Supplementary material 3. Asteroidea identification key adapted for deep-sea images.

Asteroids in the Mozambique Channel: image-based identification key.

Vocabulary: R = length from disk center to armtip / r = length from disk center to edge of the disk

(0) Arms 6 or more, extremely elongate (R/r =>10) when observed in situ often extended into water current (not frequently observed on substrate). Spines present along sides of arm. Disk small, arms discontinuous.

(1)

(0') Arms 5. Disk small or large, continuous with arms distinct or indistinct. Body variably stellate (i.e., arms triangular, distinct from disk) to pentagonal in shape (i.e., arms indistinct from disk).

(8)

(1) Arms moderately long, distinct, moderately thick, fleshy and elongate but R/r (ratio) less than 10, numbering 6 to 18. Lateral spines absent or present, if present not elongate but forming a rough outline along arm's ventrolateral edge in some taxa (e.g., Solasteridae). Disk small or large.

(4)

(1') Arms extremely elongate, tapering, R/r > 15.0, numbering 6 to 20. In some instances, diameter of complete organism ranges between 30 to 60 cm (1 to 2 feet). Prominent, elongate spines present extending along lateral side of arm forming serial series. When viewed in situ, arms in most observations, extended into water currents, or lifted above the surface, although arms are sometimes lying on substrate. Disk very small.

Brisingida (Brisingidae (two types) and Freyellidae) (2)

(2) Lateral spines club-shaped, prominent, but not needle-like. Papulae present on disk and arm surface. Color rich orange/red with white plates or pure orange. Arms always 12 or more. Present primarily 100-600 m settings. Difficult to identify family level without close evaluation of the specimen. Look similar to Crinoids, but for the Brisingids, the mouth face down.

Brisingaster* or *Novodinia

Brisingida indeterminabilis

(2') Lateral spines needle-like, elongate. No papulae evident. Color orange, yellow to white. Arms 6 or more, sometimes at great length (up to 60 cm). Occurring to 6000 m depths.

Freyellidae or Brisingidae (3)

(3) Arm surface covered by distinct ribs along arms.

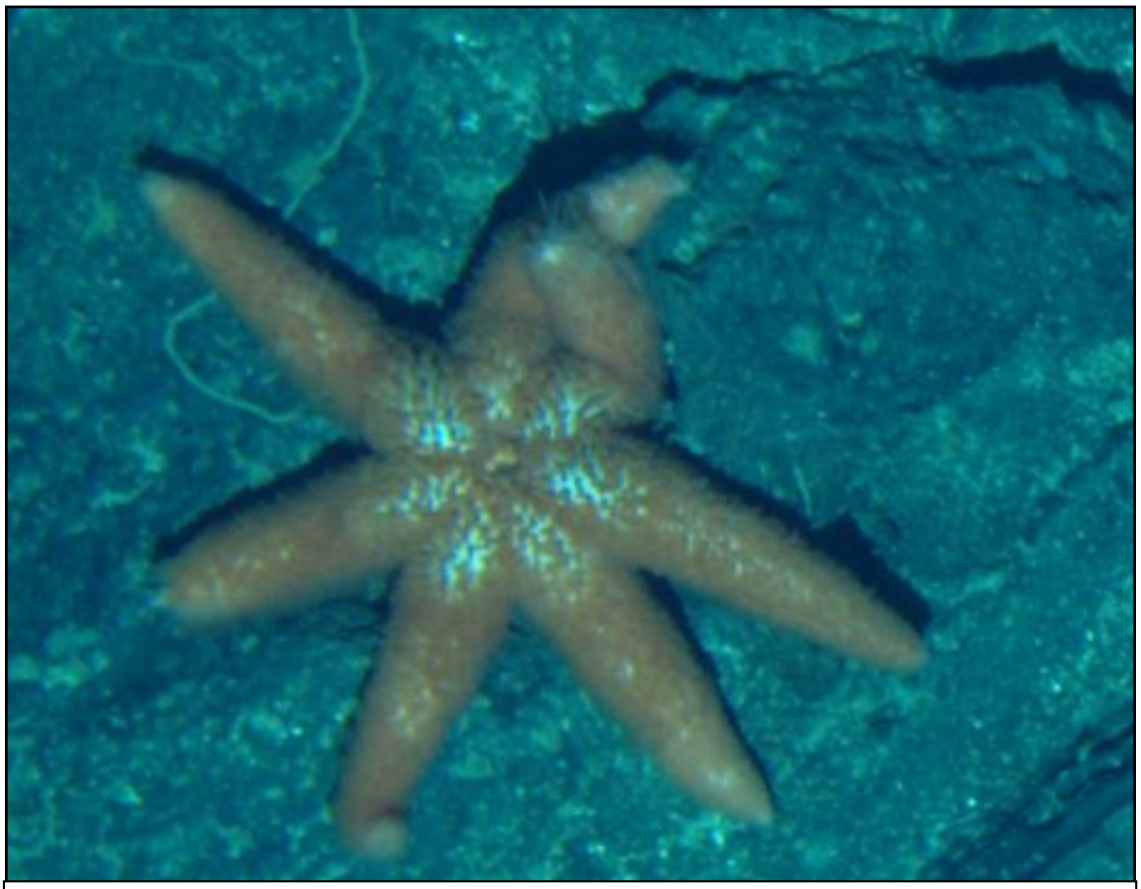
Brisingidae

(3') Arm surface covered by flattened plates along arms, disk. In some cases, spines present along lateral surface but also abactinal surface. Color orange but also completely white in some species. One genus, *Freyastera*, consistently displays six rays (= arms).

Freyellidae

(4) Opening (= osculum, "hole") present directly center on disk. Arms 6 to 11. Surface covered by widely spaced, tissue covered paxillae/spines appearing club-shaped in. These club-shaped spines convey a "fuzzy" appearance to the surface. Skeleton with window-like spaces. Body appears thick with tapering arms. Primarily observed below 1000 m.

Myxasteridae (*Asthenactis* or *Myxaster*)

