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First report of live deep-water cnidarian assemblages from the Malta Escarpment

L. ANGELETTI[1], A. MECHO[2], C. DOYA[2], A. MICALLEF[3*], V. HUVENNE[4], A. GEORGIOPOULOU[5], & M. TAVIANI[1]

[1]*ISMAR-CNR, UOS Bologna, Italy,* [2]*Institut de Ciències del Mar, CSIC, Passeig Marítim de la Barceloneta, Spain,* [3]*Department of Physics, Faculty of Science, University of Malta, Malta,* [4]*National Oceanography Centre, University of Southampton Waterfront Campus, United Kingdom, and* [5]*School of Geological Sciences, Science Centre, Belfield, University College Dublin, Ireland*

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Abstract
A recent geo-marine survey of the Malta Escarpment revealed for the first time the existence of live cnidarian assemblages at about 300 m depth. These associations have been observed by means of a remotely operated vehicle (ROV) during surveys carried out on the upper part of the Malta Escarpment. The assemblages established on hard bedrock were chiefly composed of the antipatharian *Leiopathes glaberrima*. The Malta Escarpment is known to have been successfully colonised by deep-water scleractinian assemblages until the last glacial age. However, no living specimens had been observed, and only specimens of dead but relatively fresh *Dendrophyllia cornigera* had been reported. This area of the Mediterranean Sea, which connects the deep Ionian basin to the western Mediterranean, is largely unknown and in clear need of thorough exploration.

Keywords: Leiopathes glaberrima*, cnidarian assemblages, Malta Escarpment, ROV, central Mediterranean*

Introduction

The routine application of detailed multibeam mapping, coupled with remotely operated vehicle (ROV) inspection of promising submerged topographies, has often led to the discovery of deep-water habitats characterised by sessile megabenthic communities in the Mediterranean Sea. By and large, the most relevant actors of such aphotic communities are cnidarians and sponges associated with poorly sampled hard bottoms at depths exceeding 200 m. This is primarily the case for the so-called white coral communities documented at bathyal depths in the Strait of Sicily, southern Adriatic, Ionian, Ligurian, Marmara, northwestern Mediterranean and Alboran seas (Tursi et al. 2004; Taviani et al. 2005a, 2005b, 2011a; Freiwald et al. 2009; Mastrototaro et al. 2010; Vertino et al. 2010; Gori et al. 2013; Angeletti et al. 2014; Fabri et al. 2014), the sponge-dominated habitats in the Tyrrhenian, Ionian and Adriatic seas (Bo et al. 2012; Calcinai et al. 2013), and antipatharian–gorgonacean communities in the Tyrrhenian, Ionian and Adriatic seas and in the Strait of Sicily (Costantini et al. 2010; Taviani et al. 2010; Bo et al. 2011; Angeletti et al. 2014; Deidun et al. 2014). From this ecological perspective, the Malta Escarpment in the central Mediterranean happens to be one of the least explored in European waters. It borders westwards the deep Ionian Sea and comprises the eastern entrance into the Strait of Sicily, both areas hosting significant deep-water coral presence (Taviani et al. 2011a). A recent ROV-assisted geo-marine survey inspected the upper part of the north Malta Escarpment, discovering for the first time live cnidarian assemblages dominated by antipatharians (black corals) in this region. The scope of this study is to describe new findings of hard-bottom assemblages present in the upper Malta Escarpment.

Regional setting

The Malta Escarpment is a dominant physiographic element in the central Mediterranean Sea

*Correspondence: A. Micallef, Department of Physics, Faculty of Science, University of Malta, Msida, MSD 2080, Malta. Tel: +356 23403613. Fax: +356 23403613. Email: aaron.micallef@um.edu.mt

