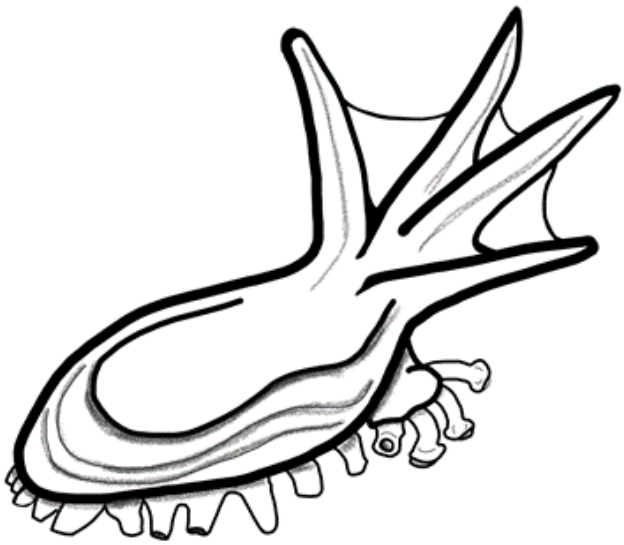
Benthic Megafauna from the North Pacific Abyss

Phylum **Echinodermata**

Class **Holothuroidea**



APSMA Vol. 3b / v.1

Abyssal Pacific seafloor image-based megafauna morphotype catalogue v.1

Phylum **Echinodermata:** Class **Holothuroidea**

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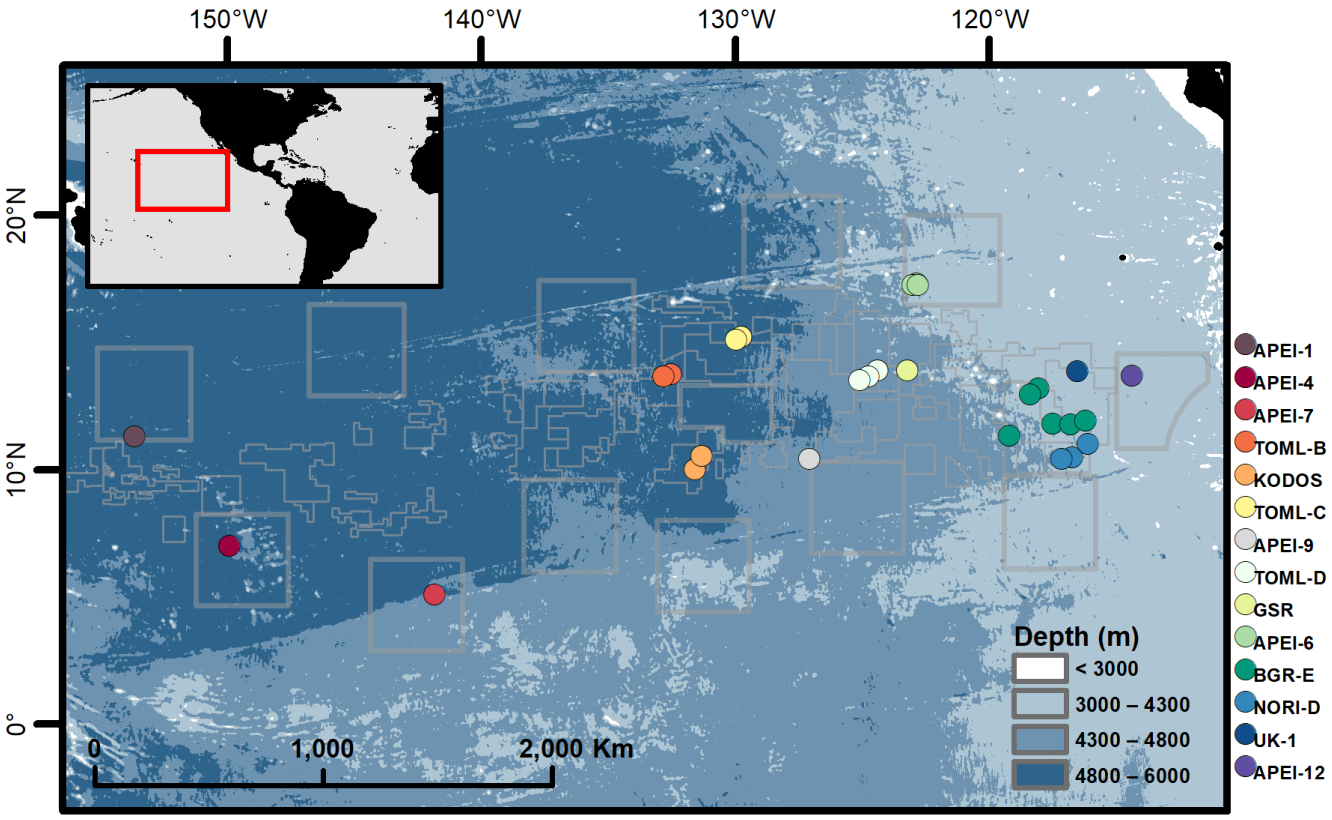
Standardised taxonomic field guide used to develop (please cite as): Simon-Lledó, et al. (2023). Carbonate compensation depth drives abyssal biogeography in the northeast Pacific. *Nature Ecology & Evolution;* doi:10.1038/s41559-023-02122-9

