

1 **ON AND OFF THE BEATEN TRACK: MEGAFANAL SESSILE LIFE AND ADRIATIC**
2 **CASCADING PROCESSES**

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4 M. Taviani^{1,2}, L. Angeletti^{1*}, L. Beuck³, E. Campiani¹, S. Canese⁴, F. Foglini¹, A. Freiwald³, P.
5 Montagna^{1,5,6}, F. Trincardi^{1,7}

6

7 ¹ ISMAR-CNR, UOS Bologna, Via Gobetti 101, 40129, Bologna, Italy

8 ² Woods Hole Oceanographic Institution, 266 Woods Hole Rd, Woods Hole, Ma. 02543, USA

9 ³Abteilung Meeresforschung, Senckenberg am Meer, Südstrand 40, D-26382 Wilhelmshaven,
10 Germany

11 ⁴ ISPRA, Via Branconi 48, 00144 Rome, Italy

12 ⁵ Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, U.S.A.

13 ⁶ Laboratoire des Sciences du Climat et de l'Environnement, Laboratoire mixte CNRS-CEA, Gif-
14 sur-Yvette, France

15 ⁷ ISMAR-CNR Headquarters, Arsenale Tesa 104, Castello 2737/F, Venice, Italy

16 *Corresponding author

17 Tel: +39 0516398936

18 Fax: +39 0516398940

19 Email: lorenzo.angeletti@bo.ismar.cnr.it

20

21 **Abstract.** Valuable megafaunal sessile assemblages in the southern Adriatic basin present a
22 western-eastern asymmetric distribution. This is particularly evident when considering cold-water
23 coral (CWC) communities, with most diverse and abundant live corals to be found along the
24 western side. On the contrary, only spotty occurrences are documented in the eastern side and at
25 times only in a sub-fossil state. We hypothesize that this asymmetry might possibly derive from
26 differential exposure of the Adriatic floor to polarized hydrological processes. In such a perspective,

27 vigorous albeit a-periodical flushing of deep-sea bottoms at times of cascading processes could be
28 beneficial to sessile deep-sea benthic communities by reinforcing the North Adriatic Deep Water
29 (NAdDW), contrasting excess silting and by enhancing the trophic web. Although no experimental
30 evidence has been yet produced to test this hypothesis, it gains some support by the observation that
31 CWC are flourishing in the general area of the Bari Canyon and adjacent bottoms flushed by dense
32 shelf water (DSW) cascading while they are much less developed on the basin's opposite side,
33 unaffected by this phenomenon.

34

35 **Key words:** Adriatic Sea, deep-sea, megabenthos, cold-water corals, cascading, distribution.

36 **1. Introduction**

37

38 The formation of dense shelf water (hereafter DSW) and its down-slope overflowing
39 (cascading) is regarded as a significant oceanographic process in the ocean, affecting at places polar
40 to tropical regions worldwide (Ivanov et al., 2004; Puig et al., 2008a). It also occurs in the present
41 Mediterranean basin (Fig. 1), being a prominent, albeit seasonal and a-periodical, phenomenon in
42 the Gulf of Lions, Adriatic and Aegean seas, associated with the formation of Mediterranean deep
43 waters (Durrieu de Madron et al., 2005, 2008; Canals et al., 2006, 2009; Palanques et al., 2006;
44 Trincardi et al., 2007; Puig et al., 2008a; Ribó et al., 2011; Vilibić et al., 2013).

45 A number of studies have elucidated the multiple repercussions connected to DSW
46 cascading. In the Mediterranean Sea, cascading acts either singularly or by reinforcing storm-related
47 down-welling, and results in shelf water export (Ulses et al., 2008a,b), particle/sediment re-
48 suspension and off-shelf transport (Canals et al., 2006; Guarracino et al., 2006; Heussner et al.,
49 2006; Palanques et al., 2006, 2008, 2009, 2012; Trincardi et al., 2007; Turchetto et al., 2007;
50 Bonnin et al., 2008; Ogston et al., 2008), organic matter supply (Canals et al., 2006; Tesi et al.,
51 2010), pollutant input (Sanchez-Vidal et al., 2015), sediment deposition (Gaudin et al., 2006;
52 DeGeest et al., 2008), and seabottom shaping (Canals et al., 2006; Lastras et al., 2007; Trincardi et
53 al., 2007; Bourrin et al., 2008; Puig et al., 2008b; Foglini et al., this volume).

54 Besides such physical responses, DSW cascading events reverberate also on ecosystems
55 (Canals et al., 2006; Puig et al., 2008a, 2013), impinging on the nutrient cycle by increasing organic
56 matter availability at depth, modifying the local biodiversity, and temporarily altering the trophic
57 state of the deep-sea benthic communities (Pusceddu et al., 2010, 2013; Dell'Anno et al., 2013). A
58 recent study suggests that DSW cascading events in the north-western Mediterranean are directly
59 correlated with fluctuations in the populations of the commercially-valuable deep-sea shrimp
60 *Aristeus antennatus* (Company et al., 2008).

61 Yet, not much is known at present on the possible action of DSW on complex benthic
62 epifaunal communities. Here, we provide a preliminary evaluation on the potential role of cascading
63 processes in controlling some aspects in the distribution of sessile megabenthos in the southern
64 Adriatic Sea. Our exercise consists in the plotting of easily recognizable sessile deep-sea
65 megabenthos occurrences, mainly derived from ROV inspections, on the morphological map of the
66 southern Adriatic basin, and with respect to dominant oceanographic situations.

67 The main scope of this study is to document differences in biological distribution that might
68 be related to the sea floor impingement of DSW trajectories.

69

70 **2. Study area**

71 The area taken into account in this study is that part of the Adriatic comprised from
72 42°50.00' Lat N, roughly the transverse between Vieste in Apulia and Otok Mljet in Croatia, to
73 39°30.00' Lat N, roughly the transverse between Otranto in Apulia and Kerkyra Island in Greece
74 (Fig. 1). The general submarine morphology of this region reveals approximates a ca. 400 km long
75 irregular club-like shape basin reaching down to 1200 m, rimmed by steeped flanks, and narrowing
76 southwards where it opens to the Ionian Sea (e.g., Trincardi et al., 2014; EMODnet, 2014). More in
77 detail, the morphology is quite complex and definitely asymmetrical with a western sector carved
78 by multiple canyons, including such conspicuous features as Bari Canyon, the biggest in the
79 southern Adriatic, topographic highs such as the Dauno Seamount, rough macrotopographies linked
80 to sediment failure deposits from blocky slumps to large size olistostromes, mudwave fields and
81 other sea-bottom irregularities (Trincardi et al., 2007; Argnani et al., 2011; Foglini et al., this issue,
82 with references therein). Conversely, the eastern side margin displays an overall less pronounced
83 topographic roughness (Fig. 2).

84

85 **3. Oceanographic setting**

86 Salinity-temperature transects in the southern Adriatic highlights that North Adriatic Deep
87 Water (NAdDW) is clearly a relevant water mass typically bathing in early spring the western
88 margin between ca. -300 and -800 m, whilst is almost unappreciable on the eastern side (Cardin et
89 al., 2011). DSW events likely add to the Coriolis-forced NAdDW flows that intercept then the
90 modified Levantine Intermediate Water (LIW) in a region and depth range of the southern Adriatic
91 where the CWC are most prolific (Freiwald et al., 2009; Angeletti et al., 2014), eventually outgoing
92 in the Ionian Sea through the Otranto Strait as Adriatic Bottom Water (ABW). Far from being a
93 simple and linear situation, the southern Adriatic has also been affected by the strong influence of
94 the Eastern Mediterranean Transient, which forces changes in the vertical salinity and temperature
95 patterns (Cardin et al., 2011). To complicate further this picture, it must be also taken into account
96 that the southern Adriatic region where the ecosystems under scrutiny are located, is further
97 influenced in late winter to early spring by open water convection processes with variable
98 intensities in different years (Civitarese et al., 2005). These latter necessarily impinge on critical
99 water mass attributes, as particulate mass fluxes and nutrient cycle, as seen from chlorophyll data,
100 which in some years may be relevant to deep-sea benthos.

101

102

103 **4. Material and methods**

104 We selected for this study macroscopic benthic organisms whose distribution in the southern
105 Adriatic Sea might in principle represent a possible response to DSW cascading events which could
106 follow the seasonal formation on the northern Adriatic continental shelf of North Adriatic Deep (or
107 Dense) Water (NAdDW: Vilibić and Supić, 2005). Accordingly, we picked up some of the most
108 relevant deep-sea sessile habitat formers, with precise requirements in terms of hydrological
109 regimes, substrate and trophism. Our choice as best candidates fell on the CWC (white corals)
110 *Lophelia pertusa* (Linnaeus, 1758), *Madrepora oculata* Linnaeus, 1758, *Desmophyllum dianthus*
111 (Esper, 1794), the antipatharian (black coral) *Leiopathes glaberrima* (Esper, 1792), the gorgonacean
112 *Callogorgia verticillata* (Pallas, 1766), and the demosponges *Pachastrella monilifera* Schmidt,
113 1868, and *Poecillastra compressa* (Bowerbank, 1866). All such organisms settle hard substrates
114 influenced by current at depths > 300 m (Freiwald et al., 2009; Taviani et al., 2011; Bo et al., 2012;
115 Sanfilippo et al., 2013; Angeletti et al., 2014). Their sessile habit requires a predictable and, at least
116 at times, substantial availability of food, whose typology varies according to the trophism of each
117 taxon, encompassing filter feeding in demosponges up to occasional active catch of live prey in
118 scleractinians.

119 Data presented are sourced from a total of 10 oceanographic missions in the southern
120 Adriatic carried out from 2006 to 2014.

121 R/V *Meteor* cruise M70/1 surveyed in the southern Adriatic parts of the Bari Canyon, the
122 deeper section of the Gondola Slide and the western flank of the Dauno Seamount with the Quest
123 4000m-ROV of MARUM, University of Bremen in the period October 12 to 15, 2006 (Freiwald et
124 al., 2006, 2011). This survey is to date the best documentation of deep-water macro- (>1 mm) and
125 megabenthic (> 1 cm and easily recognizable in video and/or photographs) epifaunal organisms
126 distributed between ca. 300-1110 m (see Table 1 for detailed ROV station data; Freiwald et al.,
127 2009). The QUEST ROV was equipped with two manipulator systems (ORION 7P and

128 RIGMASTER) to grab samples directly or execute the sampling process with “hand” tools, like
129 nets, boxes or push cores. Furthermore, the ROV was provided with a rotary suction sampler, a
130 temperature-conductivity-pressure sensor and with various camera systems. The video streams of
131 the video camera system DSPL SSC 6500 Colorzoom as well as Insite Pegasus Colorzoom were
132 continuously recorded on miniDV tapes (including time code) and additional compilation of
133 minifilms with an interval of 10 seconds were generated during the dives with the underwater
134 vehicle data post-processing software ADELIE of IFREMER. The HDTV video camera Insite
135 ZEUS Plus Colorzoom was recorded selectively on HDCAM HDTV tapes and a continuously
136 creation of minifilms. With a digital camera (NIKON coolpix) additional colour high resolution
137 photographs were taken and with the aid of the ADELIE observation tool, biodiversity and geology
138 were recorded by scientists “on the fly”.

