Deep-Sea Life

Issue 14, January 2020

Welcome to the 14th edition of Deep-Sea Life (a little later than anticipated… such is life). As always there is bound to be something in here for everyone. Illustrated by stunning photography throughout, learn about the deep-water canyons of Lebanon, remote Pacific Island seamounts, deep coral habitats of the Caribbean Sea, Gulf of Mexico, Southeast USA and the North Atlantic (with good, bad and ugly news), first trials of BioCam 3D imaging technology (very clever stuff), new deep pelagic and benthic discoveries from the Bahamas, high-risk explorations under ice in the Arctic (with a spot of astrobiology thrown in), deep-sea fauna sensitivity assessments happening in the UK and a new photo ID guide for mesopelagic fish. Read about new projects to study unexplored areas of the Mid-Atlantic Ridge and Azores Plateau, plans to develop a water-column exploration programme, and assessment of effects of ice shelf collapse on faunal assemblages in the Antarctic. You may also be interested in ongoing projects to address and respond to governance issues and marine conservation. It's all here folks! There are also reports from past meetings and workshops related to deep seabed mining, deep-water corals, deep-water sharks and rays and information about upcoming events in 2020. Glance over the many interesting new papers for 2019 you may have missed, the scientist profiles, job and publishing opportunities and the wanted section – please help your colleagues if you can. There are brief updates from the Deep-Ocean Stewardship Initiative and for the deep-sea ecologists amongst you, do browse the Deep-Sea Biology Society president's letter. Finally, in 2019 we sadly said goodbye to Rudi Scheltema (WHOI), but you can read about his rich life and important contributions to marine research and education in this issue.

Many in our deep-sea community work hard to impart their knowledge to younger generations. This photo of the issue is a delightful example of education in action – how can those children fail to be enthralled with Angelika Brandt adorning a crustacean and having a giant isopod for them to cuddle? Just wonderful (and not a hand-held device in sight…).

The editors, Dr Abigail Pattenden (University of Limerick, Ireland), Dr Eva Ramirez-Llodra (REV Ocean, Norway) & Dr Paris Stefanoudis (University of Oxford / Nekton Foundation, UK) and I all thoroughly enjoyed reading about your work during the editing process – thank you for your submissions.

Dr Maria Baker (University of Southampton – mb11@noc.soton.ac.uk)

An INDEEP, DOSI and DSBS collaborative publication.

Issue Contents

Cruise News

E/V *Nautilus* telepresence exploration of the U.S. Line Islands (Kingman Reef, Palmyra Atoll, and Jarvis Island)

Steve Auscavitch[1] & Rob Pockalny[2]

[1]PhD Candidate, Temple University, Philadelphia, PA; [2]Marine Research Scientist, University of Rhode Island, Graduate School of Oceanography

In June and July 2019, the E/V *Nautilus* and ROV *Hercules* explored the Kingman Reef & Palmyra Atoll and Jarvis Island units of the Pacific Remote Islands Marine National Monument. This expedition was a follow-up on recent explorations throughout the Pacific as a part of the 2013-2015 NOAA Campaign to Address Pacific Monument Science Technology and Ocean Needs (CAPSTONE). Previous expeditions had provided brief glimpses at the geological composition and biological diversity of the deep-sea environment. This expedition focused on leveraging previous mapping and exploration dives in order to maximize bottom time and sampling effort at undersampled locations within the units. Across 7 dives, we accumulated 117 hours of bottom time and traversed approximately 23 linear km of seafloor on seamounts, ridges, and island flanks. Biological sampling resulted in 76 primary collections, including 64 deep-water corals, sponges, as well as their associates. Biological collections targeted individuals that represented characteristic fauna for the area, new records for the Line Islands, or potential new species requiring further examination by taxonomic experts. In support of geological studies, 39 rocks were collected to better understand seamount ages as well as characterizing the composition of regional ferromanganese crusts. In total, 28,340 km^2 of seafloor were mapped both in transit between sites and while gap-filling partially mapped seamounts.

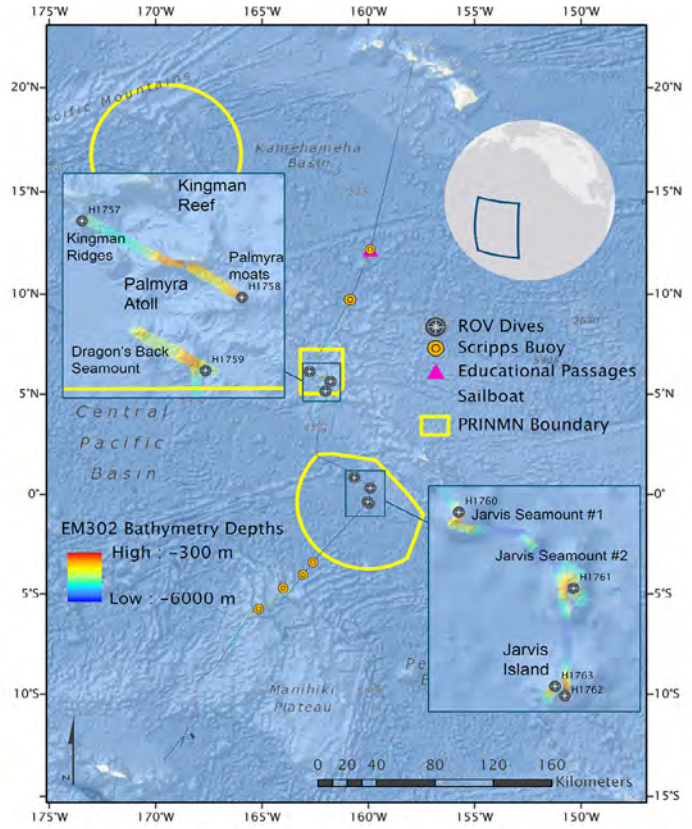


Figure 1: Overview map showing the locations of ROV dives and mapping operations completed during NA110. Yellow boxes identify the boundaries of the two Pacific Remote Islands Marine National Monument units. Map credit: Erin Heffron and Ocean Exploration Trust.

Immediate follow-up work to this expedition will focus on identifying high-diversity and high-density deep-water benthic communities from annotation of ROV video and identification of collected specimens. Ultimately, these data are valuable additions to management efforts that seek to identify and characterize biodiverse communities and features within monument boundaries and other data-deficient areas of the central Pacific Ocean.

Expedition links:

Blog: https://nautiluslive.org/blog/2019/06/24/exploring-deep-waters-kingman-reef-palmyra-atoll-and-jarvis-island

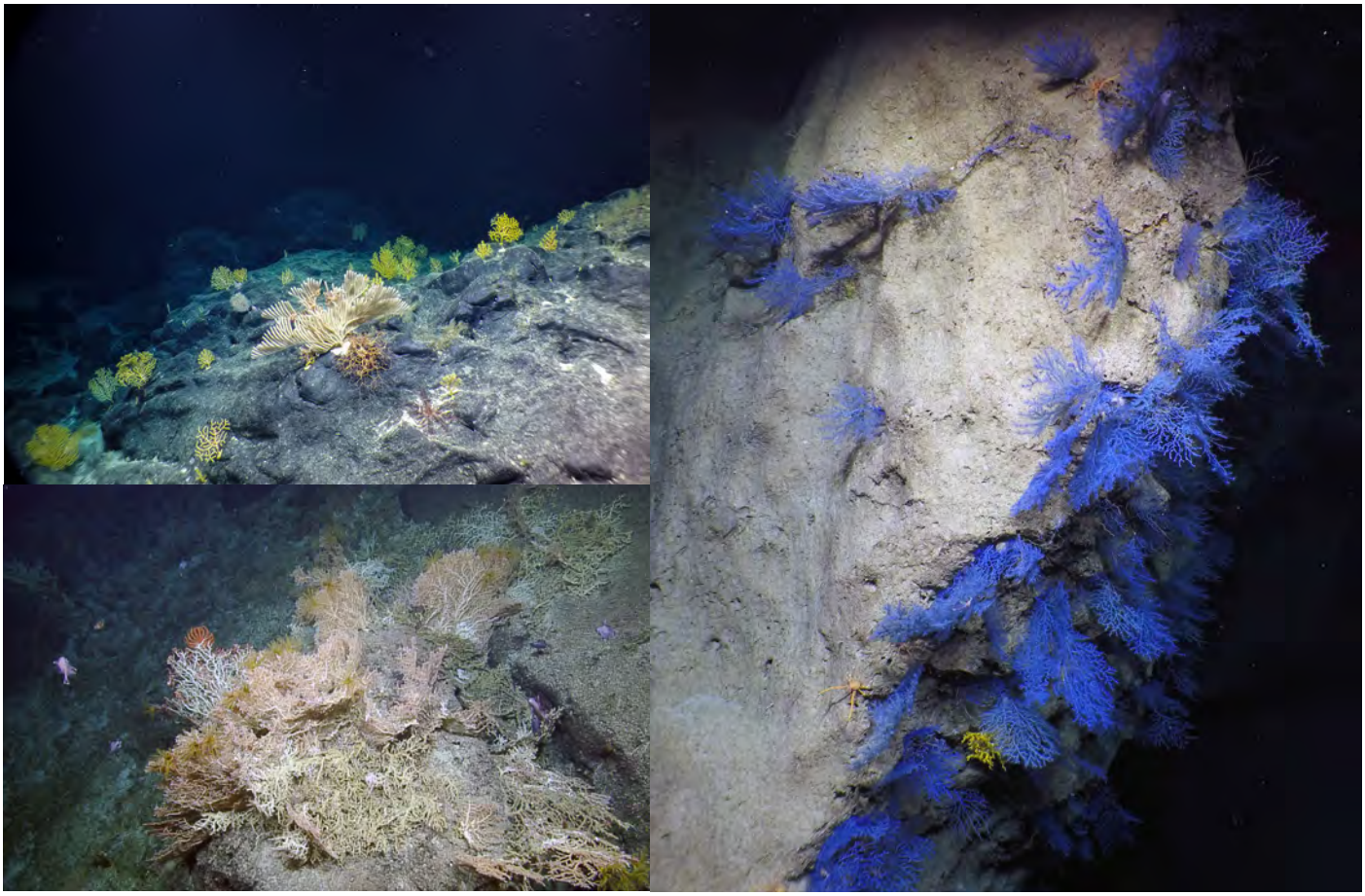


Figure 2 (top left): A mixed assemblage of sea fans and echinoderms at Jarvis Seamount #2 at 1463m. Figure 3 (bottom left): Extensive *Madrepora oculata* and *Enallopsammia rostrata* reef structures and debris fields dominated the southeastern ridge of Jarvis Island between 600-1000m (Photo: 874m). Figure 4 (right): A striking and enigmatic blue octocoral was observed at high densities along the western carbonate slope of Jarvis Island at 386 m. Photo credit: Ocean Exploration Trust.

