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Sharks, rays and chimaeras of the Seine and Unicorn seamounts (NE Atlantic Ocean)

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Abstract

Background: Seamounts are underwater mountains which typically rise rather steeply at least several hundred meters above the deep-sea floor. These geological features interrupt water flow and hence may induce changes in the circulation of different water masses, in turn causing different physical and biological effects. For this reason, seamounts are biodiversity hotspots, housing a wide number of species, as is with the case of the Seine and Unicorn seamounts, which are a part of the Madeira-Tore seamount chain located between Portugal mainland, southwestern Europe and Madeira archipelago (NE Atlantic).

Methods: Fisheries independent surveys allowed the collection of Chondrichthyes specimens from the Seine and Unicorn seamounts. Individuals were caught over the course of two research cruises, first in 2004 and later in 2017, with species distribution ranging from the summit down to 2500 m of depth.

Results: Fifteen species belonging to 7 different taxonomical families were collected in the two surveyed areas. Two species were recorded for the first time and added to the checklist of the Seine seamount (*Centrophorus granulosus* and *Somniosus rostratus*), and three species for the Unicorn seamount (*C. granulosus*, *Centroscymnus coelolepis* and *Centroselachus crepidater*). Distribution and frequency of occurrence for the collected species were evaluated in relation to depth.

Conclusions: This work is a valuable contribution to the knowledge of seamount-associated fish fauna. Moreover, the checklist of sharks, rays and chimaeras was updated for the Seine and Unicorn seamounts, summing up 20 species.

Keywords: Chondrichthyes, Seamounts, Fisheries, Conservation, NE Atlantic Ocean

Background

Seamounts are underwater volcanoes that did not break the sea surface and turn into islands (Kitcingman & Lai, 2004). They host a wide number of species and are considered as biodiversity hotspots, due to their intrinsic

physical and biological characteristics. Nonetheless, many seamount species (ca. 26%) have been discovered and described in the last 50 years (Froese & Sampang, 2004). In fact, if scientific surveys at seamounts were further encouraged, many new and undescribed species would likely be found (Froese & Sampang, 2004).

The deep-sea fish fauna of Madeira archipelago (NE Atlantic) has been the object of study of several ichthyologists over the last 150 years. Most species are caught in drifting longlines by local fishermen during the artisanal black-scabbard (*Aphanopus carbo* Lowe, 1839 and *Aphanopus intermedius* Parin, 1983) fishery, which dates

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back to the early seventeenth century (Merrett and Hae-drich, 1997; Silva and Menezes, 1921).

Despite seamount fish fauna having been previously described in several studies, few works have included species captured below 600 m (Tracey et al., 2004). Therefore, many of these deep ocean fish communities remain uncovered and descriptions are restricted to sampling effort, which is primarily associated with fishing activities. Consequently, there is still a knowledge gap regarding seamount associated elasmobranchs (Menezes et al., 2009; Christiansen et al., 2015; Vieira et al., 2018).

The Seine and Unicorn seamounts belong to the Madeira-Tore seamount chain located between Portugal mainland and Madeira archipelago. These seamounts are of special interest and Portugal plans to classify them as Marine Protected Areas (MPAs) in the next years under the European Marine Strategy Framework Directive (EU-MSFD), in light of the fact that these areas often play an important role in species biogeography and connectivity between key stone habitats (Koslow et al., 2016).

This study aims to contribute to the knowledge of fish diversity of the Seine and Unicorn seamounts at different depth strata down to 2500 m. Data on the occurrence of Chondrichthyes species for these ecologically important areas is provided with an update of the existing checklist.

Materials and methods

Specimens were collected in 2004 and in 2017, within the scope of RECPROF MAD and BIOMETORE research surveys. Both surveys were conducted for biodiversity assessment of seamount-associated fish fauna. Fishing sets were carried out from the top of the seamounts to around 2500 m depth. Drifting and bottom longlines, as well as two types of baited traps were used at Unicorn (34° 35'N, 14° 28'W) and Seine seamounts (33° 45'N, 14° 22'W) (Biscoito et al., 2017).

