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ROV AND SUBMERSIBLE SURVEYS ON FAUNAL ASSEMBLAGES IN A DEEP-SEA CANYON (RECH LACAZE-DUTHIERS, WESTERN MEDITERRANEAN SEA)

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ROV AND SUBMERSIBLE SURVEYS
CANYONS
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ABSTRACT. – 52 years after the first explorations in the Lacaze-Duthiers Canyon and the observation of living populations of cold-water corals, recent video surveys using deployments of the ROV "Super-Achille" and the submersible "REMORA" (COMEX), have allowed the discovery of new sites colonized by cold-water coral populations *(Lophelia pertusa*, *Madrepora oculata*, *Dendrophyllia cornigera* and *Desmophyllum dianthus)*. Dense populations were observed, from 250 to 535 m, either on blocks or cliffs. The coral community consisted of a rich fauna of invertebrates including numerous sponges, brachiopods, echinoderms, oysters, ascidians and bryozoans as well as vagile cephalopods and fishes. Among the 51 identified species, 4 species are protected by the French regulation (corals), 13 species are cited in European directives 79/109/EEC (Art 4) and 92/43/EEC (Annex 2), 2 species are cited in the OSPAR convention and 15 are of commercial interest. Direct observations allowed also establishing an increase of anthropogenic wastes mainly related to fishing.

INTRODUCTION

The Gulf of Lions is morphologically characterized by a dense network of submarine canyons that deeply (up to 1000 m) incise the continental slope. These canyons are all parallel, beginning at around 100 m depth and dropping down to 2000 m (Bourcart 1948). Canyons are known to funnel large volumes of sediments and organic matter, suggesting an important role in concentrating POM and transferring it from shallow to deep-sea habitats and affecting therefore the deep-sea environment (Bourcier *et al*. 1993, Della Tommasa *et al*. 2000, Palanques *et al*. 2005, 2006, Canals *et al*. 2006, 2009, Trincardi *et al*. 2009). Sedimentation in the canyon is moreover spatially and seasonally variable (Mullenbach *et al*. 2006). Additionally, these canyons experience occasional great sediment gravity flows, which are thought to be triggered by sediment collapsing, by river flooding or by dense shelf water cascading, a type of current that is driven solely by seawater density contrast (Heussner *et al*. 2006, Canals *et al*. 2006). The total mass transported increases along the slope, particularly between the NE (Planier Canyon) and the SW (Lacaze-Duthiers and the Cap Creus Canyons) limits of the Gulf of Lions, indicating an increased shelf export of particulate matter in the western part of the system. Correlations between sources of particulate material on the shelf (i.e., river and atmospheric inputs, phytoplankton biomass and sediment resuspension), cross-slope exchange mechanisms (derived from *in situ* temperature and current records) and flux data indicate a predominant effect of dense cold water cascading on the exchange of particulate matter between the shelf and the slope. Although, also upwelling return and slope-shelf exchange occurs (Tintoré *et al*. 1990, Sabatés & Masó 1992). These events are characterized by strong currents and high particulate loadings that have pronounced effects on the biological diversity (Company *et al*. 2008).

The Lacaze-Duthiers canyon was discovered in 1893-1894 by G Pruvot, who already mentioned the existence of cold water corals (CWC) associated with brachiopods and serpulids (Pruvot 1894a, b). Oriented NNW-SSE, the Lacaze-Duthiers Canyon begins at 90-100 m depth by a narrow ravine of 4-4.8 km width about 13 miles offshore Cap Bear which drops at about 520 m depth. This region is characterized by rocky cliffs with zones of stairs or fallen blocks and a rocky hill on the canyon head named the

"Fountaindreau" (Reyss & Soyer 1965, Got *et al*. 1968). Around 520 m depth, the valley is deflected to the East and widens to 9 km. At the bottom the dominant sediment contains more than 80 % of mud, although irregular sediment with large granulometry and dead shells have also been observed (Got *et al*. 1969). The first dives, made with the submersible SP 300 (*Commandant Cousteau*) at 200-230 m depth on a cliff near the seamount "the Fountaindreau", allowed the observation of *Madrepora oculata* and *Dendrohyllia cornigera,* as well as numerous brachiopods (Petit & Laubier 1962, Reyss 1964a, b). These were the first observations *in situ* of living corals in the Mediterranean.

Two cruises were carried out in May and July 2008: "MINIBEX" by OOB (Observatoire océanologique de Banyuls, supported by DIREN) with two major objectives: 1) Check the present status of white coral populations observed 50 years ago; 2) Select a location to deploy in the near future a deep observatory in order a) to monitor the most important species (size, abundance); b) sample deep-water for bacterial biodiversity; c) determine bioconservation strategies for deep-water corals; d) experiment tools for deep studies (incubators, labelling, growth).

Additional cruises of the MEDSEACAN Programme were carried out in November 2008 and June and July 2009 by the AAMP (Agence des Aires Marines Protégées) in order to survey the biodiversity of the Lacaze-Duthiers Canyon.

The objective of the present paper is thus to describe the main findings during the two sets of cruises mentioned above with special emphasis on CWC and associated fauna in the Lacaze Duthiers Canyon.

STATUS OF MEDITERRANEAN WHITE CORAL POPULATIONS

Living cold-water coral reefs are well-documented in the word ocean (e.g. Freiwald *et al*. 2004, Hovland 2008, Murray *et al*. 2009).

Alike the northeastern Atlantic, Mediterranean deep-water coral reefs are mainly constructed by the scleractinians *Lophelia pertusa* (Linnaeus, 1758) and *Madrepora oculata* Linnaeus, 1758, which forms anatomizing colonies, although solitary species such as *Desmophyllum dianthus* (Esper 1794) (= *D. cristagalli* Milne Edwards & Haines, 1848) and *Caryophyllia* sp. may also contribute to the reef construction framework (e.g. see reviews by Freiwald *et al*. 2009, Taviani *et al*. 2005a, 2011a, with references therein).

In their milestone monograph on the bionomy of Mediterranean benthic communities, Pérès & Picard (1964) introduced the "Biocoenose des coraux blancs" to define a bathyal hard-bottom community dominated by such scleractinian corals. In general, subfossil deep corals of Pleistocene age are widespread and abundant basinwide in the Mediterranean (Taviani & Colantoni 1984, Delibrias & Taviani 1984, Remia & Taviani, 2005, Taviani *et al*. 2005a, 2011a, b, Zibrowius & Taviani 2005, McCulloch *et al*. 2010, Malinverno *et al*. 2010).

They also occur alive, and the last years witness a steady acceleration in locating more and more living cold water scleractinians, also thank to an enhanced implementation of ROV and submersible exploration (Taviani *et al* 2011b, with references therein). Historically, the first observations *in situ* of living corals in the Mediterranean have to be credited to the SP300 Calypso submersible expedition of Commandant Jacques Cousteau (Petit & Laubier 1962, Reyss 1964a, b). In this occasion, clusters of *Madrepora oculata* associated with yellow corals (*Dendrophyllia cornigera* (Lamarck, 1816) and brachiopods were observed from 230 m on a vertical wall in the south of the Fountaindrau Plateau on the East side at the head of the canyon *Lophelia pertusa* was also dredged in this area at greater depth.

At present, important cold water coral living occurrences are known from the western to the central Mediterranean, and this includes sizable provinces such as Santa Maria di Leuca in the Ionian sea, Bari Canyon in the southern Adriatic, the Strait of Sicily, the Catalan-Provençal canyons and Alboran (Blanc *et al*. 1959, Mastrototaro *et al*. 2002, 2011, Tursi *et al*. 2004, Taviani *et al*. 2005a, b, 2011b, Dullo *et al*. 2007, Schembri *et al*. 2007, Freiwald *et al*. 2009, Orejas *et al*. 2008, 2009, Rosso *et al*. 2011, Vertino *et al*. 2011).

Lophelia pertusa may extend throughout the North Atlantic, including part of the Mediterranean. It also extends down both sides of the Atlantic, along the coast of West Africa in the East and the United States and Brazil in the West. It also occurs extensively in the Eastern Gulf of Mexico and the Caribbean. There are a few scattered records from the Pacific and Indian oceans (Rogers 1999).

Living colonies of *Lophelia* were only known from a very limited number of Mediterranean sites beside Santa Maria di Leuca, including the Alboran Sea and the Gulf of Lions (Zibrovius 1980, Rogers 1999, Taviani *et al*. 2005a). These West Mediterranean systems appear to be relicts of much more extensive reefs, that populated the Pleistocene (Pérès 1985, Remia & Taviani 2005, Taviani *et al*. 2005a) and the colonies were considered to consist of mainly dead coral with living polyps only on the terminal portions of the branches (Schembri *et al*. 2007).

The solitary coral *Desmophyllum dianthus* is also a common contributor to the framework of the deep water coral reefs (Cairns 1995 *in* Rogers, Freiwald *et al*. 2009, Taviani *et al*. 2011a).