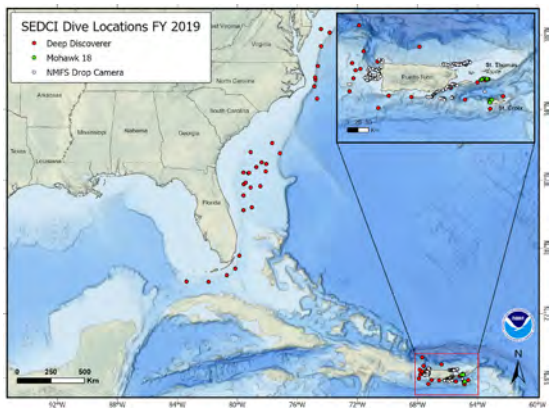
Overview of deep-sea coral diversity: https://nautiluslive.org/album/2019/07/11/get-know-deep-sea-corals-central-pacific

Benthic biodiversity gallery: https://nautiluslive.org/album/2019/07/08/standout-biodiversity-pacific-remote-islands-marine-national-monument

Southeast Deep Coral Initiative (SEDCI): Research Highlights in 2019

Rachel Bassett[1], Caitlin Adams[1], Tim Battista[2], Kate Overly[3], Dan Dorfman[1] & Peter Etnoyer[2]

[1] NOAA affiliate with CSS, Inc., [2] NOAA NCCOS, [3] NOAA affiliate with RTI, Inc.



SEDCI is a multiyear, cross-line-office project, funded by NOAA's Deep Sea Coral Research and Technology Program. The initiative has been exploring and documenting deep-water seafloor habitats (> 50 m) in the Caribbean Sea, Gulf of Mexico, and Southeastern US EEZ since 2016.

In 2019, five expeditions were conducted in partnership with NOAA Office of Ocean Exploration (OER) and NOAA Coral Reef Conservation Program (CRCP). Altogether, researchers spent a total of 88 days at sea in the Atlantic and Caribbean, mapping over 50,000 square kilometers with 82 remotely operated vehicle (ROV) dives between November 2018 and November 2019.

Photo credit: NOAA NCCOS. .

Three of the NOAA OER expeditions characterized extensive *Lophelia* coral habitats in the Northwest Atlantic on the Blake Plateau. Field teams mapped and explored "Richardson Hills" reef complex and the "Million Mounds" area, the largest extent of *Lophelia* reef habitat currently known in US waters. Follow these links to view the expedition websites: DEEP SEARCH 2019, Windows to the Deep 2019, and the 2019 Southeastern U.S. Deep-sea Exploration.

In the U.S. Caribbean, researchers conducted surveys aboard the NOAA Ship Nancy Foster in the fifteenth year of coral ecosystem investigations supported by NOAA's CRCP. The ongoing project is mapping coral reef ecosystems in the U.S. Virgin Islands and Puerto Rico down to 300 m depth. The 2019 cruise collected samples for the first time. The team collected octocoral and black corals to support habitat models, contribute to population connectivity studies, and develop new field guides. Sonar was used to determine distribution and size of fish. Over 170 square miles were mapped in St. Croix and St. Thomas in depths from 11-324m. ROV surveys traversed 12 km, collecting HD video for benthic habitat characterization. The northwest shelf of St. Croix, USVI was previously unmapped and unexplored. These data will assist policy makers and managers regarding essential coral reef ecosystems in the USVI.

Nearby in Puerto Rico, scientists from NOAA National Marine Fisheries Service worked with commercial fishermen to gather information on habitat association and life history of the Queen Snapper - a valuable but little-known fisheries resource. Vertical longlines were used to deploy cameras to capture video of 215 Queen Snapper sites. Preliminary data show deep corals in 78 percent of sites on the West coast, 61 percent in the Southeast and 17 percent in the Northeast. Sixty-six fish species were seen and 46 Queen Snapper were caught for age and growth studies. A total of 225 stations should be completed in summer 2020. The knowledge gained in this study will inform future ecosystem-based management decisions.

To bring these data together and make it public, SEDCI developed a web-accessible geodatabase designed to share maps, observations, submersible dive locations, and managed area boundaries. NOAA's National Database of Deep-sea Corals and Sponges is served directly from the National Centers for Environmental Information. Bathymetric contours, a 1 km grid of coral abundance, ports and harbors, and up-to-date managed area information are also available.

For more information, contact Peter Etnoyer, NCCOS Deep Coral Ecology Lab.

Photo credit: NOAA NMFS

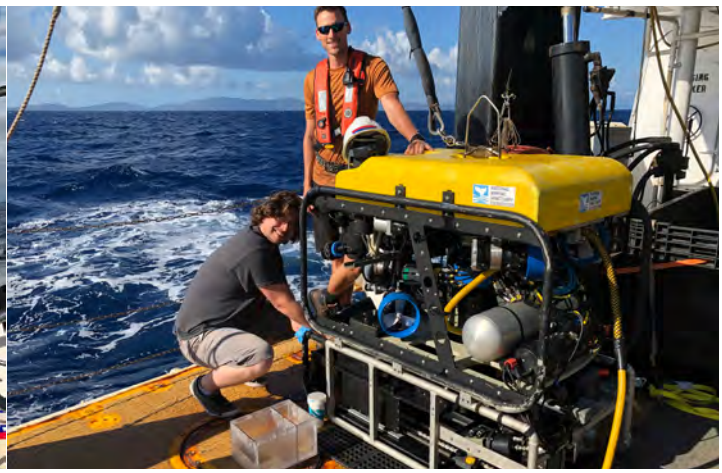


Photo credit: NOAA NCCOS. .

DY109: BioCam & Autosub6000 Dancing over the Darwin Mounds

Blair Thornton[1]*, Veerle Huvenne[2]*, *et al*.

[1]*University of Southampton, UK,* [2]*National Oceanography Centre, UK*

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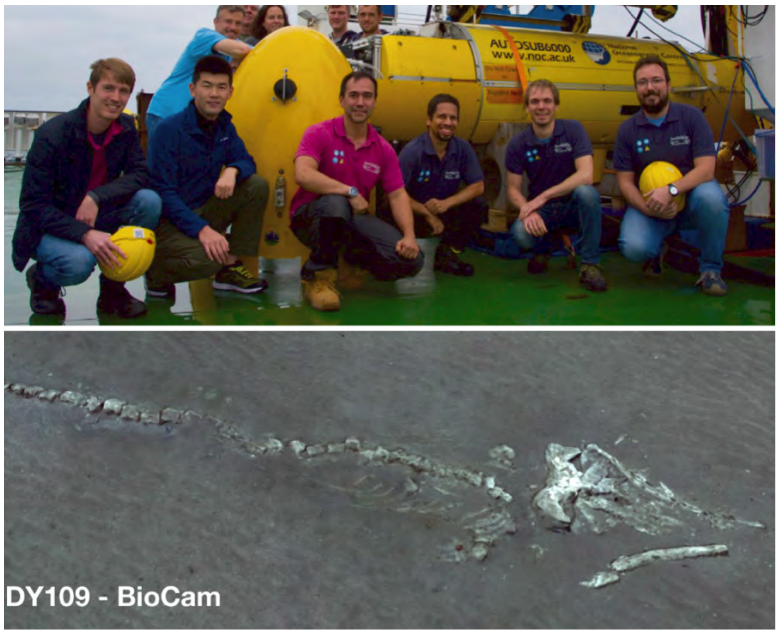
The hundreds of person hours of preparation, integration, and testing could not prevent members of the University of Southampton's Ocean Perception team, National Oceanography Centre's MARS group, and CLASS project crew from crossing all 1120 sets of fingers and toes onboard RRS *Discovery* as BioCam dived into the depths at the Darwin Mounds on NOC's AUV Autosub6000. However, the coordinated efforts of these teams during the run up to this first deployment of BioCam did ensure that it went off without a hitch.

BioCam is a deep-sea 3D seafloor mapping system developed as part of the UK Natural Environment Research Council's OCEANIDS programme. Although DY109 was its first deployment, BioCam builds on 10 years' experience of deep-sea 3D imaging systems. It consists of a pair of high-dynamic range stereo cameras, a pair of LED strobes, and a pair of laser plane projectors used to gather high-resolution colour images and 3D shape information from the seafloor. The high-dynamic range and powerful illumination means BioCam can acquire data from altitudes of 5-8 m as opposed to the 2-3 m typically required for colour images. This gives BioCam a larger footprint for each image and allows flight-style AUVs like Autosub6000 to operate at faster speeds and safer altitudes. A single 24-hour deployment of Autosub6000 can cover a continuous 50-hectare region at a seafloor resolution of 3 mm, more than an order of magnitude more than typical imaging setups on hover-capable AUVs.

In addition to the large mapped areas, a key feature of BioCam is the data processing. Images are fused with vehicle navigational data to generate seamless 3D reconstructions that can be efficiently interrogated using machine learning algorithms in cruise relevant timeframes. The 3D reconstructions allow the full range of spatial scales observed to be intuitively visualised and explored, and algorithms automatically organise images by their similarity in appearance, allowing broad-scale spatial patterns to be rapidly identified.



Upper: University of Southampton BioCam team and National Oceanography Centre Marine Autonomous and Robotic Systems team. Lower: BioCam image of whale skeleton on rippled sandy seafloor of the Darwin Mounds Marine Protected Area. © UoS, 2019.

These features, and in particular the speed with which they can be deployed, played an important role informing plans during the month-long expedition and focusing our efforts in observation. Although the main aim of DY109 was to test the technology, this soon became deeply intertwined with the scientific objectives of the DY108 CLASS project, as the algorithms interrogated data during the cruise soon after it was collected, illustrating the related spatial patterns of the living cold-water corals, coral fragments, and xenophyophores, even quickly spotting an 8 m long whale skeleton among the 100,374 images taken by BioCam on a single dive.