All specimens were identified to species level, counted and weighed on board. Additionally, they were photographed before being preserved. Once at the laboratory, all individuals were measured (total length TL, in mm), weighed (total weight TW, in g) and sexed. Voucher specimens from the 2004 and 2017 cruises were deposited in museum collections (Funchal Natural History Museum - MMF and The National Museum of Natural History, Lisbon).

A new complete annotated checklist for the Seine and Unicorn seamounts was produced. In order to revise the list of Chondrichthyes species previously recorded for these areas, MMF collections and scientific literature were assessed.

Species frequency of occurrence was classified into four classes, to which different colours were assigned: red – rare (1 specimen); yellow – occasional (2 to 4 specimens); light green – common (5 to 10 specimens) and dark green – very common (> 10 specimens).

Furthermore, the Food and Agriculture Organization (FAO) species catalog for fisheries purposes for the North Atlantic (Ebert and Stehmann, 2013) was consulted for geographic distribution confirmation and previous records for the archipelago of Madeira.

For each species depth range and maximum size are listed according to Ebert and Stehmann (2013). In addition, species susceptibility to locally used fishing gear and corresponding IUCN Red List status in Europe (Nieto et al., 2015) is provided.

Occurrence data for the collected species was plotted against depth to illustrate the dominant depth strata for each species. This allowed the addition of new information on the vertical distribution of these species at the Seine and Unicorn seamounts.

Results

A total of 134 chondrichthyans (129 sharks, 3 rays and 2 chimaeras species) were captured and correspond to fifteen different species from 7 families: Carcharhinidae, Centrophoridae, Etmopteridae, Somniosidae, Torpedinidae, Rajidae and Chimaeridae.

For the Seine seamount, 66 specimens belonging to 14 different species were identified in the present study (Table 1). Two species (*Centrophorus granulosus* and *Somniosus rostratus*) are recorded for the first time for this seamount, increasing the total number of species to 17.

Regarding the Unicorn seamount, 8 species from a total of 68 specimens were reported in the present study. Three (*Centrophorus granulosus*, *Centroscymnus coelolepis* and *Centroselachus crepidater*) of which were recorded for the first time for this seamount, consequently increasing the total number of species to 11.

Finally, frequency of occurrence of cartilaginous fish species is presented in Table 2. The most frequently observed species were *D. calcea*, *Etmopterus princeps*, *Etmopterus pusillus*, *C. coelolepis* and *Centroscymnus owstonii*, with more than 10 specimens captured each. In turn, the less frequently observed species were *Prionace glauca*, *S. rostratus* and *Tetronarce. Nobiliana*, with only 1 specimen collected.

Detailed information regarding the species collected during the present study is given below:

ORDER CARCHARHINIFORMES

Family carcharhinidae

Prionace glauca (Linnaeus, 1758) - Common names: Tintureira; Blue shark.

Table 1 List of cartilaginous fish species recorded for the Seine and Unicorn seamounts from the present study and previous work