Overall, it seems that in the Mediterranean, *Madrepora oculata* is at present more common than *Lophelia pertusa* while in the Pleistocene past of this basin *L. pertusa* was more common and widespread.

Fig. 1. – **A**: Oceanographic ship "MINIBEX" (COMEX); **B** and **C**: Submersible "REMORA"; **D**: ROV "ACHILLE".

Madrepora oculata is a quasi-cosmopolitan scleractinian coral recorded at depths ranging from 15 to 1500 m (Cairns 1995). It dominates coral communities in the Mediterranean Sea and the Northeast Atlantic. In the Mediterranean Sea, this species, abundant in the submerged Late Pleistocene and emerged Early Pleistocene, was considered currently in decline, in relation with the warming of the intermediate and deep Mediterranean water masses and with - episodic - hypoxici water column conditions (Dullo *et al*. 2007).

MATERIALS AND METHODS

A total of five surveys were conducted in the Lacaze-Duthiers Canyon by the COMEX RV Minibex, using the remotely operated vehicle ROV Super-Achille and the REMORA submersible (Fig. 1) Two cruises under the MINIBEX project in May and July 2008, and 3 cruises in November 2008, June and July 2009 as part of the project MEDSEACAN (Mediterranean Sea Canyons) were carried out (Fig. 2, Table I). Photographic and video surveys were performed in all cruises by the ROV Super-Achille

Table I. – Dives made in the Lacaze-Duthiers Canyon with "Achille" ROV (ACH) and "Remora" submersible (R2K).

Dive reference	Date	Location	Maximal depth	Minimal depth	Ride length (m)
"MINIBEX" cruises					
ACHILLE Dives					
ACH1	28/05/08		618	599	
ACH2	28/05/08		540	195	
ACH3	29/05/08	East side	453	273	
ACH4	29/05/08	West side	374	288	
ACH5	30/06/08	West side	286		
ACH6	30/06/08	West side	222		
ACH7	30/06/08	East side	230	130	1200
REMORA Dive					
R2K1	30/06/08	West side	300	153	1500
"MEDSEACAN" cruises					
ACHILLE Dives					
B1LDACHP02	6/11/08	West side	293	239	550
B1LDACHP03	7/11/08	East side	303	220	2000
B1LDACHP04	8/11/08	East side	254	246	860
B1LDACHP05	8/11/08	East side	250	250	
B1LDACHP06	9/06/09	West side	535	198	1350
B1LDACHP07	9/06/09	East side	540	191	1450
B1LDACHP08	9/06/09	West side	500	500	
B1LDACHP09	10/06/09	West side	507	495	
B1LDACHP10	10/06/09	East side	276	266	1140
B1LDACHP11	10/06/09	West side	266	218	
B1LDACHP12	10/06/09	East side	260	248	
B1LDACHP13	11/06/09	West side	656	219	2450
B1LDACHP14	11/06/09	East side	360	190	
B1LDACHP15	12/06/09	West side	377	322	
REMORA Dives					
B1LDR2KP01	7/11/08	West side	343	290	1500
B1LDR2KP02	8/11/08	East side	328	300	2480
B1LDR2KP03	9/11/08	West side	250	190	1670

(800 m operation depth) and the submersible REMORA (600 m operation depth), both equipped with 700 horizontal lines resolution color video camera, and a pair of parallel laser beams mounted 6 cm apart, and a full HD camera. Bathymetry was obtained using a multibeam sonar RESON SEABAT 8101. All representative fauna observed during transects was photographed. Only high-resolution pictures saved along transects were examined in the present work. Since identification is made on pictures taken haphazardly, it was not possible to estimate the abundance of main species. All species were identified visually to species level whenever possible, using classical identification books.

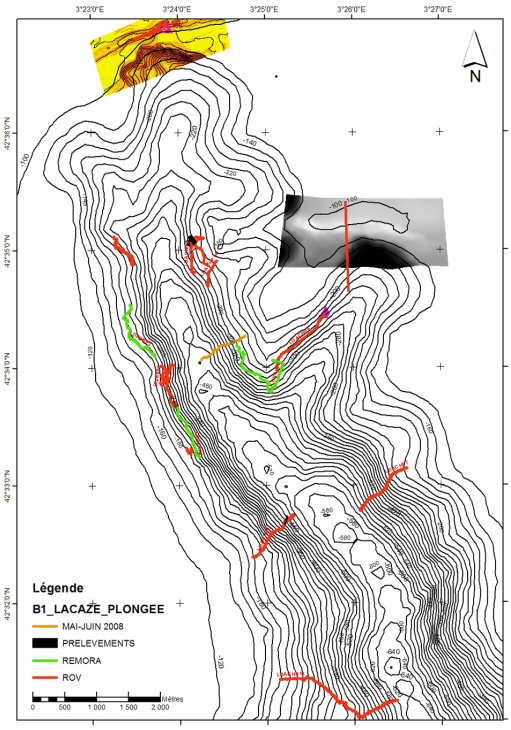

Fig. 2. – Lacaze-Dutiers Canyon, MINIBEX (2008) and MEDSEACAN (2008, 2009) cruises. Video surveys with RV "ACHILLE" (red and yellow lines) and submersible "REMORA" (green lines).

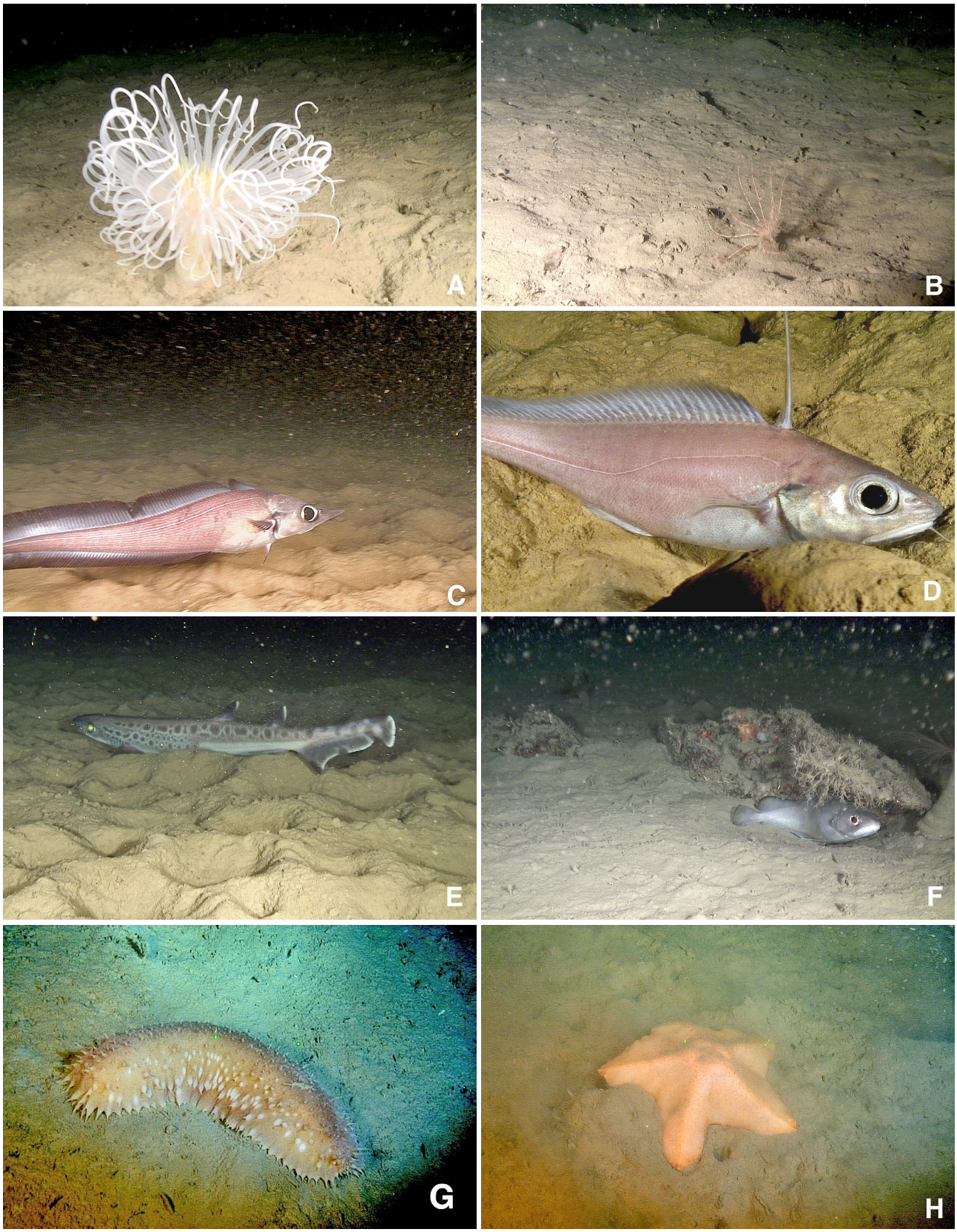

Fig. 3. – Muddy bottom, MINIBEX (2008). **A**: *Cerianthus* sp. (599 m); **B**: *Leptometra phalangium* (451 m); **C**: *Trachyrincus scabrus* (602 m); **D**: *Lepidion lepidion* (600 m); **E**: *Galeus melanostomus* (600 m); **F**: *Moro moro* (310 m). MEDSEACAN (2008); **G**: *Stichopus regalis* (346 m); **H**: *Anseropoda placenta* (430 m).

