The activity of "Osservatorio Coste E Ambiente Naturale Sottomarino" (OCEANS) and the implementation of a monitoring network and study methodology for sedimentological and morphodynamic processes of mediterranean microtidal wave-dominated beaches (Sardinia)

Sandro De Muro, Claudio Kalb, Nicola Pusceddu and Angelo Ibba

Coastal and Marine Geology Group
Osservatorio Coste E Ambiente Naturale Sottomarino (OCEANS)
University of Cagliari, Department of Chemical and Geological Sciences
Via Trentino 51, 09127 Cagliari, Tel/Fax 0706757733,
e-mail: marinegeology@unica.it

Abstract

The monitoring network, set up in 2005 for Project "Gestion intègrèe de l'environnement à haute risque d'èrosion" (Interreg IIIA GERER), was initially based on 4 sample beaches in Corsica and Sardinia, and was later extended, including other 31 beaches over a 6 year-period. A methodology for the study of sedimentary processes and morphodynamics of microtidal wave-dominated beaches in a Mediterranean environment was also implemented. A database was created by the "Coastal and Marine Geology Group" using the monitoring network and study methodology. Data from aerial photographs and satellite images, and on bathymetry-topography (DTM), sedimentology, wind and wave energy and hydrodynamics of the beach systems were collected, catalogued, archived and analysed.

A cross-border centre for the study of littoral dynamics ("Centro Transfrontaliero per lo studio della dinamica dei litorali") has been recently developed as part of the P.O. Maritimo Res.Mar "Rete per l'ambiente nello spazio marittimo" – Sub-project B.

Data flow is originated at Osservatorio Coste E Ambiente Naturale Sottomarino - OCEANS from where it is made available to the centre ("Centro Transfrontaliero per lo studio della dinamica dei litorali").

Free use of OCEANS lighthouse has been granted to the university, which has been using it for institutional objectives, mainly by researchers from the Coastal and Marine Geology Group, coordinated by Prof. Sandro DeMuro.

Research results are available in scientific publications, popular publications and on a webgis (www.osservatoriocostesardegna.eu).

Introduction

The beaches of Gallura and Sardinia in general, undergo strong infrastructural pressure which increases during the summer due to tourism.

The response of the beach systems to this increment of "workload" is influenced by ongoing global climate change. As a result of this well-known situation of climatic instability the equilibrium of the beach-dune systems is even more delicate and critical. Signs of environmental distress are already evident in many beaches such as: changes to sedimentary systems, withdrawal, reduction or fragmentation of dune habitats caused mainly by the lack of efficient management.

The extraordinary quality of the Sardinian beaches and the beaches of Gallura is also attributable to the unique composition and structure of the sands. These sands are disappearing and being eroded due to the incorrect use of the resource. The negative experience of Poetto's beach nourishment (Cagliari) is a good example showing that these materials are not artificially reproducible.

The Sardinian beaches are an invaluable resource and should be protected as such.

In 2008, the Osservatorio Coste E Ambiente Naturale Sottomarino (OCEANS), well aware of this serious emergency situation, began a detailed study to understand and use a new monitoring method. It was created by the Coastal and marine Geology Group of Cagliari University and based on scientific knowledge acquired.

Efficient management practice inspired by sustainable development was experimented and promoted on the foundations of this new knowledge.

In this sense, the use of scientific data is of fundamental importance for planning; the database is constantly updated and constitutes a valid support instrument for town councils, PULs (Littoral Use Plans) and good management practices in general. Regional Law DGR 29/15, from 22.05.2008, has given directions for the elaboration of a Coastal Usage Plan, and regulated uses in the territorial sea and in the public maritime domain (owned by the state).

This policy regulates the local authority functions related to the use of National maritime property and areas of territorial sea, as well as recreational use of Nation-owned areas by tourists, regulated by PULs. The scientific knowledge acquired so far shows that a thorough and urgent review of this policy is urgently required, as it does not consider the extreme dynamism of beaches and dunes (also related to the climatic variations underway and the impact of incorrect use of resources).

The creation of this database, aimed at sample beaches, was possible due to to the experience that OCEANS researchers have acquired in implementing the European Project "*Gestione Ambientale Integrata in Località ad Elevato Rischio d'Erosione GERER*" (INTERREG III A) and from the experience gained from the study and monitoring of dune systems in the project Life+ Nature & Biodiversity PROVIDUNE, which OCEANS is coordinating on a national scale.

These two projects, INTERREG IIIA-GERER and LIFE+ PROVIDUNE, are 'pilot projects' based on solid scientific knowledge, providing a concrete contribution on the complex issues related to the dynamics of coastal sand bodies and the management and use of beach systems, for the use of the local authorities directly involved.

