COASTAL AREA MANAGEMENT AND MONITORING

Coastal protection strategies

Mr. Stefano Corsini

APAT

Agency for Environmental Protection and Technical Services

Beach

Termoli

Ramitelli

Petacciato

Campomarino

Are hard coastal defences better than erosion ?

Roseto

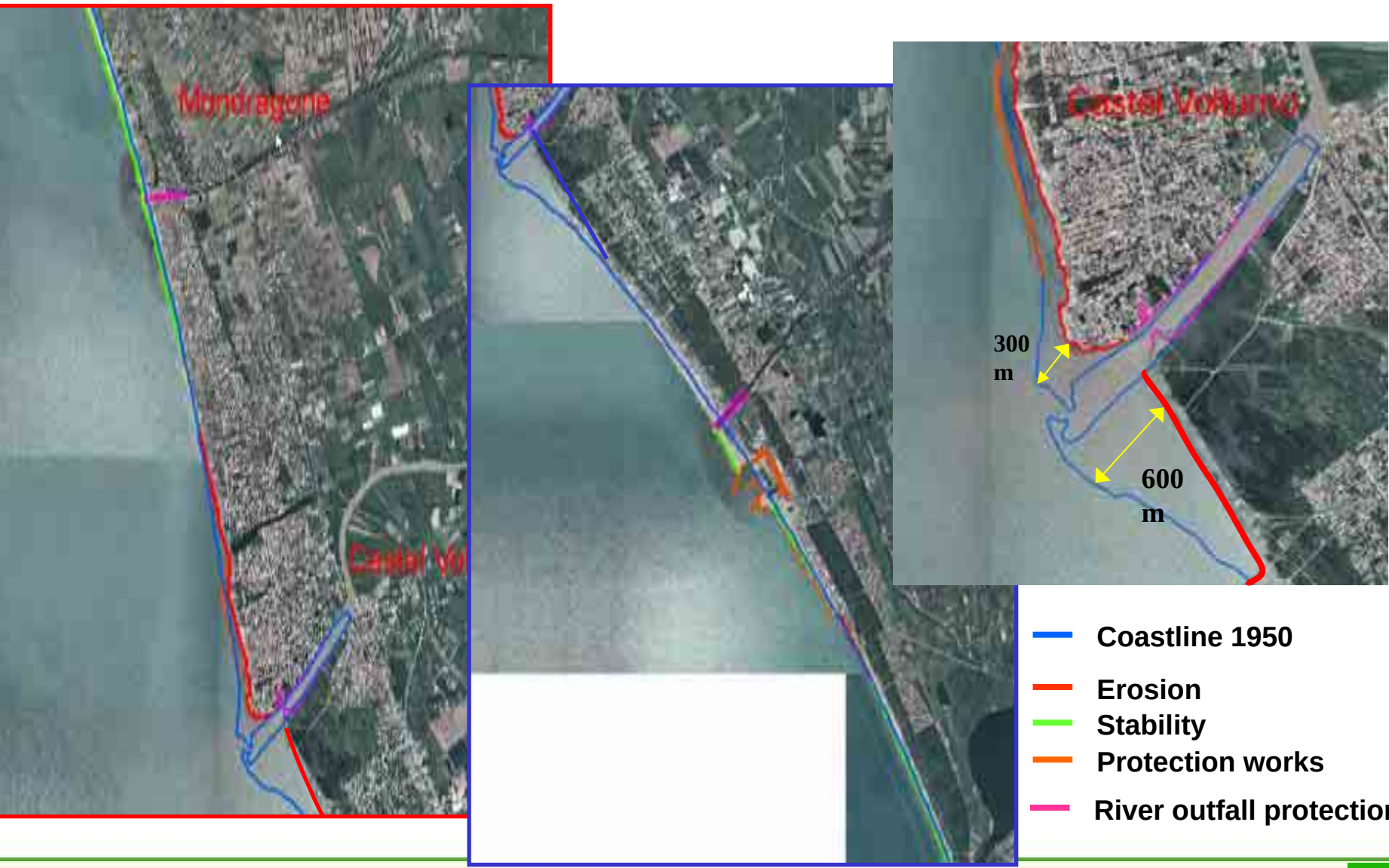
Francavilla

Montesilvano

Martinsicuro

Ortona

Foce del Volturno: destruction of outfall cusp



Storms impact !

Storms impact !

Flooding in Toscana

Flooding in Campania

IMPORTANCE OF KNOWLEDGE ACTIVITY

THE COASTAL GEOGRAPHICAL INFORMATION SYSTEM → **NATIONAL SCALE SUPORTS DECISION AT CENTRAL LEVEL**

DATA AND CHARTOGRAPHIC THEMES

Coastline

- Phisiographic units
- Coastlines base on aerial photos IT2000
- Coastline 1950
- Coastal typologies (nat/art/fictitious, high/low)

Infrastructures

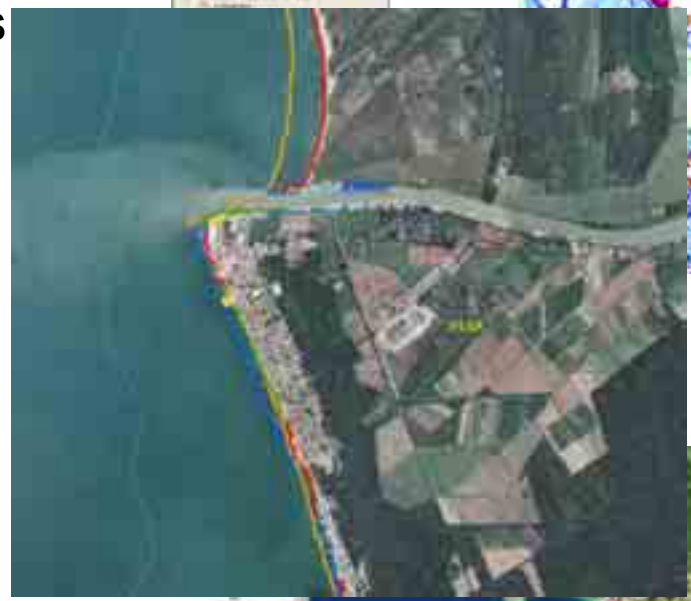
- Ports (census and typologies)
- Defence works (cens. e classifiction)
- Monitoring stations waves and sea level

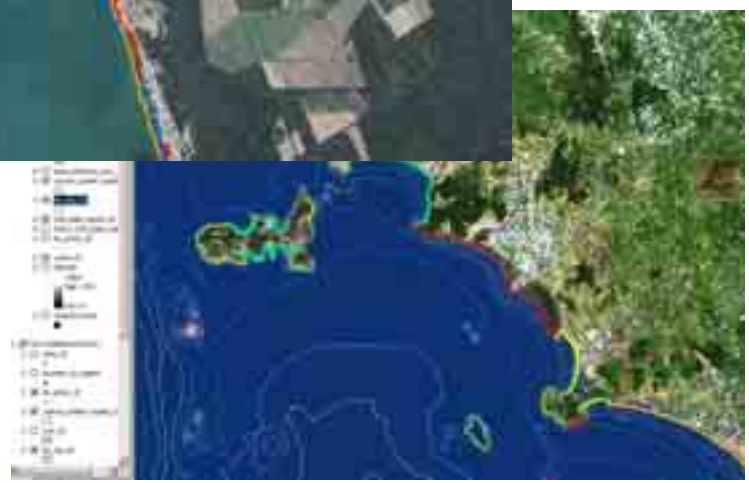
Meteomarine data

- Coastal sectors in front of buoys
- Meteomarine climatology

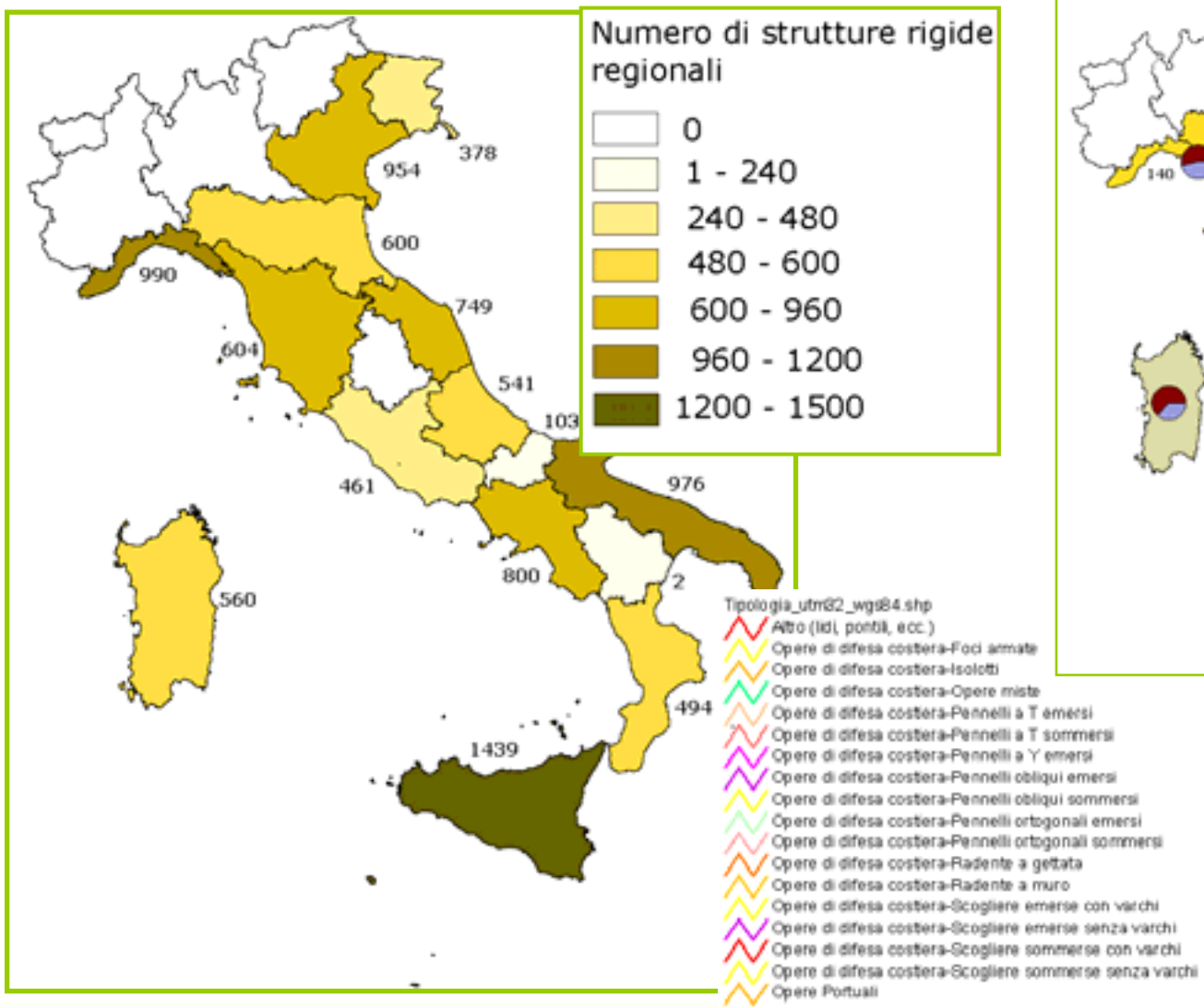
Coastal administrative data

Municipalities, Regions, Toponyms ecc.

