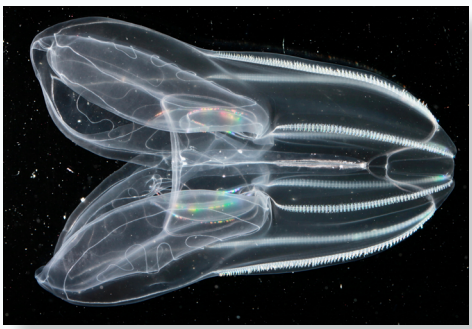
Deep-Sea Life

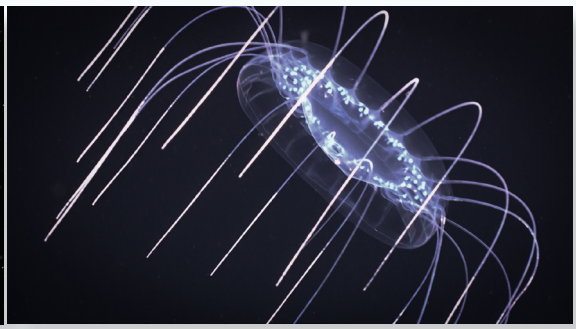
CELEBRATE!

Issue 20 January 2023

Today we celebrate our 20th edition of *Deep-Sea Life* – that's 10 years of exciting news shared by, and for, our deep-ocean community. We know so much more about life in the deep than we did in 2013 and *Deep-Sea Life* has helped to keep the community aware of these new findings and related activities. Thank you to all our colleagues who have made this effort a success. I am going to put all your names in a (virtual) hat and select one lucky contributor who will receive a mystery deep-sea gift from DOSI HQ in celebration of this DSL milestone! I will be in touch soon if you are the winner.

Deep-Sea Life was inspired by the original *Deep-Sea Newsletter* that many of us remember fondly, which started in October 1978 and was edited by Dr Torben Wolff (University of Copenhagen). It was our sincere hope that *Deep-Sea Life* (originally an INDEEP production) would be a useful read and would enhance our communication on an international level. Over the years, we have received heaps of positive feedback from readers that convinced us it was a good use of our time! In 2018, the Deep-Sea Biology Society provided additional production support to DSL and enhancement in the form of web-based media elements with a view to improving clarity and communication to the general deep-sea biology community.





We couldn't choose between these two beauties for the 20th anniversary photo of the issue so have gone with both! The first is the stunning *Bolinopsis microptera* which was photographed by Shannon Johnson from Monterey Bay, California. Read the related article: Speciation of pelagic zooplankton on page 41. The second image is *Solmissus* and the observation was made during the final midwater transect of the third dive of the second NOAA OE Voyage to the Ridge 2022 expedition, at 500 meters (1,640 feet) depth.

Thanks as ever to the editorial team: Drs Abi Pattenden - University of Limerick, Ireland, Eva Ramirez-Llodra - REV Ocean, Norway, Bhavani Narayanaswamy SAMS,Scotland, Franck Lejzerowicz - University of Oslo and Michelle Taylor - University of Essex, UK. Special thanks to Abi and Eva who have been working with me on DSL from the very start and without them this production would not have been possible.

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DOSI DEEP-OCEAN STEWARDSHIP INITIATIVE

DEEP-SEA BIOLOGY SOCIETY

A DOSI and DSBS collaborative publication

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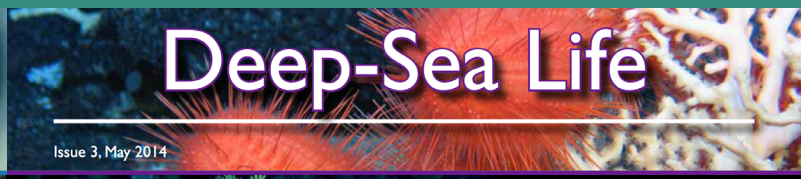
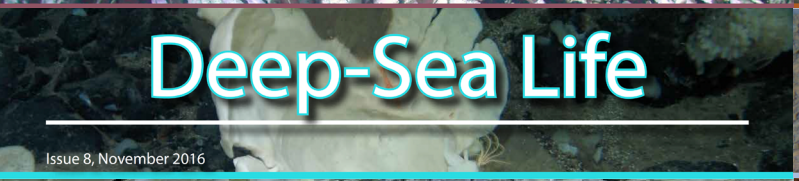
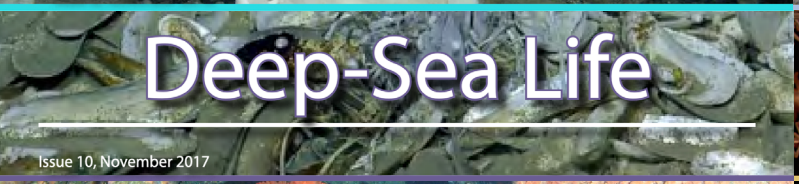
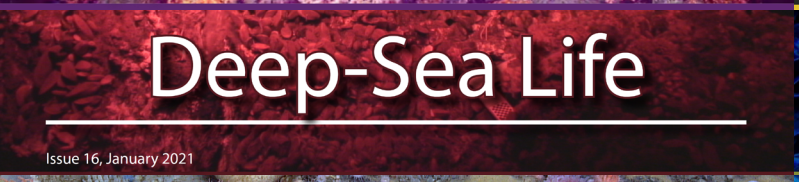








Deep-Sea Life

CELEBRATE!

Issue 20

January 2023

Cruise News

AleutBio Expedition 2022

Angelika Brandt, Saskia Brix, Pedro Martinez Arbizu, Davide Di Franco, Andreas Kelch, Henry Knauber, Frederic Bonk, Stefanie Kaiser, Senckenberg and the AleutBio team

The AleutBio (Aleutian Trench Biodiversity Studies) expedition was conducted from 24.7.-6.9.2022 with RV *Sonne* to explore deep-sea communities of the Northeast (NE) Pacific into the Bering Sea as well as the eastern Aleutian Trench (SO-293). The "AleutBio Project" has been officially declared a UN Decade project contributing to the Challenger 150 program.

During the AleutBio (SO293) expedition, we were aboard RV *Sonne* for a total of 44 days, 2 hours and 34 minutes, and travelled over a distance of 3631 nautical miles. We sampled 15 station areas and 952 stations using standardised deployment of our equipment. Over the course of six weeks, we deployed 108,000 m of single-wire cable and 643,000 m of deep-water cable, equalling the approximate distance from Frankfurt to Monaco. In our Access database we have recorded 1765 numbers for Kautex jars containing bulk-fixed samples and 4972 inventory numbers for sorted samples. Despite major logistical difficulties in organizing transatlantic container transport we were able to bring very extensive animal material and PCR products back home to our laboratories under refrigeration. In addition, we have informed the public about AleutBio via 40 daily blogs in two languages (German and English) via the Senckenberg Museum blog site. This blog page also includes the cruise report SO293.

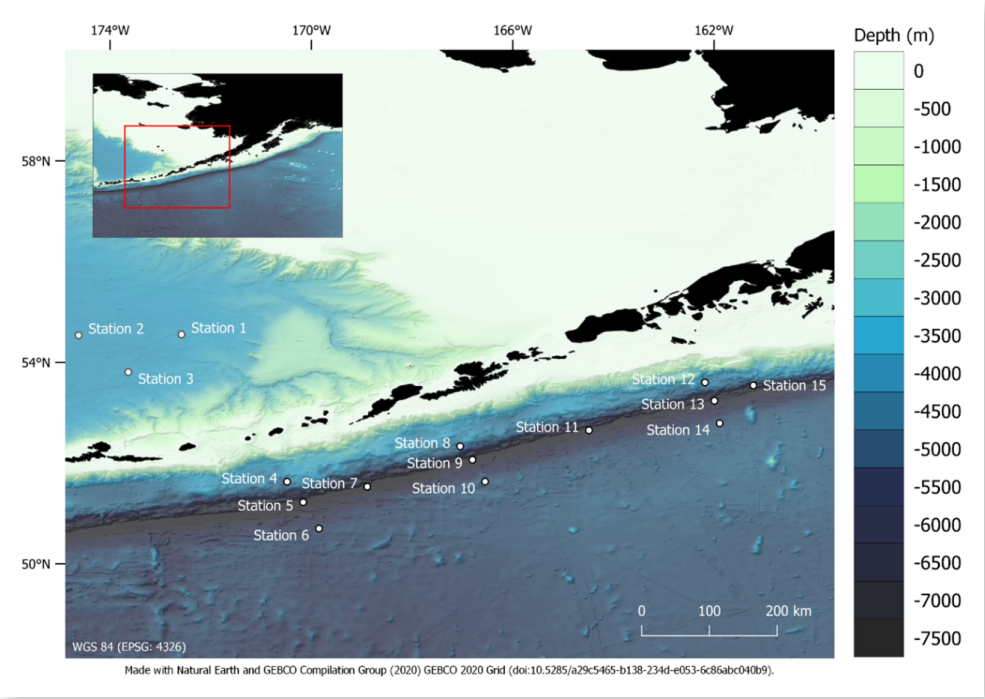


Figure 1: Station areas 1-15 of the SO293 (AleutBio) expedition (Image: A.-C. Wölfl & K. Kess, Geomar).

The Aleutian Biodiversity studies support protecting the deep sea and its species!

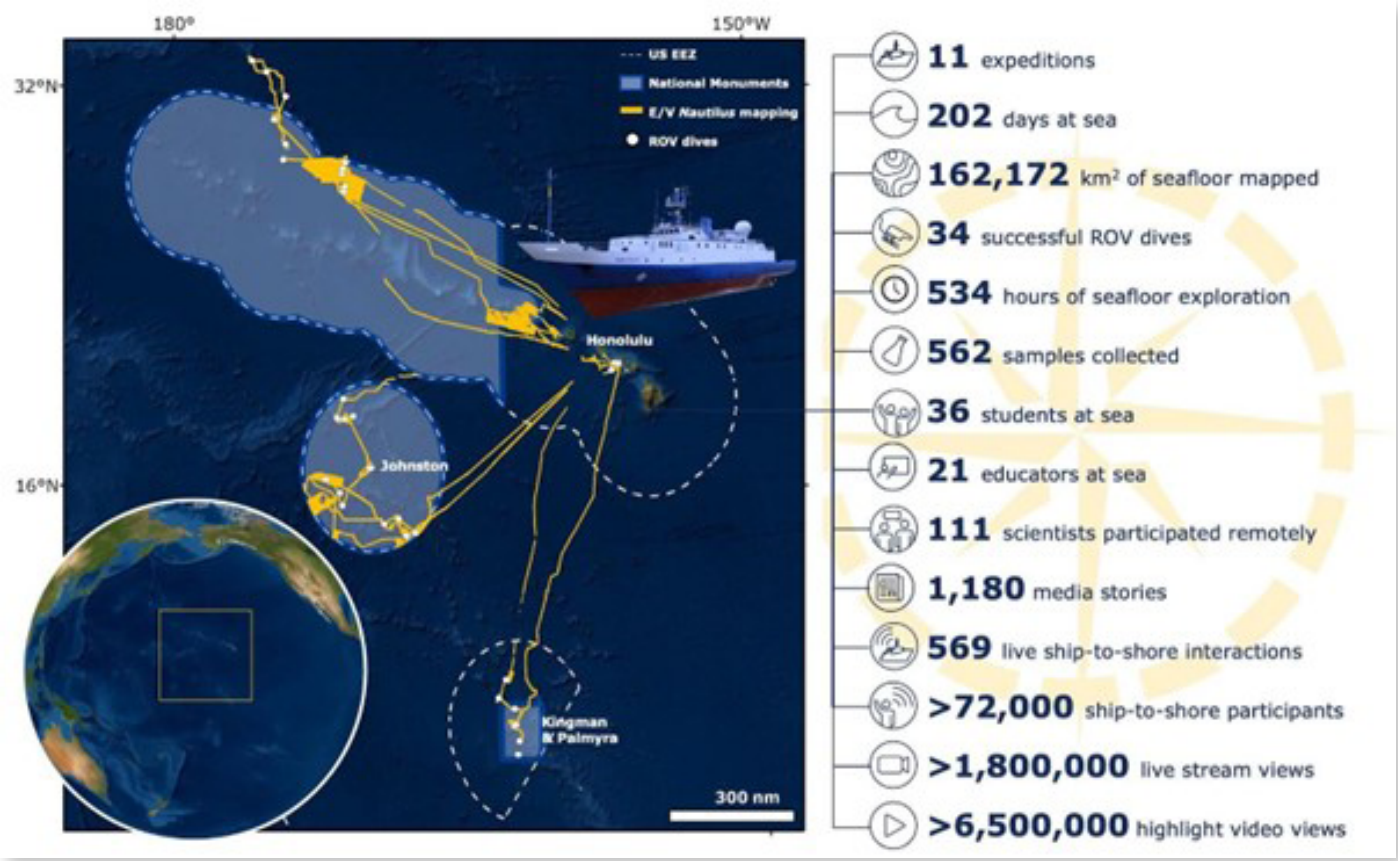
Read the Senckenberg Policy Brief here.

2022 E/V Nautilus Field Season Overview

Daniel Wagner, Ph.D., Chief Scientist

OVERVIEW

In 2022, E/V *Nautilus* completed 11 expeditions that mapped and characterised some of the most remote deep-water locations in the US Pacific, integrating emerging exploration technologies, and showcasing a new shallow-water program. Funded by NOAA Ocean Exploration via the Ocean Exploration Cooperative Institute, NOAA Office of Coast Survey via the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, and the National Geographic Society, 2022 expeditions surveyed a wide diversity of habitats and geological features, ranging from coral reefs just a few metres below the surface to abyssal depths approaching 4,000 m.



KINGMAN & PALMYRA

Between March 14-April 5, E/V *Nautilus* conducted an expedition to map and explore the US EEZ surrounding Kingman and Palmyra islands. The expedition completed eight ROV dives, six of which were within the Pacific Remote Islands Marine National Monument, and two in an area that may be considered for Monument expansion in the future. During one of these dives, the ROVs documented an enigmatic sedimentary deposit, which may represent turbidites deposited after a slump failure, a phenomenon that has not been recorded in this region before.

PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT

Between 7 April - 13 September, E/V Nautilus conducted three expeditions in and around the Papahānaumokuākea Marine National Monument. The first of these included ROV explorations, and the other two were dedicated to

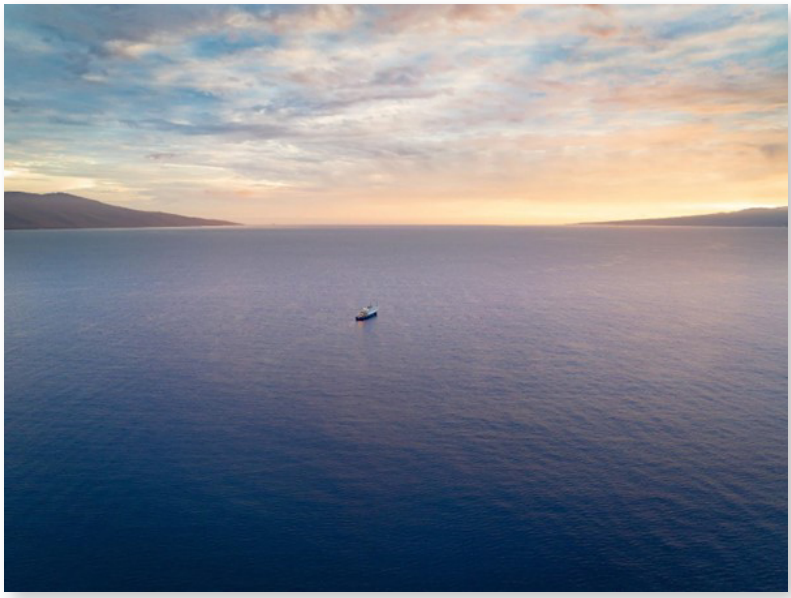
mapping. Noteworthy ROV observations included a "yellow brick road" documented at 1,029 m, a geological formation that likely represents the fractured crust of a hyaloclastite deposit where the fractures intersected at right angles. While this formation is a result of natural causes, its resemblance to human-made structures resulted in the story obtaining close to 1.5 billion in press reach. Building on previous mapping efforts by other programs, E/V *Nautilus* mapped 89,330 km^2 of seafloor during these expeditions. Collectively, over half of the seafloor inside the Monument has now been mapped at a high resolution.

JOHNSTON

Between 25 May - 13 July 2022, E/V *Nautilus* conducted two expeditions that mapped and explored the Johnston Unit of the Pacific Remote Islands Marine National Monument. The expeditions mapped over 55,275 km^2 of previously unsurveyed seafloor, including several seamounts and larger ridge features. This mapping was key to the successful execution of 13 ROV dives. Noteworthy ROV observations included recording basalt atop most guyots with basalt morphologies overlying limestones, indicating that this region experienced multiple phases of volcanism. Other noteworthy observations included the discovery of a fossilised Megalodon tooth, fossilised whale bones, and the first record of the seapen *Solumbellula* from the Pacific.

TECHNOLOGY CHALLENGE & DUAL-TECHNOLOGY MAPPING

Between 6-22 May, E/V *Nautilus* supported an expedition that combined various exploration technologies, including USV *DriX* from the University of New Hampshire, as well as the autonomous underwater vehicle *Mesobot* and hybrid vehicle *Nereid Under Ice* from Woods Hole Oceanographic Institution. The team successfully demonstrated the complimentary capabilities of these technologies at sea, including communications between the three vehicles while they were simultaneously deployed, the vehicles being re-tasked based on information gained from a partner vehicle, and remotely operating the vehicles by personnel back on shore. Between 16 July – 8 August, E/V *Nautilus* conducted an expedition that mapped seafloor around the Northwestern Hawaiian Islands using sonars of both the ship and USV *DriX*. During six USV *DriX* deployments, the shallow-water mapping capabilities of USV *DriX* were progressively integrated into simultaneous mapping operations with the deep-water sonars of E/V *Nautilus*.



FROM THE SHORE TO THE ABYSS

Between 15 September - 24 October, E/V *Nautilus* conducted three expeditions in support of the new "From Shore to the Abyss" program funded by the National Geographic Society. This new shallow-water program included the deployment of divers, snorkelers and sampling equipment in nearshore waters around Hawai'i to support studies on

marine mammal communication, shark communities, maritime heritage, and microplastic pollution.

BROADER IMPACTS

E/V *Nautilus* expeditions were executed around US government priorities to close knowledge gaps. Mapping and ROV operations were all conducted in unexplored areas, thus contributing directly to the National Strategy for Mapping, Exploring, and Characterising the United States, Seabed 2030, and the UN Decade of Ocean Science for Sustainable Development. The successful integration of several autonomous vehicles onto E/V *Nautilus* demonstrated that the use of multiple robotic vehicles is a powerful force multiplier in collecting ocean data.

Expedition activities also advanced priorities on education, diversity, and inclusion by providing opportunities for under-represented minority groups to participate in expeditions. Finally, the data collected on these missions is an essential precursor to future explorations throughout the region, which will undoubtedly lead to many more discoveries. To this end, data and samples collected on these missions have been deposited in publicly available repositories to enable follow-on science and management activities.

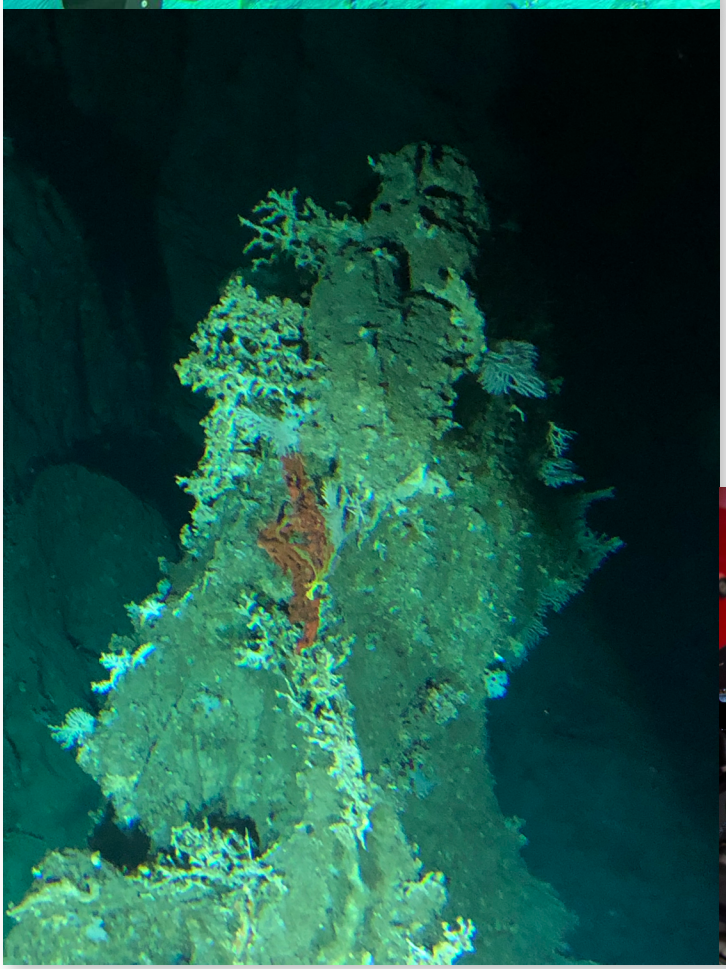
Exploration of rariphotic, mesophotic and upper bathyal ecosystems in the Chagos Archipelago, British Indian Ocean Territory

Alex Rogers, Eva Ramirez-Llodra and the Chagos expedition team

The Chagos Marine Reserve lies in the central Indian Ocean and is the largest no-take marine protected area in the world. It was established to conserve some of the ocean's most pristine coral reefs, but it is estimated that only 3% of the marine ecosystems of the reserve have been studied. The deep-sea benthic ecosystems, in particular, remain poorly documented, yet may be important in the wider functional ecology of the archipelago, especially its role as a habitat for large pelagic predators. These deep-water ecosystems include mesophotic coral reef ecosystems (30 – 150 m depth), but also the recently discovered rariphotic ecosystems (150 – 300 m depth), which may include macroalgal and deep-water coral habitats but are as yet uncharacterized in the Chagos Archipelago. Beyond these depths the bathyal zone (300 m – 4000 m depth) is poorly characterized for the entire western Indian Ocean. The reserve also includes an estimated 10% of the seamounts of the Indian Ocean.

