

## “Capacity Building and Strengthening Institutional Arrangement”

### Analysis and sampling of water and water pollution

# Application of system for coastal impact analysis

Mr.S.Corsini, Ms.S.Mandrone, Ms.  
A.Barbano, Mr. M.Paone, Mr. M.Rotunno

APAT

Agency for Environmental Protection and Technical Services

# COASTAL PROTECTION UNIT

## INSTITUTIONAL TASKS

Analizing the different kinds of coastal zones and studying the modification in the times of the shoreline, of the beaches and of the some specific feature of the coast

Collecting cartography and thematic data at a national scale focused on marine-coastal areas

Meteo-Marine data processing and numeric modelling to study coastal stability

Guide lines and best practices in order to:  
measuring beaches in a systematic way  
selecting the appropriate kind of intervention to protect the coasts  
designing effective hard works or planning nourishment programmes

Reports on shoreline dynamics and on coastal protection

Studies, analysis and guide lines about coastal dredging and remediation and cleanups of polluted sites

# COASTAL ANALYSIS PROGRAM

## OBJECTIVES

- Coastal zones assessment and characterization
- Estimation of the shoreline modification
- Analysis of natural and anthropic pressures

### Collecting information

At a national scale: morphology, meteo-marine, infrastructural, land use issues

At a local scale: laws, researches and initiatives for coastal management carried out by appropriate institutional offices (Regions, ARPA);

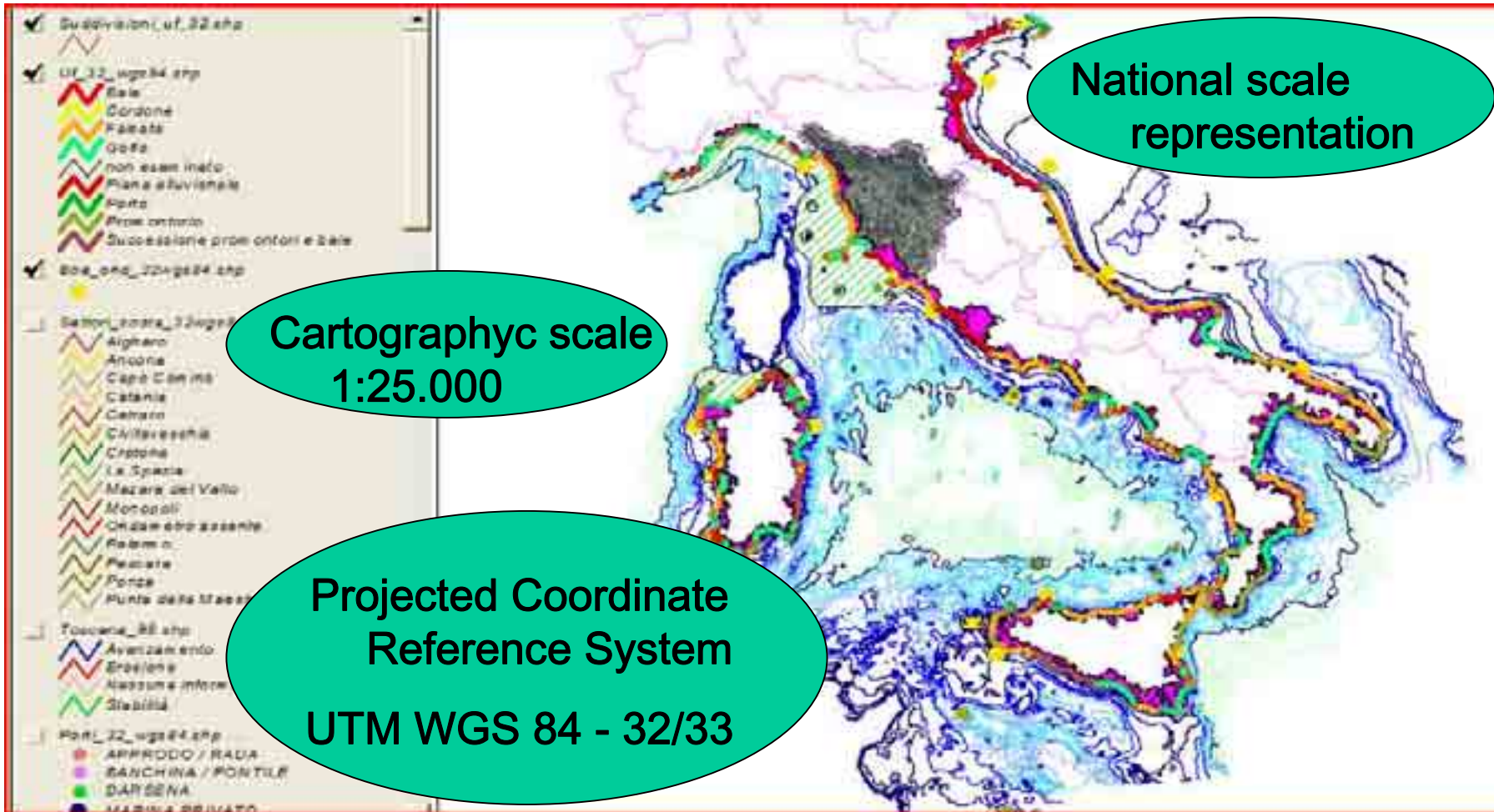
### Analysis and experimentation models

Analysing the Italian coast conditions, that is the aim of the Coastal Geographical Information System

Collecting remote sensed and aerial imagery focused on coastal zones to insert in the SIGC, and establishing methodologies

Carrying out statistics and reports

# THE COASTAL GEOGRAPHICAL INFORMATION SYSTEM



# BACKGROUND CARTOGRAPHY

## VECTORIAL DATA

### Environmental Data

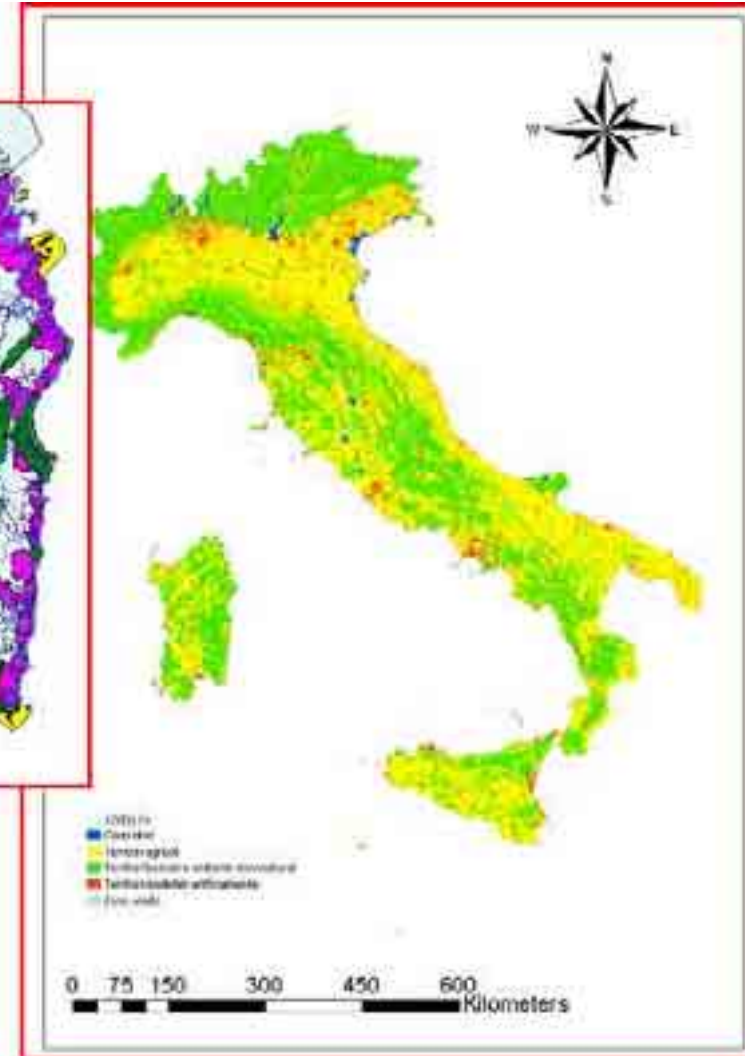
- BATHIMETRY
- HYDROGRAPHY and LAKES
- LITOLOGIC MAP
- LAND USE MAP (CLC2000)
- SUBMARINE VOLCANOS
- 20-mt DTM

### Infrastructures

- ROADS, RAILWAYS, AIRPORTS
- DAMS, other

### Administrative data

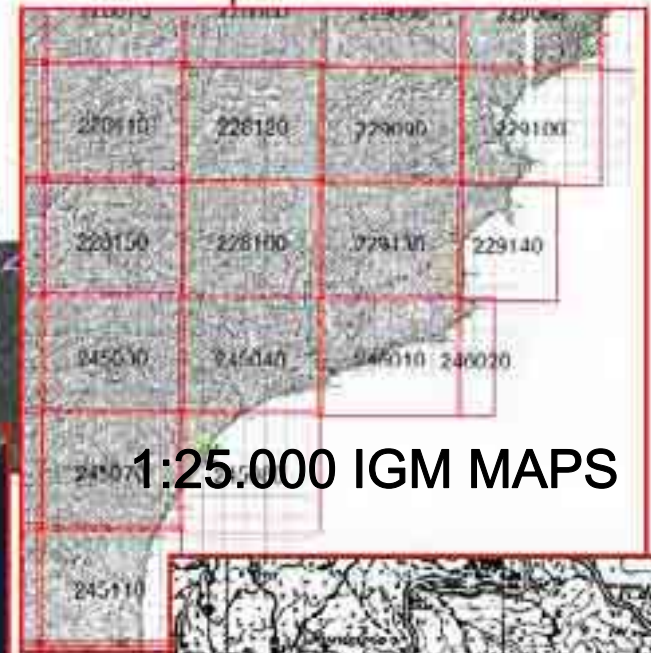
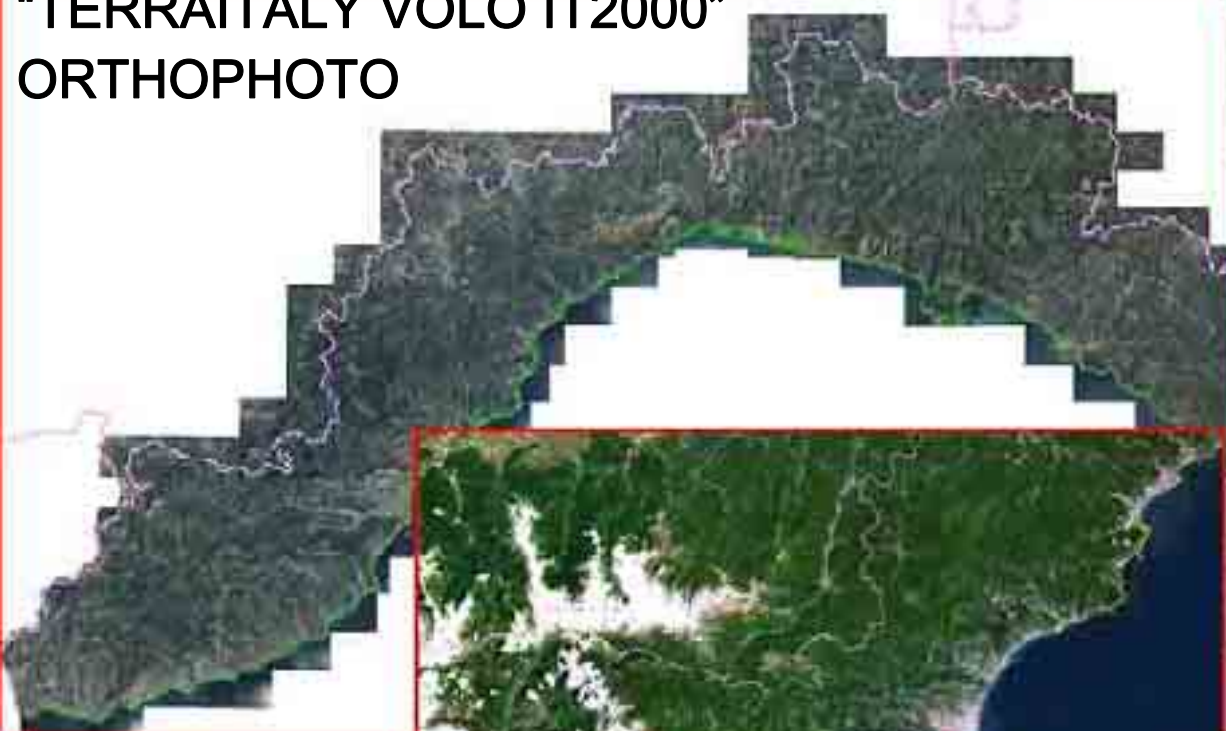
- COMMUNAL/PROV./REGIONAL BOUNDARIES
- TOPONYMS, URBAN CENTERS
- MARINE / TERRESTRIAL PROTECTED AREAS