	Occurrence in seamounts		References
	Seine	Unicorn	
Family Chlamydoselachidae			
<i>Chlamydoselachus anguineus</i> Garman, 1884		✓	Delgado et al. (2017)
Family Carcharhinidae			
<i>Prionace glauca</i> (Linnaeus, 1758)		✓	Biscoito et al. (2017); present study
Family Pentanchidae			
<i>Galeus melastomus</i> Rafinesque, 1810	✓		Menezes et al. (2009)
Family Pseudotriakidae			
<i>Pseudotriakis microdon</i> Brito Capello, 1868	✓		Menezes et al. (2009)
Family Centrophoridae			
<i>Centrophorus granulosus</i> (Bloch & Schneider, 1801)	*	✓	Seine: present study. Unicorn: Biscoito et al. (2017); present study
<i>Centrophorus squamosus</i> (Bonaterre, 1788)	✓	*	Seine: Menezes et al. (2009); present study. Unicorn: present study
<i>Deania calcea</i> (Lowe, 1839)	✓		Menezes et al. (2009)
<i>Deania profundorum</i> (Smith & Radcliffe, 1912)	✓	✓	Seine: Menezes et al. (2009); present study. Unicorn: Biscoito et al. (2017); Freitas & Biscoito (2007); present study
Family Dalatiidae			
<i>Squaliolus laticaudus</i> Smith & Radcliffe, 1912	✓		Menezes et al. (2009)
Family Etmopteridae			
<i>Etmopterus princeps</i> Collet, 1904	✓	✓	Seine: Menezes et al. (2009); Freitas & Biscoito (2005); present study. Unicorn: Biscoito et al. (2017); Freitas & Biscoito (2007); present study
<i>Etmopterus pusillus</i> (Lowe, 1839)	✓	✓	Seine: Menezes et al. (2009); Christiansen et al. (2015); present study. Unicorn: Biscoito et al. (2017); present study
<i>Etmopterus spinax</i> (Linnaeus, 1758)		✓	Seine: present study. Unicorn: Biscoito et al. (2018); present study
Family Somniosidae			
<i>Centroscymnus coelelepis</i> Barbosa du Bocage & de Brito Capello, 1864	✓	*	Seine: Menezes et al. (2009); Biscoito et al. (2017); present study. Unicorn: present study
<i>Centroscymnus owstonii</i> Garman, 1906	✓	✓	Seine: Menezes et al. (2009); Biscoito et al. (2018); present study. Unicorn: Biscoito et al. (2018); Biscoito et al. (2017); present study
<i>Centroselachus crepidater</i> (Barbosa du Bocage & de Brito Capello, 1864)	✓	*	Seine: Menezes et al. (2009); present study. Unicorn: present study
<i>Somniosus rostratus</i> (Risso, 1827)	*		Present study
Family Torpedinidae			
<i>Tetronarce nobiliana</i> (Bonaparte, 1835)	✓		Hirsch & Christiansen (2010); Biscoito et al. (2018); present study
Family Rajidae			
<i>Raja clavata</i> Linnaeus, 1758	✓		Menezes et al. (2009)
<i>Raja maderensis</i> Lowe, 1838	✓		Christiansen et al. (2009); Biscoito et al. (2017); present study
Family Chimaeridae			
<i>Hydrolagus affinis</i> (de Brito Capello, 1868)	✓		Menezes et al. (2009); Freitas et al. (2011); Biscoito et al. (2018); present study

* -first record.

First published record for Madeira archipelago in Lowe (1838).

This species is a common oceanic shark usually caught with pelagic longlines, hook and lines, pelagic trawls and bottom trawls near the coast (Davidson et al., 2015).

One specimen with 1910 mm TL was caught at 750 m at Unicorn seamount.

Frequency of occurrence: Red (rare).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Table 2 Frequency of occurrence of cartilaginous fish species caught at the Seine and Unicorn seamounts during the present study. Red - rare (1 specimen); yellow – occasional (2 to 4 specimens); light green - common (5 to 10 specimens); dark green - very common (> 10 specimens)

Taxonomy	Occurrence
Order Carcharhiniiformes	
Family Carcharhinidae	
<i>Prionace glauca</i> (Linnaeus, 1758)	Red
Order Squaliformes	
Family Centrophoridae	
<i>Centrophorus granulosus</i> (Bloch & Schneider, 1801)	Light green
<i>Centrophorus squamosus</i> (Bonnaterre, 1788)	Dark green
<i>Deania calcea</i> (Lowe, 1839)	Light green
<i>Deania profundorum</i> (Smith & Radcliffe, 1912)	Light green
Family Etmopteridae	
<i>Etmopterus princeps</i> Collett, 1904	Dark green
<i>Etmopterus pusillus</i> (Lowe, 1839)	Dark green
<i>Etmopterus spinax</i> (Linnaeus, 1758)	Yellow
Family Somniosidae	
<i>Centroscymnus coelolepis</i> Barbosa du Bocage & de Brito Capello, 1864	Dark green
<i>Centroscymnus owstonii</i> Garman, 1906	Dark green
<i>Centroselachus crepidater</i> (Barbosa du Bocage & de Brito Capello, 1864)	Light green
<i>Somniosus rostratus</i> (Risso, 1827)	Red
Order Torpediniiformes	
Family Torpedinidae	
<i>Tetronarce nobiliana</i> (Bonaparte, 1835)	Red
Order Rajiformes	
Family Rajidae	
<i>Raja maderensis</i> Lowe, 1838	Yellow
Order Chimaeriformes	
Family Chimaeridae	
<i>Hydrolagus affinis</i> (de Brito Capello, 1867)	Yellow

Depth range (Ebert and Stehmann, 2013): 0 to 350 m.