Figure 1. RV *Odyssey* recovering DSV Aurelia in Chagos, Indian Ocean.

The Chagos expedition, led by Prof Alex Rogers (REV Ocean) on board the RV *Odyssey*, took place in October 2023. The vessel was equipped with two Triton submersibles: a Triton 3K3 capable do diving to 1000 m and REV Ocean's DSV *Aurelia*, a Triton 7K3 capable of diving to 2300 m (Fig. 1). These submersibles are excellent platforms for submarine survey of seafloor ecosystems and DSV *Aurelia* is currently equipped with a science skid containing a comprehensive suite of instrumentation for sampling biota, taking sediment cores and for undertaking video transects. In addition, RV *Odyssey* has a multibeam mapping system and a CTD / Niskin bottle rosette for sampling of the water column.



The expedition focused on three locations in British Indian Ocean Territory: western Peros Banhos Atoll, Eagle Island (Great Chagos Bank) and Pitt Bank. However, Pitt Bank is a submerged atoll and sea state did not allow diving on this site. At each of the sampling sites we undertook video surveys and sampling of benthic communities, including sessile and mobile benthic fauna as well as near seafloor fish communities. The surveys focused on 4 depths: 60 m (shallow), 120 m (rariphotic), 250 m (mesophotic) and upper bathyal (500 m). At each depth, we conducted replicated submersible dives. The two submersibles operated in tandem, with the Triton 3k3 conducting replicated video transects and DSV *Aurelia* sampling key organisms for taxonomic studies on the same transects (Fig. 2). The goal of the surveys was to characterize habitat at these 4 depths to significantly increase current knowledge of the deep-water benthic ecosystems of British Indian Ocean Territory and allow an initial assessment of the importance of these in relation to the overall functioning of marine ecosystems within the marine protected area (Fig. 3).

The Chagos expedition contributes directly to the UN Ocean Decade programme Challenger 150 and provided berths for 4 Early Career Researchers currently conducting research on relevant topics and who greatly contributed to the cruise (Fig. 4).

Figure 2 (top). DSV *Aurelia* during a dive at Peros Banhos, 150 m depth.
Figure 3 (left). Mesophotic corals off Eagle Island, Chagos.
Figure 4 (below). Early career researchers learning about Triton submersibles from a Triton 3k3 pilot.

Project Focus

AI routines for automated species classification and tracking by mobile crawler platform

[1]Monte A., [2]Marsiske R., [3]Ortenzi L., [4]Chatzievangelou D., [5]Costa C., [6]Thomsen L., [7]Marini S., [4,8]Aguzzi J.

[1]University of Cagliari (Italy), [2]University of Barcelona (UB; Spain), [3]Tuscia University of Viterbo (Italy), [4]Instituto de Ciencias del Mar (ICM-CSIC; Spain), [5]Consiglio Per La Ricerca in Agricoltura e L'analisi Dell'economia Agraria (CREA)-Centro Di Ricerca Ingegneria E Trasformazioni Agroalimentari (Italy), [6]University of Gothenburg (Sweden), [7]CNR-ISMAR (La Spezia; Italy), [8]Stazione Zoologica of Naples (SZN; Italy)

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Animal detection, classification and tracking as edge computing functionalities of mobile robotic platforms are increasingly relevant in marine ecosystem monitoring (Aguzzi *et al.*, 2020; 2022). Time-series of geo-referenced counts for different species are crucial to train AI-based data processing algorithms. These will be executed on-board underwater robotic platforms, to deliver real-time, remote information on abundances and biodiversity. Crawlers are emerging mobile robotic platforms, either tethered to permanent infrastructures like cabled observatories, offshore industrial rigs, and mariculture assets (Danovaro *et al*., 2019), or moving autonomously along the seafloor for extended periods. Bearing cameras and complex sets of oceanographic and geochemical sensors, they can be used to consistently expand the radius of ecological monitoring of fixed cabled observatories by video-sweeping large seabed surfaces (Chatzievangelou *et al.*, 2020), the benthic boundary layer (as the benthic-pelagic ecotone; Chatzievangelou *et al*., 2021), and the overlaying water column. Our objective is the automated, real-time image processing to classify and track multiple species, opening the pathway toward the creation of crawler on-board video-intelligence. Accordingly, manual classification of animals in videos acquired by the crawler Wally at the Barkley Canyon hydrates (900 m depth; NE Pacific) site of Ocean Networks Canada's NEPTUNE observatory is ongoing, as a necessary step to create ground-truth datasets to train AI algorithms. Examples of key species (Figure 1) and AI tracking and classification (Figure 2) are provided.

Figure 1. Species for which trainings sets are being created. Top row: Unidentified sessile fauna (sea pen or crinoid); Unidentified starfish 1; Unidentified starfish 2; Unidentified starfish 3; *Poralia rufescens.* Middle row: Unidentified harpacticoid shrimps; *Chionoecetes tanneri;* Unidentified Opisthoteuthidae octopus; *Bathyagonus nigripinnis;* Unidentified Sebastidae rockfish and *Eptatretus stoutii.* Bottom row: *Embassichthys bathybius; Microstomus pacificus; Hippoglossus stenolepis; Anoplopoma fimbria.*

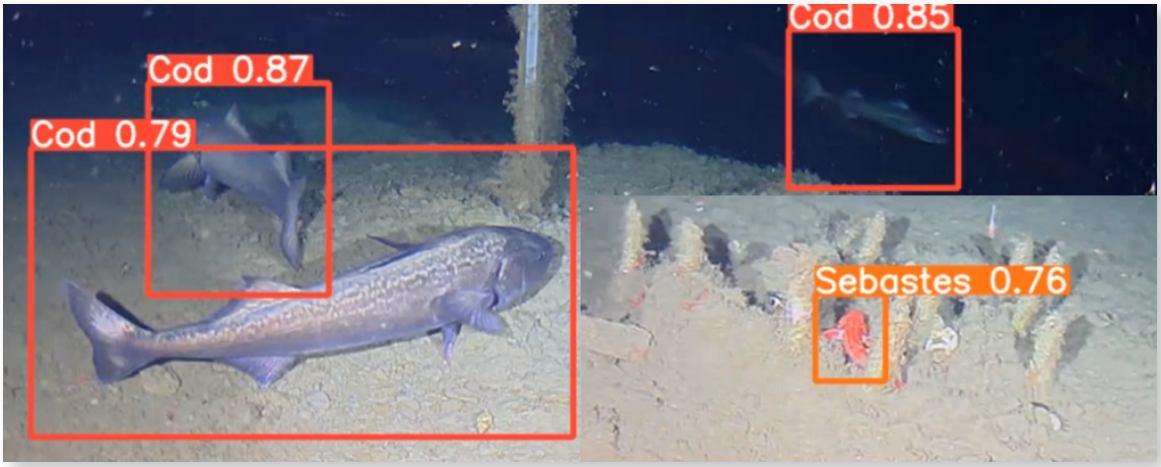


Figure 2. Example of video species tracking and classification. Numbers represent the probability assigned by the object detection algorithm.

References
Aguzzi J., et al. 2020. The hierarchic treatment of marine ecological information from spatial networks of benthic platforms. Sensors, 20: 1751.
Aguzzi J., Flögel S., Marini S., et al. 2022. Developing technological synergies between deep-sea and space research. Elem. Sci. Anth., 10: 00064.
Chatzievangelou D., et al. 2020. Spatio-temporal monitoring of key deep-sea megafauna with Internet Operated crawlers as a tool for ecological status assessment. Prog. Oceanogr., 184: 102321.
Chatzievangelou D., et al. 2021. Integration diel vertical migrations of bioluminescent deep scattering layers into monitoring programs. Front Mar. Sci. 8: 661809.
Danovaro R., et al. 2017. A new international ecosystem-based strategy for the global deep ocean. Science, 355: 452-454.

The Deep Ocean Observing Strategy: A Reflection on 2022 and a Glance at the Coming Year

Leslie Smith
DOOS Project Director, USA

2022 was a busy year for the deep-ocean observing community. On the global political stage were the BBNJ negotiations and COP 15 on biodiversity, COP 27 on climate, the UN Ocean meeting and the 27th Session of the ISA on seabed mining. The UN Ocean Decade ramped up with vast options to join and organize webinars and discussions, and the Ocean Discovery League published its Global Deep-Sea Capacity Assessment. As a result, we have had more opportunities than ever to connect across the globe and bring to light global needs and gaps.

For DOOS' part, we ticked many boxes – four publications, a dozen presentations, webinars and conference events, meetings with UN agency representatives, and a virtual annual meeting with over 260 registered attendees from over 40 countries. Not to mention Ocean Bottom Pressure was officially named an Essential Ocean Variable!

But we were left wondering, do these metrics really indicate success?

DOOS is a community-driven, grass roots, international initiative with the goal to help strategically align the deep-ocean observing community toward collective solution-based science. It seems a better way to measure our year is to reflect on what we learned from listening to you all, our community, and how we used what we learned to shape a DOOS that is "fit-for-purpose."

1) **The deep ocean observing community has deep expertise, but there are gaps at the key nexus points between disciplines and communities**. To maximize the value of individual efforts we must work across these connection points yielding models better constrained by observations, observatories with optimal infrastructure deployment, and conservation decisions based on science. We must leverage activities (especially those that are expensive and/or logistically challenging) across disciplines and nations. DOOS initiatives address these critical connection points

spanning observing, modeling, technology, data, mapping communities and all the disciplines in between.

2) **Innovation comes from bringing new voices to the table, not simply more voices.** We need to make conscious efforts to bring in and elevate the voices of early career researchers as well as scientists from developing countries and historically underrepresented groups. DOOS is buoyed by our DOERs (Deep Ocean Early-career Researchers) from around the world. We stand on principles of open data and knowledge sharing, communication, and the promotion and development of future leaders that represent our strong and diverse global community.

3) **The community needs another program seeking to push its own agenda like it needs a hole in its submersible… it doesn't**. DOOS doesn't have an agenda, it has a belief - if we bring together people/communities/networks already working toward the same aim, we can achieve more than any individual, allowing us to actually tackle global deep-sea challenges. There are recognized gaps in the deep ocean within the global ocean observing system; DOOS seeks to bridge these community-defined gaps by facilitating connections and leverage existing research efforts and resources. DOOS seeks to be a mechanism to build careers, not add burden to people or programs.

In this next year, DOOS will continue to further its community-driven initiatives (see Smith *et al.,* 2022; www.deepoceanobserving.org). But more important than what we will be doing is how: by listening, elevating all voices in the conversation, and connecting communities to accelerate deep ocean research.

We hope you will join our virtual Annual Meeting in May 2023, and stay tuned for more information on DOOS' inaugural "Deep Ocean Collective Solution Accelerator" Workshop in October 2023 in San Diego, CA. We will concurrently host five small workshops, each focused on a different global deep-sea challenge: 1) Cheap and deep technology for capacity development, 2) Habitat conservation and marine spatial planning, 3) Improving ties between modeling and observing communities, 4) Seafloor microbial ecosystem services, and 5) Amplifying a UN "deep" Ocean Decade. For more information, contact leslie.smith@youroceanconsulting.com.

SeaFAIRing: Easy Resources for Managing Your Deep Ocean Data

Karen Stocks, Stace Beaulieu, Carolina Berys-Gonzalez, Mathew Biddle, Allison Mills, Sarah O'Connor, Leslie M. Smith, Michael Vardaro, Dawn J. Wright

What are the top things data curators wish scientists with deep-ocean data were aware of? Where can you and your community start learning how to do a bit better with managing your data, so it is useful for addressing big science and policy questions about the deep ocean and preserved for future use?

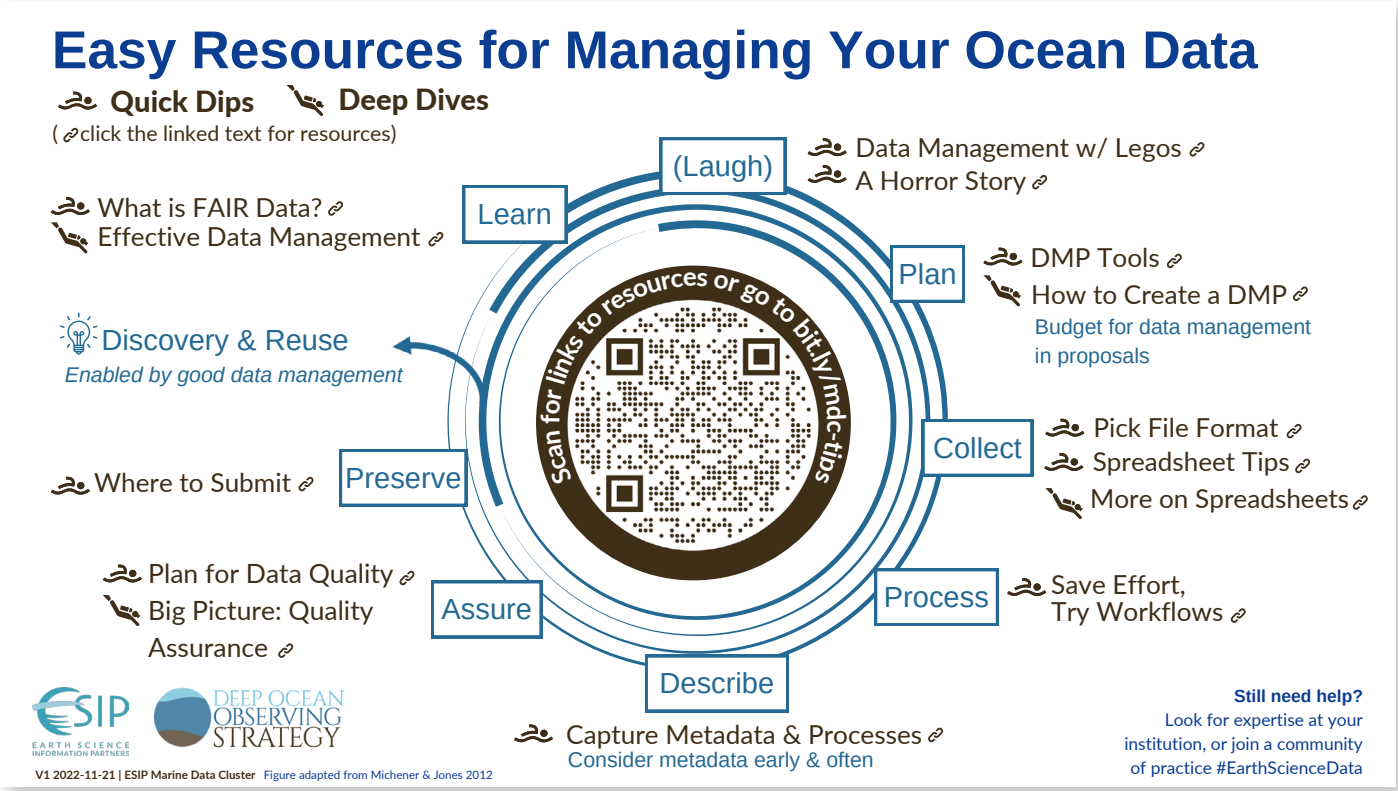
DOOS and the ESIP Marine Data Cluster have collaborated on an infographic, Easy Resources for Ocean Data Management giving pointers to a small set of key entry-level data management concepts and resources.

This infographic is the product of two facilitated community discussions that sought to better define the needs and gaps of deep ocean data creator and repository communities. This effort was initiated based on requests from the DOOS community, and primarily aimed at smaller investigator-scale projects without access to data management support.

The first discussion was with data repositories and curators and sought to create an initial "Ten Things for (Deep) Ocean Data Management" list. The goal was a small, highly accessible, entry-level set of guiding principles and pointers to key resources, aimed at very busy people. The second discussion solicited feedback from researchers within the DOOS network on the list, and additionally asked "what things do you wish data repositories understood about you?"

Please feel free to use and share the infographic with your communities!

We'd be happy to hear your feedback through this form. More information can also be found on the DOOS website here.

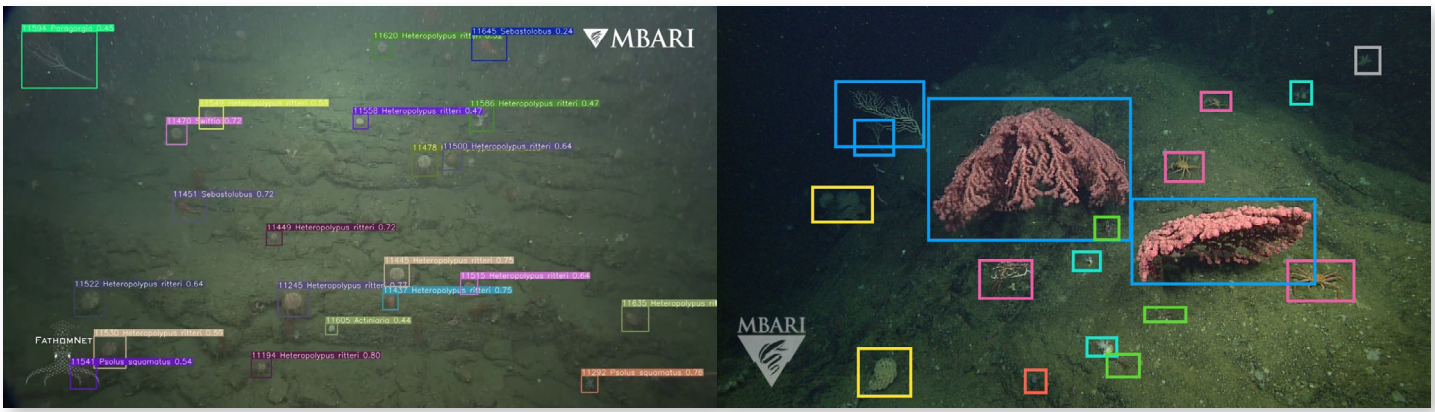


FathomNet: A global image database for enabling artificial intelligence in the ocean

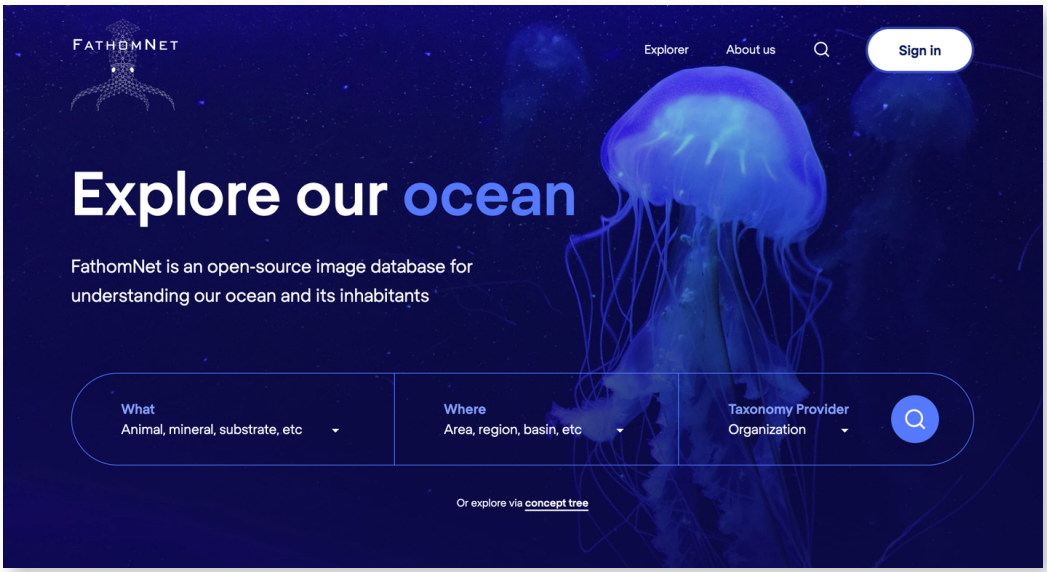
Kakani Katija[1], Eric Orenstein[1], Brian Schlining[1], Lonny Lundsten[1], Kevin Barnard[1], Giovanna Sainz[1], Oceane Boulais[2], Megan Cromwell[3], Erin Butler[4], Benjamin Woodward[4] & Katherine L. C. Bell[5]

[1]Monterey Bay Aquarium Research Institute, [2]NOAA Southeast Fisheries Science Center, [3]NOAA National Centers for Environmental Information, [4]CVision AI, [5]Ocean Discovery League

Ocean-going platforms and instruments are integrating high-resolution camera feeds for observation and navigation, producing a deluge of visual data that rapidly outpaces researchers' abilities to process and analyze them. Recent advances in machine learning enable fast, sophisticated analysis of visual data, but have had limited success in the ocean due to lack of data set standardization and insufficient availability of existing, expertly curated imagery. FathomNet addresses this need by aggregating images from multiple sources to create a publicly-available, expertly-curated underwater image-training database.