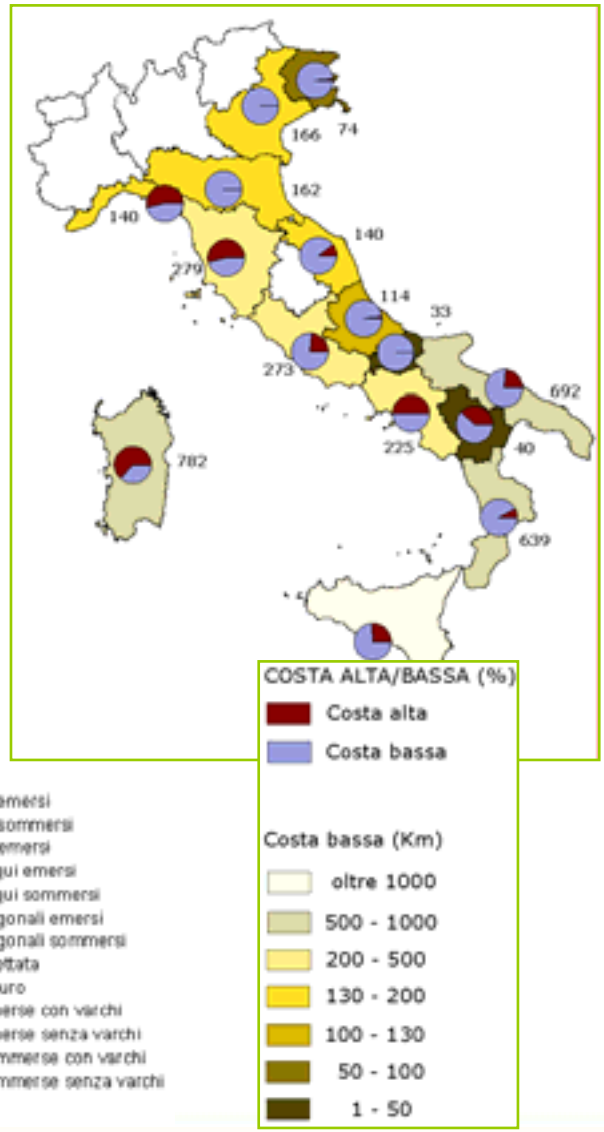




ARTIFICIAL COASTLINE
Hard protection works per region



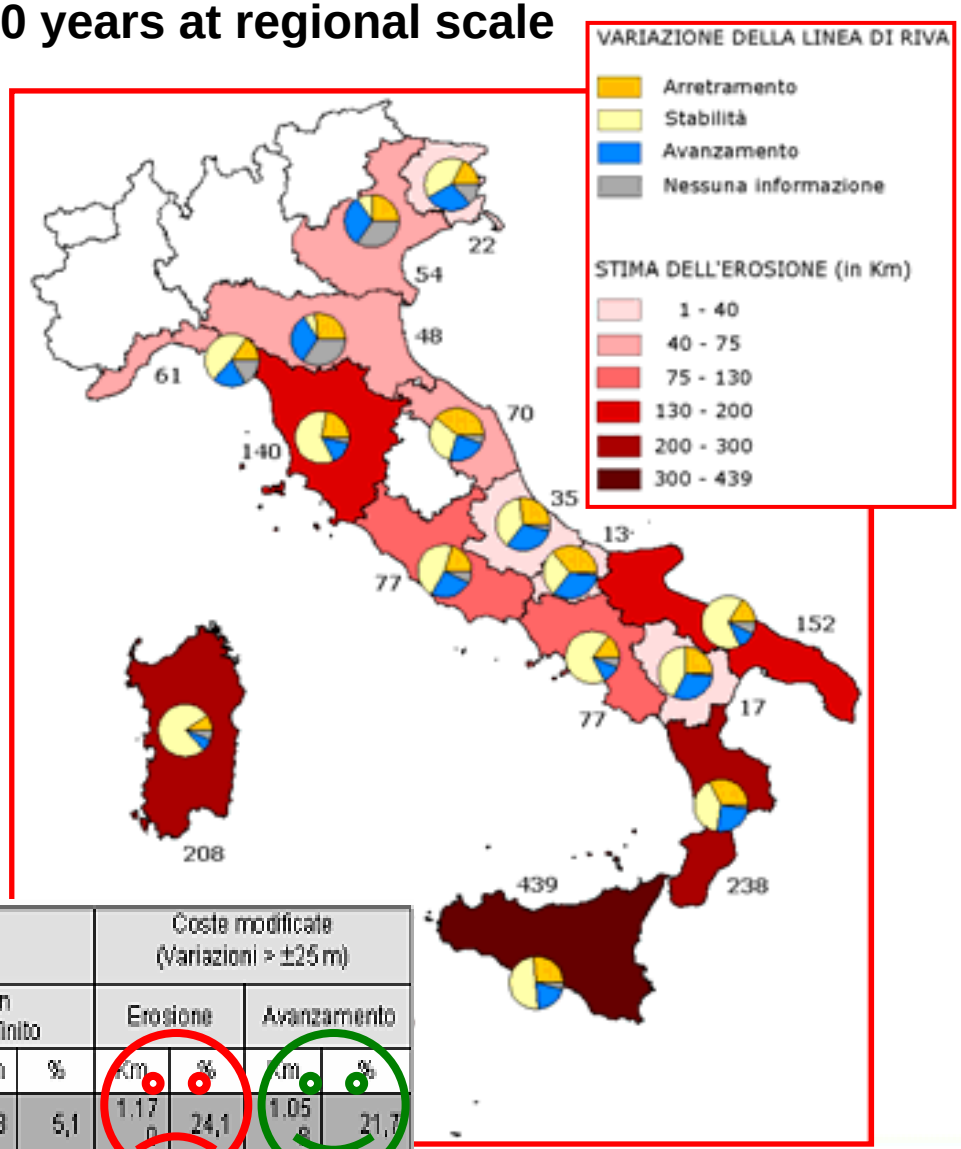
COASTLINE TYPOLOGY



Analysis of coastline modifications (>25 m)
Estimate in the last 40-50 years at regional scale

Regione	Superfici Coste modificate (Variazioni > ± 25 m)	
	Erosione	Avanzamento
	Km²	Km²
Italia	54.2	48.1
Liguria	1.3	1.9
Toscana	4.3	4.4
Lazio	2.2	3.1
Campania	2.4	1.6
Basilicata	1.4	1.4
Calabria	8.7	6.7
Puglia	3.6	2.9
Molise	1.2	0.5
Abruzzo	1.7	1.4
Marche	3.1	1.2
Emilia Romagna	4.7	5.0
Veneto	2.5	4.5
Friuli Venezia Giulia	0.8	2.9
Sardegna	2.8	4.6
Sicilia	13.5	7.0

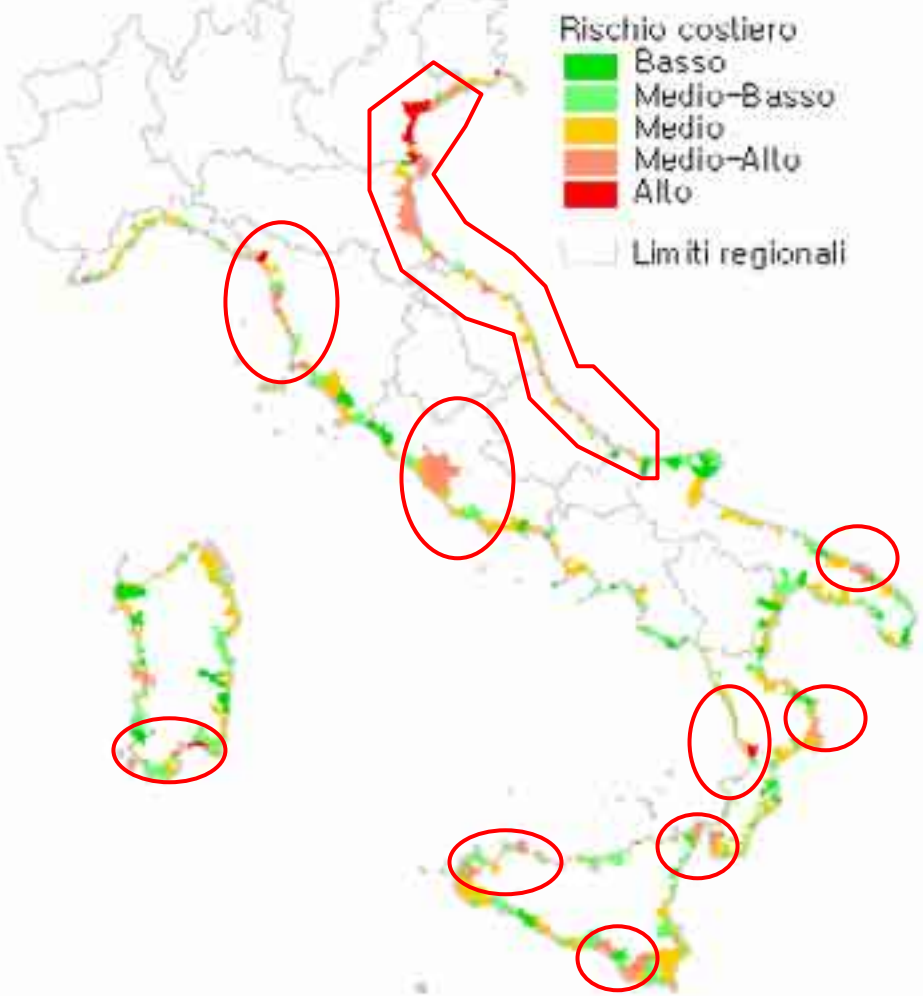
About
-5 Kmq



Lunghezza	Tipo Costa						Analisi coste basse						Coste modificate (Variazioni > ±25 m)			
	Naturale		Artificiale		Fittizia [1]		Stabili [2]		Modificate [3]		Non definito		Erosione		Avanzamento	
Km	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%
8.353	7.687	92,0	314	3,8	352	4,2	2.387	49,1	2.227	45,8	248	5,1	1.17 0	24,1	1.05 8	21,7

Mapping of coastal risk

Experimentation of EUROSION model to Italian coasts



C. D'Acquino (APAT, ACQ-COS), 2007

* River sediment supply not considered because information is not available at national scale

- **Coastal risk could be defined as the product of the coastal sensitivity index (measuring pressure factors) by coastal vulnerability index (measuring impact factors).**
- **Applied to coastal Italian municipalities, and appropriately normalised, shows the behaviour in the figure**

Pressure factors

1. **Sea level rise**
2. **Maximum sea level**
3. **Coastal urbanisation**
4. **Coastal stretch height**
5. **Coastal erosion and accretion**
6. **Coastal geology**
7. **Sediment supply***

Impact factors

1. **Population in coastal area**
2. **% di coastal urbanisation**
3. **% di urbanisation growth**
4. **Presence of significant biotopes**


ATLANTE DELLE ONDE
NEI MARI ITALIANI
ITALIAN WAVE AT
APAT
PROGETTO ATLAN
APAT
Agenzia per la Protezione dell'Ambiente
e per i servizi Tecnici
Atlante delle opere
di sistemazione costi
44/2007
UIDA
MANUALE PER LA
MOVIMENTAZIONE DI SEDIMENTI MARINI
ICRAM
APAT

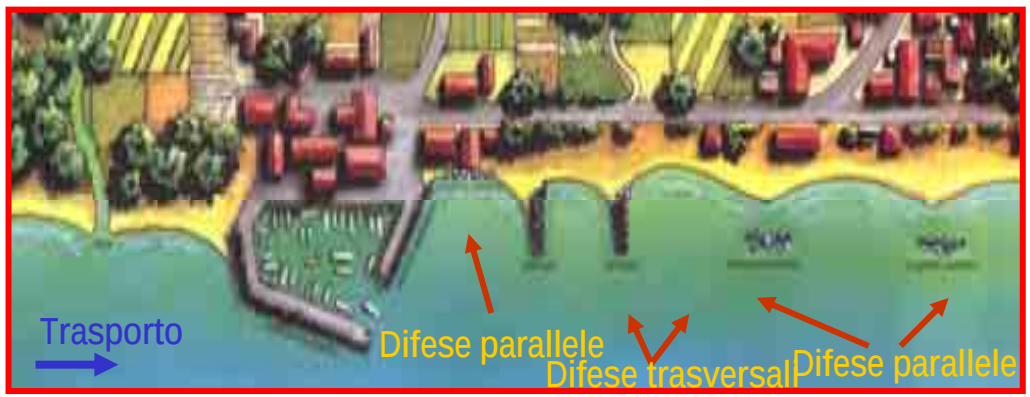
Regional and local administrations realised many littoral protection works, either implementing planned actions aimed to the rehabilitation of beaches and coastal habitats, or emergency works to protect roads, railways and buildings near the beach line, and again experimental works.

