

Benthic invertebrates associated with subfossil cold-water coral frames and hardgrounds in the Albanian deep waters (Adriatic Sea)

Ina NASTO^{1,*}, Frine CARDONE², Francesco MASTROTOTARO², Piero PANETTA²,
Antonietta ROSSO³, Rosanna SANFILIPPO³, Marco TAVIANI^{4,5}, Angelo TURSI²

¹Department of Geological Sciences and Geotechnologies, Milano-Bicocca University, Milan, Italy

²Local Research Unit of the National Interuniversity Consortium for Marine Sciences (ULR CoNISMa),
Department of Biology, University of Bari, Bari, Italy

³Local Research Unit of the National Interuniversity Consortium for Marine Sciences (ULR CoNISMa),
Department of Biological, Geological, and Environmental Sciences, University of Catania, Catania, Italy

⁴Marine Science Institute (ISMAR), National Research Council (CNR), Bologna, Italy

⁵Anton Dohrn Zoological Station, Naples, Italy

Received: 31.08.2017 • Accepted/Published Online: 24.04.2018 • Final Version: 26.07.2018

Abstract: The fauna collected associated with subfossil *Lophelia pertusa* and *Dendrophyllia cornigera* coral samples and hardgrounds from Albanian waters between 190–230 m is discussed. Eighty-three benthic species are recorded: 2 Foraminifera, 22 Porifera, 6 Cnidaria, 25 Mollusca, 14 Annelida, 1 Arthropoda, 12 Bryozoa, and 1 Echinodermata. Seventy-four species are new records for the poorly investigated Albanian deep waters.

Key words: Cold-water corals, biodiversity, Mediterranean basin, Adriatic Sea, Albania, *Lophelia pertusa*, *Dendrophyllia cornigera*, deep-water benthos

1. Introduction

The habitat-forming ability of corals has fascinated generations of marine biologists and this role has been formalized through the concept of ‘ecological engineering’ (Jones et al., 1994; Wright and Jones, 2006). Cold-water coral (CWC) bioconstructions providing structural habitats promote a high level of diversity during their lifetimes and after (e.g., Jensen and Frederiksen, 1992; Freiwald and Wilson, 1998; Mortensen and Fossa, 2006). CWCs such as the frame-builder scleractinian corals *Lophelia pertusa* and *Madrepora oculata* have been documented from various parts of the Mediterranean basin (Taviani et al., 2017, with references therein). As for the Atlantic Ocean, *L. pertusa* and *M. oculata* may form three-dimensional structures in the Mediterranean, which provide a substrate for various sessile benthic invertebrates, thus increasing the environmental biodiversity of CWC habitats, including their thanatofacies (Carlier et al., 2009; Freiwald et al., 2009; Bongiorno et al., 2010; Mastrototaro et al., 2010; Rosso et al., 2010; Vertino et al., 2010; D’Onghia et al. 2015; Bargain et al., 2017; Taviani et al., 2017). The subfossil coral frames have been documented to act as taphonomic traps, at times including representatives both

of the CWC-associated fauna and skeletal remains from adjacent habitats (Remia and Taviani, 2005; Angeletti and Taviani, 2011; Taviani et al., 2011b). The most important live CWC sites in the southeastern Adriatic are the Bari Canyon, the Gondola Slide, the Dauno Seamount, and off Tricase (Freiwald et al., 2009; Taviani et al., 2011a, 2016; Angeletti et al., 2014). In the eastern side of this basin, CWC growth appears sporadic and localized, and records often refer to subfossil material (Angeletti et al., 2014, 2015; Nasto, 2017). This asymmetrical CWC distribution in the southern Adriatic has been hypothesized to be governed by hydrologic processes, including North Adriatic Dense Water cascading (Taviani et al., 2016). Although the Adriatic Albanian margin is indented by a number of small canyons, evidence of living megabenthic sessile fauna in such environments is almost lacking. This is true for CWCs, which are documented to date only as subfossil records of *L. pertusa* and *Desmophyllum dianthus* found in the Albanian part of the Otranto channel (Angeletti et al., 2014).

The occurrence of dead (subfossil) CWC frames in Albanian deep waters has been known to fishermen for a while. This serendipitous information generated curiosity

* Correspondence: ina.nasto@yahoo.com

in the scientific community, which led to the organization of a first exploratory investigation of anecdotally reported CWC sites. Two surveys dedicated to getting more in-depth information on CWC distribution were therefore conducted onboard commercial fishing boats. Two areas of the southern Albanian coast between 190 and 210 m were trawled off Vlorë Bay in 2015 and 2016 (stations AL15SE1 and AL16SE2 are illustrated Figure 1 and Table 1). Our research resulted in the recovery of two large subfossil *Lophelia* colonies and hardground slabs and fragments fouled by serpulids, sponges, bivalves, bryozoans, and solitary scleractinian corals. This paper provides new information about the benthic fauna associated with these subfossil coral frameworks and cooccurring hardgrounds. Such material comprises both live and dead representatives, here considered cumulatively. It should be noted, however, that the latter may well include late Pleistocene subfossils, including CWCs, whose presence in the deep southern Adriatic Sea was ascertained long ago (Colantoni et al., 1975; McCulloch et al., 2010). Finally, this study also offers a contribution to the current renewed interest for the marine taxonomy of the Mediterranean Sea (Cirino et al., 2016; Boero et al., 2017; Keppell et al., 2017), and to helping to establish a better governance of CWC habitats

in light of current anthropic and climatic threats (Fossà et al., 2002; Orejas et al., 2009; Fabri et al., 2012; Maier et al., 2012; McCulloch et al., 2012; Rodolfo-Metalpa et al., 2015; D’Onghia et al., 2017).

A further sampling site was located at the southern Albanian margin off Saranda (AL16SA1) and close to the Greek island of Corfu (Figure 1; Table 1), characterized by the predominance of coral rubble of *Dendrophyllia cornigera* (yellow coral) and hardgrounds. Fragments of *D. cornigera* appear patinated by oxides, bioeroded, and partly covered by sediment. Subfossil coral remains are fouled by serpulids, sponges, and solitary scleractinians like *Caryophyllia calveri* and, subordinately, *D. dianthus* and *Stenocyathus vermiformis*.

2. Materials and methods

All living taxa were picked from the substrate and fixed in 95% ethanol. For species identification of sponges, slides of dissociated spicules were prepared and observed with an optical microscope (Leica DM500) and, when needed, examined by scanning electron microscope (SEM, model Hitachi TM3000), as for some bryozoans. Taxa have been identified to the possible lowest taxonomic level. Nomenclature follows WoRMS (World Register of Marine



Figure 1. a) Map of the southern Adriatic Sea showing the two sampling areas discussed in the text; b) location of stations AL15SE1 and AL16SE2; c) location of station AL16SA1.

Table 1. Main station characteristics and material typology.

| Stations | Material | Latitude, N | Longitude, E | Depth (m) |
|----------|--|-------------|--------------|-----------|
| AL15SE1 | <i>L. pertusa</i> , hardgrounds | 40°48'26" | 18°59'24" | 190 |
| AL16SE2 | <i>L. pertusa</i> | 40°50'730" | 18°59'970" | 210 |
| AL16SA1 | <i>D. cornigera</i> , <i>L. glaberrima</i> , hardgrounds | 39°55'938" | 19°48'248" | 208 |

Species: available online at <http://www.marinespecies.org>) and Rosso and Di Martino (2016) for bryozoans. The subfossil *Lophelia* colonies are stored in the zoological collection of the University “Ismail Qemali” Vlora, Albania; sponges, cnidarians, and mollusks are hosted in the Department of Biology, University of Bari, Italy; and bryozoan and serpulid samples are located in the Paleontological Museum of the University of Catania, Italy, under the collective codes ‘Rosso bryozoans collections Albania, PI-H’ and ‘Sanfilippo serpulid collections Albania, PI-H’, respectively.