The following phases were carried out to create the Database on Coastal Observations:

- reorganization and integration of existing data, using the laboratories, means and

advanced instruments available to OCEANS for the monitoring of beach systems;
- enlargement of the cognitive framework regarding the functional mechanisms of beach systems;
- elaboration of monitoring information from sample beaches to highlight the main criticality and to formulate management proposals for the use of coastal resources according to sustainable development guidelines;

The aim was to obtain a basic computerized picture of the 35 beaches studied that is easy to consult and implement, allowing the following (Fig. 1):

- preparing documents and preliminary research activities required to define a Pilot Project for integrated management of the coastal zone;
- planning and testing a database on Sardinian beaches;
- providing management support and guidelines for local authorities;
- continuing information exchange between the University (institution for research and higher education) and intermediate local government bodies in charge of territorial control (institutions for management).

The first objective reached by the Observatory was to contribute towards a deeper understanding of the historical-geographical evolution of sample beaches located along the entire Sardinian coast. The collection and analysis of these initial data constituted an essential basis required for reaching a second objective: construction of an experimental database containing basic and easily readable information related to the beaches studied, whereas offering the necessary statistics for setting up a model for an integrated coastal zone environmental management programme (see www.osservatoriocostesardegna.eu website).

An important third objective (management orientation) was reached by charting the main threats and criticality of the dune areas of the 35 sample beaches monitored and studied by OCEANS.

The fourth and possibly the most difficult objective aimed at establishing a continuous and regular exchange of information between the world of research and the world of local authorities; it has been partially reached. The different hydrodynamic and morpho-bathymetric responses in the bars-and-trough zone (the most dynamic area of the beach above and below sea-level) of all 35 beaches were studied according to the main wind directions included in the onshore wind sections. Slope variations and changes in volume and the position of the shoreline were studied; numerical models based on high precision measurement techniques were created. Measurement was carried out seasonally (bathymetrical-topographical and sedimentological surveys at dry beach and nearshore were integrated, on some sites, using webcams and weather stations.

The coastline and continental platform of Gallura have been subject of numerous geomorphological, sedimentological, geophysical and geological studies, carried out sporadically since the 1970s, mainly by the University of Cagliari, as part of national and international projects. The launching of OCEANS, located at Punta Sardegna Lighthouse, centre of the database, the laboratories and Scuola di Geologia Ambientale Subacquea (school of underwater environmental geology) (Fig. 2), have provided a new input of research activity through the development and management of national and international projects. Through the Coastal Marine Geology Group, OCEANS has also worked on the

Figure 1 - Position of the 35 nodes of the Monitoring Network maintained by Coastal and Marine Geology Group.

renovation and organisation of Punta Sardegna Lighthouse (Fig. 2), on the preparation of two research boats and on supporting and promoting good management practices (www.osservatoriocostesardegna.eu).

The "Coastal and Marine Geology Group" used, tested and implemented a series of protocols and methodological standards for the study and monitoring of 35 beaches. The network was based on three beaches in the north of Sardinia and one in the south of Corsica: Cala di Trana, La Sciumara, Venalonga (Palau) and Paragan (Bonifacio) [3] [4] [5]

Figure 2 - Picture of Punta Sardegna Lighthouse and OCEANS headquarters.

[7] [8] [9] [11]. It was created in 2005, for the Interreg IIIA GERER Project "Gestion intègrèe de l'environnement à haute risque d'èrosion", and was extended in 2006 to the beaches of Solanas (Sinnai) and Santa Margherita di Pula [7] [8] [10] [17] as part of the project "Sistema di controllo Ambientale e gestione territoriale del Golfo di Cagliari", funded by Research, University and Instruction Ministry (M.I.U.R./Ministero Istruzione Università e Ricerca) (Fig. 1).

In 2009, the network was further extended, thanks to Project LIFE+ Providune, to 8 other beaches in the south of Sardinia: Piscinnì, Su Giudeu, Campana, Sa Colonia (Domus de Maria) and Porto Giunco, Simius, Is Traias and Punta Molentis (Villasimius) [6] [12] [16] [17]. Finally, in 2010, 4 more beaches were added (Is Arenas in Narbolia, La Cinta (San Teodoro), Cala Budoni and Poetto (Cagliari) [1] [2] [20] [21] [22] [23]), thanks to the contribution of research projects and scholarships funded by the Sardinian Regional Government through Regional Law L.R. 7/2007 (RIsposta e Adattamento dei sistemi costieri della Sardegna alle variazioni climatiche globali – RI.A.S. and Beach Environment, management