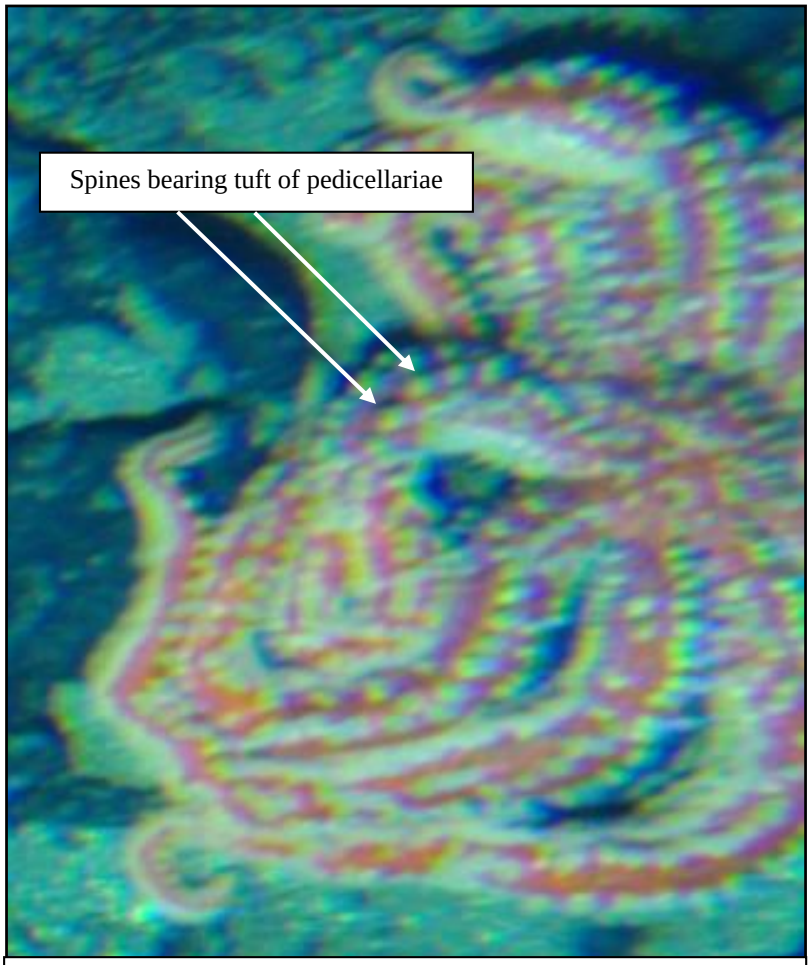


Myxasteridae indeterminabilis

(4') Osculum absent. No spines forming "fuzzy" surface. Skeleton without window-like spaces (= fenestrate). **(5)**

(5) Surface covered by sharp spines, each bearing a prominent tuft of pedicellariae. These spines are arranged in regular rows along arms. Arms number 6 to 12 (8 to 10 in most Pacific species), arms either splayed out or jumbled into a big pile. Some individuals up to 25 cm diameter.

Asteriidae (*Coronaster*)



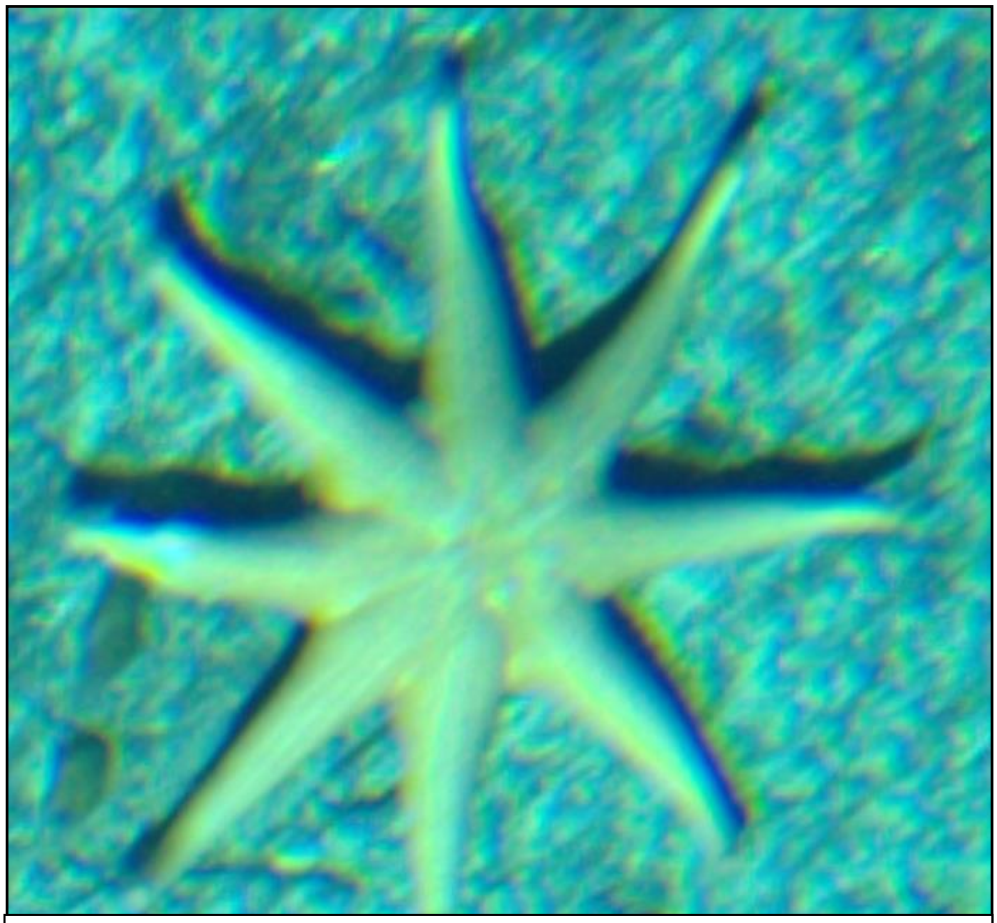
Coronaster indeterminabilis

(5') Surface with no prominent spines, although smaller present in some. Arms number 6 to 12. Body shape variable.

(6)

(6) Disk large (i.e., about 20% or more of arm length from center to arm tip), arms and body thick. Surface rough in appearance with some genera (e.g., *Crossaster*) having prominent paxillae on surface. Paxillae present around marginal periphery in some species, edge around arms is rough and appears serrated in some taxa. Arms 6 to 15, variably short to moderate in length. Predatory on sea cucumbers, sea stars and other megafauna.

Solasteridae



Solasteridae indeterminabilis

(6') Disk small, surface composed of smooth plates or soft surface. Arms number 6* to 8.

*5 arms possible (e.g., *Nepanthia*)

(7)

(7) Surface composed of overlapping or imbricate plates (rugged appearance, weakly visible depending on images quality). If more than 6 arms present, they are regrowing, following asexual fissiparity. Disk small, arms moderately elongated. Present at shallower depths (< 300 m). Arm tips curved, round-like, cylindrical.

Asterinidae (*Nepanthia*)

Nepanthia indeterminabilis

(7') Surface appears soft, thin body membrane. Weakly developed spines along radius present in some taxa. Disk small, arms long but narrow, elongate in one taxon. No spines around periphery. Similar to some shallow water Asteriidae. Six armed forms in abyssal deep-sea settings, seven or eight armed forms in Southern Ocean waters.

Pedicellasteridae or Paulasteriidae

No photo-taxa identified.

(8) Body form pentagonal or nearly so (R/r < 2.0). Arms weakly expressed, continuous with disk. Interradial arcs tend to be weakly curved to straight.

(9)

(8') Body form with distinct arms (R/r > 3.0), triangular to rounded, extending well away from disk. Interradial arcs curved, varying from wide to acute.

(11)

(9) Osculum (hole in disk center) absent. Body surface not appearing as such. Plates articulated, forming body surface. Peripheral (= marginal) plates present. Body shape flattened, dome-shaped or pentagonal.