139 R/V *Urania* Cruises SETE06, BARCA07, SASSI08, ARCADIA and MEMA12 surveyed
140 the entire Apulian margin, whereas ALTRO and CROMA surveyed the Montenegrin margin,
141 COCOMAP13 the Albanian, and COCOMAP14 the Greek margins respectively. Swath bathymetry
142 data were acquired using three different systems: 1) Kongsberg Simrad EM710 multibeam echo-
143 sounder with nominal sonar frequency of 70-100 kHz, 2) EM3002D with nominal sonar frequency
144 of 300 kHz; 3) Reson 8160 with nominal frequency of 50 kHz. Water column attributes were
145 measured with a Seabird SBE 11 PLUS CTD. Visual inspection was conducted using the ROV
146 ‘Achille M4’ (ARCADIA cruise), equipped with a CCD camera, and the ROV ‘Pollux III’
147 (ALTRO, COCOMAP13, COCOMAP14 cruises) equipped with a digital camera (Nikon D80, 10
148 mega pixels) and a high-definition video camera (SonyHDR-HC7). Sea bottom sampling was
149 performed using a large-volume (60 l) Van Veen grab, box-corer, epibenthic hauls, and with the
150 ROV robotic arm (see Table 2 for station information and main findings). ROV operations launched
151 from R/V *Urania* never exceeded 600 m water depth (see Table 1 for ROV station information).

152 The surveyed ground covers a depth range between 300 - 1000 m for a total linear distance
153 of ca. 37 km. More in detail, over 14,5 km pertain to the southwestern Adriatic (Italian side: Bari

154 Canyon, Dauno Semount and Gondola Slide); 2 km refer to the south-central Adriatic (Croatia); ca.
155 5,8 km (Montenegrin waters), 6,9 km (Albanian waters), and 5 km (Greek waters) concern the
156 southeastern Adriatic (Table 1). In addition, this documentation and sampling by ROV has been
157 further integrated at specific sites by a grabs and box-cores (see Angeletti et al., 2014).

158 In total, we have analysed over 45 hours of video recording related to 27 ROV dives (Table
159 1) by extracting a snapshot every 20 s from each video track to classify habitat features. We adopted
160 the tool ‘minifilms’ of the ADELIE software, obtaining over 8000 images from the low-definition
161 videos. On occasion, the same procedure has been adopted for the high-definition recorded video.

162 Because of the exploratory nature of the oceanographic missions here considered, our
163 approach is by large qualitative, focusing upon presence/absence of the target megabenthic
164 epifauna.

165 U-series dating of the *Madrepora oculata* specimen collected along the Montenegrin margin
166 was determined at the Laboratoire des Sciences du Climat et de l’Environnement (LSCE) at Gif-
167 sur-Yvette following the protocol reported in Pons-Branchu et al. (2014). Prior to analysis the
168 sample was carefully cleaned using a fine diamond saw and then leached with 0.1 M HCl. The
169 sample was dissolved with diluted HCl, equilibrated with a mixed ^{236}U - ^{233}U - ^{229}Th spike, and the U
170 and Th fractions separated using UTEVA resin (Eichrom Technologies, USA). Uranium and
171 thorium isotopes were analysed using a ThermoScientific NeptunePlus multi-collector inductively
172 coupled plasma mass spectrometer. Based on the measured atomic ratios, U-series ages were
173 calculated using the half-life of Jaffey et al. (1971), and Cheng et al. (2013).

174

175 **5. Results**

176

177 The occurrences of the selected target megabenthic species on a presence/absence base is
178 presented in Table 2 and Figure 2, which provide the very first overview of such megabenthos-
179 bearing communities in the southern Adriatic. We are also showing separately the distribution of

180 CWC (Fig. 3), which are considered on a global scale among the most ecologically and
181 economically valuable deep-water ecosystems (Roberts et al., 2009; Foley et al., 2010).
182 Additionally, their carbonate exoskeleton permits keeping memory on former CWC presence at
183 sites where they are either at present disappeared or waning (Delibrias and Taviani, 1985; Remia
184 and Taviani, 2005; McCulloch et al., 2010; Malinverno et al., 2010). When combined, these plots
185 also reveal important traits in the distribution of such organisms. The most relevant is that their
186 overall distribution is asymmetrical. In the same depth belt, there is a larger concentration of CWC
187 sites on the western margin (Figs. 2-3) while the opposite side reveals in comparison an apparent
188 absence or more spotty presence. Regarding other cnidarians, they form more evident communities
189 on the eastern side, often dominating the habitat. Being solely based on mere presence/absence,
190 Figures 2 and 3, however, neglect to provide any quantification of CWC presence. As such, it
191 shows that CWC sites containing the classic triad *Lophelia-Madrepora-Desmophyllum* (Taviani et
192 al., 2005a) do equally occur on both sides, what could be misleading. There are instead marked
193 differences, with much more CWC areal cover in terms of number of colonies on the western side
194 than on the eastern margin (as visually evidenced in Fig. 4 for the western Adriatic side and in Fig.
195 7 for the eastern side, respectively). No CWC sites comparable in extension and number of colonies
196 to what observed in the Bari Canyon and adjacencies have been so far identified on the opposite
197 site, even at the best Montenegrin stations.

198 This trend is further discussed in the following section that documents more in detail the
199 various habitats exploited at variable extents by the megabenthic target species and associated
200 macrobenthos

201

202 **5.1. Megabenthic deep-sea epifauna in the southern Adriatic**

203

204 **5.1.1 The western side (Figs. 4-6)**

205 *Bari Canyon*

206 During R/V *Meteor* Cruise M70/1 two ROV dives were carried out to inspect benthic communities
207 on the steeply inclined, E-W striking southern slope of the canyon (GeoB 11190/Station 735) and
208 about 10 nm further west, along a spur of the southern Bari Canyon wall (GeoB 11200/Station 745;
209 see Table 1). Detailed seabed topography and sedimentary facies is published to some extent in
210 Freiwald et al. (2009), and Sanfilippo et al. (2013) and only main results are provided. The
211 framework-constructing corals encountered are *M. oculata*, *L. pertusa* and *Dendrophyllia cornigera*
212 (Lamarck, 1816) in the depth interval 310-650 m (Fig. 4A). The solitary corals *D. dianthus*,
213 *Stenocyathus vermiformis* (Portualès, 1868), and *Caryophyllia calveri* Duncan, 1873, are commonly
214 attached to the dead or tissue-barren basal parts of the colonial scleractinians. The lobate sponges *P.*
215 *monilifera* and *P. compressa* are further characteristic and locally the dominating structural faunal
216 elements on the southern Bari Canyon slope and thereby attracting a diverse mobile assemblage
217 consisting of shrimps, crabs, echinoderms and gastropods (see also Bo et al., 2012; Angeletti et al.,
218 2014). In the shallowest section of ROV dive GeoB 11200/Station 745 from 315 to 306 m depth, up
219 to 12-cm-large colonies of the reddish bryozoan *Smittina cervicornis* (Pallas, 1766) are associated
220 with *M. oculata* and sponges (*P. monilifera*, *P. compressa*). The most conspicuous discovery,
221 however, are the coral-serpulid frameworks dominated by *Serpula vermicularis* Linnaeus, 1767,
222 described in detail by Sanfilippo et al. (2013). *S. vermicularis* has never been found as substantial
223 contributor to coral frameworks in the bathyal zone before and elsewhere. Beside *S. vermicularis*,
224 other sedentary calcareous polychaetes such as *Filogranula gracilis* (Langerhans, 1844),
225 *Metavermlia multicristata* (Philippi, 1844), *Vermiliopsis monodiscus* Zibrowius, 1968,
226 *Bathyvermlia eliasoni* (Zibrowius, 1970) and *Hyalopomatus madreporae* Sanfilippo, 2009, add to
227 the serpulid-constructing part of the skeletal frameworks (Sanfilippo et al., 2013). This area has
228 been also surveyed during R/V *Urania* ARCADIA cruise (Angeletti et al., 2014). In this context,
229 the ROV stations A77, A208 and A210 have been carried out which focused upon coral and sponge
230 growth between 380-480 m (Fig. 4B-G).

231

232 *Dauno Seamount*

233 ROV dive GeoB 11194/Station 739 surveyed the southwestern flank of Dauno Seamount from 997
234 to 733 m water depth upslope (Fig. 5A-D). Compared to the more landward sites such as Bari
235 Canyon and Gondola Slide, the seamount flank shows sparse megafauna presence. The most
236 prominent element is *P. monilifera* rooted on outcropping hard substrates such as bedrock or
237 hardground crusts. No colonial scleractinians were observed on the ROV track. Only sparse
238 colonisation of *D. dianthus* both alive and *in situ* dead or subfossil occurs in the depth range 929-
239 780 m.

240

241 *Gondola Slide*

242 ROV dive GeoB 11207/Station 752 was directed over a section of the deeper part of the Gondola
243 Slide in the depth range 674-710 m (Fig. 5E-H). The seabed is highly variable with sandwaves,
244 often completely covered by indurated hardground crusts in which gravity transported slabs or
245 olistostromes are interspersed (Minisini et al., 2006; Trincardi et al., 2008; Dalla Valle et al., 2014).
246 In places, the lithified crusts are washed out and provide suitable habitat for *L. pertusa*, *D. dianthus*
247 and *Paracyathus pulchellus* (Philippi, 1842). In the current lee of such outwashed areas, freshly
248 sedimented detritus comprising of *Delectopecten vitreus* (Gmelin, 1791), *Argonauta* sp. and
249 pteropod shells preferably accumulates. Unlithified sandwave bedforms are densely colonized by
250 tube-building amphipods. A main target of this dive was a 900-m-long and about 50-m-high
251 olistostrome that contains fossil shellbeds of *Pseudamussium peslutrae* (Linnaeus, 1771: syn. = *P.*
252 *septemradiatum*), a characteristic glacial Pleistocene pectinid of the shallow shelf environment
253 (Colantoni et al., 1975). The current-exposed flanks and summit areas of this olistostrome are
254 covered by a thick hardground crust that in turn serves as preferred substrate for *L. pertusa* colonies
255 and *P. monilifera* and to a lesser degree for *P. compressa*. North of Gondola slide there is a bedform
256 field with mudwaves whose crests appear at places colonized by coral mounds, still unexplored at
257 present (Fig. 6).

258

259 **5.1.2 The eastern side** (Fig. 7)

260 *Croatian margin*

261 Only a single ROV dive (R/V *Urania* cruise ARCADIA st. A121) was conducted in the
262 northernmost rim of the deep southern Adriatic basin. We surveyed a canyon incision between 395-
263 490 m draped by substantial amount of bioturbated sediment and no emerging hard substrate. No
264 megabenthic sessile fauna was noticed at this site (Fig. 7A).

