Sous Projet: GESA

# « GEstion des stocks SAbleux interceptés par les ouvrages côtiers. Récupération du transport solide »

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**ICM-CSIC, Barcelona**

***Conférence d´ Advancement de la Phase C (Composante 3)***
***Montpellier , Novembre 30, 2007***

# Progress PHASE C

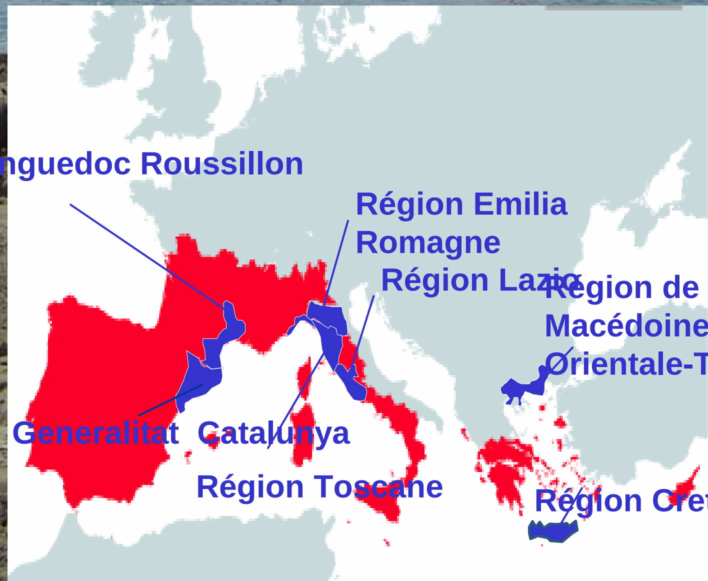
- 1, Instituto de Ciencias del Mar
R. Catalunya
- 2, Univ. Barcelona
R. Catalunya
- 3, Univ. Bologna
DISTART
R. Emilia-Romagna
- 4, Univ. Florence
R. Toscana

**8 Partners**

**7 Regions**

**4 Countries**

- 5, Registro Italiano Dighe
R. Lazio
- 6, Univ. Perpignan
LEGEM
R. Languedoc-Roussillon
- 7, Univ.Democritus de Thrace
Laboratoire de l´hydraulique et des Traveaux Hydrauliques
R. East Macedonia-Thrace
- 8, Foundation pour la Recherce et La Technologie/
Inst. De Mathématiques Appliquées
R. Crete



# Progress- PHASE C

**Juil-Déc 2007**

Activités

**CONTINUATION ET PREPARATION DU RAPPORT DE PHASE C**

**1- Continuation Phase C** : Derniers travaux de terrain, complémentation des donnés le cas ou il y ait des manquantes.

**2- Analyse de l'ensemble**

**3- Caractérisation du comportement morphologique des secteurs de drague et d'alimentation**.

**4- Analyses relatives aux qualité des sédiments pour éventuelle réutilisation des mêmes.** .

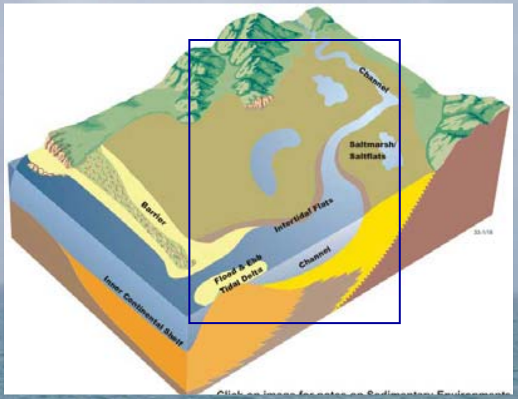
**5- Appliquer les modèles mathématiques**

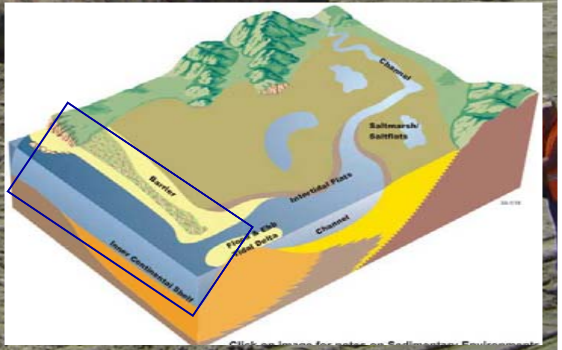
# PHASE A

# PHASE B

# Progress PHASE C

| | *Problem* | *Main goals* | *Strategy* |
|---|---|---|---|
| **HYDROGRAPHIC BASIN** | Rivers are often not able to provide enough sediments to the coast<br>↓<br>Main causes are: dams and weirs, land uses and climate<br>→ Recover sediments from rivers<br>→ Keep the sedimentary cycle stable | Accumulation areas with high hydraulic risk<br><br>Sediments entrapped by dams | Analysis of sediments (laboratory)<br><br>Quantification of sediments and possible re-use<br><br>Quantification (numerical models) |
| **COAST** | Infrastructure plays an important role in altering coastal processes<br>↓<br>Sand usually accumulates on one side of the port and erodes on the other<br>→ Periodical dredges<br>→ Beach nourishment | Morphodynamic evolution<br><br>Sand stocks availability | Infralittoral wedge (HRS, bathymetry, vibrocorer)<br><br>Sand intercepted by coastal structures (HRS, bathymetry, vibrocorer)<br><br>Sedimentary dynamic (physical & numerical models) |





# RESULTS - PROGRESS PHASE C
## Layout

UFL- P4
DUTH- P7

## I. Hydrographic Basins

**Reduction to fluvial inputs:**

- Sediment accumulation in the hydrographical basins
- Turbidity currents

ICM- P1
UB- P2
DISTART-P3
UFL- P4
LEGEM- P6
IACM- P8

## II. Coastal Areas

**Morphology, Sand stocks, Sand quality**

**Modelling**

GESA Partners

## Summarize

## Accumulated sediments: quantification in the River Magra watershed

UFLOR-P4

Hydrographical basins

Sediment accumulation

↓

Consequences of dredging

↓

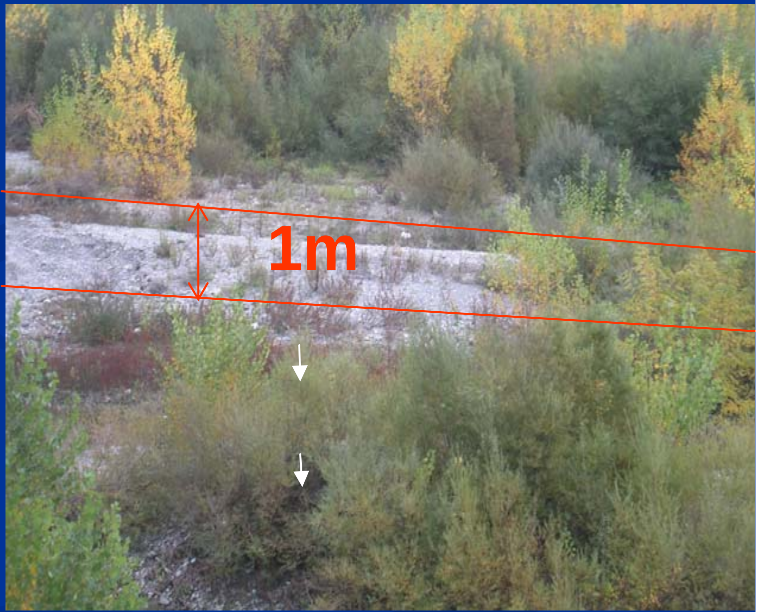
Re-Use for small nourishments

↓

Thickness from 0,5 m to 1m

Volume from 500 to 5000mc

- Geomorphological exploration on the sites have enhanced the presence of anomalous fluvial bars with:



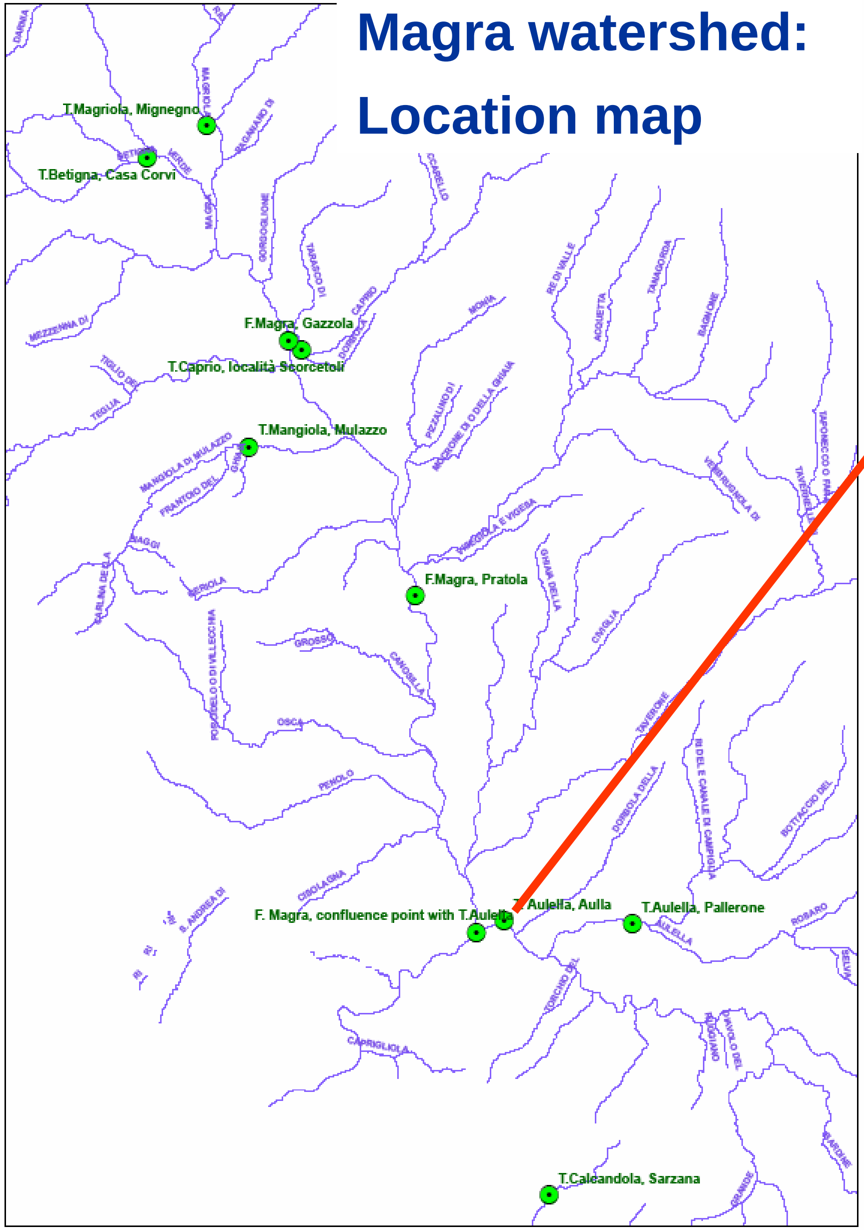

Quantification of sediments **(Phase C)**

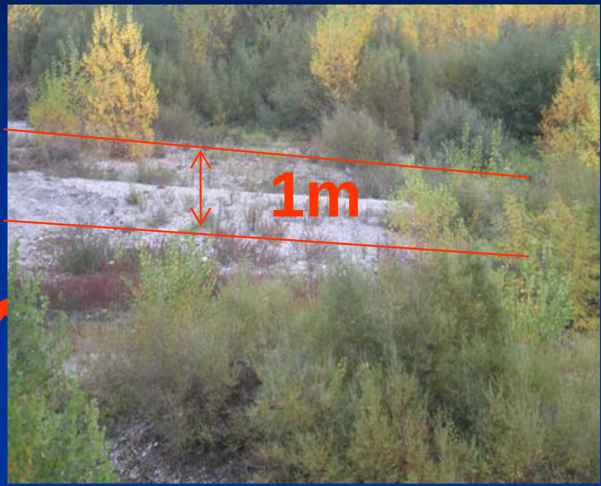
In some of these cases, the sediments are main cause of damages to public infrastructures (bridges, pipelines…..)

Hydrographical basins

UFLOR-P4

# Magra watershed: Location map



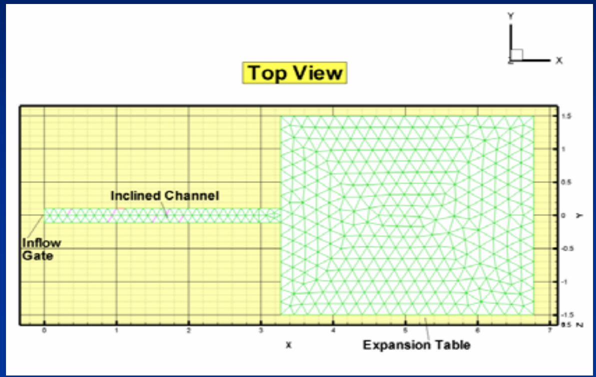



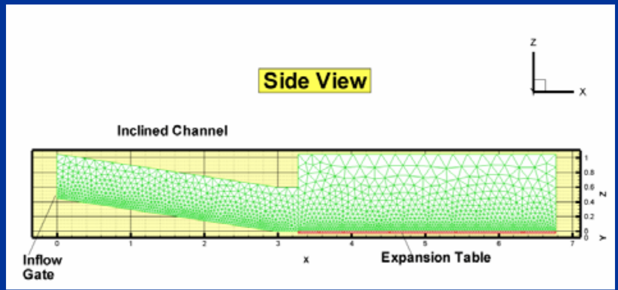

**TOTAL VOLUME** from the 9 sites is about **14.800 mc** **can be extracted**

## Numerical simulation for turbidity currents of river outflows

**DUTH-P7**

Hydrographical basins

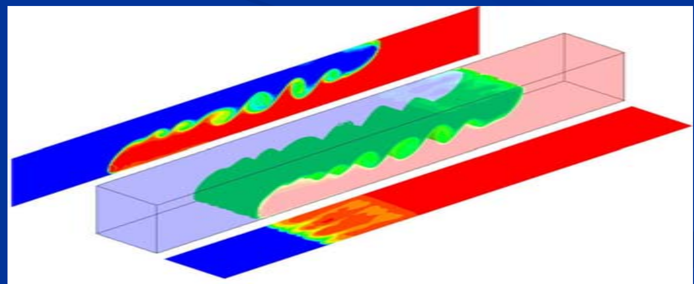


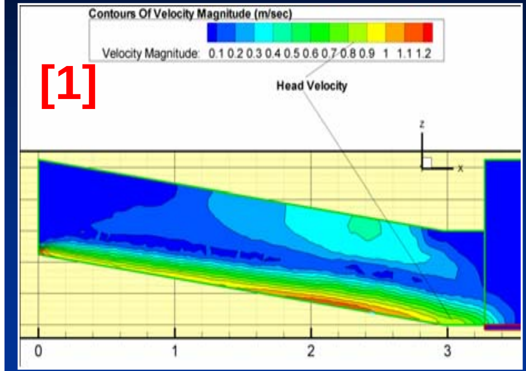

- Computational, Fluid Dynamic solver (**FLUENT)**

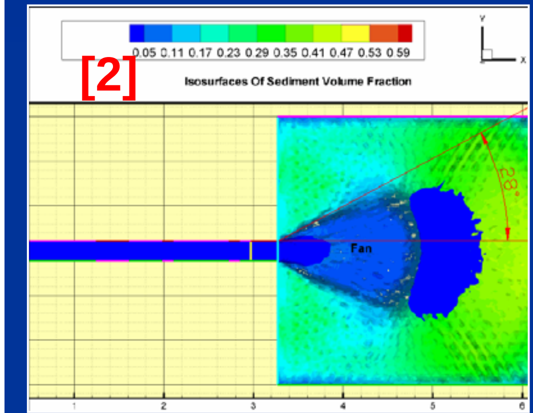
- **I.** 3D Numerical Model has been developed to simulate turbidity Currents
- **II.** Validation the proposed numerical model

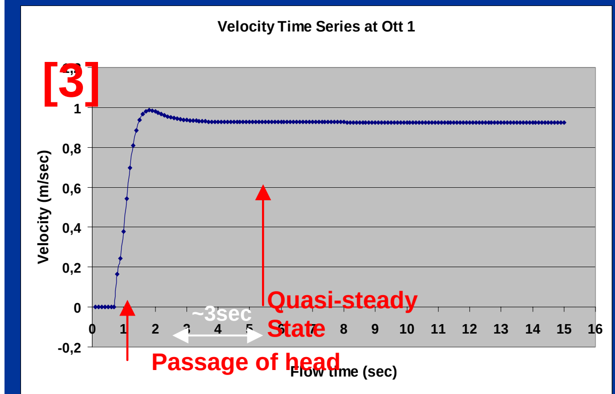
**II a**. Simulate numerically the runs of the experimental work by BAAS et al. (2004).
**II b**. Our numerical results are compared with the experimental results.