3. Results and discussion

A total of 83 benthic species were identified (Table 2), predominantly Porifera, Mollusca, and Annelida, with 22, 25, and 14 species, respectively.

3.1. Porifera

A total of 22 sponge taxa (4 at genus level, 18 at species level), all belonging to the class Demospongiae, were identified. Among them, 16 species were recorded from stations AL15SE1 and AL16SE2, and 6 taxa (*Jaspis incrustans*, *Pachastrella monilifera*, *Poecillastra compressa*, *Leiodermatium lynceus*, *Hamacantha* sp., *Sceptrella insignis*) also occurred at station AL16SA1. The order Tetractinellida, with 5 families and 7 species, represents ca. 31% of the sponges, while the other 10 orders (Polymastiida, Tethyida, Poecilosclerida, Axinellida, Desmacellida, Merliida, Bubarida, Agelasida, Haplosclerida, Verongiida) include a few taxa each.

With a few exceptions (*P. compressa*, *P. monilifera*, and *L. lynceus*), sponges mainly occurred as small thin incrustations on the exposed surfaces and branches of subfossil coral colonies. Heavy bioerosion observed on *L. pertusa* and *D. cornigera* likely points to the presence of boring sponges, a common case on dead coral substrates (Beuck et al., 2010), but extraction of sponge tissue and/or spicules for species identification proved unfeasible.

Most of the detected sponge species have a North Atlantic distribution and were previously reported from a few Mediterranean sites (Pansini and Longo, 2003; Van Soest et al., 2018). All such taxa were already recorded from CWC grounds at Santa Maria di Leuca (SML) and the Bari Canyon (11 for Bari Canyon and 14 for SML: Longo et al., 2005; Mastrototaro et al., 2010; Bo et al. 2011; D’Onghia et al., 2015). The range of *Antho signata* and *Geodia nodastrella* (identified at SML as first Mediterranean records: Longo et al., 2005; Mastrototaro et al., 2010) is expanded to the Albanian waters. This holds true also for the lithistid *Siphonidium ramosum* (Figure 2), originally described from Florida seamounts (Van Soest et al., 2018) and equally displaying a patchy Mediterranean distribution (Longo et al., 2005; Mastrototaro et al., 2010).

Analogously, the finding of the lithistid sponge *Siphonidium ramosum* (Figure 2), first described from Florida seamounts (Van Soest et al., 2018), is interesting because its distribution is presently restricted to a few areas in the Mediterranean Sea (Topsent, 1925; Longo et al., 2005; Mastrototaro et al., 2010).

3.2. Cnidaria

The fauna encrusting subfossil colonies of *L. pertusa* include *C. cyathus* (Figure 3) and *Caryophyllia calveri*, the latter being a first record for the Adriatic Sea. On the basal part of these *L. pertusa* colonies, solitary polyps of *Stenocyathus vermiformis* (Figure 3) formed a canopy of dead and living individuals. Dead specimens of *C. cyathus* and *C. calveri* were used as a substrate by juveniles belonging to the same species, as also observed for the Eratosthenes Seamount (Galil and Zibrowius, 1998).

The presence of the bamboo coral *Isidella elongata* (Figure 3) was ascertained on muddy bottoms at both sites. Furthermore, a number of *Stephaniscyphistoma* specimens were noticed, the benthic stage of bathypelagic medusae of the genus *Nausithoe* (Scyphozoa: family Coronatae), in analogy with other coral banks (Jarms et al., 2003; Mastrototaro et al., 2010). *C. cyathus* was also observed to colonize *D. cornigera* rubble at station AL16SA1. Two living colonies of *Leiopathes glaberrima* were also recovered during our survey. It is worth mentioning that the presence of *L. glaberrima* in this sector of the Mediterranean was documented offshore Saranda associated with *D. dianthus* (CNR oceanographic cruise CoCoMap 2014: unpublished data). Solitary corals such as *D. dianthus*, *S. vermiformis*, and *C. calveri* often settle on subfossil coral substrate.

3.3. Mollusca

A total of 25 benthic species was identified pertaining to Gastropoda (13 species) and Bivalvia (12 species). Shells of the holoplanktic thecosomatous pteropod *Cavolinia gibbosa*, shed from the water column, also occurred. As a whole, the fauna is characterized by typical epibathyal mollusks of the Mediterranean Sea (Oliverio, 2008; Negri and Corselli, 2016). Station AL15SE provided the highest number of species, all already previously reported for the deep Adriatic Sea (Taviani, 1978; Panetta et al., 2013; Negri and Corselli, 2016). The large majority of the mollusk fauna is represented by taxa dwelling on mobile bottoms such as the infaunal mud-dwelling bivalves *Yoldiella philippiana* and *Abra longicallus* (Figure 4). The mollusk fauna mainly consisted of empty shells typical of muddy bottoms. Only a few species (including living representatives) were identified associated with *Lophelia* subfossil colonies and hardgrounds. Some shells are cemented or encased into the subfossil coral frames, a case reported from other CWC situations in the Mediterranean Sea (Remia and Taviani 2005; Taviani et al., 2005; Angeletti and Taviani, 2014). No mollusks strictly associated with CWCs habitats,

Table 2. Taxa associated with subfossil *L. pertusa* and *D. cornigera* colonies and hardgrounds (* = first record for the Albanian fauna).

| Phylum | Order | Family | Species | |
|--------------|-----------------|------------------|--|--|
| Foraminifera | Rotaliida | Homotrematidae | <i>Miniacina miniacea</i> (Pallas, 1766)* | |
| | Miliolida | Nubeculariidae | <i>Cornuspiramia</i> sp.* | |
| Porifera | Tetractinellida | Ancorinidae | <i>Jaspis incrustans</i> (Topsent, 1890)* | |
| | | Geodiidae | <i>Geodia nodastrella</i> Carter, 1876* | |
| | | Pachastrellidae | <i>Pachastrella</i> sp.* | |
| | | | | <i>Pachastrella monilifera</i> Schmidt, 1868* |
| | | | Vulcanellidae | <i>Poecillastra compressa</i> (Bowerbank, 1866)* |
| | | | | <i>Vulcanella gracilis</i> (Sollas, 1888)* |
| | | | Siphonidiidae | <i>Siphonidium ramosum</i> (Schmidt, 1870)* |
| | | Polymastiida | Polymastiidae | <i>Polymastia</i> sp.* |
| | | Tethyida | Timeidae | <i>Timea</i> sp.* |
| | | Poecilosclerida | Microcionidae | <i>Antho signata</i> (Topsent, 1904)* |
| | | | Hymedesmiidae | <i>Hymedesmia mutabilis</i> (Topsent, 1904)* |
| | | | Latrunculiidae | <i>Sceptrella insignis</i> (Topsent, 1890)* |
| | | Desmacellida | Desmacellidae | <i>Desmacella inornata</i> (Bowerbank, 1866)* |
| | | Merliida | Hamacanthidae | <i>Hamacantha johnsoni</i> (Bowerbank, 1864)* |
| | | | Hamacanthidae | <i>Hamacantha papillata</i> Vosmaer, 1885* |
| | | | | <i>Hamacantha</i> sp.* |
| | | Axinellida | Raspailiidae | <i>Eurypon clavatum</i> (Bowerbank, 1866)* |
| | | | Axinellidae | <i>Phakellia robusta</i> Bowerbank, 1866* |
| | | Bubarida | Bubaridae | <i>Bubaris vermiculata</i> (Bowerbank, 1866)* |
| | Agelasida | Hymerhabdiidae | <i>Hymerhabdia typica</i> Topsent, 1892* | |
| | Haplosclerida | Chalinidae | <i>Haliclona flagellifera</i> (Ridley & Dendy, 1886)* | |
| | Verongiida | Ianthellidae | <i>Hexadella dedritifera</i> Topsent, 1913* | |
| Cnidaria | Coronatae | Nausithoidae | <i>Nausithoe</i> spp.* | |
| | Alcyonacea | Isididae | <i>Isidella elongata</i> (Esper, 1788)* | |
| | Antipatharia | Leiopathidae | <i>Leiopathes glaberrima</i> (Esper, 1788)* | |
| | Scleractinia | Caryophylliidae | | <i>Caryophyllia calveri</i> Duncan, 1873* |
| | | | | <i>Caryophyllia cyathus</i> (Ellis & Solander, 1786)* |
| | | | | <i>Desmophyllum dianthus</i> (Esper, 1794) (subfossil)* |
| | | | | <i>Lophelia pertusa</i> (Linnaeus, 1758) (subfossil)* |
| | | | Guyniidae | <i>Stenocyathus vermiformis</i> (Pourtalès, 1868)* |
| | | Dendrophylliidae | <i>Dendrophyllia cornigera</i> (Lamarck, 1816) (subfossil)* | |
| Mollusca | Vetigastropoda | Fissurellidae | <i>Emarginula adriatica</i> O. G. Costa, 1830* | |
| | | Trochidae | <i>Clelandella miliaris</i> (Brocchi, 1814)* | |
| | | Eucyclinae | <i>Putzeysia wiseri</i> (Calcara, 1842)* | |
| | Neotaenioglossa | Rissoidae | <i>Alvania cimicoides</i> (Forbes, 1844) | |
| | | Ranellidae | <i>Ranella olearia</i> (Linnaeus, 1758) | |
| | Ptenoglossa | Muricidae | | <i>Orania fusulus</i> (Brocchi, 1814)* |
| | | | | <i>Pagodula echinata</i> (Kiener, 1840)* |
| | | Nassariidae | <i>Nassarius lima</i> (Dillwyn, 1817) | |

