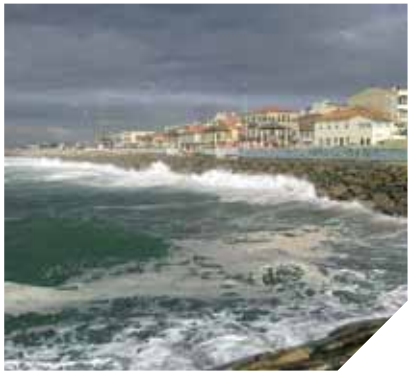
The fact that the coast is capable of resisting and recovering by itself should be taken into account when it comes to plan the actions to be applied against coastal risks. The study of such a capability helps to know when to intervene and which intensity should it have. It also shows less aggressive measures that could stabilize the ecosystem without the necessity of big works and infrastructures.

Resilience:

is the capability of a system, community or society exposed to hazards to resist them, absorb them, accommodate to them and recover from the effects of a hazard in efficient time and ways, including the preservation and restoration of its basic structure and functions.



St Jean-de-Luz, Aquitaine (France)



North Portugal

As can be seen, the definition includes communities, their capability to organize, learn and improve, and not only the natural capability to do this. Impacts are hazard consequences (positive or negative) on natural and human systems.

As a consequence of the concept of resilience, the coastal risks' impacts have to be analyzed from two different points of view:

- Potential impacts: impacts that can occur without taking adaptation into account.
- Residual impacts: impacts still visible after adaptation. Long term and permanent consequences.

[4]http://www.vulnerabilityindex.net/index.htm

Natural protections and defenses

Each coastal typology features different characteristics and natural recovery capability. Preserving these areas can be a purpose itself, but also a strategy to preserve other environments which are directly linked to them.
The concept of "natural coastal infrastructure" puts the focus on the defense capacity offered by certain coastal areas against erosion, flooding, storms[5].

> Sandy coast function in the protection against coastal risks

The sandy areas of the Atlantic coast have developed and are still developing very important functions. Sandy coasts preserve biodiversity and geodiversity: dunes and beaches associated with them have a high environmental value. They are dynamic environments subject to very fast and original change, and with species that are difficult to find in other environments. Dunes and beaches are the two main sediment deposits. There is a dynamic balance, and this allows them to absorb the sea storm effects, dispersing the energy.
The adaptation to changes or resilience is ideal when the system has no artificial interferences and it is wide enough. When dunes precede low areas, they play the same role as docks, and they can protect against floods.

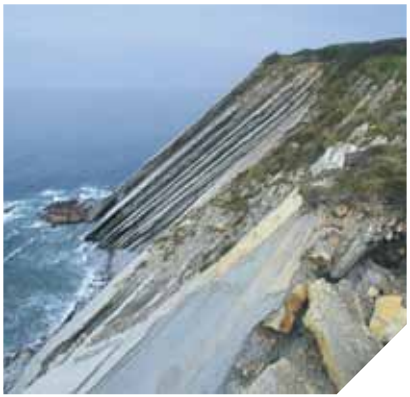
> Rocky coasts' functions in the protection against coastal risks

Rocky coasts, mainly cliffs, are natural barriers, and they prevent flood risks of sea origin. Furthermore, the coastal rocky platform disperses the wave energy and mitigates erosion in the cliff bottom. Moreover, sediment material detached from cliffs due to erosion feeds sediment areas, beaches and dunes.

> Coastal marshes' functions in the protection against coastal risks

The existence of intertidal plains mitigates wave action in the coast. Marshes also play an important role by filtering polluted water. This water is transported from inland areas towards the sea through river systems.
Furthermore, these marshes also have to preserve very rich and sensitive ecosystems. Coastal marshes are one of the less extensive natural habitats. Most of the sea birds and many fishes depend on these environments.

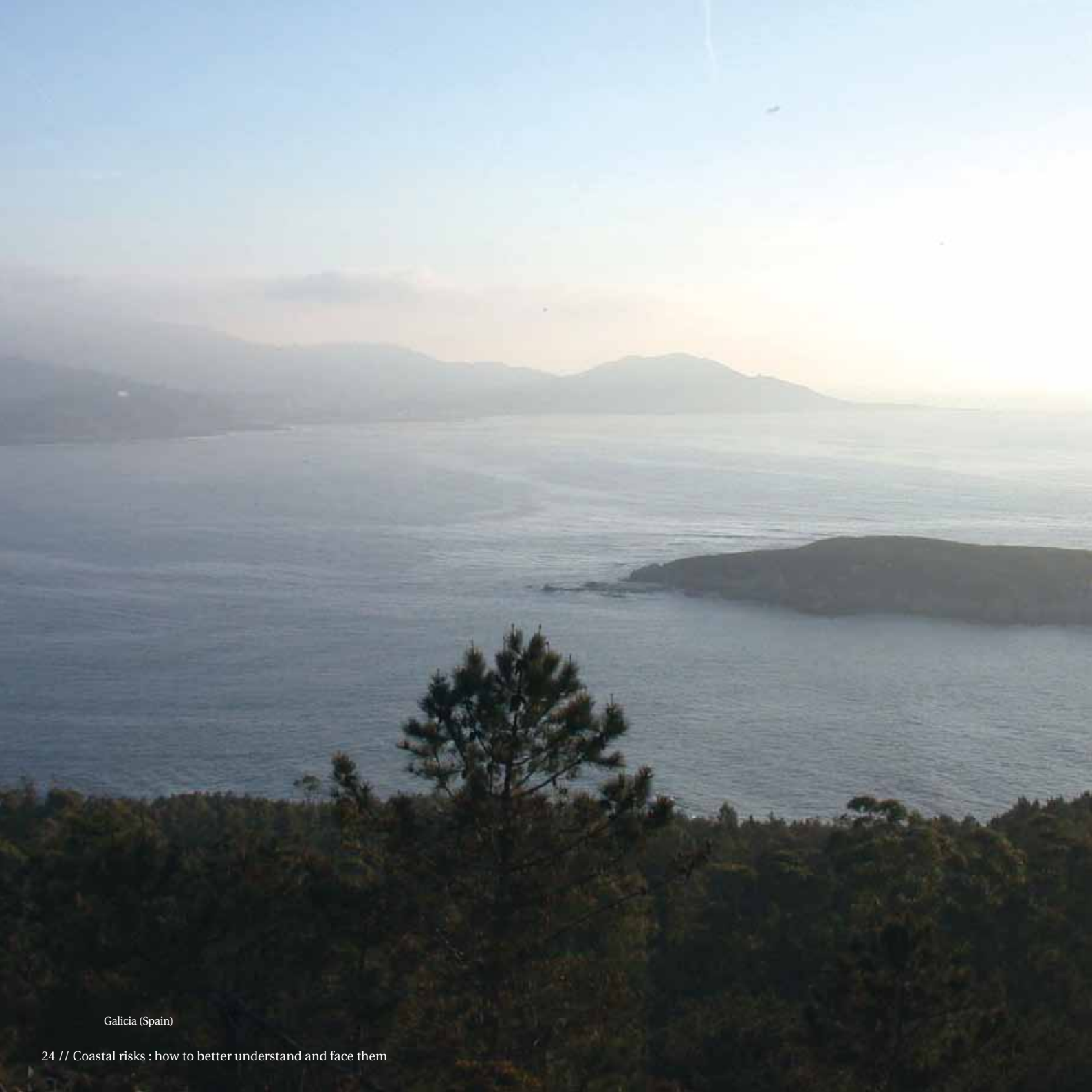
Aquitaine coast (France)