RESULTS

The different biotopes observed in this study can be summarized as follows:

On muddy bottoms (Figs 3, 4) between 200 and 600 m the sessile fauna included the cnidarian *Cerianthus* sp., the sabellid polychaete *Spirographis spallanzani*, the holothurian *Stichopus regalis*, the crinoid *Leptometra phalangium*, the asterid *Anseropoda placenta* and the bivalve mollusc *Atrina pectinata*. The vagile fauna was represented by the crustaceans decapods *Nephrops norvegicus* and other pagurids and peneid shrimps. The cephalopod *Octopus salutii* was also observed. Abundant fishes were also identified from this biotope: *Scorpaena scrofa*, *Lophius piscatorius*, *Coelorhyncus coelorhyncus*, *Conger conger*, *Aspidotrygla lyra, Moro moro, Scylliorhinus canicula*, *Physis blennoides*, *Helicolenus dactylopterus*, *Trahyrhyncus scabrus*, *Lepidopus caudatus, Lepidion lepidion, Merlucius merlucius, Galeus melanostomus, Lepidorhombus boscii* and *Chimaera monstrosa*. A single specimen of *Oxynotus centrina* was observed at 210 m.

Irregular sand with shells fragments (Fig. 5) was colonized between 280 and 350 m depth by the sponge *Haliclona plana*, the cnidarians *Cerianthus membranaceus* and *Dendrophyllia cornigera*, the holothurians *Holothuria forskali* and *Stichopus regalis*, the echinids *Echinus acutus* and *Spatangus purpureus*, the mollusc *Atrina pec-*

Table II. – Species identified in the Lacaze-Duthiers Canyon during the MINIBEX and MEDSEACAN surveys

PORIFERA	*Spatangus purpureus* (O.F. Müller, 1776)
Geodia sp.	*Stichopus regalis* (Cuvier, 1817)
Haliclona plana (Topsent, 1892)	*Stylocidaris affinis* (Philippi, 1845)
Poecillastra compressa (Bowerbank, 1866)	CRUSTACEA
CNIDARIA	*Munida rugosa* (Fabricius, 1775)
Cerianthus membranaceus (Spallanzani, 1784)	*Nephrops norvegicus* (Linnaeus, 1758)
Cerianthus sp.	Pagurid
Dendrophyllia cornigera (Lamarck, 1816)	*Palinurus mauritanicus* (Gruvel, 1911)
Desmophyllum dianthus (Edwards & Haimes, 1848)	Peneids shrimps
Epizoanthus sp.	TUNICATA
Hydrozoa	*Diazona violacea* (Savigny, 1816)
Lophelia pertusa (Linnaeus, 1757)	*Microcosmus vulgaris* (Heller, 1877)
Madrepora oculata (Linnaeus, 1757)	*Polysyncraton* sp.
POLYCHAETA	FISHES
Serpula vermicularis (Linnaeus, 1767)	*Capros aper* (Linnaeus, 1758)
Serpulids	*Chimaera monstrosa* (Linnaeus, 1758)
Spiochaeptopterus sp.	*Coelorhyncus coelorhyncus* (Risso, 1810)
Spirographis spallanzani (Viviani, 1805)	*Conger conger* (Linnaeus, 1758)
MOLLUSCA	*Galeus melanostomus* (Rafinesque, 1810)
Atrina pectinata (Linnaeus, 1767)	*Helicolenus dactylopterus* (Delaroche, 1809)
Eledone cirrhosa (Lamarck, 1798)	*Lepidion lepidion* (Swainson, 1838)
Neopycnodonte cochlear (Poli, 1795)	*Lepidopus caudatus* (Euphrasen, 1788)
Neopycnodonte sp.	*Lepidorhombus boscii* (Risso, 1810)
Octopus salutii (Verany, 1839)	*Lophius piscatorius* (Linnaeus, 1758)
Undetermined gastropod	*Merlucius merlucius* (Linnaeus, 1758)
BRACHIOPODA	*Moro moro* (Risso, 1810)
Gripheus vitreus (Born, 1778)	*Mullus barbatus* (Linnaeus, 1758)
Mergela truncata (Linnaeus, 1758)	*Oxynotus centrina* (Linnaeus, 1758)
undetermined species	*Physis blennoides* (Brünnich, 1768)
BRYOZOA	*Pagellus* sp.
undetermined encrusting species	*Scylliorhinus canicula* (Linnaeus, 1758)
ECHINODERMATA	*Scorpaena elongata* (Cadenat, 1943)
Anseropoda placenta (Pennant, 1777)	*Scorpaena scrofa* (Linnaeus, 1758)
Echinus acutus (Lamarck, 1816)	*Trachurus trachurus* (Linnaeus, 1758)
Holothuria forskali (DellaChiaje, 1823)	*Trachyrhyncus scabrus* (Raf.)
Leptometra phalangium (Müller, 1841)	*Trachiurus* sp.
Ophiotrix fragilis (Abildgaard, 1789)	*Trigla lyra* (Linnaeus, 1758)
Parastichopus regalis (Cuvier, 1817)	

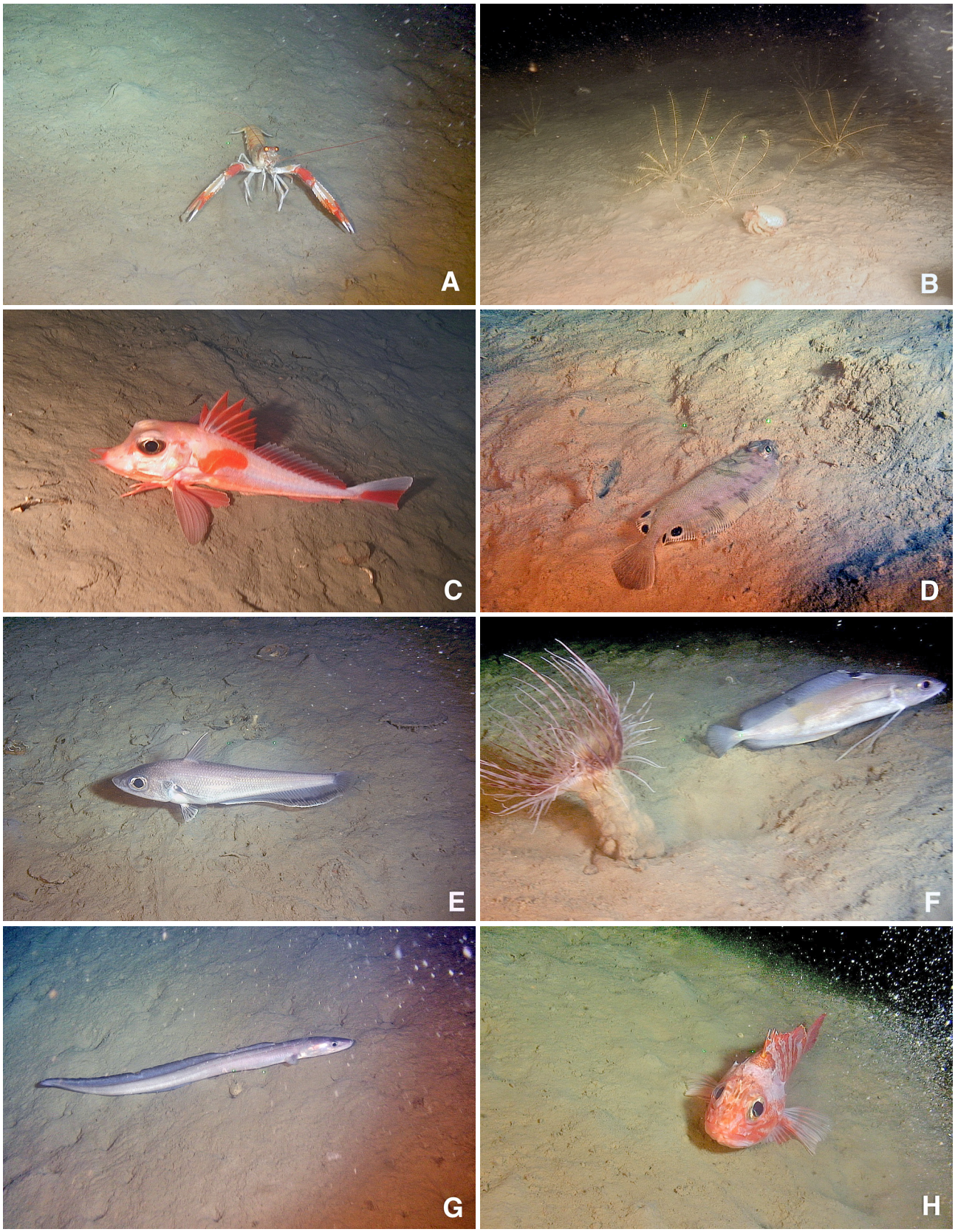

Fig. 4 . – Muddy bottom, MEDSEACAN (2009). **A**: *Nephrops norvegicus* (316m); **B**: *Paguridae* and *Leptometra phalangium* (266 m); **C**: T*rigla lyra* (292 m); **D**: *Lepidorhombus boscii* (293 m); **E**: *Coelorhynchus coelorhynchus* (315 m); **F**: *Cerianthus* sp. and *Phycis blenoides* (328 m); **G**: *Conger conger* (425 m); **H**: *Heliconus dactylopterus* (620 m).