Barriers (emerged or submerged)

More or less permeable, longitudinally laying with the aim to reduce wave energy, onshore or offshore.

Cross sectional barriers (emerged or submerged)

Groins, aimed to intercept the sediments transported by long shore currents.



Artificial nourishments:

Placings of Sediments of appropriate grain distribution often protected by barriers to control material losses.

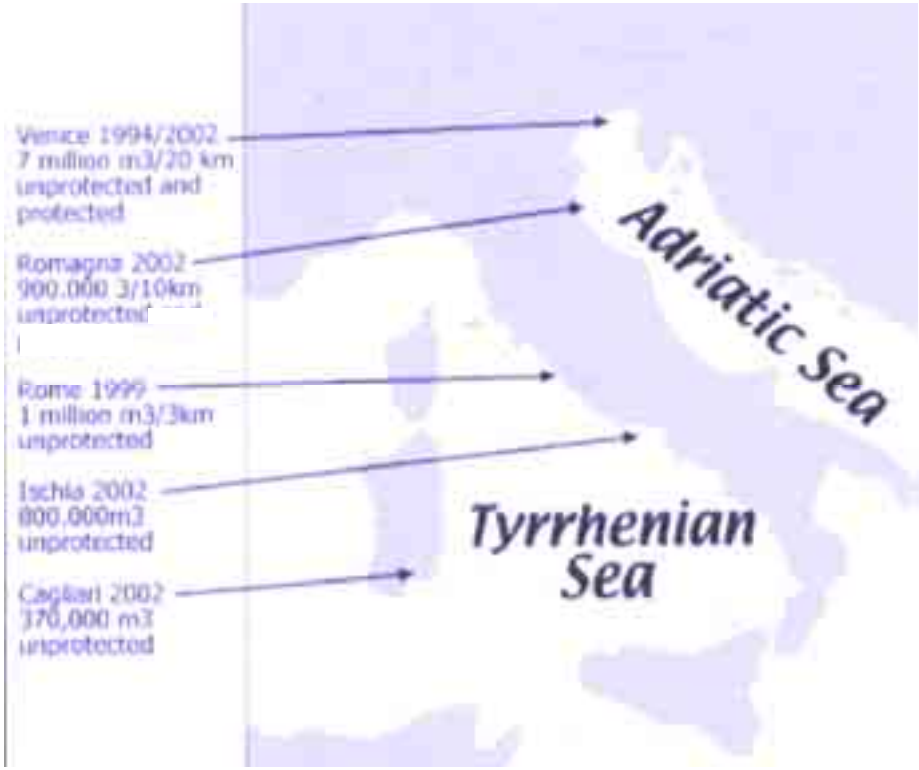
Or integrated protection systems with a combination of two or all the three protection systems

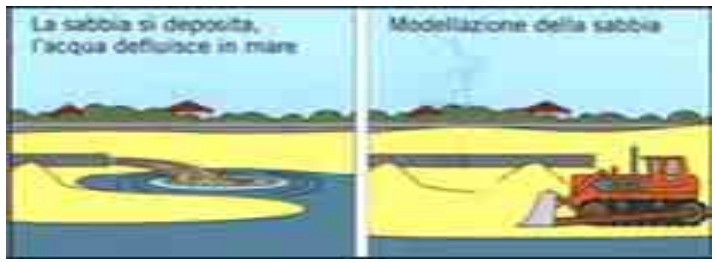
In many cases beach erosion has been fight realising hard defence works like revetments, barriers, groins and mixed structures works along the coasts (in the examples the coastline south of Fano, the littoral zone south of Termoli, the coast between Abruzzo e Molise) to protect linear transport and urbanised sites

Such works have protected in a partial way the inland area and have exported down drift the erosion process


CAPO D'ORLANDO
BROLO
NASO
BROLO
PIRAINO
NASO

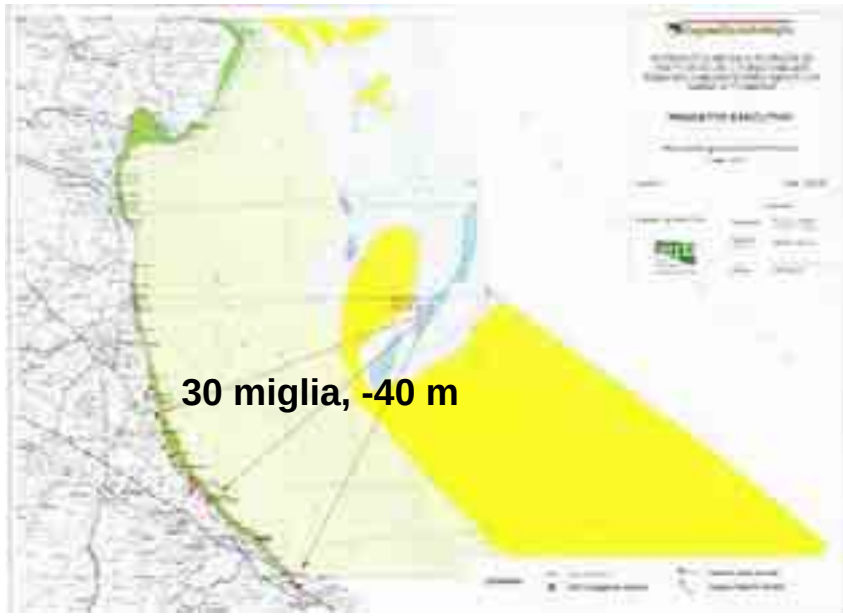
Initiatives for the rehabilitation of beaches and the protection of habitats with nourishment works have been implemented in:





Da M.Preti (2002) Studi Costieri –5:107-134

Emilia Romagna coast



800.000 mc of sand dredged offshore on 9 coastal stretches for a total of 10 Km, 2002

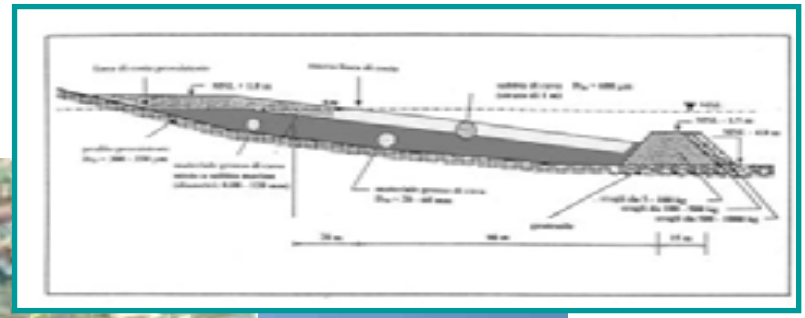
Sardegna (spiaggia del Poetto – Cagliari)

370.000 mc of offshore dredged sand, year 2002

Spiaggia dei Maronti (Ischia)

800.000 mc of sand, 2002

Ostia – Roma e litorale laziale



Nourishments

1.000.000 mc of offshore dredged sand, 3 Km - 1999

Beach of Cavallino– Venezia

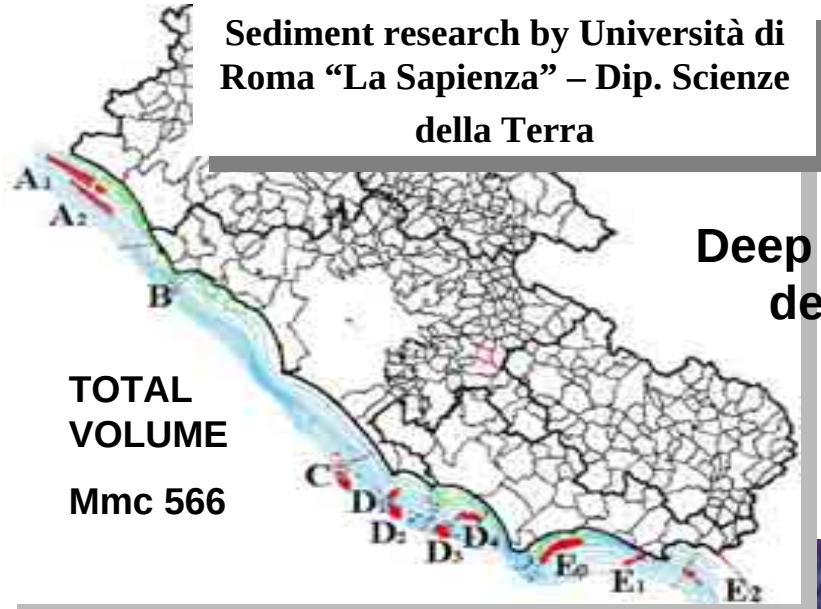
over 9 km , almost 5.000.000 cubic meters of sand protected by 18 conteinment lateral groins, connnected each other by a submerged breakwater parallel to the coastline

spiagge di Pellestrina – Venezia

11 km of beach, over 2.000.000 cm of sand, dredged offshore 20 km far from Venice coastline

Coastal undersea deposits

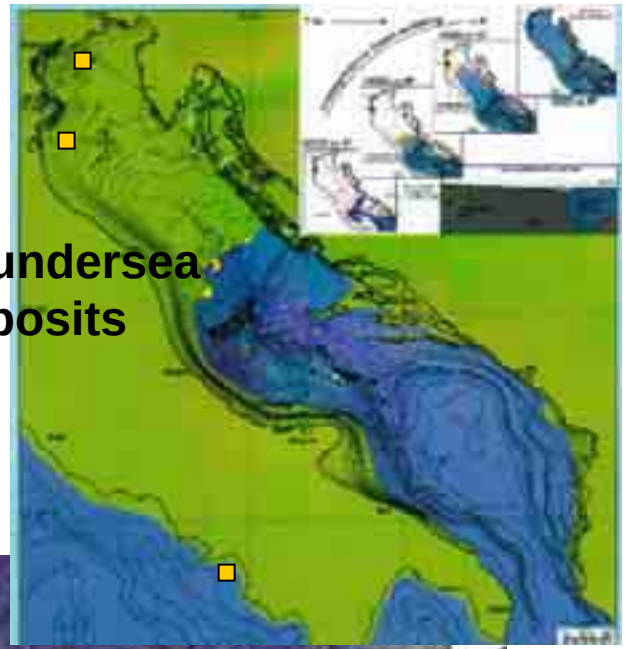
Sediment research by Università di Roma "La Sapienza" – Dip. Scienze della Terra

