Macro- and megafauna recorded in the submarine Bari Canyon (southern Adriatic, Mediterranean Sea) using different tools

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Abstract
Macro- and megafauna were recorded in the submarine Bari Canyon, located in the southern Adriatic Sea (Mediterranean Sea) during an oceanographic cruise carried out in May-June 2012 and an experimental fishing survey conducted in November 2013. During the former, 20 benthic samples were taken using a Van Veen grab at depths between 268 and 770 m and four deployments of a baited lander, for approximately 43 hours of video records, were carried out at depths between 443 and 788 m. During the latter, eight longline fishing operations were conducted from 338 m down to 612 m. Eighty-five living benthic and bentho-pelagic species were recorded: 29 Porifera, 1 Cnidaria, 2 Mollusca, 11 Annelida, 1 Arthropoda, 19 Bryozoa, 3 Echinodermata, and 19 Chordata. Fifty-one species are new records for the Bari Canyon, and 29 species are new records for the Adriatic Sea. Among the Porifera Cerbaris curvispiculifer is a new addition for the Italian sponge fauna.

Keywords: Canyon, Deep-sea coral, Macrofauna, Megafauna, Distribution, Biodiversity, Mediterranean.

Introduction
The Mediterranean Sea is a semi-enclosed basin characterised by more than 500 submarine canyons widespread along the continental margin (Harris & Whiteway, 2011). Some of them, mostly in the western Mediterranean, have long been investigated in relation to their morpho-sedimentology and oceanographic processes (e.g. Berne et al., 1999; Canals et al., 2004, 2009; Puig et al., 2008) as well as to their biodiversity and fishery resources (e.g. Cartes et al., 1994; Stefanescu et al., 1994; Gili et al., 2000; Palanques et al., 2005; Sardà et al., 2009; Farrugio, 2012; Revenge Martinez de Pazos, 2012; Fabri et al., 2014). In the last two decades, the canyons have been investigated as a part of national projects carried out in different countries as well as in the context of European projects designed to gain new insight into the biodiversity, ecosystem structure, and function in the deep sea (e.g. EUROMARGE, HERMES, HERMIONE). In fact, canyons act as conduits favouring dense shelf water cascades and transport of sediments, organic matter and nutrients from the continental shelf to the deep sea, enhancing the abundance and the diversity of benthic and bentho-pelagic fauna (De Leo et al., 2010; Ramírez-Llodra et al., 2010). Canyons can provide spawning and recruitment areas for this type of fauna (e.g. Sardà et al., 1994, 2009). The upwelling generated by the local water mass dynamics enhances local primary productivity, influencing the food chain up to mammals and birds (e.g. Danovaro et al., 2010; Vella & Vella, 2012; Würtz, 2012). Moreover, the increasing interest in the biocology of the Mediterranean canyons is also related to the high rates of endemism and the presence of Cold-Water Corals (CWC) (e.g. Gili et al., 2000; Freiwald et al., 2009; Orejas et al., 2009). The downwelling currents, which enhance the availability of trophic resources associated with the complex physical setting, make canyons favourable habitats for suspension feeders such as CWC (Freiwald et al., 2009; Orejas et al., 2009; Madurell et al., 2012).

One of these Mediterranean canyons characterised by the presence of CWC, episodic cascading processes and habitat heterogeneity is located off the city of Bari in the southern Adriatic Sea (central Mediterranean). The role
of this canyon in sediment transport and water cascading processes has been well documented (Ridente et al., 2007; Trincardi et al., 2007; Turchetto et al., 2007; Verdiècio et al., 2007; Rubino et al., 2010) whereas less effort has been devoted to the assessment of its biodiversity. In this respect, the Bari Canyon was explored during the HERMES and HERMIONE cruises, using Remotely Operated Vehicles (ROVs) and revealing a CWC community mainly structured by *Madrepora oculata* and to a lesser extent, by *Lophelia pertusa* and *Dendrophyllia cornigera* (Freiwald et al., 2009). Solitary corals, sponges, serpulids, boring clams, and colonies of bryozoans were also recorded during these cruises (Freiwald et al., 2009; Bo et al., 2012; Sanfilippo et al., 2013). In particular, the sponge *Pachastrella monilifera* mixed with living colonies of the scleractinian *M. oculata* dominates the deep assemblage in the Bari Canyon, between 380 and 500 m (Bo et al., 2012). A remarkable abundance of the tubeworm *Serpula vermicularis* associated with *M. oculata* build-ups and other stony corals were also observed to increase the biogenic frameworks and habitat complexity (Sanfilippo et al., 2013). The study of dead molluscs from the Bari Canyon led to 55 species being identified, from typical epibathyal mollusc communities currently present in the Mediterranean basin as well as those from Würmian paleocommunities (Panetta et al., 2013). Corals and a variety of sessile benthic organisms contribute to creating complex three-dimensional habitats exposed to high sedimentation rates and attract numerous species of mobile invertebrates (mainly echinoderms) and fish, as recently reported by Angeletti et al. (2014). Fish faunal composition and behaviour have also recently been investigated using a baited lander (D’Onghia et al., 2014).