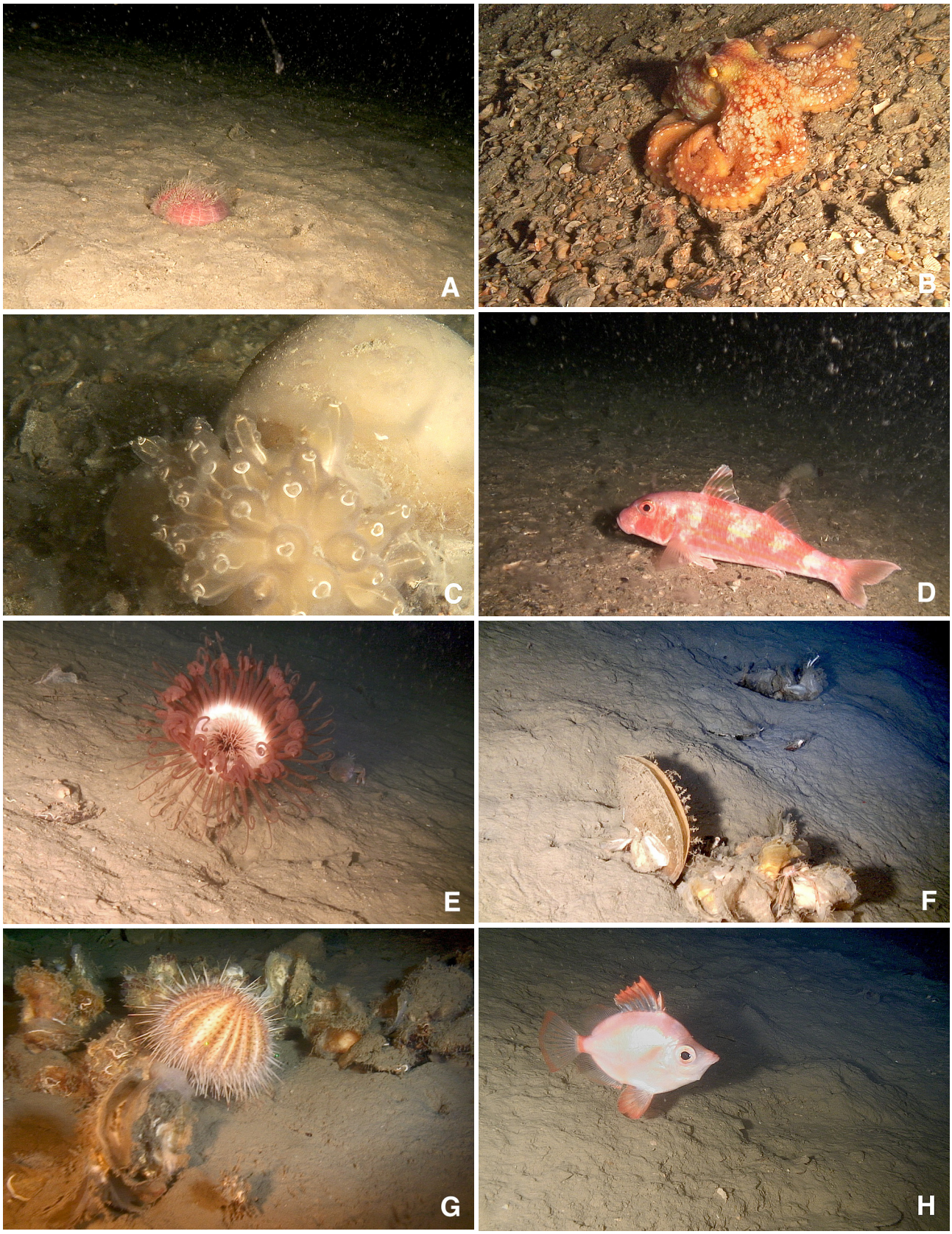

Fig. 5. – Irregular sand with shells fragments, MINIBE (2008), (between 210 and 130 m). **A**: *Spatangus purpureus*; **B**: *Octopus salutii*; **C**: *Diazona violacea*; **D**: *Mullus barbatus*. MEDSEACAN cruise (2009); **E**: *Cerianthus membranaceus* (251 m); **F**: *Atrina pectinata* and *Neopycnodonte* sp. (250 m); **G**: *Echinus acutus* (206 m); **H**: *Capros aper* (250 m).

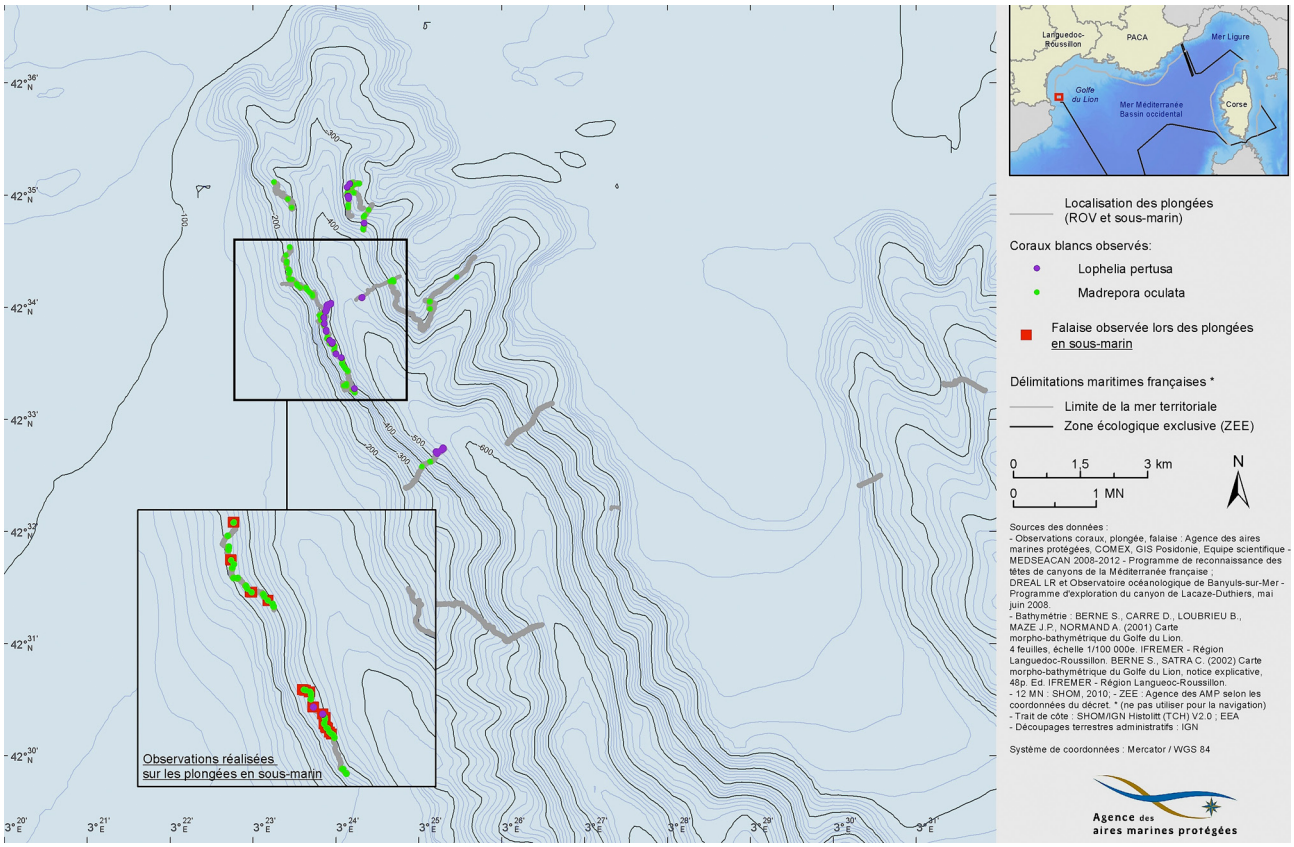

Fig. 6. – Lacaze-Dutiers Canyon. MINIBEX (2008) and MEDSEACAN (2008, 2009) cruises. Localization of cliffs (red lines) and white coral colonies of *Madrepora oculata* (green dots) and *Lophelia pertusa* (violin dots).

tinata, a number of serpulids, some oysters *Neopycnodonte* sp., Pagurids, penaeid shrimps and *Nephrops norvegicus*, the ascidian *Diazona violacea* and the cephalopods *Octopus salutii and O. vulgaris*. Fishes were represented by *Scylliorhinus canicula; Capros aper* and *Mullus barbatus*.