# BACKGROUND CARTOGRAPHY RASTER DATA

“TERRAITALY VOLO IT2000”  
 ORTHOPHOTO



1:25.000 IGM MAPS

30 mt -  
 LANDSAT  
 TM  
 SATELLITE  
 IMAGES



# DATA PROCESSING AND OUTPUTS THEMES

## Coastal line

- Physiographic units (census and classification)
- Coast line digitized on the "IT2000" orthophoto's
- Coast line derivated by 1:25.000 IGM maps
- Coast classification

## Infrastructures

- Harbours (census and classification)
- Hard works (census and classification)
- Measure stations: Wave Buoys and Tide Gauges

## Meteo-marine data

- Coastal sectors in front of the Wave Buoys
- Meteo-marine climate

## Coastal administrative data



## MORPHO-PHYSIOGRAPHIC UNITS

Coastal tracts where sediments move remaining confined between the two extreme limits (along these limits, the changes are null)

330 physiographic units have been created by processing the coastal line

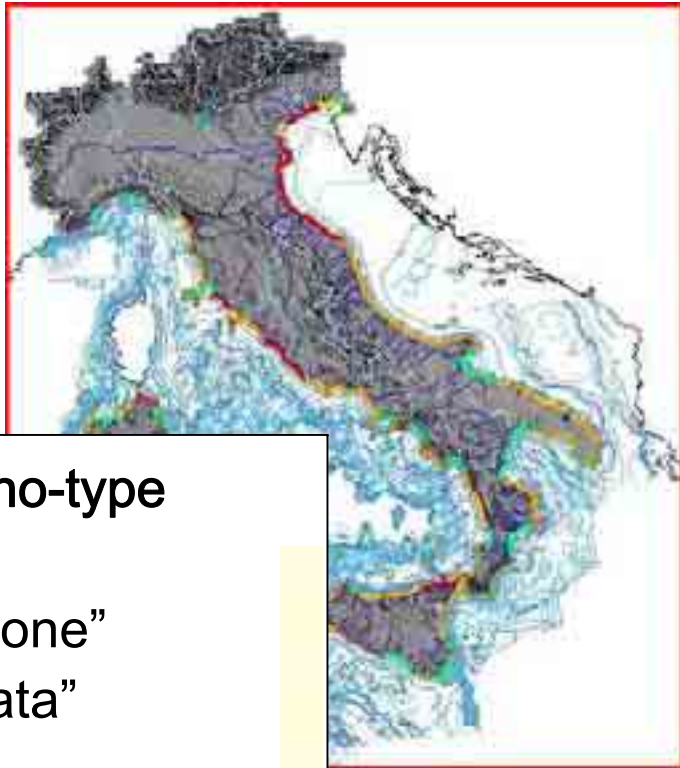
Criteria for their definition:

- terrestrial and submarine coastal geomorphology
- shoreline orientation
- the assumption that the solid transportation along the coast not exceed the 10mt - bathymetry line













# MORPHO-PHYSIOGRAPHIC UNITS



**Morpho-type**

-  Bay
-  "Cordone"
-  "Falcata"
-  Gulf
-  Alluvial plain
-  Harbour
-  Promontory
-  Promontory/bay alternancy


**APAT - SERVIZIO DIFESA DELLE COSTE**


Unità Fisio-grafiche Morfologiche

*Uf. VIAREGGIO*

*Morfologia: SICOMA*

<b>Scala 1:</b>	1:50.000
<b>Scala 2:</b>	1:25.000
<b>Coordinate:</b>	UTM

## METEO-MARINE DATA



- 14 Wave Buoys (RON)
- ★ 26 Tide Gauge Stations (RMN)

### Wave Climate: coastal sectors

Specific coastal tracts has been defined where, by numeric processing, the wave climate measured off-shore is trasposed on the shoreline

Criteria to select each sector:

- Being in front of a wave buoy
- Depending on the shoreline geophysical orientation
- Having a homogenous lenght



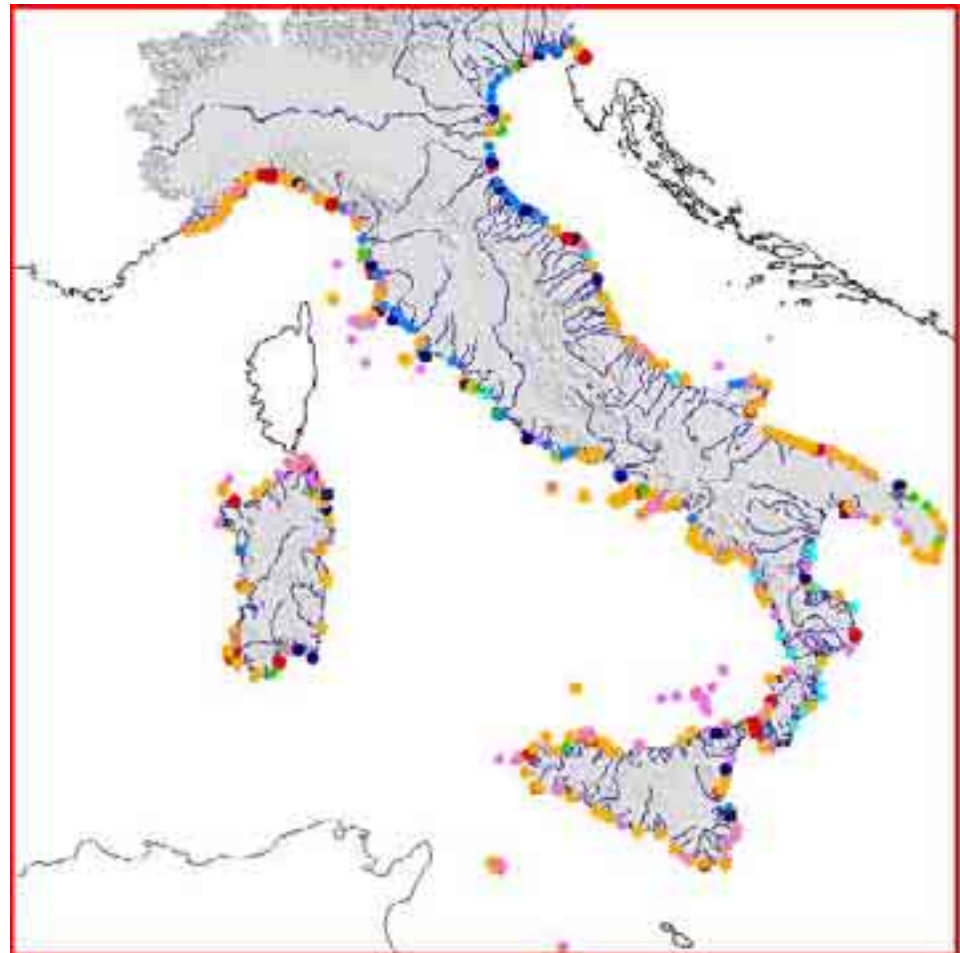


# HARBOURS

653 harbours georeferenciated

- Region, provincial, communal code
- Typology
- Description html web pages

TIPOLOGIA DI PORTO	
<span style="color: red;">●</span>	APPRODO / RADA
<span style="color: magenta;">●</span>	BANCHINA / PONTILE
<span style="color: green;">●</span>	DARSENA
<span style="color: blue;">●</span>	MARINA PRIVATO
<span style="color: orange;">●</span>	PORTO / PORTICCIOLO
<span style="color: cyan;">●</span>	PORTO CANALE
<span style="color: red;">■</span>	PORTO INDUSTRIALE / COMMERCIALE
<span style="color: darkblue;">■</span>	PORTO MILITARE
<span style="color: cyan;">●</span>	SPIAGGIA ATTREZZATA





# HARBOURS - Description



**APAT - SERVIZIO DIFESA DELLE COSTE**

## PORTI D'ITALIA

*Porto:* **PORTOVENERE**

*Tipologia:* **PORTO / PORTICCIULO**



Data: 01/01/2000 in scala 1:12000



Data: 01/01/2000 in scala 1:4200

<b>Descrizione:</b>	Spazio di Porto Venere è racchiuso da due moli fasciati a galleria, rispettivamente di 160 m (molo Droghiera) e 90 m (molo Cava).
<b>Località:</b>	PORTOVENERE, La Spezia (Liguria)
<b>Coordinate:</b>	44°02'10" N 10°10'24" E