For information: http://www.ocean.soton.ac.uk/biocam.

For data: http://soi.squidle.org.

Hydrodynamics and Habitat Suitability for Meiofauna And Corals (HydroSMAC)

Sandra Brooke, Ph.D.

Florida State University, USA

The eastern Gulf of Mexico is dominated by a massive carbonate platform that slopes gently for over 200km, before dropping sharply to ~3000m. Extensive deep coral habitats occur on the upper slope (300-700m), but the deep escarpment remains virtually unexplored.

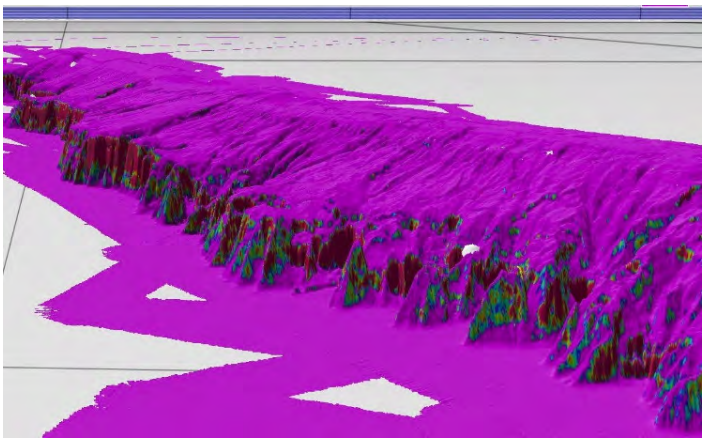


Figure 1. Multibeam map showing miles of the rugged West Florida Escarpment. The red areas are steep slopes, which are likely to support deep sea corals. (Image: M. Potti and A. Winship NOAA NCCOS)

On October 1st, our team of scientists set sail to study deep benthic communities of the west Florida escarpment, with funding provided by NOAAs Office of Ocean Exploration and Research.

A primary project objective was to generate coral distribution data (> 1500m) on the escarpment, and improve habitat suitability models for this region. The models are strongly influenced by coral records, so data-limited areas produce inaccurate habitat suitability predictions. These models may be further refined by incorporating coral-relevant variables such as current speed. Another project objective was to assess the utility of meiofauna communities for 'ground-truthing' oceanographic currents and improving model predictions.

Despite the usual weather and technical setbacks, we surveyed ~ 5km of seafloor, collected > 80 samples of corals,

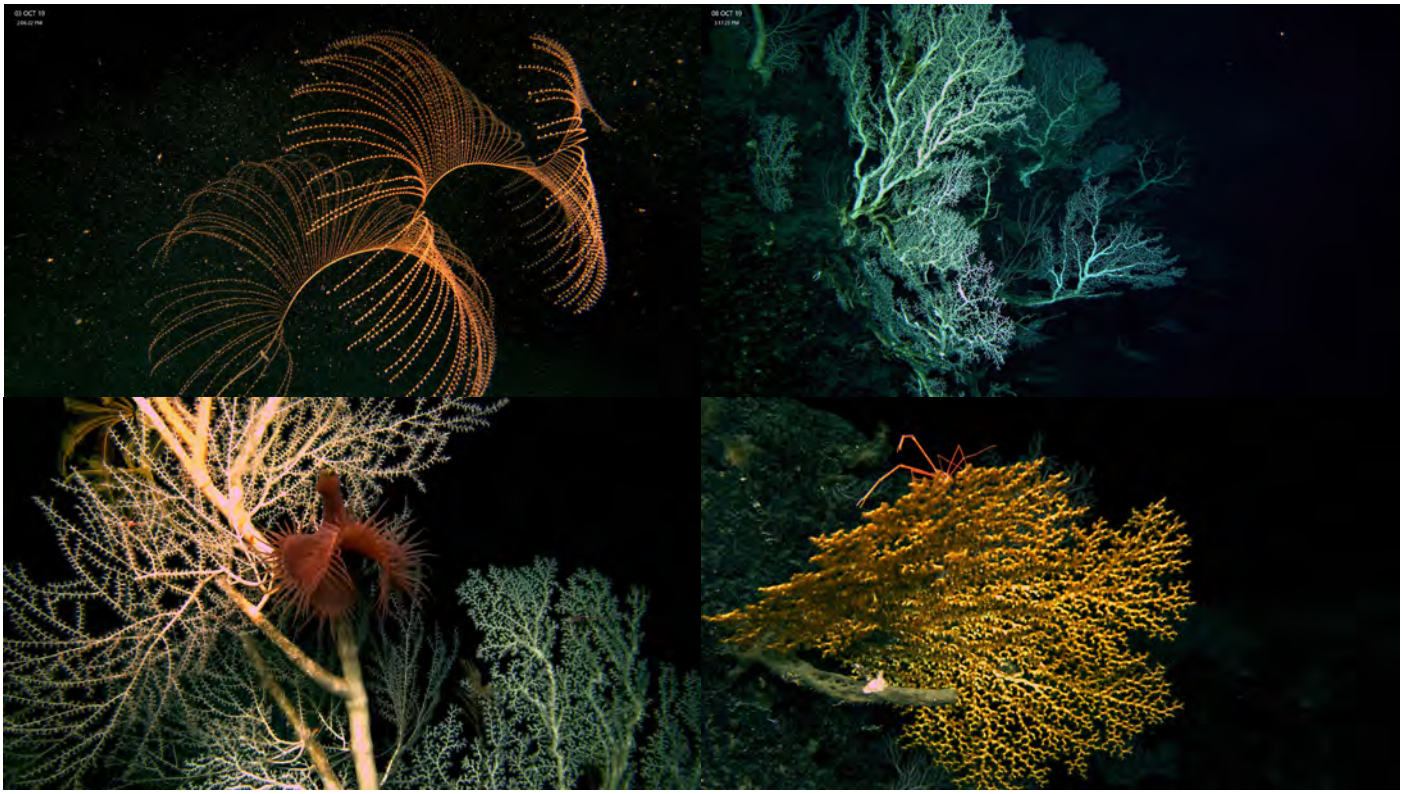


Figure 2 (top left). Delicate *Iridigorgia* sp. octocorals are common residents of the deep escarpment. Figure 3 (top right). Large colonies of the precious coral *Hemicorallium* sp., often occurred in dense formations in high current areas of the escarpment. Figure 4 (bottom left). Large bamboo coral with *Actinoscyphia* anemone and *Hemicorallium* sp. colonies. Figure 5 (bottom right). A large intact colony of the stony coral *Enallopsammia rostrata* on the escarpment wall. (Images: Brooke *et al* 2019, NOAA Office of Ocean Exploration and ROV *Global Explorer*).

some of which may be new species, and collected > 180 samples for infaunal community analysis. Every dive revealed dense coral communities with entirely different species assemblages from those on the slope. We could only survey a tiny fraction of the seafloor, but if our observations are representative of the > 600 km of the west Florida escarpment, this may be the largest deep coral province in the Gulf of Mexico.

For more cruise information please go to https://marinelab.fsu.edu/hydrosmac/

New deep-sea discoveries from The Bahamas

Nick Higgs

Director of the Cape Eleuthera Institute, The Bahamas

The Cape Eleuthera Institute (CEI) in The Bahamas has been a hive of deep-sea activity in 2019. Two research cruises with OceanX onboard the *Alucia* have been documenting deep-sea fauna of the Exuma Sound basin down to 1,000 m using their two submersibles. Previous multibeam mapping allowed us to make the most of sub-time to systematically survey the benthic communities associated with the steep rocky drop-offs and sedimented ledges on our doorstep. Large deposits of seagrass detritus were discovered on the slopes, suggesting a substantial input of carbon into this non-continental canyon system. We are currently in the process of analysing video footage and working up samples, including a probable new species of cirolanid isopod.

Figure 1: Exploring the deep walls of the Exuma Sound. Credit: Cape Eleuthera Institute

Night dives on the cruises were used to study the behaviour of bluntnose sixgill sharks (*Hexanchus griseus*), with the ultimate goal of deploying a satellite tag to characterise movement at depth of this poorly studied species. These sharks migrate into shallower water at night, bringing them within reach of the submersible. The team had developed a modified spear gun system to deploy the tag and after multiple failed attempts (including a grouper that tagged itself after swimming into the speargun), a shark was finally tagged on the very last dive of the cruise. To our knowledge this is the first time that a satellite tag has been deployed from a manned submersible at depth. We await results from the 3 month tag deployment.

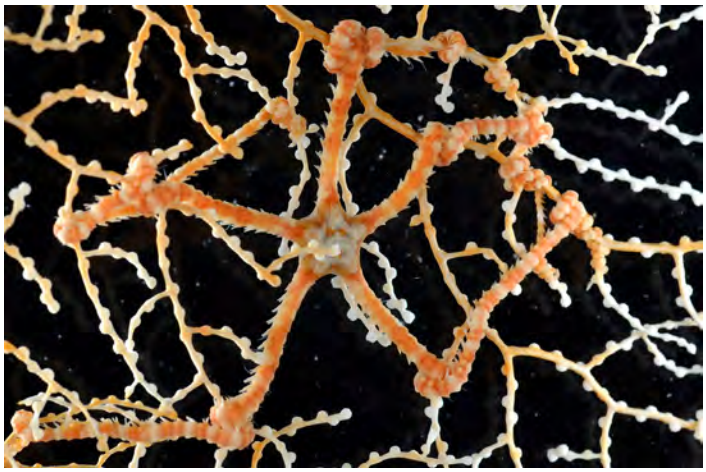


Figure 2: Some of the invertebrate samples recovered from the Exuma Sound. Credit: Eve Moore (Florida Museum of Natural History)

In addition to working with the *Alucia*, CEI researcher Dr Nathan Robinson accompanied Dr Edith Widder and Dr Sönke Johnsen on a research cruise to the Gulf of Mexico to study mid-water fauna. After analysing >120 hours of video footage from the MEDUSA camera system, he spotted something truly remarkable: a giant squid (*Architeuthis dux*). This footage represents only the second time that these animals have been filmed alive in their natural habitat. Dr Widder is a long-term collaborator of

the Cape Eleuthera Institute and has graciously donated the MEDUSA system to our institution. We hope to make many more discoveries in the near future.

