



# School Guide

Atlantic Network for Coastal Risks Management



North Portugal

## CONTENTS

INTRODUCTION	3
1 - THE EUROPEAN ATLANTIC COAST : A VERY SPECIAL ENVIRONMENT	4
2 - DEFINITION OF COASTAL RISK	4
3 - WHICH HAZARDS ALONG THE ATLANTIC COAST ?	5
4 - SENSITIVITY OF OUR COASTAL AREAS	6
5 - EXPOSURE OF GOODS AND STAKES TO RISK	9
6 - NATURAL RESILIENCE AND RECOVERY CAPACITY	9
7 - POTENTIAL SOLUTIONS TO IMPROVE COASTAL RISK PREVENTION AND MANAGEMENT	10
8 - BIBLIOGRAPHY	10

## INTRODUCTION

This guide is aimed at pupils to promote a better knowledge and awareness of coastal risks, in the framework of school teaching.

This document is part of an information kit on coastal risks. It can be used alone, or together with the User guide in order to customize

the General guide and adapt the content to the local area where pupils live. Thus, it can be used as a support for a participatory initiative, with the active involvement of pupils, so that they develop a better understanding of where they live and of the complexity of coastal risk issues.

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.**

## 1 - REGIONAL CONTEXT AND MAIN CONCEPTS

The coastal areas are constantly changing due to the interaction between sea and coast. The waves and the wind are probably the most important elements,

since they generate erosion and sediment dynamics.

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:** this region features mild winters and cool summers and the predominance of westerly winds and moderate rain throughout the year.
- **Different landscapes:** this coastline is comprised of a heterogeneous landscape with cliffs, rocky capes, narrow



Member regions of the European Atlantic Area

estuaries, long sandy beaches, sheltered bays and vast marshes, as well as large estuaries, mainly formed at the mouths of rivers of great importance.

- **Biodiversity:** in the coastal zone there exists varied, dynamic and rich habitats with many species. Its fauna includes a high number of migratory birds. We also find abundant sea life in its waters.



Throughout the year, the Gulf Stream moves a great mass of warm water and a rich nutrient supply from the Caribbean to the west coast of Europe. These conditions provide a special nutrient richness (phytoplankton) in shallow wa-

ters, that feed a high range of sea organisms (plankton, crustaceans, bivalve molluscs and fish). They are also the primary food of many sea birds and mammals in these regions.

- **Human presence:** nowadays, the landscape of the European Atlantic coast is mainly a farming landscape, with some heavily built-up areas. As a result, the remaining natural and semi-natural habitats are nowadays scattered among artificial landscapes in a fragmented way.

About 16% of Europe's population lives in coastal areas, and this is steadily increasing. Economic activities located in and dependant on coastal areas have increased in recent decades (leisure and tourism activities, aquaculture and fishing, urbanization and related economic activities, etc. ).

- **Coasts typology:** there are several ways of classifying coasts

### ERODING COASTS

#### CLIFFS, PLATFORMS AND ROCK FORMATIONS

Types: 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, by the impact of the waves or by land processes (wind, rain, infiltrations, salinity).

#### CAPIES AND BAYS

These are highly characteristic of the European Atlantic coast due in large measure to geological formations lying at right angles to the coast.

### SEDIMENTARY OR SANDY COASTS

#### BEACHES

They 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 irregular shapes, with spreading sandy bars extending out to sea or joining a continental area together with an island.

#### DUNES

They are sand reserves, and they allow beaches to feed from them when the latter lose sediments due to the action of the waves. They offer a variety of landscapes, biodiversity and contribute to the conservation of beaches. They may also protect inland areas from sea flooding.

### COASTAL MARSHES

They are wet areas that are created when salt and fresh water mix in areas quite protected from swell. They can be highly beneficial since they can stop river floods as well as sea flooding and retain much sediment. These areas are natural barriers. They reduce water speed and force during sea and river storms. They also filter river water, so they prevent the modification of sea water quality. They are really rich ecosystems.

Most regions along the European Atlantic coast have examples of full variety of coastal areas described.