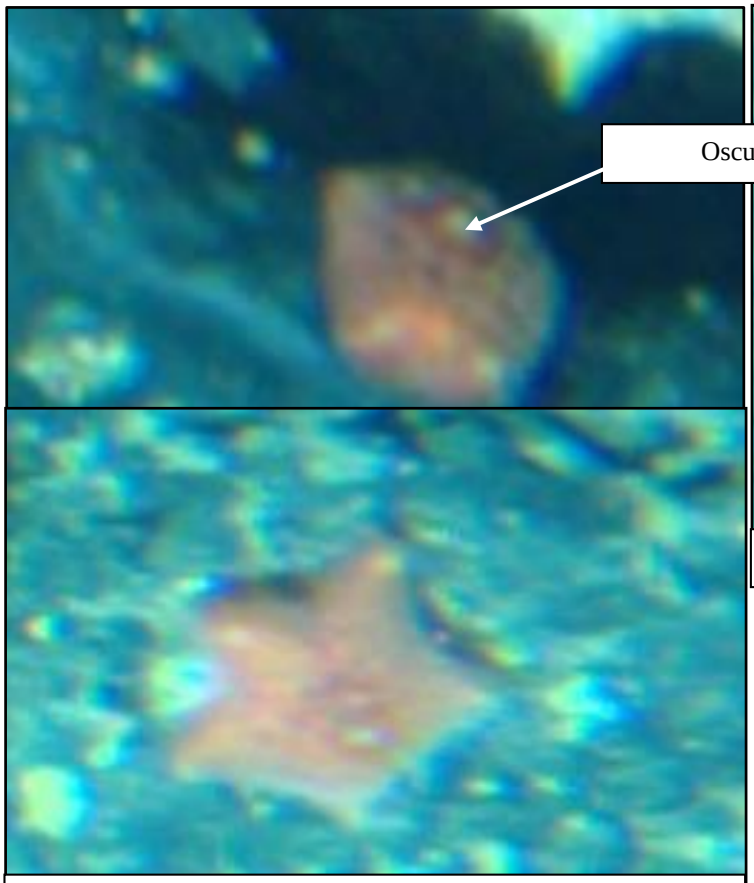
(10)

(9') Osculum present, body often appears inflated or swollen due to supradorsal membrane. Surface varies from appearing rough to pillow-like or transparent. Disk and arms thick. Body shape varies from pentagonal to weakly stellate. Marginal plates not evident. No apparent plates composing body surface. Color in life varies from white to bright red or purple.

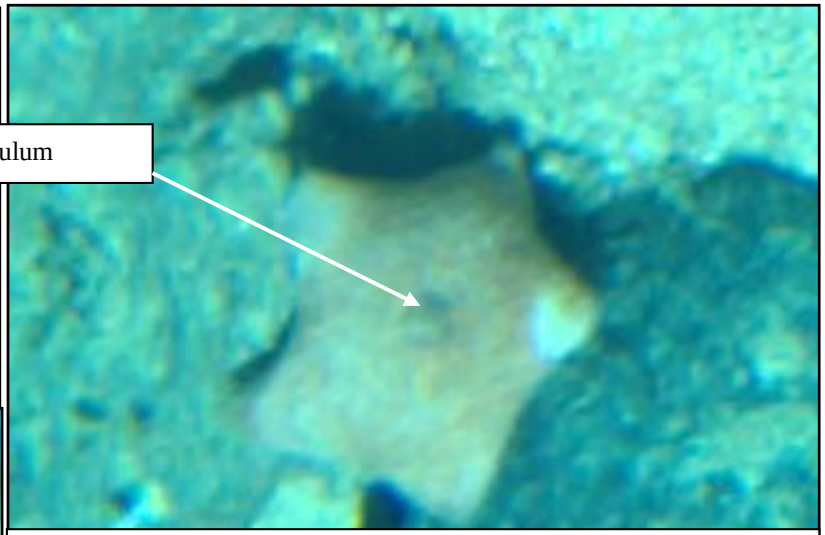
Pterasteridae ("look fat")

(Commonly encountered genera include ***Pteraster****and ***Hymenaster*****, but many more are known)

****Pteraster***: look more textured and thicker.
****Hymenaster***: softer surface, look fleshier than *Pteraster*.



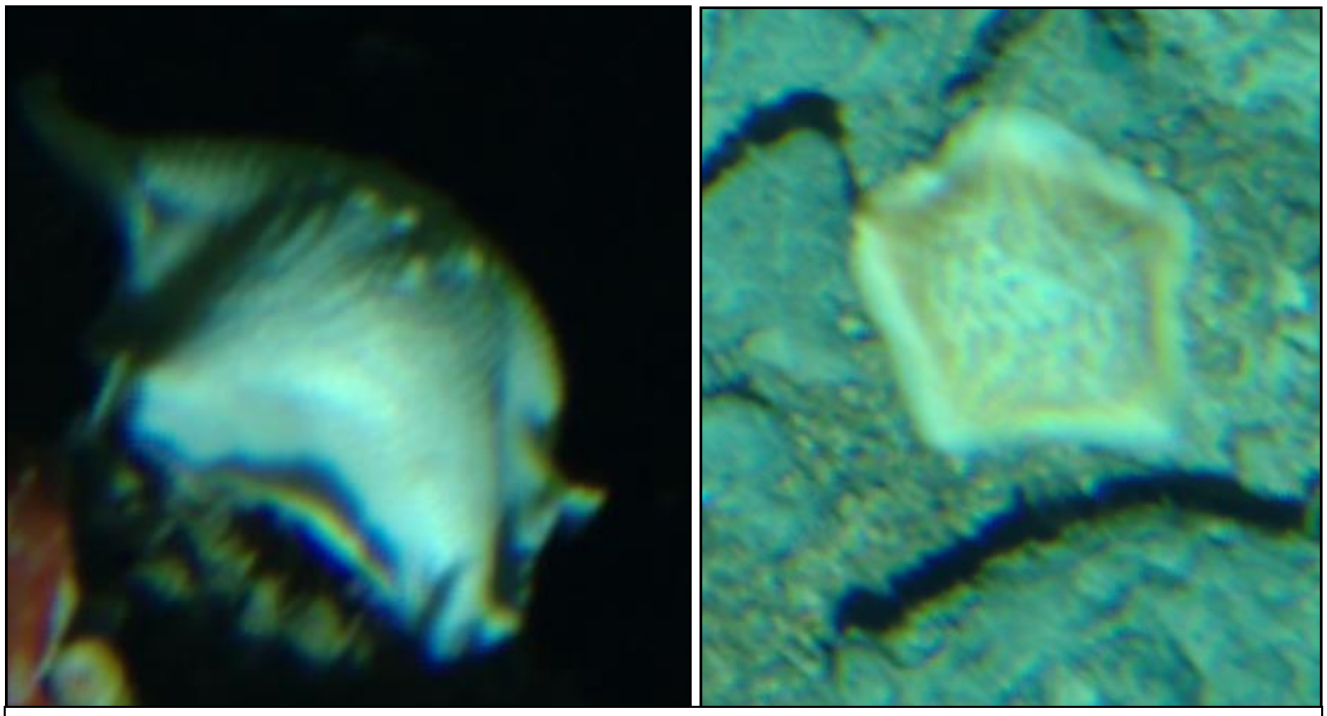
Pterasteridae, potentially *Pteraster* Gen. inc. sp. indet.



