



Università  
di Genova

DICCA DIPARTIMENTO  
DI INGEGNERIA CIVILE, CHIMICA  
E AMBIENTALE

# CENNI DI MORFODINAMICA COSTIERA: CAUSE E POSSIBILI INTERVENTI DI MITIGAZIONE

Ordine Geologi Liguria

Ordine Ingegneri Province di Imperia e Savona

Ing. Francesco De Leo

[francesco.deleo@unige.it](mailto:francesco.deleo@unige.it)

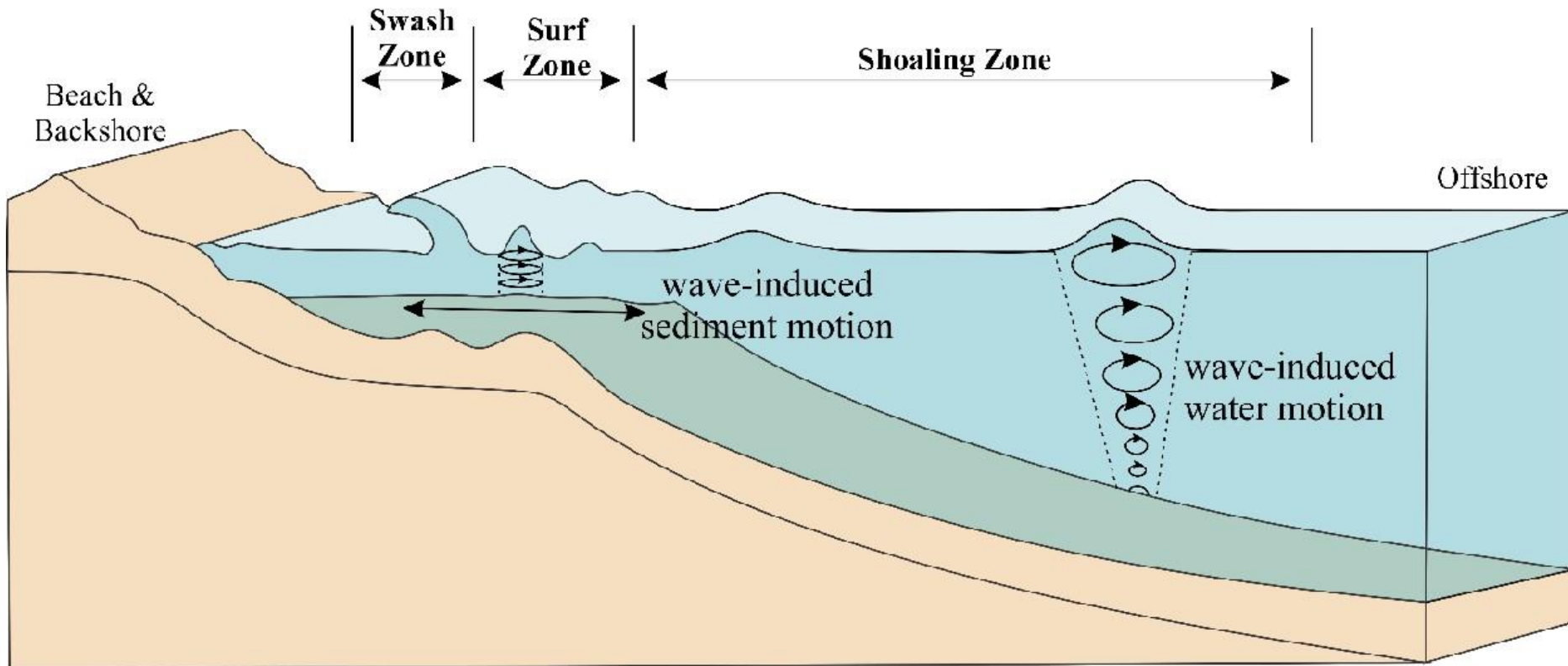
*Albenga, 29/11/2024*



## MORFODINAMICA COSTIERA: UN PROBLEMA ARTICOLATO

- Quali sono i fattori che determinano la morfodinamica delle spiagge?
  - *morfologia della costa*
  - *forzanti meteo-marine*
- Le diverse scale spazio-temporali coinvolte
  - *fenomeni nel lungo periodo*
  - *fenomeni puntuali*
- Possibili interventi di mitigazione
  - «*soft engineering*»
  - «*hard engineering*»

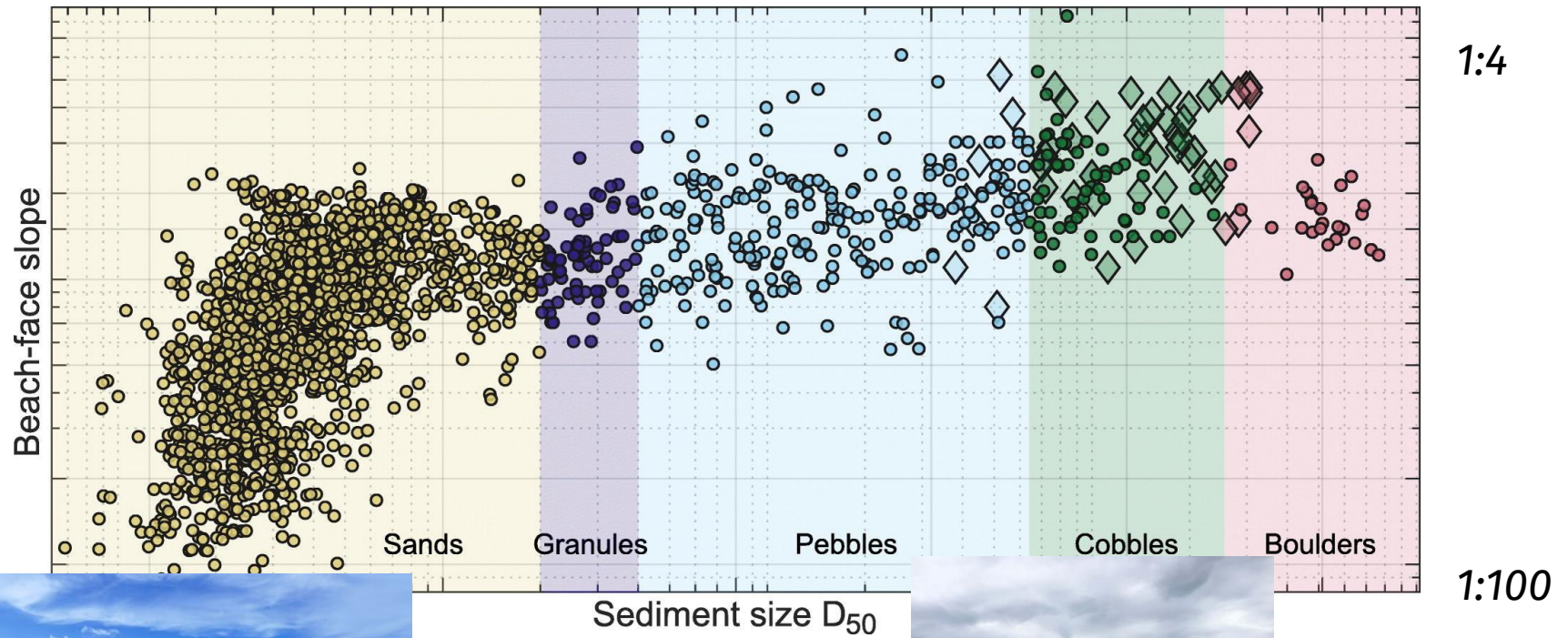
# I diversi «corpi» di una costa



*Shanganiali (2007)*

# Morfologia della costa

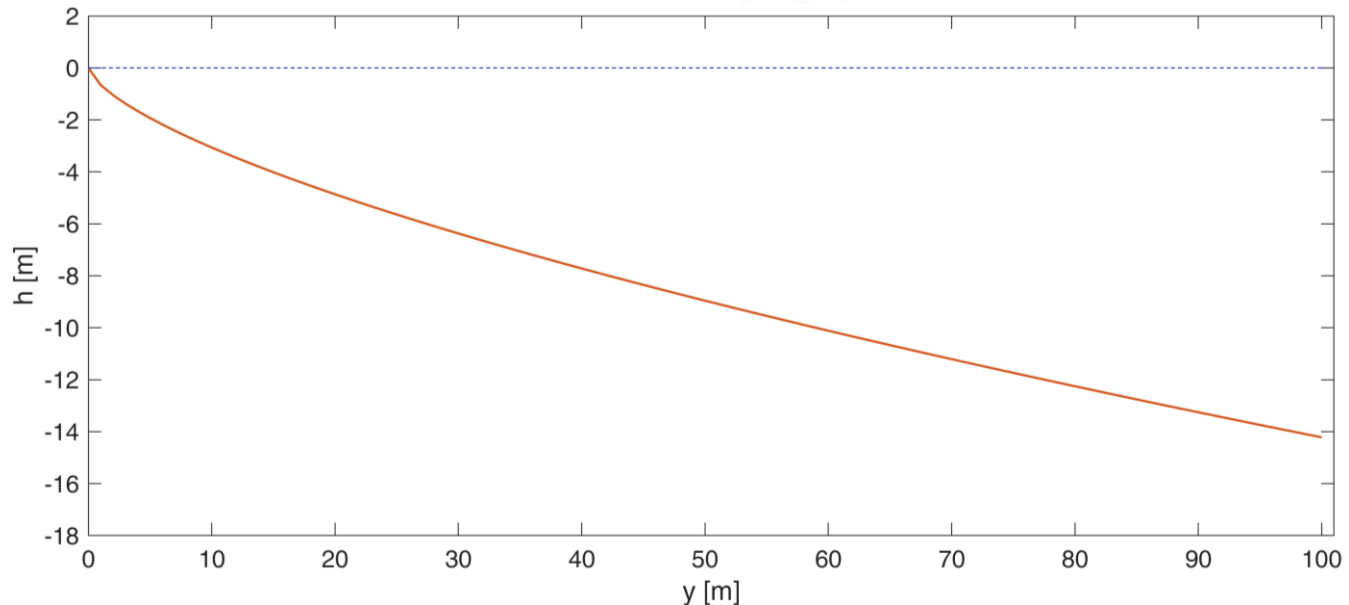
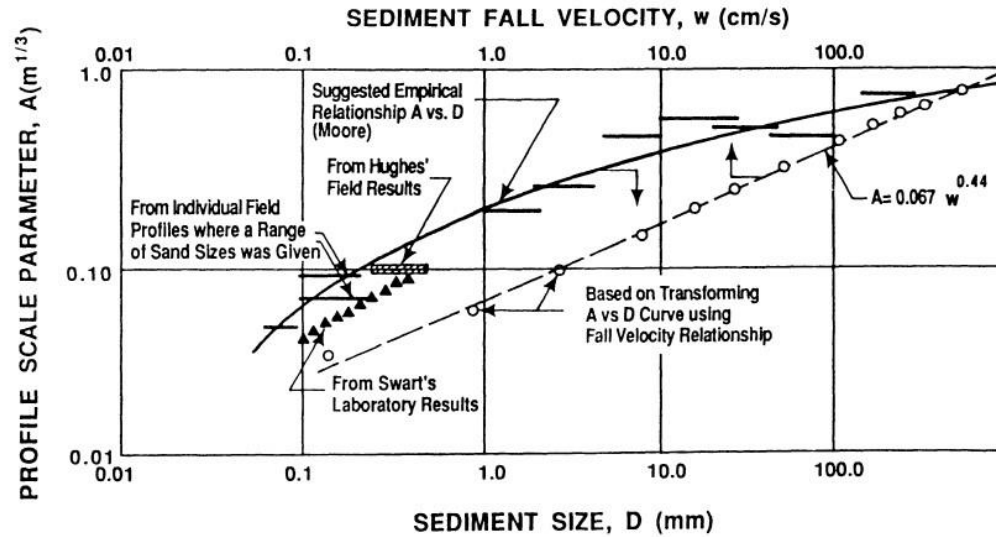
Bujan et al., (2019)



# Morfologia della costa

$$h = Ay^{2/3}$$

Dean (1977)



