The Mediterranean Sea of the future: climate change and the adaptation of coastal systems

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The future of Sardinia's beaches and coastal ecosystems: what action to take in the face of climate change?– Massama-OR, 30 gennaio 2025

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Swiss Confederation

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01 Coastal systems

02 Lessons from recent past

03 CC effetcs on coasts

04 Adaptation strategies

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What do we mean by coastal system?

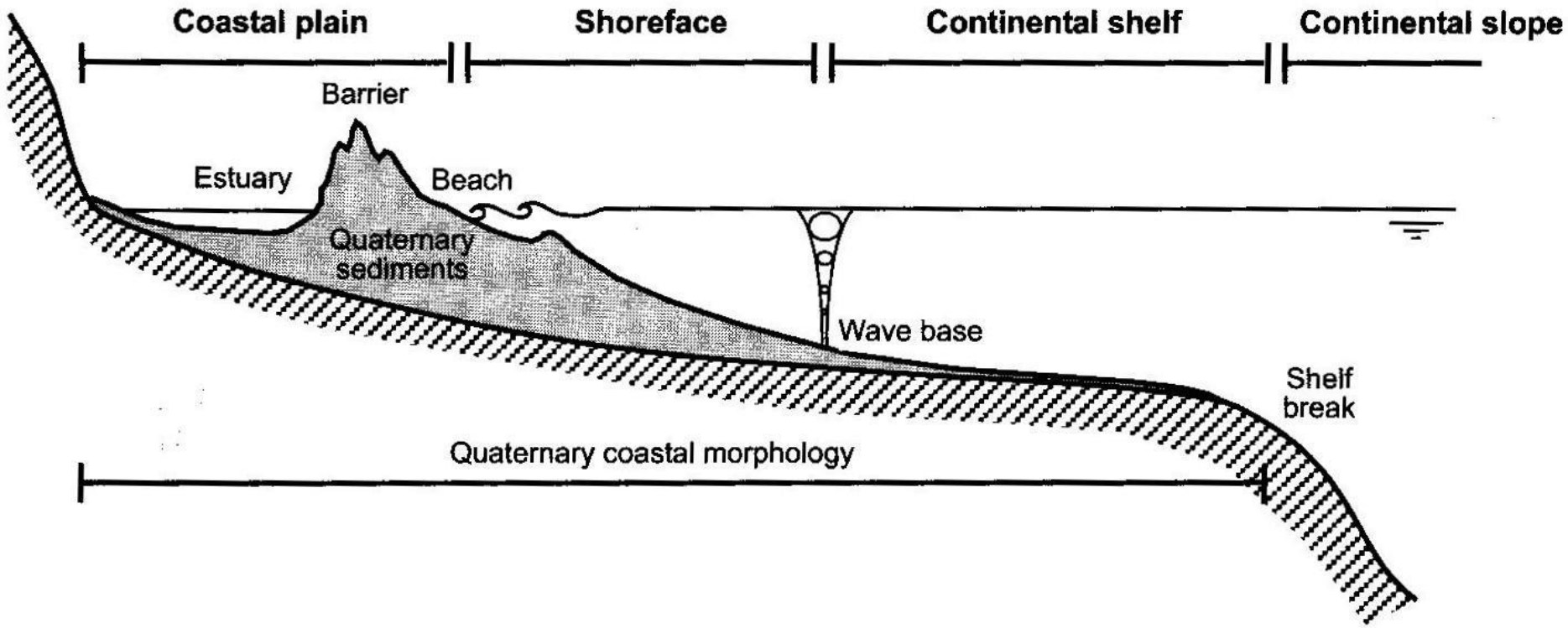

Figure 1.1 – Spatial boundaries of the coastal zone.

The coastal zone encompasses a wide spatial area, defined by the limits in which coastal processes extended during the Quaternary period in relation to sea-level fluctuations.

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When are coastlines changed?
What environmental conditions control the evolution of coastlines?

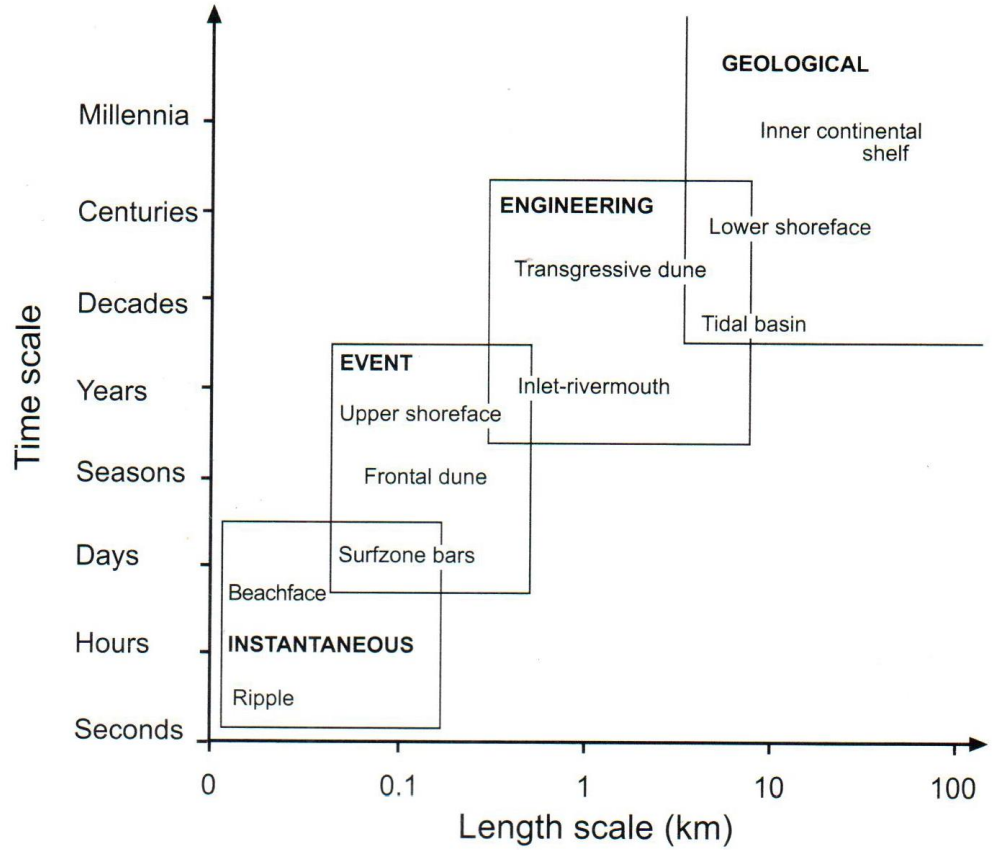

Figure 1.2 – Definition of spatial and temporal scales involved in coastal evolution. Large-scale coastal landforms operate over long time scales, whereas small-scale coastal features respond over short time scales. [From Cowell and Thom, 1994.] [Copyright © 1994 Cambridge University Press, reproduced with permission.]

Typically, these are 'short' time scales from a geological point of view: from instantaneous processes to tens of thousands of years.