St Jean-de-Luz (France)

Ramallosa, Galicia (Spain)

[5]For further details, refer to the Ancorim publication "Overview of soft coastal protection solutions".



Galicia (Spain)

7 - POTENTIAL SOLUTIONS TO IMPROVE COASTAL RISK PREVENTION AND MANAGEMENT

Neither universal truths nor "magic" solutions are suggested, but this guide briefly presents experiences or examples that have helped to improve certain European coastal areas to a greater or lesser extent. These can be useful references for the development and implementation of new solutions to improve governance of risks.

Two aspects are illustrated below:

- first of all, the importance of governance and of a multi-stakeholder approach has to be underlined, by considering all the interested sectors, according to the Integrated Coastal Zone Management (ICZM) promoted by the European Commission since 2002[6].

- then, an overview of the main technical solutions existing at present to mitigate coastal risks' impacts, focusing mainly on erosion and shoreline mobility issues[7].

Sand feeding on the atlantic coast

Governance of coastal risks

In order to improve prevention and management of coastal risks, appropriate planning and public governance are required, as well as appropriate technical solutions.

> Planning and public governance

- Main european guidelines: Integrated coastal zone management and maritime spatial planning

Since 2002, the EU promotes the adoption of an Integrated Coastal Zone Management (ICZM)[8] by coastal actors in all the European countries (Recommendation 2002/413/EC) with the aim of managing coastal areas through a sustainable and integrated approach, taking into consideration the different stakes (economic, social, environmental) and actors involved.

Integrated Coastal Zone Management (ICZM) can be achieved through appropriate organization and collaboration among all public authorities responsible for the coast (national, regional), littoral related sectors (fishing, agriculture, tourism, industry, transportation and environment) and local communities. The implementation of ICZM doesn't depend on the European Commission, but on the States which define its application according to their own legislative and institutional framework. That's why each country may adopt different measures.

The European Commission also promotes Maritime Spatial Planning[9] (MSP), with the publication in 2008 of a Maritime spatial planning roadmap, which was drafted in closed cooperation with many stakeholders. Maritime spatial planning is a process designed to promote rational and sustainable use of the sea, balance different interests including the

[6] For further details, refer to the Ancorim publication "Governance and integration of coastal risks issues in land planning processes".
[7] For further details, refer to the Ancorim publication "Overview of soft coastal protection solutions"
[8] http://ec.europa.eu/environment/iczm/home.htm
[9] http://ec.europa.eu/maritimeaffairs/spatial_planning_en.html

environmental aspects and improve the quality of decisions. It entails the development of maritime spatial plans. The EU countries are not obliged to carry out maritime spatial planning but are encouraged by the EC to adopt them.
At present, the European Commission is working on an Integrated Maritime Policy[10], to connect all policies involving marine and coastal exploitation and management, among them MSP and ICZM.

• Coastal governance: who are the decision makers?

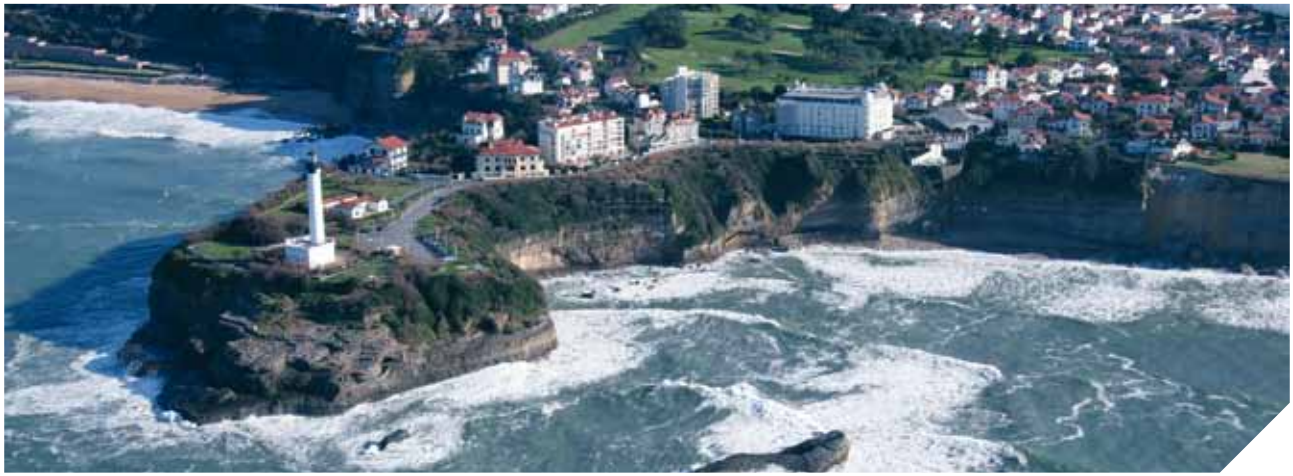
Every country has a different governance system concerning the management of coastal risks, depending on the institutions, history and practices. Here is a brief overview of the situation in the countries taking part in Ancorim.

