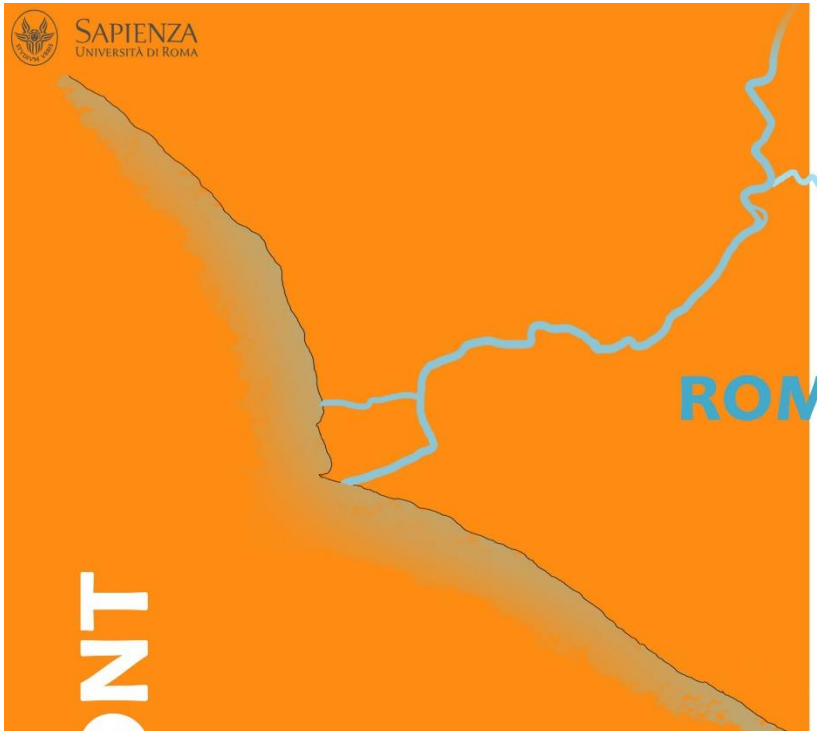

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FoCuS FORMAZIONE CULTURA STORIA SAPIENZA UNIVERSITÀ DI ROMA

DICEA
Department of Civil, Constructional and Environmental Engineering

DISDRA
Department of History, Representation and Restoration of Architecture

14-15 march 2022

ROMAN COASTAL SYSTEM

ARCHITECTURE and LANDSCAPE between HISTORY and CLIMATE CHANGE

Horizon 2020 MSCA 2018
Strategy of Excellence in Research and Innovation
Ricerca d'Ateneo 2020-Sapienza Rome University

III Session
Climate Change Water Policies and Project
tuesday 15 march _10 am-1 pm

Coastline and climate change.
The delta Tiber River coast from ancient Rome to the sea level rise

Paolo De Girolamo
paolo.degirolamo@uniroma1.it

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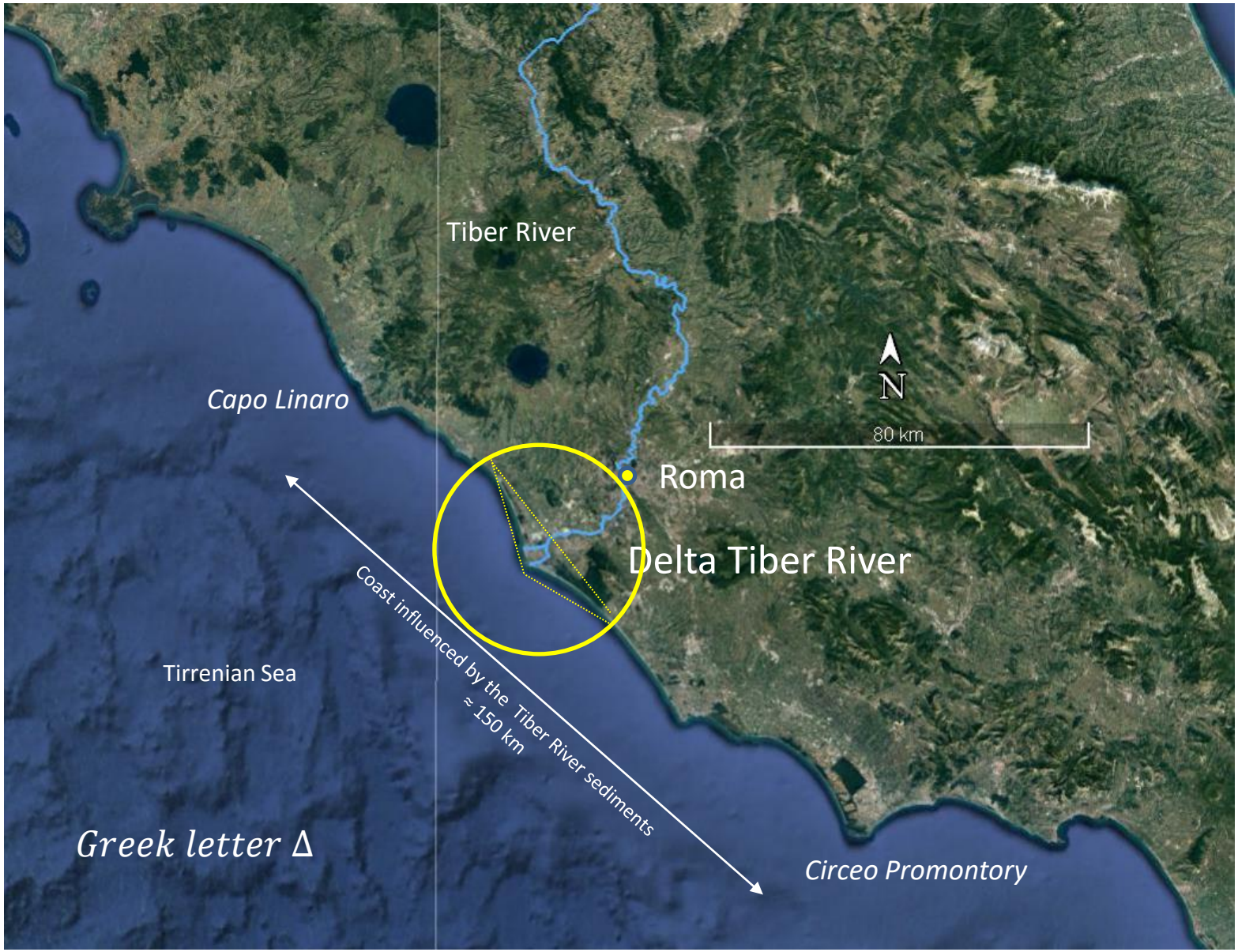

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Leonardo da Vinci Airport
Traiano Ancient Port
Head two branches
(Capo due rami)
Fiumicino Mouth
Fiumicino spillway canal
Fiumicino
Tiber River
Tiber Mouth
(Fiumara Grande)
Ostia
N
4 km
Tirrenian Sea