ENVIRONMENTAL CONDITIONS

Geology: pre-existing geological and geomorphological characteristics of the coastal zone.

Sediments: they are essential for the formation and evolution of coastal systems, varying in quantity and type.

External forcings: sea level, waves and currents, wind, river inputs.

Coastal ecosystems: sediment production and morphological control.

Time: it determines the evolution of the coastal system.

Human activity also deeply modifies coastal systems.

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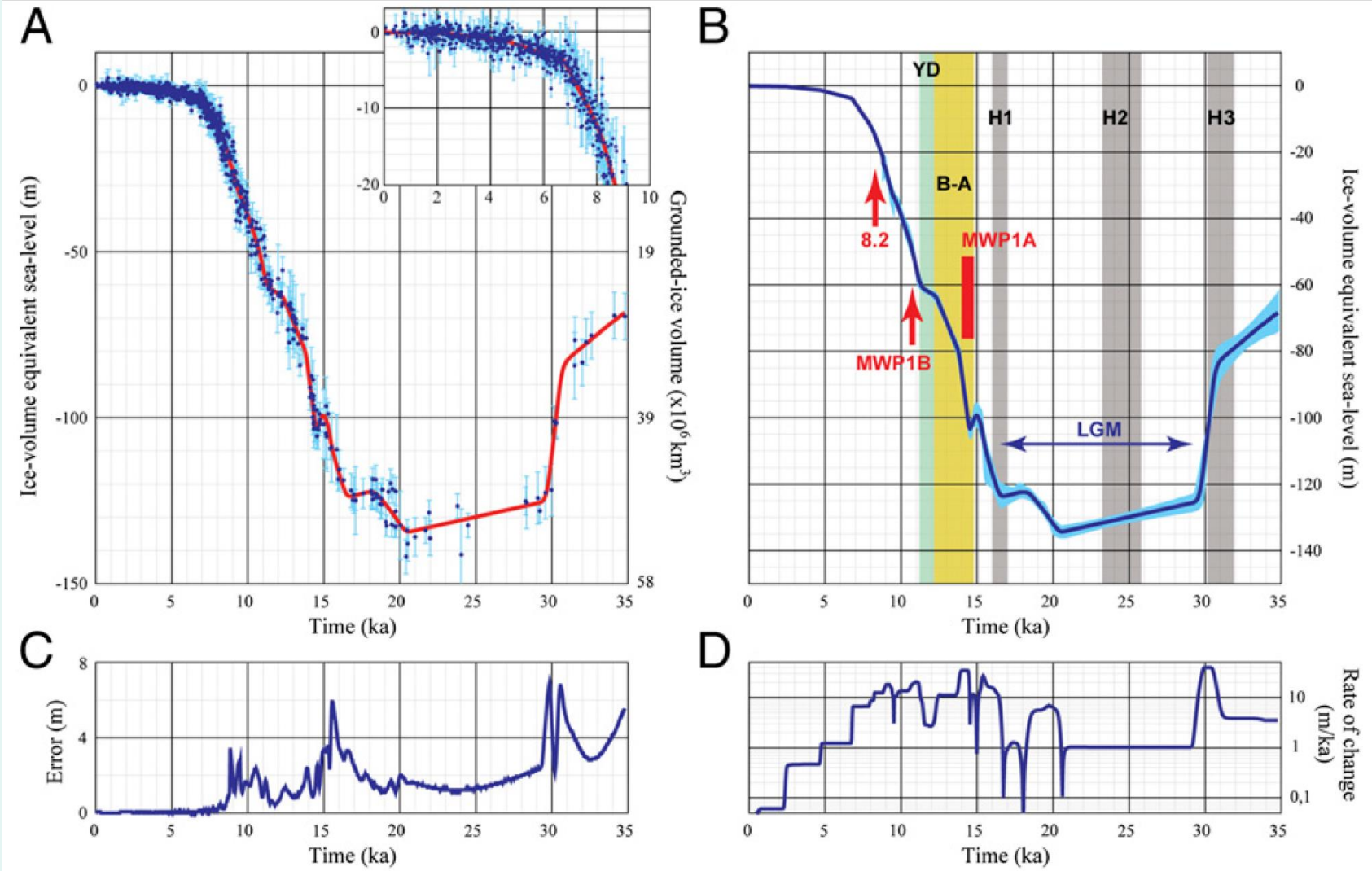
Lessons from recent past



Sea-level rise curves over the last 35,000 years

Over the last 5,000 years the rate of sea level rise has been less than 1 mm/year

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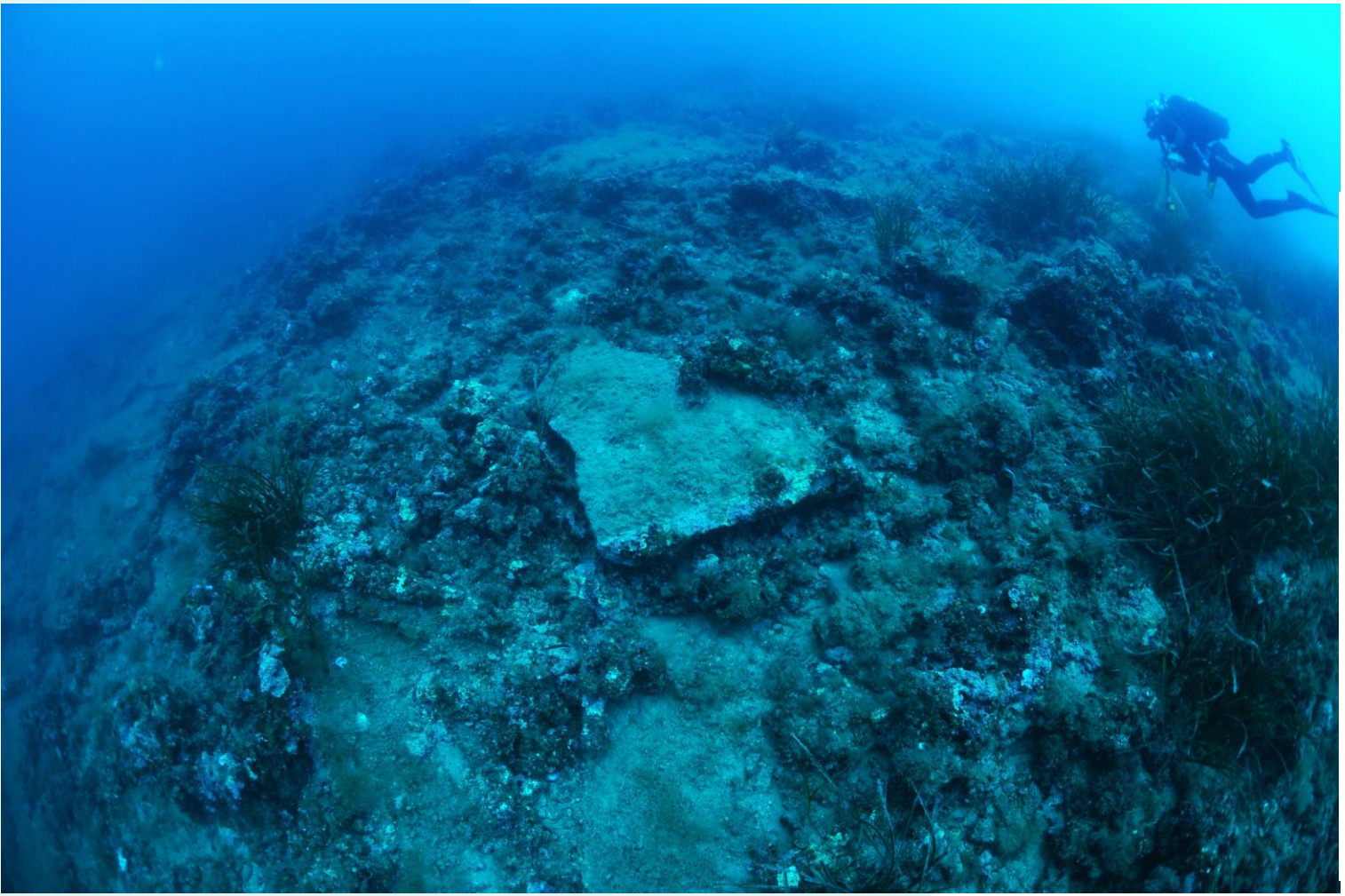
Lessons from recent past