In Spain, there is a highly decentralized government; that is why multi-level structures are needed for coastal governance. Spain is divided into Autonomous Communities, and each of them has its own regional coastal planning set-up. Although governance structures vary by region, there are some general principles applicable to each region (UE, 2002). In general terms, governance of coastal risks is organized by river basins, but it is really rare to find plans based on studies about possible floods or possible climate change scenarios.

In France, coastal hazard control is mainly coordinated by the central government. In the late 90s, the French government promoted Prevention Plans of Natural Risks (PPRn), as a part of ICZM, in order to contribute to controlling the development of coastal areas. In a centralized country like France, a new collaborative approach has been recently set up, to enable better co-operation and complementarity between the central government, regional institutions and local authorities.

Ireland has not developed any comprehensive global plan for the governance of coastal risks. In 2007, several responsibilities related to coastal risks were transferred between central government departments but there is insufficient coordination of related functions.

Portugal follows a national strategy with nine principles based on the European ICZM. In this country, there is a global and clear strategy based on European directives.



Rocky coast (France)

[10] http://ec.europa.eu/maritimeaffairs/subpage_en.html

> Examples of good practices

In order to concretely apply the European recommendation on ICZM, some guidelines are suggested, on the basis of good experiences in various countries:

• Governance good practices

• Establishing a coordination body where all the public decision makers and other interested parties are represented.

In 2009, a public interest group (gip) was established in aquitaine to organize their littoral governance in a global way. The gip includes, among other, the state representatives, the regional council, the coastal municipalities.

• Approving, updating and standardizing policies, laws and programmes for the comprehensive governance of coastal areas, considering natural risks and climate change.

- River basin governance.
- Water quality governance.
- Coastal planning to avoid uncontrolled growth of population settlements and infrastructures.
- Economic activity planning in coastal areas (tourism and leisure activities, agricultural activities…): searching for more sustainable ways; avoiding duplication of activities, etc.
- Management of waste and other pollution sources, by taking more strict control.

In Spain, there is a discussion about applying fiscal and non-fiscal policies, such as green taxes, or acquisition taxes, both public and private, in coastal areas of special natural value in order to make sure they are protected.

In the regions of Central Portugal, a Public Maritime Domain has being established to control coastal uses and activities. It also classifies beaches and assesses strategic beaches.

• Defining the competences of the various governmental departments, national, regional and institutional structures engaged in coastal governance in order to avoid overlapping responsibilities.

• Working for sustainable development at a regional scale for more appropriate governance. Each region has different peculiarities and has defined concrete objectives at that scale.

• Taking the opinions of marine and coastal users and professionals, the scientific community, experts and associations into account in decision making.

In Aquitaine (France), the advice of experts is taken into account in deciding on planning projects thanks to the expertise of the Aquitaine Coastal Observatory.

In Gâvres (Brittany, France), an experience was tested in year 2011 to involve the local population in a constructive dialogue with the scientific community and the municipality in order to collect their opinions, attitudes and recollections of local coastal risks.

- Transferring and exchanging information about activities and programmes among governance decision makers in order to avoid duplication and to share experiences and solutions.
- Establishing and/or improving institutes, laboratories and research centres responsible for carrying out studies and operational tools for coastal governance.

- Technical good practices

To help the comprehensive governance of the coastal area, there must be an increase in the knowledge, awareness and implications for the responsible bodies and interested parties by creating and analysing different methodologies and tools for coastal governance, and by evaluating impacts, vulnerability and adaptation of coastal areas:

- Compiling and analysing interesting good practices of the comprehensive governance of the coastal area, to draw useful conclusions in order to improve action strategies.
- Compiling and analysing the risks that affected the coast in the past (risks memory) and the limitations and bad experiences in governance plans in order to improve future plans.

It is important to take past experiences into account in order to improve the prevention of future risks.

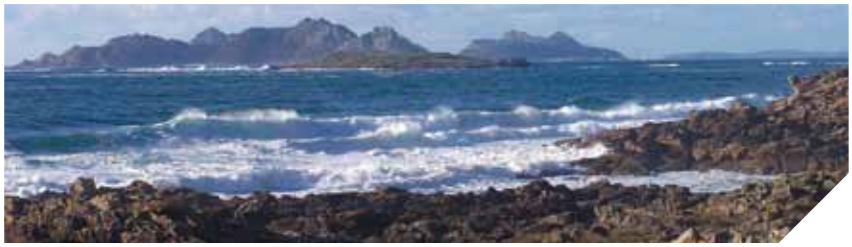
- Preparing and training managers, agents and the population in general through courses, seminars and conferences.
- Creating coastal protection infrastructures and regenerating beaches and dunes, for instance, by artificial supply of sand; cliff protection; implementing by-pass systems; using hard defences against erosion (docks, rocks or breakwaters) or some other advanced solutions, such as dune re-vegetation, so they can absorb the sea energy in a natural way; etc.

Different activities of artificial sand feeding in beaches and dune regeneration are being carried out in Galicia (Spain), County Mayo (Ireland) northern region of Portugal and Poitou-Charentes (France).

- Drawing up didactic tools (guides, manuals,…) to educate the coastal agents, educational community and general public and make them aware of risks and potential solutions.
- Carry out technical studies to get information about coastal resources and their impacts. This information will enhance understanding of the local situation and inform action plans designed to prevent further occurrences.