Leonardo da Vinci Airport
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Head two branches
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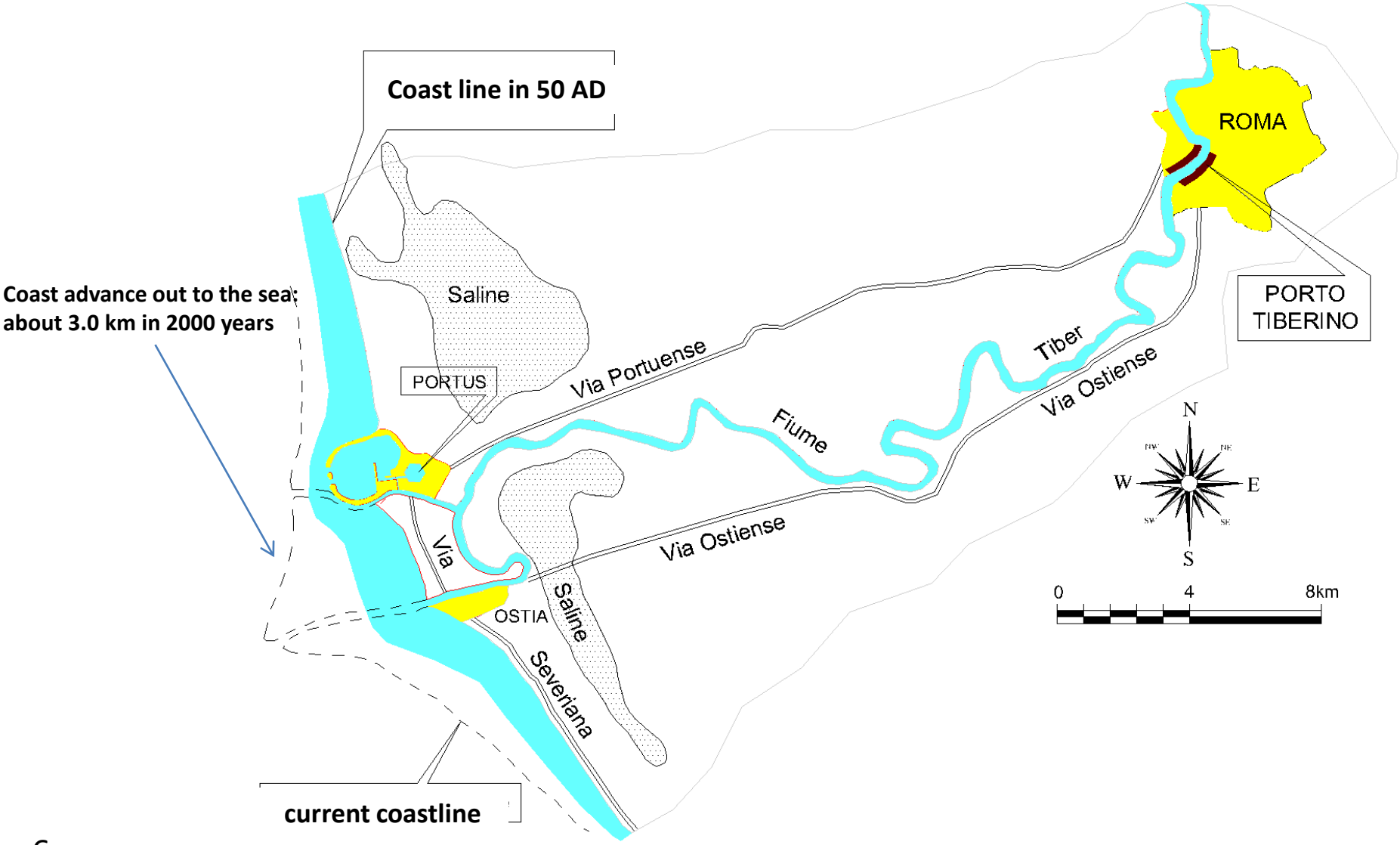
Fiumicino spillway canal
Fiumicino
Tiber River
(Fiumara Grande)
Ostia
N
4 km
Tirrenian Sea
Coastal erosion
defense breakwaters

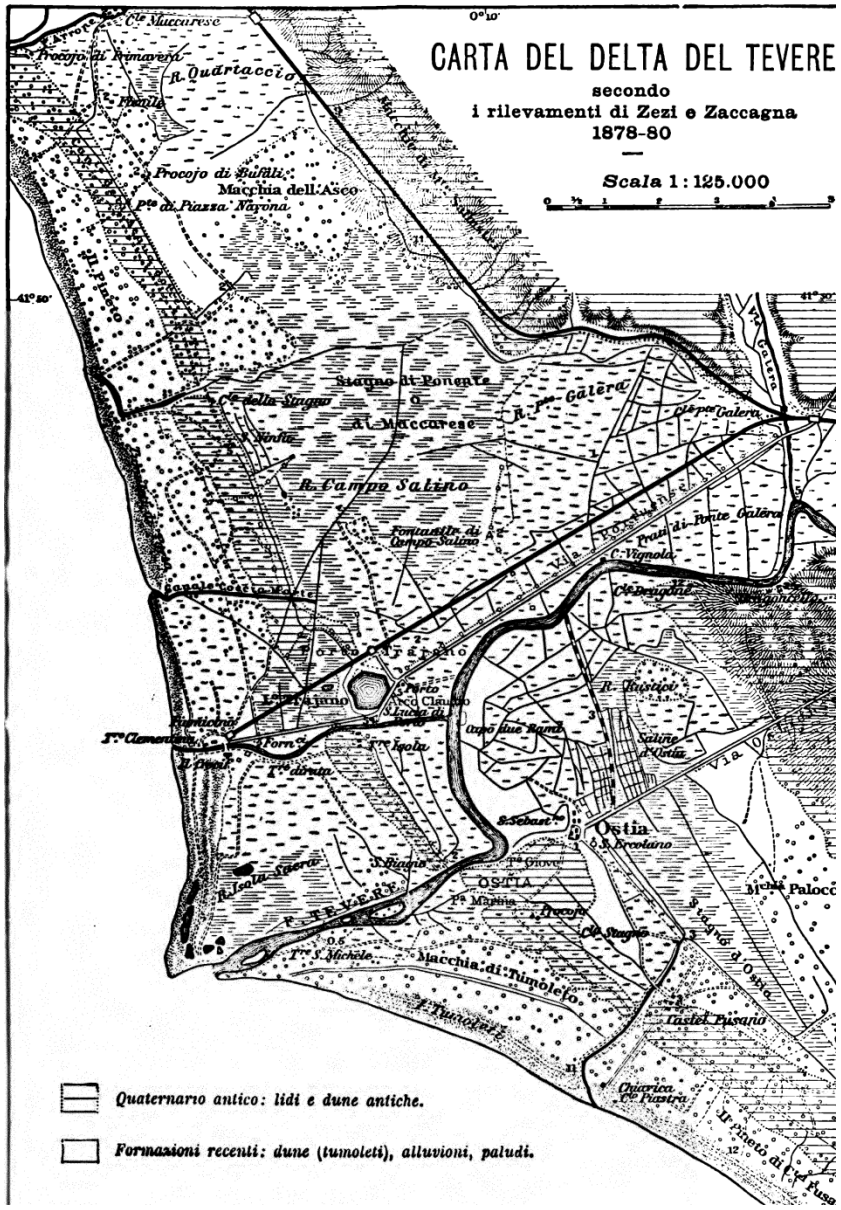

Coastal erosion
defense breakwaters
N
900 m

Rome during the Roman Empire

The Claudio and Traiano Port (Portus) was a **transhipment port** (maritime - fluvial).

