



Isidella elongata (Cnidaria: Alcyonacea) facies in the western Mediterranean Sea: visual surveys and descriptions of its ecological role

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Abstract

Isidella elongata is a candelabrum-shaped alcyonacean forming important facies on the bathyal muddy bottoms of the Mediterranean Sea, currently considered a sensitive habitat and heavily impacted by deep-sea fisheries. Until a few decades ago, this facies was a widespread habitat of the deep Mediterranean seabed and *I. elongata* was a common species in the trawling fishery's bycatch. Despite its current persistence in dense aggregations being very scarce, a dense facies of *I. elongata* was revealed during several ROV (Remotely Operated Vehicle) surveys carried out from 2010 to 2014 on the muddy bottoms between two seamounts east of Ibiza (Balearic Sea). The facies developed in an area between 480 and 615 m in depth where trawling is forbidden, with an extraordinary density of about 2300–2683 colonies/ha, representing one of the biggest facies of *I. elongata* currently known for the Mediterranean Sea considering the surface covered and the colonies' density. The associated community was surveyed, with 50 taxa identified. Moreover, a canyon southwest of Formentera characterised by the presence of *I. elongata* together with a high trawling impact was investigated. The density of the colonies was 53–62 colonies/ha and only 19 taxa of associated fauna were observed. The results of the two areas are compared and discussed in the framework of the protection of such an important habitat.

Keywords: *Isidella elongata*, biodiversity, deep sea, Balearic, Mediterranean Sea

Introduction

Isidella elongata (Esper, 1788), also known as bamboo coral, is a deep-sea alcyonacean belonging to the Isididae family. In the Mediterranean Sea, this species can characterise a facies on bathyal compact mud between 500 and 1200 m depth (occasionally shallower, up to 210 m in depth) on relatively flat bottoms with a slope of less than 5% (Pérès & Picard 1964; Pérès 1967; Bellan-Santini 1985; Laubier & Emig 1993; Bo et al. 2015). Grasshoff (1989) defined *I. elongata* as a near-endemic species in the Mediterranean Sea, although it has also been collected in the Ibero-Moroccan Gulf (Atlantic Ocean). Pérès and Picard in their *Nouveau manuel de Bionomie benthique de la Mer Méditerranée* (1964) wrote about a facies of the biocoenosis of the bathyal mud (VP)

characterised by the branched gorgonian *I. elongata* settled on firm and compact mud, but Pérès himself (1967) later regretted not having any images showing such facies. Carpine (1970) confirms that *I. elongata* is (or maybe was) the most common gorgonian species in the middle horizon of the bathyal zone of the Western Mediterranean Sea, and Laubier and Emig (1993) emphasised the ecological role of such deep-sea species not only as a habitat former, but also as a secondary biological hard substratum for other species such as epibiotic species or as a spawning substratum for cephalopods and sharks.

The real exploitation of deep-sea habitats in the Mediterranean Sea only started in the first few decades of the last century with the relentless development of trawl fishing activities mainly to capture red shrimps

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Aristeus antennatus and *Aristaemorpha foliacea* as well as the Norway lobster *Nephrops norvegicus* (Sardà et al. 2004). However, with the advance in fishing gear technology, trawling activities began what became the most devastating impact on these particular deep-sea habitats. Among the habitats affected by the deep-water fisheries in the Mediterranean Sea, the biocoenosis of bathyal mud and in particular the viscous mud with a very fluid superficial layer (250–500 m in depth) as well as the firm and compact mud (500–1000 m in depth), *sensu* Pérès and Picard (1964), proved to be the most damaged. The benthic facies of the sea pen *Funiculina quadrangularis* and of the alcyonacean *I. elongata*, that both develop on the above-cited biocoenosis, almost completely disappeared from most of the trawlable bottoms of the Mediterranean Sea (D’Onghia et al. 2003; Sardà et al. 2006; Mastrototaro et al. 2013, 2015). For this reason, coral forests *sensu lato* (including sea pens and alcyonacean gardens) were identified as Vulnerable Marine Ecosystems in the FAO’s (Food and Agriculture Organization) *International guideline for the management of the deep sea fisheries in the high seas* (FAO 2009, 2011). At the same time the General Fisheries Commission for the Mediterranean (GFCM) included *I. elongata* facies (IF) on the list of Sensitive Habitats (GFCM 2009). Mapping vulnerable marine ecosystems is considered the first and an indispensable step in the framework of environmental protection, as declared in the European Marine Strategy Framework Directive (2008/56/EC), aiming to preserve and restore marine biodiversity and reach good environmental status of the marine environment in 2020 (the so-called Horizon 2020).

In spite of the widespread decline of Mediterranean muddy-bottom facies characterised by sessile organisms such as sea pens and alcyonaceans, these peculiar and fragile bathyal facies have been accidentally preserved in some areas – for instance, where trawling activities are not possible such as in areas near deep-sea coral banks (Mastrototaro et al. 2013, 2015) or canyon flanks (Fabri et al. 2014), as well as where trawling is forbidden due to the presence of submarine cables or pipelines. This is the case of the muddy bottoms located 20 nautical miles east off Ibiza (Balearic Sea, Western Mediterranean) where trawling activities are forbidden because of submarine electricity cables (Acosta et al. 2004). Several ROV dives on these accidentally protected areas revealed the presence of a wide IF between 480 and 615 m in depth. ROV (Remotely Operated Vehicle) visual surveys provided data on the conservation status and the density of the *I. elongata* population, and allowed observation of the associated biodiversity and the real distribution of the species in this particular facies. Moreover, some peculiar behaviours of uncommon deep-sea species,

most of them considered rare and very scarcely known (Fabri et al. 2014), were observed. The density of the colonies and the associated animal community in the untrawled area was then compared with the ones observed in a nearby area, with comparable depth and environmental features, but – unlike the first one – affected by trawling activities.

Study area

The study area is located in the Balearic Promontory, in the block formed by the islands of Ibiza and Formentera. The eastern flank of this block is characterised by two seamounts, located on the upper slope east of Ibiza, Ausias March and Oliva Bank (Canals et al. 1982). Both seamounts seem to be affected by a NE–SW oriented fault system (Acosta et al. 2001a). The flat summits of the seamounts appear to rest at two different bathymetric levels, bounded by faults, which could indicate relative displacements between the seamounts (Acosta et al. 2001b). In particular, the investigated area lies in the Mallorca Channel, between Ausias March and Oliva Bank seamounts (Figure 1), in a muddy area covering approximately 80 km², where trawling activity is forbidden because of the presence of marine cables. This area is characterised by large pockmarks from 400 to 750 m in depth (Acosta et al. 2004) and it was identified as a gas seepage zone by the Spanish Institute of Oceanography (IEO 2005). Seabed features such as the consistency and compactness of the mud make this area feasible for the settling of *I. elongata*.

A second area, located in a canyon southwest of Formentera (close to Emile Baudot escarpment, about 20 nautical miles south-west of the main surveyed area) was also investigated (Figure 1). This area proved of comparable depth and edaphic features with respect to the first one, as well as being characterised by the presence of *I. elongata*. Differently from the first area, this second one was affected by trawling impacts, and it was investigated in order to compare its *I. elongata* population and benthic community with those found in the untrawled area.

Material and methods

The morpho-bathymetric data were collected using Simrad EM-12S and EM-1000 multibeam systems operating at frequencies of 12 and 100 kHz, respectively. The survey was designed in order to insonify 100% of the seafloor by overlapping the outer beams between tracks. Positioning was obtained via a double-frequency differential correction GPS (Global Positioning System) system using satellite corrections from the Skyfix and

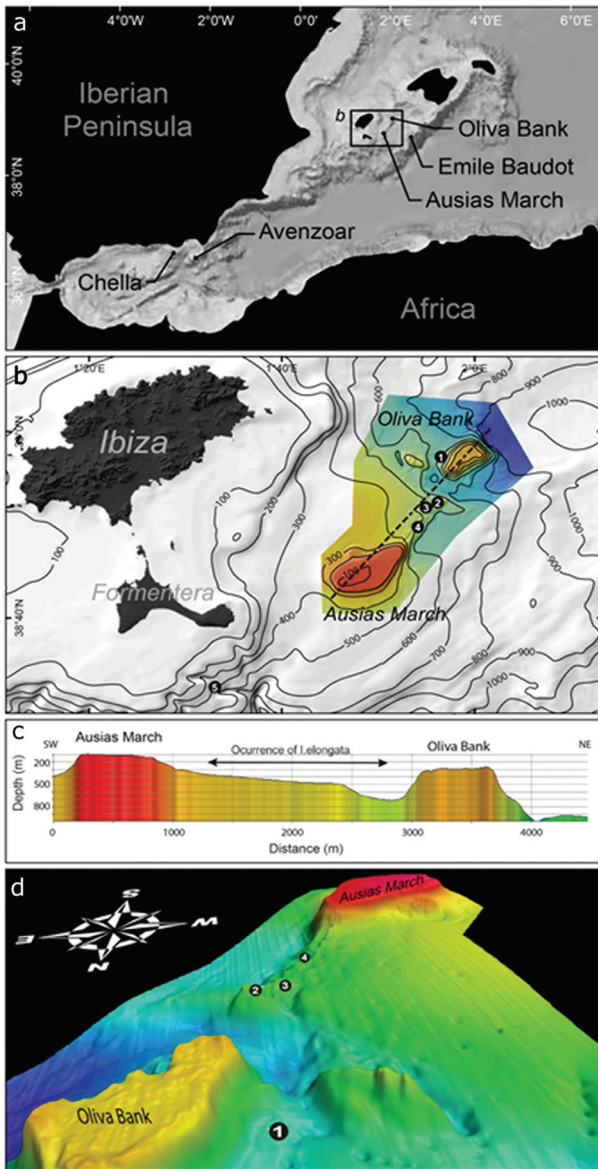


Figure 1. (a) Location map of the study area. (b) Map showing the East of Ibiza and Formentera Islands; numbers indicate the ROV dives performed (1–4: untrawled area; 5: trawled area). (c) Bathymetric profile across Ausias March and Oliva Bank seamounts; (d) Three-dimensional view showing the location of the ROV dives.

Omnistar systems integrated in a Konmap navigation software package.

Multibeam data were processed using Neptune from Kongsber. Fledermaus 7.0 from IVS and ArcGis 10.2 from ESRI were used for analysis and editing. The digital elevation model (DEM) used in the morphometric analysis is shown in colour in Figure 1(b) and (c). The extension of this DEM and subsequent digital terrain models (DTM), shown in Figure 2, was 825 km². The final data resolution was 50 × 50 m in the geographic system WGS84 UTM31 N.