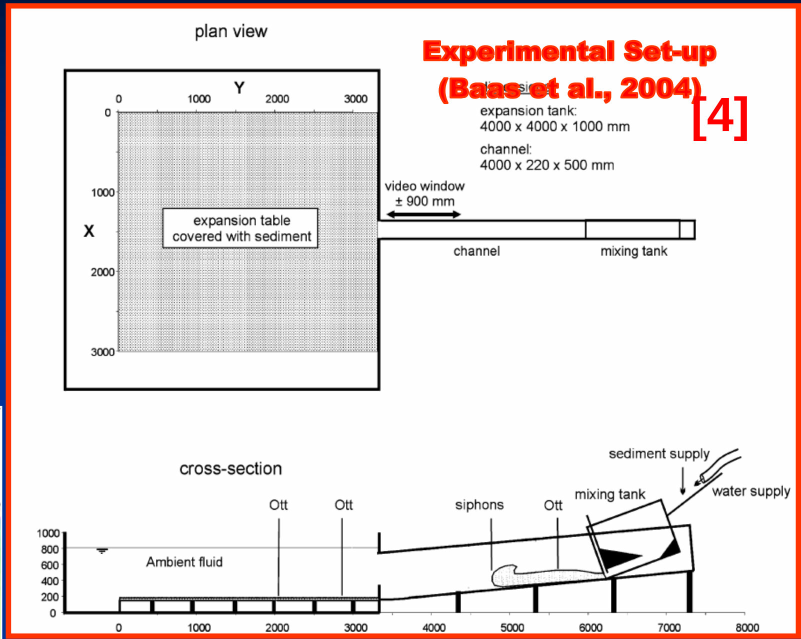


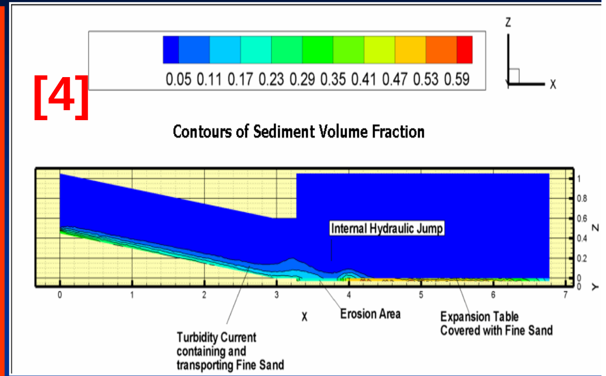
**TURBIDITY CURRENT MODELING**

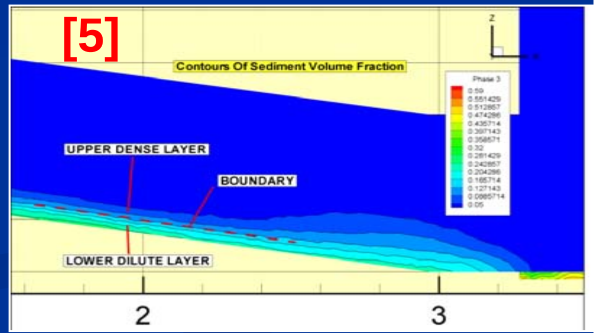



-Turbidity Current Head Velocity = 0.952 m/sec [1]

-Spreading Angle of Fan = 28.5° [2]

-3 sec after passage of head from position Ott1 Quasi-Steady flow established in the body of the turbidity current [3].

-Internal Hydraulic Jump at the entrance to the expansion table [4].

- Two layers developed. A dense bottom layer moving parallel to the channel bed and an upper dilute layer where mixing with ambient fluid takes place [5].

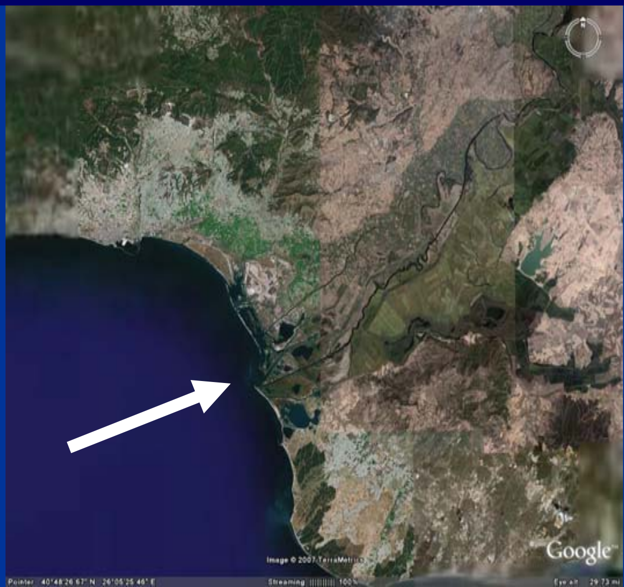
**DUTH-P7**

**Experimental Run**
(Baas et al.)
**MAIN RESULTS**

DUTH-P7

• **After the comparison**, we conclude that the proposed Numerical Model predicts VERY WELL the dynamic as well as the erosion and depositional characteristics of the developed TURBIDITY CURRENTS

DUTH is now in the process to apply this model to **Evros River**




TURBIDITY CURRENT MODELING

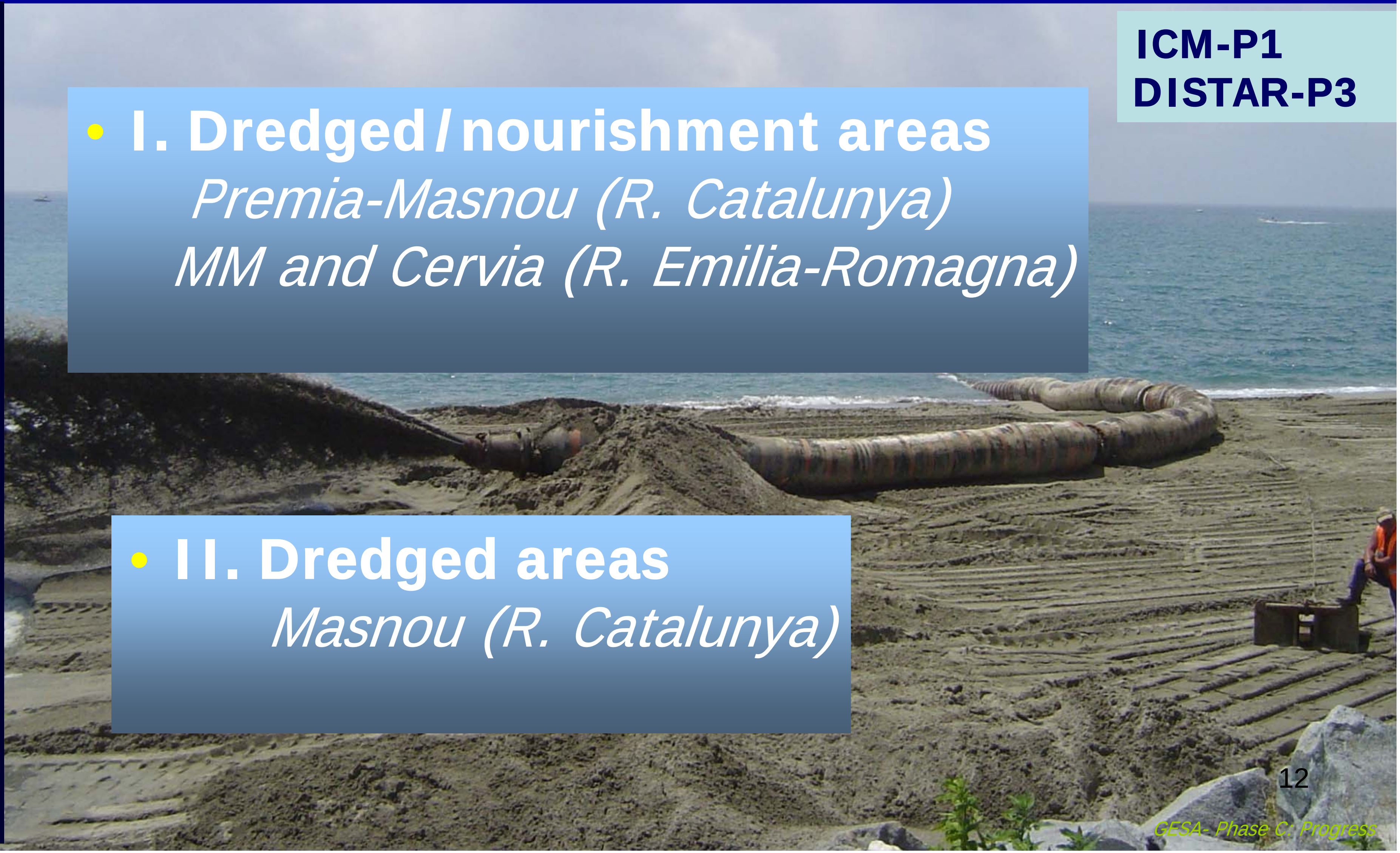
Hydrographical basins

# II. Results: Coastal area

- Characterization of morphological evolution
- Evaluation of the sand stocks availability
- Determination of sediment quality to be used for nourishment
- Application of the models (physical & numerical) to understand of the coastal morpho-dynamic and nourishment evolution

ICM- P1
UB- P2
DISTART-P3
UFL- P4
LEGEM- P6
IACM- P8

# Characterization of coastal morphological evolution



**ICM-P1**
**DISTAR-P3**

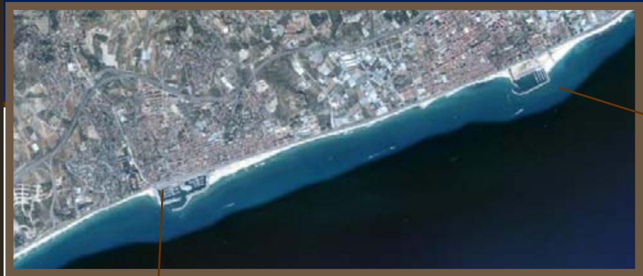
- **I. Dredged/nourishment areas**
  *Premia-Masnou (R. Catalunya)*
  *MM and Cervia (R. Emilia-Romagna)*

- **II. Dredged areas**
  *Masnou (R. Catalunya)*

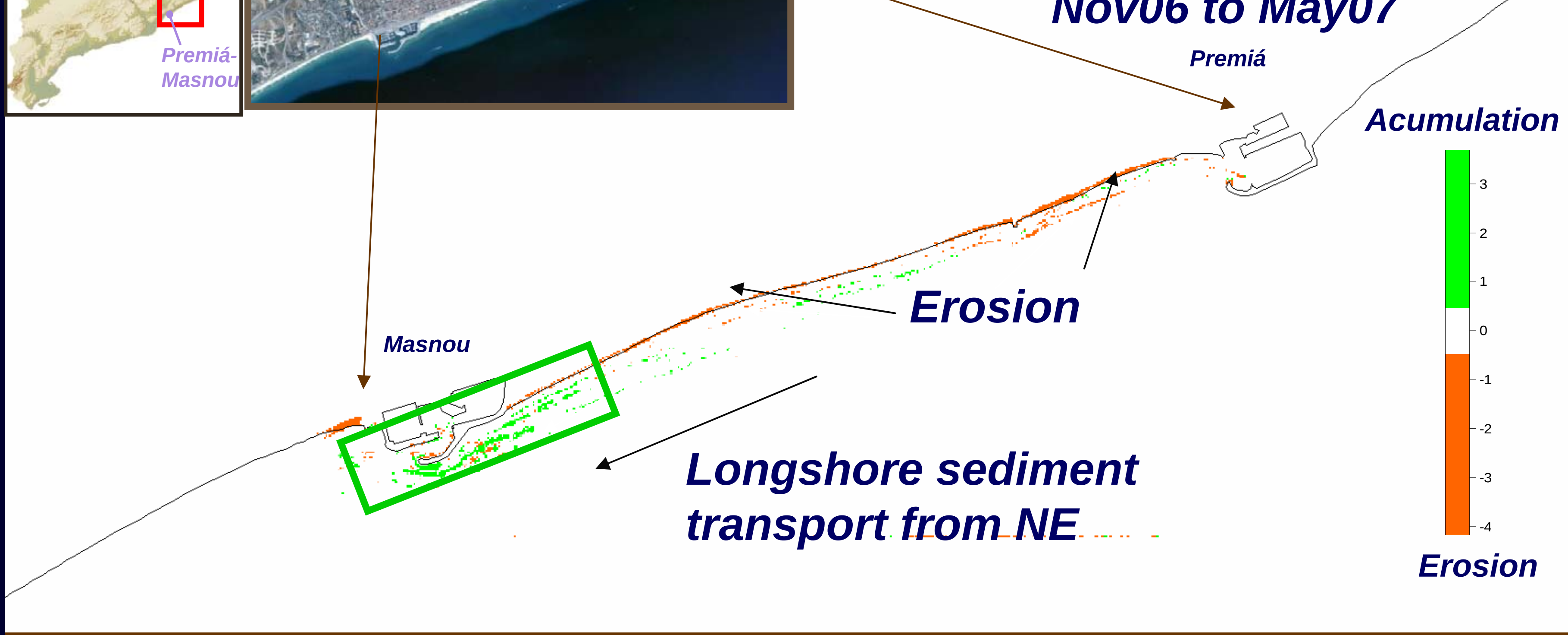
**Coastal area**

ICM-P1

## Morphological evolution of dredge & nourishment area

### Accumulation-Erosion balance of the whole area




- ***Net erosion on the beach:***

  *Some areas of the beach between Premia-Masnou are strongly eroded*

- ***Accumulation***

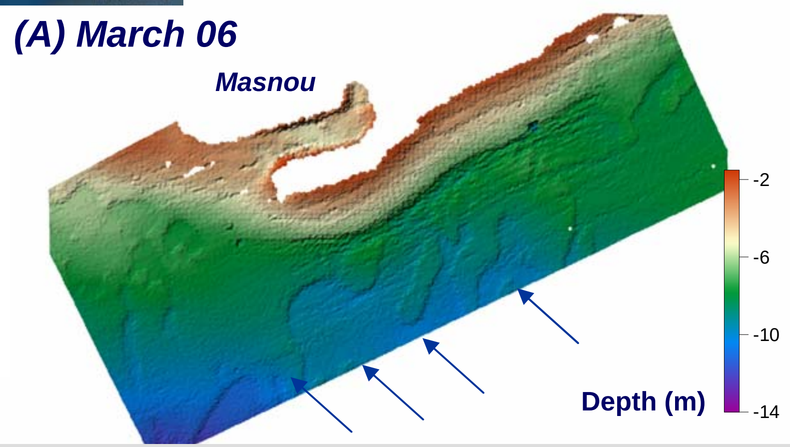
  *Most significant accumulation in the Masnou area*

Coastal area

# Morphological evolution of dredged area: Masnou

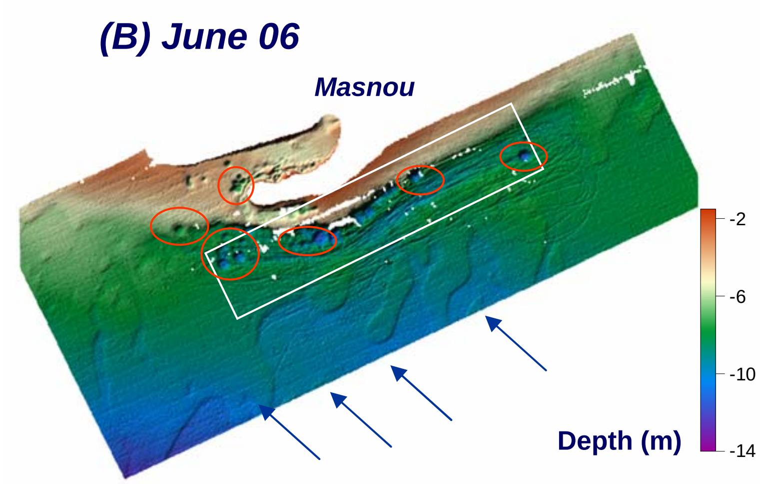
**ICM-P1**


***Begining of dredge activities***



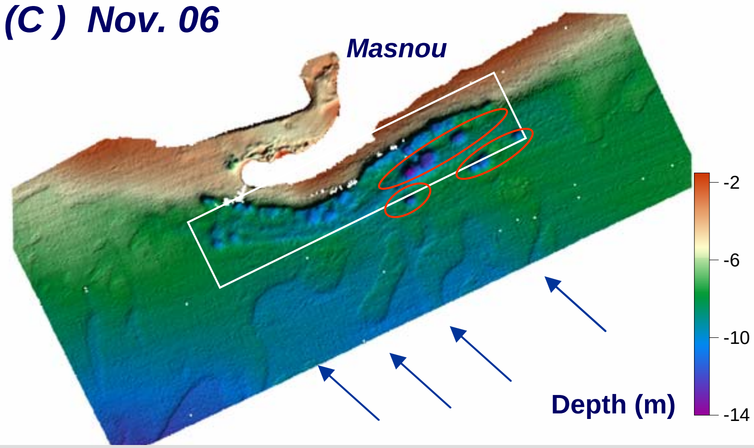

Undisturbed seabed, (bedforms)