The APSMA image-based taxonomical catalogue

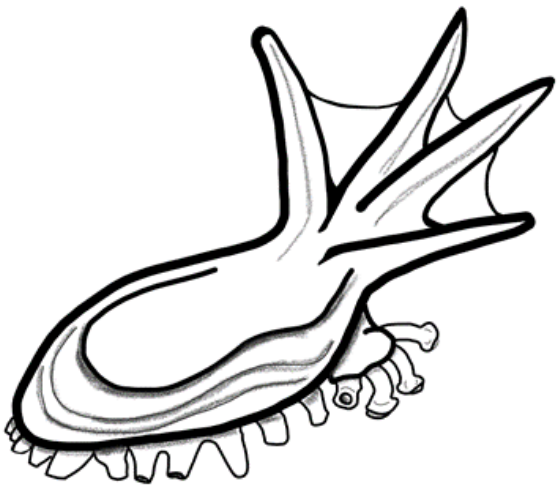
This code-based abyssal megafauna (invertebrates > 1 cm) catalogue was developed by morphological and taxonomical alignment of specimens encountered in seabed imagery collected across multiple seabed locations across the Clarion Clipperton Fracture Zone, in the NE Pacific basin (see map below and main study, Simon-Lledó et al. 2023, for further details). This work was conducted during a range of scientific workshops held between 2016 and 2021, in collaboration with taxonomic experts (see acknowledgements section) and by reference to existing literature (e.g. where available, links to studies describing physically collected specimens are provided in taxon descriptions). The catalogue follows the Horton et al. 2021 open nomenclature (e.g. 10.3389/fmars.2021.620702) to report the taxonomic resolution reached in the identification of each classified metazoan morphotype. Each morphotype was assigned a unique 7 character identification code (i.e. "XXX_nnn"). All taxa identified were deemed as sufficiently different morphologically by taxonomic experts to be confidently considered separate species. Note the catalogue is periodically revised, as new photographed and collected specimens get described, and hence some taxonomic identifications may vary in subsequent versions of this guide. The latest version of the APSMA catalogue is available as label tree for image/video annotation on BIIGLE (biigle.de; please contact the authors for more detail).



Map of the Clarion Clipperton Zone in the North Pacific basin with detail on locations surveyed with photographic and video cameras mounted on autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), and towed cameras; between 2010 and 2021. Areas managed by the International Seabed Authority: Thick polygons, Areas of Particular Environmental Interest, and; Thin polygons, polymetallic nodule exploration licensed sites.

Phylum Echinodermata

Class Holothuroidea



HOL_001

Mesothuria sp. indet.

Morphology: wide body (tapering distally) covered in thin homogenous layer of brown fine sediment. No velum, often wrinkled opaque skin. Few pairs of thin ventral tube feet along the whole length of the body

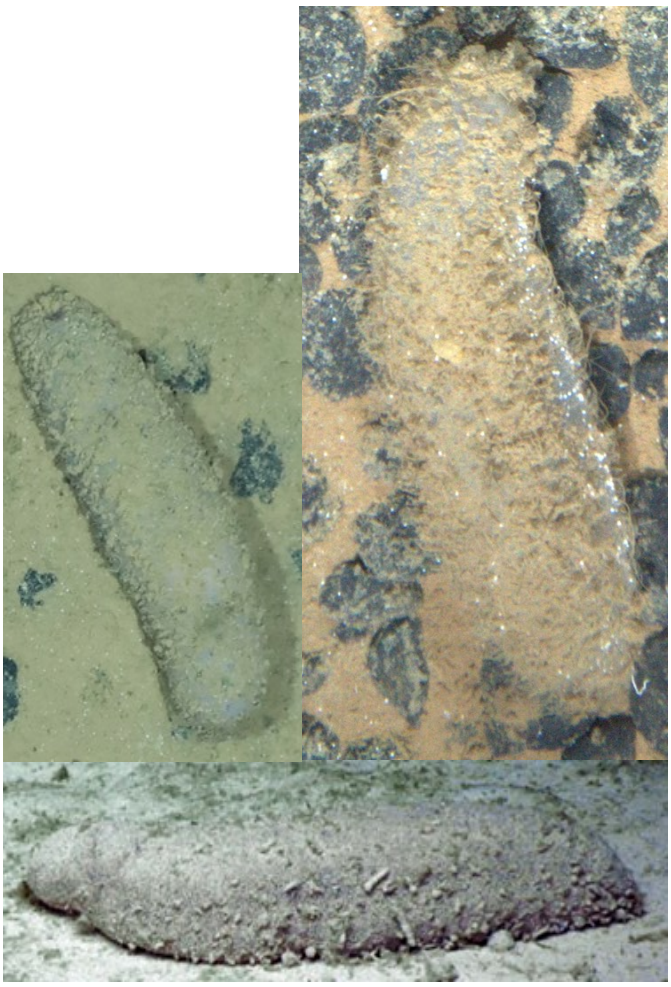
HOL_004

Molpadiodemas sp. indet.

Morphology: white to yellow subcylindrical body (tapering anteriorly) somewhat covered in thin sparse layer of brown fine sediment. No velum, with sparse very short and thin lateral papillae. More detail: doi:10.3897/zookeys.1113.82172; doi:10.3897/BDJ.5.e11794

HOL_103

Molpadiodemas sp. indet



Morphology: subcylindrical body (tapering distally) covered in heterogeneous layer of fine sediment and other seabed particles (e.g. globigerinas). No velum, with few very short and thin dorsolateral papillae (e.g. holding fine sediment particles). More detail: doi:10.3897/zookeys.1113.82172.

HOL_005

Paroriza sp. indet.

Morphology: elongated white body covered in thin sparse layer of brown fine sediment. No velum; body fully covered in short thin dorsal and lateral rows of short papillae. Ventral area densely covered by thin tube feet. More detail: doi:10.3897/BDJ.5.e11794.

Notes: often found in pairs or triplets (e.g. doi:10.1017/S0025315400037814)

HOL_006

Pseudostichopus sp. indet.

Morphology: wide dorsoventrally flattened body (slightly tapering towards the edges) covered in thick homogenous layer of dark particles (e.g. small xenophyophore thecae). No velum, often wrinkled opaque skin.

HOL_094

Pseudostichopus sp. indet.

Morphology: elongated body (slightly tapering towards the edges) covered in thick heterogenous layer of dark plates (e.g. large xenophyophore thecae). No velum, often wrinkled opaque skin.

HOL_007

Synallactes sp. indet.

Morphology: cylindrical bright white body, flattened proximally and rounded distally. Many papillae: two rows of lateral, small, conical, thin papillae similar to those around the proximal edge. Small ventral tube feet. More detail: doi:10.3897/zookeys.1113.82172.

HOL_104

Synallactes sp. indet.

Morphology: cylindrical semi-translucent white body, flattened proximally and rounded distally. Few large papillae: two rows of lateral processes; one (upper) with small, conical, thin papillae (upper) similar to those around the proximal edge and one (lower) with long, conical, thick papillae. Small ventral tube feet.

HOL_108

Synallactes sp. indet.

Morphology: cylindrical red body, flattened proximally and rounded distally. Two rows of lateral, small, conical, thick papillae similar to those around the proximal edge. Small ventral tube feet.

