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2000 feet under the sea – visiting deep sea habitats off Roatan (Honduras)

Martin Heß & Christoph Haacke

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In this report we describe the course of a submarine dive to 628 m at the continental slope of the Cayman Trench, together with observations and some insights based on the photos taken with time stamps and pressure gauge readings. We would like to take the reader into a fascinating world below the area accessible to scuba divers and share our impressions through the dive protocol and selected images.

Martin Heß (corresponding author), Biozentrum der Ludwig-Maximilians-Universität München, Großhaderner Str. 2, 82152 Planegg-Martinsried, Germany; and GeoBio-CenterLMU, Richard Wagner Straße 10, 80333 München, Germany;
e-mail: hess@bio.lmu.de

Christoph Haacke, BioDivers, Forellenstr. 3, 85625 Glonn, Germany

Context and mission

On the lifelong path of a biologist to gain a realistic and authentic picture of the living environment of our planet – not least knowledge of species diversity and the relation to habitats – one can partly rely on literature studies, but the direct observation of living organisms in the environment is of particular value and importance. Size and the wealth of detail of this picture depend on the personal interests and initiative, and the feasible expenditure of time and resources. In the field of marine zoology and ecology, there are different approaches to get to know and understand the authentic conditions and processes in the "classroom nature": (1) line fishing, net fishing or grabber samples – invasive methods in which the natural habitat reference is largely lost, (2) visiting aquaria – an often underestimated access to knowledge about morphological appearance and behaviour of animals, yet in artificial habitats, (3) snorkeling – not invasive but very limited in terms of length of stay and diving depth, (4) SCUBA diving – as a rule limited to a diving depth of ca. 40 m with a comparatively high scope of action (mobility, photos and videography, targeted sampling), and (5) the use of submarines or ROVs – not easily accessible and expensive, but with a significantly expanded depth range.

Caribbean inshore waters with their fish species, corals, sponges and other invertebrates, are colourful and puzzling diverse (see. e. g. Charteris 2022). In an era of affordable air travel and a boom in snorkeling and scuba diving, however, they are not unknown to us. Many nature lovers, amateurs as well as professionals, bustle in the warm, light-flooded upper water layer of the lagoons and reefs and enjoy the underwater landscapes, their inhabitants and the marine zoological and ecological insights first-hand. In special cases, especially if an area is far away or otherwise hard to reach, the publication of nature observations by other researchers (photographic documentation, descriptions) can replace one's own observation and represent an adequate way of participation and multiplication among interested parties. In this sense, the article in hand is intended to let the reader participate in an organizationally