265

266 *Montenegrin margin*

267 Up to 10 dives were carried out during ARCADIA (R/V *Urania* ROV A63, A65, A67, A68),
268 ALTRO (R/V *Urania* ROV ALTRO31, ALTRO35, ALTRO36), and CROMA cruises along this
269 highly sculptured margin to inspect for megabenthic communities. Three canyon incisions were
270 explored in detail from ca. -400 m to -600 m and relevant results have been published by Angeletti
271 et al. (2014). More in detail, the southernmost incision is settled by dense cnidarian assemblages
272 dominated by *L. glaberrima*, *C. verticillata*, plus common *P. monilifera* and *M. oculata*. The best
273 cnidarian and sponge growth was observed on hardgrounds between -420 and -490 m where *C.*
274 *verticillata* fans may attain 1 m in height and a density > 5 individuals per square meter (Fig. 7B).
275 Other megabenthic organisms are *L. glaberrima* colonies up to 1 m in height, large *M. oculata*
276 colonies and abundant *P. monilifera*. Between -500 and -550 m, the megafauna is depauperated and
277 includes sparse small colonies of *M. oculata* (less than 15 cm) and *P. monilifera*. CWC are quite
278 scarce here being limited to a few *L. pertusa* and *D. dianthus* settled on *L. glaberrima* (Fig. 7C, D;
279 see also Angeletti et al., 2014).

280 In contrast, the northern incision explored by a ROV dive between -400 and -500 m did not
281 show any appreciable sessile megabenthos at all. The seabottom is characterized by bioturbated
282 muds, with no emerging hard substrates, and the occasional presence of the alcyonacean octocoral
283 *Isidella elongata* (Esper, 1788) (Fig. 7E).

284

285 *Albanian margin*

286 We have investigated the ca. 40 km long southern area of the Albanian margin south of 40°20' Lat
287 N. This margin is incised by several canyon systems and by common slope failure deposits. Swath
288 bathymetry and backscatter data have documented a gentler topography in the northern canyons
289 blanketed by sediments, whereas the southern canyons are more rugged with exposed hard
290 substrates. The area has been explored during R/V *Urania* COCOMAP13 cruise by means of three
291 ROV dives between -300 and -482 m and some grabs sampling. No evidence of living megabenthic
292 sessile fauna was encountered at these sites. Bioturbated muddy sediment, with sparse occurrence
293 of hardground slabs and bedrock is common. The latter are colonized by serpulids and brachiopods
294 (*Novocrania anomala* (Müller, 1776)) with rare encrusting sponges (Fig. 7F). Interestingly, dead
295 fragments of *D. cornigera* and subordinate *M. oculata* and *L. pertusa* have been sampled by grab
296 from this otherwise CWC-deprived margin.

297

298 *Greek margin*

299 Steep areas along the Greek margin from Kerkyra Island north to the Albanian margin were
300 explored during R/V *Urania* COCOMAP14 cruise by four ROV dives between -363 and -535 m.
301 Most substrates, including apparently propitious hardgrounds are barren of obvious megabenthos,
302 similarly to the Albanian margin (Fig. 7G). The only remarkable exception is represented at one site
303 by isolated occurrences of *L. glaberrima* colonies settled on calcareous bedrock, which can attain
304 up 1 m in height. Remarkably, some such antipatharians located between -508 and -496 m, host
305 individual aggregates (with probable clones) of *D. dianthus* up to 15 cm in size (Fig. 7H).
306 Occasionally, smaller (< 3-4 cm) *D. dianthus* were also observed attached on the bedrock.

307

308 **6. Discussion**

309

310 Summarizing the available evidence, we suggest that the most successful CWC colonization
311 in terms of coral coverage, diversity and habitats is found in the western side of the southern
312 Adriatic basin. The Bari Canyon and slumped blocks of the Gondola slide are the best examples of
313 such. In addition, demosponges are also common. The occurrence of CWC in the eastern side is
314 much more sporadic, absent at most places and often represented by singular colonies or clusters.
315 Here, antipatharians and gorgonians, when present, often dominate the deep seascape at times
316 serving as an attachment substrate to sporadic CWC settlement. Admittedly, a complete inventory
317 of the deep-sea habitats in the Adriatic sea and contiguous areas is still in its infancy, but it should
318 be realized that it was only some eight years ago that the ROV exploration of this margin started. A
319 further bias stays with the limitation of the depth range explored, limited to the 600-m isobath for
320 ROV dives from R/V *Urania*.

321 Regarding dead CWC occurrences, we observe that they are present on both sides, at places
322 co-occurring with living representatives; however, on the eastern side some of the sites explored by
323 ROV or tested with grabs only provided dead colonial corals, such for example the Albanian
324 margin. Available chronological information (Table 3 and tab. 2 in McCulloch et al., 2010)
325 documents a Holocene age for most such occurrences, with one remarkable exception provided by a
326 last glacial *Lophelia pertusa* (Fig. 4H), which points out to a longer history of coral presence in the
327 western Adriatic margin. However, it remains an open question as to whether coral colonisation was
328 persisting in the western Adriatic margin, or only present at distinct time intervals as has been
329 documented for the Western Mediterranean Sea and Ionian Sea CWC occurrences (Malinverno et
330 al., 2010; Fink et al., 2012, 2013).

331 As discussed previously, the southern Adriatic hydrology is subjected to highly variable
332 situations whose multiple variables affect its salinity, temperature, density, nutrients and water-mass
333 movements. Said that, water temperature, salinity, density and dissolved oxygen ranges in the
334 southern Adriatic do not appear so appreciably diverse on both sides (Cardin et al., 2011) to justify
335 the differences observed in the sessile megabenthos distribution. Accordingly, it is conjectured that

336 this skewed pattern may be at least partly backed instead by the energetic action associated with
337 NAdDW, amplified by DSW cascading events.

338 The observed uneven CWC distribution could be, in principle, directed by nature and
339 steepness of substrate. However, this seems not to be the case since potentially favourable
340 topographies, such as subvertical canyon walls in the Montenegrin and Albanian margins, and other
341 hard substrates, appear not colonized by any obvious CWC growth. On the contrary the
342 southwestern Adriatic segment of the margin, as for the closely located Santa Maria di Leuca CWC
343 province (Taviani et al., 2005b; Rosso et al., 2010; Vertino et al., 2010; Savini et al., 2014), has
344 revealed consistent coral growth on a variety of substrates from vertical cliffs, to slumped blocks
345 and hardgrounds on gently dipping situations (Freiwald et al 2009; Trincardi et al., 2010; Angeletti
346 et al., 2014).

347 On theoretical grounds, DSW cascading events that are dense enough to flow close to the
348 sea floor may affect directly and indirectly the quality and quantity of sessile deep-water benthic
349 organisms under different perspectives, some even in all appearance mutually contrasting. For
350 instance, by imposing anomalously vigorous flushing of the sea-bottom, it is an efficient
351 mechanism to prevent excess silting which is notoriously detrimental to immobile organisms as
352 those here contemplated (e.g., Canals et al., 2006; Bonnin et al., 2008). The energy conveyed by
353 DSW cascading events also helps enhancing submarine lithification processes capable to turn soft
354 and firmgrounds into hardgrounds suitable to the settlement of corals, sponges and other
355 invertebrates (e.g., McKenzie and Bernoulli, 1982; Allouc, 1986; Noé et al., 2006; Malinverno et
356 al., 2010). As such, bottom current speeds up to 70 cm s^{-1} in the open slope north of Gondola slide
357 (Chiggiato et al., this issue) and Bari Canyon area have been documented in relation to three distinct
358 events by Turchetto et al. (2007) and Langone et al. (this issue).

359 On the other hand, DSW cascading has been documented to be capable to re-suspend
360 sediment and eventually organic matter trapped within, thus providing a source of food to resident
361 benthos. Regarding this aspect, one of the few studies devoted to the diet of CWC inhabiting the

362 'Santa Maria di Leuca' coral province (see Taviani et al., 2011, with references therein), sheds light
363 on the trophic loop. In fact, based upon nitrogen and carbon stable isotope composition, Carlier et
364 al. (2009) suggest that the antipatharian *Leiopathes glaberrima* seems to include in its diet also
365 decayed organic matter, while the CWC triad and gorgonians, are consuming relatively fresh
366 zooplankton. The use of live zooplankton in the CWC diet is further substantiated by the study of
367 Naumann et al. (2015) on *Madrepora* and *Desmophyllum* from the 'South Malta' coral province..
368 This latter feeding option is interesting since, in principle, DSW cascading may also enhance the
369 deep-sea fertilization and convey down-slope pulses of fresh organic matter generated in the shelf
370 as suggested for the Gulf of Lions (Canals et al., 2006; Company et al., 2008; Puig et al., 2013).
371 This action is not yet observed in the southern Adriatic Sea where, conversely, direct transport of
372 such material from shelf to slope is not evident, and re-suspension of outer shelf sediment prevails
373 instead (Tesi et al., 2008).

374 With respect to the DSW cascading capability of hosting and exporting at depth fresh
375 material generated up-north in the more euphotic Adriatic shallow water, it is not yet demonstrated
376 that this factor can readily assist the distant and aphotic deep-sea communities in the southern
377 Adriatic. The occurrence of nektobenthos remains (swimmers, mainly copepods) has been noticed
378 in sediment traps put in the southern Adriatic (Langone et al., this issue), but this component has
379 not been quantified and studied in detail yet.

380 Regarding the potential role of DSW cascading as conveyor belt for dispersal of propagules
381 is considered not to be too significant, with respect to the more steady current field related to the
382 intrusion and exit of the LIW along the South Adriatic slopes.

383 Finally, in a mid- to long-term perspective, any possible weakening trend of the termohaline
384 circulation (Vilibić et al., 2013) could have serious repercussions on the Adriatic dense water
385 formation and dynamics, being therefore potentially deleterious to deep-water megabenthic
386 ecosystems inhabiting the southern Adriatic basin up to their potential collapse.

387

388 **7. Conclusions**

389

390 Available evidence of occurrences of deep-water habitat-forming sessile megabenthos in the
391 southern Adriatic Sea suggests an asymmetrical pattern in their distribution. In particular, better
392 conditions for CWC are encountered in the western side (Apulian margin), whilst a marked paucity
393 **if** not absence seems to characterize at present the eastern side. This observation seems to reflect
394 the importance of main known trajectories of NAdDW, flushing stronger at bathyal depths the
395 western margin than the eastern side.

396 Although still very conjectural, it is hypothesized that DSW cascading may play a role in the
397 regulation of deep-sea sessile epifauna while flushing these habitats. It favors the formation of firm-
398 and hard-grounds by sweeping the sea floor and winnowing out and concentrating locally the fine-
399 grained (muddy) sediment; by doing so this oceanographic process broadens the areas that are
400 potentially suitable for the life of sessile communities compared to the opportunity offered on the
401 Eastern Adriatic slope by the occurrence of local slide blocks or of small, steep-walled, canyons. It
402 may contribute to the nourishment of the living CWC by transporting organic matter in increased
403 concentrations during the cascading events, although part of this organic matter may be recycled
404 from outer shelf environment at times of stronger events. It is, however, premature at this stage to
405 select DSW cascading has a major driver and controller in the distribution of such valuable deep-
406 water ecosystems in the southern Adriatic, which may by large be governed by coupling the more
407 regular and predictable NAdDW regime instead. Summarizing, DSW cascading may provide a
408 significant addition by winnowing the seafloor and conveying a surplus of nutrition to the sea-
409 bottom and, ultimately exporting and/or re-suspending organic matter deeper than usual.

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427

428 **References**

429

430 Allouc, J., 1986, Les encroûtements sous-marin de Méditerranée orientale: une explication
431 génétique. *Revue Institute Francais du Pétrole* 41, 351-376.