Benthic macro- and megafauna were collected using a grab during an oceanographic cruise carried out in 2012 and benthic-pelagic megafauna was recorded using a lander equipped with digital cameras. A bentho-pelagic megafauna was also caught during an experimental longline survey carried out in 2013. The results on the taxonomy and distribution of the macro- and megafauna collected during these cruises are provided in this paper with the aim of updating knowledge on the biodiversity in the Bari Canyon. Due to the different tools (grab, lander, longline) used on different substrates as well as the different sampling period and effort by tool, no quantitative analyses have been undertaken here.

**Materials and Methods**

The Bari Canyon System (BCS) is a complex morphological structure that cuts through the south-western Adriatic shelf with a west-east trend. It is 10 km wide and 30 km long ranging between 200 and 1700 m in depth. The BCS consists of two main branches separated by a mounded relief, a slope-confined trough between 500 and 700 m in depth. The southern branch is wider (approximately 4 km), markedly asymmetrical and U-shaped with a very steep wall (Fig. 1) (Ridente et al., 2007; Trincardi et al., 2007).

An oceanographic survey was carried out from 28 May to 1 June 2012 using the R/V MINERVA UNO. The fauna was sampled using a grab and observed by means of a baited lander. Samples were taken using a Van Veen grab with a collection surface of 0.2 m$^2$ and a sediment volume of up to 0.06 m$^3$. Van Veen grab samples were collected at depths between 268 and 770 m, both on the rocky walls and on the soft seafloor of the canyon. Due to the steep slope of the walls only 20 positive samples were obtained, 7 on rocky substrate and 13 on the sediment (Table 1). The samples were washed in multiple sieves. Soft-bodied animals belonging to Cnidaria and Annelida were immediately anaes-
thetized with a saturated solution of menthol in sea water for 2-4 hours depending on the nature and size of the individual or colonies. All species were fixed on board in 5% formaldehyde solution with sea water and afterwards preserved in 70% ethanol. All specimens were identified in the laboratory to the lowest possible taxonomic level and counted. Invertebrate species identification was performed using the most recent identification manuals. For sponges, slides of dissociated skeletal elements were prepared and observed under an optical microscope. In addition, for the identification of some sponge species, transverse sections of paraffin wax-embedded samples were prepared and observed using an optical microscope. The nomenclature adopted for the different taxonomic groups is that reported in the relevant updated check-lists. In particular, for bryozoans, systematic order follows the working list available online at http://www.bryozoa.net, while for all the other taxa the systematic order is that reported online at http://www.marinespecies.org (WoRMS, or the World Register of Marine Species).

The MEMO (Marine Environment MOnitoring system) lander was also deployed in the southern branch of the Bari Canyon. This lander, developed as part of the CoralFISH EU_7FP project, consisted of a stainless steel metal frame, two digital cameras (Sony ICX414) with two LED lights (12 V, 700 mA), an electronic compass, inclinometer and altimeter, a multiparametric probe, a doppler current meter, four Deep-Sea batteries for power supply, and an ICT infrastructure capable of managing...
the entire system (D’Onghia et al., 2014). On the seabed the lander is linked by a zinc-coated steel cable to buoys which keep the cable under tension and then to a surface floating signalling buoy. Continuous connection is maintained via an acoustic modem with an onboard PC software platform, making images and sensor data available. A total of four deployments between 443 and 788 m were carried out, for a total time of 43 hours of video recordings (Table 1). Considering that the MEMO system takes four video frames each second, 619,200 video frames were taken by each camera. During each deployment the lander was baited with specimens of the teleost fish Scomber scombrus. The bait produces an odour plume stretching downstream from the lander and attracting animals in view of the camera (Bailey et al., 2007). The hydrographic parameters at each station were also recorded by means of CTD and a current meter. The mean salinity recorded on the bottom was 38.72 psu, the mean temperature values varied from 13.32 to 13.38°C, and those of the current speed from 0.06 to 0.14 m s⁻¹.

The different species were identified using morphological characteristics observed in the video frames. In addition, the single individuals of all recorded species could often be distinguished by their different sizes and morphological features, such as marks and scars on the skin. This was not the case for the blackspot sea bream Pagellus bogaraveo since individual numbers gradually increased after lander touchdown but with individuals moving in and out of camera view it was impossible to distinguish between the individuals (D’Onghia et al., 2014).

A longline experimental survey was carried out in the Bari Canyon during November 2013. A commercial fishing vessel was hired, equipped with a 3 km monofilament longline with 500 hooks and snoods of 2.5 m in length; the types of hooks employed were J-hook 7 and J-hook 10. Sardinia pilchardus was used as bait. The longline is a selective gear and its selectivity mostly depends on the type of hooks employed. The number 10 J-hook was used with the aim of catching P. bogaraveo since it almost catches fish species associated with the presence of corals (D’Onghia et al., 2010, 2011, 2012). Eight longline deployments were carried out at depths between 338 and 612 m. The set-time lasted three hours on average and the fishing effort was 2000 hooks/day. A total of four hauls with hook size 7 and 4 with hook size 10 were carried out in the Bari Canyon (Table 1). Total length (TL) (in mm), weight (in g), and sex were recorded for each specimen collected.