Table 2. (Continued).

| | | | |
|---------------|-----------------|-----------------|---|
| | | Fasciolariidae | <i>Fusinus rostratus</i> (Olivi, 1792) |
| | | Conidae | <i>Bela nuperrima</i> (Tiberi, 1855) |
| | Heterostropha | Odostomiidae | <i>Chrysallida stefanisi</i> (Jeffreys, 1869)* |
| | | Pyramidellidae | <i>Eulimella bogii</i> Van Aartsen, 1995* |
| | Cephalaspidea | Acteonidae | <i>Callostracon tyrrhenicum</i> (Smriglio & Mariottini, 1996) |
| | Solemyoidea | Yoldiidae | <i>Yoldiella philippiana</i> (Nyst, 1845)* |
| | Arcoida | Arcidae | <i>Asperarca nodulosa</i> (O. F. Müller, 1776)* |
| | | | <i>Bathyarca philippiana</i> (Nyst, 1848)* |
| | Pterioidea | Propeamussiidae | <i>Parvamussium fenestratum</i> (Forbes, 1844)* |
| | | Pectinidae | <i>Pseudamussium peslutrae</i> (Linnaeus, 1771)* |
| | | | <i>Karnekampia sulcata</i> (Müller, 1776)* |
| | | Spondylidae | <i>Spondylus gussoni</i> O. G. Costa, 1830* |
| | Veneroidea | Chamidae | <i>Pseudochama gryphina</i> (Lamarck, 1819)* |
| | | Semelidae | <i>Abra longicallus</i> (Scacchi, 1835) |
| | | Kellielliidae | <i>Kelliella miliaris</i> (Philippi, 1844)* |
| | | Veneridae | <i>Timoclea ovata</i> (Pennant, 1777) |
| | Pholadomyoidea | Cuspidariidae | <i>Tropidomya abbreviata</i> (Forbes, 1843)* |
| Annelida | Sabellida | Serpulidae | <i>Filigranula gracilis</i> Langerhans, 1884* |
| | | | <i>Filigranula stellata</i> (Southward, 1963)* |
| | | | <i>Filigranula annulata</i> (O.G. Costa, 1861)* |
| | | | <i>Filigrana</i> sp. 1* |
| | | | <i>Filigrana</i> sp. 2* |
| | | | <i>Hyalopomatus madreporae</i> Sanfilippo, 2009* |
| | | | <i>Hyalopomatus</i> sp.* |
| | | | <i>Janita fimbriata</i> (Delle Chiaje, 1822)* |
| | | | <i>Metavermlia multicristata</i> (Philippi, 1844)* |
| | | | <i>Placostegus tridentatus</i> (Fabricius, 1779)* |
| | | | <i>Protis</i> sp. * |
| | | | <i>Serpula</i> cf. <i>vermicularis</i> Linnaeus 1767* |
| | | | <i>Vermilopsis monodiscus</i> Zibrowius, 1968* |
| | | | <i>Serpulidae</i> sp. 1 |
| Bryozoa | Cyclostomatida | Tubuliporidae | <i>Idmidronea</i> sp.* |
| | | Crisiidae | <i>Crisia tenella longinodata</i> Rosso, 1998* |
| | Cheilostomatida | Calloporidae | <i>Ramphonotus</i> sp.* |
| | | | <i>Copidozoum exiguum</i> (Barroso, 1920)* |
| | | Cribrilinidae | <i>Puellina pedunculata</i> (Gautier, 1956)* |
| | | Romancheinidae | <i>Neolagenipora eximia</i> (Hincks, 1860)* |
| | | Smittinidae | <i>Smittina</i> cf. <i>crystallina</i> (Norman, 1867)* |
| | | Escharinidae | <i>Herentia hyndmanni</i> (Johnston, 1847)* |
| | | Celleporidae | <i>Turbicellepora coronopus</i> (Wood, 1844)* |
| Arthropoda | Decapoda | Leucosiidae | <i>Ebalia nux</i> A. Milne-Edwards, 1883* |
| Echinodermata | Cidaroida | Cidaridae | <i>Cidaris cidaris</i> (Linnaeus, 1758)* |