HOL_009

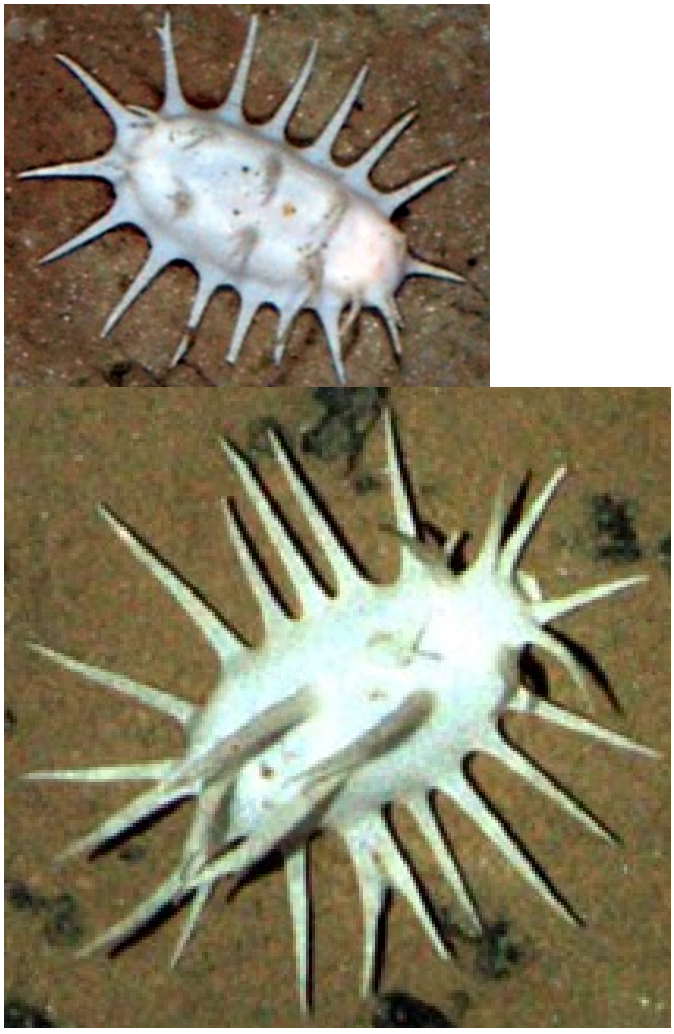
Synallactes sp. indet.

Morphology: cylindrical semi-translucent pink body, flattened proximally and rounded distally. Few large papillae: two rows of lateral papillae; one (upper) with small, conical, thin papillae (upper) similar to those around the proximal edge and one (lower) with long, conical, thick papillae. Small ventral tube feet.

HOL_019

Deimatidae gen. indet

Morphology: bright white, dorsoventrally flattened, elongated and symmetrical body. With 18+ pairs of long and peltate-shaped papillae the ventral surface (acting as tube feet); and 10+ long, dorsal (and non-retractile) papillae arranged in two rows.



HOL_018

Deima sp. indet.

Morphology: bright white, dorsoventrally flattened, ovoid and symmetrical, body. With 8 pairs of long peltate-shaped long papillae surrounding the ventral surface; and 8+ long, dorsal (and non-retractile) papillae arranged in two rows. More detail: doi:10.3897/BDJ.5.e11794.

HOL_058

Oneirophanta sp. indet.

Morphology: body uniformly white and almost cylindrical; almost equal breadth throughout the whole length and tapering posteriorly. Long, pointed papillae of different lengths (longest ~body width), arranged in four distinct rows, two rows running along the dorsal ambulacra with >8 processes on each row. More detail: doi:10.3897/zookeys.1113.82172.

HOL_062

Oneirophanta sp. indet.

Morphology: body uniformly bone-white and almost cylindrical; almost equal breadth throughout the whole length and tapering posteriorly. Long, pointed papillae of similar lengths (~half of the body width), arranged in four distinct rows, two rows running along the dorsal ambulacra with >20 processes on each row.

HOL_108

Deimatidae gen. indet

Morphology: body uniformly grey to whitish (i.e. bone white) and cylindrical; almost equal breadth throughout the whole length and tapering posteriorly. Short, pointed papillae of equal length (~half of the body width), arranged in four distinct rows, two rows running along the dorsal ambulacra with ~10+ processes on each row.

HOL_068

Actinopoda order indet.

Morphology: elongated yellow body. Long, pointed papillae of different lengths arranged in four rows, with >8 processes (each). Oral (ventral) area surrounded by crown of small tentacles with apical lobes (hard to distinguish in vertical imagery).

HOL_059

Peniagone vitrea sp. inc

Morphology: long white body, with neck-like part bent forwards with ten tentacles. Velum: two pairs processes, fully fused by a membrane forming a lobe, with only the tips free; the two middle processes are much larger. Translucent skin. Eight pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally. More detail: doi:10.3897/zookeys.1113.82172.

HOL_126

Peniagone sp. indet.

Morphology: tulip-shaped white (semi-transparent skin) body, with neck-like part bent forwards and surrounded by tentacles. Velum: few processes fully fused by a membrane forming a lobe. Pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally.

HOL_024

Peniagone sp. indet.

Morphology: ovoid (slightly elongated) transparent body, with neck-like part bent forwards surrounded by crown of tentacles. Velum with four processes semi fused by a membrane forming a lobe, with the tips free; the two middle processes are slightly larger. Pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally.

HOL_114

Amperima sp. indet.

Morphology: ovoid transparent body, with neck-like part bent forwards surrounded by crown of tentacles. Short velum with four equally sized processes, semi fused by a membrane forming a lobe. Pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally.

HOL_023

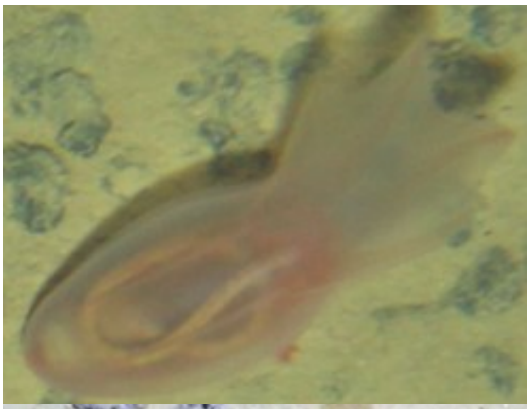
Amperima sp. indet.