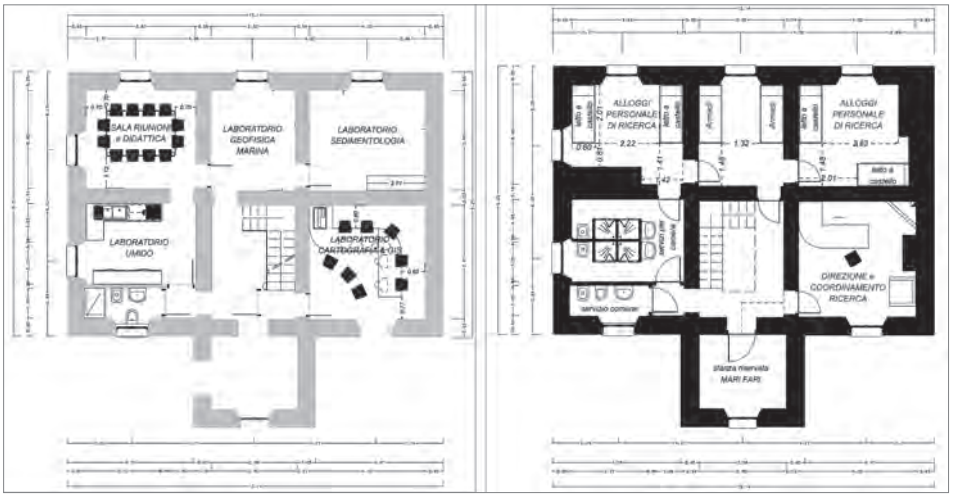

Figure 3 - Plan of the Lighthouse, ground floor and first floor.

And Coastal Hazard – B.E.A.C.H.). Later, the framework for the running of OCEANS permitted the network to include 17 other beaches: Lu Litarroni (Aglientu), Rena Majori (Aglientu), Badesi (Badesi, Trinità d'Agultu e Vignola), La Colba (Santa Teresa di Gallura), Porto Liscia (Santa Teresa di Gallura, Palau), Porto Pollo (Palau), Le Saline (Palau, Arzachena),

Figure 4 - Punta Sardegna Lighthouse, operating headquarters for OCEANS and the "Centro Transfrontaliero per lo Studio della Dinamica dei Litorali" (cross-border centre for the study of coastal dynamics), before and after renovation.

Figure 5 - Punta Sardegna Lighthouse, inside before and after renovation.

Cala Ciaccaro (La Maddalena), Cala Portese (La Maddalena), Cala Corsara (La Maddalena), Cala Majore (La Maddalena), Cavalieri (La Maddalena), Grande Pevero (Arzachena), Capriccioli (Arzachena), Cala Sassari (Golfo Aranci), Le Saline (Olbia) and Cala Brandinchi (San Teodoro) [19]. Today we have a total of 35 beaches being monitored.

All data are stored into the database situated in Punta Sardegna Lighthouse (OCEANS headquarters), created and managed by the Coastal and Marine Geology Group (Fig. 4 and Fig. 5).
The beaches are studied seasonally with the aim to evaluate sedimentary and morphodynamic processes, anthropic impact, criticality and evolution trends, and also to provide management guidelines.

Methodology

The studies are carried out according to the chart in Fig. 6. This illustrates the configuration of instrumentation used, the work performed and the data obtained [7] [9].