Maximum size (Ebert and Stehmann, 2013): 3830 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Near Threatened (NT) [Europe] / Least Concern (LC) [Global]
Remarks: Although this specimen was caught on a bottom longline set at 750 m of depth, it is not possible to confirm if it was hooked at that depth or at midwater, either during the setting or hauling the gear.

Order squaliformes

Family centrophoridae

Centrophorus granulosus (Bloch & Schneider, 1801) - Common names: Ramudo; Gulper shark.

First published record for Madeira in Günther (1870).

This species occurs off the outer continental shelves and upper slopes, frequently over or near the bottom.

Nine specimens ranging from 474 to 1540 mm TL were caught at Seine (3) and Unicorn (6) seamounts between 750 and 1000 m depth, using bottom longlines.

Frequency of occurrence: Light green (common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 50 to 1440 m.

Maximum size (Ebert and Stehmann, 2013): 1660 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Critically Endangered (CR) [Europe] / Endangered (E) [Global].

Centrophorus squamosus (Bonnaterre, 1788) - Common names: Xara-branca; Leafscale gulper shark.

First published record for Madeira in Lowe (1852). This species is a large deep-water gulper shark that occurs on the continental slopes and in the epipelagic or mesopelagic zone.

Five specimens ranging from 1062 to 1275 mm TL were caught at Seine (4) and Unicorn (1) seamounts at 1000 m depth, using bottom longlines.

Frequency of occurrence: Light green (common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 229 to 2359 m.

Maximum size (Ebert and Stehmann, 2013): 1640 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Endangered (EN) [Europe] / Endangered (EN) [Global].

Deania calcea (Lowe, 1839) - Common names: Gata; Birdbeak dogfish.

First published record from Madeira in Lowe (1839) as *Acanthidium calceus*.

This is the largest and probably the most common of the three *Deania* species occurring in Madeira (see remarks) and is caught as by-catch of the black scabbardfish fishery. The biology of this species is poorly known.

Fifteen specimens ranging from 579 to 1033 mm TL were caught at Seine seamount at 1000 m depth, using bottom longline.

Frequency of occurrence: Dark green (very common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 60 to 1490 m.

Maximum size (Ebert and Stehmann, 2013): 1110 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Data Deficient (DD) [Europe]/ Near Threatened (NT) [Global].

Remarks: This species validity has recently been questioned as phylogenetic analyses did not indicate *D.*

calcea to be a distinct lineage from *D. hystricosa* in the NE Atlantic (Steffani et al., 2021). If accepted, there are only two species of *Deania* in Madeiran waters, *D. calcea* and *D. profundorum*, both occurring at the Seine Seamount.

Deania profundorum (Smith & Radcliffe, 1912) - Common names: Sapata; Arrowhead dogfish.

First published record for Madeira and Seine seamount in Freitas & Biscoito (2007).

This is the only *Deania* species with a subcaudal keel beneath the caudal peduncle. It is caught as by-catch in the demersal fishery and its biology is poorly known.

Nine specimens ranging from 551 to 983 mm TL were caught at Seine (4) and Unicorn (5) seamounts between 750 and 1000 m depth, using bottom longlines.

Frequency of occurrence: Light green (common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): No.

Depth range (Ebert and Stehmann, 2013): 275 to 1785 m.

Maximum size (Ebert and Stehmann, 2013): 970 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Data Deficient (DD) [Europe] / Endangered (E) [Global].

Family etmopteridae

Etmopterus princeps Collett, 1904 - Common names: Lixinha-da-fundura; Great lanternshark.