**Results and Discussion**

A total of 85 species were recorded using the three different sampling gears, including 65 benthic and 20 bentho-pelagic taxa (Table 2). Most benthic species were collected associated to Madrepora oculata colonies at station 1B1 (280 m). Van Veen grab samples differed markedly from each other in the presence and abundance of living organ-

**Porifera**

The analysis of the hard ground block and M. oculata colony sampled at station 1B1 allowed us to detect a total of 29 sponge taxa (Table 2). Two classes are represented, Homoscleromorpha and Demospongiae, with 1 and 28 species, respectively. The order Poecilosclerida comprises more than 70% of the recorded Demospongiae. The remaining five orders detected (Astrophorida, Hadromerida, Agelasida, Haplosclerida, Verongida) only include a few taxa each, except for two Bubaridae, all the recorded sponges were identified to species level. Among the 29 taxa identified, more than 80% (24 species) were exclusively found on the hard ground block, three were exclusively found on the coral colony, and only two species were recorded on both substrates. Most of the sponges occurred as small thin incrustations on the exposed side of the hard ground block or on the branches of the coral colony. The few massive sponge detected were Pachastrella monilifera and Poecillastra compressa and the pedunculate erect Phakellia robusta. Only one boring species was recorded, Siphonodictyon infestum, which heavily attacks the basal portion of a coral colony up to a few centimetres from the living coral tissue. The species Cerbaris curvispiculifer represents a new addition to the Italian sponge fauna (Pansini & Longo, 2008) (Fig. 3); including C. curvispiculifer, 17 species are new records for the Adriatic Sea and five species are new records for the southern Adriatic Sea (Table 2).

Most of the sponge fauna detected have an Atlantic-Mediterranean distribution. Four species (13.8%) are Mediterranean endemics (Table 2) (Pansini & Longo, 2003; Soest et al., 2014). With the exception of E. cinctum and E. topsenti, all the remaining species are known from substrates deeper in the Mediterranean Sea.
Table 2. List of the species collected in the Bari Canyon using the Van Veen grab (VG), the MEMO baited lander (MM) and the longline (LL), with indication of the new records, the presence of endemic species and the depth range of occurrence (* first record for the Mediterranean Sea; ** new records for the Adriatic Sea; *** new records for the Southern Adriatic Sea; ¤ new record for the Italian Sponge Fauna; § new records for the Bari Canyon; E Mediterranean endemic species).

<table>
<thead>
<tr>
<th>PHYLUM</th>
<th>Class</th>
<th>Order</th>
<th>Family</th>
<th>Species</th>
<th>Depth range (m)</th>
<th>Gear</th>
<th>VG</th>
<th>MM</th>
<th>LL</th>
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<td>PORIFERA</td>
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<td>Anchiridae</td>
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<td>Ancorinidae</td>
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<tr>
<td></td>
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<td>Anchiridae</td>
<td>Pachastrellida</td>
<td>Pocillastra compressa (Bowerbank, 1866)</td>
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<td>Pachastrellida</td>
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<td>Bubaris</td>
<td>Bubaris vermiculata (Bowerbank, 1866)</td>
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Fig. 3: Spicules of Cerbaris curvispiculifer: (a) style; (b) acanthorhabdostyle; (c) acanthoxea; (d) acanthostrongyle.

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### Table 2 (continued)

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<th>Depth range (m)</th>
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<td></td>
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### Table 2 (continued)

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than 100 m depth in the Mediterranean Sea. Some studies carried out on the biological community of the Bari Canyon have only recently documented a very abundant sponge fauna referred to five sponge taxa (Rhizaxinella pyrifera, Poecillasistra compressa, Pachastrella monilifora, Haliclona sp., Hexadella sp.) (Anonymous, 2009; Freiwald et al., 2009; Bo et al., 2012; Angeletti et al., 2014). The present study, recording 29 sponge taxa, demonstrates that, as already known in Mediterranean and Atlantic CWC communities, poriferans are one of the most common benthic organisms inhabiting these deep biocoenosis, also in terms of species richness (Longo et al., 2005; Soest & Lavaleye, 2005; Soest et al., 2007; Mastrotortaro et al., 2010; Calcinai et al., 2013).