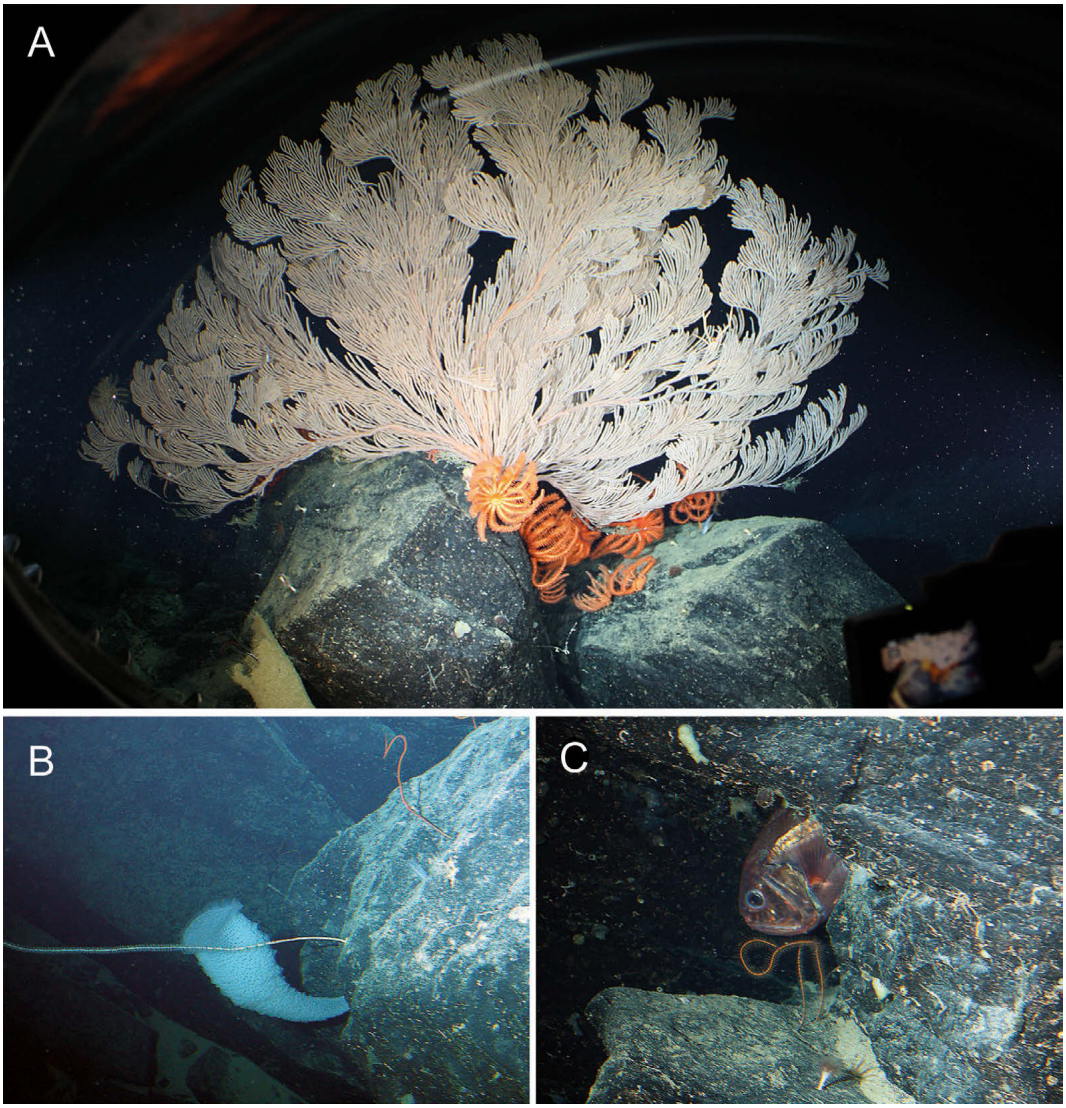

Fig. 1. Selected photos from 605 to 595 m: **A.** A gorgeous whitish sea fan (*Calyptrophora* sp.) with a squat lobster on the right and several brisingid "velcro" sea stars (*Novodinia antillensis*) at the base, waiting to climb up as soon as current comes up at 600 m. **B.** Hexactinnelid "glass" sponge at 595 m. **C**. Big roughy (*Gephyroberyx darwini*), delicate orange sea whips (*Stichopathes* sp.), *Javania* sp. sea anemone at 605 m.

complex and expensive ($1000 per person in the year 2010) "once-in-a-lifetime" excursion into the deep sea.

With the intention of broadening their horizons in marine biology and learning about the macroscopic fauna of marine habitats in a water layer below the area accessible to the SCUBA diver, the authors undertook a journey to the upper southern slope of the Cayman Trench off Roatan (Honduras), where the "Roatan Institute of Deep Sea Exploration" aka "Stanley Submarines" – headed by the American engineer Karl A. Stanley – is located, providing one of the few commercially operated submersibles in the world for use well below 100 m.