Morphology: ovoid white body, with neck-like part bent forwards surrounded by crown of tentacles. Velum with four processes (same length) semi fused by a membrane forming a lobe, with the tips free. Translucent skin. Eight pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally.

More detail: doi:10.3897/BDJ.5.e11794

HOL_025

Amperima sp. indet.



Morphology: ovoid reddish body, with neck-like part bent forwards surrounded by crown of tentacles. Velum: two pairs processes, fully fused by a membrane forming a lobe, with only the tips free; the two middle processes are larger. Translucent skin. Few pairs of tube feet surrounding the posterior third of ventral surface, decreasing in size distally.

HOL_055

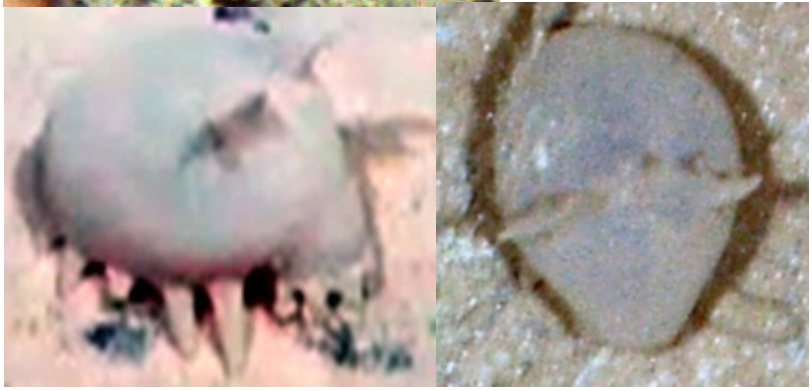
Elpidiidae sp. indet.

Morphology: ovoid transparent body with very long velum (> 3 times body length) composed by a bifid, long, tail-like process.

HOL_021

Elpidiidae gen. indet.

Morphology: ovoid and globular grey body, with neck-like part bent forwards surrounded by crown of tentacles. Double, symmetrical velum composed by 2 separated pairs of fully-fused papillae. Two pairs of very small dorsal papillae and several pairs of tube feet surrounding the posterior third of the ventral surface, decreasing in size distally.



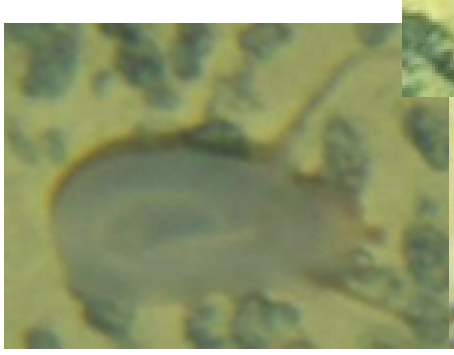
HOL_128

Peniagone sp. indet.

Morphology: elongated white body, with neck-like part bent forwards surrounded by thick tentacles. Velum composed by two separated, pointed, long processes. Nine pairs of tube feet surrounding the posterior third of ventral surface: 8 equally-sized and a smaller, distal pair.

HOL_096

Elpidiidae gen. indet.



Morphology: ovoid (though slightly elongated) grey body, with neck-like part bent forwards surrounded by thick tentacles. Velum composed by two long, separated and pointed processes. Translucent skin. Pairs of tube feet surrounding the posterior third of ventral surface.

HOL_074

Peniagone sp. indet.

Morphology: elongated brown to reddish body, with neck -like part bent forwards surrounded by tentacles. Velum composed by two pairs processes fully fused by a membrane forming a lobe, with only the tips free; the two middle processes are slightly larger. Translucent skin. With 5+ pairs of tube feet surrounding the posterior third of ventral surface.

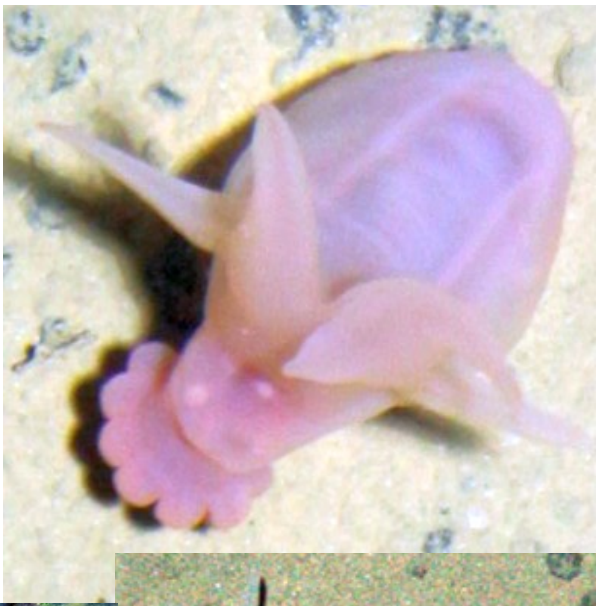
HOL_064

Peniagone longipapillata sp. inc.

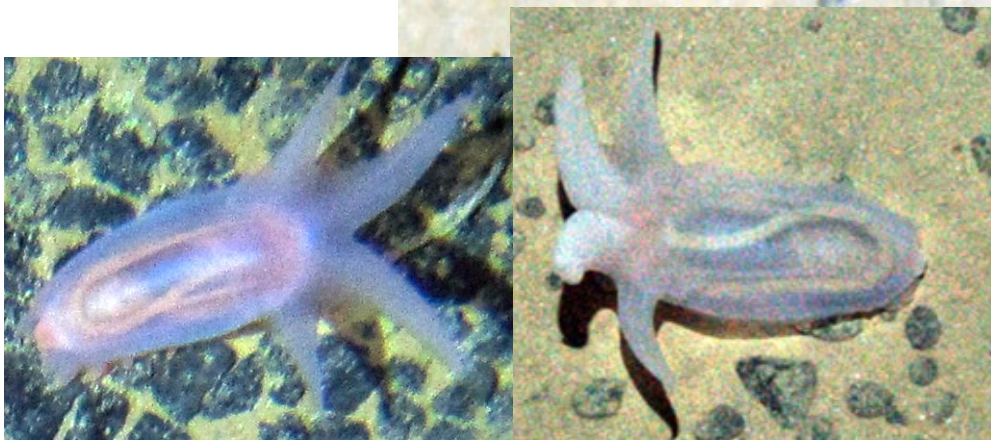
Morphology: elongated red to violet body, with neck-like part bent forwards surrounded by thick tentacles. Velum composed by two pairs processes fully fused by a membrane forming a lobe, with only the tips free; the two middle processes are much smaller. Translucent skin. With 12+ pairs of tube feet surrounding the posterior third of ventral surface; the most distal ones are fused.