Video footage was gathered between 2006 and 2014, when 58 ROV dives were performed on and around the Mallorca Channel seamounts. IF was found during five of these dives (Figure 1), carried out within the research cruises BALSEA 2010, BALBAU 2013 and BALSEA 2014. In particular, four ROV dives were carried out in the area between the Ausias March and Ses Olives seamounts (untrawled area), for a total of 6 hours and 8 minutes of underwater video, while only one ROV dive was carried out in a canyon southeast of Formentera (trawled area), with 1 hour and 15 minutes of recording (Table I). All the ROV surveys were performed from the Ketch Catamaran *Ranger* using a Saab Seaeye Falcon DR ROV equipped with an HDV (High Definition Video) camera of 480 TVL (Tele Vision Lines) with Minimum Scene Illumination of 2.0 lux (F1.4), a 1/2" CCD (Charge-Coupled Device) pick-up device, an image sensor, and a 3.8-mm spherical and wide angle lenses. The ROV performed transects from 1 to 2 km in length with an average speed of 0.2–0.3 knots, by recording at the same time in both high-definition (HD) and low-resolution modes. The average speed and wide angle of the camera filming an aisle of approximately 1.5–1.75 m allowed the observation of approximately 1500–1750 m² in each kilometre of transect. The position of the ROV was continuously recorded using a LinkQuest Tracklink USBL Transponder with up to 0.25° accuracy.

All the colonies of *I. elongata* observed were counted. Considering the ROV track length and the camera objective width, the density of the colonies was estimated in colonies per hectare by considering a range of values based on the minimum and maximum of the wide angle of the camera. Moreover, every specimen belonging to other taxa was identified at the lowest possible taxonomic level, and one or more frames were taken from the video to provide a visual identification of each taxa. Specific identification by images was driven by expert opinions (see Acknowledgements).

Considering the different sampling efforts between the two surveyed areas, a quantitative comparison of *I. elongata* density and only a qualitative comparison of the associated fauna were performed.

Results

On the muddy seabed of the Mallorca Channel, between Ausias March and Oliva Bank seamounts (untrawled area), a wide IF was observed on an area of about 0.72–0.84 ha, from 485 to 616 m depth (Table I; Figure 3(a)). A total of 1932 *I. elongata* colonies were counted, estimating a mean density of 2300–2683 colonies per hectare (Table II). Most of the colonies observed were in good development

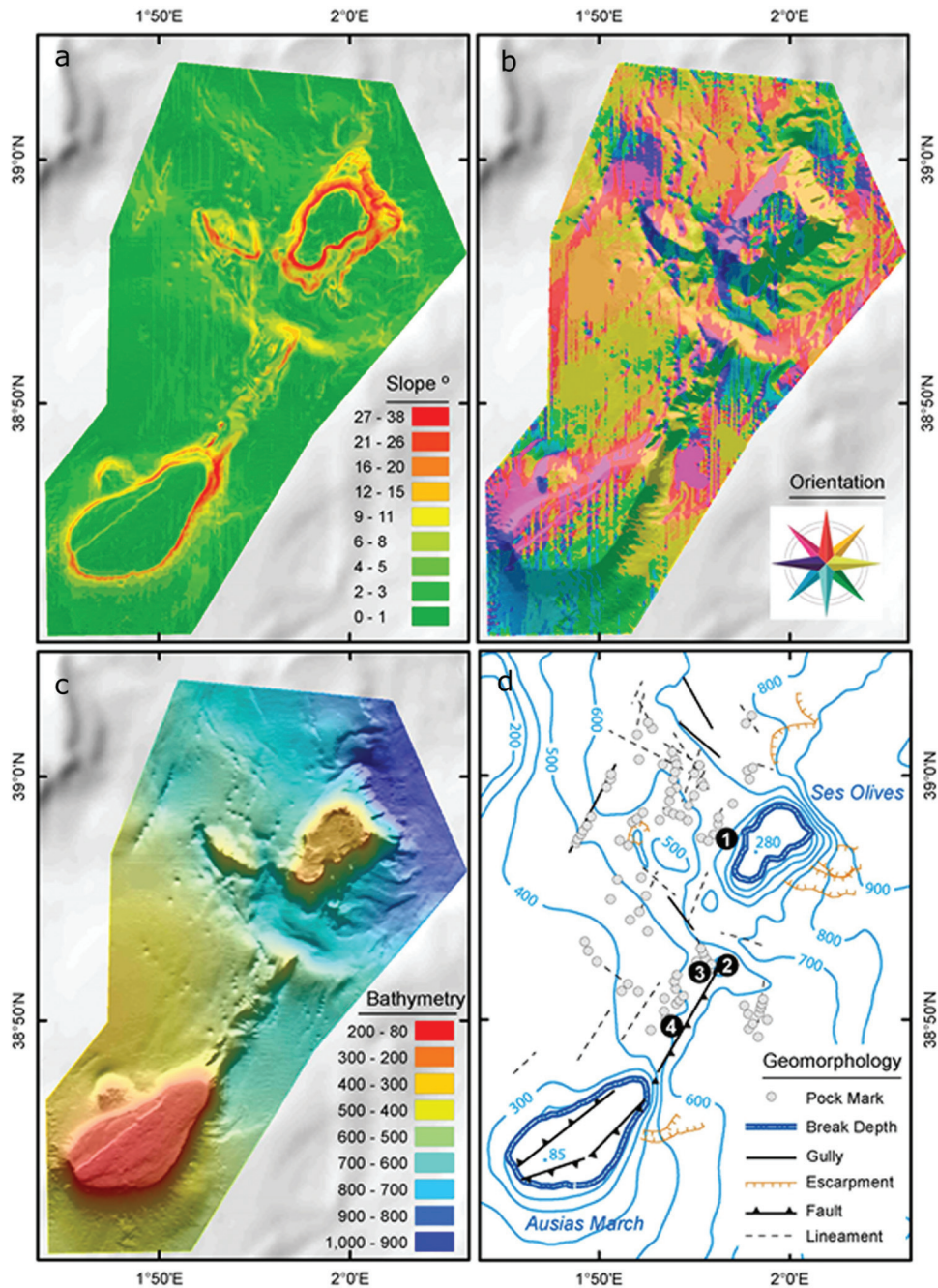


Figure 2. DTMs showing the following morphological characteristics of the study area: (a) slope; (b) orientation, where seabed is coloured according to the tilting direction, following the legend schema; (c) shaded relief and depths, following the legend; (d) geomorphological interpretation and location of ROV dives, where numbers indicate the ROV dives performed.

Table I. List of the five ROV dives performed during the three research cruises in the Balearic Sea. Cruise, geographic coordinates and depths range of starting and ending points of the stations are indicated, as well as the area surveyed.

ID dive	Cruise	Starting point	End point	Depth	Area surveyed (ha)
1	BALSEA 2014 (untrawled area)	38°57.2417'N, 001°56.5428'E	38°57.3816'N, 001°56.3352'E	611–616	0.20–0.24
2	BALSEA 2010 (untrawled area)	38°51.9347'N, 001°55.5567'E	38°51.7911'N, 001°54.9629'E	526–542	0.21–0.25
3	BALSEA 2010 (untrawled area)	38°51.8969'N, 001°56.0495'E	38°52.5085'N, 001°56.4879'E	485–518	0.16–0.18
4	BALSEA 2014 (untrawled area)	38°49.5847'N, 001°53.9466'E	38°49.7341'N, 001°54.1648°E	541–559	0.15–0.17
5	BALBAU 2013 (trawled area)	38°32.5604'N, 001°33.1547'E	38°32.5280'N, 001°32.8893'E	473–552	0.11–0.13

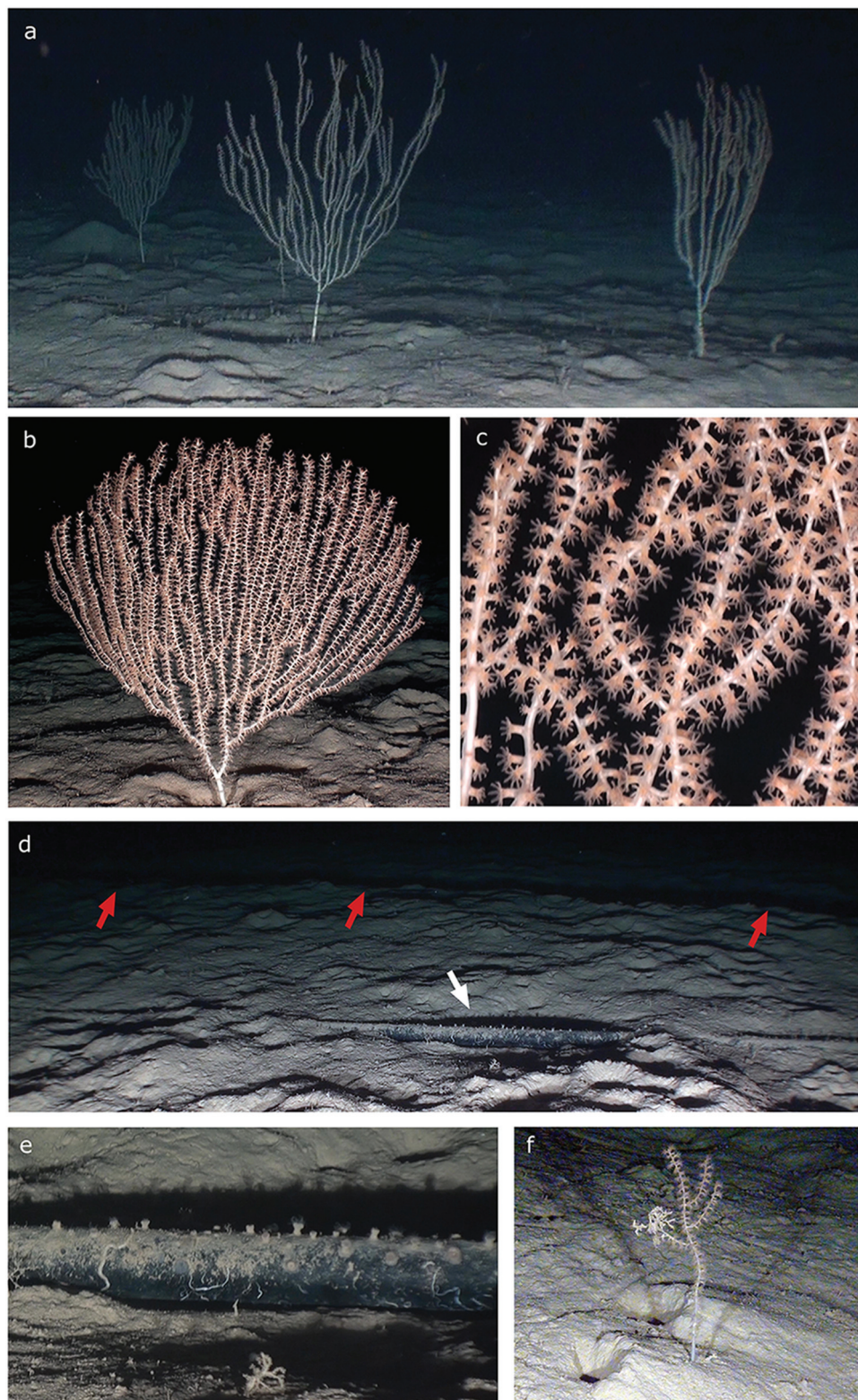


Figure 3. Facies of *Isidella elongata* (a) in the Mallorca Channel, with (b) detail of a branched colony and (c) living polyps. (d) Submarine cable present in the area (downward arrow) and trawl mark close to it (upward arrows), (e) with detail of the cable colonised by Caryophylliidae corals. (f) *I. elongata* colony in the trawled area of the Formentera canyon.

