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SUBMERGED GEOMORPHOSITES IN THE MARINE PROTECTED AREAS OF SARDINIA (ITALY): ASSESSMENT AND IMPROVEMENT

Paolo Orrù[1], Valeria Panizza[2] & Antonio Ulzega[1]
[1]Dipartimento di Scienze della Terra, Università di Cagliari
[2]Dipartimento di Teorie e Ricerche dei Sistemi culturali, Università di Sassari

ABSTRACT: P. Orrù *et al.*, *Submerged Geomorphosites in the marine protected areas of Sardinia (Italy): assessment and improvement.* (IT ISSN 0394-3356, 2005).
Inside the studies conducted around the theme of the improvement of the Italian geological and geomorphological heritage, studies undertaken in the ambit of different research projects and working groups, we want, with this work, to experiment and to verify the applicability of the methodologies of assessment and census of the sites of geological and geomorphological interest in submerged areas. This with the aim to gather the most greater number of possible data on the characteristics of the physical submerged resources in protected sea areas, both for scientific purpose and for a possible fruition by the public of the scuba divers. Further intent is, in fact, that to drive the "tourist" toward a more aware and global knowledge and perception of the underwater world, in all the aspects of any cultural interest, and not only for those aspects tied up to the complex of the living organisms. The experimentation of the methodology and the study on two protected sea areas of the island of Sardinia (Italy) is proposed: the protected sea area of C. Carbonara and the protected sea area of C. Caccia.

RIASSUNTO: P. Orrù et al*.,* Geomorfositi sommersi nelle aree marine protette della Sardegna (Italia) *. (IT ISSN 0394-3356, 2005).*
All'interno degli studi condotti intorno al tema della valorizzazione del patrimonio geologico e geomorfologico del territorio italiano, studi intrapresi nell'ambito di diversi progetti di ricerca e gruppi di lavoro, si è voluto, con questo lavoro, sperimentare e verificare l'applicabilità delle metodologie di valutazione e censimento dei siti di interesse geologico e geomorfologico in aree sommerse. Questo al fine di raccogliere il maggior numero di dati possibili sulle caratteristiche delle risorse fisiche sommerse di aree marine protette, sia a fini puramente scientifici che per un'eventuale fruizione rivolta al pubblico dei subacquei. Ulteriore intento è, infatti, quello di guidare il "turista" verso una percezione e conoscenza più consapevole e globale del mondo subacqueo, in tutti gli aspetti di interesse culturale, inteso nel senso più ampio, e non solo per gli aspetti legati al complesso degli organismi viventi. Si propone lo studio e la sperimentazione della metodologia a due aree marine protette dell'isola di Sardegna (Italia): l'area marina protetta di C. Carbonara e l'area marina protetta di C. Caccia.

Key words: Geomorphosites, continental shelf, palaeo-shorelines, tourism, Sardinia.

Parole chiave: Geomorfositi, piattaforma continentale, paleo-linee di riva, fruizione turistica, Sardegna.

1. FOREWORD

The present paper has the purpose to extend the already very well established growing interest in geological and geomorphological heritage of continental contexts also to the submerged areas. The marine environment is normally frequented for its biological aspects, and even experienced divers generally have no knowledge at all of the physical aspects, such as geology and geomorphology, that sustain underwater life.

More and more attention has been focussed on geological and geomorphological heritage in the past few years, leading to several researches in the framework of conservation projects, both at administrative and at scientific level involving national and international research groups. Associations such as ProGEO (European Association for the Conservation of the Geological Heritage) have the purpose of promoting the knowledge and the conservation of the geological heritage at European level, and started the compilation of a list of European Geosites. The project Geosites of the International Union of Geological Sciences (IUGS) started shortly after, with the scope of making an inventory for the collection of all data on the most important geological sites of Europe and of the World. This last project has stimulated the formation of other working groups and research projects all aiming at elaborating and improving methodologies for the inventory, selection and assessment of geological and geomorphological sites.

This research fits in the framework of such studies that have developed also in Italy in the past ten years, and has been performed inside the National Project COFIN 2001-2003 "Geosites in the Italian Landscape" and in the Working Group "Geomorphosites" of the International Association of Geomorphologists (IAG).