We are ideally placed to access the deep-sea habitats of The Bahamas, which hosts one of the most remarkable canyon systems in the world, with some of the steepest slopes plunging ~4,000 m down. If you would like to work with us in the future, please get in touch.

For more information on our deep-sea research please contact Nick Higgs (nickhiggs@ceibahamas.org), Director of the Cape Eleuthera Institute, The Bahamas or see our highlights video: vimeo.com/321287408

The science teams on the Exuma Sound cruises included Dean Grubbs, Sandra Brooke, Charles Messing, Gavin Naylor, Eve Moore, Oliver Shipley, Lucy Howie-Jordan, Brendan Talwar, Eric Schneider, Nathan Robinson, Candace Fields, Valeria Pizarro and Nick Higgs.

Figure 3: A bluntnose sixgill shark investigates the sub during a tagging dive. Credit: OceanX.

Figure 4: A giant squid caught on camera in the Gulf of Mexico. Credit: Nathan Robinson (CEI) and Edie Widder (ORCA)

The icebreaker Kronprins Haakon explores deep hydrothermal vents under ice in the Arctic

Eva Ramirez-Llodra[1], Stefan Buenz[2] and the HACON cruise team.

[1]Norwegian Institute for Water Research, Oslo, Norway, [2] CAGE-Uni. Tromsø, Norway

https://haconfrinatek.com/

On 19 September, a team of 36 scientists and engineers from 9 research institutions (NIVA, Uni. Tromsø, Uni. Bergen, IMR, WHOI, AWI, Uni. Aveiro and NASA-JPL), together with a writer from National Geographic and film director from Avatar Alliance Foundation, sat sail from Longyearbyen (Svalbard) towards the high Arctic on the Norwegian ice breaker *Kronprins Haakon* (Figure 1). On board we had the recently upgraded hybrid ROV/AUV *Nereus Under Ice* (NUI, WHOI)

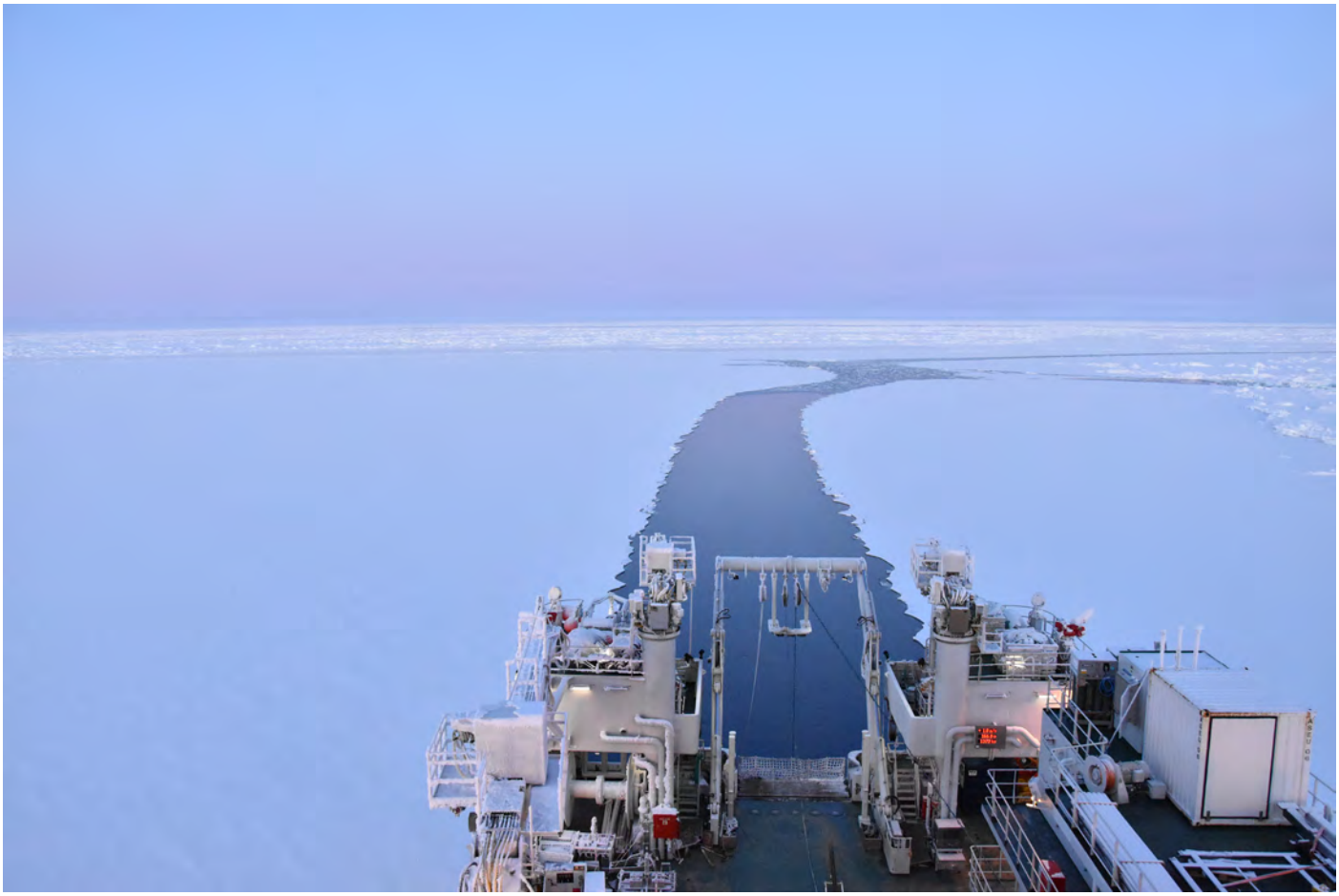


Figure 1: R/V *Kronprins Haakon* sailing through thin ice between two large ice floes. Photo: E. Ramirez-Llodra, NIVA.

and the towed ocean floor observation and bathymetry system OFOBS (AWI), as well as a CTD, gravity core, multicore, megacore and plankton net. The aim of the HACON cruise was to investigate the Aurora vent field on the Gakkel Ridge, located at 83.5°N at 4000 m water depth under ice.

The first black smokers ever to be observed in the Arctic were discovered on the Aurora seamount, during the *Polarstern* expedition PS86 led by Prof Antje Boetius (AWI, Germany). The Gakkel Ridge region, at this time of year, is covered by large ice floes slowly drifting (most of the time at 0.2-0.4 knots) with incredible force. The ocean temperatures under the ice are below zero and the terrain on the seafloor is complex. All this poses considerable challenges and demands on technology and crew. This was a high-risk, high-gain type of expedition. Anything could go wrong. But any new observations and samples would greatly increase our understanding of these remote ecosystems. And we had it all!

Figure 2: OFOBS (AWI) and Sponge Bob Spare Parts being deployed for test in deep water. Photo: E. Ramirez-Llodra, NIVA.

We had technological issues, but these only fuelled new collaborations amongst the engineers from WHOI, AWI and NASA-JPL. So much as to build, from spare parts, a mini, deep-diving ROV that could go down to 4000 m attached on OFOBS, giving OFOBS the capacity to “look” around: Sponge Bob Spare Parts (Figure 2).

We faced the challenge of non-collaborative ice floes that would drift on top of the Aurora vent site limiting our access to it. But the excellent team on the bridge of the Kronprins Haakon and the cruise lead (with a lot of patience too) found ways of getting us on station when the Aurora vent site “came out” under a large lead of open water or thin ice, so we could operate our deep-diving equipment safely. One of the best days of the cruise was the first dive of the towed OFOBS system over the vent site. After a very long transect over sedimentary

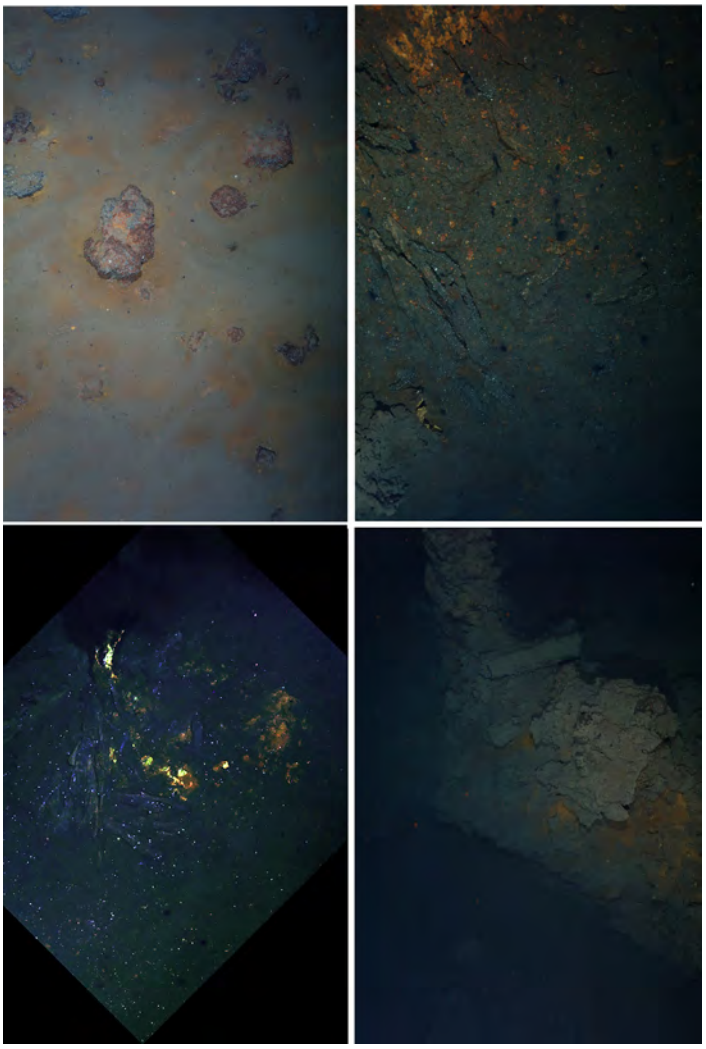


Figure 3: The Aurora sulphide mound showing one of the active black smokers observed. Photo: OFOBS/AWI team.

background, we started climbing up a large mound until, to everyone's excitement and delight, OFOBS flew over a very large black smoker acquiring excellent images of the system (Figure 3). Several more dives were made over the vent field, providing a unique data set of videos and high-definition photographs from which we could identify at least 2 new black smokers.