Inspired by annotated image databases such as ImageNet and COCO, FathomNet aims to establish the same kind of reference data set for images of ocean life. The long-term goal of FathomNet is to aggregate >1k fully annotated and localized images per marine species of *Animalia* (>200k), with the ability to expand and include other underwater concepts (e.g., substrate type, equipment, debris, etc.) for training and validating machine learning models. We hope that contributions from the broader community will realize our goals for FathomNet.



To learn more about FathomNet, read our recently published study in Scientific Reports, visit our website, youtube and blog sites for helpful tutorials, and github for code and models. Join us for our upcoming online workshop February 22-23 at 1500-1900 Pacific (UTC-8) by registering here. We will be providing updates on our progress as well as introducing an end-to-end solution for automated image analysis called Ocean Vision AI.

The Deep-Ocean Project: History, Goals and Perspectives

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The objectives of the "Diversidade E Evolução de Peixes de Oceano Profundo – DEEP-OCEAN" project are to study the diversity and evolution of deep-sea fishes in the western South Atlantic. Two cruises aboard the Brazilian RV *Alpha Crucis*, off São Paulo and Santa Catarina states (24°22'S to 28°31'S), were conducted in 2019 and 2022 respectively. During these cruises biological samples were collected from the continental slope, at depths between 180m - 1500m. Samples were collected from a total of 52 stations, including CTDs, bottom trawls, and fish traps. The multidisciplinary scientific team is

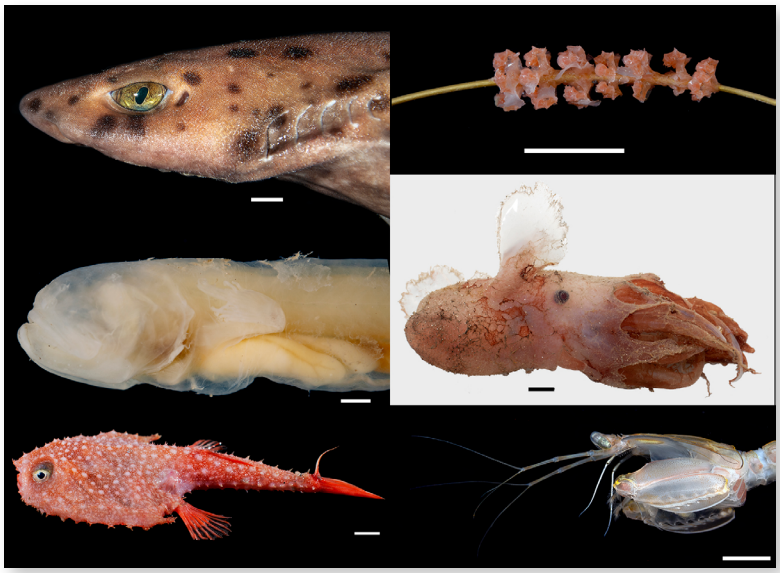

Figure 1. Diversity of deep-sea fauna collected during the DEEP-OCEAN project.

Figure 2. Team of the DEEP-OCEAN project, onboard the RV *Alpha Crucis*, during the 2019 (top) and 2022 (bottom) expeditions.

composed of engineers, biologists, and oceanographers and includes professionals, graduate, and undergraduate students from the University of São Paulo. The specimens were photographed soon after collection; muscle samples were preserved in ethanol or liquid nitrogen for DNA analyses, and then the specimens were fixed in formalin. Beside fishes, many invertebrates were also collected and preserved, such as cnidarians, crustaceans, echinoderms, mollusks, sponges, and tunicates. The next DEEP-OEAN expedition is planned for February/March 2023. The DEEP-OCEAN project is funded by the São Paulo Research Foundation – FAPESP (2017/12909-4).

MonitorMyOcean.com Web App: Measuring Silence of Global Oceans during Covid-19 Lockdown

Artash Nath

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Low-frequency noise from marine shipping is an underwater acoustic pollutant in oceans. The noise spectrum overlaps with frequencies marine mammals use to communicate and navigate, leading to stress and increasing collision with ships.

This research established a model to measure the contribution of anthropogenic activities to underwater noise levels. The COVID-19 lockdown led to a global decline in commercial and cruise shipping. The model quantified the reduction in noise levels before and during the lockdown in the Arctic, Atlantic, Pacific Oceans, and the Mediterranean Sea.

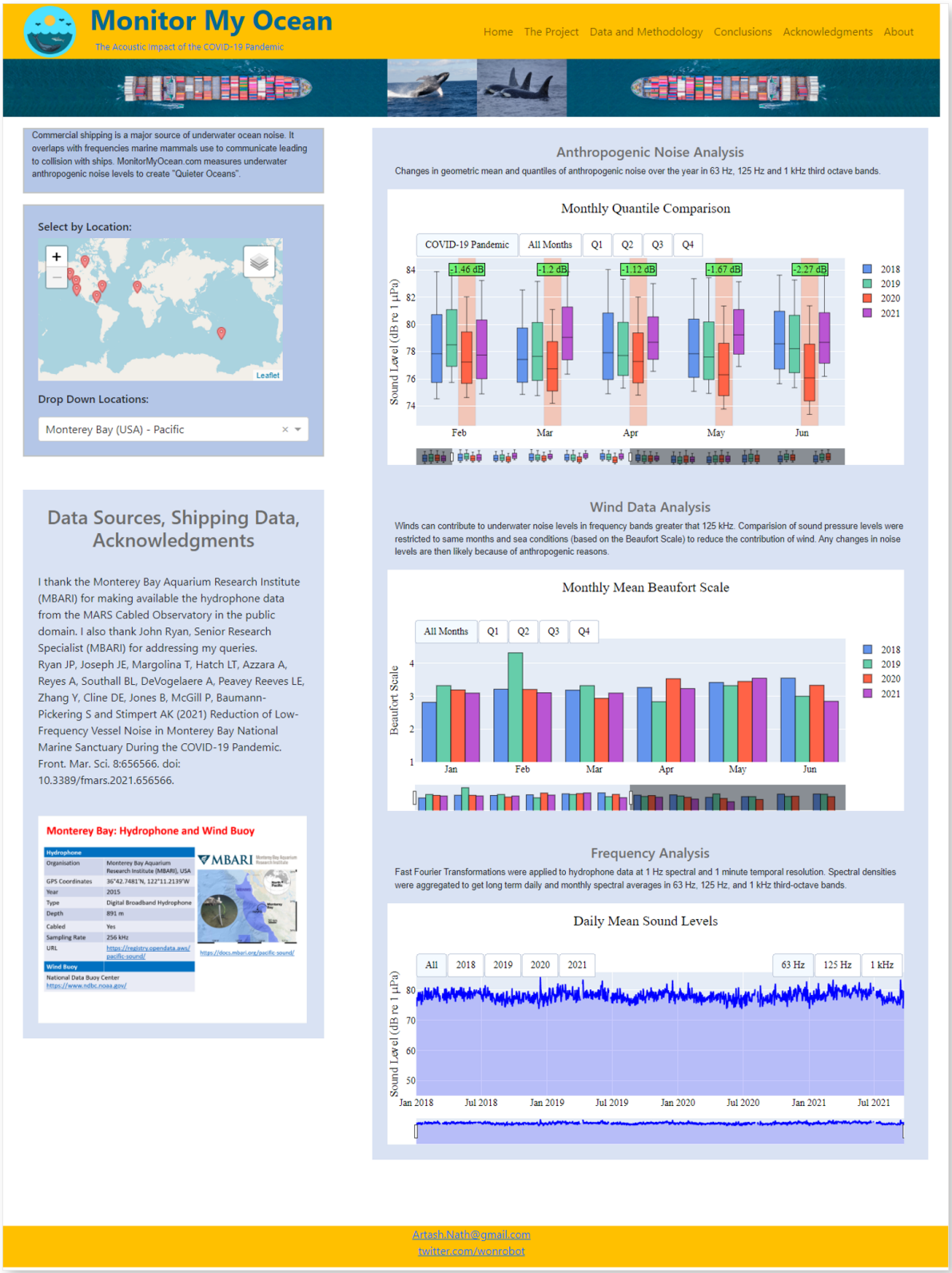
Underwater ocean sound peaks between 10 – 100 Hz and is dominated by noise from shipping traffic. Hydrophones (underwater microphones) data from seven ocean observatories were analyzed at 1 Hz spectral and 1-minute temporal resolution. Power spectral densities were calculated, aggregated into monthly long-term spectral averages, and noise levels in the 63 Hz third-octave band compared to previous years.

The analysis revealed that global oceans quietened by an average of 4.5 dB, or the peak sound intensity decreased

2.8 times during the lockdown period. The maximum decrease was at locations close to major shipping channels and cruise tourism destinations. The findings were validated by comparing shipping traffic using the satellite-based Automated Identification System.

The study proved that strategic "anthropauses" can reduce underwater noise levels and give marine mammals a chance to reverse the decline in their population.

A web application MonitorMyOcean.com was created to provide updated anthropogenic noise levels in global oceans. Policymakers can determine if measures such as shifting shipping channels or moratorium on new shipping routes are leading to "Quieter Oceans." The App has been endorsed as a UN Ocean Decade Activity.



Accelerating deep-sea expedition leadership via a new COBRA Master Class

Randi Rotjan[1], Julie Huber[2], Katherine Croff-Bell[3], Andrew T. Fisher[4], C. Geoff Wheat[5], Rosalynn Sylvan[6], and Beth N. Orcutt[6].

[1]Department of Biology, Boston University, [2]Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, [3]Ocean Discovery League. [4]Department of Earth and Planetary Sciences, University of California, Santa Cruz, [5]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, [6]Bigelow Laboratory for Ocean Sciences

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Understanding the deep ocean is critical, now more than ever. For example, the rapid development of industrial-scale tools for mining of deep seafloor mineral deposits has outpaced the scientific understanding of the environmental impacts, which could rival or exceed in scale the impacts of fishing. Likewise, there is accelerating interest in carbon sequestration below the seafloor as a strategy to mitigate climate change, but short- and long-term effects are poorly understood. The Crustal Ocean Biosphere Research Accelerator (COBRA, https://cobra.bigelow.org/) is a US National Science Foundation (NSF)-funded initiative to accelerate research on the structure, function, resilience, and ecosystem services of the crustal ocean biosphere – the rocky parts of the seafloor such as deep-sea seamounts, hydrothermal vents, volcanic crust, and manganese nodules – to inform decision making.

Accelerating deep-sea research to meet these societal needs requires having a broader community of deep-sea expedition leaders. To train future ocean leaders in inclusive ocean exploration, policy, research, and data accessibility, in 2022, COBRA launched its inaugural virtual COBRA Deep Sea Expedition Leadership Master Class. This 13-week course equipped early-career Fellows with the skills and tools to successfully design, propose, and execute deep-sea oceanographic field research, with a collaborative, just, equitable, diverse, and inclusive approach. To plan expeditions,

Figure 1. 2022 COBRA Master Class Fellows and Core Instructors

Fellows engaged in topics related to choosing the appropriate deep-sea research asset for their project, learning how to find funding and write proposals, develop concepts respectfully with regard to geographic and cultural considerations of their intended study sites, and work through an essential checklist of pre-cruise planning and operations. At-sea expedition training included details of at-sea operations and ship-board etiquette, the strengths and challenges of telepresence, and data management. For post-cruise training, Fellows were introduced to a variety of data types and analyses, including data management strategies, and also discussed cruise report development and agency reporting needs. Throughout the Master Class, Fellows also discussed education and outreach, international ocean law and policy, and the importance and unique joys and challenges of team science. The Fellows were compensated for their participation. The course will be held annually for at least five years, each time contributing content freely and publicly (https://cobra.pubpub.org/) to make these topics accessible to all.

Through these Fellows, their networks, and the accompanying open-access materials, COBRA hopes to enlarge and diversify the community of scientists engaged in deep-sea research, policy, and engagement. The push for ocean exploration is primarily driven by a fundamental need to understand our planet and its ecosystems, but it is also driven by the increased potential for ocean exploitation as well as ocean conservation. In recognition of this urgency, we are in the midst of the UN Decade of Ocean Science for Sustainable Development. We invite all interested future deep-sea expedition leaders to apply for and engage with materials from the COBRA Master Class, in an effort to accelerate scientific understanding of deep-sea crustal ecosystems and their resilience to inform decision making, prevent serious harm, and provide benefit to society.

NGO Beneath The Waves launches expansive deep-sea biodiversity monitoring throughout The Caribbean

Oliver Shipley[1], Alexis Janosik[2], Austin Gallagher[1]

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Contact: oliver@beneaththewaves.org

Researchers at the NGO Beneath The Waves and University of West Florida have embarked on an ambitious project to survey patterns of biodiversity throughout some of the most poorly-studied deep-sea ecosystems on earth. Prior to 2022, Beneath The Waves had performed a series of preliminary deep-sea biodiversity assessments throughout deep waters of several Caribbean islands including The Bahamas, Turks and Caicos, and The Cayman Islands. These findings prompted the need for more expansive and systematic efforts to survey regions for which almost no biological information currently exists.

The research team uses a combination of non-invasive deep-sea landers (Fig. 1A) and environmental DNA, in addition to targeted specimen collection. They will apply a suite of molecular assays to quantify several aspects of community structure, gene flow, and identify major energetic pathways supporting faunal biomass. In 2022, initial sampling throughout The Tongue of The Ocean and northwest Exuma Sound, The Bahamas has revealed that deep-sea communities adjacent to the regions extensive carbonate banks, house an incredible diversity and abundance of large fauna. The team has observed and sampled several species of deep-sea elasmobranch, including bluntnose sixgill sharks, gulper sharks (Fig. 1B), Cuban dogfish, and sharpnose sevengill sharks (Phillips *et al.* 2019). Also common were giant isopods (*Bathynomus* sp, Fig. 1C), including the newly described species *Bathynomus maxeyorum* (Shipley *et al.* 2016). These species will be the focus of genetic barcoding to explore patterns of gene flow with neighboring regions, such as the Gulf of Mexico.

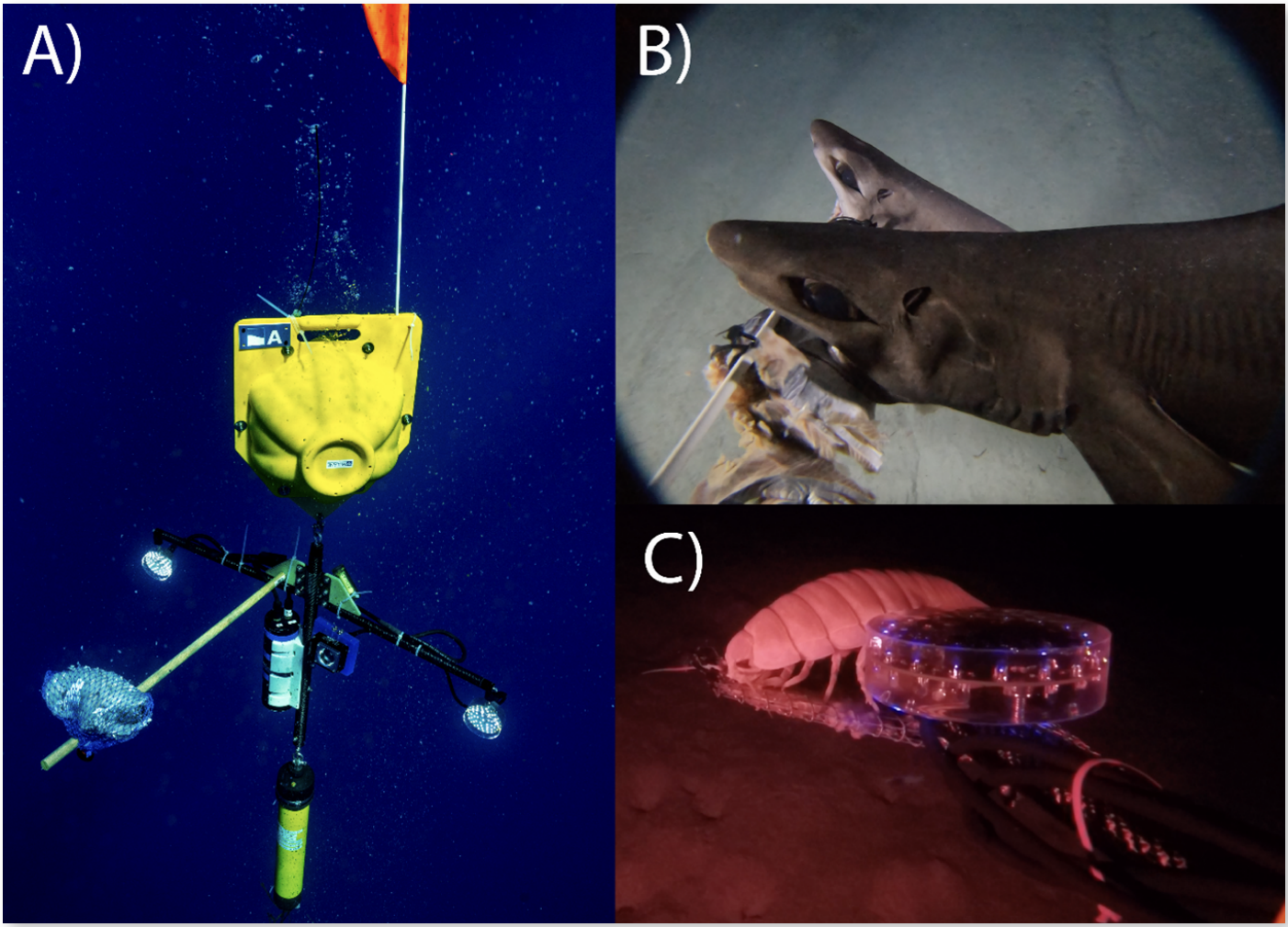


Figure 1. A) Deep-sea drop camera systems used for biodiversity assessments up to 2000m; B) Gulper shark (*Centrophorus* spp.) and C) giant isopod (*Bathynomus giganteus*) sampled during deep-water biodiversity assessment throughout The Caribbean.

Overall, these focused sampling efforts provide a great opportunity to provide fundamental biological knowledge on poorly studied deep-sea fauna from the Caribbean. In 2023, Beneath The Waves will perform several targeted deep-sea cruises throughout The Caribbean, which are likely to provide novel discoveries and critical information to assist with the expansion of novel marine protected area networks.

DOSI

DEEP-OCEAN STEWARDSHIP INITIATIVE

Thanks to researchers from the DOSI climate change working group, the deep ocean received strong representation at COP-27 in Sharm El-Sheikh, Egypt.

Narissa Bax and Maria Baker

The deep ocean is both threatened by climate change and human activity while also playing a significant and frequently underappreciated role in climate mitigation. This year's COP-27 in Sharm El-Sheikh, Egypt, was attended by a group of 16 deep-sea experts from a variety of countries, including the USA, New Zealand, Australia, Brazil, Nigeria, Germany,

Monaco, South Africa, Mexico, the UK, and the Falkland Islands. The DOSI delegation advocated for the deep sea's inclusion in climate change negotiations and commitments to keep global warming below 1.5°C and 2°C while highlighting the importance of the deep sea.

Figure 1: DOSI members following their presentation at the Climate Education Hub on Earth Day on the deep sea, the climate, and the next generation. Panelists, from left to right: Dr Lisa Levin (moderator), Dr Isa Elegbede, Dr Sarah Seabrook, Olivia Pereira, Michelle Guraieb, and Dr Narissa Bax. This presentation was live streamed on Earth Day and has been viewed over 55.5K times, with 56,134 total views across all social media platforms to date. Check it out on the Earth Day Network here: https://twitter.com/EarthDay/status/1590351977594388484

Climate change is increasing and causing problems worldwide. The Paris Agreement to keep global warming below 1.5–2 °C has not been met, and the road towards it is not well laid out. The most recent report of the Intergovernmental Panel on Climate Change (IPCC) has shown that haste is required. The 27th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP-27) is a platform for 197 states, or «parties,» to discuss lessons learned from the 6th IPCC report and how they will achieve the goals agreed to in the Paris Agreement to keep global warming below 1.5 °C and 2 °C.