# Morfologia della costa

## Tensione critica per diversi tipi di materiale solido

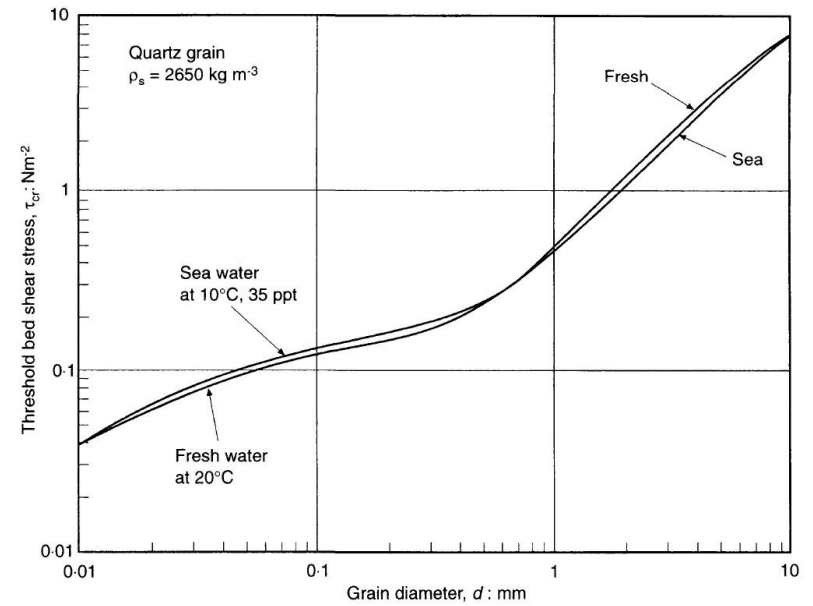
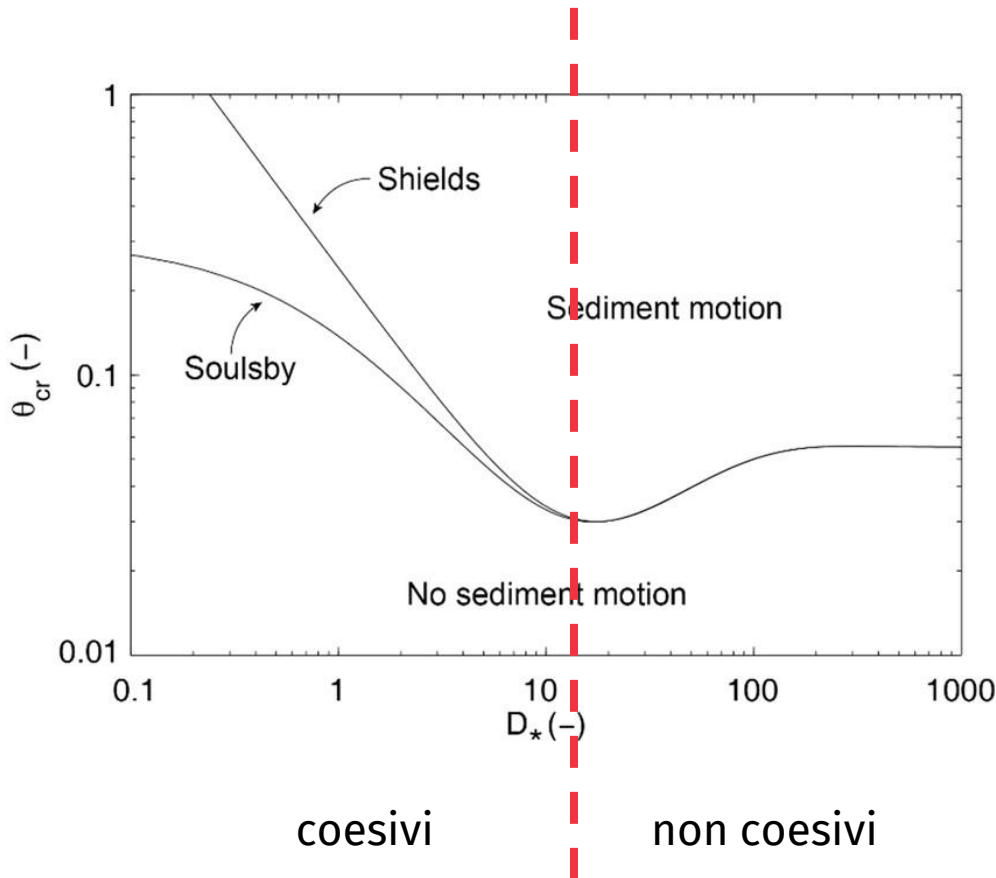


Figure 21. Threshold bed shear-stress for motion of quartz grains of sieve diameter  $d$

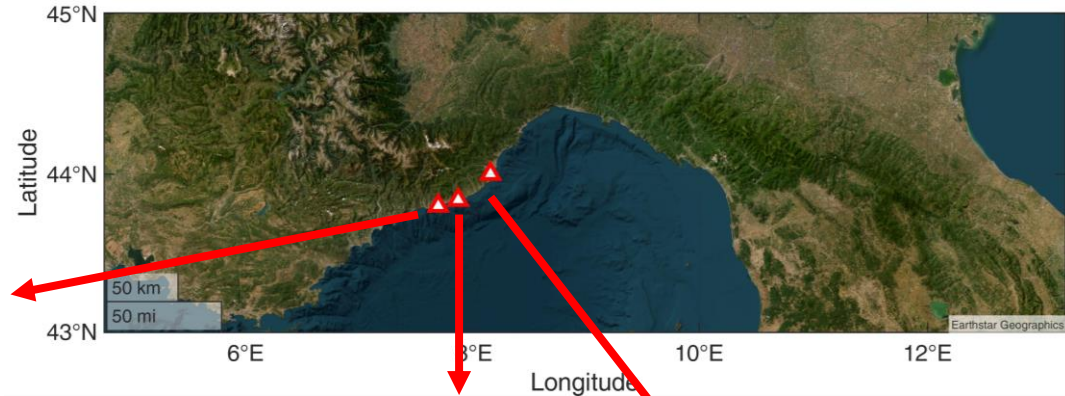
*Soulsby (1997)*

# Morfologia della costa

## Le spiagge liguri



Ospedaletti (IM)



Santo Stefano (IM)



Alassio (SV)

