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Development of Regional Joint Master Program in Maritime Environmental Protection and Management
- MEP&M -

ENVIRONMENTAL SENSITIVITY MAPS: A TOOL TO FACE BEACH OILING POLLUTION

WP3. Capacity Building through staff training and equipment purchase.
Dev. 3.4.1 KNOW-HOW TRANSFER TO TEACHING STAFF RELATED TO THE MEP&M

Prof. Dr. Giorgio Anfuso, Faculty of Marine and Environmental Sciences (University of Cádiz)

28th June 2021

Virtual meeting via Google-meet application

Project no. 619239-EPP-1-2020-1-ME-EPPKA2-CBHE-JP

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Prof. Dr. Giorgio Anfuso – Full Professor, Department of Earth Sciences – Faculty of Marine and Environmental Sciences, UCA. Spain.
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I work on different topics related to coastal morphology and management in Europe and Latin America

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Main research topics are:

- Coastal changes at small temporal scale (hours/days)

ELSEVIER

Marine Geology 220 (2005) 101–112

MARINE GEOLOGY

www.elsevier.com/locate/margeo

Sediment-activation depth values for gentle and steep beaches

Giorgio Anfuso *

Departamento de Geología, Facultad de Ciencias del Mar y Ambientales, Universidad de Cádiz. Polígono Río San Pedro s/n, 11510 Puerto Real, Cádiz, Spain

Received 28 April 2004; received in revised form 20 June 2005; accepted 27 June 2005

Journal of Coastal Research	21	6	1139–1153	West Palm Beach, Florida	November 2005

Morphodynamic Characteristics and Short-Term Evolution of a Coastal Sector in SW Spain: Implications for Coastal Erosion Management

Giorgio Anfuso and Francisco-Javier Gracia

Departamento de Geología
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Polígono Río San Pedro s/n
11510 Puerto Real, Cádiz, España
giorgio.anfuso@uca.es

- Coastal changes at medium temporal scale (months/years)

- Coastal changes at large temporal scale (years/decades)

Geomorphology 129 (2011) 204–214

ELSEVIER

Contents lists available at ScienceDirect

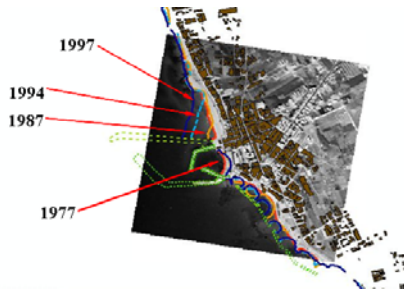
Geomorphology

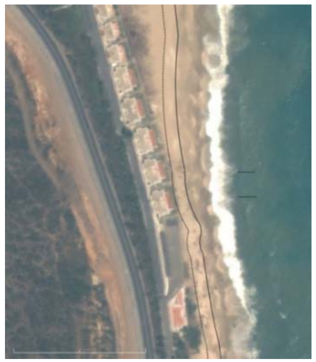
journal homepage: www.elsevier.com/locate/geomorph

An integrated approach to coastal erosion problems in northern Tuscany (Italy): Littoral morphological evolution and cell distribution

G. Anfuso [a,*], E. Pranzini [b,1], G. Vitale [b,1]

[a] Departamento de Ciencias de la Tierra, Facultad de Ciencias del Mar y Ambientales, Universidad de Cádiz, Polígono Río San Pedro s/n, 11510 Puerto Real (Cádiz), Spain
[b] Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Borgo Albizi 28, 50122 Firenze, Italy





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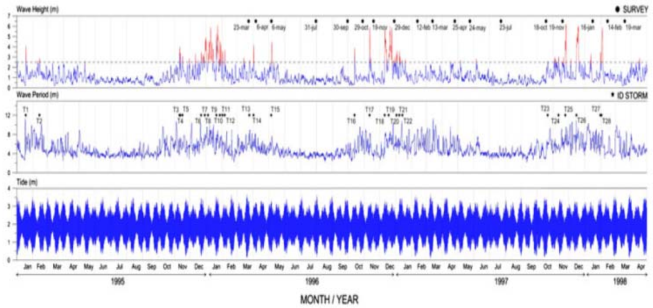
- Coastal storms and impacts

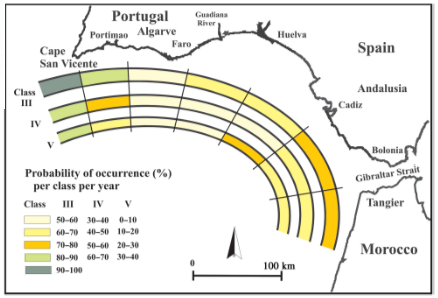
INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. 33: 2142–2156 (2013)
Published online 30 August 2012 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/joc.3579

RMetS Royal Meteorological Society

Winter wave climate, storms and regional cycles: the SW Spanish Atlantic coast

N. Rangel-Buitrago* and G. Anfuso
Departamento de Ciencias de la Tierra, Facultad de Ciencias del Mar y Ambientales, Universidad de Cádiz, Cádiz, Spain





- Coastal sensitivity/vulnerability to erosion/flooding

Ocean and Coastal Management 179 (2019) 104876

Contents lists available at ScienceDirect

Ocean and Coastal Management

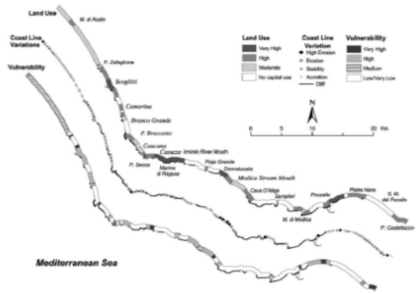
journal homepage: www.elsevier.com/locate/ocecoaman

ELSEVIER

A tool for evaluating the archaeological heritage vulnerability to coastal processes: The case study of Naples Gulf (southern Italy)

G. Mattei[a,*], A. Rizzo[b], G. Anfuso[c], P.P.C. Aucelli[a], F.J. Gracia[c]

[a] Department of Science and Technology (DiST), Parthenope University, Naples, Italy



- Coastal sensitivity to beach oiling: Environmental Sensitivity Maps

Journal of Coastal Research	SI 64	875 - 879	ICS2011 (Proceedings)	Poland	ISSN 0749-0208

Environmental Sensitivity Maps: the northern coast of Gibraltar Strait example

A. Bello Smith†, G. Cerasuolo†, J.A. Perales†‡ and G. Anfuso†

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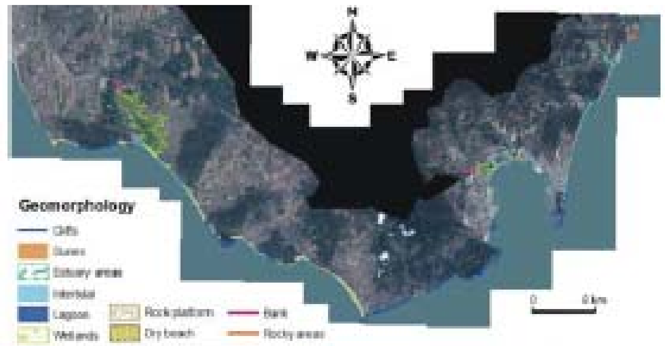
E-mail: joseantonio.perales@uca.es;



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- Coastal management

Ocean & Coastal Management 126 (2016) 51–60

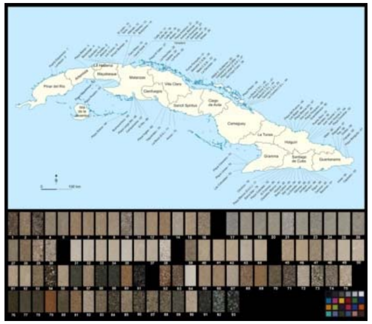
Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Sand colour at Cuba and its influence on beach nourishment and management

Enzo Pranzini [a,*], Giorgio Anfuso [b], Camilo-Mateo Botero [c], Alfredo Cabrera [d], Yanet Apin Campos [e], Grace Casas Martinez [f], Allan T. Williams [g,h]



- Coastal scenery value

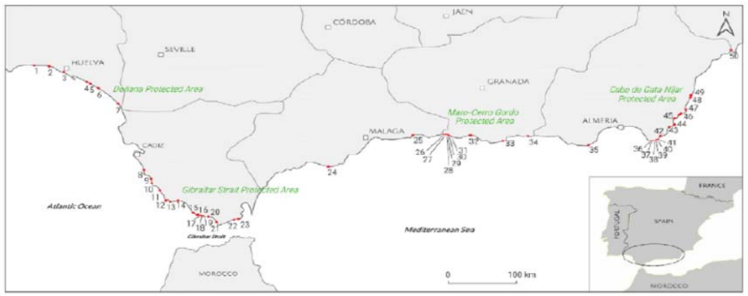
sustainability

MDPI

Article

Management Implications for the Most Attractive Scenic Sites along the Andalusia Coast (SW Spain)

Alexis Mooser [1], Giorgio Anfuso [1,*], Carlos Mestanza [2] and Allan Thomas Williams [3,4]



Tourism Management 42 (2014) 307–320

Contents lists available at ScienceDirect

Tourism Management

journal homepage: www.elsevier.com/locate/tourman

Coastal scenic assessment and tourism management in western Cuba

G. Anfuso [a,*], A.T. Williams [b], J.A. Cabrera Hernández [c], E. Pranzini [d]

- Beach litter characterization and dynamics

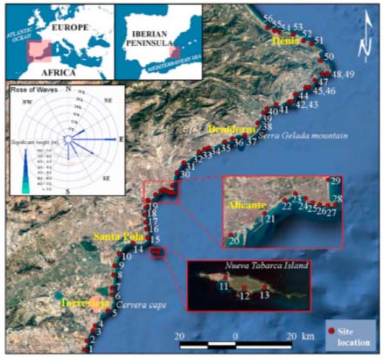
Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Distribution of beach litter along the coastline of Cádiz, Spain

Allan Thomas Williams[a,b], Peter Randerson[c], Carlo Di Giacomo[d], Giorgio Anfuso[d,*], Ana Macias[e], José Antonio Perales[f]



- Coastal water quality

Marine Pollution Bulletin 142 (2019) 303–308

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Microbiological water quality and sources of contamination along the coast of the Department of Atlántico (Caribbean Sea of Colombia). Preliminary results

Hernando Sánchez Moreno[a], Hernando José Bolívar-Anillo[a], Zamira E. Soto-Varela[a], Yani Aranguren[a], Camila Pichón González[a], Diego Andrés Villate Daza[b], Giorgio Anfuso[c,*]

Fig. 1. Location map with beach water sampled areas (numbers) and streams (letters, for details see Table 1).

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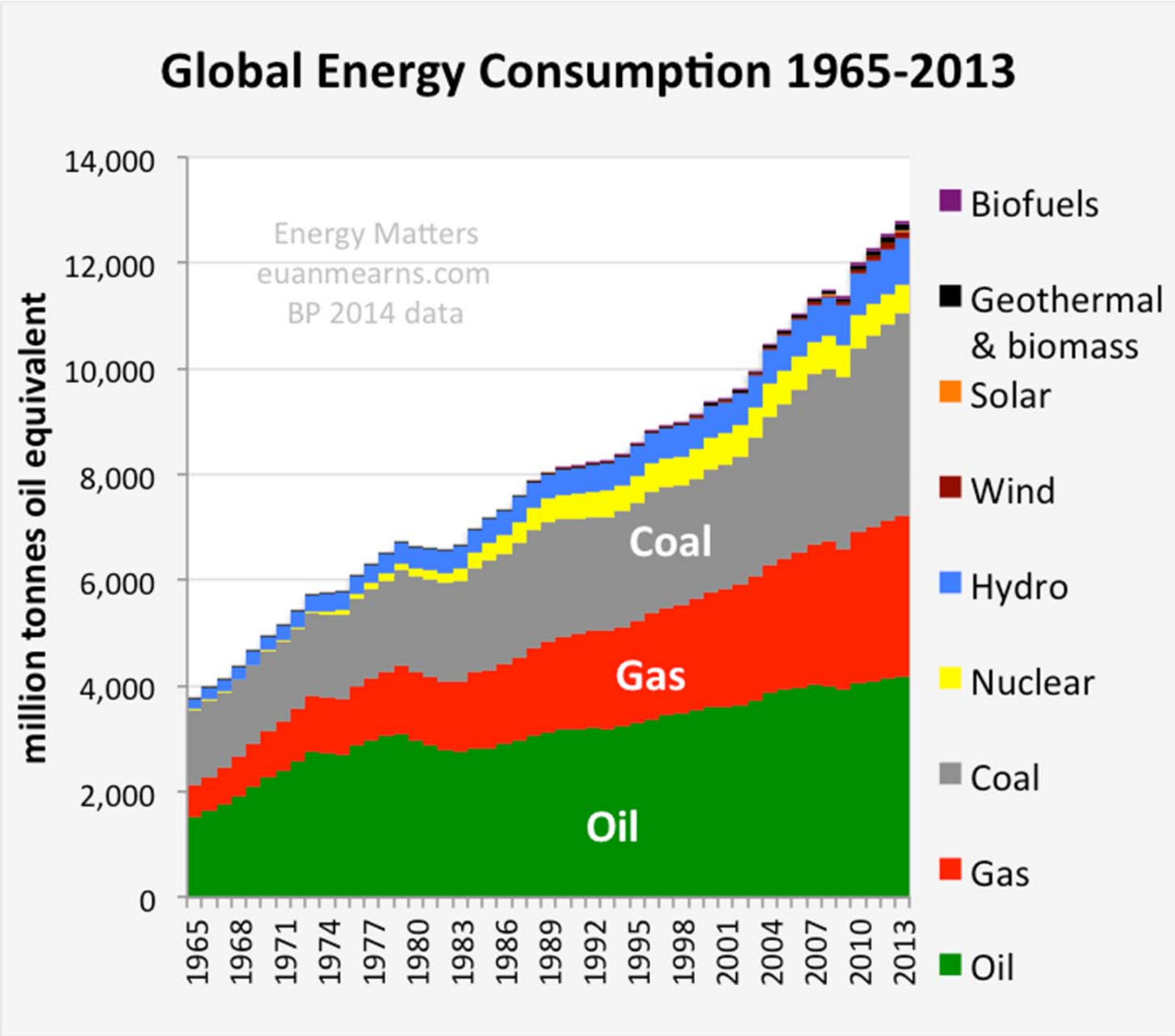
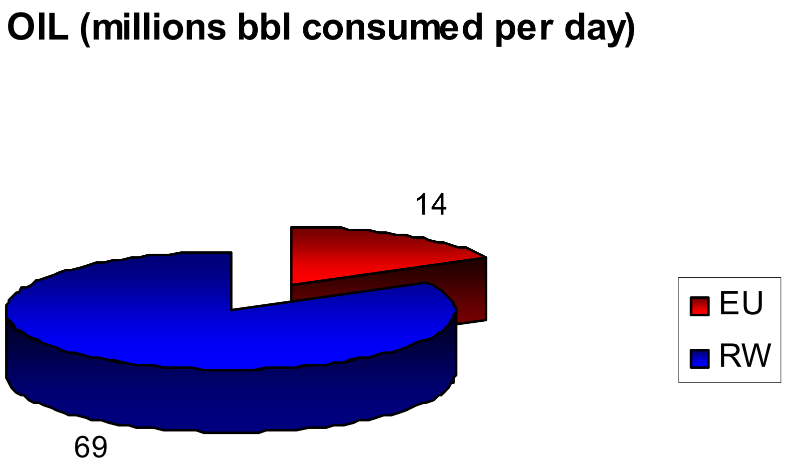
ENVIRONMENTAL SENSITIVITY MAPS: A TOOL TO FACE BEACH OILING POLLUTION

INTRODUCTION



INTRODUCTION



Total oil consumption in 2019 was almost 100 million barrels per day

INTRODUCTION

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The "Europe" (IMO Number: 9235268; Type: Crude oil Tanker; DWT = 441561 Tons) transports all the oil consumed in one year

In Montenegro the average consumption in 2016 was 7,000 barrels per day

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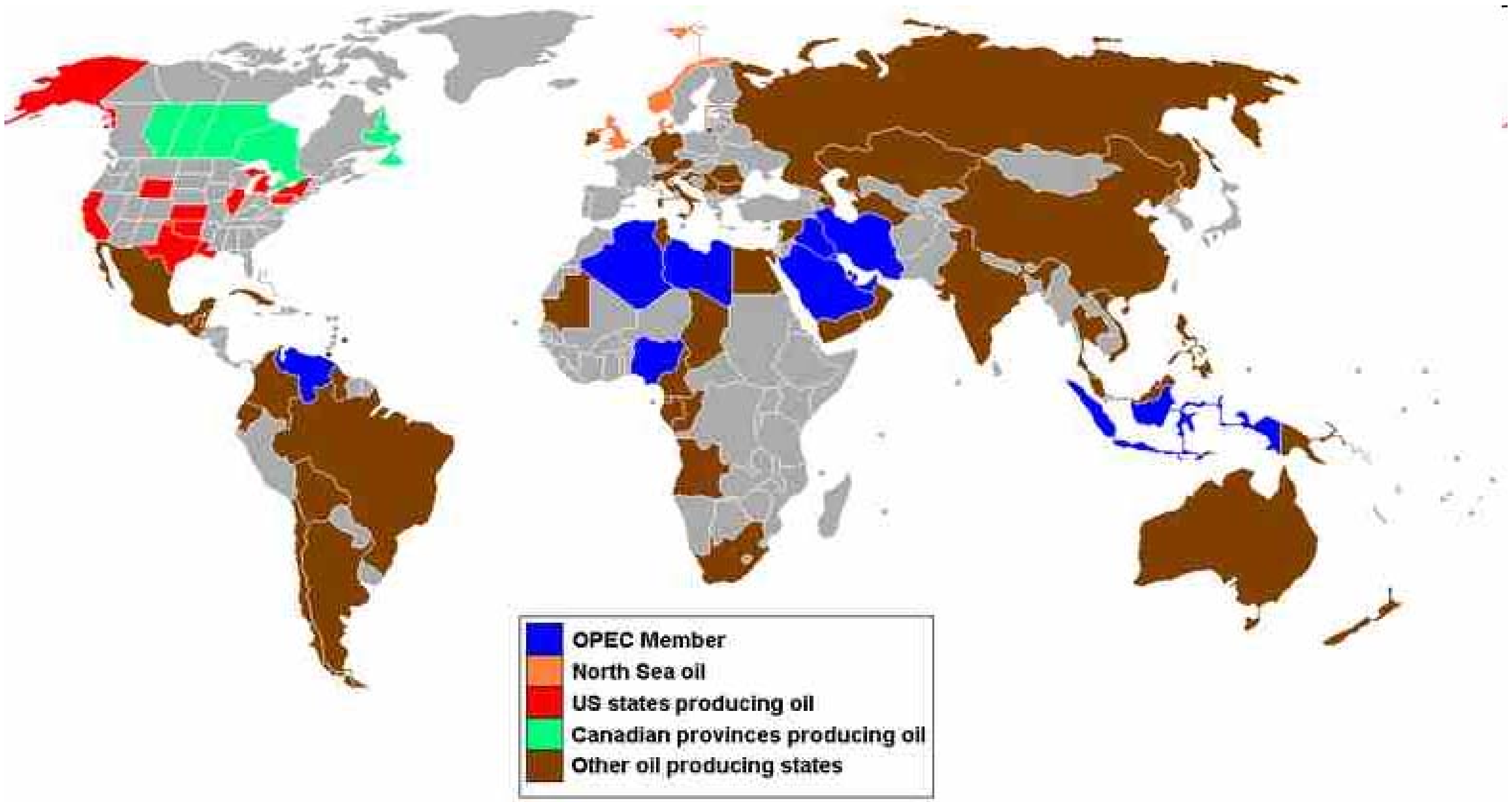

Petroleum is not homogenously distributed

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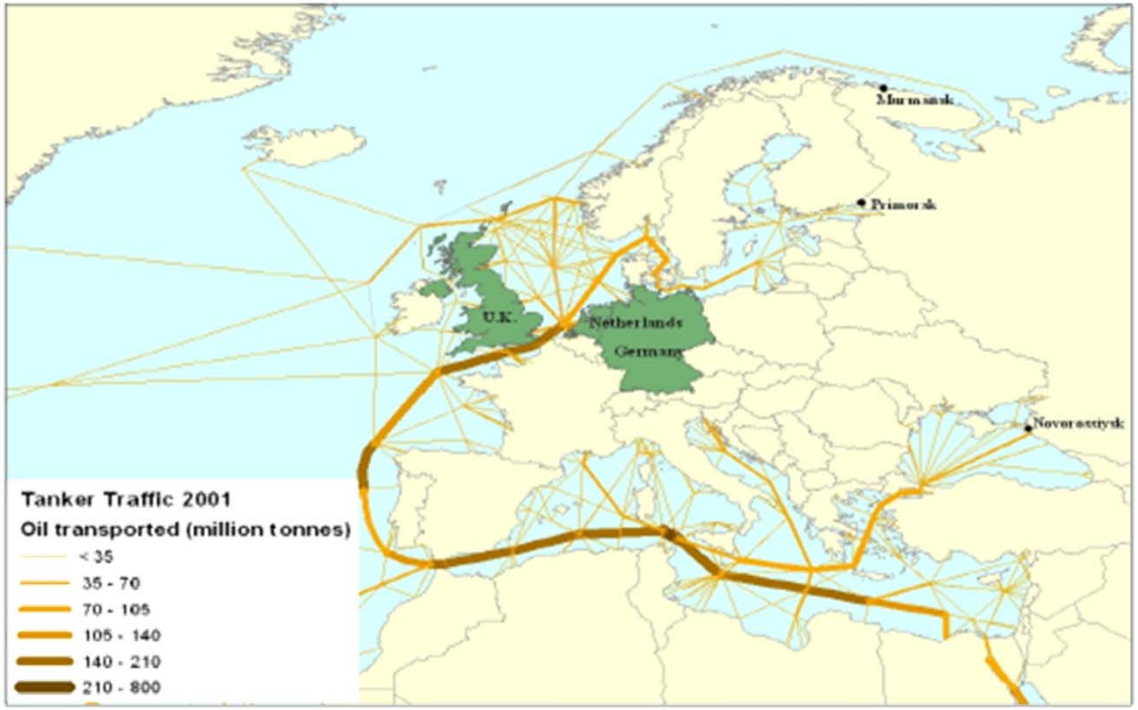
Oil shipping accounts for nearly a third of global maritime trade. The capacity of the world’s fleet of tankers, the ships that transport crude oil and petroleum products, has increased by 73% since 2000.