First observations of the common occurrence of colonies of *Madrepora oculata* (up to 50 cm high) refer to a cliff at ca. 250 m. At this depth, cliffs along the west side of the canyon were abundantly covered with this species (Figs 6, 7). Living colonies of *Lophelia pertusa* appeared on cliffs found around 300 m until 535 m depths (Figs 6, 7). The size (up to 1 m) and the density of the colonies increased between 450 and 535 m (deepest observation). They were associated with numerous colonies of *M. oculata* and high densities of the solitary coral *D. dianthus*. Other invertebrates included abundant clusters of oysters (*Neopycnodonte* sp.), serpulids, sponges and bryozoans. The vagile fauna was represented by sea urchins (*Stylocidaris affinis*) crustaceans (*Munida rugosa*) and fishes *(Heliconus dactylopterus* and *Scorpaena elongata)*.

On steps of overhanging rocky bedrock (Fig. 8), dense populations of brachiopods (*Gripheus vitreus*), oysters (*Neopycnodonte cochlear*) and serpulids (*Serpula vermicularis*) were observed at about 330 m depth. Small living colonies of *Madrepora oculata* were present and associated with sponges such as *Geodia* sp., *Poecillastra compressa*, undetermined encrusting bryozoans, the holothurid *Holothuria tubulosa*, the galatheid *Munida rugosa* and the coral *Dendrophyllia cornigera*.

Fallen blocks (Figs 9, 10) of 2 or 3 m large, found at the base of slopes in the head of the rech between 280 and 300 m depth, were covered with small colonies of *M. oculata*. This species was accompanied by *D. cornigera* and *D. dianthus*. Other invertebrates included brachiopods, the oyster *N. cochlear*, serpulids and sabellid (*Spirographis spallanzanii*), sponges (*Poecillastra compressa, Geodia* sp.), sea urchins *(Stylocidaris affinis* and *Echinus acutus)*, the ophiurid *Ophiothrix fragili* crustaceans (*Palinurus mauritanicus* and *Munida rugosa*, cephalopods (*Eledone cirrhosa* and *Octopus salutii*), ascidians (*Microcosmus vulgaris),* and fishes *(Scorpaena scrofa*, *Trachurus trachurus* and *Trichiurius* sp.*). S*ome small colonies of *L. pertusa* were also observed between 350 and 448 m depth .

In all sites, an abundant zooplankton, mainly crustaceans, was also observed between the coral frameworks.

Anthropogenic impact was also observed in the canyon, indicated by fishing lines, nets, wooden pieces, plastic bags, pipes, ballasts and other litter (Figs 11, 12)

Among the 51 identified species in the Lacaze-Duthiers Canyon (Table II), some are of remarkable importance,

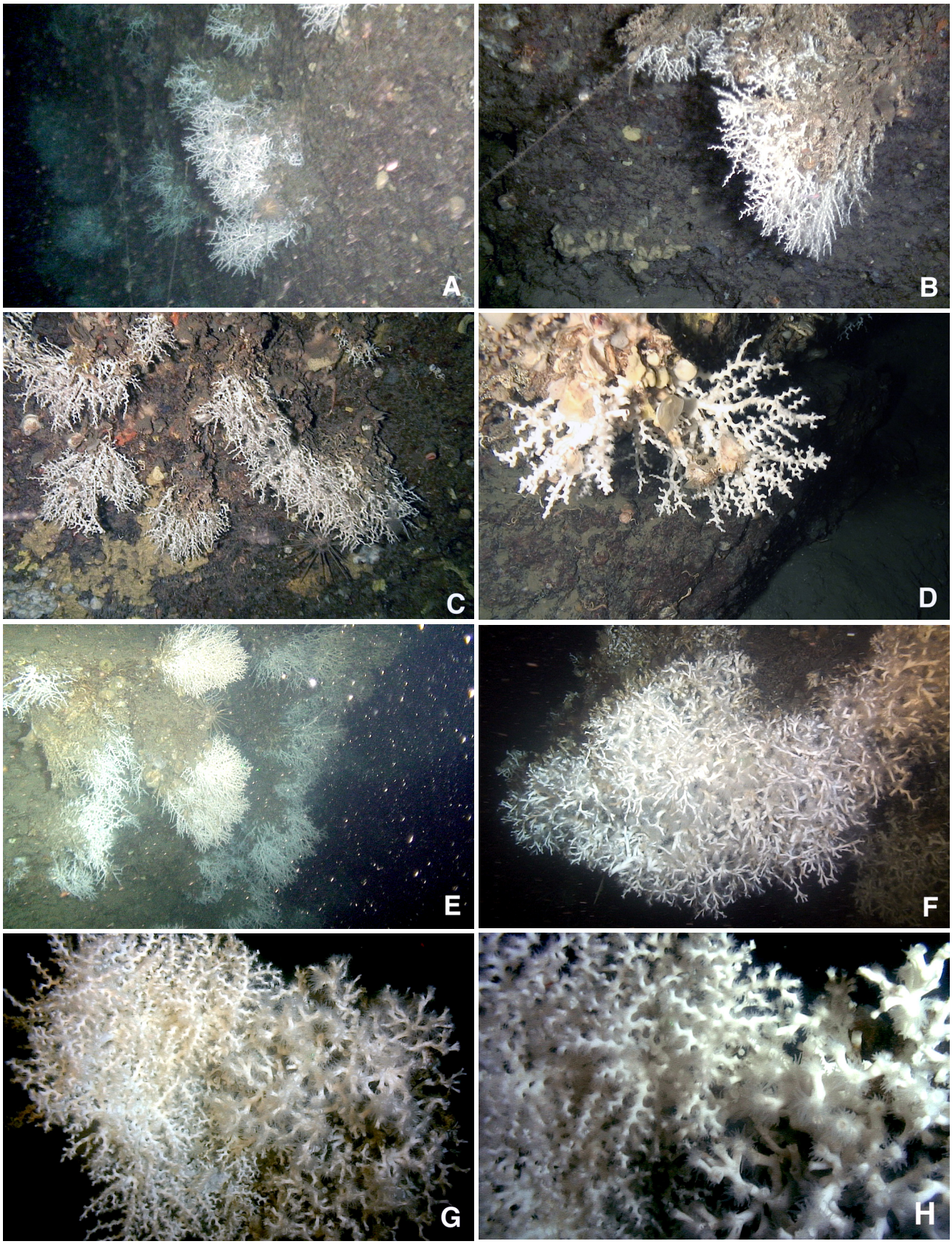

Fig. 7. – Rocky cliff, MINIBEX (2008). **A**: *Madrepora oculata* (285 m); **B**: *Madrepora oculata*; *Madrepora oculata* and undetermined uncrusting sponges (285 m); **C** and **D**: *Madrepora oculata* and undetermined sponges and ascidians (286 m). MEDSEACAN (2009); **E**: *Madrepora oculata* (322 m); **F**: *Lophelia pertusa* (349 m); **G**: *Madrepora oculata* and *Lophelia pertusa* (363 m); **H**: *Madrepora oculata* and *Lophelia pertusa* (363 m).

