



Deep sea starfishes (Echinodermata: Asteroidea) from the Avilés Canyon System (Bay of Biscay), including two new records

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ABSTRACT

The Avilés Canyon System (ACS) is located at the Southern Bay of Biscay (Northern Spain, Cantabrian Sea). The ACS occupies a total of 339.026 ha and is composed of three canyons, reaching the abyssal plain at 4700 m depth. Water masses that mix in the area form gyres and upwelling that contribute to increasing the nutrients at different depths, which makes it an important place for the settlement of benthic communities. They have been declared Site of Community Importance (SCI: C ESZZ12003) within the Natura 2000 Network and recognized as a Vulnerable Marine Ecosystem where Echinoderms play an important role in these communities and habitats.

The present study tries to inventory and review asteroid fauna collected during the INDEMARES project in the ACS and compare the new findings with previous studies Official Spanish Checklist (IEEM: "Inventario Español de Especies Marinas", 2017, 2020) to update our knowledge on the diversity and distribution of the asteroid's species.

During the surveys carried out within the project LIFE + INDEMARES-Avilés Canyon System (2010–2012) a total of 445 specimens, belonging to 25 Asteroids species, were collected from 36 stations in a depth range between 266 and 1476 m. The most frequent species were *Nymphaster arenatus* (Perrier, 1881) (30.55%) and *Henricia caudani* (Koehler, 1895) (25%). After public datasets, two species should be considered as new records for Spanish waters: *Radiaster tizardi* (Sladen, 1882) and *Henricia sexradiata* (Perrier, 1881), and 4 species expand their bathymetric range: *Novodinia pandina* (Sladen, 1889), *H. caudani*, *H. sexradiata* (Perrier, 1881) and *Myxaster perrieri* Koehler, 1895.

1. Introduction

The Avilés Canyon System (ACS) (43.87°N and –6.10°W) begins on the continental slope of the Biscay Bay, in the Cantabrian Sea (Northeast Atlantic Ocean) and belongs to the Spanish Exclusive Economic Zone (EEZ: Sánchez et al., 2014). It is composed of three canyons of tectonic compressive origin: the Avilés Canyon (AC), El Corburo Canyon (CC) and La Gavierna Canyon (GC) (Fig. 1), covering a total surface of 3390 km² (Cristobo et al., 2010; Sánchez et al., 2014; Orejas et al., 2010). The ACS has been declared by the Spanish Ministry of Agriculture, Food and Environment (2014) as a Site of Community Importance (SCI: C ESZZ12003) within the Natura 2000 Network (Ministry of Agriculture, Food and Environment, 2017; 2020), and recognized as a Vulnerable Marine Ecosystem (EMV: follow OSPAR Convention for the Protection of the Marine environment of the North-East Atlantic (<https://www.ospar.org/convention/text>)) where Echinoderms play an important role, in

these communities and habitats.

The Cantabrian Sea is reached by Caribbean water (Gulf Stream, warm and shallow), in addition, it is characterized by different water masses: East North Atlantic Central Water (ENACW), Labrador Sea Water (LSW), North Atlantic Deep Water (NAWD), the deepest and cold, and Mediterranean water (MW) which comes to Biscay Bay through Gibraltar Strait. Therefore, marine species of the Cantabrian Sea could have different biogeographic origins (Arias and Crocetta, 2016).

The study area is rich in nutrients at different depth due to the geomorphology of the place and local currents which makes this area an important place for the settlement benthic communities, where Echinoderms play an important role (Botas et al., 1990; Sánchez and Gil, 2000, 2014; Lavin et al., 2004).

Previous taxonomic works on Asteroids in this area were published by several authors in the late 19th and the 20th centuries. Their studies were carried out on the shelf or on the limit of the slope, but rarely inside

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de canyons: Sladen, 1889 (Challenger); Perrier, 1885 (Travailleur and Talisman); Koehler, 1895 (Caudan); Koehler, 1909, 1921a (Princesse Alice; and Hirondele); Morgan, 1913 (Huxley); Grieg, 1932 (Michael Sars); Lieberkind, 1935 (Danish Ingolf Expedition); Cherbonnier, 1969 (Thalassa); Cherbonnier and Sibuet, 1972 (Northatlantic campaign); Monteiro-Marques, 1980 (Hespérides 76), Laubier and Monniot, 1985 (Biogas), López-Ibor, 1987 (Cantábrico 83).

Recently, other expeditions have been developed with different approaches (fisheries, ecological and/or protected areas management) as Louzao et al., 2010 (COCACE), Sánchez et al., 2014 (LIFE + INDEMARES-ACS) Manjón-Cabeza et al., 2021 (ECOMARG, LIFE + INDEMARES-ACS and SponGES) where our laboratory has been involved, giving us the opportunity to study the asteroid communities at depths that were not sampled before in ACS.

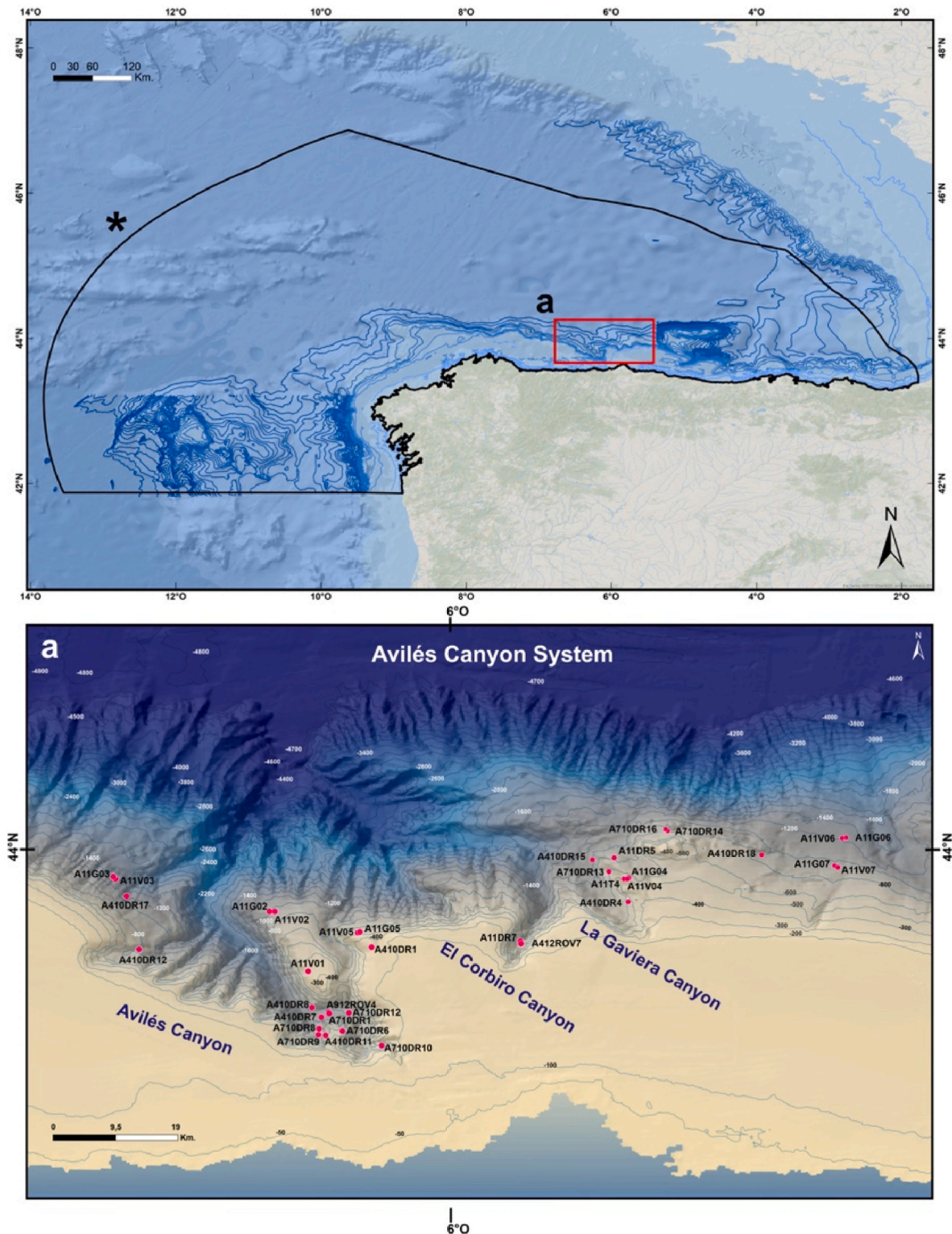


Fig. 1. Sampling. a. ACS sampling stations with presence of Asteroids. *, North Atlantic Spanish Marine Sub-Division (NAMD) polygon.

2. Material and methods

2.1. Sampling

LIFE + INDEMARES-ACS surveys consisted of five multidisciplinary surveys (2010–2012), using four different vessels (*Vizconde de Eza*; *Thalassa*; *Ramon Margalef* and *Angeles Alvarino*). Asteroids were collected in a total of 36 stations between 266 m and 1476 m depth (Table 1, Fig. 1) using multiple gear types, including: rock dredge (DR: 0.8 m wide and 0.3 m high: mesh size of 10 mm), bou de Vara (V: 3.50 m wide/0.65 m high: mesh size of 10 mm) beam trawl (GOC-73: 19.44 ± 0.59 m wide/2.68 ± 0.12 m high: mesh size of 10 mm), supra-benthic sledge (TS: 2 nets, mesh size of 0.5 mm) and a remote operated vehicle, ROV *Liropus 2000* (ROV) (5 video cameras, 2 hydraulics collecting arms, suction sampler and a box to keep the samples).

2.2. Systematics

Asteroids were sorted and fixed in 70% ethanol and their identification was based on morphological characters according to Bell (1892), Perrier (1881), Sladen (1882), Susaeta (1913), Koehler (1921b), Mortensen (1927), Madsen (1961), Rasmussen (1965) and Clark and Downey (1992). All taxon names were checked for relevance and synonymies based on the original descriptions. Asteroid classifications were checked in World Register of Marine Species (WoRMS), and new records of species AphiaID (urn:lsid:marinespecies.org:taxname) Mah, (2021) were included for consulting and referring to synonymies. Morphological notations follow Mah (2018, 2020).