The aim is to make the enjoyment of the submerged resource less controlled by emotion and more by awareness through the realisation of guided diving routes. In fact, the submarine environment, more than the terrestrial one, is typically characterised by an emotional approach. To have a complete interpretation of the landscape one needs decoding instruments (Bini & Poli, 2003), thus capable of guiding the awareness of the entire system through its most significant variables once an evolutional context is identified (Panizza & Piacente, 2003).

A scientific approach aiming to the enjoyment of

the submerged geomorphological landscape is proposed in this paper taking as example a selection of sites. A geomorphosite, according to Panizza M. (2001) is "a landform with particular and significant attributes that qualify the site as part of the cultural heritage (*latu sensu*) of a territory". According to this definition the value of a geomorphosite comprises also their relationship with other significant components of their environment, such as biological, historical, archaeological etc.

The preliminary study, analysis and census of the most significant sites is followed by the realisation of guided diving routes that give the opportunity to enjoy the different aspects of geology, geomorphology, biocoenosis etc.. Similar guided diving routes are lacking in other European Marine Protected areas where biological themes are normally put in evidence, leaving geology and geomorphology as simple "containers". It is our purpose to give a central role to these last aspects for the interpretation of the submarine environment that, in many cases, is much more conservative than the terrestrial one. In the submerged environment, in fact, relict landforms, testifying past geological and geomorphological events or paleo-environments, and direct consequences of human interaction are usual better conserved than in a continental environment.

In planning submarine diving routes one needs to consider the technical preparation of the divers, differentiating routes according to the different diver's licences. Thus, the choice of the sites is limited to the depth of 40 meters, on the continental shelf, where the variety of present landforms, derived from submarine processes and in equilibrium with the present sea level, and relict landforms, related to continental processes or in equilibrium with sea level low stands, is highest. Also the biological aspects are the most interesting and varying in the same ambit, because directly correlated to the variety of the local morphological conditions.

The past negative experiences documented in Marine Reserves of the Mediterranean (Ribera Siguan, 1990; Ramos, 1990) and in the tropics (Hawkins & Roberts, 1993) suggest to devote special attention to the aspects related to the capacity of absorbing tourist presence, the so-called carrying capacity, of certain extremely vulnerable submarine environments (Agardy, 1993; Di Gregorio, 1993).

Two Protected Marine areas of Sardinia have been chosen for the experimentation of the methodology: the Marine Protected Areas of Capo Carbonara (South-East Sardinia) and of Capo Caccia (North-West Sardinia) (Fig. 1). Both areas are very different for what concerns geology and present and relict geomorphology. These differences, creating a wide variety of micro-environments, also cause different biocoenosis, adding interest and value to the single sites.

2. METHODOLOGY

2.1 Surveying methods

The mapping of the landforms and of the biocoenosis (Peres & Picard, 1964) has been done by the integrated overlapping of data acquired with different methods: for the shallow underwater environments remote sensing data have allowed to distinguish the limits of the submerged beaches and the rocky coastal abrasion platform up to a depth of 10 meters. Satellite images also allow to map the areas occupied by Posidonia oceanica up to 20 meters of depth. The survey of submerged landforms with geophysical techniques has involved the proximal continental shelf at depths between 20 and 40 meters, using vertical and side scan sonar technology. These remote sensing data have been verified by direct underwater surveys.

The specific oceanographic survey has been planned on the ground of the Nautical Maps of the Italian "Istituto Idrografico della Marina" at scale 1:100.000 and 1:50.000. The main problem in surveying and mapping submerged geomorphosites is the construction of reliable and detailed bathymetric maps in scale 1:10.000, maps that can be also the basis for the tourist and diver's enjoyment.

The following step is the preparation of a geomorphological map that represents the coast and the continental shelf using criteria and legends proposed by the Geological Service of Italy for the Geomorphological Map of Italy in scale 1:50.000.