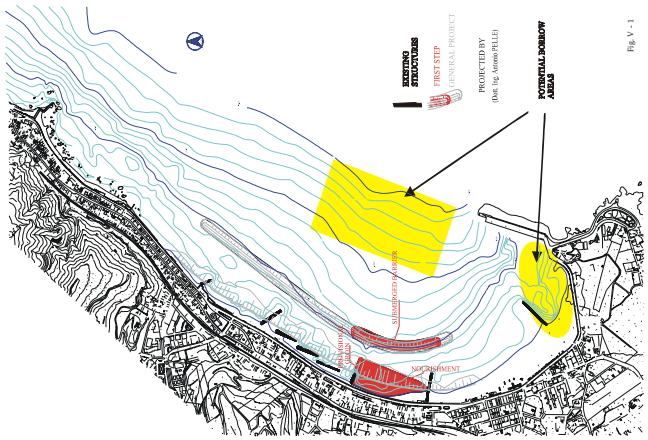


TOTAL VOLUME

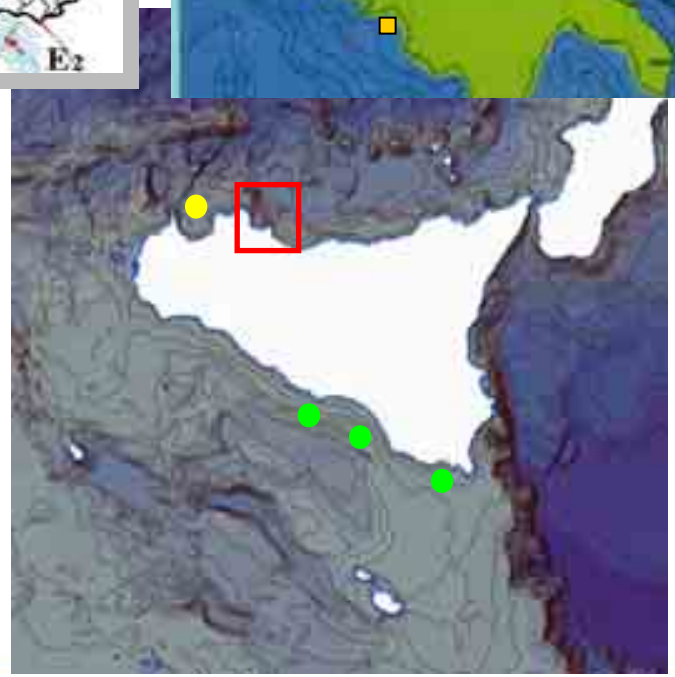
Mmc 566

Deep undersea deposits





G Randazzo, Milazzo 2003



Origin of the sediments

- Sub aerial deposits
- Undersea deposits
- Buried ports
- Quarries of opportunity

Onshore

Offshore

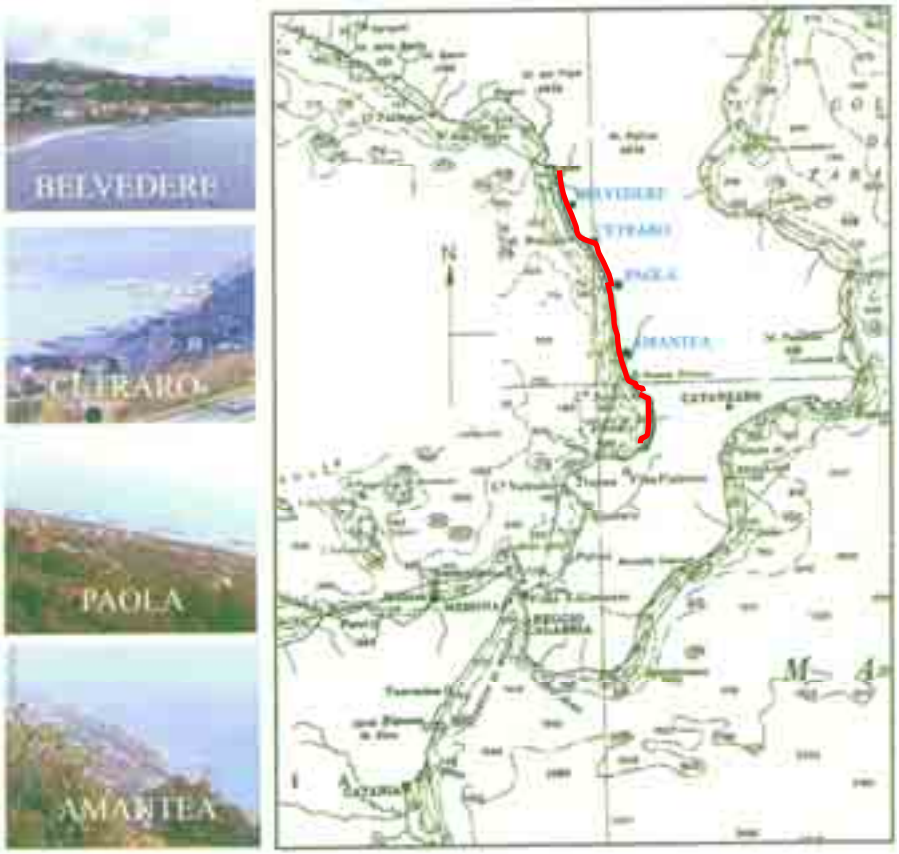
Buried ports

G Randazzo, 2003

Sub aerial deposits

Quarry of opportunity

Combined interventions with partial nourishments from inland or onshore quarries



Inland quarry material 2.815.000 mc D50=2.5 mm

Port dredging material 50.000 mc D50=0.65 mm

F. Guiducci, G. Paolella: "Learning from 20 years of coastal protection design and realisation along the tyrrhenian calabrian coast", ICCE 2004 Lisbon

Inland quarry material

400.000 mc 100.000 mc

D50=4 mm D50=45 mm

Port dredging material

1.800.000 mc

D50=0.65 mm

Littoral deposit material at the foot of harbour breakwater

300.000 mc

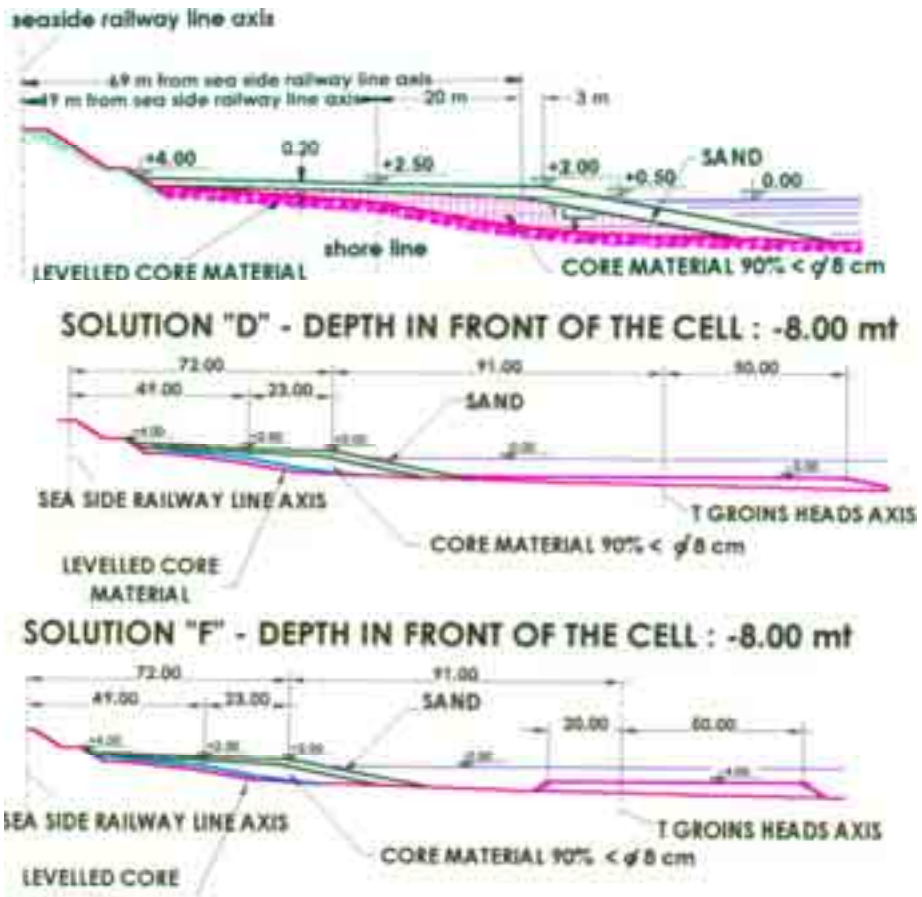
D50=2 mm

F. Guiducci, G. Paolella: "Learning from 20 years of coastal protection design and realisation along the tyrrhenian calabrian coast", ICCE 2004 Lisbon

Inland quarry material

800.000 mc **250.000 mc**

D50=0.35 mm **D50=45 mm**



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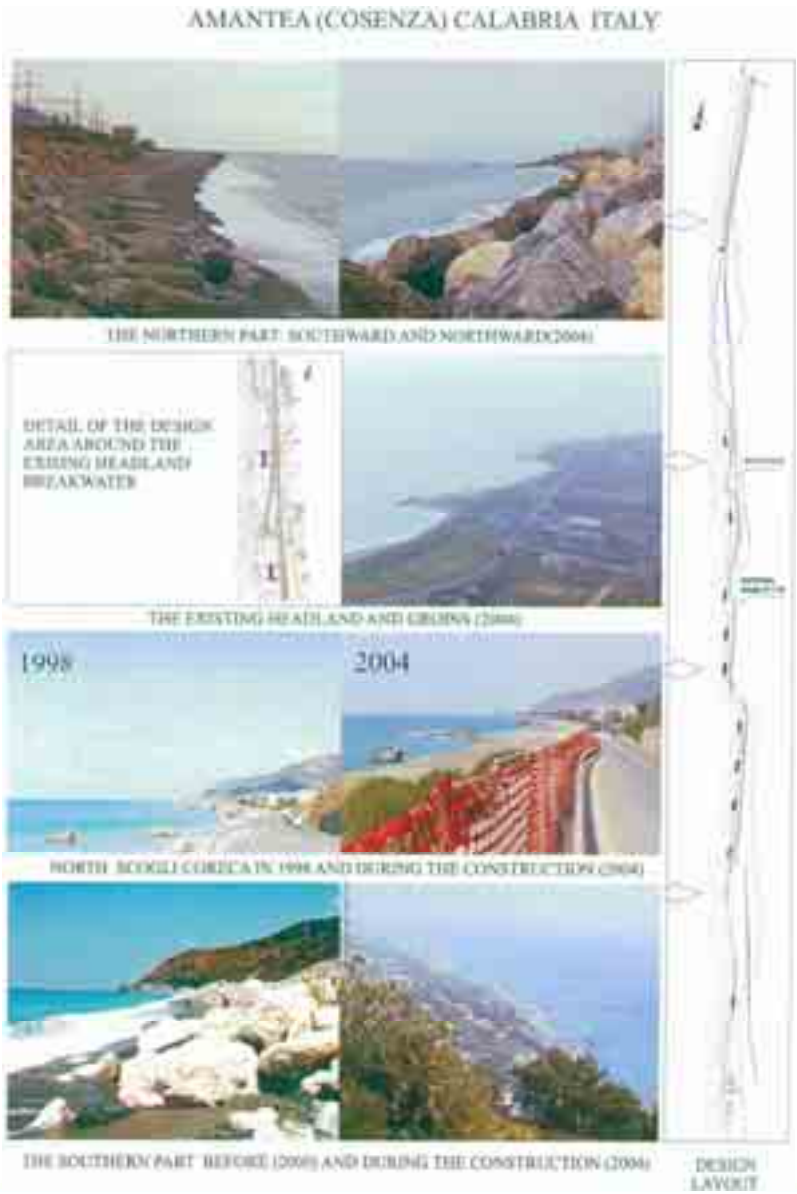