Table II. Total dive time, area covered and density of *Isidella elongata* colonies in the two areas investigated: the untrawled area of the canyon between Ausias March and Ses Olives seamounts, and the trawled area of the canyon south-west of Formentera.

Area	Dive time	Area surveyed (ha)	Density (colonies/ha)
Untrawled area	06h 08 m	0.72–0.84	2300–2683
Trawled area	01h 15 m	0.11–0.13	53–62

conditions, large and tall (up to 40 cm), with the typical candelabrum-shaped morphology, numerous branches and open polyps (Figure 3(b)). The alternation of white carbonatic internodes and brown organic nodes was evident along the ramifications (Carpine & Grasshoff 1973). The high number of living polyps confirmed the healthy condition of the colonies (Figure 3(c)). Although fishing activity is forbidden, some trawl marks and longlines were observed, together with some plastic litter (Figure 4). One of the submarine cables present in the area, colonised by some Caryophylliidae corals, was observed (Figure 3(d) and (e)). Close to the cable, a trawl mark was present too (Figure 3(d)).

Isidella elongata colonies also occurred in the canyon southwest of Formentera (trawled area), with a density of about 53–62 colonies per hectare (Table II). In this area the colonies were mostly small (up to 15–20 cm), and young or damaged, with a low number of branches (Figure 3(f)).

Considering the associate community, a total of 50 taxa (one Foraminifera, three Porifera, seven Cnidaria, one Sipuncula, two Mollusca, two Annelida, 14 Crustacea, two Bryozoa, four Echinodermata and 15 Pisces) were observed living on the *I. elongata* colonies as epibionts, near the colonies or around them in the untrawled area of the Mallorca Channel, while only 19 taxa (one Foraminifera, three Porifera, five Cnidaria, one Mollusca, three Crustacea, one Echinodermata and five Pisces) were observed in the trawled area, 16 of them in common with the untrawled area (Table III).

Foraminifera

Arborescent colonial Foraminifera, which seems to belong to the genus *Pelosina* (courtesy D. Violante), was found in both areas (untrawled and trawled) (Figure 5(a)). Although we were not able to collect a sample, it was tentatively identified as *Pelosina arborescens* Pearcey, 1914, considering that this species is widespread along the North-East Atlantic coasts on soft muddy bottoms in both shallow and deep water (Cedhagen 1993; Alve 2009).

Porifera

Several colonies of the bathyal Demospongiae *Thenea muricata* (Bowerbank, 1858) (Figure 5(d) and (e)), a peculiar mushroom-shaped sponge considered one of the characteristic species of the Mediterranean bathyal mud (*sensu* Pérès & Picard 1964), were observed around *Isidella* colonies in both trawled and untrawled areas. This sponge is often stalked or rooted, as it lives on muddy bottoms in deep water (Pérès 1967) in which it can make a facies of the bathyal sandy muds (Laubier & Emig 1993). The carnivorous sponge *Cladorhiza abyssicola* Sars, 1872 (courtesy C. Longo; see Figure 5(b) and (c)) was also recorded in both areas, with several colonies in the IF of the pockmarks' field (untrawled area). Moreover, an unidentified massive whitish Demospongiae was also observed (Figure 5(f)).

Cnidaria

Seven taxa (six species and one family) of cnidarians were observed, apart from *I. elongata*. The epibiont actinia *Amphianthus dohrni* (Koch, 1878) colonised the branches of some colonies of *I. elongata* in both areas (Figure 5(g) and (h)). Sometimes this actinia could be so abundant as to partially or totally cover the branches of the gorgonian to the point of choking it. In both areas, muddy-bottom species were also observed such as the Ceriantharia *Pachycerianthus dohrni* (Van Beneden, 1923) (Figure 5(i)) and the sea pen *Funiculina quadrangularis* (Pallas, 1766) (Figure 5(m)), while the sea pens *Protoptilum carpenteri* Kölliker, 1872 and *Pennatulula phosphorea* Linnaeus, 1758 were observed in the untrawled and trawled areas, respectively (Figure 5(l) and (n)). Moreover, as already reported by Mastrototaro et al. (2016), several colonies of the hydroid *Rosalinda incrustans* (Kramp, 1947) were observed as epibionts on the carapace's dorsal spines of the decapod *Anamathia rissoana* (Roux, 1828) (Figure 5(j) and (k)). Some Caryophylliidae corals colonised the submarine cable present in the area (Figure 3(e)). Finally, several coronate jellyfish *Solmissus albescens* (Gegenbaur, 1856) (courtesy F. Boero) were spotted floating within the two areas (Figure 5(o) and (p)).

Sipuncula

One peanut worm was observed at the base of a colony of *I. elongata* in the untrawled area (Figure 6(a)). Considering its size of about 30–40 mm, the specimen seems to belong to the *Sipunculus* genus, a widespread peanut worm genus of the bathyal seabed (Southern 1913; Cutler 1977).

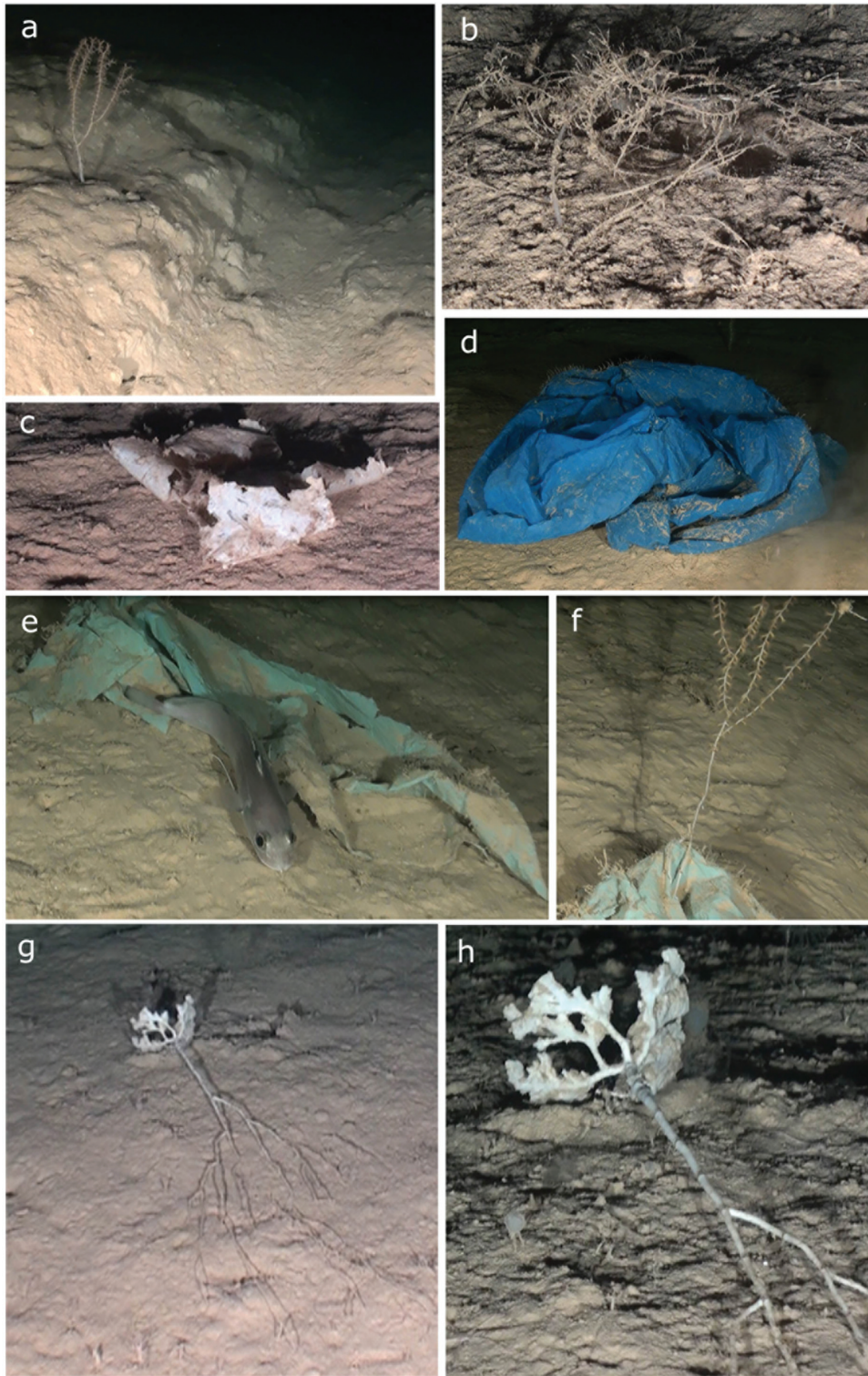


Figure 4. Impacts on the *Isidella elongata facies*. (a) Small colony with trawl mark; (b) longline; (c,d) plastic; (e) *Phycis bleunoides* taking refuge near plastic litter; (f) plastic at the base of *Isidella elongata*; (g) felled colony with (h) detail of the base.