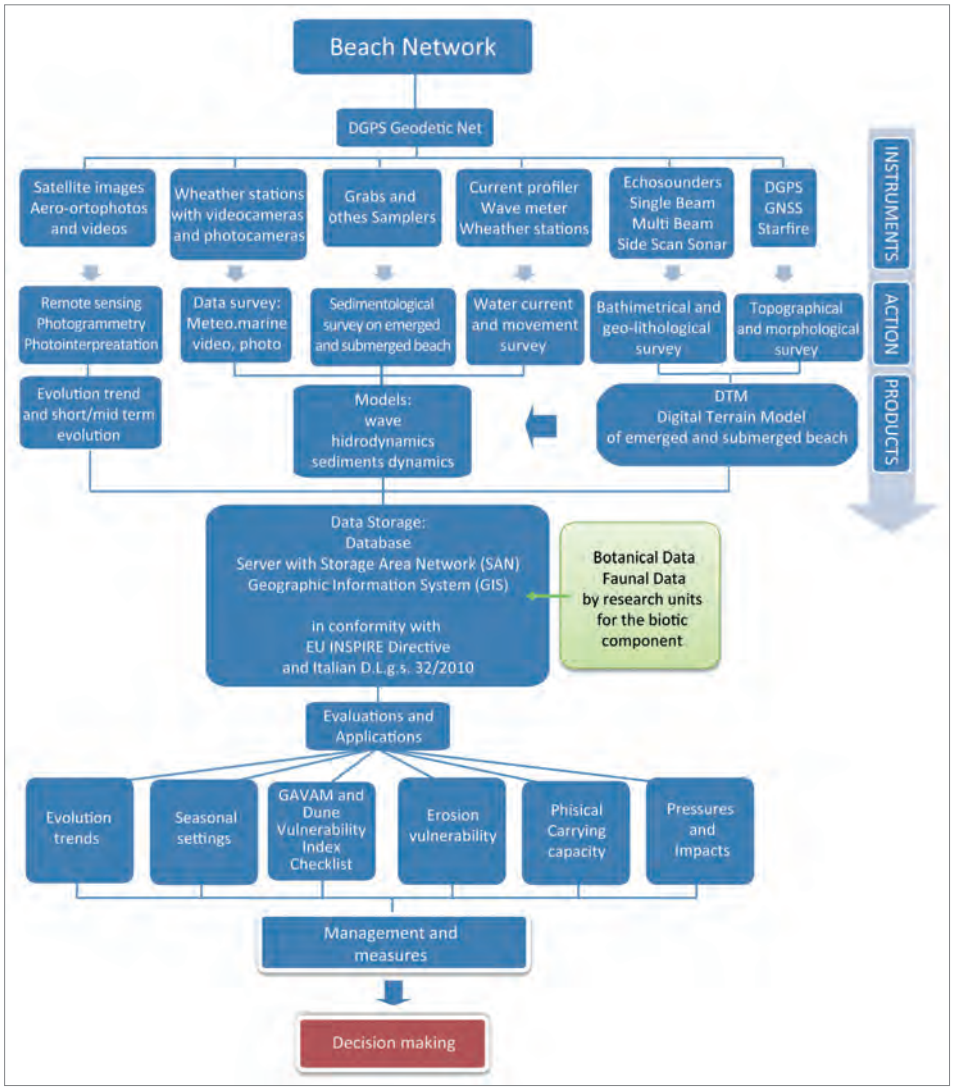

Figure 6 – Methodological chart created with Interreg IIIA GERER Project [7] and implemented with project LIFE+ Providune [13] [14].

The historical reconstruction of evolution in the area is carried out for each beach using the interpretation of aerial photographs, in order to identify "macroindicators" [19] such as: extension of the dune area, position of the shoreline, distribution of marine phanerogams (e.g. *Posidonia* etc.), anthropological elements (buildings and coastal infrastructure,

for example) and hydrography. This allows evaluating the evolution in the area in short and medium term studies. All the data acquired are linked to the geodetic network points created on all the beaches (Fig. 7).

Figure 7 - Implementation of geodetic network.

The topographical data are acquired using DGPS or GNSS and/or StarFire systems with a point sampling frequency of 1Hz. An Echosounder/DGPS system is used for the beach below sea level together with a navigation software with a sampling frequency of 5Hz. All results are referred to the UTM – WGS84 *Datum* coordinating system (Fig. 8).

Figure 8 – Morpho-bathymetrical and topographical findings in the study sites.

The sediments collected from the morpho-sedimentological units (dune, emerged and submerged beach) (Fig. 9 a, b) are dealt with according to standard sedimentological methods (texture, composition and facies analysis - Fig. 9 c, d).
Current direction and speed are simultaneously verified and measured (Fig. 10) and meteorological and video data from the sample sites are collected using a remote control system of video cameras and meteorological stations (Fig. 11).

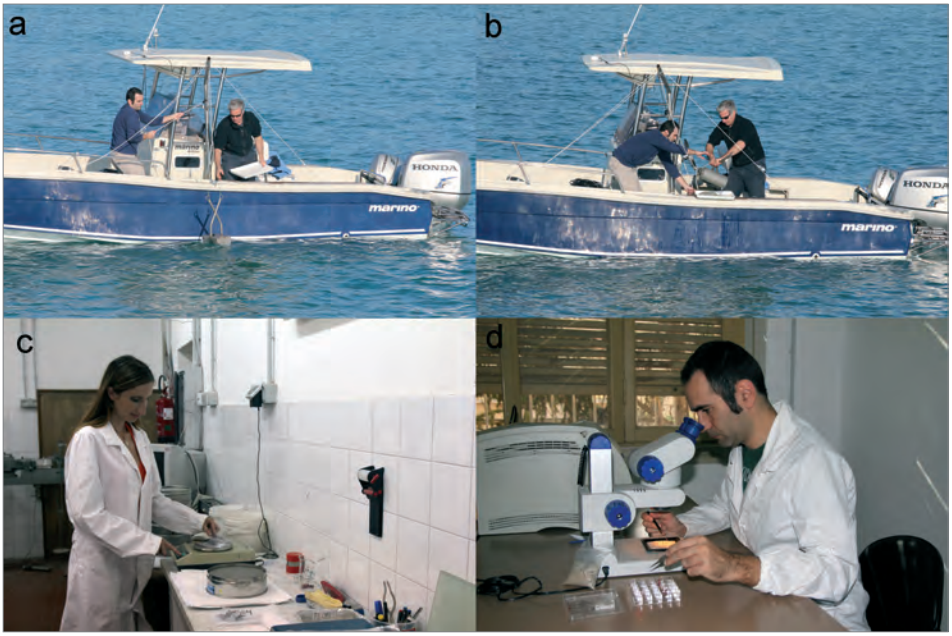

Figure 9 - Collection of sediment samples using the Van Veen grab (a, b); analysis of sediments in laboratory (c, d).