# THE COASTAL LINE

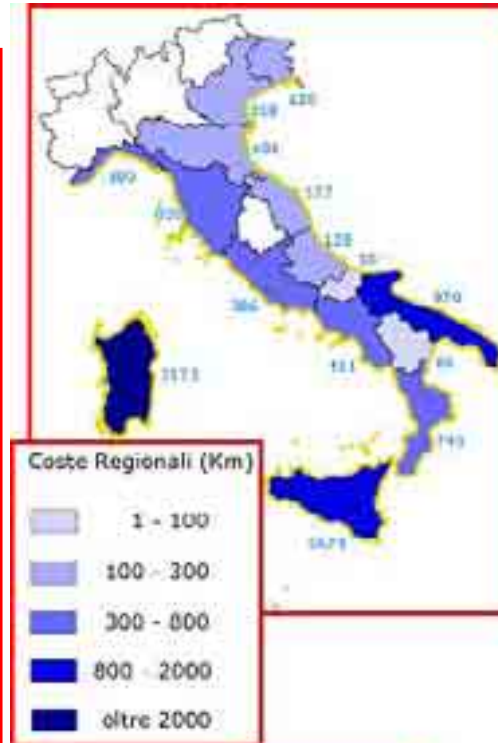
Available data at national scale coming from “Atlante delle Spiagge Italiane”

Regioni	Opere portuali e banchine		Coste alte		Spiagge erosione		in Spiagge accrescimento		in Spiagge stabili		Totale spiagge		Totale litorali	Codice regione
	km	%	km	%	km	%	km	%	km	%	km	%	km	
Friuli Venezia Giulia	29	28	15	14	2	3	2	3	56	94	60	58	104	6
Veneto	0	0	0	0	18	11	20	13	122	76	160	100	160	5
Liguria	63	15	145	35	70	33	3	1	138	66	211	50	419	7
Emilia Romagna	2	1	0	0	31	20	16	10	108	70	155	99	157	8
Toscana	14	3	242	51	122	57	22	10	72	33	216	46	472	9
Marche	4	2	37	22	57	44	7	5	65	51	129	76	170	11
Lazio	13	5	61	21	117	54	12	6	87	40	216	74	290	12
Abruzzo	3	2	23	19	48	48	2	2	49	50	99	79	125	13
Molise	1	3	2	6	26	81	0	0	6	19	32	91	35	14
Campania	23	6	200	54	100	67	0	0	50	33	150	40	373	15
Puglia	58	7	450	56	89	30	1	0	212	70	302	37	610	16
Basilicata	0	0	19	32	40	98	0	0	1	2	41	68	60	17
Calabria	5	1	44	6	300	43	23	4	369	53	692	93	741	18
Sicilia	44	4	375	36	167	27	34	5	420	68	621	60	1040	19
Sardegna	12	1	960	71	62	17	17	4	295	79	374	26	1346	20
<b>Mari</b>														
Tirreno	136	4	1796	50	659	40	74	5	896	55	1629	46	3561	
Adriatico	80	6	353	28	229	27	48	6	568	67	845	65	1278	
Ionio	55	4	422	29	361	37	37	4	586	59	984	67	1461	
<b>Italia</b>	<b>271</b>	<b>4</b>	<b>2571</b>	<b>41</b>	<b>1249</b>	<b>36</b>	<b>159</b>	<b>5</b>	<b>2050</b>	<b>59</b>	<b>3458</b>	<b>55</b>	<b>6300</b>	

Al valore relativo alle spiagge in erosione occorre aggiungere un ulteriore 9% (oltre 300 km), per quei litorali che sono stati resi stabili mediante opere di protezione. Pertanto le spiagge "naturalmente" stabili costituiscono circa il 50% del totale

Il totale dei km dei litorali italiani comprende l'isola d'Elba ma non comprende le isole minori, i cui litorali hanno uno sviluppo di circa 1200 km (per la gran parte coste alte)

Fonte: Atlante delle Spiagge Italiane, C.N.R. - M.U.R.S.T., 1985-1997



IT BECAME CRUCIAL:

HAVING UPDATED AND HOMOGENOUS DATA ON

- SHORELINE DYNAMICS
- SPATIAL AND DIACHRONICAL MODIFICATIONS
- UPDATED BACKGROUND CARTOGRAPHY



## IGM COASTAL LINE



Derived by a GIS processing on the Italian administrative boundaries theme

Checked and re-edited, in some parts, on the 1:25.000 IGM Maps

It is a homogenous theme at the 1:25.000 national scale





## COASTAL LINE 2000 DIGITALIZATION

- Coming from a GIS digitalization on the “Volo IT2000” - orthophoto's
- Scales of the digitalization: *1:5.000* in corrispondence of natural tracts;  
*1:3.000* in corrispondence of harbours and hard structures
- It is a homogenous theme at the 1:10.000 national scale

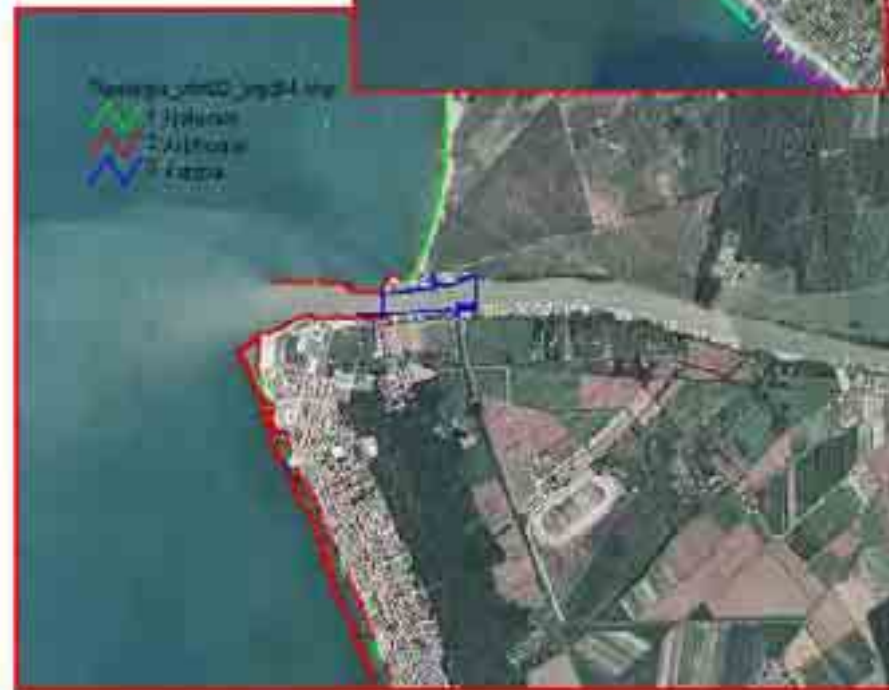




## COASTAL LINE 2000 Classification

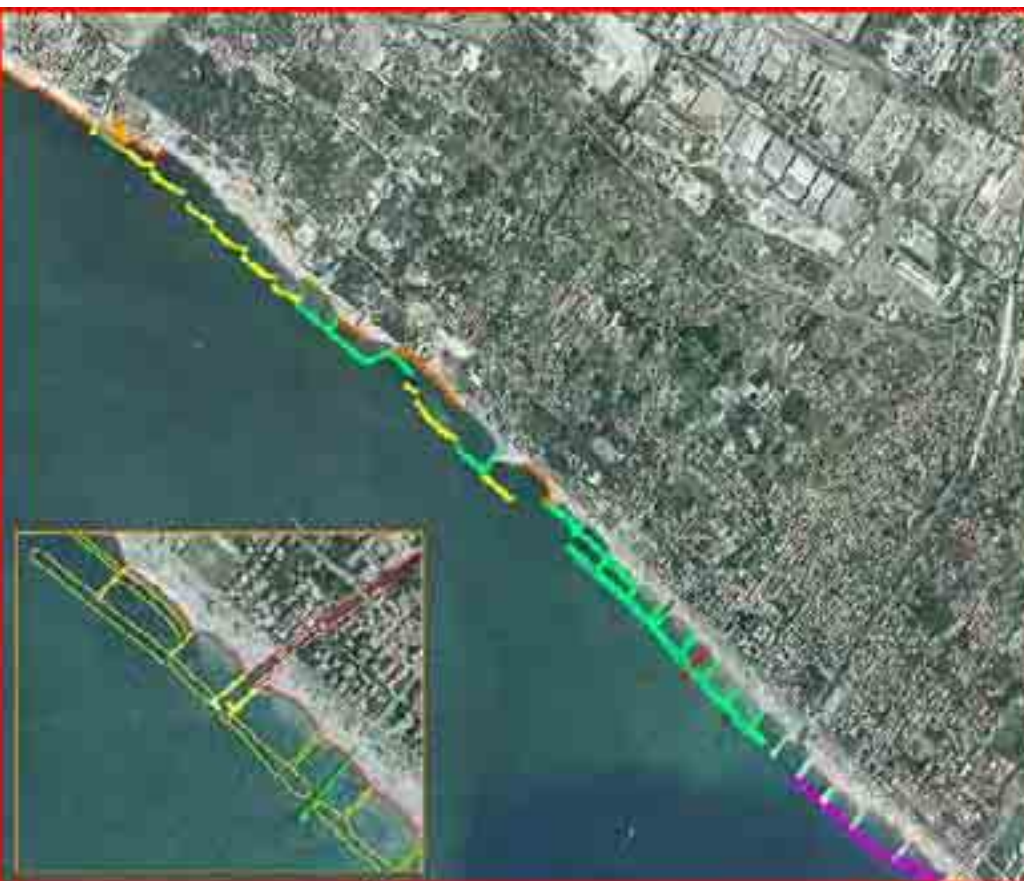
The digitized coastal line has been classified in :  
 natural, artificial and fictitious.

The natural coast has been divided in :  
 high coast tracts and low coast tracts.