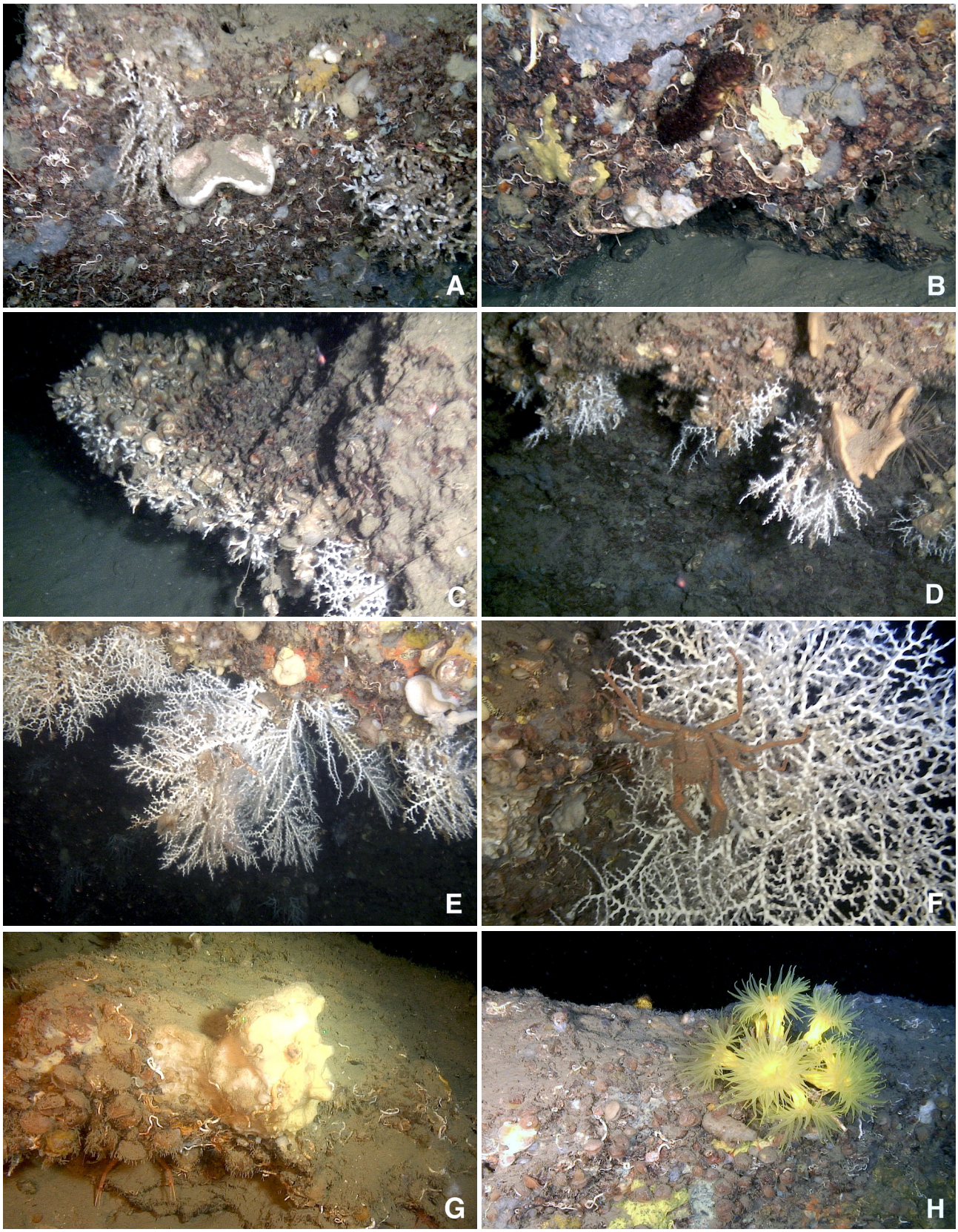

Fig. 8. – Overhanging rocks, MINIBEX (2008). **A**: *Geodia* sp., undetermined encrusting sponges, bryozans and serpulids, *Madrepora oculata*; **B**: Undetermined uncrusting sponges, bryozans and serpulids, *Holothuria forskali*; **C**: *Neopycnodonte cochlear*, brachiopods and *Madrepora oculata*; **D**: *Poecillastra compressa*, undetermined hydroids and sponges, *Madrepora oculata*. MEDSEACAN (2009); **E**: Undetermined sponges and *Madrepora oculata* (252 m); **F**: Undetermined crab and *Madrepora oculata* (221 m); **G**: Undetermined sponges and brachiopods, *Munida rugosa* (250 m); **H**: Undetermined brachiopods and sponges, *Dendrophyllia cornigera* (221 m).

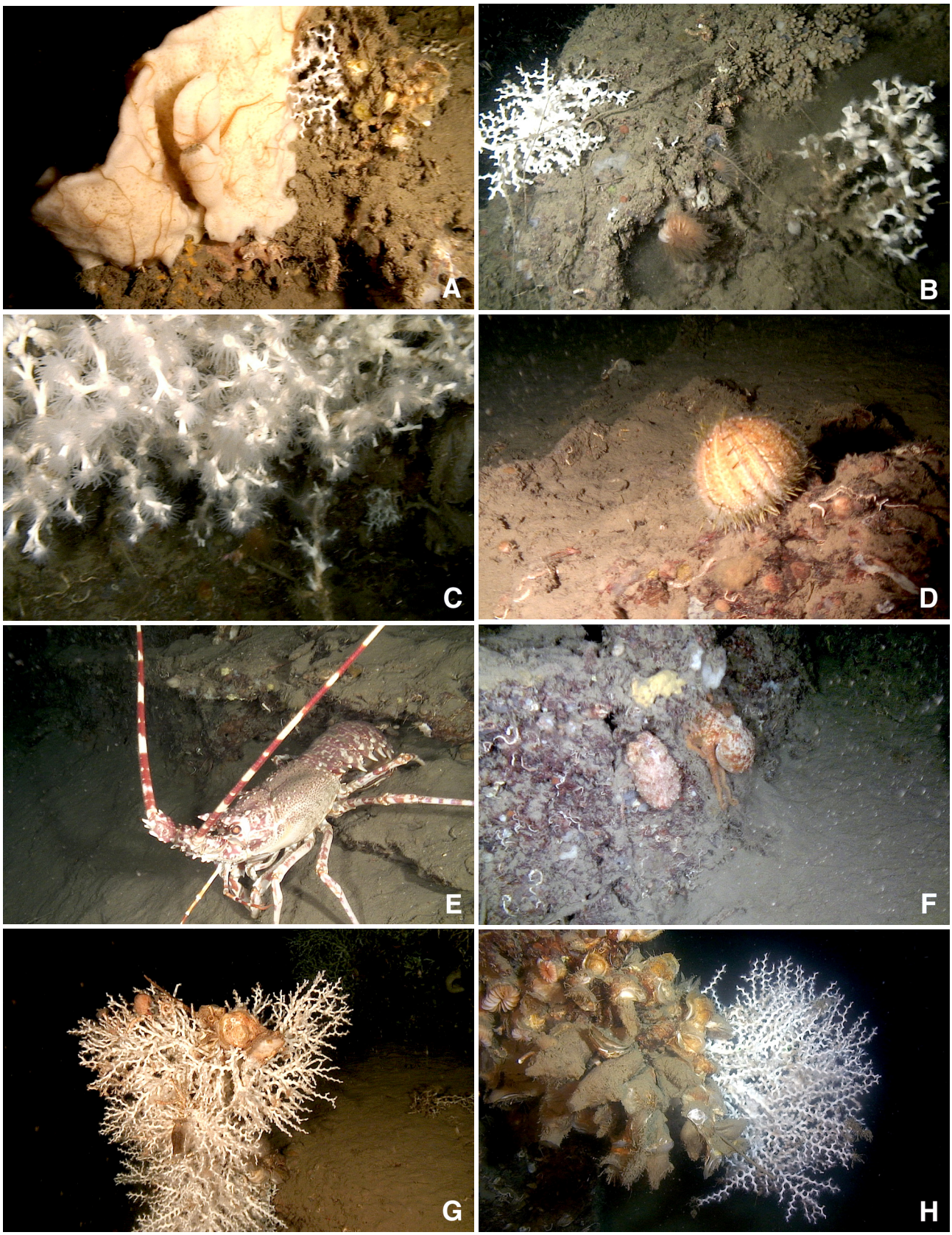

Fig. 9. – Fallen blocks. MINIBEX (2008). **A**: Undetermined sponge and *Madrepora oculata, Ophiothrix fragilis* and other undetermined ophiurids (222 m); **B**: *Madrepra oculata*, *Lophelia pertusa*, *Desmophyllum dianthus* and undetermined zoantharian (350 m); **C**: *Lophelia pertusa* (350 m); **D**: *Echinus acutus* (320 m); **E**: *Palinurus mauritanicus* (325 m); **F**: *Eledona cirrhosa* (315 m). MEDSEACAN (2009); **G**: *Madrepora oculata* and *Neopycnodonte cochlear* (282 m); **H**: *Madrepora oculata* , *Neopycnodonte cochlear*, *Desmophyllum dianthus* and ascidians (500 m).