***End of main dredge activities** (188.743 m³ of sand has been removed*



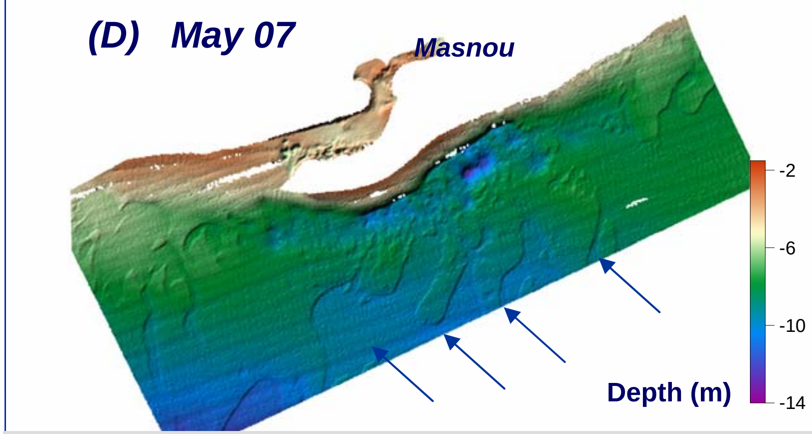

Trench, sand pits, (bedforms)

*6 months **after main dredge activities***




Completed infilled of western sand pits, (bedforms)

*1 year after **main dredge activities***




Infill of trench & sand pits, (bedforms). *Sediment accumulation*.

# Dredged/nourishment evolution in M.M./Cervia

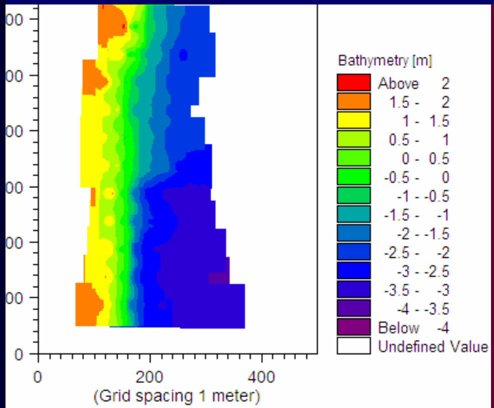
DISTART-P3

**Bathymetric surveys**

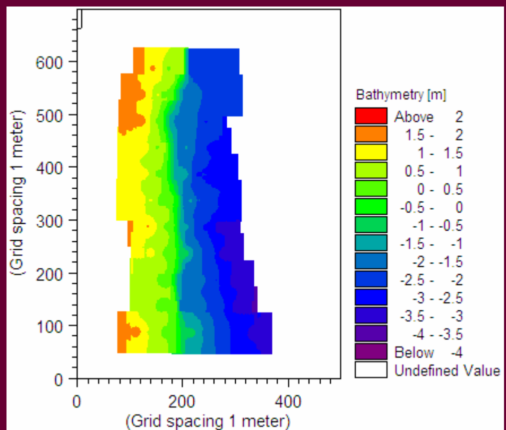
**Differences**

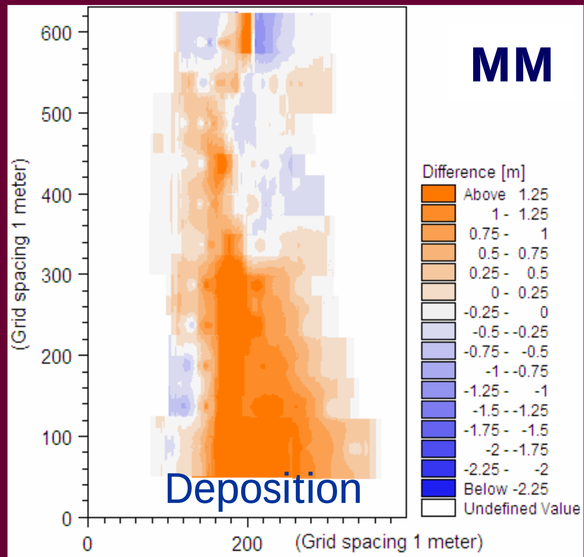
## Milano Maritimmo

### 11 April-07 (Before works)



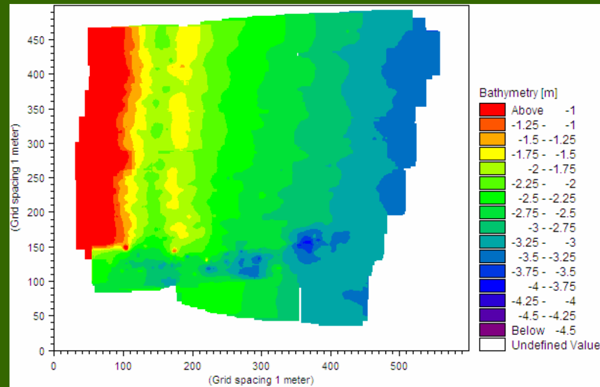

### 1 June- 07 (After works)



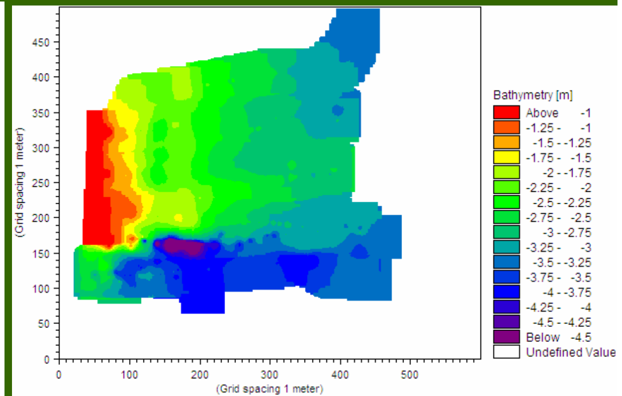



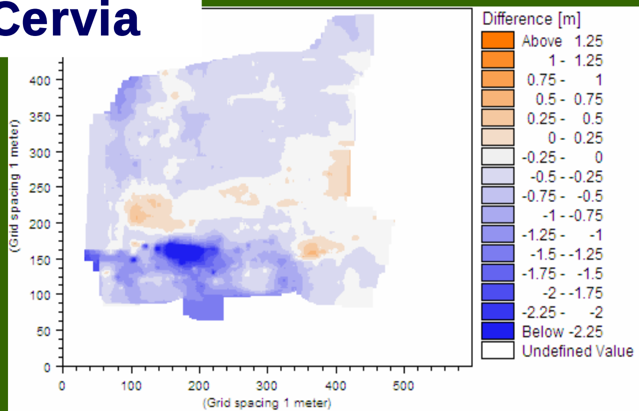

## Cervia

### 13 April-07 (Before works)




### 1 June- 07 (After works)

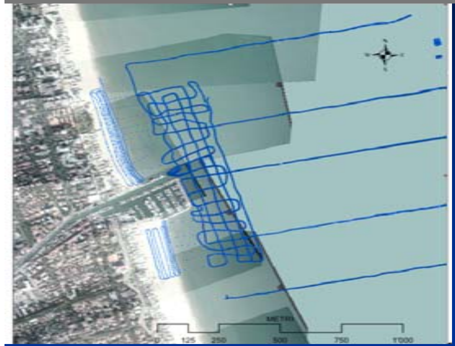



**Coastal area**

## Dredged/nourishment evolution in Cervia

DISTART-P3



- By comparing the old bathymetries (Phase B) and the more recent ones (Phase C) it was seen that the port entrance channel is not filled with sediments **but they tends to bend on the direction of the storm**.

- The old strategy of dragging the channel slightly deeper, did not prove much effective since a single storm difficult the access to the port.

- DISTART suggests a dredging strategy:
To drag wider channel.

The numerical simulations will give quantitative results

# Coastal Sand Stocks Availability

Coastal area

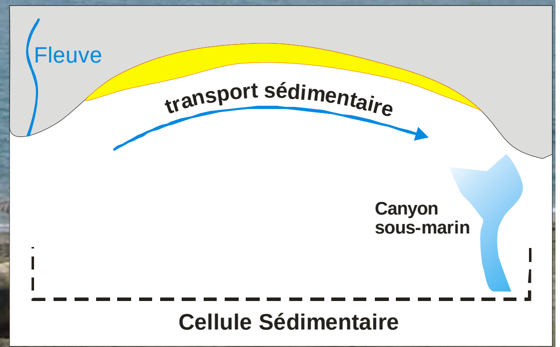
- Deltaic formations

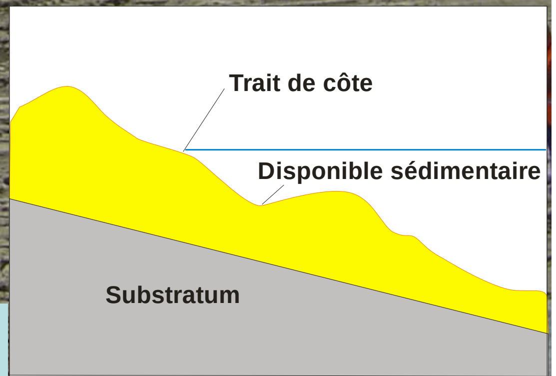

UB-P2

- Intercepted by coastal infrastructures


ICM-P1
DISTART-P3
UFLOR-P4 (Phase B)

- Sedimentary cell

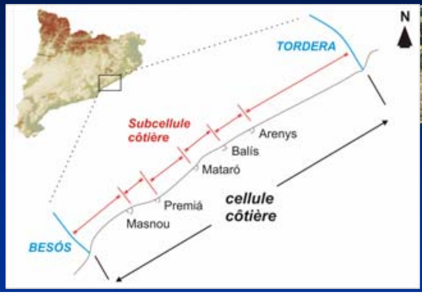


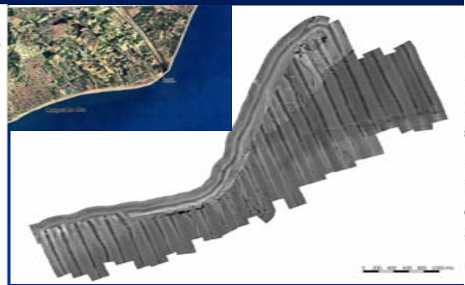



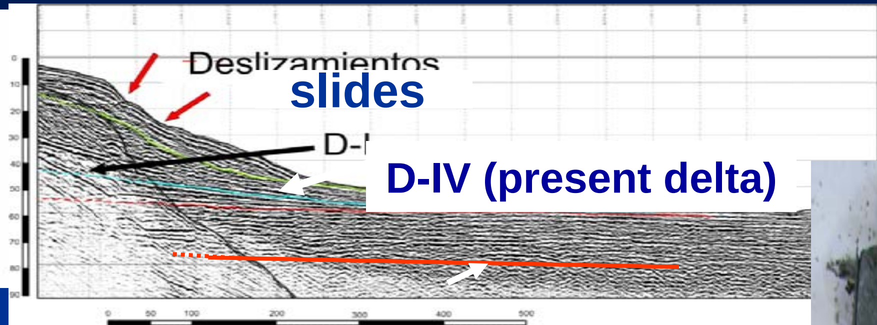

ICM-P1
LEGEM-P6

## Sand resource on relict delta formations

UB-P2



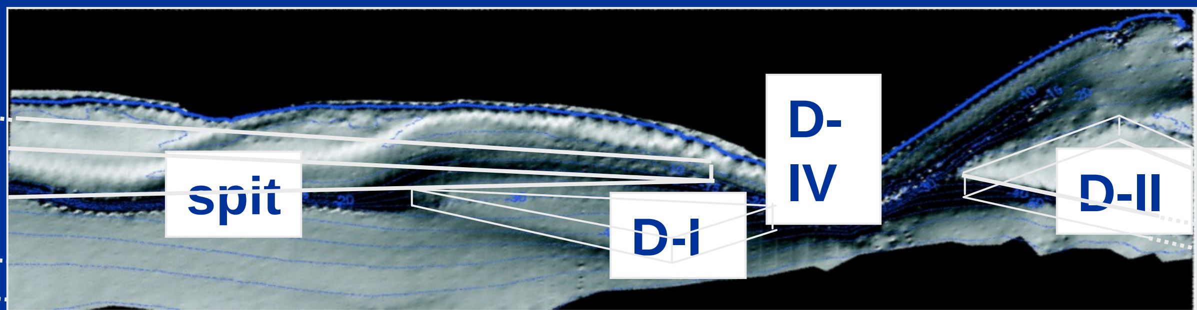


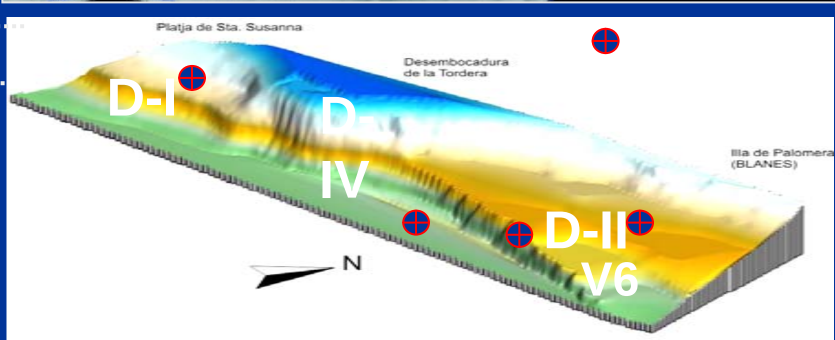

Tordera Prodelta

**Holocene transgressive surface**



• Tordera relict deltas and present submerged spit have at least a **Volume of 38 million cubic meters of sand**.