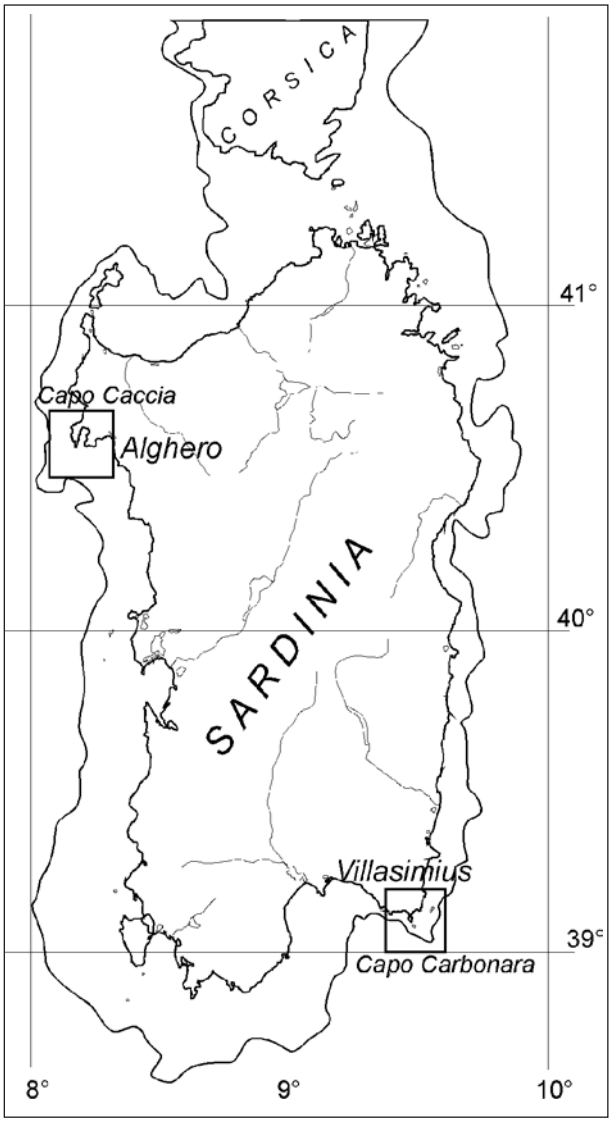

Fig. 1 - Location of the study areas.
Localizzazione delle aree di studio.

2.2 Selection and cataloguing

By means of a methodology of selection, study and cataloguing of the geomorphosites, adopted in the framework of the specific research projects mentioned earlier in this paper, several sites have been identified in both study areas. The considered sites possess one or more attributes of scientific value as an essential condition for their choice (Panizza 1988; Panizza & Piacente, 1989; Carton *et al*., 1994; Panizza & Piacente, 2003). The sites, because of the genetic characteristics of the internal continental shelf, practically always have a high paleo-geomorphological significance besides their ecological valence related to the hosted biocoenosis. In both study areas sites with the following significant valences have been chosen (Panizza & Piacente, 1989):

Model of geomorphological evolution (wave notch, karstic caves, slope of the cliff etc.);

Didactic exemplarity (fault cliff, abrasion platform, landslides, sand waves, etc.);

Paleo-geomorphological testimonial (inselberg and tor formed in continental environment, beach rocks, tafoni, carbonate precipitation forms such as stalactites and stalagmites, etc.);

Ecological valence (almost vertical walls, tafoni and karstic cavities with development of biocoenosis with Porifera and Coelenterata, isolated reliefs with concentration of big lair fish).

The sheet file, elaborated in the framework of the National Project "Geosites in the Italian Landscape" and realised by the National Geological Service and the Centre of Documentation on Geosites of Genova University, has been used for the cataloguing of the sites (Fig. 2). This sheet file, being made for the documentation of continental geosites, has been adapted and revised in some of its contents. The location of the site can be done referring to the new edition of the Topographical Map of Italy if the detail of bathymetry is sufficiently reported, otherwise the Bathymetric Maps of the Italian "Istituto Idrografico della Marina" or other bathymetric documents can be used as long as the type of Map is referred to in the sheet file. Maximum and minimum depth are indicated to know the relative depths to which one has to dive to appreciate the qualifying elements of the chosen site. Given the strict interdependence between biocoenosis and geodiversity, this last intended as the variety of morphological and lithological micro-conditions, the submarine geomorphosite will present, in the majority of cases, a secondary naturalistic or ecological interest indicated in the sheet file in Field C. Other fields of compilation, such as the field I related to the type of Soil in the original sheet file, have been enlarged to be able to contain the necessary information of certain marine environments, such as the type of seafloor: sandy, pebbly, outcropping rocks etc..

3. MARINE PROTECTED AREA OF CAPO CARBONARA

The Marine Protected Area of Capo Carbonara is located in the south-eastern most part of Sardinia and is comprised in the commune of Villasimius in Cagliari province. The promontory of Capo Carbonara closes the Gulf of Cagliari to the East with the Islets of Cavoli and Serpentara. The crystalline basement of South-East Sardinia is tectonically strongly deformed according to NW-SE lineations of Alpine age (Cherchi & Montadert, 1984). The same tectonic imprint strongly influences the coastal and the submarine landscape. The development of the coastline is characterised by iso-oriented promontories, dominated by Capo Carbonara, all of which are aligned along main veins (Brotzu & Morbidelli, 1974); the promontories of the eastern sector comprise a system of small pocket beaches.