A diagnosis of the coastal situation has been carried out within the planning and governance programme of the coast of Brittany (France) in order to establish challenges and appropriate responses.

- Create operational tools (databases, GIS, observatories, early warnings…) in order to improve coastal managers' capabilities.
- Implementation of monitoring systems and systematic data collection of parameters to validate models.
- Mapping of coastal vulnerability against sea level rise considering different climate change scenarios, and the assessment of its impact along the coast and on coastal urban communities.
- Creation of risk simulation models and the assessments of their effects.
- Assessment of adaptation options by means of actions on factors related to coastal stability, such as the maintenance of river unloading and solid feeding.
- Assessment of potential actions to help beach and dune stabilization, build works to minimize the capability of the incident swell transportation and artificial sediment feeding.



Rocky coast (France)

Sand feeding in Larmor-Plage, Brittany (France)

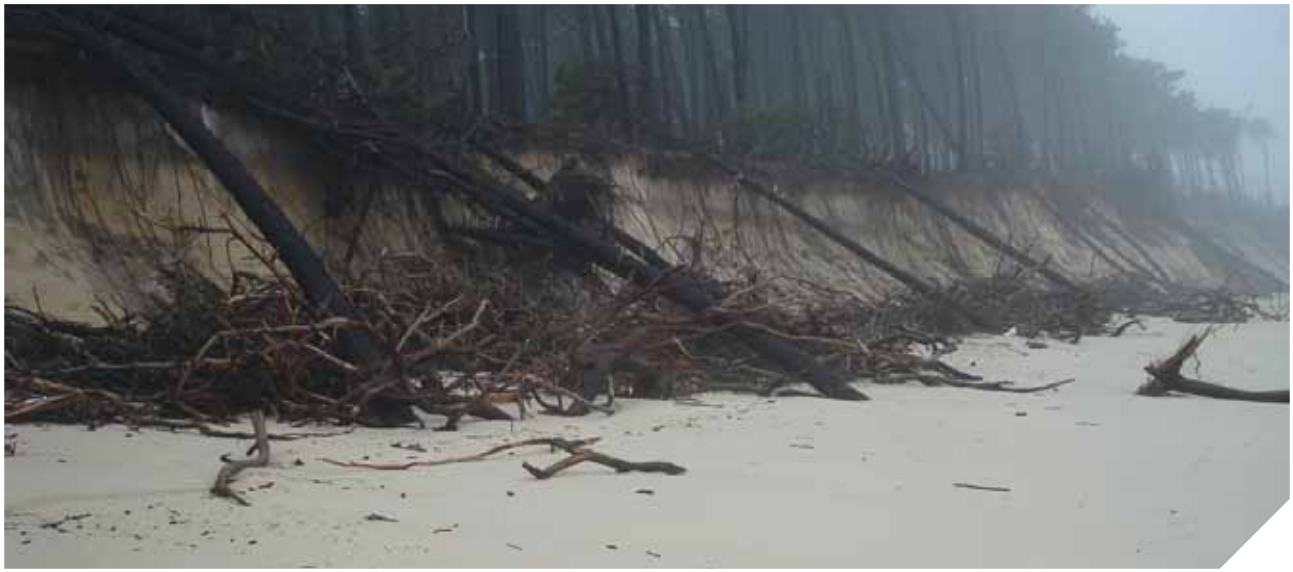
A GIS has been developed in Brittany (France) from previous studies of the coastal situation.
A photographic observatory has also been implemented to track littoral erosion. Galicia (Spain) has an Environmental Observation Network (ROAGA, developed by the Regional Ministry of Environment, land and infrastructures), where information about the ecological status of the Galician waters is obtained and processed. (http://www.cmati.xunta.es/portal/cidadan/lang/gl/pid/2538)

- Establish thematic networks to inform and/or put in contact agents, final users, authorities and research groups, so they can exchange opinions, experiences, doubts (websites, forums…).

As an example, a communication portal (http://littoral-aquitain.fr) between the scientific community, experts and government has been created in Aquitaine (France).

Overview of the main options to mitigate erosion and shoreline mobility issues

> Four possible strategies for the management of coastal erosion risks



North Portugal

There are different strategies that can be adopted to face coastal erosion and flooding risks. They are summarized in four categories that imply the use of different approaches:

- No intervention: if the exposed stakes do not justify intervention, or if there are no exposed stakes, the natural tendency is allowed to continue, and the anthropogenic impacts are restricted. This is the best solution in cases such as when there is erosion without any significant risk.

- Limited intervention: if there is a need for intervention, but stakes are not exposed to high risk, limited intervention using soft solutions is appropriate, so as to conform with the natural processes of shoreline mobility.

- Strategic retreat: This option should be considered if the stakes' value or the cost of their protection does not justify intervention, if there are not many interests, or if protection measures would not guarantee security. This applies to areas where the cost/benefit analysis of laying down measures to maintain the shoreline does not justify intervention measures. Applying natural or artificial protection measures can be considered; however, we have three options in the case of retreat: remove beach equipment, remove equipment and infrastructure that are hardly used and evacuation of areas with private properties. The evacuation can be permanent or reversible. Permanent evacuation would necessitate new reorganization and town planning of the area.

- Hold the shoreline: if there are big stakes, those areas should be protected by soft or hard techniques as appropriate.

> The debate between “hard” and “soft” solutions

Portugal

The measures applied can be divided in hard or soft solutions.

- Hard solutions: These solutions (docks, breakwaters, barriers, channels…) basically function by establishing and protecting a shoreline that protects the stakes; they have a longer lifetime expectancy compared to soft solutions. Those solutions may have some negative impacts in the medium-term. They modify environmental dynamics, are normally very expensive, damage ecosystems and worsen erosion. Furthermore, these solutions do not guarantee complete protection of the population against erosion and flood risks especially in the event of heavy storms.
- Soft solutions: They can be regarded as “working with the environment”, and can be integrated with littoral natural dynamics and shoreline mobility: refilling beaches with sediment, reforesting or restoring vegetation where it has disappeared, etc. These interventions have limited lifespans; they are lreversible and their characteristics depend on environmental trends at a global scale (climate change) or a local scale (town planning, amount of visitors).