per gentile  
concessione di  
Geoscape

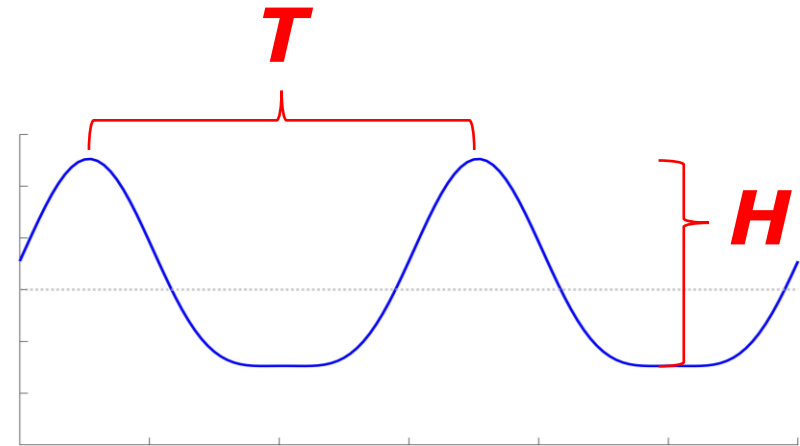


# Le forzanti ambientali

onde di mare

I parametri principali

sup. libera



tempo



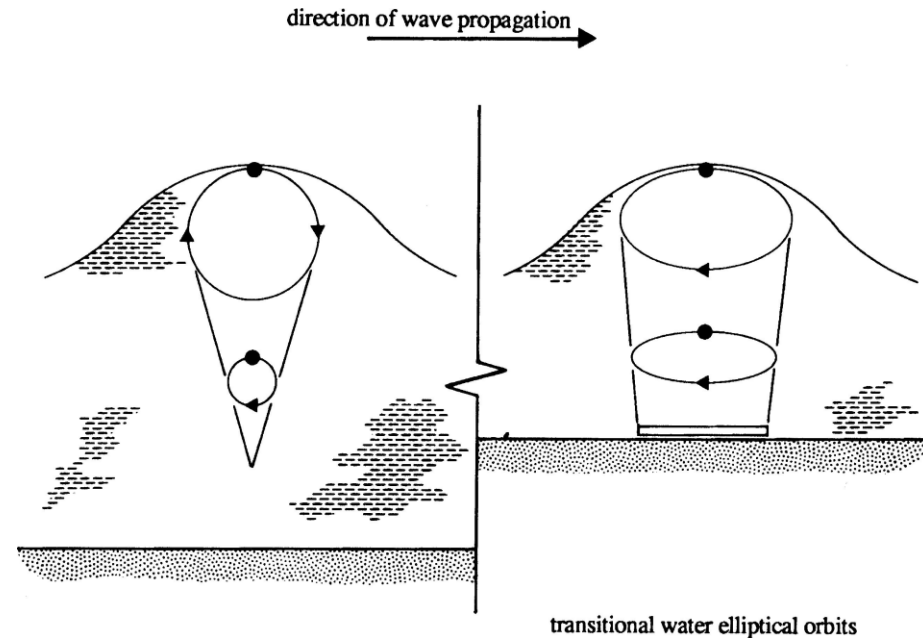


# Le forzanti ambientali

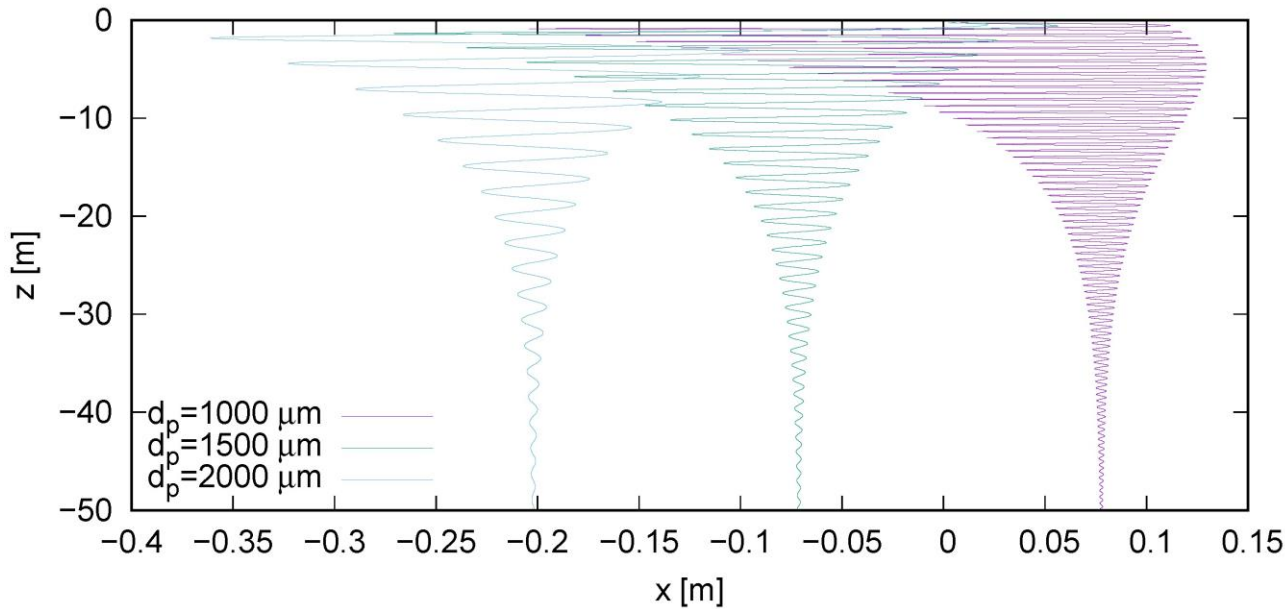
onde di mare

I moti indotti

*Sorensen (1993)*



RUN 12

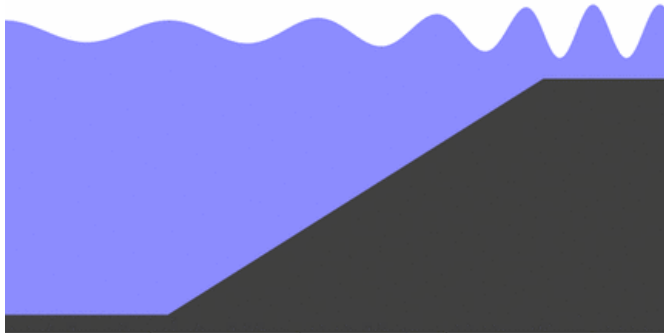


*Stocchino et al., (2019)*

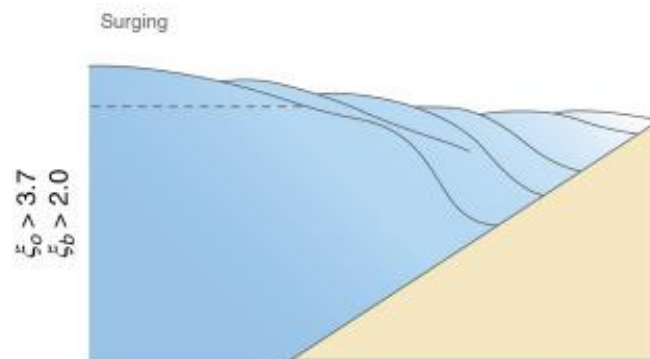
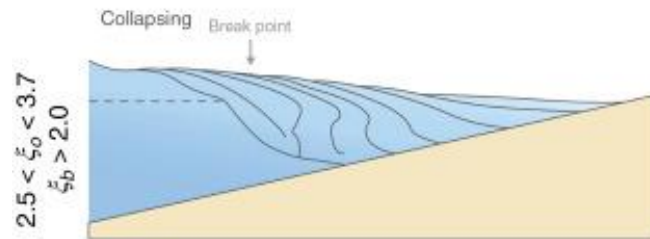
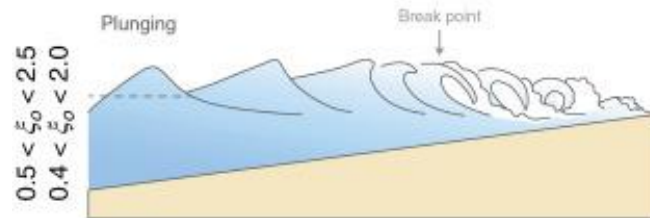
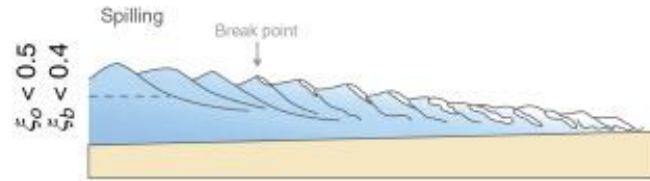
# Le forzanti ambientali

onde di mare

Wave shoaling



Frangimento



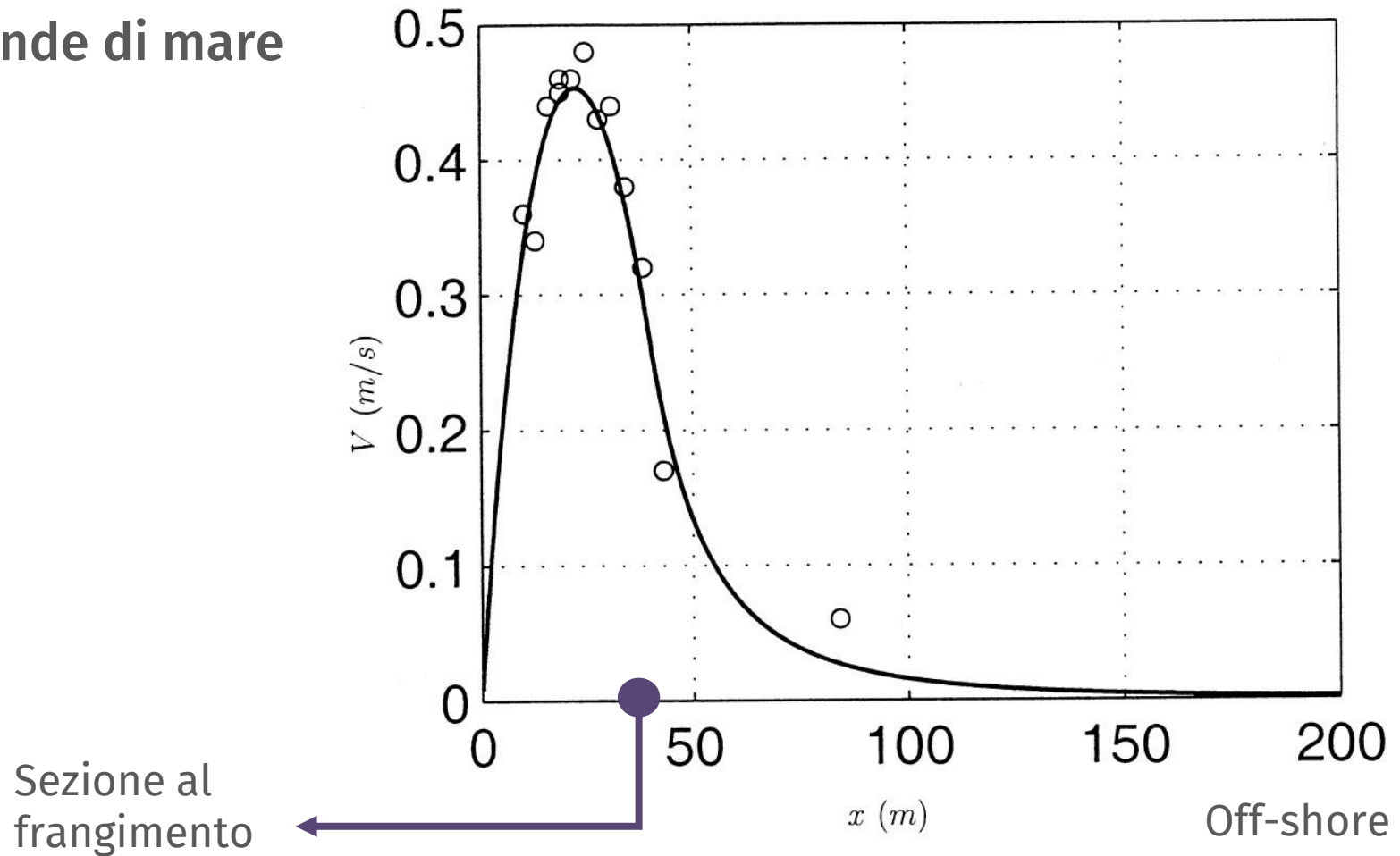
Power (2020)



# Le forzanti ambientali

Haller & Dalrymple (1999)

onde di mare

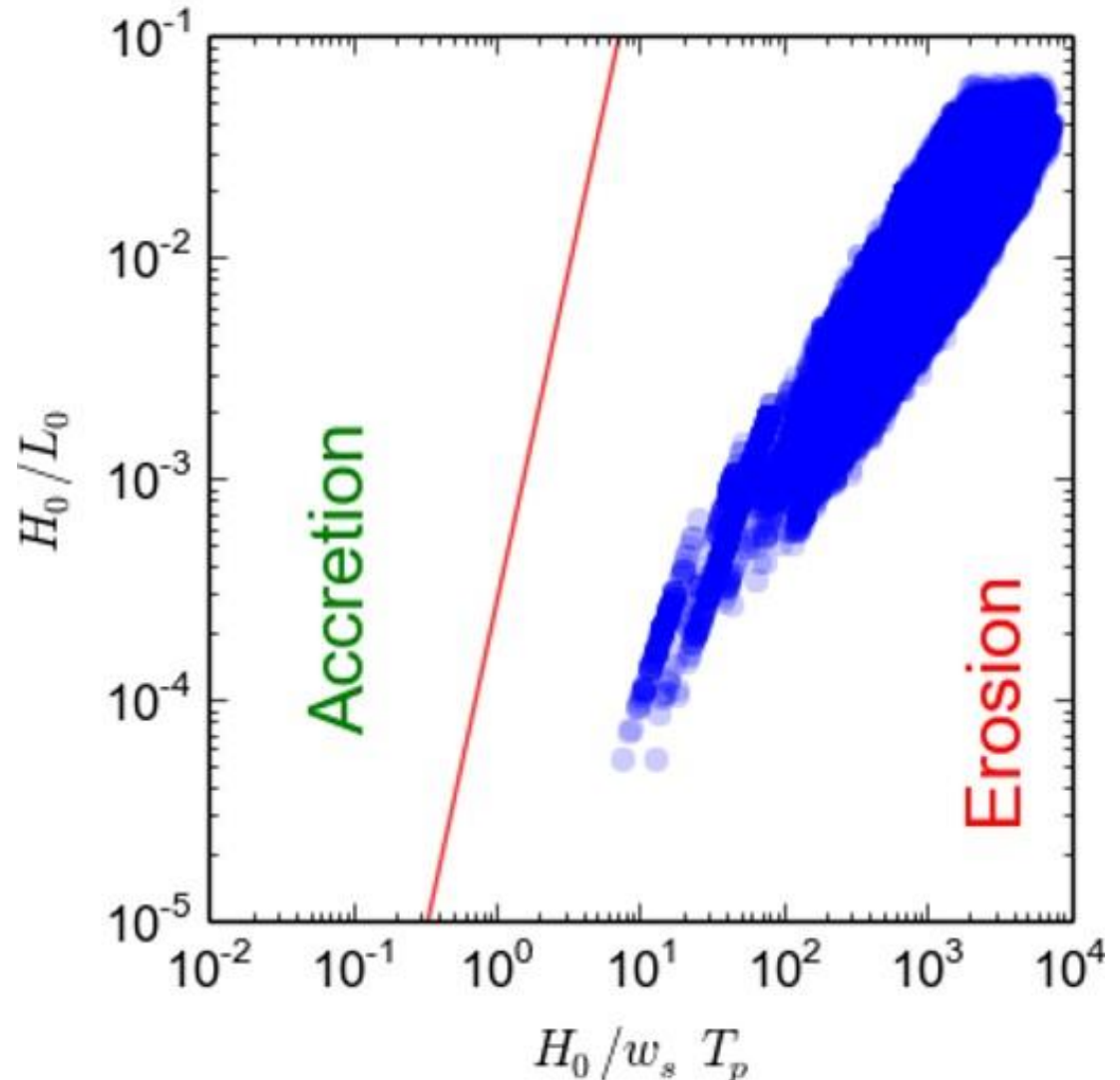


# Le forzanti ambientali

## onde di mare

- $H_o \rightarrow$  altezza d'onda
- $L_o \rightarrow$  lunghezza d'onda
- $T_p \rightarrow$  periodo d'onda
- $w_s \rightarrow$  velocità di caduta dei sedimenti

Dean & Dalrymple (2004)



