COMMISSION EUROPEENNE
DIRECTION GENERALE AUX POLITIQUES REGIONALES ET A LA COHESION
PROGRAMME OPÉRATIONNEL INTERREG III C – ZONE SUD

BEACHMED-e

Strategic management of beach protection for sustainable development of Mediterranean coastal zones» (code 3S0155R)

ObseMedi TOOL

COASTAL SERVICES
Operative and consultative services for the Coastal Monitoring

PARTENARIAT:

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(Region de Crète)

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(Regione Lazio)

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OPERATIVE SERVICES

1. COLLECTION OF INFORMATION; ARCHIVE OF IMAGES AND EXISTENCE OF AN ORGANISATIONAL SYSTEM

A good management of the coastal zone and the development of useful tools for administrators require an input of specific data in a form scientifically coherent, which, according to EUROSION, have to focus on:

- Aerial orthophotographs (alternatively, satellite images)
- Historic and actual coastline
- Terrestrial elevation
- Nearshore bathymetry (eventually, offshore bathymetry)
- Cross-shore profiles
- Coastal geomorphology
- Coastal geology
- Seafloor sedimentology
- Sediment transport
- Nearshore waves regime
- Offshore waves and winds regime
- Nearshore currents
- Astronomic tides
- Still water level
- Coastal defence structures

Therefore it would be necessary to localise and collect the available data before integrating them in a system of data organisation and collection. The Geographical Information Systems (GIS) and the databases (and metadata) are useful tools for coastal study, as they allow the storage and use of pieces of information of different nature and origin in the same system.

The **localisation and inventory of the existent data** can be realised according to the indications reported in the "Manual of procedures for setting up Local Information Systems" of the EUROSION project. This procedure may be divided in three phases to answer the following questions: What data and information are available? Where are they available and how? In which format? And in which language?

The first step consists of finding the available data. For this, one (or several) person from each structure (public and private) will be identified and contacted in order to obtain the principal information of the data (including metadata) they own. Then a questionnaire will be specifically elaborated in order to obtain the necessary information for the identification and description of the available information.

The second step consists of identifying the gaps in the data and information that was located in the previous step, by comparing these data with the necessary data for the management of the coastal zone.

The last step consists of trying to fill these gaps by re-contacting the identified person(s).

Once the inventory is realised, an **information system** must be elaborated. An information system (IS) can be defined as "a set of technological, human, organisational, financial, and information resources organised in such a way as to produce, archive, retrieve, modify, process, combine, represent, exchange and/or disseminate information with a view to reach the objectives the system is designed for", for which user training must be provided.

Designing, developing, installing and maintaining a local information system (LIS) dedicated to coastal erosion management requires taking into consideration the following aspects:

a) Functional specifications aim at clarifying the objectives of the IS. They describe which coastal management decisions are to be supported by the system, as well as their data requirements (indicated above).

b) The objectives of ***the organisational and institutional procedures*** are to ensure that the system will meet the expectations within an agreed time schedule and budget constraints. These dispositions express the willingness of the interested groups to put their information resources on a common platform and therefore guarantee its sustainability.

c) Data content specifications describe the typology and nature of the data which have been identified by the technical specifications. According to the EUROSION project, the topic groups of data/information are: Administrative boundaries; Topography and Bathymetry; Geomorphology, Geology and Sedimentology; Hydrodynamic; Land Cover, Demography; Heritage, Economic assets; Coastal defences. These data and information need to be associated with their metadata.

d) Data storage and access technologies describe the mechanisms through which the information is physically archived and made available to a wide public and also the standards to be used for exchanging data from one computer to another and for documenting their content, quality and access conditions. Five aspects need to be considered:

- **Storage** of the presently existing data in a physical place.
- **Access** of the data and information has to allow the provision of actual data, leaving the storage at the original place. The services to be provided need to encompass the effective searching, photo downloading, transformation and metadata existence.
- **Security**
- **Maintenance**
- **Interface**.

In the course of EUROSION, a prototype of data storage and access technologies has been developed and can be obtained upon request. This prototype has been elaborated upon the Coastbase technologies.

e) **Data modelling** concerns the architecture and structure of the data, concentrating on the logical entities and the logical dependencies between these entities. The common requirements in an information system have to facilitate: (i) the data exchange among data providers and users, (ii) the maintenance operations of the information system, as well as (iii) further improvements to the information system.

The standard for metadata, to be established in a coastal information system, should comply with ISO 19115, Geographic Information – Metadata. ISO 19115 includes a minimal set of metadata, which is highly recommended to follow.

f) **Spatial data representation**, preferably at a scale of 1/5.000-1/25.000, concerns the localisation of physical objects or phenomena described by the data collected and how this localisation will be characterised. In order to describe a site, a common way of describing location is to use geographic or cartographic coordinates which refers to a specific geographic reference system and a specific cartographic system, for which it is suggested to adopt some norms:

- ***Geographical extent of coastal information system.*** EUROSION strongly recommends implementing coastal information systems at the level of coastal administrative regions, extended to the boundary of the sediment cells overlapping with the region' extent.
- ***Coordinate reference system.*** According to the resolutions of the European mapping agencies and the European Commission, EUROSION recommends the adoption of ETRS89 for producing and archiving spatial data on the European coastal zones. For this purpose, it is useful to mention that some institutions, such as the International Association of Geodesy (IAG) or Eurogeographics (www.eurogeographics.org), provide the methodology and the necessary parameters (7 parameters) to convert the data from any coordinate system into the ETRS89 system.
- ***Vertical reference system***. According to the resolutions of the IAG and of the European Commission, EUROSION recommends the adoption of EVRF2000 as the vertical reference system for altitude related to the spatial data in the European coastal zones. EVRF 2000 is characterised by: the height of "Normal Amsterdam Peil" (NAP) and the gravity potential differences with respect to NAP or equivalent normal heights.

OPTIMAL SCALE/S OF ACQUISITION

International to local

OPTIMAL FREQUENCY(IES) OF ACQUISITION

COST(S) PER UNIT OF MEASURE

According to the indication of the EUROSION project, the costs for the information collection are of 2.5 man/week. Moreover, the displacement and communication costs need to be considered.

Typology of the Technical Service	**Optimal scale/s of acquisition** (Max scale: regional)	**Optimal frequency(ies) of acquisition**	**Cost(s)/ unit of measure/frequency**	**Other indications**
Collection of data and information	International to local	Regularly at the beginning of the project, then annually for the update.	……………..	The work needs to be done by specialists
Installation and maintenance of the information system	Regional	.	……………..	Necessity to train the personnel of the interested administrations

2. PERIODIC SURVEYING OF SHORELINE POSITION AT LOCAL SCALE

The technique based on the analysis of beach images taken by special cameras allows monitoring the changes of the beach surface with high temporal resolution. There are many systems of acquisition and elaboration, at different costs: the first system that was developed (Argus) is still the most expensive one. The systems use digital sensors that make automatic shots of the beach at regular intervals, usually many shots at each time period of acquisition (two or three times a day). The photos taken are stored, rectified and processed with specific software which rectifies the image, producing instantaneous, mean and variance shots that can provide information on shoreline position but also on the morphology and dynamics of the nearshore zone. Total Station is a goniometer of digital reading of circles, having a distance meter of varying capacity and precision. This type of survey requires framing through a discrete number of known points. In order to obtain the identification of orthometric level points at 0.00 m (shoreline) it is possible to perform a double survey, firstly following the dry contour of the shoreline, in order to obtain points of positive elevation, and then a second time following the change of slope in the wet section that is associated with the step at the lower end of the beach face. Interpolation will provide the desired level. On the other hand, a GPS with a geodetic receiver that records data according to phase measurements allows obtaining high precision at useful capacities. The high productivity is further increased with RTK (Real Time Kinematic) methods, that use a link (by radio, telephone or internet) between 2 receivers and allow determining the position of the shoreline accurately and in very short time. Compared to traditional survey methods, RTK has the advantage of independence from inter-visibility and distance limitations between the survey point and the reference station; also, the elaboration of data is relatively simple and there is no risk of systematic errors due to problems during the framing phases of the survey. For shoreline surveying, a vehicle can be used on the beach, like a motorbike. In addition, the "RTK" mode allows the operator to follow the shoreline in real time directly over the zero level, allowing the survey to be performed without further interpolation. For those scopes where data at decimetric precision is required we can use a "code-only" receiver, which is much less expensive and handier than the geodetic ones.