HOL_026

Peniagone sp. indet.



Morphology: elongated pink body, with neck-like part bent forwards surrounded by thick, fused tentacles. Velum composed by 4 separated, pointed, long processes (middle processes sometimes slightly larger). Pairs of tube feet surrounding the posterior third of ventral surface.



HOL_115

Peniagone sp. indet.

Morphology: elongated whitish but almost transparent body, with neck-like part bent forwards surrounded by thick, fused tentacles. Palm-shaped velum composed by 4 separated, pointed, and very long processes (> body length). 7+ pairs of thick and equally-sized tube feet surrounding the posterior third of ventral surface.

HOL_029

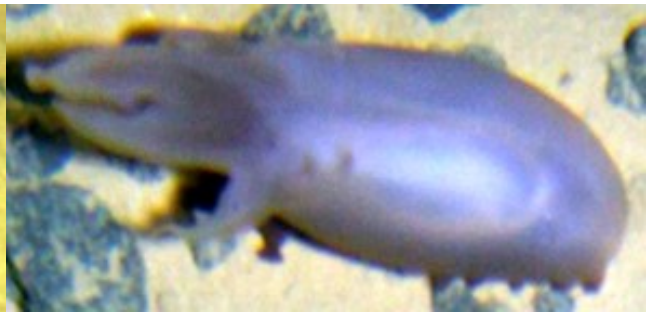
Peniagone sp. indet.

Morphology: elongated transparent body, with neck-like part bent forwards surrounded by crown of tentacles. Thin palm-shaped velum composed by 4 separated, pointed, and very long processes (> body length); the two middle ones are slightly fused. Pairs of long thin tube feet surrounding the posterior third of ventral surface.

HOL_097

Peniagone sp. indet.

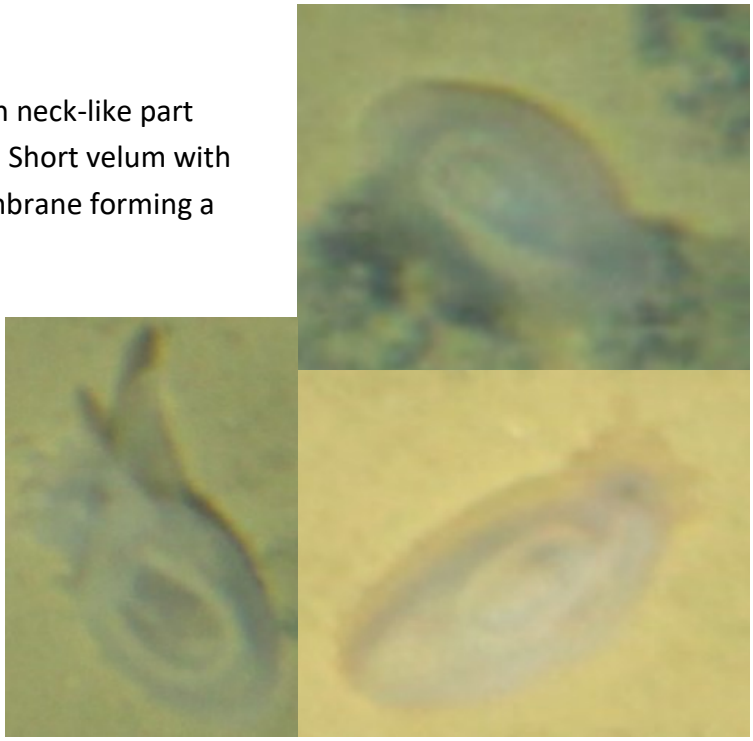
Morphology: elongated violet to grey body, with neck-like part bent forwards surrounded crown of tentacles. Velum composed by 4 short (but thick), wide and somewhat fused processes. Pairs of tube feet surrounding the posterior third of ventral surface.



HOL_076

Elpidiidae gen. indet.

Morphology: ovoid (slightly elongated) body with neck-like part bent forwards surrounded by crown of tentacles. Short velum with few equally sized processes, fully fused by a membrane forming a lobe. Semi transparent skin.



HOL_100

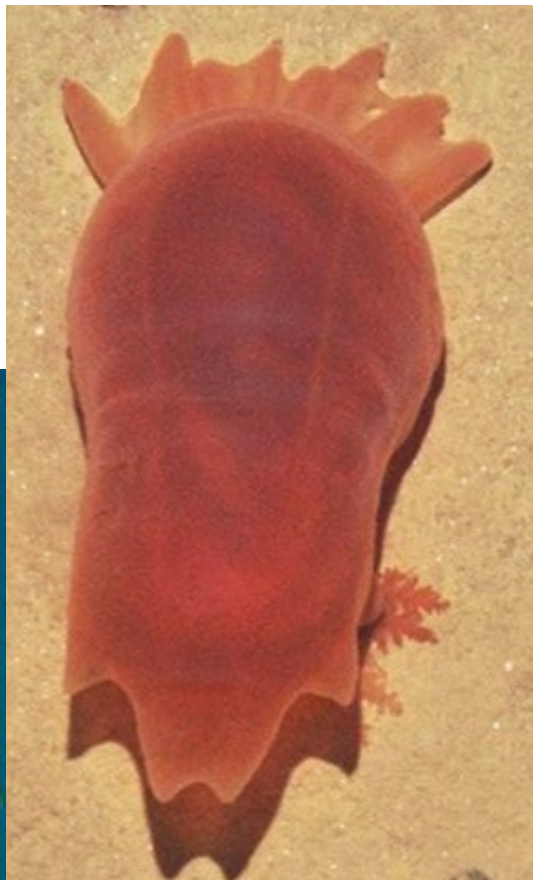
Actinopoda order indet.

Morphology: round strongly dorsoventrally flattened body. Very short velum with few equally sized processes, fully fused by a membrane forming a short lobe. Transparent skin.

HOL_028

Peniagone leander

Morphology: bright red ovoid body; ~twice as long as wide. Velum: two pairs of fully fused papillae. Tube feet in four pairs; three posterior-most pairs fused together forming a posterior swimming lobe; anterior-most pair of tube feet very reduced. More detail: doi:10.3897/zookeys.1113.82172.