The sponge assemblage described consists mainly of species (59.3%) already reported in association with Mediterranean CWC (Vacelet, 1969; Longo et al., 2005; Mastrotortaro et al., 2010; Calcinai et al., 2013), even though, eleven species (Prosobruberis longispinus, Antho (Antho) involvens, Eurypon cinctum, E. topsenti, Bienna parthenopea, B. tenasimagia, Axinella pumila, Babarbus subtyla, Cerbaris curvispicalifer, Hymerabalia typica and Hexadella pruvoti) were found for the first time in association with Mediterranean CWC. Eleven species of our records have also been recorded by Vacelet (Vacelet, 1969) in the Gulf of Lion, and 10 of the species recorded here are in common with the sponge assemblage from the Santa Maria di Leuca (SML) CWC province (Longo et al., 2005; Mastrotortaro et al., 2010). Only four of the species recorded are also on the sponge species list reported by Calcinai et al. (2013) for the CWC from the Strait of Sicily. Currently, 112 sponge species have been found associated with the four closely studied Mediterranean CWC communities in the Gulf of Lion, SML CWC province, the Strait of Sicily, and the Bari Canyon, but only three species are always present at all these sites - Desmacella inornata, Jaspis inornatus, and Poecillasistra compressa.

According to the Mediterranean literature, the order Poecilosclerida is the most represented (Vacelet 1969; Longo et al. 2005; Calcinai et al., 2013), whereas the number of species belonging to the order Astrophytonida found during the present study is low (only three species recorded), in contrast to those reported in other CWC Mediterranean biocoenosis. The percentage of Mediterranean endemic species found associated with CWC in the Bari Canyon (13.8%) is comparable to literature data on other CWC biocoenosis (Vacelet, 1969; Longo et al. 2005; Calcinai et al., 2013). The sponge assemblage described here is characterized by the rather scarce presence of boring sponges, with only one species recorded (S. infestum). This feature is consistent with previous observations on Mediterranean and Atlantic CWC biocoenosis, where little more than five species infesting the scleraxis of CWC colonies have been reported (Vacelet, 1969; Jensen & Frederiksen, 1992; Longo et al., 2005; Beuck et al., 2007, 2010; Calcinai et al., 2013). Despite the low number of species, boring sponges may greatly affect white coral colonies (see also Jensen & Frederiksen, 1992; Beuck et al., 2007, 2010), with heavy excavating activity mainly limited to the dead portion of the colonies, as observed in the present study. However, the availability of a single colony of M. oculata does not permit us to generalize about the frequency or the impact of boring species in the Bari Canyon.

**Cnidaria**

One live colony of the scleractinian M. oculata was sampled at 280 m in depth using the Van Veen grab (station 1B1). Living polyps were present at the top of the colony while its lower part was dead, with exposed skeleton completely covered by serpulids, sponges and bryozoans. Another live colony of M. oculata was also collected by longline at station 5 (551 m). As shown by the ROV images (Freiwald et al., 2009; Sanfilippo et al., 2013; Angeletti et al., 2014), the vertical walls of the canyon host an extended facies of M. oculata. Although M. oculata seems to be the most abundant cold-water coral, other species, both colonial (Lophelia pertusa, Dendrophyllia cornigera) and solitary (Desmophyllum dianthus, Stenocyathus vermiciformis), inhabit this canyon (Freiwald et al., 2009) but these species were not recorded in this study. Recently, the anemone Peachia sp. has been recorded using an ROV (Angeletti et al., 2014).

**Mollusca**

One Bivalvia and one Cephalopoda were recorded, the Pectinidae Delectopecten vitreus and the Ommastrephidae Todarodes sagittatus. One living specimen of D. vitreus was found to be associated with the M. oculata colony sampled at station 1B1, at a depth of 280 m, and two other living specimens were collected at station 2B5a on hard ground located at 475 m depth. A single large specimen of T. sagittatus was caught at station 4 (608 m in depth) using a longline (4 LL in Table 1). The presence of D. vitreus on hard substrates of Bari Canyon at station 1B1 confirms the association of this species with CWC (Tursi et al., 2004; Mastrotortaro et al., 2010; Rosso et al., 2010a; Taviani et al., 2011). Living benthic molluscs were not found on soft substrates of the Bari Canyon where, on the contrary, a large number of shells of dead molluscs were identified to 55 species belonging to the typical epibathyal mollusc communities currently present in the Mediterranean Sea (Panetta et al., 2013). Todarodes sagittatus was the only cephalopod collected in this study. Although this ommastrephid squid has been previously reported in the southern Adriatic Sea (Ungaro et al., 1999), its occurrence represents the first record in the Bari Canyon; it is a common pelagic and bentho-pelagic species in the Mediterranean where it preys actively in deep waters (Rosas-Luis et al., 2014).

**Annelida**

The living communities from samples 1B1 and 1B18 consisted of eight and nine species, respectively. Serpulids from sample 1B1 were found on living and dead M. oculata colonies as well as on a hard ground block approximately 30
cm in size. Sample 1B18 consisted of slabs of lithified mud (hard substrate). The species detected in both samples were Serpula vermicularis, Filograna gracilis, Metavermilia multicristata, Vermiliposis monodiscus, Janita fimбриата and Placostegus tridentatus. The species Serpula concharum (deep sea morphotype), Filograna implexa, and a new species belonging to the same genus here called Filograna sp. 1, were relatively abundant on coral branches (Fig. 4). Hyalopomatus madreporae was also present on the branches of a Madrepora colony. Further differences were also observed in serpulid structure between communities on corals or hard substrates: serpulids were more abundant on Madrepora branches, where specimens of Filograna implexa and Filograna sp. 1 prevailed. Conversely, communities on the hard base surfaces consisted of a lower number of specimens although the species richness was higher; F. gracilis, M. multicristata, and J. fimбриата were the dominant taxa here. Besides serpulids, the only other polychaete species was Eunice norvegica, a single specimen found associated with the living colony of M. oculata in sample 1B1.