The continental shelf is characterised by an eastern sector controlled by tectonic N-S movements and a western sector guided by NW-SE alignments, separated by the promontory of Capo Carbonara. The first researches on the south-eastern continental shelf of Sardinia concerned the types of margins and the characteristics of the sedimentary units (Lecca *et al.*, 1979). The head of the Simius canyon rises up on the border of the continental shelf, Southeast of the Islet of Cavoli, along a NW-SE direction (Lecca *et al*., 1998). Ancient coastlines, recognisable in beach rocks, have been found at depths of 45 meters (Ulzega *et al.*, 1984; Orrù *et al.*, 1997).

The submarine landscape of the Villasimius area is dominated by the outcropping of granite rocks and associated magmatic differentiated rocks; the morphological asset is organised in a system of irregular surfaces that develop at different depths. An ancient, irregular and gently seawards inclining surface of continental erosion is visible at depths between 40 and 60 meters, characterised by relict landforms such as tor and inselberg on the shallows of Berni, of Libeccio and on the isolated relief South of the islet of Serpentara. These landforms are difficult to date, even though their state of evolution does testify very long time of formation, probably related to a pre-Quaternary period characterised by warm-wet climate and a much lower sea level than today.

More rapidly evolving continental landforms, presently underwater, are the large-sized tafoni with chambers characterised by sub-spherical roofs; these landforms can frequently be found in the whole area at depths comprised between 15 and 30 meters. An irregular erosion surface fossilised by aeolian sandstones with cross-bedding, from a sedimentological point of view similar to the aeolian deposits of the actual coastline, is reported at 15 meters depth in the southern bay of the Islet of Cavoli (Palmerini, 1967). Other parts of almost horizontal surfaces with homogeneous characteristics are concentrated in some precise bathymetric intervals: an abrasion surface at average depth of 25 meters is reported at Capo Boi, in the shallows of S. Caterinia, of Libeccio and of Berni.

Active marine abrasion surfaces at depths between 1 and 3 meters border all the main promontories of the study area. The veins of acid rocks arise from these surfaces due to differential erosion.

Many sandy-conglomerate beach-rocks have been preserved on the seafloor of Villasimius both on the proximal and the external continental shelf: these are ancient shorelines related to the Holocene sea level rise. The deepest of these is located to the North of the Islet of Serpentara, at 45 meters depth; this ancient shoreline is particularly important because it can be retraced along most of the eastern continental shelf of

SCHEDA SPERIMENTALE PER L'INVENTARIO DEI GEOSITI ITALIANI

Servizio Geologico Nazionale
Dipartimento per i Sevizi Tecnici Roma

Centro Documentazione Geositi
Dipartimento Polis
Università di Genova

0 - IDENTIFICATIVO SCHEDA

REG	COD PROV.	COD COMUNE	COD RILEV.	N° SCHEDA	SCHEDA COLLEGATA	VERSIONE SCHEDA

A – NOME DEL GEOSITO: GROTTA DI NEREO

B – UBICAZIONE

REGIONE	
PROVINCIA	SASSARI
COMUNE	ALGHERO
TOPONIMO/ LOCALITÀ	CAPO CACCIA

COORDINATE GEOGRAFICHE - *UTM, GAUSS-BOAGA*

LONGITUDINE	8°9'43" EG
LATITUDINE	40°33'42" N

PROFONDITÀ MAX	31
PROFONDITÀ MIN	15
PROFONDITÀ MEDIA	18

RIFERIMENTI CARTOGRAFICI (STRALCIO CARTOGRAFICO) N. FOGLIO: F. 478 SEZ. IV — DENOMINAZIONE: Capo Caccia
SCALA: 1: 25000 — TIPO (I.G.M.):

C – INTERESSE SCIENTIFICO (1= PRIMARIO - 2= SECONDARIO/I)

GEOGRAFICO		IDROGEOLOGICO		PETROGRAFICO	
GEOLOGIA MARINA		MINERALOGICO		SEDIMENTOLOGICO	
GEOLOGIA STRATIGRAFICA		NATURALISTICO	2	VULCANOLOGICO	
GEOLOGIA STRUTTURALE		PAESISTICO	2	.....	
GEOMINERARIO		PALEONTOLOGICO		.....	
GEOMORFOLOGICO	1	PEDOLOGICO		.....	