It is important to remember that every time these interventions are implemented, whether hard and soft, the surrounding environment is affected. They can cause modifications to sediment balance, circulation restrictions, biodiversity, deterioration in traffic problems, etc..

In any given situation, the option for one type of solution, or a combination of two or more, is always a compromise between the specificity of the problem being solved (persistent erosion at the shoreline, flooding of low-lying areas, etc.), the morphological conditions (the shoreline type and the beach-profile type), the land-use (residential, recreational, agricultural, etc.), and the anticipated impacts of intervention measures on coastal processes[11].

[11] Das Neves, 2011

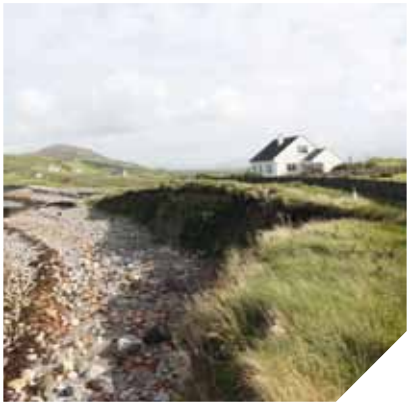
A few case studies on the European Atlantic space

In order to help the management and/or the prevention of coastal risks, we present below some good practices and case studies carried out in the member regions of the European Atlantic area. They may be applicable to other regional contexts or provide the inspiration for newinitiatives in particular areas.

> Case study in County Mayo (Ireland)

County Mayo in Ireland has 1,168 km of coastline with considerable natural diversity - estuaries, rocky coast, dune systems, etc, and also areas with rural and urban housing. Coastal activities include aquaculture, fishing, mollusc culture and tourism.

Among the coastal risks that threaten this region, there are strong pressures from tourism development urban expansion, all of which are aggravated because of the climate change. This case study is focused on a micro scale analysis of natural risks and the implications of climate change in this area and on the evaluation of planning policies in order to ascertain if the risks are adequately weighted in planning decisions relating to this coastal area. Arising from an analysis of good practices and innovative measures some recommendations are also advanced to enhance capacity to make appropriate planning decisions.



Cliff in County Mayo (Ireland)

Organization:
Marine Institute
Website:
http://www.marine.ie

> Case study in the peninsula of Gâvres, l'Orient (France)

The peninsula of Gâvres is a very vulnerable area, weakened by the gradual reduction of the level of its beaches and by the swell energy. The storm on the 10 March 2008 caused important sea floods in this region. This situation lead to a study of flooding from which some practical solutions to limit erosion and advance sea protection emerged. Following this initiative, a methodology was suggested in order to monitor the coastline, together with the tools to put it into practical effect, and a programme of public education were advanced.

Pointe de Gâvres, Brittany (France)

Organization:
Observatoire Départemantale de l'Environnement du Morbihan
Website:
http://www.odem.fr/

> Case study of Marennes-Oleron Bay (france)

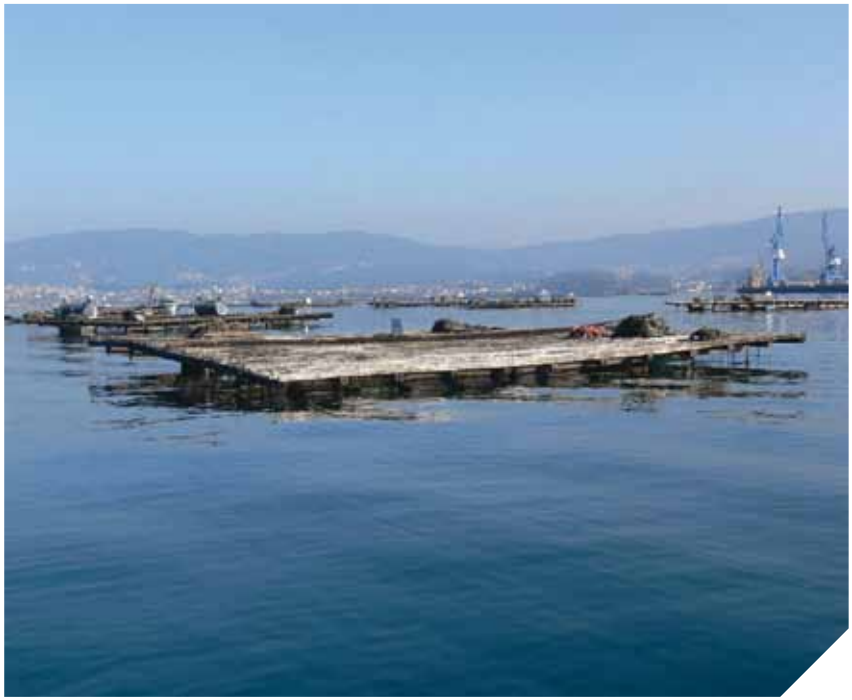
The study area is the shellfish bay of Marennes-Oleron, which is, together with the rest of the Poitou-Charentes coast, the most important area of oyster production in Europe. The current shellfish activity is threatened by coastal risks, such as the effects of climate change and associated changes in water quality.
This case study suggests a methodology of risk identification, based on the use of a dispersion model (Mars 2D), in which the effects of those risks that threaten the shellfish culture hatcheries are simulated.

To promote the adaptation of culture areas to environmental changes, the use of a space-time model, with the integration of environmental changes in order to define the vulnerability areas, is suggested: also the testing of a model for off-shore production involving an instrument for greater specialization of egg-laying and dispersal risks.