Ancient submerged beaches

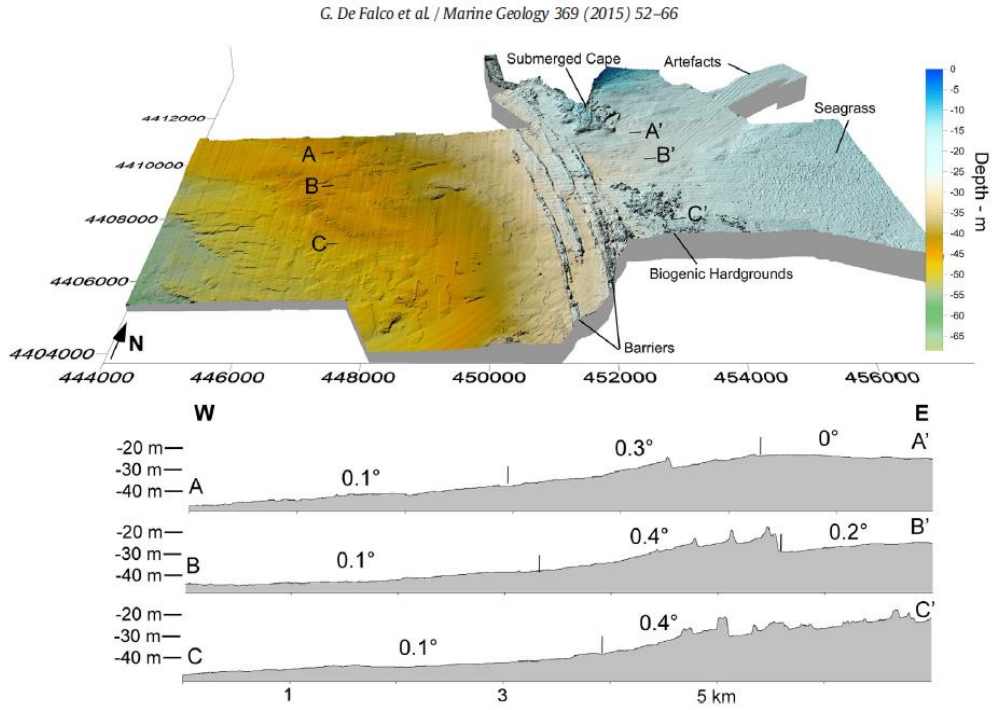


Fig. 2. Three-dimensional view of the seabed with drowned barriers. In the lower part, bathymetric profiles with the seabed gradient values.

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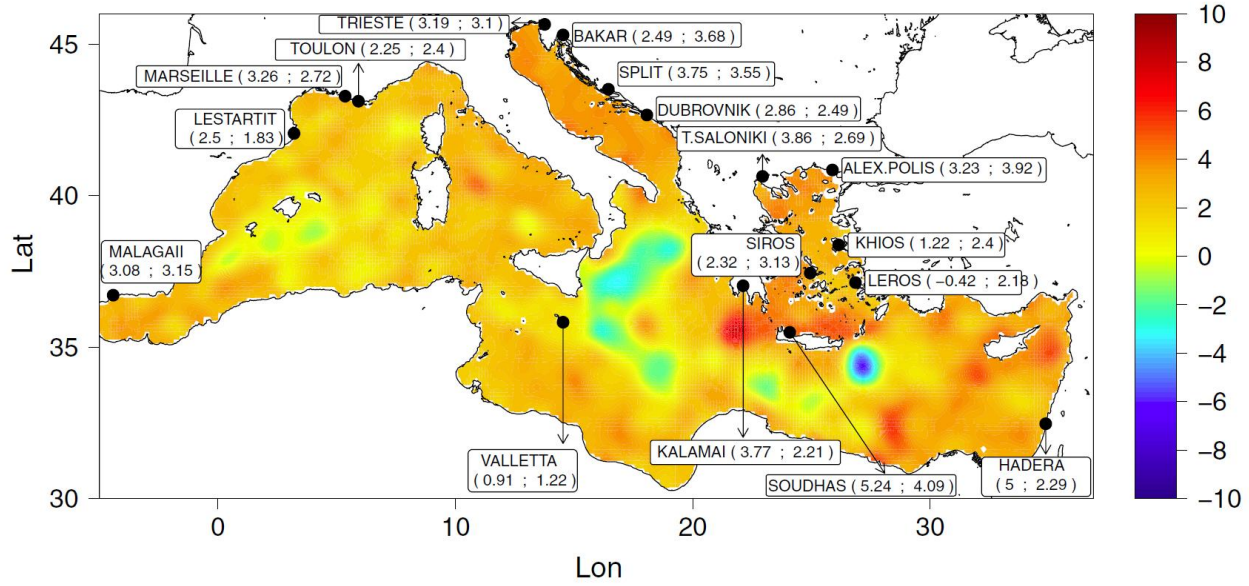
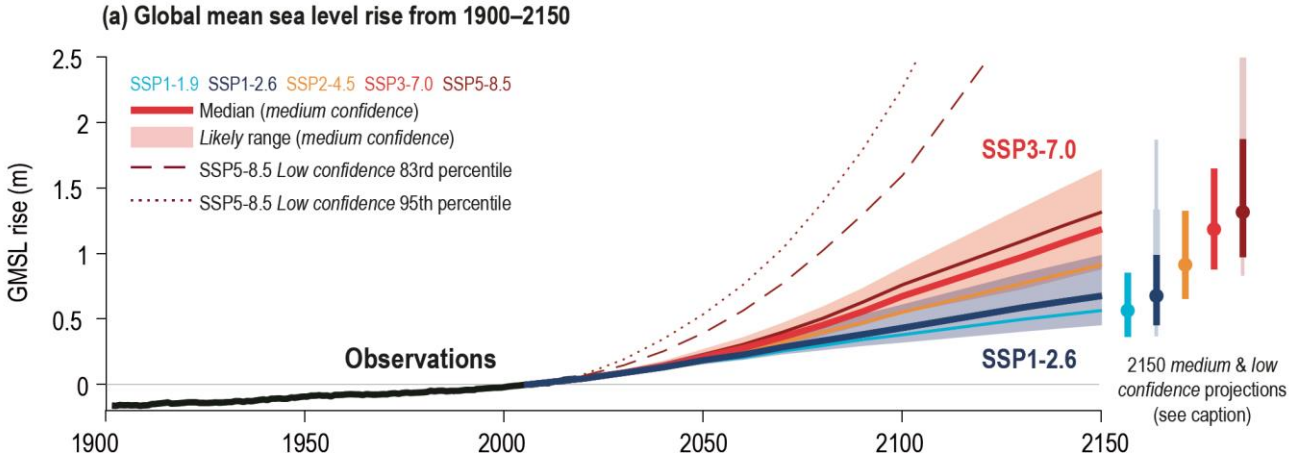
Is the sea level rising?