Most of the detected species are widely distributed in the eastern Atlantic and Mediterranean (Ben-Eliahu & Fiege, 1996; Castelli et al., 2008; Sanfilippo, 2009; Mastrototaro et al., 2010). Serpula vermicularis, F. gracilis, M. multicristata, and V. monodiscus have previously been recorded in the same study area (Freiwald et al., 2009; Sanfilippo et al., 2013). The latter species is endemic, though more abundant in the western and central Mediterranean (Zibrowius, 1968). Serpula concharum (deep sea morphotype) and Hyalopomatus madreporae are new records for the Adriatic Sea; the latter is also endemic in the Mediterranean, recently recorded in the northem Ionian Sea (Sanfilippo, 2009; Mastrototaro et al., 2010). It is worth noting the discovery of Filograna sp. 1, a species that still needs to be formally described: tubes of this species are extremely abundant on living and dead coral branches and resemble those of F. implexa, being perfectly circular in cross-section, but their diameter is smaller (approximately half) and they do not seem to branch off for scissiparity. Both species of Filograna form aggregations with their tubes extensively covering the branches and calices of M. oculata. In particular, Filograna sp. 1 seems to be cryptic, mainly colonising the sheltered cavities of the internal parts of the Madrepora calices, also observed for other small-sized serpulids (Sanfilippo, 1998). As a whole, the serpulid communities of the studied samples comprised species distributed in deep-circalittoral to bathyal environments, as well as at shallower depths in coralligenous sciaphilic habitats and within caves (Bianchi & Sanfilippo, 2003; Rosso et al., 2013). They have been previously recorded on deep-water scleractinians (M. oculata, Dendrophyllia cornigera) in the Mediterranean Sea (Zibrowius 1968, 1971; Bourcier & Zibrowius, 1972; Di Geronimo et al., 1993; Mastrototaro et al., 2010).

Mediterranean fossil records of serpulids from cold-water Plio-Pleistocene deposits of the Messina Straits (Barrier et al., 1989) as well as from Pleistocene upper circalittoral (within sciaphilic microhabitats) to bathyal palaeo-environments (Di Geronimo & Sanfilippo, 1992; Di Geronimo et al., 1998) have been recorded. Some of these species are also known from canyon habitats; in particular, S. vermicularis has been recorded in the Cassidaigne and Cape de Creus canyons in the Gulf of Lion, NW Mediterranean (Bourcier & Zibrowius, 1972; Orejas et al., 2009; Sanfilippo et al., 2013), where white coral communities occur at comparable depths. Recently, large specimens of S. vermicularis have also been found forming coral-serpulid build-ups (Madrepora, Lophelia, Desmophyllum) from the Bari Canyon at greater depths (Sanfilippo et al., 2013; Angelletti et al., 2014). Finally, F. implexa, M. multicristata, and V. monodiscus have been recorded by Bourcier and Zibrowius (1972) associated to Madrepora and Dendrophyllia colonies from the Cassidaigne canyon.

The recurrent interaction between E. norvegica and CWC is noteworthy, and has yet to be investigated in detail. This polychaete lives in close association with the coral host, building a parchment tube between the living coral branches, and somehow stimulating the coral to produce additional exoskeletal calcification on the thin tube of the polychaete. This interaction contributes to a strengthening of the reef framework by thickening and connecting coral branches, acting as a positive feedback on the development of CWC bioconstructions, although it is still not clear whether or not this process also enhances the food relationship between corals and E. norvegica (Roberts, 2005; Carlier et al., 2009; Mueller et al., 2013). This Eunicidae is widespread on CWC reefs and its presence on the Bari Canyon CWC bio-constructs was already known, in association with both M. oculata and L. pertusa colonies (Roberts et al., 2006, 2009).

**Arthropoda**

Only one large specimen of the crustacean decapod Paromola cuvieri was caught using a longline at 338 m depth (station 3). This homolid crab had previously been observed in the Bari Canyon using an ROV (Angelletti et al., 2014).
Bryozoa