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(Figure 1a). It consists of a steep, NNW–SSE trending slope that extends southwards from the east coast of Sicily for 250 km with a vertical relief of up to 3.5 km (Biju-Duval et al. 1982, 1983; Groupe Escarmed 1982). The Malta Escarpment is the expression of a passive margin separating the continental crust of the Malta Plateau from the oceanic crust of the Ionian Basin (Argnani & Bonazzi 2005). The age of the Malta Escarpment remains controversial, with estimates ranging from Late Triassic to Early Cretaceous (Argnani et al. 2012). Triassic–Neogene shallow-water to basinal carbonate sequences outcrop along the escarpment (Scandone et al. 1981; Casero et al. 1984). The Malta Escarpment incorporates extensional block faulting and sinistral strike-slip deformation as a result of the different rates of underthrusting between the buoyant Malta Plateau and the Ionian crust (Grasso 1993; Adam et al. 2000; Catalano et al. 2000). The Malta Escarpment can be classified as a sediment-starved margin (at least since the Messinian), with an estimated post-Messinian sedimentation rate of ~6 cm ka^{-1} (Max et al. 1993; Osler & Algan 1999). A series of submarine canyons has been mapped from bathymetric data acquired in the late 1970s (Scandone et al. 1981). Landslide activity across the Malta Escarpment had mainly been inferred from sediment cores, with turbidites, megaturbidites and debris flows being reported from the base of the Malta Escarpment (Scandone et al. 1981; Casero et al. 1984; Rebesco et al. 2000). More recently, submarine landslides, in the form of translational slides, spreads and debris flows, have been shown to be a widespread geomorphologic phenomenon across the outer Malta Plateau and upper Malta Escarpment (Micallef et al. 2013). The outer Malta Plateau also hosts four channels and a number of straight to non-linear bedrock ridges (Micallef et al. 2013).

Material and methods

The outer Malta Plateau and upper Malta Escarpment (Figure 1a) were surveyed during the CUMECS (Canyon processes in sediment-undersupplied margins: A geomorphometric investigation of the Malta Escarpment submarine canyons) cruise (28 June–2 July 2012) on board the R/V (Research Vessel) Urania. Swath bathymetry data were acquired from 370 km^2 of seafloor using a Kongsberg Simrad EM710 multibeam echosounder with a nominal sonar frequency of 70–100 kHz (Micallef et al. 2013). An ROV dive was carried out to obtain video footage and still photographs of small-scale morphology, benthic habitats and biota from the canyon heads in order to ground-truth the acoustic data. The ROV carried a forward-looking 1/3 ” Sony CCD (charge coupling device) colour video camera placed inside the pod. Video frames of the seabed described in the present study were acquired along one transect on the upper Malta Escarpment (Figure 2; Table I). The survey lasted approximately 5 h. The covered distance was ca. 2.7 km and the depth range surveyed was from 300 to 537 m depth. One bottom sampling was carried out across a non-linear bedrock ridge using a rock dredge to allow the correct taxonomic identification of the species observed by ROV (Table I).

Results

ROV imagery shows a general habitat covered with a thick drape of fine-grained sediment displaying a wide variety of bioturbation features. Sedimentary bottoms of the shelf edge and upper slope (300–310 m) were colonised by octocorals such as *Funiculina quadrangularis* (Pallas, 1766) (Figure 2). Fish fauna included the trumpet fish, *Macroromphosus scolopax* (Linnaeus, 1758), *Helicolenus dactylopterus* (Delaroche, 1809), *Lepidopus caudatus* (Euphrasen, 1788), *Polyprion americanus* (Bloch and Schneider, 1801) and *Naucrates ductor* (Linnaeus, 1758).

The ROV dive showed the presence of antipatharian assemblages on a bedrock ridge of the Malta Escarpment, where large colonies of two different black coral species, *Leiopathes glaberrima* (Esper, 1788) and *Antipathes dichotoma* (Pallas, 1776), were observed at depths of 310–315 m (Figure 2). Colonies are sparsely distributed along the ROV track, although *L. glaberrima* dominates over *A. dichotoma*. Most of the colonies appeared healthy, although some showed signs of degradation. *L. glaberrima* branches hosted decapods (i.e. *Anamathia rissoana* Roux, 1828), barnacles (i.e. *Verruca* sp.) and other unidentified fauna.

Somewhat deeper (342 m depth), gorgonians (e.g. cf. *Paramuricea macrospina*) and encrusting yellow and blue hexactinelliid sponges were found. Vagile benthos included crustaceans (i.e. *Munida tenuimana* Sars, 1872) and echinoids (i.e. *Cidaris cidaris* Linnaeus, 1758)

Along the transect we observed several linear elongate depressions on the sediment surface, which we interpret as trawl marks, as well as lost fishing gear snagged around the rock outcrops.