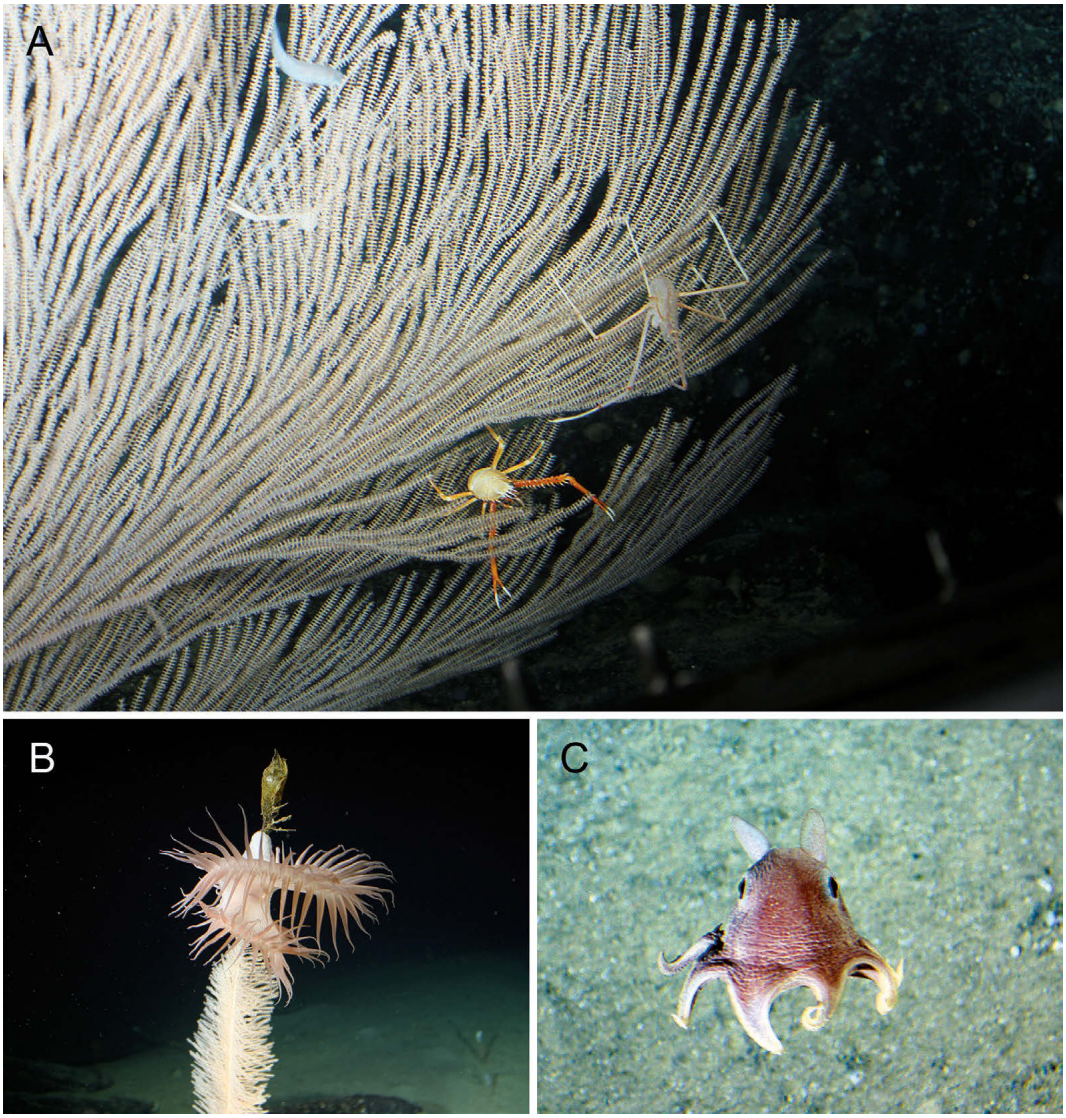

Fig. 2. Selected photos from 555 to 445 m: **A.** Primnoid soft coral with squat lobsters (e. g. *Eumunida picta*) at 445 m. **B.** Venus flytrap sea anemone (*Actinoscyphia aurelia*) on top of a white antipatharian (*Parantipathes* sp.) at 545 m. **C.** Dumbo octopus (Opisthoteuthidae) hovering above the sediment at 555 m.

The submarine

The self-designed and self-built submersible called "Idabel" is the second boat in its series designed for a maximum diving depth of 915 m (3000 feet) and several hours of diving time per trip. It consists of three steel spheres welded together, a minimalistic chassis, seats for two passengers on a small bench behind the 32 inch dome window and the pilot standing behind. It features electric motors with propellers and buoyancy bodies for buoyancy and positioning control, powerful external LED lights and an internal SLR camera with external TTL flash. CO_2 absorbers and O_2 tanks ensure that the right atmosphere is maintained in the limited volume inside the submersible.