Cliffs of Moher (Ireland)



Soulac, Aquitaine (France)



Ramalloso (Spain)

## EXERCISE

### CHARACTERISTICS OF YOUR COASTAL AREA:

Consider what kind of elements there are in your coastal area, (cliffs, beaches, dunes. . .)? Take photographs of some of them and compare them with your classmates' photographs. According to the elements identified, discuss in class the typology of your coastal area.

## 2 - DEFINITION OF COASTAL RISKS



Galicia (Spain)

The coast can be defined as the space where land and sea environments interact. This interaction takes place also in the air, inland and at the sea shore or in the seabed. The coast is also comprised of animals and plants, humans, infrastructures, goods, buildings and companies

**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 over a specific period. The severity of these potential risks basically depends on the stakes that can be affected, on the level of vulnerability and on exposure to the hazard.

### HAZARDS

Natural or human phenomenon that may cause a possible loss or represent a risk to people or things (see Chapter 3).

### STAKES

in this context, they are activities, elements or systems which generate value for a area or region (goods, economic activities, infrastructures, natural ecosystems) (see Chapter 5).

### VULNERABILITY

It is the exposure level of every stake in every territory combined with the capability of the territories to cope with the hazards (see Chapter 6).

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

The stakes existing in a given

area will determine whether the above hazards may potentially represent a risk for the territory. For instance, there is no coastal risk if there is a flood plain without any buildings, as that flood does

not cause any significant negative consequence to people, activities or ecosystems, since the system is able to recover its natural state without affecting biodiversity, infrastructures, or people.

If the stakes are of a high value in a territory and if it is vulnerable to the point that it cannot cope with the hazards through its own resources, the human population have to adopt solutions in order to prevent and/or minimize negative impacts. We all have a specific role to play in this preventative action (see Chapter 7).

### 3 - WHICH HAZARDS ALONG THE ATLANTIC COAST ?

#### Littoral erosion and shoreline mobility

The main causes of naturally occurring 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 their effects.

#### Loss & transformation of beaches and dune systems

Some dune systems balance erosive events. On the one hand, these dunes return part of the sand received during good weather conditions and on the other hand, they absorb the effect of the incident swell.

Urban development, tourism and sand extraction and dredging activities are other human causes of erosion and littoral mobility. Docks, breakwaters and some other harbour works interrupt the transportation of sediment. This creates deposit areas upstream, and areas subject to erosion downstream. It sometimes changes coastal morphology.

#### Floods

The main causes of floods are heavy storms. The action of storms causes a 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 other coastal defences, especially when the storms occur at the same time as spring high tides.



Nemiña, Muxía, Galicia (Spain)



Gávres area (France) (storm from year 2008)

#### Changes in water quality

These kinds of changes range from water temperature variation, water salinity and pH changes. It is important to highlight the impacts of fertilizers, pesticides and herbicides used in agriculture on water composition. Other sources of water pollution are maritime transport, urban and industrial waste disposal, discharges of ballast water and the introduction of marine pests.

#### Watercourse change

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

Basin deforestation and clearing for agricultural purposes speed up soil erosion, and the resultant products are carried towards the coast.

### Strong winds and storms

Coastal infrastructures are more exposed to strong winds due to their location. Those are some factors to take into account when laying down building regulations for street furniture or designing warning systems for extreme events. In Ireland, for instance, this hazard may be particularly serious along exposed coasts.

### Pollution from industrial activities and urban waste disposal

Pollution from industrial and urban activities, agricultural and forest pollution and recklessness with the urban waste are also responsible for coastal pollution, as well as pollution of water (pH, salinity...), where many different species of flora and fauna live.

### Pollution from accidents

Concentration of activity along the coast or offshore makes it necessary to evaluate and guard against risks due to accidents and their possible consequences (For instance, the sinking of the oil tanker Prestige (2002) along the Galician coast, or the sinking of the Erika in Brittany (1999)).

## Climate Change

The climate has always changed and so has ecosystems. However, human activities have accelerated this change primarily through atmospheric pollution.

The most important consequences of climate change are sea level rise,

and water and atmospheric temperature rises. These phenomena could also cause indirect changes in currents, water composition, erosion, wind and storm strength and frequency. Climate change is thus likely to have an impact on many coastal risks.