New record was compared to the known distribution of species using the Official Spanish Check List (IEEM: “Inventario Español de Especies Marinas”). Asteroidea: Manjón-Cabeza et al., 2017, 2020) related to the North Atlantic Spanish Marine Sub-Division (NAMSD) (see polygon at Fig. 1. *) and supported by other open-access databases: GBIF.org. (2021), Muséum National d’Histoire Naturelle (2021), OBIS (2021), and USNM Invertebrate Zoology Collection (Smithsonian National Museum of Natural History, 2021), as well as other sources as Perrier (1881).

3. Results

A total of 445 specimens, belonging to 25 Asteroids species (Table 2), were collected from 36 stations. The most frequent species (percentage of occurrence per station) were *N. arenatus* (Perrier, 1881) (30.55%) and *H. caudani* (Koehler, 1895) (25%).

Table 1

Geographical positions and depth of the sampled stations. ST: station, LAT: latitude (decimal grade), LON: longitude (decimal grade), D: depth (m).

ST	LAT	LON	D	ST	LAT	LON	D
A912ROV4	43.78	-6.17	942	A410DR1	43.87	-6.11	266
A412ROV7	43.88	-5.91	487	A410DR4	43.93	-5.76	700
A11DR5	43.99	-5.78	908	A410DR7	43.77	-6.18	1150
A11DR7	43.88	-5.91	551	A410DR8	43.78	-6.20	844
A11G02	43.92	-6.25	1051	A410DR11	43.74	-6.18	636
A11G03	43.96	-6.47	1464	A410DR12	43.86	-6.43	828
A11G04	43.96	-5.76	535	A410DR15	43.86	-6.26	1660
A11G05	43.89	-6.13	578	A410DR17	43.94	-6.45	1476
A11G06	44.02	-5.46	1244	A410DR18	44.00	-5.58	767
A11G07	43.98	-5.48	990	A710DR1	43.78	-6.17	810
A11T4	43.96	-5.77	530	A710DR6	43.75	-6.15	649
A11V01	43.83	-6.20	355	A710DR8	43.76	-6.19	800
A11V02	43.92	-6.25	1008	A710DR9	43.75	-6.19	626
A11V03	43.96	-6.47	1473	A710DR10	43.73	-6.10	342
A11V04	43.96	-5.76	510	A710DR12	43.78	-6.15	843
A11V05	43.89	-6.13	552	A710DR13	43.97	-5.79	769
A11V06	44.02	-5.47	1228	A710DR14	44.02	-5.71	772
A11V07	43.98	-5.48	984	A710DR16	44.03	-5.72	928

3.1. Systematics, distribution and bathymetric ranges

Two species should be considered as new records for Spanish waters (Table 2): *R. tizardi* (Sladen, 1882) and *H. sexradiata* (Perrier, 1881). In addition, the bathymetric range of four species, *N. pandina* (Sladen, 1889), *H. caudani*, *H. sexradiata* and *M. perrieri* Koehler, (1895) was extended (see the description below).

Order Brisingida

Family Brisingidae.

Brisinga cf. *endecacnemus* Asbjørnsen 1856. AphiaID: 123673. (Supplementary material: Fig. 1a and b).

Material examined. 38 specimens: A410DR17, A11V04, A11G04, A11G05.

Diagnosis. Arms 7–13, with transverse bars along them (Fig. 1a). Gonad lobes in rows along arms. Abactinal plates imbricate with one spinelet, no pedicellariae associated or papulae between them (Fig. 1a). Marginal plates inconspicuous, only inferomarginal ones small but visible. The first pair of adambulacral plates joining in the interradial mid-line. Furrow spines 1–2, with crossed and/or straight pedicellariae associated and two rows of tube feet. Oral spine per plate: 1. Suboral spine per plate: 1 often with pedicellariae.

Distribution. North Atlantic Ocean, Bay of Biscay, Faroe Channel, British Island, Ireland, coast of Portugal (between Lisbon and Oporto). It is distributed elsewhere all around the coast from Trondheim Fjord to western South Africa.

Bathymetric range. 183–2245 m (Dilman, 2014; Sibuet, 1974; OBIS database).

Present study: 510–1476 m.

Remarks. There are 19 species of the genus *Brisinga* Asbjørnsen, 1856. But *B. endecacnemus*, is easy to confuse with 2 species: *B. costata* Verrill, 1884 and *B. hirsuta* Perrier, 1894. *Brisinga endecacnemus*, 2 lateral oral spines. Many spinelets in single row on costal plates. 1 furrow spines. *Brisinga costata*, 1 lateral oral spine. Spinelets on costal plates 1–3. Furrow spines 1–3. *Brisinga hirsuta*, lateral oral spines 2. Many spinelets in double row or irregular on costal plates. Furrow spines 2. In addition, *B. endecacnemus* could be confused with *Hymenodiscus coronata* (Sars, 1871). To distinguishing them, an arm dissection is needed to appreciate the morphology of gonads. Following Mortensen (1927), gonads lobes of *B. endecacnemus*, are arranged in series along either side of each arm, nevertheless *H. coronata* has only two pairs of lobes at the base of arm. In addition, in *H. coronata* the first pair of adambulacral plates not joining in the interradial mid-line (Fig. 1b).

Hymenodiscus cf. *coronata* (Sars, 1871). AphiaID: 381759. (Supplementary material: Fig. 1 c-d).

Material examined. 31 specimens: A410DR8, A410DR11, A410DR12, A710DR6, A710DR9, A912ROV4.

Table 2
Species records from ACS: taxonomic position.

Order	Family	Species
Brisingida Fisher, 1928	Brisingidae G.O. Sars, 1875	<i>Brisinga endecacemos</i> Asbjørnsen, 1856 <i>Hymenodiscus coronata</i> (Sars, 1871) <i>Novodinia pandina</i> (Sladen, 1889)
Forcipulatida Perrier, 1884	Stichasteridae Perrier, 1885 Zoroasteridae Sladen, 1889	<i>Neomorphaster margaritaceus</i> (Perrier in Milne-Edwards, 1882) <i>Zoroaster fulgens</i> Wyville Thomson, 1873 <i>Benthopecten simplex</i> (Perrier, 1881) <i>Pontaster tenuispinus</i> (Düben & Koren, 1846)
Notomyotida Ludwig, 1910	Benthopectinidae Verrill, 1899	<i>Astropecten irregularis</i> (Pennant, 1777) <i>Persephonaster patagiatus</i> (Sladen, 1889) <i>Plutonaster bifrons</i> (Wyville Thomson, 1873) <i>Psilaster andromeda</i> (Müller & Troschel, 1842) <i>Luidia sarsii</i> Düben & Koren in Düben, 1844
Paxillosida Perrier, 1884	Astropectinidae Gray, 1840 Luidiidae Sladen, 1889 Pseudarchasteridae Sladen, 1889 Radiasteridae Fisher, 1916	<i>Astropecten irregularis</i> (Pennant, 1777) <i>Persephonaster patagiatus</i> (Sladen, 1889) <i>Plutonaster bifrons</i> (Wyville Thomson, 1873) <i>Psilaster andromeda</i> (Müller & Troschel, 1842) <i>Luidia sarsii</i> Düben & Koren in Düben, 1844 <i>Pseudarchaster parelii</i> (Düben & Koren, 1846) <i>Radiaster tizardi</i> (Sladen, 1882)
Spinulosida Perrier, 1884	Echinasteridae Verrill, 1867	<i>Henricia caudani</i> (Koehler, 1895) <i>Henricia sexradiata</i> (Perrier, 1881)
Valvatida Perrier, 1884	Goniasteridae Forbes, 1841 Odontasteridae Verrill, 1899 Poraniidae Perrier, 1894	<i>Ceramaster grenadensis</i> (Perrier, 1881) <i>Nymphaster arenatus</i> (Perrier, 1881) <i>Peltaster placenta</i> (Müller & Troschel, 1842) <i>Plinthaster dentatus</i> (Perrier, 1884) <i>Odontaster mediterraneus</i> (von Marenzeller, 1893) <i>Porania pulvillus</i> (O.F. Müller, 1776) <i>Poraniomorpha hispida</i> (M. Sars, 1872)
Velatida Perrier, 1884	Korethrasteridae Korethrasteridae Danielssen & Koren, 1884 Myxasteridae Perrier, 1885 Pterasteridae Perrier, 1875	<i>Korethraster hispidus</i> Wyville Thomson, 1873 <i>Myxaster perrieri</i> Koehler, (1895) <i>Pteraster militaris</i> (O.F. Müller, 1776)

Diagnosis. It presents 9–12 arms, with transverse bars along arms (Fig. 1c). Two pair of gonad lobes at the base of arm. Small abactinal plates of the disk with one moderately long denticulate spine (Fig. 1d). Abactinal arm plates rod-like. Costal plates with a long spine. Small and irregular inferomarginal plates with 1 spinelet (Fig. 1d). Ambulacral plates: Y-shaped. Furrow spines: 2–4. Subambulacral spines: 1–2 Preoral spines: 2. Lateral oral spine: 1. Suboral spines: 1 Rich in pedicellariae.

Distribution. North Atlantic Ocean, Atlantic Oceanic Dorsal, Norway, British Island, Azores, Mediterranean Sea.

Bathymetric range. 100–2600 m (Dilman, 2014).

Present study: 626–942 m.

Remarks. See this remark in *B. endecacemos*.

Novodinia pandina (Sladen, 1889). AphiaID: 123680. New bathymetric record. (Supplementary material: Fig. 1 e-h).

Material examined. 33 specimens: A410DR15, A912ROV4, A710DR12, A710DR8.

Diagnosis. Arms 13–20 (Fig. 1e). The proximal part of arms swollen (because of gonads), abruptly thin at the middle of their length to the distal area thin (Fig. 1f). Abactinal papular areas scattered on the disc and on proximal arms (Fig. 1g). Primary plates imbricated and with 1–14 stout and little spinelets (Fig. 1g). Suboral spines: 1–3. Oral spines: 1–3 (Fig. 1h). Pedicellariae small, absent on the disc.