This allows video-monitoring of the areas, evaluating for example: movement of the shoreline, areas affected by overwashing, duration of stranded seagrass (*Posidonia)* deposition and elimination processes, etc.

Figure 10 - Current speed and direction survey.

Meteorological stations collect and record other important data (wind direction, intensity and persistence, etc.) directly at the study area.
Models of beach wave and hydrodynamics are created from the wind direction and intensity detected in the study area (Fig. 12).

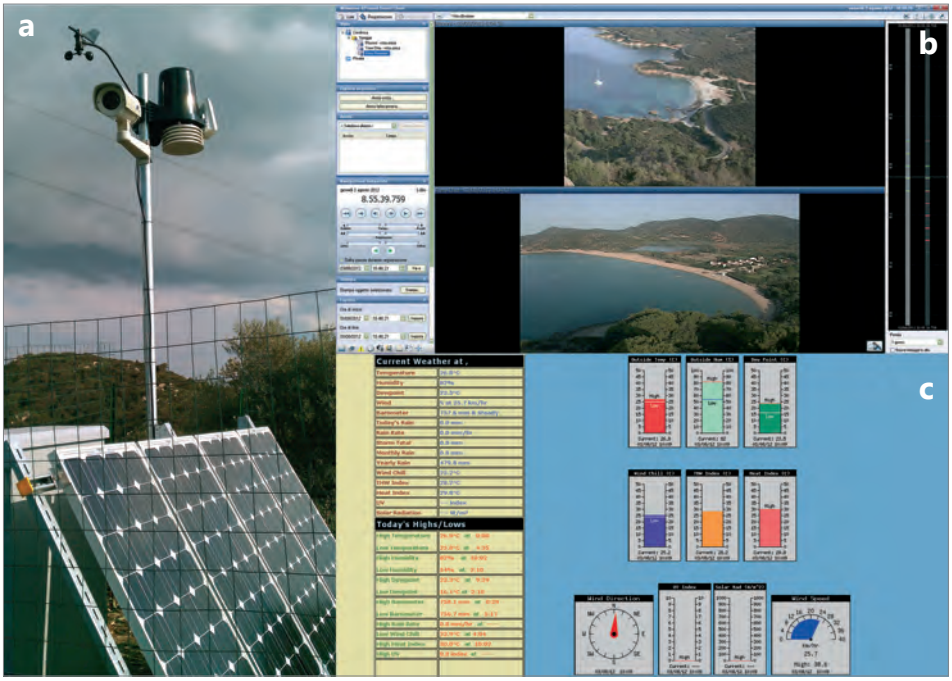

Figure 11 - Remote control system with Video-Meteo centre (a); acquisition software screen for video images (b); meteorological data acquisition software screen (c).

They are based on Digital Terrain models (DTM), built from bathymetric-topographical data, and from the results of sedimentological analyses and meteorological-climatic and current speed/direction analyses.
The methodology described in projects Life+ Providune and Res.Mar "Centro Transfrontaliero" was implemented through the construction of a database infrastructure formed by Server and SAN (Storage Area Network) for archiving purposes.
The territorial geographical, aerial-photogrammetric, satellite images, cartographical, bathymetrical-topographical (DTM), sedimentological, wind, wave and hydrodynamic (in raster and vectorial format) data was constructed, archived and indexed in GIS format, in accordance with EU INSPIRE normative and Italian Law D.L.g.s. 32/2010.

Through the elaboration and interpretation of all data, scientific results are obtained, providing the basis for applications and evaluations such as: detection of evolution trends, seasonal sequences, dune vulnerability (DVI/GAVAM checklist [15]), erosion vulnerability, physical load capacity, pressure and impact on the beach system.
The method provides information for the elaboration of management guidelines and for the planning of conservation works.
The results are available to a wide public of potential users in scientific publications and journals and in a WebGIS (www.osservatoriocostesardegna.eu).

