

# RAPID PROCEDURES FOR COASTAL ENVIRONMENTAL ASSESSMENT: CASE HISTORIES IN LIGURIAN AND TYRRHENIAN LITTORAL

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**KEY WORDS:** Beach, Morphology, Sediment, Rapid Environmental Assessment

## ABSTRACT:

Different approaches are used to characterize and monitor coastal evolution. In particular circumstances there is an urgent need to obtain information for a Rapid Environmental Assessment – REA. A morphodynamic survey has been carried out in two littoral sectors of Northern Italy (Western Liguria and Tuscany) characterized by different morphological features and human pressure with microtidal regime, in order to test the application of REA, which is a system for early evaluation and management of environmental problems immediately before, during and straight after extraordinary events. GPS- RTK, Emery's method, photographs, and sediment sampling are used to collect morphological and sedimentological parameters to classify the beach morphodynamic type. The comparison of the results from different systems provides useful information of morphodynamic rapid assessment; in particular the use of calibrated photos is a good method for a rapid characterization of the littoral where high accuracy is not necessary.

## 1. INTRODUCTION

The literature presents different approaches to characterizing and monitoring coastal evolution. In particular circumstances there is an urgent need to obtain information for a Rapid Environmental Assessment - REA (Bush et al., 1999; Huang et al., 2002). This system is based on a simple analysis of semi-quantitative measurements of processes to identify environmental characteristics and problems and to determine subsequent actions (Kairu & Nyandwi, 2000; Ozolcer, 2008). REA is a tool for early evaluation and management of environmental problems: immediately before, during and straight after extraordinary events. Its processes and the structure take into account that, in the case of a disaster, there is very short time to analyse and study the problem in detail (Szlyk & Ciminello, 2002; Asian Development Bank, 2003; Kelly, 2005).

The microtidal beach is the most changeable coastal sector, subject to continuous wave action and sediment movement. This system is sensitive and vulnerable not only to variations in natural processes but also to increasing anthropic pressure (Clark, 1996). It changes both the emerged and submerged sector of the beach and consequently the coastline. Defining operatively this limit is very important because it bounds the coastal zone, the most critical part of the Earth's surface in terms of global economy, strategies and management needs. Infact nearly half of the global population lives within less than 100 km of the coastline. High population densities and increasing urban development, tourism and industrialization in coastal areas pose major threats to natural resources and ecological diversity (Nelson & Botteril, 2002). Uncontrolled development results in destabilizing ecosystems, changing land use patterns and making communities vulnerable to natural events such as seastorms.

In this paper some morphodynamic parameters of the beach (i.e. slope and width, shoreline, grain size, composition and consistency of sediment) obtained from morphological and sedimentological surveys were determined for the development of a REA system. In order to rapidly analyse the morphology and the relative sedimentary deposits of the microtidal beach,

stretches of the Tyrrhenian littoral (*Marina di Grosseto* - Tuscany, Fig. 1) and of the Western Ligurian coast (*Varazze*, Fig. 2) have been chosen. This test is part of a long-term project, called M-REA (Maritime-REA), which is being developed by the *Istituto Idrografico della Marina* (Italy) together with other research groups for the rapid oceanographic characterization of a part of the sea involved in disastrous events (Demarte et al., 2008 and 2009).

## 2. STUDY AREA

The Tuscany littoral study area presents different morphological and sedimentological characters such as a regular coastline, dune belts and submarine bars along the coast, low slope, sandy sediment supplied prevalently by Ombrone river (Bellotti et al., 1999). The submarine bars have variable shape, size and position referring to sediment supply and marine climate conditions with prevailing waves from 200-242° (Bartolini, 1982). The recent dynamic evolution of this sectors is stable and shows a good general state of the beach (GNRAC, 2006). Infact the human pressure along the coast is limited to bathing activities and rare coastal urbanization with buildings and access ways. It is apparently a main natural feature of the system where the rapid assessment could be a good tool not only for the beach but also for the coastal zone where the human pressure is very high.