Distribution. North Atlantic Ocean, Faroe Channel, coast of North and South Carolina, Gulf of Mexico, Cuba.

Bathymetric range. 278–990 m (Clark and Downey, 1992).

Present study: 800–1660 m.

Remarks. There are 13 species of the genus *Novodinia* Dartnall, Pawson, Pope & B.J. Smith, 1969, nevertheless only 5 of them present North Atlantic distribution: *N. pandina*, *N. homonyma* Downey, 1986, *N. semicoronata* (Perrier, 1885), *N. americana* (Verrill, 1880) and *N. antillensis* (A.H. Clark, 1934). *Novodinia pandina* display 13–18 arms and many abactinal spinelets, however the rest of species with a different arms number and less abactinal plates spinelets on the disc.

Order Forcipulatida

Family Stichasteridae.

Neomorphaster margaritaceus (Perrier in Milne-Edwards, 1882). AphiaID: 123820. (Supplementary material: Fig. 2 a-f).

Material examined. 6 specimens: A11V03, A11V04, A11V06.

Diagnosis. Arms 5. Abactinal plates in a regular rosette, with clavate spinelets, small hidden madreporite (Fig. 2a, b, c). Abactinal and marginal plates with 4–12 spinules and crossed pedicellariae (Fig. 2d). Adambulacral plates diplanthid. Rows of tube feet: 4. Straight and crossed pedicellariae (Fig. 2e and f).

Distribution. North Atlantic Ocean, Ireland, Hebridean Slope, Rockall Trough, Bay of Biscay, Azores, The Canary Island (Fuerteventura), coast of Morocco and coast of Angola.

Bathymetric range. 400–5413 m. (Clark and Downey, 1927; Mortensen, 1927).

Present study: 510–1473 m.

Remarks. There are 2 species of the genus *Neomorphaster* Sladen, 1889 in the North Atlantic Ocean: *N. margaritaceus* and *N. forcipatus* Verrill, 1894. *Neomorphaster margaritaceus* with 1 papulae (sometimes 2) per papular area and abactinal clavate spinelets, while *N. forcipatus* with 3–10 papulae per area and abactinal granuliform spinelets.

Family Zoroasteridae.

Zoroaster fulgens Wyville Thomson, 1873. AphiaID: 123826. (Supplementary material: Fig. 2 g-k).

Material examined. 80 specimens: A11G02, A11G03, A11G04, A11G07, A11V02, A11V06.

Diagnosis. Arms 5, long and subcylindrical (Fig. 2g). Small disc with lobed plates (Fig. 2h). Carinal plates on arms (Fig. 2i). Actinal plates usually with a central spine. Adambulacral plates with 2 spines (Fig. 2j). Subambulacral spines: 3. Usually with many pedicellariae in the furrow (Fig. 2k).

Distribution. Atlantic Ocean, Iceland, British island, Faroe channel, Ireland, Bay of Biscay, Azores, The Canary Island, coast of Morocco, coast of Senegal, North-East America in front of San Pedro and Miquelon, from Main to Virginia, Gulf of Mexico, Caribbean Sea, Brazil (coast of Rio de Janeiro), East of South Georgia and Sandwich Island, Indian Ocean, Laquedivas Sea, Pacific Ocean, Salomon Sea, Coral Sea.

Bathymetric range. 48–4810 m (USNM E 43024 Ahearn, Smithsonian Institution, 1993; Dilman, 2014).

Present study: 535–1464 m.

Remarks. There are 20 species of the genus *Zoroaster* Wyville Thomson, 1873. However, they present other morphological features to *Z. fulgens*. In addition, they show different distribution areas. There are no other similar species in the ACS that could be confused with *Z. fulgens*. Moreover, there are, at least, 3 morphotypes of this species, which could make difficulties in the identification process. These morphotypes were described by Howell et al. (2004) based on the length, slenderness or robustly of the arm.

Order Notomyotida



Fig. 2. *Radiaster tizardi* new record: a. Abactinal general view. Scale bar: 10 mm. b. Marginal fringe. Scale bar: 5 mm. c. Actinal general view (plates arrangement). Scale bar: 5 mm. *Radiaster elegans*: d. Actinal/Abactinal general view. Scale bar: 10 mm. e. Detail of actinal plates arrangement. Scale bar: 2 mm. f. Detail of abactinal paxillae. Scale bar: 2 mm. g. Adambulacral plates and furrow spines Scale bar: 2 mm. h. Superomarginal plates and spines. Scale bar: 2 mm. **Map.** Both species world distribution area (see legend).

Family Benthoplectinidae.

Benthopecten simplex (Perrier, 1881). AphiaID: 123837. (Supplementary material: Fig. 3 a-d).

Material examined. 1 specimen: A11G06.

Diagnosis. Arms 5 (Fig. 3a). Interradial area of disc with a large spine (Fig. 3a). Scattered papulae on the base of arms (Fig. 3b). Abactinal plates of the disc with armament as paxillae with a central spinelet, besides, with multiple spinules smaller than the previous one, although sometimes with the same size of spinelets (Fig. 3b). Inferomarginal plates with a medium/large spine and smaller ones (Fig. 3c). Spines on adambulacral plates 5–7. Subambulacral spines: 1–2 (Fig. 3d). Pedicellariae often on actinal plates and inferomarginal ones and less frequent on abactinal plates.

Distribution. North Atlantic Ocean, British Island, Bay of Biscay, coast of Portugal, Atlantic Oceanic Dorsal between East of Labrador and Ireland, North-East America from Rhode Island to Gulf of Mexico. Caribbean Sea (Cuba), coast of Guyana. South-West of Africa in front of Ghana, Gulf of Guinea, in front of Gabon and Namibia.

Bathymetric range. 1174–3757 m (Sibuet, 1969; OBIS database; Dilman, 2014).

Present study: 1244 m.

Remarks. There are 23 species within the genus *Benthopecten* Verrill, 1884. However, only 2 occur in ACS. *Benthopecten simplex* (Perrier, 1881) (Considered as subspecies by Clark 1981; and cited by Clark and Downey, 1992) and *B. spinosus* Verrill, 1884. *Benthopecten simplex* show 5–7 furrow spines, 1–2 subambulacral spines and pedicellariae are present on the actinal and inferomarginal plates. *Benthopecten spinosus* 4–5 (sometimes 6) furrow spines, 2 subambulacral spines, pedicellariae only present on inferomarginal plates. The species *B. folini* (Perrier, 1894) also occur in Atlantic waters they present 7 (sometimes 8–9) furrow spines, 2 (sometimes 1) subambulacral spines, pedicellariae are present on abactinal, actinal and inferomarginal plates. When some of this species overlap in number of spines, it should be needed to review the presence of pedicellariae on abactinal/actinal sides.

Pontaster tenuispinus (Düben & Koren, 1846). AphiaID: 123851. (Supplementary material: Fig. 3 e-i).

Material examined. 12 specimens: A11G04, A11T4, A11V04, A11V05.

Diagnosis. Arms 5 (Fig. 3e). Papular area at the base of each arm with a petal shape (Fig. 3f). Paxillae on abactinal plates with 5–15 spinules and a central spinelet (Fig. 3g). Superomarginal and inferomarginal plates do not match each other (Fig. 3h). Each marginal plate with a conical large spine (Fig. 3h). Adambulacral plates: 5–6 spines and 2–3 spines of the furrow (Fig. 3i). Usually without pedicellariae, sometimes on adambulacral plates.

Distribution. Arctic Ocean, middle of Arctic Ocean (North of Greenland), Beaufort Sea, Bay of Cambridge, North Atlantic Ocean, Kara Sea, Greenland Sea, Barents Sea, Norwegian Sea, North Sea, British Island, Faroe Chanel, Ireland, Bay of Biscay, Baffin Bay, Labrador Sea, From New Scotia to Delaware.

Bathymetric range. 16–3193 m (Dilman, 2014; Sibuet, 1975; OBIS database).

Present study: 510–552 m.

Remarks. There is only one species of the genus *Pontaster* Sladen, 1885, *P. tenuispinus*. It is easy to confuse with the genus *Cheiraster* Studer, 1883. *Cheiraster* has a papular area bilobed distally and limited to the arm bases, pedicellariae are fasciculate with multiple narrow valves present on actinal plates. However, in the genus *Pontaster*, present a well-defined, oval and swollen papular area, pedicellariae only present on adambulacral plates.

Order Paxillosida**Family Astropectinidae.**

Astropecten irregularis (Pennant, 1777). AphiaID: 123867. (Supplementary material: Fig. 4 a-e).

Material examined. 22 specimens: A410DR1, A11V01, A11V04.

Diagnosis. Arms 5 (Fig. 4a). Paxillae of abactinal plates with 6–20

spinelets (Fig. 4b). Superomarginal plates with granules and usually a large spine (Fig. 4c). Inferomarginal plates: 4–5 conspicuous spines and another few small ones (Fig. 4d). Adambulacral plates: 3 furrow spines and 2–3 subambulacral ones (Fig. 4e). Mouth plates: 3 rows of long spines. Sometimes with pedicellariae.

Distribution. Atlantic Ocean: South of Svalbard, Norwegian Sea, North Sea, Baltic Sea, British island, Bay of Biscay, South-West of Portugal, coast of New Jersey, Caribbean Sea (Puerto Rico), coast of Rio de Janeiro, Morocco coast, Senegal coast, Cape Verde, coast of Sierra Leona, Guinea Ghana, Congo, South of Angola, South of Namibia, South Africa. Mediterranean Sea: West Mediterranean Sea, Greece, Egypt (in front of Beheire).

Bathymetric range. 10–1000 m. (Clark and Downey, 1992; Mortensen, 1927).

Present study: 266–510 m.

Remarks. This species is very variable. It presents different shapes, sizes, relative arms lengths, and shapes and lengths of superomarginal spines. Furthermore, pedicellariae sometimes are absent.