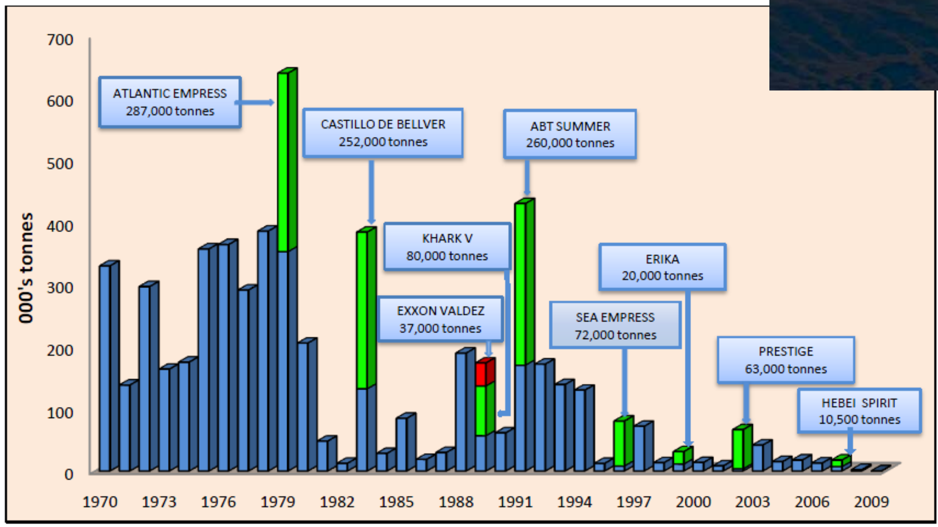
INTRODUCTION



In 2019, 2600 million tons of oil were transported by sea, compared to 500 million in 1960 and 100 million in 1935

INTRODUCTION

The average total worldwide annual release of petroleum (oils) from all known sources to the sea has been estimated at 1.3 million tons



Oil spill accidents have a great ecological and economic impact on ecosystems and human coastal activities linked to tourism, industry and on the exploitation of marine resources.

Such impacts can be permanent or not and are very much associated with the physical characteristics of the oil.
Negative effects on the environments are related to oil toxicity (i.e. the toxicity of oil components) and to the covering of animals. The final effects on animals depend on the *characteristics of the oil (density), oil chemical composition,* and the *sensitivity, abundance* and *diversity of the biological system affected*.

How oil spill accidents take place?

Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Usually it takes place when the oil is transported from place to place.

Main causes can be:

- Human errors.
- Mechanical errors.
- Natural disasters.
- Planned actions (wars, illegal spills, vandalism).

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What we have to do when a spill took place?

CONTINGENCY PLAN

A contingency plan is a course of action designed to help an organization to respond effectively to a significant future event or situation that may or may not happen.
Contingency planning is a component of disaster recovery and risk management.

When an oil spill takes place several institutions and national and international organizations are involved to control the accident, repair the damages and help, assist and refund affected entities in a short time.

First step since 1979: Environmental Sensitivity Maps

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All information regarding coastal resources sensitivity, areas that have to be protected, etc. are contained in the **Environmental Sensitivity Maps** that are a first step for the preparation of the Contingency Plan.

It is possible to establish which areas are at risk by analysing the different activities linked to **oil transportation, bunkering operations**, etc.

There is a **simulation** of oil dispersion from the realise point, this is according to **oil typology** and the **meteorological** and **oceanographic conditions**.

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Environmental Sensitivity Maps contain three types of information, which has to be depicted using symbols or colors in maps. The interpretation of such maps has to be simple and easy:

- ☒ **Coastal Typology, has to be classified according to its sensitivity, persistence of oil and facility of cleanup operations. Geomorphological criteria are essentially used.**

- ☒ **Biological resources**

- ☒ **Human resources**

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COASTAL CLASSIFICATION (principally geomorphological characteristics)

The classification presented is based on different factors that determine coastal sensitivity to oil spill:

- **Type of substrate (rocky, sandy, silty or clay – importance of grain size and mineralogy)**
- **Permeability of sediments**
- **Transitability and mobility of cleaning machines (tracks, etc.)**
- **Beach foreshore slope**
- **Level of beach exposition to energy**
- **Facility of cleanup operations (e.g. access)**
- **Biological productivity and sensitivity**

According to such criteria a value of 1 is attributed to less sensitivity areas, and a value of 10 to most sensitivity areas.

1st - 2nd place

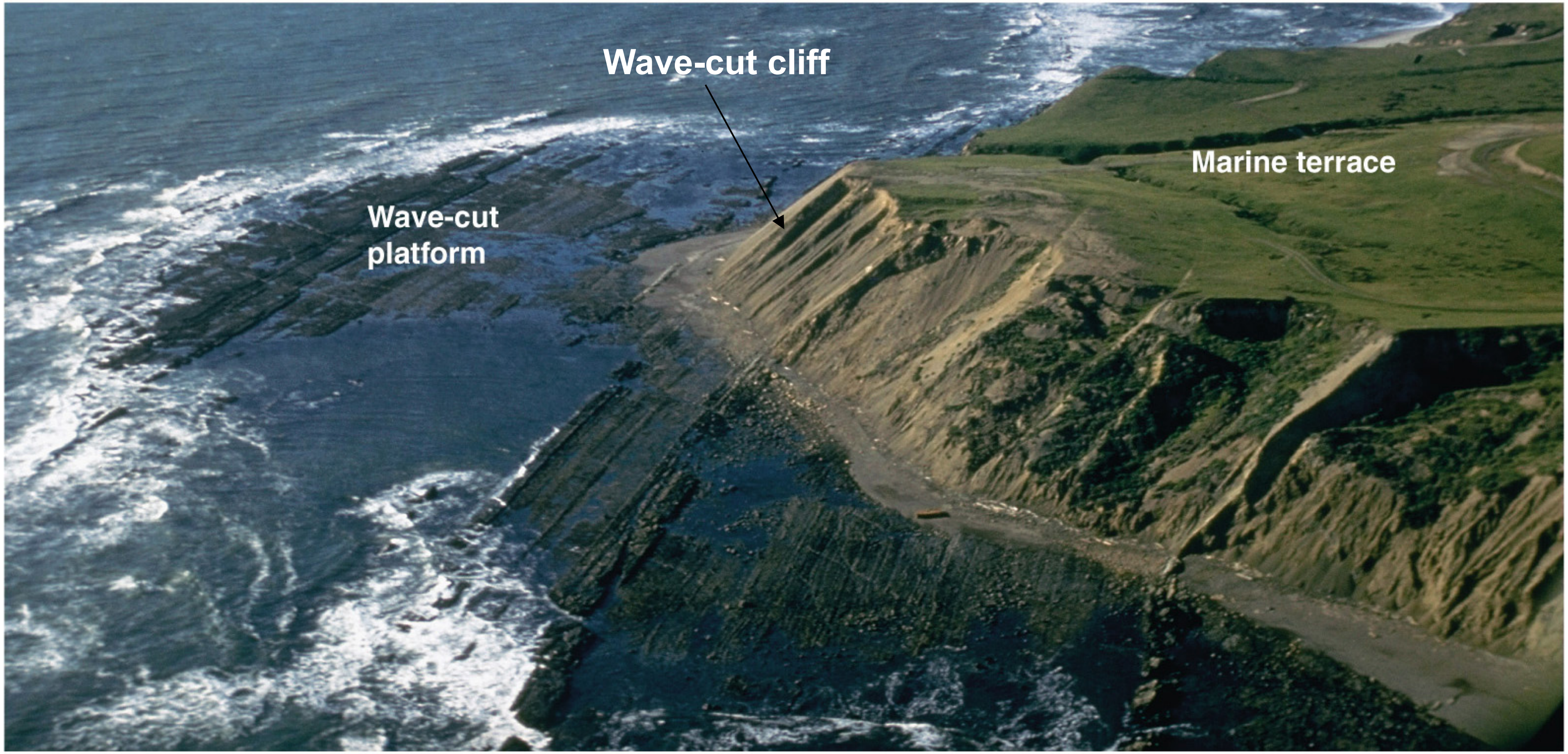
Coastal classification

(1) Cliff

(2) Rocky platform

1st - 2nd place

Rocky coasts



1st - 2nd place

Rocky coasts

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Cliff: a vertical, or near vertical (bluff), rock exposure. Cliffs are formed as erosion landforms due to the processes of erosion and weathering that produce them.





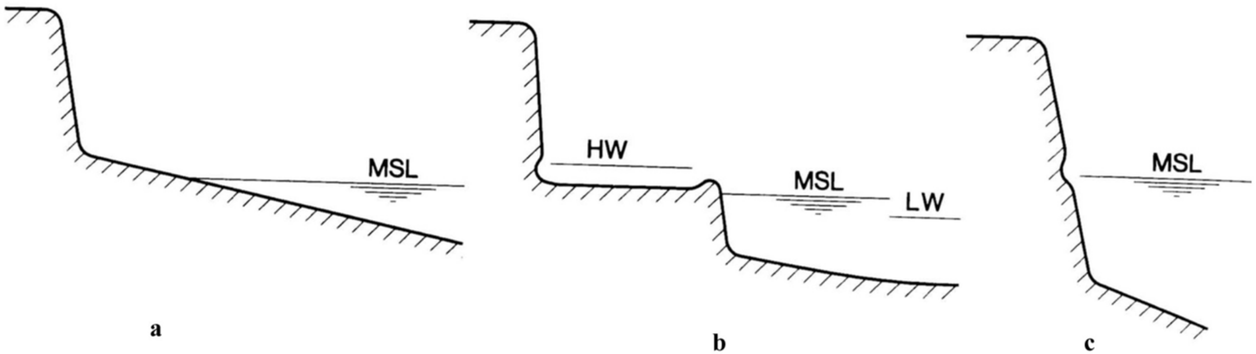
Sedimentary rocks most likely to form cliffs include sandstone, limestone, chalk, and dolomite, usually are friable and present a certain level of porosity.

Igneous rocks such as granite and basalt usually form more resistant cliffs with a lower degree of porosity.

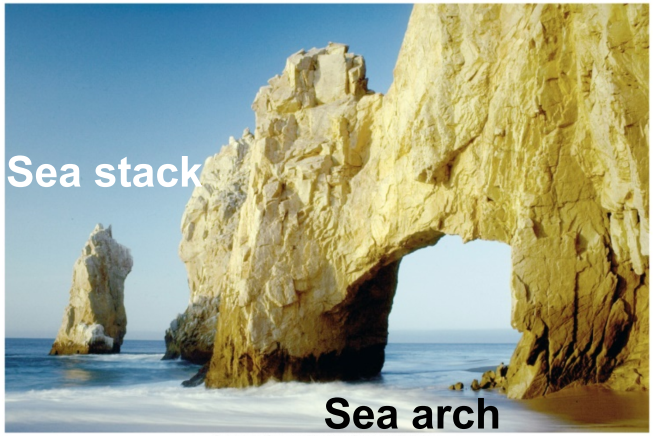
1st - 2nd place

Rocky coasts

A wave-cut platform, coastal benches, or wave-cut benches is the narrow flat area often found at the base of a sea cliff or along the shoreline of a lake, bay, or sea that was created by the erosion of waves.



a) Microtidal; b) tidal and c) no important subsidence or uplift



1st - 2nd place

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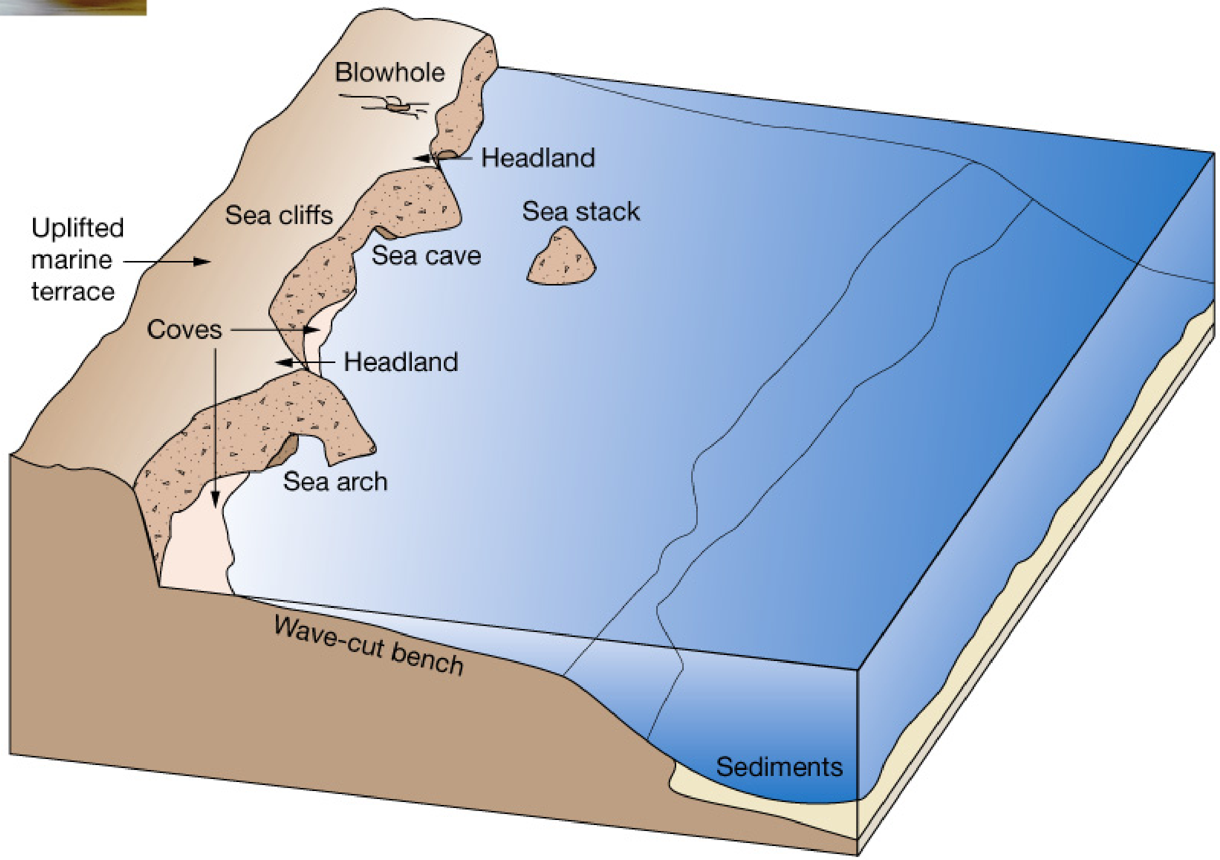
Rocky coasts



- Headland
- Wave-cut cliff
- Wave-cut terrace (bench)
- Sea cave
- Sea arch
- Sea stack

1st - 2nd place

Coastal classification

(1) Cliff

(2) Rocky platform

Rocky coasts have low sensitivity

They are energetic areas usually with an impermeable substrate. Problems are observed when the rocks are fractured and hence permeable - the oil can penetrate into the substrate.

Usually are remote and very difficult to access areas.