Mollusca

Two species of cephalopods, *Octopus salutii* (courtesy G. Bello) Vérany, 1836 and *Loligo vulgaris* Lamarck,

1798, were observed in the untrawled area (Figure 6(c) and (d)). The first species was documented using the bioturbated seabed and the base of the felled colonies

Table III. List of taxa observed in the untrawled area between Ausias March and Ses Olives seamounts, and in the trawled area of the canyon south-west of Formentera.

Taxa	Untrawled area	Trawled area	Taxa	Untrawled area	Trawled area
Foraminifera			<i>Nephrops norvegicus</i>	•	
<i>Pelosina</i> sp.	•	•	<i>Palinurus mauritanicus</i>	•	
Porifera			Pasiphaeidae	•	•
<i>Cladorhiza abyssicola</i>	•	•	<i>Plesionika gigliolii</i>	•	
Demospongiae	•	•	<i>Plesionika heterocarpus</i>	•	
<i>Thenea muricata</i>	•	•	<i>Plesionika martia</i>	•	
Cnidaria			Bryozoa		
<i>Amphianthus dohrnii</i>	•	•	Bryozoa	•	
Caryophylliidae	•		<i>Kinetoskias</i> cf. <i>cyathus</i>	•	
<i>Funiculina quadrangularis</i>	•	•	Echinodermata		
<i>Pachycerianthus dohrnii</i>	•	•	<i>Antedon mediterranea</i>	•	•
<i>Penmatula phosphorea</i>	•	•	Holothuroidea	•	
<i>Protoptilum carpenteri</i>	•		<i>Ophiura ophiura</i>	•	
<i>Rosalinda incrustans</i>	•		<i>Penilpidia</i> cf. <i>ludwigi</i>	•	
<i>Solmissus albescens</i>	•	•	Pisces		
Sipuncula			Argentinidae	•	
cf. <i>Sipunculus</i> sp.	•		<i>Benthocometes robustus</i>	•	
Mollusca			cf. <i>Bentosema glaciale</i>	•	
Facelinidae		•	cf. <i>Ceratoscopelus maderensis</i>		•
<i>Loligo vulgaris</i>	•		<i>Chlorophthalmus agassizii</i>	•	
<i>Octopus salutti</i>	•		<i>Etmopterus spinax</i>	•	
Annelida			<i>Gadiculus argenteus</i>	•	
<i>Filogranula</i> sp.	•		<i>Galeus melastomus</i>	•	
Serpulidae	•		<i>Helicolenus dactylopterus</i>	•	•
Crustacea			<i>Hoplostethus mediterraneus mediterraneus</i>	•	
Ampeliscidae	•				
<i>Anamathia rissoana</i>	•		<i>Lepidorhombus boscii</i>	•	•
Copepoda	•		<i>Merluccius merluccius</i>	•	
Euphasiacea	•		<i>Micromesistius poutassou</i>	•	
<i>Geryon longipes</i>	•		<i>Phycis blennoides</i>	•	•
<i>Macropipus tuberculatus</i>	•		<i>Stomias boa boa</i>	•	•
<i>Munida</i> sp.	•	•	<i>Synchiropus phaeton</i>	•	
Mysida	•	•			

as a refuge, while *L. vulgaris* was recorded swimming among the colonies. In contrast, one nudibranch belonging to the Facelinidae family was observed moving on the muddy seabed of the Formentera canyon (trawled area; Figure 6(b)). This species showed a *Facelina* genus' morphology and in particular it is likely to be *Facelina bostoniensis* (Couthouy, 1838) (courtesy M. Doneddu and E. Trainito) even though this species is usually observed in shallower waters (Lipej et al. 2008).

Annelida

Sessile polychaetes were observed in the untrawled area, but their specific identification was not possible with visual surveys alone. In particular, several specimens of *Filogranula* sp. (courtesy R. Sanfilippo) were observed on *I. elongata* branches (Figure 7(g)) and small Serpulidae in the central part of some colonies of the bryozoan *Kinetoskias* sp. colonies (Figure 7(a) and (b)).

Crustacea

Nine Decapoda species were identified in the untrawled area: the crabs *Macropipus tuberculatus* (Roux, 1830), *Geryon longipes* A. Milne-Edwards, 1882 and *A. rissoana*, the lobsters *Nephrops norvegicus* (Linnaeus, 1758) and *Palinurus mauritanicus* Gravel, 1911, the prawns *Plesionika gigliolii* (Senna, 1902), *Plesionika martia* (A. Milne-Edwards, 1883) and *Plesionika heterocarpus* (A. Costa, 1871), and the anomuran *Munida* sp. The Pandalidae of the genus *Plesionika* (Figure 6(i), (o) and (r)) and the long-clawed squat lobster *Munida* sp. (Figure 6(p)) were mainly observed recovering in proximity of the small holes in the bioturbated muddy seabed as well as near the root-shaped bases of felled *I. elongata*. Occasionally, *G. longipes*, *M. tuberculatus* and the lobster *P. mauritanicus* were also observed in proximity to seabed small holes and felled *Isidella* colonies (Figure 6(e-g)). The digger Norway lobster *N. norvegicus* (Figure 6(h)) was common along the whole IF, as confirmed by the high number of its

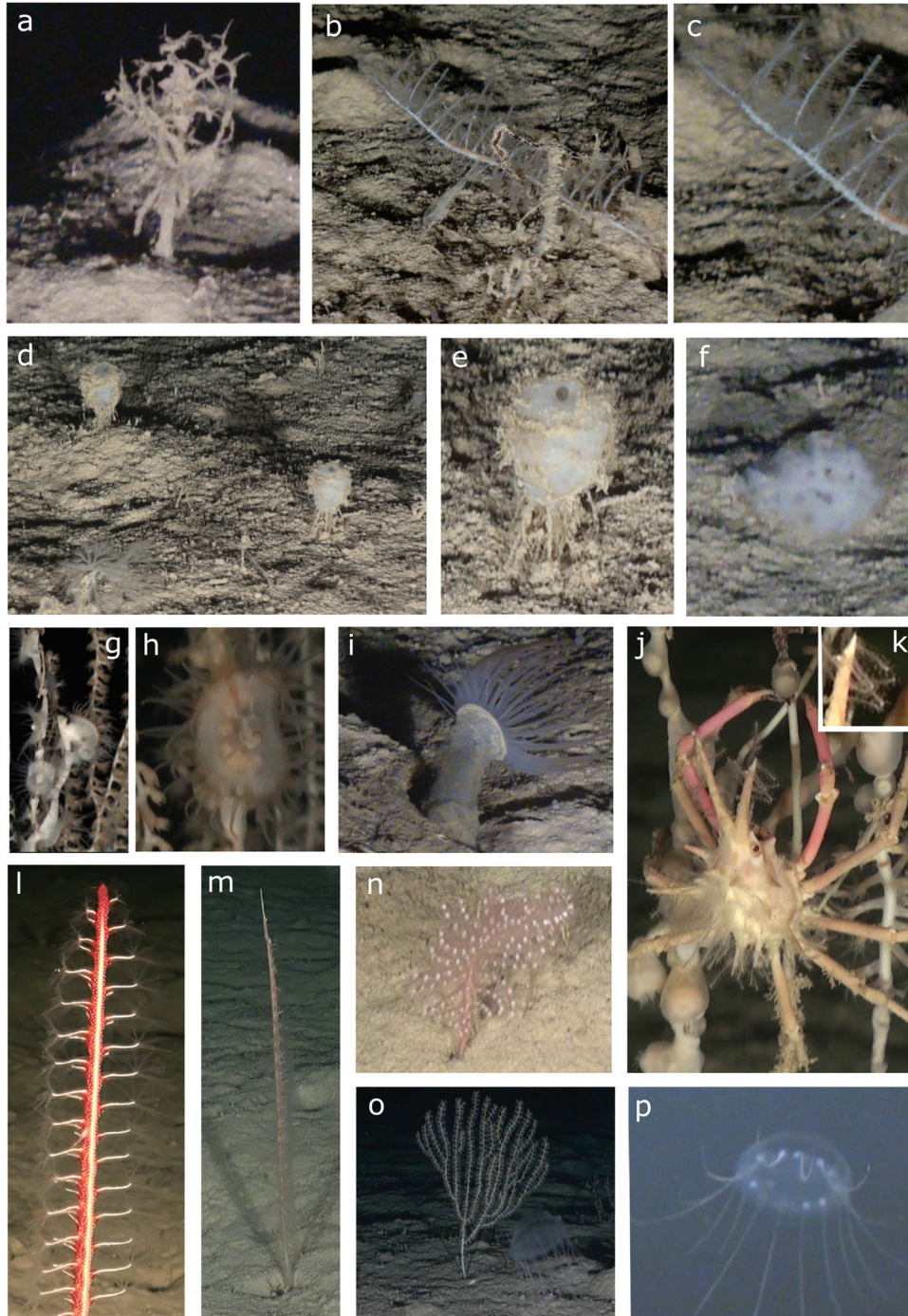


Figure 5. Foraminifera, sponges and cnidarians observed. In particular, (a) the dubious Foraminifera *Pelosina* sp.; (b) the sponges *Cladorhiza abyssicola* with (c) particulars of the branch, (d) *Thenea muricata* with (e) detail of the colony and (f) an unidentified Demospongiae; (g) the actinia *Amphianthus dohrnii* on *Isidella elongata* with (h) detail of the polyp; (i) the Ceriantharia *Pachycerianthus dohrni*; (j) the hydroid *Rosalinda incrustans* on the carapace of *Anamathia rissoana*, with (k) detail of the crab's spine with the epibiont; (l) the sea pens *Protoptilum carpenteri*, (m) *Funiculina quadrangularis* and (n) *Pennatulula phosphorea*; (o) the jellyfish *Solmissus albescens* floating within the *Isidella elongata facies* with (p) the detail of the species.

characteristic burrows. The particular trophic behaviour of the crab *A. rissoana*, climbing on the *I. elongata* colonies to catch its small preys, was also observed (Figure 6(j–n)).