First published record for Madeira and for the Seine seamount in Freitas & Biscoito (2007).

This is the largest species of *Etmopterus* and can be distinguished from other species of the genus by its lateral trunk denticles with fairly thick and stout cusps, forming inconspicuous, regular longitudinal rows on caudal peduncle and caudal-fin base. It has been recorded for both sides of the North Atlantic.

Twenty-five specimens ranging from 230 to 678 mm TL were caught at Seine (4) and Unicorn (21) seamounts between 750 and 2000 m depth, using bottom longlines and traps.

Frequency of occurrence: Dark green (very common).

Recorded from Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): No.

Depth range (Ebert and Stehmann, 2013): 800 to 1000 m.

Maximum size (Ebert and Stehmann, 2013): 890 mm TL.

Local gear susceptibility: Bottom longlines and traps.

IUCN Red List status: Least Concern (LC) [Europe] / Least Concern (LC) [Global].

Etmopterus pusillus (Lowe, 1839) - Common names: Xarinha-preta; Smooth lanternshark.

Species described by Lowe (1839) as *Acanthidium pusillum*, although previously recorded by the same author (Lowe, 1834) under the preoccupied name *Centrina nigra*.

This species is caught as by-catch of the black scabbardfish fishery and Madeira is the locality type for this species (Syntype BMNH 1855.11.19.27).

Sixteen specimens ranging from 350 to 467 mm TL were caught at Seine (4) and Unicorn (12) seamounts between 750 and 2500 m depth, using bottom longlines and traps.

Frequency of occurrence: Dark green (very common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 110 to 1000 m.

Maximum size (Ebert and Stehmann, 2013): 502 mm TL.

Local gear susceptibility: Bottom longlines and traps.

IUCN Red List status in Europe: Data Deficient (DD) [Europe] / Least Concern (LC) [Global].

Etmopterus spinax (Linnaeus, 1758) - Common names: Lixinha-da-fundura; Velvet belly.

First published record for Madeira by Noronha & Sarmento (1934) as *Spinax spinax*.

According to Maul (1948) this species is rare and occurs offshore.

Three specimens ranging from 411 to 461 mm TL were caught at Unicorn seamount at 750 m depth, using bottom longlines and traps.

Frequency of occurrence: Yellow (occasional).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): No.

Depth range (Ebert and Stehmann, 2013): 70 to 2000 m.

Maximum size (Ebert and Stehmann, 2013): 410 mm TL.

Local gear susceptibility: Bottom longlines and traps.

IUCN Red List status: Near Threatened (NT) [Europe] / Vulnerable (VU) [Global].

Family somniosidae

Centroscymnus coelolepis Barbosa du Bocage & de Brito Capello, 1864 - Common names: Xara-preta; Portuguese dogfish.

First published record for Madeira in Günther (1870) as *Centrophorus coelolepis*.

This little-known species occurs on or near the bottom on continental slopes and upper and middle rises.

Twenty-nine specimens ranging from 713 to 1115 mm TL were caught at Seine (17) and Unicorn (12) seamounts between 1500 and 2500 m depth, using bottom longlines and traps.

Frequency of occurrence: Dark green (very common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 128 to 3675 m.

Maximum size (Ebert and Stehmann, 2013): 1220 mm TL.

Local gear susceptibility: Bottom longlines and traps.

IUCN Red List status: Endangered (EN) [Europe] / Near Threatened (NT) [Global].

Centroscymnus owstonii Garman, 1906 - Common names: Xara-preta-de-natura; Roughskin dogfish.

First published record for Madeira in Günther (1870) as *Centrophorus coelolepis* (see remarks in Biscoito et al. 2018: 474).

This little-known dogfish occurs off the outer continental shelves and upper continental slopes, on or near bottom.

Eleven specimens ranging from 711 to 1096 mm TL were caught at Seine (7) and Unicorn (4) seamounts between 1000 and 1500 m depth using bottom longlines and traps.

Frequency of occurrence: Dark green (very common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 150–1459 m.

Maximum size (Ebert and Stehmann, 2013): 1200 mm TL.