Saint Jean de Luz, Aquitaine (France)

In any case, all the hazards that have been described have very different impacts depending on the stakes existing in the territory (see Chapter 5) and on

the vulnerability of each territory (see Chapter 6). Damage can be reduced and the recovery can be faster and more complete with appropriate management

strategies in each territory. To do this, it is necessary to know the sensitivity and natural recovery capability of each kind of coastal zone.

## 4 - SENSITIVITY OF OUR COASTAL AREAS

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...), after an event and protection measures have not been set up

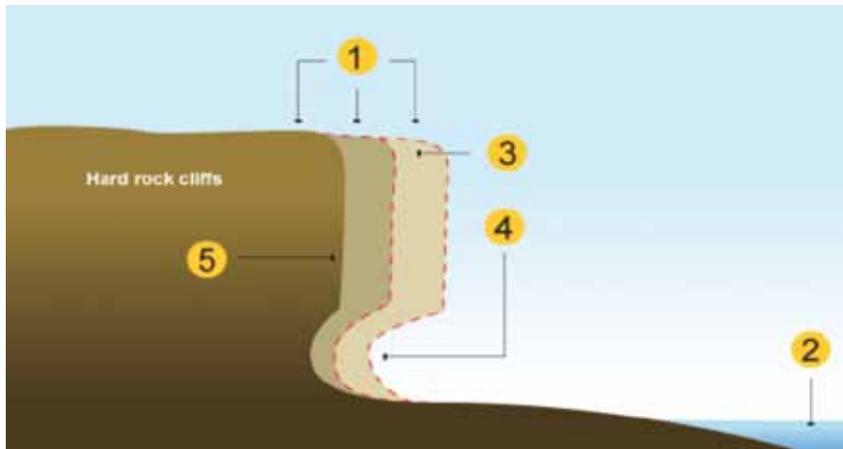
and the system is not be able to recover from the negative impact, then we are facing a risk.

### Sandy coast sensitivity

Beach outlines vary due to seasons, wave direction, wave type, winds or sediment supply. Beaches lose and receive sediments from offshore sea bottoms and other beaches, so any change affecting any of them or the transportation channel can cause sudden changes in beach morphology. Also, the

building of infrastructures that isolate interdependent system elements can be a problem that increases risks for these natural phenomena.

In the case of dunes, there is a continuous exchange between dunes and underwater areas, so a change in one of them may affect the other one.



### Cliffs are eroded a number of actions:

- 1 - Weather elements weaken the top of the cliff
- 2 - The sea attacks the base of the cliff forming a wave-cut notch.
- 3 - The notch increases in size causing the cliff to collapse.
- 4 - The backwash carries the rubble towards the sea forming a wave-cut platform
- 5 - The process repeats

### 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 can also cause other phenomena, such as landslides or slope decrease.

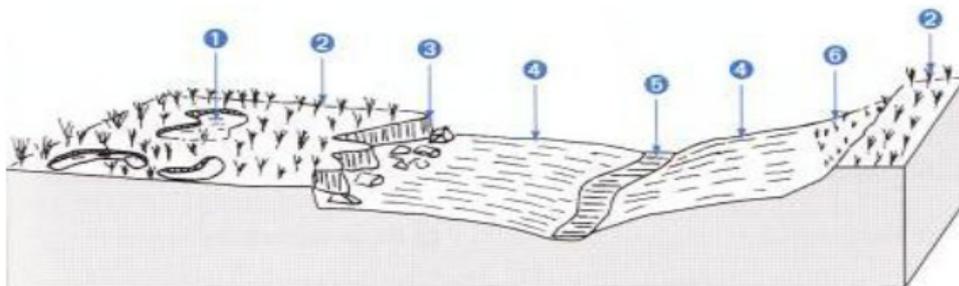
This kind of erosion increases due to human causes: urban development at the top of the cliff or construction of communication routes creates alterations in water seepage to the subsoil. Pebble extraction at the cliff bottom also leaves it unprotected against the waves' impacts.