## COASTAL LINE 2000 Harbours and hard works

Each portual and coastal hard structure recognized on the orthophoto's has been digitized and classified by typology



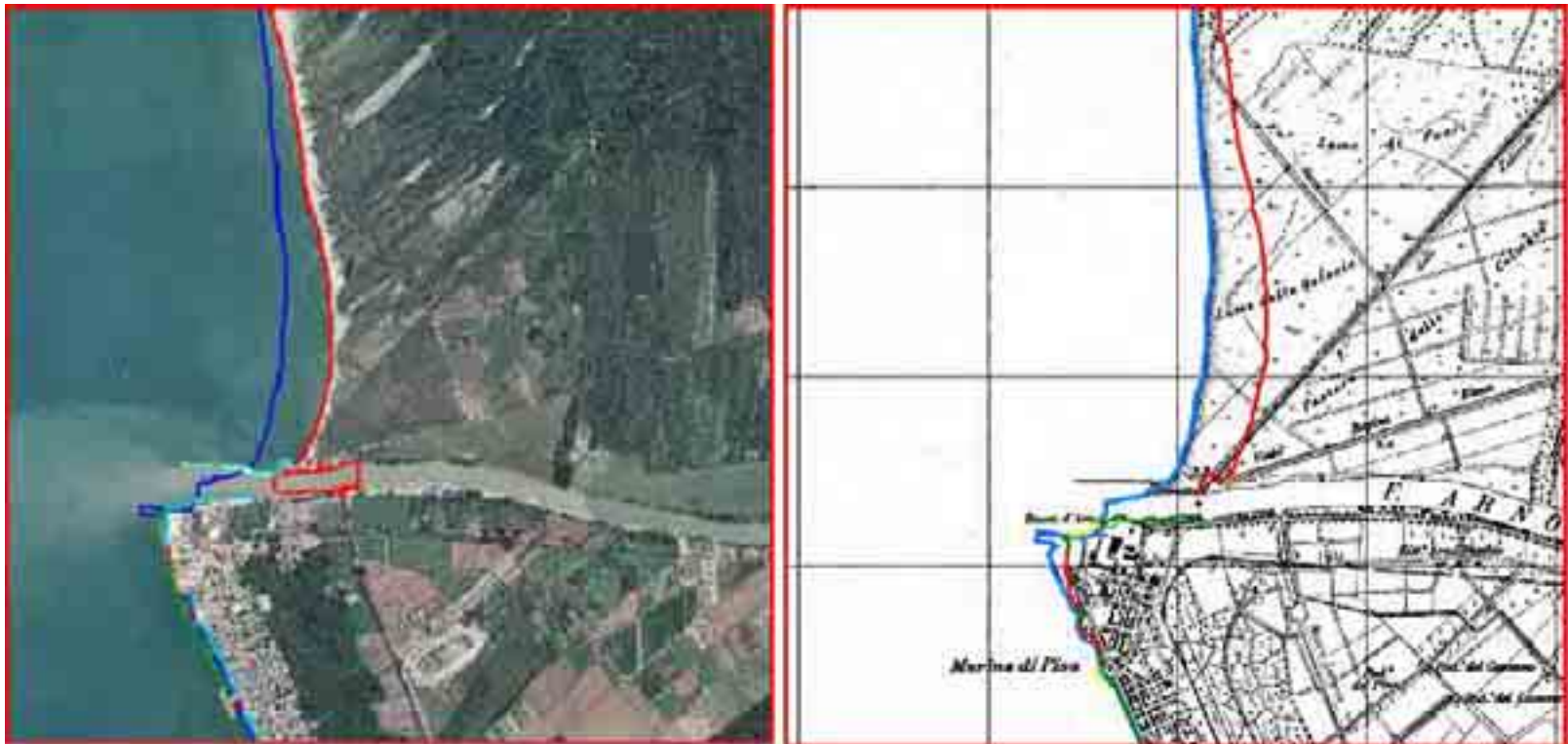
Tipologia\_ultr82\_wgs84.shp

-  Altro (Ild, pontili, ecc.)
-  Opere di difesa costiera-Foci armate
-  Opere di difesa costiera-Icolotti
-  Opere di difesa costiera-Opere miste
-  Opere di difesa costiera-Pennelli a T emersi
-  Opere di difesa costiera-Pennelli a T sommersi
-  Opere di difesa costiera-Pennelli a Y emersi
-  Opere di difesa costiera-Pennelli obliqui emersi
-  Opere di difesa costiera-Pennelli obliqui sommersi
-  Opere di difesa costiera-Pennelli ortogonali emersi
-  Opere di difesa costiera-Pennelli ortogonali sommersi
-  Opere di difesa costiera-Radente a gettata
-  Opere di difesa costiera-Radente a muro
-  Opere di difesa costiera-Scogliere emerse con varchi
-  Opere di difesa costiera-Scogliere emerse senza varchi
-  Opere di difesa costiera-Scogliere sommerse con varchi
-  Opere di difesa costiera-Scogliere sommerse senza varchi
-  Opere Portuali



## SHORE LINE MODIFICATION

- The two coastal lines (“2000”, IGM) have been compared at the 1:25.000 cartographic scale
- Linear and areal modifications on the last 40-50 years have been estimated



## METHODOLOGY

- Starting from the IGM reference coastal line, a 5-mt buffer zone and a 30-mt buffer zone have been created in a parallel direction;
- The two coastal lines (IGM and 2000) have been overlaid in order to make a spatial analysis;
- After comparing the two lines, shoreline tracts resulting in accrescion or in erosion have been individuated;
- The dimensions of the linear and areal modification have been calculated.





# OUTPUTS

The Italian coastal line is updated (to the year 2000)

Background cartography data allows to analyse the shoreline modification

Statistical reports for each administrative unit and for each physiographic unit

Italia Costa 8.353 Km						
Tipi costa	Descrizione	Libri/ptg	Lunghezza		N°	Opere
			[m]	[%]		N°/N°
<b>Totale</b>			<b>8.353.264</b>	<b>100,0</b>		
<b>Naturale</b>			<b>7.687.574</b>	<b>92,0</b>		
	Alta		2.824.289	36,1		
	Bassa		4.863.285	63,3		
	Sabbiose		3.347.379	68,8		
	Cottolose		1.484	0,0		
	Roccciose		1.182.999	23,5		
	Non definite		360.907	7,2		
<b>Artificiale</b>			<b>313.796</b>	<b>3,8</b>	<b>3.544</b>	<b>100,0</b>
	Ridotte a gettate		187.715			
	Ridotte a mura		68.881			
	Bagniere emerse con varchi					
	Bagniere emerse senza varchi					
	Bagniere sommerse con varchi					
	Bagniere sommerse senza varchi					
	Pinnacoli cilindrici emersi					
	Pinnacoli cilindrici sommersi					
	Pinnacoli tetragonali emersi					
	Pinnacoli tetragonali sommersi					
	Pinnacoli a T emersi					
	Pinnacoli a T sommersi					
	Pinnacoli a T emersi					
	Scalette					
	Opere emerse		1.000			
	Fiori artificiali					
	Opere portuali					
	Altri (dali, pontili, ecc.)		55.480			
<b>Fittizie</b>			<b>361.524</b>			
	Collegamento porto		201.379			
	Collegamento opera		112.966			
	Collegamento fuori dal fiume		38.583			

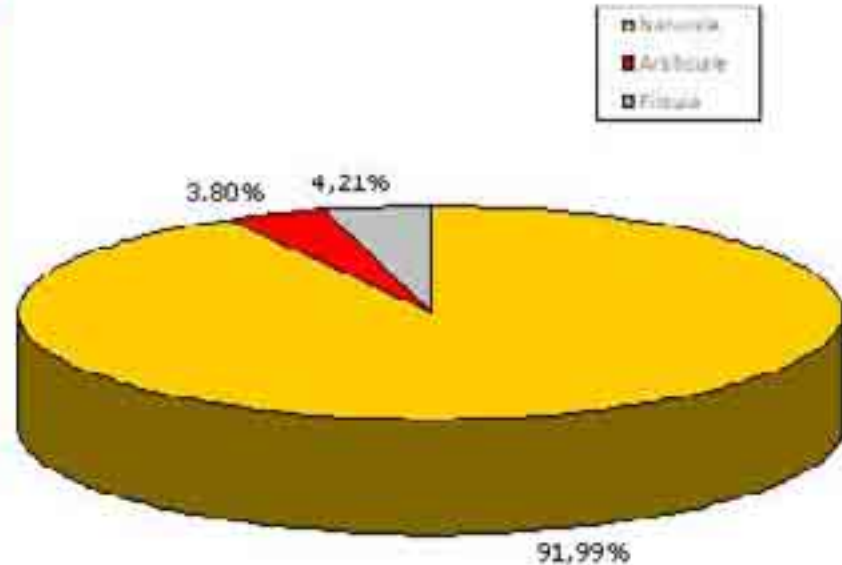
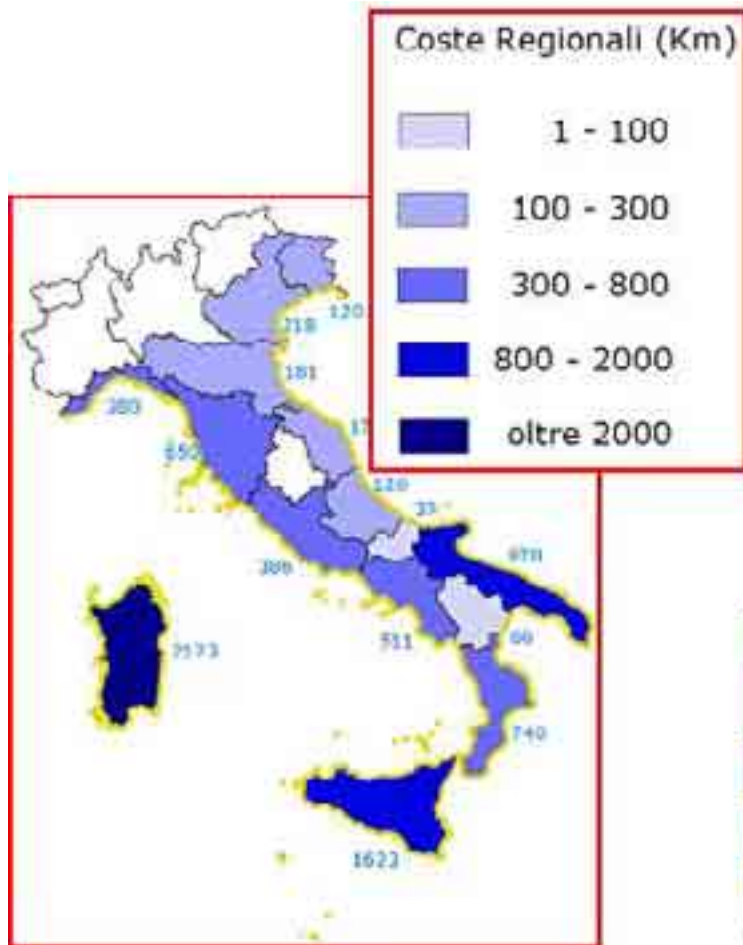
Analisi estesa a tutte le coste

	Lunghezza	
	[m]	[%]
<b>Coste</b>	<b>8.353.264</b>	<b>100,0</b>
<b>Stabili</b>	<b>5.385.058</b>	<b>64,5</b>
<b>Modificate</b>	<b>2.448.213</b>	<b>29,3</b>
<b>Non definito*</b>	<b>519.993</b>	<b>6,2</b>
<b>Coste modificate</b>	<b>2.448.213</b>	<b>29,3</b>
<b>Arretramento</b>	<b>1.284.978</b>	<b>15,4</b>
<b>Avanzamento</b>	<b>1.163.235</b>	<b>13,9</b>