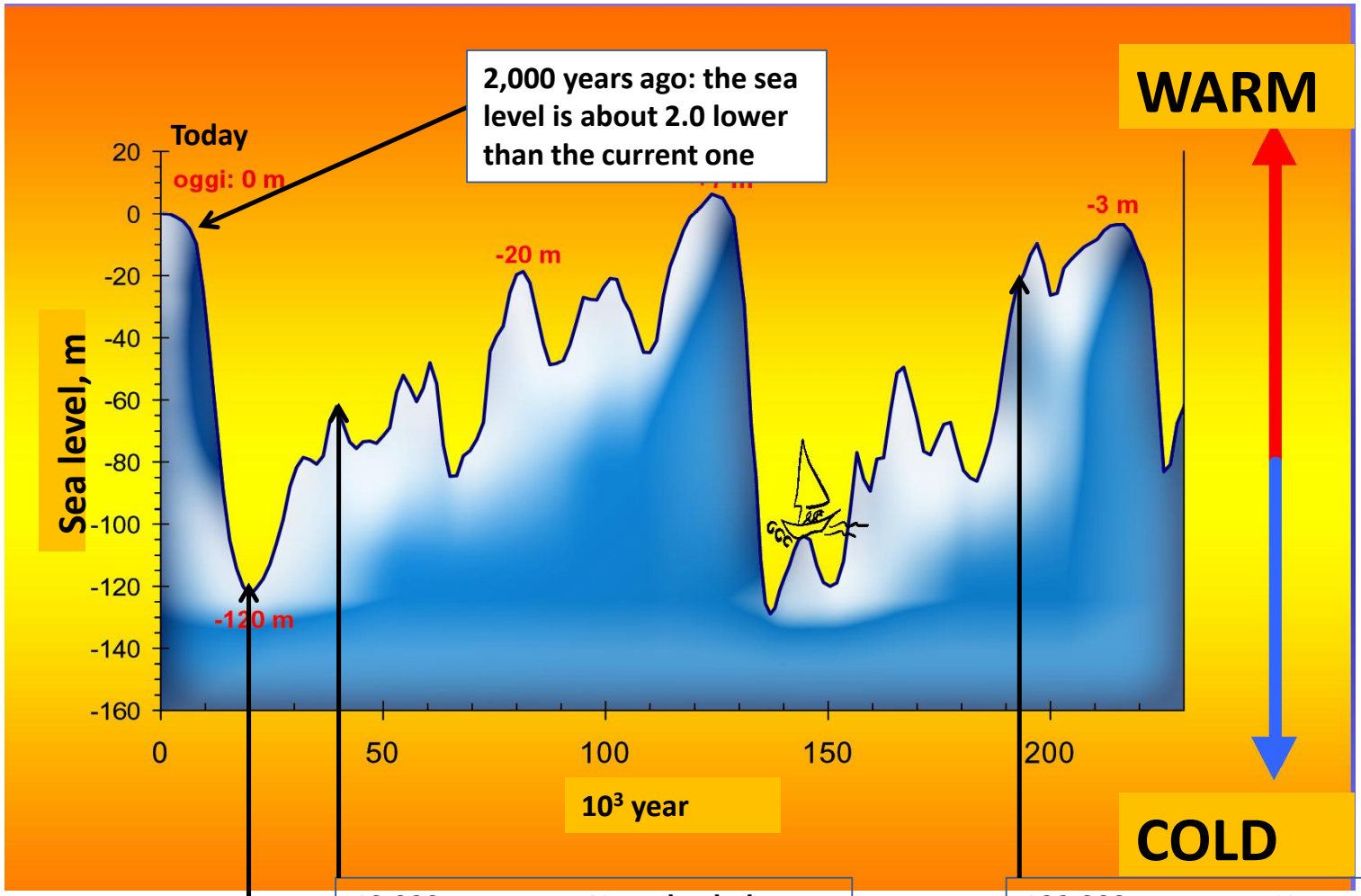


Coastline position at the end of the 19th century

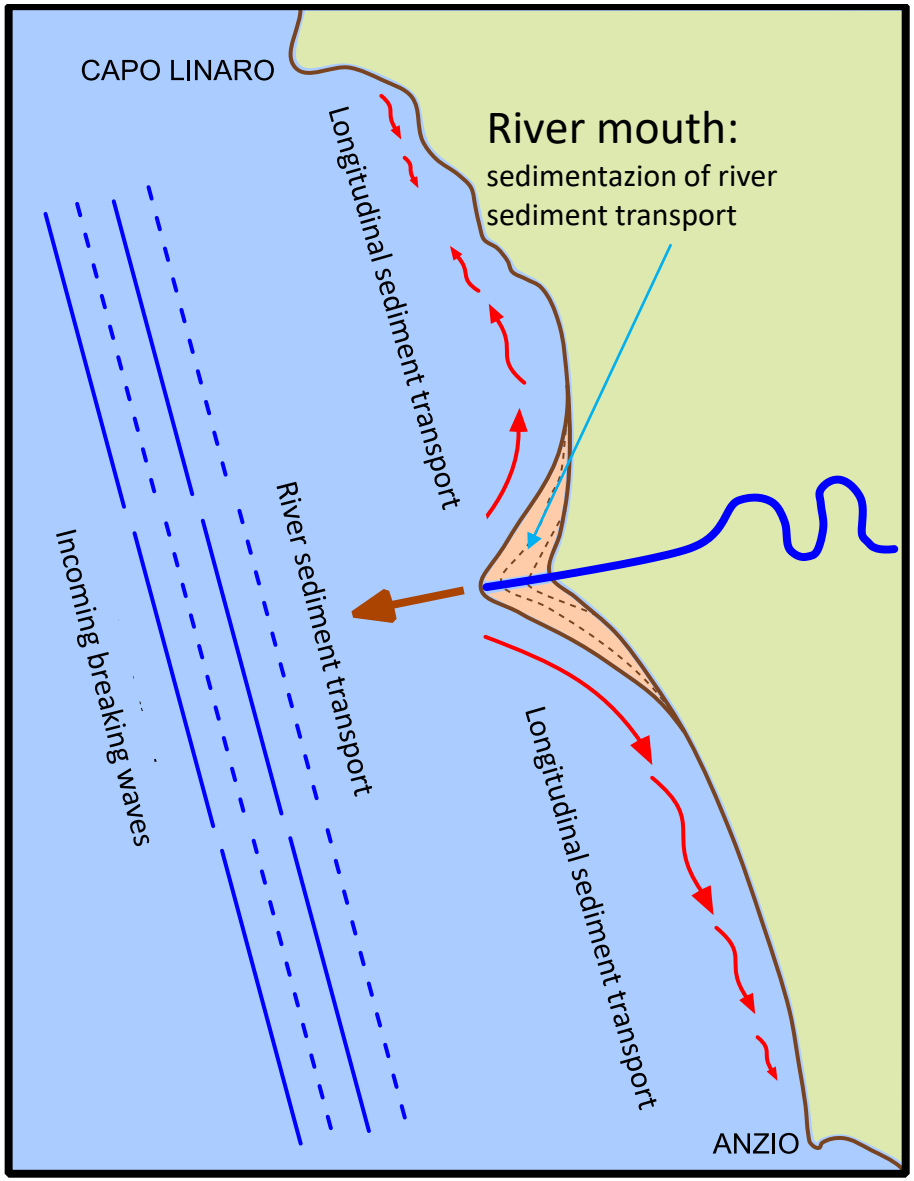


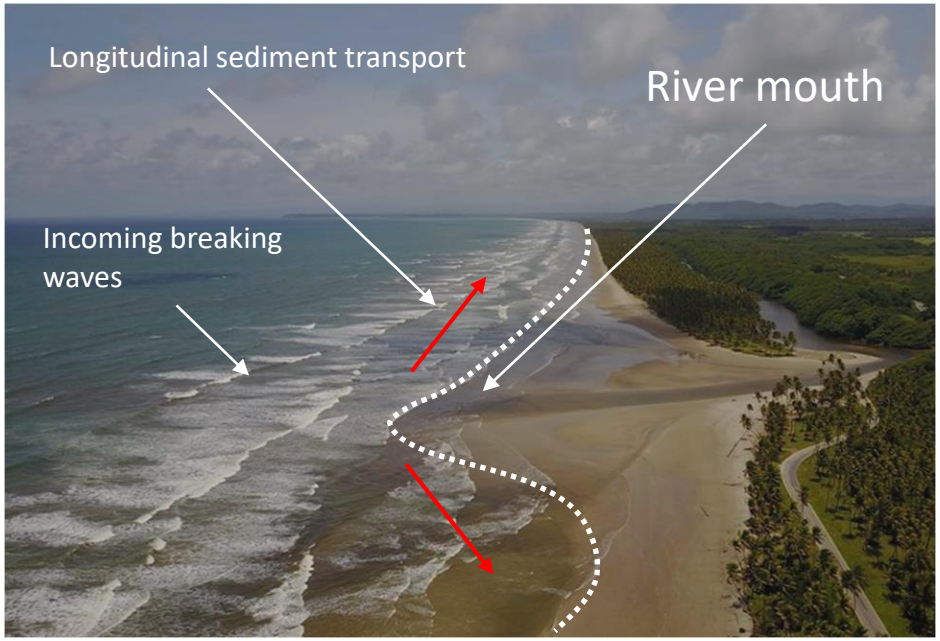
Current position of the coastline

Sea level changes in the last 250,000 years



Natural (without anthropogenic changes) river delta formation





Wave breaking distributes river sediment transport to adjacent coasts

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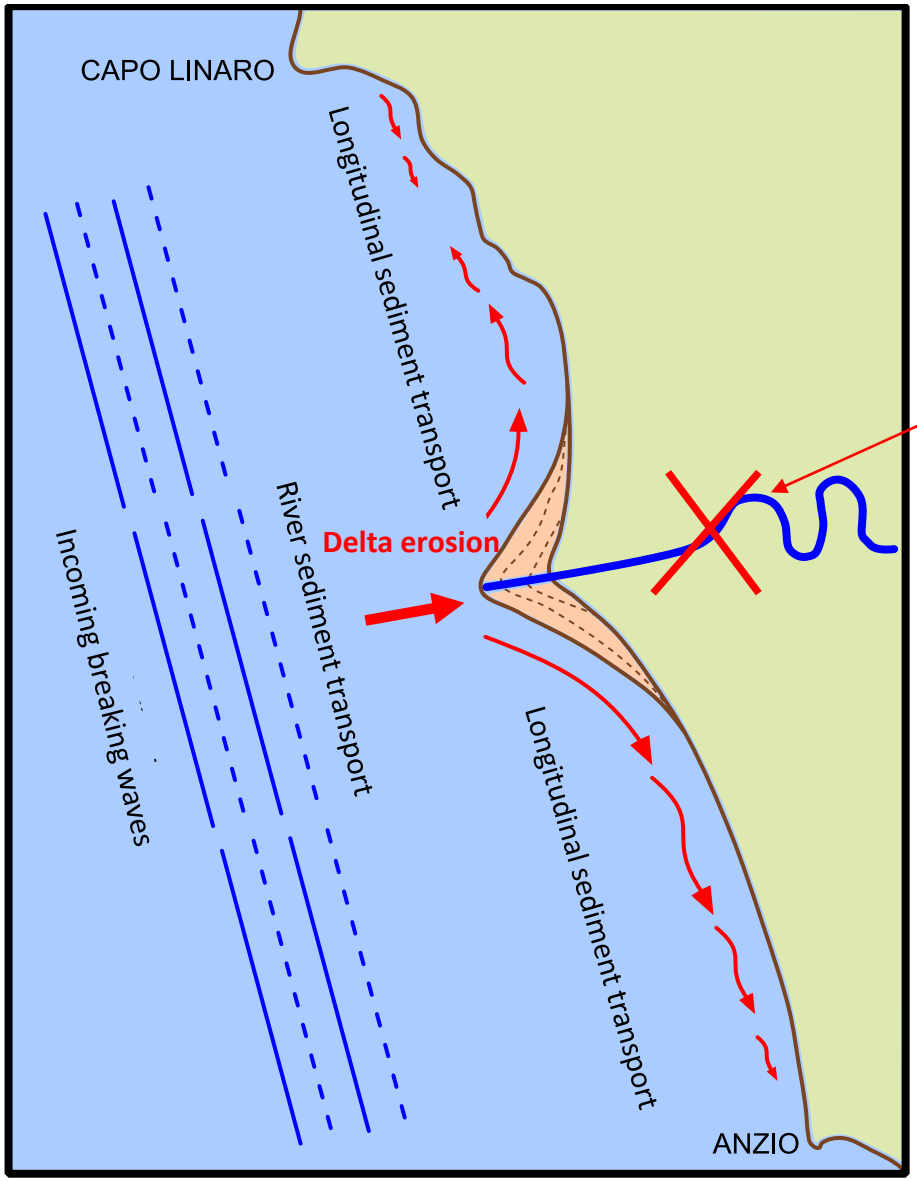
Reduction of river sediment transport induces delta erosion



Rivers no longer carry sediment transport

Delta and coastal erosion