C.1 – ALTRO TIPO DI INTERESSE(1= PRIMARIO - 2= SECONDARIO/I)

CULTURALE	
DIDATTICO	
ESCURSIONISTICO	1
STORICO	
.....	
.....	
.....	

C.2 – VALUTAZIONE INTERESSE SCIENTIFICO PRIMARIO

RARO (RA)	
RAPPRESENTATIVO (RP)	RP
ESEMPLIFICATIVO (ES)	

C.3 – GRADO INTERESSE SCIENTIFICO PRIMARIO

MONDIALE (M)	
EUROPEO (E)	E
NAZIONALE (N)	
REGIONALE (R)	
LOCALE (L)	

Fig. 2 - Excerpt of the sheet file for the inventory of the Italian geosites, compiled for the cataloguing of the Cave of Nereo (C. Caccia, Alghero).

Stralcio di scheda per l'inventario dei geositi italiani, compilata per la catalogazione della Grotta di Nereo (C. Caccia, Alghero).

Sardinia right up to the Strait of Bonifacio (Ulzega *et al.*, 1984).

The *Posidinia oceanica* meadow colonises most of the upper continental shelf of Carbonara for a total surface of over 40 square km. Coralligenous or precoralligenous biocoenosis, dominated by Gorgonia, Coelenterata in general, Porifera and calcareous Algae facies, develop especially on the cliffs or on isolated blocks. The deepest biocoenosis are represented by carbonate constructions of Algae with *Pseudolithophyllum expansum*. The littoral bench of the Vermetid *Dendropoma* is the only animal biological construction represented in the area and found in the northern part of the islet of Cavoli; this Gastropod formation is very important being an indicator of the most recent variations of sea level. This is the northernmost occurrence of this kind of biological constructions along the Italian coasts; similar formations are well

developed along the northern coasts of Sicily. The submarine surveys have allowed to map the main biotic communities in detail (Meinesz et al., 1983), putting also in evidence the tight existing interrelations between geomorphological characteristics, distribution of morpho-sedimentary units and main benthic biocoenosis.

In the framework of the geomorphological context of the continental shelf of Carbonara the site named "shallow of Berni" has been selected according to the previously described criteria. This isolated almost surfacing granite relief is located offshore the Simius Bay, in an axial position respect to the channel between Capo Carbonara and the Islet of Cavoli. The shallow of Berni is a tor represented by a central column of 15 meters height, circled by residual peaks and accumulations of big sub-spheroidal tafoni (Fig. 3). The ancient, gently seawards inclining continental erosion surface, characterised by a biocoenosis of *Posidonia oceanica* and Coralligenous platform reefs with red Algae (*Pseudolithopyllum expansum*), locally crops out at the foot of the relief.

The dominating valence of this selected geomorphosite is the paleo-geomorphological and paleogeographical one, related to the evolution of a broad continental erosion surface now submerged. Also the biological valence related to the strong currents and to the related circulation of nutrients is very important. Another important aspect is related to the historical and cultural importance of this site, being a privileged embarkation point for horses and herds from Sardinia to other beaches of the Mediterranean starting from the Roman Imperial period; this practice continued during the Medieval and arrived up to the XIX century. Nowadays an exceptional concentration of shipwrecks and ceramics of different ages together with animal remains are found.