432

433 Angeletti, L., Taviani, M., Canese, S., Fogliani, F., Mastrototaro, F., Argnani, A., Trincardi, F.,
434 Bakran-Petricioli, T., Ceregato, A., Chimienti, G., Mačić, V., Poliseo, A., 2014. New deep-water
435 cnidarian sites in the southern Adriatic Sea. *Mediterranean Marine Science* 15/2, 263-273.

436

437 Argnani, A., Tinti, S., Zaniboni, F., Pagnoni, G., Armigliato, A., Panetta, D., Tonini, R., 2011. The
438 eastern slope of the southern Adriatic basin: a case study of submarine landslide characterization
439 and tsunamigenic potential assessment. *Marine Geophysical Research* 32, 299-311.

440

441 Bo, M., Bertolino, M., Bavestrello, G., Canese, S., Giusti, M., Angiolillo, M., Pansini, M., Taviani
442 M., 2012. Role of deep sponge grounds in the Mediterranean Sea: a case study in southern Italy.
443 *Hydrobiologia* 687, 163-177.

444

445 Bonnin, J., Heussner, S., Calafat, A., Fabres, J., Palanques, A., Durrieu du Madron, X., Canals, M.,
446 Puig, P., Avril, J., Delsaut, N., 2008. Comparison of horizontal and downward particle fluxes across
447 canyons of the Gulf of Lions (NW Mediterranean): Meteorological and hydrodynamical forcing.
448 *Continental Shelf Research* 28, 1957-1970.

449

450 Bourrin, F., Durrieu de Madron, X., Heussner, S., Estournel, C., 2008. Impact of winter dense water
451 formation on shelf sediment erosion (evidence from the Gulf of Lions, NW Mediterranean).
452 *Continental Shelf Research* 28, 1984-1999.

453

454 Canals, M., Danovaro, R., Heussner, S., Lykousis, V., Puig, P., Trincardi, F., Calafat, A., Durrieu
455 de Madron, X., Palanques, A., Sanchez-Vidal, A., 2009. Cascades in Mediterranean Submarine
456 Grand Canyons. *Oceanography* 22, 26-43.

457

458 Canals, M., Puig, P., Durrieu de Madron, X., Heussner, S., Palanques, A., Fabres, J., 2006. Flushing
459 submarine canyons. *Nature* 444, 354-357.

460

461 Cardin, V., Bensi, M., Pacciaroni, M., 2011. Variability of water mass properties in the last two
462 decades in the South Adriatic Sea with emphasis on the period 2006-2009. *Continental Shelf*
463 *Research* 31, 951-965.

464

465 Carlier, A., Le Guilloux, E., Olu, K., Sarrazin, J., Mastrototaro, F., Taviani, M., Clavier, J., 2009.
466 Trophic relationships in a deep Mediterranean cold-water coral bank (Santa Maria di Leuca, Ionian
467 Sea). *Marine Ecology Progress Series* 397, 125–137.

468

469 Cheng, H., Edwards, R.L., Shen, C.-C., Polyak, V.J., Asmeron, Y., Woodhead, J., Hellstrom, J.,
470 Wang, Y., Kong, X., Spötl, C., Wang, X., Alexander Jr., E.C., 2013. Improvements in ^{230}Th
471 dating, ^{230}Th and ^{234}U half-life values, and U/Th isotopic measurements by multi-collector
472 inductively coupled plasma mass spectrometry. *Earth and Planetary Science Letters* 371-372, 82–
473 91.

474

475 Chiggiato, J., Bergamasco, A., Borghini, M., Falceri, F.M., Falco, P., Langone, L., Miserocchi, S.,
476 Russo, A., Schroeder, K., 2015. Dense water bottom currents in the Southern Adriatic Sea in spring
477 2012. *Marine Geology*, this Issue.

478

479 Civitarese, G., Gačić, V., Cardin, V., Ibello, V., 2005. Winter Convection Continues in the
480 Warming Southern Adriatic. *Eos* 86/45, 445-451.

481

482 Colantoni, P., Noto, P., Taviani, M., 1975. Prime datazioni assolute di una fauna fossile a
483 *Pseudamussium septemradiatum* dragata nel basso Adriatico. *Giornale di Geologia* (s. 2a) 40, 133-
484 140.

485

486 Company, J.B., Puig, P., Sardá, F., Palanques, A., Latasa, M., Scharek, R., 2008. Climate Influence
487 on Deep Sea Populations. *PLoS ONE* 3(1), e1431.doi:10.1371/journal.pone.0001431.

488

489 Dalla Valle, G., Campiani, E., Foglini, F., Gamberi, F., Trincardi, F., 2014. Mass Transport
490 Complexes from Contourite and Shelf-Edge Deposits Along the South-Western Adriatic Margin
491 (Italy). In: Krastel, S., Behrmann, J.-H., Völker, D., Stipp, M., Berndt, C., Urgeles, R., Chaytor, J.,
492 Huhn, K., Strasser, M., Harbitz, C.B. (Eds.) *Submarine Mass Movements and Their Consequences*.
493 Springer International Publishing.pp. 447-457.

494

495 DeGeest, A.L., Mullenbach, B.L., Puig, P., Nittrouer, C.A, Drexler, T.M., Durrieu de Madron, X.,
496 Orange, D.L., 2008. Sediment accumulation in the western Gulf of Lions, France: The role of Cap
497 the Creus Canyon in linking shelf and slope sediment dispersal systems. *Continental Shelf Research*
498 28, 2031-2047.

499

500 Delibrias, G., Taviani, M., 1985. Dating the death of Mediterranean deep-sea scleractinian corals.
501 *Marine Geology* 62, 175–180.

502

503 Dell'Anno, A., Pusceddu, A., Corinaldesi, C., Canals, M., Heussner, S., Thomsen, L., Danovaro,
504 R., 2013. Trophic state of benthic deep-sea ecosystems from two different continental margins off
505 Iberia. *Biogeosciences* 10, 2945-2957.

506

507 Durrieu de Madron, X., Wiberg, P.L., Puig, P., 2008. Sediment dynamics in the Gulf of Lions: The
508 impact of extreme events. *Continental Shelf Research* 28, 1867-1876.

509

510 Durrieu de Madron, X., Zervakis, V., Theocharis, A., Georgopoulos, D., 2005. Comments on
511 "Cascades of dense water around the world ocean". *Progress in Oceanography* 64, 83-90.

512

513 EMODnet, 2014. EMODnet European Marine Observation and Data Network, Hydrography portal.
514 <http://www.emodnet-hydrography.eu>.

515

516 Fink, H., Wienberg, C., De Pol-Holz, R., Wintersteller, P., Hebbeln, D., 2013. Cold-water coral
517 growth in the Alboran Sea related to high productivity during the Late Pleistocene and Holocene.
518 *Marine Geology* 339, 71-82.

519

520 Fink, H., Wienberg, C., Hebbeln, D., McGregor, H.V., Schmiedl, G., Taviani, M., Freiwald, A.,
521 2012. Oxygen control on Holocene cold-water coral development in the eastern Mediterranean Sea.
522 *Deep-Sea Research I* 62, 89-96.

523

524 Foglini, F., Campiani, E., Trincardi, F., 2014. The reshaping of the South West Adriatic Margin by
525 cascading of dense shelf waters. *Marine Geology*, this issue.

526

527 Foley, N., van Rensburg, T.M., Armstrong, C.W., 2010. The ecological and economic value
528 of cold-water coral ecosystems. *Ocean and Coastal Management* 53, 313-326.

529

530 Freiwald, A., Beuck, L., Rüggeberg, A., Taviani, M., Hebbeln, D. and R/V METEOR Cruise M70-
531 1 Participants, 2009. The white coral community in the central Mediterranean Sea revealed by ROV
532 surveys. *Oceanography* 22, 58-74.

533

534 Freiwald, A., Boetius, A., Bohrmann, G., 2006. RV METEOR, Cruise Report M70/L1, M70/L2a+b,
535 M70/L3, Deep water ecosystems of the Eastern Mediterranean 2006. DFG Senatskommission für
536 Ozeanographie, 313 pp.

537

538 Freiwald, A., Boetius, A., Bohrmann, G., 2011. Deep water ecosystems of the Eastern
539 Mediterranean – Cruise No. M70 – September 24 – December 8, 2006 – La Valletta (Malta) –
540 Heraklion (Greece). METEOR-Berichte, M70, 146 pp., DFG-Senatskommission für
541 Ozeanographie, DOI:10.2312/cr_m70

542

543 Gaudin, M., Berné, S., Jouanneau, J.-M., Palanques, A., Puig, P., Mulder, T., Cirac, P., Rabineau,
544 M., Imbert, P., 2006. Massive sand beds attribute to deposition by dense water cascades in the
545 Bourcart canyon head, Gulf of Lions (northwestern Mediterranean Sea). *Marine Geology* 234, 111-
546 128.

547

548 Guarracino, M., Barnier, B., Marsaleix, P., Durrieu de Madron, X., Monaco, A., Escoubevrou, K.,
549 Marty, J.-C., 2006. Transfer of particulate matter from the northwestern Mediterranean continental
550 margin: Variability and controlling factors. *Journal of Marine Research* 64, 195-220.

551

552 Heussner, S., Durrieu de Madron, X., Calafat, A., Canals, M., Carbonne, J., Delsaut, N., Saragoni,
553 G., 2006. Spatial and temporal variability of downward particle fluxes on a continental slope:

554 Lessons from an 8-yr experiment in the Gulf of Lions (NW Mediterranean). *Marine Geology* 234,
555 63-92.

556

557 Ivanov, V.V., Shapiro, G.I., Huthance, J.M., Aleynik, D.L., Golovin, P.N., 2004. Cascades of dense
558 water around the world ocean. *Progress in Oceanography* 60, 47-98.

559

560 Jaffey, A.H., Flynn, K.F., Glendenin, L.E., Bentley, W.C., Essling, A.M., 1971. Precision
561 measurement of half-lives and specific activities of ²³⁵U and ²³⁸U. *Physical Review C* 4, 1889-
562 1906.

563

564 Lastras, G., Canals, M., Urgeles, R., Amblas, D., Ivanov, M., Droz, L., Dennielou, B., Fabrés, J.,
565 Schoolmeester, T., Akhmetzhanov, A., Orange, D., García-García, A., 2007. A walk down the Cap
566 de Creus canyon, Northwestern Mediterranean Sea: Recent processes inferred from morphology
567 and sediment bedforms. *Marine Geology* 246, 176-192.

568

569 Langone, L., Conese, I., Miserocchi, S., Boldrin, A., Turchetto, M., 2015. Sediment transport to the
570 western margin of the Southern Adriatic: processes involved in transferring particulate matter to the
571 deep basin. *Marine Geology*, this issue.

572

573 Malinverno, E., Taviani, M., Rosso, A., Violanti, D., Villa, I., Savini, A., Vertino, A., Remia, A.,
574 Corselli, C., 2010. Stratigraphic framework of the Apulian deep-water coral province, Ionian Sea.
575 *Deep-Sea Research II* 57(5/6): 345–359.

576

577 McKenzie, J.A., Bernoulli, D., 1982. Geochemical variations in Quaternary hardgrounds from the
578 Hellenic Trench region and possible relationship to their tectonic setting. *Tectonophysics* 86, 149-
579 157.

580

581 Minisini, D., Trincardi, F., Asioli, A., 2006. Evidence of slope instability in the Southwestern
582 Adriatic Margin. *Natural Hazards and Earth System Sciences* 6, 1-20.