Analisi estesa alle coste basse

	Lunghezza	
	[m]	[%]
<b>Coste</b>	<b>4.863.285</b>	<b>100,0</b>
<b>Stabili</b>	<b>2.387.415</b>	<b>49,1</b>
<b>Modificate</b>	<b>2.227.431</b>	<b>45,8</b>
<b>Non definito*</b>	<b>248.439</b>	<b>5,1</b>
<b>Coste modificate</b>	<b>2.227.431</b>	<b>45,8</b>
<b>Arretramento</b>	<b>1.169.823</b>	<b>24,1</b>
<b>Avanzamento</b>	<b>1.057.608</b>	<b>21,7</b>

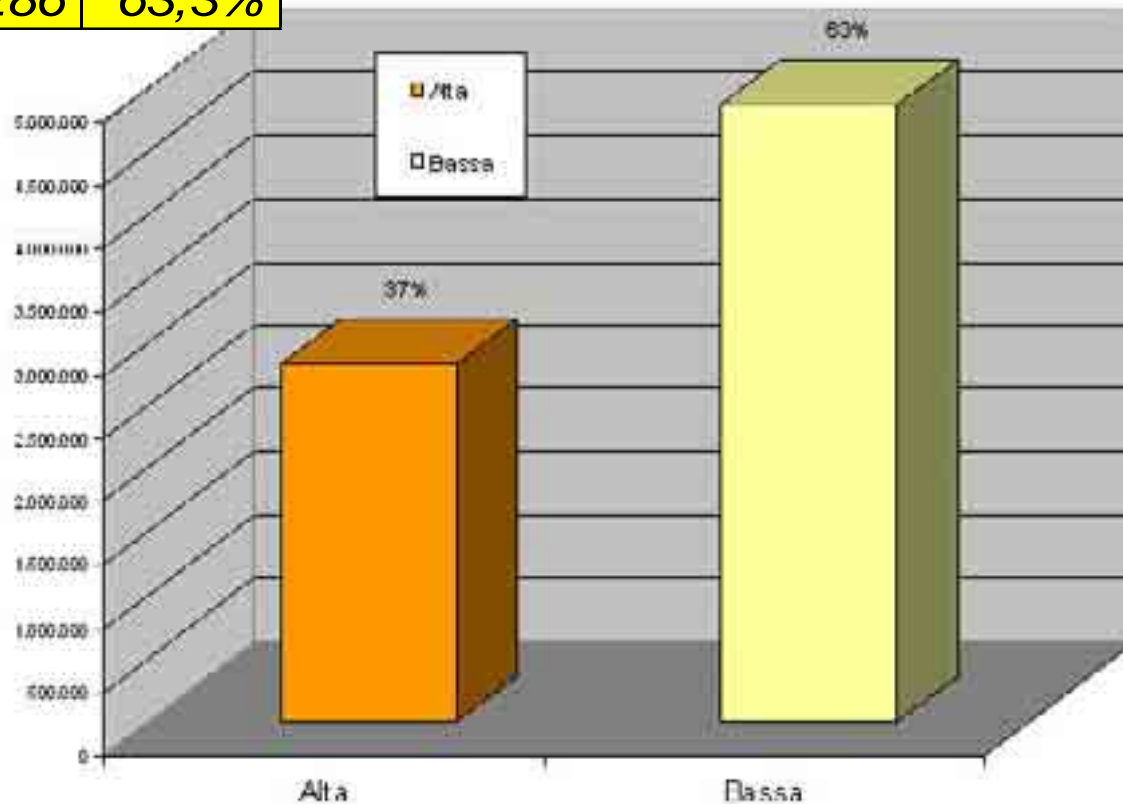
# NATURAL / ARTIFICIAL COASTLINE



Lunghezza della costa (metri)		
<b>Totale</b>	<b>8.353.264</b>	<b>100%</b>
<i>Naturale</i>	7.687.574	92%
<i>Artificiale</i>	313.766	3,80%
<i>Fittizia</i>	351.924	4,20%

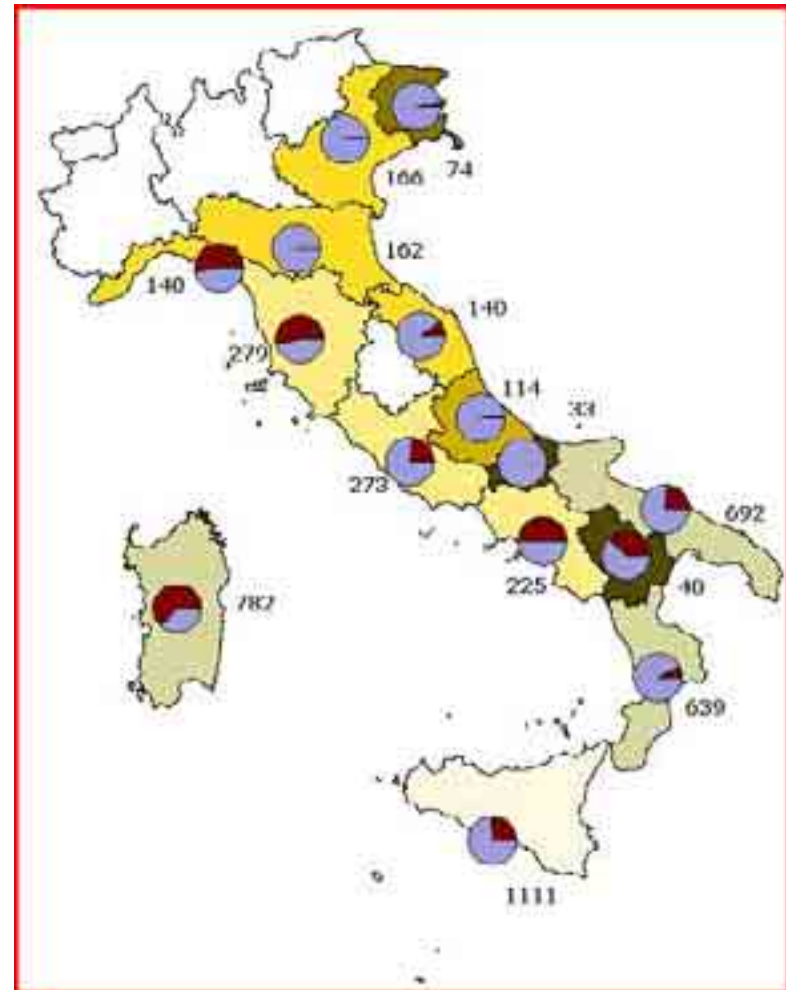
## HIGH / LOW NATURAL COASTLINE

Lunghezza costa in metri		
<b>Naturale</b>	<b>7.687.574</b>	<b>100%</b>
<i>Alta</i>	<i>2.824.288</i>	<i>36,7%</i>
<i>Bassa</i>	<i>4.863.286</i>	<i>63,3%</i>