There are 104 species of the genus *Astropecten* Gray, 1840. In Atlantic waters there are 28 species. But only 5 species are present in the area, *A. aranciatus* (Linnaeus, 1758), *A. cingulatus* Sladen, 1883, *A. ibericus* Perrier, 1894, *A. irregularis* (Pennant, 1777) and *A. jonstoni* (Delle Chiaje, 1827). *Astropecten irregularis* show more than 12 clavate spinelets on paxillae and 3 inferomarginal spines per plate, however it is easy to distinguish from other species of the genus: *A. aranciatus* has 1 inferomarginal spine per plate. *Astropecten cingulatus* present more than 12 granulose spinelets on paxillae. *Astropecten ibericus* carry less than 12 clavate spinelets on paxillae and 1 inferomarginal spine per plate and in case of *A. jonstoni* present 1 compress marginal spine.

Persephonaster patagiatus (Sladen, 1889). AphiaID: 123899. (Supplementary material: Fig. 4 f-j).

Material examined. 13 specimens: A11G03, A11V03, A11V04.

Diagnosis. Arms 5 (Fig. 4f). Paxillae on abactinal plates (Fig. 4g). Quite big and tumid superomarginal plates (Fig. 4h). Granules in the middle of Inferomarginal plates and 3–6 spines (Fig. 4i). Spines on actinal plates. Adambulacral plates: 8–10 spines, however up to 17 of them. Rows of tube feet: 2 (Fig. 4j). Small pedicellariae.

Distribution. Atlantic Ocean, Iceland, Norwegian Sea, British Island, Azores, coast of Morocco, Cape Verde, coast of New York, Gulf of Mexico, Caribbean Sea, coast of Jamaica, coast of Panama, Gulf of Darien, coast of Venezuela, Dominica and Martirica island.

Bathymetric range. 55–2970 m (USNM 1226466 Mah, 2019; Clark and Downey, 1992).

Present study: 510–1473 m.

Remarks. There are 23 species of the genus *Persephonaster* Wood-Mason and Alcock, 1891, but only 5 are present in North Atlantic waters. *Persephonaster patagiatus*, *P. pulcher* (Perrier, 1881), *P. sphenoplax* (Bell, 1892), *P. echinulatus* H.L. Clark, 1941 and *P. leptactis* H.L. Clark, 1941. *Persephonaster patagiatus*: the superomarginal armament is tubercular or granuliform and they present 8–10 furrow spines. *Persephonaster echinulatus*: superomarginal plates carry 1 spine (sometimes missed) and these plates are full of slender spinelets, in addition it has 5–6 furrow spines. *Persephonaster leptactis*: the superomarginal armament has short spinelets and less than 8 furrow spines. *Persephonaster sphenoplax*: show 4–5 furrow spines. *Persephonaster pulcher*: the superomarginal armament is granuliform and furrow spines are less than 8. On the other hand, *P. patagiatus* is easily confused with *Psilaster andromeda* (Müller & Troschel, 1842) and *Bathybiaster vexillifer* (Wyville Thomson, 1873) and they share part of their distribution area. Nevertheless, *P. patagiatus* with quite big and tumid superomarginal plates and 8–10 similar size spines (up to 17) of the furrow. *Bathybiaster vexillifer* with 5 spines of the furrow, one of them longer than the other ones and *P. andromeda* with numerous superomarginal plates (more and smaller plates than in *P. patagiatus*) besides usually 7–8 furrow spines.

Plutonaster bifrons (Wyville Thomson, 1873). AphiaID: 123904. (Supplementary material: Fig. 4 k-m).

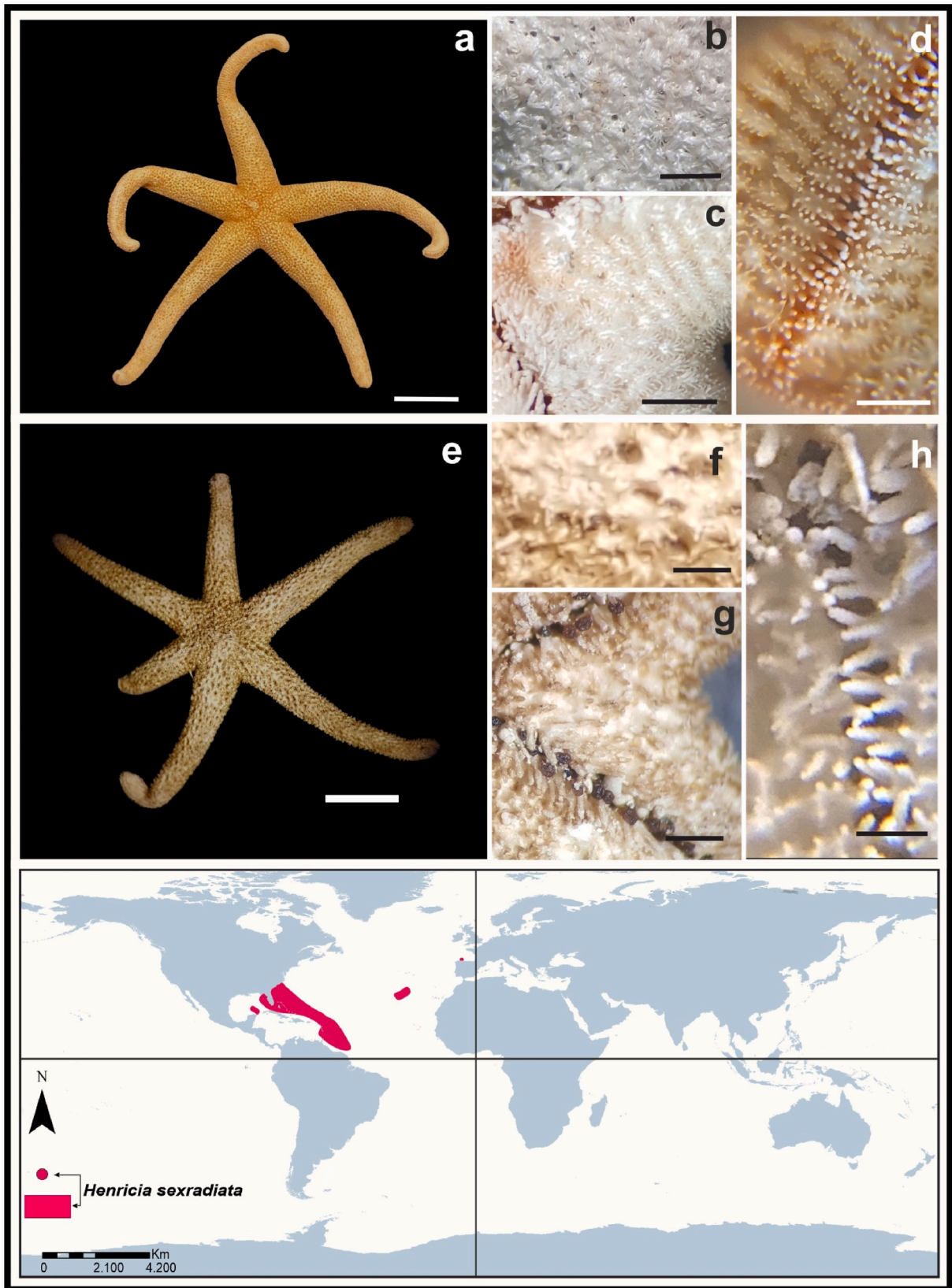


Fig. 3. *Henricia caudani*: a. General view. Scale bar: 10 mm. b. Abactinal spines. Scale bar: 1.2 mm. c. Actinal papulae. Scale bar: 10 mm. d. Adambulacral plates and furrow spines. Scale bar: 5 mm. *Henricia sexradiata* new record: e. Abactinal side. Scale bar: 5 mm. f. Abactinal spines. Scale bar: 1.2 mm. g. Actinal plates. Scale bar: 1.2 mm. h. Adambulacral plates and furrow spines. Scale bar: 5 mm. **Map.** *Henricia sexradiata* world distribution area (see legend).