## Coastal marshes and estuaries sensitivity

Marshes are flat areas protected from waves. Some areas have vegetation cover, mainly herbaceous vegetation, and some other areas are comprised of sediments transported by

rivers and tides. One of the main characteristics of coastal marshes is the change in its hydrological component, from sea water to fresh water depending on tides and on the prevailing hydrological

regime. Marshes are essential ecosystems to preserve the life cycle of many kinds of fishes, amphibians, birds and insects.



- 1 Basin
- 2 Schorre
- 3 Microcliff
- 4 Mud Flat
- 5 Tidal channel
- 6 High mud flat

Morphology of a coastal marsh in a temperate climate zone

Impacts to these areas 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 soil elements from forest areas (deforestation increases erosion and the amount of sediments).

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). These policies should be questioned and discussed. Water movement restriction impedes the natural flooding of these areas by the tide, and changes biological cycles. It can also modify the sediment

transportation rhythm, and it may 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 hazards, and protect inland areas.



Arcachon Delta, Aquitaine (France)

**SOME RISKS OF NATURAL ORIGIN  
MAY BE AGGRAVATED BY CLIMATE CHANGE.**

**OTHER FACTORS THAT CAN INCREASE  
THE RISKS ARE LINKED TO HUMAN ACTIVITIES**

like urban planning, activities being developed too near the coast, coastal resources exploitation and coastal infrastructures.

## 5 - EXPOSURE OF GOODS AND STAKES TO RISK

As introduced in the Chapter 2, the stakes existing in an area (goods, economic activities, infrastructures, natural ecosystems, etc. ) will determine whether the

hazards considered above may potentially generate a risk for a territory. 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 from coastal risks:

- The stakes exposed to risk at the present time in an area should be analyzed in order to take appropriate measures, such as prevention, security, hazard warning, access or circulation restrictions...
- Work should be done in order to avoid future exposure of stakes to risk as far as possible. To do this, the areas to be built up should be carefully studied, by considering the risks to which they are exposed.

### Impacts of natural risks and risks of human origin

#### HUMAN SYSTEM

- Impact on security of human beings and their belongings.
- 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/forestry.
- Impact on built-up areas, hazards for people, goods and infrastructures.

#### NATURAL SYSTEM

- 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.

Trends in human activities constituting high stakes that need to be taken into consideration and are likely to affect coastal risks at a global level include:

More **human activities** such as urbanization and littoralization. There are also more risk activities in the sea that can result in spills and pollution. These trends are not likely to stop or decrease significantly 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.



Rocky coast (France)

**Ecosystems and natural environment:** these stakes are increasingly taken into consideration in policies but their exposure to coastal risks doesn't look likely to decrease into the future.

Excessive **exploitation of water resources:** regarding fishing, aquaculture and mineral resources.



## EXERCISE

### STAKES IN YOUR COASTAL AREA:

Can you describe the most important stakes in your local coastal area? Which economic activities may be impacted by water quality changes (i. e. fisheries, aquaculture, tourism) or shoreline mobility (i. e. urban areas)?

Are there constructions near the coast that may be damaged by huge storms or flooding?

What about natural systems? Are dunes, cliffs, sandy coasts, marshes threatened by erosion or shoreline mobility? By human constructions (e. g. by preventing sediments to reach beaches)?

Bidart, St Jean-de-Luz (France)

## 6 - NATURAL RESILIENCE AND RECOVERY CAPACITY

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, if there are not enough channels and sediment is blocking water courses. Another example is the circulation of vessels with dangerous goods

(hazard) together with a lack of measures against pollution, ports of refuge or inspections (vulnerability).

### VULNERABILITY

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

### RESILIENCE

is the capability of a system or society exposed to hazards to resist them, absorb them, accommodate to them and recover from the effects of hazards in efficient time and ways.



Arguin, Cap Ferret, Aquitaine (France)

In some cases, nature can protect itself. Each coastal typology features different characteristics and natural recovery capability. The natural coastal infrastructures put the focus on the defense capacity offered by certain coastal areas against erosion, flooding, storms. Preserving these areas can serve

a useful purpose in itself, but is also a strategy to preserve other environments.