The dive

August 17th 2010, Halfmoon Bay, West End, Roatan Island, Honduras (16°18'27.5" N 86°35'37.6" W): Once the authors climbed into the boat and sat down on a small bench behind the dome window, the pilot got ready and the hatch was closed, the submersible was pulled a few 100 m NW from the Halfmoon Bay by a small motorboat on a rope. A special feature of the Cayman Trench off Roatan (and according to K. Stanley a reason for the choice of site) is the lack of a continental shelf: just after the reef top, the continental slope drops down in steep steps and allows rapid access to deep-water habitats.

At 3:48 p.m. the ballast tanks were flooded and the boat began its descent through the clear open Caribbean waters. The boat sank at about 30 m/min, the ocean appeared in increasingly darker blue, surprisingly bright for a long time, while small fish, shrimp and medusa passed the field of view. After about 10 minutes, the lamps were switched on at a depth of ca. 300 m (whereby the light regime suddenly changed to give the impression of a night trip) and we dropped a little slower to 380 m where the first steep black rock blocks with some sediment on top appeared in the light cone in front of the dome window. After 30 °C water temperature on the surface it was now pleasantly cool. Scattered on the rocks whitish sponge cups (Hexactinellida) and robust blue-grey holopodid crinoids (*Holopus* cf. *mikihe* Donovan & Pawson, 2008) and a big-eyed blueish epigonid fish were seen. The descent now slowed down a little but aimed to the maximum depth – at 4:23 p.m. the manometer showed 2060 feet (628 m). Fascination, curiosity and the trust in the technology kept our heads clear. Initially, the scenario at this depth was a barren sediment slope, with inhabitants basically familiar but nevertheless completely new to us: First we saw a nephropid lobster with fine scissors looking out of its burrow, followed by a tripod fish or "stilt walker" (*Bathypterois* sp.) and a cute looking dumbo octopus (Opisthoteuthidae) hovering above the sediment (Fig. 2C).

From now on it went constantly up again, with small sedimentary areas and steep rocks alternating. As soon as interesting creatures appeared, we stopped and took photos: at about 610 m we saw feather stars in orange and white on black rocks, scattered small calcareous tube worms, glass sponges of various types, including textbook-like tube-shaped and goblet-shaped Euplectellidae (Fig. 1B) and the glassy plexus of *Farrea* sp. Various hydrozoans colonized the rocks, white/straight and orange/coiled delicate sea whips (*Stichopathes* sp.), a fleshy *Actinia*-like sea anemone and the small *Javania* sp. (Skleractinia! see e. g. Auscavitch et al. 2020, fig. 8E) with their conical white skeletons. Moreover a colourful squat lobster and a shiny reddish fish (the big roughy, *Gephyroberyx darwinii* (Johnson, 1866), life expectancy approx. 200 years, Fig. 1C) were seen. At approx. 600 m a magnificent large whitish gorgonian appeared with pink branches (Primnoidaea, Calyptrophorinae, Fig. 1A) and at its base some sturdy orange "velcro" sea stars (*Novodinia antillensis* (A.H. Clark, 1934), Brisingidae) were waiting – various small brittle stars sat on the rock. Passing a fish in head down posture and a white bottlebrush anthipatharian (*Parantipathes* cf. *tetrasticha* (Pourtalès, 1868)), at 580 m we reached another rock step with thin sediment cover, on which a thick-lipped brown-spotted lophiid fish (*Lophiodes* cf. *beroe* Caruso, 1981) has made itself comfortable, accompanied by a red and white cross-banded shrimp with red legs. Again, at 555 m, we met a dumbo octopus (Fig. 2C) hovering over a flat sediment slope with isolated black stones, attracted by the searchlights. A Venus flytrap sea anemone (*Actinoscyphia aurelia* (Stephenson, 1918)) sat on top of a yellowish-white antipatharian (Fig. 2B). All around stalked cup-shaped glass sponges (*Hyalonema* sp. with numerous small anemones colonizing the stalk) were found and some eelgrass detritus testifying the entry of particulate organic material from the euphotic zone into deep water. 15 m further up, the submersible approached a dogfish (squalid shark), which slowly pulled away. Just as if it was ordered from the standard cabinet of deep-sea animals, a giant isopod (*Bathynomus giganteus* A. Milne-Edwards, 1879) appeared, crawling and swimming, and a beautyful palm-sized dinner-plate jellyfish (*Solmissus* sp., an actively hunting hydromedusa) floated near the dome window.