Pterasteridae sp. indeterminabilis

(10-1) Body bowl or dome-shaped, high aspect, with rim around edge. Surface composed of imbricate (overlapping) plates with 5 distinct openings on disk center. Marginal plates indistinct. In situ observations show them flush on hard substrates, variably orange to white and orange.

Asterinidae (*Tremaster mirabilis*)



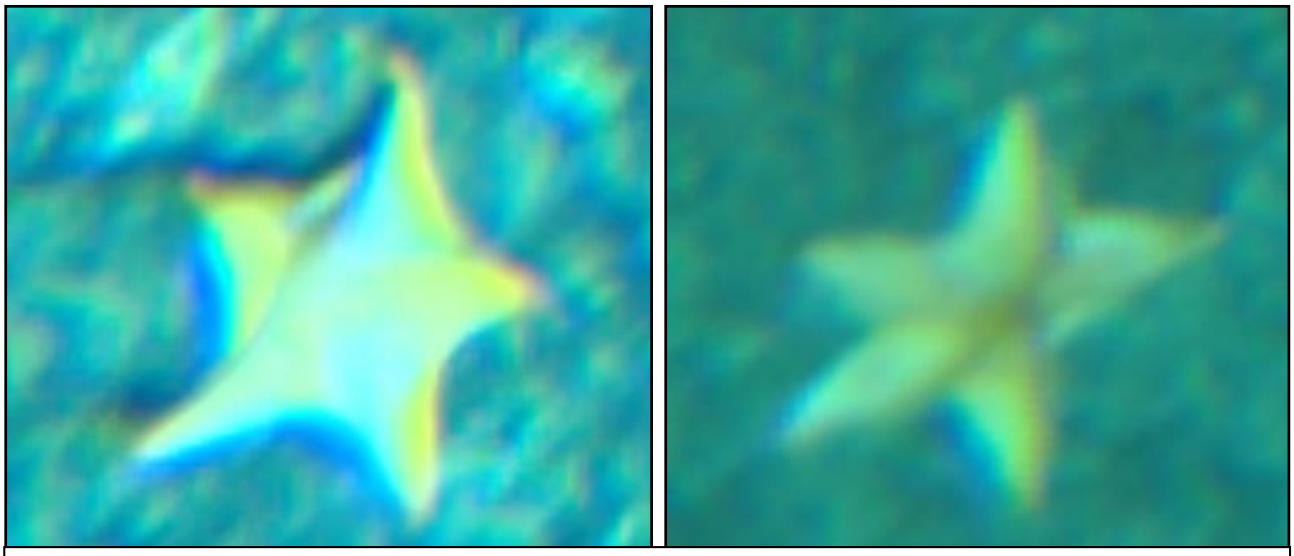
Tremaster mirabilis

(10-2) Body is flattened, sometimes extremely so, ranging from paper-thin to simply flat and thick, but with interradial arc flush with the surface (bottom).

Asterinidae (*Anseropoda or *Paranepanthia***)**

****Anseropoda:*** 5 or more short arms. Body extremely thin. Narrow mid radial bands thickened (thick bands visible in the middle of the arms). Margins straight to slightly curved.
Photo-taxon not identified.

** ***Paranepanthia**:* Arms 5, medium length, wide basally and pointed or rounded distally. Disk flat actinally and rays (arms) elevated to low. In situ observations show them flush on hard substrates.



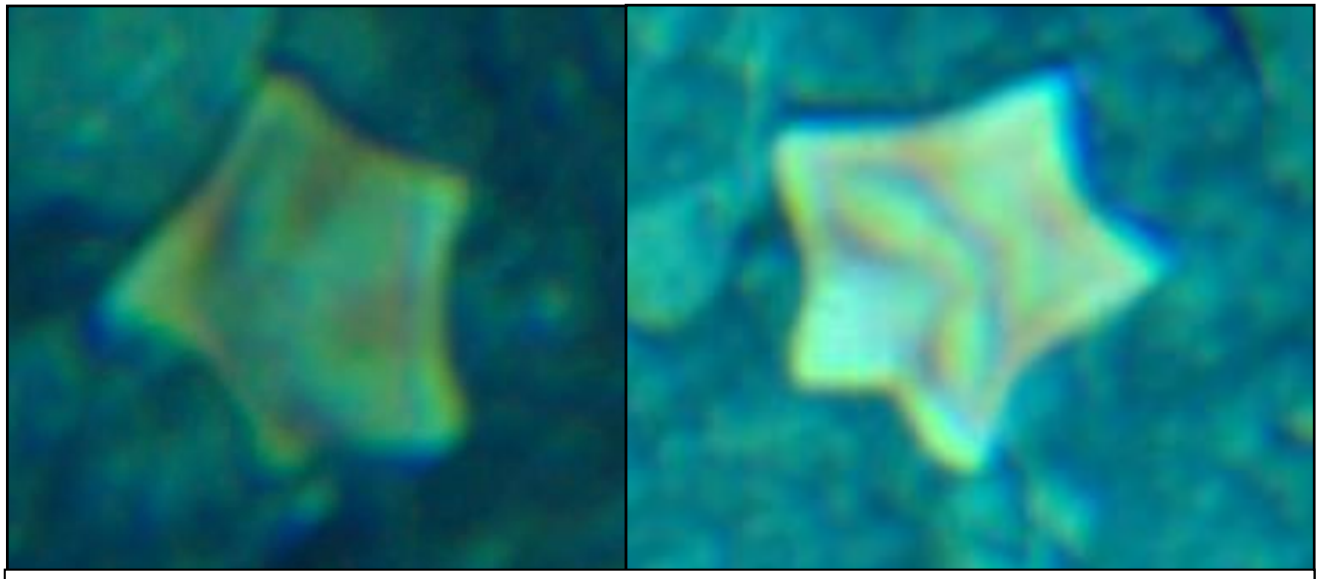
Asterinidae, potentially *Paranepanthia* Gen. inc.

(10-3) Body pentagonal or weakly stellate in shape with distinct, prominent peripheral edge. Body appears "cookie" or biscuit-shaped. Body composed of distinct plates which vary in size but are large enough to be counted from imagery in some species (e.g., *Sphaeriodiscus*). When observed alive, disk varies from flat to swollen.