OPTIMAL* AREA OF REFERENCE

For surveying the shoreline position at local scale, in order to monitor the effects of a specific defence structure/work, one must consider a shore length of at least one order of magnitude higher than that of the structure/work. In particular, video and webcam systems are adequate for short sections of sandy beach or for pocket beaches and beaches of average height and depth, enclosed by high rocky shores.

OPTIMAL* ACQUISITION FREQUENCY(IES)

Whereas GPS systems and Total station are instruments that are usually used in survey campaigns, video/webcam systems allow to acquire data continuously during the whole period of operation of the station, giving instantaneous, mean and variance images that are acquired several times a day.

COST(S) PER MEASURE UNIT

Video/webcam systems have a significant initial cost, and annual maintenance and image elaboration (personnel) costs. A low-cost system covering 180° of a beach that is circa 2 km long may cost € 21000 (initial costs) + €9000/yr (personnel) + €3000/yr (maintenance). For GPS and Total Station, we can consider a cost per km of beach length without necessarily having to pay any installation/calibration initial costs.

Method	Accuracy	Survey coverage per time (km/day)	Minimum survey costs	Remarks
Total Station	5 cm	10	€ 200/km	Requires framing (only for the first survey)
Geodetic GPS	5 cm	20	€ 150/km	Requires initial framing (only for the first survey) and post-elaboration
"Code-only" GPS	30 cm	20	€ 100/km	Requires post-elaboration with Permanent Station
Video/ webcam systems	0.5 m	1	Installation (fix): € 21000 Maintenance: € 3000/yr Elaboration: € 9000/yr*	Only for limited zones** and set on top of a building/tower. Allows several shots a day.

Approximate prices in Italy, in 2007.

*Initial service of system configuration (€ 2000); installation of station and first camera (€ 12000); minimum 2 additional webcams to 180° (€ 1500 x 2 = € 3000); p reliminary topographic surveys (€ 2000); server for image storage (€ 2000); image elaboration - 1 part-time person per station (€ 9000/yr); Maintenance visits/technical assistance (€ 3000/yr/station).
** Survey coverage depends on the optics used and level of camera installation. As an indication, 3 cameras at 12m level can allow surveying of shorelines sections circa 2 km long.

OTHER INDICATIONS

SYNTHESIS TABLE

<table>
<tr><th>Type of Operating/Consultative Technical Service</th><th>Optimal* Area of reference (Max scale: regional)</th><th>Optimal* Acquisition Frequency(ies)</th><th colspan="2">Cost(s) per Measure Unit/frequency</th><th>Other Indications</th></tr>
<tr><td rowspan="4">Operative Service 2:
Periodic surveying of shoreline position at local scale</td><td rowspan="4">Local</td><td rowspan="4">For general monitoring, at least once a year, always under the same oceanographic conditions.

To evaluate the effects of defence works/structures, it is necessary to survey before the construction and after with at least monthly periodicity (with GPS or ST), or with webcams in a more continuous way (every 8h, for example).</td><td>Total Station</td><td>€ 200/km</td><td rowspan="4"></td></tr>
<tr><td>Geodetic GPS</td><td>€ 150/km</td></tr>
<tr><td>“Code-only” GPS</td><td>€ 100/km</td></tr>
<tr><td>Video systems*</td><td>Installation (fix): € 21000
Maintenance/yr: € 3000
Elaboration/yr: € 9000

*€ 16500/km/yr (first year) + € 6000/km/yr (following years)</td></tr>
</table>

3. PERIODIC SURVEYING OF SHORELINE POSITION AT REGIONAL SCALE

Total Station is a goniometer of digital reading of circles, having a distance meter of varying capacity and precision. This type of survey requires framing through a discrete number of known points. In order to obtain the identification of orthometric level points at 0.00 m (shoreline) it is possible to perform a double survey, firstly following the dry contour of the shoreline, in order to obtain points of positive elevation, and then a second time following the change of slope in the wet section that is associated with the step at the lower end of the beach face. Interpolation will provide the desired level. On the other hand, a GPS with a geodetic receiver that records data according to phase measurements allows obtaining high precision at useful capacities. The high productivity is further increased with RTK (Real Time Kinematic) methods, that use a link (by radio, telephone or internet) between 2 receivers and allow determining the position of the shoreline accurately and in very short time. Compared to traditional survey methods, RTK has the advantage of independence from inter-visibility and distance limitations between the survey point and the reference station; also, the elaboration of data is relatively simple and there is no risk of systematic errors due to problems during the framing phases of the survey. For shoreline surveying, a vehicle can be used on the beach, like a motorbike. In addition, the “RTK” mode allows the operator to follow the shoreline in real time directly over the zero level, allowing the survey to be performed without further interpolation. For those scopes where data at decimetric precision is required we can use a “code-only” receiver, which is much less expensive and handier than the geodetic ones. Photogrammetry is a survey technique that allows obtaining metric data of an object (form and position), that is used especially for topographic land surveys and represents one of the most reliable, economic and precise data acquisition techniques. Aerial photogrammetry is very useful in studying the position of the shoreline, since it allows repeating the acquisition of data very quickly and therefore to have the photo restitution of the shoreline in short times. A photogram is not simple photography, but a real technical document which usually needs experts for interpretation, and software that allows viewing air-photoigraphs in stereoscopy in order to have proper photo restitution Data on temporal variations of shoreline position can be obtained using satellite images. Their advantage is their high spatial coverage (hundreds of square kilometres). Choice of the appropriate sensor depends on the parameter to be measured and the frequency of measurement that is required for monitoring coastal changes. For coastal erosion studies the choice of sensor depends on the magnitude of processes that need to be monitored. For modest variations, images of high spatial resolution, less than 1m, such as IKONOS and Quickbird, should be used. To evaluate the accuracy of shoreline position obtained with remote sensing, we can perform in situ measurements using high precision GPS systems. The process of shoreline extraction has evolved from digitisation by hand to semiautomatic and automatic processes. There are several techniques of data processing for identifying shoreline position and exporting data into a GIS system, and these methodologies are now available as packages of commercial software used for image processing.

OPTIMAL* AREA OF REFERENCE
For the survey of shoreline position at regional scale, with the scope of evaluating medium- and long-term evolution trends, it is necessary to consider the physiographic unit as reference area.

OPTIMAL* ACQUISITION FREQUENCY(IES)
The optimal frequency depends on the scope of monitoring. For general monitoring at regional level it is advisable to survey once a year every 3-5 years, under the same oceanographic conditions.

COST(S) PER MEASURE UNIT

Method	Accuracy	Minimum survey costs	Remarks
Total Station	5 cm	€ 200/km	Requires framing (only for the first survey)
Geodetic GPS	5 cm	€ 150/km	Requires initial framing (only for the first survey) and post-elaboration
“Code-only” GPS	30 cm	€ 100/km	Requires post-elaboration with Permanent Station
Aerial photogrammetry	2 m	€ 1/ha (stereoscopic photograms)-cartographic restitution not included	Needs support points (also regional Technical Maps) and digital photogrammetric elaboration (only for first survey). Minimum area for acquisition of 1000 ha.
Satellite Images	1 m	€ 22/ km^2	Only for extensive areas, Needs support points (also

		€ 85/ km^2 (stereoscopic)	regional Technical Maps). Possibility of cover under stormy sea, and of cover under different times of the same zone. Minimum area for acquisition of 100 km^2.