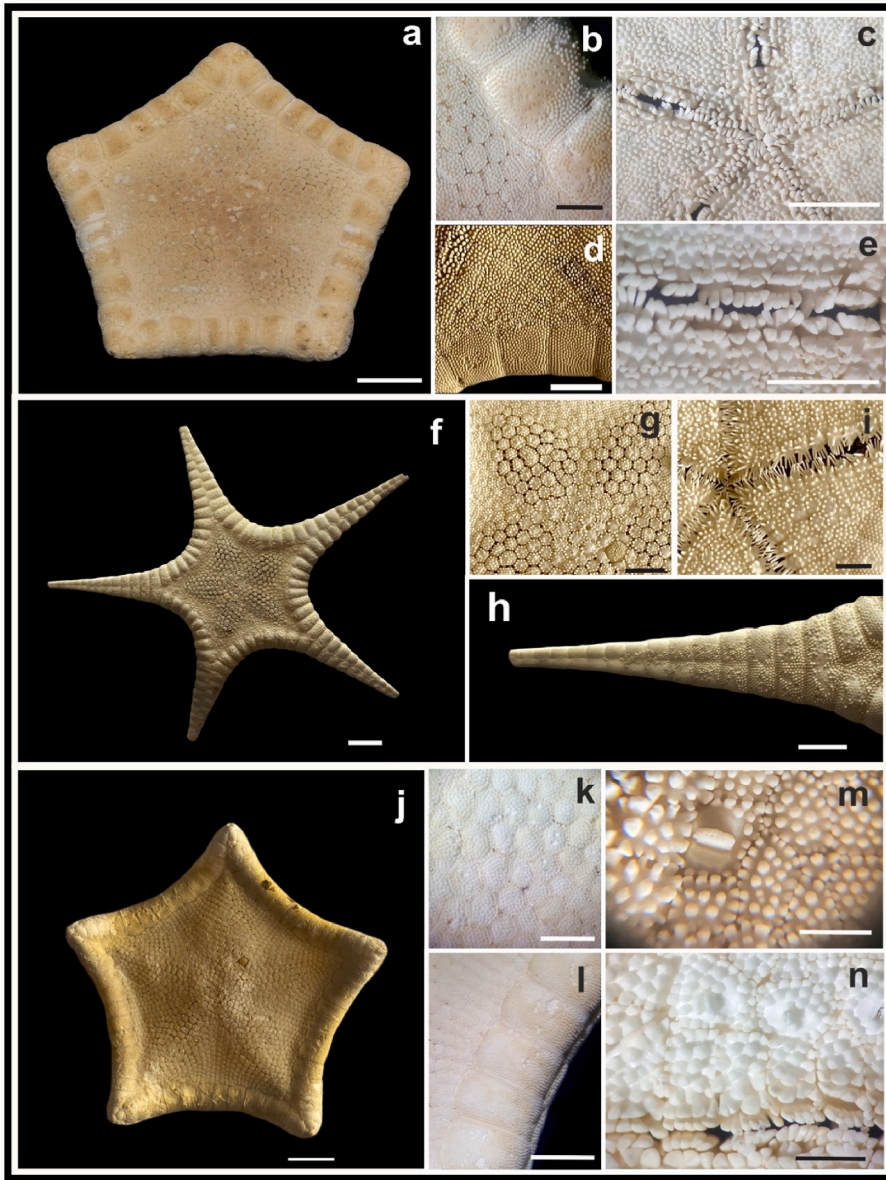


Fig. 4. *Ceramaster grenadensis*: a. General view. Scale bar: 10 mm. b. Superomarginal plates. Scale bar: 2.5 mm. c. Actinal-oral side. Scale bar: 5 mm. d. Inferomarginal plates and actinal plates. Scale bar: 5 mm. e. Adambulacral plates and furrow spines. Scale bar: 2.5 mm. *Nymphaster arenatus*: f. Abactinal side. Scale bar: 10 mm. g. Abactinal plates. Scale bar: 5 mm. h. Superomarginal plates. Scale bar: 5 mm. i. Actinal-oral side. Scale bar: 5 mm. *Peltaster placenta*: j. Abactinal general view. Scale bar: 10 mm. k. Abactinal plates. Scale bar: 1.2 mm. l. Marginal plates. Scale bar: 4 mm. m. Pedicellariae. Scale bar: 1.2 mm. n. Actinal plates, pedicellariae, and adambulacral plates and furrow spines. Scale bar: 1.2 mm.

Material examined. 4 specimens: A11G03, A11V03.

Diagnosis. Arms 5, long with narrow tips, almost pointed (Fig. 4k). Paxillae on abactinal plates, in transverse series with 15–25 short spinelets. Papulae on the proximal area of arms (Fig. 4k). Each superomarginal and inferomarginal plate with a stout spine, otherwise with very minute spines (Fig. 4l). Granules or spinelets on actinal plates and usually a big spine. Spines of the furrow: 7–10 (Fig. 4m). Pedicellariae usually on marginal and actinal plates, even, sometimes on abactinal plates.

Distribution. Atlantic Ocean, coast of Delaware, British Island, Faroe Channel, Ireland, Bay of Biscay, South of Portugal coast, The Canary Islands, Gulf of Guinea, Gabon coast, Angola coast, West Mediterranean Sea, south of Greece.

Bathymetric range. 100–4252 m (Mortensen, 1927; Dilman, 2014).

Present study: 1464–1473 m.

Remarks. There are 12 species of the genus *Plutonaster* Sladen 1889. Only, the species *P. agassizi* (Verrill, 1880) is present next to ACS. *Plutonaster bifrons* is the only species of this genus which present a long spine on each superomarginal and inferomarginal plate, in addition it shows narrow and more or less pointed tips of arms, superomarginal

plates carrying long and pointed spines and 7–10 furrow spines. Whereas *P. agassizi* shows rounded arms with blunt tips. The superomarginal armament usually not present spines and 6–9 furrow spines.

Psilaster andromeda (Müller & Troschel, 1842). AphiaID: 123908. (Supplementary material: Fig. 4 n–q).

Material examined. 33 specimens: A710DR1, A710DR8, A11G02, A11G03, A11G04, A11V02, A11V07.

Diagnosis. Arms 5 (Fig. 4n). Paxillae on abactinal plates (Fig. 4o). Small protuberance in the centre of the disc. (Fig. 4n). Superomarginal plates numerous and higher than wide (Fig. 4p). Adambulacral plates usually with 6–8 same length spines of the furrow and 2 rows of tube feet (Fig. 4q). Without pedicellariae.

Distribution. North Atlantic Ocean, Greenland Sea, Norwegian Sea, North Sea, British island, Ireland, Bay of Biscay, Azores, Cape Verde. North-east America, Bay of Baffin, Davis Strait, Labrador Sea, the North coast of EEUU from New Scotia to North Carolina, East of Florida, Gulf of Mexico, coast of Venezuela and coast of Guyana.

Bathymetric range. 35–3193 m (Dilman, 2014; Sibuet, 1975; OBIS database).

Present study: 535–1464 m.

Remarks. The genus *Psilaster* Sladen, 1885, has 11 species from which only 2 occur in the North Atlantic Ocean: *P. andromeda* and *P. cassiope* Sladen, (1889). *Psilaster andromeda* has paxillae with blunt spinelets and the armament of superomarginal plates carry squamiform spinelets irregularly scattered. In case of *P. cassiope*, paxillae present short and clavate spinelets. Armament of superomarginal plates have spaced squamiform granules. Also, it is possible to confuse with *P. patagiatus* and *B. vexillifer*. (Previously explained in remarks of *P. patagiatus*).

Family Luidiidae.

Luidia sarsii Düben & Koren in Düben, 1844). AphiaID: 123922. (Supplementary material: Fig. 5 a-e).

Material examined. 6 specimens: A11G05, A11V04, A11V05.

Diagnosis. Arms 5, long (Fig. 5a). Moderate disk (Fig. 5b). Paxillae on abactinal plates with a central spinelet (Fig. 5c). Elongated superomarginal paxillae (Fig. 5d). Inferomarginal plates with 2–4 spines. Adambulacral plates with 3 large spines in series transverse to the furrow and sometimes 1 or 2 spinelets (Fig. 5e). Usually with pedicellariae on actinal plates.

Distribution. Atlantic Ocean, Norwegian Sea, North Sea, British island, Bay of Biscay, South-West of Portugal, coast of Morocco, the Canary Islands, Cape Verde, coast of New York, coast of Delaware, coast of North Carolina, Gulf of Mexico, coast of Colombia, West Mediterranean Sea, North-East of Greece.

Bathymetric range. 9–1300 m (Clark and Downey, 1992; Mortensen, 1927).

Present study: 510–578 m.

Remarks. There are 50 species of the genus *Luidia* Forbes, 1839, only 11 are present in North Atlantic waters. In the area are present 3 of them, *L. atlantidea* Madsen, 1950, *L. ciliaris* (Philippi, 1837) and *L. sarsii*. *Luidia sarsii*: 5 arms. Paxillar armament with central and peripheral spinelets uniform. Elongated superomarginal paxillae. *Luidia atlantidea*: 5 arms. Paxillar armament with central spinelets distinctly coarser than peripheral ones. Rounded or squared superomarginal paxillae. *Luidia ciliaris*: sometimes 8 arms.

Family Pseudarchasteridae.

Pseudarchaster parelii (Düben&Koren, 1846). AphiaID: 124085.

(Supplementary material: Fig. 5 f-j).

Material examined. 1 specimen: A11G02.

Diagnosis. Arms 5, narrow with more than one row of plates on each one (Fig. 5f). Tabulated abactinal plates with granules (Fig. 5g). Superomarginal plates wider than longer with granules (Fig. 5h). Inferomarginal and superomarginal plates similar but inferomarginal ones usually with spines (Fig. 5i). Actinal plates also with granules besides, sometimes an enlarged lanceolate spine (Fig. 5j). Furrow spines: 5–6. Oral spines: 7–8 (Fig. 5j). With pedicellariae.

Distribution. Atlantic Ocean, Norwegian Sea, North Sea, British island, Ireland, Bay of Biscay, Azores, coast of Morocco, Along the North-East American coast from Labrador Sea to Virginia, Florida, Caribbean Sea, West Mediterranean Sea, in front of Algeria and South of Balearic Islands, Pacific Ocean, Alaska Gulf, Bering Sea.

Bathymetric range. 75–3540 m (Clark and Downey, 1992; Dilman, 2014).

Present study: 1051 m.

Remarks. There are 22 species of the genus *Pseudarchaster* Sladen, 1889. Only 3 are present in North Atlantic waters, *P. gracilis* (Sladen, 1889), *P. parelii* and *P. tessellatus* Sladen, (1889). *Pseudarchaster parelii*: inferomarginal (large) lanceolate spines. Actinal plates with granules and sometimes an enlarged lanceolate spine. Furrow spines: 4–6. *Pseudarchaster gracilis*: inferomarginal (large) conical spines. Actinal plates with spinelets (not dense) and a few larger conical spines. More than 6 furrow spines. *Pseudarchaster tessellatus*: inferomarginal (large) conical spines. Actinal plates with small clavate spines or granules and sometimes with a large conical spine. More than 6 furrow spines.

Family Radiasteridae.

Radiaster tizardi (Sladen, 1882). AphiaID: 123950. New record. (Fig. 2 a-c).

Material examined. 2 specimens: A11V06.

Diagnosis. Arms 5, short (Fig. 2a). Paxillae in irregular series on the abactinal surface, usually with hidden madreporite and 15–20 spinelets. Scattered papulae on its abactinal surface (Fig. 2a). Superomarginal and inferomarginal plates with clusters of spinelets (Fig. 2b). Adambulacral plates, joined to the actinal row, with spinelets and 2–3 spines of the furrow (Fig. 2c).