(3) Fine sand beach

3rd - 6th place

Classification of sandy coasts

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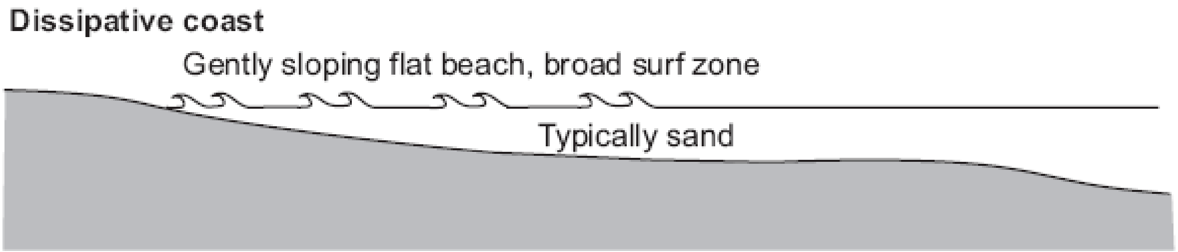
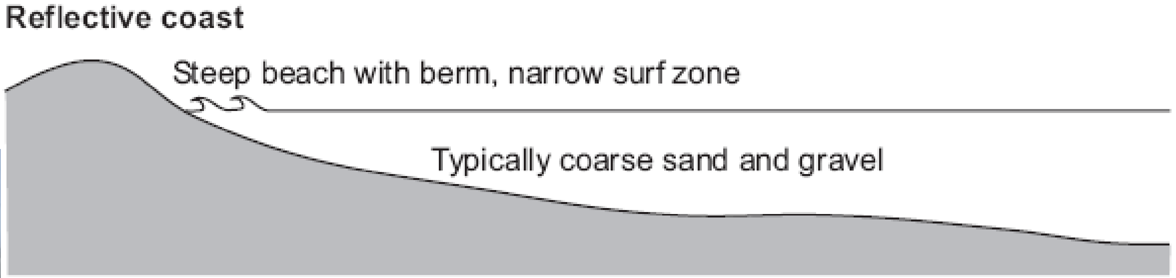
(4) Coarse sand beach





(5) Gravel-sand mixed beach

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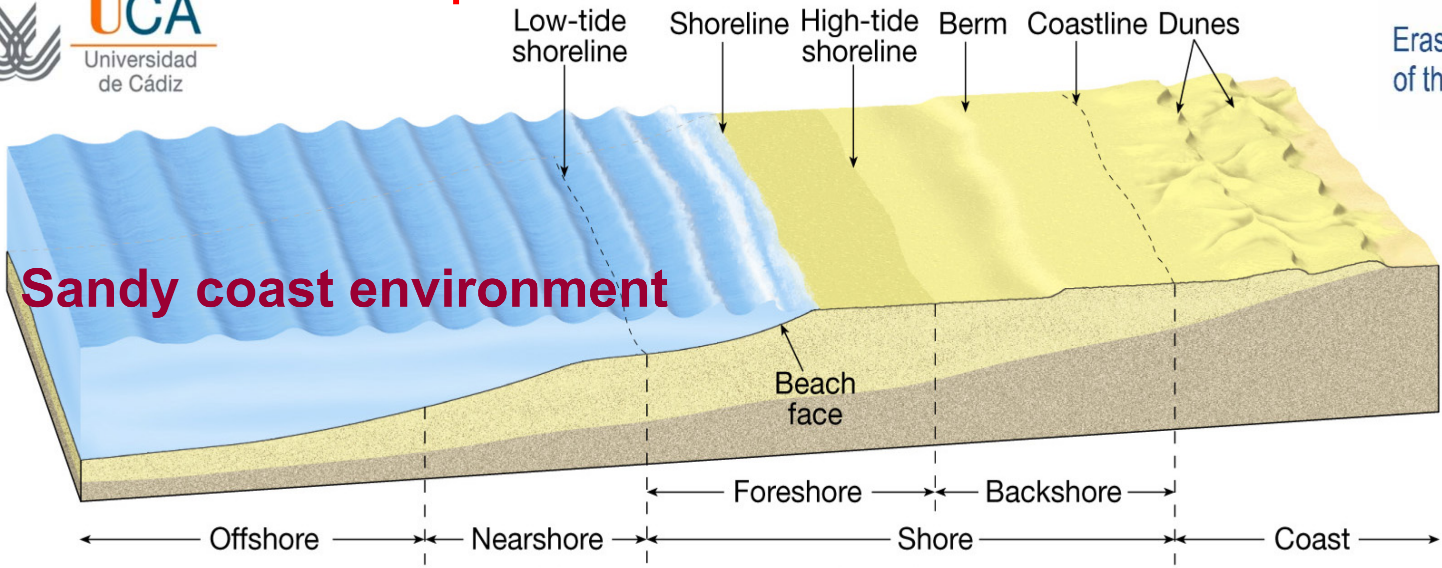
(6) Pebble beach

3rd - 6th place

Sandy coast environment



- **Beach – accumulation of sediment along the landward edge of an ocean or lake**
  - **Berms – relatively flat platforms, usually composed of sand, adjacent to coastal dunes or cliffs**
  - **Beach face – wet, sloping surface extending from the berm to the shoreline**

- **Backbeach – landward of the high tide, eolian processes dominate**

- **Nearshore zone – between low-tide shoreline and line where waves break at low tide**

- **Shoreline – line marking contact between land and sea**

- **Shore – area between lowest tide and highest point on land affected by storm waves**
  - **Foreshore – area exposed at low tide and submerged during high tide**
  - **Backshore – landward of high-tide shoreline**

- **Coast – area inland from shore extending as far as ocean-related features are found**

Beach sediments

- Beach sediments
  - Often dominated by quartz grains
  - May be composed of other minerals or materials
    - Southern Florida – shell fragments, remains of coastal organisms
    - Volcanic islands – weathered grains of basaltic lava
    - Tropical islands – debris eroded from surrounding coral reefs

- The material making the beach does not stay put; it is constantly being moved by waves

3rd - 6th place

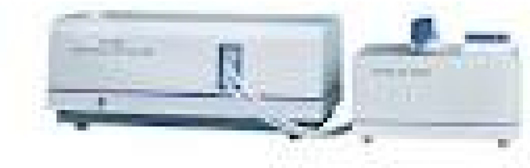
Sedimentological characterization

Ro-Tap machine (shaking movement)

Sand sediments

Sieve analysis is a procedure used to assess the particle size distribution of a granular material.

Settling tube



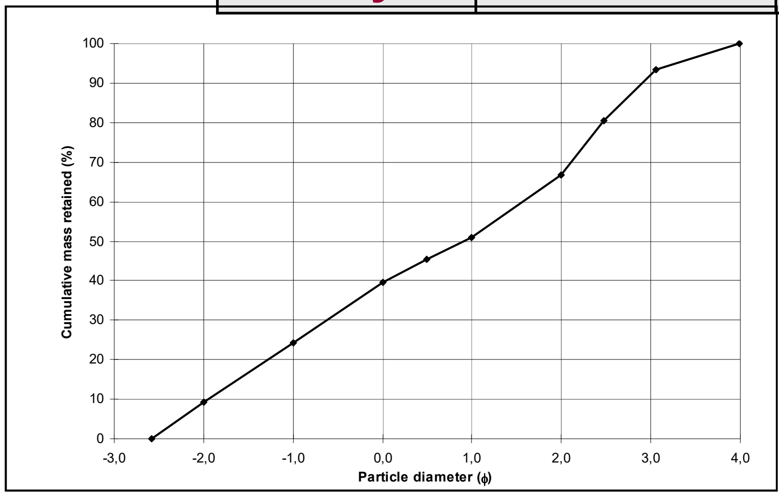
Silt and clay
Laser particle analyser

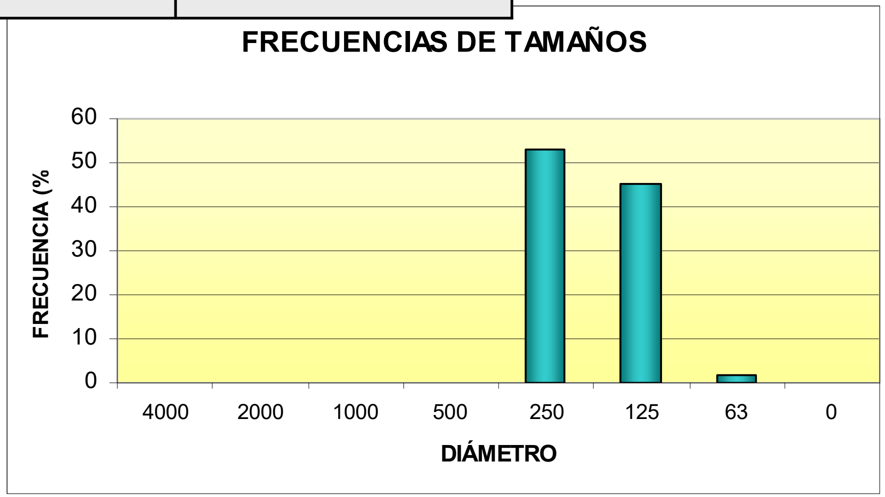
Grain size

3rd - 6th place

Sedimentological characterization

Grain size		phi	mm
	Very	-1 ÷ 0	2 ÷ 1
	coarse	0 ÷ 1	1 ÷ 0.5
Sand	medium	1 ÷ 2	0.5 ÷ 0.25
	fine	2 ÷ 3	0.25 ÷ 0.125
	Very fine	3 ÷ 4	0.125 ÷ 0.062
Silt		4 ÷ 8	0.062 ÷ 0.004
Clay		8 ÷ 9	0.004 ÷ 0.002





Grain size

Statistical pameters

Mean (D50)
D50= ϕ 50

Median (M)
M=(ϕ16+ϕ50+ϕ84)/3

Standar Deviation (σ)
σ = (ϕ84+ϕ16)/4+(ϕ95+ϕ5)/6.6

Kurtosis (KG)
KG= (ϕ95-ϕ5)/2.44(ϕ75-ϕ25)

Skewness
SK = (ϕ16+ϕ84-2ϕ50)/2(ϕ84-ϕ16)+(SK)(ϕ5+ϕ95-2ϕ50)/2(ϕ95-ϕ5)

Standard Deviation (Sorting)

Very well classified <0.35

Well classified 0.35÷0.50

Moderately well clas. 0.50÷0.70

Moderately clas. 0.70÷1.0

Poorly clas. 1.0÷2.0

Very poorly clas. 2.0÷4.0

Extr. poorly clas. >4.0

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3rd - 6th place

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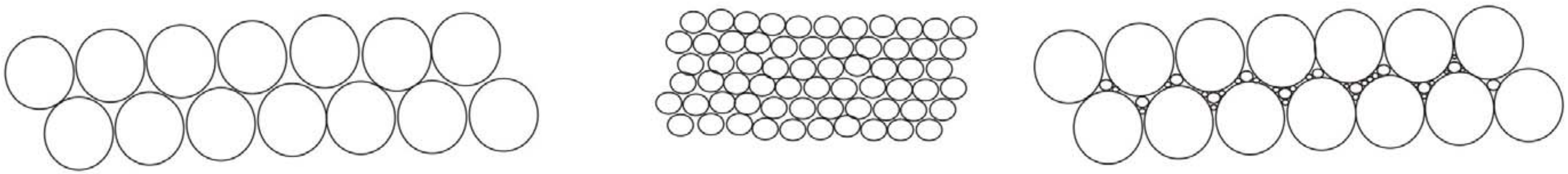
Sedimentological characterization

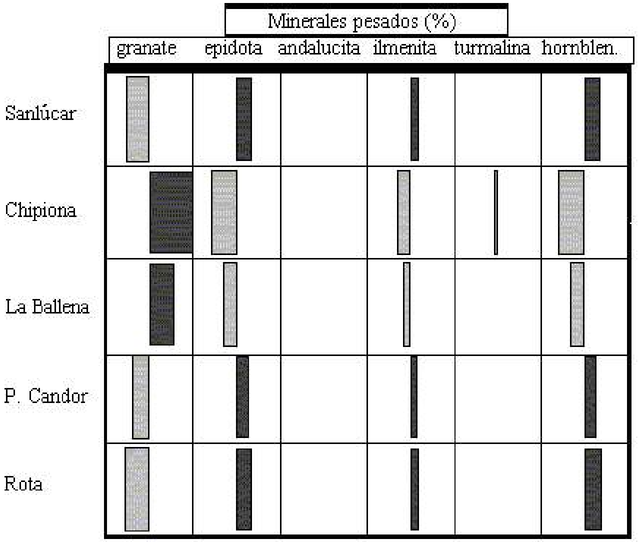
Sediments packing with different degree of permeability

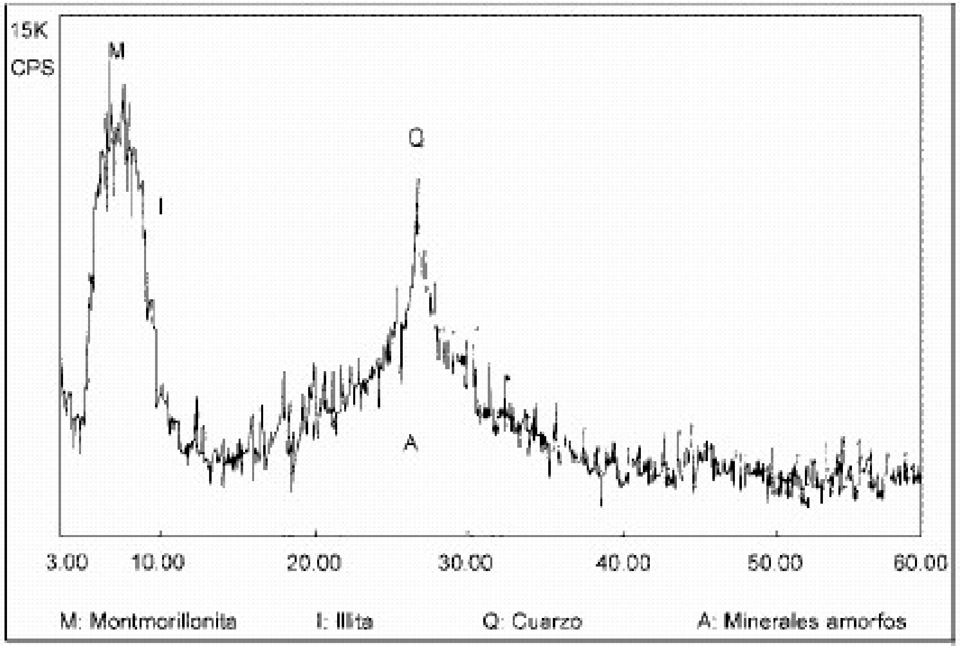


Fine-grained sediments have high contents in organic matter and are better able to adsorb the pollutants than coarser particles. Essentially clay sediments –phyllosilicates.

Grain size

Mineralogical characterization





Semi-quantitative analysis by means of X-Ray diffraction; you can obtain mineralogical content

3rd - 6th place

Beach composition and shape

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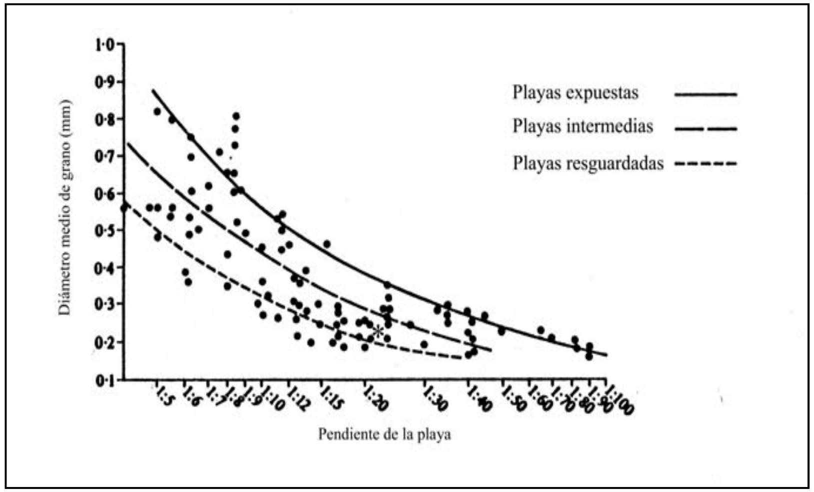
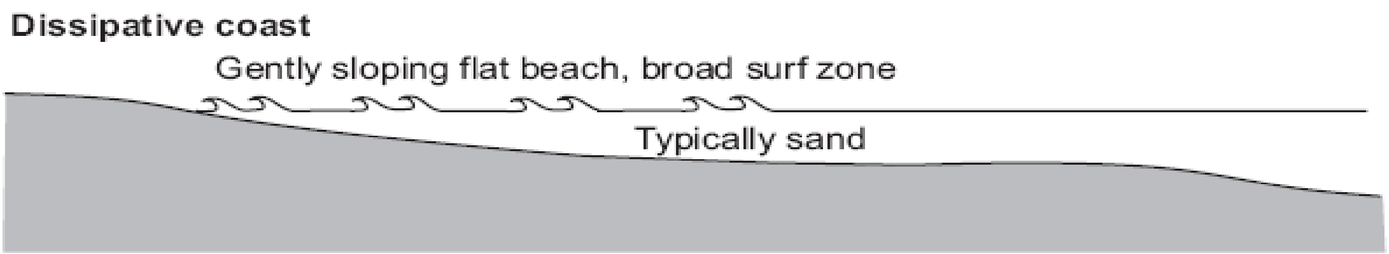
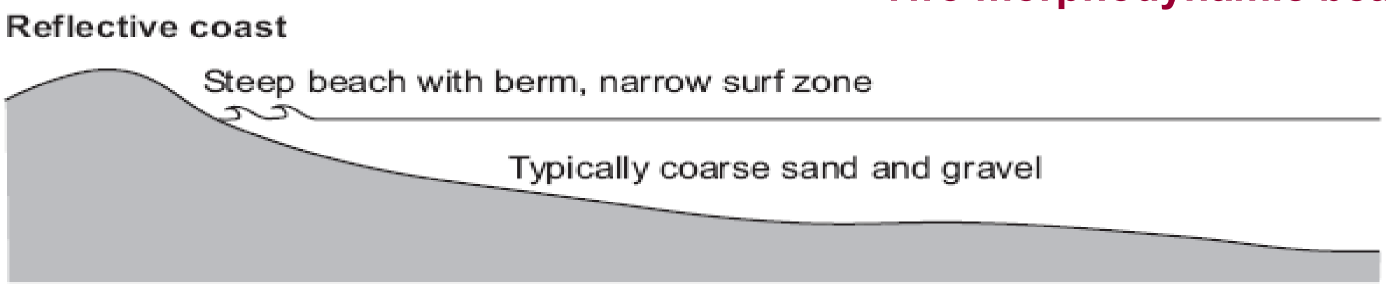
- **Locally available material**
- **Coarser sediment**
  - **Steeper beach profile**
- **Finer sediment**
  - **More gentle beach profile**





Two morphodynamic beach states



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3rd - 6th place

Beaches

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Disipative (tan β=0.02)

Reflective (tan β = 0.10)

Intermediate (tan β= 0.03-0.06)

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3rd - 6th place

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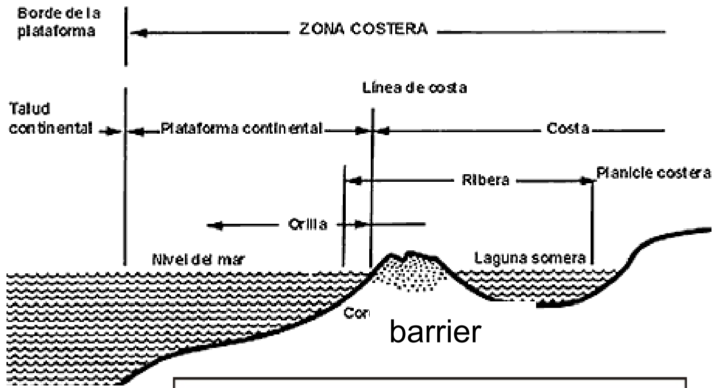
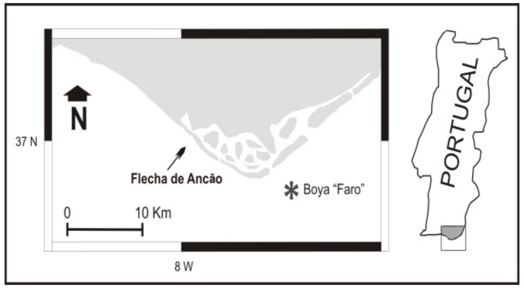
Sandy coasts –special features

Barrier islands are exceptionally flat and lumpy areas of sand, that are parallel to the mainland coast. They usually occur in chains, consisting of anything from a few islands to more than a dozen. Excepting the tidal inlets that separate the islands, a barrier chain may extend uninterrupted for over a hundred kilometers. Lagoon or salt marsh, dunes, beaches, etc..





Coastal area can be attached to the continent

Sandy coasts – special features

A spit is a sedimentary body elongated parallel to the coastline with a free edge and a fixed one. They present different environments such as lagoons, salt marshes, dunes, beaches, etc.