Living bryozoans were only found at two stations, namely 1B1 and 1B18, in the depth interval 277-280 m. Nineteen species, distributed within 11 families, were identified: 3 cyclostomes and 16 cheilostomes (3 anasans and 13 ascophorans) (see Table 2). Bryozoans were found to be more abundant and diversified (103 colonies and 19 species) in sample 1B1, where they colonised a large hard ground slab (Rosso et al., 2014) and some branches of M. oculata (Fig. 5). In contrast, they were markedly less abundant and diversified (14 colonies and 7 species) in sample 1B18. Two species, Smittina cf. ophiidiana and S. linearis, were exclusively found on exposed coral skeletons, whereas Crisia tenella longinodata, Atea truncata, Scrupocellaria delili, Smittina crystallina, Stephanotheca watersi, Stephanotheca arrogata, and Herentia hyndmanni were only found on hard ground pieces. The most abundant species was Puella (Glabribrillaria) pedunculata followed by Escharina vulgaris and S. watersi, Puellina (Cribribrillaria) gr. venesta, S. delili, and C. tenella longinodata, Gregarinidra gregaria, ?Turbinicellepora coronopus, and H. hyndmanni. Encrusting morphotypes largely prevailed, consisting of both multi-serial species forming spots (S. crystallina, P. (G.) pedunculata, H. hyndmanni, and Schizomavella discoides) or patches of single or multiple layers (G. gregaria, Puellina spp., E. vulgaris, Stephanotheca spp., and H. mucronelliformis) and uniserial runners (Entalophoroecea). Erect morphotypes were represented by flexible Crisia and Scrupocellaria colonies.

Bryozoans were first reported in the Bari Canyon by Freiwald et al. (2009) who, using an ROV, recorded red-coloured colonies up to 20 cm high associated with sponges and white corals in the depth range 600-664 m. Specimens at 306 m were identified as Myriapora truncata (Freiwald et al., 2009), but colonies collected at approximately the same depth near build-ups of scleractinian-serpulid concretions were revealed as belonging to Smittina cervicornis (Sanfilippo et al., 2013). Thus, the presence of M. truncata remains to be ascertained. None of these conspicuous species was found in the present samples. However, at least one of these two unidentified species from Freiwald et al. (2009) should be added to the reported 19 taxa, raising to 20 (or even to 21) the number of bryozoan species presently known in the Bari Canyon, between depths of 277 and 306 m.

None of the species recorded seems to be specifically adapted to colonising exposed coral skeletons, which appear to be only one of the exploitable substrata. Indeed, species found on corals were also present as dead specimens on hard grounds and other substrata, suggesting that they are not actually selective. Some species not found on corals in the examined samples have been reported as encrusting coral skeletons in other Mediterranean localities (Zabala et al., 1993; Mastrototaro et al., 2010).

As many as nine of the bryozoan species reported here from the Bari Canyon, namely E. deflexa, C. ramosa, G. gregaria, S. discoides, S. linearis, A. truncata, S. delili, P. (C.) radiata, and E. vulgaris, had previously been recorded from the Adriatic Sea (Rosso et al., 2010b). Nevertheless, most of them were only known in the northern sector, and the last four species from northern and southern sectors but not from the intermediate areas (Rosso et al., 2010b). Stephanotheca watersi could be added to this group because this newly erected species (Reverter-Gil et al., 2012) could include some specimens previously reported as Schizomavella radiis (Rosso et al., 2010b). All other species are reported here for the first time from this area, but nearly all of them were already known from the Ionian Sea, whereas H. mucronelliformis and S. watersi were known from the Tyrrhenian Sea and the Messina Strait (Rosso et al., 2010b) and from the Tyrrhenian Sea (Reverter-Gil et al., 2012), respectively. Most species have already been reported from cold-water coral ecosystems of the Mediterranean Sea. Scrupocellaria delili, S. crystallina, H. hyndmanni, P. (G.) pedunculata, and C. tenella longinodata were known from greater depths in the SML CWC province (Mastrototaro et al., 2010). The first three species, together with E. deflexa, G. gregaria, P. (C.) radiata, S. ophiidiana, S. linearis, E. vulgaris and T. coronopus, have also been reported as epibionts on live and/or dead Madrepora and Lophelia colonies collected within canyons along the Catalonia slope, off Blanes and Banyuls-sur-Mer in the entire 180-350 m sampled depth range, or in parts of it (Zabala et al., 1993). Almost all of these species are also typically widespread on shelf environments with the possible exception of H. hyndmanni, S. crystallina, and P. (G.) pedunculata, seemingly restricted to the very outer shelf and the upper slope (Berning et al., 2008; Mastrototaro et al., 2010); only the latter is able to live at shallow depths, in submarine caves (Harmelin, 1970; Rosso et al., 2013; Sanfilippo et al., 2014). A further species, S. arrogata, has been recorded only once as encrusting on dead Madrepora skeletons in waters 105-110 m deep, in the Sicily Strait (Gautier, 1962). The discovery of C. tenella longinodata in the Bari Canyon is worthy of note because it definitely confirms that this taxon is still living in the Mediterranean. This species was described as a Lower Pleistocene deep-water bryozoan by Rosso (1998) and considered as an extinct endemic taxon (Rosso & Di Gieronimo 1998; Rosso et al., 1998; Rosso, 2005). Comparable specimens found in the SML coral province were named Crisidae sp. due to the absence of gonozooids, hampering a reliable taxonomic attribution (Mastrototaro et al., 2010). This taxon seems to be typically restricted to bathyal environments. In contrast, S. discoides and H. mucronelliformis presently known from shelf environments (Gautier, 1962; Hayward & Ryland, 1999) but extending to deeper waters, had never previously been reported from cold-water coral ecosystems. Smittina cervicornis (and even the doubtfully present M. truncata) might be added to this stock of species with wide bathymetric distributions. This is probably the deepest record for S. watersi, so far known from shelf bottoms (Reverter-Gil et al., 2012). The described bryozoan community lacks some of the typical Mediterranean bathyal species as well as some ubiquitous deep-water taxa reported by Harmelin & d’Hondt.
Interestingly, the bryozoan association in the Bari Canyon coral ecosystem explored so far appears to be different from that recorded in the SML coral province, with which it shares only five species (nearly 25%). A higher number of species (ten: 50%) is shared with the bryozoan communities of the Catalonia canyons from where as many as 36 species have been recorded (Zabala et al., 1993).