*Example: coastal marshes are able to protect inland areas from huge flooding, by partly absorbing sea water and mixing it with river water, and by reducing water flows.*

Depending on the vulnerability of the territory, the human community may have to take action and implement prevention or other management measures. Some of these are described in the next chapter.

## 7 - HUMAN ACTION TO MITIGATE EROSION AND SHORELINE MOBILITY

Different strategies can be adopted in confronting coastal risks such as erosion and flooding. They are summarized as four broad types:

### 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 anthropogenic interventions are limited. this is the best solution in cases where erosion poses no significant risk.

### Strategic retreat

is appropriate if the value of the stakes or the cost of their protection does not justify intervention, or if protection measures would not guarantee security. evacuation can be permanent or reversible.

### Limited intervention

if there is a need for intervention, but stakes are not exposed to high risk, this intervention may be confined to soft solutions.

### Hold the shoreline

if there are big stakes, those areas should be protected by soft or hard techniques, as appropriate.

## The difference between «soft» and «hard» solutions

### Hard solutions:

These kinds of interventions (docks, breakwaters, barriers, channels...) basically work by establishing and protecting a shoreline. Those solutions, however, have some negative impacts in the medium-term. They modify environmental dynamics, are normally very expensive, and may damage ecosystems and worsen erosion. Furthermore, these solutions do not guarantee complete protection of the population against erosion and flood risks in the case of heavy storms. Sometimes, however, hard solutions are the only appropriate measure to protect human constructions.



North Portugal



Larmor Plage, Brittany (France)

### Soft solutions:

They may be regarded as «working with the environment», and can be integrated in littoral natural dynamics and shoreline mobility: refilling beaches with sediment, reforestation or restoring vegetation where it has disappeared, etc. These kinds of intervention have a limited lifespan and are reversible.

It is important to bear in mind that, every time these interventions are made, the surrounding environment is affected. They can cause modifications in sediment balance, circulation restrictions, biodiversity reductions, and cause traffic problems to increase.

## EXERCISE

### SOLUTIONS IN YOUR COASTAL AREA:

Can you give examples of soft and/or hard solutions existing along your coast?

## 8 - OUR ROLE IN THE PREVENTION OF COASTAL RISKS

### The administration is in charge of:

- Delimitation of the use of the land in the coast when planning infrastructure, urbanism and economic activities.
- Ensuring appropriate waste treatment, checking, sanctioning and improving risky activities (industry and agricultural activities, leisure and tourism activities, etc.)
- The establishment of emergency plans and infrastructures in case of extreme and dangerous phenomena for the population and the ecosystems.
- Undertaking studies and monitoring that can establish the vulnerability level of each area.
- The promotion of a wider knowledge about coastal risks, dissemination of information, sharing experiences and good practices.

### The scientific community must:

- Design tracking systems and systematic data gathering about the evolution of coastal risks and the degree of damage in different areas.
- Map coastal vulnerability to rising sea levels against different scenarios of climate change.
- Evaluate the adaptation options to factors related to coastal stability.
- Share their conclusions with the relevant authorities in order to help when taking prevention measures.

### Citizens must:

- Put pressure on politicians and public representatives to make the protection of coastal risks a priority.
- Obey authorities when they notify dangerous situations.
- Keep an eye out and report to the authorities any activities and property that could be at risk.

### And you, what can your role be in this prevention of coastal risks?

- 1 Become better informed about your environment and the dynamics of local ecosystems and how to respect them, as well as activities that can damage them.
- 2 Respect rules and any restrictions on movements along the shoreline.
- 3 Do not alter natural systems: never remove or harm materials, animals or plants.
- 4 Be aware about sources of risk. Be aware about sources of risk.
- 5 Be aware of extreme weather events and follow the instructions of relevant authorities during such events.

### EXERCISE

Make a list and discuss in class the solutions to various coastal risks.



Instituto de Hidráulica e Recursos Hídricos



Universidade de Vigo



LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL



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**Coordination of the editing project**

Diputación de A Coruña (Spain)  
Région Aquitaine (France)

**Editors**

Diputación de A Coruña and Ideara SL (Spain)  
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**Editorial direction**

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

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