Inland quarry material

1.000.000 mc 700.000 mc

D50=45 mm D50=100 mm

River sediment material

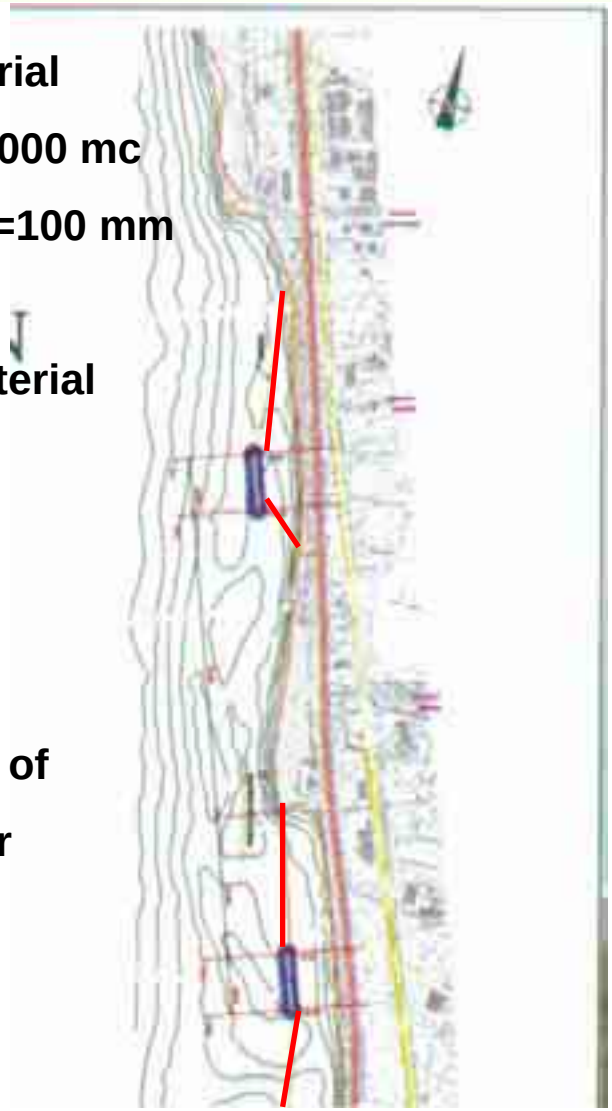
600.000 mc

D50=4 mm

Littoral deposit material at the foot of harbour breakwater

60.000 mc

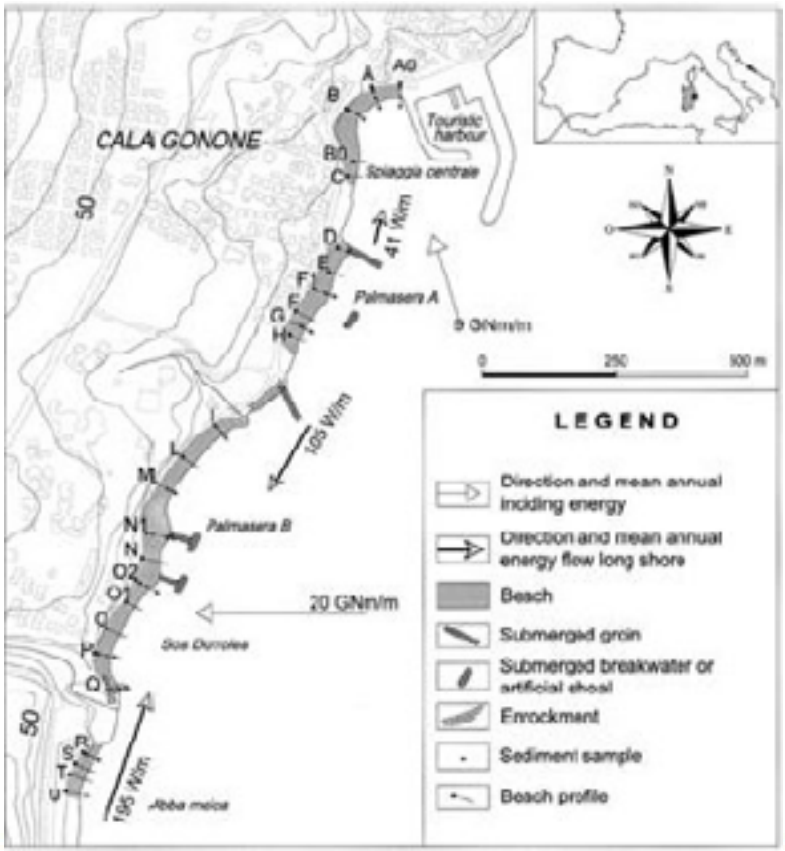
D50=0.69 mm

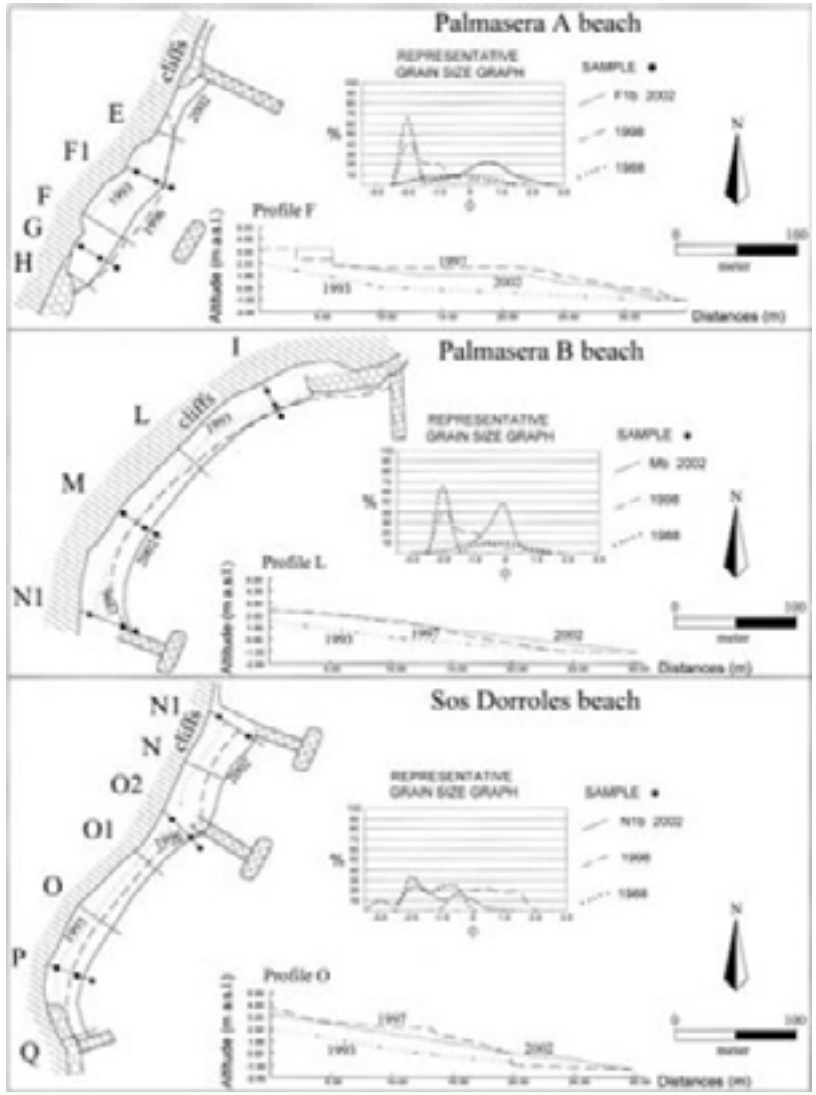


F. Guiducci, G. Paolella: "Learning from 20 years of coastal protection design and realisation along the tyrrhenian calabrian coast", ICCE 2004 Lisbon

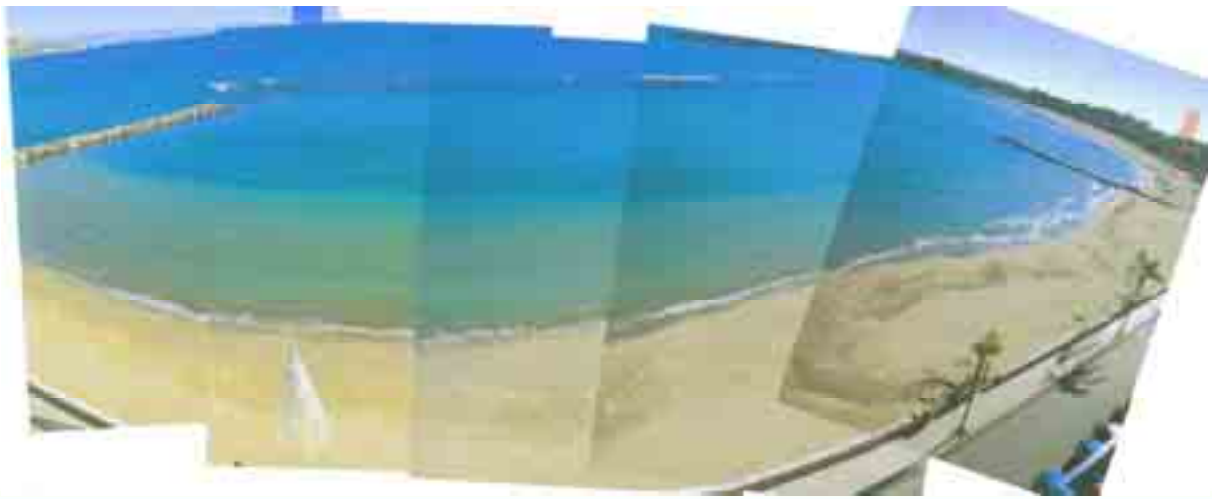
Cala Gonone – Nuoro

80.000 mc of coarse sediments, composed by 30% of fractured limestone and 70% of granite, have been distributed over the sandy beaches obtaining an enlargement of 10 m.