The special compositional features of the Bari Canyon bryozoan community and its particular affinity with that of the Catalonia canyons could be related to the relatively shallow location of the investigated sites (in comparison to SML coral community, 500 to 800 m in depth; Mastrototaro et al., 2010) and/or to the locations within a canyon. In particular, the presence of *H. mucronelliformis*, a species common in current-swept communities in submarine caves (Taddei-Rug-
Echinodermata

Living echinoderms were found at 10 stations, both on hard and soft substrates. In particular, the ophiuroid *Amphiura filiformis* was sampled at nine stations, with 8 and 10 specimens at stations 1B17c and 2B3, respectively. Four specimens of *Ophiothrix quinquemaculata*, a large orange ophiuroid, were found to be associated to *M. oculata* and on the hard substrate sampled at station 1B1. Only one specimen of the regular echinoid *Gracilechinus acutus* was sampled at station 2B8. The widespread presence of *A. filiformis* in most of the sampling stations is not surprising; in fact, even though there are no studies of echinoderms in the Bari Canyon, it is well known that this ophiuroid is quite common in the bathyal muddy sediments of the Mediterranean (Tortone 1965, 1980). On the contrary, our finding of *O. quinquemaculata* at 280 m in depth slightly extends the bathymetrical range (previously 40 - 250 m) reported for this species by Tortone (1965) in the Mediterranean Sea. The record of this species on a *M. oculata* colony and on the hard ground confirms that, even though it is usually reported as a soft-bottom species, *O. quinquemaculata* may prefer small hard substrates (e.g. stones, shells, big pebbles) scattered upon the sediment (Czihak, 1954; Tortone, 1965).

Elasmobranchii and Holocephali

Eight cartilaginous species of fishes (seven Elasmobranchii and one Holocephali) were observed during this study. Those observed both with the MEMO lander and caught using longline were *Centrophorus granulosus*, *Etmopterus spinax*, and *Galeus melastomus*. The sharks *Dalatias licha* and *Hexanchus griseus* were only identified during the video records (Fig. 6) while *Scylliorhinus canicula*, *Pteroplatus typhon violacea*, and *Chimaera monstrosa* were only caught using a longline (Table 2). The most frequently caught cartilaginous fish was the blackmouth cat shark *G. melastomus*. The widest depth distribution of 344 m was observed for *H. griseus* (caught between 443-787 m). The species *S. canicula*, *P. violacea*, and *C. monstrosa* are new records for the Bari Canyon; however, they belong to the southern Adriatic fish fauna (Ungaro *et al*., 1999; De Zio *et al*., 2000). The cartilaginous fishes represent 42% of the fishes collected. The presence of species at the top of the marine food web such as *C. granulosus* and *H. griseus* considered “vulnerable” on the published IUCN Mediterranean Regional Red List (Abdul Malak *et al*., 2011) could emphasize the role of the Bari Canyon as a refuge because fishing is poorly developed in this site. This is further confirmed by the frequent capture of *G. melastomus* in this canyon, since this shark is generally removed from fishing grounds by commercial trawl fishing.

Actinopterygii

Eleven species of osteichthyes were identified in the Bari Canyon: one Anguilliformes, one Beryciformes, four Gadiformes, three Perciformes, and two Scorpaeniformes encompassing 11 families, each of them present with only one species. Seven species were recorded during the MEMO lander deployments and nine were collected by longline (Table 2). Most of them were detected by both lander and longline while two species, *Hoplostethus mediterraneus* and *Lepidopus caudatus*, were only recorded during the video recording and four species, *Micromesistius poutassou*, *Molva dypterygia*, *Physix blennoides*, and *Scorpaena elongata*, were only caught by longline. The Anguilliformes *Conger conger* and the Scorpaeniformes *Helicolenus dactylopterus* showed the widest depth distribution (338-788 m) and were recorded by both lander and longline while the Scorpaenidae *S. elongata* was only collected at the shallowest station by longline (Table 2). The species *C. conger*, *P. blennoides*, *Pagellus bogaraveo* and *H. dactylopterus* were found to be associated with

Fig. 6: The sharks *Dalatias licha* (A) and *Hexanchus griseus* (B) swimming near the MEMO lander in the Bari Canyon.
the cold-water coral *M. oculata* which was directly entangled in the longline as coral by-catch at station 5 (551 m). Apart from *H. mediterraneus*, which is always discarded, all the recorded species are of commercial interest in the Adriatic fisheries, although with different economic values. The species *P. bogaraveo*, *C. conger*, and *H. dactylopterus* were the teleost fishes most frequently observed during the MEMO lander deployments (Fig. 7); other fish species were recorded less frequently. Using longline, *H. dactylopterus* was the most collected species, and other commonly caught species were the Gadiformes *P. blennoides* and *Merluccius merluccius*, and the Anguilliformes *C. conger*.