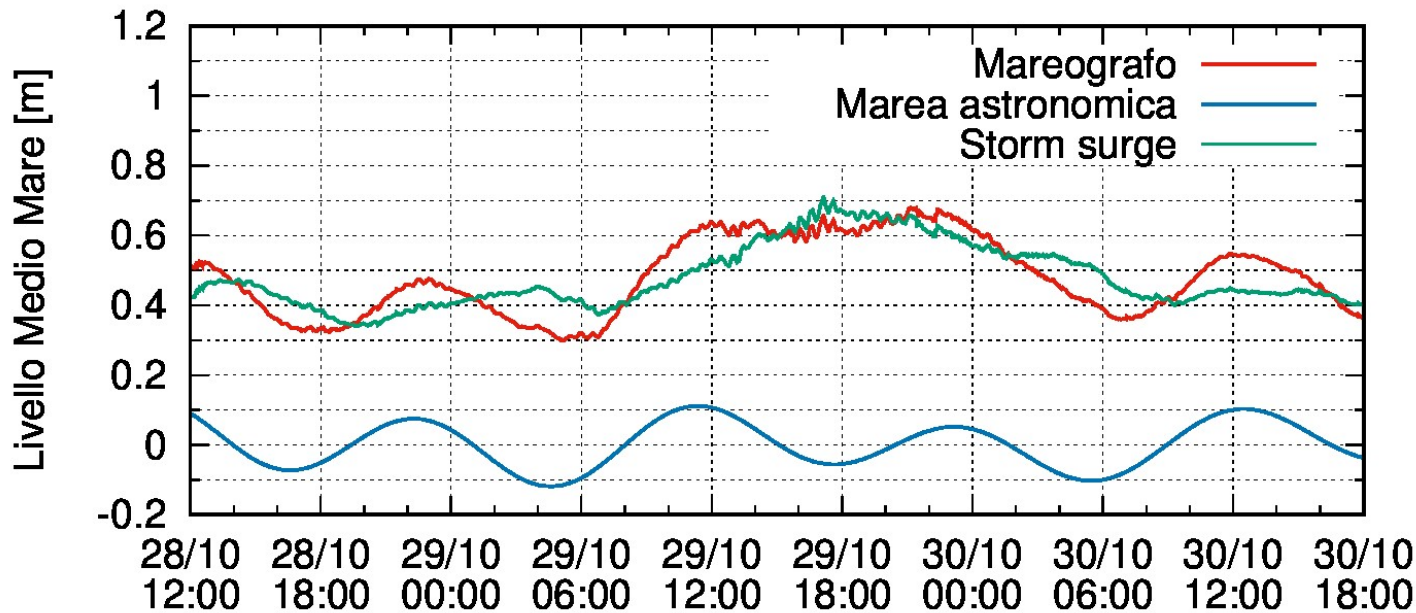
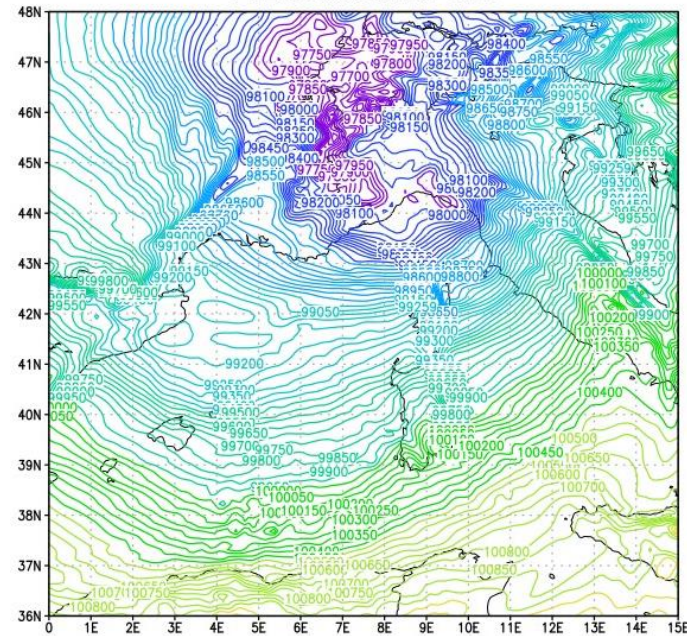
# Le forzanti ambientali

## Storm surge

$$\Delta p = \rho g \Delta h$$

“la mareggiata del secolo”

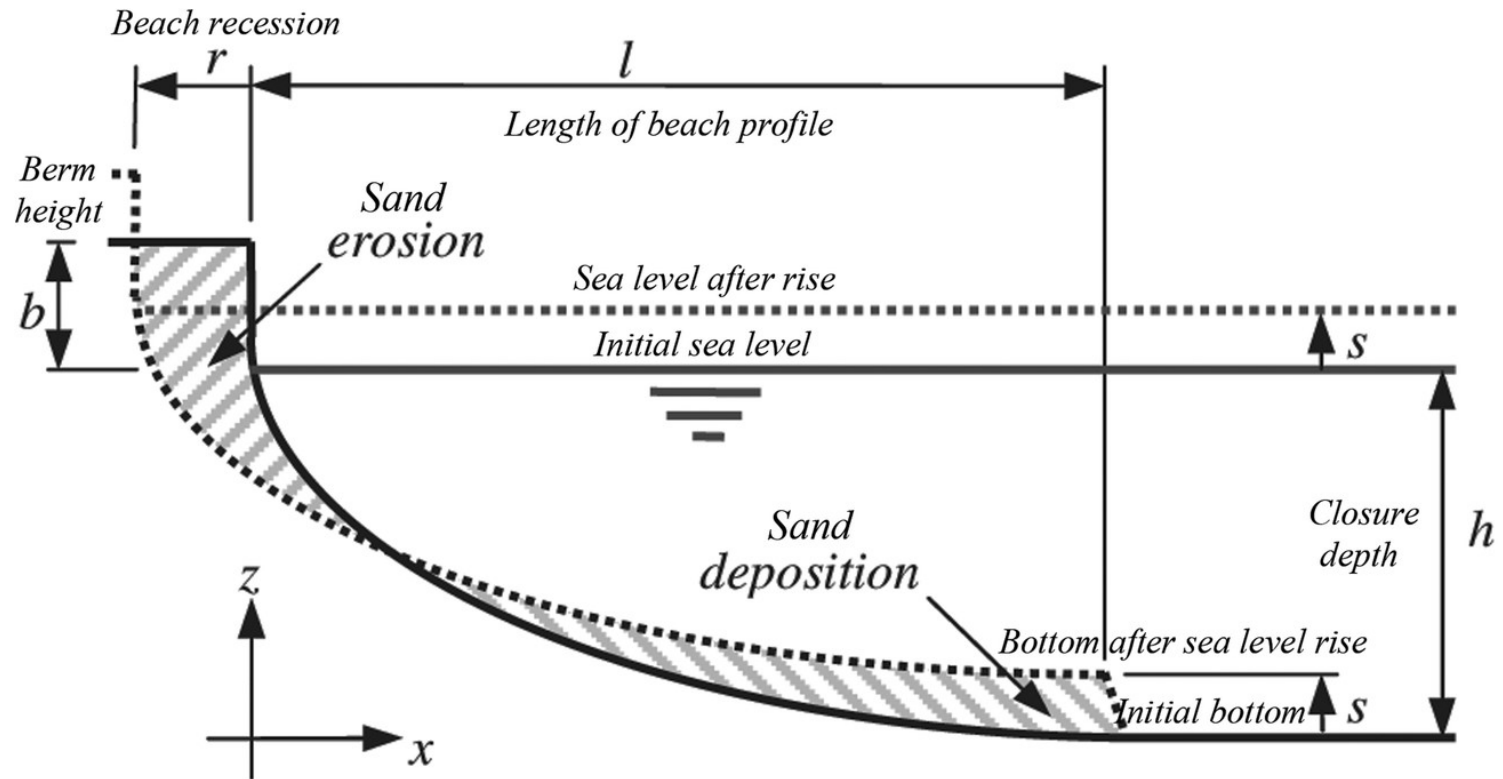
19Z29OCT2018 UTC



*per gentile  
concessione di  
Giovanni Besio e  
Francesco Ferrari*

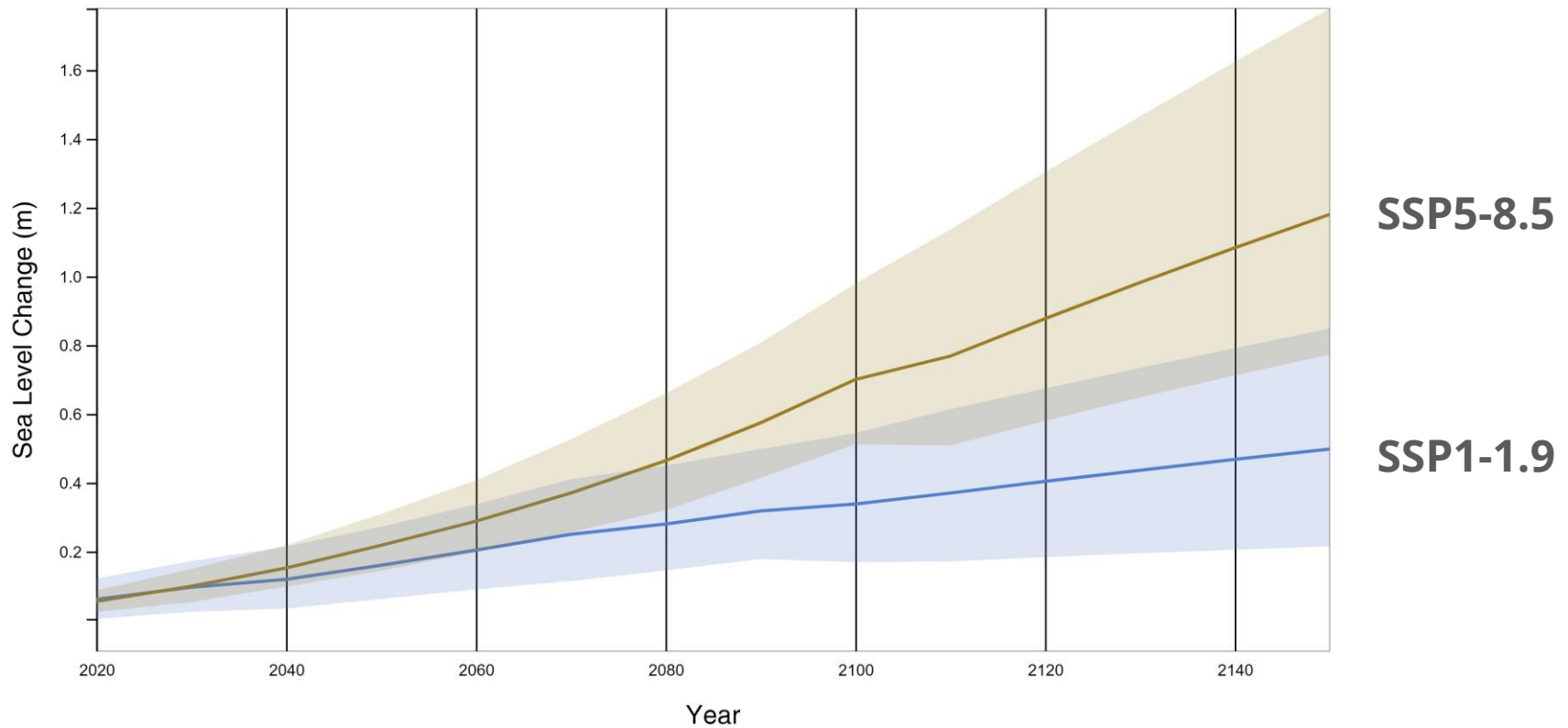
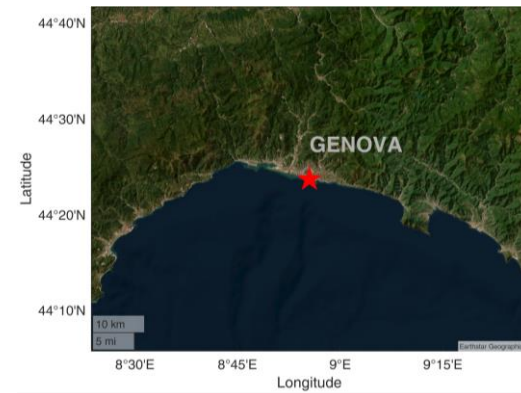
# Le forzanti ambientali

SLR  $r = \frac{s \times l}{h + b}$  Brunn (1962)



# Le forzanti ambientali

## SLR

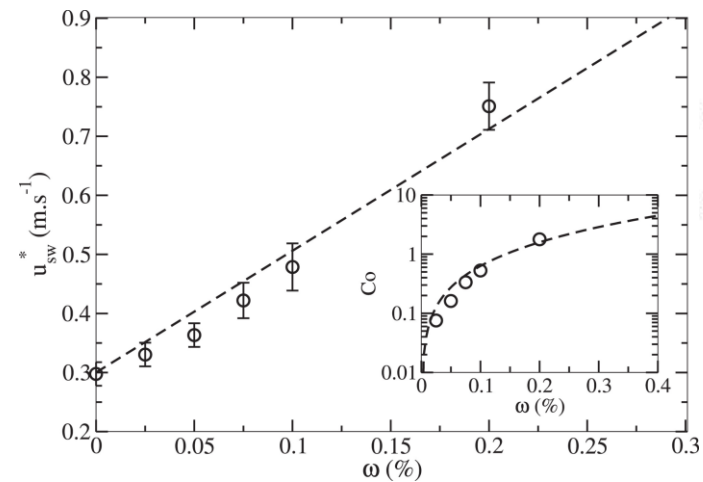


<https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool>

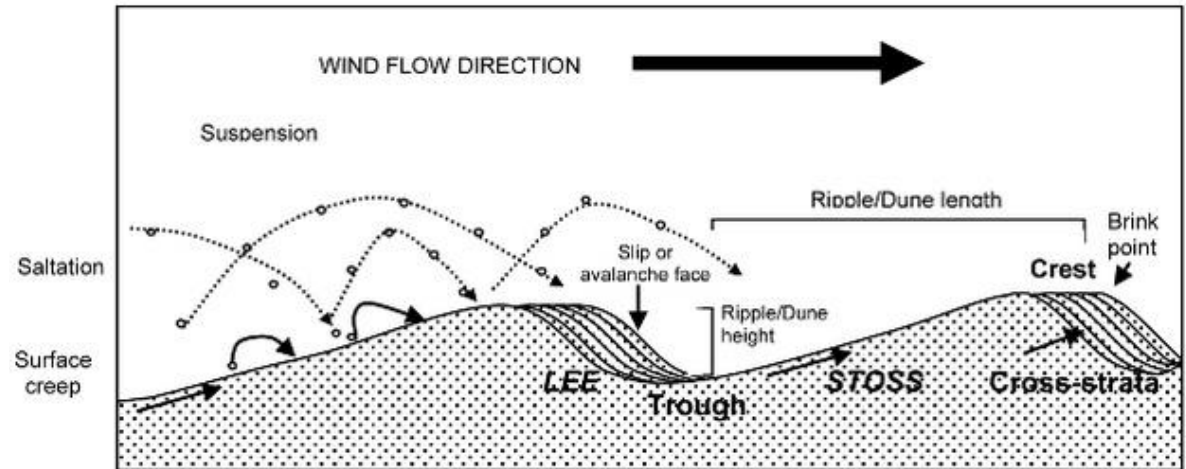
# Le forzanti ambientali

## Vento

Besnard et al., (2022)