Sea level measurements indicate an average rise of **0.2m** over the period **1901-2018 (1.7 mm yr-1)**. This is the fastest rise in the last 3 millennia. Since the second half of the 20th century there has been an acceleration, with an average rise rate of the sea level of

2.3 mm yr-1 in the period **1971-2018**,

increasing to

3.7 mm yr-1 in the period **2006-2018**.

<u>A great acceleration is taking place</u>

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CC effects on coasts

Potential impact	Main factor
Flooding of low-lying areas above sea level	Sea level rise (SLR)
Flash flooding and/or erosion and/or retreat due to ineffective coastal defences	SLR, increased intensity and frequency of storms and increased storm surge
Shoreline retreat	SLR, change in sediment transport regimes
Increased erosion due to storms	Increased intensity and frequency of storms and increased storm surge; modification of wave regimes
realignment of beach scour	Modification of wave regimes (direction and origin)

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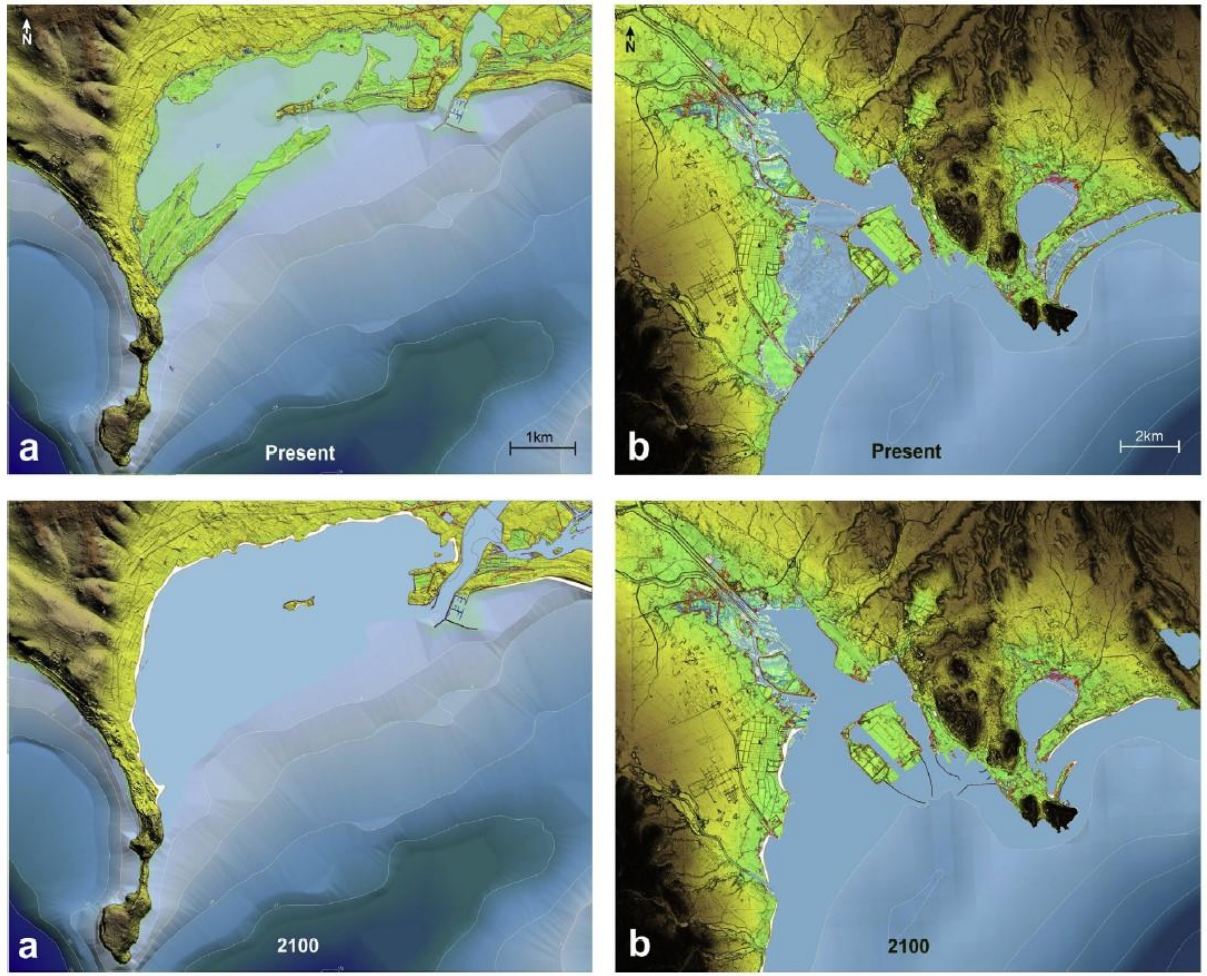
CC effects on coasts