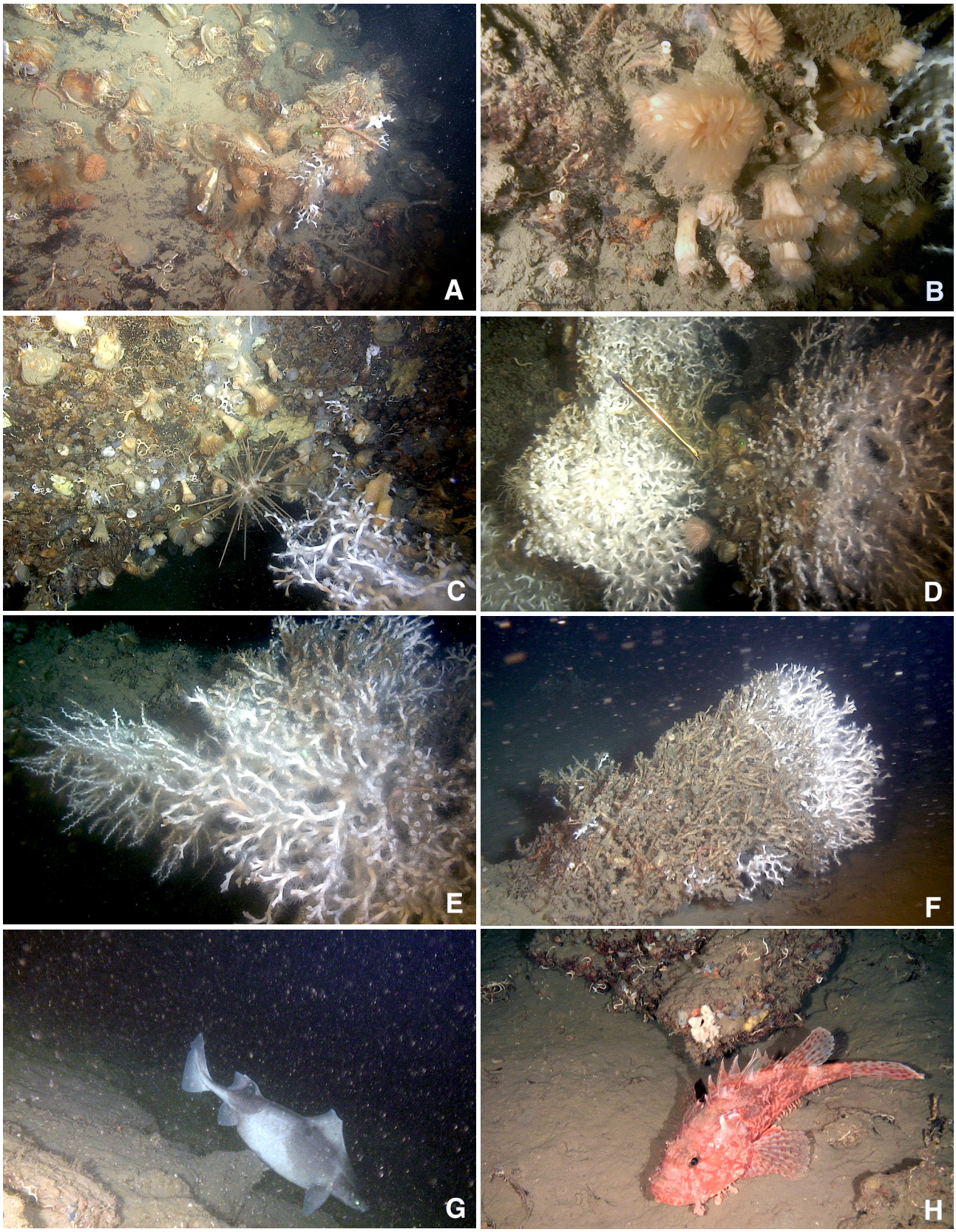

Fig. 10. – Fallen blocks, MEDSEACAN (2009). **A**: *Neopycnodonte cochlear*, *Desmophyllum dianthus* and *Munida rugosa* (376 m); **B**: *Desmophyllum dianthus* (500 m); **C**: Sponges, serpulids, *Stylocidaris affinis*, *Desmophyllum dianthus* and *Lophelia pertusa* (349 m); **D**: *Lophelia pertusa* and *Trichurius* sp. (346 m); **E**: *Madrepora oculata* and *Lophelia pertusa* (500 m); **F**: Deepest *Lophelia pertusa* colony observed (535 m); **G**: *Oxynotus centrina* (220 m); **H**: *Scorpaena scrofa*.

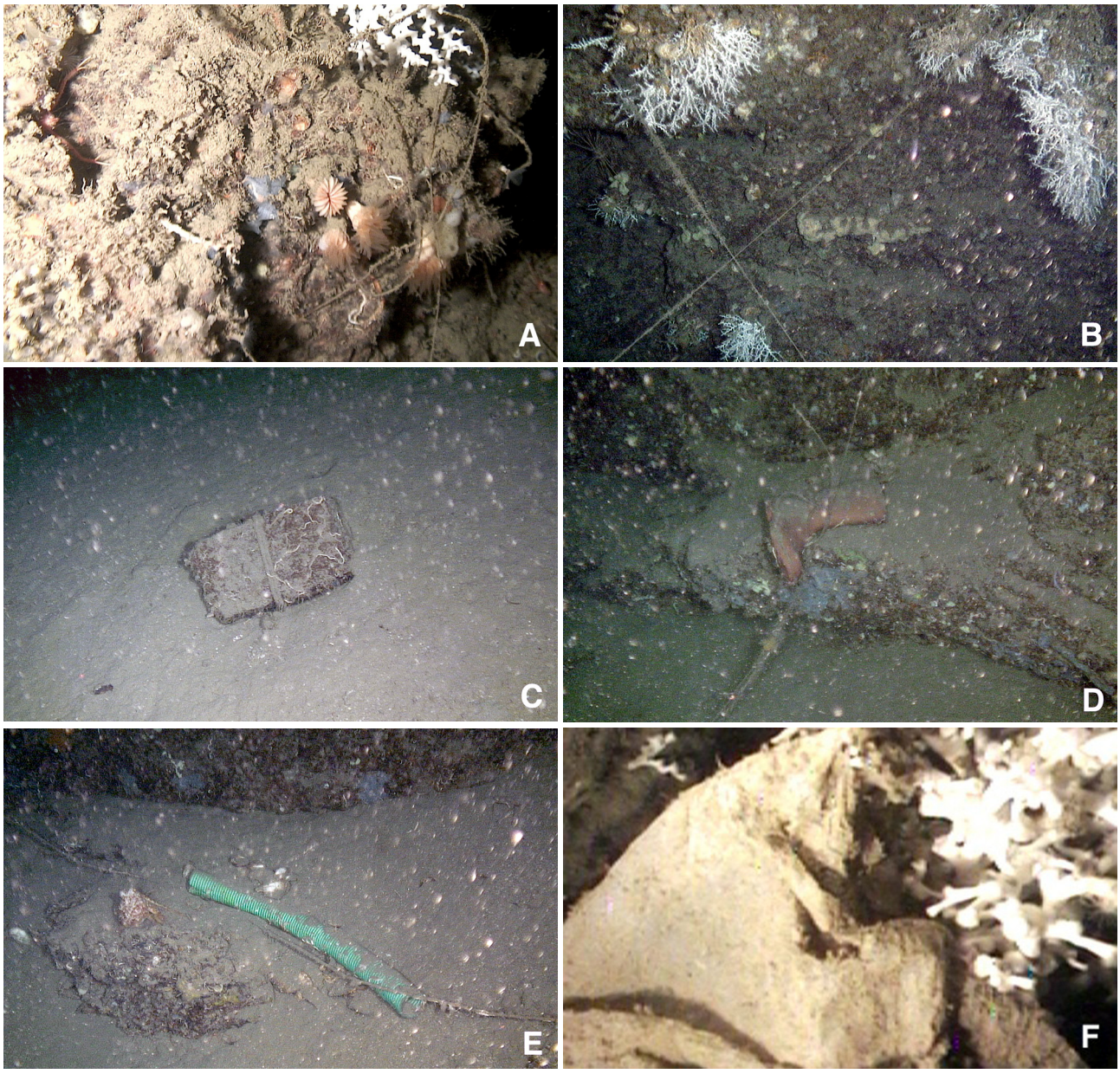

Fig. 11. – Anthropic wastes, MINIBEX (2008). **A** and **B**: Fishing lines on corals (283 m); **C**: Ballast (220 m); **D**: Boot (283 m); **E**: Plastic tube (280 m); **F**: Plastic bag on coral (450 m).

thus 4 species are Protected Species in France (*Desmophyllum dianthus*, *Madrepora oculata*, *Lophelia pertusa* and *Dendrophyllia cornigera)*. The white coral *Lophelia pertusa* is listed Under CITES (Convention on International Trade in Endangered Species of wild Flora and Fauna) Annex I and II, and by the OSPAR convention. Also, 13 species are found on the European Directive List 79/409/EEC (Article 4) and Directive 92/43/EEC (Annexe 2). These are the brachiopods *Gryphus vitreus, Mergelia truncata,* the crustacean *Nephrops norvegicus*, the echinoderm *Echinus acutus*, the cephalopod *Octopus salutii*, the fishes *Galeus melanostomus, Conger conger, Phycis blennoides, Lophius piscatorius, Moro moro, Coelorhynchus coelorhynchus* and *Trigla lyra*. In addition, one species is considered as very rare *(Oxynotus centrina* and critically endangered in the Mediterranean Sea, according to a report from the World Conservation Union (IUCN). Fifteen species are of commercial interest: the crustaceans *Palinurus mauritanicus* and *Nephrops norvegicus,* the cephalopods *Sepia vulgaris* and *Octopus vulgaris*, the fishes *Trygla lyra, Lophius piscatorius*, *Scorpaena scrofa*, *Scorpaena elongata, Conger conger*, *Mullus barbatus*, *Physis blenoides*, *Galeus melanostomus*, *Scyliorhinus canicula*, *Helicolenus dactylopterus*, *Coelorhyncus coelorhyncus*, *Trachyrhyncus scabrus* and *Lepidopus caudatus*.