Organization:
CREAA and IFREMER
Website:
http://ancorim.aquitaine.fr/
http://wwz.ifremer.fr/institut

Marennes Oléron, Poitou-Charentes (France)

> Case study Rias Baixas (Spain)

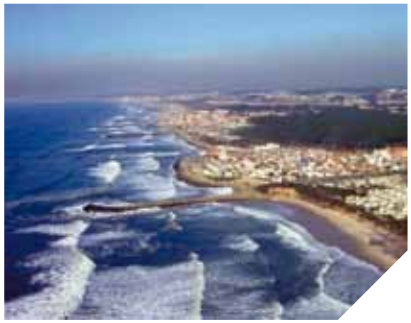


Ria de Vigo, Galicia (Spain)

The Ria of Vigo is one of the Rias Baixas in Galicia, located in the Northwestern coast of Spain. This area has a large number of socioeconomic coastal activities – harbour activities, aquacultures ground facilities and floating structures, shellfish gathering, sea transport, tourism, etc. The aim of this case study is to identify potential risk sources than can affect the floating aquaculture structures (mussel rafts) in the Ria of Vigo, and to calculate suitability indexes for its current location. To this end, a model based on GIS analysis has been developed. This model takes into account the distance from the aquaculture areas to the potential risk sources, showing the most suitable areas for shellfish culture in this ria.

Organization:
CETMAR
Website:
www.cetmar.org

> Case study in Esmoriz and Cortegaça (Portugal)



Esmoriz (Portugal)

Esmoriz and Cortegaça, in the North of Portugal, are two coastal urban regions sheltered by four dykes and three protection walls which are in a very vulnerable situation and with high risk zones. In some of them, the erosion has increased and the houses in the front line are only separated from the sea by the coastal protection structures. Apart from the urban area, there is also a forest zone affected by the erosion, and it is resulting in hundreds of trees falling into the sea.

The aim of this study is to define likely coastal mobility scenarios and to suggest alternatives for the protection of coastal urban fronts, including other management options for coastal areas - for example, the management of the coastline.

Organization :
Faculdade de Engenharia
Universidade do Porto
Website :
http://www.fe.up.pt

> Case study in Algarve (Portugal)

The study was carried out on the south coast of Portugal, in the coastal sector Quarteira-Cacela, between the Quarteira promenade and the Manta Rota beach. Its length is 63 km. This space presents a cliff zone, and also sand dunes which belong to the islands and peninsulas of Ria Formosa. The area of this bay has 84 km2, with mud flats, sandbanks and a complex channel network.

A great part of the West sector has undergone an erosion process for many decades. This phenomenon has spread faster with recent storms and with the construction of piers, harbours, fishing ports, etc.

So we find a coastal region, where dune systems and cliffs have been removed, where the beach has got narrower and where the erosion has sometimes intensified. In view of these impacts, the local authorities have implemented protection and restoration measures of beaches in the foreshore area in front of the cliffs, and also the reinforcement of the dune systems in the barrier islands:

- To repair sandy areas with sediments from the sea bottom.
- Vegetation plantation in order to consolidate the dunes.
- Prohibition/regulation of coastal occupation.
- Implementation of project for the promotion of natural processes of dune recuperation.

Algarve (Portugal)

Organization:
LNEC-Laboratorio Nacional de Engenharia Civil
Website:
http://www.lnec.pt

> Case study “BY PASS” (France)

This case is focused on the rapid increase (around 200 m) in the beach located on the North coast of the dyke of Boucarot channel (Aquitaine), caused by sedimentary movement (around 100,000 m3/year) towards the South.

Today, the sand surrounds and blocks the channel entry. The consequences have increased the erosion of beaches in the South, and, therefore, the need of a reinforcement through heavy constructions, such as retaining walls, droynes, rocky bottoms in sea and land areas, etc. Since 1983, 15,000 m3/year of sand have been taken from the North of the channel by the local government of Capbreton (with a lorry) in order to feed the southern beaches.
An hydraulic “by-pass” system has been implemented in order to replace the overland route. Sediments in Boucarot are extracted mechanically in the Northern beach. Then they are transferred tp the Southern beaches through a rigid, buried pipe which has exit holes to distribute the sand along the sea bottom.

Organization:
SOGREAH
Website:
http://littoral.aquitaine.fr

> Practical tool: statistic model of swell prediction (Spain)

Together with the rising sea level and the occupation of these areas for economic or residential motives, many experts have been signalling risks related to swell and associated damage to beaches and promenades, etc.. The installation of big buoys for the exploitation of tidal and wind power of the sea environment, as well as the destruction of fishing or aquaculture infrastructures are other prevailing risks.

During recent years, the Instituto de Hidráulica Ambiental de la Universidad de Cantabria has focused on a swell study, developing a statistical prediction model. The studies have determined that, depending on the area, wave size varies greatly among the different seasons of the year. For example, in the Cantabrian Sea, waves can reach 7 metres high in the middle of the winter, while in the Atlantic region they range between 6 and 8 metres, depending on the area. And in the Mediterranean region, waves barely reach 3 metres.
From this data, they can test the validity of the statistical methodology that they have developed, and establish the probabilities and risks of a huge wave, a hurricane force wind or an extreme rise in the sea level. All this taking into account the current climate change.

Organization:
Instituto de Hidráulica Ambiental de la Universidad de Cantabria
Website:
http://www.ihcantabria.unican.es

> Practical tool: Coastal Modeling System (Spain)

The Coastal Modeling System (Sistema de Modelado Costero - SMC) is a computer tool that includes several methodologies and numerical models, to study coastal processes and estimate the changes that the beach suffers in relation to natural causes, or human actions on the coast. In confronting a coastal, the methodology allows one to establish which studies need to be undertaken,, which time and space scales need to be analysed, which numeric tools do we must to use and the necessary baseline data for the analysis.
With SMC a study of the impact on the coast, leading to practical proposals, can be carried out. For example, in the case of an extension of a shelter dyke in the harbour, it would show the swell spreading in the area, taking the actual harbour into account and its extension, stream system, etc.