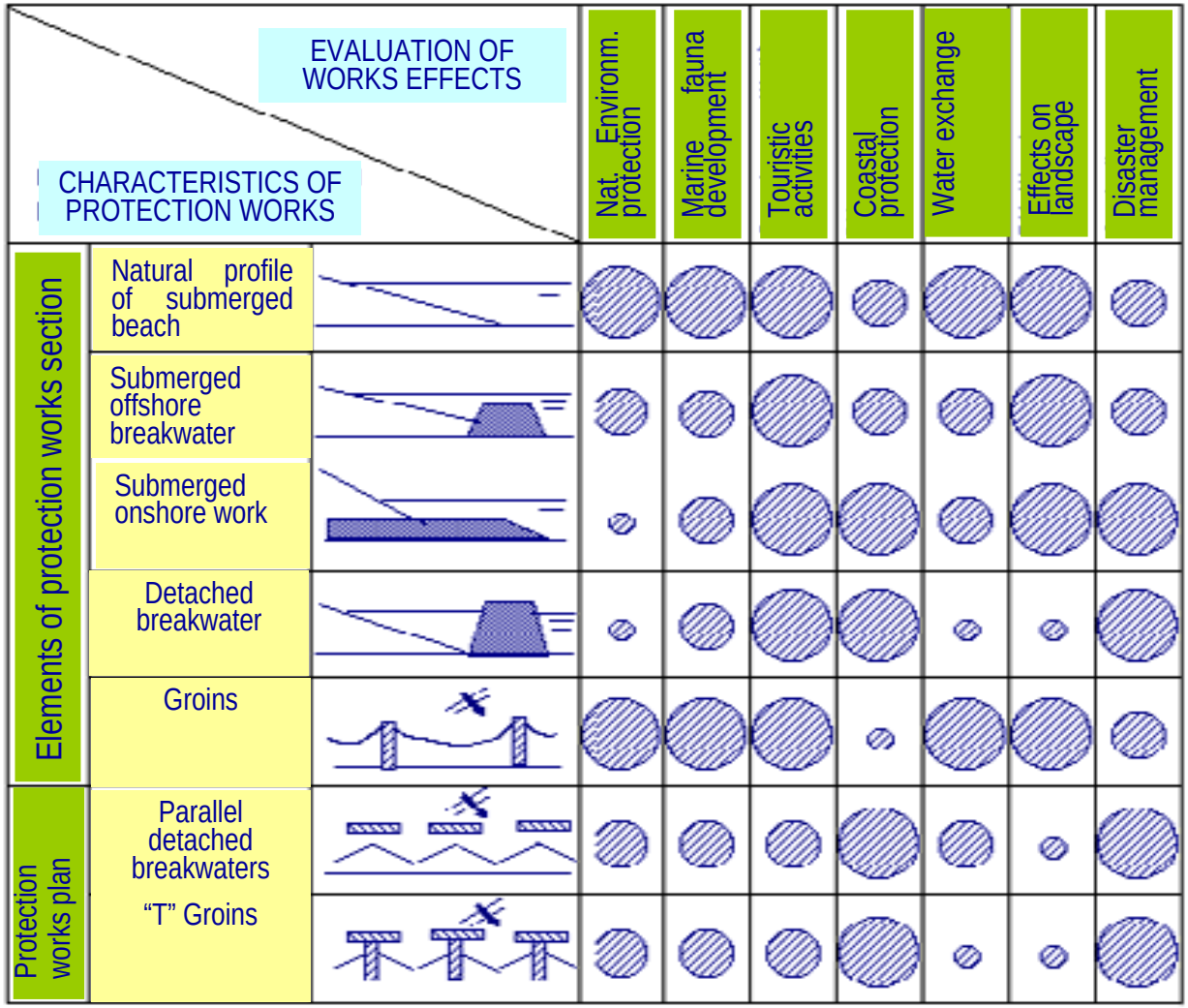


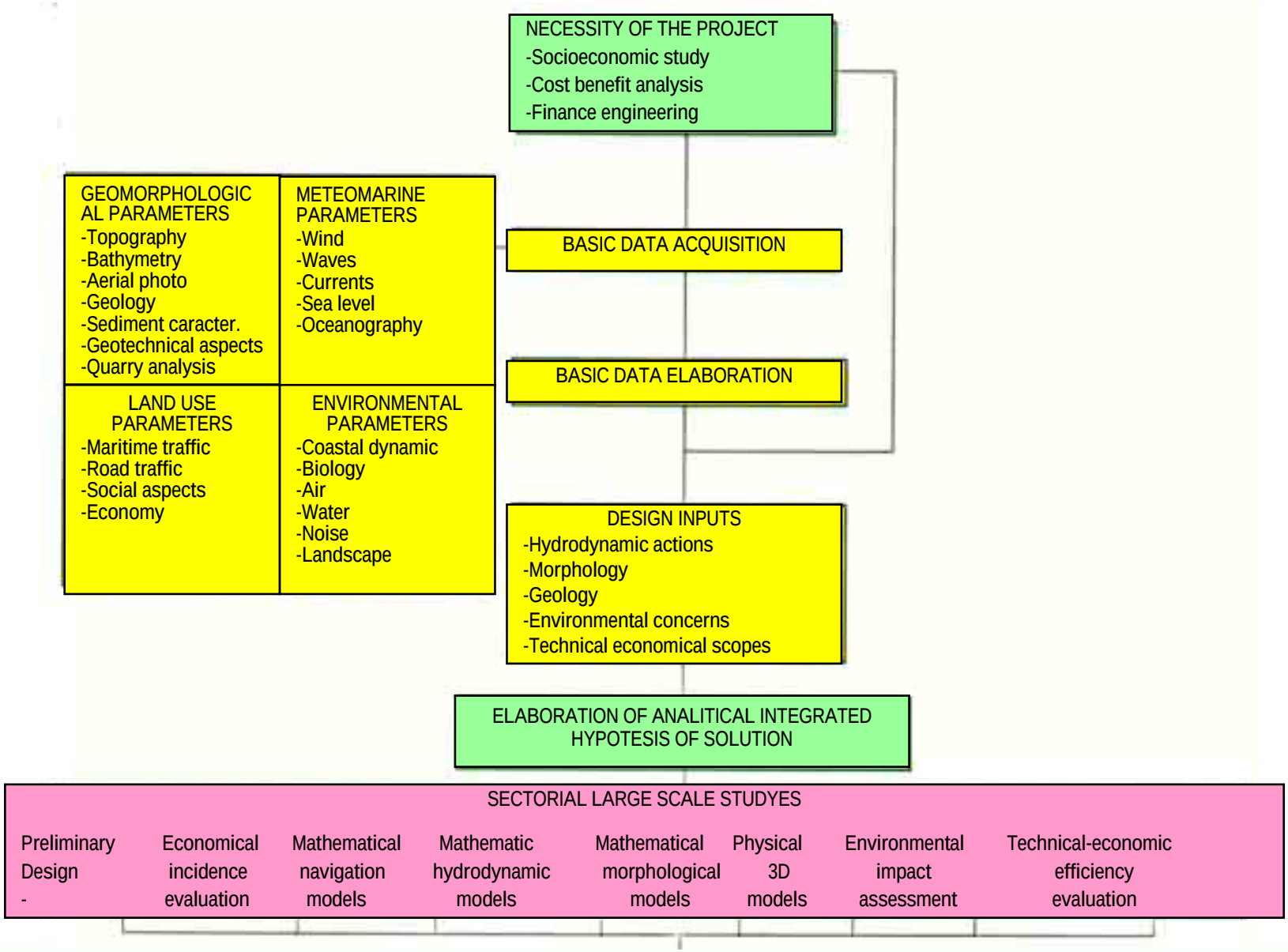


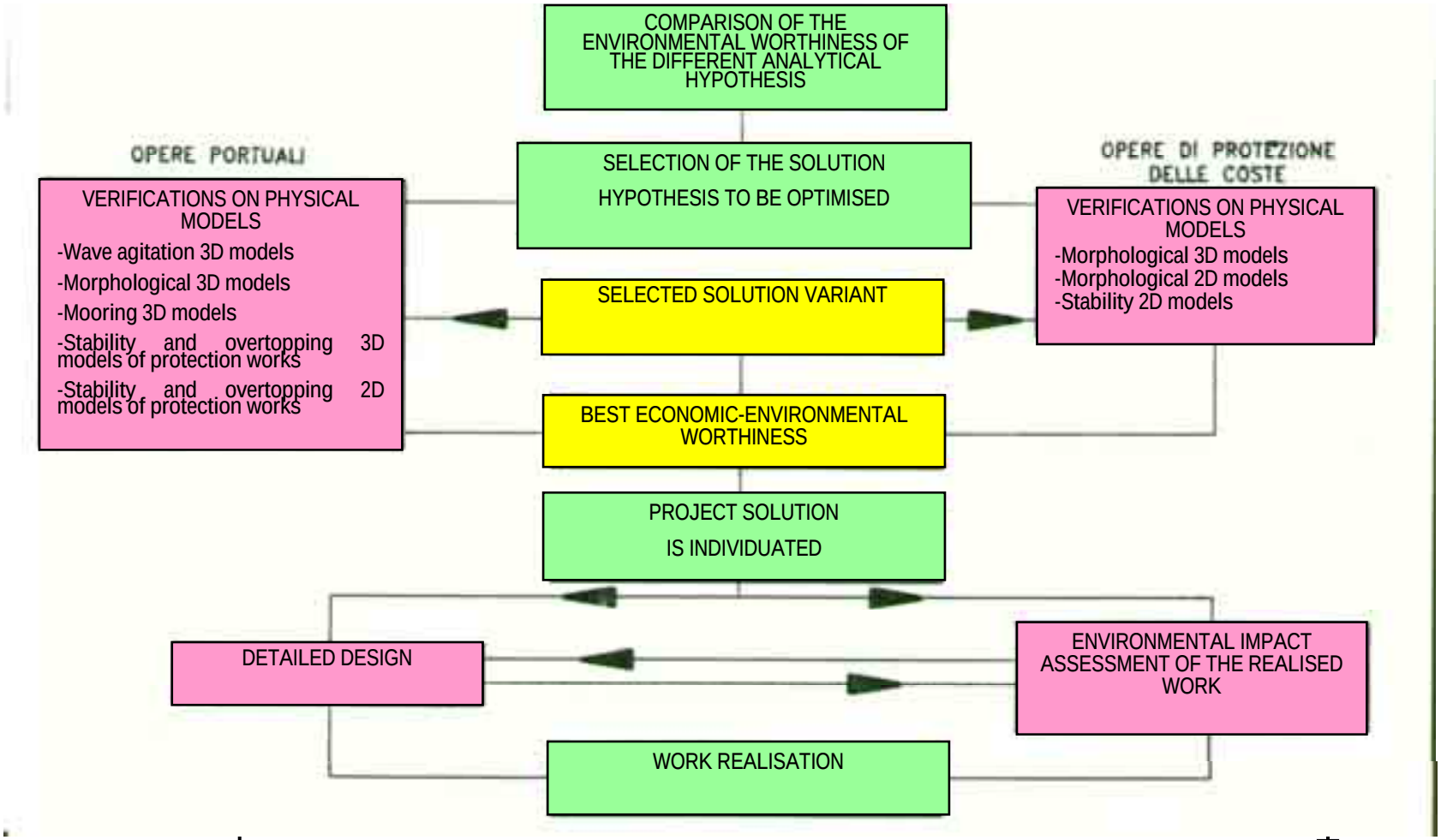
Giardini Naxos (Sicilia)



Sandy material taken from the seafloor in front of the beach


EVALUATION OF WORKS EFFECTS
CHARACTERISTICS OF PROTECTION WORKS
Nat. Environm. protection
Marine fauna development
Touristic activities
Coastal protection
Water exchange
Effects on landscape
Disaster management
Elements of protection works section
Natural profile of submerged beach
Submerged offshore breakwater
Submerged onshore work
Detached breakwater
Groins
Protection works plan
Parallel detached breakwaters
"T" Groins
Effective and feasible
Moderately effective but feasible
Not very effective but feasible