HOL_032

Enypniastes eximia

Morphology: bulbous brown-red to purple body with a convex dorsal surface, flattened ventrally; ventral mouth, dorsal anus. ~20 leaf-like bifurcated tentacles; webbed podia fused to form a broad anterior cowl and 10-15 forming the smaller lateral posterior brim, creating fin-like structures for swimming.

HOL_030

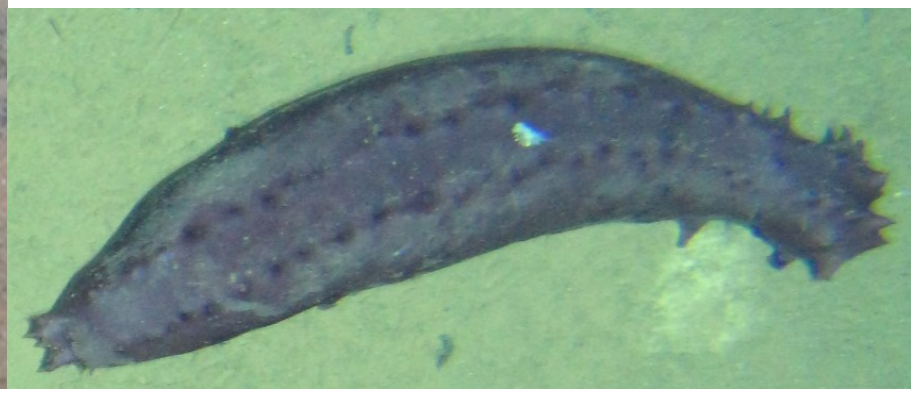
Psychronaetes sp. indet.

Morphology: dark violet cylindrical body, slightly dorsoventrally flattened, tapering at both ends. Pronounced anterior neck-like constriction. Ventral mouth, dorsal anus. Paired dorsal ambulacra with two rows of parallel papillae; few long thick papillae interspersed with smaller ones. Papillae surrounding the anterior margin dorsally, fully fused forming a fringe.

HOL_031

Psychronaetes hanseni

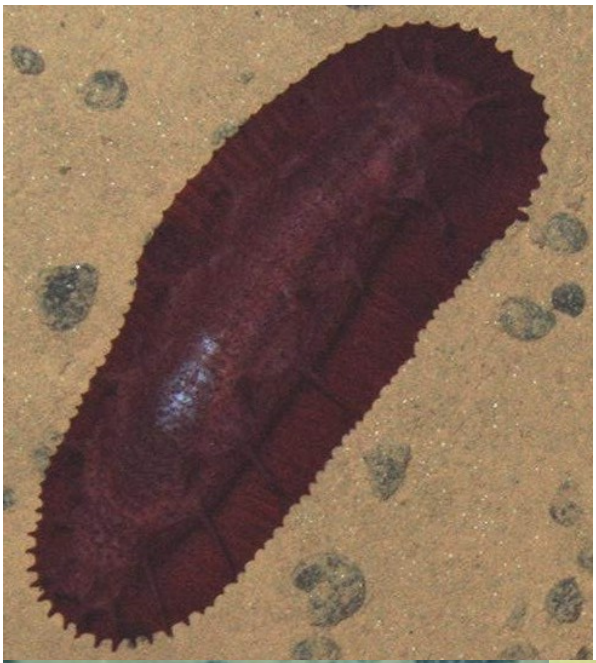
Morphology: cylindrical violet to dark (navy) blue body tapering at both ends, with slight neck-like constriction proximally. With two dorsal rows of parallel short thick papillae and ventral tube feet. Few papillae surrounding the anterior margin dorsally, somewhat fused forming a fringe.



HOL_080

Psychropotidae gen. indet.

Morphology: dark-violet elongated body, with wide brim, and dorsoventrally flattened. Flat ventral surface and inflated dorsal surface; anteriorly depressed and tapering posteriorly. Two rows of thick pointed papillae pairs running along the paired dorsal ambulacra.



HOL_037

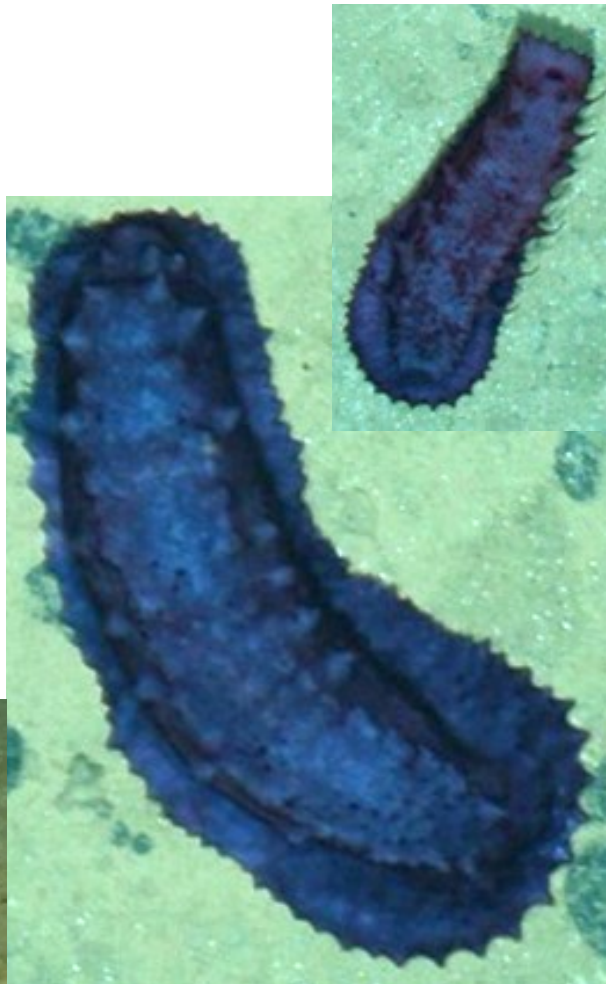
Benthodytes sp. indet.

Morphology: dark-violet to brown elongated body, with wide brim, and dorsoventrally flattened. Flat ventral surface and inflated dorsal surface; anteriorly depressed and tapering posteriorly. Two rows of thin pointed papillae running along the paired dorsal ambulacra.