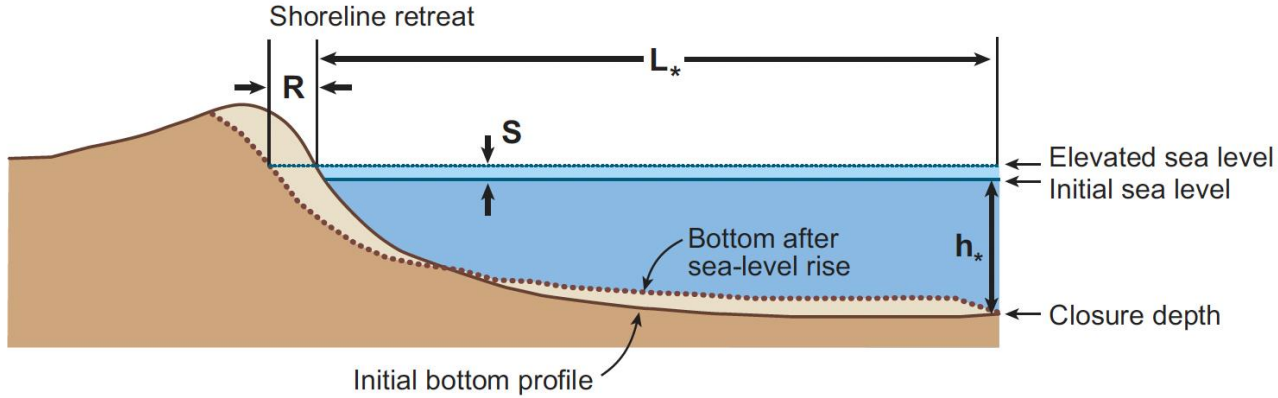
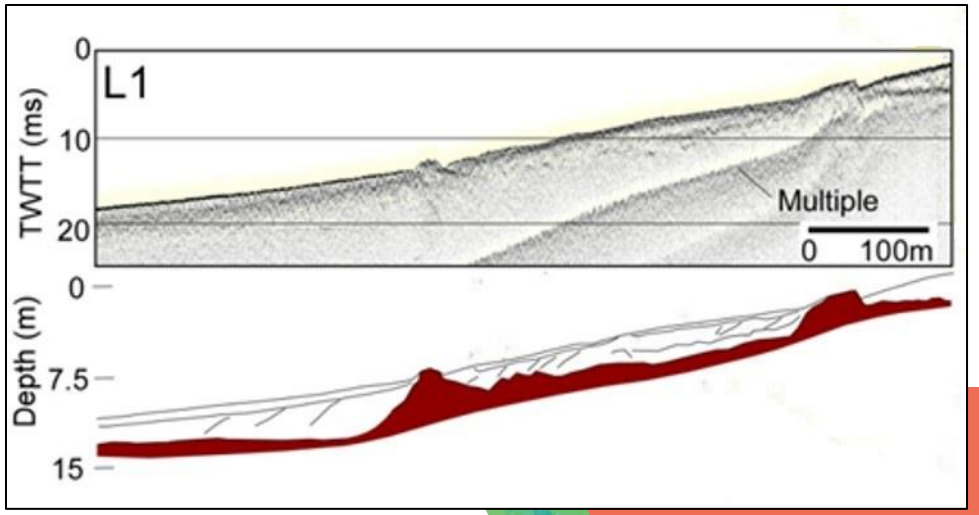


Figure 5

The Bruun rule of shoreline retreat (after Cooper & Pilkey 2004).



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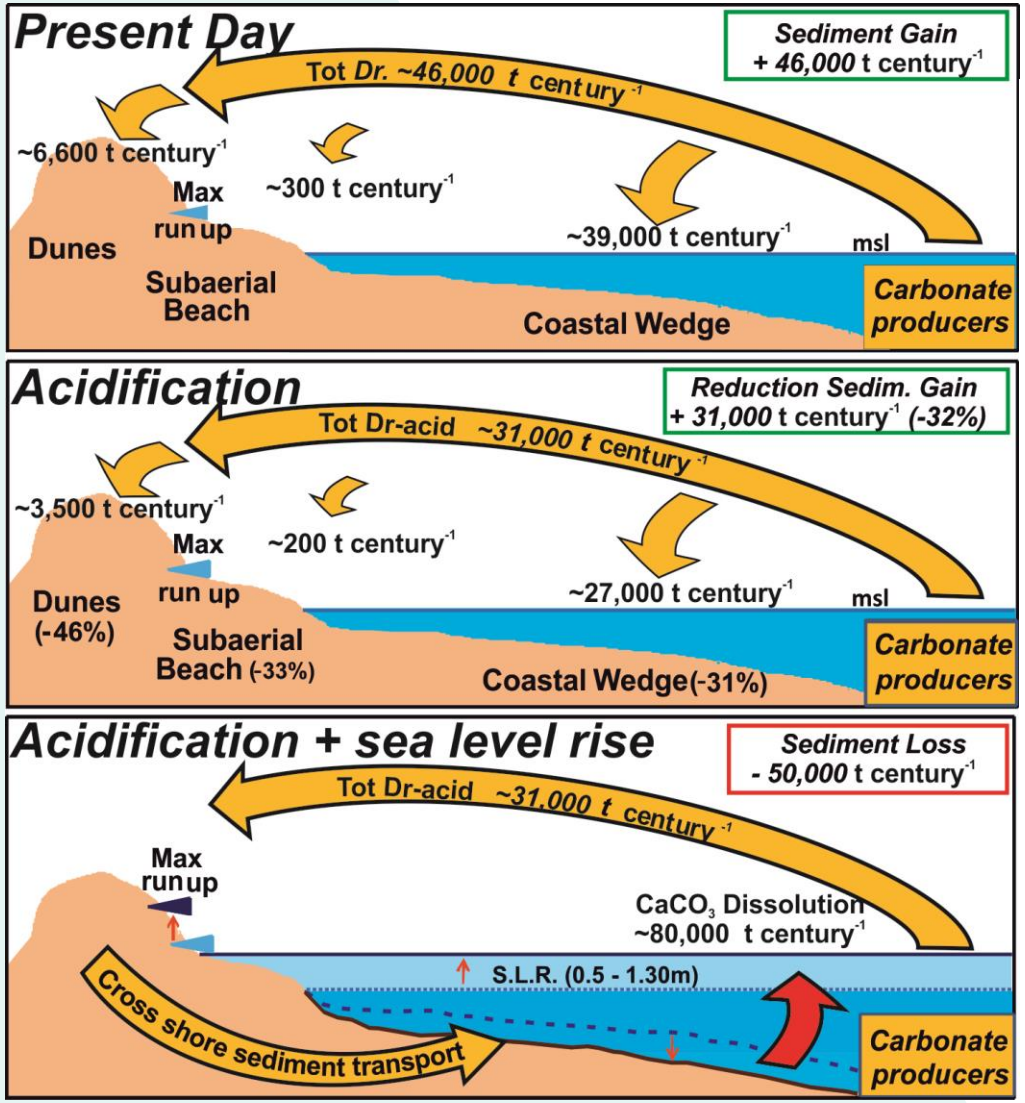
Carbonate beaches at risk from rising CO_2



Giovanni De Falco

Molluscs	Calcifying Algae	Benthic Foraminifera	Echinoids	Bryozoans

L'acidificazione degli oceani amplifica l'effetto dell'innalzamento del livello del mare sull'erosione di spiagge e dune