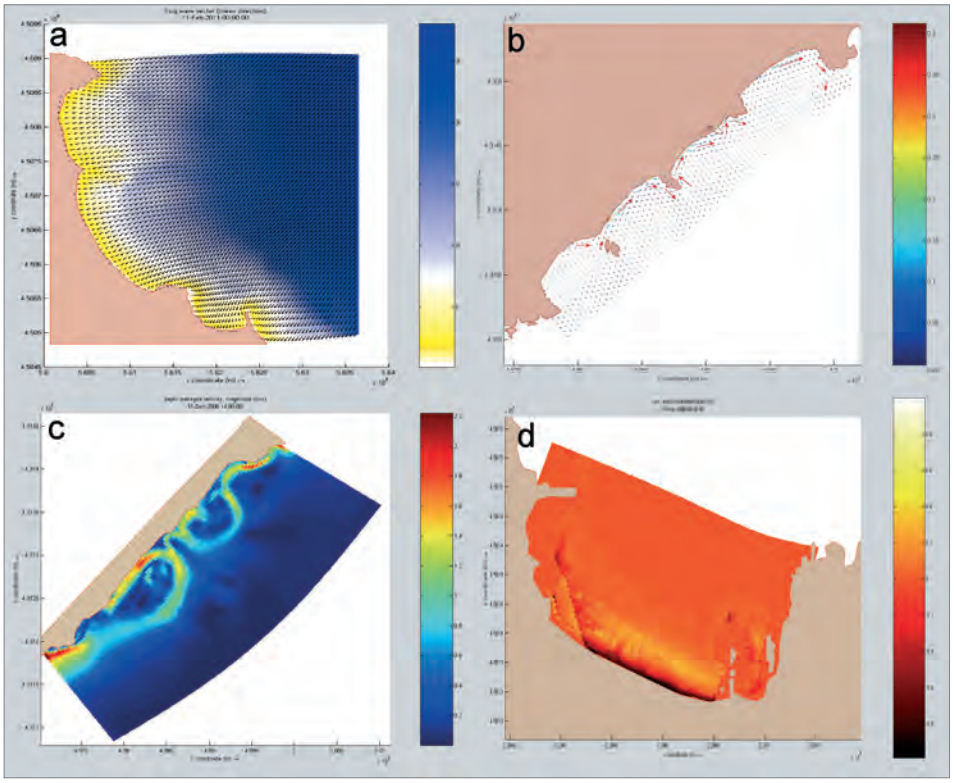

Figure 12 – Examples of wave refraction and hydrodynamics: a) vectors of the wave front; b) vectors of the hydrodynamic flow; c) representation of energy associated to hydrodynamic flows; d) representation of bar-and-trough area (surf zone).

Conclusions

The Osservatorio Coste E Ambiente Naturale Sottomarino, OCEANS, was created thanks to the work of the Coastal and Marine Geology Group – University of Cagliari, at Punta Sardegna Lighthouse (OCEANS). The numerous research projects carried out since 2000 have provided information to create a network for the study and monitoring of 35 beaches in Sardinia. A new methodology has been experimented and implemented since 2005. This has focused on the study of sedimentological and morphodynamic processes of wave-dominated microtidal beaches in a Mediterranean environment. The study began in 2005 as part of the Interreg IIIA GERER Project, and was applied and developed within Project Progetto LIFE+ Providune. In 2010, the network was extended to include a total of 35 sites under study and monitoring, as part of projects L.R. 7/2007 RI.A.S. and B.E.A.C.H., and ResMar Sottoprogetto B "Centro Transfrontaliero studio dinamica dei litorali".

The extension of the methodology used, permitted OCEANS to create a database for collecting, cataloguing, archiving and analysing aerial-photogrammetric, satellite image, cartographical, bathymetrical-topographical, sedimentological, wind, wave and current data related to the beach systems studied by the "Coastal and Marine Geology Group" from University of Cagliari.

The data collected, catalogued, archived and analysed has been published in the usual scientific channels and also on a WebGIS platform on the OCEANS website (www.osservatoriocostesardegna.eu) and are stored in a server, created by and housed in the Department of Chemical and Geological Sciences of the University Cagliari.
Data flow is made available from OCEANS to the "Centro Transfrontaliero per lo studio della dinamica dei litorali" (cross-border centre for the study of coastal dynamics).
Together, the methodology, database system and publication through WebGIS allow providing, for a large number of beaches in Sardegna guidelines for management and planning of conservation works, accessible to a wide public of potential users.