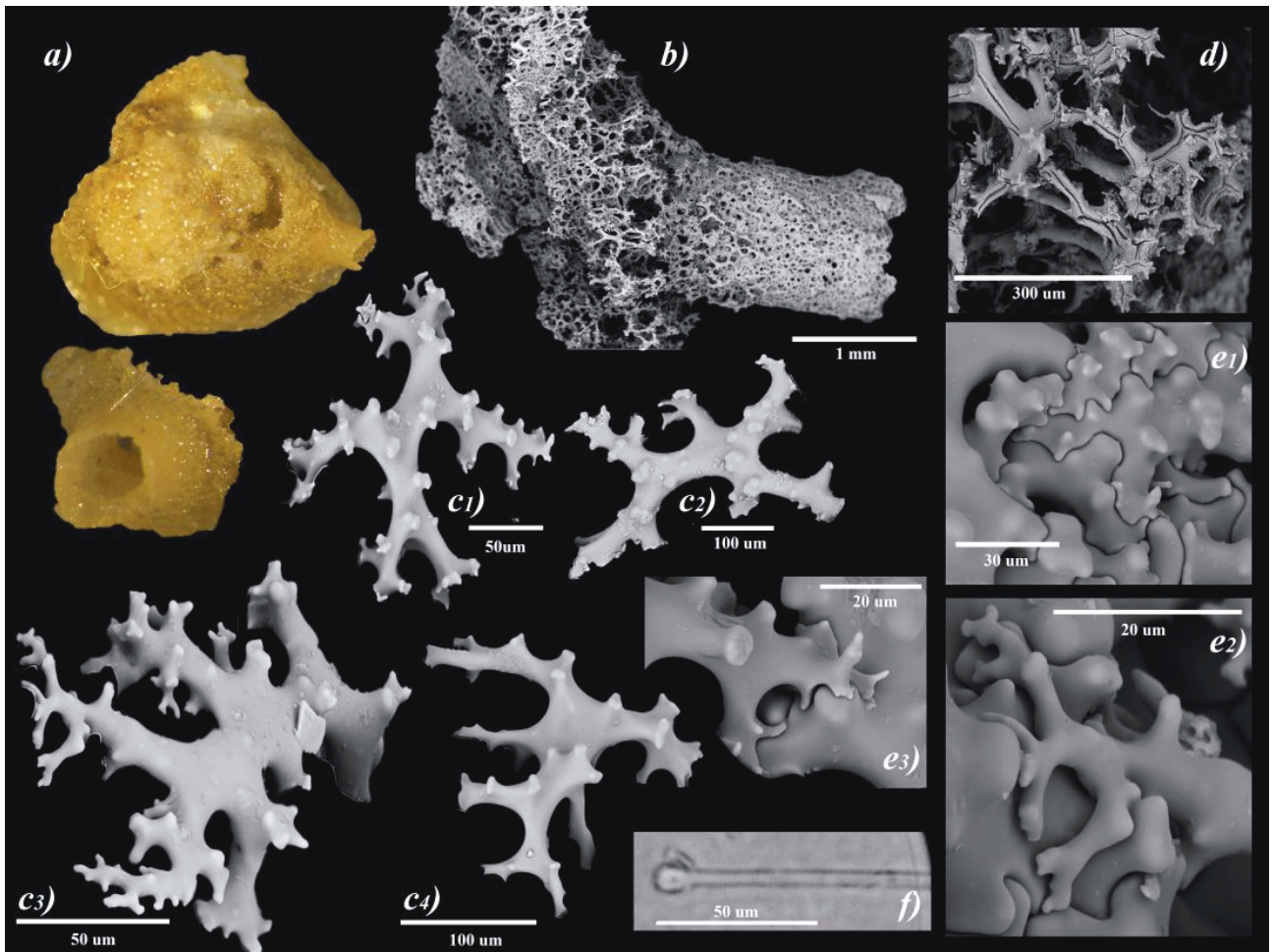


Figure 2. *Siphonidium ramosum* (Schmidt, 1870): a) specimen collected at AL15SE1; b) skeleton formed by extremely compacted rhizoclones; c₁, c₂, c₃, c₄) rhizoclone desmas; d) general view of the framework of spiny rhizoclone desmas; e₁, e₂, e₃) detail of contacts between adjacent desmas; f) heads of exotylostyles.

such as corallivorous or ectoparasite gastropods (Taviani and Colantoni, 1979; Taviani and Sabelli, 1982; Taviani et al., 2009), or large bivalves (López Correa et al., 2005; Gofas et al., 2007), have been observed in our samples. The arcid bivalves *Asperarca nodulosa* and *Bathyarca philippiana* were commonly found byssated on hard substrates. The presence of gastropods, such as *Emarginula adriatica*, *Clelandella miliaris*, *Putzeysia wiseri*, and *Alvania cimicoides*, and bivalves, *A. nodulosa*, *Bathyarca philippiana*, *Karnekampia sulcata*, and *Spondylus gussoni*, is consistent with, although not exclusive to, CWC habitats s.l. (Guidastri et al., 1983; Tursi et al., 2004; Remia and Taviani, 2005; Toscano and Raspini, 2005; Mastrototaro et al., 2010; Rosso et al., 2010; Trincardi et al., 2010; Taviani et al., 2011b; Negri and Corselli, 2016).

3.4. Annelida

The annelid stock identified at stations AL15SE1 and AL16SE2 consists of 14 species at station AL15SE1

and 11 species at AL16SE2. *Metavermilium multicristata*, *Filigranula gracilis*, and *Filigrana* sp. 1 are the dominant species in both stations and also included living specimens. The species occurring at both stations are *Filigranula gracilis*, *F. stellata*, *F. annulata*, *Hyalopomatus madreporae*, *Metavermilium multicristata*, *Janita fimbriata* (Figure 5), *Placostegus tridentatus*, *Serpula* cfr. *vermicularis*, and *Vermiliopsis monodiscus*. Two morphotypes that may prove to be separate species in the genus *Filigrana* (*Filigrana* sp. 1 and *Filigrana* sp. 2: Table 2) occur at both stations. Most taxa are widely distributed in the Mediterranean Sea and eastern Atlantic Ocean (Castelli et al., 2008; Sanfilippo, 2009; Mastrototaro et al., 2010; D'Onghia et al., 2015).

Dense aggregates of *Filigrana* encrust the surface of coral colonies (stat. AL15SE1). Similar *Filigrana* tube aggregates have been previously recorded from the Bari Canyon (D'Onghia et al., 2015). The Mediterranean endemic serpulids *Vermiliopsis monodiscus* and

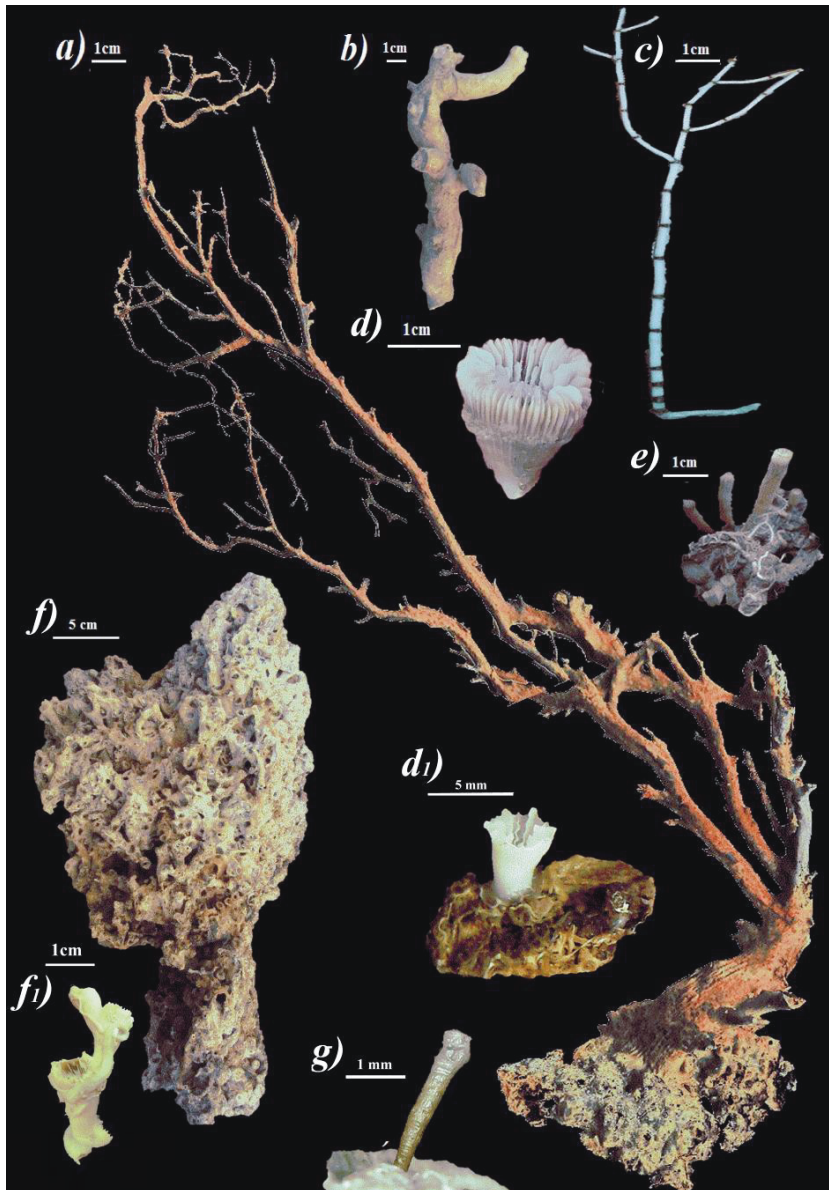


Figure 3. Cnidaria recorded from the study area: a) *Leiopathes glaberrima* (AL16SA1); b) *Dendrophyllia cornigera* (AL16SA1); c) *Isidella elongata* (AL16SE2); d, d1) *Caryophyllia calveri* (AL15SE1); e) *Stenocyathus vermiformis* (AL16SE2); f, f1) *Lophelia pertusa* (AL15SE1); g) *Nausithoe* sp. (AL15SE1)