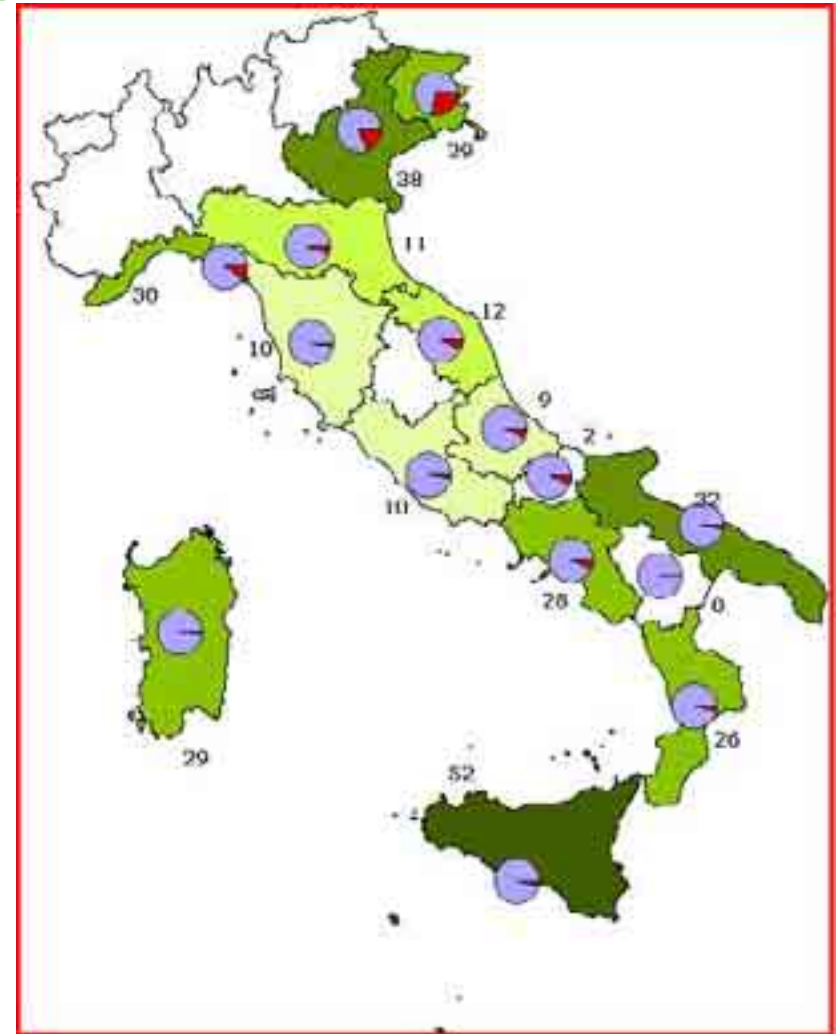


# STATISTICS AT A REGIONAL LEVEL :LENGHT and PERCENTAGE OF THE HIGH / LOW COAST

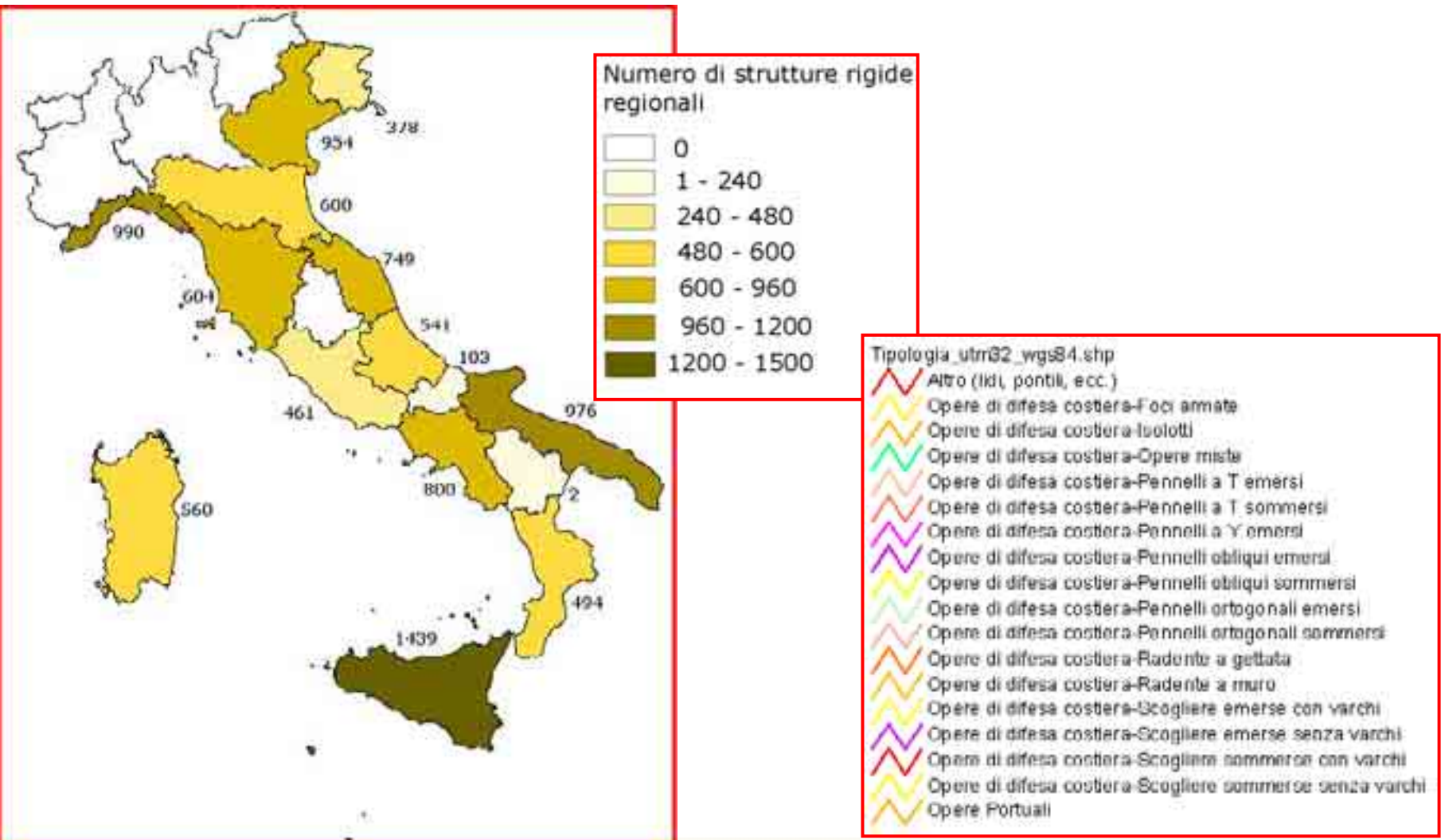


# STATISTICS AT A REGIONAL LEVEL :THE ARTIFICIAL COAST

- Tipologia\_utm22\_wgs84.shp
- Alto (ist. pontili, ecc.)
  - Opere di difesa costiera-Foci armate
  - Opere di difesa costiera-Isolotti
  - Opere di difesa costiera-Opere miste
  - Opere di difesa costiera-Pennelli a T emersi
  - Opere di difesa costiera-Pennelli a T sommersi
  - Opere di difesa costiera-Pennelli a Y emersi
  - Opere di difesa costiera-Pennelli obliqui emersi
  - Opere di difesa costiera-Pennelli obliqui sommersi
  - Opere di difesa costiera-Pennelli ortogonali emersi
  - Opere di difesa costiera-Pennelli ortogonali sommersi
  - Opere di difesa costiera-Radente a pettate
  - Opere di difesa costiera-Radente a
  - Opere di difesa costiera-Scogliere e
  - Opere di difesa costiera-Scogliere e
  - Opere di difesa costiera-Scogliere e
  - Opere di difesa costiera-Scogliere e
  - Opere Portuali