The Actinopterygii species observed in the Bari Canyon using the MEMO lander and the longline have been commonly reported at a regional level in the southern Adriatic Sea (e.g. Stefanescu et al., 1998a, 1998b). Most of these species have been recently recorded in the Bari Canyon by *in situ* observations with an ROV and a baited lander (Angeletti et al., 2014; D’Onghia et al., 2014) and the vertical distribution of *P. bogaraveo* and *H. dactylopterus* in this area has also been updated (D’Onghia et al., 2014). *M. poutassou*, *M. dypterygia*, and *S. elongata* previously recorded from the southern Adriatic Sea (Ungaro et al., 1999) are here reported for the first time from Bari Canyon. Almost all the fish species found generally occur in other Mediterranean canyons (e.g. Stefanesco et al., 1994; Ramirez-Llodra et al., 2010; Company et al., 2012; Farrugio, 2012; Watremez, 2012; Fabri et al., 2014). The association of *C. conger*, *P. bogaraveo*, and *H. dactylopterus* with the cold-water coral *M. oculata* in the catch also confirms the preferred distribution of these species within the coral habitat, previously documented in the SML CWC province (D’Onghia et al., 2010, 2011, 2012). Moreover, the most frequent observations of *C. conger* and *H. dactylopterus* in the present study using both baited lander and longline could be due to a preferential distribution of these fishes in a complex and heterogeneous habitat (D’Onghia et al., 2014; Fabri et al., 2014).

**Conservation issues and concluding remarks**

The use of different sampling equipment and the collaboration of different specialists has allowed the updating of knowledge on the macro- and megafauna biodiversity in the Bari Canyon as well as in the Adriatic Sea. A total of 85 benthic and bentho-pelagic species was identified including 51 species that are new records for the Bari Canyon and 29 that are new records for the Adriatic Sea. Six Mediterranean endemic species were identified, four Porifera and two Annelida. The deepest and the shallowest bathymetric limits have been extended for some species and the first record of living specimens of the bryozoan *C. tenella longinodata* is reported. Most new records regard sponges, for which new information is reported for deep-sea species confirming their importance in the structure of CWC communities. An important contribution to the biodiversity is also presented for bryozoans, fishes, and annelids; many species previously reported from cold-water coral communities of the Mediterranean Sea (Longo et al., 2005; Mastrotortaro et al., 2010; D’Onghia et al., 2011; Fabri et al., 2014) had not been recorded in the Bari Canyon.

Although the Bari Canyon has been mostly investigated using ROV and only recently, to date a total of 111 species have been recorded in it, suggesting that the Adriatic populations of benthic species in this canyon could be connected with the well known SML CWC province in the northern Ionian Sea (Fig. 8) along the south-western Adriatic margin, in agreement with Angeletti et al. (2014). The greater number of species recorded until now in the SML CWC province is mostly due to a greater number of studies and explorations carried out with different types of sampling gear (e.g. Tursi et al., 2004; Longo et al., 2005; Freiwald et al., 2009; D’Onghia et al., 2010, 2011, 2012; Mastrotortaro et al., 2010, 2013). The number of bryozoan species greater in the Bari Canyon than in the SML CWC province, is possibly derived from the different depth ranges and habitat settings investigated. The high biodiversity detected in this area could be due to the “canyon effect” (Ramirez-Llodra et al., 2010), which is related to the increase in trophic resources in the canyon, the absence of trawl fishing and the presence of cold-water corals.

The Bari Canyon, like most Mediterranean canyons, might play an important role as protected habitats for many species and, probably, for others of fishing interest (Revenge Martinez de Pazos, 2012). Several spatial designations and conservation plans have been put in place globally for the protection of these CWC ecosystems including areas with the presence of canyons (e.g. Micheli et al., 2013). To
date, apart from the Gulf of Lion, there are no protection measures in place for the Mediterranean submarine canyons (Marin & Aguilar, 2012), although UNEP-MAP-RAC/SPA (2010) suggests that canyons together with other deep-sea features should be protected through implementation of a Precautionary Principle as they are great reservoirs of biodiversity. The role of canyons and CWC ecosystems in marine biodiversity highlights the need for a representative network of Marine Protected Areas for the Mediterranean (Tudela et al., 2010, 2011, 2012; Mastrototaro et al., 2010, 2013, 2014).

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