583

584 McCulloch, M., Taviani, M., Montagna, P., López Correa, M., Remia, A., Mortimer, G., 2010.
585 Proliferation and demise of deep-sea corals in the Mediterranean during the Younger Dryas. *Earth
586 and Planetary Science Letters* 298, 143–152.

587

588 Naumann, M.S., Tolosa, I., Taviani, M., Grover, R., Ferrier-Pagès, C., 2015. Trophic ecology of
589 two cold-water coral species from the Mediterranean Sea revealed by lipid biomarkers and
590 compound-specific isotope analyses. *Coral Reefs*, DOI 10.1007/s00338-015-1325-8.

591

592 Noé, S., Titschack, J., Freiwald, A., Dullo, W-C., 2006. From sediment to rock: diagenetic
593 processes of hardground formation in deep-water carbonate mounds of the NE Atlantic. *Facies* 52,
594 183-208.

595

596 Ogston, A.S., Drexler, T.M., Puig, P., 2008. Sediment delivery, resuspension, and transport in two
597 contrasting canyon environments in the southwest Gulf of Lions. *Continental Shelf Research* 28,
598 2000-2016.

599

600 Palanques, A., Guillén, J., Puig, P., Durrieu de Madron, X., 2008. Storm-driven shelf-to-canyon
601 suspended sediment transport at the southwestern Gulf of Lions. *Continental Shelf Research* 28,
602 1947-1956.

603

604 Palanques, A., Durrieu de Madron, X., Puig, P., Fabres, J., Guillén, J., Calafat, A., Canals, M.,
605 Heussner, S., Bonnín, J., 2006. Suspended sediment fluxes and transport processes in the Gulf of

606 Lions submarine canyons. The role of storms and dense water cascading. *Marine Geology* 234, 43-
607 61.
608

609 Palanques, A., Puig, P., Latasa, M., Scharek, R., 2009. Deep sediment transport induced by storms
610 and dense shelf-water cascading in the northwestern Mediterranean basin. *Deep-Sea Research I* 56,
611 425-434.
612

613 Palanques, A., Puig, P., Durrieru de Madron, X., Sanchez-Vidal, A., Pascual, C., Martín, J., Calafat,
614 A., Heussner, S., Canals, M., 2012. Sediment transport to the deep canyons and open-slope of the
615 western Gulf of Lions during the 2006 intense cascading and open-sea convection period. *Progress*
616 *in Oceanography* 106, 1-15.
617

618 Pons-Branchu, E., Douville, E., Roy-Barman, M., Dumont, E., Branchu, P., Thil, F., Frank, N.,
619 Bordier, L., Borst, W., 2014. A geochemical perspective on Parisian urban history based on U-Th
620 dating, laminae counting and yttrium and REE concentrations of recent carbonates in underground
621 aqueducts. *Quaternary Geochronology* 24, 44-58.
622

623 Puig, P., Font, J., Company, J.B., Palanques, A., Sardà, F., 2008a. Monitoring dense shelf water
624 cascades: an assessment tool for understanding deep-sea ecosystems functioning. In: Briand, F.,
625 (Ed.), *Towards an integrated system of Mediterranean marine observatories*. N° 34 in CIESM
626 *Workshop Monographs*, Monaco, pp. 81-86.
627

628 Puig, P., Palanques, A., Orange, D.L., Lastras, G., Canals, M., 2008b. Dense shelf water cascades
629 and sedimentary furrow formation in the Cap de Creus Canyon, northwestern Mediterranean Sea.
630 *Continental Shelf Research* 28, 2017-2030.
631

632 Puig, P., Durrieu de Madron, X., Salat, J., Schroeder, K., Martín, J., Karageorgis, A.P., Palanques,
633 A., Roullier, F., Lopez-Jurado, J.L., Emelianov, M., Moutin, T., Houpert, L., 2013. Thick bottom
634 nepheloid layers in the western Mediterranean generated by deep dense shelf water cascading.
635 Progress in Oceanography 111, 1-23.

636

637

638 Pusceddu, A., Mea, M., Canals, M., Heussner, S., Durrieu de Madron, X., Sanchez-Vidal, A.,
639 Bianchelli, S., Corinaldesi, C., Dell'Anno, A., Thomsen, L., Danovaro, R., 2013. Major
640 consequences of an intense dense shelf water cascading event on deep-sea benthic trophic
641 conditions and meiofaunal biodiversity. Biogeosciences 10, 2659–2670.

642

643 Pusceddu, A., Mea, M., Gambi, C., Bianchelli, S., Canals, M., Sanchez-Vidal, A., Calafat, A.,
644 Heussner, S., Durrieu De Madron, X., Avril, J., Thomsen, L., García, R., Danovaro, R., 2010.
645 Ecosystem effects of dense water formation on deep Mediterranean Sea ecosystems: an overview.
646 Advances in Oceanography and Limnology 1:1, 67-83

647

648

649 Remia, A., Taviani, M., 2005. Shallow-buried Pleistocene *Madrepora*-dominated coral mounds on
650 a muddy continental slope, Tuscan Archipelago, NE Tyrrhenian Sea. Facies 50 (3-4), 419-425.

651

652 Ribó, M., Puig, P., Palanques, A., Lo Iacono, C., 2011. Dense shelf water cascades in the Cap de
653 Creus and Palamós submarine canyons during winters 2007 and 2008. Marine Geology 284, 175-
654 188.

655

656 Roberts, J.M., Wheeler, A., Freiwald, A., Cairns, S., 2009. Cold-Water Corals: The Biology and
657 Geology of Deep-Sea Coral Habitats. Cambridge University Press, New York, 334 pp.

658

659 Rosso, A., Vertino, A., Di Geronimo, I., Sanfilippo, R., Sciuto, F., Di Geronimo, R., Violanti, D.,
660 Corselli, C., Taviani, M., Mastrototaro, F., Tursi, A., 2010. Hard-and soft-bottom thanatofacies
661 from the Santa Maria di Leuca deep-water coral province, Mediterranean. *Deep-Sea Research* 57/5-
662 6, 360-379.

663

664 Sanchez-Vidal, A., Lorca, M., Farré, M., Canals, M., Barceló, D., Puig, P., Calafat, A., 2015.
665 Delivery of unprecedented amounts of perfluoroalkyl substances towards the deep-sea. *Science of*
666 *the Total Environment* 526, 41-48.

667

668 Sanfilippo, R., Vertino, A., Rosso, A., Beuck, L., Freiwald, A., Taviani, M., 2013. *Serpula*
669 aggregates and their role in deep-sea coral communities in the southern Adriatic Sea. *Facies* 59,
670 663-677.

671

672 Savini, A., Corselli, C., 2010. High-resolution bathymetry and acoustic geophysical data from Santa
673 Maria di Leuca Cold Water Coral province (Northern Ionian Sea—Apulian continental slope).
674 *Deep-Sea Research II* 57/5, 326-344.

675

676 Savini, A., Vertino, A., Marchese, F., Beuck, L., Freiwald, A., 2014. Mapping cold-water coral
677 habitats at different scales within the northern Ionian Sea (Central Mediterranean): an assessment of
678 coral coverage and associated vulnerability. *PLoS ONE* 9(7): e102405. doi:
679 10.1371/journal.pone.0102405

680

681 Taviani, M., Freiwald, A., Zibrowius, H., 2005a. Deep coral growth in the Mediterranean Sea: an
682 overview. In: *Cold-water Corals and Ecosystems*. Freiwald, A., Roberts, J.M. (Eds). Springer-
683 Verlag, Berlin Heidelberg, pp.137-156.

684

685 Taviani, M., Remia, A., Corselli, C., Freiwald, A., Malinverno, E., Mastrototaro, F., Savini, A.,
686 Tursi, A., 2005b. First geo-marine survey of living cold-water *Lophelia* reefs in the Ionian Sea
687 (Mediterranean basin). *Facies* 50 3/4, 409-417.

688

689 Taviani, M., Angeletti, L., Antolini, B., Ceregato, A., Frogli, C., López Correa, M., Montagna, P.,
690 Remia, A., Trincardi, F., Vertino, A., 2011. Geo-biology of Mediterranean Deep-Water Coral
691 Ecosystems. *CNR@Sea, DTA/06-2011*, 705-720.

692

693 Tesi, T., Langone, L., Goñi, M.A., Turchetto, M., Miserocchi, S., Boldrin, A., 2008. Source and
694 composition of organic matter in the Bari canyon (Italy): Dense water cascading versus particulate
695 export from the upper ocean. *Deep-Sea Research I* 55, 813– 831.

696

697 Tesi, T., Puig, P., Palanques, A., Goni, M.A., 2010. Lateral advection of organic matter in
698 cascading-dominated submarine canyons. *Progress in Oceanography* 84, 185-203.

699

700 Trincardi, F., Angeletti, L., Asioli, A., Campiani, E., Ceregato, A., Fogli, F., Freiwald, A., Remia,
701 A., Taviani, M., Vertino, A., 2010. South Western Adriatic Margin morphology and deep-sea
702 macrobenthic ecosystems. *Rapports Commission interational Mer Méditerranée* 39, 70.

703

704 Trincardi, F., Taviani, M., Freiwald, A., Angeletti, L., Fogli, F., Minisini, D., Piva, A.,
705 Verdicchio, G., 2008. An actualistic scenario for olistostrome genesis and emplacement (Gondola
706 Slide, SW Adriatic Margin). *Rendiconti Online Società Geologica Italiana* 3, 762-763.

707

708 Trincardi, F., Campiani, E., Correggiari, A., Foglini, F., Maselli, V., Remia, A., 2014. Bathymetry
709 of the Adriatic Sea: The legacy of the last eustatic cycle and the impact of modern sediment
710 dispersal, *Journal of Maps* 10/1, 151-158, DOI:10.1080/17445647.2013.864844
711

712 Trincardi, F., Foglini, F., Verdicchio, G., Asioli, A., Correggiari, A., Minisini, D., Piva, A., Remia,
713 A., Ridente, D., Taviani, M., 2007. The impact of cascading currents on the Bari Canyon System,
714 SW-Adriatic Margin (Central Mediterranean). *Marine Geology* 246, 208-230.
715

716 Turchetto, M., Boldrin, A., Langone, L., Miserochi, S., Tesi, T., Foglini, F., 2007. Particle
717 transport in the Bari Canyon (southern Adriatic Sea). *Marine Geology* 246, 231–247.
718

719 Ulses, C., Estorunel, C., Bonnin, J., Durrieu de Madron, X., Marsaleix, P., 2008a. Impact of storms
720 and dense water cascading on shelf-slope exchanges in the Gulf of Lion (NW Mediterranean).
721 *Journal of Geophysical Research* 113, C02010.
722

723 Ulses, C., Estournel, C., Puig, P., Durrieu de Madron, X., Marsaleix, P., 2008b. Dense shelf water
724 cascading in the northwestern Mediterranean during the cold winter 2005: Quantification of the
725 export through the Gulf of Lion and the Catalan margin. *Geophysical Research Letters* 35, L07610.
726

727 Vertino, A., Savini, A., Rosso, A., Di Geronimo, I., Mastrototaro, F., Sanfilippo, R., Gay, G.,
728 Etiope, G., 2010. Benthic habitat characterization and distribution from two representative sites of
729 the deep-water SML Coral Province (Mediterranean). *Deep-Sea Research II* 57/5, 380-396.
730

731 Vilibić, I., Supić, N., 2005. Dense water generation on a shelf: the case of the Adriatic Sea. *Ocean*
732 *Geodynamics* 55, 403-415.
733

- 734 Vilibić, I., Šepić, J., Proust, N., 2013. Weakening thermohaline circulation in the Adriatic Sea.
735 *Climate Research* 55, 217-255.