We also made several interesting OFOBS dives around the seamount, showing the variety of habitats in the region, including sediment with rocks colonised by sponges (Figure 4) and associated fauna, sinkholes, basalt rocks and rusty soft and coarse sediments on the sulphide mound. These data, together with a wealth of samples taken around the seamount, will greatly contribute to the data collected in 2014 and help us understand the processes driving the communities on the Aurora seamount, from viruses and microbes to the sponges that thrive in this region.

The scientific institutions represented on the cruise had a focus on life in ice-covered oceans, including ecology, micropaleontology, oceanography and geochemistry. But astrobiology was a completely new topic for many of us. Together with UiT, National Geographic and Avatar Alliance Foundation, the NASA-JPL team took ice-core samples to investigate if biogeochemical signatures and microbes from the Aurora vent field might be found in the overlying ice. The results will contribute to the planning of future projects that aim at exploring for life in other frozen oceans, such as the ones found on Europa (Moon of Jupiter) or Encedalus (moon of Saturn).

Figure 4: Sponge community on the Aurora seamount. Photo: AWI/OFOBS team.

The HACON cruise was high-risk, and we did have challenges. But it was, without a doubt, a successful cruise with an excellent atmosphere on board (Figure 5). We already know much more about the Aurora vent field than we did before and as the sample and data analyses progresses in the labs, a fuller picture will emerge of the composition and functioning of this remote and pristine ecosystem.

Figure 5: The HACON team. Photo: Aleksander Eeg, R/V *Kronprins Haakon*.

Project Focus

NOAA Office of Ocean Exploration and Research announces 2020 *Okeanos Explorer* Expeditions

National Oceanic and Atmospheric Administration

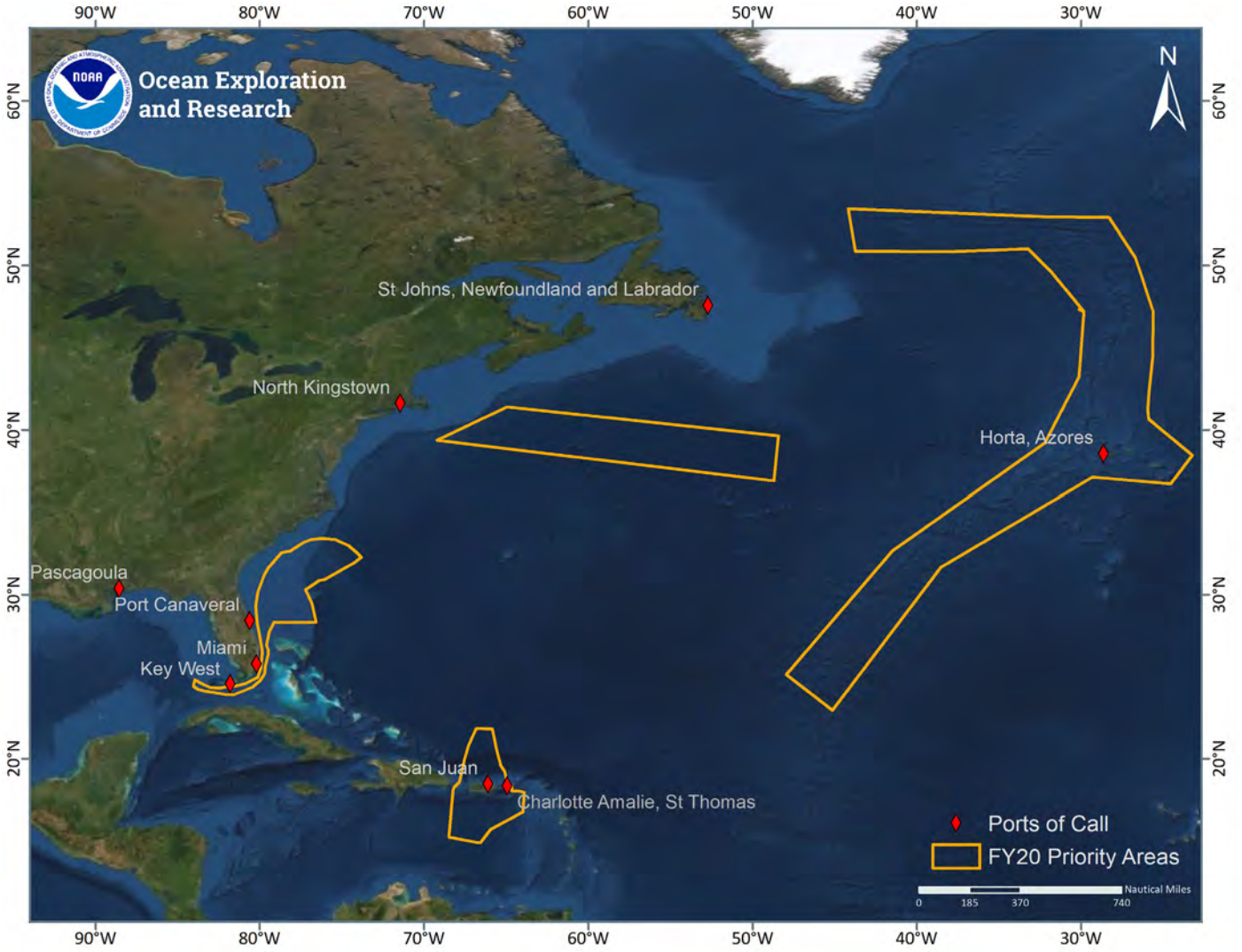


Figure 1: Map showing the operating areas (gold polygons) and ports (red diamonds) for expeditions aboard NOAA Ship *Okeanos Explorer* to be conducted in FY2020, including the just-completed 2019 U.S. Southeastern Deep-sea Exploration (EX1906 and EX1907). Image courtesy of NOAA Office of Ocean Exploration and Research.

From October 2019 to September 2020, the NOAA Office of Ocean Exploration and Research (OER) will embark on NOAA Ship *Okeanos Explorer* to conduct three regional expeditions starting with the U.S. Southeastern Continental Margin in Fall 2019, and focusing on the Northern Caribbean and Mid-Atlantic Ridge in 2020. Multidisciplinary teams of scientists, technicians, and engineers will conduct undersea mapping and ROV explorations of the geological, biological, oceanographic, and archaeological resources of these ocean areas, the majority of which remain largely unexplored. These expeditions will contribute to the Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE) campaign, a major multi-year, multi-national collaborative field program focused on increasing our collective knowledge of the North Atlantic Ocean in support of the Galway Statement on Atlantic Ocean Cooperation.

The 2019 U.S. Southeastern Deep-Sea Exploration expedition concluded at the end of November, and the ship is now in

a winter repair period until March 2020 when mission operations will resume with sea trials and shakedown operations off of southern Florida. In Spring of 2020, OER will explore and map deep waters in and around Puerto Rico and test emerging technologies. This involves collaboration with NOAA's Office of Coast Survey and will help fulfill a request from the Meso American-Caribbean Sea Hydrographic Commission (MACHC) to acquire bathymetry in areas with substantial gaps in coverage.

During the summer of 2020, OER will use NOAA Ship *Okeanos Explorer* to conduct a 70-day Voyage to the Ridge expedition to characterize unexplored areas of the Mid-Atlantic Ridge and the Azores Plateau. In addition to supporting science and management priorities of this region, this expedition will also address other ASPIRE priorities, such as leveraging international partnerships to conduct coordinated exploration across the North Atlantic Ocean in support of Galway. ROV and mapping operations conducted during this expedition will complement previous and upcoming work in the region. Mapping operations will target seafloor and water column areas with little or no high-quality sonar data and support follow-on ROV operations. ROV dives will characterize hydrothermal vents, deep-sea coral and sponge communities, fracture zones, and rift zones.

Following the Voyage to the Ridge expedition, OER will conduct a 15-day transit mapping mission on the NOAA Ship *Okeanos Explorer* to fill data gaps in multibeam bathymetry coverage in support of Seabed 2030, ASPIRE priorities, and critical marine mineral inventory initiatives. Transit mapping will be planned to match and expand existing track lines en route to home port in North Kingstown, Rhode Island.

Throughout the year, telepresence technology will allow you to follow discoveries via the NOAA Office of Ocean Exploration and Research website. **NOAA is currently seeking scientists and managers interested in actively participating during 2020 expeditions.** For details on opportunities to get involved, please visit this page. If you are interested in providing input into expedition planning or participating as a scientist or student, please contact the Expeditions Science Advisor, Dr. Scott France, at france@louisiana.edu.

Review - From Surface to Seafloor: Exploration of the Water Column

Aria Ritz Finkelstein

September 23, 2019

We still have much to learn about the dynamics and structure of the water column from the surface of the sea down to the seafloor. Our knowledge of the organisms that populate this space is far from complete, as is our understanding of how human activities will influence it. Recently, NOAA held a workshop with the goal of answering a number of questions: What lives in the water column? What are the "biodiversity, biogeography, ecology, and behavior" of organisms in the water column, and what is its structure? Second, what is the water column's structure? How do anthropogenic activities influence this structure and these organisms? Finally, how do we communicate the importance of this knowledge to both the general public and policymakers?

The workshop's result was a report outlining a broad, diverse range of research tools and potential collaborations. The report identifies unexplored regions, biodiversity hotspots, intersections between two very different environments, and places where the seafloor is already well understood as priorities for water column research. And, it lists the data to collect in order to understand both the current state of these regions and their variability across spatial and temporal scales.

There are a number of ways to collect each type of data—from chemical and physical characteristics to single cell biology to multicellular organisms all the way up to more complex data such as food webs, long-range tracking, and

responses of animals to their environments. Long-term observation networks are important for understanding basic physical features—temperature, salinity, chemical levels, and so on. These can be ship-based, but they can also be floating, moored, or attached to stationary platforms. They can also take advantage of other already existing resources to piggyback research onto operations such as drilling ships. Remotely operated vehicles (ROV) are more useful for gathering *in situ* data about organisms—especially delicate ones—and the relationship between their distribution and physical and chemical conditions. There are many less traditional, autonomous systems too, including sensors mounted on animals, autonomous underwater vehicles (AUVs), and floating platforms with new capabilities like collecting eDNA samples. The main obstacles in the way of using these are battery power, biofouling, and the difficulty of ground-truthing, and these are areas that offer much room for innovation.