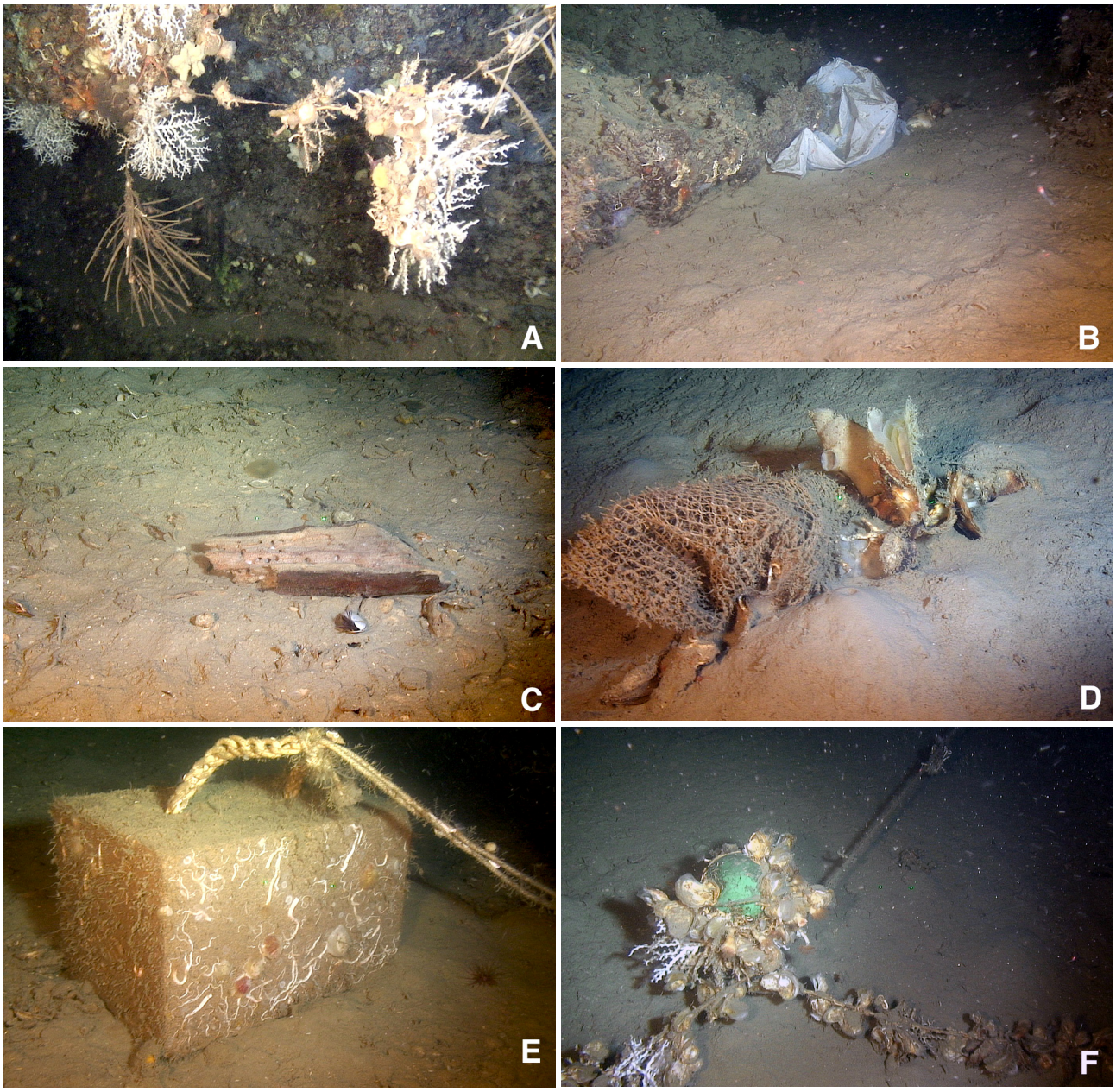

Fig. 12. – Anthropic wastes, MEDSEACAN (2009). **A**: Fishing lines on corals (260 m); **B**: Plastic bag (435 m); **C**: Wooden waste (226 m); **D**: Net with ascidian (316 m); **E**: Ballast (263 m); **F**: Float and fishing line (355 m).

DISCUSSION

The main features observed in the Lacaze-Duthiers Canyon are the diverse vagile fauna and other benthic invertebrates, as well as the presence of abundant colonies of CWC (*Madrepora oculata* and *Lophelia pertusa*). The highly diverse vagile fauna observed in the present study seems to corroborate that CWC sites offer a sheltered reproductive ground and trophic ressources to a variety of species (e.g. Taviani *et al*. 2009, Carlier *et al*. 2009, Bongiorni *et al*. 2009, Mastrototaro *et al*. 2010).

Moreover, CWC in the Lacaze-Duthiers Canyon are remarkable for the size of their colonies (up to 50 cm for *M. oculata* and up to 1 m for *L. pertusa*) occurring with maximal densities at 250 m depth for *M. oculata* and 500 m depth for *L. pertusa*.

The prospective work carried out during the MEDSEACAN programme explored all canyons along the French Mediterranean coast and CWC were only observed in Cassidaigne canyon (Watremez 2012). CWC have also been observed in the adjacent canyon, the Cap de Creus (Orejas *et al*. 2008, 2009). These CWC populations from Lacaze-Duthiers canyon (and those in Cap de Creus Canyon) seem to be found at shallower depths than in other Mediterranean sites. Thus, the coral bank discovered off the coast of Santa Maria di Leuca (Apulia, Italy) on the

eastern side of the Ionian Sea, North of the Calabrian Arc, extended between 425 and 1110 m (Mastrototaro *et al*. 2002, Tursi *et al*. 2004, Taviani *et al*. 2005b). Near the Maltese islands, considerable quantities of living *Madrepora oculata* were discovered at depths from 395 to 588 m, and only small living colonies of *Lophelia* were observed between 420 and 617 m (Schembri *et al*. 2007). Differences in depth distribution might be well related to differences in sampling effort. However, oceanographic factors (temperature, salinity, currents) and proper substrates (with steep or rugged topography) determine CWC distribution and their abundance (Roberts *et al*. 2009, Taviani *et al*. 2011). The remarkable abundance of the CWC and the diverse associated fauna in the Lacaze-Duthiers Canyon is thus probably related to the specific ecological conditions in this canyon with currents strong enough to bring abundant organic particles (Canals *et al*. 2006, Palanques *et al*. 2006, Oogston *et al*. 2008). These water fluxes are sufficient to allow the emergence of rocky cliffs despite the abundant mud flow but not too strong to prevent larval recruitment.

It appears to be difficult to compare our observations with the precedent detailed work from Reyss (1970, 1971) based on seven years study (using dredges, cores, grabs and a submersible). The present work is purely descriptive, the impossibility to sample with proper gears for collecting small species (meiofauna), soft species (ascidians), encrusting species (bryozoans, some sponges) or species firmly attached to rocks (oysters, brachiopods) renders the comparison with the previous work impractical. Nevertheless, an important difference is observed with that work: the increase of anthropic litter found in the canyon, also entangling the CWC colonies. Human activities in the deep sea are increasing in intensity and distribution, especially fishing gears. In the Gulf of Lions, most anthropic wastes were found in canyons descending from the continental slope and in the bathyal plain, with high amounts occurring to a depth over 500 m (Galgani & Andreal 1998, Galgani *et al*. 1996). These activities have evident impacts on gravity flows (Palanques *et al*. 2006), and fauna (Bourcier *et al*. 1993, Cartes *et al*. 2004) in the canyons, and they have already impacted CWC reefs worldwide (Rogers 1999).

In conclusion, live CWC populations still inhabit in the Lacaze-Duthiers Canyon and with a diverse associated fauna. On the French Mediterranean coast, this canyon represents a hot spot of ecological relevance, and therefore as in other canyons, it deserves the implementation of proper guidelines to preserve at most their fragile and diverse habitats, since they are easily exposed to anthropogenic pressure (e.g. fishing and pollution).

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