Approximate prices in Italy, in 2007.

OTHER INDICATIONS

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Area of Reference (Max scale: regional)	Optimal* Acquisition Frequency(ies)	Cost(s) per Measure Unit/frequency		Other Indications
Operational Service 3: **Periodic surveying of shoreline position at regional scale**	Regional	For general monitoring at regional level it is advisable to survey once a year every 3-5 years, under the same oceanographic conditions.	Total Station	€ 200/km	
			Geodetic GPS	€ 150/km	
			“Code-only” GPS	€ 100/km	
			Aerial photogrammetry	€ 1/ha (stereoscopic photographs) – cartographic restitution not included	
			Satellite images	€ 22/ km^2 € 85/ km^2 (stereoscopic)	

4. SEDIMENTOLOGICAL AND MINERALOGICAL CHARACTERISATION

SEDIMENTOLOGICAL CHARACTERISATION

Minimum requirements: sampling of emerged and submerged beach sediments with spatial profiles of 500 m maximum, or less where sea structures may interfere with sediment dynamics (in smaller physiographic units it is necessary to sample at 5 profiles at least).

Sampling position: crest of foredune, base of foredune, mid-beach (eventual storm berm crests), swash zone, step, and successively at bathymetric intervals of 1m up to the depth of closure.

Method: granulometric analysis with dry mechanical sieving at 0,5 phi intervals, after separation by wet medium of the fraction of fines (if this is higher than 5% it is important to analyse its distribution with hydrometric techniques); calculation of the statistical parameters of Folk & Ward (Mean-size, Sorting, Asymmetry and Skewness) and determination of the percentage of fines (< 4 phi) and of the size of the first percentile; analysis of the variation along the shoreline of the statistical parameters for morphologically homogeneous areas; elaboration of maps at a scale of 1:10.000 of the following parameters: Mean-size, Sorting, First percentile, % fines.

MINERALOGICAL CHARACTERISATION (IACM-FORTH/UNIV. ATHENS)

Knowledge of the mineralogical composition of beach material is very important, because it provides significant information on the properties of the sediments and their behaviour in the coastal zone, such as identification of their sources, their specific gravity in relation to their transport processes and to their specific granulometric characteristics.

The determination of mineralogical composition may concern the whole sediment sample and/or only the clay fraction; the former is mostly associated with the identification of the total number of the minerals involved, whilst the latter with the quantitative and qualitative identification of the clay-minerals which are related mostly to the absorption of pollutants.

The identification of any mineral in the case of the coarse fraction (e.g. sandy) may be carried out macroscopically by a geologist/mineralogist, in the field, using a magnifying lens, and in the laboratory under a microscope. Detailed identification, accompanied by a semi-quantitative estimate of the minerals involved, is carried out with the use of an XRD (X-Ray Diffraction) device; the later is needed in the case of fine-grained (muddy) samples. The X-ray identification of the minerals is dependent upon their different molecular plane distances (d), expressed in Armstrongs; these are shown on the diffractogram by peak areas at different angles (2θ). Hence, the type of the clay mineral can be identified from the diffractogram (e.g. Brindley & Brown, 1980), using previously prepared Tables of (2θ) angles versus the (d) spacings (for the X-ray wavelength used).

OPTIMAL AREA OF REFERENCE

Monitoring should consider the physiographic unit as reference area.

OPTIMAL ACQUISITION FREQUENCY(IES)

Under the absence of sea defence structures/works and with a beach that has linear development with low evolution trends, monitoring should be done every 10 years. Where dynamics are faster and articulated (river and lagoon mouths, significant subsidence, etc) it is advisable to do it every 5 years. For monitoring of structures/works of coastal defence, as well as for rapidly changing shores, it is advisable to do one survey a year, always in the same season.

For the mineralogical composition study, one sample every 100-250 m along the beach-face is required. For rapidly changing shores, it is advisable to do one survey per year (not necessarily with the use of X-ray devices). For slowly changing shores, one survey every 5 years should be adequate. At least two additional samples should be collected from each river and from each other sediment source (e.g. cliffs) that supply sediments to the coastal zone under investigation for the initial mineralogical study. This may facilitate the identification of sediment transport paths along the shoreline.

COST(S) PER MEASURE UNIT

Cost of sedimentological sampling and sample analysis, cartography and elaboration: € 40.000 – 50.000 (depending on closure depth, presence of coastal defence structures, low sea floor) for a length of 10 km.

Cost of mineralogical sampling and analysis (field observations and microscopic study) is 10-20€ per sample; with the use of X-ray devices the cost is 50 € per sample. The total cost for the mineralogical study of a coast is estimated at 1500 € /km of shoreline, for the initial survey, and at 500€ /km of shoreline for subsequent surveys.

Method	Minimum survey costs*	Remarks
Sedimentological characterisation	€ 4000-5000 /km of shoreline	Costs vary depending on depth of closure, presence of coastal structures, etc.
Mineralogical characterisation	€ 1500 /km of shoreline for initial survey € 500 /km of shoreline for subsequent surveys	Initial survey costs include sampling and analysis of sediment sources. Subsequent survey costs do not include XRD analyses.

* Costs of sedimentological characterisation are indicative and valid for Italy only.
  Costs of mineralogical characterisation are indicative and valid for Greece only.

OTHER INDICATIONS

Both the sedimentological and mineralogical studies should be carried out by coastal geologists, who can identify sediment sources and mineralogical changes in the field and interpret the results of the analyses correctly

SYNTHESIS TABLE

Type of Operative / Consultative Technical Service	Optimal Area of reference (Max scale: regional)	Optimal Acquisition Frequency(ies)		Cost(s) per Unit of Measure /Frequency*	Other Indications
Operative Service 4: **Sedimentological and mineralogical characterisation**	Local (Physiographic Unit)	Sedimentological characterisation	Every 1 year for rapidly changing coasts and for monitoring coastal structures and coastal defence systems or Every 5-10 years for coasts that have slower evolution trends and for relatively stable coasts	€ 4000-5000 /km of shoreline /survey	Studies carried out by coastal geologists
		Mineralogical characterisation	Every 1 year for rapidly changing coasts or Every 5 years for slowly changing coasts	€ 1500 /km of shoreline for the initial survey € 500 /km of shoreline for subsequent surveys	

Costs of sedimentological characterisation are indicative and valid for Italy only.
Costs of mineralogical characterisation are indicative and valid for Greece only

5. DEVELOPMENT OF SEA CONTROL POINTS

A frame network for coastal surveying should be considered to use satellite instruments and therefore as detail of a national or regional GPS network, where present. This network should consider current survey technologies and available instruments, as well as future trends of technology evolution. At regional level networks of VRS or MRS type are becoming available and could be able to cover geodetic framing problems, even at the coast, using phone modems. Further networks of support to coastal surveys could be proposed regarding the calibration of hydrographical instruments, like control points positioned over the sea floor using special poles. Since coastal survey techniques rarely exceed 5 cm accuracy, the network should be adequate, and GPS in static mode should be used. On the other hand, if the scope of the network is to verify phenomena of variation of orthometric level along time, the level of sea control points should be calculated using levelling surveys. The primary national network should be used as reference for designing and building a detailed coastal network. The design of a coastal network of control points could be compared to a more generic network for survey operations and its density and location should follow the scope of use. Sides therefore not necessarily should have the typical configuration of a geodetic network (connection and high redundancy).