Specimens of Pasiphaeidae (Figure 6(q)), probably *Pasiphaea sivado* (Risso, 1816), were observed swimming around *I. elongata* colonies together with many other small crustaceans. Moreover, a great

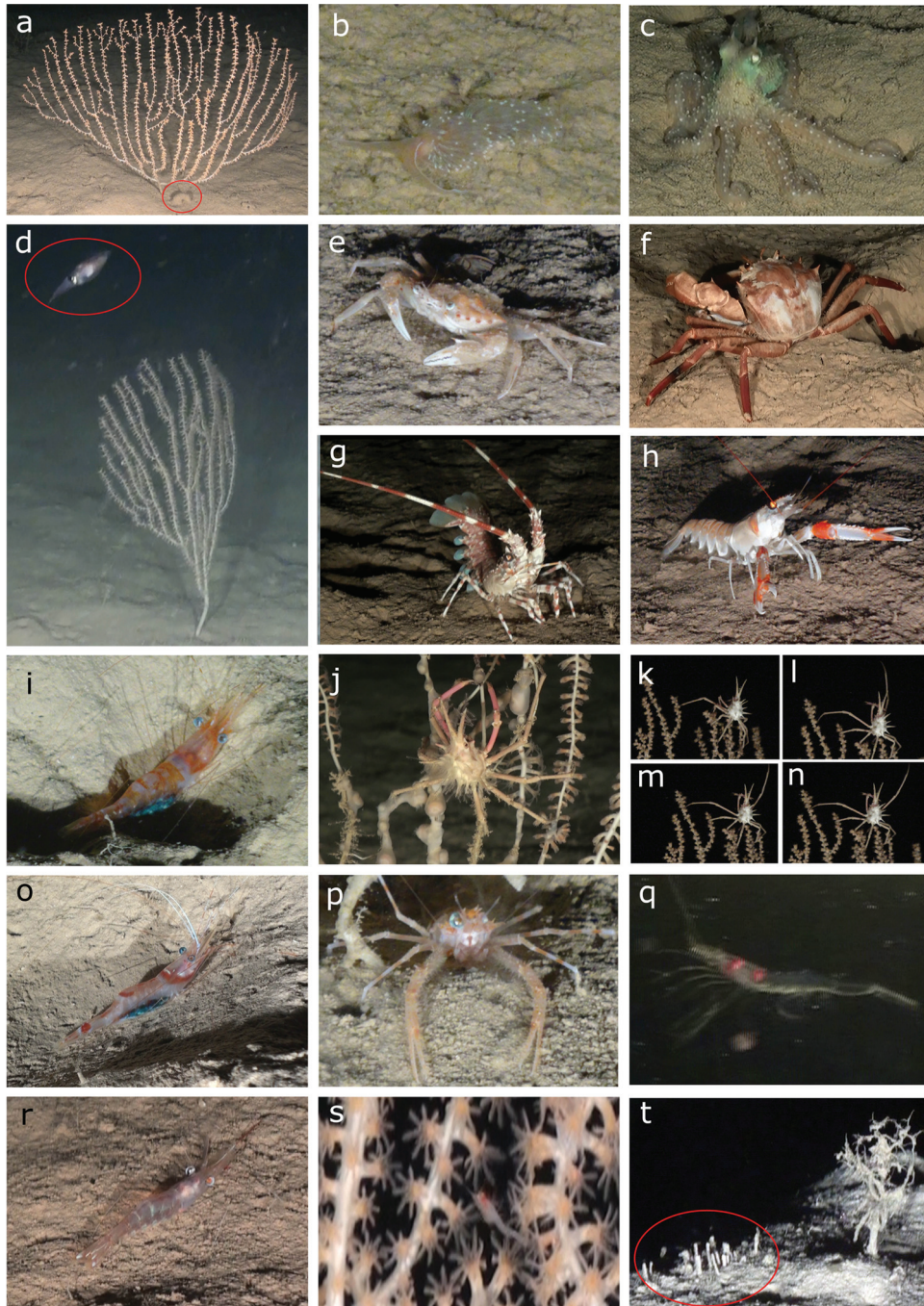


Figure 6. Sipuncula, molluscs and crustaceans observed. In particular, (a) the dubious Sipuncula; (b) the nudibranch belonging to Facelinidae family, cf. *Facelina bostoniensis*; (c) the cephalopods *Octopus salutii* and (d) *Loligo vulgaris*; (e) the crustaceans *Macropipus tuberculatus*, (f) *Geryon longipes*, (g) *Palinurus mauritanicus*, (h) *Nephrops norvegicus*, (i) *Plesionika martia*, (j) *Anamathia rissoana* with (k–n) predation sequences, (o) *Plesionika giglioli*, (p) *Munida* sp., (q) Pasiphaeidae, (r) *Plesionika heterocarpus*, (s) Mysida swimming around *Isidella elongata* branches, and (t) Ampeliscidae tubes close to *Pelosina* sp.

number of small crustaceans were observed around the *Isidella* colonies, but due to their small size and their frenetic activity, specific identification was possible only to the orders Mysida (Figure 6(s)) and Euphausiacea, and subclass Copepoda. Several

Ampeliscidae tubes were observed on the muddy seabed (Figure 6(t)).

No crustaceans were observed in the trawled area, except for one specimen of *Munida* sp. and some swimming Mysida and Pasiphaeidae.

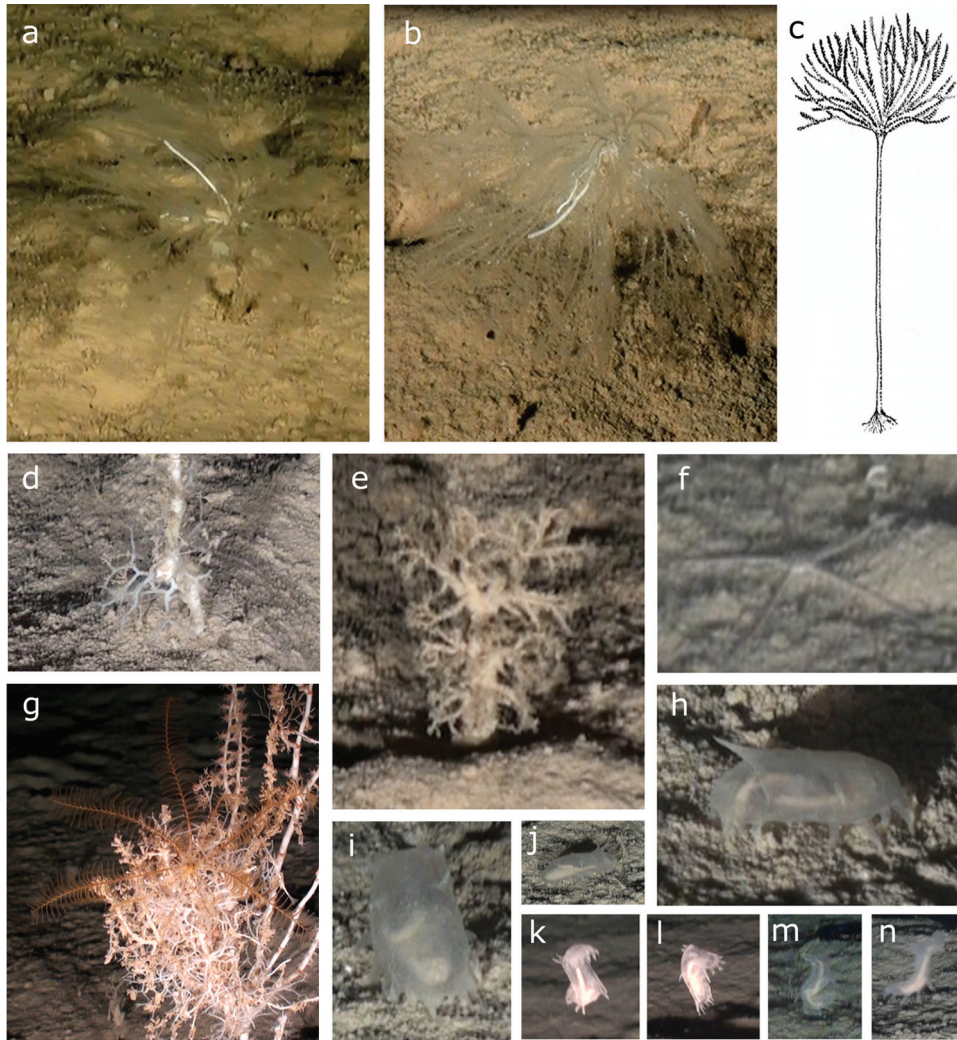


Figure 7. Bryozoans, polychaetes and echinoderms observed. In particular, (a,b) *Kinetoskias* sp. with Serpulidae in the central part of the colony with (c) scheme of the genus *Kinetoskias*, (d) unidentified branched bryozoan at the base of a *Isidella elongata* colony, (e) undetermined holothurian tentacles, (f) Ophiuridae species, probably *Ophiura ophiura*, (g) *Antedon mediterranea* with *Filogranula* sp., (h–j) *Penilpidia ludwigi* with (k–n) swimming sequences.

Bryozoa

Several colonies of the arborescent Bryozoa *Kinetoskias* sp. (Wyville Thomson, 1873) (courtesy A. Rosso) were spotted within the untrawled area (Figure 7(a–c)). Moreover, an unidentified branched bryozoan was also observed settled on an *I. elongata* stem (Figure 7(d)).

Echinodermata

Four echinoderms were observed within the untrawled area: the crinoid *Antedon mediterranea* (Lamarck, 1816); a small Ophiurida, likely to be *Ophiura ophiura* (Linnaeus, 1758) (Figure 7(f)); an Elaspodida species, tentatively identified as

Penilpidia ludwigi (von Marenzeller, 1893) (courtesy A. Gebruk); and another undetermined holothurian species only detected by the observation of its tentacles arising from the mud (Figure 7(e)). In particular, *A. mediterranea* used *Isidella* branches to arise from the muddy bottom (Figure 7(g)), while several specimens of *P. ludwigi* were observed moving on the muddy bottom and sometimes swimming with a characteristic “S” movement (Figure 7(h–n)). In some of these specimens, the two anteriormost pairs of dorsal papillae forming a small velum (lobe) were particularly evident (Figure 7(h–n)). On the contrary, only one specimen of *A. mediterranea* was observed in the trawled area south-west of Formentera.

Pisces

A total of 15 fishes were observed in the untrawled area: two Chondrichthyes and 13 Osteichthyes.

The two Chondrichthyes, the Carcharhiniformes *Galeus melastomus* Rafinesque, 1810 and the Squaliformes *Etmopterus spinax* (Linnaeus, 1758), were observed swimming within the IF (Figure 8(a) and (c)). Some *G. melastomus* eggs anchored to the branches of *I. elongata* were also recorded (Figure 8(b)).