©Nature communication (2012)



Strypsteen et al., (2021)



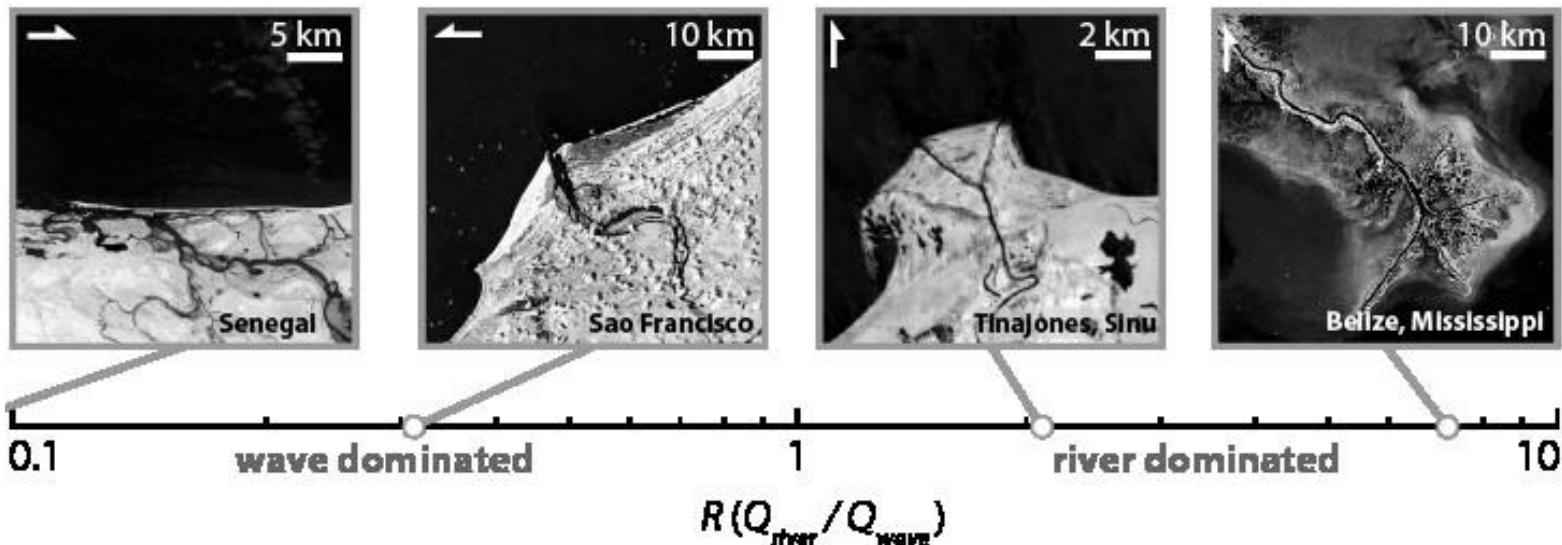
# Le forzanti ambientali

## Fiumi

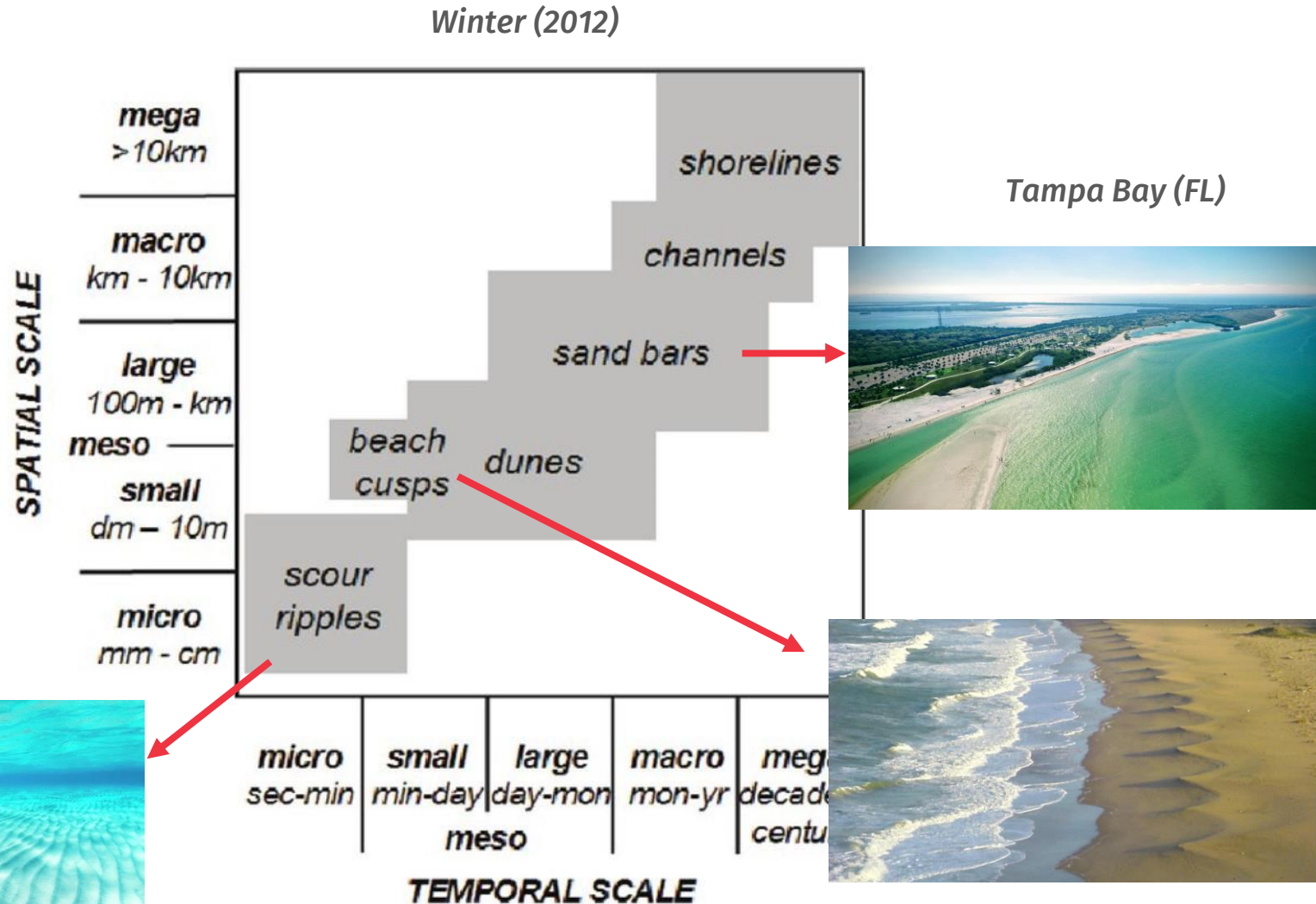
Galloway, (1975)



<https://www.coastalwiki.org>



# I fattori decorrono su diverse scale spazio/temporali



©Alex Mustard



# scale «macro/mega»

$\approx [10^3; 10^4]m$  /  $\approx [10^0; 10^3]y$



©Marli Miller



San Diego (CA)

<https://www.geocaching.com/geocache/GC20FPC>

# scale «macro/mega»

$\approx [10^3; 10^4]m$  /  $\approx [10^0; 10^3]y$



*Durdle door (UK)*

*L'arche et l'aiguille d'Etretat (FR)*

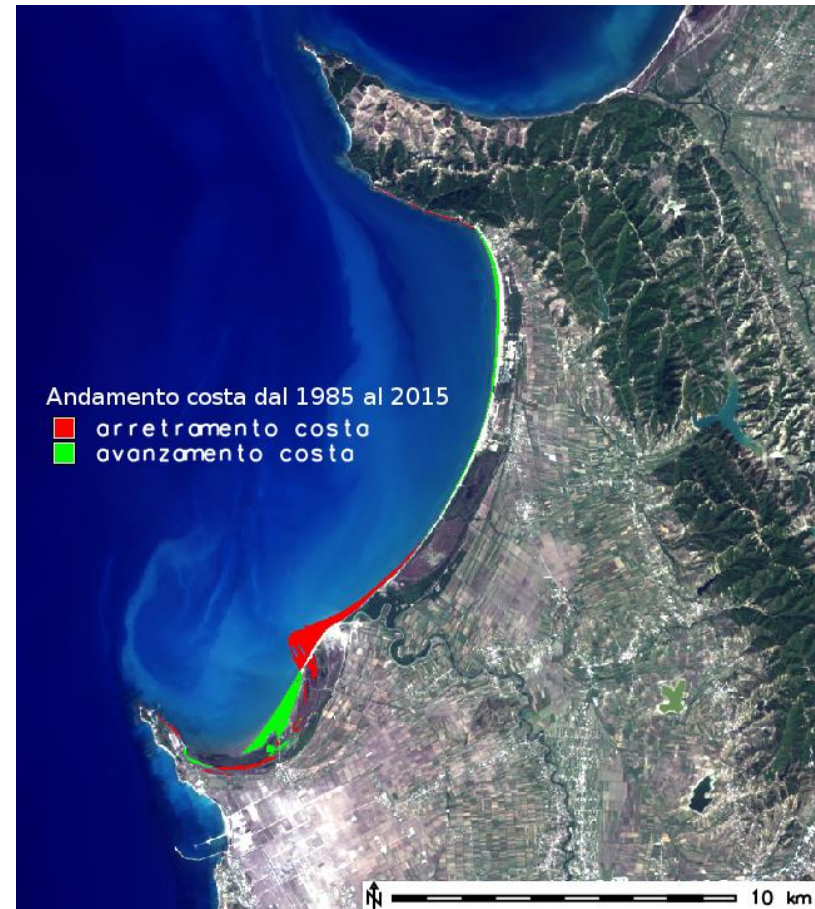


[e-education.psu.edu](http://e-education.psu.edu)

# scale «large/macro»

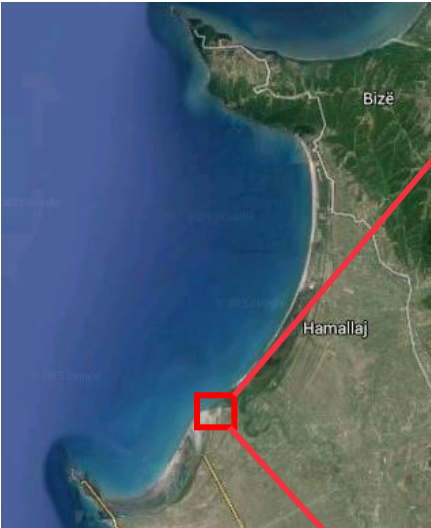
$\approx [10^0; 10^3]m$  /  $\approx [10^0; 10^3]d$

De Leo et al., (2017)