Organization:
Instituto de Hidráulica Ambiental de la Universidad de Cantabria
Website:
http://www.ihcantabria.unican.es

> Case study of Rosslare, County Wexford (Ireland)

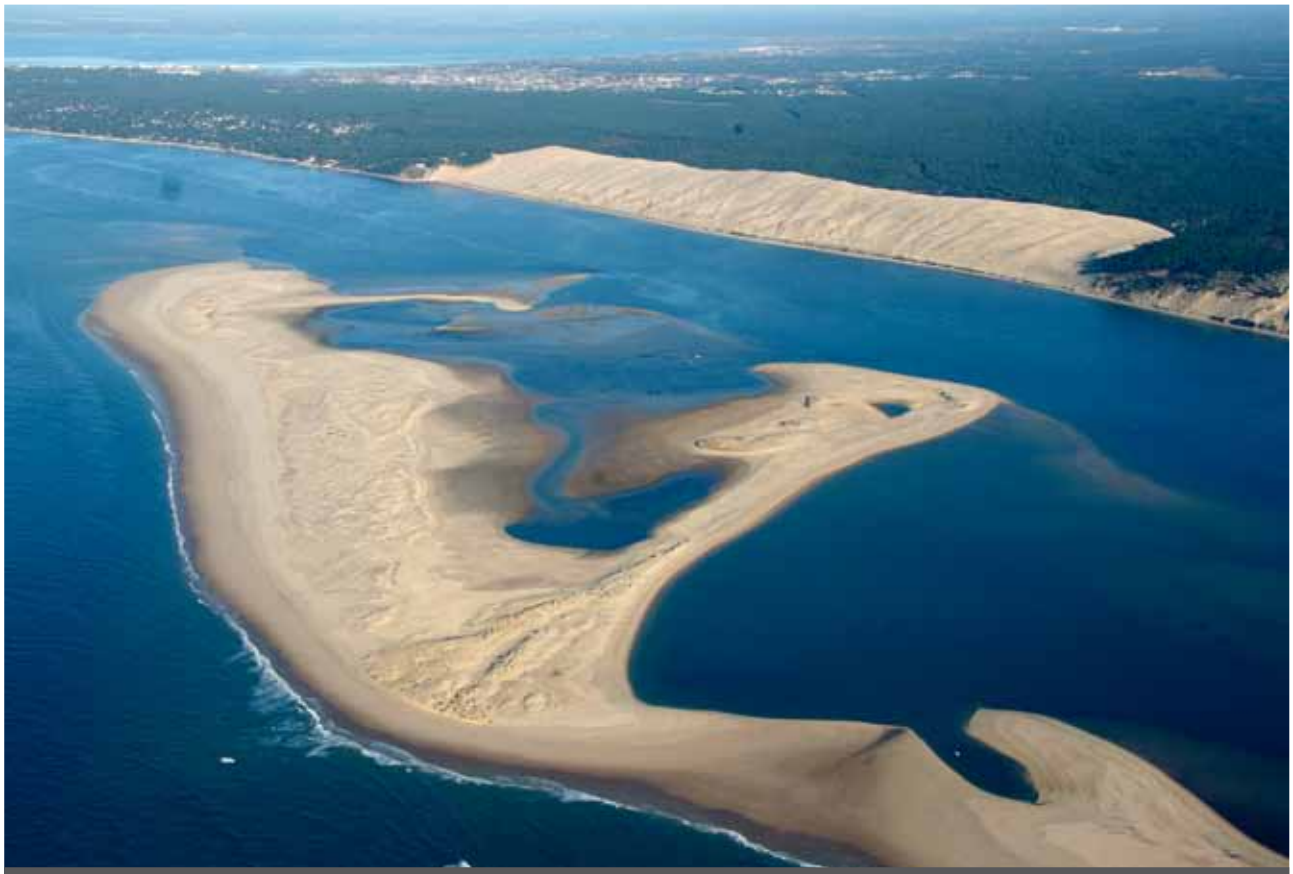
This study compiles information about the measures taken during the 90s in County Wexford (Ireland) in order to stope erosion and protect the coastline, including beach restoration and the construction of rocky groynes, instead of the wooden ones, as was done in the 50s. It was discovered that these wooden groynes involved loss of considerable sedimentaton along the coast, apart from the high cost of this material.

Organization:
DHV group
Website:
http://databases.eucc-d.de/files/000125_EUROSION_Rosslare.pdf

> Good practice of sea environment control and water quality (Spain)

The Instituto Tecnológico para o control do medio mariño de Galicia (INTECMAR), in Spain, has been developing a monitoring programme to control and investigate the environmental quality of coastal waters in Galicia for the development of aquaculture and shellfisheries activities. It also develops initiatives in the field of operational oceanography and in combating marine accidental pollution (as in the Prestige case). and it is integrated with the Regional Contingency Plan for Marine Pollution in Galicia.
For this purpose, it has a Unit of Oceanographic Modeling that uses knowledge about numerical modeling, in oceanography and meteorology, in order to provide answers in emergency situations (such as spillages or the control of drifting objects), and also to diagnose and predict the dynamics of the sea system and its consequences for water quality. The Unit of Documentation and Scientific Support compiles technical, scientific and operational information, continuously making and updating databases.

Organization: INTECMAR
Website: www.intecmar.org



LINKS OF INTEREST

- European Environment Agency:
  http://www.eea.europa.eu/
- European Commission Environment-Integrated Coastal Zone Management (CZM):
  http://ec.europa.eu/environment/iczm/home.htm
- European Commission Environment- Projects of ICZM:
  http://ec.europa.eu/environment/iczm/projects.htm
- Arc Atlantique:
  http://www.arcatlantique.org
- CPMR - Conference of Peripheral Maritim Regions of Europe:
  http://www.intecmar.org
- Project ANCORIM:
  http://www.crpm.org

Arguin, Aquitaine (France)

8 - BIBLIOGRAPHY

Galicia (Spain)