3rd - 6th place

Classification of sandy coasts

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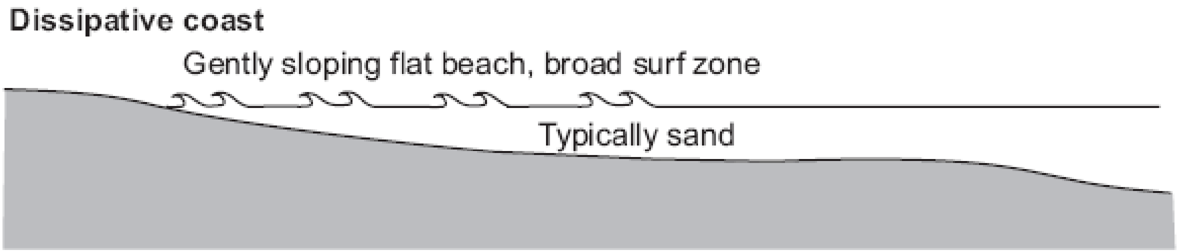
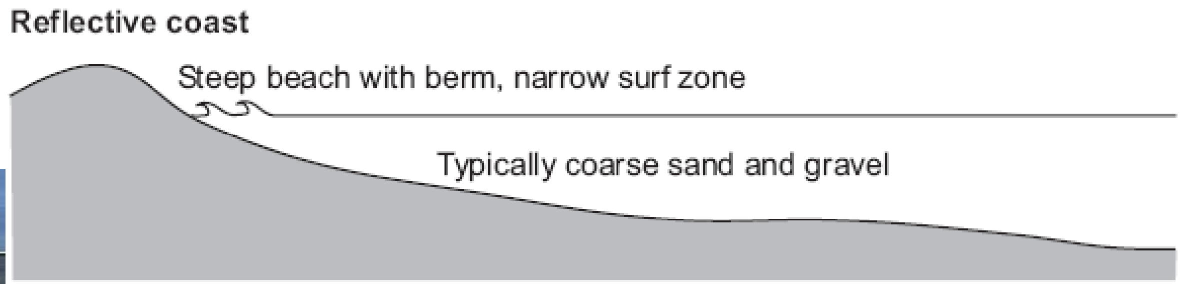
(3) Fine sand beach



(4) Coarse sand beach



(5) Gravel-sand mixed beach

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(6) Pebble beach

3rd - 6th place

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Sandy –gravel coasts present medium sensitivity depending on the grain size

Sediment permeability, and hence oil penetration potential, depends on grain size and sediment classification (standard deviation)…..coarse and well classified sediments are very permeable…

Mixed sediments usually have a lower permeability because are usually poorly classified and oil is able to penetrate to a maximum depth of 50 cm

An other aspect to be considered is the velocity/modalities of beach morphological changes, if changes are rapid the oil can be easily buried….so these are aspects of great relevance. Coarse grained beaches record rapid changes respect to fine grained sediments

The substrate characteristics determine the transitability too. Fine grained beaches present best transitability characteristics

6th place

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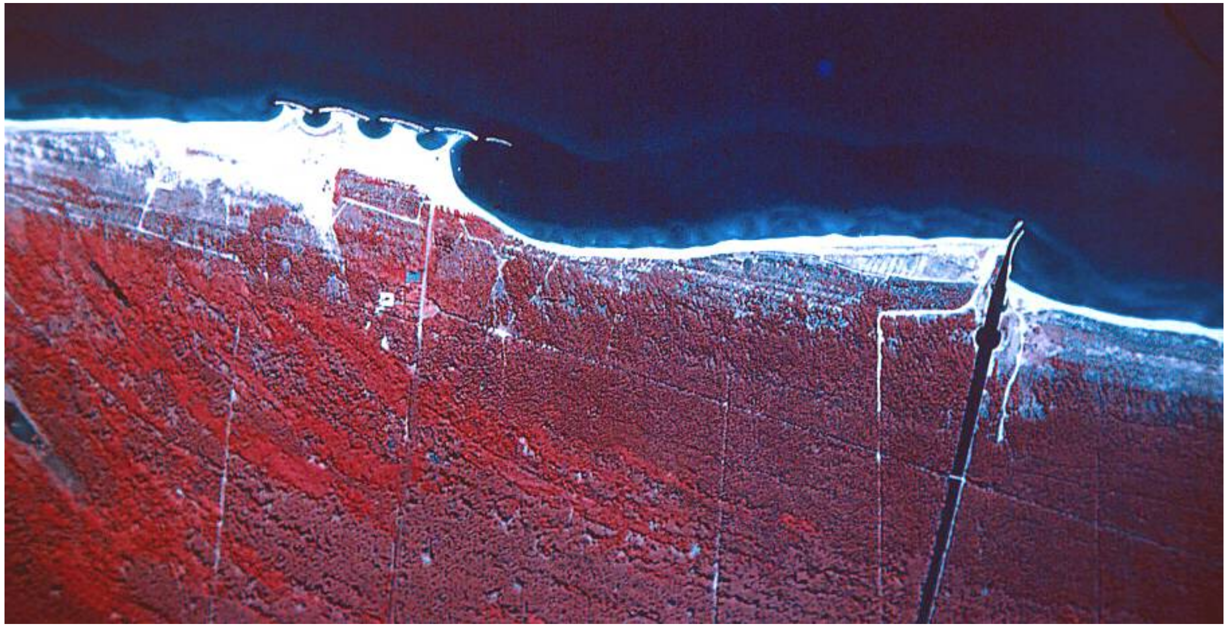
Coastal classification



(6) Groins, breackwaters and revetments

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Seawalls

Revetments

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6th place

Rip-rap revetment

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UCA
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6th place

Groins

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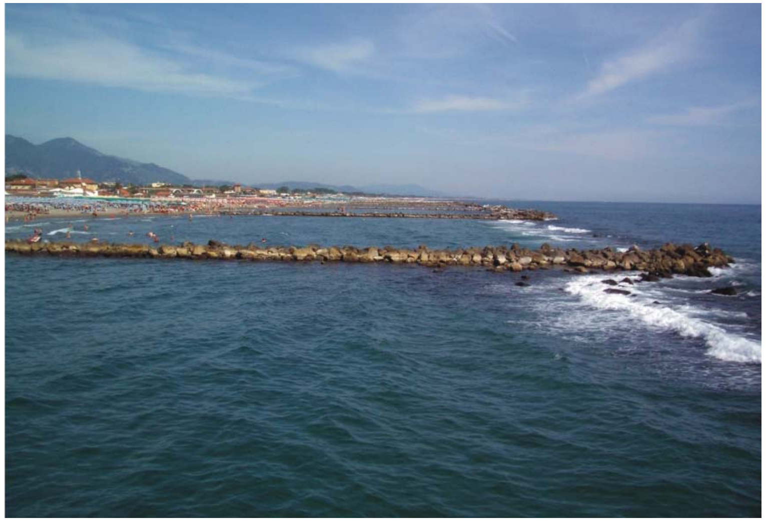

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Breakwaters

6th place

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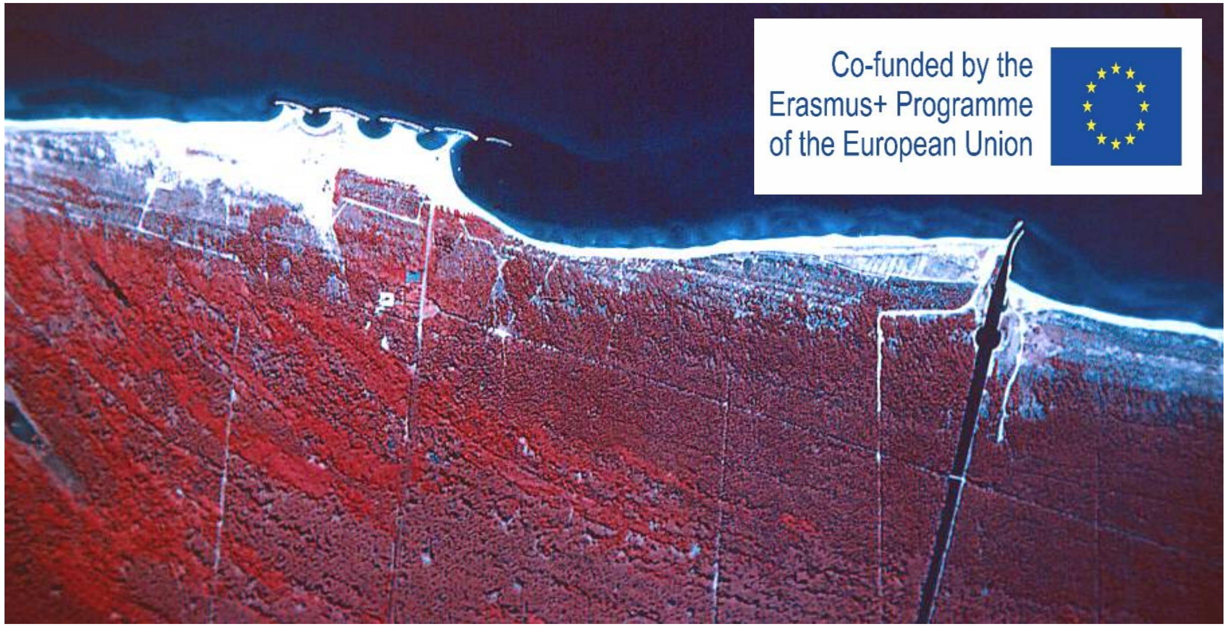
6th place

Coastal classification



(6) Groins, breackwaters and revetments

Exposed protection structures present medium-high sensitivity according to the level of porosity they have

Oil penetration potential depends on coastal structures characteristics

Breakwaters and revetments show great porosity respect to flat seawalls – which are impermeable

Such structures are located in very energetic areas so approaching waves hit them and reflected waves transport oil offshore

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7th place

Tidal flats present fine sediments and meso or macrotidal regime and very smooth slopes (1‰)

Waves have not a great importance and tidal currents determine erosion/accretion processes

Coastal classification

(7) Exposed tidal flats

Exposed tidal flats have a high sensitivity

Sediments have very low permeability but cleanup operations are complex due to the low transitability

They have relevant biological interest because of birds and invertebrates

Waves break far from the shore and push oil landward

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8th place

Coastal classification

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Different types of defense structures or docks observed in sheltered environments

(8) Coastal structures in a sheltered environment

High sensitivity

There are different types of structures, with a great porosity (and hence permeability, e.g. breakwaters, etc.) or almost impermeable ones (e.g. docks, etc.)

Natural cleanup is almost null since structures are in sheltered environments

9th- 10th place

Coastal classification

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A salt marsh is a coastal ecosystem in the intertidal zone and is regularly flooded by the tides. It is dominated by dense stands of salt-tolerant plants such as herbs, grasses, or low shrubs. These plants are essential to the stability of the salt marsh in trapping sediments. Salt marshes play a large role in the aquatic food web and the delivery of nutrients to coastal waters. They also support terrestrial animals and provide coastal protection.

The **Slikke is unvegetated lower part, the Shorre is vegetated upper part.**

Salt marshes have the highest sensitivity

They have a great interest from a biological point of view and often host human activities (salt harvesting areas, fishing, etc.)

Sheltered areas where oil is accumulated

Sediments consist of clay, silt or very fine sand and are almost impermeable but the presence of vegetation makes cleanup operations very difficult and transitability is very low

(9) Saltmarshes in sheltered areas

(10) Mangroves

COASTAL CLASSIFICATION (principally geomorphological characteristics)

Final coastal classification:

1 is attributed to less sensitivity areas

10 most sensitivity areas

1st - 2nd place

Coastal classification

(1) Cliff

(2) Rocky platform

Rocky coasts have low sensitivity

They are energetic areas usually with an impermeable substrate. Problems are observed when the rocks are fractured and hence permeable - oil can penetrate into the substrate.
Usually are remote and very difficult to access areas.

3rd - 6th place

Classification of sandy coasts

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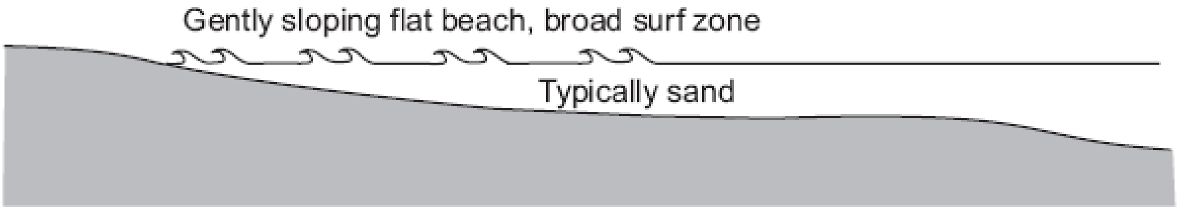
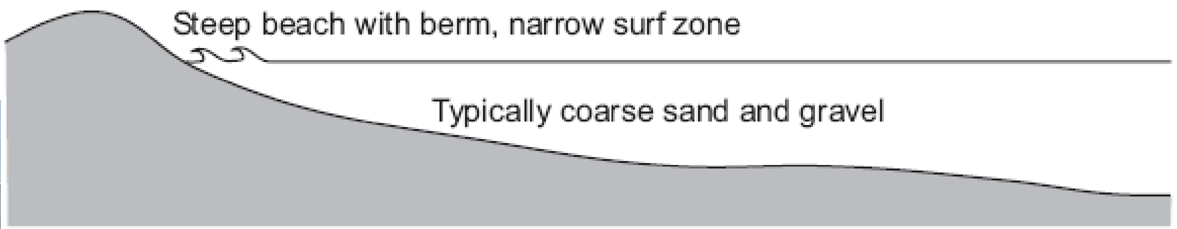
(3) Fine sand beach

(4) Coarse sand beach

Dissipative coast



Reflective coast



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(6) Pebble beach

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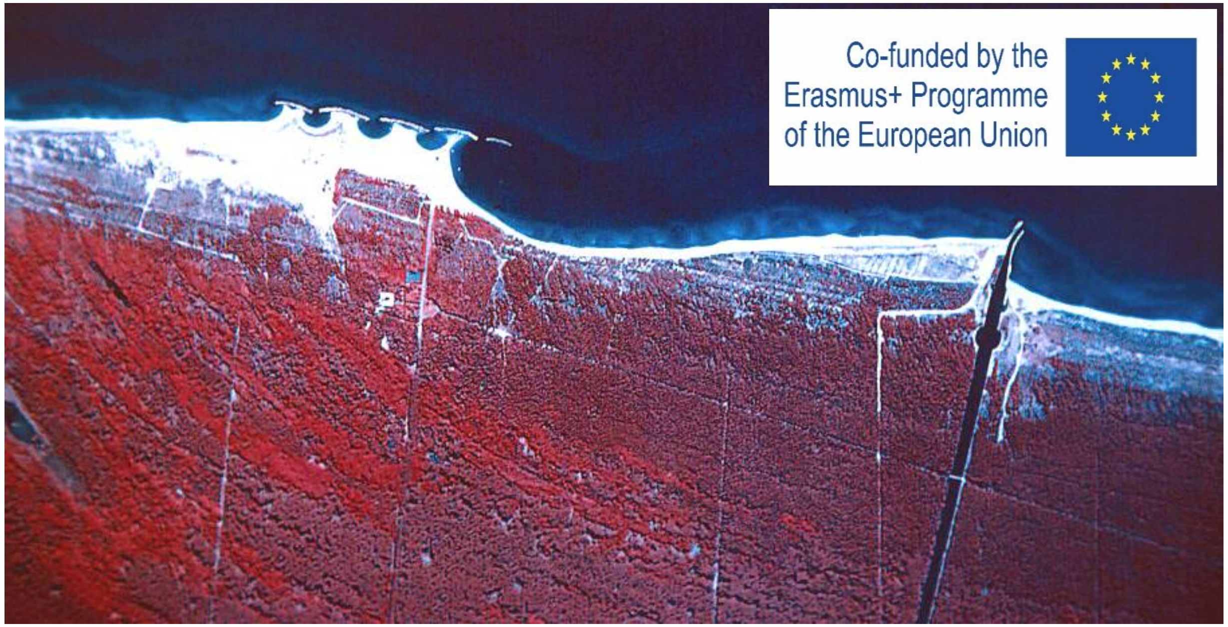
6th place

Coastal classification



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7th place

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Waves have not a great importance and tidal currents determine erosion/accretion processes.

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(10) Mangroves

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Environmental Sensitivity Maps: the northern coast of Gibraltar Strait example

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E-mail: giorgio.anfuso@uca.es;

‡ Dep. Tecnología del Medio Ambiente, Centro Andaluz de Ciencia y Tecnologías Marinas (CACYTMAR), Universidad de Cádiz, Polígono Río San Pedro s/n, 11510 Puerto Real, Spain.
E-mail: joseantonio.perales@uca.es;

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The Strait of Gibraltar is the entrance to the Mediterranean Sea from the Atlantic Ocean

INTRODUCTION

ENVIRONMENTAL SENSITIVITY MAPS: THE NORTHERN COAST OF GIBRALTAR STRAIT EXAMPLE

A. Bello Smith, G. Cerasuolo, J.A. Perales, G. Anfuso

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INTRODUCTION

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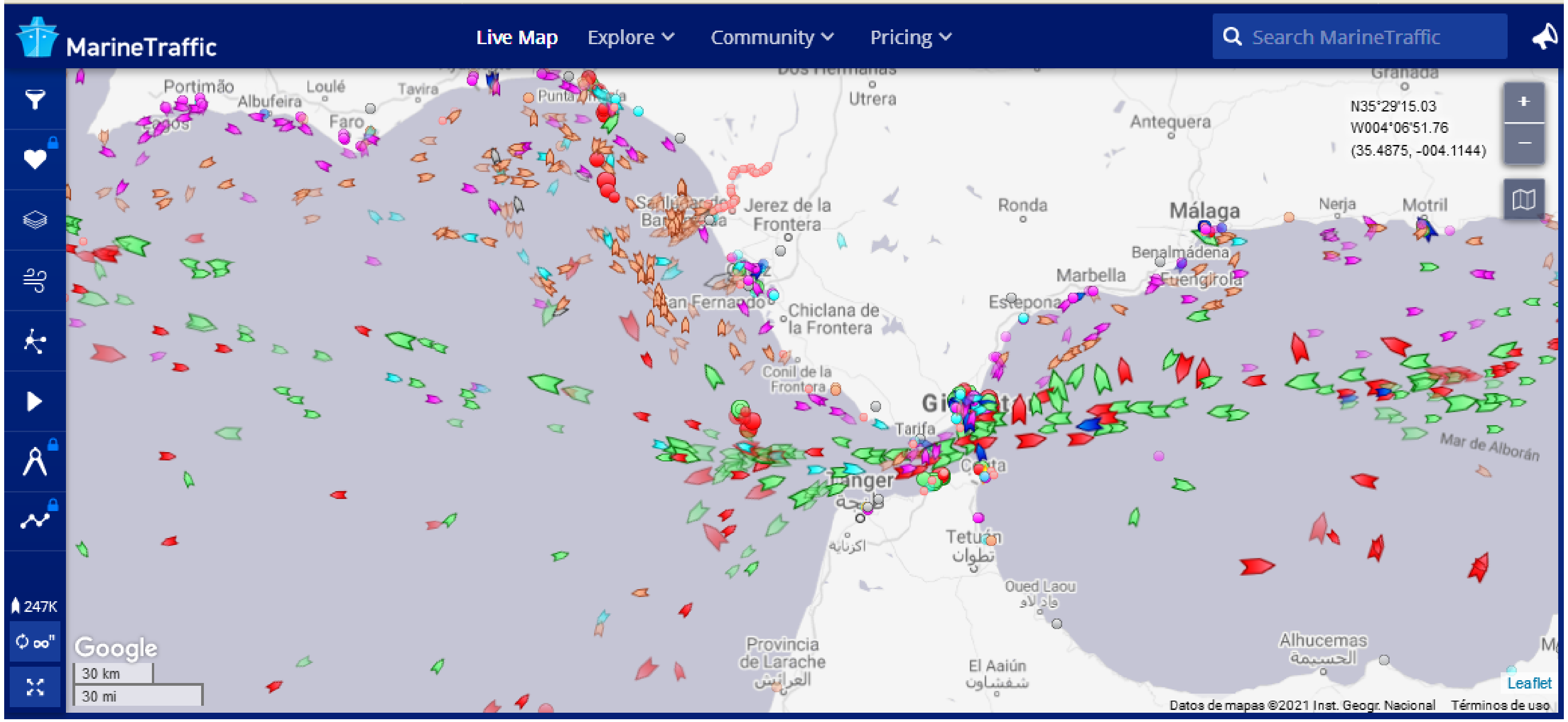
Around 120,000 vessels per year