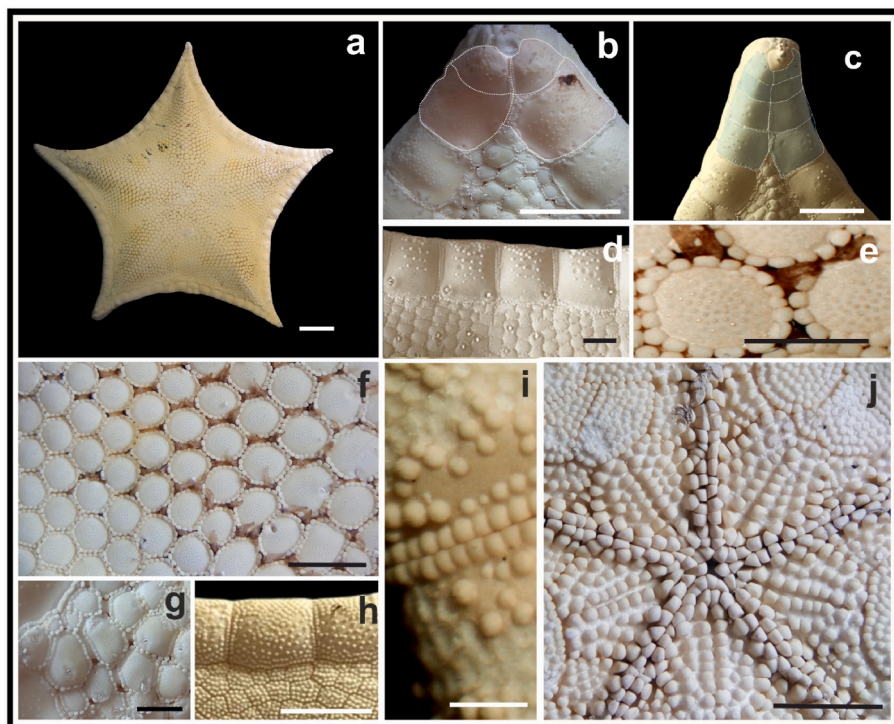


Fig. 5. *Plinthaster dentatus*: a. Abactinal general view. Scale bar: 20 mm. b. Superomarginal plates at the end of the arms. Scale bar: 5 mm. c. Two joined plates pattern. Scale bar: 5 mm. d. Five joined plates patterns. Scale bar: 5 mm. e. Superomarginal plates. Scale bar: 5 mm. f. Abactinal plate with crystal bodies. Scale bar: 2.5 mm. g. Abactinal plates. Scale bar: 5 mm. h. Pedicellariae on abactinal plates. Scale bar: 1.2 mm. i. Inferomarginal plates detail. Scale bar: 5 mm. j. Inferomarginal granules. Scale bar: 1.2 mm. k. Oral plates. Scale bar: 5 mm.

Distribution. Atlantic Ocean, British Seas, Faroe Channel, Ireland, Cantabrian Sea.

Bathymetric range. 700–1500 m (Mortensen, 1927).

Present study: 1228 m.

Remarks. There are 5 species of the genus *Radiaster* Perrier, 1881. Only *R. elegans* Perrier (1881) (Fig. 2 d,e,f,g,h) is present in the influence area. *Radiaster tizardi*: moderate arm length and a large madreporite. *Radiaster elegans*: long arms and a small madreporite.

Order Spinulosida

Family Echinasteridae.

***Henricia caudani* (Koehler, 1895).** AphiaID: 123962. New bathymetric record. (Fig. 3 a-d).

Material examined. 21 specimens: A410DR4, A410DR8, A410DR18, A710DR6, A710DR13, A11DR5, A11DR7, A11G06, A11V06.

Diagnosis. Arms 5, long (Fig. 3a). Reticulated abactinal plates with papulae and a cover of more or less dense spinelets which are fine and slender, in which, each one has 4–7 tips (Fig. 3b). Superomarginal plates merged with abactinal ones (Fig. 3a). Papulae also on the actinal surface (Fig. 3c). Adambulacral plates with a lot of spinelets. Spines in the furrow: up to 3 (Fig. 3d).

Distribution. Atlantic Ocean, Bay of Biscay, North-West Africa, The Canary Islands, both sides of Cape Province, South Africa, Morocco.

Bathymetric range. 650–1140 m (Koehler, 1895; Clark and Downey, 1992).

Present study: 551–1244 m.

Remarks. There are 96 species of the genus *Henricia* Gray, 1840. *Henricia caudani* can be confused with *H. sanguinolenta* (O.F. Müller, 1776), *H. oculata* (Pennant, 1777) and *H. cylindrella* (Sladen, 1883). *Henricia caudani*: long arms broadened basally and narrow tips. Papulae 1–3 per mesh. Adambulacral spines 3, sometimes 4. *Henricia sanguinolenta*: short arms broadened basally and narrow tips. Papulae: 1 (sometimes 3 per mesh). Adambulacral spines: 2–3. *Henricia oculata*: short arms broadened basally and wide and blunt tips. Papulae: 1 (sometimes 2) per mesh. Adambulacral spines: 1–2.

***Henricia sexradiata* (Perrier, 1881).** AphiaID: 178759. New record. New bathymetric record. (Fig. 3 e-h).

Material examined. 1 specimen: A410DR4.

Diagnosis. Arms 6, sometimes 7 (Fig. 3e). Single papulae on abactinal surface (Fig. 3f). The abactinal area with fine spinelets (Fig. 3f). Usually 2 madreporites (sometimes hidden). Rectangular adambulacral plates with small spines or spinelets and 3 furrow spines, 2 of them towards the furrow (Fig. 3g and h).

Distribution. South of Carolina, South of Florida, Gulf of Mexico, Caribbean Sea, coast of Guyana, between Nicaragua and Jamaica and East of Surinam.

Bathymetric range. 29–420 m (USNM E 9735 Downey 1960; Mah, 1993; OBIS database).

Present study: 700 m.

Remarks. This species is easy to identify because it has 6 arms. Nowadays, any other species of Genus *Henricia* with more than 5 arms has been described.

Order Valvatida

Family Goniasteridae.

***Ceramaster grenadensis* (Perrier, 1881).** AphiaID: 124021. (Fig. 4 a-e).

Material examined. 5 specimens: A410DR7, A710DR10, A11DR5.

Diagnosis. Arms 5, short (Fig. 4a). Abactinal plates completely covered by granules (Fig. 4a and b). Usually small and rhombic madreporite. Superomarginal plates crowded by granules, except in the naked patches area. Each superomarginal plate with a naked patch (Fig. 4b). Inferomarginal plates mostly without naked patches and actinal plates completely covered by granules (Fig. 4c and d). Adambulacral plates with 4–6 furrow spines (Fig. 4c, e). Oral spines: 9 (Fig. 4c). Small pedicellariae.

Distribution. Atlantic Ocean, Bay of Biscay, Morocco, The Canary Island, Azores, South Carolina, Florida, Gulf of Mexico, Caribbean Sea,

South of Chile, Brazil, South of Argentina, Antarctic Ocean, Coronation Island, Iles Crozet, Marion Island, West and East Mediterranean Sea, none in the middle of Mediterranean Sea.

Bathymetric range. 0 to 166–2850 m (USNM 33338 Fisher, 1893; Mecho, 2009; OBIS database).

Present study: 342–1150 m.

Remarks. There are 15 species of the genus *Ceramaster* Verrill, 1899. In the area *C. grenadensis* is possible to confuse with *C. granularis* (Retzius, 1783) and *P. placenta* (Müller & Troschel, 1842). *Ceramaster grenadensis* with 9 oral spines. *Ceramaster granularis* with 6–7 oral spines. *Ceramaster grenadensis*: naked patch on each superomarginal. *Peltaster placenta*: completely covered by granules.

***Nymphaster arenatus* (Perrier, 1881).** AphiaID: 124048. (Fig. 4 f-h).

Material examined. 112 specimens: A710DR16, A11G02, A11G03, A11G04, A11G06, A11G07, A11V02, A11V04, A11V05, A11V06, A11V07.

Diagnosis. Arms 5, very long and thin (Fig. 4f). Abactinal plates: completely covered by granules (Fig. 4g). Superomarginal plates abutted over midline for most of the arm distancer. (Fig. 4h). Adambulacral plates with 4–9 spines, usually 7 spines. Oral spines: 8–12 (Fig. 4i). Sugar-tong pedicellariae.

Distribution. British Seas, Ireland, Bay of Biscay, South of Portugal, The Canary Island, coast of Morocco, Cape Verde, Georgia, Gulf of Mexico, Caribbean Sea, coast of Guyana, Brazil from Spirit Santo to Rio de Janeiro, Indic Ocean, Arabian Sea and Bay of Bengal.

Bathymetric range. 20–5053 to 5113 m (FCMM, Balan, 2011; OBIS database; USNM E 38696 Ahearn, 1989).

Present study: 510–1464 m.

Remarks. There are 16 species of the genus *Nymphaster* Sladen, 1889. However, traditionally only three has been mentioned by Clark and Downey (1992) with an Atlantic distribution. The existence of this species was based on the shape of the actinal granules, the presence of one spine on the marginal plates and the length of the subambulacral spine. Nevertheless, the same authors made a careful analysis (involving numerous characters) of numerous specimens from different collections and concluded that there was no basis for distinguishing those three species and therefore they considered only one: *N. arenatus*.

***Peltaster placenta* (Müller & Troschel, 1842).** AphiaID: 124055. (Fig. 4 j-n).

Material examined. 6 specimens: A710DR6, A710DR10, A710DR14, A710DR16, A11DR5, A412ROV7.

Diagnosis. Arms 5, short (Fig. 4j). Abactinal and superomarginal plates: completely covered by granules (Fig. 4k and l). Usually large and round madreporite (Fig. 4j). Inferomarginal and actinal plates covered by granules (Fig. 4m). Adambulacral plates with 4–7 spines of furrow (Fig. 4n). Oral spines: 7–9. With pedicellariae (Fig. 4n).

Distribution. Atlantic Ocean, Iceland, Norway from near Trondheimsfjord South to the Equator, coast of Rhode Island, coast of Georgia, Gulf of Mexico, Caribbean Sea, Argentina Basin, coast of Morocco, West Mediterranean Sea.