To map a way forward, the workshop participants developed a six-piece plan to develop a water column exploration program. First, the group will prioritize questions and key regions. Second, they will collect data from already existing and implemented sensors and expeditions. Third, they will use the prioritized questions to guide the development of new technologies. Fourth, they will dedicate ships to collect midwater samples. Fifth, they will standardize sampling and data management protocols. Sixth, they will prepare research infrastructure to respond quickly to anomalous events, because understanding the water column under perturbation or unusual conditions can be as useful as understanding its «normal state». Finally, as important as these structural and technical questions are, perhaps the most important task the workshop participants discussed is the work of communicating the importance of their research to the general public and to policymakers.

DY108: Return to the Darwin Mounds, the UK's 1st deep-sea MPA

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September found us returning to the Darwin Mounds for our sixth look at these cold-water coral systems. In the now 21-year time span since we discovered the site, we have documented its degradation by bottom trawling, contributed to its designation and protection as the UK's first deep-sea Special Area of Conservation (SAC), and begun the process of monitoring its progress. In the course of RRS *Discovery* cruise 108 we were able to confirm the continuing good status of corals in the West Field, the continuing poor condition of corals in the East Field, and the occurrence of particularly good coral frameworks in the Pocket Field (Figure 1, upper image), last imaged in 2000.

In broad terms, little appeared to have changed since our last visit in 2011, at which time the ban on bottom contact fisheries (initiated in 2003) appeared to have been effective, but there was little if any evidence of coral recruitment or regrowth in the impacted East Field (see Huvenne et al., 2016. Biol. Conserv., 200: 60-69. doi:10.1016/j.biocon.2016.05.030). Highlights of DY108 included – the good news that settlement plates, and their moorings, deployed in 2011 and recovered during the cruise had very healthy epigrowth including corals (*Desmophyllum* spp.) – and the bad news that macroplastic debris continues to stand on the Darwin Mounds coral frameworks in significant quantities, notably lost / discarded fishing gear (Figure 1, lower images).

DY108 was funded by the UK Natural Environmental Research Council's Climate Linked Atlantic Sector Science (CLASS) project that enables us to carry out time-series research at the Darwin Mounds SAC, the Greater Haig Fras Marine Conservation Zone (MCZ; see Benoist et al., 2019. Conserv. Biol., 33: 1174-1186. doi:10.1111/cobi.13312) in the Celtic Sea, the Whittard Canyon MCZ, and the long-running Porcupine Abyssal Plain Sustained Observatory. The cruise was further boosted by a joint venture with the University of Southampton's Ocean Perception team and their BioCam

system described in the previous DY109 article

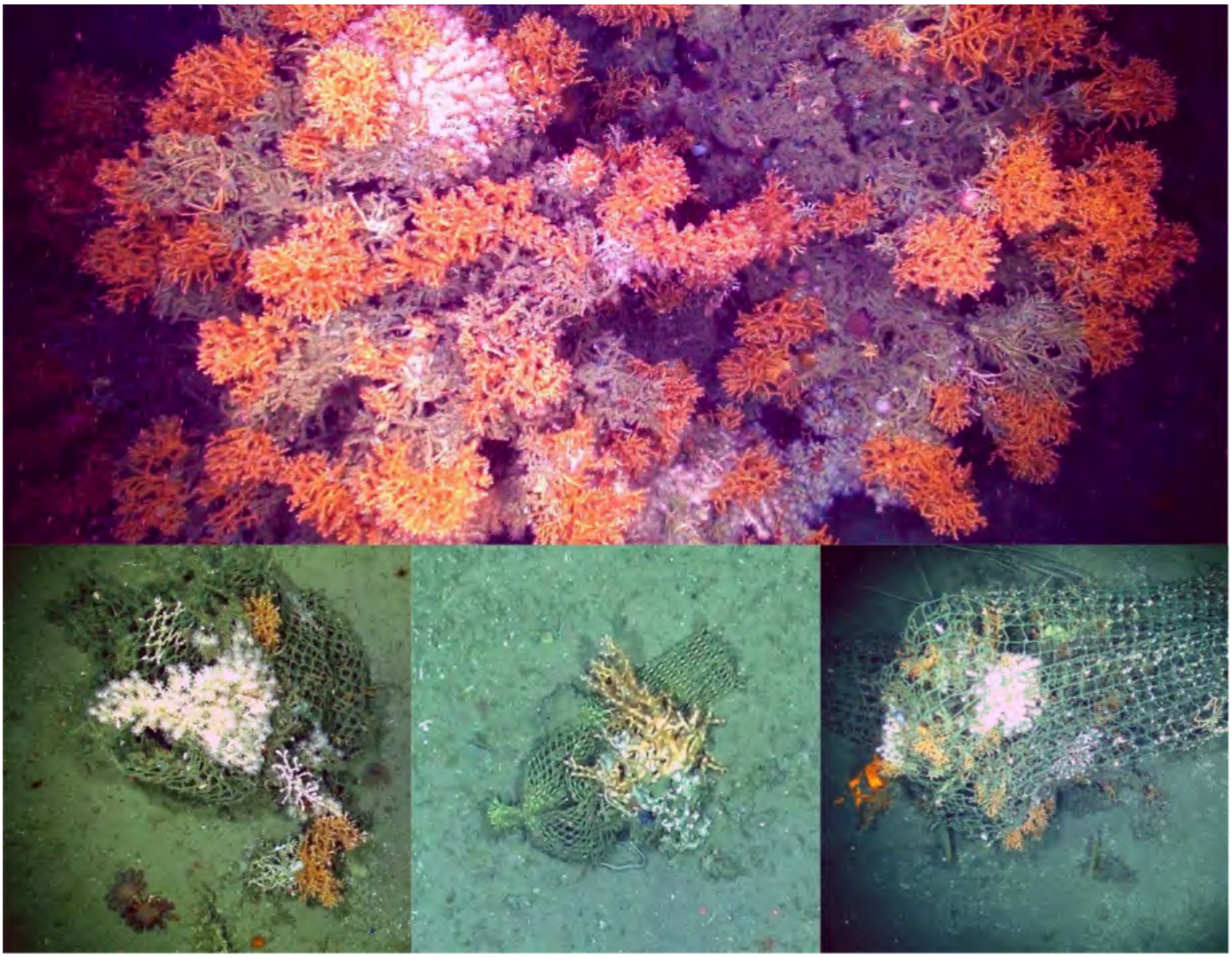

Figure 1 (top). Healthy coral framework from the Darwin Mounds Pocket Field. (bottom): Fishing gear remnants stranded on Darwin Mounds corals. © NOC, 2019.

Influence of ice cover and latitude on Antarctic peracarid crustaceans in a changing environment

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During the expedition PS118 (February 2019) and in the framework of the project Larsen-C PEARL, the RV *Polarstern* sailed towards the western Weddell Sea, east of the Antarctic Peninsula. There, on the 12th of July 2017, a huge portion of ice (iceberg A68) had calved from the Larsen-C Ice Shelf, exposing the underlying seafloor for the first time to new environmental conditions. The aim of the project was to investigate the communities of macrobenthic peracarid crustaceans (Malacostraca; Figure 1B, 1C, 1D) which lived under the ice shelf and assess the influence of the latter on their diversity and abundance.

The project was driven by the hypothesis that peracarid faunal assemblages that live beneath an ice shelf likely comprised assemblages resembling those from the deep Weddell Sea.