Vibrocores from

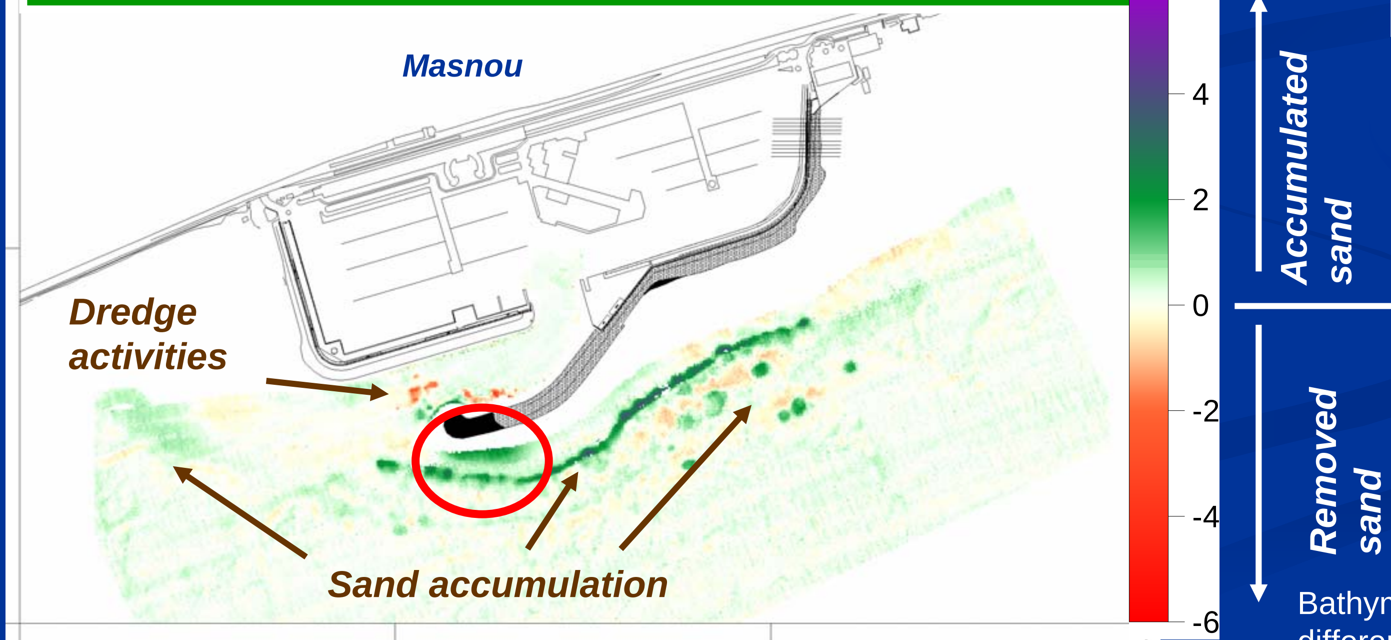
Tordera prodelta zone (Holocene transgressive surface)

Hydrographical basin

**ICM-P1**

## TOTAL ACCUMULATED SAND IN MASNOU

## (Jun06 to may07, area of 1.2 km²) = 77.208 m³




Bathymetric difference (m)

June 06-Nov. 06
19.853 m³ (Phase B)

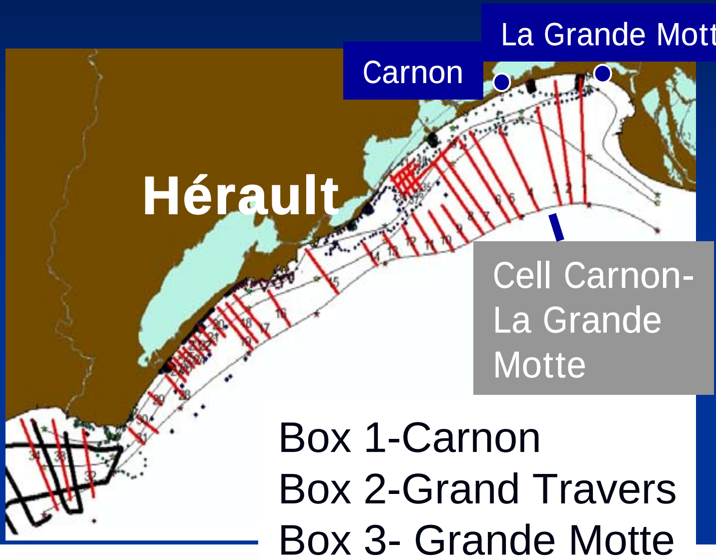
+

Nov 06-May07
57.355 m³

## Seismic stratigraphy: Cartography of seismic units: SED CELL

**LEGEM-P6**

- General increase of stocks to the coast
- Increase of these volumes towards the North-East of the cell (La Grand Motte)



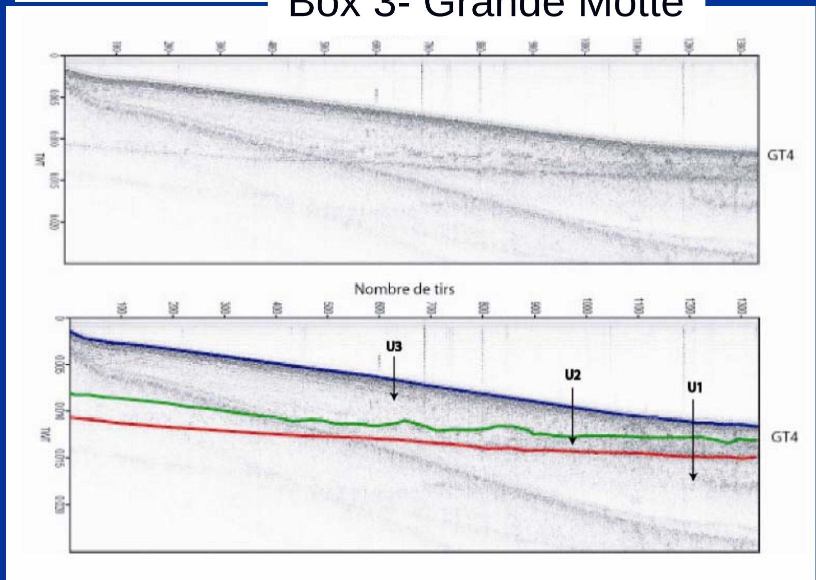
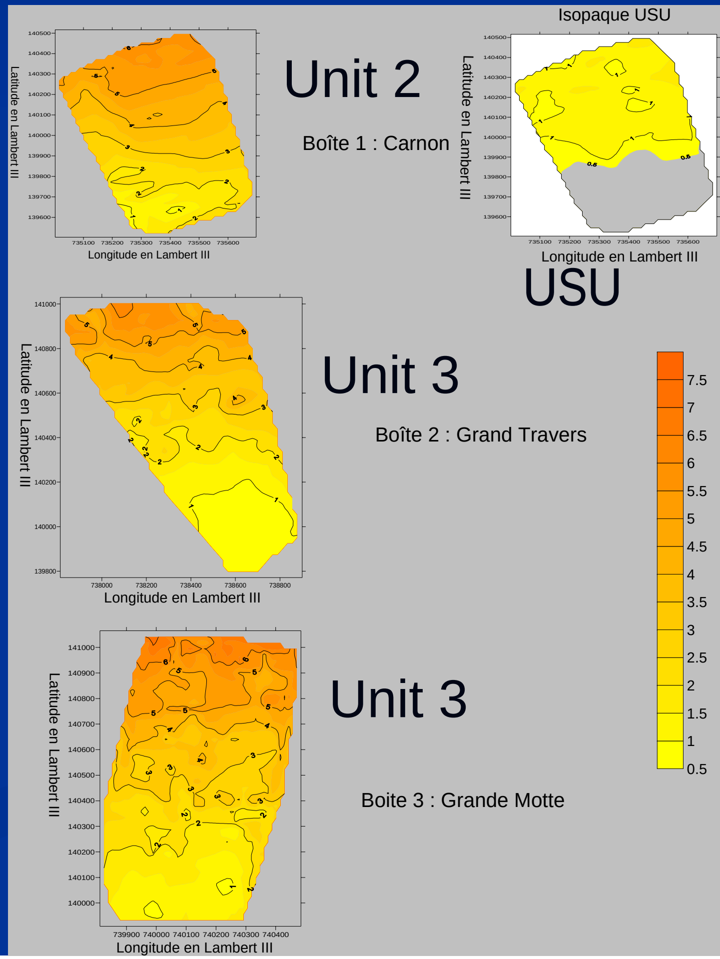




*Figure 16 : Interprétation d'un profil de la boite 2*




Isopach maps of sand deposits (metres)

Coastal area

LEGEM-P6

# Volumes of units potentially available

| | Surface des boîtes (m²) | Volume (m³) |
|---|---|---|
| **Boîte 1 : Carnon** | *431 000* | *353 459 (USU)* |
| **Boîte 2 : Grand Travers** | 728 000 | 2 187 289 (U3) |
| **Boîte 3 : Grande Motte** | 595 000 | 2 059 871 (U3) |

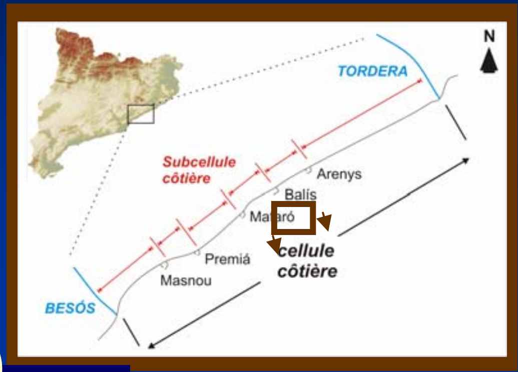
*(All these volumes present an uncertainty of several tens of thousands of m3).*

- The important sedimentary deficit on **Carnon** resulting from this study confirms the tendency of important erosion of this zone.

**Coastal area**

## Morphology & Seismic Stratigraphy on the infralittoral: Masnou Subcell

ICM-P1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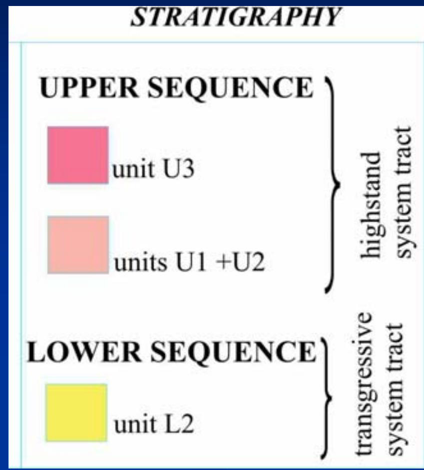


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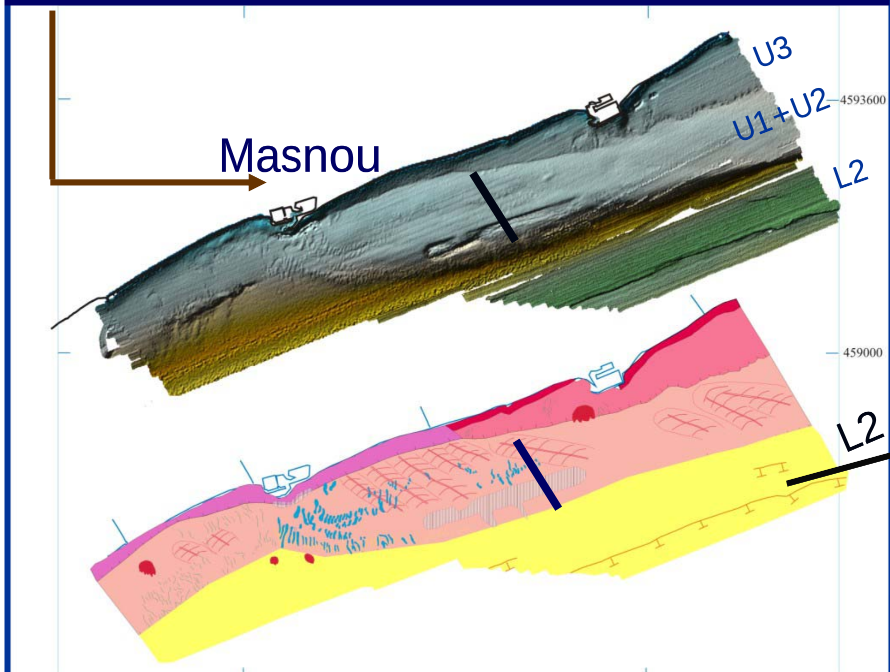
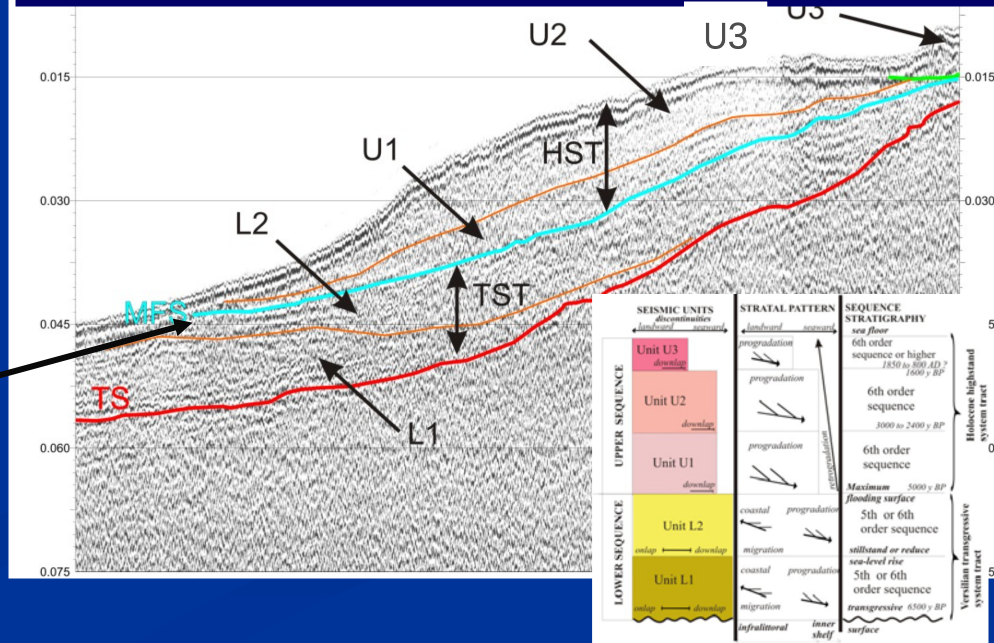
## Morphologic features Map

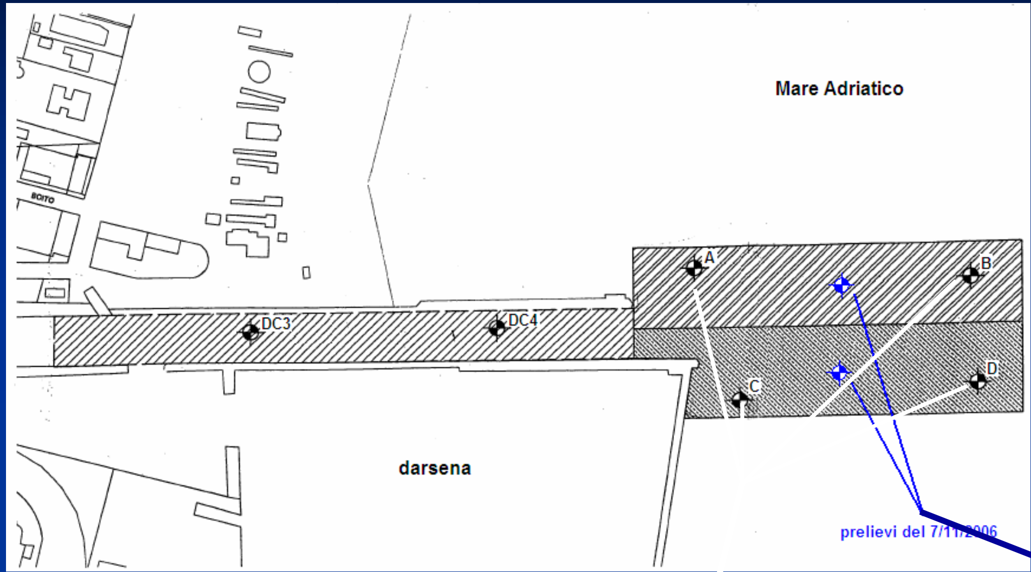



## Seismic profile



## Compatibility between dredged deposits & plage

**DISTART-P3**

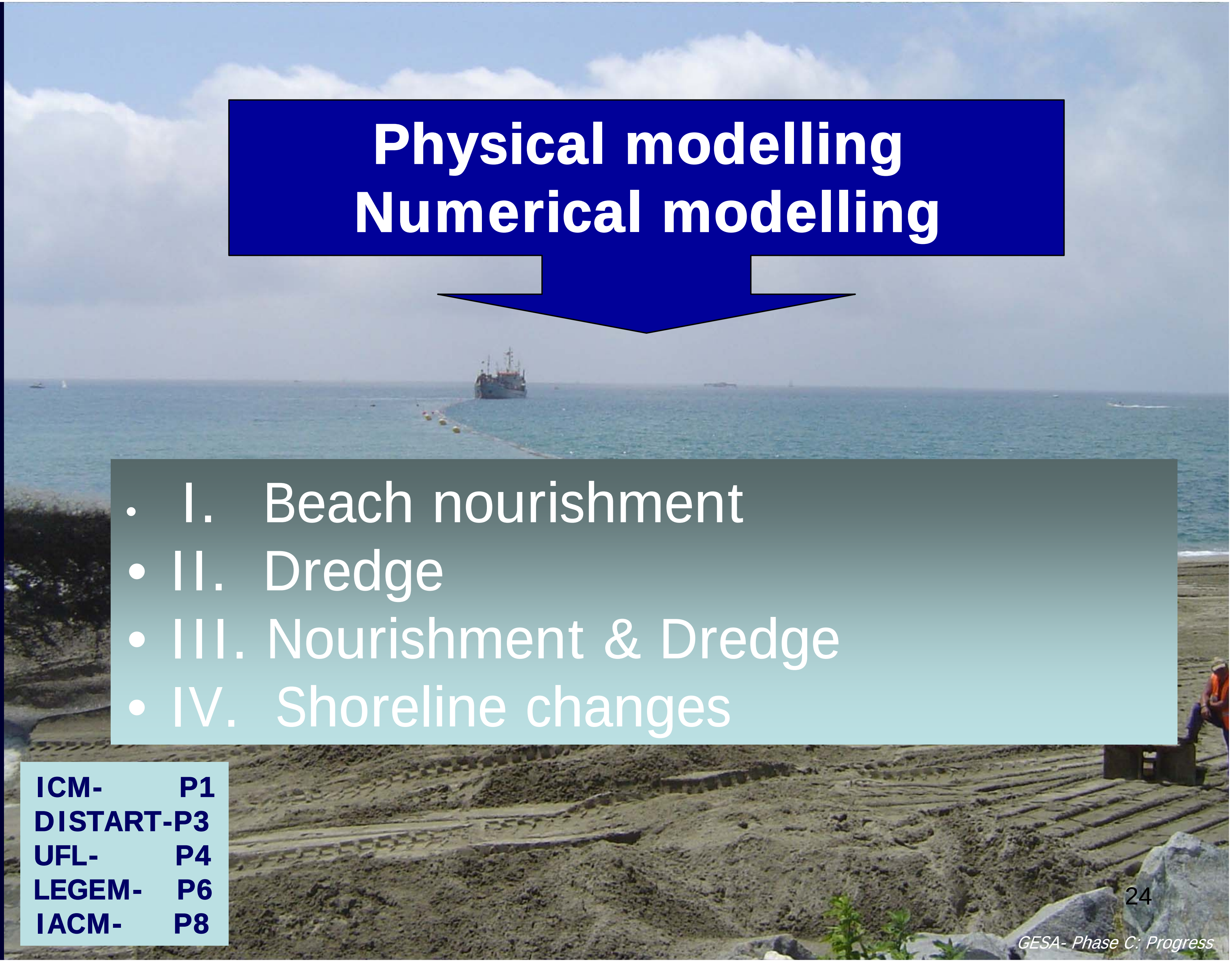



- The material used for the nourishment **is qualitatively suited to the nourishment**