Acknowledgements
Work carried out with project funding:
Interreg III A "It, Fr, Isole" "Gestione ambientale integrata in località ad alto rischio d'erosione" GERER;
LIFE+ NATURE & BIODIVERSITY – PROVIDUNE (LIFE07NAT/IT/000519), "Conservazione e ripristino di habitat dunali nei siti delle Province di Cagliari, Matera e Caserta".
Progetto RIAS - RIsposta e Adattamento dei sistemi costieri della Sardegna alle variazioni climatiche globali. Legge regionale 7 Agosto 2007, N. 7: "Promozione della ricerca scientifica e dell'innovazione tecnologica in Sardegna"- Annualità 2008.
Programma Operativo di Cooperazione Territoriale Transfrontaliera Italia-Francia "Marittimo" - ResMar. "Rete per l'ambiente nello spazio marittimo" – Sottoprogetto B) Centro Transfrontaliero studio dinamica dei litorali.
Progetto B.E.A.C.H, – Beach Environment, management And Coastal Hazard (ambiente spiaggia, gestione e rischio costiero). Legge regionale 7 Agosto 2007, N. 7: "Promozione della ricerca scientifica e dell'innovazione tecnologica in Sardegna" - annualità 2009

References

[1] Batzella T., Pusceddu N., Kalb C., Ferraro F., Ibba A., DeMuro S. – Bars and troughs dynamic and evolution trend of La Cinta beach (San Teodoro OT) - NE Sardinia, Rend. Online Soc. Geol. It., Vol. 17 (2011), 17-23 (DOI 10.3301/ROL.2011.13).
[2] Batzella T., Pusceddu N., Kalb C., Ibba A, Ferraro F., DeMuro S. – Bars and troughs dynamic and short-term evolution of two beaches on NE Sardinia: La Cinta (San Teodoro, OT) and Budoni (OT), in: Abstract 28th IAS Meeting of Sedimentology, Zaragoza, Spain - July 5-8th 2011 (Eds. B. Bàdenas, M. Aurell and A.M. Alonso-Zarza), p.145. ISBN 978-84-615-1755-8.
[3] De Falco G., Simeone S., Batzella T., Cancemi G., Cancemi M, DeMuro S. –Arretramento della linea di riva e rimozione della banquette di Posidonia oceanica nella spiaggia di Paragan (Corsica meridionale), Atti del "84° Congresso Nazionale della Società Geologica Italiana" 15-17 Settembre 2008, Sassari - Rend.online Soc. Geol. It., 3 (2008), 296-297. ISSN 2035-8008.
[4] De Falco G., Simeone S., DeMuro S. - Analisi della dinamica deposizionale delle banquette di Posidonia oceanica nella spiaggia di Cala di Trana (Palau) mediante videomonitoraggio, in De Muro S. e De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 136-150. ISBN 978-88-8467-629-0.

[5] De Falco G., Simeone S., Solinas G., Batzella T., Cancemi G., Cancemi M., DeMuro S. – Relazione tra arretramento della linea di riva e rimozione delle banquette di Posidonia oceanica nella spiaggia di Paragan (Corsica meridionale), in De Muro S. e De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 151-163. ISBN 978-88-8467-629-0.

[6] De Muro S., Ibba A., Ferraro F., Ferrara C., Batzella T., Pusceddu N., Kalb, C. - Morpho-sedimentological map of Chia beaches - SCI ITB042230 "Porto Campana" (SW Sardinia, Mediterranean Sea - Italy), Atti del "29th IAS Meeting of Sedimentology Schladming, Austria 10th-13th September 2012, p.243.

[7] DeMuro S., De Falco G. (a cura di) – Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge sarde e corse, University press – Scienze Costiere e Marine, CUEC. ISBN 978-88-8467-629-0 (2010), pp. 368.

[8] DeMuro S., Batzella T., Kalb C., Pusceddu N. – Processi sedimentari, idrodinamica e modellizzazione delle spiagge di Santa Margherita, Solanas, Cala di Trana e La Sciumara (Sardegna – Italia), Atti del "84° Congresso Nazionale della Società Geologica Italiana" 15-17 Settembre 2008, Sassari - Rend.online Soc. Geol. It., 3 (2008), 308-309. ISSN 2035-8008.

[9] DeMuro S., Dore G.P. – Dove inizia il mare. Buone pratiche per lo studio, la salvaguardia e la gestione delle spiagge sarde, (Documentario) Atti scientifici e divulgativi del Progetto Interreg IIIA GERER "Gestion intègrèe de l'environnement à haute risque d'èrosion" (2008), Università degli Studi di Cagliari.

[10] DeMuro S., Kalb C.– Distribuzione sedimentaria, moto ondoso e monitoraggio della spiaggia di Solanas (Sinnai - Sardegna Sud-Orientale), in De Muro S., De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 260-288. ISBN 978-88-8467-629-0.

[11] DeMuro S., Kalb C., Batzella T., Pusceddu N. – Morfologia, idrodinamica e sedimentologia dei sistemi di spiaggia di Cala di Trana, La Sciumara e Venalonga (Palau - Sardegna Nord Orientale), in De Muro S., De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 103-135. ISBN 978-88-8467-629-0.