Dredged material from one of these escarpments consists of carbonate hardgrounds.

Discussion

The high, steep and sediment-starved flanks of the Malta Escarpment are ideal sites for the formation of hardgrounds, which also served as

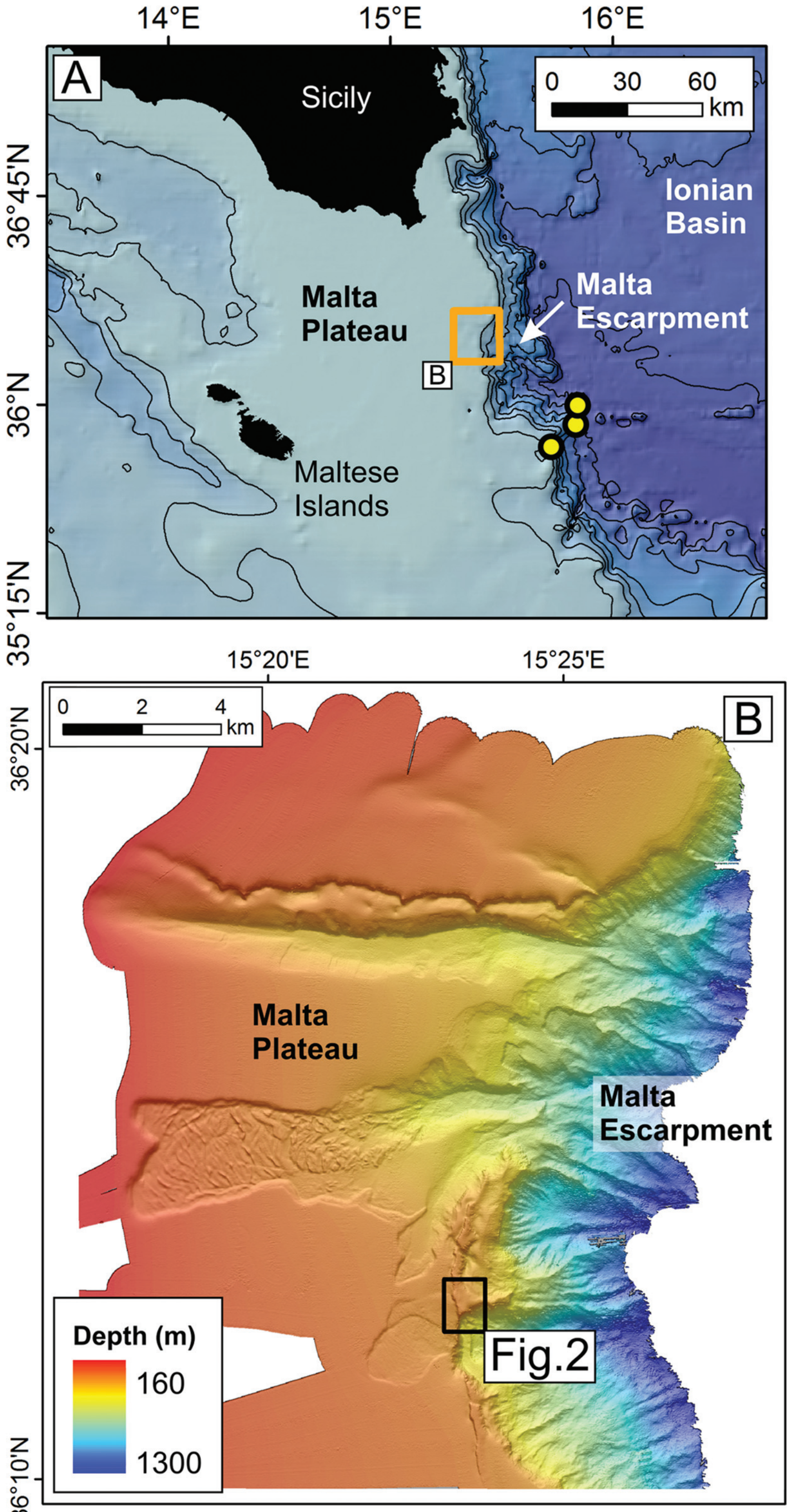

Figure 1. (A) Bathymetric map of the Malta Escarpment, central Mediterranean Sea (Source: IOC et al. 2003). The yellow dots indicate the locations of glacial Pleistocene deep-water coral hardgrounds found during previous campaigns (Taviani & Colantoni 1984). (B) Detailed multibeam bathymetric data of the upper Malta Escarpment, acquired during the CUMECS cruise, where the live cnidarian-dominated assemblages were discovered.