| | (A&B)s | (C&D)s | (A&B)d | BAT |
|---|---|---|---|---|
| Colour | gray/brown | gray/brown | gray/brown | gray |
| Smell | sulphureous | sulphureous | odourless | odourless |
| Thick fraction | shells | shells | shells | shells |
| Losses at 600°C (% s.s.) | 3.2 | 2.9 | 2.8 | 1.0 |
| Humidity at 105°C (%) | 28.9 | 27.5 | 30.3 | 25.0 |
| Gravel - 2 mm (%) | 0.3 | 0.1 | 0.1 | 1.5 |
| Sand - 0.4 mm (%) | 94.7 | 94.9 | 93.9 | 97.5 |
| Silt - 0.074 mm (%) | 1.0 | 1.0 | 2.0 | 0.0 |
| Clay - 0.02 mm (%) | 4.0 | 4.0 | 4.0 | 1.0 |

| | Sup | Deep |
|---|---|---|
| Humidity at 105°C (%) | 22.87 | 35.98 |
| Loss at 105°C (%) | 77.13 | 64.02 |
| Skeleton > 2mm (%) | 2.2 | < 0.1 |
| Sand 2000÷1000 μm (%) | 0.7 | 0.6 |
| Sand 1000÷500 μm (%) | 0.8 | 0.9 |
| Sand 500÷250 μm (%) | 5.0 | 2.4 |
| Sand 250÷125 μm (%) | 65.3 | 27.8 |
| Sand 125÷63 μm (%) | 23.7 | 12.9 |
| Sand 63÷50 μm (%) | 0.5 | 13.7 |
| Silt 50÷20 μm (%) | < 0.1 | 19.3 |
| Silt 20÷2 μm (%) | 2.5 | 14.6 |
| Clay < 2 μm (%) | 1.5 | 7.8 |

**Coastal area**



# Physical modelling
# Numerical modelling

- I. Beach nourishment
- II. Dredge
- III. Nourishment & Dredge
- IV. Shoreline changes

ICM- P1
DISTART-P3
UFL- P4
LEGEM- P6
IACM- P8

Coastal area

## Lab. Test on inner bar

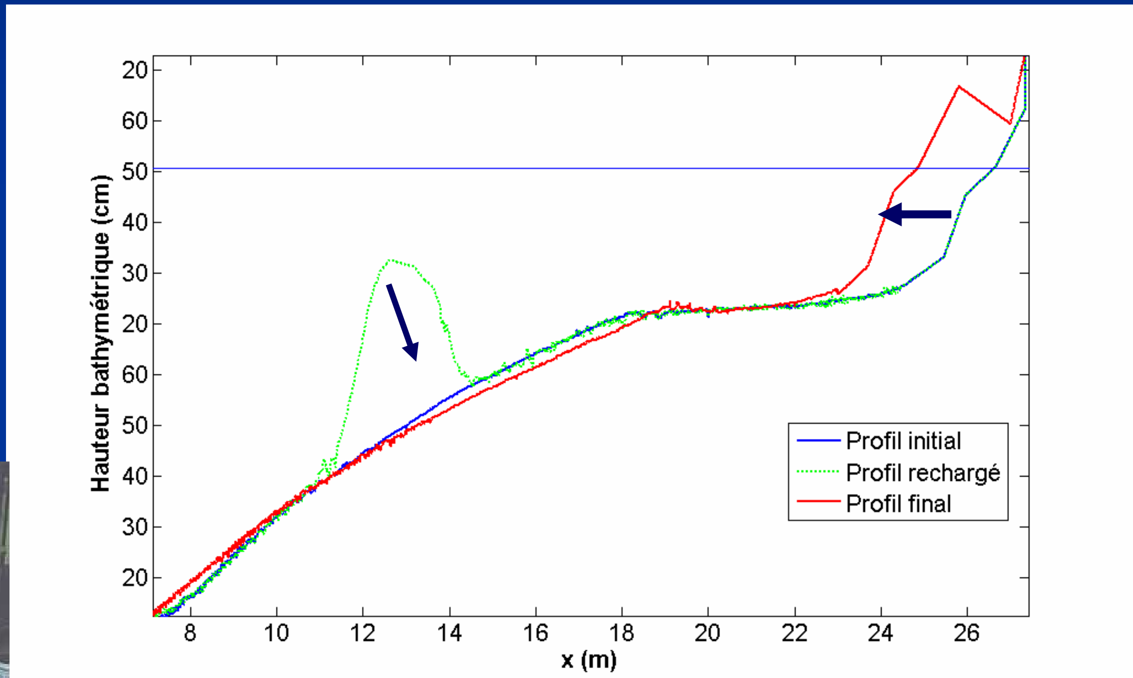
LEGEM-P6

## The first experiment realized

Nourishment of the **inner bar** (green) and a long period of constructive waves,

- We can see the shoreface nourishment migrate onshore and aggregate to the shore (red), leading to a larger beach.
- Good result or this case.

*Equilibrium profile before & after nourishment*
*(wave: "vag2s107mm" TT)*




Temps terrain *3;
Longueur*10, soit env. 250 m d'avant-côte

- Necessity to test others, in particular deeper and seaward shore face nourishment (this goes on actually)

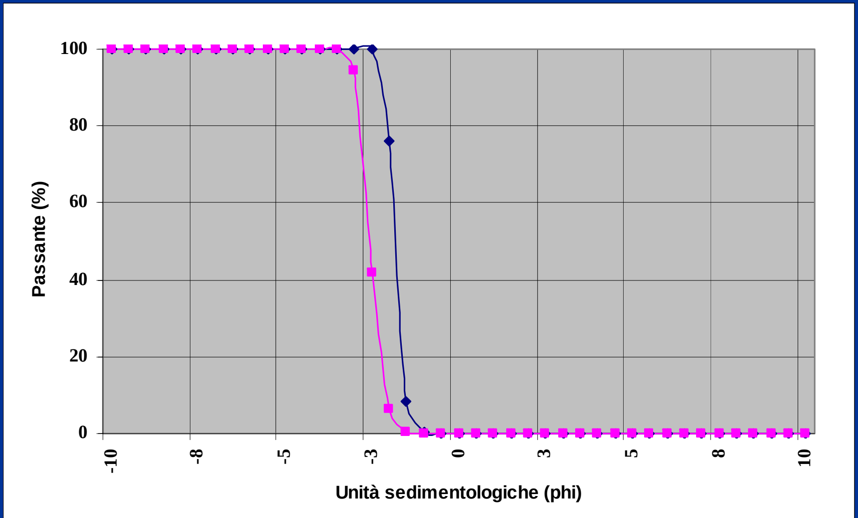
UFLOR-P4

# Lab. Test on gravels beaches

**Two types of gravels**
(4 & 8 mm-mean diameter)

**Narrow grading curve**

**Two types beaches**
(natural & protected by a submerged structure)

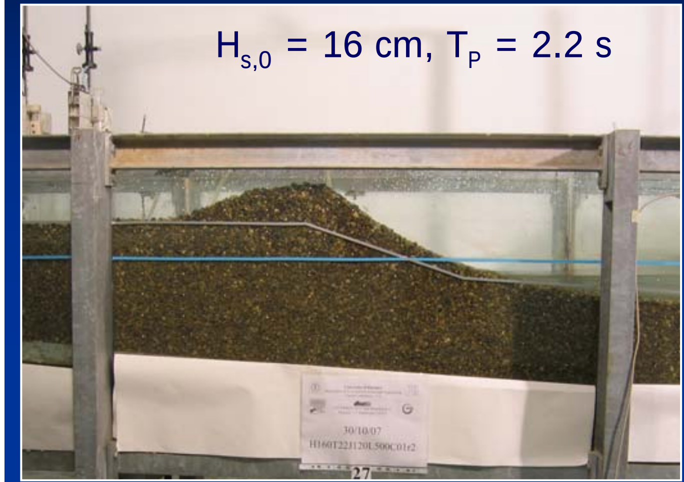



**Three different waves Steepness & deepwater**

| $H/L_0$ | 0.02 | 0.04 | 0.06 |
|---|---|---|---|
| $H_{s,0}$ [m] | 6 | 11 | 16 |
| $T_p$ [s] | 0,8 | 1,1 | 1,3 |
| | 1 | 1,3 | 1,6 |
| | 1,4 | 1,9 | 2,2 |

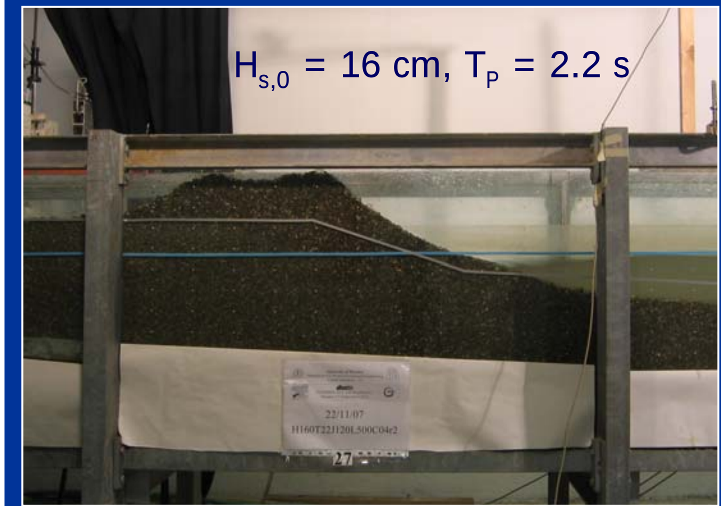
UFLOR-P4

Coarser gravel

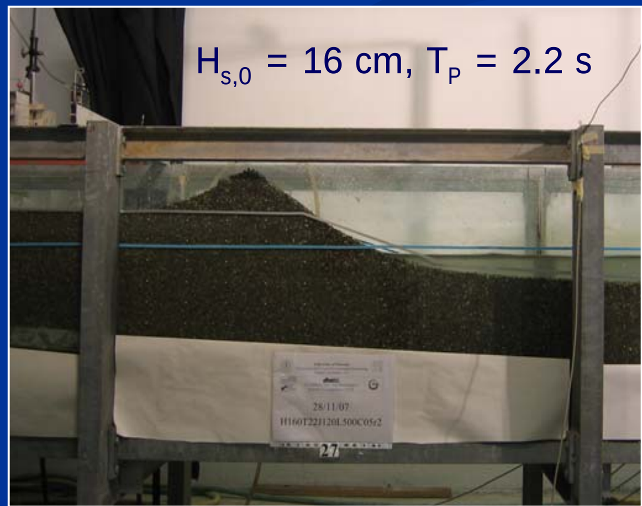



Coarser gravel with structure


Finer gravel




Finer gravel with structure




**Influence of the structure** is:

- Qualitatively shown in these pictures
- Quantitative data processing is still on-going.

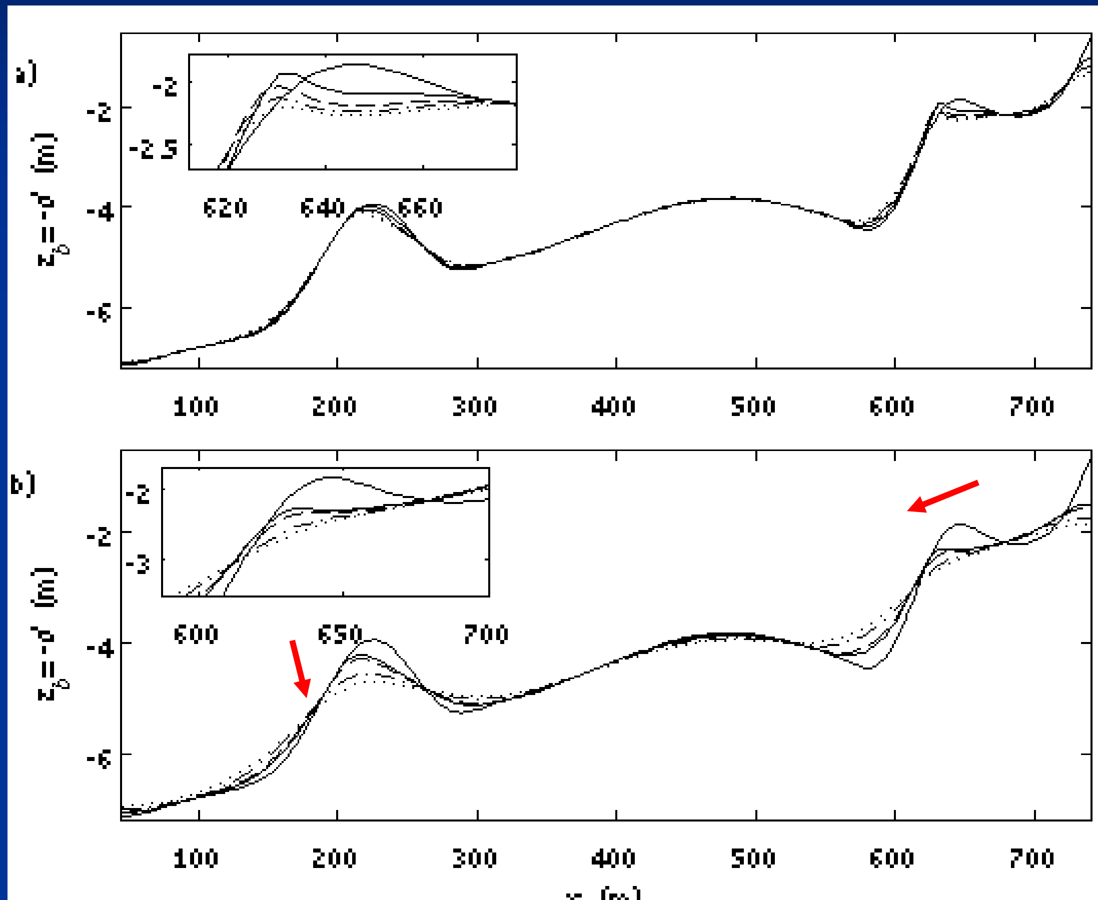
## Nourishment a  new bar offshore

LEGEM-P6

**Used Models**:
Modhys
Telemac
S-Beach

- **Creation** of a new bar offshore= slow disparition of the nourishment and erosion off the inner system