Goniasteridae

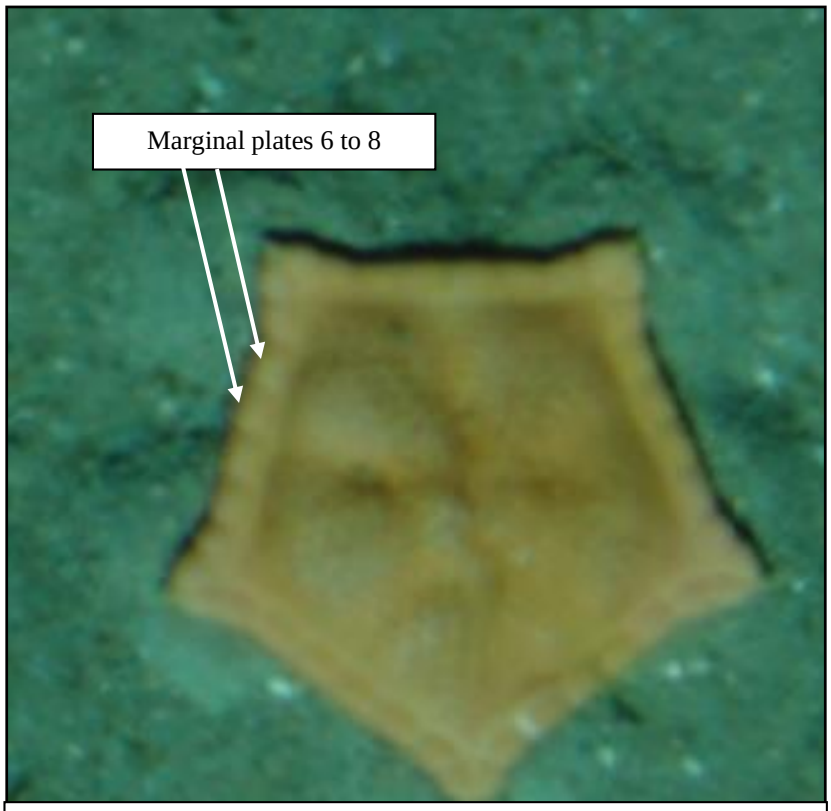
("cookies" such as *Sphaeriodiscus*[1], *Plinthaster*[2], *Ceramaster*, *Apollonaster*, some *Astroceramus* species, etc.)

[1]***Sphaeriodiscus**:* Specimens from the South Indian Ocean observed with a color pattern of light red to dark orange interradial bands. Three species in the area*: S. biomaglo, S. ganae,* and *S. mirabilis.*



Sphaeriodiscus indeterminabilis

[2]***Plinthaster***: Disk very large, pentagonal and arms very short. Interradial arc straight. Marginal plates relatively few per interadius (6 to 8). Orange color pattern.
Nb: pentagonal-shaped or small-sized *Astroceramus* can look similar to *Plinthaster*. Small-sized *Sibogaster* can look similar to very stellate *Plinthaster*.



Plinthaster indeterminabilis

(11) Marginal plates indistinct, not evident from immediate viewing. Disk small with elongate arms in most taxa (R/r = 5.0 to 10.0), which are round or triangular in shape.

(14)

(11') Body with distinct peripheral frame or border (the marginal plates) present around edge of body. The marginal plates can be strongly expressed from the surface or facing laterally. Prominent spines present on marginals and/or abactinal surface in some taxa but others are bare or covered in other accessories, such as tubercles, etc. Disk large or small, arms variable in length and size.

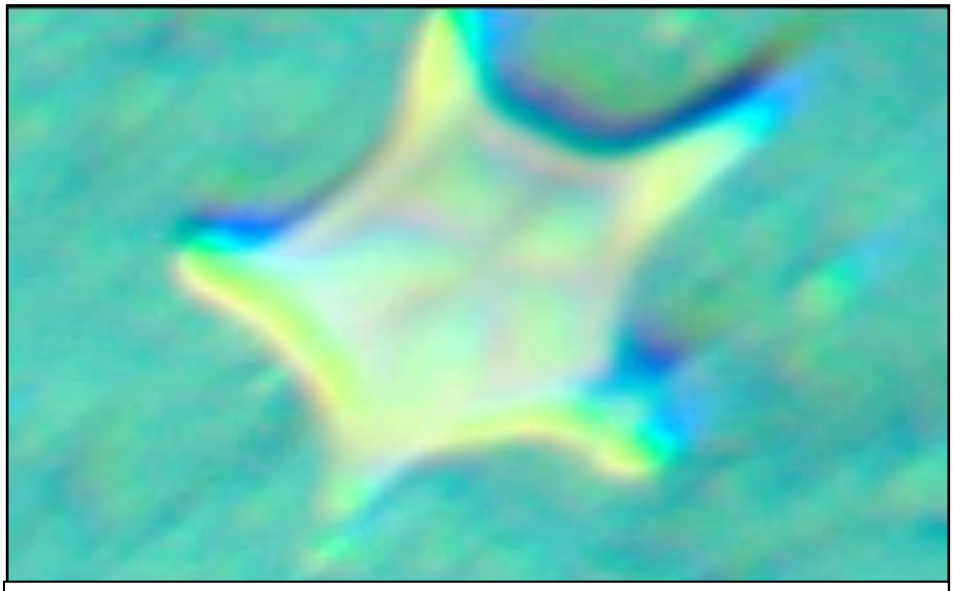
(12)

(12) Arms not strap-like, disk thick and large. Marginal plates distinctly observed forming peripheral edge. Abactinal surface and marginal plate surfaces variably covered by spines, tubercles, granules or by no accessories. Skeleton is well-developed and many taxa display plates in distinct and ordered patterns. The most diverse group within the Asteroidea, demonstrating a wide range of habitats, from deposit feeding to predation on corals.

Goniasteridae

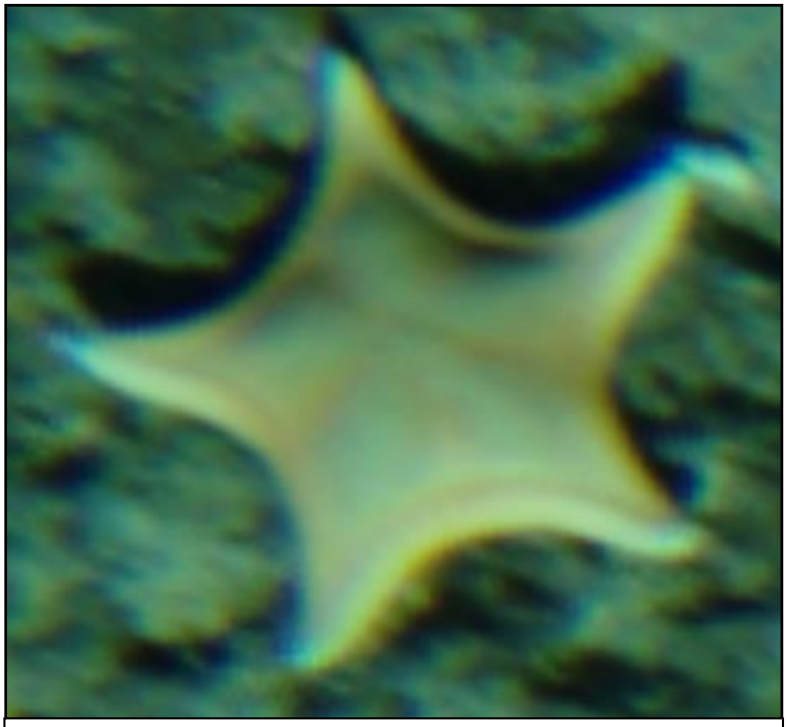
("stellate" shape: such as *Calliderma emma* [1], *Circeaster*, *Anthenoides marleyi*[2], *Lithosoma*[3], *Mediaster*[4], *Wallastra)*

[1]***Calliderma emma****:* Disk flat, arms triangular and tapering abruptly to tip.
Arm tips upturned (shadow visible under the arms). Interradial arc weakly curved to straight. Abactinal surface covered with spines over radial area and absent interradially (image observation show white stellate pattern on the abactinal surface, where the spines are located). Documented distribution in the Mozambique Channel and Pacific. Ranging around 138 to 407 m depth.