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Anthropogenic causes of river sediment transport reduction

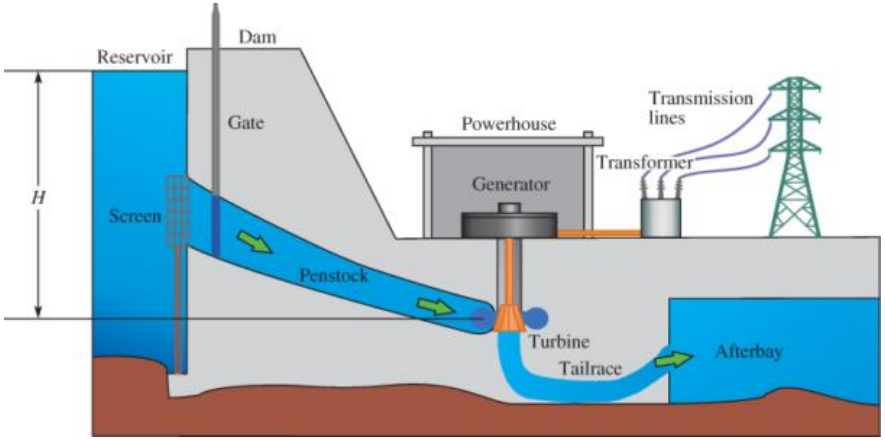
Construction of dams for the creation of artificial water reservoirs

Benefits:

•hydroelectric energy production (green energy renewable)

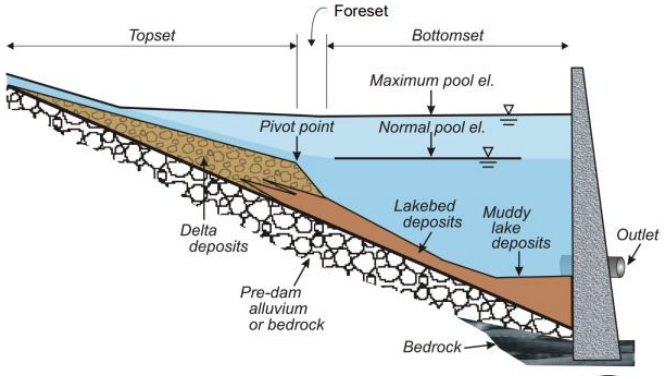
• reduction of river floods (defense from flooding of inhabited areas)

• water reservoirs for irrigation and for drinking water (defense against drought)



Drawbacks:

• **Reduction of river sediment transport: coastal erosion**



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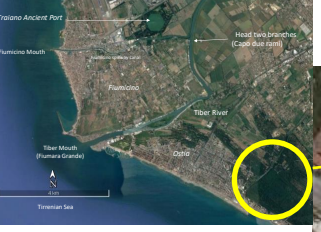