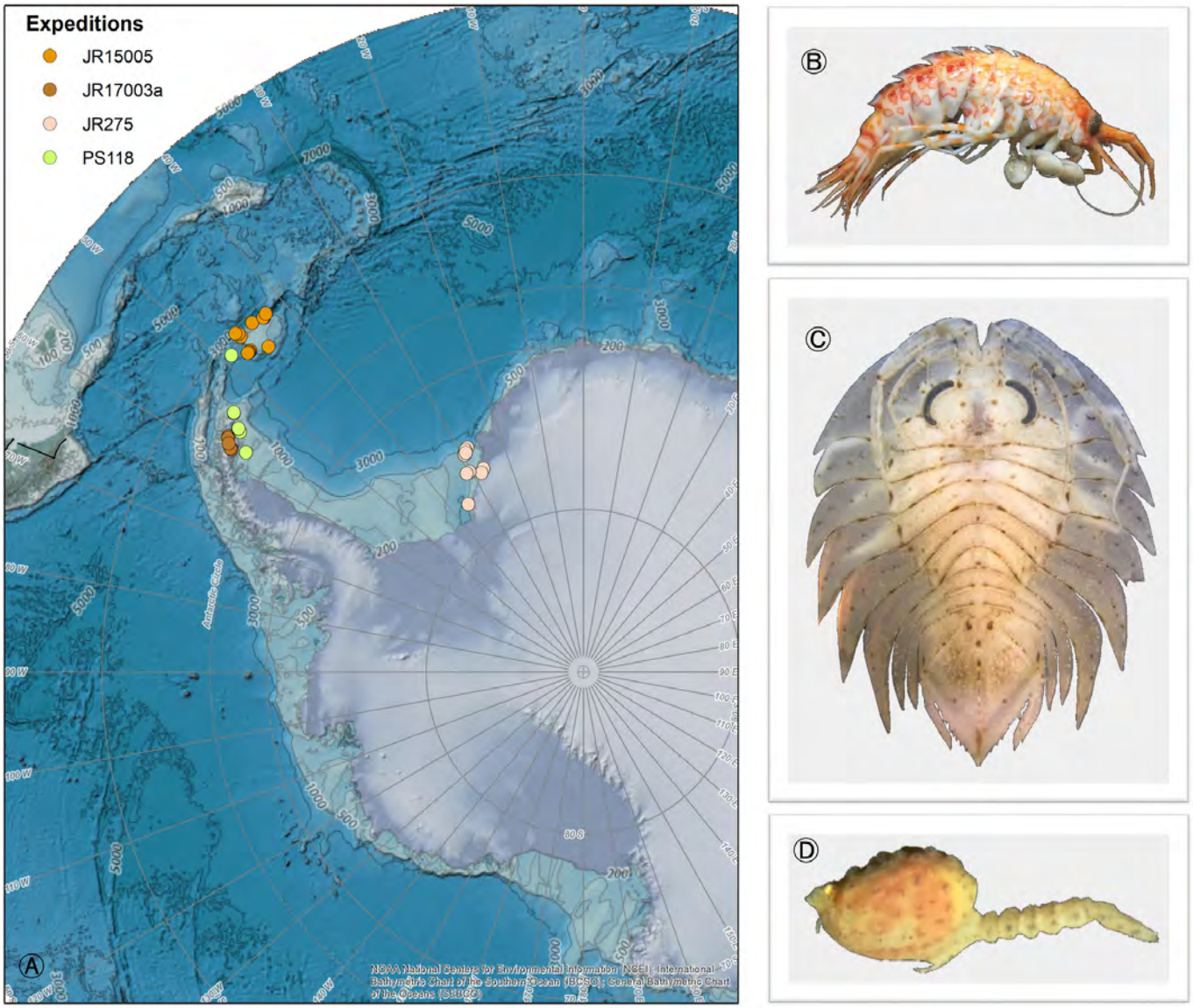

Figure 1: Expeditions and sampling stations (A); Amphipoda, *Eusirus perdentatus* Chevreux, 1912 (B); Isopoda, *Ceratoserolis trilobitoides* (Eights, 1833) (C); Cumacea, *Campylaspis* G.O. Sars, 1865 (D).

For this purpose, deep-sea samples of the peracarid fauna collected during previous expeditions in the Weddell Sea and in other Antarctic areas characterised by different extents of ice-cover are also available for direct comparison (Figure 1A): the ice free area of the South Orkney Islands (JR15005), Prince Gustav Channel (JR17003a) in which the ice-shelf collapsed in 1995 and the seasonally ice-covered Filchner Trough (JR275). Unfortunately, neither during expedition JR17003a with RRS *James Clarke Ross*, nor during expedition PS118 with RV *Polarstern* was it possible to reach the Larsen-C area due to heavy ice conditions. Therefore samples were collected in alternative locations along the eastern Antarctic Peninsula, following a latitudinal gradient and leading to new scientific questions.

The aim of the project is to investigate the influence of ice cover and latitude on peracarid abundance and species composition comparing areas characterised by different ice cover regime and latitudinal gradients. Besides we plan to investigate the influence of other environmental parameters (e.g. depth, temperature, salinity, type of sediments, primary production) and evaluate which functional groups of selected peracarid taxa may exist or dominate under different environmental conditions.

Collected data from Prince Gustav Channel and the comparison with samples from the deep Weddell Sea and the other study areas will also still allow us to evaluate the main hypothesis assessing the effect of the ice shelf and its collapse on peracarid faunal assemblages.

The results of the project will improve our knowledge on how components of the benthic community interact with

the abiotic factors of their inhabiting environment. They will also provide useful information on how possible changes of such parameters could influence their present distribution and diversity. Ultimately, a better understanding of the aforementioned interactions might help to predict the ecological impact induced by the on-going climate change.

Taking Stock of STRONG High Seas Project two years on

Lewis Kihumba[1], Ben Boteler[2] and Carole Durussel[2]

[1]Birdlife International, [2]STRONG High Seas Project

As the world grapples with a myriad of environmental challenges including climate change, focus is shifting to another environmental frontier that requires urgent collective attention and action - Areas Beyond National Jurisdiction (ABNJ), commonly defined as areas extending more than 200 nautical miles from coastlines. ABNJ cover about two thirds of the world's oceans and account for a significant proportion of the planet's biodiversity, from planktons to whales. Moreover, they hold more than 90% of the world's fish stocks and play a crucial role in the regulation of climate by absorbing carbon dioxide from the atmosphere, thus slowing impact of climate change. Human activities are increasingly putting pressure on biodiversity in ABNJ. Further aggravating the situation is a fragmented legal and institutional framework to regulate activities in these jurisdictions. In addition, Sustainable Development Goal (SDG) 14 underlines the need for sustainable use of oceans, seas and marine resources for sustainable development, highlighting the importance of oceans, including ABNJ.

The STRONG High Seas (Strengthening Regional Ocean Governance for the High Seas) project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through the International Climate Initiative (IKI) focusses on conducting scientific assessments and supporting dialogue to contribute to the development of effective frameworks and approaches for ocean governance in the Southeast Pacific and Southeast Atlantic regions, as well as contributing to the ongoing negotiations for a global legally binding treaty on marine biodiversity in areas beyond national jurisdiction (BBNJ) conducted under the United Nations. The project also facilitates dialogue between various stakeholders, including national and regional authorities, academia, science institutions in addition to NGOs in order to develop a collaborative approach towards governance measures for the sustainable use of marine biodiversity and effective management of ABNJ. Moreover, it provides a platform for stakeholders to deliberate on challenges facing governance of ABNJ, facilitate knowledge exchange while at the same identifying areas for further collaboration.

A number of organizations in the two regions have area-based management tools (ABMTs), including marine protected areas (MPAs), and marine spatial planning (MSP), among others. However, these tools are only applicable within the jurisdiction of countries that have developed them and not in ABNJ. The dialogue workshops in the two regions will be instrumental in development of a cross sectoral ecosystem-based approach. Since the project's inception in 2017, a number of dialogue workshops have been held including inter regional workshops, with more dialogues planned by 2022. Through established working groups, it is hoped that these dialogues will be able to promote the exchange of ideas and enable the development of feasible ocean governance frameworks. Additionally, cross-sectoral management approaches will be instrumental in streamlining regional ocean governance. Capacity building among key sectoral organizations is integral in the Southeast Pacific and Southeast Atlantic regions. Sectoral organizations are benefitting from technical support, trainings, and workshops being held in the two regions to increase ability of these organizations to address and respond to High Seas governance issues. It is envisaged that through these exchanges, ocean governance in the two regions', ABNJ can be strengthened and effectively contribute to a global instrument under the United Nations Law of the Sea Convention (UNCLOS) framework.

Author Profiles:

Lewis Kihumba is communication lead at Birdlife International one of the Strong High Seas project implementation partner in Africa. He is the communications focal point for the STRONG High Seas Project in the South East Atlantic region.

Ben Boteler is one of the co-leads of the STRONG High Seas project and is conducting research in an effort to advance and strengthen regional ocean governance for the high seas in the South East Atlantic and South East Pacific as well as globally. In particular, his focus is on the socioeconomic uses and benefits obtained from the marine environment.

Dr. Carole Durussel conducts research to advance and strengthen regional ocean governance, with a particular focus on the legal and institutional framework for the conservation and sustainable use of marine biodiversity in ABNJ. She is the co-lead of the STRONG High Seas project.

Website: https://www.prog-ocean.org/our-work/strong-high-seas/

Publication of first UK deep-sea biotope sensitivity assessments

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The Joint Nature Conservation Committee (JNCC) has recently been undertaking sensitivity assessments for deep-sea biotopes from the Britain and Ireland Habitat classification. The first assessments are now published on the MarLIN website for *Leptometra celtica* assemblages, found on Atlantic upper/mid bathyal sand and coarse sediments. Assessments for *Geodia* and other massive sponges, found on Atlanto-Arctic upper bathyal coarse and mixed sediments are currently in press. The assessments follow the Marine Evidence-based Sensitivity assessment (MarESA) method, which involves a detailed literature review, and each assessment has been through a peer-review process involving deep-sea experts. The assessments provide resistance, resilience and overall sensitivity scores for each of the biotopes to a range of hydrological, physical, biological and chemical pressures. Climate change pressures have also been assessed for a number of biotopes as part of a separate project (also available on the MarLIN website). A selection of pressures for the '*Leptometra celtica* assemblages' sensitivity assessment are discussed below.

Information on the ecology and biology of *Leptometra celtica* was collated to help determine potential resilience (the rate of, or time taken for, recovery once the pressure has abated or been removed). Although the species can regenerate lost or damaged arms, as well as having the ability to crawl or swim short distances, modelled data showed that the species has a short pelagic duration (Gallego et al., 2013), meaning that recovery could take between 2-10 years.

Evidence on the effects of 'Litter' on *Leptometra celtica* indicated that individuals may get entangled in relict fishing

gear (Oliveira et al., 2015). However, a fishing net was also found to act as a fixation point for the species, providing an advantageous position for filter feeding. Resistance was therefore assessed as 'Medium', giving an overall sensitivity of 'Medium'.

Evidence on the effects of 'Abrasion/disturbance of the surface of the substratum or seabed' was mainly based on the Mediterranean congeneric spp. *Leptometra phalangium*. One study found aggregations of this species either side of a trawling lane, with solitary individuals on the raised banks of trawl-door plough marks (Smith et al., 2000). Another study only found the species in areas of less intensive fishing (Mangano et al., 2013). The resistance of *Leptometra celtica* was hence deemed to be 'None'. As the species is likely to recover within 2-10 years (i.e. 'Medium' resilience), overall sensitivity was considered as 'Medium'.

For the pressure 'Smothering and siltation rate changes', the feeding and respiratory surfaces of *Leptometra celtica* may become clogged. However, the species is thought to have the ability to compensate by shaking its arms. Individuals may also raise up and extend their arms, and/or use their cirri to raise themselves up above the substratum, allowing them to filter feed. Therefore, *Leptometra celtica* assemblages were assessed as 'Not sensitive' at this pressure benchmark (deposition of <5cm of fine material).

The full sensitivity assessment for the biotope '*Leptometra celtica* assemblages' can be found here. Thanks goes to Charles Messing and Marc Eleaume for peer-reviewing the assessment.

New photo ID guide for meso pelagic fish in the NE Atlantic

A new photo ID guide for meso pelagic fish in the NE Atlantic, freely downloadable (80Mb) is now available:

https://www.wur.nl/en/Research-Results/Research-Institutes/marine-research/show-marine/Deep-sea-creeps-in-new-photo-guide.htm

Researchers from Wageningen Marine Research and the pelagic fisheries sector have jointly published a photo ID guide for deep-sea fish species. The guide contains photographs of nearly 100 fish species and 10 cephalopod species from the mesopelagic zone, which is between 200 and 1,000 meters in depth, in the north-eastern regions of the Atlantic Ocean. It helps fishermen and researchers on fishing vessels improve their identification of these species and their understanding of underwater life in the ocean depths.