NECESSITY OF THE PROJECT
-Socioeconomic study
-Cost benefit analysis
-Finance engineering
GEOMORPHOLOGICAL PARAMETERS
-Topography
-Bathymetry
-Aerial photo
-Geology
-Sediment caracter.
-Geotechnical aspects
-Quarry analysis
METEOMARINE PARAMETERS
-Wind
-Waves
-Currents
-Sea level
-Oceanography
BASIC DATA ACQUISITION
LAND USE PARAMETERS
-Maritime traffic
-Road traffic
-Social aspects
-Economy
ENVIRONMENTAL PARAMETERS
-Coastal dynamic
-Biology
-Air
-Water
-Noise
-Landscape
BASIC DATA ELABORATION
DESIGN INPUTS
-Hydrodynamic actions
-Morphology
-Geology
-Environmental concerns
-Technical economical scopes
ELABORATION OF ANALITICAL INTEGRATED HYPOTESIS OF SOLUTION
SECTORIAL LARGE SCALE STUDYES
Preliminary Design -
Economical incidence evaluation
Mathematical navigation models
Mathematic hydrodynamic models
Mathematical morphological models
Physical 3D models
Environmental impact assessment
Technical-economic efficiency evaluation



Forecasting the final shape of intervention with individuation of the reference line

Monitoring and maintenance plan

- **The good success of a nourishment intervention depends by the characteristics of the used material**

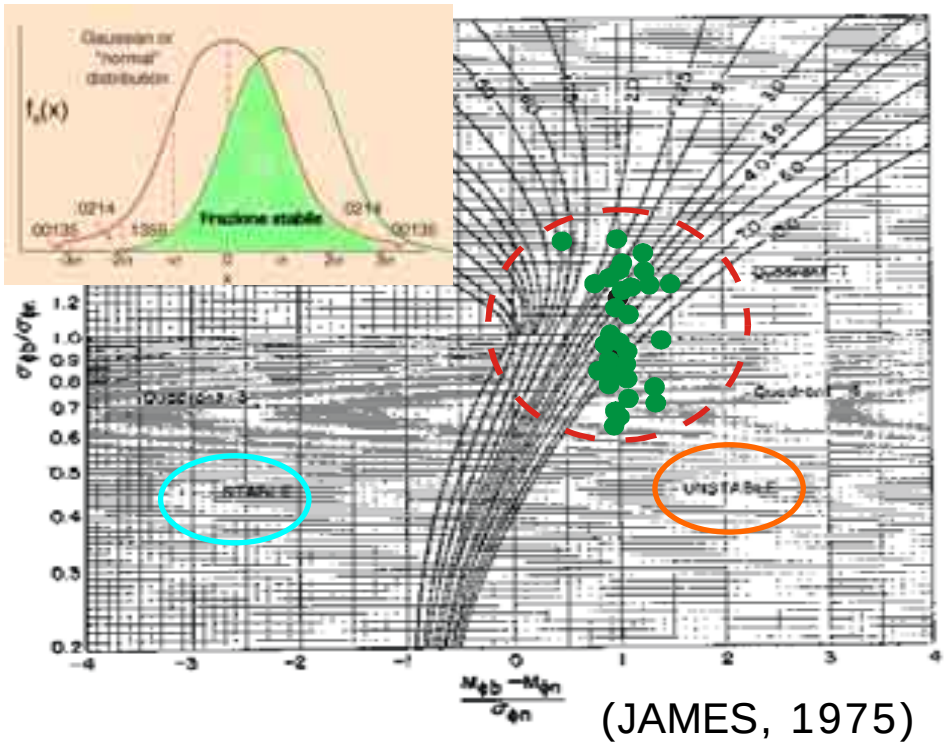
- **The main parameters to be considered to define the compatibility of the sediments and the methods to find such sediments are:**

Compatibility of sediments

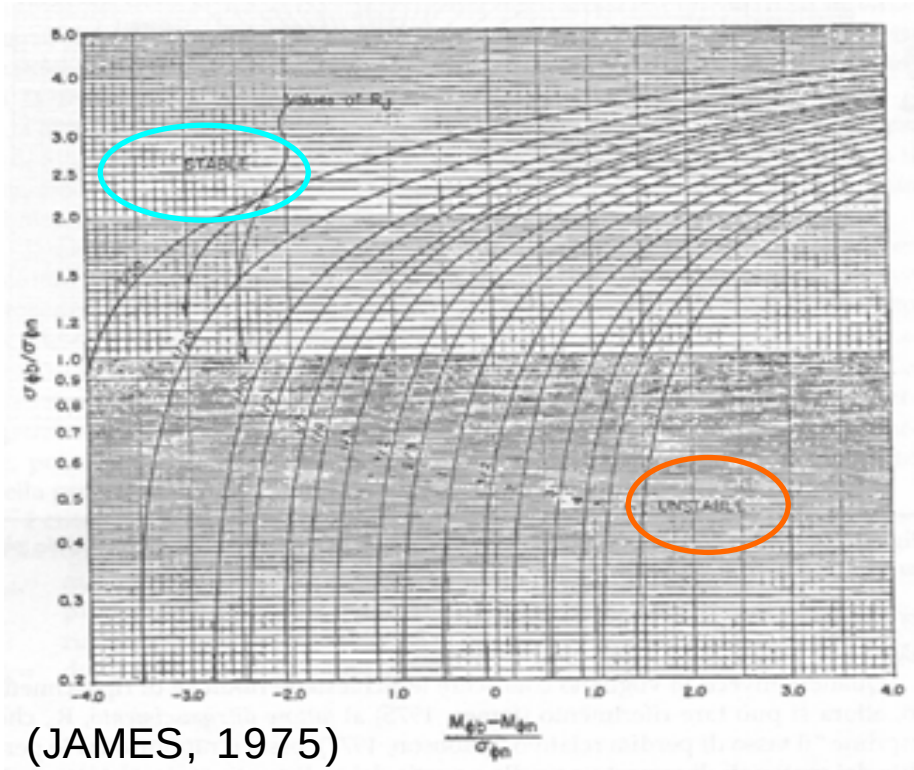
Grain size distribution **Mineralogical composition**

G Randazzo, Milazzo 2003

GRAIN SIZE DISTRIBUTION COMPATIBILITY



(JAMES, 1975)



(JAMES, 1975)

Fill factor

The sudden loss of material is often <u>VERY</u> significant and has to be taken into account

Renourishment factor

The long term loss is to be considered in the technical economical evaluation of the project

G Randazzo, Milazzo 2003

ESTIMATE (MEuro) OF THE TOTAL ECONOMIC NEED FOR ITALY

regioni	Length of coast potentially at risk	Need for hard works (barriers etc.)	Need for nourishments (20 m beach extra width)	Average need (hard works+nourishment)
ABR	19,3	€ 86,9	€ 77,2	€ 125,5
BAS	0,4	€ 1,8	€ 1,6	€ 2,6
CAL	115,4	€ 519,2	€ 461,5	€ 750,0
CAM	35,6	€ 160,4	€ 142,6	€ 231,7
EMR	24,8	€ 111,7	€ 99,3	€ 161,3
FVG	9,5	€ 42,7	€ 38,0	€ 61,7
LAZ	35,3	€ 158,8	€ 141,2	€ 229,4
LIG	48,1	€ 216,4	€ 192,4	€ 312,6
MAR	37,1	€ 167,1	€ 148,5	€ 241,3
MOL	3,7	€ 16,5	€ 14,6	€ 23,8
PUG	43,3	€ 194,7	€ 173,1	€ 281,2
SAR	11,9	€ 53,8	€ 47,8	€ 77,7
SIC	119,0	€ 535,5	€ 476,0	€ 773,5
TOS	20,4	€ 91,7	€ 81,5	€ 132,5
VEN	16,0	€ 71,9	€ 63,9	€ 103,8
totale	**539,8**	**€ 2.429,0**	**€ 2.159,1**	**€ 3.508,6**

Average coasts of hard protection works and nourishment respect. 4.5 MEuro/km and 4.0 MEuro/km

MATTM-Segreteria Tecnica per la Difesa del Suolo, intervallo 1960- 2000.

IT LEADS TO ESTIMATE A NEED OF ABOUT 150-200 MILLION CUBIC METERS OF SEDIMENTS

IS IT SUSTAINABLE ?

PORT BASIN CHART

Instrument for collection of information related to every port site

CONTEIN

- Physical characterisation and meteo marine conditions
- Present and previous activities
- Nature and location of possible pollution sources
- Typology and location of dredging activities during time
- Actual management of dredged materials.

REGIONAL SEDIMENTS MANAGEMENT PLAN

COASTAL SEDIMENTS

STRATEGIC OFFSHORE DEPOSITS

WHO REGULATES THE EXPLOITATION AND FOR WHICH USE?

- **Strategic deposits of sediments could be defined as quantities of sediments with appropriate characteristics, available for nourishments, which are located either offshore or near the coast, within the closure depth of the active beach, generally characterized by good quality and large volumes**
- **Considering that the national coordination of coastal protection policy is fundamental, it is necessary, for a rational and environmentally compatible use of the strategic offshore sediments deposits, to plan the use of such resource, making that useful for the real territorial demand during time.**
- **All the extractions from strategic deposits and their uses shoul be considered in a Sediments Management Plan (SMP) at national or at least regional level to be included in the Coastal Plan.**

ALL THE SEDIMENTS MANAGEMENT PLANS SHOULD BE COHERENT TO A STRATEGIC AND SUSTAINABLE VISION AT NATIONAL SCALE

COMPOSITIONAL COMPATIBILITY

Beeing the textural characteristics the same, an important role is played by the composition of the material in terms of differences of:

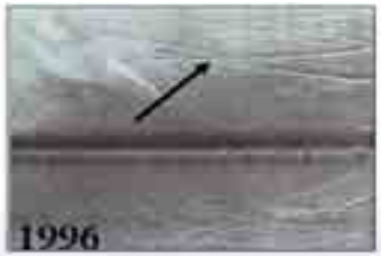
Specific weight

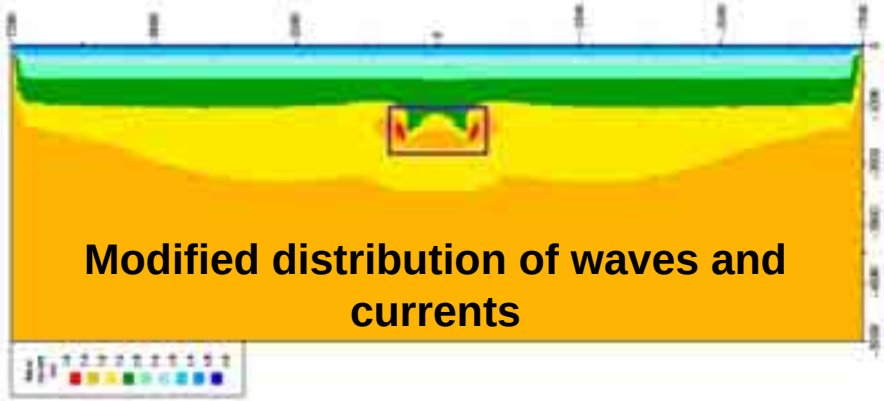
Color

G Randazzo, Milazzo 2003

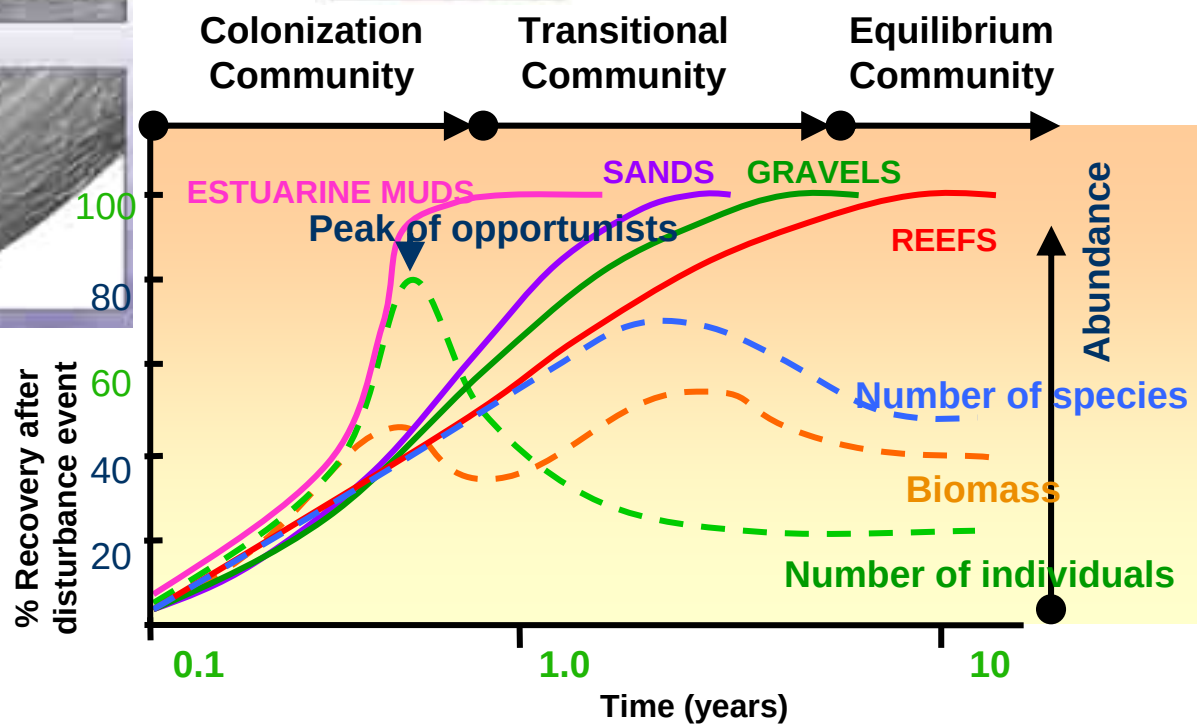
EFFECTS OF SAND EXTRACTION

PHISICAL EFFECTS AND RE COLONISATION





- Reconstruction of density relatively fast
- Depends by sediment type and extraction method
- Should be measured considering refferring sites, not only considering initial conditions



SEDIMENT PLUMES

- Levels of suspended sediment
- increase untill 300-500 m from
- dredging site
- Bottom plumes arrive even
- more far away
- Visible plumes extend several
- chilometers

Lite screen effect causes a reduction of productivity

LOSS OF SEDIMENTS AND DEPOSITION

Stable and well populated gravel

Sand with gravel

scarcely populated

- **Gradual placing has a lower impact than the massive placing**

REGULATIONS	UK	NL	DK	IT	NO	FR
Authorities involved						
Govt. ministries & agencies	X	X	X	X	X	X
Regional/local authorities	X			X	X	X
Conservation bodies	X		X			
Others	X					X
Consultation procedure						
Coastal/seabed Impact	X	X	X			X
Environmental Impact	X	X	X	X		X
Local knowledge					X	X

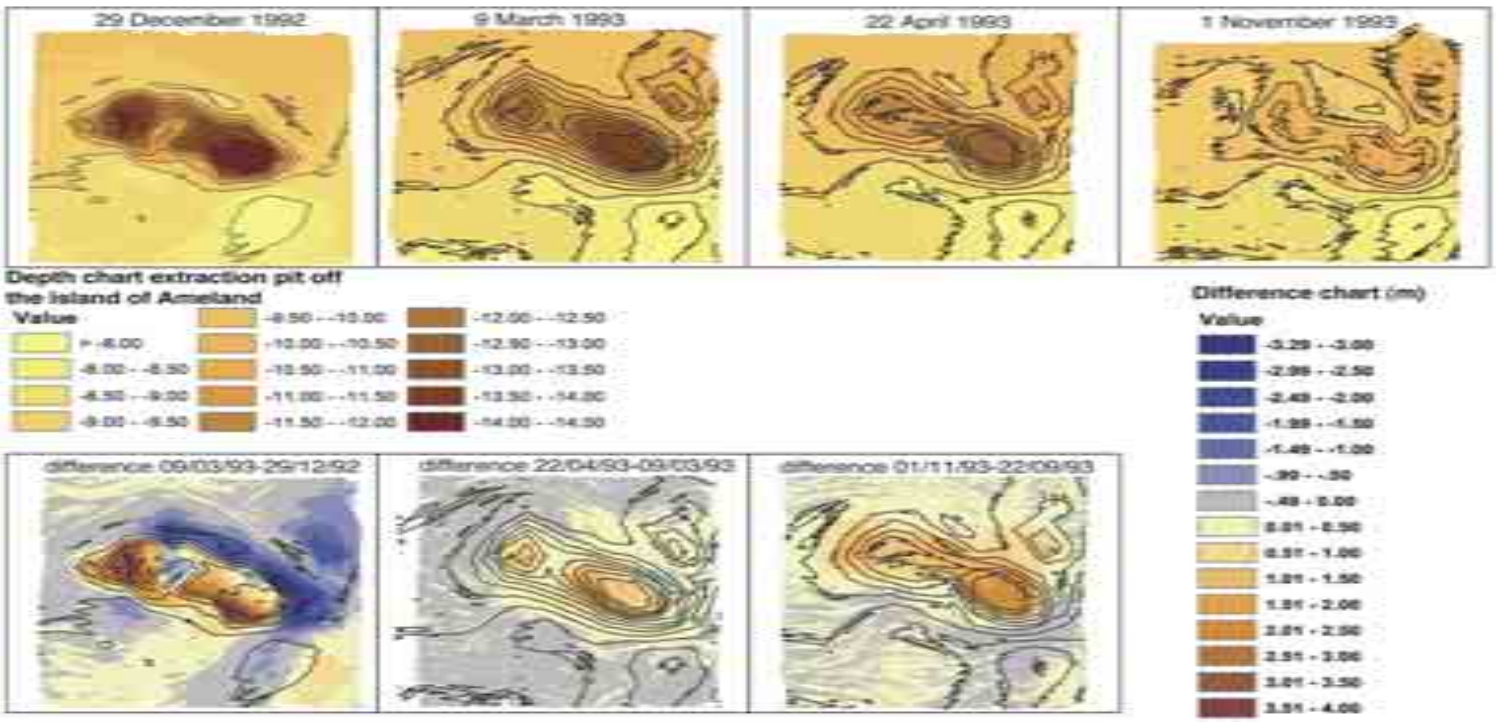
VOLUMES EXTRACTED	UK	NL	DK	IT	NO	FR
Demand						
Current annual demand (Mm^3 per annum)	14	32	8	N/A	0.06	3
Demand in next 50 years (Mm^3)	500 - 1000	1600 - 3000	300 - 500	Not available	3	up to 600
Type						
Sand (%)	40	100	10	100		35
Gravel (%)	60	0	15			50
Fill sand(*) (%)			75			
Carbonate sand (%)					100	15
Use						
Beach nourishment	X	X	X	X		
Construction	X	X	X			X
Land reclamation	X	X	X			
Industrial		X	X			
Agriculture	X				X	X
Export	X		X			

EVALUATIONS	UK	NL	DK	IT	NO	FR
Hydro/morpho evaluation						
Beach	X	X	X			X
Coastal seds	X	X	X	X		X
Banks/bars	X	X	X			
Waves	X	X	X			X
Currents	X	X	X			X
Ecological evaluation						
Turbid plumes/smothering	X	X	X			
Describe existing situation	X	X	X			X
Impact on flora & fauna	X	X	X	X		X
Consider alternatives	X	X	X			
Avoid env. sensitive areas				X	X	

CRITERIA & EXPERIENCES	UK	NL	DK	IT	NO	FR
Criteria	(approx)					
Min. water-depth	LAT-15m	MSL-20m	none	50m(*)	none	$4.08H_{smax}$
Min. distance from coast	600m	none	none	5.6km	none	none
Max pit-depth	none	2m	~3m	none	none	none
Experience						
Coastline problems	none	none	none			none
Pit infill (deep water)	v. slow					v. slow
Pit infill (shallow water)	fast					
Pit migration		v. slow				1m/yr
Changed water levels/prism			none			

An area at a lower depth

has a faster response



CONCLUSIONS

- **If sand extraction is made inappropriately, it can cause significant damage to environment. The benefits mats be balanced in comparison to potential negative impacts**
- **The administrators should work in a strategic contest**
  - **Encouraging use efficiency**
  - **Minimizing negative effects**
  - **Protecting sensitive areas and habitats**

- **A good project of coastal nourishment with dredged sediments extracted from offshore deposits should take into account:**

  •ACTIVITIES

  •Extracted volumes, extracted quantities in time, used equipments, spatial configuration of project and timing

  •PHISICAL CONTEXT

  •Bathymetry, distance from the coast, type of material, extension and volume, local hydrodynamic, wind and waves, bottom sediment transport, sediments contamination etc.

BIOLOGICAL CONTEXT

- **Physical impact assessment**
  - **Impact on coastline, bathymetric variations, exposure of different ground layers, changing of sea floor shapes behaviour, contaminants release, transport and deposition of fine sediments on the sea floor, effects on water quality, time scale of physical rehabilitation etc.**
- **Biological impact assessment**
- **Mitigation measures**
  - **Selection of optimal dredging equipment and work timing**
  - **Limit water depth modification**
  - **Spatial and time subdivision in suitable zones**
  - **Prevention of overflow**
  - **Exclusion areas, compensations**
- **Monitoring**
  - **Location and timing of dredging operations**
  - **Bathymetric variations, sediment motion, sediment plumes in suspension**
  - **Benthos communities**
  - **Options for design and operational methodology revision**

THE AUTHORITATIVE PROCESS = MANAGEMENT INSTRUMENT

- **Artificial nourishments have to be suggested where the sediment transport is not excessive. Where the sediment transport is consistent the nourishments could be coupled to containment works to reduce maintenance costs**
- **Maintenance problems of a nourishment, if acceptable in a limited sediment transport condition, can become not sustainable in the case of large sediment transport**
- **For the real efficiency of the intervention it is necessary to use sediments with a grain size distribution larger than that present on the emerged beach**
- **In the case of marine sand the volumes to move are generally larger (even 2-3 times) than the volumes geometrically necessary, due to material losses in the transport and placing phases and the immediate losses due to the not perfect grain size compatibility (overfilling)**
- **To have recourse to the so called "protected nourishments", coupling to the intervention of placement of nourishment sediments a series of works aimed to control the losses, either transversal or longitudinal, have been proved as an adequate solution when the site is exposed to a large wave energy level**

- **The use of an artificial submerged bar with the aim to limit the wave energy that can attack the nourishment require a very small submergence. The use of the bar, with an adequate submergence, can be more useful to fix the equilibrium profile of the nourishment.**

- **With the use of materials extracted from land quarries and with a coarse grain size distribution, an artificial beach obviously more stable is obtained, but it is less usable than the original beach.**

- **The coastal protection works require plans extended to physiographic units of tenths of Km and a strong design experience.**

- **IT COULD BE DESIRABLE THAT THE MINIMUM LEVEL OF AGGREGATION OF COMPETENCE IS THE NATIONAL OR AT LEAST THE REGIONAL ONE.**