HOL_111

Benthodytes marianensis sp. inc.

Morphology: dark-violet to blue elongated body, with wide brim, and somewhat dorsoventrally flattened. Flat ventral surface and inflated dorsal surface; anteriorly depressed and tapering posteriorly. Two irregular rows of small conical papillae running along the paired dorsal ambulacra. More detail: doi:10.3897/zookeys.1113.82172.



HOL_129

Benthodytes sp. indet.

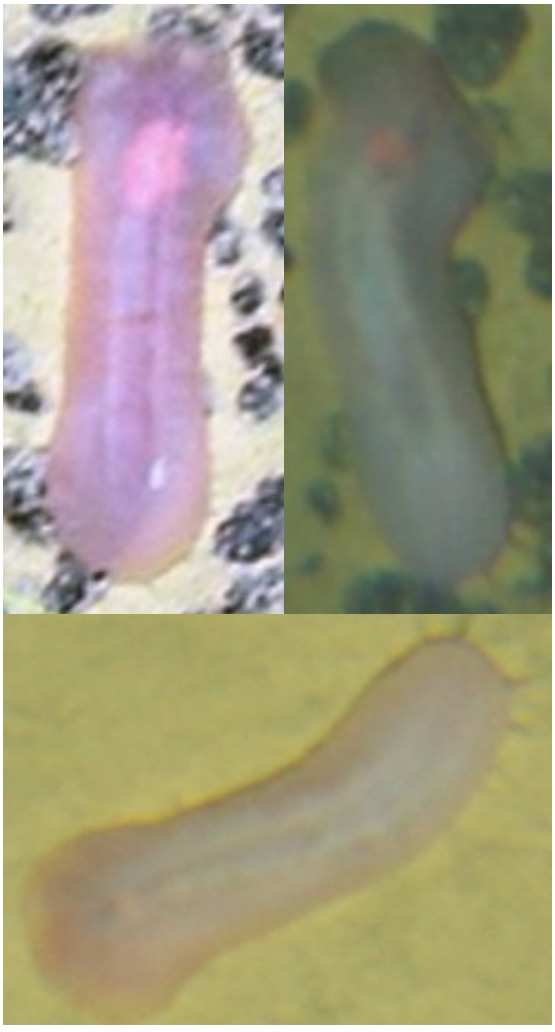
Morphology: dark purple to violet, wide and anteriorly depressed body with a broad brim (darkening distally). Semi-translucent skin covered in warts dorsally.

HOL_041

Benthodytes sp. indet.

Morphology: elongated light blue to dark violet body, somewhat dorsoventrally flattened. Wide and darker coloured brim only surrounding the proximal end. With two rows of thin, pointed, dorsal papillae.

Notes: sometimes exhibiting a thin membrane across the dorsal skin, between papillae rows.



HOL_099

Benthodytes sp. indet.

Morphology: elongated pink to light reddish body, somewhat dorsoventrally flattened. Wide and slightly darker coloured brim only surrounding the proximal end. With two rows of thin, pointed, dorsal papillae (few extending to the posterior third of ventral surface)

HOL_086

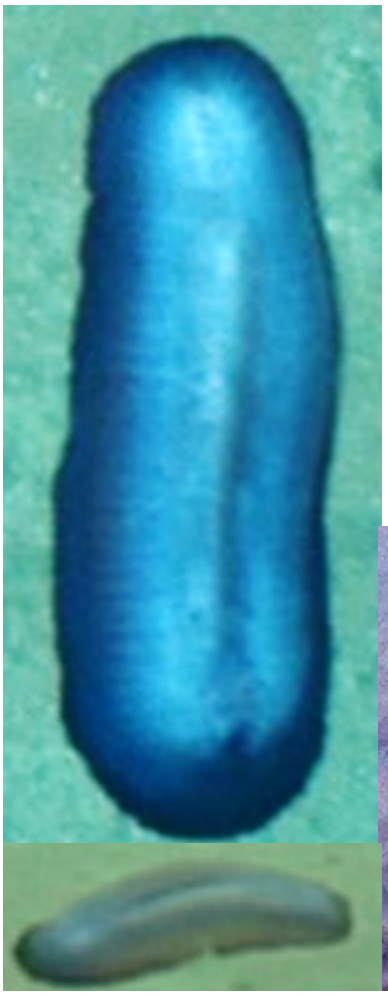
Benthodytes sp. indet.

Morphology: elongated bright red to light brown body, somewhat dorsoventrally flattened. Bilobate and slightly darker coloured brim on (each side of) the proximal end. With wo rows of thin, pointed, dorsal papillae extending to the posterior third of ventral surface.

HOL_052

Psychropotidae gen. indet.

Morphology: elongated bright blue body, somewhat dorsoventrally flattened. Brim surrounding the whole body, but much wider and dark violet coloured on the proximal end.



HOL_042

Benthodytes sp. indet.

Morphology: blue to dark blue, elongated, wide and somewhat dorso-ventrally flattened body; with a ventrally darkening short brim. 5+ pairs of warts on the dorsal skin. More detail: doi:10.3897/BDJ.5.e11794

Notes: thought to potentially be *B. typica* or *B. sanguinolenta* (see e.g. doi:10.3897/BDJ.5.e11794)

HOL_012

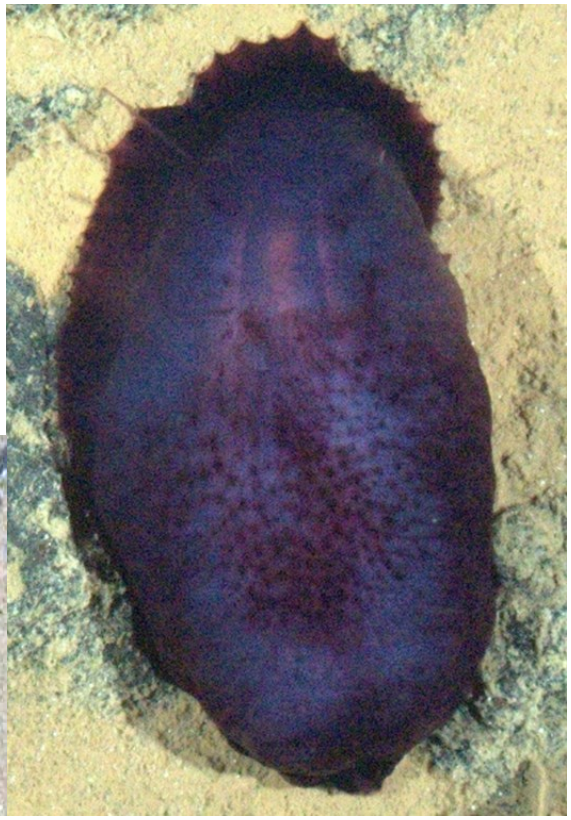
Paelopatides sp. indet.