OPTIMAL* AREA OF REFERENCE

Control points can be used for surveys from a regional scale (a few kilometres) to a lager scale (hundreds of kilometres). For sea control points, it is enough to have control points spaced a few kilometres (3-5 km) apart in order to have full coverage for the development of a GPS-RTK survey. If more traditional survey methods should be used (such as using Total Station), the distance between control points should be smaller. It is possible however to use control points of existing networks, national or regional, if they are close enough to the coast and if this proves useful. However, for small coastal sections, of less than 3 km, two control points should be set at the extremities of the area.

OPTIMAL* ACQUISITION FREQUENCE/S

All points should be identified and their position should be recorded (*una tantum*). However, it is advisable to perform periodically (at least every 10 years) a control evaluation of control points.

COST(S) PER MEASURE UNIT

Indicative costs for such a network of sea control points is of € 5000 for a section of 10 km.
Approximate prices, in Italy, in 2007.

OTHER INDICATIONS

Regarding the design, we can follow general recommendations made for geodetic networks, where the main aspects are: 1) the network should be connected at least to two vertices of the framing network, and should be constituted by at least two independent bases for each new vertice. 2) Determination of the network should use precision polygons or GPS measurements (differential static mode). All sessions of measurement should be done using double frequency GPS receivers (L1/L2) according to the mode and specifications of measurement and positioning, typical of geodetic network surveys. Levels of control points over the mean sea level should be derived using sometimes GPS levelling.

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Area of reference (Max scale: regional)	Optimal* Acquisition Frequency(ies)	Cost(s) per Measure Unit/frequency	Other Indications
Operative Service 5: **Development of sea control points**	Local to regional	*Una tantum* (control of sea control points every 10 years)	€ 5000/10 km	

6. TOPOBATHYMETRIC SURVEYING OF LITTORAL MORPHOLOGY

The survey should aim at the morphological description of the coast in order to identify its morphodynamic characteristics and allow the analysis of variations in the area of the emerged beach and in the volume of both emerged and submerged beaches up to the depth of closure.

OPTIMAL* AREA OF REFERENCE
The scale of acquisition depends on the extent of the survey area, its morphologic characteristics and the method used. For the analysis of evolution trends at medium and long terms, the area of reference is the physiographic unit. If monitoring is carried in order to evaluate the impact of coastal structures such as ports, the study zone should consider a length of beach that is one order of magnitude lager than that of the structure. Cartographic representation may vary in scale from 1:1000 to 1:5.000. Survey profiles may be 10 m equidistant, near the structures up to 250 m in longer morphologically homogeneous areas. In order to calculate the sediment budget of a beach, the area of observation should go from the dune toe to the depth of closure related to events that have a similar return period to the time interval that is being considered. This interval can be synthesised in the following: 3-5 years in order to evaluate the effects of a costal defence structure; 5-10 years for a medium term monitoring in order to plan defence strategies; 30 years to evaluate secular trends for the scope of coastal planning.

OPTIMAL* ACQUISITION FREQUENCY(IES)
The optimal frequency depends on the scope of monitoring. For a general monitoring at local level the position of the shoreline should be surveyed at least once a year, always under the same oceanographic conditions. Regarding the evaluation of the effects of a specific defence structure, it is important to perform an initial survey before the construction followed by at least monthly surveys after the construction. For monitoring at the scale of physiographic unit, it is advisable to perform the survey every 3-5 years.

COST(S) PER MEASURE UNIT

Emerged beach (Required planimetric and altimetric accuracy: from 1 (*) to 10 (**) cm)	**Considered survey density**	**Survey times (km/days)**	**Indicative costs (***)**	**Remarks**
Total Station (*)	50 m section	3	€ 1000/km	
Geodetic GPS (*)	50 m section	5	€ 1000/km	
Laser Scanner (*)	DTM 1x1 dm	1	€ 1000/km	Only for limited zones or structures
Airborne LIDAR (**)	DTM 1x1 m	50	€ 1000/km	Only for wide areas
Aerial photogrammetry (**)	1 m section	30	€ 1000/km	Needs "*markers*"
Submerged beach (Required planimetric and altimetric accuracy: from 10 (*) to 30 (**) cm)	**Considered survey density**	**Survey times (km/days)**	**Indicative costs (***)**	**Remarks**
Single-beam (*)	100 m section	5	1000	
Multibeam (*)	DTM 1x1 m	3	3000	Difficult to survey between 0 m and – 2 m.
ALB/LIDAR (**)	DTM 2x2 m	40	4000	Surveys also emerged beach but is affected by water turbidity
Side-Scan Sonar (SSS)		3	1000	Morphological survey
Sub-bottom profiler (SBP)	100 m section	4	1000	Stratigraphic survey

Approximate prices in Italy, in 2007.
(***) Not considered: mob/demob, stand-by etc.

OTHER INDICATIONS

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Area of reference (Max scale: regional)	Optimal* Acquisition Frequency(ies)	Cost(s) per Measure Unit/frequency		Other Indications
Operative Service 6: **Topobathymetric coastal survey**	Coastal length at least one order of magnitude greater than that of the structure (to monitor the effects of a specific coastal defence structure) Physiographic unit (to evaluate the evolution trends at medium and long terms)	For a general monitoring at least once a year, always under the same oceanographic conditions. To evaluate the effects of coastal defence structures, survey before the construction and afterwards at least monthly. To monitor at the physiographic unit level, it is advisable to survey every 3-5 years.	EMERGED BEACH Total Station (**) Geodetic GPS (**) *Laser Scanner* (**) Airborne LIDAR (***) Aerial photogrammetry (***) SUBMERGED BEACH *Single-beam* (****) *Multibeam* (****) ALB/LIDAR (*****) SSS SBP	 € 1000/km € 1000/km € 1000/km € 1000/km € 1000/km € 1000/km € 3000/km € 4000/km € 1000/km € 1000/km	Surveys must be performed in the same season of the year.

(**) Not considered: mob/demob, stand-by etc.
Required planimetric and altimetric accuracy: from 1 (**) to 10 (***) cm
Required planimetric and altimetric accuracy: from 10 (****) to 30 (*****) cm

7. ACQUISITION OF SEDIMENTOLOGICAL AND STRATIGRAPHIC DATA OF THE SEAFLOOR

The objectives are:

- To document the composition and texture of the surficial sediments on the seafloor.
- To measure the density of the surficial sediments, which is necessary for the calculations of the morphodynamic models
- To map stable areas of the sea-floor (such as areas covered by beach rock or seaweed)
- To estimate the volume of sediments available in the nearshore zone
- To estimate the depth of disturbance of the sea-floor sediments by storm waves and to estimate a "depth of closure" to be used in modelling of the morphological changes of the nearshore zone
- To identify possible sediment transport paths, as well as sources and sinks of beach sediments
- To detect the presence of any hazardous morphological or geological features on the sea bed. Such features include active faults, slumping, pockmarks/gas seeps, active erosion, excessive slope gradients, outcropping rocks, etc.

EQUIPMENT AND METHODS

The operations will be carried out using a small (~12 m long) motor-boat and one or two divers. An image-correcting, digital Side Scan Sonar system will be used to map the nearshore bottom. The Scan Range should be 75 m or less, to provide a resolution better than 20 cm for a detailed study of sea bottom features. The sonar fish will be towed over the sea bed at a height of about 20% of the map range. The collected sea floor images will be used for the construction of a sea floor mosaic showing the different sediment types, bedforms, areas covered by seaweed, rocks and outcrops, etc. A Van-Veen grab will be used to collect surficial sediment samples from the seafloor along the profile lines described in Oper. Serv. 6 and wherever changes of the acoustic properties of the seafloor are observed. A high resolution sub-bottom profiler (such as a 3.5 kHz Pinger) will be used to obtain sub-bottom stratigraphic information and to estimate the thickness of the top sedimentary layer. The profiler data may be supplemented by sediment cores obtained with gravity corers in deeper waters and diver-operated Klovan-type box corers in shallower waters. Where the seafloor sediments are underlain by rocky formations, a water- or air-powered penetration rod may be used by divers to measure the thickness of the sedimentary cover. Depth-of-Disturbance (DoD) rods may be deployed along a selected profile, and measured by divers, to measure the thickness of the sedimentary layer that is mobilised during storms.