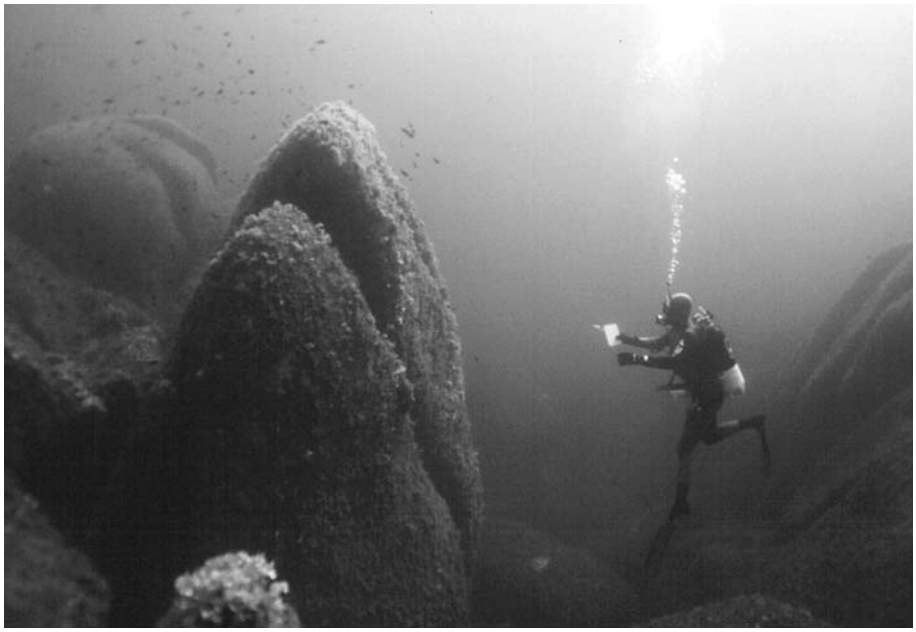

Fig. 3 - Simius Bay – Berni shallow. Picture of the bottom at -15 m. Residual pinnacles and sub-spherical blocks on the border of a Tor relief; a network of joints in which archaeological remains are concentrated and conserved develops at the foot of the ridge.

Baia di Simius - Secca dei Berni . Foto del fondo a -15 m. guglie residuali e blocchi sub-sferoidali ai bordi del rilievo a tor; alla base delle cornici si sviluppa un reticolo di diaclasi, luogo di concentrazione e di conservazione dei materiali di interesse archeologico.

4. PROTECTED AREA OF CAPO CACCIA

The promontory of Capo Caccia is located in Northwest Sardinia, in the so-called Nurra of Alghero, in the territory of the commune Alghero in Sassari province. Is characterised by high cliffs that arrive at heights of 170 meters a.s.l., forming, in its southern extremity, a N-S directed promontory that closes the broad Gulf of Porto Conte to the Southwest.

Capo Caccia is part of the Regional Natural Park of Porto Conte, instituted in 1999 and comprising, aside the promontory, the entire peninsula, with the hilly complex of Monte Timidone (361 m), the Bay of Porto Conte and, towards the East, the vast territory that extends from Monte Doglia (436 m) up to the rocky promontory of Punta Giglio. The Marine Protected Area of national interest "Capo Caccia-Porto Conte-Punta Giglio" has been instituted recently and includes the near shore seafloor of the Regional Natural Park up to a depth of 50 meters.

The whole Mesozoic carbonatic sequence crops out in the area, except for some local Quaternary deposits and the Permian-Triassic alluvial plain sediments (*Verrucano Sardo*, Pecorini, 1962) that characterise the coastal strip North of Cala Viola. This Mesozoic sequence represents a general transgression of this part of Sardinia with the deposition of carbonate platform sediments characterised by limestones, dolomitic limestones, marly limestones and marls. The platform sedimentation is interrupted by a bauxite deposition during meso-Cretaceous, representing a period of emersion and thus continental tropical or sub-tropical warm-wet climatic conditions (Carmignani *et al*., 2001).

The thick carbonatic sequences of neritic environment of Upper Cretaceous, attaining their maximum thickness of 140 meters at Capo Caccia, evidence a general return to typical marine conditions (Carmignani *et al*., 2001). The main tectonic alignments mostly of Tertiary age are directed N-S and NW-SE (Cherchi & Montadert, 1984) and guide the evolution of the morphologies characterised by scarps in the internal areas and also control the high cliffs that are typical of the entire coastal perimeter of Capo Caccia (Federici *et al*., 1999; Ginesu, 1999).

From a geomorphological point of view the whole area is characterised by a wide variety of landforms deriving from intense and differentiated fossil and still active processes of karst dissolution. For what concerns the

promontory of Capo Caccia the impressive cliffs that characterise its entire profile and continue along the whole western coast of the peninsula, reaching a height of 203 meters, show active processes of retreat and several levels of wave notches related to the Quaternary sea level variations. Many and complex natural caves are clearly visible along the calcareous cliffs, and many of these are accessible only by diving. A first karstic phase is related to the continental meso-Cretaceous period, enhanced by the wet and warm climatic conditions (Federici *et al*., 1999). A paleokarst phase can thus be hypothesised along faults and discontinuities during Cretaceous, before the Upper Cretaceous transgression and marine sedimentation (Mucedda *et al*., 1997). Other karst dissolution phases followed the first one in the geological and climatic history of Sardinia, and the presence of many caves along the coast testifies a long-during dissolution enhanced by an intense underground circulation (Ginesu, 1999).