The next 50 meters in hight were characterized by a sediment slope with some eelgrass detritus, a brownish regular sea urchin with delicate white spines, a black tube anemone, an unidentified slender eel-shaped fish (grey dorsally, white ventrally), an orange-coloured sead toad or frogmouth (*Chaunax* cf. *pictus* Lowe, 1846) in a sediment pit, and a white sea cucumber with two rows of dark "spines", surrounded by signs of sediment-digging animals. At about 445 m another white-pink primnoid sea fan with chirostyloid squat lobsters (e. g. *Eumunida picta* Smith, 1883 and other more whitish ones) appeared, which we photographed from close up (Fig. 2A). Following this, the Idabel slowly floated upwards along dark rock steps, again with *Holopus*, glass sponges, antipatharians, and sturdy whitish sea fans.

From 435 m upward we finally could catch sight of the long-awaited "*Lophelia*" reef with the deep-water hard corals *Dendrophyllia alternata* (Pourtalès, 1880) (yellow) and *Desmophyllum pertusum* (Linnaeus, 1758) (white) (Fig. 3C). They were scattered on top

of rock steps, and – unlike their shallow water relatives – they grow very slowly without the help of the photosynthetic-symbiosis with Zooxathellae. There also was a yellow crinoid (*Crinometra brevipinna* (Pourtalès, 1868)), a squat lobster, small red brittle stars, a flat "armless" *Tremaster*-like starfish and a cidarid sea urchin. A long-tailed, silvery zeiform fish (*Grammicolepis brachiusculus* Poey, 1873) with an isopod attached to its flank passes by and, on a sponge, a large pleurotomariid slit-snail (*Perotrochus* sp., see e. g. Etnoyer et al. 2011) was busy feeding. In the open water, a shrimp floated by with its antennae bent backwards and on the sediment a *Nymphaster* sp. sea star was found at 415 m.

At 18:18 we reached a conspicuous yellow gorgonian (*Paramuricea* sp., Fig. 3B) at a depth of 408 m. A suspension-feeding velcro seastar sat on its fan on the right and a brittle star (*Asteroschema laeve* (Lyman, 1872)) on the left, each on half of the available surface. A time series study on exactly this individual (Etnoyer et al. 2022, fig. 11) probably shows the same individuals in the same place for years. Stony corals were found basally. At about 385 m we saw another large yellow gorgonian fan (*Paramuricea* sp., Fig. 3A) in a typically raised position with a few crustaceans and 15 white-pink brittle stars (*A. laeve*). Consecutive photos show their arm tips snaking around the gorgonian's branches in constant motion. After Girard et al. (2016) they are mutualistic symbionts and again the same individuals sit in the same place for years (Etnoyer et al. 2022, fig. 10).

On the next sediment slope (approx. 375–325 m) the ride went up a little faster at approx. 3–4 m/min. We now encountered the white sea cucumber species already known to us swimming, i. e. undulating dorso-ventrally according to their secondary bilateral symmetry (Fig. 4C), a yellowish moray eel with white spots and a distinctively patterned dorsal fin (*Gymnothorax* sp., Fig. 4B), moreover a tube anemone with striped tentacles, as well as creep marks on the sediment surface together with pans and small heaps as signs of the bioturbation of burrowing organisms. After further ascent we saw stalked crinoids with a small yellow crown (*Democrinus* sp.) on the sediment at 250 m depth and at 210 m rough rocks with small caves appeared as relicts of former ice age reefs. Small whitish cup-shaped sponges (Corallistidae), whip corals, gorgonian fans and the magnificent white sea lilies *Cenocrinus asterius* (Linnaeus, 1767), which appeared somehow archaic for echinoderms, grew here (Fig. 4A). Signs of red calcareous algae at 150–160 m showed their lowest distribution limit in the dim daylight in the very clear Caribbean water that obviously is still sufficient for photosynthesis (see also Amado-Filho et al. 2012). In the open water a small squid and some teleosts came around.