OPTIMAL AREA OF REFERENCE

Sedimentological and stratigraphic data of the seafloor are collected and studied at a local scale, for each physiographic unit separately. The results may be synthesized to study the sub-bottom stratigraphy at a regional scale and to produce a regional sedimentological map.

OPTIMAL SCALE OF ACQUISITION

The scale of acquisition depends on the extent of the nearshore zone, which is controlled by the beach length, the slope of the nearshore bottom and the depth of closure (which depends on the sediment characteristics and the nearshore hydrodynamic conditions).

Generally, two or three shore-parallel side scan lines are sufficient to cover the nearshore zone up to the depth of closure. At least five 3.5 kHz profiles (for small beaches) or profiles spaced 100 m apart are required. The number of box cores required depends on the seafloor morphology and on the homogeneity of the sedimentary cover. Generally, six to ten box cores should be adequate for most beaches.

OPTIMAL ACQUISITION FREQUENCY(IES)

A complete initial sedimentological/stratigraphic survey of the nearshore zone is required. During the first year of monitoring, bedforms and DoD rods should be surveyed at least four times and after each major storm, during subsequent years four surveys per year are adequate. Actively changing beaches may need complete surveys every 1-3 years. Relatively stable beaches may be re-surveyed every 5-10 years. Nearshore zones with extensive parts of the nearshore bottom stabilised by seaweed (e.g. Poseidonia fields) may require more frequent surveys if the vegetative cover becomes damaged.

COST(S) PER UNIT OF MEASURE

Costs vary widely, depending on methods and equipment used, width of nearshore zone, uniformity of seafloor sediments, etc.

Indicative cost of initial survey, sampling and sample analysis, and presentation of results: € 4.000 – 5.000 /km of shoreline (excluding mob/demob and standby costs). Diver operations costs are to be estimated on the basis of approximately 60 man-days for the first year and 8-10 days for subsequent years, for beaches with 5 monitored profiles.

Method	Minimum survey costs*	Remarks
Complete sedimentological and stratigraphic survey	€ 4000-5000/km of shoreline	Includes geophysical survey, sedimentological sampling and analyses and presentation of results. Mob/demob and standby costs are not included.
Diver operations	€ 18000 for the first year € 3000 for subsequent years	Indicative cost for coasts with 5 monitored profiles

* Costs are indicative and valid for Greece only.

OTHER INDICATIONS:
Most of the operations described above can be performed in tandem with operations described in Operative Service 6 and 8. This can reduce the cost of complete surveys significantly.

SYNTHESIS TABLE

Type of Operative / Consultative Technical Service	Optimal Area of reference (Max scale: regional)	Optimal Acquisition Frequency(ies)		Cost(s) per Unit of Measure /Frequency*	Other Indications
Operative Service 7: **Acquisition of sedimentological and stratigraphic data of the seafloor**	Local / Regional	Complete sedimentological and stratigraphic survey	Every 1-3 years for actively changing coasts Every 5-10 years for relatively stable coasts	€ 4000-5000 /km of shoreline /survey	If operations are performed in tandem with operations described in Oper. Serv. 6 and 8, the cost of complete surveys can be reduced significantly. Mob/demob and standby costs are not included. Diver operations costs are estimates for coasts with 5 monitored profiles.
		Diver operations	At least 4 surveys and after each major storm for the first year, 4 surveys/year thereafter	€ 18000 for the first year € 3000 for subsequent years	

* Costs are indicative and valid for Greece only.

8. DATA ACQUISITION FOR EVALUATION OF SUBSIDENCE IN THE COASTAL ZONE

Various techniques with different accuracies of measurements, cost and execution time can be used to establish a subsidence control network.

Optical levelling

An optical levelling network consists of stretches (portions of levelling located between two successive benchmarks). When the stretches are consecutive and have two benchmarks as extremes, they constitute a line of levelling. The lines can be principal or secondary when they allow the measurement of benchmarks located around the network. The distance between two consecutive benchmarks is variable but generally ranges between 0.8 and 1.2 km.

In general the measurement of level difference between two consecutive benchmarks is realised in going (A) and back (R). The discordance between the absolute values of measurements is given by $t=2.5\sqrt{D}$ mm (D = length of the feature in kilometres), and the absolute value of the difference between the sum lengths of the two series of levelling cannot exceed 4 m/km.

The network of measurement must be compensated (criterion of minimal squares) and after that, analyses of the possible systematic errors of measurements in the difference of level and in the distances between the benchmarks measured in going and back must be realised.

<u>Costs</u>

According to the costs realised by the Emilia-Romagna Region for the measurements of high resolution geometric levelling along lines, a cost of about 220 € (VAT excluded) for each kilometre of levelling and about 50 € (VAT excluded) for the supply and installation of possibly removed benchmarks may be estimated.

Global Positioning System (GPS)

The GPS survey method for the territory deformations is currently widely used. The more suitable acquisition method is in relative static positioning, that uses more double frequency geodetic receivers with an acquisition interval of 15 seconds and a shear angle of 15° elevation for the observations. Previous experiments show that many more observations are needed, approximately tree times the required number.

This procedure allows obtaining high quality results from a planimetric point of view, with the greater semi-diameter of the ellipses of error at 95% in the order of 1 cm, while the error on the vertical component can be estimated to ± 0,7 cm. The lowest system precision for the altitude depends on various factors such as the system geometry, the troposphere effect, the modelling of the variation of the antennas phase centres, etc.

The experiments performed on GPS networks for the subsidence movements control suggest that the method, even if it presents high potentialities, can only be applied to measure important variations, while for smaller movements it may not supply adequate results for the phenomenon studied.

<u>Costs</u>

The costs calculation is not easy because it varies extremely from situation to situation. For instance, those supported for the IGM95 densification network monitored by the Province of Ferrara presented a mean density of GPS vertex of 7 km (approximately one every 50 km^2). In total, the cost of monitoring the network (80 vertex, 140 baselines and 4 receivers) was 20.000 € + VAT, with 15.000 € for measurements and 5.000 € for the elaboration and calculation.

Interferometer

The interferometer is an advanced tool for the elaboration of datasets acquired from radar sensors with synthetic aperture (SAR) mounted on satellite platforms. It allows the measurement of small land movements that took place between two successive satellite acquisitions.

The SAR methodology is based on the estimation, pixel by pixel, of the phase variation between successive radar images and therefore permits the identification of eventual deformation phenomena with a theoretical precision of some hundredths of the wavelength at which the system works: for example for the satellites ERS-1 and ERS-2 of the European Spatial Agency λ = 5,66 cm. The main limitations in the use of the SAR are due to various factors, as the static nature of the observed signal (*decorrelation* noise), the artefacts induced by the atmosphere (propagation through ionosphere and troposphere) and the imprecise knowledge of the satellites' position along the orbit (orbital data).

In order to correct this imprecision various techniques have been elaborated, such as the Permanent Scatterers (PS) that allow to reconstruct and monitor the territory deformation phenomena using only PS weakly affected by *decorrelation* (parts of structures, buildings, outcrops, etc). These PS can, therefore, constitute a natural geodetic network, the benchmarks of which have not been created with *in situ* intervention.

The interferometer can obtain: the position (geographic coordinates and altitude) of each PS in respect to a terrestrial reference point of known coordinates; the average speed of the permanent scater deformation with a precision between 0.1 and 0.5 mm/yr; the deformation of each PS in relation to an acquisition, considered as reference, with a precision between 1-3 millimetres for each measurement.