In this particular geological and geomorphological context the methodology for selecting and cataloguing geomorphosites has been directed towards the many submarine caves present along the cliffs of the Capo Caccia promontory. The Nereo cave has thus been chosen, for its genetic characteristics, for its importance in the reconstruction of paleo-environments, for the variety and the differentiation of its ecosystems and for its potential to attract tourists, many of the attributes that can give value to this geological and geomorphological site (Panizza & Piacente, 2003).

The Nereo cave is located at the foot of the promontory of Capo Caccia, hosted in white and compact limestones of Lower Cretaceous in which many of the caves of the promontory are formed. The cave was discovered in 1957 by two local divers and has become famous especially for the presence of many colonies of red coral (*Corallium rubrum*). Today, unfortunately, this coral is present only in small groups in the less exposed sites of the cave (Chessa *et al*., 1991). Only recently the cave has been thoroughly explored and surveyed for a total development of more than 400 meters, along a complex series of chambers, tunnels and shafts. The Nereo cave, that represents the biggest sea cave of the Mediterranean, has 7 communicating entrances located at variable depths between 8 and 31 meters, of which only three can be defined as main entrances (Mulas, 2000). The cave, in this case, has a mixed origin, being formed by a combination of karstic and marine erosion phenomena (Chessa *et al*., 1999). The deepest entrance (-31 meters) opens towards the North, corresponding to the Cala del Sommergibile, and leads into a big chamber which floor is covered with rocks fallen from the roof and sandy patches. Many tunnels start from here and lead towards the other two entrances, one to the West one to the South. The most external parts of these tunnels often show clear pebbles modelled by marine abrasion, sandy sediments and fragments of sea shells. From the biggest chambers and from the main branches departs a labyrinth of tunnels and fissures, not always accessible, some of which develop vertically (sumps) and open in subaerial and concretioned parts of the cave, with stalactites and stalagmites (Mulas, 2000; Chessa *et al.*, 1999). These parts of the cave have been explored only very recently and are accessible only to expert and well equipped cave divers. Also the western entrance, at 18 meters depth, leads into a very big chamber characterised by big blocks at the entrance forming a beautiful sight. From here one can proceed towards the South to gain the third entrance that has two openings one above the other, respectively at 9 and at 14 meters depth. One of the few remaining colonies of red coral can be seen in correspondence of this entrance, towards the left. The big blocks, with differing degree of biological colonisation, present at the different entrances are the proof that the cliffs are still retreating and subjected to sporadic rockfall. Furthermore, a deep wave notch can be seen at the foot of these active cliffs.

Aside the evident valence of the cave as a model of geomorphological evolution, the dimensions of the littoral-karstic phenomenon and its relationships with the actively retreating of the cliffs, together with the paleo-geomorphological meaning of this site is of great value and significance. In fact, erosion forms related to the sea level variations and stalactite-stalagmite constructions with submarine and subaerial cements are well conserved. The presence of numerous colonies of Coelenterata (*Ceriantus membranaceus* e *Corallium rubrum*), typical of sciophilous environments, gives this site also a great ecological valence.

CONCLUSIONS

The tourist offer in Marine Protected Areas and Marine National Parks in the Mediterranean, especially in the submarine field, is related almost exclusively to the ecological valences and the value of the different submerged areas is essentially related to the level of biodiversity. Exception is made for some protected areas of Sicily, of Greece and of Turkey where cultural aspects dominate, related to the presence of important submerged archaeological resources.

The submerged landscape has thus been relegated to the role of “container” for the other valences.

In this paper a different role of the submerged landscape is put forward, following the recently introduced and proposed concepts (Panizza, 2001; Panizza & Piacente, 2003; Piacente & Poli, 2003) and the application of new methodologies for the selection and the assessment of environmental assets with a high geomorphological relevance. The examples described in this paper, in fact, show that this submerged landscape explains itself in an autonomous way, by its own physical character of great suggestion and by its history and evolution visible in the mosaic of landforms and deposits that compose a geomorphological and paleo-geomorphological picture (Fig. 4).

Also the potentiality expressed by the integration with biological and historical-cultural valences is of great interest.