Hyalopomatus madreporae (Figure 5) have both been reported from the SML and the Bari Canyon CWC provinces (Sanfilippo, 2009; Mastrototaro et al., 2010; D’Onghia et al., 2015).

In summary, the censused sessile annelid macrofauna as a whole is typical of deep-circalittoral, bathyal habitats. It also shares common traits with the Apulian CWC sites and deep-sea Mediterranean hardgrounds (Zibrowius and Taviani, 2005; Mastrototaro et al., 2010; Taviani et al., 2011b; Sanfilippo et al., 2013; D’Onghia et al., 2015).

3.5. Bryozoa

A total of 9 bryozoans have been identified on subfossil *Lophelia* colonies, most of which were determined at species level. Cyclostomes are represented by 2 taxa only (*Idmidronea* sp. 1: Figure 6, and *Crisia tenella longinodata*), whereas cheilostomes prevail with 7 species. Only 4 species occurred alive, namely *C. tenella longinodata*, *Idmidronea* sp. 1, *Neolagenipora eximia*, and *Herentia hyndmanni*. *Copidozoum exiguum*, *Smittina* cf. *crystallina*, and *Puellina pedunculata* were present with

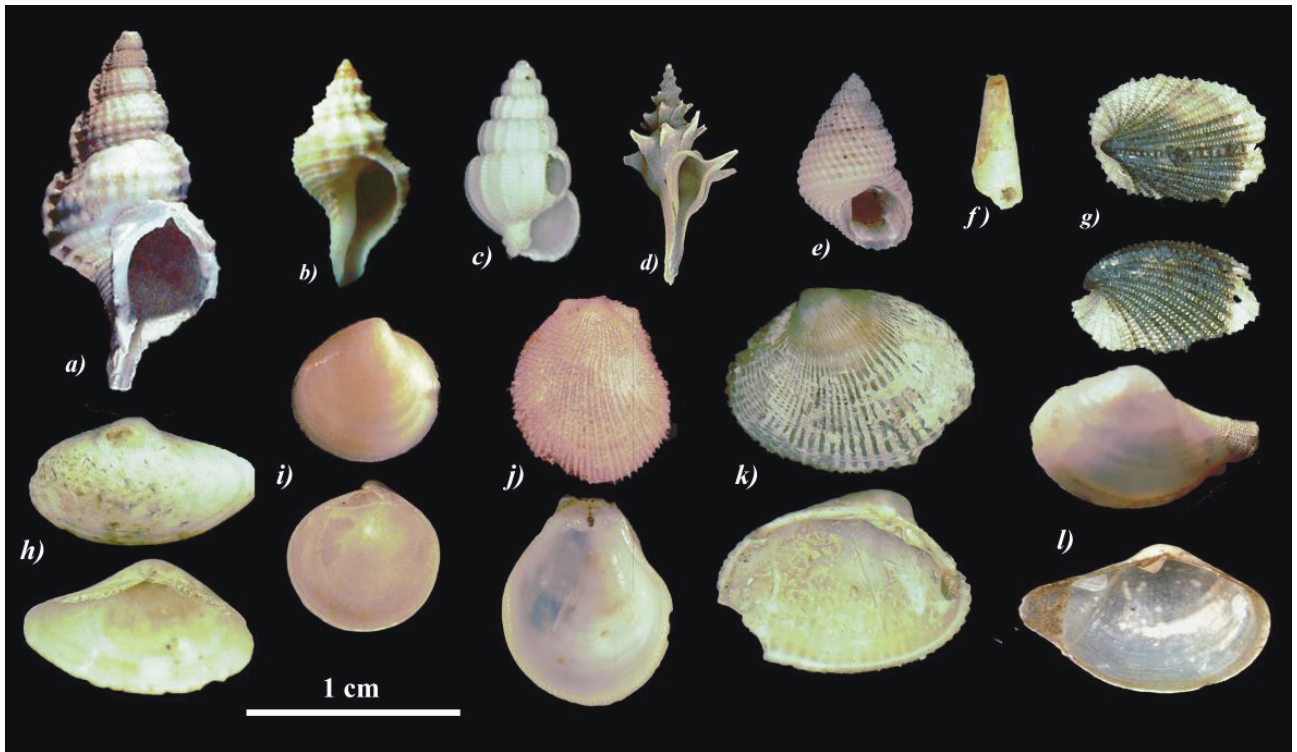


Figure 4. Mollusks associated with the *Lophelia pertusa* and *Dendrophyllia cornigera* subfossil colonies collected at AL15SE1 and AL16SE2, and AL16SA1: a) *Ranella olearia*; b) *Orania fusulus*; c) *Nassarius lima*; d) *Pagodula echinata*; e) *Putzeysia wiseri*; f) *Eulimella bogii*; g) *Emarginula adriatica*; h) *Yoldiella philippiana*; i) *Kelliella miliaris*; j) *Spondylus gussoni*; k) *Timoclea ovata*; l) *Tropidomya abbreviata*.

dead but fresh-looking colonies. The remaining species (*Ramphonotus* sp. and *Turbicellepora coronopus*), as well as fragments of additional species exclusively recorded from sediments, are only represented by old-looking specimens. These latter, namely *Diplosolen obelium*, *Adeonella pallasi*, and *Reptadeonella violacea*, were omitted from Table 2. All taxa are documented by very few colonies, with predominant encrusting morphotypes, including small unilaminar colonies and especially spots, i.e. colonies consisting of few zooids. Erect colonies are sporadic, small-sized and poorly branched. Nearly all species were previously known as colonizers of hard substrates, including live and dead coral skeletons (Zabala et al., 1993; Mastrototaro et al., 2010; D'Onghia et al., 2015; Rosso and Di Martino, 2016), but none specifically adapted to or exclusive to coral substrate. Most species were previously reported from the SML and the Bari Canyon (BC) coral provinces (Mastrototaro et al., 2010; D'Onghia et al., 2015). Both cyclostomes occurring in the Albanian waters with living colonies were first recognized as fossils from southern Italy (Rosso and Di Geronimo, 1998; Rosso, 2005), but were subsequently discovered alive in the SML and BC coral provinces (Mastrototaro et al., 2010; D'Onghia et al., 2015). Conversely, *Puellina pedunculata*,

Smittina cf. *crystallina*, and *Herentia hyndmanni* were also reported from canyons along the Catalonia slope (Zabala et al., 1993), besides the Apulian offshore (Mastrototaro et al., 2010; D'Onghia et al., 2015). *Neolagenipora eximia* (Figure 6) is a first live record for the area. This species was already known from the northwestern Mediterranean Sea (Harmelin, 1976; Zabala et al., 1993; Madurell et al., 2013). Based upon its mainly northern Atlantic distribution and its occurrence as a Pleistocene fossil in southern Italy (Rosso, 2005), *N. eximia* was considered a relic element in the Mediterranean Sea (Di Geronimo et al., 1996; Rosso and Di Geronimo, 1998). The present finding considerably expands the Mediterranean distribution of a species once considered as nearly disappeared in this basin.