The Ligurian coastal stretch is constituted by rocky-cliffs with sandy-gravel pocket beaches with moderate-high human pressure. This study area presents different orders of early Pleistocene marine terraces (about 70-105 m, 5-8 m and 1-1.5 m), neo-tectonics origin with erosive and deposition marine and continental evidences (Carobene & Firpo, 2005).

These levels are important for the developing of the motorway, the old railway (at the end of XIX century) now walkway and the small pocket beaches. The wind-wave climate (SW dominant and SE prevailing) and the orientation of the coast (WSW-ESE) contributed to this articulate setting.

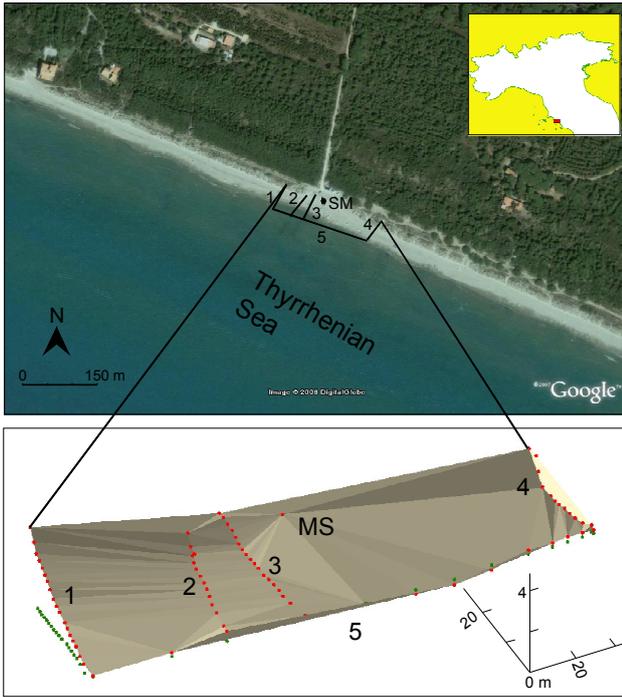


Figure 1. Tuscany littoral study area: location of the analysed sub-aerial beach profiles, (top) and three-dimensional model of the GPS-RTK survey with indication of the acquisition points (bottom). MS = Master Station.



Figure 2. Ligurian survey area and GPS-RTK points referring to cross sections. A, B and C showed in Figure 4. Recently the coastal dynamic evolution highlighted a clear retreat of the littoral with erosion of the cliff, the beaches and also the protected littoral by groins, ripraps and nourishment

(AA.VV., 1999). This littoral, part of Beigua Geopark, has high sensitivity and ecological value and is controlled by regulation to defence well preserved rocky cliff and sea grass marine habitat, identified as Special Protection Zone and Site of Community Interest (SPZ – SCI) (Regione Liguria, 2002).

### 3. METHODS AND RESULTS

Morphological and sedimentological parameters have been collected using and comparing different systems such as GPS-RTK (Global Positioning System - Real Time Kinematics), Emery's method (1961), photographs and direct sediment sampling to identify some characters (beach width and slope, shoreline, sediment grain size, cobble shape and consistency of the sediments). These data, combined with other survey information (for instance the presence of groins or walls, coastal dunes and submarine bars, Figs. 2 and 3), have been used to classify the beach morphodynamic type.

A morphological survey of the beaches has been carried out. Particular attention was given to the three-dimensional morphological variability of the sub-aerial beach as determined by the field work, using rapid techniques such as GPS-RTK system, with double frequency and high accuracy, and the simple Emery's method (Figs. 1, 2 and 4).