Ostia East side

new coastal road built on the old dunes

border

Natural reserve
Castel Porziano

tourism infrastructures built on the beach

old coastal road built behind the dunes

beach width ≈ only few meters

Sand dunes

beach width ≈200 m

N

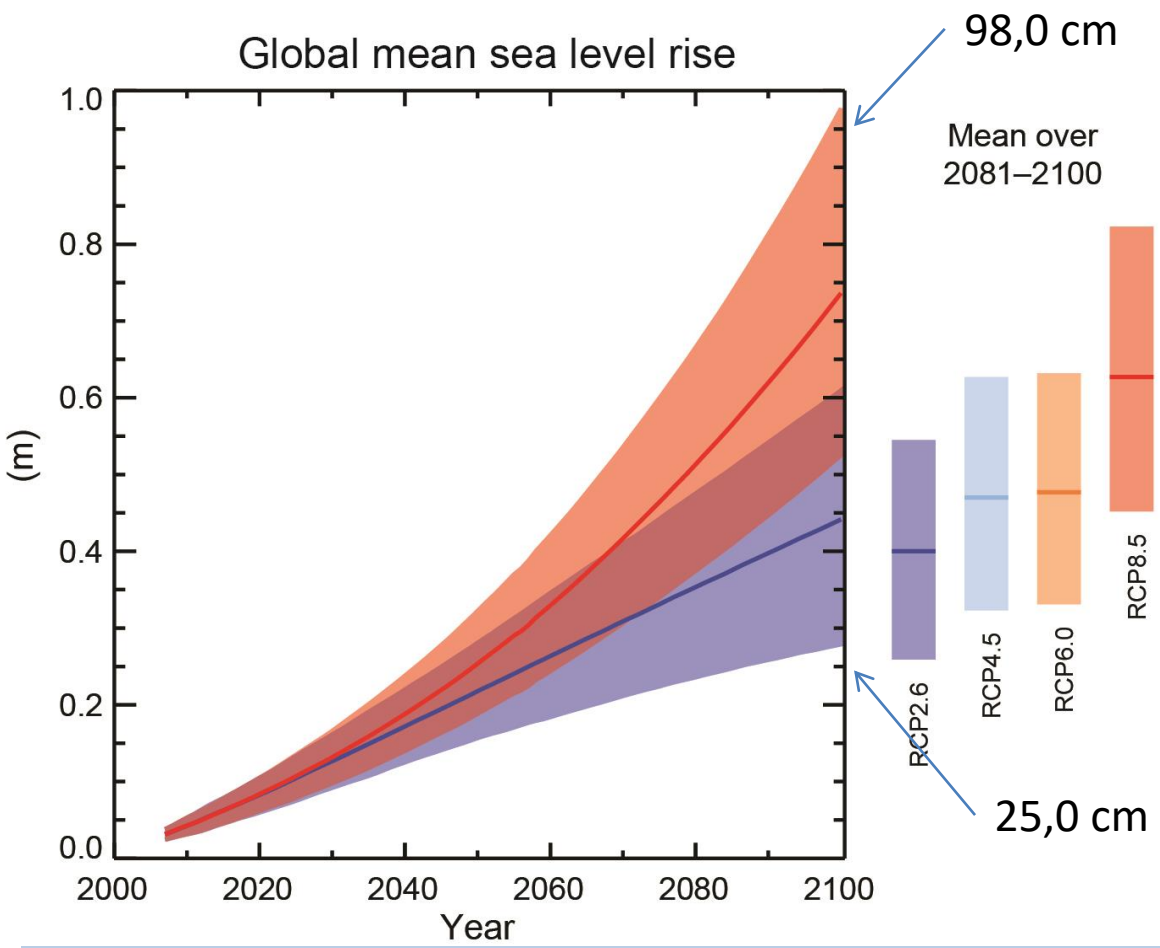
500 m

Infrastructures must be built only far from the coast and provide for comb penetration routes.

What will happen in the future?

The sea level rise in the futures

IPCC = International Panel on climate changes



Representative Concentration Pathway (**RCP**) is a greenhose gas concentration (not emissions) trajectory adopted by the IPCC. Four pathways were used for climate modeling and research for the IPCC fifth Assessment Report (AR5) in 2014. The pathways describe different climate futures, all of which are considered possible depending on the volume of greenhouse gases (GHG) emitted in the years to come. The RCPs – originally RCP2.6, RCP4.5, RCP6, and RCP8.5 – are labelled after a possible range of radiative forcing values in the year 2100 (2.6, 4.5, 6, and 8.5 W/m^2,

Between 25 and 98 cm in 100 years = between 2,5 and 9,8 mm /year

What can we do in the future?

We must reduce the coastal risk, which is function of:

- the hazard and;
- material goods and human life.

The hazard me be reduced only by reducing global warming.

Material goods and human life may be protected by a correct coasts planning and management.

Actions to protect coasts, can be divided into:

a) indirect actions and

b) direct actions

Indirect actions

Indirect actions include laws and regulations aimed at "preventive management of the territory" in a general sense.

For instance:

- limit the reduction of river sediment transport;
- avoid coastal dunes anthropization;
- prohibit the construction of structures on the beaches;
- move back structures and urbanization and prohibit the creation of new infrastructures close to the coasts;
- favor “comb” penetration systems along the coasts.

Direct actions

Direct actions include interventions to control the coastal morphdynamics evolution by stabilizing coastlines which are in a "planimetrically unstable situation" mainly due to the fluvial sediment transport reduction.

These are divided into:

- "**Active defence systems**;
- "**Passive defence interventions**.

"Active defence systems"

The goals of "Active defence systems" are:

- ***pure defence interventions (hard interventions)***;
- ***pure beach nourishment (soft interventions***).

"Active defence systems" can be divided into:

- **hard interventions***:*
  - *a) Detached parallel breakwaters which can be: emerged and submerged;*
  - *b) Groins;*
- **soft interventions**
  - *c) Pure beach nourishment;*
- **Combinations of hard and soft interventions:**
  - *d) Mixed systems given by the combination of a), b) and c);*

and finally:

e) Fixed plants or mobile systems, for the sand by-pass to restore the continuity of the longitudinal sediment transport