### Storm response

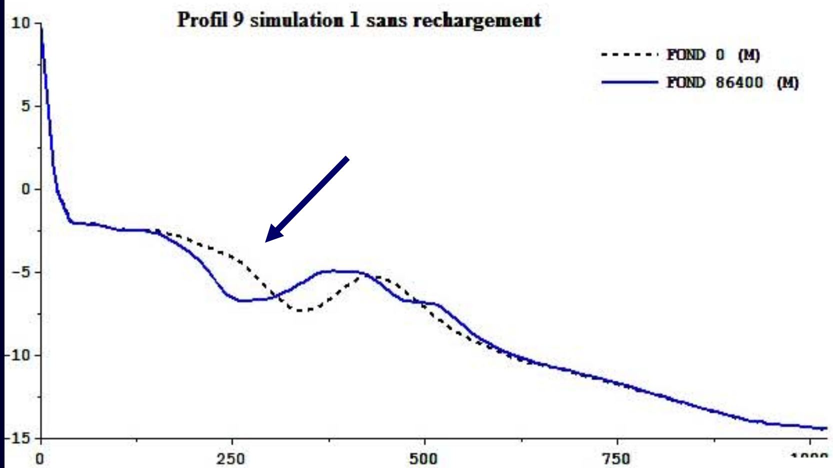


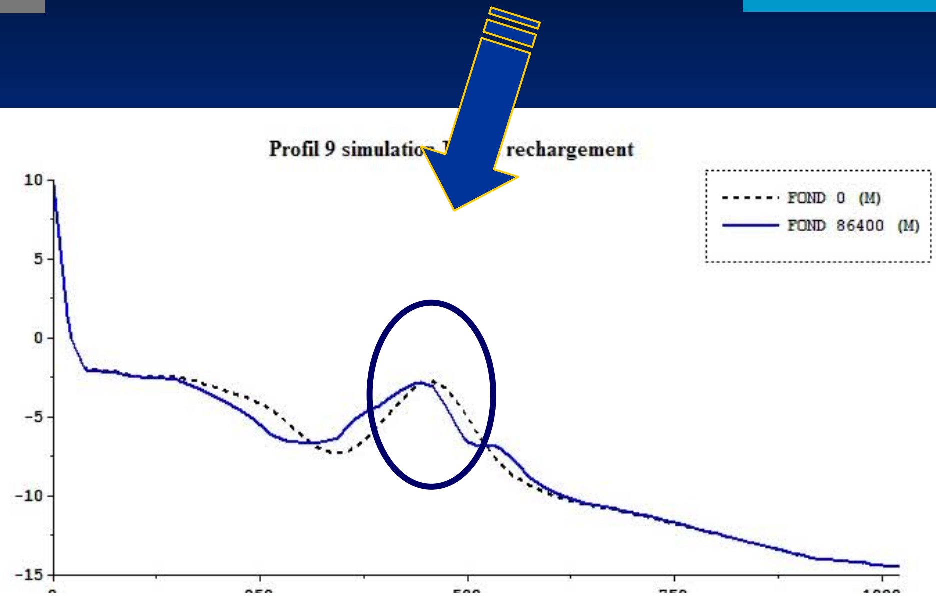

Evolution du profil de bathymétrie à 3 barres (¾) pour différentes heures : (a) (¾) t=1h, (- -) t=2h, (-6-) t=3h, (×××) t=4h, (b) (¾) t=6h, (- -) t=8h, (--‑) t=16h, (×××) t=24h.

Coastal area

# Nourishment on the outer bar

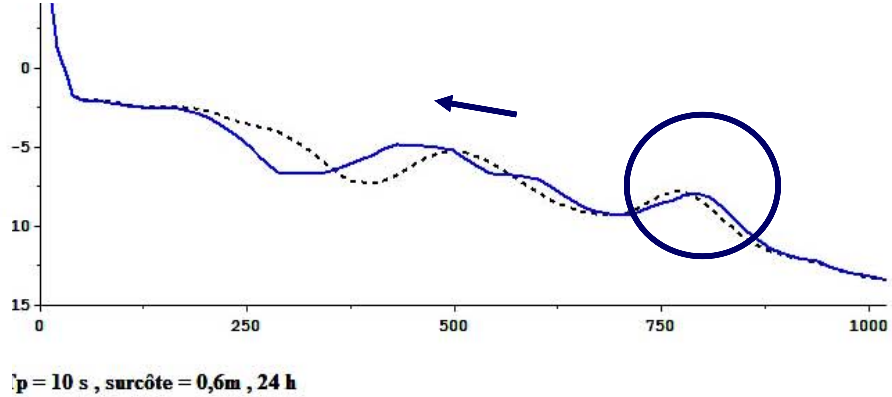
LEGEM-P6




1. **Natural evolution under storm**

**2. Nourishment on the outer bar** (2 nd fig)= diminution of the erosion of the inner system. Renforcement de la barre externe




**3. Create of a new offshore bar**= same effect as previous model=erosion of the inner system

Coastal area

## Simulation Scheveningen case: validate the model quality (ROMS MODEL)

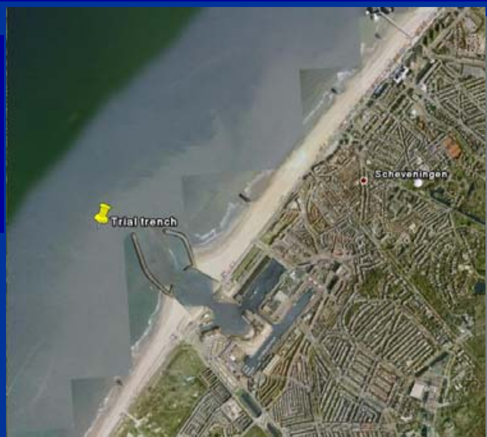
**DISTART-P3**

It will validate to ROMS
This model consider different kinds of sediments
(find sand or silt over natural sand)

Simulated case is an old (1965) experiment which was simulated by many researches using 1 o2 2D models in the recent past, and can now considered a benchmark case

- **About 30,000 m³ was dredged**

**Length** : 700 m
**Bottom width** 10 m
**Side slopes** : 1 to 7
**Depth**: **2 m**



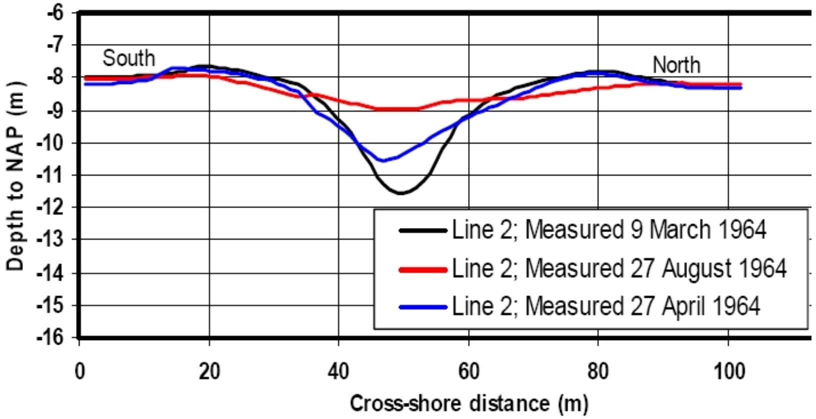


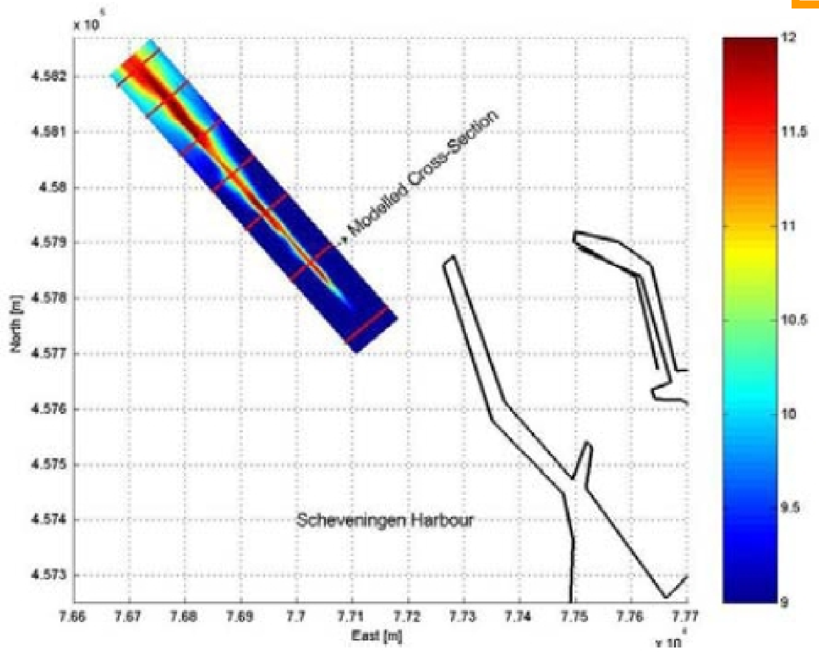

•*Trial* ***trench dredged perpendicular to the shoreline***

**Coastal area**

Coastal area

## Sedimentation in trial trench near Scheveningen



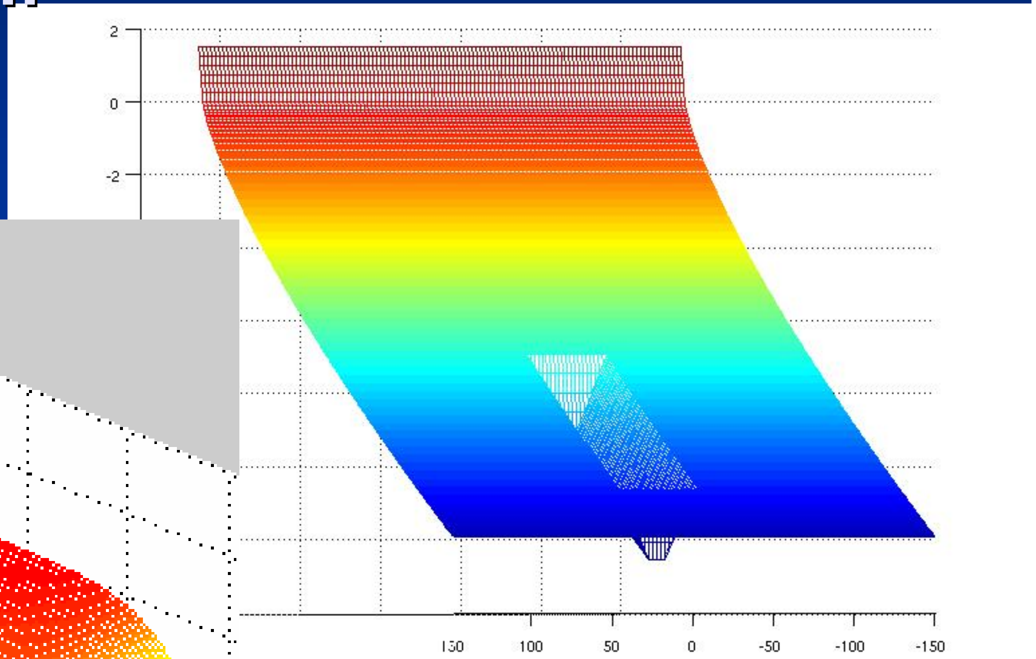



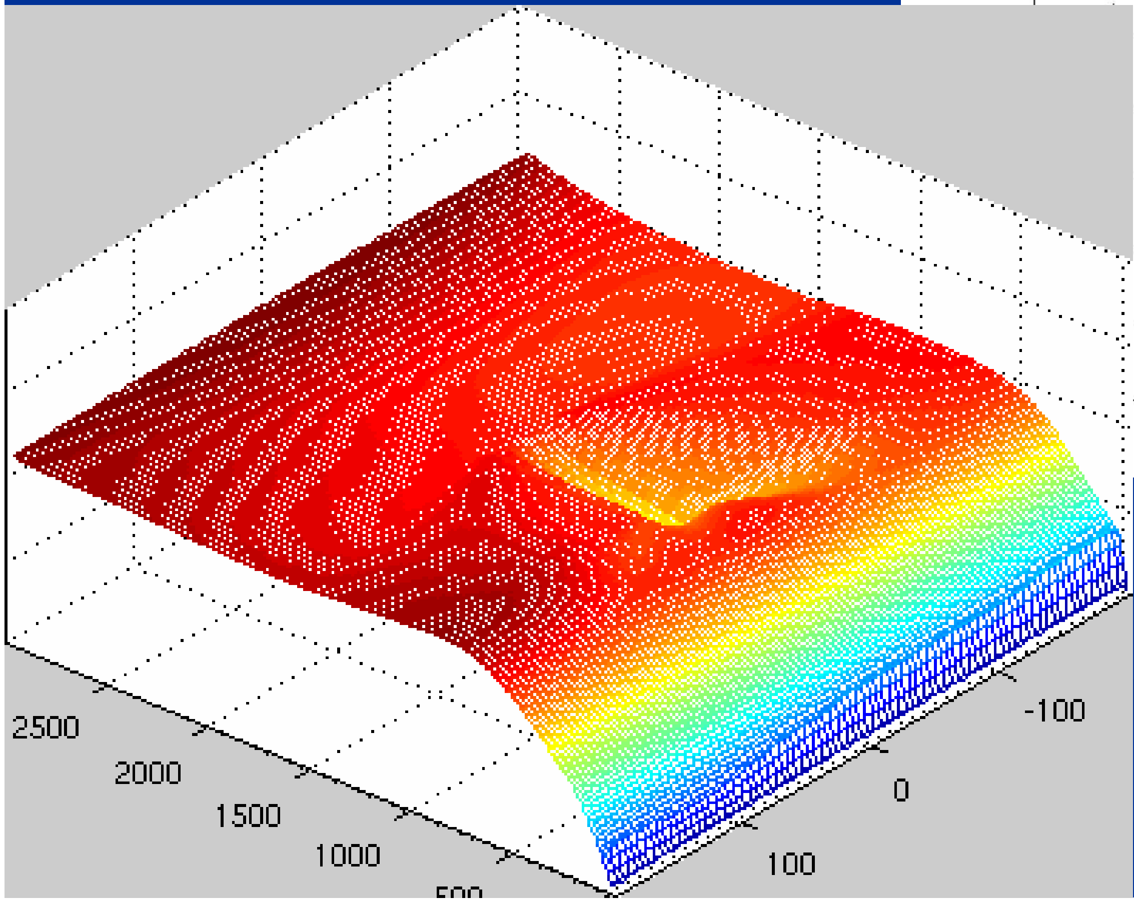

| **Trial trench** | **near Scheveningen in North Sea** | |
|---|---|---|
| **Inlet conditions** | Water depth to MSL $h_o$ (m) | 7 to 11 |
| | Approach angle $\alpha_o$ (degrees) | 90 |
| | Tidal range (m) | 1.5 to 2 |
| | Peak flow velocity (ebb) to south (m/s) | 0.5 |
| | Peak flow velocity (flood) to north (m/s) | 0.6 |
| | Measured wave height $H_s$ (m) during 173 days<br>peak period (s) | 3 m during 1 day; 2.5 m during 7 days; 1.75 m during 14 days; 1.25 m during 30 days; 0.75 m during 50 days; 0 m during 71 days<br>5 to 8 s |
| | Sediment size $d_{50}$, $d_{90}$ (fine sand in mm)<br>Gross sediment transport (estimated in $m^3/m$, bulk volume incl. pores) | 0.2; 0.3<br>40 to 55 |
| **Channel dimensions** | Water depth in channel $h_1$ (m) | 11 to 12 |
| | Bottom width (m); top width (m); slope | 10 to 20; 30 to 40; between 1 to 5 and 1 to 7 |
| **Sedimentation values** | Sedimentation area (cross-channel, dry bulk volume in $m^3/m$, including pores) | 30 to 35 during 173 days |

30-35 m3/m during 173 days

# 2D Wave (SWAN) + 3D (ROMS SED)

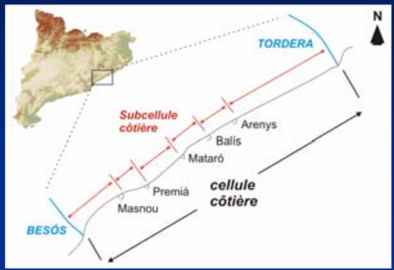
**Morphodymanic simulation under way... (ROMS Model)**



## Numerical Models applied to morphological evolution of dredges area: Masnou

**ICM-P1**





**SMC** ←

## A. Fair weather conditions

*June 2006 - November 2006*

| Direction | % occurrence | Hs (m) | Tp (s) |
|---|---|---|---|
| NE | 16,02 | 0,8 | 6,44 |
| E | 26,93 | 0,52 | 4,7 |
| SE | 21,24 | 0,52 | 4,7 |
| S | 17,5 | 0,4 | 4 |
| SO | 17,03 | 0,5 | 4,2 |