# scale «large/macro»

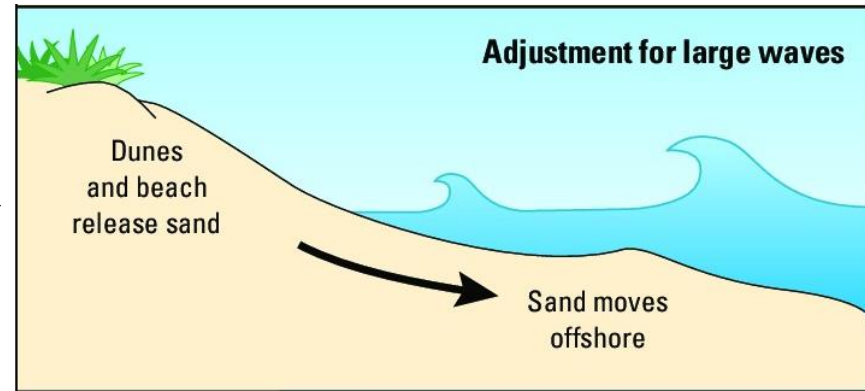
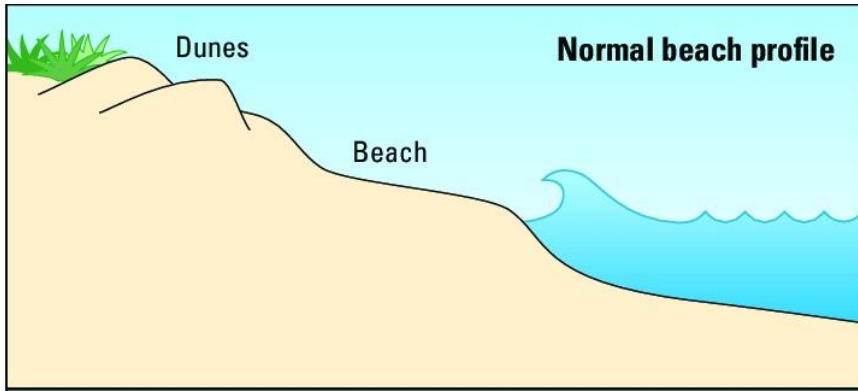
$\approx [10^0; 10^3]m / \approx [10^0; 10^3]d$



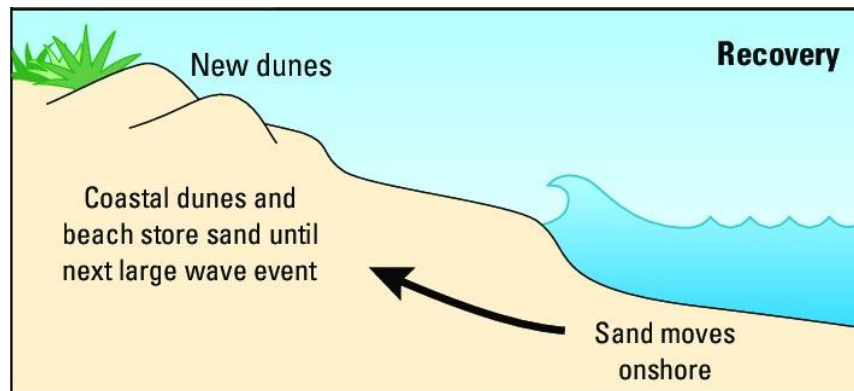
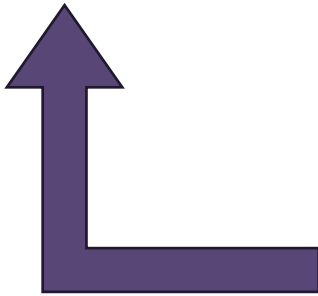
# scale «small/large»

$\approx [10^0; 10^3]m / \approx [10^0; 10^3]d$

## PROFILO INVERNALE



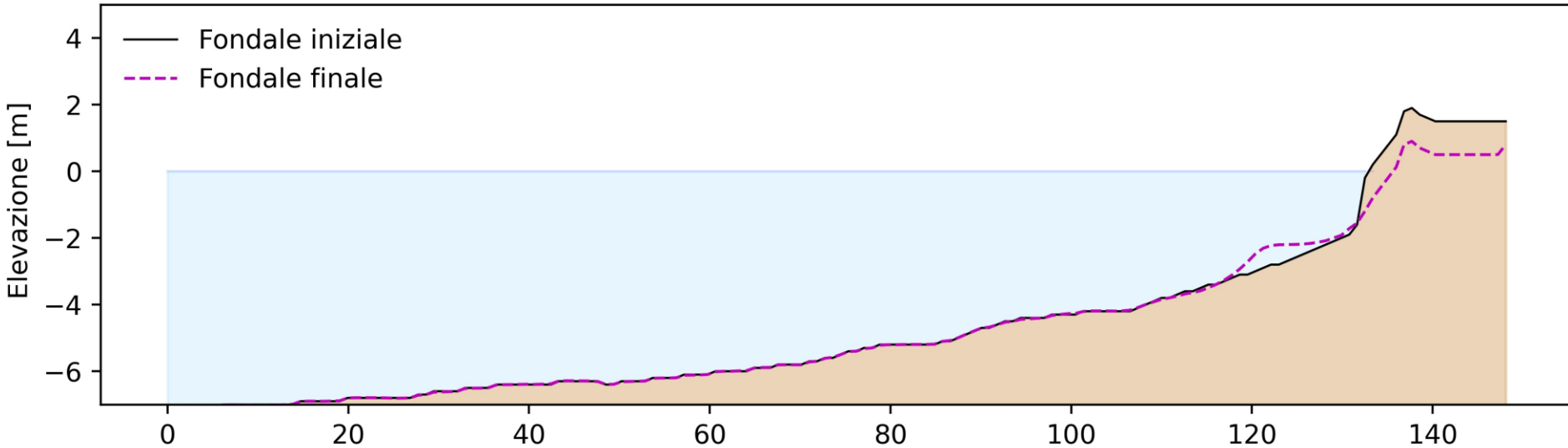
*Fletcher et al., (2012)*



# scale «small/large»

$$\approx [10^0; 10^3]m / \approx [10^0; 10^3]d$$

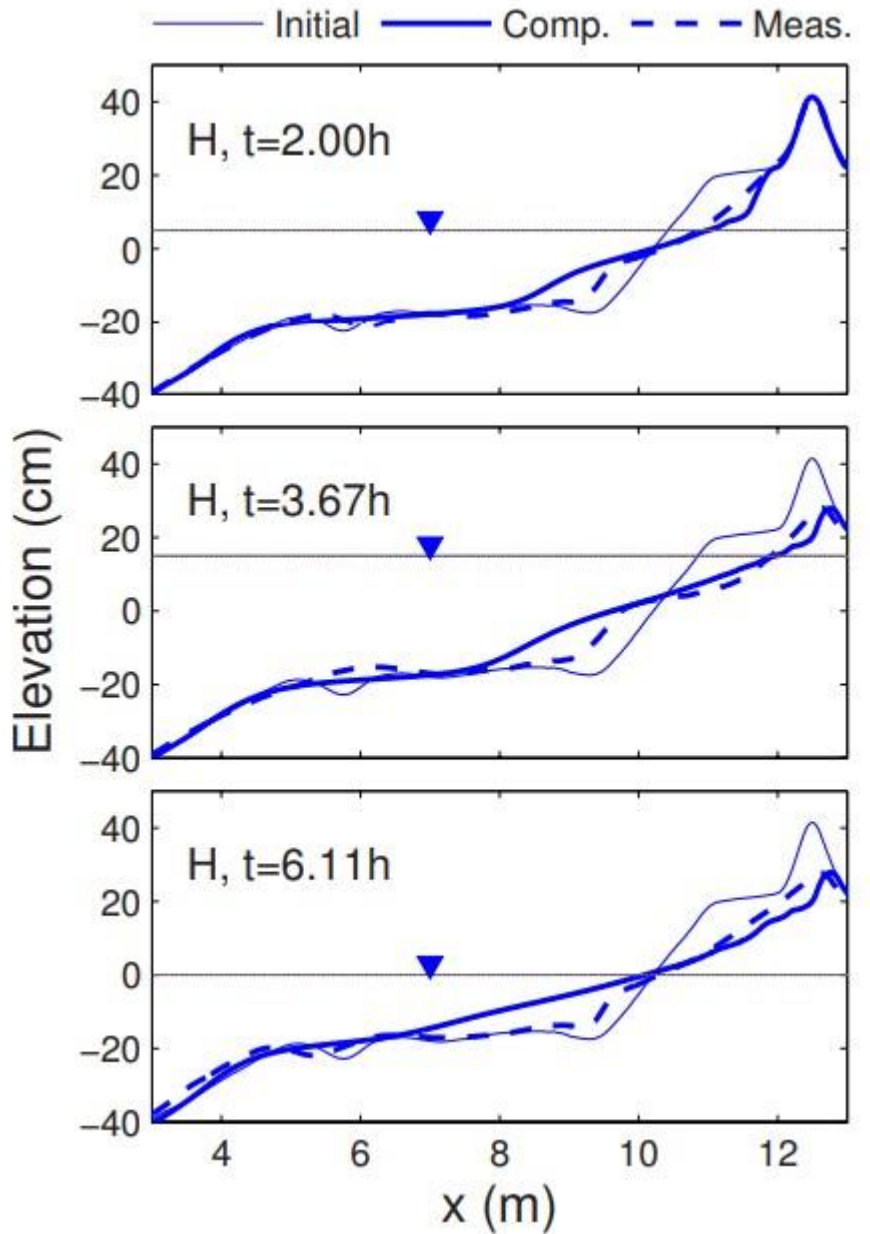
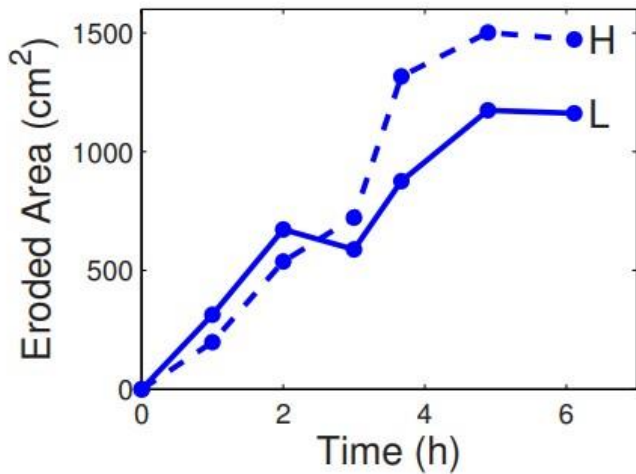
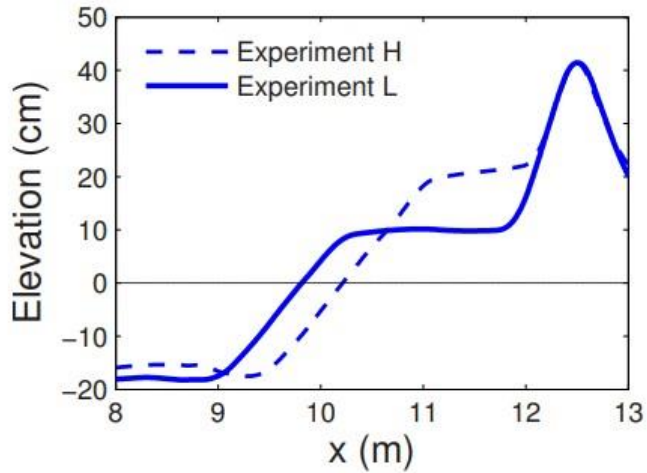
Erosione di un profilo trasversale a Sturla (GE)