736 **Figure captions**

737

738 Fig. 1. General map of the Mediterranean basin showing main areas of dense water formation,
739 trajectories of surface and Levantine water masses; inset highlights the area concerned with the
740 present study showing the main morphologic features of the southern Adriatic margin.

741

742 Fig. 2. Map of the southern Adriatic showing the presence/absence of the seven megabenthic target
743 species discussed in this article (the scleractinians *L. pertusa*, *M. oculata*, and *D. dianthus*; the
744 antipatharian *L. glaberrima*; the gorgoniacean *C. verticillata*; the demosponges *P. monilifera* and *P.*
745 *compressa*). the ‘cake’ diagrams do not represent actual percentage but offer a qualitative
746 appreciation of the occurrence of any given target species at each investigated site; white symbol
747 refers to those sites where none of the target was identified in our study (i.e, total absence).

748

749 Fig. 3. Map of the southern Adriatic showing the occurrence of living and dead CWC (*L. pertusa*,
750 *M. oculata*, and *D. dianthus*). The ‘cake’ diagrams offer a qualitative view based upon the presence
751 or absence of the selected species in the study area.

752

753

754 Fig. 4. Bathyal megabenthos of the western side, Bari Canyon area: (A) *M. oculata* with down-
755 facing growth (candelabra-like) settled in the steeper flank of the canyon at ca. -570 m (ROV
756 station M70/1 735); (B-D) coral-sponge association dominated by *M. oculata* and *P. monilifera*
757 inhabiting the canyon flank (ROV stations A208 and A210); (E, F) coral-serpulid frame constituted
758 by *M. oculata* and *S. vermicularis*, aggregates on hard substrates and boulders at depth of ca. -400
759 m (ROV stations A208 and A210); (G) close-up of the orange cup-like sponge *P. compressa*
760 associated with *M. oculata* (ROV station A208); (H) subfossil *L. pertusa* of Late Pleistocene age

761 dredged between -286 and -423 m from (Cruise SETE06, station SE06-13 41°22.100' Lat N -
762 17°07.200' Long E).

763

764 Fig. 5: Bathyal megabenthos of the western side, Dauno Seamount (A-D, ROV station M70/1 739)
765 and Gondola slide (E-F and H, ROV station M70/1 752) areas: (A) hard substrate emerging from
766 soft sediment colonized in their down face by solitary corals at depth of -780 m; (B) aggregation of
767 white sponges *P. monilifera* at ca. 780 m water depth; (C-D) lobate white sponges *P. monilifera*
768 settled on current-exposed crusts at depth of ca. -930 m; (E) *L. pertusa* and *P. monilifera*
769 association settled on top of a large slumped block at -680 m; (F) exhumed hardground on
770 particulate soft bottom colonized by amphipods (close-up in the inset) at -710 m with a localized
771 settlement of *L. pertusa*; (G) a byssate juvenile *Pseudamussium sulcatum* (Müller, 1776) facing a
772 precarious life on hardground substrate influenced by strong hydrodynamic conditions (dredge
773 carried out during cruise SETE06, station SE06-48: 41°43.31' Lat N – 17°03.39' E at -728 m); (H)
774 boulder at -676/-680 m showing dense colonization by downward-growing solitary corals (*D.*
775 *dianthus*) and serpulids.

776

777 Fig. 6. Chirp profile crossing Mudwave field A (Foglini et al., this issue), north of the Gondola slide
778 area showing an example of the acoustic response of a coral mound.

779

780 Fig. 7. Bathyal habitats of the eastern side with and without megabenthic taxa: (A) canyon incision
781 at -480 m in the Croatian margin represented by a sessile-megabenthos-deprived sediment draped
782 slope without any emerging hard substrates (ROV station A121); (B) large colonies (up to 1 m
783 high) of *C. verticillata* preferentially growing on current-exposed bedrock in the Montenegrin
784 margin between -420 and -430 m (ROV station ALTRO31); (C) large colony of a *L. glaberrima* (up
785 to 1 m high), and the gorgonian *C. verticillata* (Cv) settling a bedrock only partly buried by mud,
786 southern canyon of the Montenegrin margin at -505 m; note a *M. oculata* (Mo) colony; and (inset)

787 a scleractinian cluster, attached on *L. glaberrima*(ROV station ALTRO35); (D) same site, close-up
788 of the scleractinian cluster composed by *D. dianthus* (Dd), and *L. pertusa* (Lp) with expanded
789 polyps;(E) megabenthic habitat in a canyon of the Greek margin at ca. -508 m (ROV station
790 COC14-20) showing solitary corals (Dd=*D. dianthus*) fouling *L. glaberrima*, note the rose-shaped
791 cluster of *D. dianthus* (individuals up to 15 cm); (F) Montenegrin margin between -400 and -446 m
792 characterized by bioturbated soft sediment without hard substrates (ROV station ALTRO82), note
793 the alcyonacean octocoral *Isidella elongata*; (G) close-up of rocky bedrock exposed in a canyon
794 incision of the Albanian margin at ca. -390 m, fouled by serpulids and sponges (ROV station
795 COC13-20); (H) canyon wall of a Greek canyon at -420 m, showing a localized belt of encrusting
796 macroepifauna dominated by serpulids as the only obvious macrobenthos (COC14-21).

797

798 Fig. 8. General scheme of the Adriatic showing trajectories of main water masses and location of
799 living 'white corals' (modified from Foglini et al., this issue).

800

801 **Table 1.**

802 Cruise metadata related to ROV stations considered in this study.

803

804 **Table 2.**

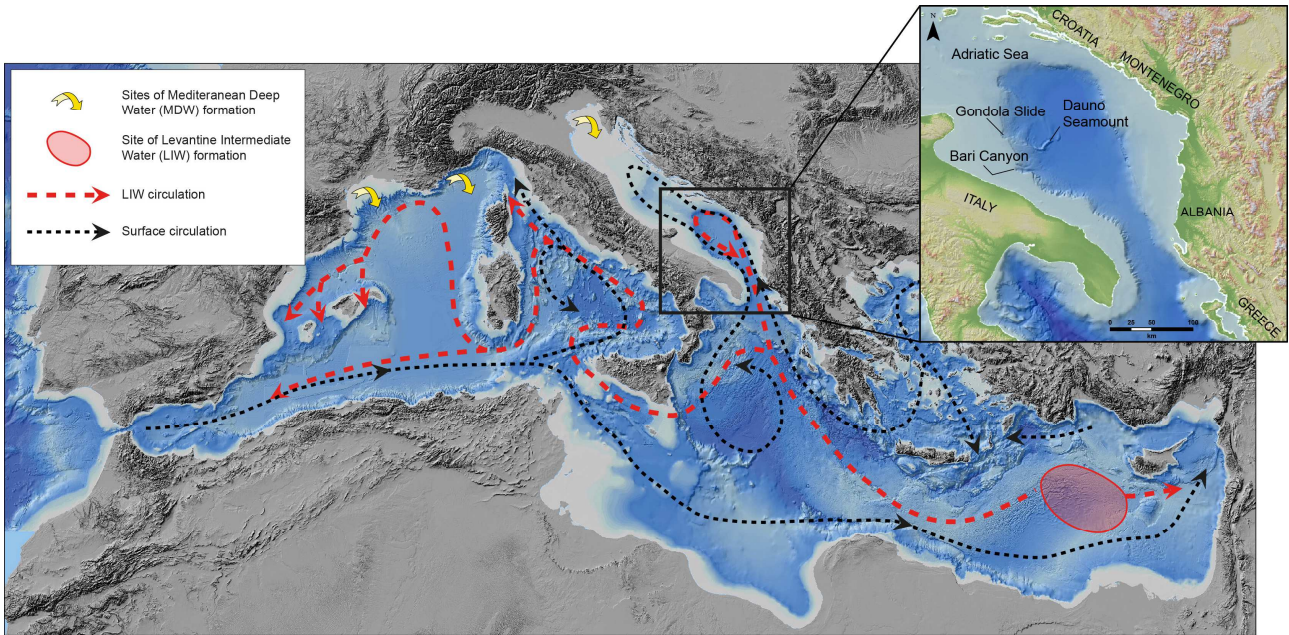
805 Main attributes of stations hosting the seven megabenthic species discussed in the present study.

806

807 **Table 3.** Absolute age of the scleractinian *Madrepora oculata* from the Montenegrin margin. U/Th
808 measurements were performed on a cleaned coral fragment (thecal wall) following the method
809 published by Pons-Branchu et al. (2014).

