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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 Mediterranee (1964) wrote about a facies of the biocenosis 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...
**Aristeus antennatus** and **Aristaeomorpha 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 trowable bottoms of the Mediterranean Sea (D’Onglia 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
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 ½″ 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. DTM 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 | Cruise          | Starting point          | End point          | Depth  | Area surveyed (ha) |
|----|-----------------|------------------------|--------------------|--------|--------------------|
| 1  | BALSEA 2014     | 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     | 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     | 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     | 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     | 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.
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 Caryophyllidae 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 dohrnii* (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 *Pennatula 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 Caryophyllidae corals colonised the submarine cable present in the area (Figure 3(e)). Finally, several coralline 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).
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.
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 *P. mauritanicus* (Gruvel, 1911), the prawns *Plesionika gigliolii* (Senna, 1902), *Plesionika martia* 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

| Taxa                      | Untrawled area | Trawled area | Taxa                      | Untrawled area | Trawled area |
|---------------------------|----------------|--------------|---------------------------|----------------|--------------|
| Foraminifera              |                |              | *Nephrops norvegicus*     |                |
| *Pelosina* sp.            |                |              | *Palinurus mauritanicus*  |                |
| Porifera                  |                |              | *Pasiphaea*               |                |
| *Cidarina*                |                |              | *Plesionika gigliolii*    |                |
| *Amphianthus dohnii*      |                |              | *Plesionika heterocarpus* |                |
| Caryophyllidae            |                |              | *Plesionika martia*       |                |
| *Funiculina quadangularis*|                |              | *Bryozoa*                |                |
| *Pachycerianthus dohnii*  |                |              | *Kinetoskias* cf. *cyathus*|                |
| *Pennatula phosphorea*    |                |              | *Echinodermata*           |                |
| *Proteopilum carpenteri*  |                |              | *Antedon mediterranea*    |                |
| *Rosalinda incrustans*    |                |              | *Holothuroidea*           |                |
| *Solenissa albecens*      |                |              | *Ophiura ophiura*         |                |
| *Sipuncula*               |                |              | *Penipidia cf. *ludwigi*  |                |
| cf. *Sipunculus* sp.      |                |              | *Pisces*                 |                |
| *Mollusca*                |                |              | *Argentinidae*            |                |
| Facelinidae               |                |              | *Benthocometes robustus*  |                |
| *Loligo vulgaris*         |                |              | *cf. Benthosoma glaciale* |                |
| *Octopus salutii*         |                |              | *cf. Ceratoscopelis maderensis* |            |
| *Echinodermata*           |                |              | *Chlorophthalmus agassizii*|                |
| *Filogranula* sp.         |                |              | *Etmopterus spinax*       |                |
| Serpulidae                |                |              | *Gadiculus argentus*      |                |
| *Crustacea*               |                |              | *Galeus melastomus*       |                |
| Ampheliscidae             |                |              | *Helioceros dactylopterus*|                |
| *Anamathia risoana*       |                |              | *Hoplostethus mediterraneus*|            |
| *Copepoda*                |                |              | *Lepidonhambus bosci*     |                |
| *Euphasiacea*             |                |              | *Merlucius merlucius*     |                |
| *Geryon longipes*         |                |              | *Micromesistius pontassou*|                |
| *Macropipus tuberculatus* |                |              | *Physiella blemnoidea*    |                |
| *Munida* sp.              |                |              | *Stomias boa boa*         |                |
| *Mysida*                  |                |              | *Synchiropus phaeton*     |                |
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
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.
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 Elasipodida 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 were 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 *Gadus morhua* Linnaeus, 1758, *Micromesistius poutassou* (Risso, 1827) and *Phycis blemnoidea* (Brünich, 1768), the Ophidiiformes *Benthocometes robustus* (Goode & Bean, 1886), the Perciformes *Synchropus phaeton* (Günther, 1861), the Pleuronectiformes *Lepidophron helicolenus* (Risso, 1810), the Scorpaeniformes *Helicolenus dactylopterus* (Delaroche, 1809), the Stomiiformes *Stomias boa boa* (Risso, 1810) and some undescribed 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. blemnoidea*, *S. phaeton*, *L. boscii* and *H. dactylopterus* were also observed standing on the muddy bottom, while *P. blemnoidea* 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. potassou* 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 Catalan coast, 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) Physic blennoides, (h) Synchiropus phaeton, (i) Lepidorhombus boscii, (j) Helicolenus dactylopterus, (k) Gadulus 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 epibionthic species such as the actinian *A. dohrnii* (Figure 5(g) and (h)) and the polychaetes *Filograna* 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. merlucius*, *M. poutassou*, *P. blennoides* and *L. boscii*.

IF also represents a trophic area for the opportunistic species which use *I. elongata* as a feeding podium, such as the decapod *A. rissoaena* that climbs on the colony to capture its preys, or the crinoid *A. mediterranea* that arises from the muddy bottom. *Anamathia rissoaena*, 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. rissoaena* (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 camouflage 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 scleractian 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.

*Penphilidia ludwigi* represents the only Elasipoda 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. smithii* 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 Euphausiacea 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. antematus 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; Aguilar & Marin 2013 – urges reflections about the role of its destruction and paradoxical protection by some anthropic impacts such as submarine cables.

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