In making submerged geomorphosites enjoyable one has to keep in mind the risk of damaging these sites, especially in the case of very fragile landforms and microforms (tafoni and residual granite blades, wall concretions and stalactites in natural caves, etc.). It is thus very important to plan and control the visits on the basis of a detailed analysis of the carrying capacity of the sites.

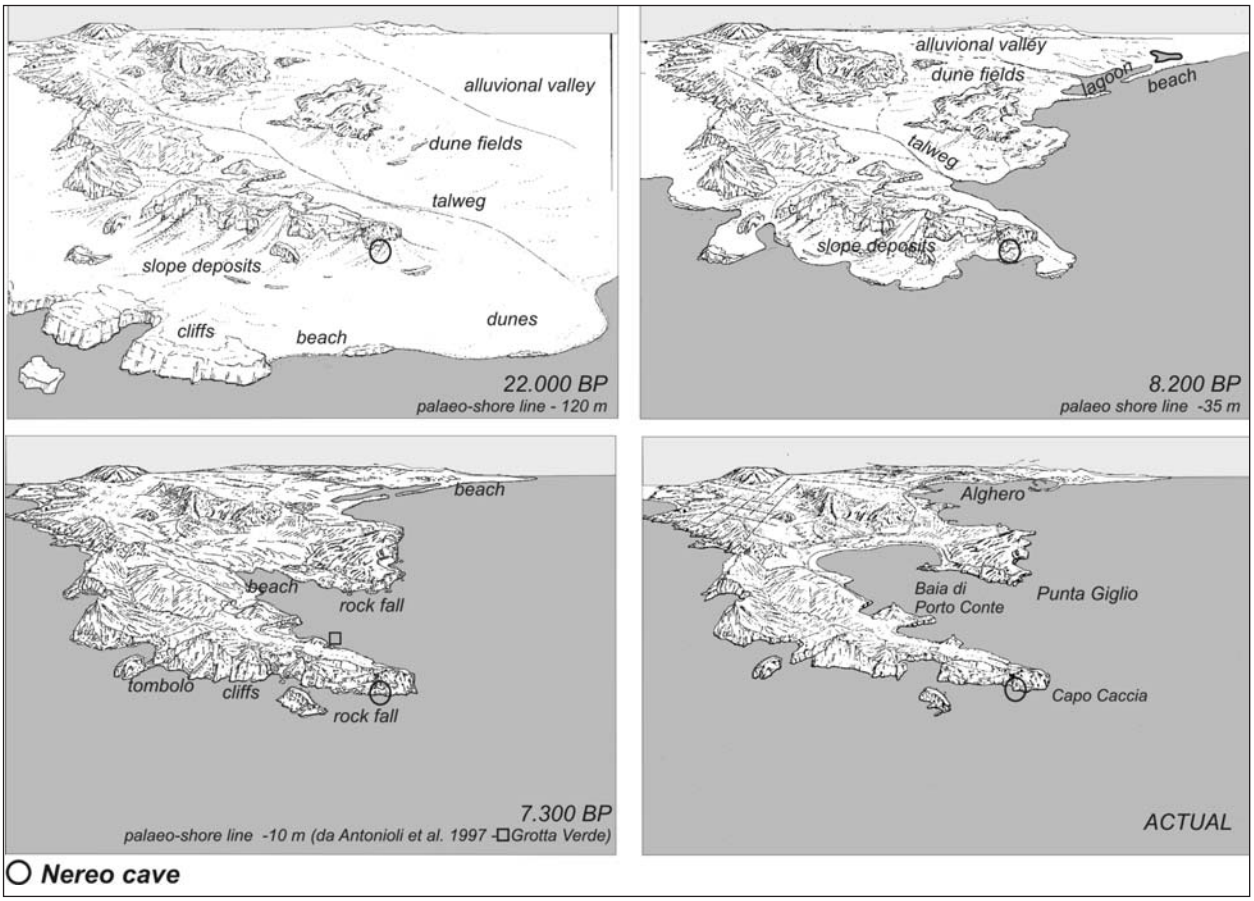

Fig. 4 - Palaeo-geographical reconstruction of the Capo Caccia-Punta Giglio area and location of the Nereo cave, based on the coastal and continental shelf geomorphological surveys.

Ricostruzione paleo-geografica dell'area Capo Caccia-Punta Giglio sulla base di indagini geomorfologiche costiere e in piattaforma continentale e localizzazione della Grotta di Nereo.

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