Many are referring to COP-26 and COP-27 as "increasingly blue COPs" and 2022 marked the first time COP-27 had an Ocean Pavilion in the official negotiations area (the "Blue Zone"), under the leadership of the Woods Hole Oceanographic Institution and Scripps Institution of Oceanography. The Ocean Pavilion featured a number of events and discussions

Figure 2: The development of a sustainable blue economy is unquestionably influenced by seabed mapping, which is undoubtedly a facilitator for global management of our ocean. A lot of ocean, climate change, and biodiversity issues can be addressed using seabed maps as a base. As a result, by 2030 a map of the entire ocean needs to be produced. Without it, we will find it difficult to implement resilient policies, which will hinder our efforts to effectively mitigate climate change, adapt to it, and create an ocean that can sustain a growing global population.

to ensure that the ocean was acknowledged as a key player in climate negotiations. This led to a strong representation of the ocean and islands at the COP, and the deep ocean is now better represented than ever thanks to the addition of scientists from the DOSI climate change working group.

From the standpoint of ocean conservation, the ultimate decision unequivocally recognised the importance of the ocean and reaffirmed the need for an annual Ocean-Climate Dialogue in the final declaration to "encourage Parties to consider, as appropriate, ocean-based action in their National Climate Goals and in the implementation of these Goals, including but not limited to Nationally Determined Contributions, Long-Term Strategies, and Adaptation Communications"

Commitments to a new fund for "loss and damage" brought on by climate change for vulnerable countries and small island states were among the major outcomes in the final COP-27 text. The creation of this special fund was viewed as the most important result of the COP this year, and the relationship between the ocean and climate was furthered by the obvious connection between developing countries and their reliance on and connection to ocean health. For instance, the Ocean and Climate Change Dialogue was mandated as an annual event in Article 45, with the appointment of two conveners to facilitate efficient communication between the dialogue and COP negotiations. Article 26 also urged research into and promotion of ocean-based actions that advance climate sustainability. Both of these requests were made in conjunction with the call for improved ocean observation. Moreover, while the ocean still lacks a defined agenda item, it is now in the cover decision stage—the overarching decision at the discretion of the presidency. This is also one of the few issues in the text's evolution that is not split between developed and developing countries' mandates (and is therefore supported globally), which is encouraging for the future.

When the Conference of the Parties (COP 28) meets in the United Arab Emirates at the end of this year, DOSI members intend to keep bringing up the ocean, in particular the deep ocean, in relation to preventing negative climate change impacts and including the deep-sea in climate negotiations. Hopefully, the foundation for ocean dialogue laid by COP-27 will soon translate into practical action and conservation measures.

Figure 3: Images from DOSI members after presentations and engagements at COP27.

This paves the way for economies reliant on the ocean and islands to think about how their rich biodiversity and untouched deep marine habitats can contribute to efforts to mitigate climate change. To conserve nature, retain important processes in nature (nature-based solutions to climate change) and acquire the data needed to safeguard the future of the planet.

Acknowledgements: *A warm thank you to the DOSI Climate Change working group, and all the DOSI members engaged during COP-27, including, but not limited to, Brandon Gertz, Sarah Seabrook, Lisa Levin, Wassim Dbouk, Isa Elegbede, Michelle Guraieb, Elva Escobar, Sonigitu Ekpe, Olivia Pereira, Eesha Rangani, Bernadette Snow, Erica Ferrer, Kiirah Green, Torsten Thiele and Nathalie Hilmi. The High Seas Alliance and DOSI Travel Fund for Deep-Sea Scientists for providing funding to attend COP-27 in Egypt. The Climate Action Hub and Ocean Pavilion for hosting deep-sea presentations and events and the National Oceanography Centre (NOCS), Woods Hole Oceanographic Institution, and Nippon Foundation-GEBCO SEABED 2030.*

CHALLENGER 150

Year 1 Highlights

This year we have worked hard to establish our 12 **Regional Scientific Research Working Groups** (RSR-WGs) covering the global ocean. The amazing scientists in these groups liaise with regional stakeholders to identify and prioritise research needs. These essential partnerships allow us to coordinate scientific research activities to identify and fill data gaps. Our regional working groups help build regional capacity in deep-sea science, moving research to policy and action.

12 REGIONAL WORKING GROUPS

Our new **Litter Recording Working Group** is developing standards for recording marine litter in the deep sea. By aligning our methods with those used on land and in shallow water, we will ensure we can combine our knowledge.

We have also established two **technical scientific research working groups** (TSR-WGs):

- Megafaunal Image-Based Working Group
- Litter Recording Working Group

CELEBRATING

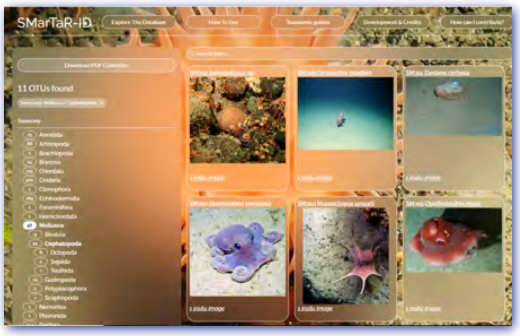
RESEARCH 15 CRUISES

OCEAN 5 BASINS

2 TECHNICAL WORKING GROUPS

Our **Megafaunal Image-Based Working Group** is developing methods, tools and training materials to raise standards in animal identification and data collection in image analysis. Working with our partner, **One Ocean Hub**, we saw the launch of the **Standardised Marine Taxon Reference Image Database** (SMarTaR-ID), a potent tool that helps people identify deep-sea animals from images using consistent naming conventions.

ONE OCEAN HUB



We are delighted to welcome the following projects into the Challenger 150 programme. Scan the QR code for links to our amazing partners!

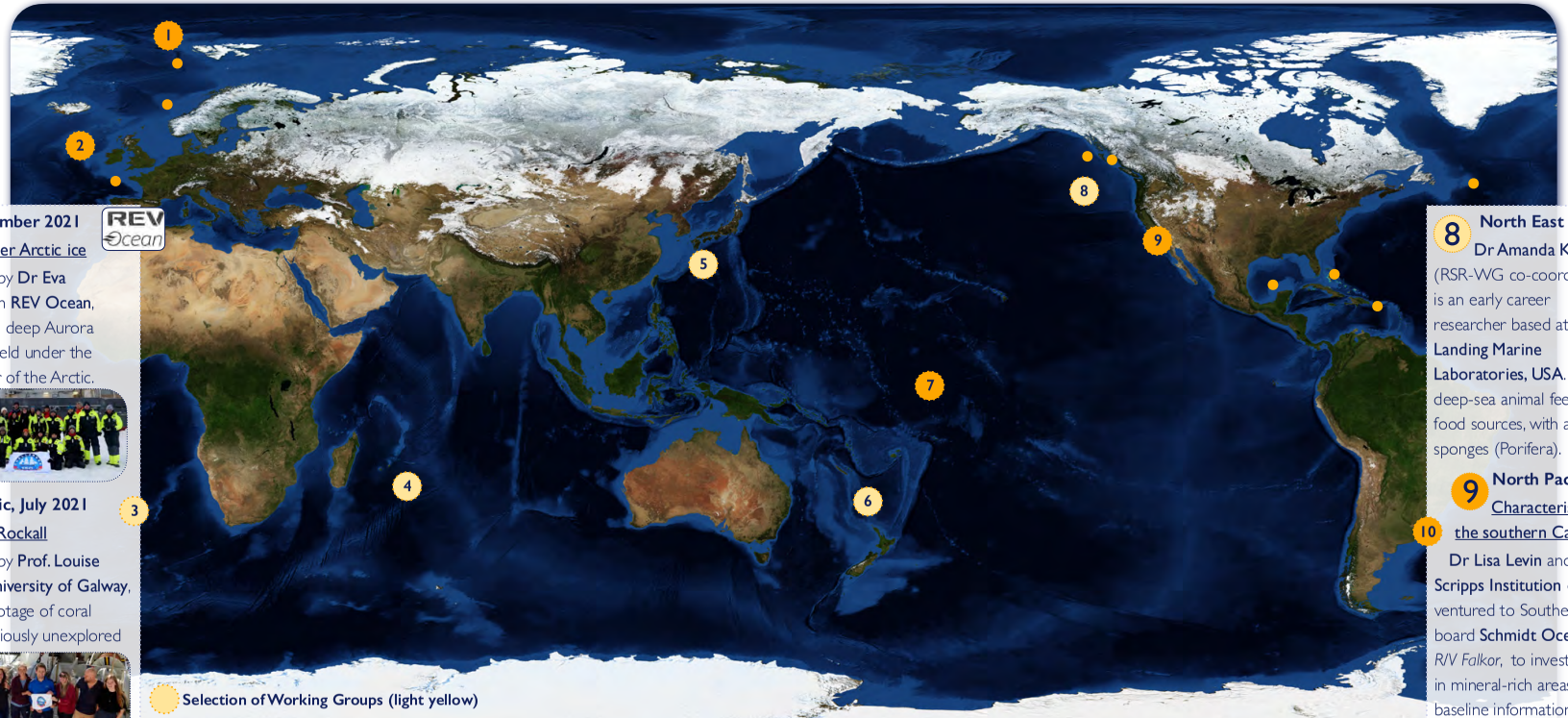
- One Ocean Hub
- Deep-Ocean Genomes Program
- SMARTEX - Seabed Mining & Resilience To EXperimental impact
- COBRA - Crustal Ocean Biosphere Research Accelerator
- AleutBio - Aleutian Trench Biodiversity Studies
- IceDivA - Icelandic marine Animals meet Diversity along latitudinal gradients in the deep sea of the Atlantic
- MAREANO

7 DEEP-SEA PROJECT PARTNERS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

MEET SOME OF THE TEAM

WORKING TOGETHER ACROSS 5 OCEAN BASINS



SELECTION OF EXPEDITIONS

1 Arctic, September 2021
Hot vents under Arctic ice

This expedition, led by **Dr Eva Ramirez-Llodra** from **REV Ocean**, explored the 4000m deep Aurora hydrothermal vent field under the permanent ice cover of the Arctic.

2 North Atlantic, July 2021
Resources of Rockall

This expedition, led by **Prof. Louise Allcock** from the **University of Galway**, provided the first footage of coral mounds on the previously unexplored Fangorn Bank.

3 Central and South Atlantic

Dr Kirsty McQuaid (RSR-WG co-coordinator) is a South African early career researcher based in Cape Town with expertise in mapping animal communities, focusing on the abyssal sea floor and marine protected areas.

Dr Maila Guilhon (RSR-WG co-coordinator) focuses on ecosystem-based management of the deep sea. She is an early career researcher from the **University of São Paulo** in Brazil.

4 Indian Ocean

Prof. Agnes Muthumbi (RSR-WG co-coordinator) is an expert on deep-sea marine worms (Nematoda) and is based at the **University of Nairobi, Kenya**.

Dr Baban Ingole (RSR-WG co-coordinator) is based at the **National Centre for Polar & Ocean Research, India**. His expertise is in deep seabed life, particularly areas where minerals of mining interest are found.

5 North West Pacific

Dr Hiromi Watanabe (RSR-WG co-coordinator) is a research scientist with expertise in life around hydrothermal vents. She works at the **Japan Agency for Marine-Earth Science and Technology.**

6 SW Pacific

Drs Malcolm Clark and **Daniel Leduc** (RSR-WG co-coordinators), both based at the **National Institute of Water & Atmospheric Research in New Zealand**. **Malcolm** has worked on deep-sea ecology & fisheries since the 1980s, with a particular focus on the management of the environmental effects of human activities (commercial fishing & potential seabed mining).

Daniel is a benthic ecologist & nematode taxonomist, with research on community ecology & ecosystem function, from intertidal to hadal habitats. He has described over 100 new marine nematode species.

7 Central Pacific, June 2021
Discovering deep-sea corals of the Phoenix Islands

Working with our partner **Schmidt Ocean Institute**, **Boston University's Dr. Randi Rotjan** & **WHOI's Dr. Tim Shank** (and team!) explored the biodiversity of the US Phoenix Islands (part of the US PRIMNM) and nearby high seas.

8 North East Pacific

Dr Amanda Kahn (RSR-WG co-coordinator) is an early career researcher based at **Moss Landing Marine Laboratories, USA**. Her expertise is in deep-sea animal feeding habits and food sources, with a particular focus on sponges (Porifera).

9 North Pacific, July 2021
Characterising communities in the southern California borderland

Dr Lisa Levin and her team from **Scripps Institution of Oceanography** ventured to Southern California on board **Schmidt Ocean Institute's** vessel, *R/V Falkor*, to investigate deep-sea life in mineral-rich areas, providing critical baseline information to guide policy.

10 South Atlantic, May 2022
YTEC-GTGM 5

This expedition, led by **Dr Alejandro Tassone** from the **Institute of Basic, Applied and Environmental Geosciences of Buenos Aires**, undertook environmental baseline studies of the physical, chemical, and biotic environment of the Argentine deep sea.

SCAN THE QR CODE AT THE TOP OF THE PAGE FOR AN INTERACTIVE MAP & OUR FULL CREW!

CHALLENGER 150 IN ACTION

July 2022, the **NW Pacific RSR-WG** organised an online scientific workshop, showcasing expert talks on

- The Regional Biodiversity of Hadal Trenches
- Molecular Approaches in Deep-Sea Hydrothermal Vents and Seeps
- Abyssal Plain Biogeochemistry.

We also held discussions on how the NW Pacific RSR-WG can work across scales—locally, regionally and globally—to

- Address our knowledge gaps in the deep-sea,
- Help early career scientists develop their expertise, and
- Strengthen collaborations and connections with stakeholders
- Grow throughout the **UN Decade of Ocean Science** and beyond.

Dr Saskia Brix from our partner project **IceDivA** hosted the **Floating Classroom Satellite Activity**. The team broadcast live from onboard R/V *Sonne* to the **Senckenberg Museum**, showcasing deep-sea research to build the clean ocean future we want.

The COBRA Project

Earlier this year, our partner project, the **Crustal Ocean Biosphere Research Accelerator** (COBRA), designed and delivered a Master Class for early career researches (ERCs) on deep-sea expedition leadership. This 13-week virtual program trained twelve globally-distributed and diverse ECRs in the "nuts and bolts" of expedition leadership. By the end of the Master Class, all participants reported feeling ready to propose and lead deep-sea expeditions! We cannot wait to see these new leaders in action, as we need their talents and passions more than ever. The program's high application demand attests to the vital need for this training and COBRA is gearing up plans for a second iteration to meet the needs of the ERC community. To learn more, scan the QR code on this page!

COBRA
CRUSTAL OCEAN BIOSPHERE RESEARCH ACCELERATOR

The **Challenger 150** programme collaborates with the **Deep Ocean Observing Strategy (DOOS)** and other programmes as part of a **Deep Sea Research and Management Community of Practice** under the **Ocean Decade** to deliver the science we need for the deep-sea we want. Our parent organisation, the **Deep Ocean Stewardship Initiative (DOSI)**, uses this collaborative research to inform and advise on international policy. We are proud to play our part in this knowledge transfer chain.

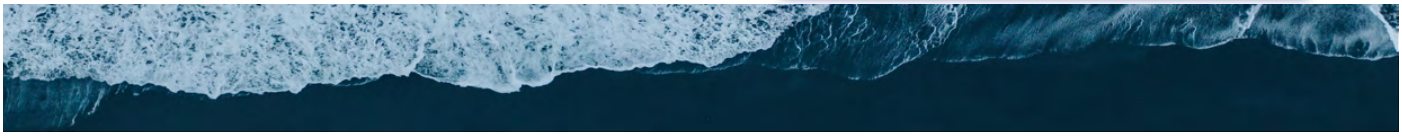
Clean Ocean Laboratory

During the **UN Ocean Decade Clean Ocean Laboratory** event, **Challenger 150** member **Professor Angelika Brandt** from the **Senckenberg Society for Nature Research** in Germany, hosted and presented a presentation on the important and immediate problems posed by ocean pollution that must be tackled during the **Decade** and beyond. During this core event, we highlighted our commitment to achieving the following goals by 2030:

- Establish working groups capable of providing regional-level advice on methods to measure and report pollution in the deep sea
- Build capacity to measure and report deep sea pollution
- Double the number of nations adopting the use of the defined standards
- Advocate for the consideration of deep-sea science in both policy development and conservation initiatives

To learn more about the **Challenger 150 Ocean Decade Programme**: and our **Global Activities**, scan the QR code or contact:

Prof Kerry Howell at the **University of Plymouth**, UK (kerry.Howell@plymouth.ac.uk), or **Dr Ana Hilário** at the **University of Aviero**, Portugal (ahilario@ua.pt)



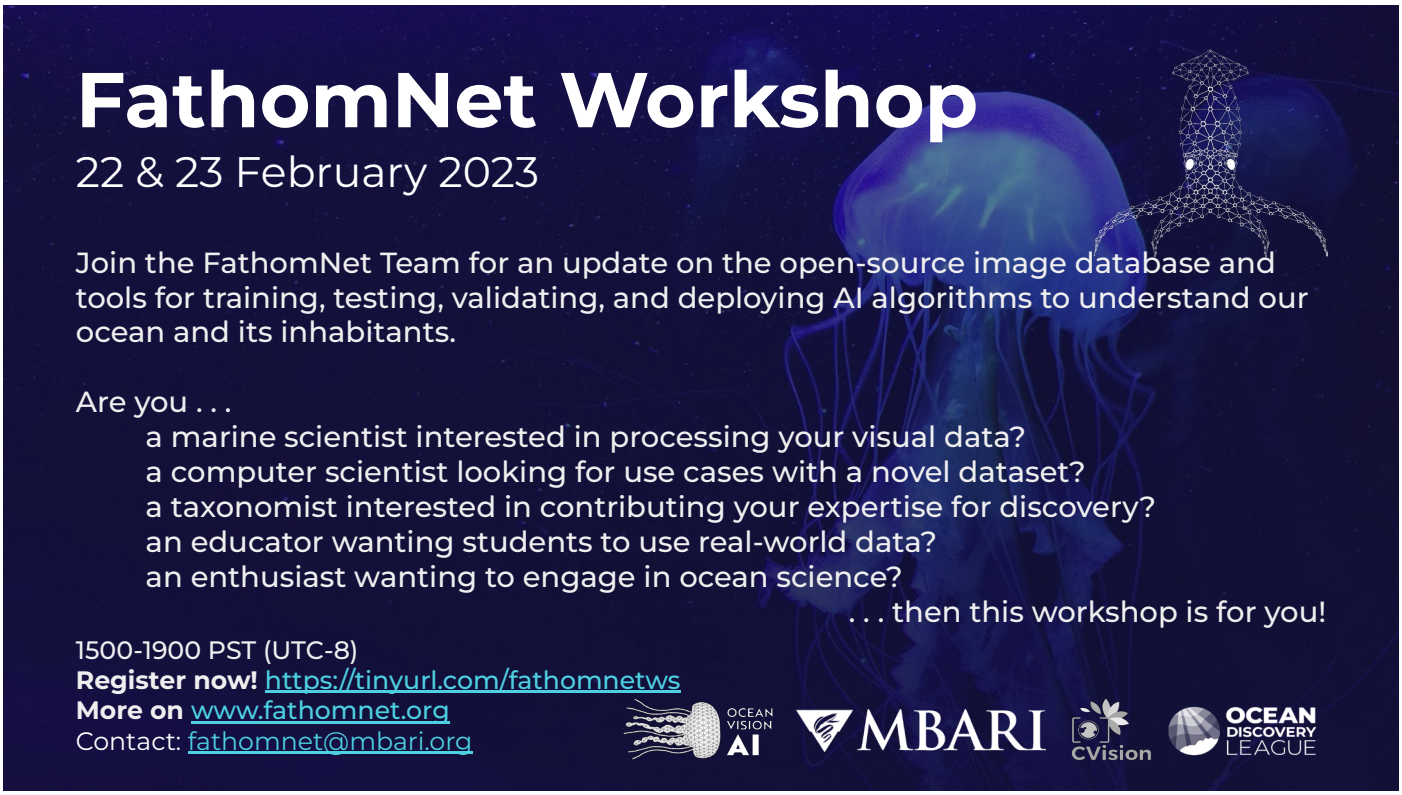
Meetings & Workshops

Resistance to Deep-Sea Mining - Voices from Indigenous Peoples and Local Communities Across the Pacific

If you are attending the 5th International Marine Protected Areas Congress (IMPAC5), we'd like to cordially extend an invitation to join a Deep-Sea Conservation Coalition and WWF co-hosted Symposium: Resistance to Deep-Sea Mining - Voices from Indigenous Peoples and Local Communities Across the Pacific

With their region targeted as the first frontier in the rush to mine the deep sea, around the circumference of the Pacific Ocean, coastal peoples and their upcountry cousins are calling for a pause or an outright ban on this risky, speculative, new industry.

The event will take place at the IMPAC5 venue, Room 202, on February 6th at 14.00 PST. For more information on how to attend the conference, please visit https://www.impac5.ca/.