Costs

The costs vary enormously depending on the methodology used.

Considerations

These three techniques of survey present a remarkable complementariness. The accuracy of high resolution optical levelling is higher and compared to the SAR or PS, allows to choose the benchmarks and the temporal interval between successive surveys. The characteristics of the optical levelling technique need the realisation of a levelling network dedicated to the subsidence control, and especially for critical situations.

At present, only the GPS monitoring allows to obtain three-dimensional data with centimetre accuracy and offers smaller realisation costs and times than an optical levelling network.

The SAR and PS methodology offer the possibility to measure the land deformations since 1992, as the data from the satellites ERS-1/2 of the European Space Agency (ESA) are stored systematically from this year on and guarantee a sufficient European coverage. Moreover, these methodologies do not require the creation and maintenance of a benchmarks network.

Even if the high resolution geometric levelling remains the first method for the monitoring of small vertical land movements and, as such, it can provide elements of geometric validation for the other measurements, its results can be usefully integrated with those obtained with the spatial techniques (GPS and SAR and PS techniques). In fact, while the GPS can supply information relative to single points and with temporal intervals defined by the user, SAR and PS supply a spatial trend that, today, is not anymore limited to the urban zones.

OPTIMAL SCALE/S OF ACQUISITION

Regional to local

OPTIMAL FREQUENCY(IES) OF ACQUISITION

Annual

COST(S) PER UNIT OF MEASURE

See in the text

OTHER INDICATIONS

SYNTHESIS TABLE

Typology of the Technical Service	Optimal scale/s of acquisition (Max scale: regional)	Optimal frequency(ies) of acquisition	Cost(s) /unit of measure/frequency	Other indications
Optical levelling	Regional	Every five years	220 € (VAT excluded) for each km of levelling and about 50 € (VAT excluded) for the supply and installation of possibly removed benchmarks.	More precise
GPS	Regional	Every 1 or 2 years in complement with optical levelling and interferometer	Variable, see in the text	
Interferometer	Regional	Every 1 or 2 years in complement with optical levelling and interferometer	Variable	

9. CENSUS WORKS AND PARTICIPATIONS THAT INTEREST THE COAST.

The taking of a census of coastal works and structures in a certain region can be organized in four steps:
- Preliminary phase;
- Documents collection;
- Database definition;
- Choice of the representative area.

The preliminary phase consists of a bibliographical search about the state of the art in coastal works census in Italy and in other countries.

ARPAL got in touch with the organizations that had already collected information about this matter, or those local bodies that had already conceived a database to organize their data on the coastal zone and the hard and soft works characterizing it, in order to establish a link between similar databases.

In the second step, paper or electronic documents were searched and collected in order to fill in the database: the plans and projects of the hard structures built in the chosen coastal stretch, the papers authorising beach nourishments of any dimension, as well as any other related information.

The data base definition takes place almost simultaneously to the previous one: the structure of the information system is defined, with the different domains and the relations between them. This kind of geographical information system can be developed under PC Windows, with GeoMedia software for the maps, and Oracle for the database.

The last step, the choice of the representative area, is a most delicate one; when loading all the information about hard and soft structures (existing or demolished) of a coastal stretch, it is possible to realize if every kind of structure has been taken into account, with the related issues.

Time table and costs
- Preliminary phase, documents collection: approximately two months' work (1 person).
- Planning and testing of the IT system: three weeks of work by an IT expert.
- Data entry: approximately six months (1 person), based on a regional data amount.

The maintenance costs for such an information system consist of:
- Hardware upgrading costs (every 3-5 years)
- Database updating costs (1 person, 2-3 days per month)

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal Acquisition Scale/s (Max scale: regional)	Optimal Acquisition Frequency(ies)	Cost(s) per Measure Unit/frequency	Other Indications
Operative Service 9: **Census of coastal works, by means of a GIS (Microsoft Windows, GeoMedia for maps and Oracle for the database)**	Regional	Annual	100.000 €	

10. Acquisition and updating of information on land use and use of the sea near the coastal zone

This sector of the Observatory will function as a mechanism of collection, organization, classification and processing of primary and secondary information and data which will concern the Coastal Zone.
Specifically it will include the monitoring of physical-planning and urban data of coastal and riverside areas, aiming at the support of the protection of these regions against natural phenomena, as well as the support of the physical-planning and urban planning and control.
It will process the indicators for the analysis of spatial changes, determine region types, formulate scripts of territorial growth and undertake the follow-up and evaluation of public policies with repercussions in these regions.
It will propose, and provide opinions on the each necessary and suitable meters and means of exercise of policy and it will, in general, provide know-how to the Services of the Region, Prefectural governments and Municipalities with periodic studies, reports and forecasts.
It is essential to include data and elements from:

- the National Frame of Physical Planning
- the Physical Planning Frames of Regions and Prefectures
- Planning of Land Use and Regulation of Rural Space

It is also essential to ensure collaboration:

- with the Public Services
- with the Regional Administration and Local Self-government
- with other Networks of Information

The Work includes the development and periodic renewal of digital terrain models, with the use of recent aerial photographs and high resolution satellite images, the development of Geographic Information Systems and special Applications, the development of a System of Data Management for the coastal and riverside areas, at a scale of 1:1000 and 1:5000 that will include:

- Shoreline and a 2km-wide land zone along the coastline
- Riverside regions with a width of 1 km along the river banks(*)
- Marine area, which should be delimited by the 50m depth contour. In the special case where this is very close to the coastline, the seaward limit must be set at a distance of 1 nautical mile from the shoreline.

(*) The regions will be determined with precision in the Analytic Plan of Work, which will be worked out during the initial Phase of Work.

These regions are beyond the 2 km area.
Normally we need the entire drainage basin of the river for the determination of its discharge and sediment transport.

The Geographic Information System will contain at least the following information:

- Limits of cities
- Seashore and beach limits
- New buildings and constructions
- Wells, boreholes
- Quarries
- Areas of dredging and sand taking
- Touristically developed regions with particular mention to:
  Hotels
  Tourist residence
  Limits of regions of seasonal residence

OPTIMAL SCALE/S OF ACQUISITION
Local (at a scale of 1:5000)

OPTIMAL FREQUENCY(IES) OF ACQUISITION

COST/S PER UNIT OF MEASURE
Creation of initial Data Base and Digital Map of territory. Cost about 10000 - 20000 Euro
Annual updating of Data Base Cost about 1000-3000 Euro/year

OTHER INDICATIONS

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal Acquisition Scale/s (Maximum scale: regional)	Optimal Acquisition Frequency/ies	Cost(s) per Measure Unit/Frequency	Other Indications
10. Acquisition and updating of information on land use and use of the sea near the coastal zone	Local 1:5000		Creation of initial Data Base and Digital Map of territory: 10.000 / 20.000 € Annual updating of Data Base: 1000-3000 €/year	

11. ELABORATION OF THEMATIC CARTOGRAPHY FOR LAND PLANNING REGARDING SHORELINE EVOLUTION SCENARIOS

The coastal zone has a central importance for economy, environment and Mediterranean culture. The peculiar geo-morphological complexity, associated to the quick development of infrastructures and productive areas, produced high potential of shoreline vulnerability, confirmed, for example, from the high percentage of beaches in erosion. In the last few decades the effects of climatic changes, both natural and induced, have overlapped with urbanization aspects and territorial use, contributing to the regression of beaches. This strengthens, therefore, the need of authorities to elaborate some planning strategies and to preview adaptation works, starting from instruments that can describe and estimate the risks associated with climatic change.
The thematic cartographic tool for coastal risk evaluation will have to contain information about scenarios of increased frequency of extreme events and their effect on the coast, the local sea level rise prediction scenarios, the local neo-tectonic conditions, the coastal geomorphologic elements, the use of the soil, the protection works, the long-term trends of the coastline, the base technical cartography. Such elements will be processed with special algorithms to produce vulnerability and risk maps in GIS environment.