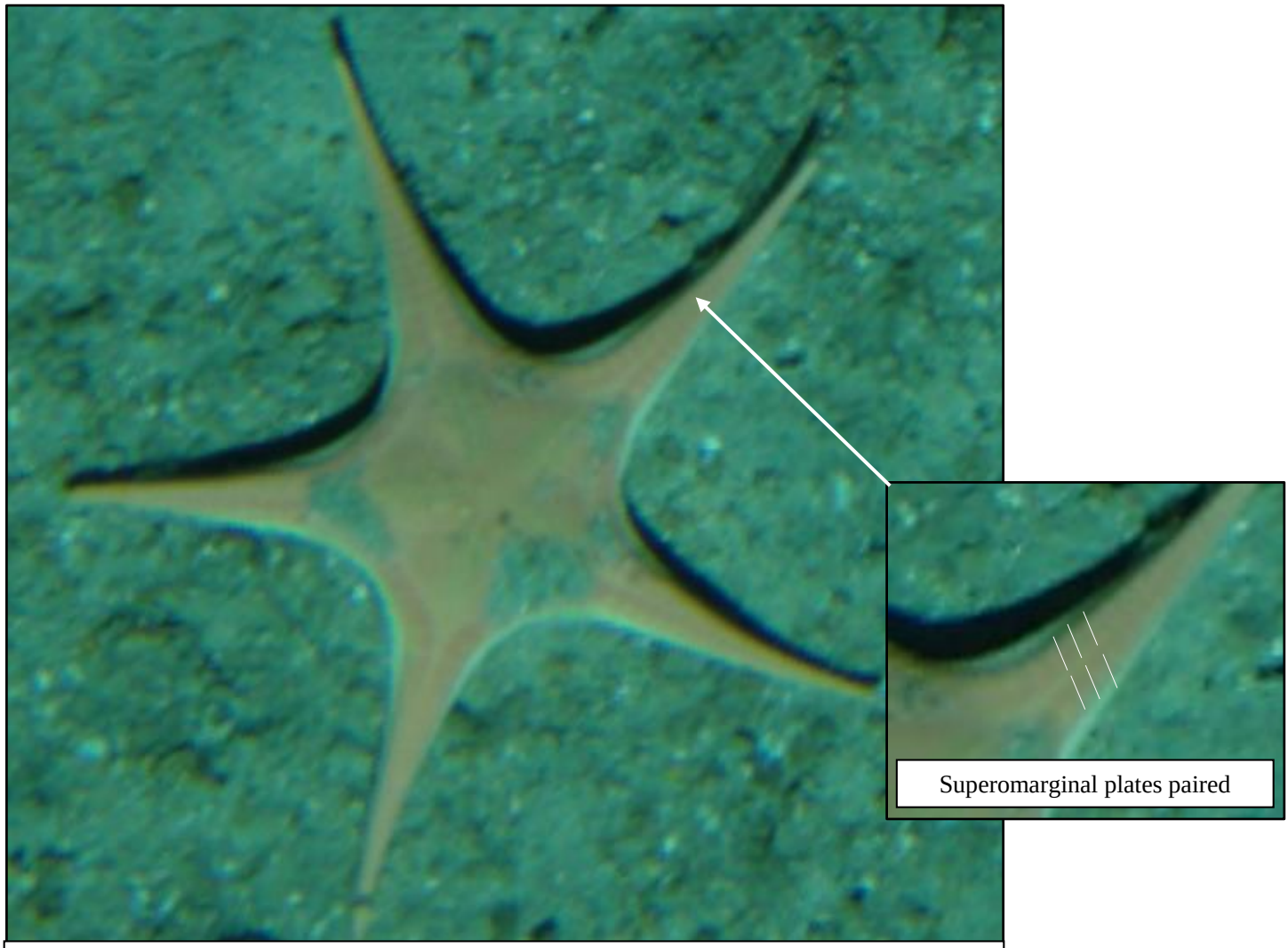
Calliderma emma sp. inc.

[2]***Anthenoides marleyi:*** Arms triangular, wide basally, pointed distally, and upturned. Interradial arcs broadly curved. Large granules button-like present on abactinal and marginal plate surfaces, giving a white stellate pattern on abactinal surface visible in the images. From images, pattern similar to *Calliderma emma*. Occurrence in South Africa, off the coast of Natal Zanzibar channel, Reunion Island, Mascarene Islands, Madagascar, north of Mayotte Island. Depth range around 183–490 m.



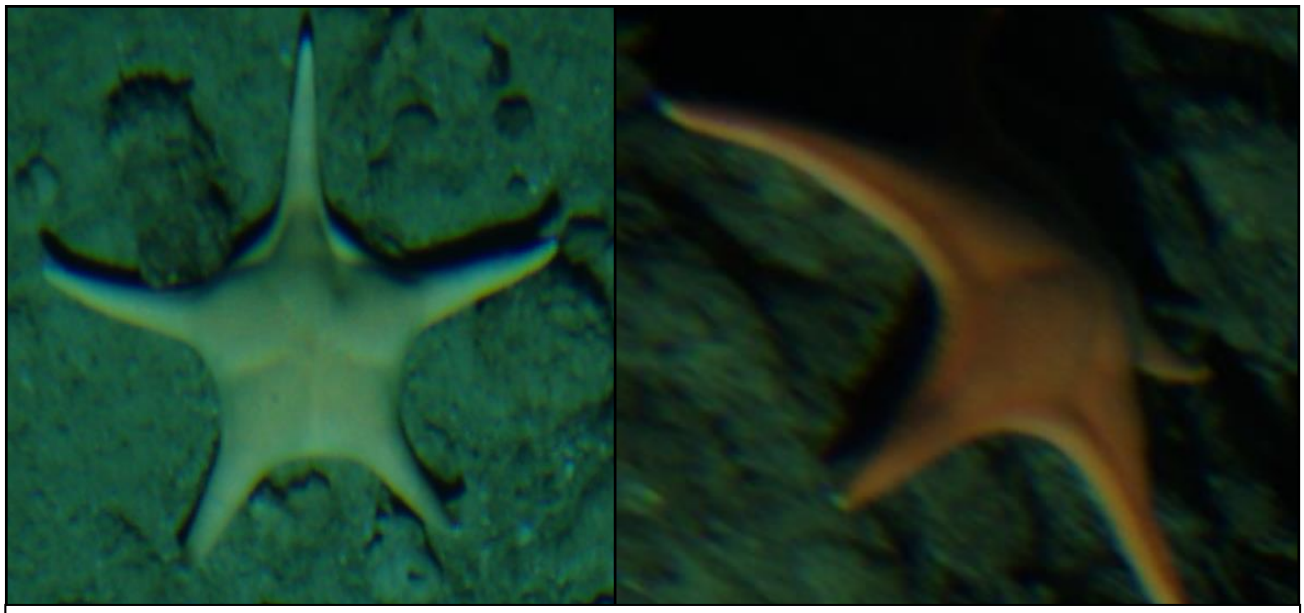
Anthenoides marleyi sp. inc.