8.1

pH

7.7

Passaggio da un sistema in accrescimento a un sistema in erosione

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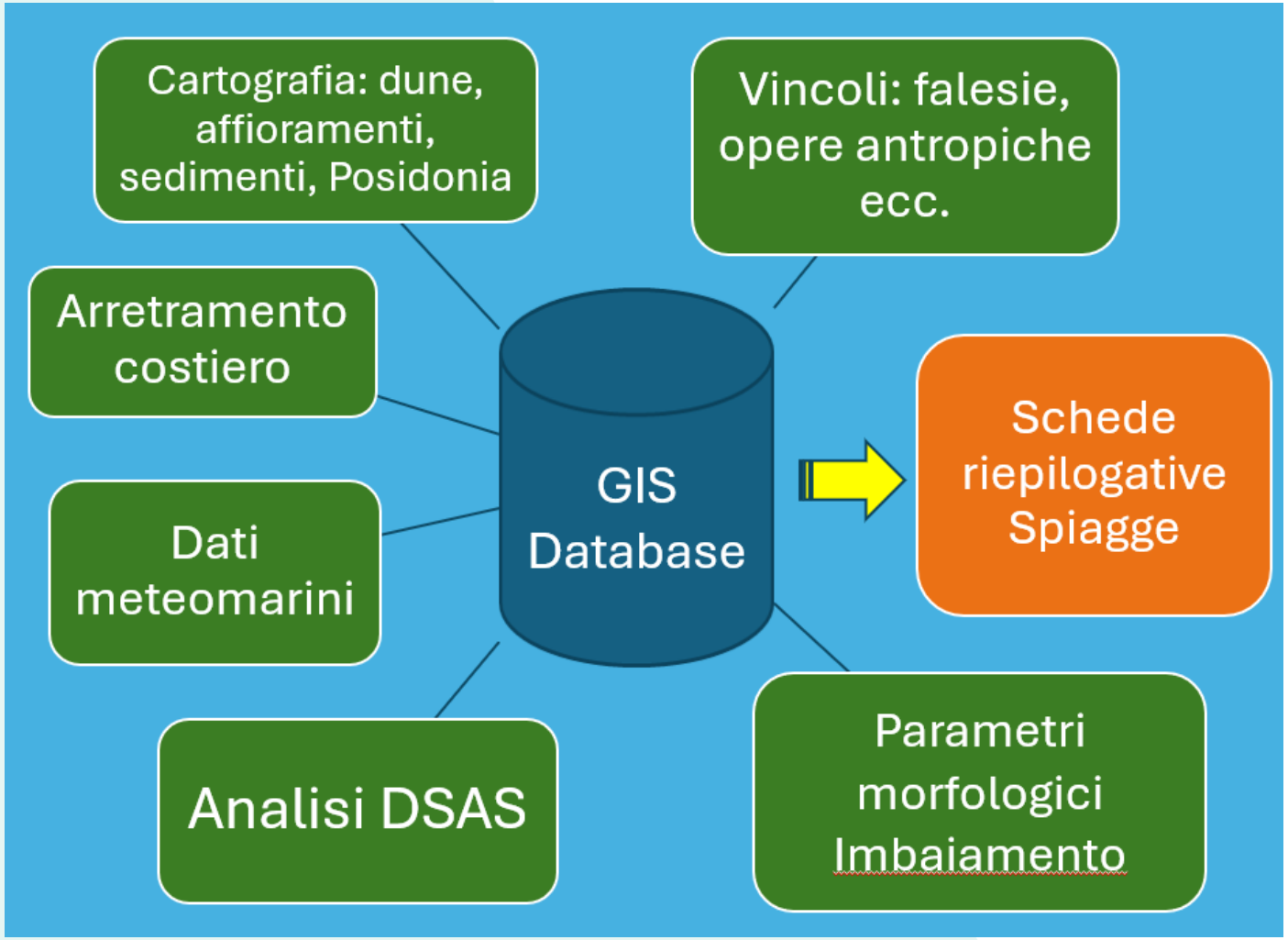
Adaptation and resilience of Sardinian beaches to climate change



CLIMATE CHANGE ADAPTATION INFORMATION SYSTEM FOR BEACHES IN SARDINIA

Retreat of beaches due to sea level rise Expansion of inundated areas as a result of storm surges;

The assessment will be carried out taking into account the site-specific characteristics of Sardinian beaches;

Identification of adaptation strategies based on the use of coastal space;

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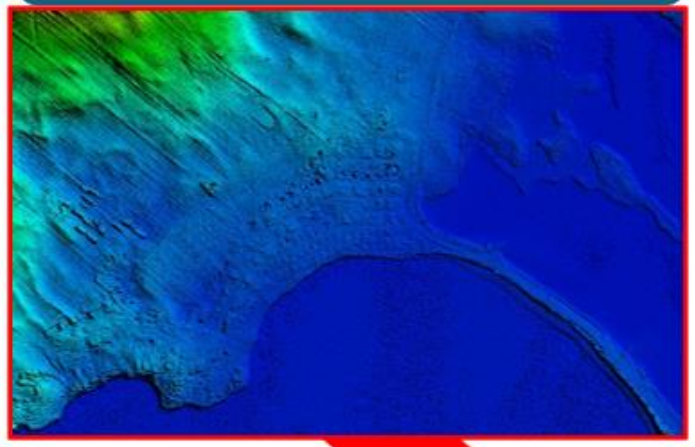
Cartography and meteomarine data

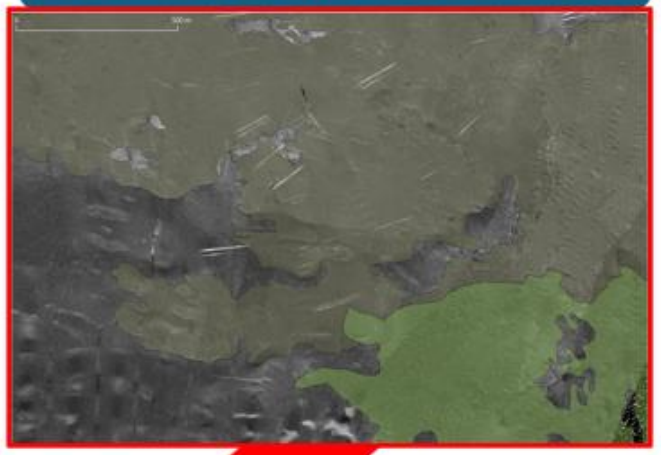
Area emersa:

DTM Lidar, Rilievi GNSS

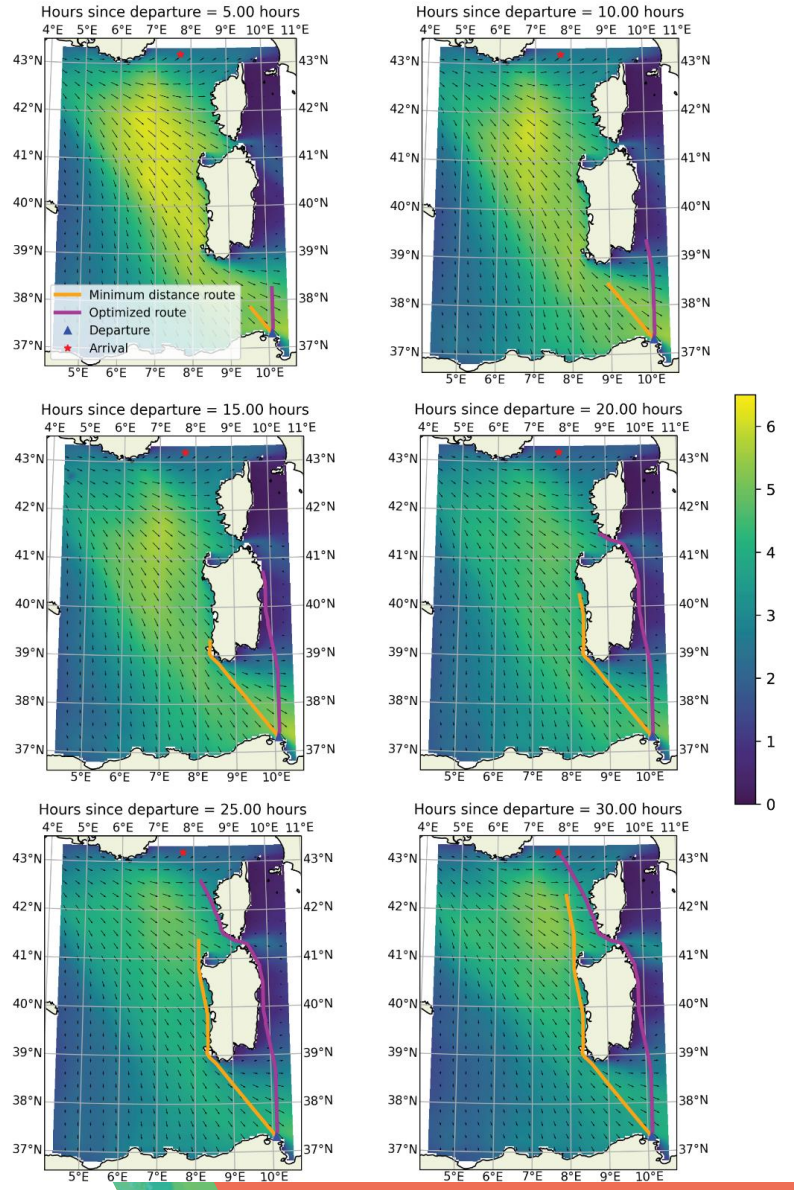


Area sommersa:

Batimetria, DTM MBES



Morfologia
Habitat,
Pendenze,
Ecc.



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Geomorphological parameters

Ro: Headland spacing - Length between the two headlands defining the inlet.

a: Bay indentation - maximum width of the bay indentation.

S1: Total length of the inlet (headlands and emerged beach).

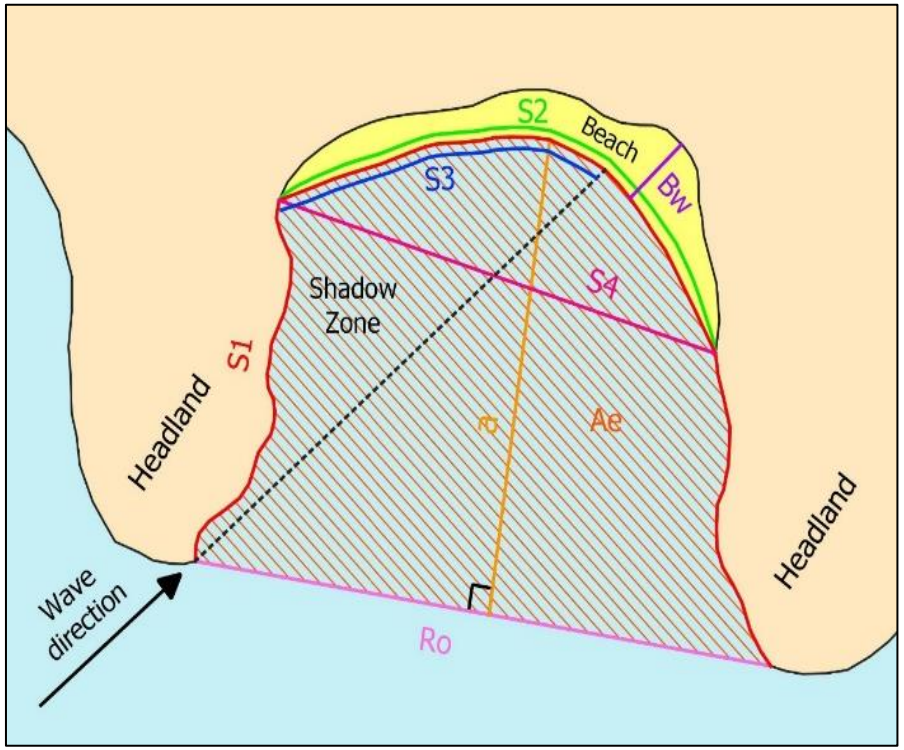
S2: Total length of emerged beach.

S3: Length of the shaded section of the emerged beach.

S4: Linear distance between the start and end point of the emerged beach.

Bw: Maximum width of the emerged beach.

Ae: Bay area.



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Shoreline Variation

DSAS v.6.0

A desktop application that complements any GIS software

Analysis of time series of aerial photographs of the region of Sardinia using GIS applications

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Shoreline retreat

Calculation of shoreline retreat in relation to sea level rise by applying specific algorithms depending on the type of beach.

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Information System

Legenda

- Linea di Riva attuale (DGBT 10K 2022)

DSAS

- Transetti (n.76)
- Variazione della posizione della Linea di riva: 20 m*
- SCE (max-min): 16 (29-3)

Posizione storica della linea di riva

- 1954
- 1968
- 1977
- 1997
- 1998
- 2004
- 2005
- 2006
- 2008
- 2010
- 2013
- 2016
- 2019
- 2021

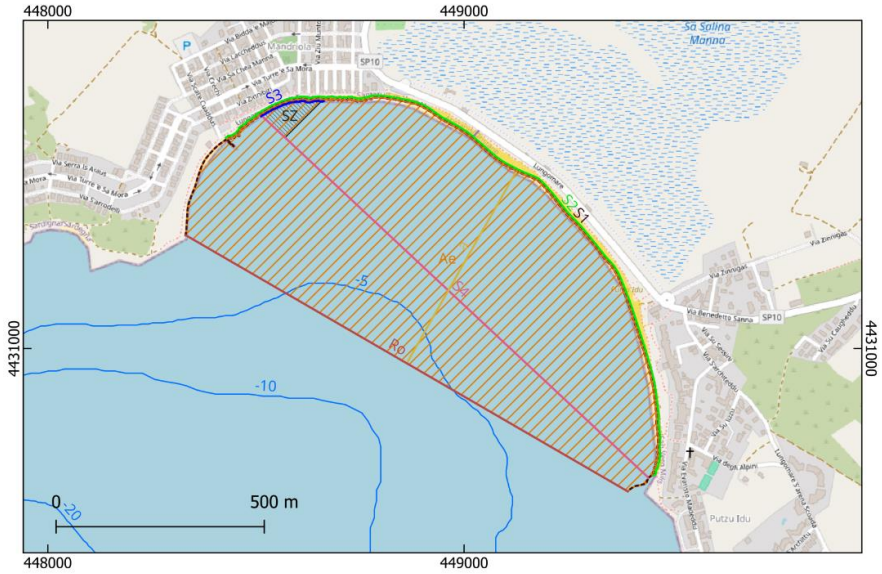
Nome: Putzu Idu (02A - 001)
Comune: SAN VERO MILIS