[12] DeMuro S., Kalb C., Ferraro F., Batzella T., Pusceddu N., Ferrara C., Ibba A. – Sedimentary and morphodynamic processes of microtidal wave dominated mediterranean beaches (Villasimius - SE Sardinia), Riassunti del "Quarto Simposio Internazionale - Il monitoraggio costiero Mediterraneo: problematiche e tecniche di misura" Livorno 12-13-14 Giugno 2012, pp. 107-108.

[13] DeMuro S., Kalb C., Ferraro F., Batzella T., Pusceddu N., Ferrara C., Ibba A. – Development of monitoring network and methodology for the study of sedimentary and morpho-dynamics processes of microtidal wave dominated mediterranean beaches (Sardinia), Atti del "Quarto Simposio Internazionale - Il monitoraggio costiero Mediterraneo: problematiche e tecniche di misura" Livorno 12-13-14 Giugno 2012, pp. 229-236. ISBN 978-88-95597-13-3.

[14] DeMuro S., Kalb C., Ferraro F., Batzella T., Pusceddu N., Ibba A. (2012) – Attività dell'Osservatorio Coste E Ambiente Naturale Sottomarino (O.C.E.A.N.S.) e implemen-

to della rete di monitoraggio e delle metodologie per lo studio dei processi sedimentari e morfo-dinamici di spiagge mediterranee microtidali dominate da moto ondoso (Sardegna). Atti della Giornata di Studio "La tutela del mare dagli inquinamenti di tipo accidentale" 18/05/2012 – Scuola Sottufficiali Marina Militare "MOVM Domenico Bastianini" - Litografia Mariscuola La Maddalena – pp. 31-55.

[15] DeMuro S., Kalb C., Ibba A., Batzella T., Pusceddu N., Ferrara C., Ferraro F. – Coastal dunes vulnerability. GAVAM checklist method used at three mediterranean microtidal wave dominated beaches (Gulf of Cagliari), Rend. Online Soc. Geol. It., Vol. 17 (2011), 77-82 (DOI: 10.3301/ROL.2011.26).

[16] DeMuro S., Kalb C., Ibba A., Ferraro F., Ferrara C. – Sedimentary processes, morphodynamics and sedimentological map of Porto Giunco-Simius-Is Traias beaches (Villasimius - SE Sardinia), Atti del Convegno GeoSed 2010, Torino, 25-26.

[17] DeMuro S., Kalb C., Ibba A., Ferraro F., Ferrara C. – Sedimentary processes, morphodynamics and sedimentological map of "Porto Campana" SCI beaches (Domus de Maria - SW Sardinia), Rend.online Soc. Geol. It., 11(2010), 756-757. ISSN 2035-8008.

[18] DeMuro S., Lai A., Pusceddu N., Kalb C. - Relazione tra idrodinamica e processi di sedimentazione nella spiaggia di Santa Margherita di Pula (Golfo di Cagliari – Sardegna Sud-Occidentale), in DeMuro S., De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 225-259. ISBN 978-88-8467-629-0.

[19] DeMuro S., Pusceddu N. (A cura di) - Atlante delle spiagge della Gallura – evoluzione recente, regime, assetti, tendenza e criticità di dieci sistemi di spiaggia campione, University press – Scienze Costiere e Marine, CUEC (2012), p. 237. ISBN 978-88-8467-732-7 (in press).

[20] DeMuro S., Pusceddu N., Batzella T., Ibba A., Ferraro F., Kalb C. – Evolution trend of La Cinta beach (San Teodoro) after the flooding on 24th September 2009, Atti del Convegno GeoSed 2010, Torino, 27.

[21] Ferrara C., Ibba A, Usai A., Onnis A., Kalb C., DeMuro S. - Dati preliminari sulla dinamica di due sistemi costieri sardi: Is Arenas di Narbolia (sardegna Centro-occidentale) e Villasimius (Sardegna Sud Orientale), in DeMuro S. e De Falco G. (A cura di) - Manuale per la gestione delle spiagge - Studi, indagini ed esperienze sulle spiagge Sarde e Corse, University press – Scienze Costiere e Marine, CUEC (2010), 289-323. ISBN 978-88-8467-629-0.

[22] Pusceddu N., Batzella T., Kalb C., Ferraro F., Ibba A. & DeMuro S. – Short-term evolution of Budoni beach on NE Sardinia, Rend. Online Soc. Geol. It., Vol. 17 (2011), 155-159 (DOI: 10.3301/ROL.2011.45).

[23] Pusceddu N., Batzella T., Kalb C., Ferraro F., Ibba A., DeMuro S. – Medium and short-term evolution of two beaches on NE Sardina: La Cinta (San Teodoro, OT) and Budoni (OT), Proceedings of the "34th International Geological Congress 2012", Brisbane, Australia, 5–10 August 2012, p.1319 ISBN 978-0-646-57800-2.