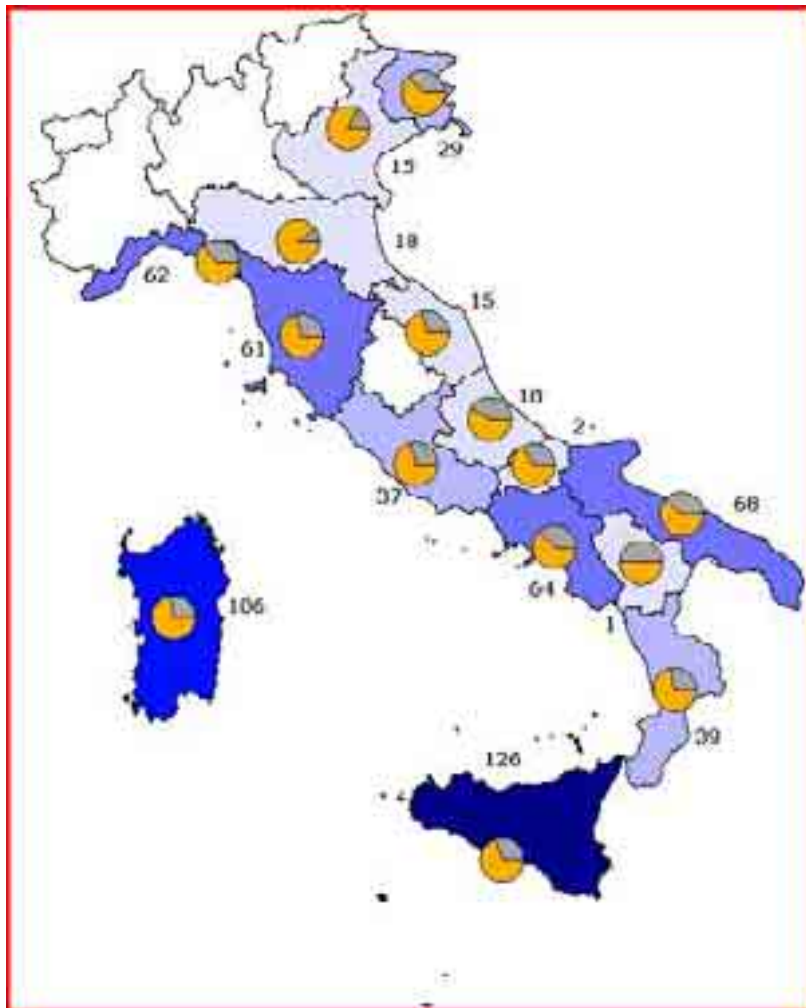


# STATISTICS AT A REGIONAL LEVEL :HARD WORKS

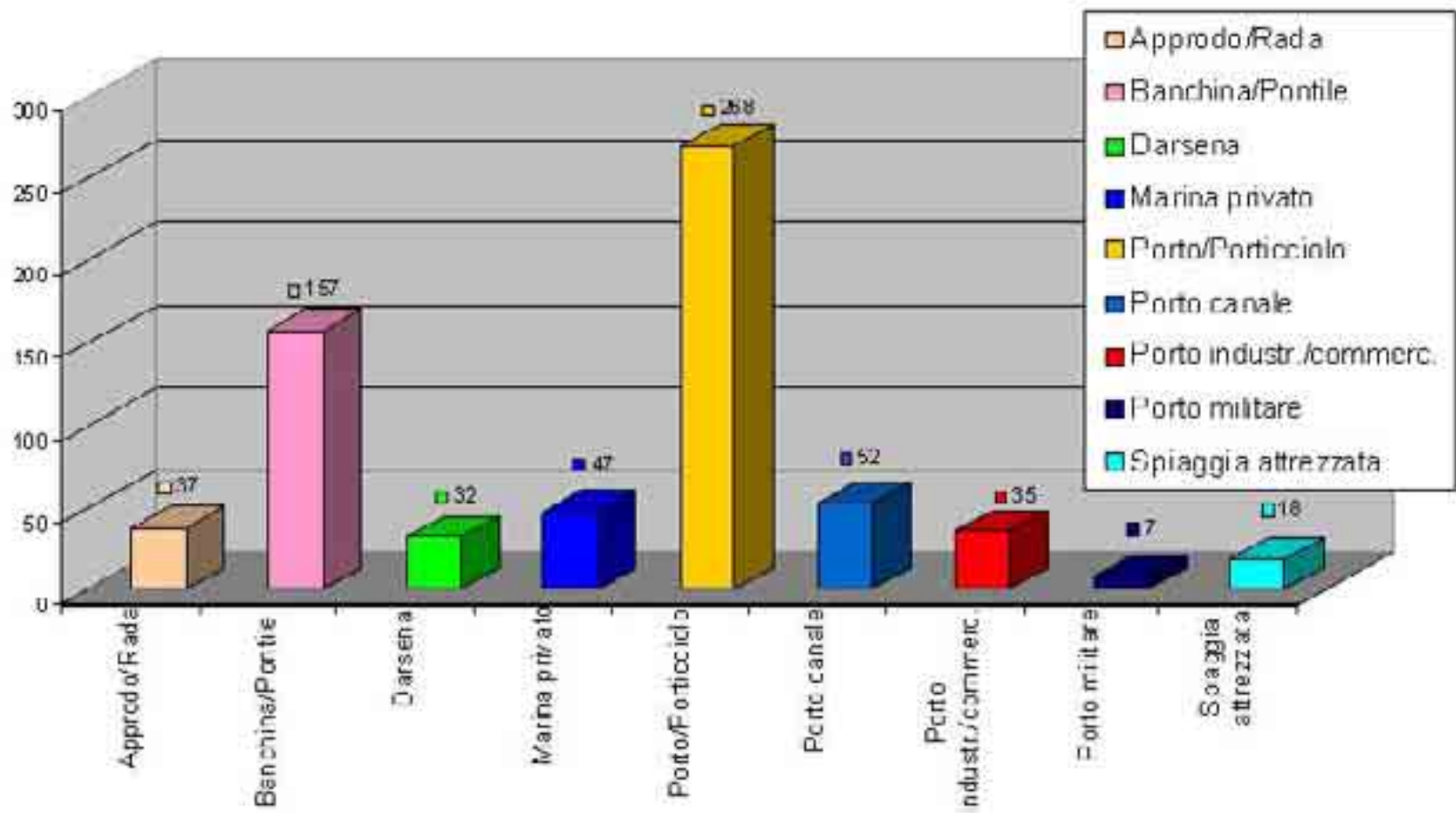




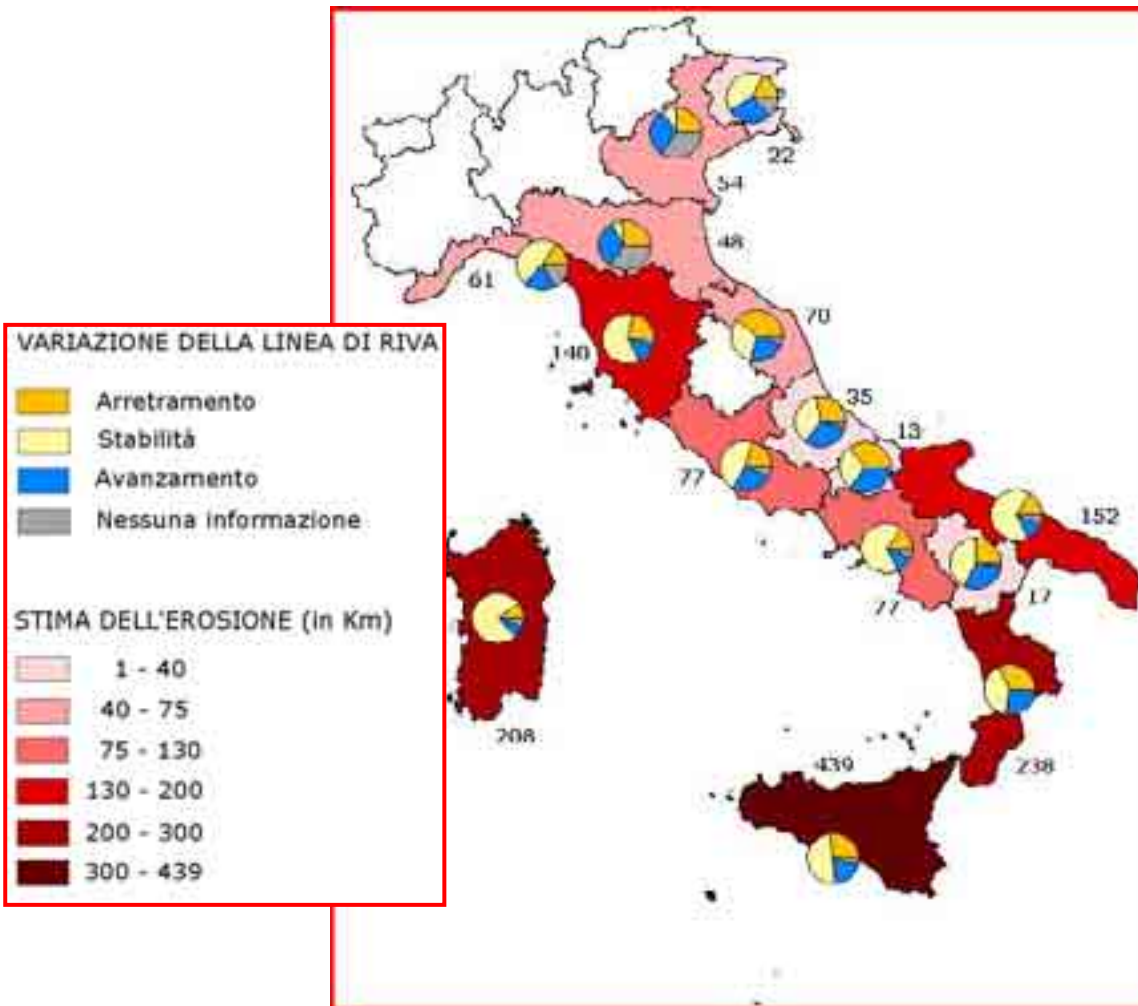
# STATISTICS AT A REGIONAL LEVEL: ENVIRONMENTAL PRESSURE BY HARBOURS



# HARBOURS : NATIONAL DISTRIBUTION FOR TYPOLOGY



# EVALUATION OF THE 1950-2000 SHORELINE MODIFICATIONS



Analisi estesa a tutte le coste

	Lunghezza	
	[m]	[%]
Coste	8.353.264	100,0
Stabili	5.385.058	64,5
Modificate	2.448.213	29,3
Non definito*	519.993	6,2
<b>Coste modificate</b>		
Arretramento	1.284.978	15,4
Avanzamento	1.163.235	13,9

Analisi estesa alle coste basse

	Lunghezza	
	[m]	[%]
Coste	4.863.285	100,0
Stabili	2.387.415	49,1
Modificate	2.227.431	45,8
Non definito*	248.439	5,1
<b>Coste modificate</b>		
Arretramento	1.169.823	24,1
Avanzamento	1.057.608	21,7



# EXPERIMENTATION: High-Resolution Satellite Imagery (Ikonos)



## Characteristics of remote sensing data:

- Large geographic coverage as well as high geometric resolution quality
- Images with high informative content (availability of 4 spectral bands)

## Purpose:

- Assessment of the satellite method efficacy for periodical coastal monitoring

## Experimental coastal sites:

- Near 20 Km stretch of Calabrian coast (Amantea-Gizzeria)
- Near 20 Km stretch of coast between Molise and Puglia regions (Foce del Saccione-Marina di Lesina)

## IKONOS characteristics:

- Space Imaging's remote sensing satellite
- Launched in September 1999
- Approximate altitude of 680 km

Spectral bands	Resolution
1 Blue	4 m
2 Green	
3 Red	
4 Near IR	
PAN Panchromatic	1 m



- By combining multispectral and panchromatic data (*Data fusion*) -> Images at 1 m resolution available on experimental coastal sites

## The Calabrian Coastal Site



- Satellite images at the same resolution of the "It2000" orthophoto (1 m)
- Near 20 Km stretch of tyrrhenian coast between Amantea and Gizzeria
- Digitalization of shoreline, harbours and defence infrastructures
- Shoreline changes and morphodynamic evolution analysis



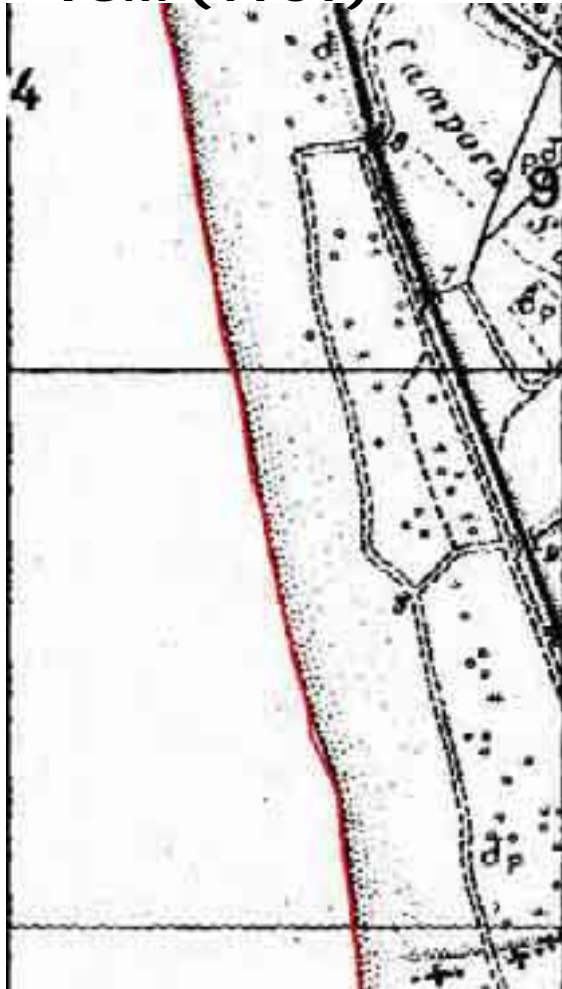
AREA 1 – Campora S. Giovanni harbour

Shoreline position analysis

IGM (1959)

ORTHOPHOTO (1999)

IKONOS (2005)



— IGM Shoreline

— Orthophoto Shoreline

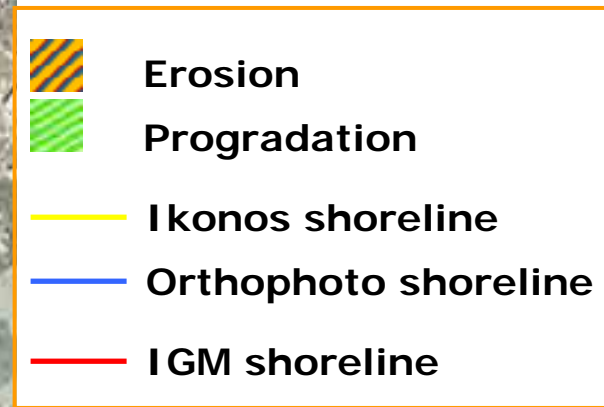
— Ikonos Shoreline

AREA 1 – Campora S. Giovanni harbour

Surface analysis

**IKONOS - IGM**

**IKONOS - ORTHOPHOTO**

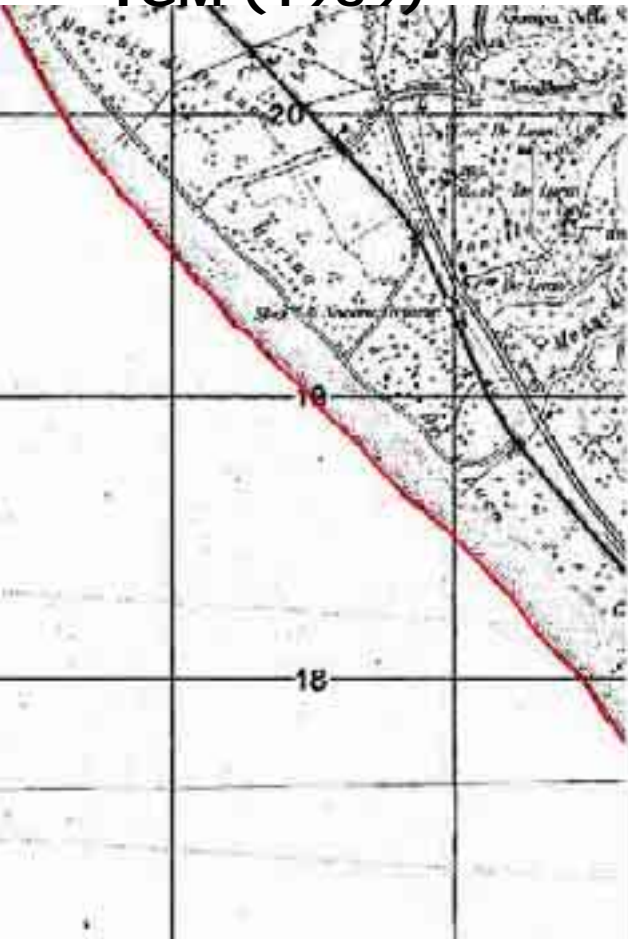




AREA 2 – Nocera Tirinese

Shoreline position analysis

IGM (1959)



ORTHOPHOTO (1999)



IKONOS (2005)