In the ascent we were now approaching the lower limit of the recent reef. The benthic macrofauna became somewhat more diverse from 90 m with numerous elongated sponges, initially quite colourless and from approx. 75 m brownish and orange. There were flat brownish corals and increased red calcareous algae – and surprisingly some large lion fishes. Suddenly we were back at the seagrass meadows of Halfmoon Bay and at the docking station. At 8:05 p.m. we left the Idabel after 4.5 hours, the windows were fogged up, it was already dark outside. Only now we noticed a little back pain from the stooped posture, which could not cloud the happiness of the very valuable and unforgettable new marine biological insights.

Reflections

In summary, it can be said that the dive was an intense experience in which we crossed the border between the well-known upper coral reef and an underwater world that was completely new to us. We have encountered organisms that we have never seen on well over 1000 dives in the last decades, which partly appear familiar due to their clear systematic affiliation, but partly also surprisingly strange due to their specific shape and behaviour (e. g. swimming sea cucumbers). In the course of the classification of these life forms and adding habitats, which are inaccessible for scuba divers, into our marine biological world view, they change from surreal to real (also confirming what we have been able to see from the media about the deep sea).

Among other things, the following insights were gained: (1) In about 150 m a zone with a characteristic community of deep-water organisms begins, a habitat that is separated from the light-flooded colourful reef top by a barren reef zone (into which technical divers occasionally penetrate with great effort and risk-taking, but usually don't leave it behind). (2) In the clear Carribean water red calcareous algae apparently survive to a depth of about 150 m (see also Almado-Filho et al. 2012). (3) Dead eelgrass material is still found on sediments in a depth of several hundred meters – luckily we found no anthropogenic waste down there (but see www.jimsadventures.com, figs 21 and 33). (4) With regard to settlement density and species diversity, the continental slope was way sparser than the reef top, but definitely colourful. Gorgonians and corals form gathering points for a diverse epifauna. (5) The organisms mentioned in the main part may be little known but nevertheless they are not rare. (6) Individuals may live many years and shape the image of the underwater world locally (e. g. single