3.6. Conclusions

The present study provides a first account of the macro- and megafauna deep-sea biodiversity associated with CWC and hardground habitats in the Adriatic Albanian waters. A total of 83 species were identified, including 74 species that are new records for the Albanian fauna, remarkably improving the knowledge of the deep-sea benthos of the southeastern Adriatic Sea.

The considerable number of species associated with subfossil *Lophelia* colonies and *Dendrophyllia*

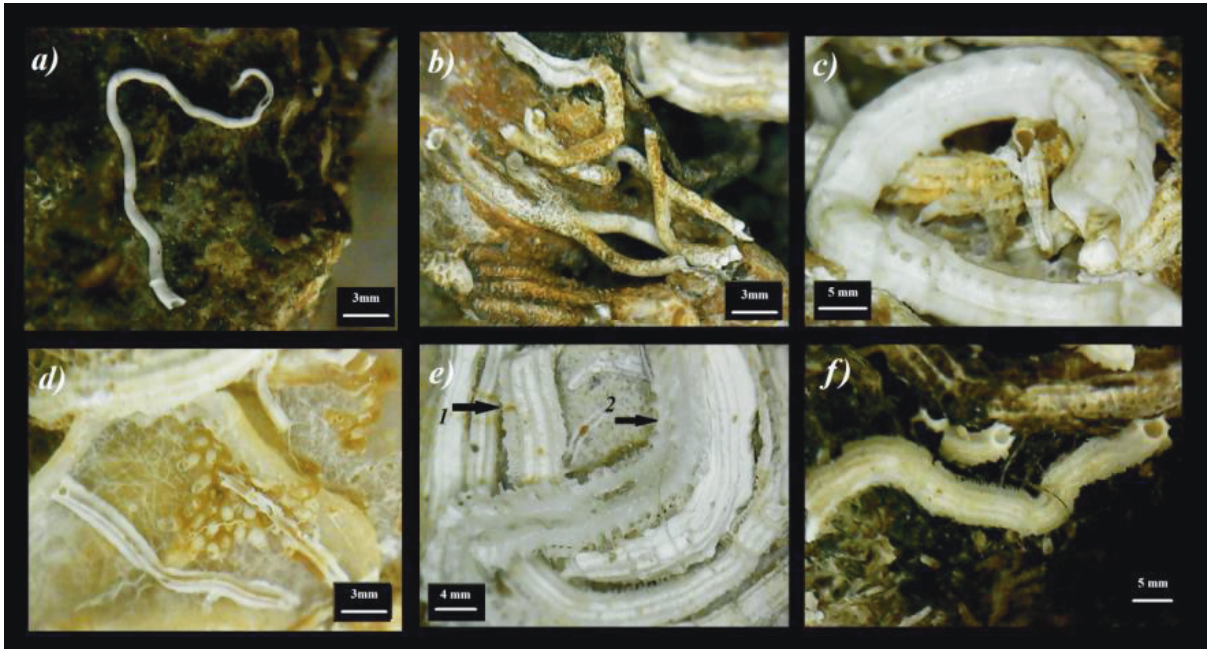


Figure 5. Annelids associated with *Lophelia* subfossil colonies from stations AL15SE1 and AL16SE2: a) *Hyalopomatus madreporae*, b, c) Serpulidae sp. 1, d) *Filigranula gracilis*, e) 1: *Metavermilia multicristata*, 2: *Janita fimbriata*, f) *Metavermilia multicristata*.

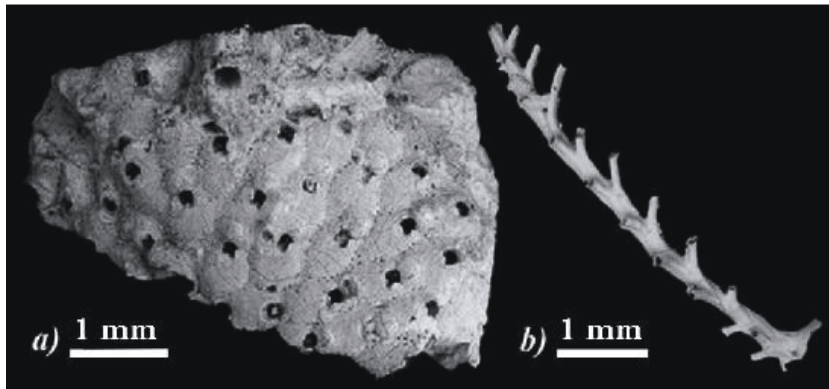


Figure 6. SEM images of bryozoans: a) *Neolagenipora eximia*, stat. AL15SE1; b) *Idmidronea* sp. 1., stat. AL15SE1.

rubble provides further confirmation that dead coral frameworks are highly significant in terms of associated species diversity (Freiwald and Wilson, 1998; Roberts et al., 2009). Dead frames are typically characterized by attached suspension-feeding fauna, including numerous sponges, actinians, and other cnidarian species, and smaller epifauna including bryozoans and serpulids. Sediment trapped in the coral framework offers niches to infaunal species, such as polychaetes and mollusks. The predominance of suspension feeders seems to be linked to the trophic energy system in these situations.

The occurrence of subfossil *L. pertusa* is documented for the first time in Albanian waters and such a finding indicates that ecological conditions were suitable for their development in the past.

Promisingly, our results thus disclosed a considerable diversity of deep-water benthos associated with dead CWC and hardground substrates in Albanian waters. This information derives from commercial fishery operations and this calls for future scientific action to fully evaluate the CWCs' precise location, extent, and biodiversity in this sector of the Adriatic Sea.

Acknowledgments

This paper is an outgrowth of part of the PhD dissertation of the senior author in the frame of the Flag Project RITMARE. We thank the fishermen Elham Malaj and Redi Nika for their assistance in sampling corals in Albanian waters, and A Viola for kindly helping with

scanning electron microscope work at the Microscopical Laboratory of the University of Catania. This study is part of the EU IDEM project, and is ISMAR-Bologna Scientific Contribution N. 1952 and Catania Palaeontological Research Group Contribution N. 438.