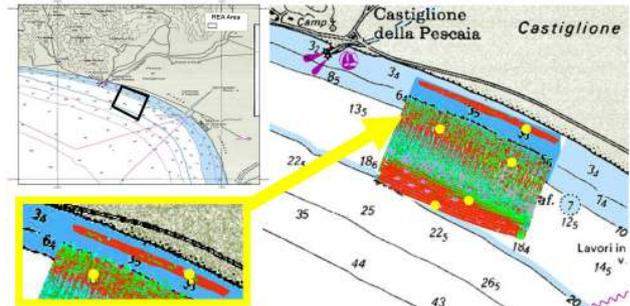


Figure 3. Bathymetric map of the Tuscany study area (*Istituto Idrografico della Marina*) and seafloor backscatter data show a pattern of highest backscatter (sediment bars along the coast) and lowest backscatter (fine sediments). Point: sediment sample site.

The sedimentological study was performed on samples from the profiles near the shoreline and the upper boundary of the beach. The samples were characterised using a speedy *in-situ* determination of the mean grain sediment grain size on the basis of comparators, composition and consistency of the shoreline sediments (with a pocket penetrometer). Subsequently a laboratory grain size analysis was performed by dry sieving controlling the *in-situ* determination. Table 1 shows, as example, morphological and sedimentological data for the Tuscany littoral stretch.

Only in the Ligurian sector, characterized by cliff and high slope, morphological data were collected using an other rapid method (Pranzini, 1979), with calibrated photo (camera with 4M 2304x1728 pixel, compass, spirit-level and rod, Figs. 4 and 5). The data were collected along beach cross sections and the shoreline.

The application of the GPS-RTK system and Emery's rapid technique strengthens the possibility of the use of both methods with comparable results, as rapid-method shows difference of only 7% from GPS-RTK system. Even if this difference is above the accuracy of the instruments used, it is negligible for

the goals of acquisition process. Certainly, the measurements performed with the GPS-RTK system make it possible to obtain a more detailed three-dimensional morphological model.

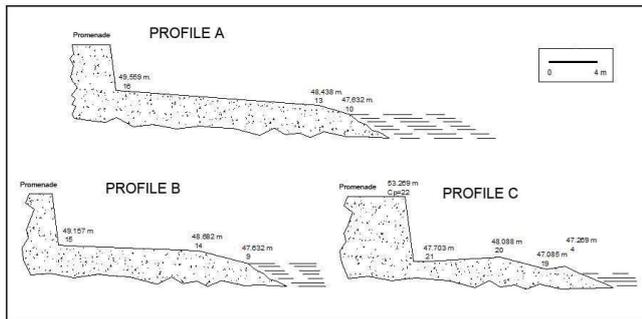


Figure 4. Morphological beach profiles obtained by GPS-RTK survey (see Figure 2 for location). The numbers are sedimentological sample sites related to ellipsoidal levels.

In the Ligurian sector the calibrated photo of profile C, 12 m width, presented a difference with GPS-RTK data equal to 2° in slope, 9 cm in difference of level and 1.34 m in width (Fig. 5). Similar results obtained for the other cross sections of the beach study confirmed that the photo technique is a good tool for rapid detection of the sea level and consequently of the shoreline. In fact a sea level variation of 0.1 m along a beach with slope between 10-20° gives a planimetric variation below 0.6 m. This value, with opportune corrections, could be a rapid updating of coastline.



Figure 5. Ligurian beach SE view shows the profile C acquired by GPS-RTK system and calibrated photo. We can see different cusps and the sediment grain size (gravel prevalently).

Profile	P (%)	A (m)	D <sub>50</sub> Ba (mm)	M <sub>Z</sub> Ba (mm)	D <sub>10</sub> Bt (mm)	M <sub>Z</sub> Bt (mm)
1	6.5	33.5	0.23	0.25	1.44	1.60
2	7.2	31.9	0.25	0.26	0.35	0.42
3	5.0	31.4	0.22	0.23	0.30	0.31
4	6.7	30.0	0.26	0.29	0.30	0.31

Table 1. Morphological and sedimentological data along the profiles of Figure 1. P = beach slope, A = width of the sub-aerial beach, D<sub>50</sub> = median grain size M<sub>Z</sub> = mean grain size by lab analyses, Ba = swash zone, Bt = storm berm or beach upper limit.