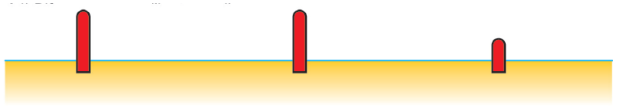
Active defence systems

Hard
Pure defence

Soft
Pure nourishment

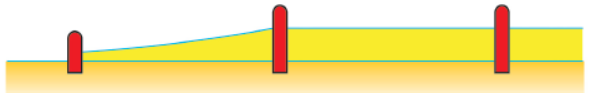
Hard - Soft
Mixed systems

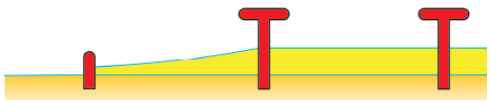
Groins



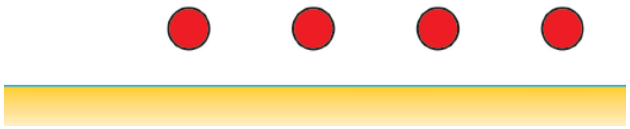
«T»groins

Pure beach nourishment

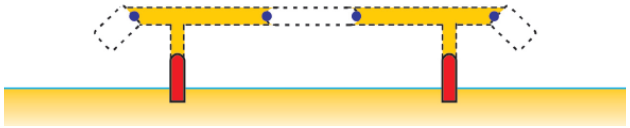


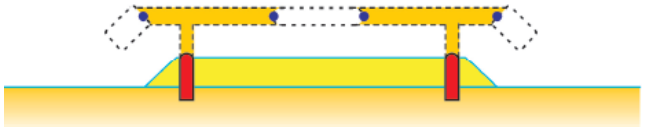


Islets



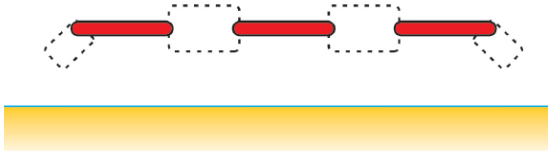
Cells

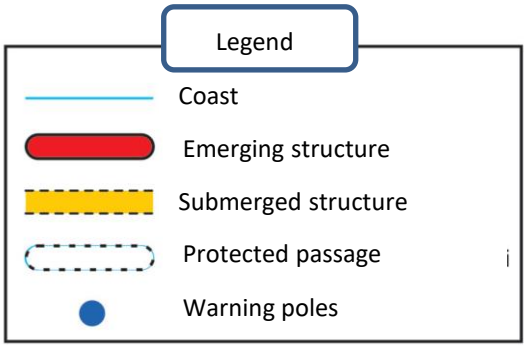




Perched beach

Detached breakwaters





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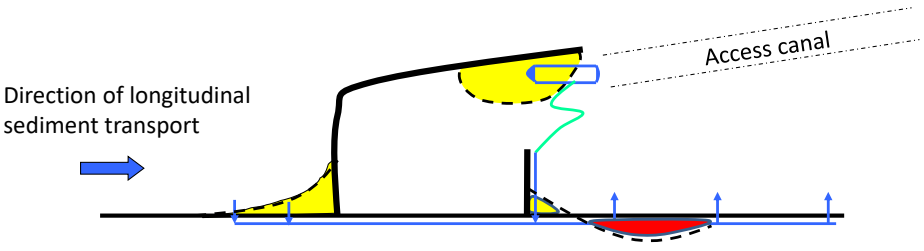
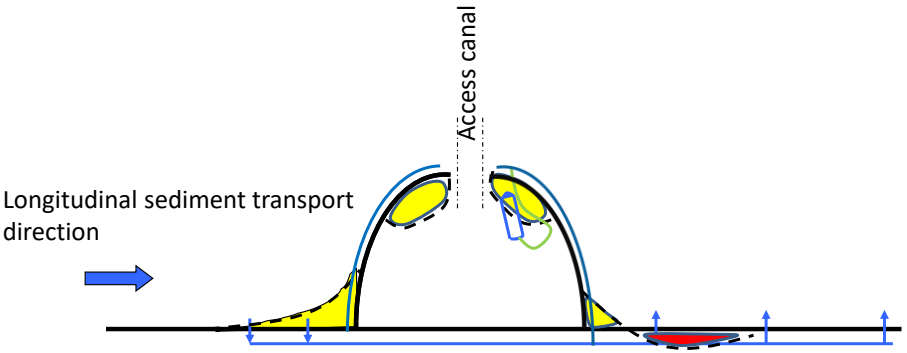
Active defence systems: sand by-pass





Flexible float piping

Fixed piping

Input points of the mixture of water and sand

Points of returning the mixture of water and sand

Suction hopper dredger

Sedimentation areas

Erosion areas

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Passive defence systems

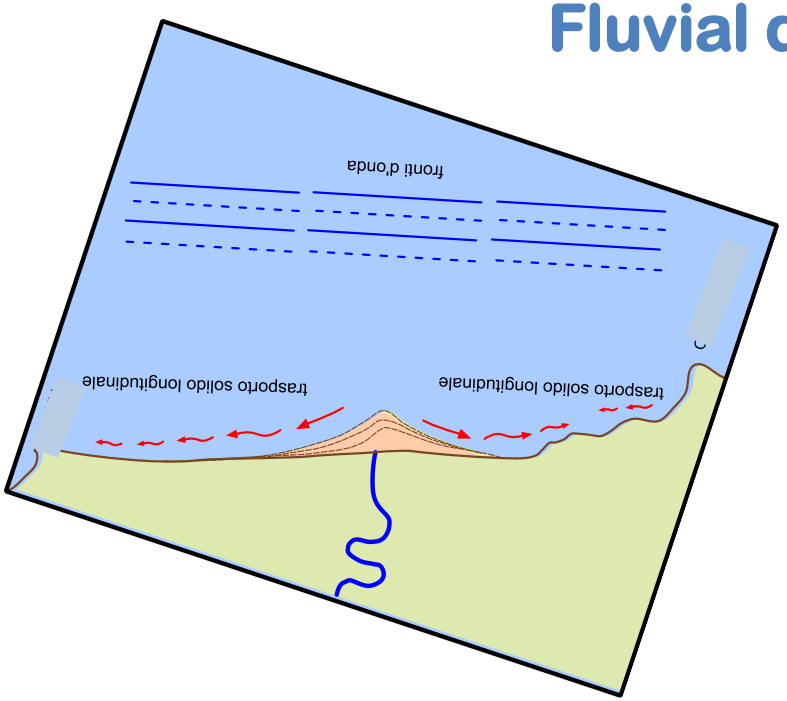
Adherent defences

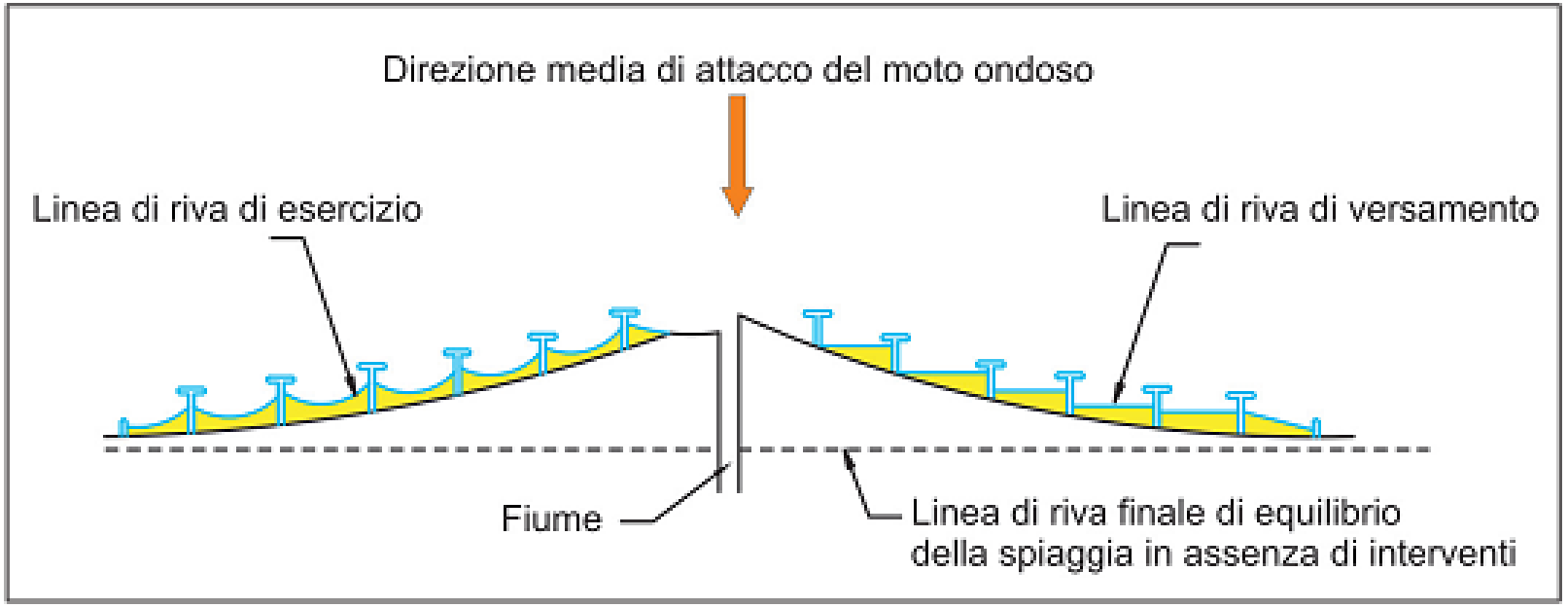
- Natural or artificial breakwaters
- Sea walls made by artificial structures
- Structures integrated with energy converters

Artificial dunes coupled with naturalistic engineering techniques

May be used with any other coastal defence system

Fluvial delta stabilization with groins





22

Coastal beach nourishment and reconstruction and stabilization of dunes with vegetation

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Submerged breakwaters coupled with submerged groins and beach nourishment