References

- Angeletti L, Canese S, Franchi F, Montagna P, Reitner J, Walliser EO, Taviani M (2015). The “chimney forest” of the deep Montenegrin margin, south-eastern Adriatic Sea. *Mar Petr Geol* 66: 542-554.
- Angeletti L, Taviani M (2011). Entrapment, preservation and incipient fossilization of benthic predatory molluscs within deep-water coral frames in the Mediterranean Sea. *Geobios* 44: 543-548.
- Angeletti L, Taviani M, Canese S, Fogliani F, Mastrototaro F, Argnani A, Trincardi F, Bakran-Petricioli T, Ceregato A, Chimienti G et al. (2014). New deep-water cnidarian sites in the southern Adriatic Sea. *Mediterr Mar Sci* 15: 225-238.
- Bargain A, Marchese F, Savini A, Taviani M, Fabri MC (2017). Santa Maria di Leuca Province (Mediterranean Sea): Identification of suitable mounds for cold-water coral settlement using geomorphometric proxies and Maxent methods. *Front Mar Sci* 4: 338.
- Beuck L, Freiwald A, Taviani M (2010) Spatio-temporal bioerosion patterns in deep-water scleractinians from off Santa Maria di Leuca (Apulia, Ionian Sea). *Deep Sea Res II* 57: 458-470.
- Bo M, Bertolino M, Bavestrello G, Canese S, Giusti M, Angiolillo M, Pansini M, Taviani M (2012). Role of deep sponge grounds in the Mediterranean Sea: a case study in southern Italy. *Hydrobiologia* 687: 163-177.
- Boero F, Fogliani F, Fraschetti S, Goriup P, Macpherson E, Planes S, Soukissian T, CoCoNet Consortium (2017). CoCoNet: towards coast to coast networks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential. *SCIRES It* 6: 1-9.
- Bongiorni L, Mea M, Gambi C, Pusceddu A, Taviani M, Danovaro R (2010). Deep-water scleractinian corals promote higher biodiversity in deep-sea meiofaunal assemblages along continental margins. *Biol Conserv* 143: 1687-1700.
- Carlier A, Le Guilloux E, Olu K, Sarrazin J, Mastrototaro M, Taviani M, Clavier J (2009). Trophic relationships in a deep Mediterranean cold-water coral bank (Santa Maria di Leuca, Ionian Sea). *Mar Ecol Prog Ser* 397: 125-137.
- Castelli A, Bianchi CN, Cantone G, Çinar ME, Gambi MC, Giangrande A, Sareri DI, Lanera P, Licciano M, Musco L et al. (2008). Annelida Polychaeta. *Biol Mar Mediter* 15: 323-73.
- Cirino P, Palumbo F, Di Capua I, editors (2016). MOTax Newsletter 0. Naples, Italy: Stazione Zoologica Anton Dohrn. Available online at http://www.szn.it/images/news/Motax/MOTax_NL_issue0.pdf (in Italian).
- Colantoni P, Noto P, Taviani M (1975). Prime datazioni assolute di una fauna fossile a *Pseudamussium septemradiatum* dragata nel basso Adriatico. *Giorn Geol* 40: 133-140 (in Italian).
- Di Geronimo I, La Perna R, Rosso A (1996). The Plio-Quaternary evolution of the deep-sea Mediterranean benthos: an outline. In: Proceedings of the Interim Colloquium “La Méditerranée: variabilité climatiques, environment et biodiversité”, pp. 286-291.
- D’Onghia G, Calulli C, Capezzuto F, Carlucci R, Carluccio A, Grehan A, Indennitate A, Maiorano P, Mastrototaro F, Pollice A et al. (2017). Anthropogenic impact in the Santa Maria di Leuca cold-water coral province (Mediterranean Sea): observations and conservation straits. *Deep Sea Res II* 145: 87-101.
- D’Onghia G, Capezzuto F, Cardone F, Carlucci R, Carluccio A, Chimienti G, Corriero G, Longo C, Maiorano P, Mastrototaro F et al. (2015). Macro- and megafauna recorded in the submarine Bari Canyon (southern Adriatic, Mediterranean Sea) using different tools. *Mediterr Mar Sci* 16: 180-96.
- Fabri MC, Pedel L, Beuck L, Galgani F, Hebbeln D, Freiwald A (2014). Megafauna of vulnerable marine ecosystems in French Mediterranean submarine canyons: spatial distribution and anthropogenic impacts. *Deep Sea Res II* 104: 184-207.
- Fosså JH, Mortensen PB, Furevik DM (2002). The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia* 471: 1-12.
- Freiwald A, Beuck L, Rüggeberg A, Taviani M, Hebbeln D (2009). The white coral community in the central Mediterranean Sea revealed by ROV surveys. *Oceanography* 22: 58-74.
- Freiwald A, Wilson JB (1998). Taphonomy of modern deep, cold temperate water coral reefs. *Hist Biol* 13: 37-52.
- Galil B, Zibrowius H (1998). First benthos samples from Eratosthenes Seamount, eastern Mediterranean. *Senckenberg Marit* 28: 111-120.
- Gofas S, Freiwald A, López Correa M, Remia A, Salas C, Taviani M, Wisshak M, Zibrowius H (2007). Oyster beds in the deep sea. In: World Congress of Malacology, Belgium, 15–20 July 2007, *Unitas Malacologica, Abstracts*, pp. 80-82.
- Guidastri R, Melone G, Taviani M (1983). Systematic position of “*Trochus*” *wiseri* Calcara (Prosobranchia: Trochidae). *Arch Mollusk* 114: 125-136.
- Harmelin JG (1976). Le sous-ordre *Tubuliporina* (Bryozoaires Cyclostomes) en Méditerranée. *Bull Inst Océanogr (Monaco)* 10: 1-326 (in French).