The comparing and integration between photos or Emery's method and GPS-RTK data provided a complete view of littoral morphodynamic rapid assessment such as the study areas and a real contribute to the following monitoring, planning and management actions in coastal forecast. In particular the photos were appropriate to return the beach slope with a difference in the data values of GPS-RTK of about 10%. The differences in height were lower (8%), while the submerged beach widths obtained by photos were higher differences with GPS-RTK data.

The morphodynamic study of the beach made it possible to check the suitability of the different methods for obtaining some indicators, such as the beach profile and the sediments which constitute the same deposit, in a rapid way, in accordance with standards for updating and comparing data.

These results, combined with other survey information (i.e. the presence of coastal dunes, cusps and submarine bars), classified the beaches as intermediate/reflective morphodynamic type (Short, 1999). Coastal dunes with no particular erosion marks at their foot or vegetation with exposed roots were indicators of beach stability.

The collected data highlighted that the Tuscany littoral stretch is characterized by a homogeneous coastline, moderate human pressure, a medium-fine sandy beach, medium sediment consistency, gentle slope (about 5%), narrow beach face (30 m), bars, a shore bounded by vegetated dune ridges.

The Ligurian stretch is characterized by moderate-high human pressure, sandy-pebble beach, high beach face slope (max 20°), cusp, no submarine bars and narrow beach face (15 m).

These parameters indicate that Tuscany stretch is a stable-low energy beach with intermediate morphodynamic characteristics while the Ligurian stretch is characterized by a high energy beach with reflective morphodynamic characters (Fig. 6).

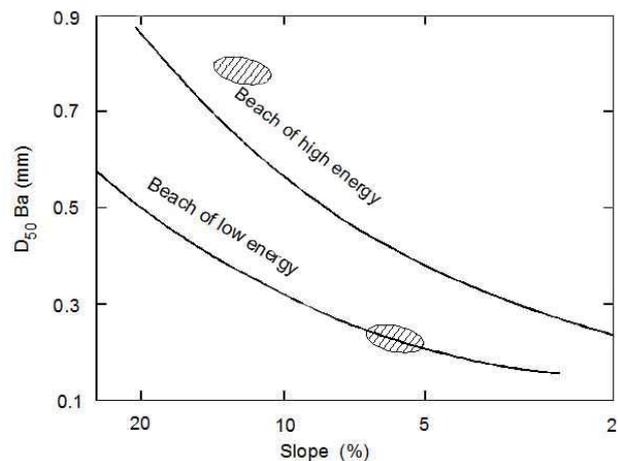


Figure 6. Beach-face slope vs. the median grain size (D<sub>50</sub> Ba) of study areas (hatched area). The curves of the beach of the high and low energy by Komar (1998).

#### 4. CONCLUDING REMARKS

In these case histories the use of two operators and the short time (48 hours) to complete the entire job, from the acquisition to the interpretation of the data, are constraints which fall within the REA parameters. GPS-RTK system and Emery's method confirmed that the results are comparable in a REA process. Certainly more data collected with GPS-RTK provide a more detailed three-dimensional model. In beach monitoring the use of GPS-RTK (high resolution and repeatability) allowed an accurate measurements either of morphological evolution or of sediment volumetric variation with a standard reference system. The results of data collected confirmed that the two coastal sectors represent different littoral areas where to understand the potential reply to a rapid intervention using the proposed procedures. In order to obtain an exhaustive view of the recent littoral evolution and to reach more immediate interpretation of the anthropogenic effects, the present study could be apply subsequently in monitoring actions, as data calibration of hydrodynamic models, i.e. shoreline detection in photogrammetry and remote sensing.

The differences of data resulted by various approaches and used systems confirmed that the photos were a good method to a rapid characterization of the littoral, but were not suitable where the interventions need a higher accuracy. Even though the M-REA research are in progress the results of these studies are particularly important as elements of application of REA developed in case of emergency or in singular situations, remote sites, with limited and hard-to-be-acquired knowledge.

Therefore this research can be interesting not only for scientific community but even for politicians, decision-makers ecc. in support to civil and environmental protection actions.

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