— IGM Shoreline

— Orthophoto Shoreline

— Ikonos Shoreline

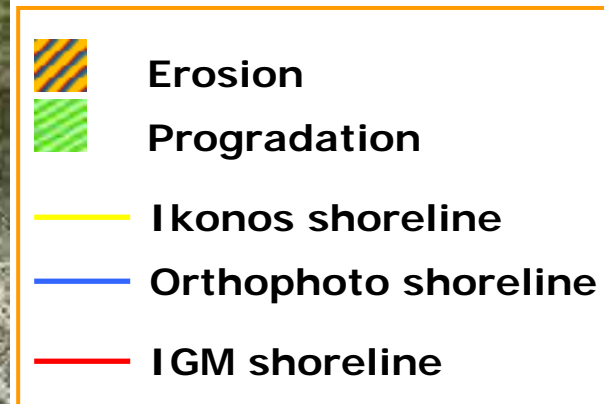


AREA 2 – Nocera Tirinese

Surface analysis

**IKONOS - IGM**

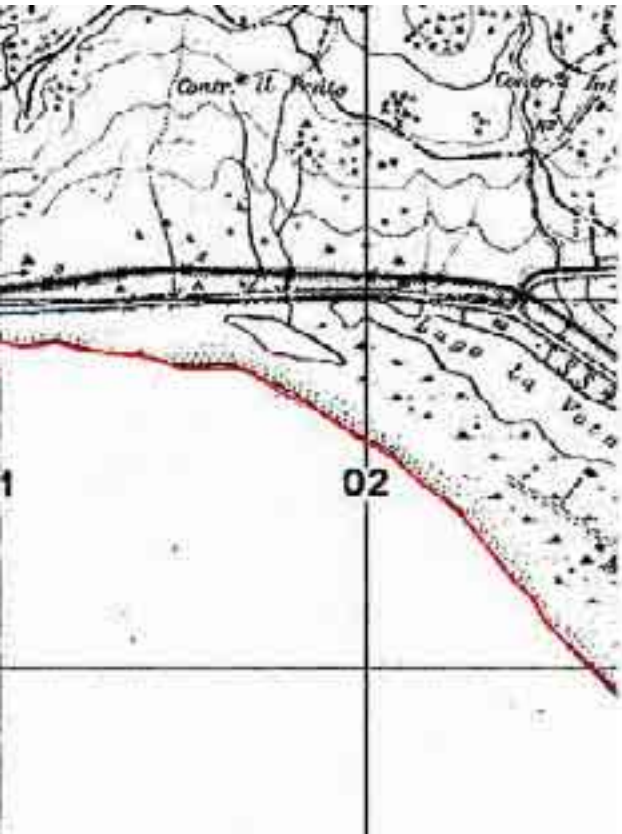
**IKONOS - ORTHOPHOTO**



AREA 3 – “La Vota” coastal lake

Shoreline position analysis

IGM (1958)



ORTHOPHOTO (1999)



IKONOS (2005)



— IGM Shoreline

— Orthophoto Shoreline

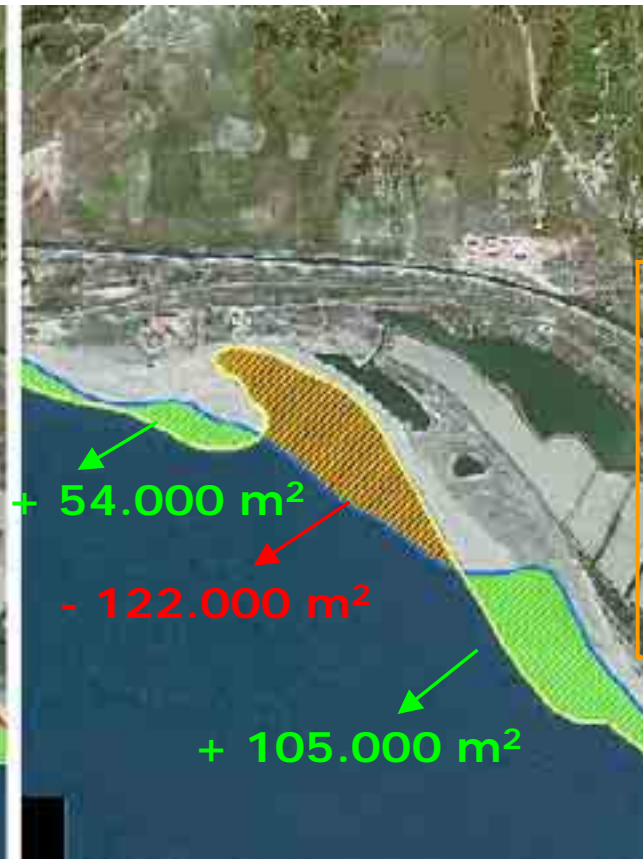
— Ikonos Shoreline

AREA 3 – “La Vota” coastal lake

Surface analysis

**IKONOS - IGM**

**IKONOS – ORTHOPHOTO**



	Erosion
	Progradation
	Ikonos shoreline
	Orthophoto shoreline
	IGM shoreline

# EXPERIMENTATION based on IKONOS Satellite Imagery

## Conclusions and Perspectives

- High resolution remote sensing data have revealed to be suitable for multitemporal monitoring and for land change mapping
- On the experimental coastal zones, Ikonos satellite images have turned out to be particularly profitable for analysis of morphodynamic evolution and change in shoreline position
- The availability of Ikonos imagery for all the Italian coasts would provide an up-to-date raster support, collatable with IGM charts and "It2000" orthophotos that are nowadays the only homogeneous data at national scale



## EXPERIMENTATION: low altitude perspective images



SIGC  
 integrated  
 photograph  
 catalogue:  
 North-  
 Western  
 Italian coast  
 line  
 experimenta  
 tions

*Ligurian  
 Region  
 cooperative  
 Project*

# EXPERIMENTATION: low altitude perspective images

## Project



Environmental plane survey, with the acquisitions of several perspective images, to study of geomorphologic characteristics of the coastal sectors, anthropic pressure, harbour and coastal defence structures (groins, break water) dimension .

## The aim

Video and photo acquisitions from sea side to obtain the total coastal zone cover of the Ligurian Region.

Digital Data-base realization of the whole data acquired, that contains the information and the parameters of the photo and video acquisitions.

GIS software development to visualize and analyse the photos and video.

# EXPERIMENTATION: low altitude perspective images

## STAGE 1

### Preliminary plane overview

Due to the complexity of the study area we improve a first set of flight plan, also to set-up the instruments under different conditions.

As the instrument set-up are complete, a valuations of results will be carried out to expand the methodology to the whole Ligurian region.



# EXPERIMENTATION: low altitude perspective images

## STAGE 1

### Preliminary plane overview

The first preliminary flight was carried out along the coastal zone with 37 km range, from Genova to Cogoleto.

The whole Ligurian land complexity is well defined by the study area as listed below:

- ✓ Complex harbour structures (Genova seaport)
- ✓ Natural sectors, linear and indented structures
- ✓ River mouth
- ✓ Defence coastal structures
- ✓ Urban areas



## EXPERIMENTATION: low altitude perspective images



# EXPERIMENTATION: low altitude perspective images

## STAGE 1 Instruments

### *Aeromobile*

- helicopter *SA318/ 5 seat*
- average speed: 30-35 nods

### *System*

GPS model *Koden GPS-20*

### *Fotocamera*

- Nikon D2x with 12.4 million pixel resolution

### *Camera*

- High definition digital camera 1920x1080

# EXPERIMENTATION: low altitude perspective images

## STAGE 1

Flight plan – from Cogoletto to Genova



Prospective acquisitions:

- Flight altitude = 300 m
- Coastal line distance = 300 m
- Broadcast angle = 45°



# EXPERIMENTATION: low altitude perspective images

## STAGE 1

### Detailed flight plane –Genova area



1st flight plane was set-up at 300m from the coastal line

2nd flight plane was set-up at 300m from port structures

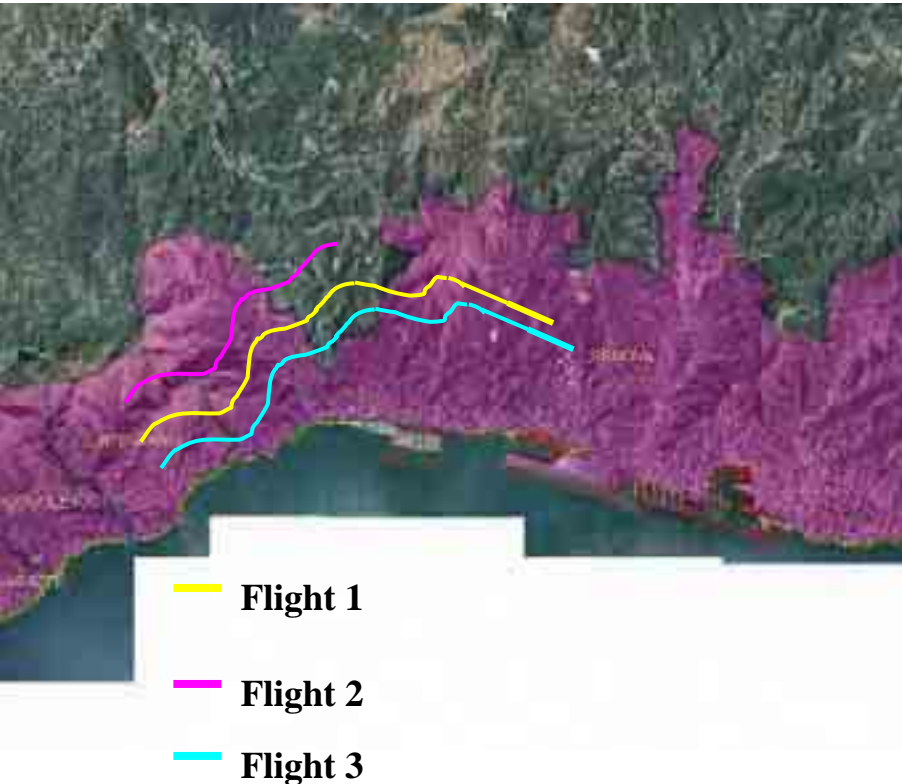
Additional flight plane was set-up to analyse the complex structures as the ancient and commercial harbour etc.

# EXPERIMENTATION: low altitude perspective images

## STAGE 1

Detailed flight plane– from Arenzano to Genova

Experimental sector used to set-up the best flight altitude, angle and distance.



## Experimental flight parameters

Flight	Altitude	Coastal line distance	Broadcast angle
1	300 m	300 m	45°
2	150 m	200 m	45°
3	500 m	450 m	45°

# EXPERIMENTATION: low altitude perspective images

## STAGE 1

Detailed flight plane – from Arenzano to Cogoleto



Prospective acquisitions:

- Flight altitude = 150 m
- Coastal line distance = 200 m
- broadcast angle = 45°

Two different photo-acquisitions procedures was improved:

- ✓ Manual aiming
- ✓ Auto aiming mainly based on the flight speed using GPS.

## EXPERIMENTATION: low altitude perspective images





# EXPERIMENTATION: low altitude perspective images

## RESULTS

### *Digital data-base*

- Mainly due to further improve the management and consulting of the acquired data set (image and video)

### *Software*

Interfaced with APAT and Ligurian Region GIS systems.

The system allow us to:

Easy access to the whole data base using:

text list, coordinate etc.

broadcast points vectorial selection

Viewing the selected images

viewing the movies of the selected images