SCALA 1:10.000

RIEPILOGO PARAMETRI

Ro: 1228.5 m
a: 531.97 m
S1: 2100.13 m
S2: 1711.5 m
S3: 168.68 m
S4: 1278.25 m
Bw: 23.29 m
Ae: 572800.45 mq
γe (Indice di imbaiamento): 0.7
I (Rapporto massimo di rientanza): 0.43
SCE (max-min): 16 (29-3)
NSM - Movimento della linea di riva (max-min): 1 (11,-10)
Vincoli: PI / P.o.
R - Arretramento stimanto: -20 m*

Summary sheets



Legenda

- Linea di Riva attuale (DGBT 10K 2022)

Parametri misurati (Fellows et al., 2019)

- Ro - Headland spacing: 1228.5 m
- a - Bay Indentation: 531.97 m
- S1 - Total length of the embayment: 2100.13 m
- S2 - Total length of the emerged beach: 1711.5 m
- S3 - Length of the shadow stretch: 168.68 m
- S4 - Linear distance: 1278.25 m
- Bw - Maximum width: 23.29 m
- Ae - Embayment area: 572800.45 mq
- SZ - Shadow zone: 6778.52 mq

Interaction between beach and coastal/backshore artefacts

Identification of specific NBS for adaptation

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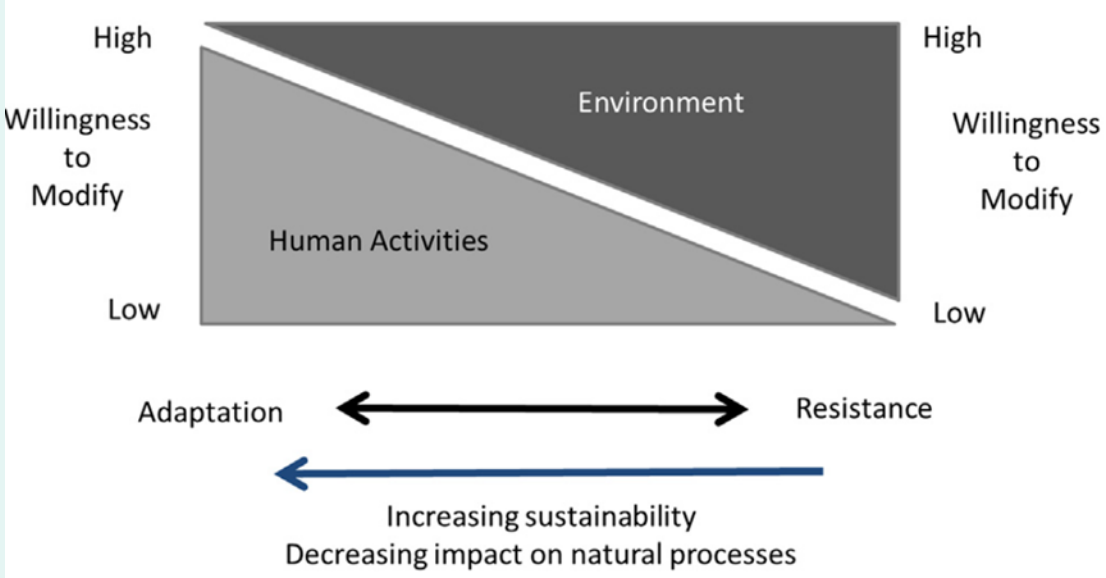
Adattamento vs. Resistenza



Due approcci contrastanti:

Intervenire sulle attività umane: comportano il cambiamento delle attività umane per adattarle alle esigenze dell'ambiente in evoluzione (ad esempio progettazione innovativa degli edifici, ricollocazione di infrastrutture e/o persone, modifica dell'uso del territorio (**ADATTAMENTO**).

Intervenire sull'ambiente fisico costiero: costruire o rafforzare le difese contro le inondazioni, costruire o rafforzare dighe marine, ripascimento delle spiagge) che implicano la resistenza ambientale al fine di preservare le infrastrutture esistenti e le attività umane (RESISTENZA).

La maggior parte delle azioni di adattamento sono di **RESISTENZA** con l'obiettivo di preservare le attività umane e le infrastrutture e non sono sostenibili, comportano costi significativi e aumentano il rischio futuro di danni ambientali.

Le misure che comportano l'**ADATTAMENTO** delle attività umane in risposta ai cambiamenti dell'ambiente costiero saranno probabilmente maggiormente sostenibili a lungo termine, ma sono politicamente più difficili da attuare.

Cooper and Pile, 2014

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Possible Nature-Based Solution

- Identifying coastal areas vulnerable to climate change
- Preserve and protect semi-natural beaches
- Preserve natural coastal system components that promote coastal resilience: (e.g. dunes, ecosystems)
- Allow coastal systems the space they need to adapt to changes
- Have adequate sediment management plans in place

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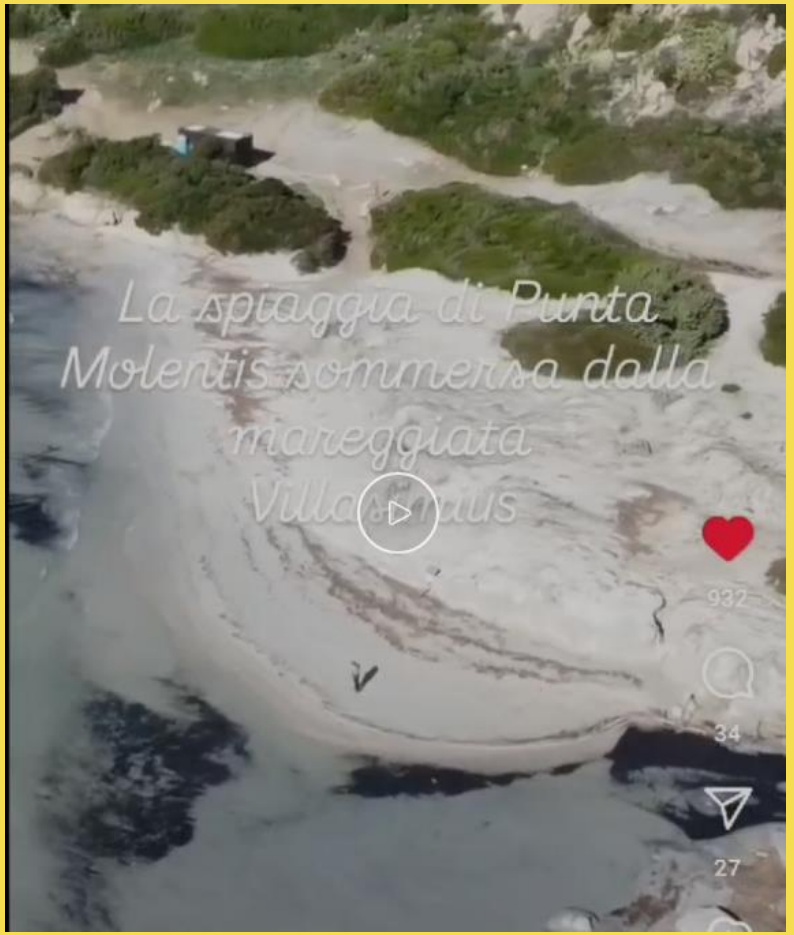

Thank you for your attention

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