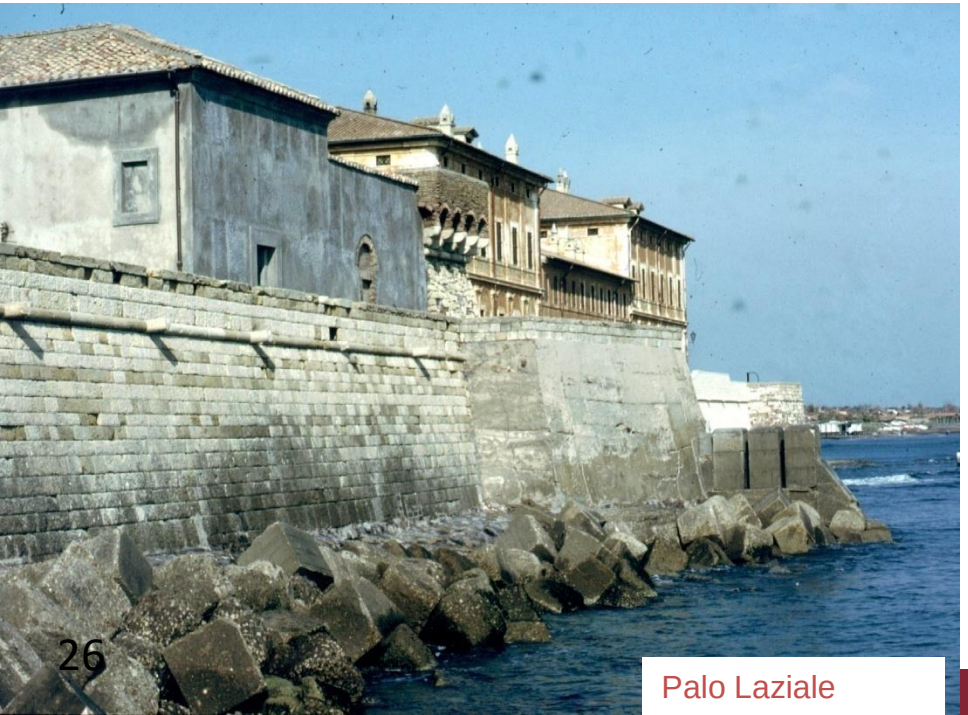
Pellestrina (Venice - Italy)

Example of coastal defense through detached breakwaters

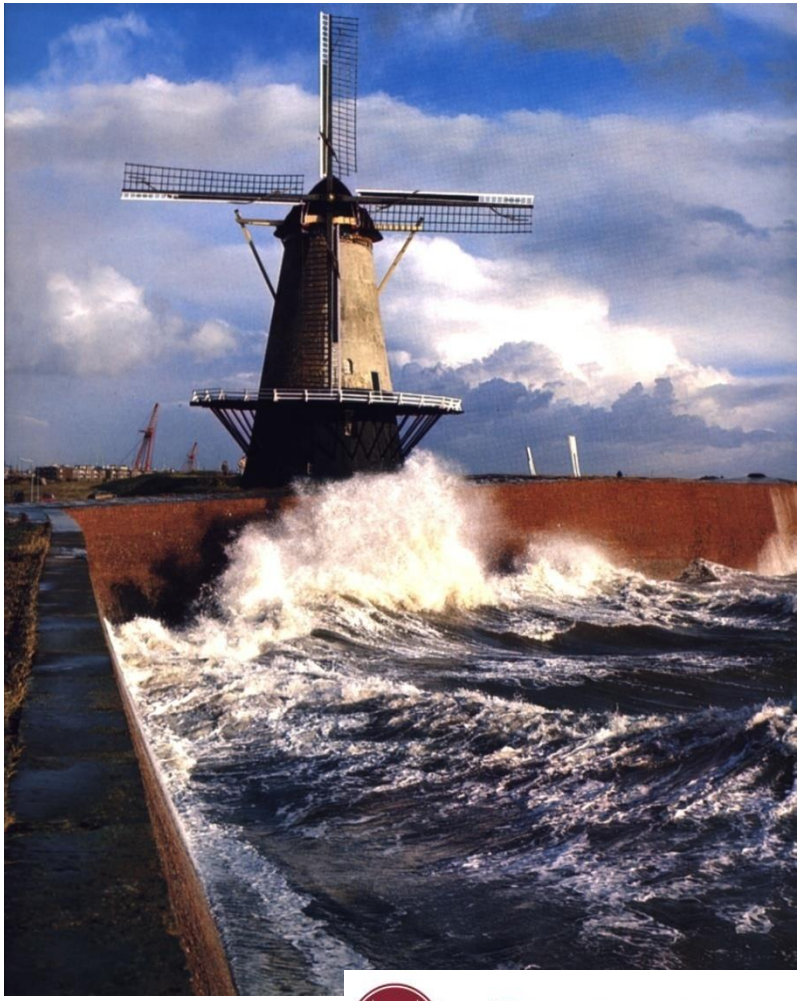
Sistema di barriere distaccate, Fiumicino