Considering the Osteichthyes, the Aulopiformes *Chlorophthalmus agassizi* Bonaparte, 1840, the Beryciformes *Hoplostethus mediterraneus mediterraneus* Cuvier, 1829, the Gadiformes *Gadiculus argenteus* Guichenot, 1850, *Merluccius merluccius* (Linnaeus, 1758), *Micromesistius poutassou* (Risso, 1827) and *Phycis blennoides* (Brünnich, 1768), the Ophidiiformes *Benthocometes robustus* (Goode & Bean, 1886), the Perciformes *Synchiropus phaeton* (Günther, 1861), the Pleuronectiformes *Lepidorhombus boscii* (Risso, 1810), the Scorpaeniformes *Helicolenus dactylopterus* (Delaroche, 1809), the Stomiiformes *Stomias boa boa* (Risso, 1810) and some undetermined Argentinidae were observed (Figure 8(d–q)). In particular, *C. agassizi* and *H. mediterraneus mediterraneus* were observed in small schools of about 3–4 specimens near the seabed within the IF (Figure 8(e)). Solitary specimens of *P. blennoides*, *S. phaeton*, *L. boscii* and *H. dactylopterus* were also observed standing on the muddy bottom, while *P. blennoides* was mainly present near the base of *I. elongata* and occasionally near some plastic or other marine litter acting as possible refuge (Figure 4(a–h)). On the contrary, *G. argenteus*, *M. merluccius* and *M. poutassou* were seen swimming among the colonies of *I. elongata*. The observation of the behaviour of *B. robustus* and *S. boa boa* was particularly interesting: the former camouflaged itself swimming vertically behind the branches of *Isidella* (Figure 8(p) and (q)), and the latter stood vertically in the water column (Figure 8(o)). Only four of these species were also observed in the trawled area (Table III).

Dense groups of Myctophidae were also recorded, likely to be *Benthosema glaciale* (Reinhardt, 1837) and *Ceratoscopelus maderensis* (Lowe, 1839) in the untrawled and trawled areas, respectively, even if their specific identification is uncertain.

Discussion

The seabed morphology of the study area is the result of a geological setting where tectonics controls an important fluid seepage, as can be deduced by the presence of numerous pockmark lineations. Both seamounts seem to be affected by a NE–SW-

oriented fault system, and a NW–SE gully system (Figure 2). With the exception of the seamount flanks, slope values are low (Figure 2), as is the sediment input (Zúñiga et al. 2007).

The deep-sea environment of this particular area of the Mediterranean Sea has been explored, for the first time, using an ROV. The most relevant outcome is the discovery of a huge IF located on the muddy seabed between the Ausias March and Ses Olives seamounts. The seabed between the two seamounts proved to be the preferential location for *I. elongata* (Figure 1). This facies was characterised by an extraordinarily high density of colonies, representing one of the last and most well-developed IF in the Mediterranean Sea and the largest one known so far in this basin, considering its extension and density of colonies (Bo et al. 2015).

Studies on bamboo coral densities are scarce. Buhl-Mortensen and Buhl-Mortensen (2014) estimated up to 16,700 colonies per hectare for a congeneric species, *Isidella lofotensis*, in specific places of Hardangerfjord in the North-East Atlantic. Farther north, the estimations are even higher, to around 57,000 colonies per hectare in the upper continental slope of East Greenland (Mayer & Piepenburg 1996). Dense bamboo coral forests on muddy bottoms have also been reported for other species of Isididae, such as *Keratoisis* sp. in Baffin Bay (NW Atlantic; Neves et al. 2015).

The high densities that *I. lofotensis* and other bamboo corals can reach in some areas of the Atlantic are very far from those of the Mediterranean facies, this latter being considerably lower in comparison. Cartes et al. (2013) described a dense coral forest of *I. elongata* at 620 m depth along the Catalonian coasts, some 110 nautical miles away from the one described here, with a highest density of 225 colonies per hectare. This value is about 10 times lower than the average density found in the pockmarked field described here (untrawled area).

Recently, a well-conserved IF has also been found in surprisingly “shallow” waters, at about 200–210 m in depth, in south-west Sardinia (Italy, Western Mediterranean) (Bo et al. 2015), with an average density of 5000 colonies/ha. The colonies were healthy and with an average size of 36 cm tall and 22 cm wide, highly branched, very similar to the ones observed in the Balearic pockmarked field, even if it seems to occur in a smaller area and the colonies’ density was about 2 times higher than the one here reported.

Visual surveys allowed us to deepen the ecological role of *I. elongata* from different points of view, considering that *Isidella* gardens are more complex and heterogeneous compared to the flat monotonous

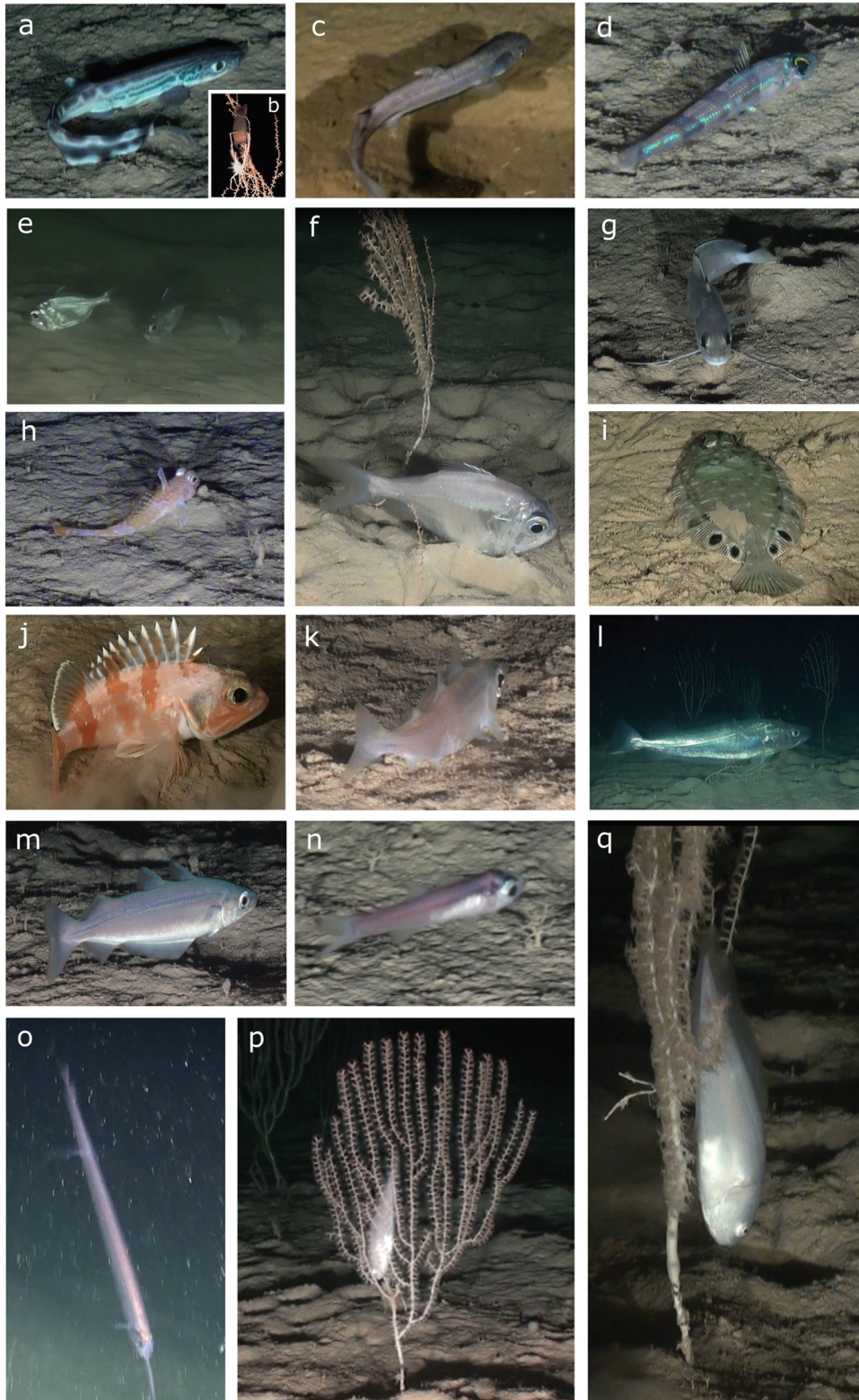


Figure 8. Fishes. (a) *Galeus melastomus* and (b) its egg, (c) *Etmopterus spinax*, (d) *Chlorophthalmus agassizi*, (e) schools of *Hoplostethus mediterraneus mediterraneus* with (f) detail of one specimen, (g) *Phycis blennoides*, (h) *Synchiropus phaeton*, (i) *Lepidorhombus boscii*, (j) *Helicolenus dactylopterus*, (k) *Gadiculus argenteus*, (l) *Merluccius merluccius*, (m) *Micromesistius poutassou*, (n) Argentinidae, (o) *Stomias boa boa*, (p) and (q) *Benthocometes robustus*.

muddy bottoms on which they are settled. In fact, the arborescent morphology of *I. elongata* and its tendency to form dense facies makes this alcyonacean a true habitat-forming species.

On the contrary, the density in the Formentera canyon, where trawling is allowed, was considerably lower (about 38 times lower). This was confirmed by the unhealthy conditions of most of the colonies, their low number of branches, the presence of mainly young colonies and their small size due to mechanical impacts of fishing activities.

As a habitat former (Buhl-Mortensen et al. 2010), *I. elongata* contributes to three-dimensionally structuring the bathyal environment, enhancing its ecological functionality and providing new ecological niches for several species, playing many different roles in the ecology of the bathyal zone. First of all, the branched colonies act as a secondary substratum for the settling of several epibiontic species such as the actinian *A. dohrnii* (Figure 5(g) and (h)) and the polychaetes *Filogramula* sp. (Figure 7(g)). Furthermore, *I. elongata* branches are also used as support to lay eggs by small oviparous sharks such as *G. melastomus* (Figure 8(a) and (b)), representing a spawning and nursery area for such species. Other species, such as the squid *Loligo forbesi*, have also been seen using *I. elongata* for spawning (Orsi-Relini et al. 2009). Bamboo coral forests also act as trophic areas where many species find preys swimming among the colonies or climbing on them. This is the case for the predators observed swimming within the facies such as the sharks *G. melastomus* and *E. spinax* and the teleost fishes such as *M. merluccius*, *M. poutassou*, *P. blennoides* and *L. boschii*. IF also represents a trophic area for the opportunistic species which use *I. elongata* as a feeding podium, such as the decapod *A. rissoana* that climbs on the colony to capture its preys, or the crinoid *A. mediterranea* that arises from the muddy bottom. *Anamathia rissoana*, often associated to *I. elongata* (Dieuzeide 1960; Cartes et al. 2013), has recently been recorded on the black coral *L. glaberrima* (Bo et al. 2015). Despite the hydroid *R. incrustans* being considered a typical epibiont on the carapace of *A. rissoana* (Vervoort 1966), it was recently reported as a missed species in the Mediterranean Sea (Gravili et al. 2015). Therefore, its occurrence here is the first documented finding of the species since 1958 (Bouillon et al. 1995; Mastrototaro et al. 2016).