Local gear susceptibility: Bottom longlines and traps.

IUCN Red List status in Europe: Not assessed [Europe] / Vulnerable (VU) [Global] (Finucci & Kyne, 2018).

Centroselachus crepidater (Barbosa du Bocage & de Brito Capello, 1864) - Common names: Sapata-de-natura; Longnose velvet dogfish.

First published record for Madeira in Günther (1870) as *Centrophorus crepidater*. This deep-water shark occurs along the upper continental and insular slopes on or near the bottom.

Five specimens ranging from 558 to 668 mm TL were caught at Seine (2) and Unicorn (3) seamounts at 1500 m depth using bottom longlines.

Frequency of occurrence: Light green (common).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 200–1500 m.

Maximum size (Ebert and Stehmann, 2013): 1050 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Least Concern (LC) [Europe] / Near Threatened (NT) [Global].

Somniosus rostratus (Risso, 1827) - Common names: Trabolha-de-natura; Little sleeper shark.

First published record for the Madeira of two specimens in Maul (1955). This deep-water shark rarely occurs in the region and only a few records exist on the outer continental shelf and upper slope of the northeast Atlantic and western Mediterranean Sea.

One specimen with 1120 mm TL was caught in Seine seamount at 1000 m depth using bottom longline.

Frequency of occurrence: Red (rare).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 180–2200 m.

Maximum size (Ebert and Stehmann, 2013): 1430 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Data Deficient (DD) [Europe] / Least Concern (LC) [Global].

Order torpediniformes

Family torpedinidae

Tetronarce nobiliana (Bonaparte, 1835) - Common names: Tremelga; Electric ray.

First published record for the Madeira by Lowe (1938) as *Torpedo hebetans* and confirmed as *T. nobiliana* by Bischoff et al. (2018).

Adults are frequently pelagic or semi-pelagic whereas juveniles are mainly benthic living on soft-substrate and coral reef habitat in shallow water. The biology of this species is poorly known.

One specimen with 972 mm TL and 510 mm DL was caught at Seine seamount at 200 m depth using bottom longline (MMF 47181).

Frequency of occurrence: Red (rare).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): No.

Depth range (Ebert and Stehmann, 2013): 10–927 m.

Maximum size (Ebert and Stehmann, 2013): 1800 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Least Concern (LC) [Europe] / Least Concern (LC) [Global].

Order rajiformes

Family rajidae

Raja maderensis Lowe, 1838 - Common names: Raia-da-Madeira; Madeira ray.

First published record for the Madeira by Lowe (1938).

Madeira is the locality type of this endemic species for Madeira and the Azores archipelagos (Portugal) in the northeastern Atlantic. The biology of this species is poorly known.

Two specimens with 680 mm TL (355 mm DL) and 700 mm TL (393 mm DL) were caught at Seine seamount at 200 m depth using bottom longline.

Frequency of occurrence: Yellow (occasional).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): Yes.

Depth range (Ebert and Stehmann, 2013): 0–150 m.

Maximum size (Ebert and Stehmann, 2013): 800 mm TL.

Local gear susceptibility: Bottom longlines.

IUCN Red List status: Vulnerable (VU) [Europe] / Vulnerable (VU) [Global].

Order chimaeriformes

Family chimaeridae

Hydrolagus affinis (de Brito Capello, 1867) - Common names: Ratazana-da-fundura; Smalleyed rabbitfish.

First published record for the Madeira in Freitas & Bischoff (2007).

It is a benthopelagic species which occurs on continental slopes and deep-sea plains, feeding on small fishes and invertebrates.

Two specimens with 1075 and 1268 mm TL were caught at Seine seamount at 2500 m depth using bottom longline.

Frequency of occurrence: Yellow (occasional).

Recorded for Madeira in FAO Species Catalogue (Ebert and Stehmann, 2013): No.

Depth range (Ebert and Stehmann, 2013): 300–2410 m.

Maximum size (Ebert and Stehmann, 2013): 1470 mm TL.

Local gear susceptibility: Bottom longlines.