D50 = 0,60 mm; D90 = 1,1 mm

## B. Strong wave conditions

*November 2006 - May 2007*

| Direction | % occurrence | Tp (s) | Hs (m) |
|---|---|---|---|
| NE | 24,1 | 6,4 | 1 |
| E | 19,73 | 5,5 | 0,78 |
| SE | 9,1 | 5,3 | 0,5 |
| S | 12,2 | 4,7 | 0,53 |
| SO | 22,8 | 4,5 | 0,6 |

D50 = 0,60 mm; D90 = 1,1 mm

# Dredge area

## ICM-P1

*June 2006 - November 2006*

**Fair weather conditions**

| Direction | % occurrence | Hs (m) | Tp (s) |
|---|---|---|---|
| NE | 16,02 | 0,8 | 6,44 |
| E | 26,93 | 0,52 | 4,7 |
| SE | 21,24 | 0,52 | 4,7 |
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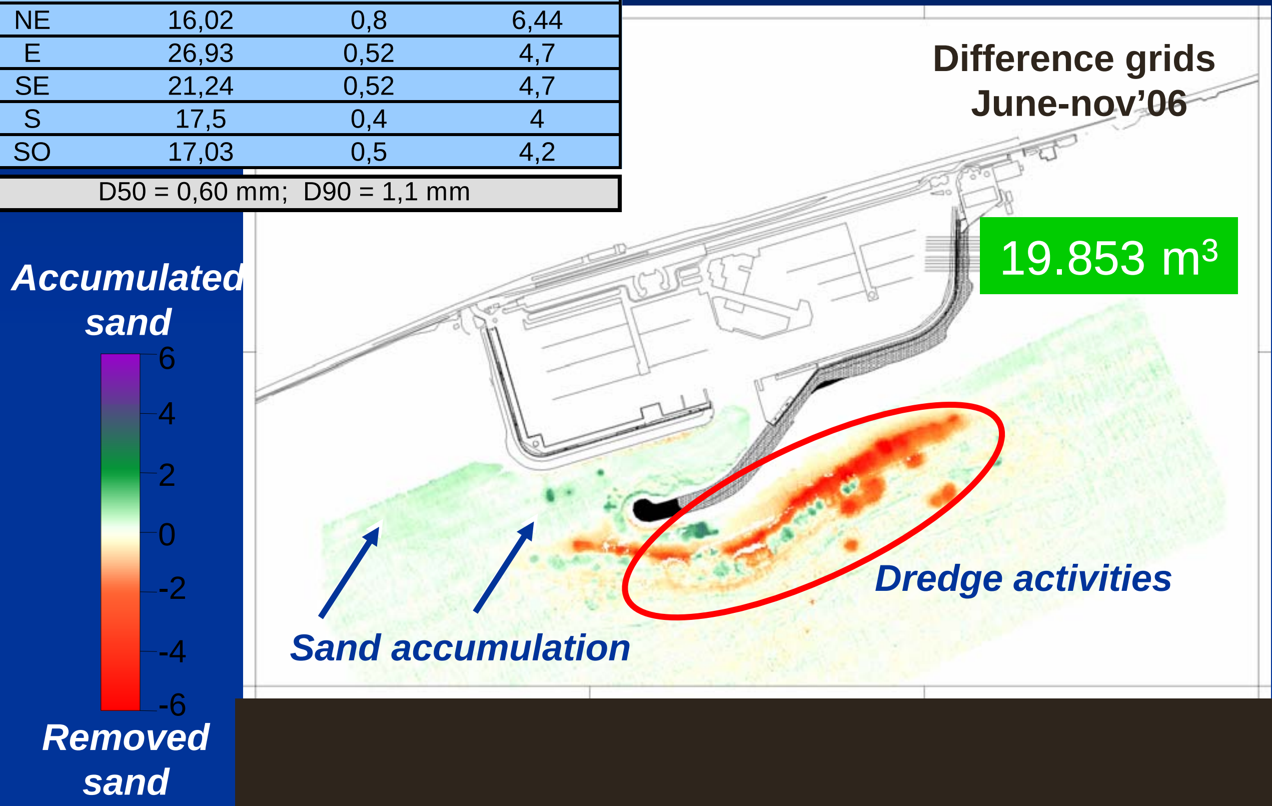
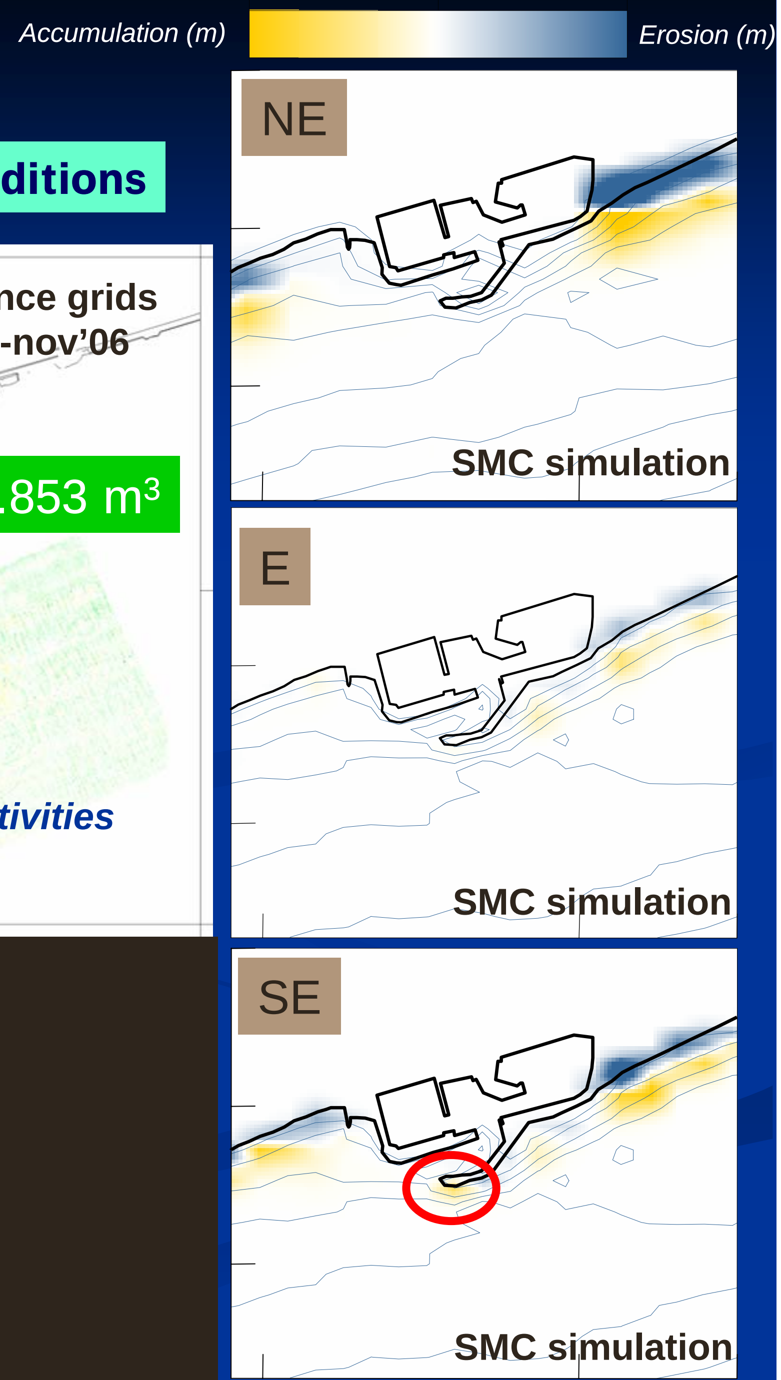
D50 = 0,60 mm; D90 = 1,1 mm



# Dredge area

## ICM-P1

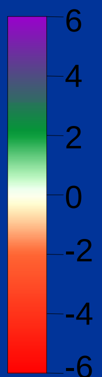
*November 2006 - May 2007*

**Strong wave conditions**

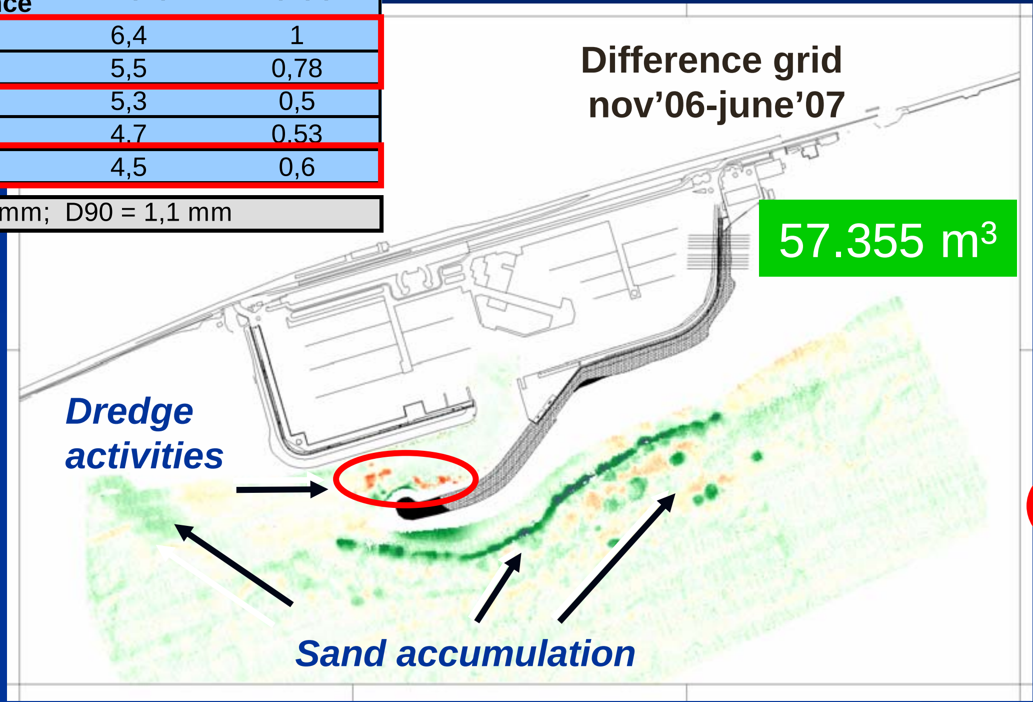
| Direction | % occurrence | Hs (m) | Tp (s) |
|---|---|---|---|
| NE | 24,1 | 6,4 | 1 |
| E | 19,73 | 5,5 | 0,78 |
| SE | 9,1 | 5,3 | 0,5 |
| S | 12,2 | 4,7 | 0,53 |
| SO | 22,8 | 4,5 | 0,6 |

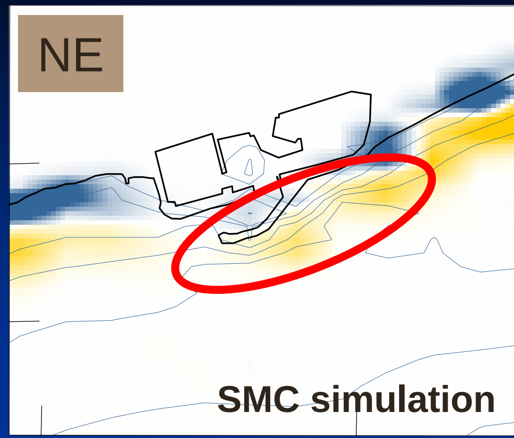
D50 = 0,60 mm; D90 = 1,1 mm

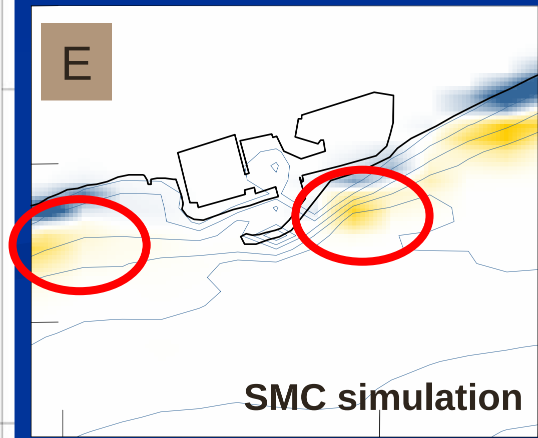

***Accumulated sand***

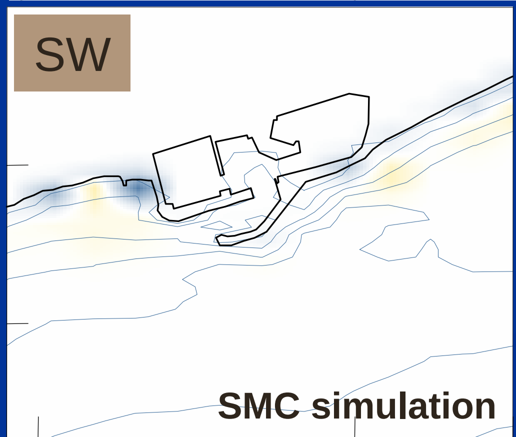



***Removed sand***



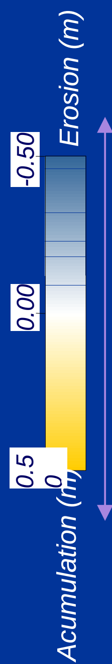



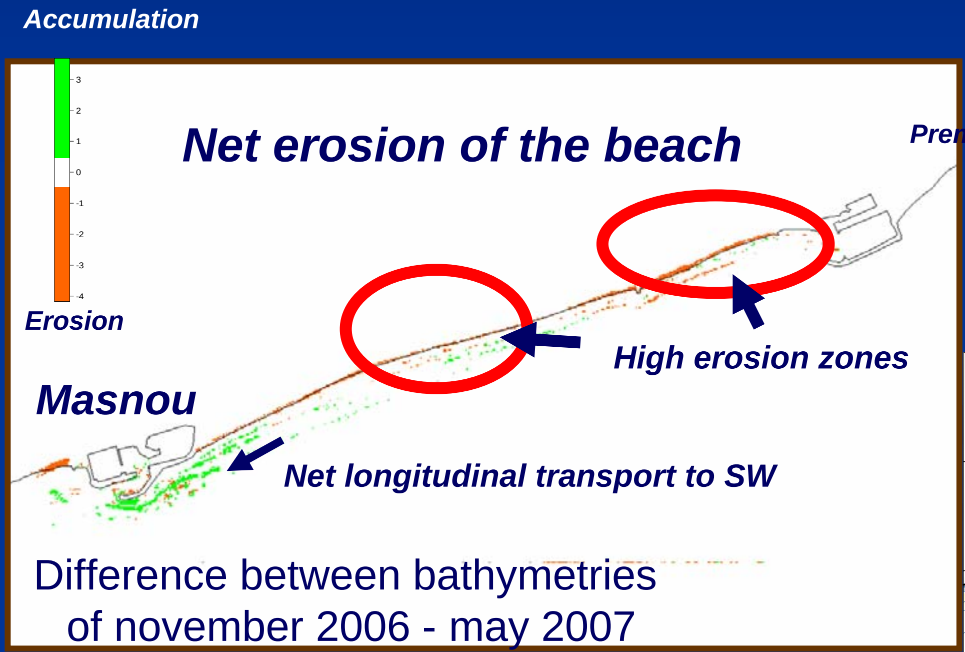



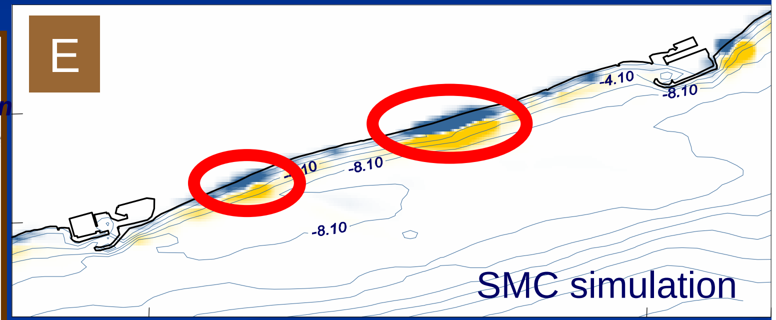
## Nourishment & dredge area: Premia-Masnou