- Keppell E, Armeli Minicante S, Bonomo S, Capotondi L, Ceregato A, Fontaneto D, Froglija C, Petrocelli A, Taviani M, CNR Taxonomic Team (2017). Taxonomy at CNR. Technical Report. Venice, Italy: ISMAR.
- Jarms G, Tiemann H, Altuna A (2003). A new bathybenthic coronate polyp, *Nausithoe sorbei* sp. nov. (Scyphozoa, Coronatae), from the Bay of Biscay and off Azores. *Mitt Hamb Zool Mus Inst [ZDB]* 100: 1-11.
- Jensen A, Frederiksen R (1992). The fauna associated with the bank-forming deepwater coral *Lophelia pertusa* (Scleractinaria) on the Faroe shelf. *Sarsia* 77: 53-69.
- Longo C, Mastrototaro F, Corriero G (2005). Sponge fauna associated with a Mediterranean deep-sea coral bank. *J Mar Biol Assoc UK* 85: 1341-1352.
- López Correa M, Hall-Spencer JM, Freiwald A, Taviani M (2005). Distribution and habitats of *Acesta excavata* (Bivalvia: Limidae) with new data on its shell ultrastructure. In: Freiwald A, Roberts JM, editors. *Cold-Water Corals and Ecosystems*. Berlin, Germany: Springer, pp. 173-205.
- Madurell T, Zabala M, Dominguez-Carrió C, Gili JM (2013). Bryozoan faunal composition and community structure from the continental shelf off Cap de Creus (Northwestern Mediterranean). *J Sea Res* 83: 123-136.
- Maier C, Watremez P, Taviani M, Weinbauer MG, Gattuso JP (2012). Calcification rates and the effect of ocean acidification on Mediterranean cold-water corals. *Proc R Soc B: Biol Sci* 279: 1716-1723.
- Mastrototaro F, D'Onghia G, Corriero G, Matarrese A, Maiorano P, Panetta P, Gherardi M, Longo C, Rosso A, Sciuto F et al. (2010). Biodiversity of the white coral bank off Cape Santa Maria di Leuca (Mediterranean Sea): an update. *Deep Sea Res II* 57: 412-430.
- McCulloch M, Taviani M, Montagna P, López Correa M, Remia A., Mortimer G (2010). Proliferation and demise of deep-sea corals in the Mediterranean during the Younger Dryas. *Earth Plan Sci Lett* 298: 143-152.
- McCulloch M, Trotter J, Montagna P, Falter J, Dunbar R, Freiwald A, Försterra G, López Correa M, Maier M, Rüggeberg A et al. (2012). Resilience of cold-water scleractinian corals to ocean acidification: boron isotopic systematics of pH and saturation state up-regulation. *Geoch Cosmoch Acta* 87: 21-34.
- Morri C, Esposito F, Pessani D (2008). Anthozoa. In: Checklist della flora e della fauna dei mari italiani (parte I). *Biol Mar Medit* 15: 92-101.
- Mortensen PB, Fossa JH (2006). Species diversity and spatial distribution of invertebrates on deep-water *Lophelia* reef in Norway. In: *Proceedings of 10th International Coral Reef Symposium*, pp. 1849-1868.
- Nasto I (2017). Characterization of cold water coral communities in the Southern Adriatic. PhD, University of Milano Bicocca, Milan, Italy.
- Negri MP, Corselli C (2016). Bathyal Mollusca from the cold-water coral biotope of Santa Maria di Leuca (Apulian margin, southern Italy). *Zootaxa* 4186: 1-97.
- Oliverio M (2008). Checklist della flora e della fauna dei mari italiani (Parte I). *Gastropoda Prosobranchia*. *Biol Mar Medit* 15: 235-278 (in Italian).
- Orejas C, Gori A, Lo Iacono C, Puig P, Gili JM, Dale MR (2009). Cold-water corals in the Cap de Creus canyon, northwestern Mediterranean: spatial distribution, density and anthropogenic impact. *Mar Ecol Prog Ser* 397: 37-51.
- Panetta P, Mastrototaro F, Chimienti G, Angeletti L, D'Onghia G (2013). Tanatocenosi Wurmiana nel Canyon di Bari (Mar Adriatico). *Biol Mar Medit* 20: 148-149 (in Italian).
- Pansini M, Longo C (2003). A review of the Mediterranean Sea sponge biogeography with, in appendix, a list of the demosponges hitherto recorded from this sea. *Biogeographia* 24: 57-73.
- Remia A, Taviani M (2005). Shallow-buried Pleistocene *Madrepora*-dominated coral mounds on a muddy continental slope, Tuscan Archipelago, NE Tyrrhenian Sea. *Facies* 50: 419-425.
- Roberts JM, Davies AJ, Henry LA, Dodds LA, Duineveld GC, Lavaley MS, Maier C, Van Soest RW, Bergman MJ, Hühnerbach V et al., (2009). Mingulay reef complex: an interdisciplinary study of cold-water coral habitat, hydrography and biodiversity. *Mar Ecol Prog Ser* 397: 139-151.
- Rodolfo-Metalpa R, Montagna P, Aliani S, Borghini M, Canese S, Hall-Spencer JM, Foggo A, Milazzo M, Taviani M, Houlbrèque F (2015). Calcification is not the Achilles' heel of cold-water corals in an acidifying ocean. *Glob Change Biol* 21: 2238-2248.
- Rosso A, Di Geronimo I (1998). Deep-sea Pleistocene Bryozoa of southern Italy. *Geobios* 31: 303-17.
- Rosso A, Di Martino E (2016). Bryozoan diversity in the Mediterranean Sea: an update. *Mediterr Mar Sci* 17: 567-607.
- Rosso A, Vertino A, Di Geronimo I, Sanfilippo R, Sciuto F, Di Geronimo R, Violanti D, Corselli C, Taviani M, Mastrototaro F et al. (2010). Hard-and soft-bottom thanatofacies from the Santa Maria di Leuca deep-water coral province, Mediterranean. *Deep Sea Res II* 57: 360-79.
- Sanfilippo R (2009). New species of *Hyalopomatus* Marenzeller, 1878 (Annelida, Polychaeta, Serpulidae) from Recent Mediterranean deep-water coral mounds and comments on some congeners. *Zoosystema* 31: 147-61.
- Sanfilippo R, Vertino A, Rosso A, Beuck L, Freiwald A, Taviani M (2013). *Serpula* aggregates and their role in deep-sea coral communities in the southern Adriatic Sea. *Facies* 59: 663-77.
- Taviani M (1978). Associazioni a Molluschi pleistoceniche-attuali dragate nell'Adriatico meridionale. *Ital J Zool* 45: 297-306 (in Italian).
- Taviani M, Angeletti L, Antolini B, Ceregato A, Froglija C, López Correa M, Montagna P, Remia A, Trincardi F, Vertino A (2011a). Geo-biology of Mediterranean deepwater coral ecosystems. In: Brugnoli E, editor. *Marine Research at CNR*. Rome, Italy: Consiglio Nazionale delle Ricerche, pp. 705-719.
- Taviani M, Angeletti L, Beuck L, Campiani E, Canese S, Fogliani F, Freiwald A, Montagna P, Trincardi F (2016). Reprint of "On and off the beaten track: Megafaunal sessile life and Adriatic cascading processes". *Mar Geol* 375: 146-160.

- Taviani M, Angeletti L, Canese S, Cannas R, Cardone F, Cau A, Cau AB, Follesa MC, Marchese F, Montagna P et al. (2017). The “Sardinian Cold-Water Coral Province” in the context of the Mediterranean coral ecosystems. *Deep Sea Res II* 145: 61-78.
- Taviani M, Angeletti L, Dimech M, Mifsud C, Freiwald A, Harasewych MG, Oliverio M (2009). Coralliophilinae (Gastropoda: Muricidae) associated with deep-water coral banks in the Mediterranean. *Nautilus* 123: 106-112.
- Taviani M, Colantoni P (1979). Thanatocoenoses wüirmiennes associées aux coraux blancs. *Rapp Proc Verb Reun CIESM* 25: 141-142 (in French).
- Taviani M, Freiwald A, Zibrowius H (2005). Deep coral growth in the Mediterranean Sea: an overview. In: Freiwald A, Roberts JM, editors. *Cold-Water Corals and Ecosystems*. Berlin, Germany: Springer, pp. 137-156.
- Taviani M, Sabelli B (1982). *Iphitus* (Mollusca, Gastropoda) a deep-water genus new to the Mediterranean Sea. *Lav Soc Malacol It* 1982: 129-131.
- Taviani M, Vertino A, López Correa M, Savini A, De Mol B, Remia A, Montagna P, Angeletti L, Zibrowius H, Alves T et al. (2011b). Pleistocene to Recent scleractinian deep-water corals and coral facies in the Eastern Mediterranean. *Facies* 57: 579-603.
- Topsent E (1925). Etude des Spongiaires du Golfe de Naples. *Arch Zool Exper Gen* 63: 623-725 (in French).
- Toscano F, Raspini A (2005). Epilithozoan fauna associated with ferromanganese crustgrounds on the continental slope segment between Capri and Li Galli Islands (Bay of Salerno, Northern Tyrrhenian Sea, Italy). *Facies* 50: 427-441.
- Trincardi, F, Fogliini F, Verdicchio G, Asioli A, Correggiari A, Minisini D, Piva A, Remia A, Ridente D, Taviani M (2007). The impact of cascading currents on the Bari Canyon System, SW-Adriatic margin (Central Mediterranean). *Mar Geol* 246: 208-230.
- Tursi A, Mastrototaro F, Matarrese A, Maiorano P, D’Onghia G (2004). Biodiversity of the white coral reefs in the Ionian Sea (Central Mediterranean). *Chem Ecol* 20: 107-116.
- Van Soest RWM, Boury-Esnault N, Hooper JNA, Rützler K, de Voogd NJ, Alvarez B, Hajdu E, Pisera AB, Manconi R, Schönberg C et al. (2018). World Porifera Database. Available online at <http://www.marinespecies.org/porifera>.
- Vertino A, Savini A, Rosso A, Di Geronimo I, Mastrototaro F, Sanfilippo R, Gay G, Etioppe G (2010). Benthic habitat characterization and distribution from two representative sites of the deep-water SML Coral Province (Mediterranean). *Deep Sea Res II* 57: 380-396.
- Zabala M, Maluquer P, Harmelin JG (1993). Epibiotic bryozoans on deep-water scleractinian corals from the Catalonia slope (western Mediterranean, Spain, France). *Sci Mar* 57: 65-78.
- Zibrowius H, Taviani M (2005). Remarkable sessile fauna associated with deep coral and other calcareous substrates in the Strait of Sicily, Mediterranean Sea. In: Freiwald A, Roberts JM, editors. *Cold-Water Corals and Ecosystems*. Berlin, Germany: Springer, pp. 807-819.