Source: http://www.marinetraffic.com/ais/default.aspx

16th June 2021, 12:22 PM

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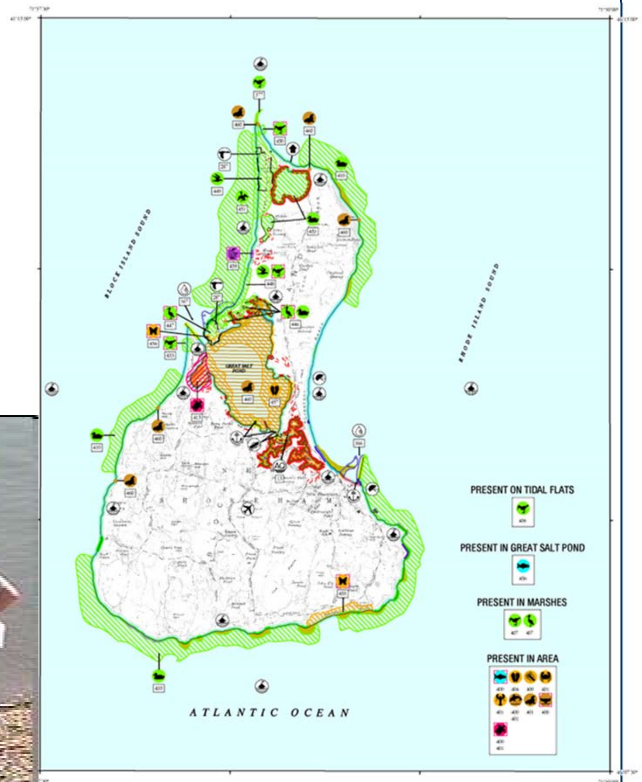
INTRODUCTION

Environmental Sensitivity maps is an important tool in a contingency plan for oil spill responders



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STUDY AREA

The studied area in the Northern side: 130 km

The studied area in the Southern side: 20 km

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METHODS

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They were investigated

Socio-economic

Biological resources

Geomorphologic

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METHODS

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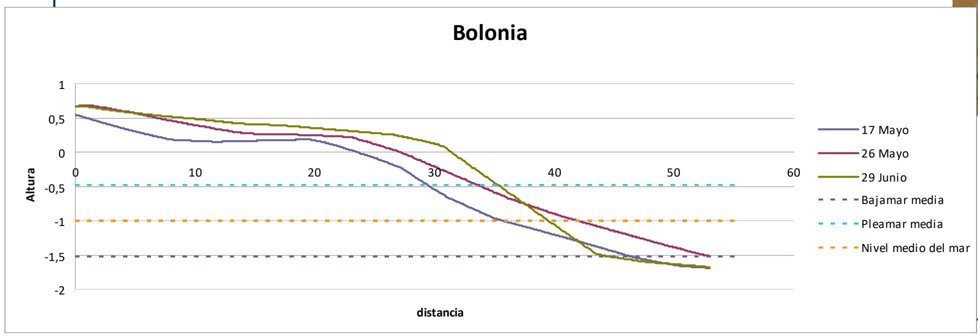
Within the geomorphologic characteristics special attention was devoted to beach characteristics



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METHODS

Four beach surveys have been carried out in May, June, August and September 2010 at 12 beach locations

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RESULTS AND DISCUSSION

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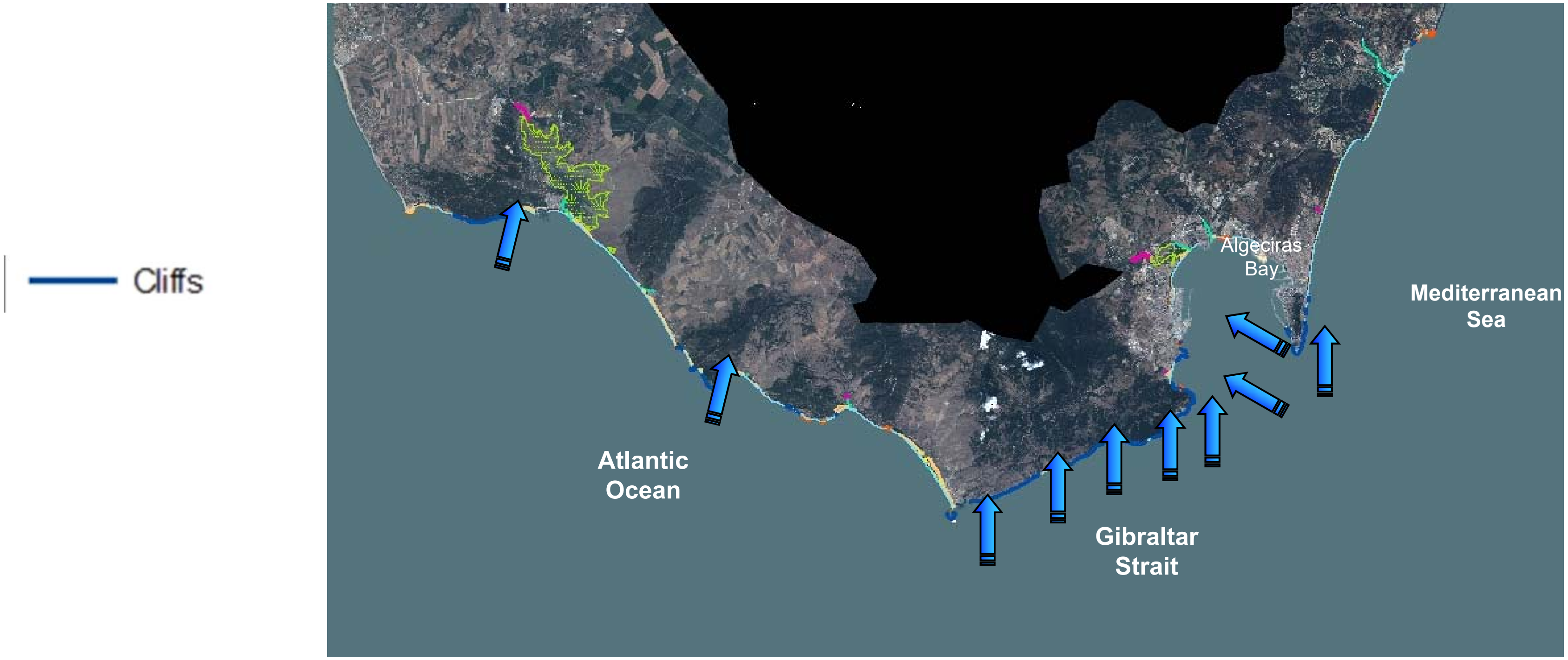
Geomorphologic characteristics



Cliffed sectors and rock shore platforms especially prevail in the Gibraltar Strait and within Algeciras Bay

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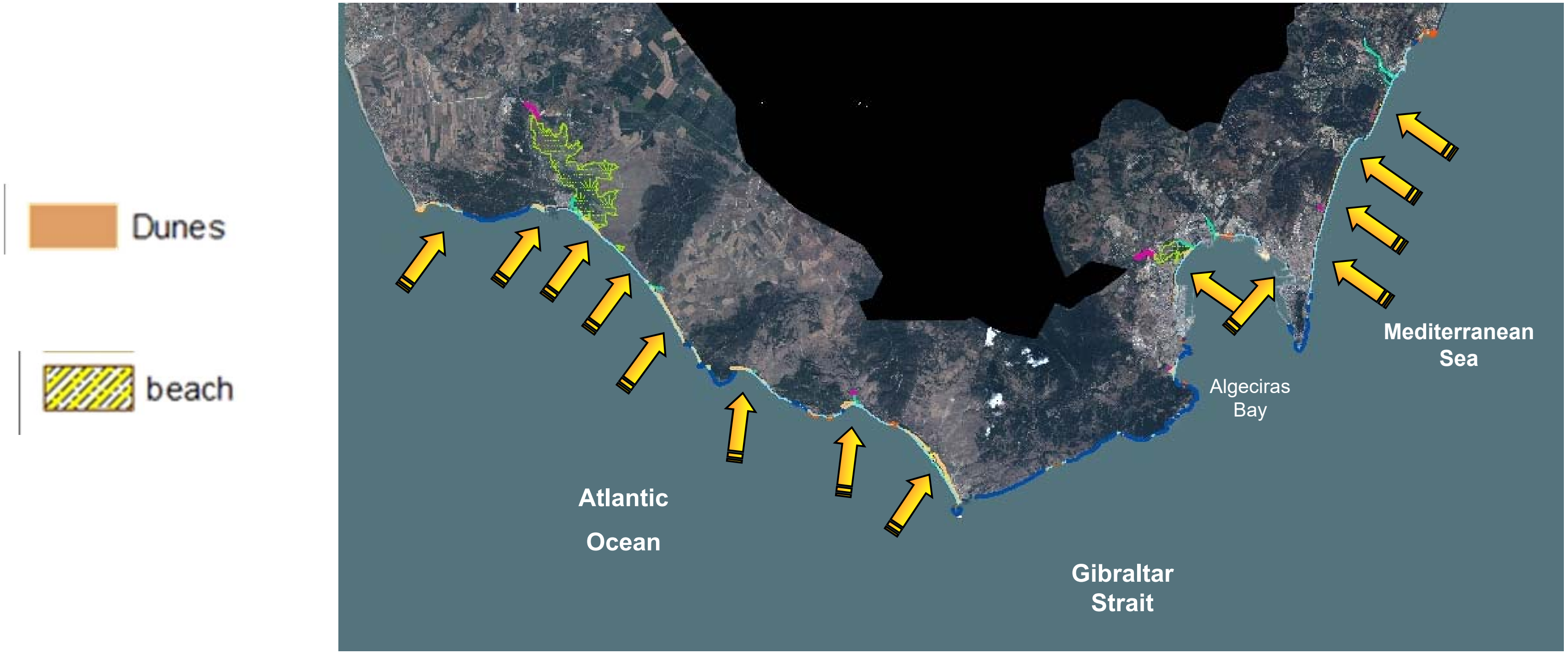
RESULTS AND DISCUSSION

Geomorphologic characteristics



Beaches and dunes are observed, on the Atlantic side and on the Mediterranean side

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RESULTS AND DISCUSSION

Geomorphologic characteristics

Most important estuaries, lagoons and freshwater wetlands are observed at Palmones, Guadiaro and Barbate river mouths

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RESULTS AND DISCUSSION

Trafalgar, Hierbabuena and Cañillo recorded important morphological changes due to berm or beach cusps formation

Geomorphologic characteristics

Morphological changes, slope and grain size at the investigated beaches.

	Location	Changes (m) Berm	Changes (m) Foreshore	Slope (º)	Gr. Size Ber./For.
Atlantic Ocean	Trafalgar	+0.41	+0.15	M	F-M/C
	Hierbabuena	+0.35	-0.75	F	F-M
	Cañillo	-0.18	0.01	M	C/G
	Zahara	-0.25	+0.98	F	F-M
	Bolonia	+0.45	+0.30	F	F-M
	Valdevaqueros	-0.20	+0.38	M	F-M
	Los Lances	+0.24	+0.55	F	F-M
Gibraltar Strait	Getares	+0.25	+0.15	M	F-M/G
	Rinconcillo	+0.12	+0.15	F	F-M
	Espigon	-0.13	0.01	M	G/F-M
Med. Sea	Castillo	+0.65	+0.20	M	F-M
	Torrenueva	+0.22	+0.15	M	F-M/G

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RESULTS AND DISCUSSION

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Geomorphologic characteristics

Intermediate beaches between "dissipative" and "reflective" *

* Wright and Short (1984) and Masselink and Short (1993)

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RESULTS AND DISCUSSION

Geomorphologic characteristics

Zahara and Bolonia were "Low tide terrace" beaches*

* Wright and Short (1984) and Masselink and Short (1993)

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RESULTS AND DISCUSSION

Valdevaqueros and Los Lances presented moderate beach slopes and small-intermediate changes in the foreshore

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Geomorphologic characteristics

Morphological changes, slope and grain size at the investigated beaches.

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Med. Sea	Castillo	+0.65	+0.20	M	F-M
	Torrenueva	+0.22	+0.15	M	F-M/G

Getares, Rinconcillo and Espigon, showed very small morphological changes

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RESULTS AND DISCUSSION

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Geomorphologic characteristics

Getares, Rinconcillo and Espigon, showed relatively steep and narrow foreshore areas

RESULTS AND DISCUSSION

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Geomorphologic characteristics

Morphological changes, slope and grain size at the investigated beaches.

	Location	Changes (m) Berm	Changes (m) Foreshore	Slope (º)	Gr. Size Ber./For.
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Mediterranean beaches presented moderate slope and significant changes in the upper foreshore

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Geomorphologic characteristics

Mediterranean beaches can be classified as reflective *

* Wright and Short (1984) and Masselink and Short (1993)

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RESULTS AND DISCUSSION

Biological characteristics

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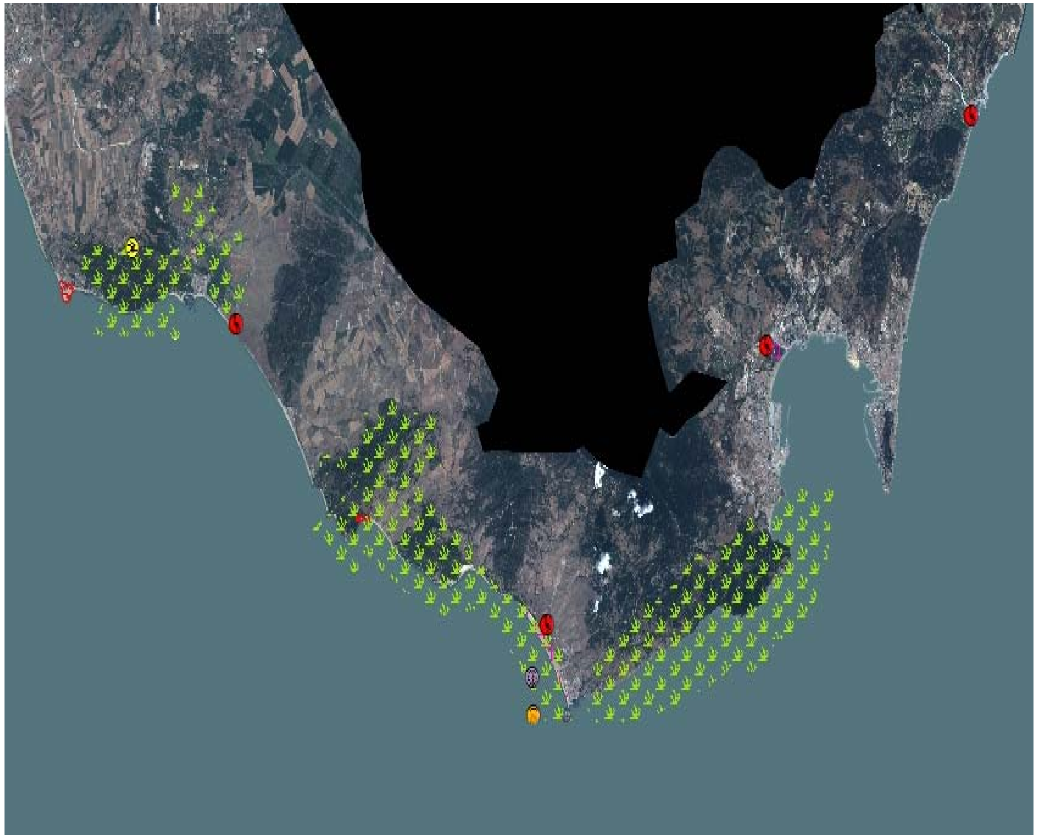
The "Biological" layer contained different categories according to their level of protection

Birds
Birds 2
Orange corals
Laminaria
Natural Parks
Natural Landscapes
Natural Monuments



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RESULTS AND DISCUSSION

Biological characteristics

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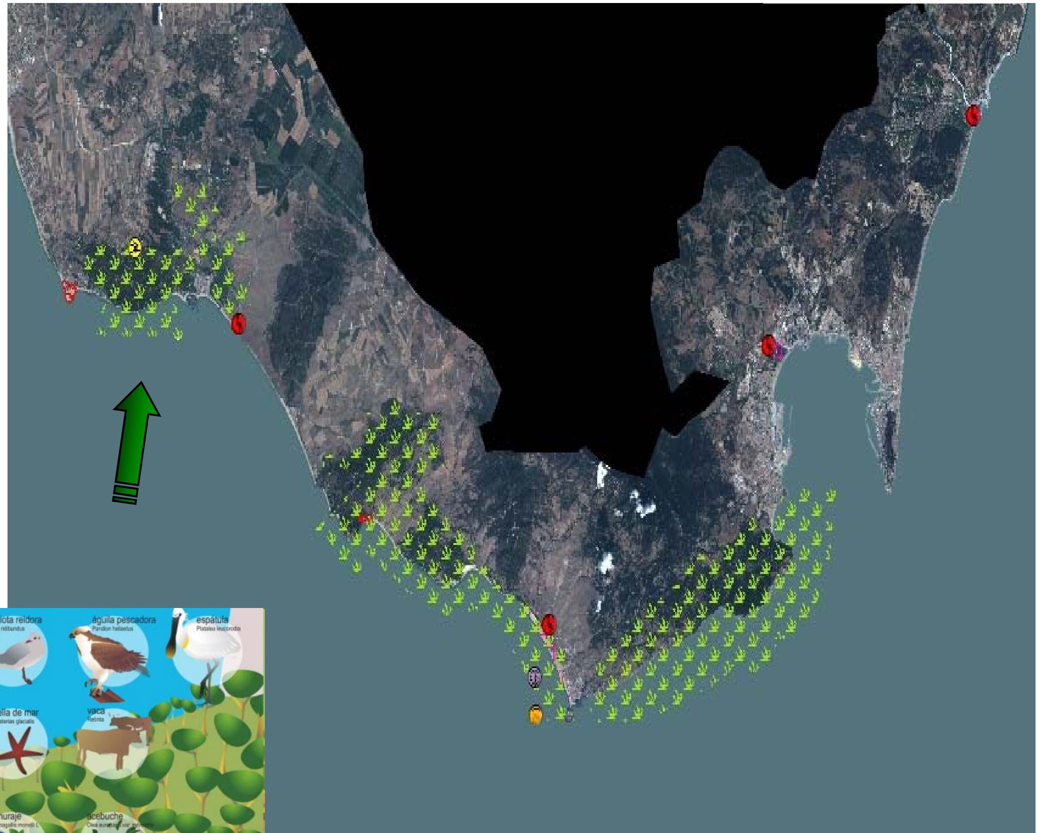
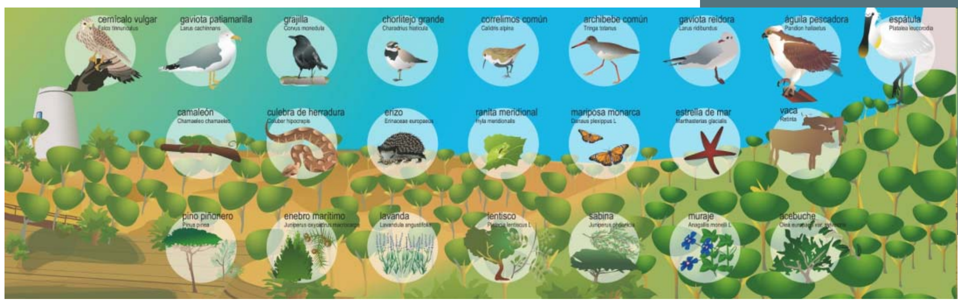
Natural parks