Moreover, IF represents an important recovery area for many fish and invertebrate species that use the gorgonian to camouflage or protect themselves. An interesting example is provided by the ray-finned fish *B. robustus* that camouflages itself among the branches of *Isidella* swimming vertically (Figure 8

(p) and (q)). This particular behaviour was also observed by Fabri et al. (2014) in the Bourcart and Cassidaigne canyons in the Gulf of Lion, but in that case *B. robustus* took refuge close to another alcyonacean species, *Callogorgia verticillata*, or near anthipatharians such as *Leiopathes glaberrima* and *Antipathes cf. dichotoma*. *Benthocometes robustus* was reported by Bo et al. (2015) to be characteristic of *L. glaberrima* gardens, while in the North-East Atlantic this fish was observed associated with deep-sea scleractinian corals, anthipatharians and gorgonians (Fabri et al. 2014). The present finding is the first that shows *B. robustus* associated with *I. elongata*, suggesting a non-specific association of this fish to a single anthozoan species.

Stomias boa boa was also observed swimming vertically, with its chin barbel downward, probably waiting for preys (Figure 8(o)). The presence of this bathypelagic species within the IF could be accidental/coincidental, or could be related to the presence of the facies that enhances the chances for this species to catch food.

Other interesting findings not strictly related to the presence of the IF, but more likely related to the protection of the seabed, are those of the sea pen *P. carpenteri*. This species has recently been reported for the Mediterranean Sea by Mastrototaro et al. (2015) in the Ionian Sea, close to another area protected from trawling and characterised by cold-water coral reefs, Santa Maria di Leuca coral province (Italy, Ionian Sea). The occurrence of the Foraminifera *Pelosina* sp. represents the first finding of this genus in the Mediterranean Sea. It proved very common in both areas surveyed and probably it passed undetected until now only due to its small size.

Peniplidia ludwigi represents the only Elapsipoda species found so far in the Mediterranean Sea (Fiege & Liao 1996; Mecho et al. 2014). The present observations clarify its swimming behaviour (Figure 7(h–n)), suggested by Pagès et al. (2007) but never documented before (Gebruk et al. 2013). The finding of the arborescent bryozoan *Kinetoskias* sp. also represents one of the rare occurrences of this genus in the Mediterranean Sea, considering that this genus was first reported in 1993 by Harmelin and d'Hondt (1993) close to the Gibraltar Strait. In particular, these authors reported *K. smitti* Danielssen, 1868 in the Alboran Sea; thus, the specimens here observed could belong to this species (Aguilar et al. 2013).

The felled colonies and especially the root-shaped bases of *I. elongata* act as a refuge for many reptant species such as the crustacean decapods belonging to the genera *Munida* and *Plesionika*, the lobsters *N. norvegicus* and *P. mauritanicus* and also some cephalopods such as *O. salutii*.

The small crustaceans swimming around the colonies probably belonged to Euphasiacea and Copepoda species. These crustaceans are likely to provide food for many of the species associated to the facies, and for *I. elongata* itself.

The red shrimps *A. antennatus* and *A. foliacea*, often considered characteristic of the *I. elongata* facies (Nouar & Maurin 2001; Maynou & Cartes 2012), were not observed. However, since these Aristeidae species have been observed down to 3000 m deep off the Balearic Islands (Sardà et al. 2004; Cartes et al. 2009), it is possible that they live in deeper waters than the bathymetry explored by the present study in the Balearic Sea.

Considering the number of taxa observed, a preliminary qualitative comparison showed relevant differences between the untrawled and trawled areas. Despite many of the sessile species being still present in both the areas (e.g. sponges and cnidarians), the number of taxa observed in the IF (50 taxa) is considerably higher than in the trawled area (19 taxa). This difference in species number could likely be partially influenced by the different sampling effort; however, it can also be explained with the contraction of the habitat (reduction of *I. elongata* density) and the fishing impact itself occurring in the trawled area.

Despite the occurrence of some traces of illegal fishing (Figure 4(a) and (b)), the presence of a large IF suggests a certain stability of the environment and low human impact affecting it, since *I. elongata* is characterised by slow growth rates (Andrews et al. 2009) and a long life span (up to 400 years for the Isididae family) (Sherwood & Edinger 2009). Its actual persistence in the Mallorca Channel, not due to any protection strategy – notwithstanding the unquestioned worth of protection (FAO 2009, 2011; Aguilier & Marín 2013) – urges reflections about the role of its destruction and paradoxical protection by some anthropic impacts such as submarine cables.

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References

- Acosta J, Canals M, Carbó A, Muñoz A, Urgeles R, Muñoz-Martín A, Uchupi E. 2004. Sea floor morphology and Plio-Quaternary sedimentary cover of the Mallorca Channel, Balearic Islands, western Mediterranean. *Marine Geology* 206:165–179. DOI: [10.1016/j.margeo.2004.02.008](https://doi.org/10.1016/j.margeo.2004.02.008).
- Acosta J, Muñoz A, Herranz P, Palomo C, Ballesteros M, Vaquero M, Uchupi E. 2001b. Pockmarks in the Ibiza Channel and western end of the Balearic Promontory (western Mediterranean) revealed by multibeam mapping. *Geo-Marine Letters* 21:123–130. DOI: [10.1007/s003670100074](https://doi.org/10.1007/s003670100074).
- Acosta J, Muñoz A, Herranz P, Palomo C, Ballesteros M, Vaquero M, Uchupi E. 2001a. Geodynamics of the Emile Baudot escarpment and the Balearic Promontory, western Mediterranean. *Marine and Petroleum Geology* 18:349–369. DOI: [10.1016/S0264-8172\(01\)00003-4](https://doi.org/10.1016/S0264-8172(01)00003-4).
- Aguilar R, Pastor X, Garcia S, Marín P, Ubero J. 2013. Importance of seamounts-like features for Mediterranean marine habitats and threatened species. *Rapport Commission International Mer Méditerranée* 40:716.
- Aguilar R, Marín P. 2013. Mediterranean deep-sea corals: Reasons for protection under the Barcelona Convention. *Oceana*. Available: http://oceana.org/sites/default/files/euo/OCEANA_Brief_Deep-sea_Corals.pdf. Accessed Nov 2016 28.
- Alve E. 2009. A bisected *Pelosina* rejoined! *Journal of Micropalaeontology* 28:183–184. DOI: [10.1144/jm.28.2.183](https://doi.org/10.1144/jm.28.2.183).
- Andrews AH, Stone RP, Lundstrom CC, De Vogelaere AP. 2009. Growth rate and age determination of bamboo corals from the northeastern Pacific Ocean using refined ²¹⁰Pb dating. *Marine Ecology Progress Series* 397:173–185. DOI: [10.3354/meps08193](https://doi.org/10.3354/meps08193).
- Bellan-Santini D. 1985. The Mediterranean benthos: Reflections and problems raised by a classification of the benthic assemblages. In: Moraitou-Apostolopoulou M, Kiortsis V, editors. *Mediterranean marine ecosystems*. New York: Plenum Press. pp. 19–48.
- Bo M, Bavestrello G, Angiolillo M, Calcagnile L, Canese S, Cannas R, Cau A, D’Elia M, D’Orlando F, Follesa MC, Quarta G, Cau A. 2015. Persistence of pristine deep-sea coral gardens in the Mediterranean Sea (SW Sardinia). *PLoS One* 10:e0119393. DOI: [10.1371/journal.pone.0119393](https://doi.org/10.1371/journal.pone.0119393).
- Bouillon J, Massin C, Krševic R. 1995. Hydroïdomédusae de l’Institut royal des Sciences naturelles de Belgique. In: Van Ghoethem J, editor. *Bulletin de l’Institut Royal des Sciences Naturelles de Belgique*. Vol. 78. Brussels: Koninklijk Belgisch Instituut voor Natuurwetenschappen. pp. 1–106.
- Buhl-Mortensen L, Vanreusel A, Gooday AJ, Levin LA, Priede IG, Buhl-Mortensen P, Gheerardyn H, King NJ, Raes M. 2010. Biological structures as a source of habitat heterogeneity