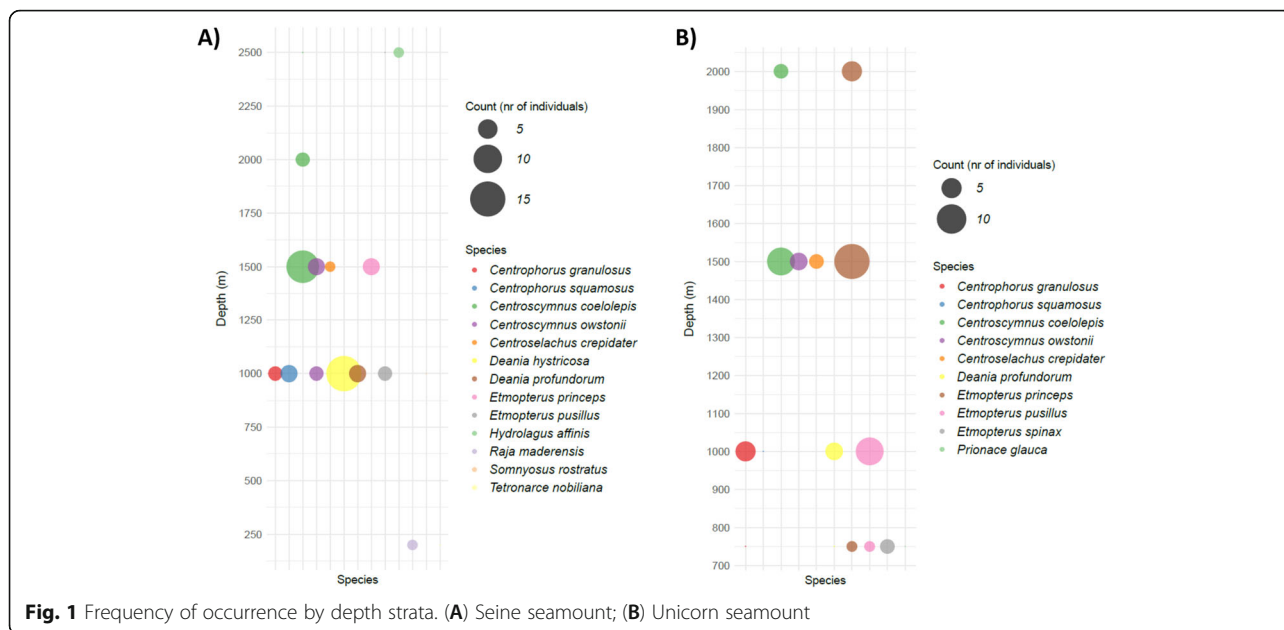
IUCN Red List status: Least Concern (LC) [Europe] / Least Concern (LC) [Global].

Species'frequency of occurrence was plotted against depth (Fig. 1).

On one hand, *Centrophorus granulosus* and *C. squamosus* occurred at 1000 m in both seamounts. On the other hand, *C. coelolepis* mainly occurred between 1500 and 2000 m deep. However, one specimen of this species was captured at 2500 m deep at the Seine seamount. Furthermore, *D. calcea* was collected at 1000 m deep only at the Seine seamount.

E. princeps occurred in both seamounts, though more frequently at 1500 m, within a depth range between 750 and 2000 m of depth. Nonetheless, *E. pusillus* was the species that presented the widest depth range. Despite being more dominant between the 750 to 1000 m of depth, it also occurred at 2500 m. Moreover, *E. spinax* and *P. glauca* were exclusively collected at the Unicorn seamount. Contrarily, *H. affinis*, *R. maderensis*, *S. rostratus* and *T. nobiliana* were only captured at the Seine seamount.

Considering the list of Chondrichthyes (20) for both seamounts (Table 1), and according to IUCN criteria for Europe (Nieto et al., 2015), 1 species (5%) is classified as Critically Endangered (*Centrophorus granulosus*), 3 (14%) as Endangered (*C. squamosus*, *C.*



coelolepis and *Deania calcea*) and 2 (10%) as Vulnerable (*Centrocygnus owstonii* and *Raja maderensis*). Similarly, 3 species (14%) are classified as Near Threatened, 5 (24%) as Data Deficient and 7 (33%) as Least Concern (Fig. 2). Overall, 28.6% of the species recorded for the Seine and Unicorn seamounts are classified as Threatened (CR + VU + EN).