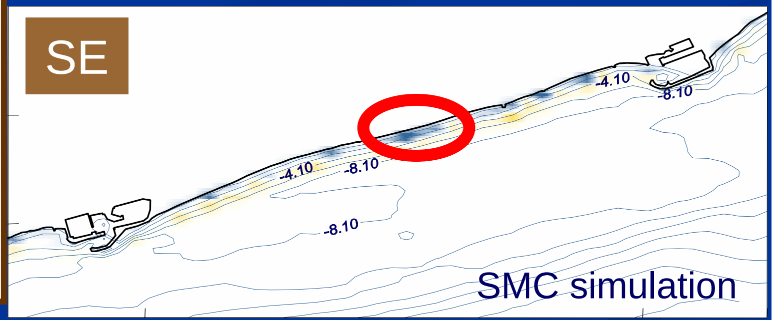
The comparison of the predictions of **numerical models and real data measurements** show good results in the prediction of erosion and accumulation

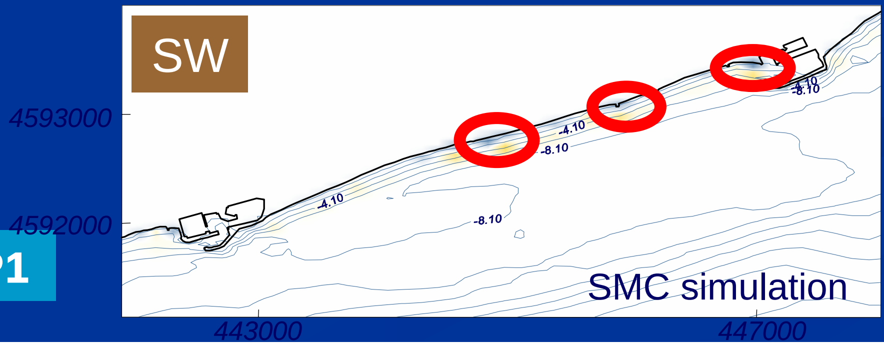


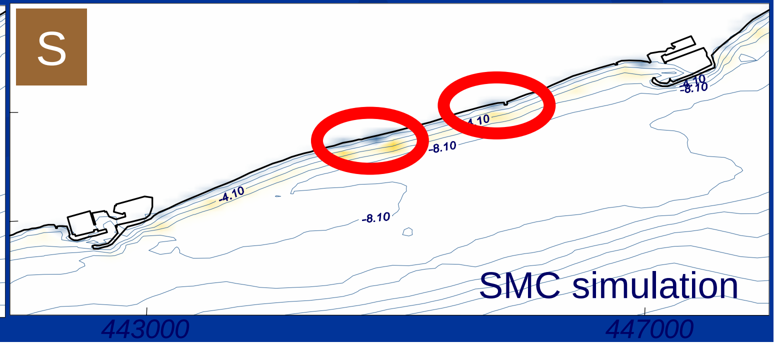







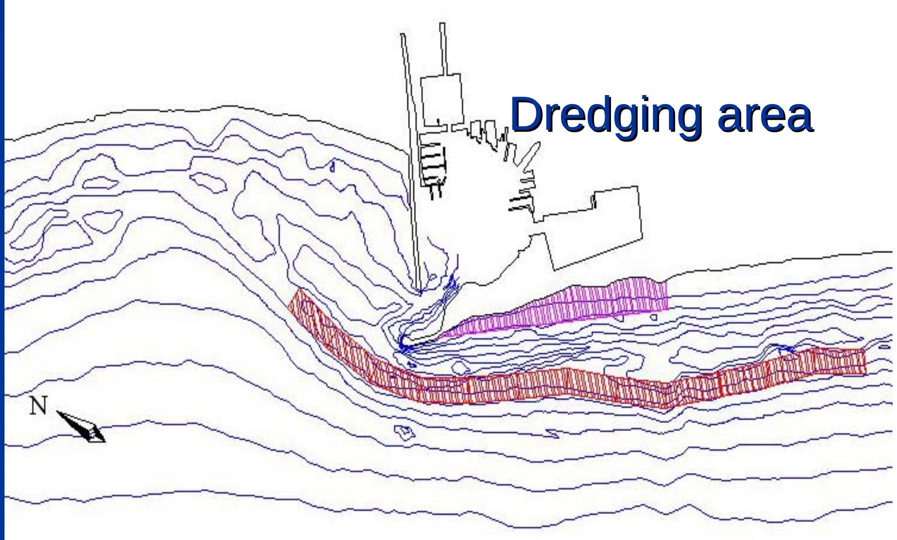

ICM-P1

**Shoreline Evolution & Consequences Of Dredging In Viareggio Harbour**

UFLOR-P4

## Viareggio Harbour

- Sedimentary stocks quantified at the major tuscan harbours (Phase B). Only the Viareggion harbour- formation of a sedimentary stock 20,000 m3/yr




## Simulations

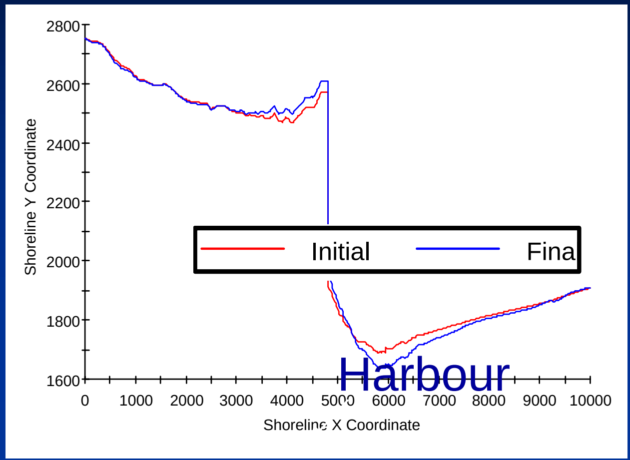
- CEDAS- 20 yr
- **(A)** Initial and final shoreline/ time of 20 yr.
- **(B)** Shoreline evolution has been simulated: after dredging to estimate the influence of dredging operations

Coastal area

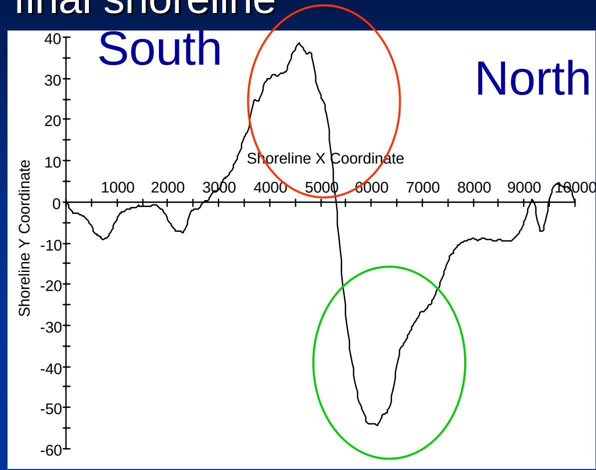
**UFLOR-P4**

**Coastal area**

Initial and final shoreline



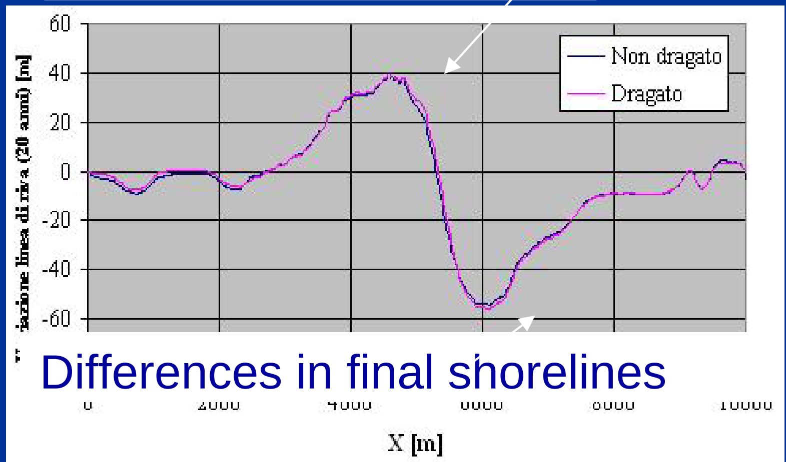

Differences between initial and final shoreline




- **(A)** Accretion is evident southward the harbour and erosion northward

Simulations

**Max accretion in case of dredging: +4-5%**




**Max erosion in case of dredging: +4-5%**

- **(B)** The amount of sediments dredged is equal to the volume of sediments accumulated between the surveys of 7 years (dredged at the sand bar, w.depth 5 m) as estimated in Phase B. Moreover, sediments have been dredged also in front of the harbour breakwater.

**Results show the effects of dredging**

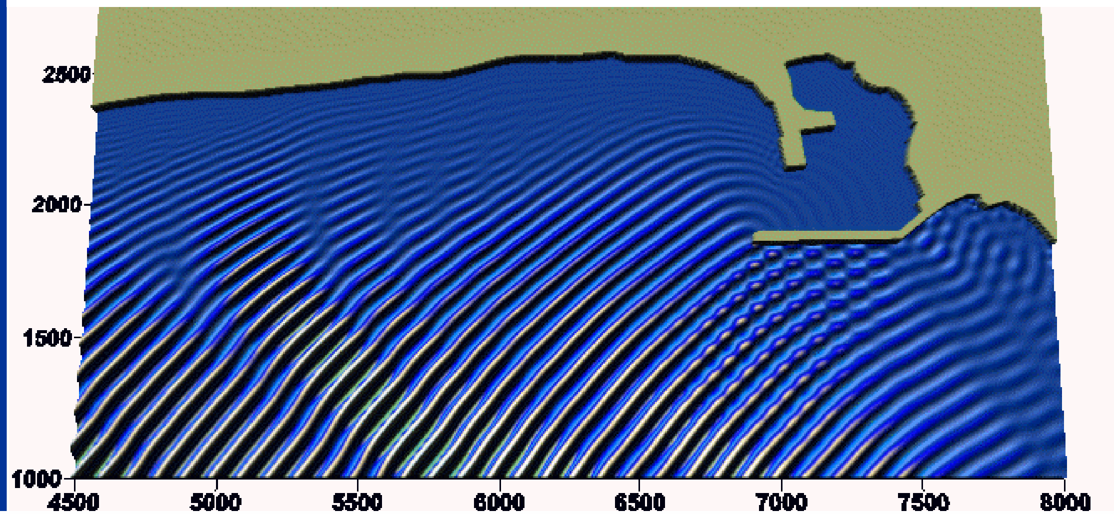
## Applications Of The Numerical Models In the Rethimno Eastern Coast Evolution (Simulation with COAST submodel)

IACM-P8

- The COAST submodel is coupled with a 3D bed evolution model or with a one-line model to provide bathymetry or shoreline changes (model ALS).
- The sediment transport module COAST for the description of the nearshore currents and beach deformation.

After the construction and extension of the breakwater, shoreline changes (erosion and accretion) had been recorded

**Sediment Transport Coast Submodel**

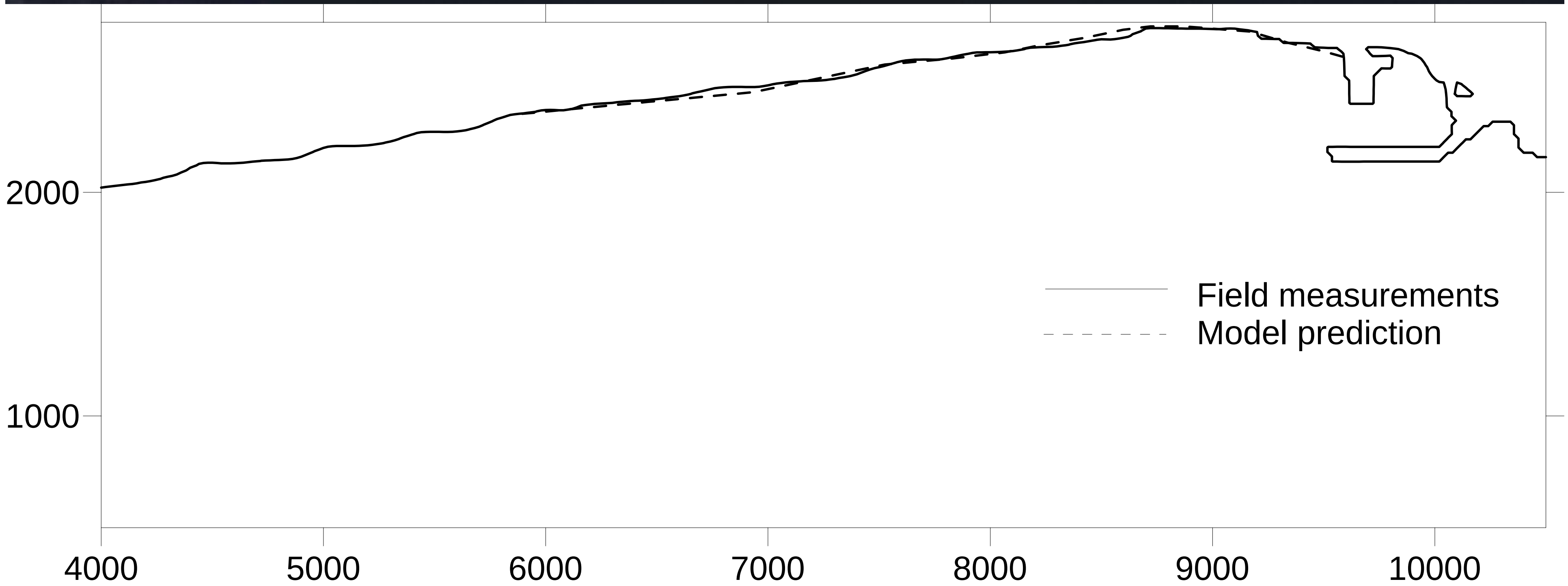



**Free surface elevation of obliquely incident waves (NW direction)**

Coastal area

IACM-P8

- The shoreline changes are well predicted by the model.

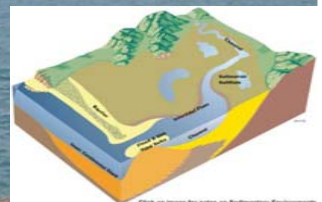



Shoreline change in Rethymno Eastern coast:

Comparison between model results and field measurements 5 years after the extension of the breakwater.

# Summarize

## Main inputs from GESA activities (Nov-07)……..

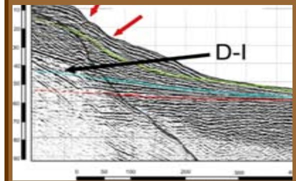


**Management of Sandy Deposits**

Hydrographic Basin

*Sediment dredging from hydrographic basin accumulation areas* (Magra B.),

✓ It is possible (according to Italian Administrative regulation). Quantitative impacts on the environment have to be still assessed in the last months of the project (P4).




Coastal Area

*Sedimentary sand stocks present around different areas* (Viareggio, Masnou, Tordera Delta),

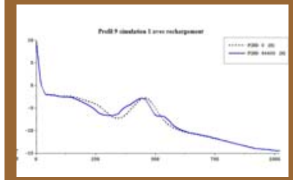
✓ The sand stocks presents around in different harbours can and should systematically be exploited (P1, P4). The sand stocks on relict deltaic formations are important strategically (P2).

Physical Mdels

*Physical models (laboratory test),*

✓ (A) P.M predicting beach evolution after a nourishment of the inner bar provides good results. The shore leading to a larger beach (P6).

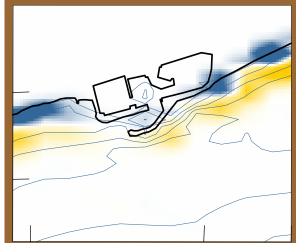
✓(B) P.M. on gravel beaches indicates a preliminary positive effect of a protective structure, but measured data will be more deeply analysed in the last months of the project (P4).



Numerical Models

*Numerical models : Beach nourishment,*

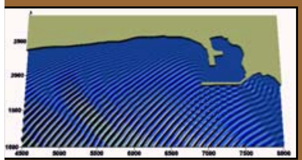
✓ Applied considering two scenarios of beach nourishment (on the outer bar or a new bar offshore) reveal a better efficiency with outer bar nourishment than offshore nourishment (P6).



Numerical Models

*Numerical models: Dredged and nourishment,*

✓ The comparison with the real data measurements show good results in the prediction of erosion and accumulation (Masnou, …. ) (P1, P4 …).



Numerical Models

*Numerical models & Shorelines changes,*

✓ They prove to be an effective approach for coastline prediction. (COAST ) (P8…….).

# THANK YOU
# MERCI
# GRAZIE
# GRACIAS

# …