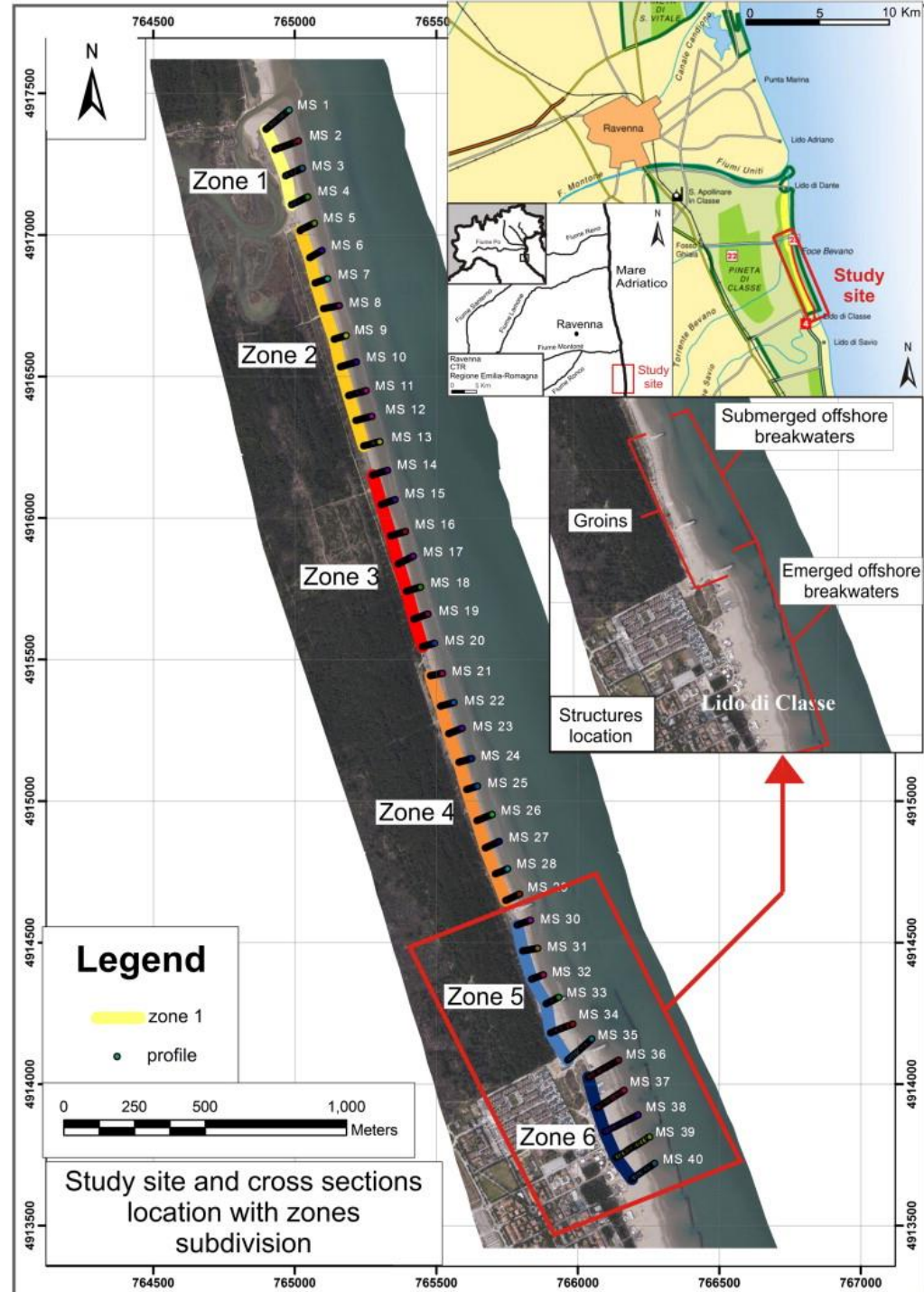
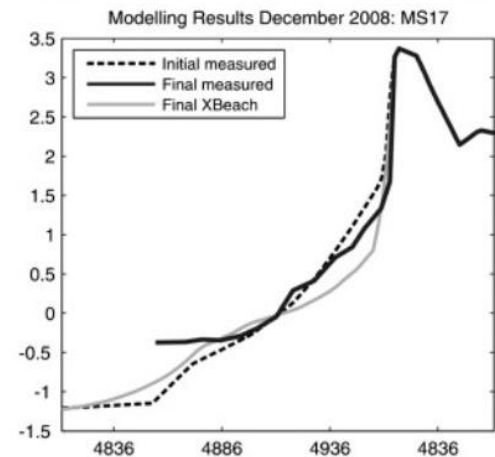
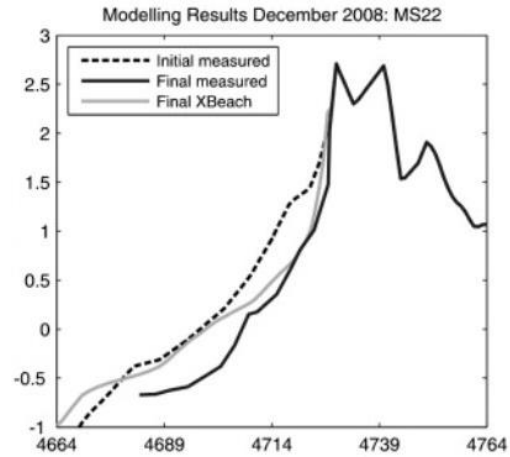
# scale «small/large»

$\approx [10^0; 10^3]m / \approx [10^0; 10^3]d$



# scale «small/large»

$$\approx [10^0; 10^3]m / \approx [10^0; 10^3]d$$



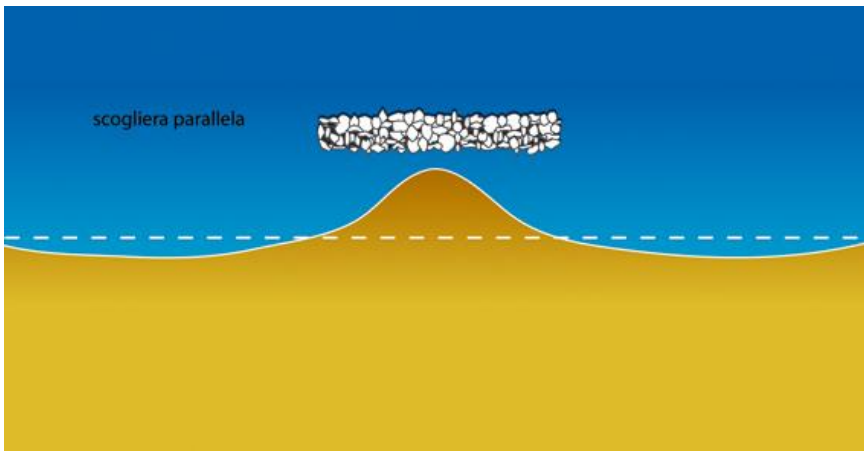
# scale «small/large»

$\approx [10^0; 10^3]m$  /  $\approx [10^0; 10^3]d$



# Interventi di mitigazione

Strutture Rigide → scogliere parallele

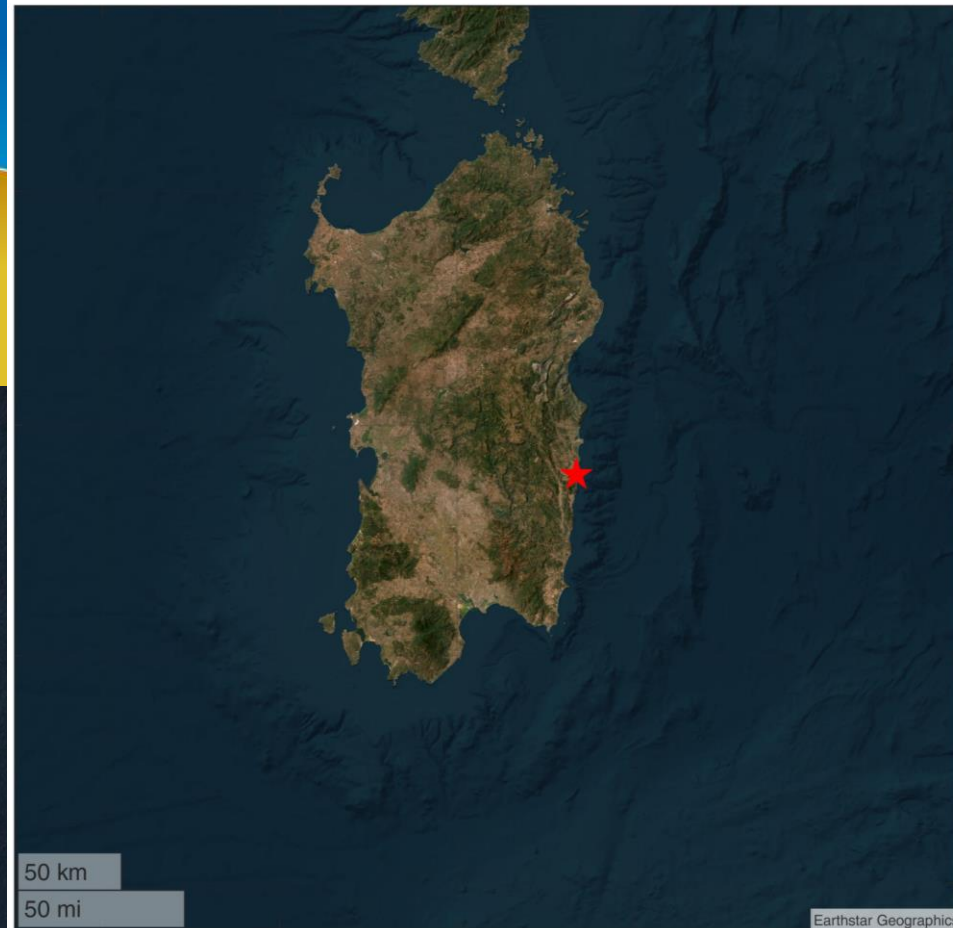
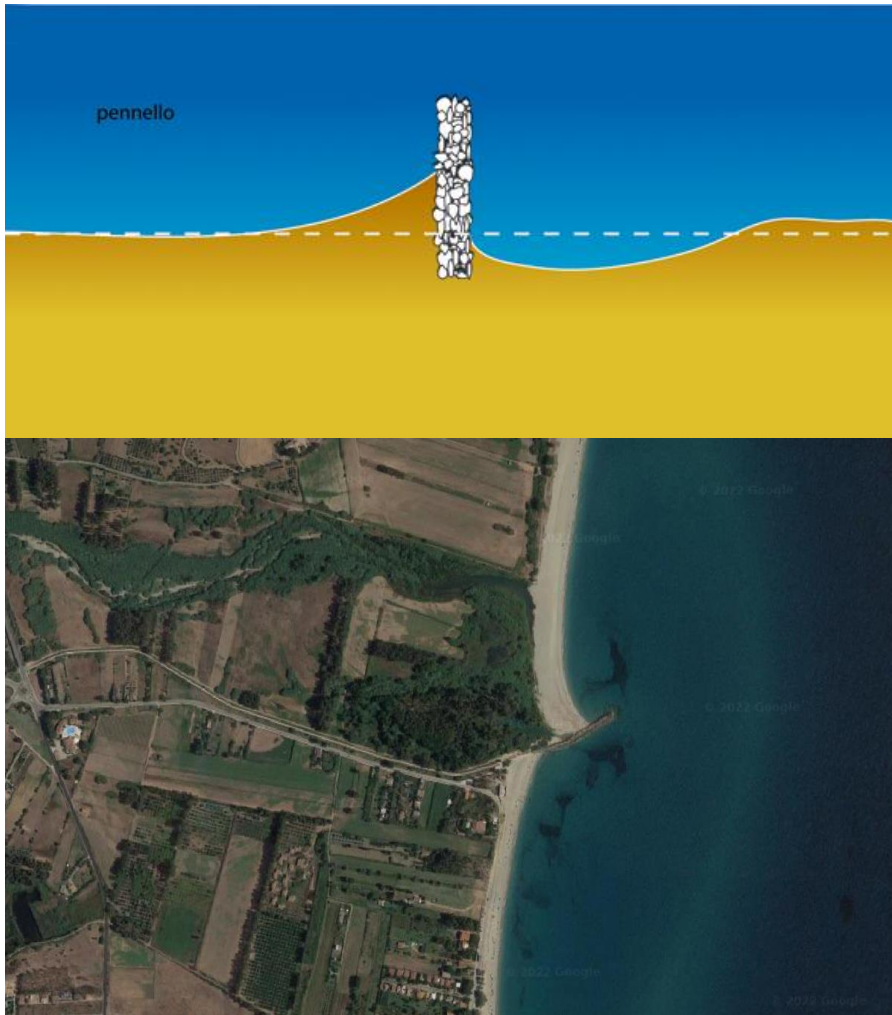