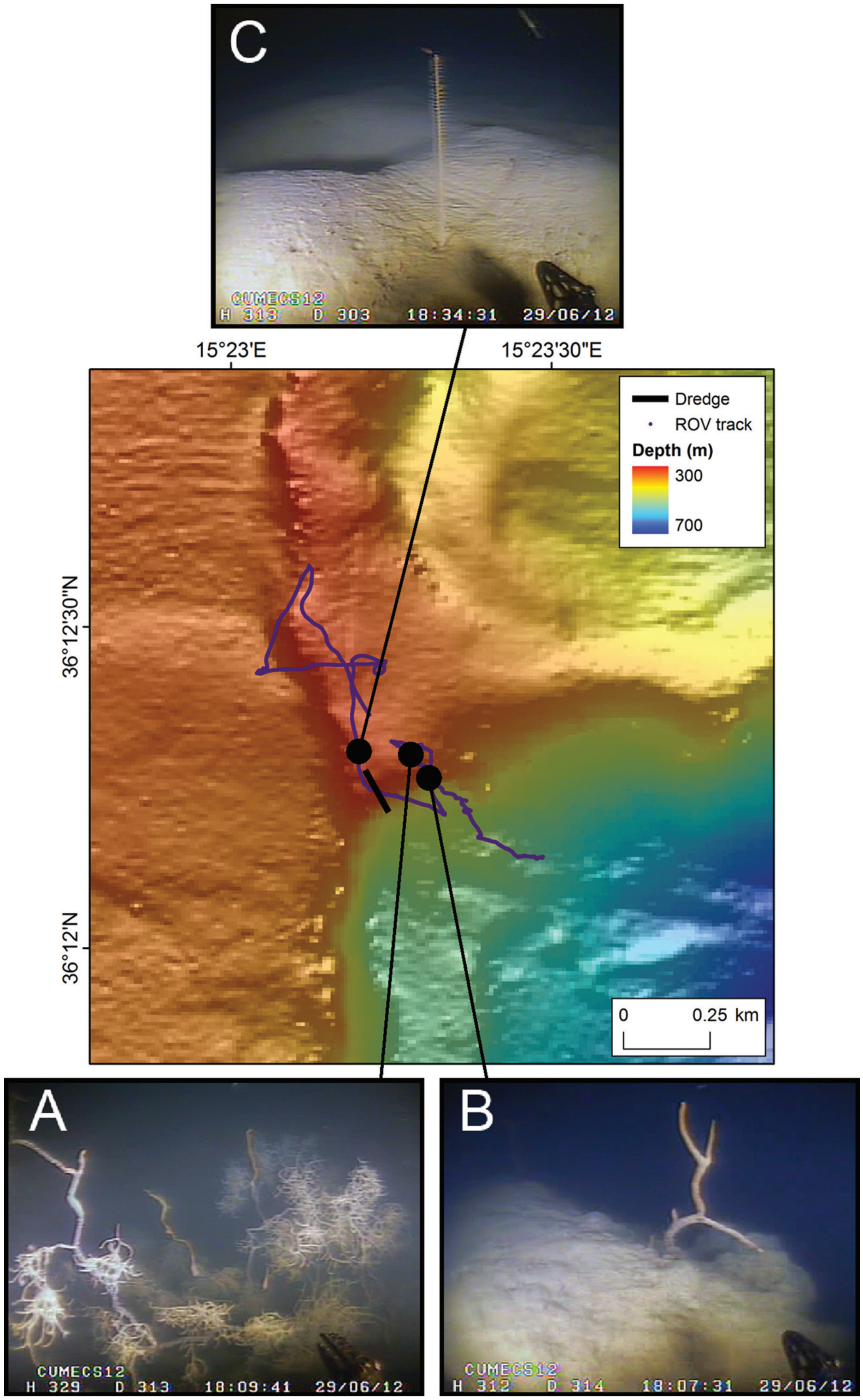

Figure 2. Detail of the Malta Escarpment showing the track of remotely operated vehicle (ROV) dive and dredge with photos of emblematic cnidarians: (A) most dense aggregation of the antipatharian *Leiopathes glaberrima* (313 m depth); (B) moribund/dead stalk of black coral (314 m depth); (C) a specimen of the octocoral *Funiculina quadrangularis*, a common inhabitant of deep-sea muddy bottoms (303 m depth).