La Breña and Marismas de Barbate





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RESULTS AND DISCUSSION

Biological characteristics

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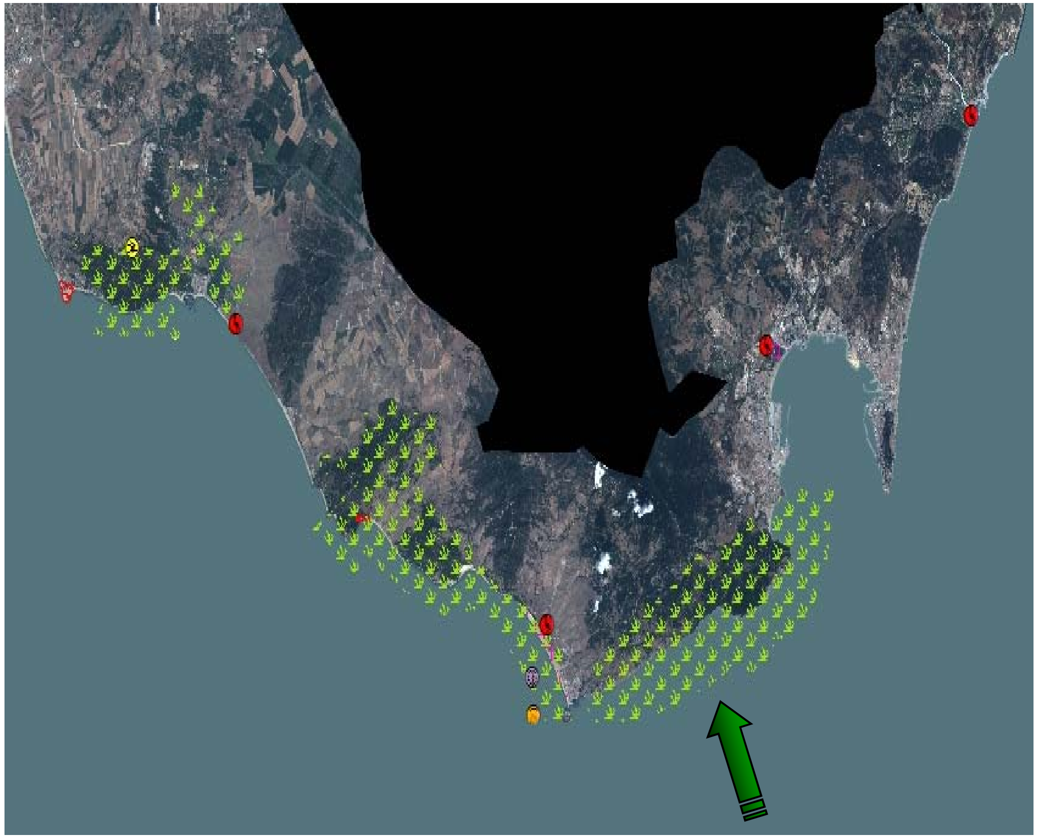
Natural parks

Estrecho de Gibraltar



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RESULTS AND DISCUSSION

Biological characteristics

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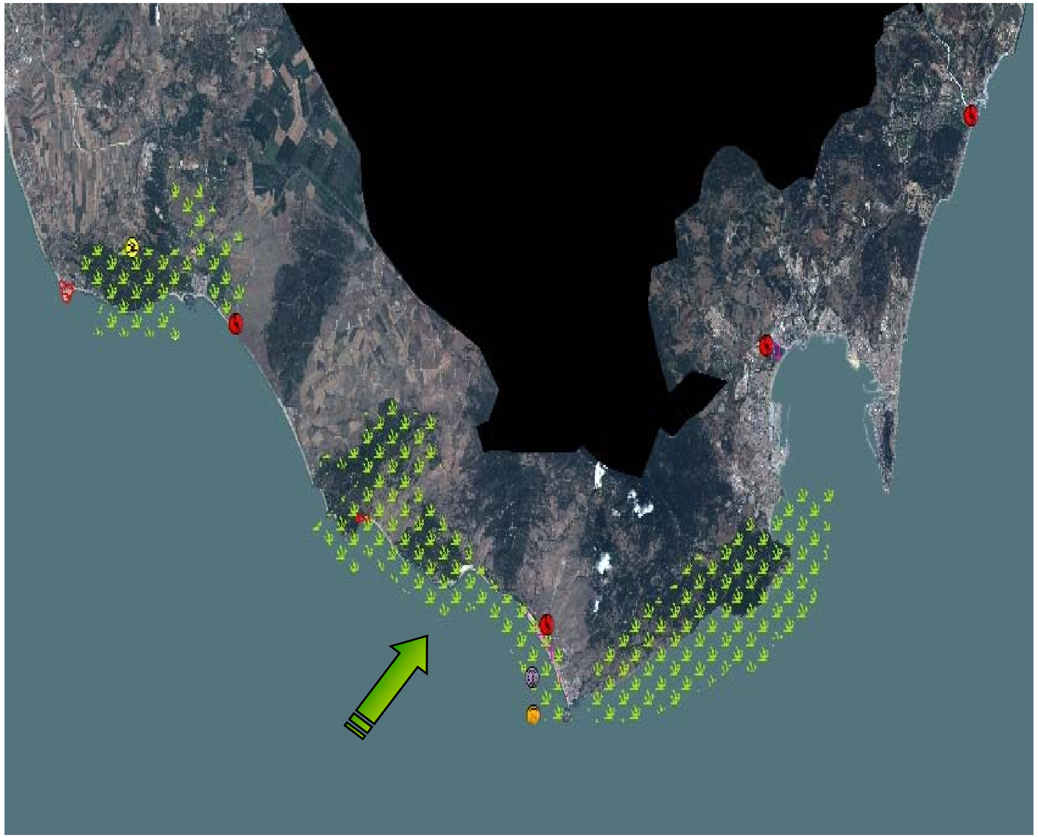
Natural Spots

Los Lances Beach



ENVIRONMENTAL SENSITIVITY MAPS: THE NORTHERN COAST OF GIBRALTAR STRAIT EXAMPLE

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RESULTS AND DISCUSSION

Biological characteristics

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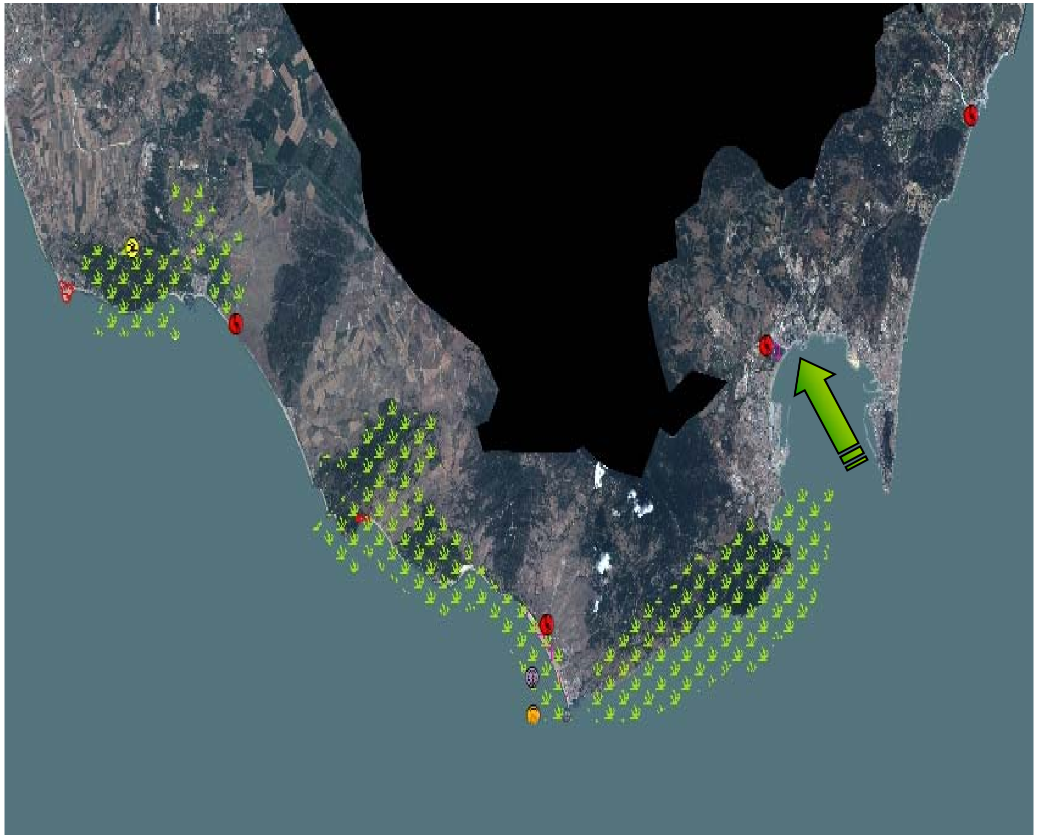
Natural Spots

Palmones Marshes



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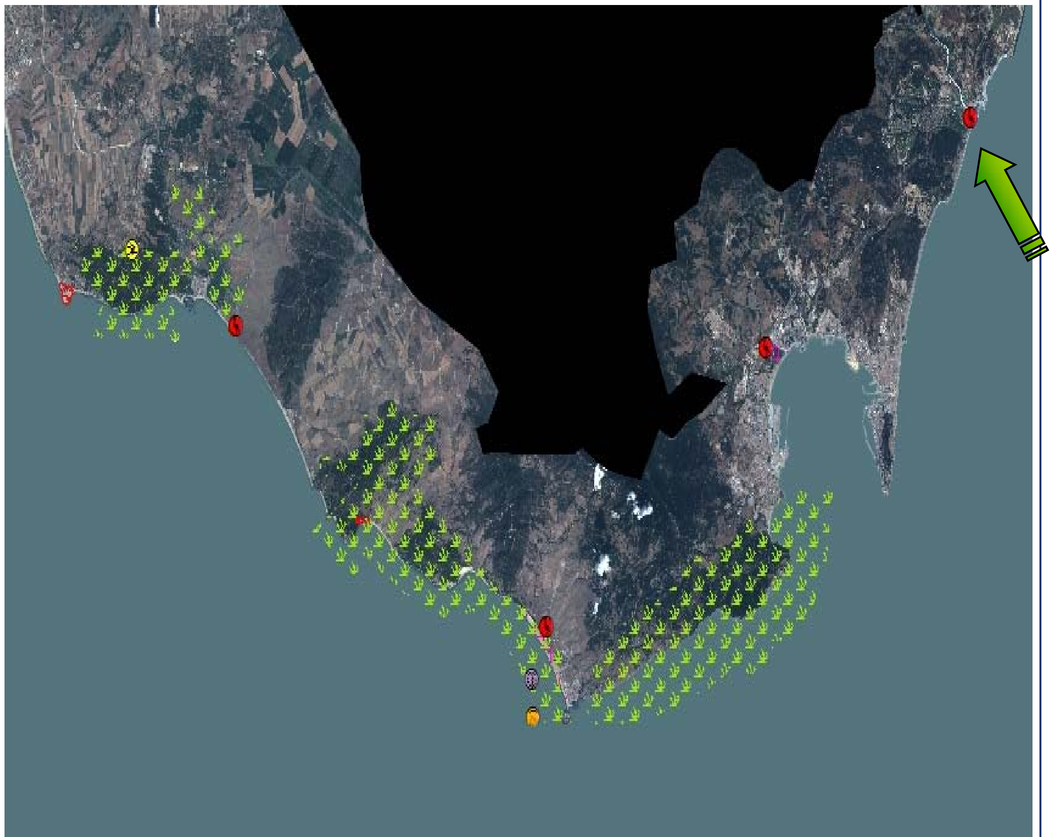
Natural Spots

Guadiaro River Estuary



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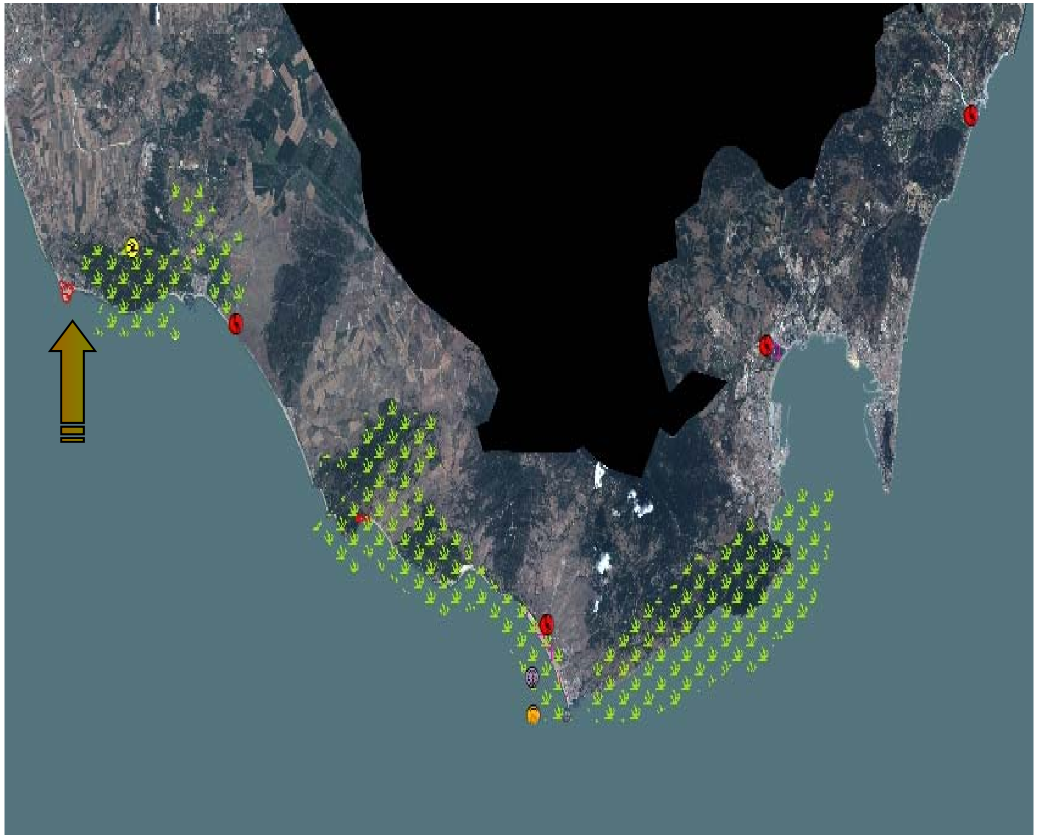
Natural Monuments

Trafalgar Isthmus



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RESULTS AND DISCUSSION

Biological characteristics

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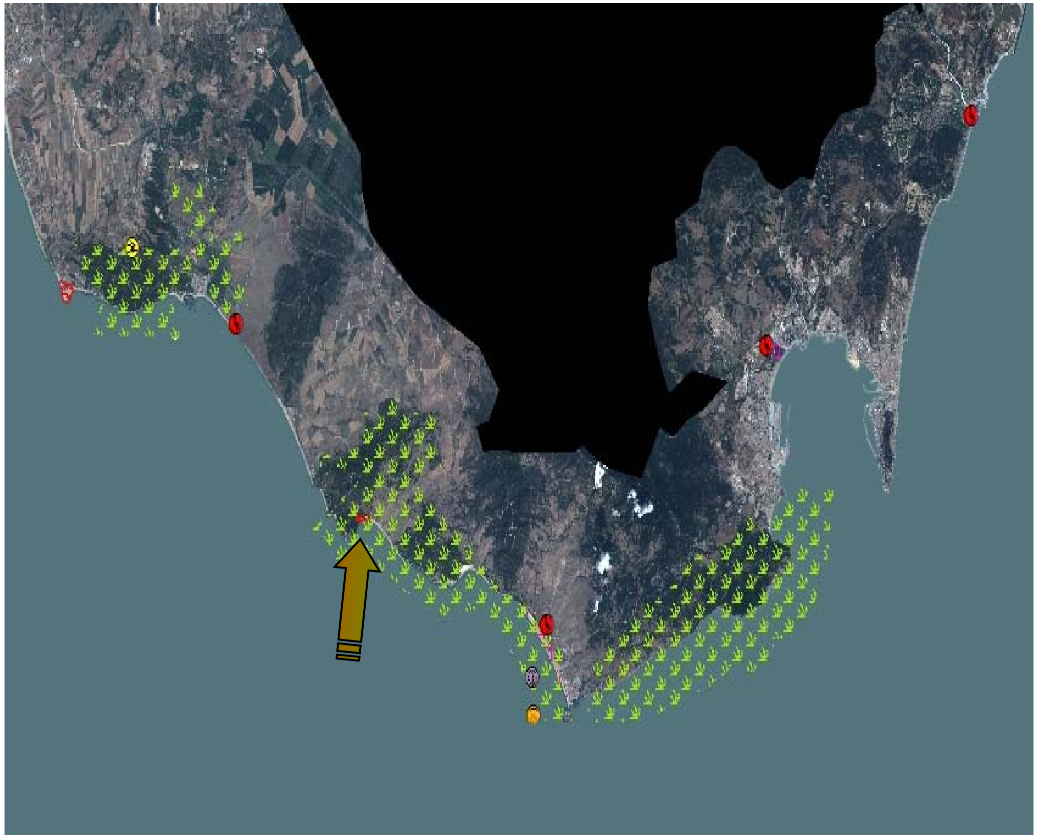
Natural Monuments

Bolonia Dune



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RESULTS AND DISCUSSION

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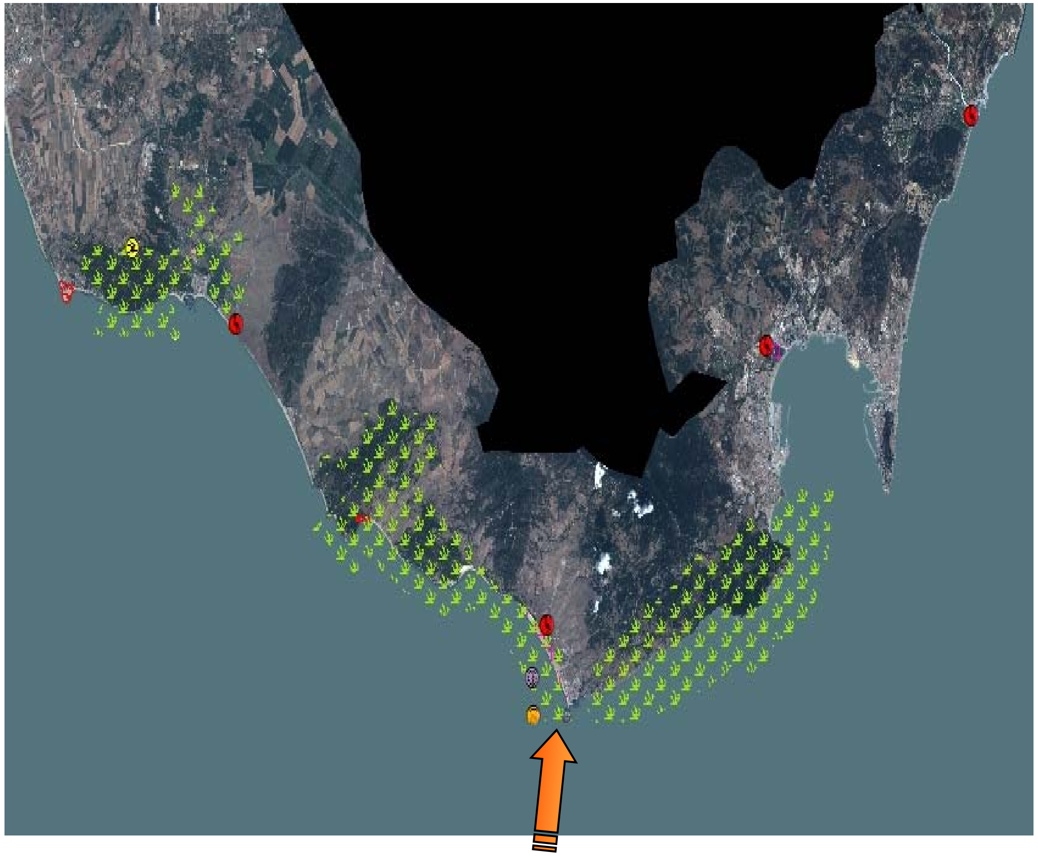
Organisms of special interest