Seawalls

Amalfi, Italia, 11 gennaio 1987

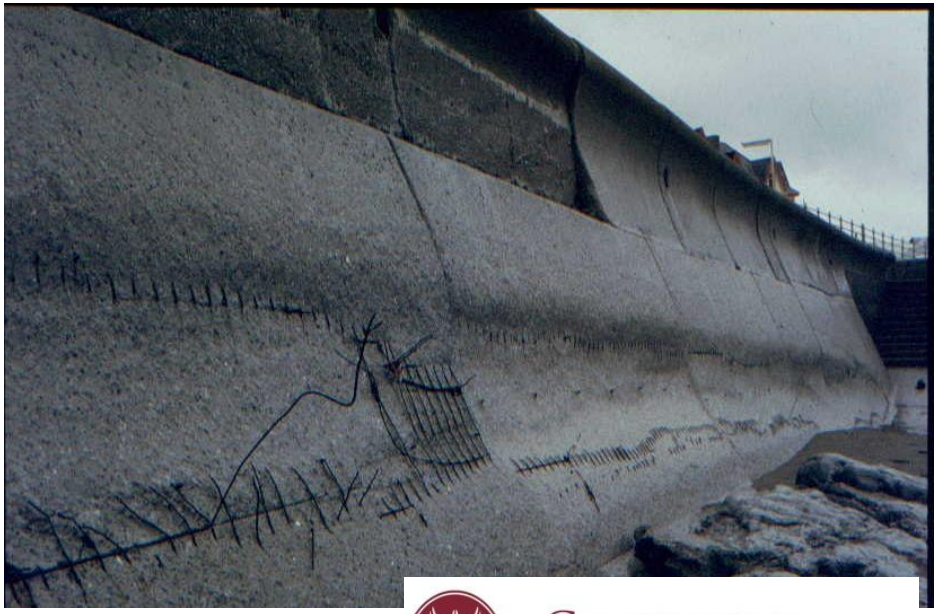


Palo Laziale



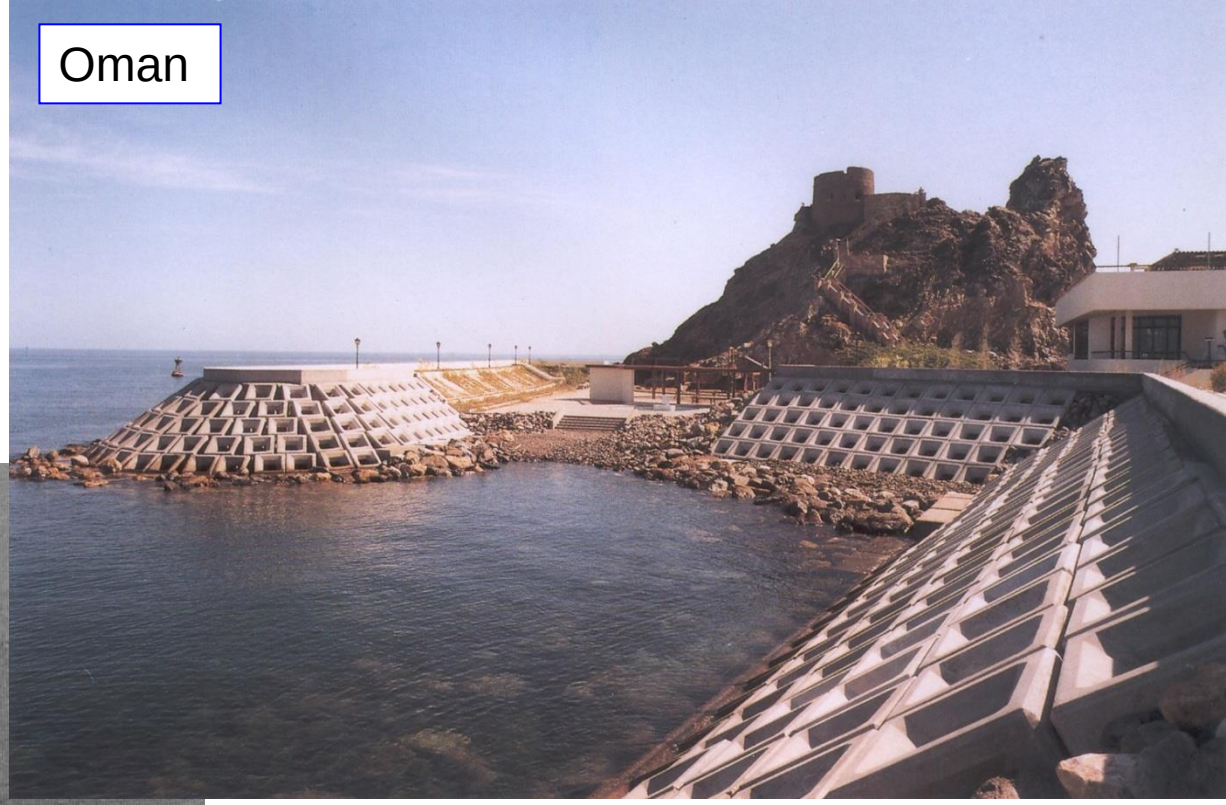
The Netherland

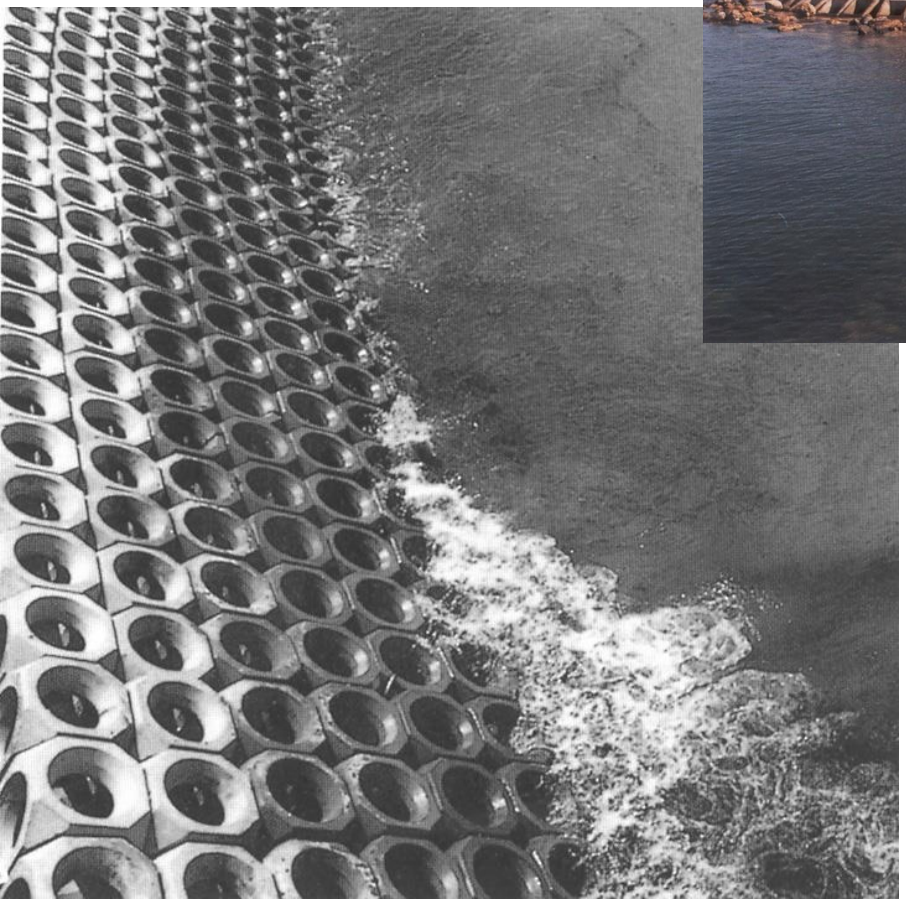
Examples of sea walls in North Europe

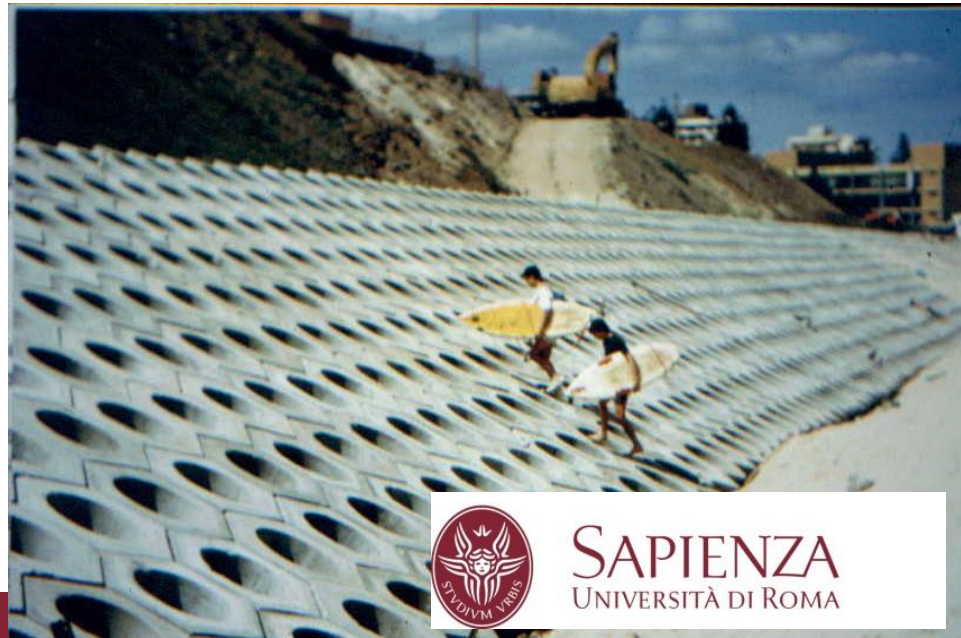


Sea walls made by hollow blocks

Oman







Japan

Stepped defense sea walls

Indicative comparative table between the various coastal protection systems

	Advantages	Drawbacks	Construction costs / Maintenance costs mainly related to sediment loss	Application field
Pure nourishment	Positive impact downstream No visual impact Excellent water exchange	Hard to find large quantity of suitable sediments High sediment loss No coastline stabilization	High High	Bimodal longshore sediment transport Marine areas of high environmental value
Groins	Adaptability over time Good coastline stabilization Good water exchange Biotic repopulation	Low-moderate impact downstream Interference with coast usability Moderate visual impact Moderate sediment loss	Low Medium/Low	Fluvial delta Presence of longshore sediment transport
Cells	Excellent coastline stabilization Almost no sediment loss Biotic repopulation	High impact downstream Interference with coast usability Moderate visual impact Moderate water exchange	Very high Negligible	Protection of infrastructures near the coast Very unstable planimetric position of the coastline New artificial beaches
Emerging detached breakwaters	Good coastline stabilization No Interference with coast usability Biotic repopulation	Very high impact downstream Very high visual impact Very low water exchange	Quite elevate Low	Protection of infrastructures near the coast Very limited longshore sediment transport
Adherent defences	Small or limited impact downstream Excellent water exchange Good coastline stabilization	Very high interf. with coast usability Increase of the beach transversal slope Very high visual impact	Low - Very costly Medium/Low	Protection of built-up areas - Coastal infrastructures
Submerged detached breakwaters	No visual impact Good water exchange Biotic repopulation	Very strong currents in the protected area Safety problems for bathing (rip currents in the passages)	Medium Low	Rocky coasts Pocket beaches

Thanks for your attention