substrate to a variety of encrusting organisms and sessile megabenthos since at least the Pleistocene (Biju-Duval et al. 1983; Allouc 1986, 1990). As such, the escarpment has also been episodically colonised by deep-water corals and other macrobenthic epifauna. This is proven by abundant

Table I. Location and depth of the remotely operated vehicle (ROV) track and dredge station discussed in text. The track of the ROV dive is not a straight line going from deep to shallow, but an irregular line that at some points covered seabed shallower than the 325 m at the final point (e.g. one of the shallowest areas explored was at 310 m where *Leiopathes glaberrima* was found).

Start			Finish		
Latitude	Longitude	Depth	Latitude	Longitude	Depth
ROV track					
36.202349°N	15.391455°E	537 m	36.206037°N	15.386949°E	325 m
Dredge track					
36.203519°N	15.387432°E	415 m	36.204625°N	15.386820°E	319 m

skeletal remains of scleractinians dredged and observed by submersible dives at depths exceeding 2000 m during Italian and French missions in the 1980s (Cita et al. 1979, 1980; Taviani & Colantoni 1984). None of the observed organisms had been proven to be alive. By and large, deep-water corals are represented by well-preserved, still- aragonitic sub-fossil corallites embedded into micritic authigenic crusts, the external surfaces of which are patinated by manganese (Mn)–iron (Fe) oxides (Taviani & Colantoni 1984). A distinct assemblage dominated by the cosmopolitan solitary taxon *Desmophyllum dianthus* (Esper, 1794), with minimal intermixing with colonial species, was identified between 2500 and 3500 m. Coral rubbles of *Dendrophyllia cornigera* (Lamarck, 1816) were present at such depths, but no live colonies had been observed. These sub-fossil corals have been dated to the last glacial age (Delibrias & Taviani 1985), and represent a distinct deep-water coral assemblage that inhabited the Mediterranean Sea during the glacial Pleistocene. Such assemblages have mostly been reported at considerable depths in the Mediterranean basin (e.g. Eastern Mediterranean Basin, Zibrowius 1981; Taviani et al. 2011b).

Our study produces evidence that sessile megabenthos, especially the black coral *Leiopathes glaberrima*, forms live assemblages at shallower depths in association with gorgonians, and confirms their cosmopolitan distribution in the Mediterranean waters at depths down to 300 m (e.g. Bo et al. 2009; Deidun et al. 2010; Angeletti et al. 2014; Deidun et al. 2014). In some cases, *L. glaberrima* provides a habitat for commercially important crustaceans, as reported in the Atlantic and Pacific Oceans (e.g. Le Guilloux et al. 2010; Cañete & Haussermann 2012).

To the best of our knowledge, no information on living deep-water scleractinian corals on the Malta Escarpment was available until the present study. This is puzzling, considering the fact that live colonies of deep-water corals such as *Lophelia pertusa* (Linnaeus, 1758), *Madrepora oculata* (Linnaeus, 1758), *Dendrophyllia cornigera* (Lamarck, 1816) and the solitary coral *Desmophyllum dianthus* (Esper, 1794) have been well documented in the Strait of Sicily and elsewhere in the Ionian Sea, at depths comparable to those in the present study (Schembri et al. 2007; Freiwald et al. 2009; Angeletti & Taviani 2011; Taviani et al. 2011a). Most occurrences in our study area often referred to dead pre-modern material (e.g. Fink et al. 2012; McCulloch et al. 2012). Nevertheless, it seems unlikely that the Malta Escarpment as a whole would be deprived of such cnidarians. Our discovery of living antipatharians may suggest that the absence of deep-water coral reports in this area could be the result of the paucity of studies carried out on the Malta Escarpment. Our results stress the need to increase the geo-marine sampling effort across the Malta Escarpment for a more complete assessment of biodiversity in the central Mediterranean basin.

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