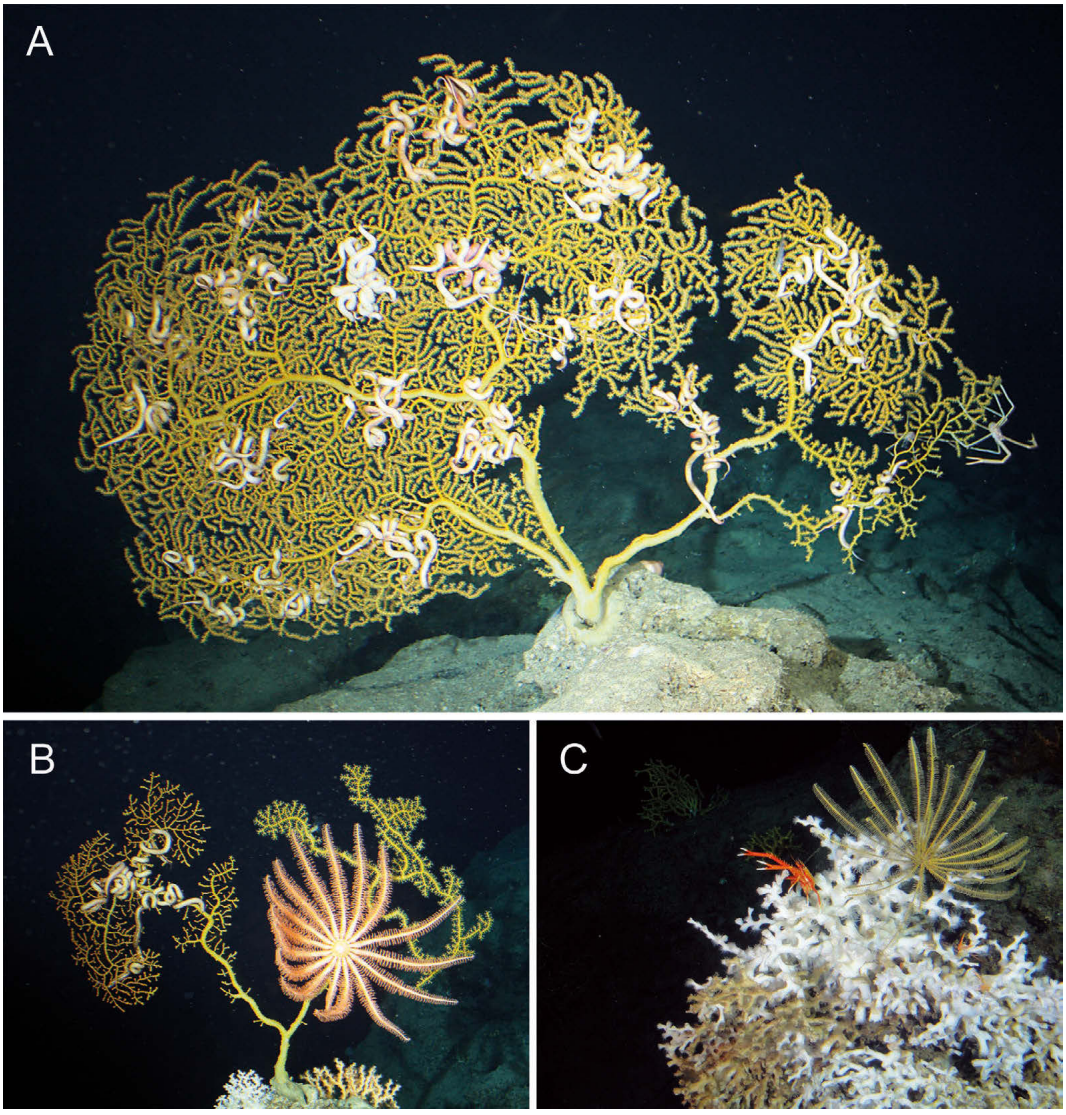

Fig. 3. Selected photos from 408 to 384 m: **A.** Yellow gorgonian fan (*Paramuricea* sp.) with 15 commensalic brittle stars (*Asteroschema* sp.) and tree chirostyloid squat lobsters at 384 m. **B.** *Paramuricea* sp. with *Asteroschema* sp. on the left and a suspension feeding velcro sea star (*Novodinia antillensis*) on the right at 408 m. **C.** Deep water coral "*Lophelia*" (*Desmophyllum pertusum*) with a colorful squat lobster and a yellow feather star (*Crinometra brevipinna*) at 395 m.

gorgonians, corals, sponges) and the epifauna (e. g. echinoderms) also remains constantly at its location for a long time (Etnoyer et al. 2022). (7) The presence of the invasive lionfish (*Pterois volitans* (Linnaeus, 1758)) at depths of up to 100 m shows the extent of their establishment (see also Gress et al. 2017). The attempts of the dive center teams to decimate them by regular harpooning on the narrow routes along their dive sites turn out to be a Sisyphean task, albeit on a small spatial and temporal scale possibly successful in protecting the native reef fish.

Finally, we hope that the valued reader of this article can relive the described visit to the "deep sea" and that the descriptions and pictures will delight and inspire him or her. In this sense we will close this trip into a hardly accessible habitat with a sentence