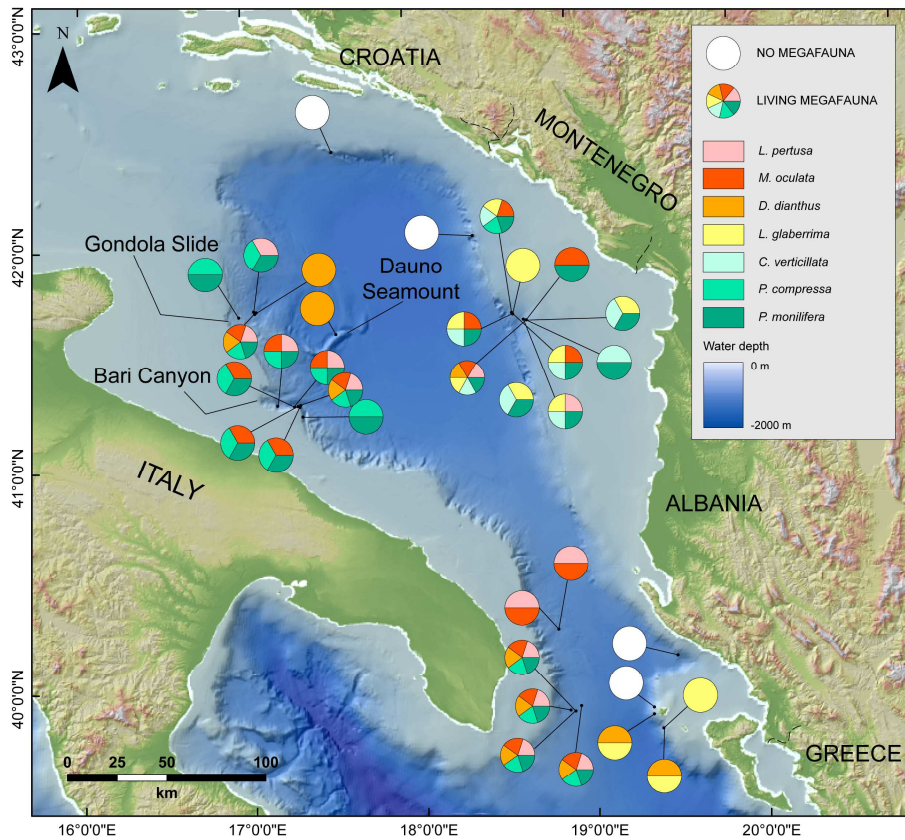
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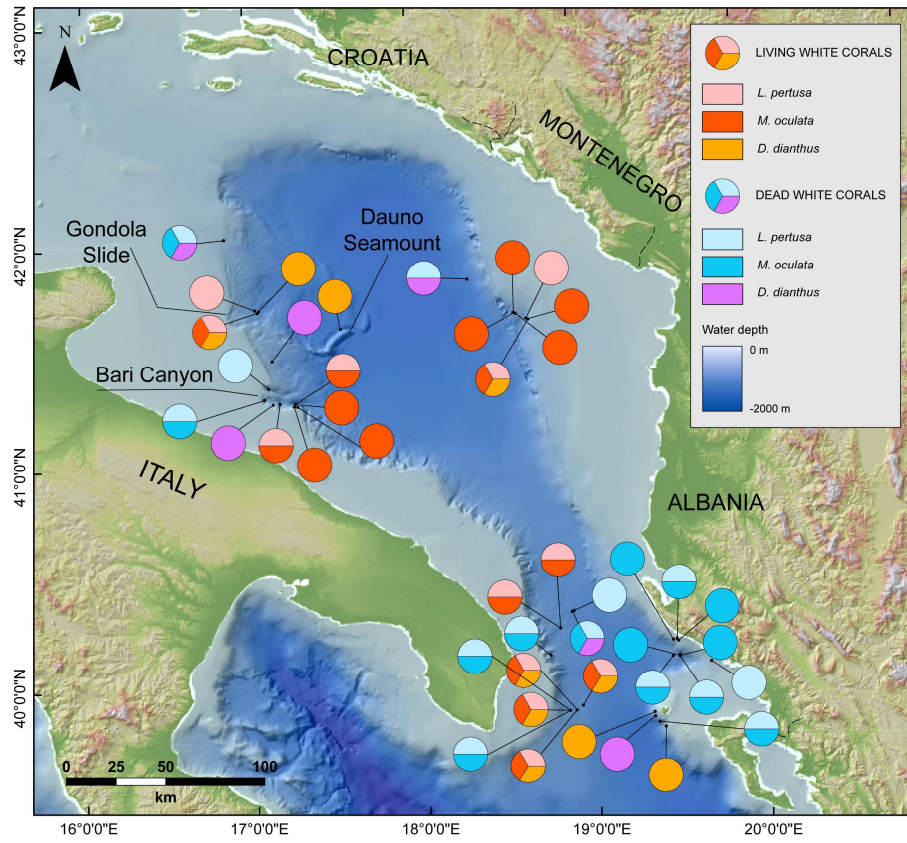
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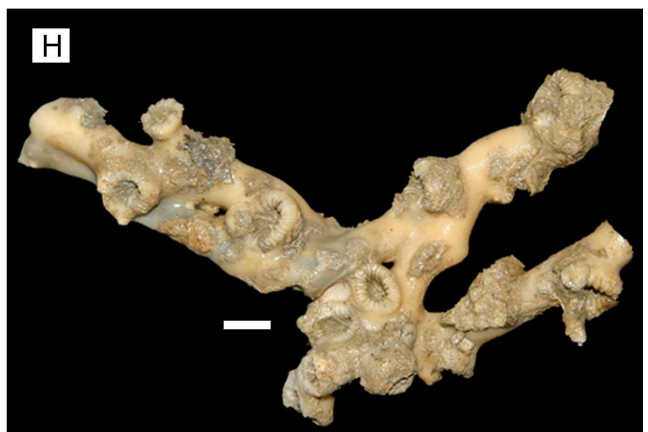
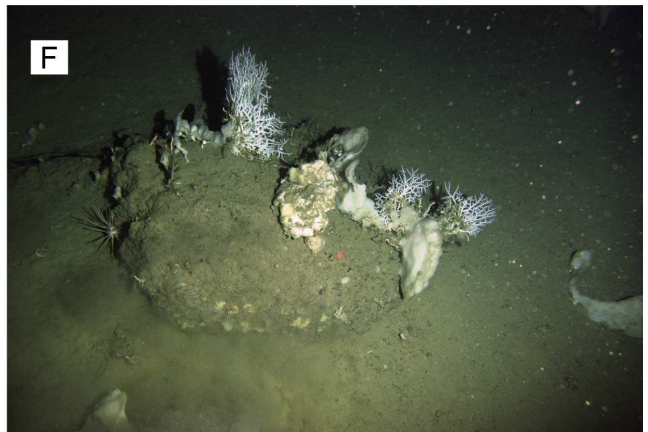
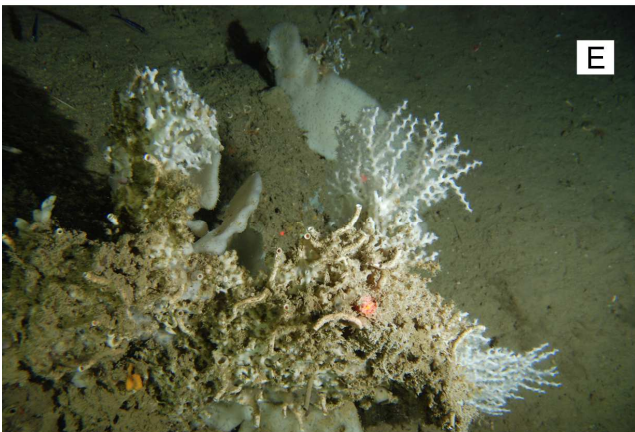
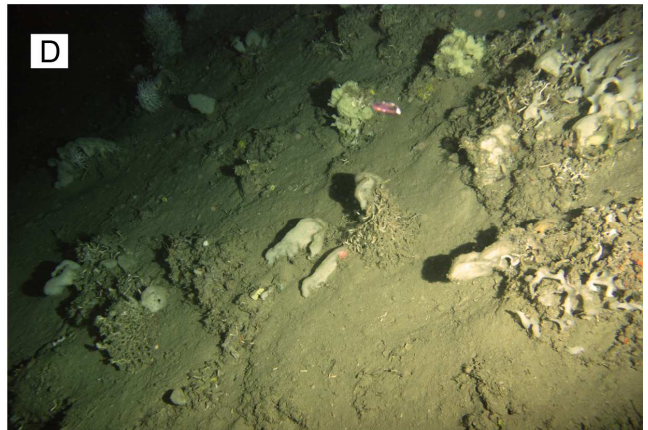
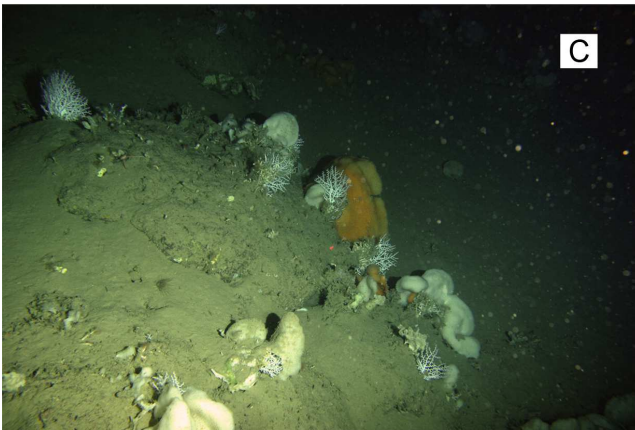
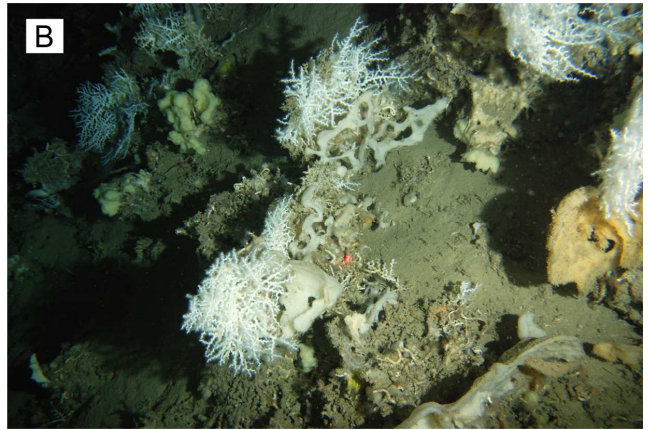
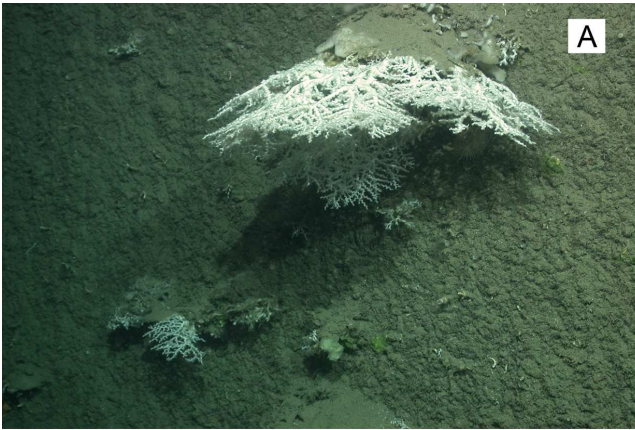
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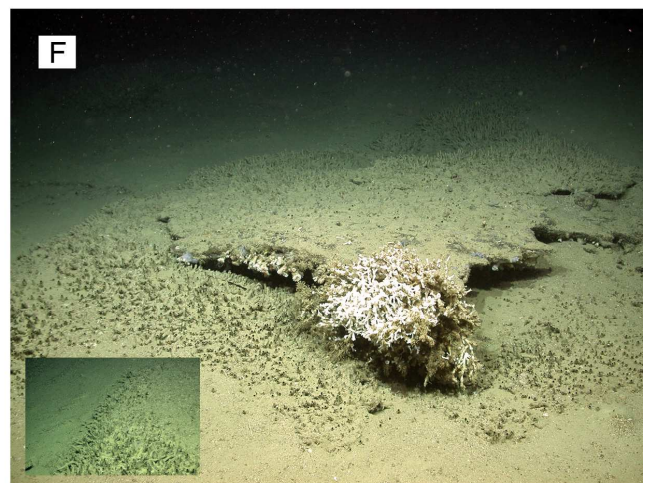
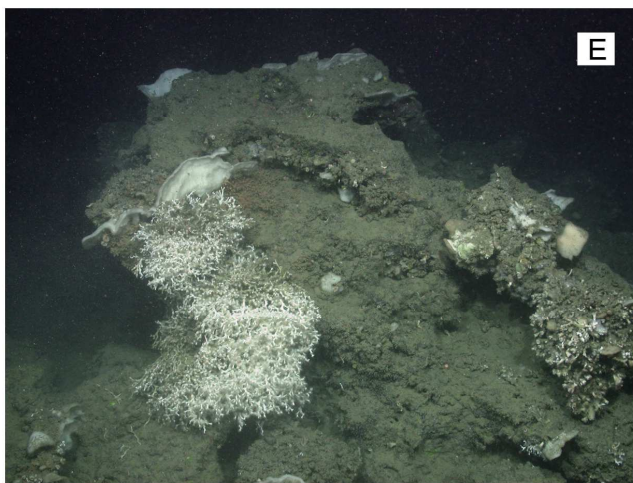