Orange corals (Astroides calycularis)



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RESULTS AND DISCUSSION

Biological characteristics

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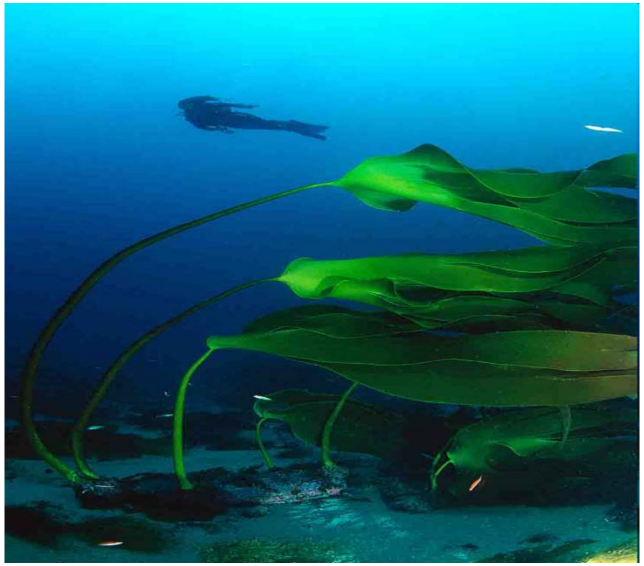
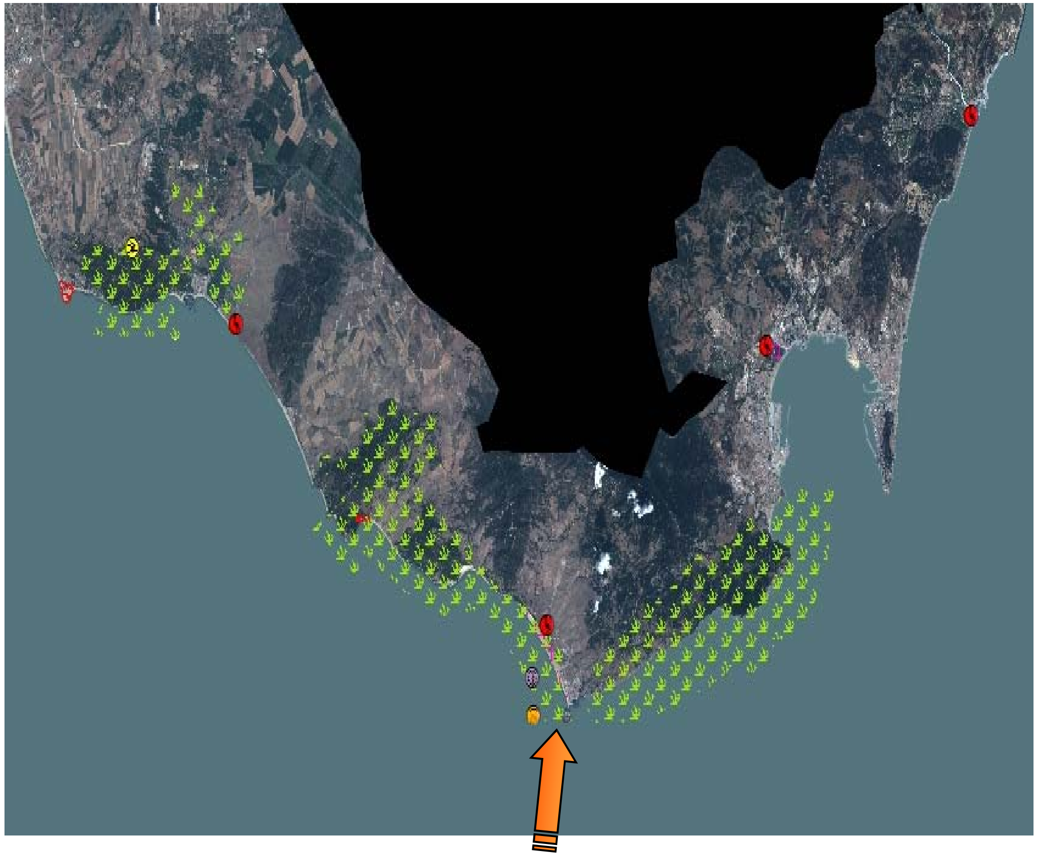
Organisms of special interest

Kelp fields (Laminarias ochroleuca)





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Socio-economic characteristics

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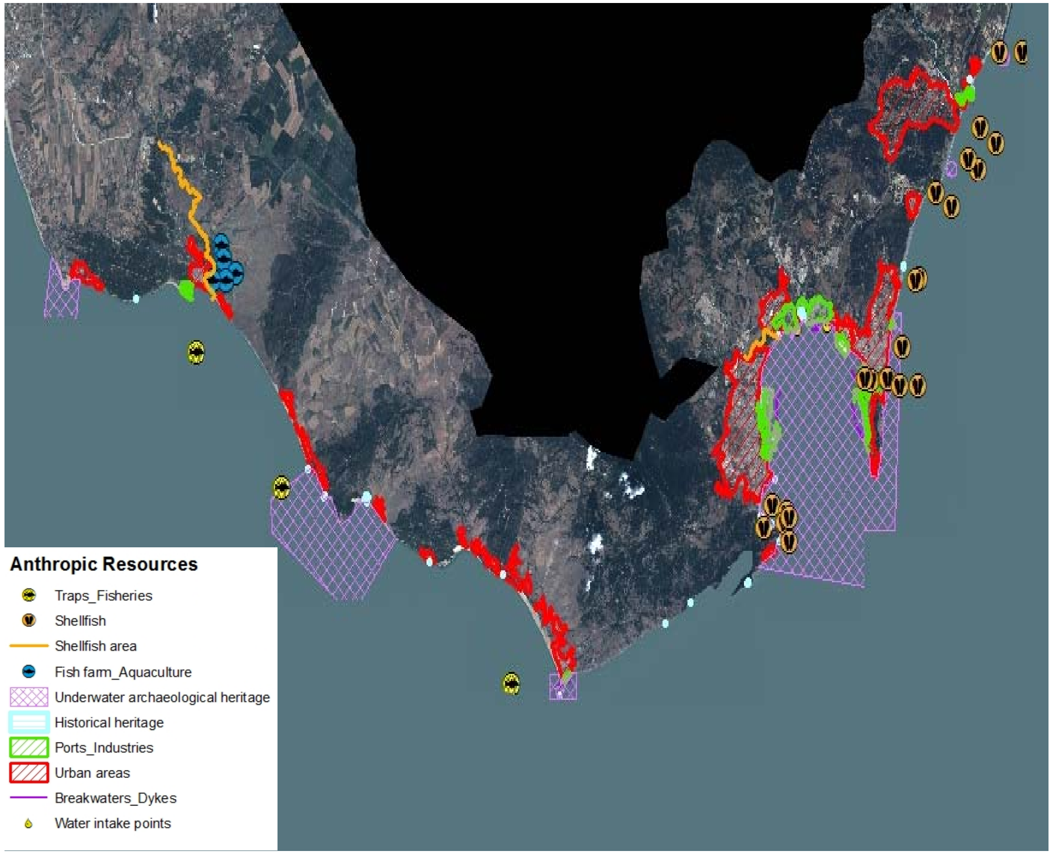
RESULTS AND DISCUSSION

Coastal uses:

- Ports and industries
- Urban Areas



Socio-economic characteristics

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RESULTS AND DISCUSSION

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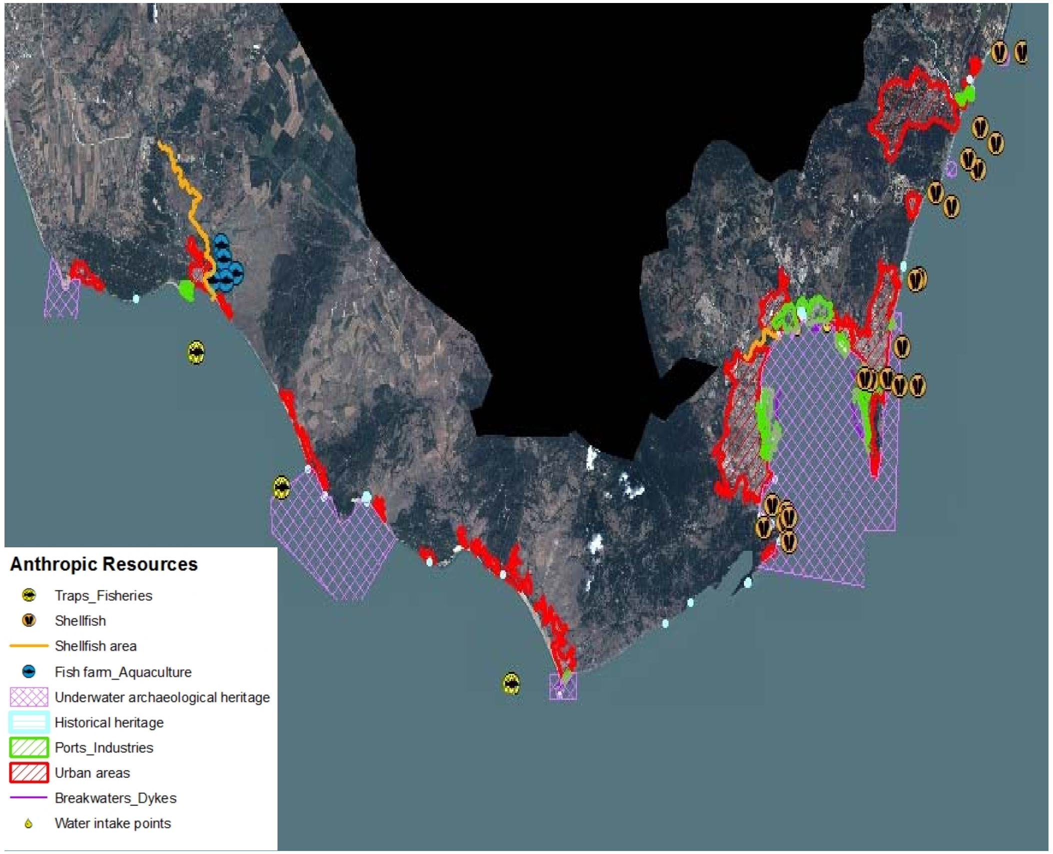
Socioeconomic activities:

- Aquaculture
- Tuna fishing
- Shellfish farming



Socio-economic characteristics

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RESULTS AND DISCUSSION

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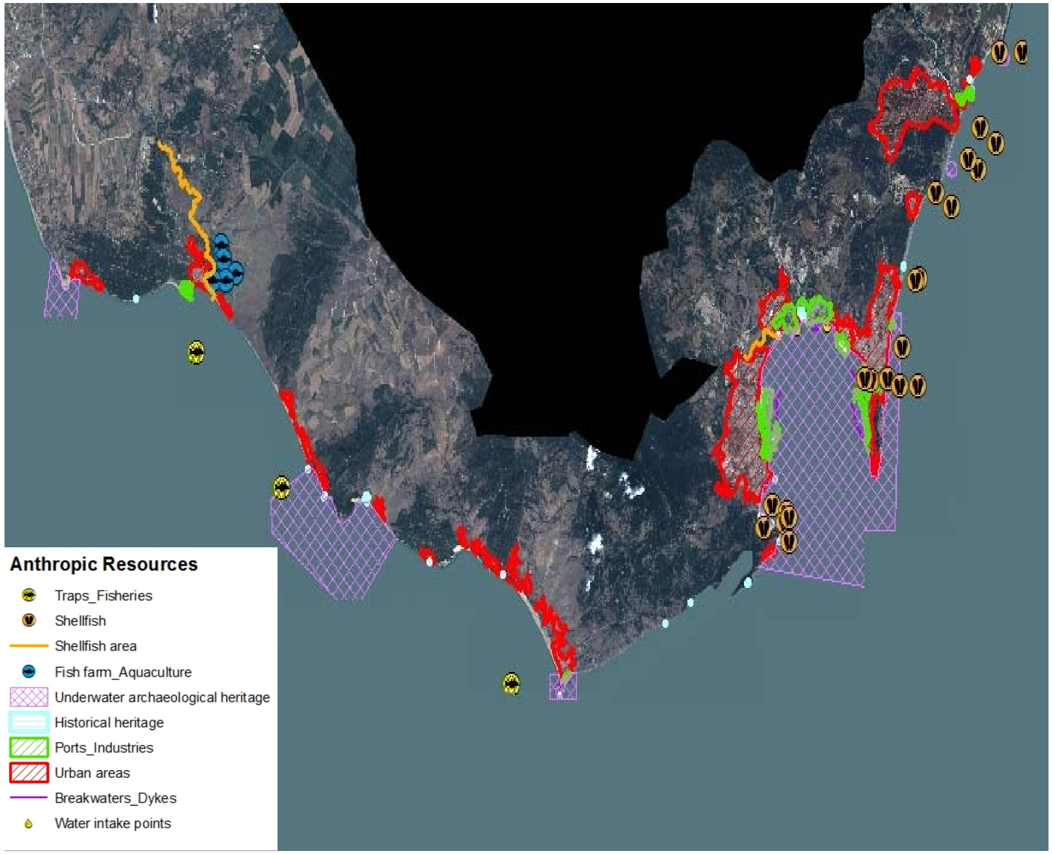
Cultural and historic patrimony:

- **Terrestrial Historic Heritage**
- **Subaquatic Archaeological Heritage**



Socio-economic characteristics

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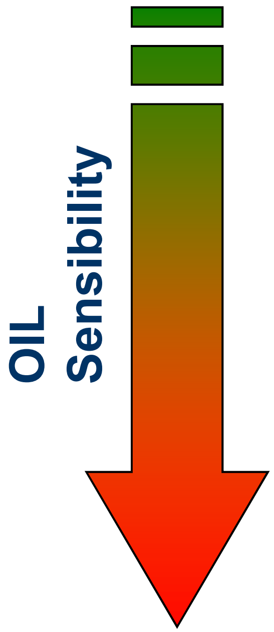
RESULTS AND DISCUSSION

Littoral operational ranking



Cliffed sectors and rock shore platforms

Sandy sectors

Exposed breakwaters and docks

Sheltered breakwaters, seawalls, docks, riprap

Salt marshes and estuarine environments

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RESULTS AND DISCUSSION

Littoral operational ranking

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Cliffed sectors and rock shore platforms

Shorelines exposed to energetic conditions which tend to keep oil offshore by reflecting waves

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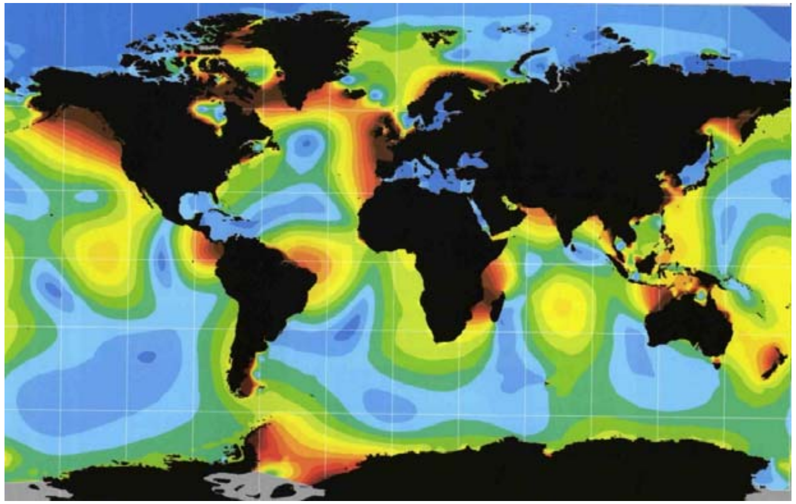
Littoral operational ranking

Sandy sectors

The application of the NOAA (2002) criteria does not take into account

-tidal range for beach classification;

-Seasonal grain size/beach slope variations.



NOAA, 2002. Environmental sensitivity index guidelines. Technical Memorandum NOS ORR 11, 192 p

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Sandy sectors

Littoral operational ranking

All beaches (but Trafalgar, Hierbabuena, Cañillo and Zahara) are microtidal environments

Foreshore slope is probably overestimated

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Sandy sectors

Littoral operational ranking

Atlantic beaches (but Trafalgar and Cañillo) and the Rinconcillo and Espigon could be classified as "Semi-Permeable Substrate, Low Potential for Oil Penetration and Burial" (NOAA, 2002).

NOAA, 2002. Environmental sensitivity index guidelines. Technical Memorandum NOS ORR 11, 192 p

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RESULTS AND DISCUSSION

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Sandy sectors

Littoral operational ranking

Exceptions can be observed at Hierbabuena and Zahara because the presence of beach cusps that can generate important morphological changes in a tidal cycle

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Sandy sectors

Littoral operational ranking

Trafalgar, Cañillo, Getares and the Mediterranean beaches could be classified as "Medium Permeability, Moderate Potential for Oil Penetration and Burial"

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Littoral operational ranking

Salt marshes and estuarine environments

These are the most sensitive habitats because of their high biological use and value, difficulty of cleanup, and potential for long-term impacts

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Littoral operational ranking

Salt marshes and estuarine environments

It is important to protect these environments by the use of booms.

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RESULTS AND DISCUSSION

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Littoral operational ranking

For each of the 58 zones of the studied area, the best coastal oil clean-up techniques have been selected according their effectiveness and environmental impact (NOAA).