ISA taxonomy workshops (Nov-Dec 2022) – Report from a Participant

Dr. Franck Lejzerowicz

University of Oslo

The International Seabed Authority (ISA) has been coordinating two consecutive events in Seocheon (Republic of Korea), hosted at the National Marine Biodiversity Institute of Korea (MABIK), with additional support from the local Ministry of Oceans and Fisheries and the European Commission. Over 6 days, at most 15 deep-sea biologists traveled from both developing and developed countries to work together at helping ISA establish a cooperation strategy that would best distribute deep-sea taxonomy knowledge gains, and notably in the form of capacity building. It appeared that describing live biodiversity in the deep sea, even at the scale of a single region such as the Clarion-Clipperton Zone (CCZ), is too daunting a task for isolated, unconcerned efforts, and that on-going initiatives must harmonize their sampling and metadata collection standards. Mature data-producing and management practices must be disseminated for realistic, data-driven solutions to emerge, and to possibly address global environmental and scientific-training challenges in the short timeframe imposed by the mining gold rush.

Inquiries about the broader strategy, vision, and mission of the ISA for these meetings should be sent to Luciana Genio (Environmental analyst, Office of Environmental Management and Mineral Resources of ISA): lgenio@isa.org.jm.

The first event was the *Workshop on Enhancing Genetic Approaches to Advance Deep-Sea Taxonomy* (23-25 November). It aimed at identifying solutions for deep-sea biodiversity assessments to yield the taxonomic knowledge that is urgently needed to build baselines and identify monitoring targets. The participants imagined a framework to reinvigorate taxonomic training and research at higher throughput, notably for developing country researchers to harness state-of-the-art technologies and build advanced, competitive capacity. Scientific or institutional, 15-minutes presentations were delivered in-person by a third of the workshop attendants, as most of the intervention consisted of pre-recorded videos. Multiple high-quality presentations did offer insights on rich subject matters, and clear targets for focused workshop inspections. Key presentations included machine learning solutions to predict the spatial distributions of taxa and discuss their possible application for deep-sea mining area-based management; innovative imaging approaches to process meiofaunal taxa and advance capacity building with training the next-generation of deep-sea taxonomists; the use of by-catches to expand the record of rare species; or novel molecular systematics and phylogenomic methods to improve taxonomic descriptions. I feel it is important to report that several experts could not join to participate in person. Moreover, only one contractor representative was present and actively contributing to the workshop discussions. Because of a lack of scientific momentum, expertise diversity and counter-expertise, and notably about new technologies, this meeting was limited to identifying high-level, cross-institutional avenues and to clarifying conceptual issues specific to the represented research fields. This meeting was meant to be technical, but inspections of actual scientific knowledge and data were not well nourished and rather superficial.

In my opinion, these achievement shortcomings call for additional sessions and more in-depth and focused discussions. I suggest that meetings are first held to deal with the same issues for each taxonomic group (or size class) before a follow-up, synthesis meeting may reconcile the outcomes, which often differ depending on the taxonomic scope. Indeed, the methods to enhance genetic approaches to advance deep-sea taxonomy for the meiofauna and megafauna often differ in terms of sampling and subsampling and post-processing. Interestingly, the Deep CCZ Biodiversity Synthesis Workshop that ISA supported in 2019 followed this model where diverse taxonomic experts gathered in independent working groups, only to consistently report at the concluding session. Then, many more participants were available to join. Yet, the organization in Korea was flawless, efficient, and friendly, although there was no stable internet connection, which was limiting for experts to access relevant resources and information, and rapidly communicate about potential breakthroughs and mobilizing ideas. Many issues related to deep-sea mining were left unaddressed,

such as the emission of plumes and its cohort of sedimentary DNA, which may impact future eDNA-based taxonomic studies. Indeed, out of three days of workshop, only half a day was open online for video contributors and other experts to join, ask questions, and propose their vision and discuss items.

The second event was the *Inception workshop of the Sustainable Seabed Knowledge Initiative* (SSKI) (29 November - 01 December). SSKI and its goals are described on the ISA website (www.isa.org.jm/sski). It will develop a central resource to deal, in the long-term, with normalizing and homogenizing efforts for the CCZ specifically, which will be referred to as "the Area". It entails all essential aspects and the interpersonal frameworks (training, collaborations, exchange visits) with which researchers and stakeholders are expected to compose to advance deep-sea science and its use for management in the CCZ.

A clear consensus emerged that more meetings are needed, which is perfectly in line with the ISA mandate for the next few years. Hence, please keep an eye out for future ISA events. Bi-directional training workshops were identified as a requirement, not only to cross-fertilize projects with easier access to public and/or proprietary data, but also to enhance cooperation through active diversity, equity, and inclusion practices. It was highlighted that follow-up mechanisms must be established for exchanged skills and ideas not to be lost because of a lack of practice and scarce data exposure. Such mechanisms could materialize with the nomination and/or appointment of coordinators positions in future Centers of Excellence, whose duties would include keeping a register of personnel, samples, activities and exchanges, building a resource, and measuring progress to improve and even resource allocations.

The information provided ahead of the workshops is still online on the ISA website, and new pages containing the official workshops reports will be uploaded soon:

- *Enhancing Genetic Approaches to Advance Deep-Sea Taxonomy*: https://www.isa.org.jm/index.php/event/workshop-enhancing-genetic-approaches-advance-deep-sea-taxonomy
- *Inception workshop of the Sustainable Seabed Knowledge Initiative*: https://www.isa.org.jm/index.php/event/inception-workshop-sustainable-seabed-knowledge-initiative

Scientist Profiles

Melissa J. Betters

Temple University, Philadelphia, PA, USA

PhD Candidate

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Growing up in southeastern Wisconsin, I am often asked how I became interested in marine biology. In fact, I cannot remember ever not being interested in it. From a very young age, it has been a source of mystery and fascination for me. Many adults tell me that they once dreamed of becoming marine biologists when they were kids. I always say that I simply never grew out of it! Motivated by these interests, I attended Florida State University for my undergraduate education with a focus in marine biology. I conducted academic research for the first time, leading my own research projects investigating sea urchin reproduction dynamics and mate choice. I was also able to conduct fieldwork around the state, working in seagrass beds, salt marshes, watersheds, and coral reefs. However, over the course of my degree, I realized that there was one place we could not seem to access: the deep sea.

Then, in the last semester of my degree, I was offered a spot on my first research cruise: 60 days at sea studying deep-sea coral communities of the Hawaiian and Emperor seamount chains. I was literally thrown into the deep end, diving nine times in the Pisces IV and V submersibles, and learning more about the deep ocean during those two months than any time before. My mind was alight with questions. Where do deep-sea species come from? What distinguishes deep-sea environments from one another? What causes species to occur in one place but not another? How are humans impacting these ecosystems?

Following this experience, I applied to PhD programs to further pursue deep-sea research. I was accepted into the Cordes Lab at Temple University in Fall 2018. During my first semester, I went on another cruise: 16 days studying hydrocarbon seeps at the Costa Rica Margin. This time, I had the opportunity to study chemosynthetic environments working alongside some of the top scientists in the field. Capitalizing on the vast abundance and diversity of marine gastropods found there, I began my dissertation research. My research investigates patterns of biogeography among chemosynthetic sites, interactions between environmental conditions and organismal biology, and the evolutionary placement of Costa Rica fauna within the broader Pacific Ocean. Encompassing each of these academic pursuits is a curiosity surrounding how our ocean, a seemingly structure-less expanse of water, is meticulously and continuously structured by a myriad of forces we have yet to fully understand. What processes generate species, structure populations, and drive adaptation in the ocean is something I would be happy to investigate for the rest of my life.

With my dissertation set to wrap up in August 2023, I am both anxious and excited for what will come next! I have so

enjoyed working within this amazing community of people for the past five years. Whatever may come, I am hopeful that I can continue conducting deep-sea research well into the future. For more information on my on-going projects or potential collaborations, please feel free to contact me.

Emily Cowell

Temple University, Philadelphia, USA

PhD Candidate

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Growing up on the wild coasts of northern England, I spent my childhood clambering about in rockpools and kayaking the beautiful coasts of Northumberland and the Scottish Highlands, allowing me to experience the hidden beauties of our marine environments which remain a mystery to many. This inspired me to pursue these interests further, and led me to completing my undergraduate degree in Marine Biology at Newcastle University (UK), with research focusing on the deep-sea invasion potential of the porcelain crab *Pisidia longicornis*. During my first semester, I took an "Introduction to Marine Environments" course, which opened my eyes to the variety of marine ecosystems that exist beyond the coastal waters I was familiar with. One environment that particularly sparked my interest was the deep sea, an area full of seemingly impossible creatures living seemingly impossible lives. I knew where my passions lay and have never looked back, going on to undertake my MRes at the National Oceanography Center with the University of Southampton (UK) with a research focus on the taxonomy and community distribution of the deep-sea decapods of the Arabian Sea, a project I completed under the supervision of Dr Tammy Horton. From there my life pivoted when I was accepted onto a PhD program in the United States, with Dr Erik Cordes at Temple University in Philadelphia.

I am currently in the 5th year of my PhD program with a research focus on modelling the abiotic niches of biogenic organisms to identify evidence of successional patterns at methane seeps off the Pacific coast of Costa Rica (ROCHITS program), as well as trying to determine the speed at which mobile biogenic organisms may be able to adapt to year-to-year changes in seepage. I have also been able to continue with my passion for everything crustacean, with my ongoing research project to study the reproductive behaviors of the Costa Rican methane seep yeti crab *Kiwa puravida* through a parentage study utilizing RAD-Seq techniques. These projects have allowed me to develop a wide range of research skills, and greatly increased my knowledge of GIS and species distribution modelling, which I would like to continue on into my future career. They have also provided me with amazing experiences, from my first dive in HOV Alvin at the Costa Rican seeps, to being part of a two month long cruise to study the Lau Basin hydrothermal vent systems on the RV *Thompson*, allowing me to be among the first people on Earth to see first hand the deep-sea effects of the Hunga Tonga-Hunga Ha'apai volcanic eruption. Through these experiences, I have seen first-hand the essential functions that our marine environments offer, but sadly also the damages that we inflict upon them. As such, I am passionate about ocean conservation and responsible resource management, and am striving for a role where my research and organizational skills can be utilized in protecting our fragile ocean environments and implementing policy changes that would conserve them indefinitely.

April Stabbins

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PhD candidate

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As with many of us, my fascination with the ocean started at a very early age, exploring tidepools along the Jurassic Coast of southwest England and everything they held within them. My real journey into marine biology started at Plymouth University and the Marine Biological Association in the UK. During my time here I learned about everything from marine microbes to migrating whales and designed my dissertation around the ecophysiology of jellyfish exposed to hypoxia, but I always remember being captivated when taking a course that covered deep-sea chemosynthetic environments. After completing my MRes I spent the next year travelling in Asia and applying for grad school when a colleague sent me an advert for a dream PhD focusing on deep-sea mussel and tubeworm communities in the US. I applied immediately and before I knew it, I had packed up my bags to make the move across the pond to join Erik Cordes' lab. I literally jumped in at the deep end (excuse the pun!) as almost as soon as I'd touched down in Philadelphia I hopped back on a plane and flew to Costa Rica. We went straight out to sea on a month-long cruise to start collecting data for a project he was leading, ROC HITS.

This collaborative project explored hydrocarbon seeps and seamounts along the Pacific Costa Rican margin. During several cruises to the area, we collected an abundance of organisms from seep habitats as well as lots of seafloor imagery, all of which have contributed to my thesis. I was interested in how energy flows through these chemosynthetic ecosystems, so during my first year I started to explore the trophic dynamics of the seep megafauna using stable isotope analysis. Thousands of samples later I am piecing together intricate food webs and exploring how mobile fauna are exporting chemosynthetically derived carbon to the wider deep-sea environment. I have also been analysing all of our benthic imagery to look at patterns in megafaunal biodiversity, distribution, and spatial variability both within and between seep sites. Another keen interest of mine has been how corals survive in seep habitats that are usually deemed too toxic for them to survive. One unusual observation we made during each cruise was how one coral species thrives in very close proximity to active seepage. We found this to be a new species of coral, that seems to have adapted a facultative symbiosis rarely seen before.

I love being a part of such wonderful research community and now I am coming to the end of my PhD I am excited to begin the search for the next chapter in my career. I am passionate about continuing research, broadly speaking within the fields of community ecology, symbiosis, invertebrate physiology, or climate change and conservation, hopefully within the deep sea! Please feel free to reach out with any postdoc or other positions/opportunities that become available or to talk more about my work.

Ryan Gasbarro

Temple University, Philadelphia

PhD candidate

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Over the years, I have found that the path to being a deep-sea biologist is rarely straight. My story is not an exception. I began my studies at Arizona State University wide-eyed and interested in climate change journalism, originally in their new 'Sustainability' major. I toyed with multiple career paths – e.g. environmental law, college dropout musician – but it wasn't until a marine invertebrates course during my junior year did I consider science. I spent the next summer doing an REU at Western Washington University's marine station working on giant green anemone reproduction and algal symbiosis. I was hooked on research. From there I went to British Columbia, Canada at the University of Victoria, where I did my MSc on macrofaunal communities on fjord walls and the community-level effects of an extreme low-oxygen event in another fjord. I spent the next year back in Arizona, applying for grad school and doing some contract work for Oceans Network Canada. I knew I wanted to continue doing ship- and ROV-based research and landed a PhD position at Temple University in Erik Cordes's lab. I was offered freedom to design a dissertation within the bounds of the exciting DEEP SEARCH project that would be exploring the deep-sea canyons, coral reefs, and hydrocarbon seeps off the southeast USA. On our multiple cruises there were exciting discoveries of new deep-sea coral reefs and lots of amazing imagery gathered that I have had the pleasure of analyzing during my PhD. I even got a dive in the HOV Alvin! I had big plans for phylogenetic community and biogeographic studies, which had already hit multiple snares by the time COVID hit and really derailed lab-work. So, I course-corrected by leaning into modeling work, predicting cold-water coral distributions and how they might be affected by climate change. We found, in our recently published paper, that some of the reefs we discovered at sea may even serve as refugia, as many of the previously-known sites in the region lie more directly under the Gulf Stream where future warming may be more severe.

It turned out I enjoyed modeling, which brought me closer to my previous interest in climate change, and I still completed pared-down versions of my PhD chapters affected by the pandemic. The modeling work also led me to my recently accepted postdoc position with NOAA & UC Santa Cruz, where I will work on predictive models for the future biodiversity in California's marine sanctuaries. While I hope to one day have a lab of my own continuing in this vein working on marine biodiversity and climate change from surface to seafloor, I know that there are few guarantees in this field. Even with the often-rudderless nature of being an early-career scientist, I remain passionate about doing impactful work and look forward to working within the deep-sea community for the rest of my career. Please feel free to reach out with any questions about my work or any collaborations you are interested in.

Opportunities

SCOR is searching for the new Executive Director

The Scientific Committee on Oceanic Research (SCOR) is seeking its next full-time Executive Director to carry on from the current Executive Director, Dr. Patricia Miloslavich.

SCOR is an interdisciplinary committee of the International Science Council and is the leading non-governmental organization for the promotion and coordination of international ocean science activities (www.scor-int.org). Thirty-three nations currently have national SCOR committees and form SCOR's foundation. SCOR activities include (1) working groups that address focused ocean science topics, (2) large-scale ocean research projects, (3) a variety of infrastructural activities for ocean science, and (4) capacity development in ocean science.

The duties of the SCOR Executive Director include the following:

- Serve as the staff for the SCOR Executive Committee, SCOR Finance Committee, and SCOR Committee on Capacity Development;
- Manage the SCOR Secretariat, raising funds from national SCOR committees, and national and international funding agencies;
- Manage spending for SCOR activities according to the annual SCOR budget and regulations of financial sponsors;
- Organize SCOR Annual Meetings;
- Coordinate with national SCOR committees and partner organizations;
- Prepare written reports for SCOR Annual Meetings and documents to publicize SCOR activities; and
- Lead outreach activities for SCOR, including preparation of tri-annual SCOR Newsletters, Tweets, and maintenance of the SCOR Website.

Applicants should preferably have (1) a Ph.D. or the equivalent in a field of Ocean, Earth, or marine environmental sciences; (2) significant management experience in such a field; (3) excellent oral and written communication skills in English; (4) a record of successful grants; and (5) basic knowledge of accounting and financial management practices.

The new SCOR Executive Director will be based in United States; the SCOR Secretariat is currently located at the University of Delaware. The candidate should be either a U.S. citizen or have permission to work in the United States, having a "green card" or H1B Visa. The position requires international travel.

The starting annual salary will be competitive and will depend on qualifications, salary history, and experience of the successful applicant. Shortlisted candidates will be interviewed via Zoom in mid-March 2023. A cover letter of application with a curriculum vitae and the names of three references should be emailed no later than 17 of February 2023 to the SCOR Secretary, Prof. Peter Croot, peter.croot@nuigalway.ie.

Starting date for the position is the 1 of June 2023. During the first month (June 2023), the new Executive Director will overlap with Dr. Patricia Miloslavich for training purposes.

Any queries about this post may be addressed to the SCOR President (Dr. Sinjae Yoo, sjyoo@kiost.ac.kr), the SCOR Past-President (Dr. Marie Alexandrine Sicre, marie-alexandrine.sicre@locean.ipsl.fr) or SCOR Executive Director (Dr. Patricia Miloslavich, patricia.miloslavich@scor-int.org).

The Commonwealth Secretariat offers a new publicly-accessible e-learning course on deep seabed minerals

The course is online now for government officials and other stakeholders who want to learn about the regulatory and environmental aspects of deep seabed minerals activities such as exploration and mining.

Deep seabed minerals are of increasing interest to a wide range of Commonwealth countries and these e-learning courses will aid in developing in-country expertise around national and international processes regarding deep seabed minerals activities, and support informed decision making.

The course is designed to provide information on a variety of important aspects of deep seabed minerals to facilitate informed engagement with this emerging industry. The Course comprises 7 modules, all written by specialists with considerable expertise in deep seabed minerals, with three available now and the remainder to be released in the coming months:

- Module A: Minerals and the Seafloor (Available now)
- Module B: The International Legal Framework (Available now)
- Module C: The International Seabed Authority (coming soon)
- Module D: Sponsoring States' Considerations (coming soon)
- Module E: National Jurisdiction Regulatory Considerations (Available now)
- Module F: Environmental Monitoring Considerations (coming soon)
- Module G: Economic and Financial Considerations (coming soon)

The course is available on the Commonwealth's Learning platform https://cwlearn.commonwealth.int/ alongside other courses that the Commonwealth offers. To access, you need to create a free account on the platform. Please ensure that you use your correct name when creating the account, as that is the name that will be used on the certificate of completion.

E-learning has been utilised by the Commonwealth Secretariat since 2011 as a means of training and upskilling professionals from across the world, and therefore helping countries to better understand and manage their resources. It has proven to be an effective and accessible option, particularly for those unable to travel for face-to-face training sessions. For any questions or feedback please email a.swaddling@commonwealth.int.

Wanted

WANTED! DEEP-SEA TELEOSTS AND/OR THEIR GI TRACTS

Good Wishes Colleagues & Fellow Members of the Deep-Sea Biology Society

I am a Parasitologist and Permanent Scholar in Residence in the Natural History Collections at the Corpus Christi Museum of Science & History in Corpus Christi, Texas (U.S.A.). For 30 years my main research focus has been describing new taxa of deep-sea helminth (worm) parasites including digeneans, cestodes, nematodes, monogeneans and acanthocephalans infecting teleosts collected at 200+ m depths.

I am looking for deep-sea benthic and benthopelagic teleosts and/or their GI tracts which I can examine to collect, describe and publish new taxa of parasitic helminths to document deep-sea parasite biodiversity. I am happy to reimburse mailing costs as well as include you as a co-author on all publications produced from your material.

Please contact me and I would be happy to discuss with you in more detail my ongoing research, project logistics and desired teleost taxa of interest. You may also keyword search “Charles Blend” and “parasites” on Google Scholar to sample, see and learn more about my work.

With Sincere Thanks,

Whatever Your Terms, We Want Your Worms

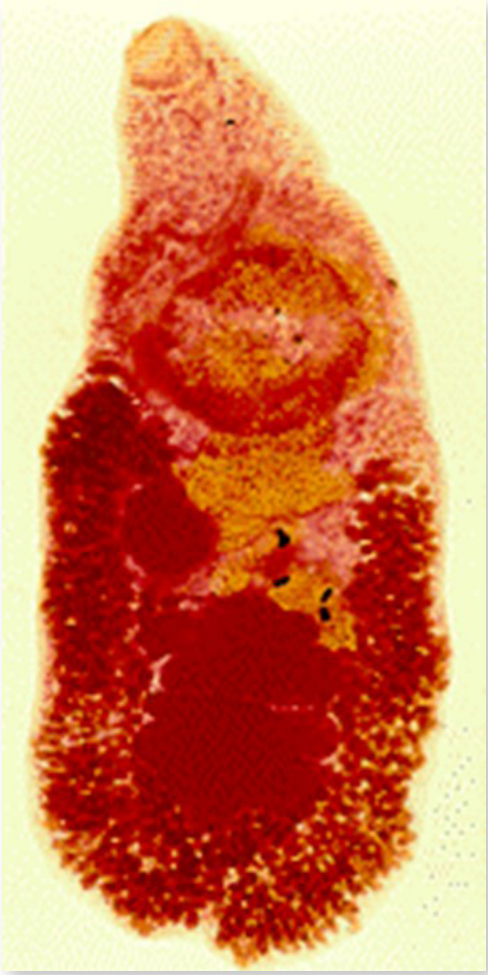


Figure 1. ***Podocotyle nimoyi*** Blend, Dronen & Armstrong, 2016 , (Trematoda: Digenea: Opecoelidae) from the pugnose grenadier, ***Sphagemacrurus grenadae***, and the common Atlantic grenadier, ***Nezumia aequalis*** (Gadiformes: Macrouridae), from the deep Gulf of Mexico

Charles (Chuck) Blend Ph.D., M.S., B.S.