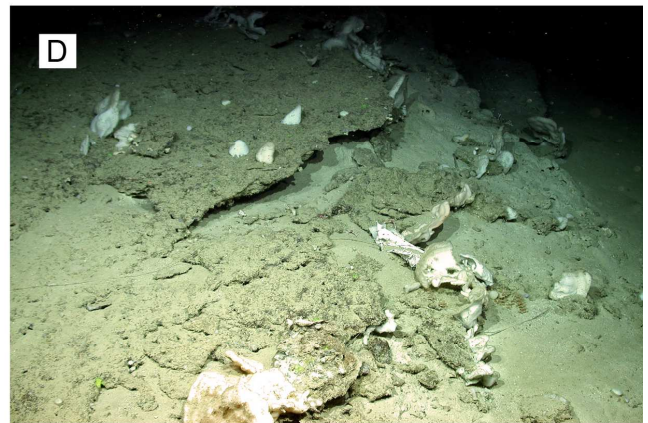
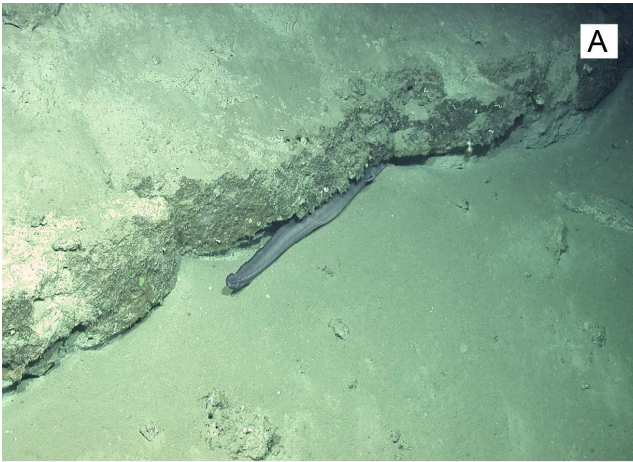
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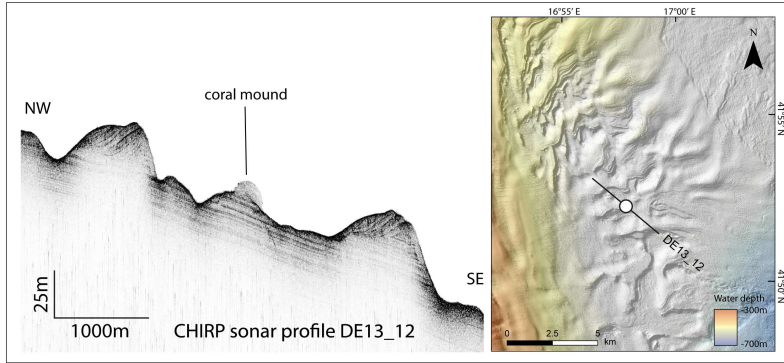
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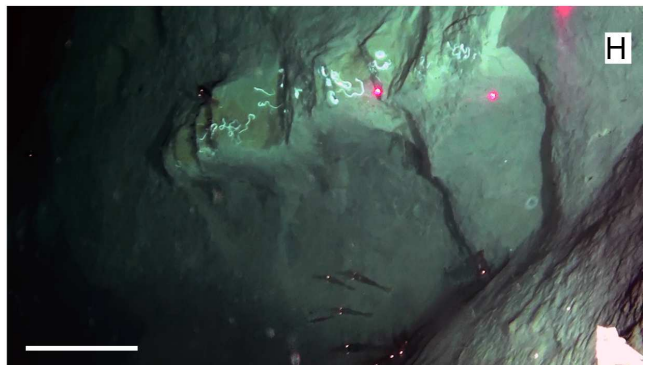
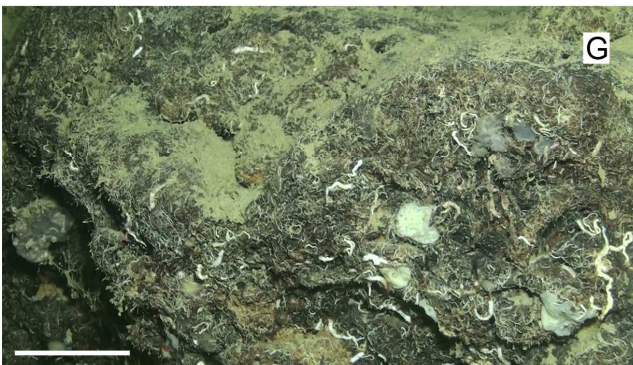
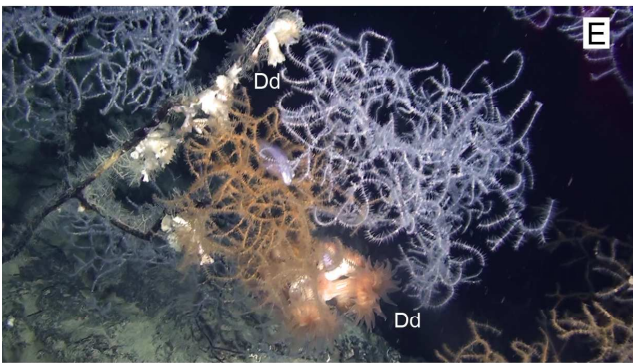
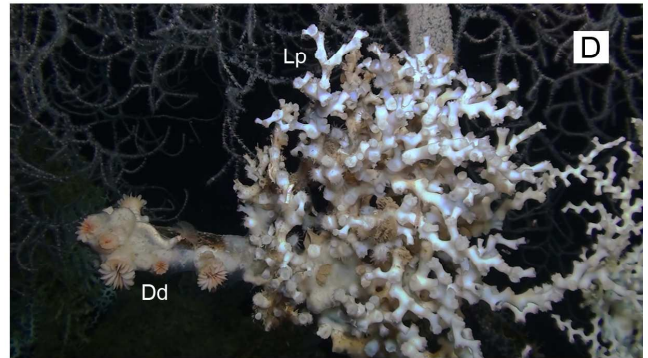
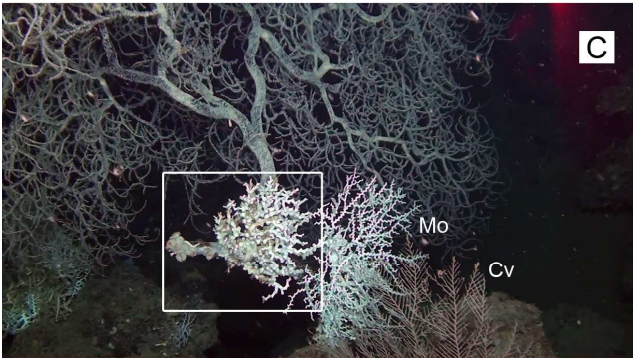
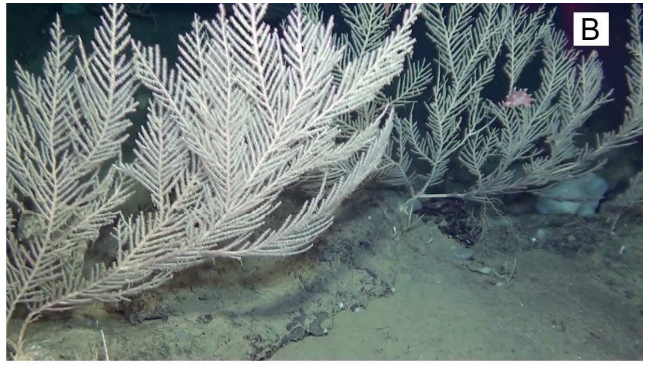
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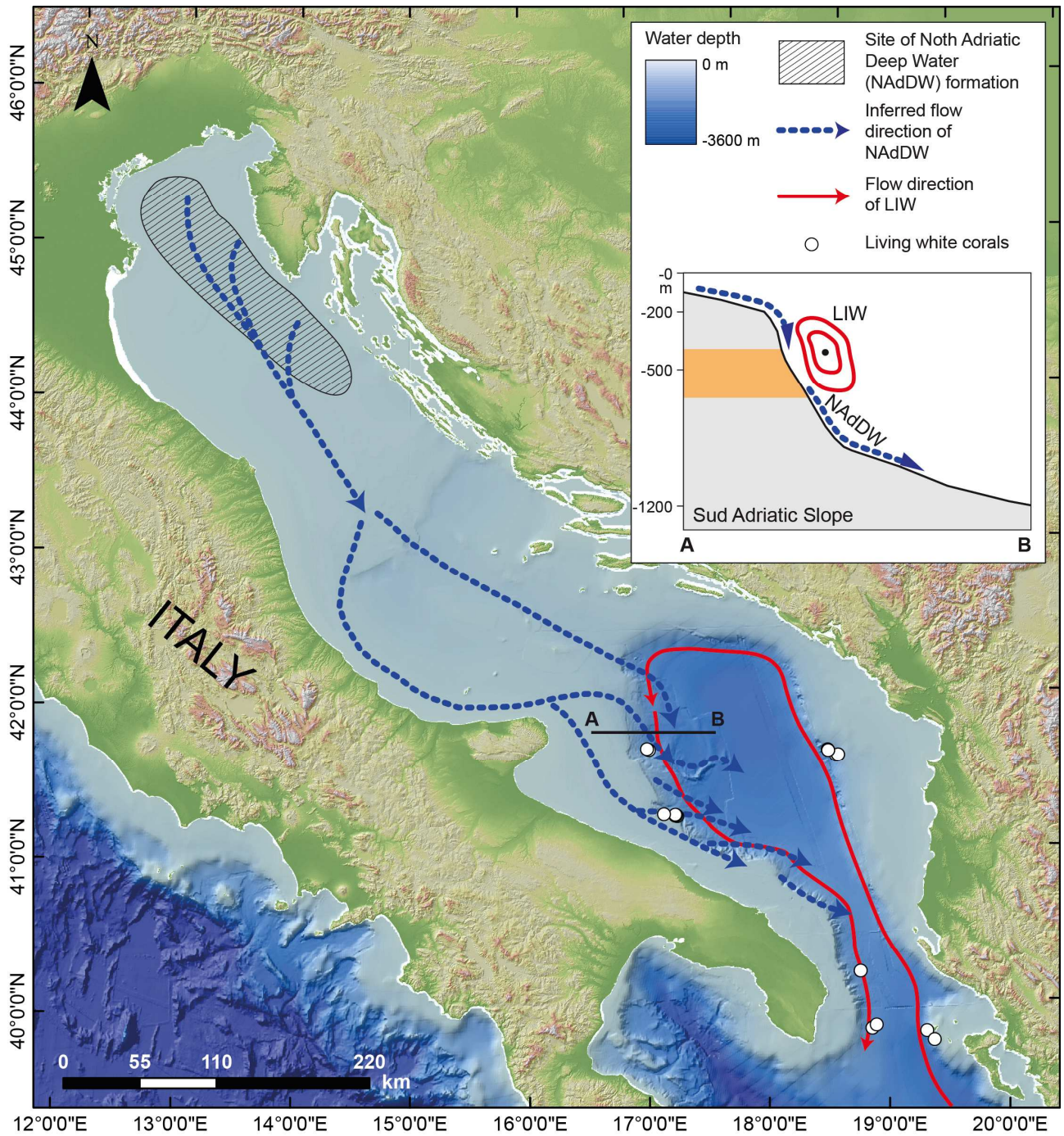
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