Morphology: dark blue to violet, elongated and strongly dorso-ventrally flattened body with darker (violet) short brim. Five pairs of warts visible along the dorsal semi-transparent skin (2 dorsal nerve cords often visible in seabed imagery)

HOL_010

Benthothuria sp. indet.

Morphology: Violet wide, bulging body; with a (darker) brim. Dorsal skin covered in warts and sometimes displaying two short anterior thin papillae.



HOL_053

Benthothuria gen. inc.

Morphology: White wide, bulging body; with no brim, darkening to dark blue/violet towards the anterior ventral side of the body.

HOL_013

Paelopatides gen. inc.

Morphology: bright red, elongated and flattened body with slightly serrated brim. Dorsal slightly-transparent skin (2 dorsal nerve cords often visible in seabed imagery)

HOL_014

Paelopatides sp. indet.

Morphology: bright white, elongated and flattened body with thin brim. Dorsal slightly-translucent skin (2 dorsal nerve cords usually visible in seabed imagery)

HOL_015

Paelopatides sp. indet.

Morphology: white elongated and flattened body; with a short serrated (reddish to violet) brim. Dorsal slightly-transparent skin (2 dorsal nerve cords clearly visible in seabed imagery)

HOL_105

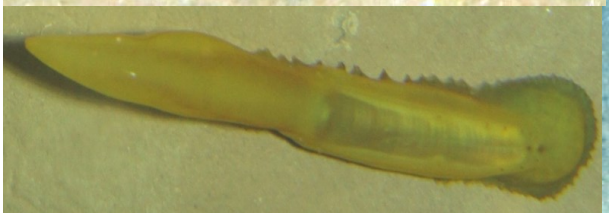
Paelopatides gen. inc.

Morphology: white, elongated, depressed, and flattened anteriorly body with double (upper and lower) serrated brim. Dorsal slightly-transparent skin (dorsal nerve cords sometimes visible in seabed imagery).

HOL_045

Psychropotes verrucicaudatus sp. inc.

Morphology: Violet body elongated and anteriorly depressed; with a broad brim. Short, conical, single-pointed, dorsal unpaired appendage, placed 2/5 of the body length from the posterior end. Dorsal skin, including the dorsal appendage, covered in warts. More detail: doi:10.3897/zookeys.1113.82172.



HOL_047

Psychropotes sp. indet.

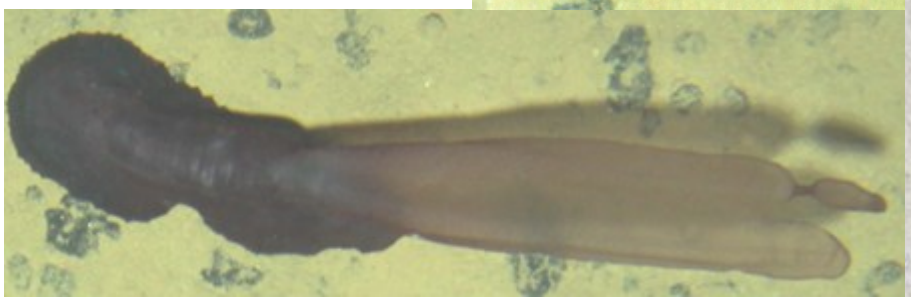
Morphology: Yellow, elongated body with a thin, digitated brim (i.e. resembling ventral tube feet). Long, dorsal appendage with round end, slightly longer than the total body length, and developed very close to the posterior end of the body. More detail: doi:10.3897/zookeys.1113.82172.

Notes: it is not possible to determine whether HOL_047 specimens are *P. dyscrita* or *P. moskalevi* from seabed imagery (i.e. ossicle assessment required).

HOL_046

Psychropotes longicauda sp. inc.

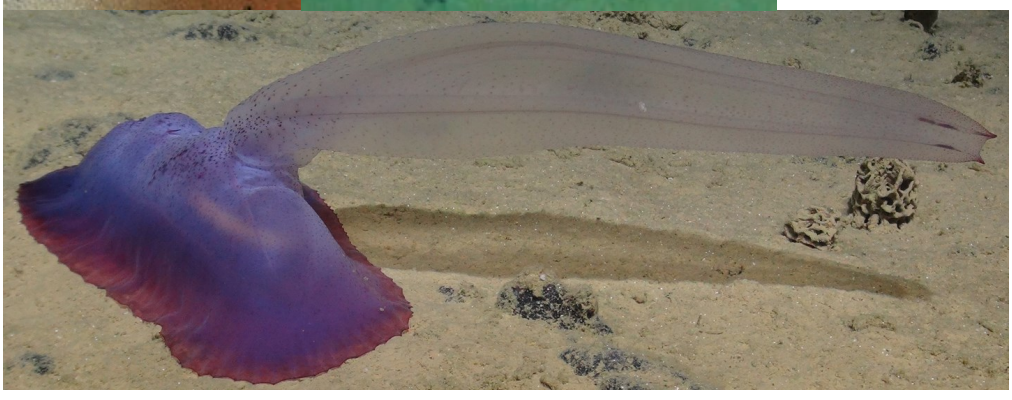
Morphology: Dark violet, elongated body with a broad, serrated brim. Long, dorsal appendage with round or bifurcated end, slightly longer than the total body length, and developed very close to the posterior end of the body.



HOL_044

Psychropotes semperiana sp. inc.

Morphology: Dark violet to blue, elongated body with a wide, serrated brim. Long, dorsal appendage with bifurcated end, slightly longer than the total body length, placed 2/5 of the body length from the posterior end. More detail: doi:10.3897/BDJ.5.e11794



HOL_040

Galatheathuria sp. indet.

Morphology: dark violet wide body and anteriorly depressed; with neck-like constriction and oral area slightly bent forwards. Wide slightly serrated brim

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