OPTIMAL* ACQUISITION SCALE/S
Spatial: Local (1:10.000)
Temporal: 10 years for erosion and submersion caused by extreme events (compatible with maximum forecasting models capacity); 50 years for the risk caused by sea level rise associated with global warming.

OPTIMAL* ACQUISITION FREQUENCY(IES)
5 years (max 10 years); optimal acquisition frequency based on the possibility to cover, with sufficient reliability, forecasting scenarios by used models (models update and climatic forecast) in considered risks. In the assessment of short-term risks it is usual to think that extreme event forecast models and linked erosion phenomena, because of the complexity of coastal systems sedimentological-morphologic modification phenomena, cannot extend beyond 10 years. Similarly, for long-term risks, like sea level rise associated with to global warming, change perception timescale must be conjugated with forecast scenarios updating. Therefore the period indicated for the short-term risks appears equally applicable to long-term risks.

COST(S) PER MEASURE UNIT
5000 €/km (elaboration of data that authorities already possess).

OTHER INDICATIONS
Operating Technical Service n. 11 is tightly correlated with Consultative Technical Service n. 5 (first questionnaire), sharing needs, times and costs. That is, the activity of cartographic elaboration for territorial planning in function of evolutionary scenarios constitutes the base and the tool to formulate evaluations on vulnerability and coastal risk.

*According to the aim of regional coastal planning

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Acquisition Scale/s (Max scale: regional)	Optimal* Acquisition Frequency/ies	Cost(s) per Measure Unit/frequency	Other Indications
11. Elaboration of thematic cartography for land planning regarding shoreline evolution scenarios.	Local	10 years	5000 €/Km	Integrate short-term risks (such as extreme events frequency) with long-term risks (such as sea level rise associated with climatic change).

CONSULTATIVE SERVICES

1. USE OF INDICATORS FOR MONITORING THE MORPHOLOGICAL STATE OF THE COAST

The following morphological features may be used as geomorphological indicators of shoreline changes (retreat or progradation):

- sea notches
- beach-rock formations
- sand dunes
- beach scarps
- vegetation line

Sea notches are usually observed on the face of carbonate cliffs that are not protected by a beach zone. In some cases, notches are observed on the back of a beach zone that is temporarily covered by water reaching the cliff, where a relatively small notch is formed. In the case of an eroding beach, the sediments in front of the notch have been removed and the notch is now at some distance (some tens of cm) above sea level. Such changes are observed only with in situ visits and quantified with the use of old and present photographs, from which the spatial changes of the beach surface can be measured.

The presence of beach rock formations along the beach face is a clear indicator of beach zone retreat, as their formation takes place below the sub-aerial surface of the beach. Their presence can be detected during in situ visits, as well as by interpretation of aerial photographs (beach-rocks usually extend seawards to a few meters of depth. Obviously, they act as erosion indicators only in the case of tectonically stable coasts.

The presence of sand dunes along the shoreline and at its backshore zone may be used as a coastline retreat (erosion) indicator, as they are formed several or even tens of metres landwards of the shoreline and beyond the usual reach of ordinary waves. If multiple lines of shore-parallel sand dunes are present, the distance between the seaward feet of successive sand dune lines can be used as a measure of shoreline displacement. In the case of extensive beach erosion, the dunes are reached and eroded by the incoming waves. Such changes may be observed with in situ measurements and by comparison of aerial photographs and satellite images.

Scarps present either along the foredunes and/or on the seaward face of alluvial coastal plains, being the landward limit of the beach zone, are profound indicators of coastal erosion. Due to their relatively small dimensions, they are usually identified by field observations.

Vegetation is a good indicator of beach zone evolution. In the case of beach zones lying in front of alluvial plains, the line where the vegetation begins denotes the maximum width (the landward limit) of the beach zone. In the case of shoreline retreat, this vegetation line moves landwards; in the first phase the roots of the trees are revealed due to the lowering of the land/beach surface and subsequently the trees die and fall.

OPTIMAL AREA OF REFERENCE

Geomorphological indicators are studied at a local scale, for each physiographic unit separately. The results may be synthesized to obtain the general trend at a regional scale.

OPTIMAL SCALE OF ACQUISITION

At the local level, geomorphological indicators of coastal changes are mapped at a scale of 1:1000; at a regional level, they are mapped at a scale of 1:5000 to 1:10000.

OPTIMAL FREQUENCY OF ACQUISITION

The geomorphological survey is repeated every 1 year for rapidly retreating shores or every 5 years for slowly retreating shores.

Two sets of aerial photographs of different acquisition dates are analysed for the initial study and an additional set of stereopairs is included in the analysis every 2 to 5 years, depending on the rate of shoreline change.

Satellite images may be analysed if and when needed for regional studies.

Photogrammetric operations apply mainly to the initial survey. Normally, only one set of aerial photographs and/or one satellite image will require accurate georeferencing. Subsequent acquisitions will be registered to the georeferenced set. (These operations could be the same as those required under Operative Service 5).

COSTS PER UNIT OF MEASURE

Costs vary widely, depending on location of shoreline, morphology of coastal zone and local conditions. An indicative cost is 500 € (excluding V.A.T.) per km of shoreline per survey. Costs for the purchase of aerial photography and satellite imagery are extra and depend on the type and amount of imagery needed, year of acquisition, etc. Indicative cost of aerial photographs (1:8.000, B&W) is between 28 € and 50 € per stereopair. The cost of photogrammetric operations cannot be estimated because it depends heavily on the type of imagery, scale of acquisition, existence of ground control points (GCPs), morphology of the coastal zone, etc. With careful planning, the same imagery can be used for Operative Service 5 and Consultative Service 2, so that efforts and costs will not be duplicated.

Method	Minimum survey costs*	Remarks
Geomorphological survey	€ 500/km	Includes cost of interpretation of aerial photographs and satellite imagery
Purchase of aerial photographs	€ 20/km/acquisition	Indicative cost for 1:8.000 B&W stereopairs. At least two sets of different acquisition dates are needed.
Purchase of satellite imagery	€ 17/km^2/acquisition	Minimum: 100 km^2 (IKONOS), 64 km^2 (QuickBird)
Photogrammetric operations	Varies (see text)	Georeferencing costs covered in Operative Service 5.

* Costs are indicative and valid for Greece only.

OTHER INDICATIONS

All geomorphological surveys should be carried out by a qualified coastal geomorphologist, under the same oceanographic conditions.

SYNTHESIS TABLE

Type of Operative / Consultative Technical Service	Optimal Area of reference (Max scale: regional)	Optimal Acquisition Frequency(ies)		Cost(s) per Unit of Measure /Frequency	Other Indications
Consultative Service 1: **Use of indicators for monitoring the morphological state of the coast**	Local / Regional	Geomorphological survey	Every 1 year for rapidly retreating shores or Every 5 years for slowly retreating shores	€ 500/km/ survey	All geomorphological surveys are to be carried out by a qualified coastal geomorphologist, under the same oceanographic conditions
		Purchase of aerial photographs	At least two sets of different acquisition dates for initial study, every 2-5 years thereafter	€ 20/km/ acquisition	
		Purchase of satellite imagery	If and as needed	€ 17/km^2/ acquisition	
		Photogrammetric operations	Once for every set of imagery acquired	Georeferencing costs covered in Operative Service 5.	

*Costs are indicative and valid for Greece only.