Bathymetric range. 2–1853 to 1858 m (USNM E 12578 Downey, 1969; USNM E 53657 Mah, 2001).

Present study: 342–928 m.

Remarks. There are 3 species for the genus *Peltaster* Verrill, 1899. Only *P. placenta* is in North Atlantic waters. *Peltaster placenta* is easy to distinguish them is naked patches on the superomarginal plates of *Ceramaster* which are lacking in *P. placenta*.

***Plinthaster dentatus* (Perrier, 1884).** AphiaID: 124080. (Fig. 5 a-j).

Material examined. 2 specimens: A11V03, A11V06.

Diagnosis. Arms 5, short (Fig. 5a). Abactinal plates surrounded by granules, the centre of plates without granules but with crystal bodies (Fig. 5b, c, d, e, f, g). Papulae: between abactinal plates (Fig. 5f). Superomarginal plates of arms in contact usually 3 of them, sometimes less (Fig. 5b and c). Superomarginal plates with scattered granules (Fig. 5b, c, d). Many granules on inferomarginal plates (Fig. 5h and i).

Extensive actinal area (Fig. 5j). Adambulacral plates: 5–8 spines of the furrow (Fig. 5j). Sometimes with pedicellariae.

Distribution. Atlantic Ocean, British island, Bay of Biscay, Azores, coast of Morocco, Cape Verde, East of North America, from North Carolina to Gulf of Mexico, Caribbean Sea, coast of Guyana, Brazil from Spirito Santo to Rio de Janeiro, Pacific Ocean, East of New Zealand, East of Australia (Tasman Sea).

Bathymetric range. 49–2997 m (USNM E 32279 Boothe, 1981; USNM 7079 Verrill, Peabody Museum, Yale, 1884).

Present study: 1228–1473 m.

Remarks. Four species are present in the genus *Plinthaster* Verrill 1899. Only *P. dentatus* is the only known Atlantic species. This species shows a wide range of variation. The number of distal superomarginal in contact depends on specimens. It can vary between 1 and 2, 3 or sometimes more. This makes it possible to confuse it with other genera, such as *Sphaeriodiscus* Fisher, 1910 or *Peltaster* but there are many

features to distinguish them. For instance, the crystal bodies of *Plinthaster* do not appear in *Peltaster* or *Sphaeriodiscus*.

Family Odontasteridae.

Odontaster mediterraneus (von Marenzeller, 1893). AphiaID: 124091. (Supplementary material: Fig. 6 a-c).

Material examined. 1 specimen: A410DR4.

Diagnosis. Arms 5, short (Fig. 6a). Papular area: at the base of arms. Abactinal plates with spinelets. A lot of short spinelets in superomarginal plates and distal areas with crystal bodies (Fig. 6a and b). Inferomarginal plates with spinelets longer than spinelets in superomarginal plates and 3–4 furrow spines (Fig. 6c). Recurved spines on jaw (Fig. 6d). Usually without pedicellariae.

Distribution. Atlantic Ocean, British Seas, Bay of Biscay, Mediterranean Sea, Alboran Sea, Tyrrhenian Sea, Adriatic Sea, Sea of Crete, South of Cyprus.

Bathymetric range. 99.6–1804 m (Mifsud et al., 2009; Koehler,

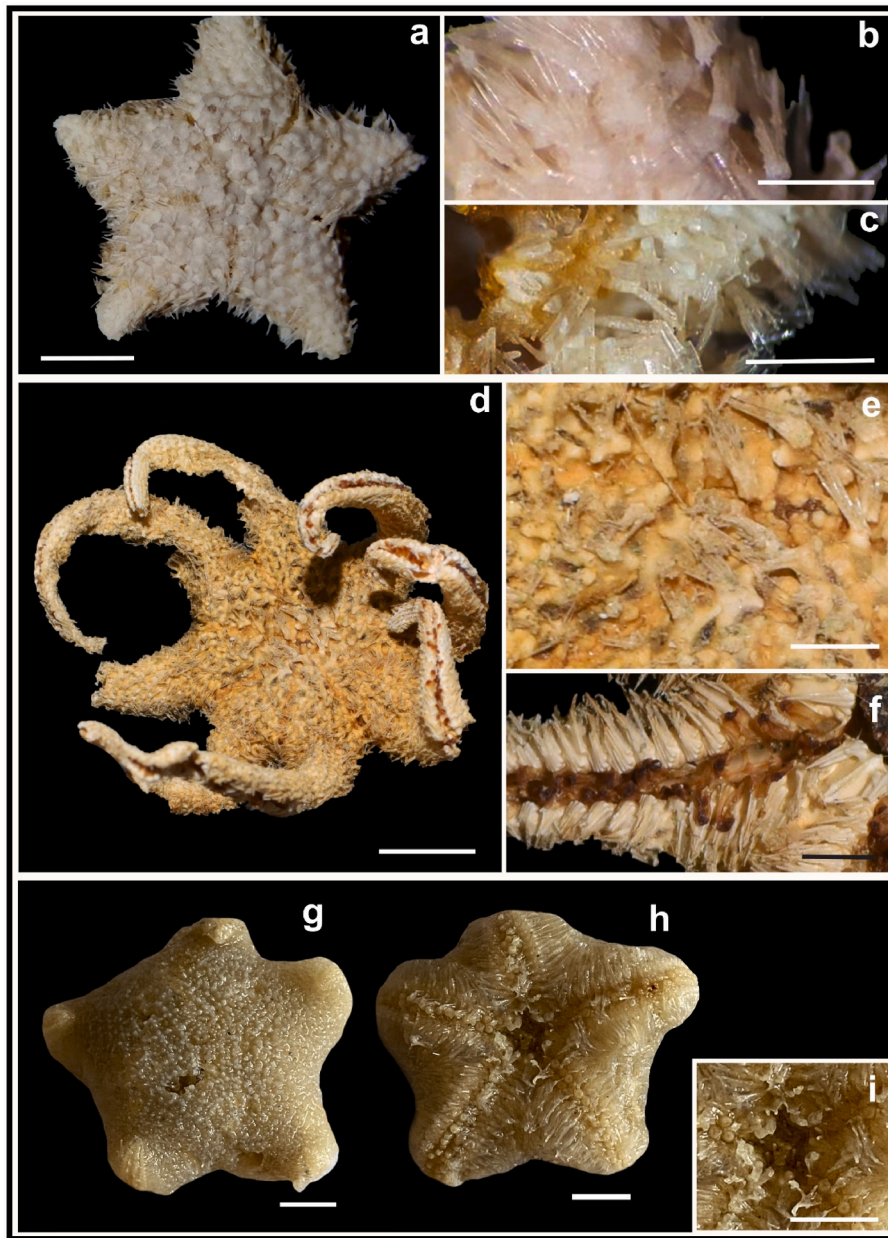


Fig. 6. *Korethraster hispidus*: a. Abactinal side. Scale bar: 2.5 mm. b. Abactinal spines. Scale bar: 0.6 mm. c. Marginal spines. Scale bar: 1.2 mm. *Myxaster perrieri*: d. Abactinal side. Scale bar: 20 mm. e. Abactinal lobed plates. Scale bar: 5 mm. f. Adambulacral plates and furrow spines. Scale bar: 10 mm. *Pteraster militaris*: g. Abactinal side. Scale bar: 5 mm. h. Actinal view. Scale bar: 5 mm. i. Oral plates. Scale bar: 5 mm.

1909).

Present study: 700 m.

Remarks. There are 16 species of the genus *Odontaster* Verrill, 1880. In North Atlantic waters there are 5 species. *Odontaster crassus* Fisher, 1905, *O. mediterraneus* (von Marenzeller, 1893), *O. hispidus* Verrill, 1880, *O. robustus* Verrill, 1899 and *O. setosus* Verrill, 1899. Due to the distribution area and morphological features, *O. mediterraneus* can be confused with *O. crassus*. *Odontaster mediterraneus*: inferomarginal plates with longer and stouter spinelets. Actinal armament fine. Spines of furrow: 3–4. Crystal bodies on distal superomarginal plates. *Odontaster crassus*: inferomarginal armament with granuliform spinulation. Actinal armament 6–7 spinelets. Spinelets on the furrow: 2 (sometimes 3).

Family Poraniidae.

Porania pulvillus (O.F. Müller, 1776). AphiaID: 125166. (Supplementary material: Fig. 6 e-g).

Material examined. 1 specimen: A11G06.

Diagnosis. Arms 5 (Fig. 6e). On the abactinal surface scattered groups of papulae (Fig. 6f). Superomarginal plates without armament (Fig. 6e). Inferomarginal plates with 1–5 spines (Fig. 6g and h). Adambulacral plates with 1–2 spines of the furrow and 1 subambulacral spine (Fig. 6g). On the distal area sometimes, with another subambulacral spine.

Distribution. Atlantic Ocean, Norwegian Sea, North Sea, British Island, Biscay Bay, North-east America from Labrador Sea to North Carolina and Gulf of Mexico, coast of Guyana.

Bathymetric range. 10–1558 m (Mortensen, 1927; USNM 11409 Verrill, 1885).

Present study: 1244 m.

Remarks. There are 3 species of *Porania* Gray, 1840). *Porania (Porania) hermanni* Madsen, 1959, *P. (Pseudoporania) stormi* Dons, 1936 and *P. pulvillus*. This species can be confused with *P. stormi* Dons, 1936. *Porania pulvillus*: more angular shape of its marginal plates and between 1 and 5 inferomarginal spines. *Porania stormi*: rounded marginal plates and usually without inferomarginal spines.

Poraniomorpha hispida (M. Sars, 1872). AphiaID: 125170. (Supplementary material: Fig. 6 i-l).

Material examined. 2 specimens: A11DR7.

Diagnosis. Arms 5, short (Fig. 6i). Inflated and cushion shape of the body (Fig. 6i). Abactinal plates with little papilliform spinules and groups of papulae 10–15, sometimes 20 (Fig. 6i and j). Actinal plates usually with stretch marks and spinules (Fig. 6k). Adambulacral plates: with 2 furrow spines (almost all of them) (Fig. 6l). Oral plate: (each one) up to 5 oral furrow spines and 3 suboral spines (Fig. 6k).