Email: ilovethesea@att.net

Phone/Voice Mail: 011-1-361-218-5276)

Corpus Christi Museum of Science & History (Website: www.ccmuseum.com)

Laboratory of Parasitology, Biodiversity & Teaching Collection, Texas A&M University, College Station, Texas

Contribute to the Micronekton Wikipedia page!

Dr Pavanee Angelee Annasawmy

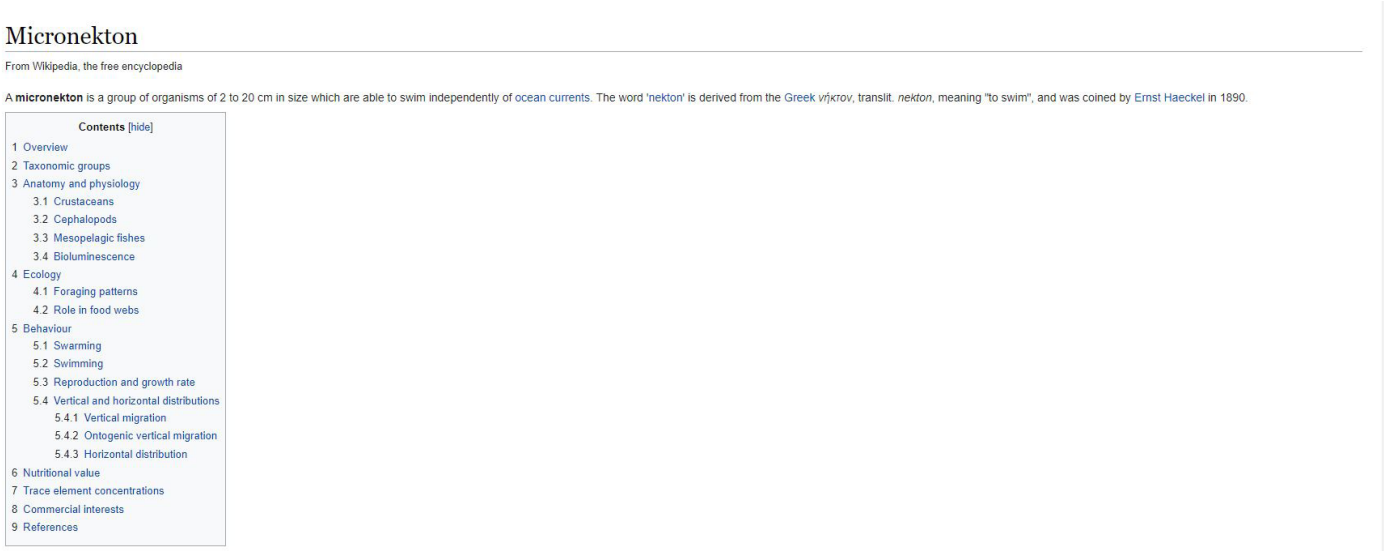
Université de Bretagne-Occidentale, COFUND BIENVENÜE MSCA H2020

Contact: pannasawmy@yahoo.com

Micronekton are fishes, crustaceans and cephalopods of 2-20 cm in size (Figure 1) which are able to actively swim against ocean currents. I have been studying the distribution, vertical migration patterns, trophic position and trace element concentrations of micronekton for more than 8 years now. Micronekton is poorly known compared to other organisms in the food web such as phytoplankton, zooplankton and top predators, even if micronekton forms a key trophic link.

Typing "micronekton" in google redirects users to institutional websites and journal articles. Not knowing anything about micronekton before I decided to study them, I googled the word and did not find any easily understandable information on the web. I feel that part of the responsibility in being a researcher is to try to communicate our research interests to the general public in a lucid, concise, and easily understandable way. Wikipedia is one of the biggest open-access online encyclopedias used by people of various backgrounds to easily access clear information on a particular topic. Having access to a Wikipedia page at the time would have saved me time in my search on the topic. Recently, I have been mentoring students for a project on the distribution of micronekton and they were struggling to find easily digestible information on these organisms online.

Hence, I decided to create a Wikipedia page dedicated to micronekton. The contents cover a broad overview of the organisms, some information on the taxonomic groups, anatomy and physiology of each broad category of organisms, their ecology, swarming, swimming, reproductive behaviors, their distributions, migrations, nutritional value, and trace element concentrations (Figure 2). Since this is the first time that I have created such a page, I believe that there is room from improvement. Hence, I would like to invite all deep-sea researchers that know of micronekton to contribute and edit the page if they wish. I believe that the page would also benefit from the inclusion of better graphics and images of the organisms and their bioluminescence.



Micronekton

From Wikipedia, the free encyclopedia

A **micronekton** is a group of organisms of 2 to 20 cm in size which are able to swim independently of ocean currents. The word 'nekton' is derived from the Greek νῆκτον, translit. *nekton*, meaning "to swim", and was coined by Ernst Haeckel in 1890.

Contents [hide]

Even if Wikipedia is not widely used among researchers, it is still used by students worldwide and I feel that it is our responsibility to ensure that the information that is published on the page is as accurate and reliable as possible. With the Wikipedia page on Micronekton, I wish to make Micronekton known to a wider range of people of various academic backgrounds.

Weblink: https://en.wikipedia.org/wiki/Micronekton

I am a Washington, D.C.-based author and policy analyst currently working on a book for Marine Corps University Press about continental shelf disputes, seabed policy, and the United Nations Convention on the Law of the Sea. The manuscript is currently in the researching and drafting phases, and MCUPress has accepted the proposal.

As part of my book, I am looking to interview members of the scientific and academic communities with subject-matter expertise on UNCLOS Articles 76-85, the International Seabed Authority, the environmental damage caused by deep seabed mining, and other forms of seabed exploitation. Experts with first-hand experience in international bodies related to seabed conservation or with first-hand experience doing field research in deep sea environments suspected of having mineral wealth (such as the Clarion Clipperton Zone) are highly desired as well!

Interviews will be done virtually, scheduled for when would be most convenient for the interviewee, and should last no more than 30 minutes. The purpose of the interviews are for background knowledge for the author and to canvas existing research on the effects of seabed mining and the state of global governance for the seabed. Unless requested by the author, no quotes from the interviewees will be written into the manuscript. Really, I am simply eager to meet the community of interest and learn about its research.

If interested, please contact Drake Long at mlongdrake@gmail.com with 'DOSI' in the subject line. Please attach or provide a link to published research/journal articles you have written on the above topics, if you'd like it to be cited in the manuscript.

With sincere thanks,

Drake Long (Primary Email: mlongdrake@gmail.com, Alt Email: dml129@georgetown.edu)


BLUE PLANET III
BBC
Blue Planet III - the next instalment of the BBC's critically acclaimed underwater flagship series - is being launched for broadcast in 2026.
We are looking for the most groundbreaking, captivating and unusual animal behaviours from the marine world - from fish to marine mammals, invertebrates, and seabirds.
The series will traverse the world's oceans, from coasts to the deep sea, the tropics to the poles, set against the backdrop of a changing planet.
If you have noticed any unique or novel animal behaviours which you think could feature in Blue Planet III, we would love to hear from you.
Please email: blueplanet3@bbc.co.uk

Hot off the Press

A forgotten element of the blue economy: marine biomimetics and inspiration from the deep sea

Robert Blasiak, Jean-Baptiste Jouffray, Diva J. Amon, Fredrik Moberg, Joachim Claudet, Peter Søgaard Jørgensen, Agnes Pranindita, Colette C. C. Wabnitz and Henrik Österblom

PNAS Nexus Volume 1 (4)

The morphology, physiology, and behavior of marine organisms have been a valuable source of inspiration for solving conceptual and design problems. In this review, we introduce this rich and rapidly expanding field of marine biomimetics, and identify it as a poorly articulated and often overlooked element of the ocean economy associated with substantial monetary benefits. We showcase innovations across seven broad categories of marine biomimetic design (adhesion, antifouling, armor, buoyancy, movement, sensory, stealth), and use this framing as context for a closer consideration of the increasingly frequent focus on deep-sea life as an inspiration for biomimetic design. We contend that marine biomimetics is not only a "forgotten" sector of the ocean economy, but has the potential to drive apreciation of nonmonetary values, conservation, and stewardship, making it well-aligned with notions of a sustainable blue economy. We note, however, that the highest ambitions for a blue economy are that it not only drives sustainability, but also greater equity and inclusivity, and conclude by articulating challenges and considerations for bringing marine biomimetics onto this trajectory.

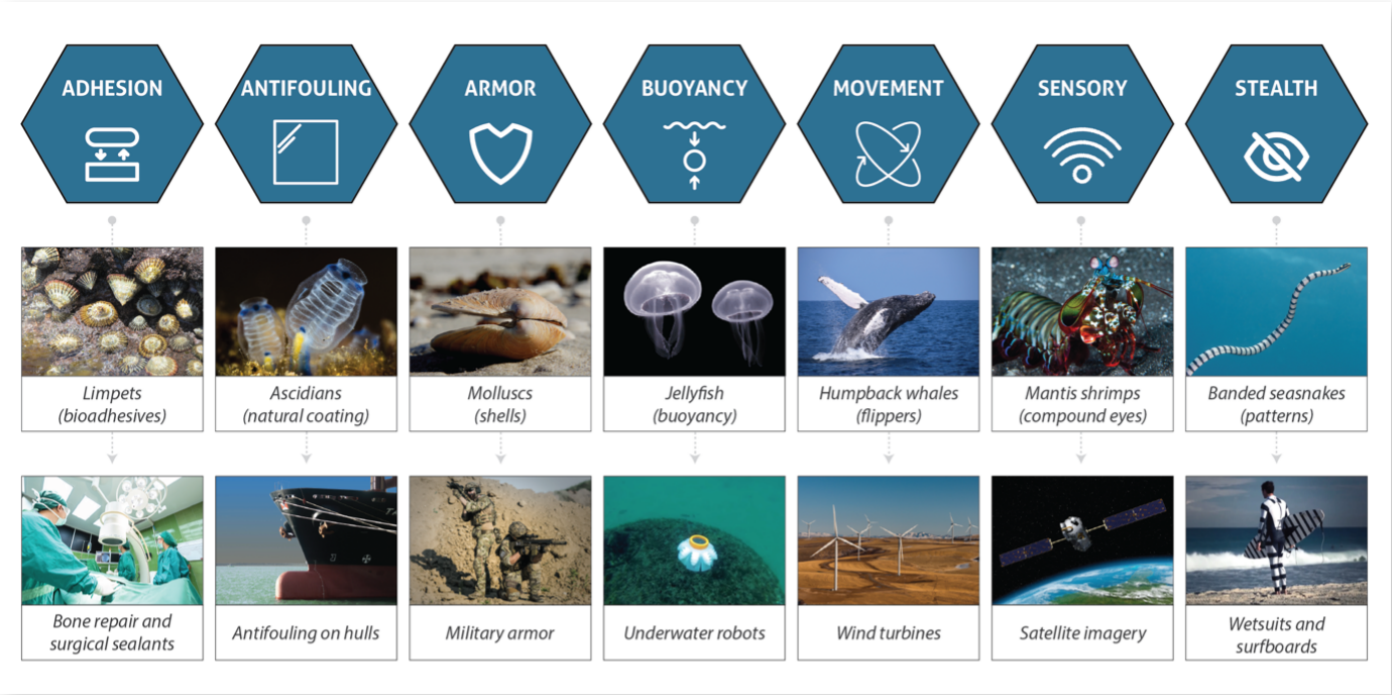


Figure 1. Marine biomimetics. The diverse morphological, physiological, and behavioral characteristics of marine species have inspired innovations that extend across diverse industries.

Link to article: https://academic.oup.com/pnasnexus/article/1/4/pgac196/6702749

Munidopsis geyeri and *M. exuta* (Crustacea: Munidopsidae): A study of two deep-sea, amphi-Atlantic species that co-occur in the southern Gulf of Mexico

Adriana Gaytán-Caballero*, Elva Escobar-Briones*, Rafael Robles, and Enrique Macpherson

Zootaxa 5213 (4): 301–335

Contact*: adriana.gaytan@ciencias.unam.mx; escobri@cmarl.unam.mx

The history of colonization and dispersal of fauna among deep-sea chemosynthetic ecosystems remains enigmatic and poorly understood. The distribution of squat lobsters of the genus *Munidopsis* Whiteaves, 1874 can be influenced by the rich organic matter and associated organism communities of chemosynthetic ecosystems. Our work analyzed the molecular relationships and morphology of individuals from different populations of *Munidopsis exuta* Macpherson & Segonzac, 2005 and *M. geyeri* Pequegnat & Pequegnat, 1970 in such ecosystems along the Atlantic Equatorial Belt, including the Chapopote Knoll, in the southern Gulf of Mexico. *Munidopsis geyeri* is re-described based on the present findings and reference to the literature. This analysis documented the genetic distances, as well as range of variation in the diagnostic characters that support the separation of *M. exuta* and *M. geyeri*. Our results confirm that the two species coexist in seep ecosystems and have an amphi-Atlantic distribution.

Link to article: https://doi.org/10.11646/ZOOTAXA.5213.4.1

Insights from the management of offshore energy resources: Toward an ecosystem-services based management approach for deep-ocean industries

M. Emilia Bravo*, Miriam I. Brandt, Jesse M. A. van der Grient, Thomas G. Dahlgren, Patricia Esquete, Sabine Gollner, Daniel O. B. Jones, Lisa A. Levin, Craig R. McClain, Bhavani E. Narayanaswamy, Tracey Sutton, Lissette Victorero and Erik E. Cordes

Frontiers in Marine Science, 9, 2576

Contact: *mebravo@gl.fcen.uba.ar

The deep ocean comprises complex ecosystems made up of numerous community and habitat types that provide multiple services that benefit humans. New technological solutions position the deep ocean as a promising frontier for the expansion and transition of energy industries (both fossil fuels and marine renewables). As the industrialization of the deep-sea proceeds, a standardized and robust set of methods and metrics need to be developed to monitor the baseline conditions and any anthropogenic and climate change-related impacts on biodiversity, ecosystem function, and ecosystem services. Here, we review what we have learned from studies involving offshore-energy industries, including state-of-the-art technologies and strategies for obtaining reliable metrics of deep-sea biodiversity and ecosystem function. An approach that includes the detection and monitoring of ecosystem services, with open access to baseline data from multiple sectors, can help to improve our global capacity for the management of the deep ocean. We propose a new framework that includes ecosystem services within ecosystem-based management and discuss how it can guide the management of renewable-energy development and other offshore industries. We believe that a number of cross-sectoral and international partnerships can act as key enablers for the integration of factors necessary for effective management, such as environmental data acquisition and interpretation, research and technological innovation, capacity building, industrial risk reduction, and financial and political considerations. We propose a series of opportunities for overcoming current challenges for fair and equitable access to energy resources as well as the other services and benefits derived from deep-sea ecosystems.

Link to paper: https://www.frontiersin.org/articles/10.3389/fmars.2022.994632/full

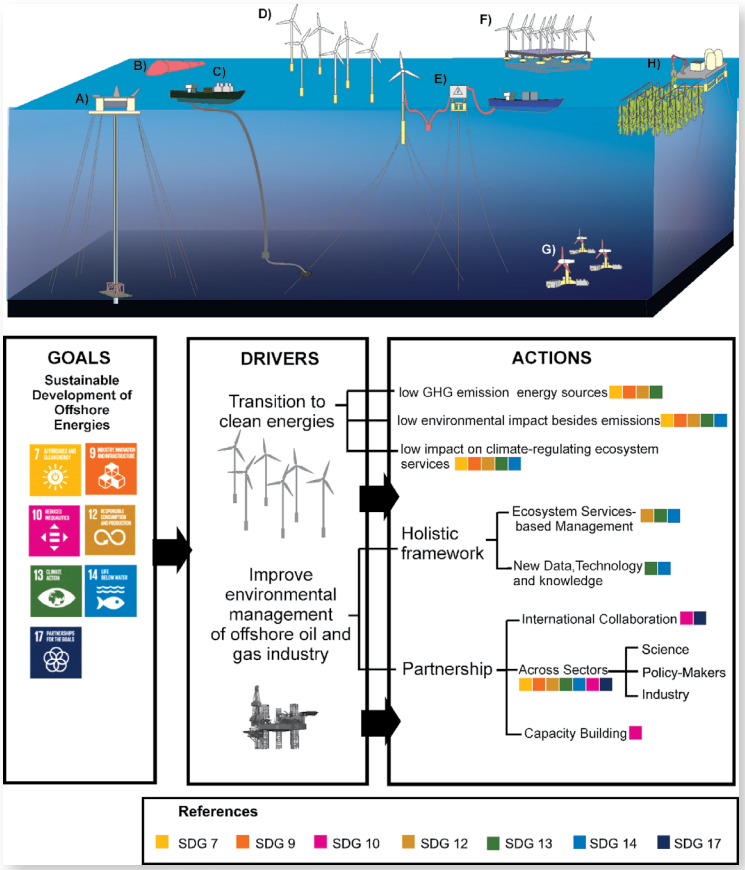


Figure 1 (top) schematic representation of different types of energy industries in current or potential development in the deep ocean.

Figure 2 (bottom) The sustainable development of offshore energy industries framed onto the United Nations Sustainable Development Goals (SFDGs).

Phenology in the deep sea: Seasonal and tidal feeding rhythms in a keystone octocoral

Fanny Girard, Steven Y. Litvin, Alana Sherman, Paul McGill, Amanda Gannon, Christopher Lovera, Andrew DeVogelaere, Erica Burton, Dale Graves, Aaron Schnittger, Jim Barry

Proceedings of the Royal Society B 289: 20221033.

Biological rhythms are widely known in terrestrial and marine systems, where the behavior or function of organisms may be tuned to environmental variation over periods from minutes to seasons or longer. Although well characterized in coastal environments, phenology remains poorly understood in the deep sea. Here we characterized intra-annual dynamics of feeding activity for the deep-sea octocoral *Paragorgia arborea*. Hourly changes in polyp activity were quantified using a time-lapse camera deployed for a year on Sur Ridge (1230 m depth; Northeast Pacific). The relationship between feeding and environmental variables, including surface primary production, temperature, acoustic backscatter, current speed and direction, was evaluated.

Figure 1. *Paragorgia arborea.*

Feeding activity was highly seasonal, with a dormancy period identified between January and early April, reflecting seasonal changes in food availability as suggested by primary production and acoustic backscatter data. Moreover, feeding varied with tides, which likely affected food delivery through cyclic oscillation in current speed and direction. This study provides the first evidence of behavioral rhythms in a coral species at depth greater than 1km. Information on the feeding biology of this cosmopolitan deep-sea octocoral will contribute to a better understanding of how future environmental change may affect deep-sea coral communities and the ecosystem services they provide.

Link to article: https://doi.org/10.1098/rspb.2022.1033

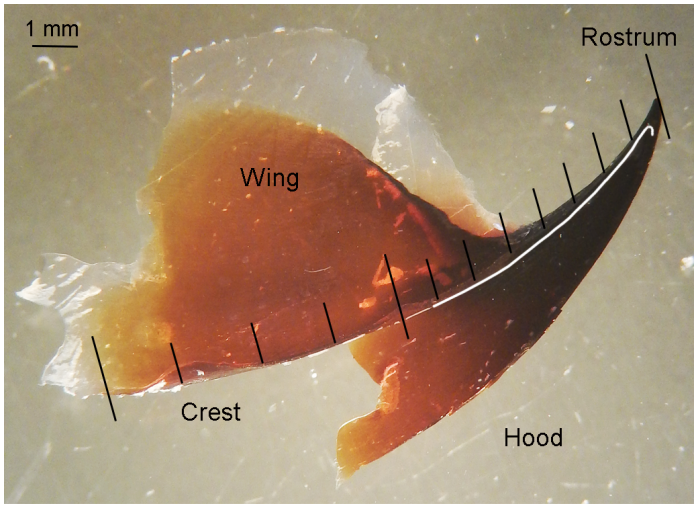
Life history of the arctic squid *Gonatus fabricii* (Cephalopoda: Oegopsida) reconstructed by analysis of individual ontogenetic stable isotopic trajectories

Alexey V. Golikov, Filipe R. Ceia, Hendrik J. T. Hoving, José P. Queirós, Rushan M. Sabirov, Martin E. Blicher, Anna M. Larionova, Wojciech Walkusz, Denis V. Zakharov, José C. Xavier

Animals 2022, 12 (24): 3548

Cephalopods are important in Arctic marine ecosystems as predators and prey, but knowledge on their life cycles is poor. The most abundant Arctic cephalopod species is the squid *Gonatus fabricii*, which also dominates northern part of North Atlantic. This species has an ontogenetic descent, from epipelagic paralarvae at the surface to larger squid in the deep bathyal layers. This peculiar life cycle precludes a correct incorporation of this species into the Arctic ecosystems assessment models. Here, the ontogenetic changes in diet and habitat of large *G. fabricii* from West Greenland are studied using stable isotope analysis of carbon (δ13C) and nitrogen (δ15N) along trajectories in chitin beaks, which function as archival structures. This approach allows an appropriate prediction of mantle length (ML) and mass when the species changes its ecological role through its life cycle. Our results show that the life history of *G. fabricii* is divided into four stages, each having a distinct ecology: 1) epipelagic squid (mantle length < 20 mm), preying mostly on copepods; 2) epi- and occasionally mesopelagic squid (mantle length 20–50 mm), preying on larger crustaceans, fishes and cephalopods; 3) meso- and bathypelagic squid (mantle length > 50 mm), preying mainly on fishes and cephalopods; and 4) non-feeding bathypelagic gelatinous females (mantle length > 200 mm). This novel ecological periodization is a crucial baseline tool in Arctic marine ecosystem studies and cephalopod biology, and should be used in models to correctly reflect the ecological roles of *G. fabricii* in the marine ecosystems.