NOAA, 2002. Environmental sensitivity index guidelines. Technical Memorandum NOS ORR 11, 192 p

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RESULTS AND DISCUSSION

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Littoral operational ranking

natural restoration

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RESULTS AND DISCUSSION

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Littoral operational ranking

mechanical clean-up

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RESULTS AND DISCUSSION

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Littoral operational ranking

manual clean-up

RESULTS AND DISCUSSION

Littoral operational ranking

flushing

RESULTS AND DISCUSSION

Littoral operational ranking

bioremediation

The Southern coast of the Gibraltar Strait

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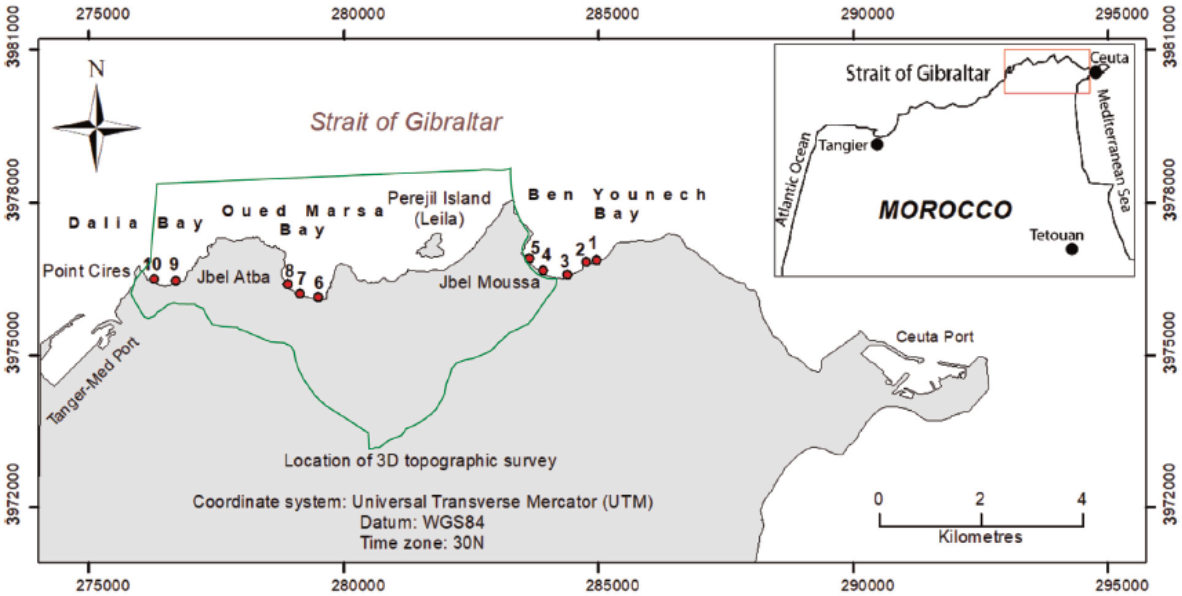
Environmental Sensitivity Index maps in a high maritime transit area: The Moroccan coast of the Gibraltar Strait study case

D. Nachite[a,*], N. Del Estal Domínguez[b], A. El M'rini[a], G. Anfuso[c]

[a] Faculty of Science of Tetouan, University Abdelmalek Essaâdi, Morocco
[b] Mott MacDonald Limited, UK
[c] Faculty of Marine and Environmental Sciences. University of Cadiz, Spain



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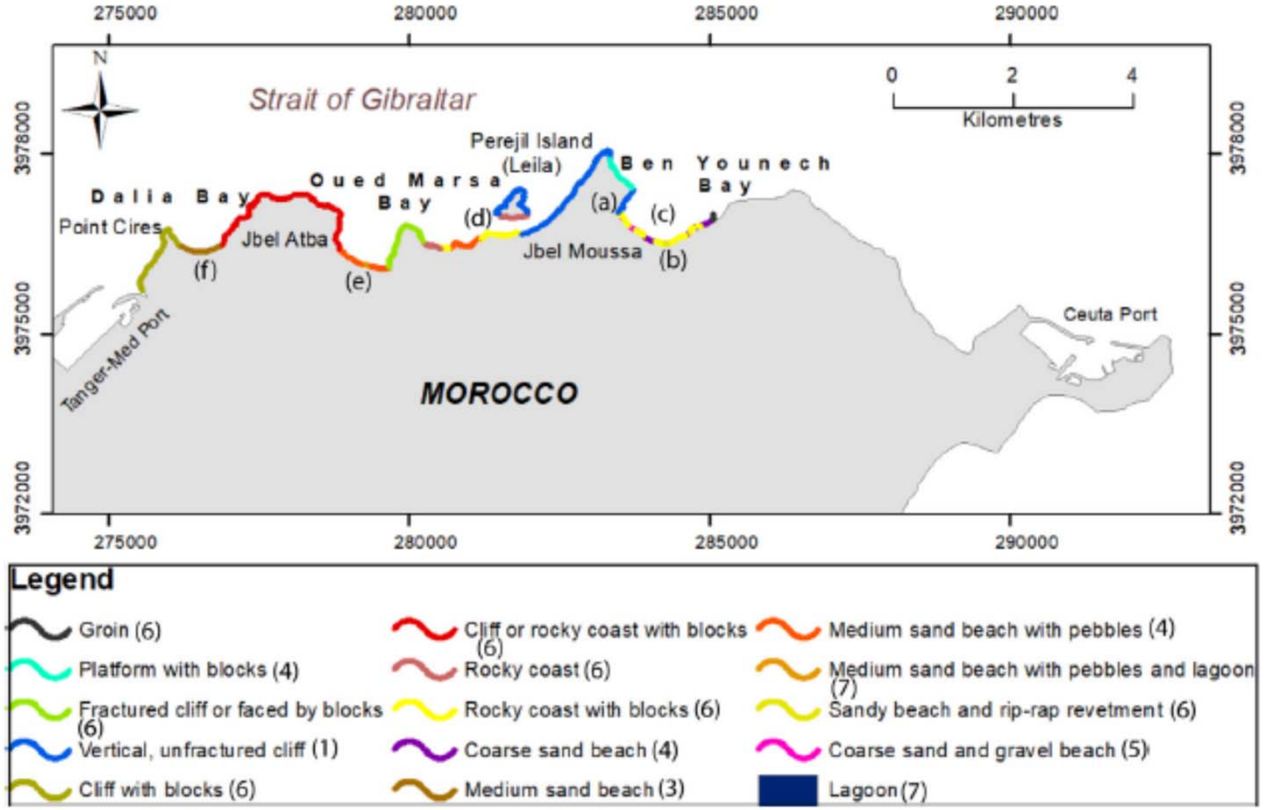
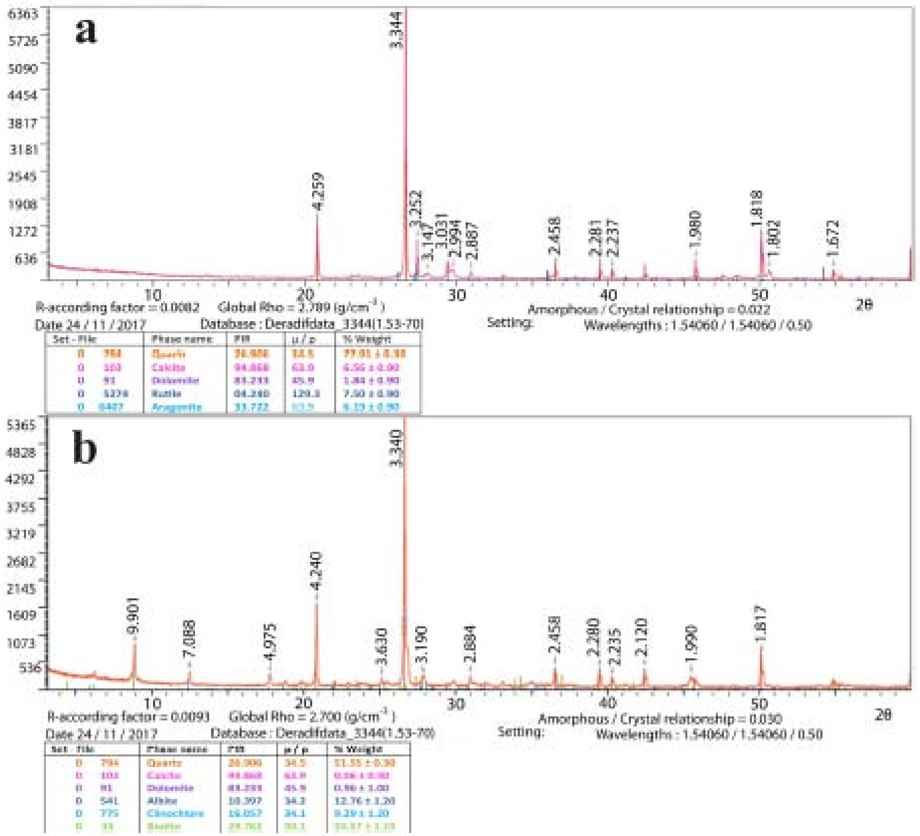


Geomorfologic characteristics

Innovation: X-Ray analysis



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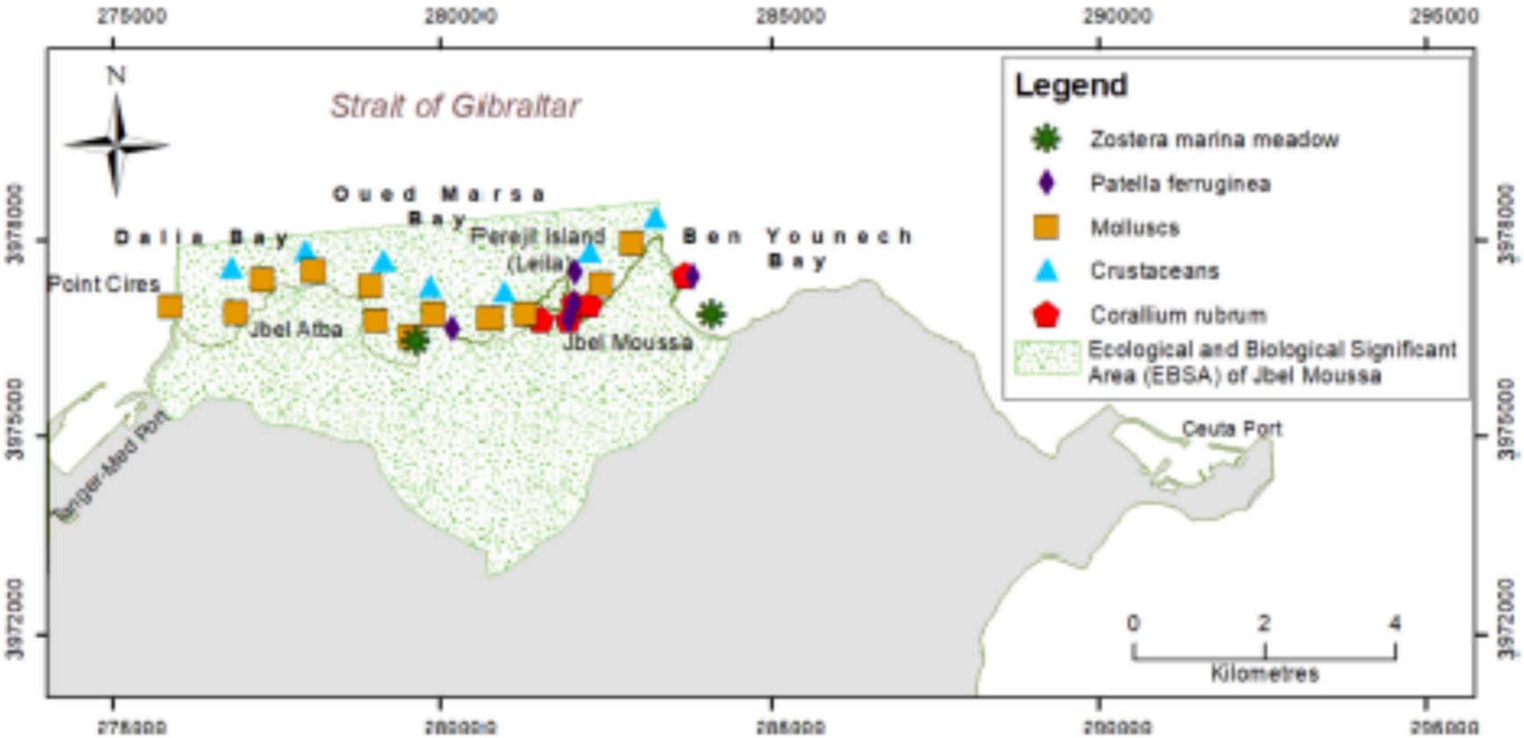
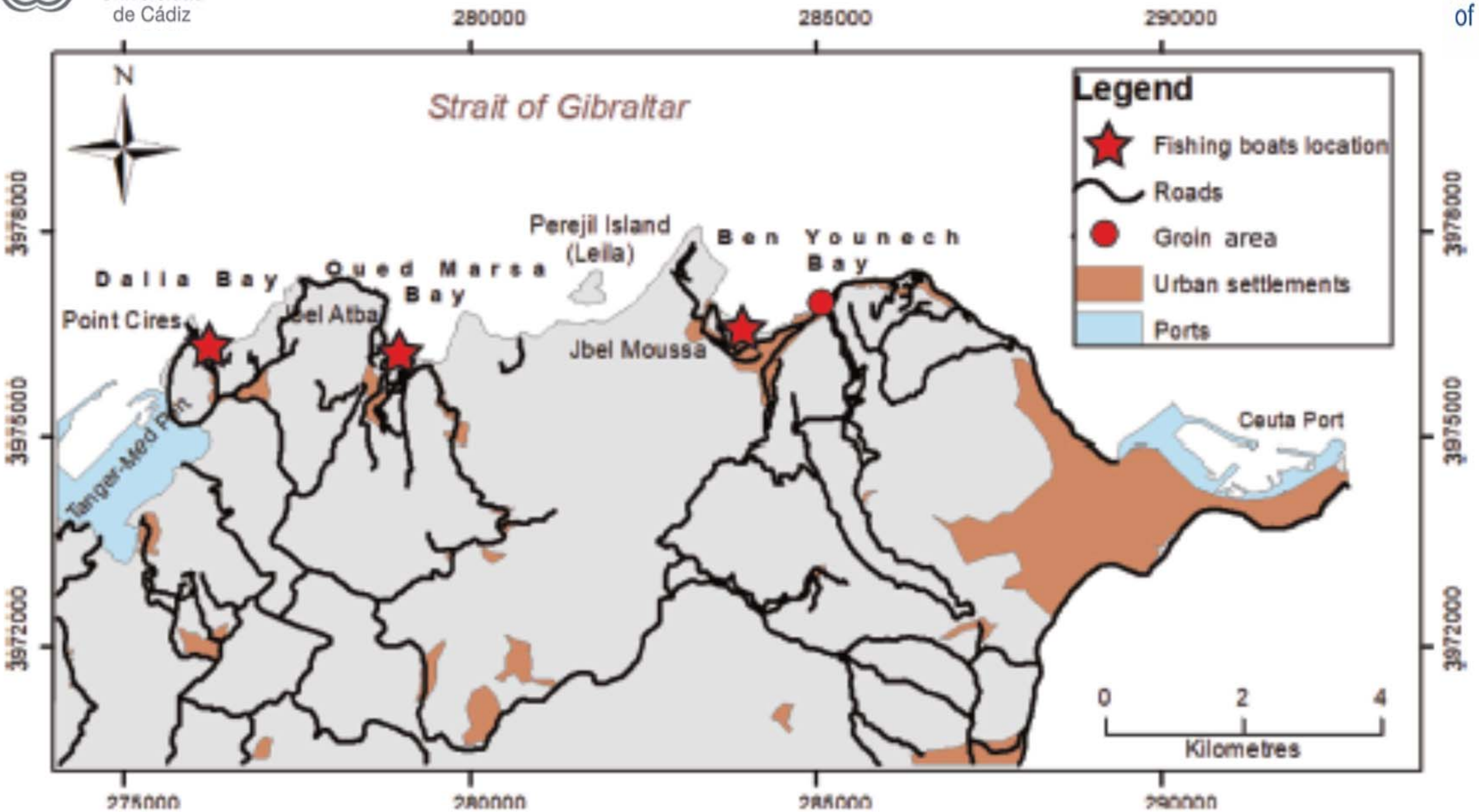
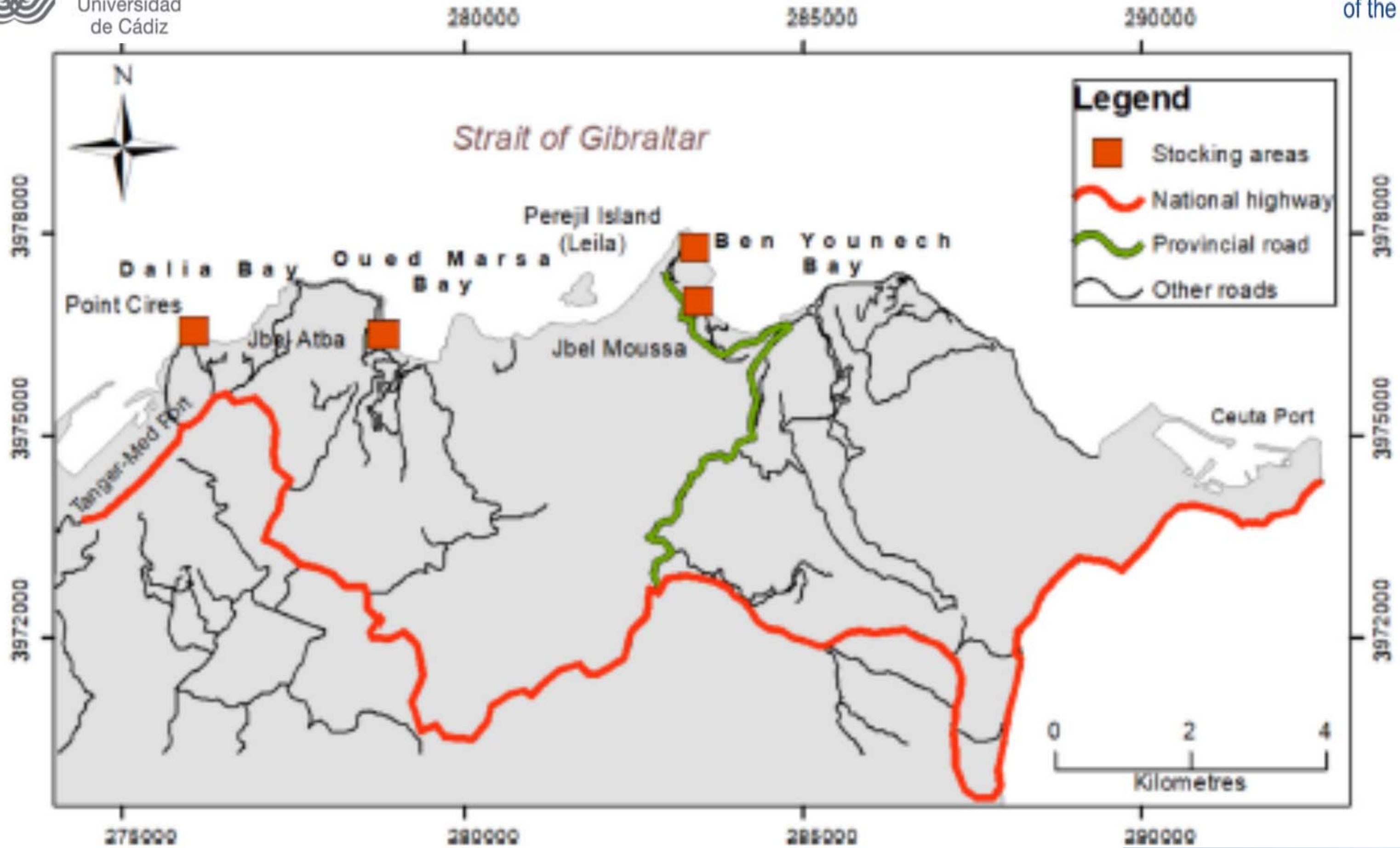


Biological characteristics



Anthropogenic activities



Stocking areas and connections

REFERENCES

Aps, R., Tõnisson, H., Anfuso, G., Perales, J.A., Orviku, K., Suursaar, Ü., 2014. Incorporating dynamic factors to the Environmental Sensitivity Index (ESI) shoreline classification – Estonian and Spanish examples. *Journal of Coastal Research*, 70, 235–240.

Bello Smith, A., Cerasuolo, G., Perales, J.A., Anfuso, G., 2011. Environmental sensitivity maps: the North coast of Gibraltar strait example. *Journal of Coastal Research*, 64, 875–879.

Masselink, G., Short, A.D., 1993. The effect of tide range on beach morphodynamics and morphology: a conceptual beach model. *Journal of Coastal Research*, 9, 785–800.

NOAA, 1992. Summaries of significant U.S. and international spills: case histories 1967 – 1991. https://repository.library.noaa.gov/view/noaa/1671 Accessed 11 December 2019.

NOAA, 2002. Characteristic coastal habitats: choosing spill response alternatives. National Oceanic and Atmospheric Administration, pp. 86. Revised 2010, reprinted March 2017. https://response.restoration.noaa.gov/sites/default/files/.

Nachite, D., Del Estal Domínguez, N., El M'rini, A., Anfuso, G., 2020. Environmental Sensitivity Index maps in a high maritime transit area: The Moroccan coast of the Gibraltar Strait study case. *Journal of African Earth Sciences,* 163 (2020) 103750.

Wright, L.D. and Short, A.D., 1984. Morphodynamic variability of surf zones and beaches: a synthesis. *Marine Geology*, 56, 93-118.

¡GRACIAS!

Thank you

Faleminderit

Hvala.

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https://ccmaryambientales.uca.es/master-en-gestion-integrada-de-areas-litorales-gial/

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MEP&M Development of Regional Joint Master Program in Maritime Environmental Protection and Management