Chiavari,  
Liguria

# Interventi di mitigazione

Strutture Rigide → pennelli trasversali

Cardedu, Sardegna



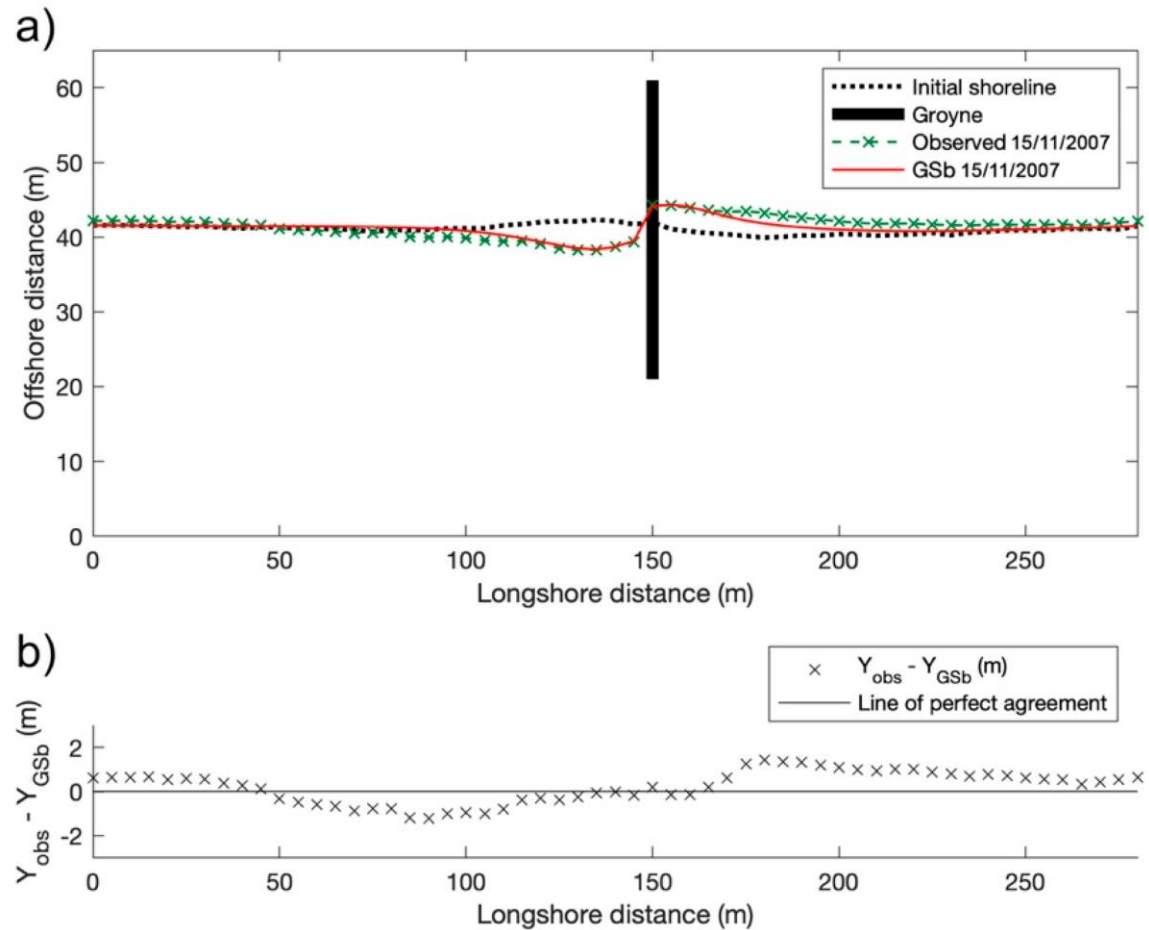
# Interventi di mitigazione

Strutture Rigide → pennelli trasversali



(a)

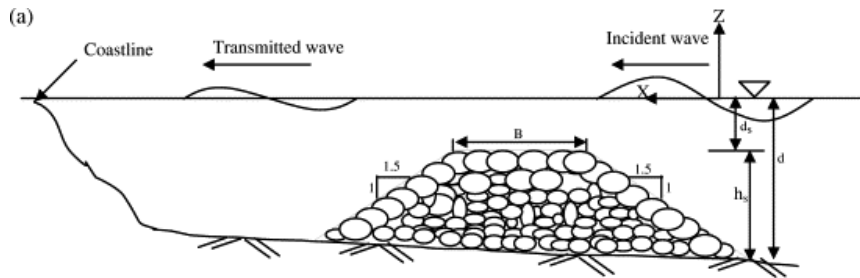
*Tomasicchio et al., (2020)*



# Interventi di mitigazione

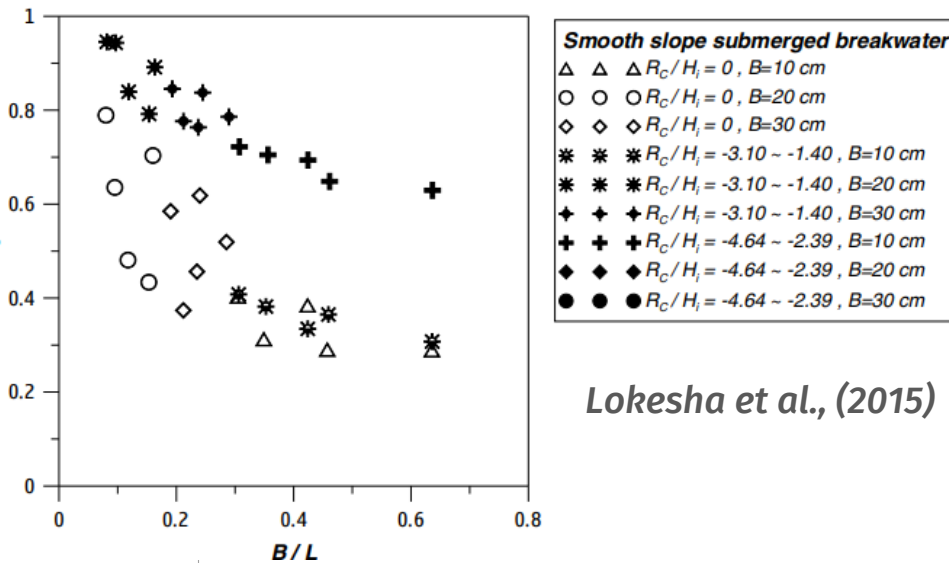
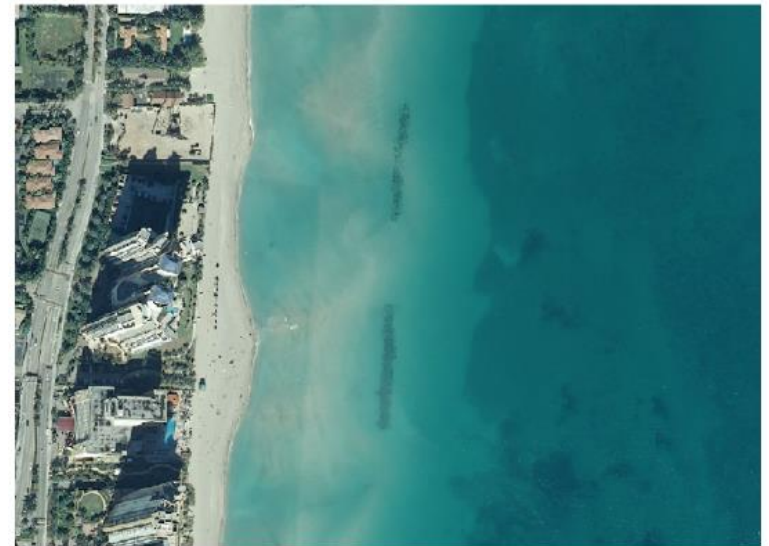
Strutture Rigide → dighe soffolte

Rambabu & Mani (2005)



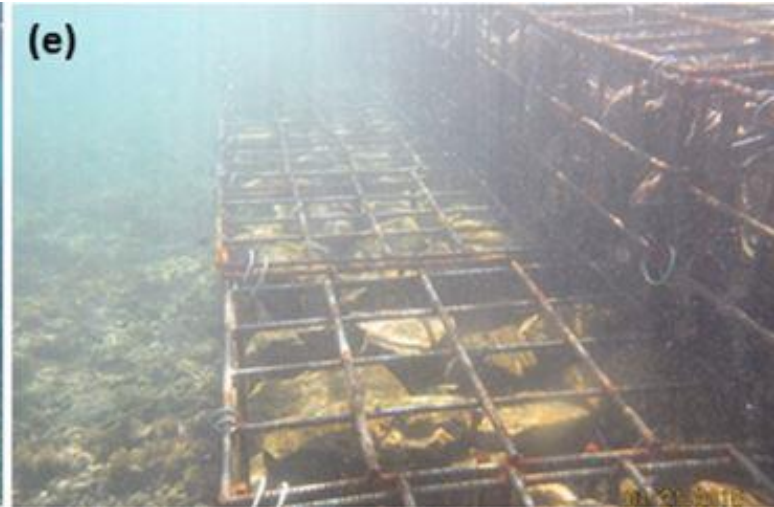
Sunny Isles (FL)

U.S. Geological Survey



# Interventi di mitigazione

Strutture Rigide → «NBS»





# Interventi di mitigazione

Strutture Rigide → barriere aderenti («revetment»)



[www.venturariver.org](http://www.venturariver.org)



©Evelyn Simak, CC BY-SA 2.0

# Interventi di mitigazione

Soft Engineering → interventi di ripascimento



*Laigueglia*

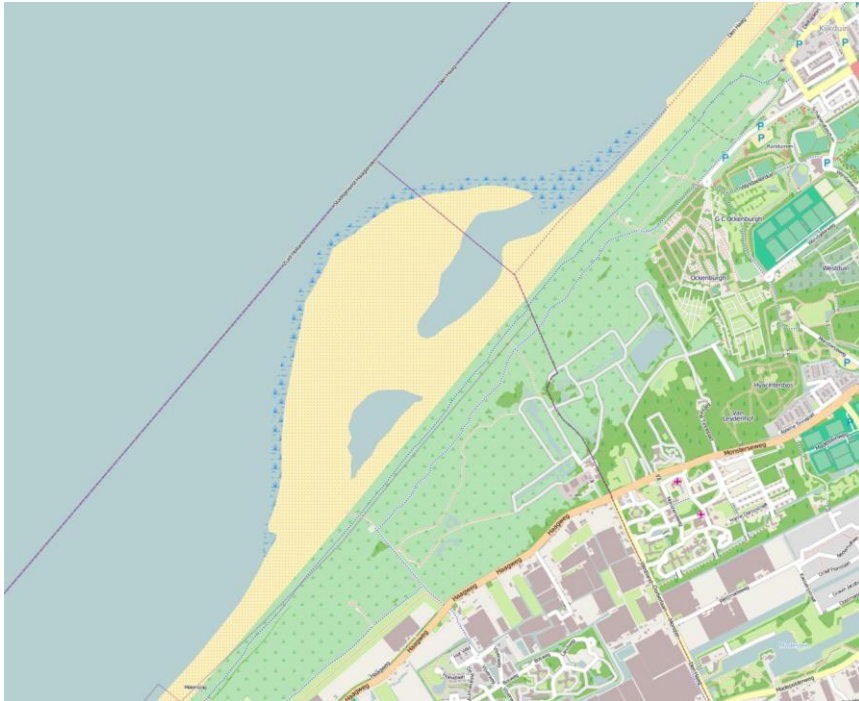
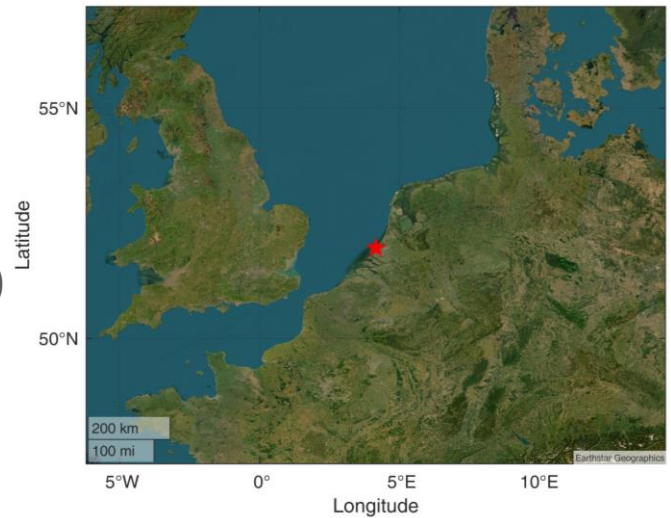
*Sori*



# Interventi di mitigazione

Soft Engineering → sand engine (o sand motor)

Ter Heijde (NL)



**UniGe**

---

**DICCA**