2. USE OF INDICATORS FOR MONITORING THE SOCIAL – ECONOMIC DEVELOPMENT IN THE COASTAL ZONE

COD	Type of activeTechnical Service /Consultative				Optimal* Level(s) of Acquisition (Max lev. : regional)			Optimale* Frequence(s) of Acquisition			Source		Priority	Other Indications
	THEMATIC SECTION	THEMATIC SUBSECTION (Description of Element)	Index		Field of reference	Administrative entity of reference		Reference periode						Observations
			Quantitative (according to the availability of the elements and the possibility of collecting them with reliability)	Qualitative	IIEL	Region	other	annual average	saisonal	comparison elements	recueil direct	Region	priority	
1	POPULATION : RESIDENCY													Collection in IIEL every 2 years, in otherregions:every 10 years after every 5 years
1.1		Numbers and administrative forms (local Community, communal territory, habitats, agglomerations)	Number per category		√	√					√		b	
1.2		Permanent residents	Number of residents per administrative entity or spatial subsction		√	√		√	√		√		a	

1.3		In vacation	as previously		√			√	√		√		a	
2	**LAND USE**													
2.1		Zones of urban development	position, extent, density, variation		√	√					√	√	a	
2.2		Continuous touristic Zones	position, extent, density, variation		√	√					√	√	a	
2.3		Areas of commercial, industrial and agricultural concentrations	position, extent, density, variation		√	√					√	√	a	
2.4		Rural culture, annual, multiannual	position, extent, variation		√	√					√	√	a	
2.5		**Iiel (Influence Index of the Erosion of the Littoral)**	position, extent, variation		√								a	
3	**ENVIRONMENT**													
3.1		Particularly protected areas	position, extent		√	√					√	√	a	

3.2		Humidity Zones	position, extent		√	√					√	√	a	
4	**INFRASTRUCTURES AND FUNCTION**		accomplished work and periodicity					√	√		√		a	
4.1		placement of Road network on littoral	typology of the responsible ainstances in km and surface	√	√			√	√		√		a	
4.2		technical infrastructural installations relative to the littoral ports of supralocale importance	favorite natural measurement according to the type of installation		√	√							a	
4.3		Organised beaches	position, extent		√						√	√	a	
4.4		Jetty	position, extent		√						√	√	a	

3. DATA SHARING WITH OTHER STRUCTURES AND STAKEHOLDERS

One of the most noteworthy initiatives in the project is the promotion of Integrated Coastal Zone Management (IZCM) as it facilitates the provision of a database with all agents, and also functions as a network of information interchange, improving coordination or participation between different areas. The establishment of a network of agents involved on the coast promotes and improves effective communication and the participation of all the administrative bodies involved at different scales. The sharing of data on the coast, and the provision of contrasting, objective information on coastal management is a basic resource for promoting the understanding and appreciation of the coast, in this case the Mediterranean Sea, as well as for providing resources to management bodies when making decisions.

The objective of this consultative survey is to share data, information and experiences concerning the coast with coastal agents and interested bodies. In order to achieve this, a database of the coastal agents in different regions and scales has been proposed as a basic resource. This information has been compiled through the use of a questionnaire which has been sent to those participating in the project. Once this base has been created, the extension of this database by the different agents detected must be promoted. This information would relate to the coastal zone where they work. In order to facilitate the gathering of this information it has been proposed that the different agents may download data using a website, after the information provided has been validated. The existence of a website with a technical file regarding the characteristics of each agent, its area of influence, and the projects and data offered, would allow information of interest to be accessible to everyone, to promote understanding and the interchange of information and projects, channel relationships and increase coordination among the agents involved in the development of the coast in order to promote local development and integrated coastal development. With respect to data, the updating of both the information provided and information regarding the agents is important, as is the search for new agents and experiences which exist on the coast by means of the same network.

OPTIMAL* ACQUISITION SCALE/S
Local and Regional

OPTIMAL* ACQUISITION FREQUENCY(IES)
The updating of the basic information should be guaranteed at least once a year, and should be facilitated directly by the reference team who provided the data.

COST(S) PER UNIT MEASURE
Variable

OTHER INDICATORS
Consultative Service nº 6 determines data sharing with other structures and with stakeholders, and is directly correlated with operative services, nº 1. Acquisition of information and no2. Existence of a system for the organisation and acquisition of data, as well as the Consultative Service nº 4. Procedures for the certification of data for database supply.

*According to the aims of regional coastal planning

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Acquisition Scale/s (Max scale: regional)	Optimal* Acquisition Frequency(ies)(ies)	Cost(s) per Unit Measure /frequency	Other Indicators
Consultative Servic 3: **Data sharing with other structures and with stakeholders**	Regional and Local	Annual	Variable	Correlated with the acquisition of existent information for a system in order to organise and gather data and data certification procedures to supply to databases

4. SPECIFIC ACTIONS FOR PUBLIC AWARENESS, COMMUNICATION, AND QUERY PROCESSING REGARDING ENTITIES WHICH CARRY OUT ACTIVITIES IN COASTAL AREAS AND/OR THE SEA

The coast requires an integrated coastal zone management service (IZCM) which guarantees and promotes the participation of all administrative bodies (national, regional and local) involved in its development, and which involves in the decision-making process and the different bodies located on the coast, in order to generate dialogue and facilitate consensus. The IZCM also has to guarantee the provision of objective and contrasting information and the establishment of effective communication channels among various disciplines and agents in order to promote the understanding and the appreciation of the coast.

In this sense the Observatory has to establish areas for the agents to communicate, it has to function as an instrument which facilitates information which is not subject to political pressure, to promote debate based on contrasting scientific and technical information, and promote the sustainable development of the coast, so contributing, in a greater or lesser degree, to policies. The provision of a web page which makes information of interest accessible and which facilitates the interchange of experiences and knowledge is important, in addition to a bulletin as a means with which to publish news and information on new initiatives.

On the other hand, the establishment of initiatives which promote awareness and participation is also important, in order to generate understanding regarding the coast and its values, and to promote social awareness and education with respect to the sustainability of natural resources and important problems, and to act directly between the agents and the general population. The Mediterranean Observatory must promote the understanding of the environmental and socioeconomic values of the coast, contribute to the education of the resident population and visitors in relation to the sustainable use of the territory, develop educational resources and promote public participation in actions of coastal conservation/restoration. It is important that a plan of action is created which determines the initiatives to be undertaken with different social groups through, for example educational programmes, campaigns, exhibitions and activities for specific groups and awareness sessions, etc.

OPTIMAL* ACQUISITION SCALE/S
Spatial: *Regional* for communication-orientated actions, and *Local* for awareness/participation initiatives (in general)

OPTIMAL* ACQUISITION FREQUENCY(IES)
Monthly for communication-orientated initiatives, and *Annual Planning* for those of awareness/participation

COST(S) PER UNIT MEASURE
Depending on activity/initiative (this is highly variable)

OTHER INDICATIONS
Communication-orientated and awareness initiatives must be based on knowledge and on scientific results obtained in the other analysis and research activities which have been carried out on the coast. This however, is especially and directly correlated with Consultative Technical Service nº 1 which determines the condition of the beaches, nº 2 and nº3 which define the state of the coast through the use of indicators, and nº 5, which evaluates the vulnerability and risks of to the coast.

*According to the aims of regional coastal planning

SYNTHESIS TABLE

Type of Operating/Consultative Technical Service	Optimal* Acquisition Scale/s (Max scale: regional)	Optimal* Acquisition Frequency(ies)	Cost(s) per Unit Measure /frequency	Other Indicators
Consultative Service 4: **Specific initiatives for public awareness, communication, and query processing regarding those who develop activities in the coastal area and/or the sea**	Regional and Local	Monthly and Annual	Variable depending on the initiative/ activity	Correlated with initiatives which define the state of the coast, which are analysed through indicators and their risks are evaluated