Link to paper: https://www.mdpi.com/2076-2615/12/24/3548



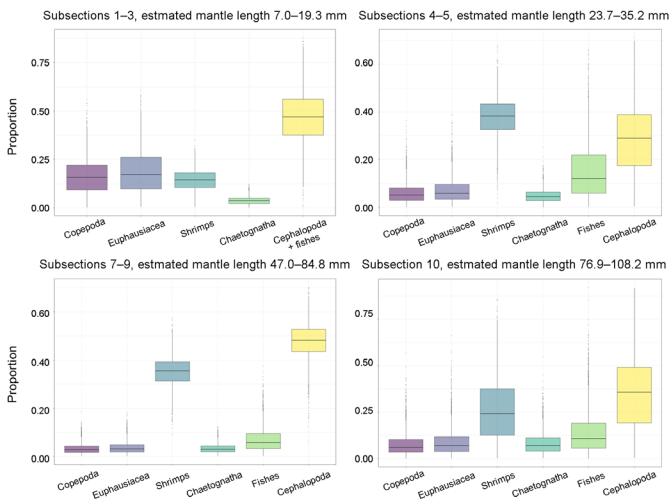


Figure 1 (left). Upper beak of *Gonatus fabricii*, showing subsections' preparation from inside the crest. Figure 2 (right). Relative contribution of different prey taxa to the diet of different ontogenetic groups of *Gonatus fabricii* (which are represented by the respective beak subsections), as predicted by Bayesian mixing model SIMMR 0.4.5. based on stable isotopic data

Local-scale feedbacks influencing cold-water coral growth and subsequent reef formation.

Guillem Corbera, Claudio Lo Iacono, Gonzalo Simarro, Jordi Grinyó, Stefano Ambroso, Veerle A. I. Huvenne, Furu Mienis, Marina Carreiro-Silva, Inês Martins, Beatriz Mano, Covadonga Orejas, Ann Larsson, Sebastian Hennige & Andrea Gori

Sci Rep 12, 20389 (2022).

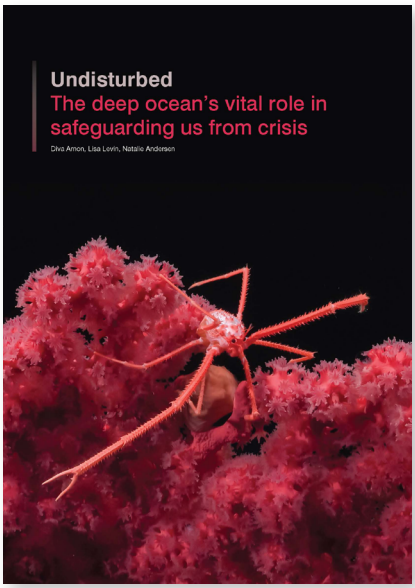
Although several studies have assessed the effect of cold-water coral reef on the hydrodynamics and how variations in the environment can affect coral growth, there is a lack of knowledge regarding what are the mechanisms driving the geomorphological development of coral reefs. Indeed, studies that relate variations in hydrodynamics caused by the reef with the growth patterns of the reef itself are still scarce, and only based on numerical simulations. In situ coral reef observations together with some studies carried out so far suggest that when subjected to a unidirectional water flow, cold-water coral reefs should grow into the current. Nonetheless, there is a lack of experimental evidence to support such observations and a considerable knowledge gap regarding the feedbacks and mechanisms driving such geomorphological development. Based on this, we laid out three hypotheses that were tested through the performance of a two-month flume experiment with living coral nubbins placed in different locations of an artificial coral reef patch subjected to a unidirectional water flow.

The results acquired suggest that due to a higher food supply and appropriate current speed that likely promoted the intake of ions involved in the calcification process, the coral nubbins located on the upstream side of the reef presented a significantly enhanced coral growth and a lower expression of stress-related proteins than the downstream ones. This indicates that, as suggested by previous studies and *in situ* observations, a coral reef influenced by a unidirectional water flow would grow into the current. We also observed that at some distance behind the reef, the flow conditions were re-established and coral growth was again enhanced, suggesting it could be possible for another reef patch to form, thus giving rise to a potential cyclic pattern of reef development.

Link to article: https://doi.org/10.1038/s41598-022-24711-7

Undisturbed: The deep ocean's vital role in safeguarding us from crisis.

Diva Amon, Lisa Levin and Natalie Andersen



Released in November 2022, ahead of UNFCCC COP27, this report calls for urgent protection of the deep sea in the face of the global climate crisis. The vast, remote deep ocean is essential to a healthy, functioning planet, helping to regulate Earth's climate by absorbing and storing excess heat and CO_2 generated by human activities. Despite playing a critical role in climate regulation, a growing body of research is revealing that climate change impacts in the deep ocean are now occurring at unprecedented rates. This is leading to a warmer, more acidified, less oxygenated deep ocean, with potentially dire consequences for deep-sea life and the ecosystem services provided, including – paradoxically – climate change mitigation. This report highlights the important role of the deep ocean in mitigating climate change and warns of the serious threats the deep-sea faces from human activity, including deepwater oil and gas extraction, deep-sea trawling, and the emerging deep-sea mining industry.

To help mitigate climate change and increase our resilience to its impacts, the deep ocean must be taken fully into account. The report outlines seven steps that can be taken now to defend the deep. These include a pause on all human activities that disturb the deep seafloor, lead to biodiversity loss, and risk disruption of irreplaceable ecosystem services; increase deep-sea research independent of extractive agendas; and adopt policies that support the protection of deep-ocean ecosystem services and take precautionary approaches to avoid irreversible losses of those services.

The report is available in English, and executive summaries are available in French, Spanish, and English: http://www.stateoftheocean.org/outreach/new-resources/

Speciation of pelagic zooplankton: Invisible boundaries can drive isolation of oceanic ctenophores

Shannon B. Johnson, Jacob R. Winnikoff, Darrin T. Schultz, Lynne M. Christianson, Wyatt L. Patry , Claudia E. Mills, Steven H. D. Haddock

Frontiers in Marine Science 2022

The study of evolution and speciation in non-model systems provides us with an opportunity to expand our understanding of biodiversity in nature. Connectivity studies generally focus on species with obvious boundaries to gene flow, but in open-ocean environments, such boundaries are difficult to identify. Due to the lack of obvious boundaries, speciation and population subdivision in the pelagic environment remain largely unexplained. Comb jellies (Phylum Ctenophora) are mostly planktonic gelatinous invertebrates, many of which are considered to have freely interbreeding distributions worldwide. It is thought that the lobate ctenophore *Bolinopsis infundibulum* is distributed throughout cooler northern latitudes and *B. vitrea* warmer. Here, we examined the global population structure for species of *Bolinopsis* with genetic and morphological data. We found distinct evolutionary patterns within the genus, where *B. infundibulum* had a broad distribution from northern Pacific to Atlantic waters despite many physical barriers, while other species were geographically segregated despite few barriers. Divergent patterns of speciation within the genus suggest that oceanic currents, sea-level, and geological changes over time can act as either barriers or aids to dispersal in the pelagic environment. Further, we used population genomic data to examine evolution in the open ocean of a distinct lineage of *Bolinopsis* ctenophores from the North Eastern Pacific. Genetic information and morphological observations validated this as a separate species, *Bolinopsis microptera*, which was previously described but has recently been called *B. infundibulum*. We found that populations of *B. microptera* from California were in cytonuclear discordance, which indicates a secondary contact zone for previously isolated populations. Discordance at this scale is rare, especially in a continuous setting.

Figure 1. Bolinopsis microptera from the Monterey Bay, California. Photo credit: Shannon B. Johnson

Link to paper: https://www.frontiersin.org/articles/10.3389/fgene.2022.970314/full

Evolution and biogeography of the *Haploniscus belyaevi* species complex (Isopoda: Haploniscidae) revealed by means of integrative taxonomy

Henry Knauber, Jona R. Silberberg, Angelika Brandt, Torben Riehl

Systematics and Biodiversity, 20:1

Contact: henry.knauber@senckenberg.de

Figure 1: CLSM images of adult males within the *Haploniscus belyaevi* species complex

The role of geomorphological features as drivers for benthic deep-sea biodiversity remains poorly understood. By disentangling the putative *Haploniscus belyaevi* Birstein, 1963 species complex from the abysso-hadal Kuril-Kamchatka Trench (KKT) region in the North-west Pacific Ocean, we aim to shed light on deep-sea differentiation and how it is related to potential bathymetric barriers such as the KKT and the Kuril-Island Ridge (KIR). Our integrative taxonomic approach featured morphological and molecular delimitation methods, also considering the post-marsupial development due to pronounced sexual dimorphism. Mitochondrial 16S and COI markers were sequenced, and several molecular species delimitation methods were applied. By combining the different results, we were able to delineate six distinct species within the *belyaevi* complex, including several morphologically cryptic species, and found hints of three additional species groups in the complex. Even though several of these species were distributed across the KKT and/or KIR, limited gene flow and depth-differentiation were indicated supporting previous notions that these geomorphological features play a role in deep-sea benthos speciation.

Link to article: https://doi.org/10.1080/14772000.2022.2099477

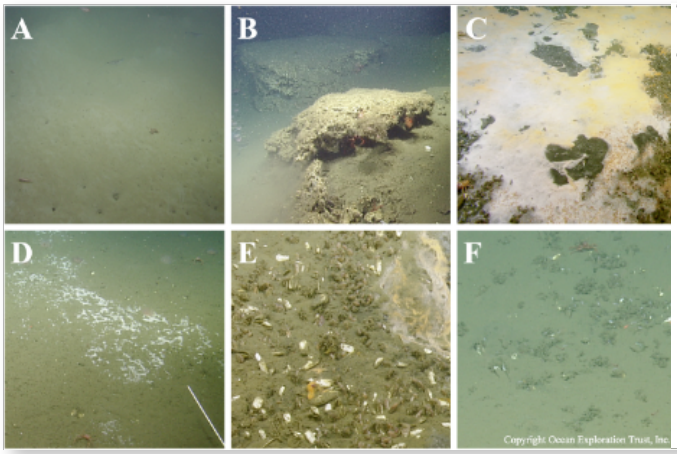
Using deep-sea images to examine ecosystem services associated with methane seeps

Jennifer T. Le, Peter R. Girguis, Lisa A. Levin

Marine Environmental Research 181 (2022) 105740

Rising management challenges in the deep ocean, including those associated with resource extraction, waste disposal and climate intervention, have created a need for ecosystem services assessment and valuation. Deep-sea images are routinely collected during at-sea expeditions and represent a repository of under-utilized knowledge. We leveraged dive videos collected by the remotely-operated vehicle *Hercules* (deployed from E/V *Nautilus*, operated by the Ocean Exploration Trust), and adapted biological trait analysis, to develop an approach that characterizes ecosystem services. Specifically, fisheries and climate-regulating services related to carbon are assessed for three southern California methane seeps: Point Dume (~725 m), Palos Verdes (~506 m), and Del Mar (~1023 m). Our results enable qualitative intra-site comparisons that suggest seep activity influences ecosystem services differentially among sites, and site-to-site comparisons that suggest the Del Mar site provides the highest relative contributions to fisheries and carbon

services. This study represents a first step towards ecosystem services characterization and quantification using deep-sea images. The results presented herein are foundational, and continued development should help guide research and management priorities by identifying potential sources of ecosystem services.



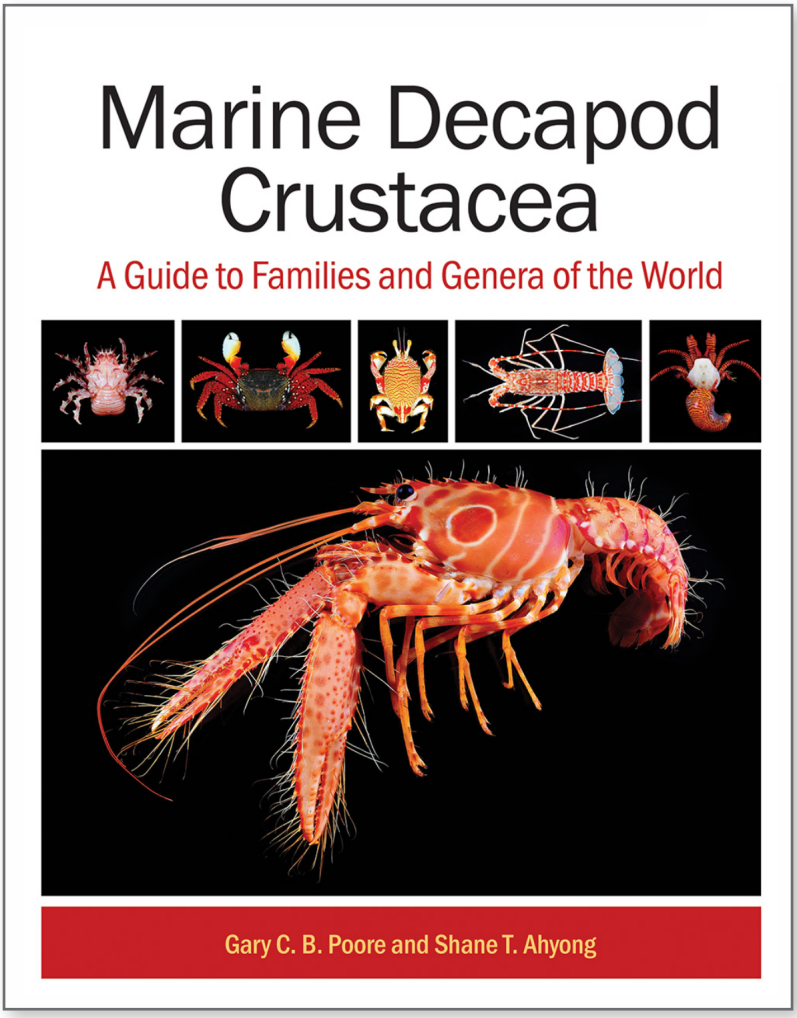
Service	Point Dume	Palos Verdes	Del Mar	Overall
Fisheries score	2.71 ± 0.86[ab]	2.61 ± 0.82[a]	3.09 ± 1.38[b]	2.72 ± 0.95
Fisheries score – 1-min	2.22 ± 0.59	2.42 ± 0.77	2.30 ± 1.30	2.32 ± 0.79
Fisheries score – active	2.38 ± 0.78[a,x]	2.35 ± 0.76[ab,x]	2.98 ± 1.45[b]	2.58 ± 1.09[x]
Fisheries score – transition	2.52 ± 0.45[a,x]	2.84 ± 0.66[b,y]	NA	2.52 ± 0.45[xy]
Fisheries score – background	3.18 ± 0.97[a,y]	2.59 ± 0.86[b,x]	3.29 ± 1.23[a]	2.82 ± 0.98[y]
Carbon score	11.69 ± 3.09[a]	11.59 ± 3.20[a]	13.96 ± 5.47[b]	11.99 ± 3.69
Carbon score – 1-min	9.47 ± 1.71	10.53 ± 2.30	10.56 ± 3.51	10.08 ± 2.33
Carbon score – active	10.61 ± 2.67[a,x]	11.63 ± 2.66[ab]	14.03 ± 5.93[b]	11.94 ± 4.34
Carbon score – transition	10.58 ± 1.54[x]	11.75 ± 2.55	NA	10.58 ± 1.54
Carbon score – background	13.57 ± 3.42[a,y]	11.53 ± 3.45[b]	13.84 ± 4.68[a]	12.34 ± 3.73

Figure 1 (left): Examples of seafloor microhabitats observed during the dives: (A) soft sediment (background), (B) carbonate mounds near Palos Verdes seep, (C) full bacterial mat near Point Dume seep, (D) patchy bacterial mat near Del Mar seep, (E) full clam bed near Point Dume seep, and (F) scattered clam bed near Del Mar seep. Figure 2 (right): Mean and standard deviation of ecosystem services scores, standardized by the number of morphotypes, for each site

Link to article: https://doi.org/10.1016/j.marenvres.2022.105740

Marine Decapod Crustacea: A Guide to Families and Genera of the World

Gary C. B. Poore & Shane T. Ahyong



This guide provides the tools to identify all 189 families and 2121 genera of marine Decapoda.

Decapod crustaceans, shrimps, crabs, prawns and their allies are highly visible and important members of marine environments. They are among the most charismatic of marine animals, inhabiting beaches, rocky shores and the deep sea, hiding under stones, burrowing in the sediment and nestling in among algae and many other microhabitats. However, most are difficult to identify by the specialist and amateur naturalist alike.

Australia and New Zealand : order now from https://www.publish.csiro.au/book/7895/

Rest of the world : order now from https://www.routledge.com/Marine-Decapod-Crustacea-A-Guide-to-Families-and-Genera-of-the-World/Poore-Ahyong/p/book/9781032138022

Hot vents beneath an icy ocean - The Aurora Vent Field, Gakkel Ridge, revealed

Eva Ramirez-Llodra, Claudio Argentino, Maria Baker, Antje Boetius, Carolina Costa, Håkon Dahle, Emily M. Denny, Pierre-Antoine Dessandier, Mari H. Eilertsen, Benedicte Ferre, Christopher R. German, Kevin Hand, Ana Hilário, John W. Jamieson, Achim Mall, Giuliana Panieri, Autun Purser, Sofia P. Ramalho, Eoghan P. Reeves, Leighton Rolley, Samuel I. Pereira, Pedro A. Ribeiro, Muhammed Fatih Sert, Ida H. Steen, Marie Stetzler, Runar Stokke, Lissette Victorero, Francesca Vulcano, Stig Vågenes, Kate Alyse Waghorn and Stefan Buenz

Oceanography. Early Online Release; published online November 28, 2022

Figure 1. RV *Kronprins Haakon* over the Aurora Vent Field, Central Arctic Ocean

Evidence of hydrothermal venting on the ultra-slow spreading Gakkel Ridge in the Central Arctic Ocean has been available since 2001, with first visual evidence of black smokers on the Aurora Vent Field (AVF) obtained in 2014. But it was not until 2021 that the first ever ROV dives to hydrothermal vents under permanent ice cover in the Arctic were conducted, during the HACON cruise under the umbrella of the UN Decade programme Challenger 150. In this paper, we present the methods employed for deep-sea ROV operations under drifting ice. We provide the first description of the AVF, based on ROV collected imagery, vent fluids, rocks, microbes and fauna. The AVF is composed of 3 actively venting black smokers and diffuse flow on the Aurora mound, at around 3888 m depth on the southern part of the Gakkel Ridge (82.5N). The biological communities are dominated by a new species of cocculinid limpet, two small gastropods and a melitid amphipod. The ongoing analyses of the AVF samples will contribute to positioning the Gakkel Ridge hydrothermal vents in the global biogeographic puzzle of hydrothermal vents.