- Alcántara, J.; Correa, I.D.; Isla, F.I.; Alvarado, M.; Klein, A.H.F.; Cabrera, A.; Sandoval, R. (Eds) (2009). Métodos en Teledetección Aplicada a la Prevención de Riesgos Naturales en el Litoral. Servicio de Publicaciones del Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo. Madrid. 297 pages.
- Anfuso, G.; Domínguez, L.; Gracia, F.J. (2007). "Short and medium-term evolution of a coastal sector in Cadiz, SW Spain". Catena, 70 (2), 229-242.
- Barragán, J. M. (2004). Las áreas litorales de España. Del análisis geográfico a la gestión integrada. Ariel, Barcelona, 214 pages.
- Bruun, P. (1954). Coastal erosion and the development of beach profiles. U.S. Army Corps of Engineers, Beach erosion board. Tech. Memor., nº 44.
- Carter, R.W.G. (1991). Coastal environments. Academic Press, 617 pages.
- Consulmar, Hidroprojecto y Risco, (1989). Study of the littoral between the Vilamoura harbour and the western jetty of Rio Guadiana. Lisboa. 109 pages (in Portuguese).
- Cooper, J.A.G.; Pilkey, O.H. (2004). "Sea-level rise and shoreline retreat: time to abandon the Bruun Rule". Global and Planetary Change, 43, pages. 157–171.
- Dabrio, C.J.; Zazo, C. (1987). "Riesgos geológicos en zonas litorales". In F.J. Ayala; J.J. Durán; T. Peinado (coords.): Riesgos geológicos, IGME, pages 227-250.
- Fenster, MS, Dolan, R, Morton, RA. (2001). "Coastal storms and shoreline change: signal or noise?". Journal of Coastal Research, 17 (3), pages 714–720.
- Ferreira, O. (2005). "Storm groups versus extreme single storms: predicted erosion and management consequences". Journal of Coastal Research. SI42, pages 221–227.
- Gracia, F.J.; Del Río, L.; Alonso, C.; Benavente, J.; Anfuso, G. (2006). "Historical evolution and present state of the coastal dune systems in the Atlantic coast of Cádiz (SW Spain)": Palaeoclimatic and environmental implications. Journal of Coastal Research, S.I. 48, pages 55-63.
- Lozano, I.; Devoy, R.J.N.; May, W.; Andersen U. (2004). "Storminess and vulnerability along the Atlantic coastlines of Europe: analysis of storm records and of a greenhouse gases induced climate scenario". Marine Geology, 210, pages 205–225.
- MMA (Ministerio de Medio Ambiente) (2004). Impactos en la costa española por efecto del cambio climático (Fase III). R. Medina (Coord.). Madrid. 130 pages.
- Morton, R.A.; Gibeaut, J.C.; Paine, J.G. (1995). "Meso-scale transfer of sand during and after storms: implications for prediction of shoreline movement". Marine Geology, 126, pages 161–179.
- Nicholls, R. J. (2002). "Analysis of global impacts of sea-level rise: a case study of flooding". Physics and Chemistry of the Earth, 27, pages 1.455–1.466.

- Olcina, J.; Ayala, F. (2002). "Riesgos naturales. Conceptos fundamentales y clasificación". In Ayala, F.; Olcina, J. (coords.): Riesgos naturales. Ariel Ciencia, pages 41-73.
- Olcina, J. (2004). "Riesgo de inundaciones y ordenación del territorio en la escala local. El papel del planeamiento urbano municipal". Boletín de la Asociación de Geógrafos Españoles, nº 37, Madrid, pages 49-84.
- Olcina, J. (2009). "Hacia una ordenación sostenible de los territorios de riesgo en Europa" In Cohesión e inteligencia territorial. Dinámicas y procesos para una mejor planificación y toma de decisiones (Farinos, J.; Romero, J.; Salom, J., eds). Publications of the Universitat de Valencia, Valencia, pages 153-182.
- Oficina Española para el Cambio Climático, Ministerio de Medio Ambiente (2006). "Plan nacional de adaptación al cambio climático". Ministerio de Medio Ambiente, Madrid.
- Pacheco, A.; Ferreira, Ó.; Williams, J.J.; Garel, E.; Vila-Concejo, A.; Dias, J.A. (2010). "Hydrodynamics and equilibrium of a multiple –inlet system". Marine Geology, 274 (1-4), pages 32-42.
- Roy, P.S.; Cowell, P.J.; Ferland, M.A.; Thom, B.G. (1994). "Wave dominated coasts". In: Carter, R.W.G.; Woodroffe, C.D. (Eds.), Coastal Evolution: Late Quaternary Shoreline Morphodynamics. Cambridge University Press, Cambridge, pages 121–186.
- Toharia, M. (2006). El clima. El calentamiento global y el futuro del planeta. Barcelona, Ed. Debate, 333 pages.
- European Union (1999). El Medio Ambiente en la Unión Europea en el umbral del Siglo XXI. European Commission. European Environment Agency. Luxembourg. Office for Official Publications of the European Communities. 43 pages.
- European Union (2007). Espacio atlántico. Cooperación transnacional 2007-2013. European Commission. Operational Programme of European Territorial Cooperation. Luxembourg. Office for Official Publications of the European Communities. 133 pages.
- European Union (2010). Natura 2000 in the Atlantic region. European Commission. Environment Directorate General. Luxembourg. Office for Official Publications of the European Communities. 12 pages.
- Vellinga, P. (1982). "Beach and dune erosion during storm surge". Coastal Engineering, 6, pages 361–387.
- Zhang, K.; Douglas, B.C.; Leatherman, S.P. (2004). "Global warming and coastal erosion". Climatic Change, 64, Berlin, pages 41–58.

North Portugal

Instituto de Hidráulica
e Recursos Hídricos

The ANCORIM project is co-financed by the European Union in the framework of the INTERREG IVB programme - Atlantic space, "Investing in our common future"

Pointe de Gâvres, Brittany (France)

Coordination of the editing project
Diputación de A Coruña (Spain)
Région Aquitaine (France)

Editors
Diputación de A Coruña and Ideara SL (Spain)
With the contribution of the Ancorim partnership

Editorial direction
Editorial director: Alain Rousset
Editorial vice-director :Philippe Buisson
Communication director: Corinne Descours

Creation, layout and printing : Akson, Bordeaux (France)