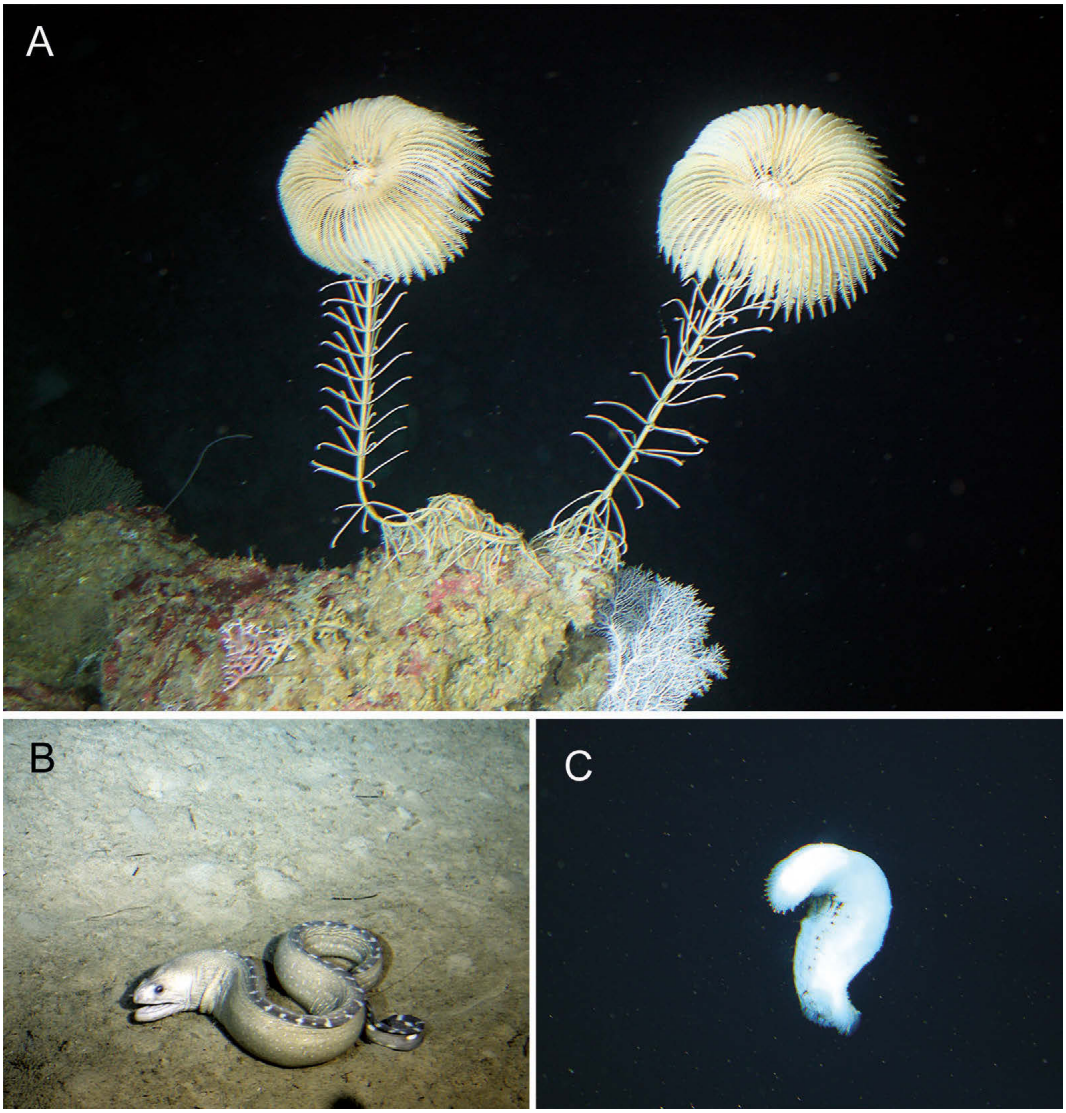

Fig. 4. Selected photos from 375 to 160 m: **A.** Two stalked crinoids (*Cenocrinus asterius*) at 160 m. **B.** Unidentified moray eel (*Gymnothorax* sp.) at 325 m. **C.** Swimming sea cucumber (Psychropodidae?) at 375 m.

of William Beebe (1926): "When you leave the world for which God made you and willfully enter other strange ones, it is reasonable to suppose that your senses and brain have to become readjusted …".

Acknowledgement

We thank Karl A. Stanley to carry us safely down and up to many appropriate spots for our deep water photo safari.

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