[3]***Lithosoma****:* Body strongly stellate and flat, arms very elongate, triangular and tapering distally. Interradial arc curved. Abactinal surface with smooth/bare appearance, with no surficial accessories. Superomarginal plates abutted over midline on arms (2 series organised) along arms. Documented distribution in the Indo-Pacific Ocean regions.



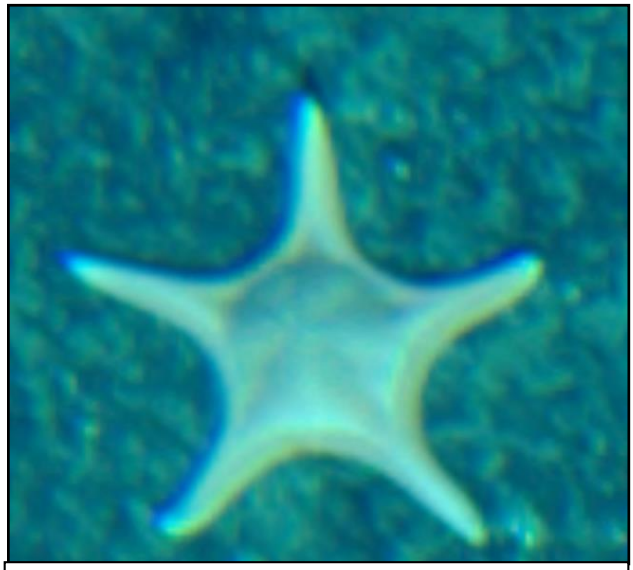
Lithosoma sp. indeterminabilis

[4]***Mediaster****:* Arms elongate with upturned or attenuated tips. Interradial arcs weakly curved to straight. Five swollen radial areas (giving five interradial marks on the abactinal surface). Abactinal, marginal, actinal surface covered by granules (Mah, 2018) (but difficult to observe from images).

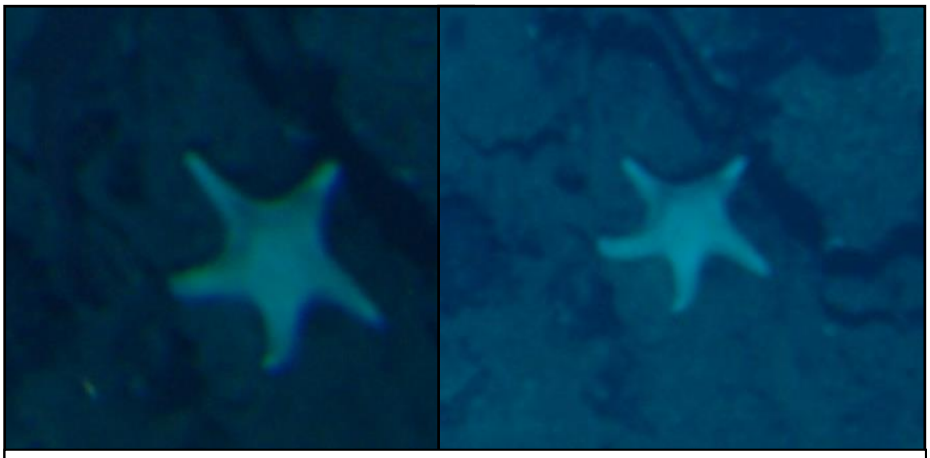


Goniasteridae indeterminabilis (*Mediaster* Gen. inc.)

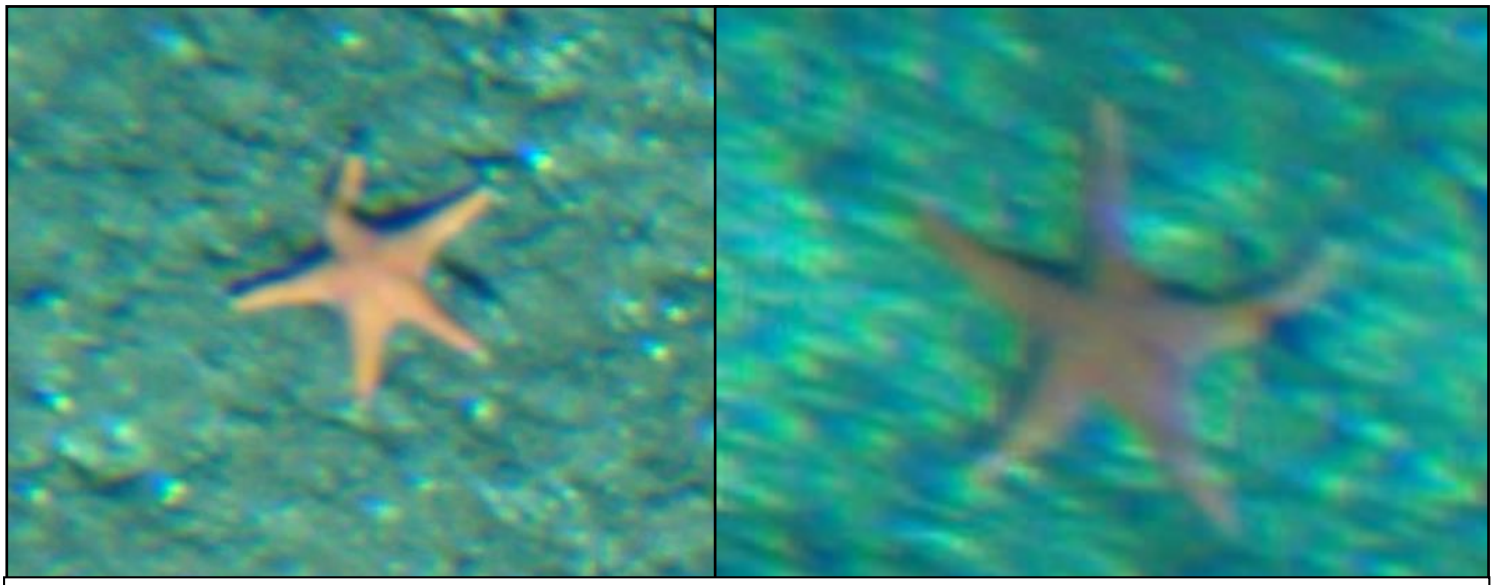
Nb: Goniasteridae morphospecies identified in the area:



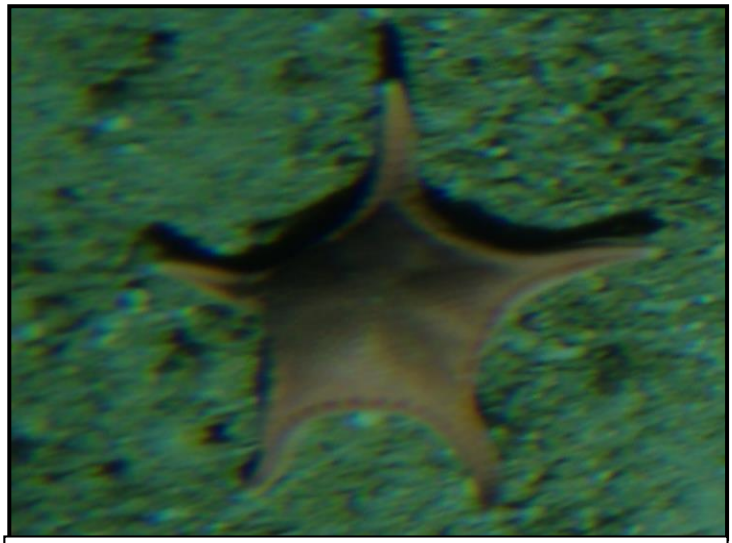
Goniasteridae sp1 (*Circeaster* Gen. inc.)



Goniasteridae sp2 (*Hippasteria* Gen. inc.)



Goniasteridae sp3 (*Mediaster* Gen. inc.)



Goniasteridae sp4 (potentially *Wallastra elenderae* sp. inc.)

Goniasteridae sp5 (Gen. indeterminabilis)

Goniasteridae sp1: Body large, arms slender, interradial arcs straight. Possibly *Circeaster*. Possibly a porcellanasterid but too shallow, and lying on the wrong substrate. Large disk, thick, body shape flat, distinct marginal frame/border (= marginal plates), bared.

Goniasteridae sp2: Whitish, swollen, big morphology.

Goniasteridae sp3: Affinity with *Mediaster* as we observe radial areas swollen on the disk. Less likely would be *Nepanthia*, but here Goniasteridae sp3 has a larger disk.

Goniasteridae sp4: Distinct marginal frame bared with dark separations, ordered. Body and disk large. Shape elevated from seabed (shadow visible under the body).

Goniasteridae sp5: Disk large, marginal plates form clear (light) periphery**.**

(12') Arms triangular in shape, flattened and strap-like and tapering. Interradial arcs narrow and acute. Plates on disk do not form ordered patterns. Paxillae present or not. Buried or not.

(13)

(13) Spines present or absent. Spines not observed on disk or arm surface, but spines present or absent on some taxa. When moving tube feet are prominent with pointed tips and animal is moving over sediment (could not be observed from still images). These taxa are often encountered buried under top layer of sediment.

Astropectinidae (and other Paxillosida)

Astropectinidae indeterminabilis

(13') Sharp spines abundant on abactinal surface, marginal plates. Arms elongate, not buried in sediment. Tube feet not prominent. Not buried in sediment***.**

Benthopectinidae

*****_Cheiraster_ sometimes observed lying on soft sediment/coarse gravels.

Cheiraster indeterminabilis

(14) Surface covered by paxillae, arms short. Peripheral edge with prominent marginal paxillae (tree-like structures) forming lateral edge (but difficult to see from images, rather with a rugged appearance, buttons-like). Body skeleton reticulate forming widely meshed net on body surface. Predatory on crinoids and other invertebrates.

Solasteridae (*Lophaster*)

No photo-taxa identified.

(14') Surface not covered by paxillae, arms elongate. Body skeleton not reticulate.

(15)

(15) Body covered by spines, along surface of arm and along lateral sides and or along mid radial series. Arms triangular or round in cross section.

(16)

(15') No spines on body surface. Arms elongate, cylindrical in cross section.

(17)

(16-1) Sharp, needle-like spines covering the body surface (difficult to see from images), with prominent series along radius of arms and along lateral surface near oral surface. Spines not present in all members but most. *Zoroaster* found in star-shaped depression in sediment. Plates on body in ordered rows. Arms very elongate and tapering, disk very small. Can often reach large size (approaching 20 cm). Color from white to reddish orange.

Zoroasteridae (*Zoroaster*)

(16-2) Short, blunt spines evenly present on body surface, in ordered rows. Arms short, disk small.

Stichasteridae

No photo-taxa identified.

(16-3) Spines along radial ridge and along sides enlarged, prominent with enlarged tufts or bushes of pedicellariae. Arms short, disk small.

Asteriidae (e.g., *Sclerasterias*)

No photo-taxa identified.

(17) Body rigid, arms cylindrical. Plates ordered with many taxa displaying plates and papulae in ordered series arranged in regular order. Tubercles or other round features present on arm and disk surface. Armtips round. Surface appears granular. Occur in shallower water.

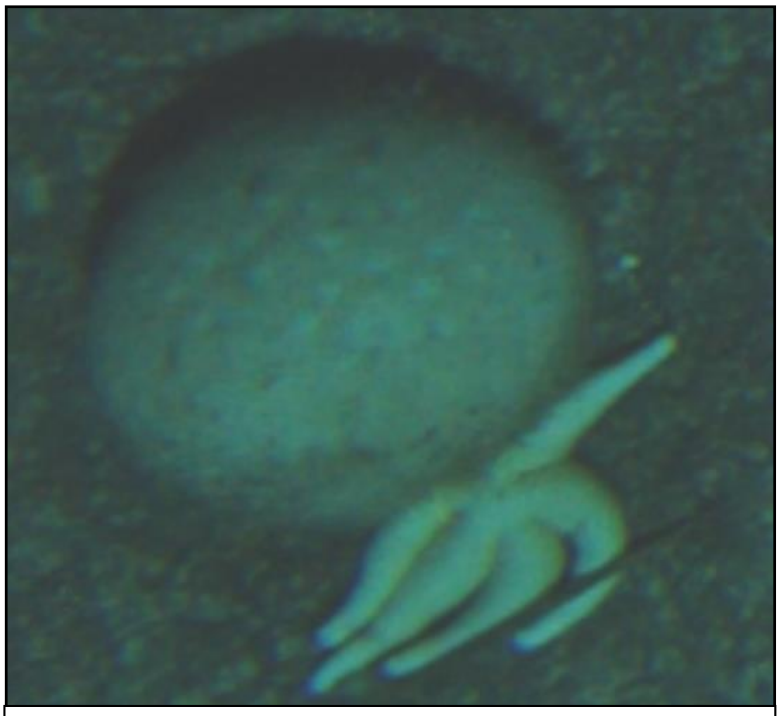
Ophidiasteridae

No photo-taxa identified.

(17') Body showing more net-like, or reticular plate pattern, not in serial arrangement. Surface almost entirely featureless otherwise. Arms elongate but many with curled armtips. In situ color white. Predatory on sponges.

Echinasteridae (*Henricia*)

Henricia indeterminabilis



Henricia indeterminabilis in predation on a sponge