Distribution. Atlantic Ocean, Extending South from the Arctic to the Cape Cod area, Norwegian Sea, North Sea, British Island, Faroe Channel, Ireland, coast of North America from Baffin Bay to Georgia.

Bathymetric range. 90–1990 to 2020 m (Mortensen, 1927; USNM E 34637 Downey, 1987).

Present study: 551 m.

Remarks. There are 4 species of the genus *Poraniomorpha* Danielssen & Koren, 1881. *Poraniomorpha hispida*, *P. abyssicola* (Verrill, 1895) from North–East America. *Poraniomorpha bidens* Mortensen, 1932 from Baffin Bay and Arctic Ocean. *Poraniomorpha tumida* (Stuxberg, 1878) from Baffin Bay North Atlantic Ocean and Arctic Ocean. *Poraniomorpha hispida*: almost pentagonal. Abactinal armament: fine papilliform spinules with groups of 10–20 papulae. Superomarginal plates similar to inferomarginal ones. *Poraniomorpha abyssicola*: stellate. Abactinal armament: is composed of coarse granules and spinules. Papulae are ungrouped. *Poraniomorpha bidens*: stellate. Abactinal armament: fine paxilliform without groups of papulae. Superomarginal plates taller than inferomarginal. *Poraniomorpha tumida*: stellate. Abactinal armament: coarse granuliform and with spinules. With groups of 10 papulae. Superomarginal plates taller than inferomarginal ones.

Order Velatida

Family Korethrasteridae.

Koethraster hispidus Wyville Thomson, 1873. AphiaID: 124123.

(Fig. 6 a-c).

Material examined. 9 specimens: A410DR18.

Diagnosis. Arms 5 (Fig. 6a). Imbricated abactinal plates with 6–10 spinelets at the base with brush-shape (Fig. 6b). Marginal plates undistinguished (Fig. 6a). Adambulacral plates with 3–4 spines. Rows of ambulacral tube feet: 4 (Fig. 6c). Oral spines in each side: 4.

Distribution. Arctic Ocean, Kara Sea, Atlantic Ocean, Faroe Channel, Norwegian Sea, coast of Galician.

Bathymetric range. 85–1226 m (Clark and Downey, 1992; Perrier, 1881).

Present study: 767 m.

Remarks. There are no other similar species in the ACS that could be confused with *K. hispidus*.

Family Myxasteridae.

Myxaster perrieri Koehler, (1895). AphiaID: 124125. New bathymetric record. (Fig. 6 d-f).

Material examined. 2 specimens: A11G03.

Diagnosis. Arms 8 (Fig. 6d). Imbricated and lobed abactinal plates with webbed spines (Fig. 6e). Isolated actinal spines (Fig. 6f). Oblique adambulacral spines: 5. Suboral spines: 3 (Fig. 6f).

Distribution. Bay of Biscay.

Bathymetric range. 1300 m (Clark and Downey, 1992).

Present study: 1464 m.

Remarks. There are 3 species of the genus *Myxaster* Perrier, 1885: *M. medusa* (Fisher, 1913) (9–10 arms and 5–6 oral spines), *M. sol* Perrier, (1885) (9–10 arms, 8 adambulacral spines and 4 oral spines) and *M. perrieri*. (8 arms, 5 adambulacral spines and 3 oral spines). The specimens collected in ACS present the same features than *M. perrieri*, except for the number of arms. The holotype of *M. perrieri* presents 6 arms as described by Koehler in 1895, based on a unique specimen which did not allow us to appreciate the probable variation of the number of arms. However, we got two specimens with 8 arms each, results which would support the idea of variability rather than be specimens of a new species.

Family Pterasteridae.

Pteraster militaris (O.F. Müller, 1776). AphiaID: 124147. (Fig. 6 g-i).

Material examined. 1 specimen: A11DR7.

Diagnosis. Arms 5–6 (Fig. 6g). Supradorsal thick and warty membrane with numerous calcareous deposits. Paxillae with 3–5 spines. Osculum surrounded by spines (Fig. 6g). Adambulacral spines: 5–9. Spines of the furrow: 2. Webbed oral spines: 5–8. Hyaline suboral spine: 1 large and stout. (Fig. 6h and i).

Distribution. Arctic ocean, Atlantic Ocean, Barents Sea, Greenland Sea, Kara Sea, Norwegian Sea, North Sea, coast of Galician, the North-East America coast from Baffin Bay to New Jersey, Gulf of Mexico, Mediterranean Sea, Siberian East Sea, Pacific Ocean, Gulf of Alaska and Bering Sea, Ojostok Sea, Japan Sea.

Bathymetric range. 5–3713 m (McClary and Mladenov, 1990; USNM E 13839 Solis-Marin, Universidad Nacional Autonoma de Mexico, 2006).

Present study: 551 m.

Remarks. There are 48 species of the genus *Pteraster* Müller & Trotschel, 1842. However, *P. militaris* can be confused with: *P. alveolatus* Perrier, 1894, *P. hystrix* Harvey, 1989, *P. obscurus* (Perrier, 1891), *P. personatus* Sladen, 1891 and *P. pulvillus* M. Sars, 1861. *Pteraster militaris* presents 3–5 paxillar spines. The other species present more than 6 paxillar spines.

3.2. Database and distribution

Asteroids IEEM framed by NAMD, and the chosen bathymetric range (266–1476m depth) contains 48 species, where 22 species of ACS are included, and 2 species should be considered new records for NAMD *H. sexradiata* and *R. tizardi*. Both together with *M. perrieri* represent 3 new contributions for IEEM.

On the other hand, 24 species from this checklist were not found.

Asterias rubens Linnaeus, 175 *B. vexillifer* (Wyville Thomson, 1873), *B. spinosus* Verrill, 1884, *C. granularis* (Retzius, 1783), *Chaetaster longipes* (Bruzelius, 1805), *Cheiraster (Cheiraster) sepius* (Verrill, 1885), *Chondraster grandis* (Verrill, 1878), *Crossaster papposus* (Linnaeus, 1767), *Culcitopsis borealis* (Süssbach & Breckner, 1911), *Dytaster grandis grandis* (Verrill, 1884), *Echinaster (Echinaster) sepositus* (Retzius, 1783), *H. cylindrella* (Sladen, 1883), *H. pertusa* (O.F. Müller, 1776), *Hymenaster pellucidus* Thomson, 1873, *H. coronata* (Sars, 1871), *L. ciliaris* (Philippi, 1837), *P. agassizi notatus* Sladen, (1889), *P. gracilis* (Sladen, 1889), *P. personatus* Sladen, 1891, *Sclerasterias guernei* Perrier, 1891, *S. neglecta* (Perrier, 1891), *Stichasterella rosea* (O.F. Müller, 1776), *Tethyaster subinermis* (Philippi, 1837) and *Pedicellaster typicus* M. Sars, 1861.

4. Discussion

Despite the scarcity of the studies on Asteroids from Spanish waters, some Asteroid checklists are available. The most important one is the IEEM (Asteroidea: Manjón-Cabeza et al., 2017, 2020). This checklist was made based on the creation of a series of geographic polygons that delimited the Spanish waters, and among them NAMD was defined, where is located ASC (Fig. 1*). This checklist is a great effort to record all those species collected in the area that come from bibliographic references, or from campaign reports and personal communications. Many of the records are not ratified by specialists, which makes it more difficult to analyze the reliability of those records. However, this is the first attempt for building a showcase for Spanish marine diversity studies and therefore it should be extensively revised and improved in the next future. To illustrate this fact, genus as *Sclerasterias* Perrier, 1891, species as *C. borealis* (Süssbach & Breckner, 1911), *S. rosea* (O.F. Müller, 1776), *P. typicus* M. Sars, 1861, and *C. granularis* (Retzius, 1783), among others, are under taxonomic revision (Manjón-Cabeza personal communication).

Based on that dataset, some species are absent of our area of study. We have not found arguments to explain the absence of the rest of the species because ecological studies have not been carried out yet. It will be done soon, and the results could help to understand the community assemblages and the appropriate species adjustment of these environments (from both a geological and biological point of view), and where the sampling methodological limitations should be considered as size of the rock dredge, among others.

According to the faunal results, ASC presents a typical Asteroids community of rocky deep seafloor, very similar to other studies made in North-Atlantic waters (Gage et al., 1983; Dilman, 2008) where Astropectinids and Goniasterids are the families that occur frequently in the area.

Two species are proposed as new records at the area of study. *Radiaster tizardi* has been collected in adjacent waters (Murillo et al., 2016; Clark and Downey, 1992), and it was a potential species for living in the SCA. *Henricia sexradiata* distribution area is restricted to Gulf of Mexico and Caribbean Sea. There is no evidence of any record in the middle of the Atlantic Sea, or near our area of study. Therefore, it should be considered as alien species although its origin is unknown. Consequently, its occurrence could be explained under different approaches, as the influence of Gulf streaming or the anthropogenic influence. Some authors argue that the continued incorporation of South America species is an indicator of the Cantabrian Sea tropicalization (Arias et al., 2014; Arias and Crocetta, 2016). However, in our view, the presence of *R. tizardi* (typical northern/cold waters) as well as *H. sexradiata* in the West Atlantic confirm their amphiatlantic distribution, which seems to be favored by the concurrence of tropical (Gulf Stream) and northern waters (ENACW, LSW and NAWD). This argument supports the idea that Cantabrian marine species could have different biogeographic origins (Arias and Crocetta, 2016).

5. Conclusions

ASC presents a typical asteroid community of rocky deep bottoms, which are represented mainly by two taxonomic families, Astropectinidae and Goniasteridae. Two species are proposed as new records at the area of study *R. tizardi* and *H. sexradiata*, showing the dual influence in the area of the North Atlantic Sea and the Caribbean one.

CRedit authorship contribution statement

Laura M. García-Guillén: Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Aurora Macías-Ramírez:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Pilar Ríos:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M. Eugenia Manjón-Cabeza:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.ecss.2022.107993>.

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