- and biodiversity on the deep ocean margins. *Marine Ecology: An Evolutionary Perspective* 31:21–50. DOI: [10.1111/j.1439-0485.2010.00359.x](https://doi.org/10.1111/j.1439-0485.2010.00359.x).
- Buhl-Mortensen P, Buhl-Mortensen L. 2014. Diverse and vulnerable deep-water biotopes in the Hardangerfjord. *Marine Biology Research* 10:253–267. DOI: [10.1080/17451000.2013.810759](https://doi.org/10.1080/17451000.2013.810759).
- Canals M, Serra J, Riba O. 1982. Toponimia de la Mar Catalano-Balear (con un glosario de términos genéricos). *Bolletí de la Societat d'Història Natural de les Balears* 26:169–194.
- Carpine C. 1970. Ecologie de l'étage bathyal dans la Méditerranée occidentale. *Bulletin de l'Institut Océanographique de Monaco* 2:1–146.
- Carpine C, Grasshoff M. 1973. Les gorgonaires de la Méditerranée. *Bulletin de l'Institut Océanographique de Monaco* 71:1–140.
- Cartes JE, Ligas A, De Biasi AM, Pacciardi L, Sartor P. 2009. Small-spatial scale changes in productivity of suprabenthic and infaunal crustaceans at the continental shelf of Ebro Delta (western Mediterranean). *Journal of Experimental Marine Biology and Ecology* 378:40–49. DOI: [10.1016/j.jembe.2009.07.025](https://doi.org/10.1016/j.jembe.2009.07.025).
- Cartes JE, Loiacono C, Mamouridis V, López-Pérez C, Rodríguez P. 2013. Geomorphological, trophic and human influences on the bamboo coral *Isidella elongata* assemblages in the deep Mediterranean: To what extent does *Isidella* form habitat for fish and invertebrates? *Deep-Sea Research Part I: Oceanographic Research Papers* 76:52–65. DOI: [10.1016/j.dsr.2013.01.006](https://doi.org/10.1016/j.dsr.2013.01.006).
- Cedhagen T. 1993. Taxonomy and biology of *Pelosina arborescens* with comparative notes on *Astrorhiza limicola* (Foraminiferida). *Ophelia* 37:143–162. DOI: [10.1080/00785326.1993.10429914](https://doi.org/10.1080/00785326.1993.10429914).
- Cutler EB. 1977. The bathyal and abyssal Sipuncula. *Galathea Report* 14:135–156.
- D'Onghia G, Carlucci R, Maiorano P, Panza M. 2003. Discards from deep-water bottom trawling in the Eastern-Central Mediterranean Sea and effects of mesh size changes. *Journal of Northwest Atlantic Fishery Science* 31:245–261.
- Dieuzeide R. 1960. Le fond chalumne à 600 m par le travers de Castiglione. *Recherches sur la faciès à Isidella elongata* Esper. *Bulletin des travaux de la Station d'aquaculture et de pêche de Castiglione* 2:9–86.
- Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (OJ L 164, 25 June 2008. p. 19).
- Fabri M-C, Pedel L, Beuck L, Galgani F, Hebbel D, Freiwald A. 2014. Megafauna of vulnerable marine ecosystems in French mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. *Deep-Sea Research Part II: Topical Studies in Oceanography* 104:184–207. DOI: [10.1016/j.dsr2.2013.06.016](https://doi.org/10.1016/j.dsr2.2013.06.016).
- FAO (Food and Agriculture Organization). 2009. International guidelines for the management of deep-sea fisheries in the high seas. Rome: FAO. p. 73.
- FAO (Food and Agriculture Organization). 2011. Report of the Workshop on deep-sea species identification, Rome, 2–4 December 2009b. FAO Fisheries and Aquaculture Report. No. 947. Rome: FAO. p. 209.
- Fiege D, Liao Y. 1996. *Penilpidia ludwigi* (Marenzeller, 1893) (Holothuroidea, Elpidiidae) rediscovered from the eastern Mediterranean Sea. In: Uiblein F, Ott J, Stachowitsch M, editors. *Deep-sea and extreme shallow-water habitats: Affinities and adaptations*. Biosystematics and Ecology Series 11. Vienna: Österreichische Akademie der Wissenschaften. pp. 61–66.
- Gebruk A, Rogacheva AV, Pawson DL, Hamel J-F, Macisaac KG, Mercier A. 2013. *Penilpidia* (sic) *desbarresi* sp. nov. (Echinodermata: Holothuroidea: Elaspodida) from the upper slope of Newfoundland and re-description of *P. ludwigi* (von Marenzeller, 1893). *Marine Biology Research* 9:1029–1036. DOI: [10.1080/17451000.2013.793810](https://doi.org/10.1080/17451000.2013.793810).
- GFCM (General Fisheries Commission For The Mediterranean). 2009. Criteria for the identification of sensitive habitats of relevance for the management of priority species. Meeting of the Sub-Committee on Marine Environment and Ecosystems (SCMEE), 30 November–3 December 2009 Malaga, Spain.
- Grasshoff M. 1989. Die Meerenge von Gibraltar als Faunen-Barriere: Die Gorgonaria, Pennatularia und Antipatharia der Balgim-Expedition (Cnidaria: Anthozoa). *Senckenbergiana Maritima* 20:201–223.
- Gravili C, Bevilacqua S, Terlizzi A, Boero F. 2015. Missing species among Mediterranean non-Siphonophoran Hydrozoa. *Biodiversity and Conservation* 24:1329–1357. DOI: [10.1007/s10531-015-0859-y](https://doi.org/10.1007/s10531-015-0859-y).
- Harmelin JG, d'Hondt JL. 1993. Transfers of bryozoan species between the Atlantic Ocean and the Mediterranean Sea via the Strait of Gibraltar. *Oceanologica Acta* 16:63–72.
- IEO (Instituto Español de Oceanografía). 2005. Mar Balear: Mapa topobatimétrico del Mar Balear y Golfo de Valencia /Ministerio de Educación y Ciencia, Instituto Español de Oceanografía. 1:500.000; Proyec. UTM Huso 31N. Madrid: Instituto Español de Oceanografía. ISBN:84-95877-29-5.
- Laubier L, Emig CC. 1993. La faune benthique profonde de Méditerranée. In: Della Croce FR, editor. *Symposium Mediterranean Seas 2000*. S. Margherita Ligure: Istituto di Scienze Ambientali Marine. pp. 397–428.
- Lipej L, Dobrajc Z, Mavrič B, Šamu S, Alajbegović S. 2008. Opisthobranch Mollusks (Mollusca: Gastropoda) from Slovenian coastal waters (Northern Adriatic). *Annales, Series Historia Naturalis* 18:1–14.
- Mastrotoaro F, Aguilar R, Chimienti G, Gravili C, Boero F. 2016. The rediscovery of *Rosalinda incrustans* (Cnidaria: Hydrozoa) in the Mediterranean Sea. *Italian Journal of Zoology* 83:244–247. DOI: [10.1080/11250003.2016.1181800](https://doi.org/10.1080/11250003.2016.1181800).
- Mastrotoaro F, Chimienti G, Capezzuto F, Carlucci R, Williams G. 2015. First record of *Protophilum carpenteri* (Cnidaria: Octocorallia: Pennatulacea) in the Mediterranean Sea. *Italian Journal of Zoology* 82:61–68. DOI: [10.1080/11250003.2014.982218](https://doi.org/10.1080/11250003.2014.982218).
- Mastrotoaro F, Maiorano P, Vertino A, Battista D, Indennidate A, Savini A, Tursi A, D'Onghia G. 2013. A facies of *Kophobelemnon* (Cnidaria, Octocorallia) from Santa Maria di Leuca coral province (Mediterranean Sea). *Marine Ecology* 34:313–320. DOI: [10.1111/maec.12017](https://doi.org/10.1111/maec.12017).
- Mayer M, Piepenburg D. 1996. Epibenthic community patterns on the continental slope off East Greenland at 75°N. *Marine Ecology Progress Series* 143:151–164. DOI: [10.3354/meps143151](https://doi.org/10.3354/meps143151).
- Maynou F, Cartes JE. 2012. Effects of trawling on fish and invertebrates from deep-sea coral facies of *Isidella elongata* in the western Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* 92:1501–1507. DOI: [10.1017/S0025315411001603](https://doi.org/10.1017/S0025315411001603).
- Mecho A, Billett DSM, Ramirez-Llodra E, Aguzzi J, Tyler PA, Company JB. 2014. First records, rediscovery and compilation of deep-sea echinoderms in the middle and lower continental slope of the Mediterranean Sea. *Scientia Marina* 78:281–302. DOI: [10.3989/scimar.03983.30C](https://doi.org/10.3989/scimar.03983.30C).
- Neves BDM, Edinger E, Hillaire-Marcel C, Heestand Saucier E, France SC, Treble MA, Wareham VE. 2015. Deep-water

- bamboo coral forests in a muddy Arctic environment. *Marine Biodiversity* 45:867–871. DOI: [10.1007/s12526-014-0291-7](https://doi.org/10.1007/s12526-014-0291-7).
- Nouar A, Maurin C. 2001. Nature of and typical populations on the characteristic facies of substratum of *Parapenaeus longirostris* (Lucas, 1846) along the Algerian coast. *Crustaceana* 74:129–135. DOI: [10.1163/156854001505398](https://doi.org/10.1163/156854001505398).
- Orsi-Relini L, Mannini A, Lanteri L, Beccornia E. 2009. First record of an egg mass of *Loligo forbesi* (Cephalopoda: Loliginidae) in the Ligurian Sea, with notes about egg laying patterns in southern populations. *Bollettino Malacologico* 45:27–33.
- Pagès F, Martín J, Palanques A, Puig P, Gili J-M. 2007. High occurrence of the elasipodid holothurian *Penipidia ludwigi* (von Marenzeller, 1893) in bathyal sediment traps moored in a western Mediterranean submarine canyon. *Deep-Sea Research Part I: Oceanographic Research Papers* 54:2170–2180. DOI: [10.1016/j.dsr.2007.09.002](https://doi.org/10.1016/j.dsr.2007.09.002).
- Pérès JM. 1967. The Mediterranean benthos. *Oceanography and Marine Biology: An Annual Review* 5:449–533.
- Pérès JM, Picard J. 1964. Nouveau manuel de bionomie benthique de la Méditerranée. *Recueil des Travaux de la Station Marine d'Endoume* 31:1–37.
- Sardà F, Bahamon N, Moli B, Sardà-Palomera F. 2006. The use of a square mesh and sorting grids to reduce catches of young fish and improve sustainability in a multispecies bottom trawl fishery in the Mediterranean. *Scientia Marina* 70:347–353. DOI: [10.3989/scimar.2006.70n3347](https://doi.org/10.3989/scimar.2006.70n3347).
- Sardà F, D'Onghia G, Politou CY, Company JB, Maiorano P, Kapisris K. 2004. Deep-sea distribution, biological and ecological aspects of *Aristeus antennatus* (Risso, 1816) in the western and central Mediterranean Sea. *Scientia Marina* 68:117–127. DOI: [10.3989/scimar.2004.68s3117](https://doi.org/10.3989/scimar.2004.68s3117).
- Sherwood OA, Edinger EN. 2009. Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 66:142–152. DOI: [10.1139/F08-195](https://doi.org/10.1139/F08-195).
- Southern R. 1913. Gephyrea of the coasts of Ireland. *Scientific Investigations of the Fisheries Branch, Department of Agriculture for Ireland* 3:1–46.
- Vervoort W. 1966. Skeletal structure in the Solanderiidae and its bearing on hydroid classification. In: *The Cnidaria and their evolution*. Symposia of the Zoological Society of London 16:373–396.
- Zúñiga D, Calafat A, Sanchez-Vidal A, Canals M, Price B, Heussner S, Miserocchi S. 2007. Particulate organic carbon budget in the open Algero-Balearic Basin (western Mediterranean): Assessment from a one-year sediment trap experiment. *Deep-Sea Research Part I: Oceanographic Research Papers* 54:1530–1548. DOI: [10.1016/j.dsr.2007.06.001](https://doi.org/10.1016/j.dsr.2007.06.001).