Link to article: https://doi.org/10.5670/oceanog.2023.103

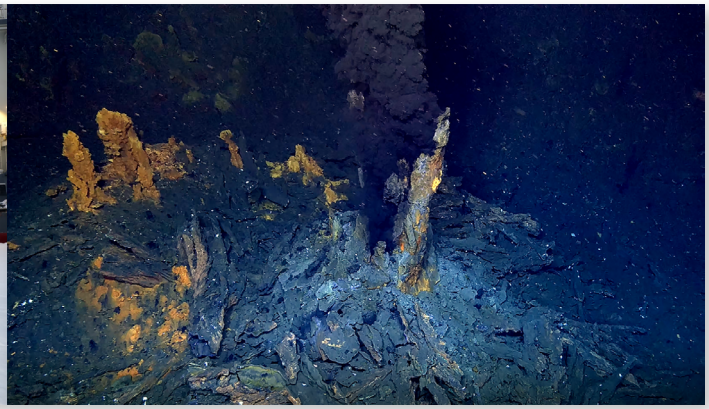


Figure 2 (left). HACON team on the ice. Figure 3 (right). The Ganymede black smoker, Aurora Vent Field, Gakkel Ridge

By-Catch Report on *Aphrodita aculeata* (Linnaeus, 1758) (Sea Mouse) off Thoothukudi Coast, India (08º 35’ 22.5” N Lat. 78º 27’ 40.9” E Long and 08º 31’ 91.2” N Lat. 78º 25’ 32.7”E) 310m

Vaitheeswaran Thiruvengadam

International University of East Africa

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The present investigation of sea mouse, *Aphrodita aculeata* (Linnaeus, 1758) found in Thoothukudi coast of Gulf of Mannar region, India. One specimen was caught at the depth of 310 m as an incidental by-catch at Thoothukudi fishing harbour, Pearl City District, India. It was found in stifling waters from about (08º 35’ 22.5” N lat. 78º 27’ 40.9” E long and 08º 31’ 91.2” N lat. 78º 25’ 32.7”E) 310 m. By-catch biodiversity assessment of the Gulf of Mannar region, a very rich source of fauna and flora specimens, a seasonal evaluation is essential in this coast.

Introduction

The Aphroditidae Malmgren, 1867, consist of nine genera widely distributed in the Indian, Pacific and Atlantic oceans (Fauvel, 1932; Hutchings and McRae, 1993; Leon-Gonzalez *et.al*., 2009), with most individuals occupy mud or gravel basement of intertidal zones, continental slope and deep waters. Fauvel and Pierre (1932) has reviewed the polychaetes in Indian waters, have a collection of three hundred species belonging to thirty different families. The huge of the collection consists of the material collected by the R.I.M.S. Specimens were obtained from the Cochin backwaters, Krusadai, Pamban and Inland sea of Singgoram, lake of Gulf of Siam, Chilka Lake and Indian ocean. Taxonomical studies on the Indian Polychaeta are scattered in a few number of papers dealing with Annelida, only some reports are specially devoted to the Indian fauna are dealt with Grube (1874), Michaelsen (1892) and Augener (1926), Willey (1905) report on the Polychaeta of the Gulf of Mannar, Southern (1911), Gravely (1921) and Fauvel (1930) from Krusadai Island and Bindra (1927) fauna of Karachi. Thoothukudi by-catch specimen were obtained from this region, Gulf of Mannar, India.

Figure 1. *Aphrodita aculeata* (Linnaeus, 1758)

Taxonomy

Phylum Annelida: Segmented worms: rag, tube, fan and spoon worms

Class Polychaeta: Bristleworms: rag. scale. paddle, fan, tube, and spoon worms

Family: Aphroditidae

Genus: *Aphrodita*

Species: *aculeta*

Aphrodita aculeata (Linnaeus, 1758)

Description: Detailed descriptions of this species are given by Fordham (1925), Chamber and Muir (1997), and Barnich and Fiege (2000). An oval bodied worm of around 12.5 cm long with a width of up to 4 cm and weighing 20 gm. Sea mouse has a distinctive covering of chaeta and bristles its appearance of a mat of 'felt'. In general chaetae are iridescent and the flanks have a blue, green, yellow and bronze shimmer. Ventral underside is pale yellow or brown and forms a ridged, flattened sole. The head is hidden but two horn-like pulps protrude in front.

Biology: According to Mettam (1980) has reviewed that *Aphrodita aculeata* is active predator, feeding primarily on small crabs, hermit crabs and other polychaete worms including *Pectinaria* and *Lumbriconereis*: polynoids, nereids, sabellids and terrebellid polychaetes: nemerteans.

Locomotion: The body shape of *A. aculeata* was an adaptation to the slow crawling mechanism of locomotion found in other polychaetes reported by Mettam (1971). Frontward propulsion is achieved by movement of individual parapodia in a fast-stepping pattern rather than the sinusoidal undulations characteristic of other polychaete worms.

Commensals: Chambers and Muir (1997) has reported this specimen to host entoprocts, e.g. *Loxosomella claviformis, L. fauveli* and *L. obesa*.

Global Distribution: North Sea, English channel, Atlantic Ocean, Mediterranean, Indian Ocean, Japan, Gulf of Mannar, India. Deep sea trawl fisheries off Thoothukudi coast of Gulf of Mannar, (08º 35' 22.5" N lat. 78º 27' 40.9" E long and 08º 31' 91.2" N lat. 78º 25' 32.7"E), 310 m (Fig 1).

Barriers to gene flow in the deepest ocean ecosystems: Evidence from global population genomics of a cosmopolitan amphipod

Johanna N. J. Weston*, Evelyn L. Jensen, Megan S. R. Hasoon, James J. N. Kitson, Heather A. Stewart, Alan J. Jamieson

Science Advances 8(43), eabo6672

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The deepest marine ecosystem, the hadal zone, hosts endemic biodiversity resulting from geographic isolation and environmental selection pressures. However, the pan-ocean distribution of some fauna challenges the concept that the hadal zone is a series of isolated island-like habitats. Whether this remains true at the population genomic level is untested. We investigated phylogeographic patterns of the amphipod, *Bathycallisoma schellenbergi*, from 12 hadal features across the Pacific, Atlantic, Indian, and Southern oceans and analysed genome-wide SNP markers and two

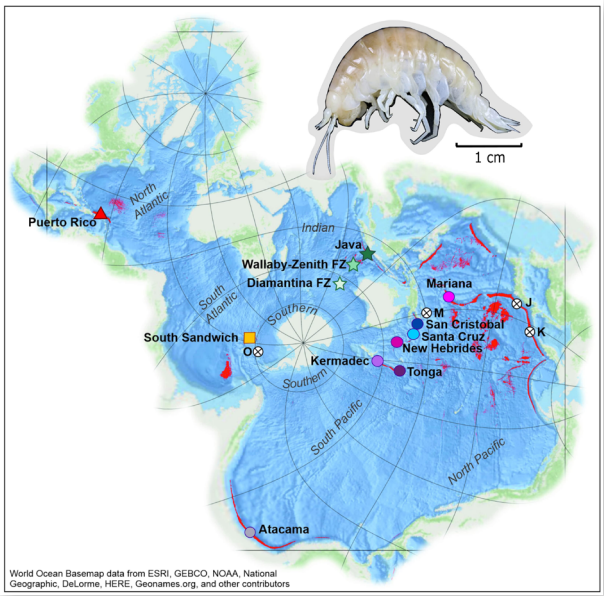


Figure 1. Localities of the twelve sampled populations of the hadal amphipod Bathcyallisoma schellenbergi, with the hadal zone (depths of >6000 m) in bright red.

mitochondrial regions. Despite a cosmopolitan distribution, populations were highly restricted to individual features with only limited gene flow between topographically connected features. This lack of connectivity suggests populations are on separate evolutionary trajectories, with evidence of potential cryptic speciation at the Atacama Trench. Together, this global study demonstrates that the shallower ocean floor separating hadal features poses strong barriers to dispersal, driving genetic isolation and creating pockets of diversity to conserve.

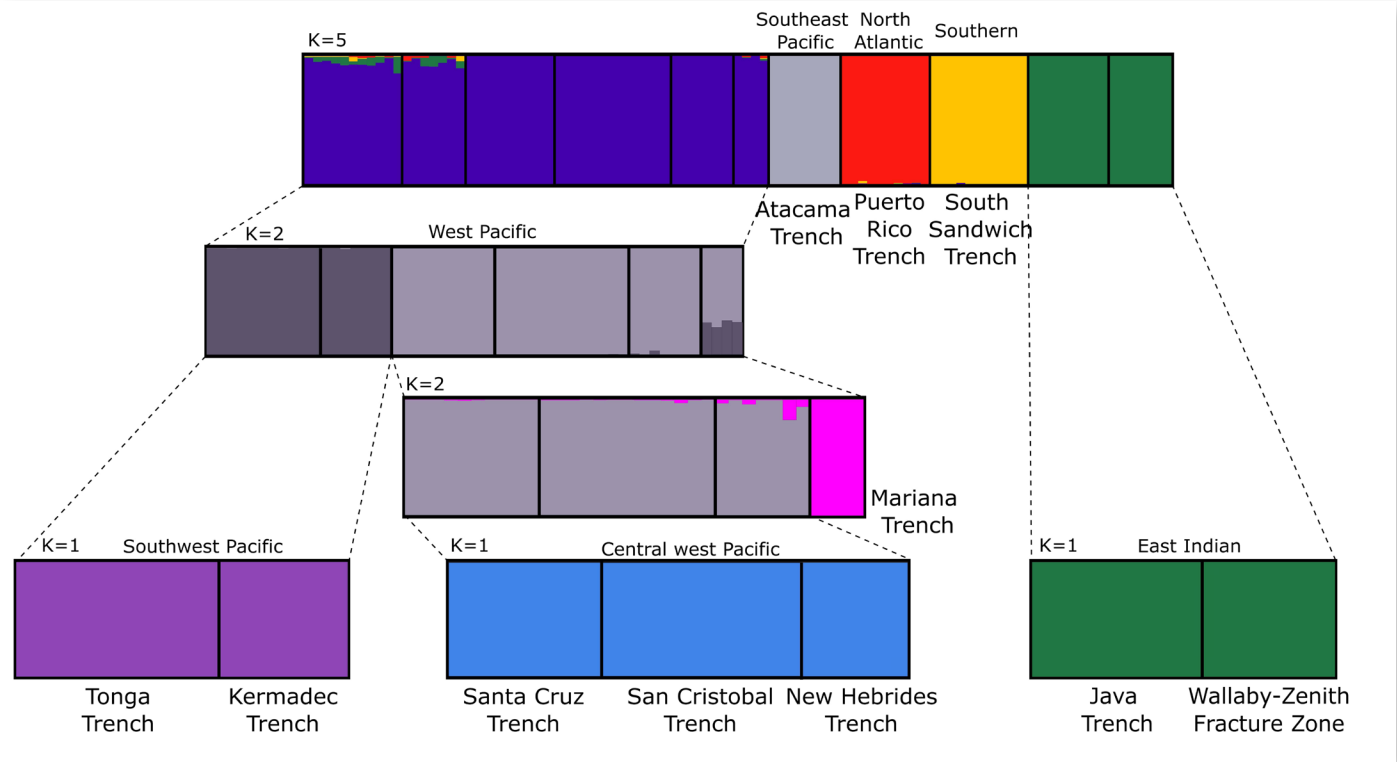


Figure 2. Bar plots showing the genetic clustering among 11 hadal feature populations of *B. schellenbergi* based on the RAD-seq dataset and analysed via STRUCTURE.

Link to article: https://doi.org/10.1126/sciadv.abo6672

Obituaries

Eve Caroline Southward (née Judges)

1930-2023

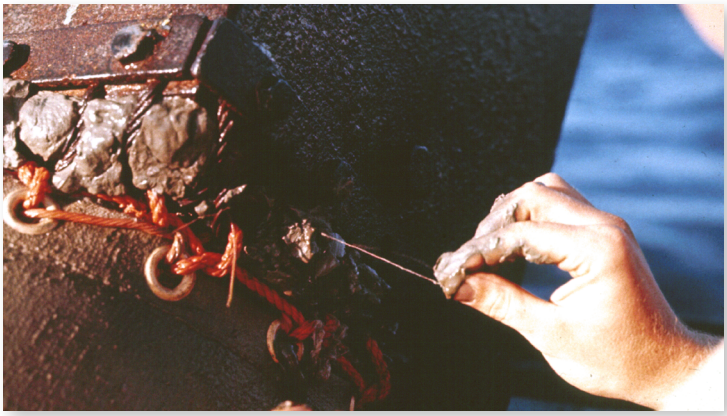
It is with great sadness that I have to report the passing of my friend and colleague Eve Caroline Southward in January, at the age of 92, following a stroke in December.

Above: Eve sorting through a dredge sample in the late 1950's. (Photo. Alan Southward)

Eve was brought up in Kew Green and Chiswick, London and recalls mud-larking on the Thames (an activity continuing in later years, Fig. 1) and frequent visits to the Natural History Museum and Kew Gardens, developing a life-long interest in identifying plants. This was re-enforced when her school, Froebels, was evacuated to a country house NW of London during the war. This countryside environment exposed her to more 'natural history'. Eve considered studying agriculture or horticulture, when a neighbour, a professor at Liverpool University, suggested she studied Zoology there, specialising in Marine Biology. After reading C.M. Yonge's "The Sea Shore", Eve thought it sounded interesting and applied.

All zoology students took field courses at the Port Erin Marine Laboratory on the Isle of Man. When Eve graduated, as the only Marine Biology student in her year, she was offered a post-graduate studentship and studied the ecology and distribution of the Polychaeta of the Isle of Man, achieving her Ph.D. in 1955. Eve married a fellow student, Alan Southward in 1954. In 1956, when Alan was appointed to a post at the Marine Biological Association of the U.K., Eve moved with him to Plymouth. An opportune timing for starting deep-sea studies, since the MBA had recently acquired a 39 m research vessel, '*Sarsia*', with 3000 m of dredge wire. Alan and Eve made use of '*Sarsia*' and started dredge-sampling for benthos on the continental slope in 1957. They found frenulate siboglinids in the Atlantic for the first time. These mouth-less and gutless tubeworms fascinated Eve, who carefully described new species and their morphology, using both light and electron microscopy.

For the next two decades Eve and Alan worked on the problem of how frenulates fed, initially working on the theory that they took up dissolved organic compounds from the interstitial water, possibly using excreted digestive enzymes. Following the discovery of clumps of large vestimentiferan siboglinids on the Galapagos Spreading Centre in 1977, Colleen Cavanaugh found that these contained sulphur-oxidising endosymbiotic bacteria and suggested to Eve that this might apply also to the frenulates. Eve examined her specimens and found high densities of bacteria in the post-annular region. Enzyme studies proved that they were indeed sulphur oxidisers. However, the problem of the energy source, since significant dissolved sulphide could not be detected. Eve first noticed an oxidized zone in the sediment adjacent to the frenulate tubes. It took her another 15 years along with detailed dissection of box cores, tracing the path of the



Top: Eve removing the first, of many, pogonophore species she described, Siboglinum atlanticum, from an anchor dredge. (Photo. Alan Southward, 1957).

Above: Eve, celebrating her birthday during Covid isolation. (Photo, Dorothea Orme, 2021)

tubes and micro-scale geochemical sampling to show that oxygen diffusion through the tube wall, leading to mobilisation of solid-phase sediment sulphides was the likely energy uptake route.

In the late 1980's Eve started collaborations with Verena Tunnicliffe, making summer visits to Victoria, B.C., describing hydrothermal vent fauna, their nutrition and reproduction. In addition Eve made significant contributions to research on bivalves with chemoautotrophic symbiotic bacteria from both deep-sea and shallow water environments.

Eve was asked in her late 70's if she had plans to retire. Her response was that "scientists never retire, they just expire". True to this, Eve published her last scientific paper in 2021 and wrote a last article, for the April 2023 issue of the "Marine Biologist", just before her death. Appropriately, for someone who loved plants and raised Camellias from seed, a single white flower of Camellia 'Winter's Snowman' was open, in her walled garden, on the morning of her death.

Paul R. Dando
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Deep-Sea Biology Society News

DEEP-SEA BIOLOGY SOCIETY

Dear readership and members of the Deep-Sea Biology Society,

As this issue marks 10 years of biannual coverage for DSL, the Deep-Sea Biology Society (DSBSoc) also will celebrate its 10 years of existence. Hence, we take the occasion to congratulate Dr. Maria Baker, Dr. Eva Ramirez-Llodra, Dr Paris Stefanoudis, Dr. Bhavani Narayanaswamy and all our successive team members at DOSI, for the stimulating content and recording of many deeply-worthy contributions to DSL over these years.

As deep-sea life continues in the depths of the planet, needing our serious and passionate attention in the face of multiple crises now more than ever, our Society is thriving. The DSBSoc was founded in early 2013, before it registered as a charity in July 2017. As this 10-year anniversary approaches we plan on inviting all members and long-term friends to think over our Society's history, and get together for fun, creative activities, exploring the willpower and motivation it takes to advance deep-sea biology research.

As well as the exciting prospect of seeing some colleagues and friends at the 17DSBS in early Jan 2025 (session proposals due before 31st March - https://dsbsoc.org/conferences/17dsbs/) we are, as always, pursuing our mission with awards, travel grants and prizes, as well support for key conferences and meeting partnerships.. Most excitingly we will not only pursue our current activities, but also initiate new ones for an ever livelier and healthier Society.

Many members recently provided a total of 235 answers to 6 different polls to express interest and comments on plans to develop new DSBSoc activities. These include DSBSoc editorial activities (or partnerships to lower publishing costs), a membership directory, and the organization of new meeting formats and outreach, such as language-specific journal clubs and a DSBSoc group on Skype A Scientist. Our external visibility is also increasing and we always welcome deep-sea enthusiasts to join our public Slack. This can help promote artists and their productions, such as children-book author Lydia Lukidis and *DEEP, DEEP, DOWN: The Secret Underwater Poetry of the Mariana Trench* (www.lydialukidis.com). Anyone can use Slack or other channels to reach out. Just this week, we were contacted by a member proposing the brilliant idea of developing teaching material, e.g. for undergrads. So, if you know how to further enrich our activities and improve communication within and beyond the Society, please contact our Communications Officer. If your help consists of building partnerships or sponsorships with financial gain for the Society, please contact our Development Officer.

The second cycle of our mentoring program is just about to get started, after a shuffling of the mentors/mentees groups to stir interests and more widely share advice and experience. Whether it is about success or failure, it is always a good time to join a respectful discussion group, where mentors and mentees are guiding one another to learn and progress at work, and in life, with a reflexive and prospective philosophy – after all, we aim/ are philosophical doctors!

This and other regular meeting initiatives, such as the popular DSBSoc Seminar Series, are led by our Student and Early-Career Officers – please get in touch to participate or present your results at the Seminar Series and obtain constructive comments.

We are also keen to help you introduce yourself and frame your inspirations and aspirations by contributing to the *Meet the Next-Generation of Deep-Sea Researchers* and *Life After PhD profiles*. Your early-career contributions will also be relayed on our Social Media platforms for the deep-sea science community and the world to know more about your interests, goals, and network.

The Deep-Sea Biology Society is particularly active on Social Media platforms such as Twitter (@DSBSoc), Instagram (@dsbsoc) and Mastodon (@dsbsoc@mstdn.science), thanks to the creativity and devoted attention of M.Sc. Janet Ferguson-Roberts (Memorial University, Canada) and M.Sc. Ariane Buckenmeyer (Swedish Museum of Natural History). Feel free to contact the Social Media team if there is any news you feel the Society should hear about.

As multiple training and mentoring efforts further unfold their programs for students and early-career scientists to develop their networks and skills, we will be offering access to our professional network, both by communicating and coordinating with DOSI, DOOS and its DOERS, the Bigelow's COBRA fellows, or for future International Seabed Authority workshops, and by offering a register of our members, incl. interests, institutions and other agreed-upon information, with the goal to enrich and update the initial INDEEP expert list. This new year will be a year of enhanced networking and communication.

Our main scientific event - the Deep-Sea Biology Symposium - is in gestation for its 17th edition. It will be hosted at the Hong Kong University of Science and Technology (Hong Kong SAR, China) on January 13-17, 2025. We are currently listing potential speakers for keynote addresses, accounting for the diversity of origins and science, as well as for previous editions, in order to renew the pool of experts that will open for topical sessions. We expect that all session proposals will be examined and that a program will be established this summer, but it is still possible for you to propose your own session until March 31st, 2023. Note that the local organization committee is particularly generous for this edition to provide resources and easy access, and waivers will be distributed for session organizers. Please visit the official DSBSoc website for more information https://dsbsoc.org/conferences/17dsbs or directly contact our Conference Officer.

Our recent intention to contribute an article to the upcoming, special issue on Building Diversity, Equity, and Inclusion in the Ocean Sciences was not retained by the journal Oceanography because editors received too many letters. This is good news indicating that DEI is a flourishing, engaging topic in marine sciences. Hence, we not only recommend that you keep an eye out for others' contributions, but also that you submit any ideas or wishes you may have for a more ethical and just Society. While our Society holds high Diversity, Equity and Inclusion (DEI) standards, promoting DEI must be proactive. We still have work to do, collectively, to ensure the Society and its activities remain safe and welcoming spaces for everybody. We work at developing training and awareness programs and for this and other ways to improve DEI and accessibility, please direct your ideas, and share your concerns or success stories to our Diversity Officer.

To contact us, please email the Trustees:

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Diversity Officer, Alycia J. Smith (Heriot-Watt University, Edinburgh): diversity@dsbsoc.org

Conference Officer, Prof. Pei-Yuan Qian (Hong Kong University of Science and Technology, China): conferences@dsbsoc.org

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Social Media team: Janet Ferguson-Roberts (M.Sc.from Memorial University Canada) and Ariane Buckenmeyer (formerly at the Swedish Museum of Natural History): socialmedia@dsbsoc.org.

Best wishes,

The Trustees of the Deep-Sea Biology Society