Discussion

Twenty cartilaginous fish species were confirmed in the present checklist for the Seine (17) and Unicorn (11) seamounts, corresponding to approximately 31% of the total valid chondrichthyan species reported for Madeira archipelago (Biscoito et al., 2018), and to 2.3% of the total species worldwide (Weigmann, 2016). Despite having been previously reported for Madeira archipelago, some of the present study’s species were reported for the first time for both the Seine (*C. granulatus* and *S.*

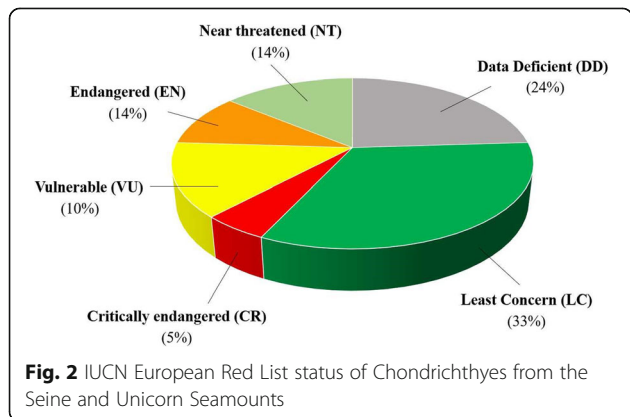
rostratus) and Unicorn (*C. granulatus*, *C. coelolepis* and *C. crepidater*) seamounts.

Only one specimen of *P. glauca*, *S. rostratus* and *T. nobiliana* was collected over the course of this study, while *C. coelolepis* and *E. princeps* were revealed as the most common species.

Regarding the collected specimens’ total length, individuals of *D. profundorum* presented a slightly larger size than the maximum length recorded by Ebert and Stehmann (2013). All other species were within their known size range.

Among the most frequent species *D. calcea* and *C. coelolepis* present a similar depth range when comparing with previous works (Menezes et al., 2009). However, three species (*E. pusillus*, *R. maderensis* and *H. affinis*) were collected at greater depths than those recorded by Ebert and Stehmann (2013). In the particular case of *E. pusillus*, a wider depth range was observed in the present study in contrast with Menezes et al. (2009). In fact, the widest depth range was recorded for the Etmopteridae family (750–2500 m), while Centrophoridae and Somniosidae species were captured mostly between 1000 and 1500 m deep, respectively. The large-scale hydrographic regime characteristic of the Northeast Atlantic might explain the similarity among species composition associated with seamounts located within the same geographical region.

In Europe, 40.4% of Chondrichthyes are listed as Threatened (Nieto et al. 2015). In Madeira archipelago, 35.8% of the total recorded species are labelled under the same category (Biscoito et al., 2018), which is only slightly more than the 28.9% species recorded for the



Seine and Unicorn seamounts. Additionally, and when considering that Chondrichthyes are a group particularly sensitive to threats posed by overfishing (Dulvy et al., 2014), this study may be of importance when aiming to improve fisheries regulations currently in place, as shedding light on these species' occurrence at different depths in commercial-fishing dominated seamounts might be of help in shark conservation. Finally, this work's relevance is also marked by the updated annotated checklist contribution to the knowledge of seamount-associated fish biodiversity, and may serve as a strengthening tool for a future proposal for the creation of an MPA within the Madeira-Tore region.

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Authors' contributions

MF: Conceptualization, data acquisition, data interpretation, writing the paper; JD/AS: revision of the paper; RS: Study design, data acquisition, data interpretation, writing the paper, critical analysis; PI: Study design, data interpretation, writing the paper, critical analysis; MG: Data interpretation, English language review; AC: Study design, writing the paper; MB: data acquisition, data interpretation, critical analysis, revision of the paper. All authors read and approved the final manuscript.

Declaration

Competing interests

The authors declare that they have no competing interests.

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