The origin

In the 1990s, researcher Bram Couperus of Wageningen Marine Research began collecting deep sea species as an on-board observer on pelagic trawlers. He was fascinated by dragon fish with large needle-like teeth, deep-sea sharks, luminous lantern fish, and other species that ended up in the net as by-catch.

As part of the annual scientific survey of blue whiting, a colleague researcher, Sytse Ybema, began working on a determination guide with the aim of facilitating future research into special by-catch species. Since 2008, the species have been photographed as a standard procedure during the blue whiting surveys. Couperus is especially enthusiastic about the efforts of all researchers and trainees involved: "Their photography and identification skills have enabled us to publish this determination manual".

The value of the photo guide

According to Martin Pastoors, Chief Science Officer at the Pelagic Freezer-trawler Association (PFA), the manual provides important added value for crew members of pelagic trawlers in the North-eastern Atlantic. "This is because special

species can now be compared with actual photographs of previously caught specimens instead of with beautifully drawn illustrations from popular market books," he says. "And the guide makes it easier for fishery researchers to study this group of species. Until now, they have been entirely dependent on scientific determination collections that were difficult to access".

The manual was compiled as a draft version by Bas Schilling, a student at Van Hall Larenstein University of Applied Sciences, and was subsequently completed by researchers at Wageningen Marine Research. It is also available as a PDF.

Deep-Sea Lebanon Project: Results of the 2016 Expedition Exploring Submarine Canyons

Towards Deep-Sea Conservation in Lebanon Project

Mira Husseini & Ziad Samaha

IUCN ROWA (Regional Office for West Asia), Lebanon Project Office

Marine sand and gravel extraction, sewage discharge and oil dumping, unsustainable and illegal fisheries, habitat degradation, recreational uses, coastal urbanisation, invasive species, and larger-scale impacts such as the effects of climate change, are threatening the Lebanese marine ecosystem. Marine Protected Areas (MPAs) are an effective tool to protect marine biodiversity, and support human wellbeing and sustainable development.

However, Lebanon suffers from a lack of information about marine habitats and species, which obstructs MPAs designation and management. Closing this knowledge gap was the primary aim of the Deep-Sea Lebanon project, which performed the first biological survey of deep-sea Lebanese waters. The Lebanese deep-sea canyons have been identified as Ecologically or Biologically Significant Areas (EBSA) because of their important role in ecosystem functioning, their uniqueness and rarity, and their special importance for life-history stages of the species that they

Figure 1 (top row): Demosponge in rocky seabed with coralligenous. Batroun, Lebanon; Lionfish (*Pterois miles*) among coralligenous. Batroun, Lebanon; Mediterranean moray (*Muraena helena*). Batroun, Lebanon. (bottom row) Seven-armed starfish (*Luidia ciliaris*). Saint George canyon, Lebanon; Tube anemones (*Cerianthus membranaceus*). Jounieh, Lebanon; Crab (*Bathynectes maravigna*) and striped soldier shrimps (*Plesionika edwardsii*). Jounieh.

host, among other characteristics.

The biological survey of deep-sea Lebanese waters was carried out in five areas: Tarablus/Batroun, Jounieh, St. George, Beirut escarpment, and Sayniq. The survey identified six main habitats over a broad depth range (36-1050m): coralligenous habitats and rhodolith/ maërl beds; rocky bottom areas; muddy and sandy-muddy bottoms; sandy bottoms; canyon heads; and bathyal muds. 622 taxa were documented, among which three species that are likely to be new to science: a sponge belonging to the genus *Axinella*, a starfish belonging to the genus *Luidia*, and a stony coral, which is pending identification, but likely belonging to the genus *Anomocora*.

Dozens of species that have not previously been recorded in Lebanon were observed. The glass sponge (*Farrea bowerbankii*), the rabbitfish (*Chimaera monstrosa*), the velvet-belly lanternshark (*Etmopterus spinax*), holothurians such as *Mesothuria intestinalis* and *Penilpidia ludwigi*, and cnidarians such as the gorgonian *Swiftia pallida*, sea pens (e.g., *Pennatula rubra, Virgularia mirabilis*, and *Funiculina quadrangularis*), and species of the subclass Hexacorallia, such as *Sideractis glacialis* and the tree coral *Dendrophyllia ramea*. Three species of starfish were spotted, previously not recorded in the Mediterranean Sea: *Hacelia superba* on bathyal rocky bottoms, *Leptasterias* sp. on ancient fossil reefs, and a species of the genus *Luidia*, abundant on sandy bottoms in the circalittoral zone.

MPAs are a management tool to limit localised threats to these important systems, including impacts from fisheries, marine litter, invasive species and oil exploratory activities that directly or indirectly damage them.

Lebanon should prioritise the conservation of coralligenous concretions and rhodolith/maërl beds, because of their vulnerability to anthropogenic impacts. There is the need to grant coralligenous habitat and maërl beds the same degree of legal protection as *Posidonia oceanica* meadows, possibly using the tools of the Barcelona Convention. As a party to the Barcelona Convention Lebanon should ensure that, fossil reefs are managed under the same framework as other 'dark habitats', to ensure that threats to these systems are minimised or avoided altogether. All pennatulaceans should be included as habitat builders under the Mediterranean Action Plan for protecting dark habitats. The red sea pen (*P. rubra*) is particularly diffuse and considered as one of the key deep-sea community types in Lebanon. The tall sea pen (*F. quadrangularis*) should be protected not only in Lebanese waters. Lebanon should take legal steps to ensure the protection of these habitats and limit the challenges they face.

Further information: https://www.iucn.org/regions/west-asia/projects/completed-projects/towards-deep-sea-conservation-lebanon-project

First results of the Project "Deep-sea soft-bottom benthic communities: Exploring biogeography and genetic connectivity of southeast Pacific Seamounts"

Eulogio Soto[1], Eduardo Quiroga[2], Jeroen Ingels[3], Charlotte Seid[4], Joseph Horacek[3], Natalia Catalán[5], Jaime Romero[5] and Dhugal Lindsay[6]

[1]Universidad de Valparaíso, [2]Pontificia Universidad Católica de Valparaíso, [3]Florida State University, [4]Scripps Institution of Oceanography, [5]Universidad de Chile, [6]Jamstec

Between January 27th and March 2nd 2019, the oceanographic cruise MR18-06 "East/central Pacific International Campaign (EPIC)" aboard the R/V *Mirai*, JAMSTEC was carried out from Valparaiso, Chile to Tahiti, French Polynesia. Seven study sites (Figure 1) were successfully sampled using a Multicore. Core samples with surficial sediments (columns up to 40 cm) were obtained from the Atacama Trench (7742 m depth, Figure 2) and at the base of different seamounts

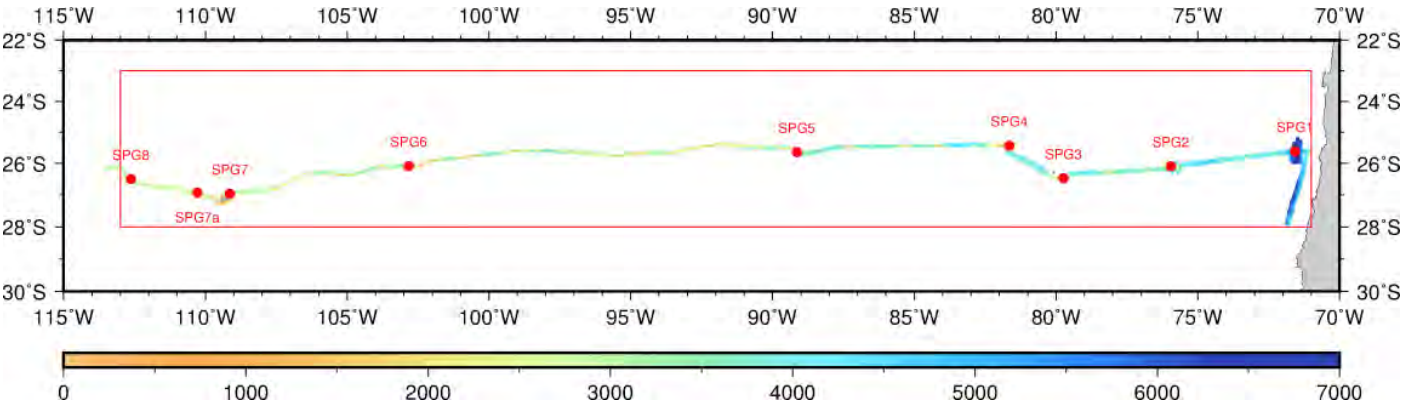

Figure 1. Sampling stations (SPG1 to SPG7) where sediment samples were collected.

(depths between 2895 and 4114 meters) located inside the jurisdiction of Marine Protected Areas belonging to Chile as well as in the high seas (Figure 1).

Live-sorting of macrofauna from the upper ~5 cm of a subset of sediment cores yielded very few organisms (average ~2 per core), chiefly polychaetes and copepods (Figure 3). Analysis of the remaining cores has not yet been completed.

Meiofaunal samples contained very low abundances of organisms (<170 per core) compared to other seamounts and Atacama Trench studies, but with distinct assemblages. Communities were dominated by nematodes (Figure 3), followed by copepods, polychaetes, tardigrades, gastrotrichs, kinorhynchs, and hydrozoans. The nematodes are currently being extracted and vouchered, prior to molecular analyses to investigate phylogeny and across-site diversity.

Bacterial communities were also examined using high-throughput sequencing of bacterial 16S rRNA gene fragments from DNA extracted from sediments samples. After taxonomic assignation (OTUs; defined at 99% 16S rRNA gene identity) the structure of the comminuty was revealed in the 7 samples analysed. Similar composition of the bacterial community at phylum level was also observed (Figure 5). Most of the sequences correspond to phylum Proteobacteria, with a relative abundance near to 50%. Other phyla showing similar relative abundance were Firmicutes, Acidobacteria,

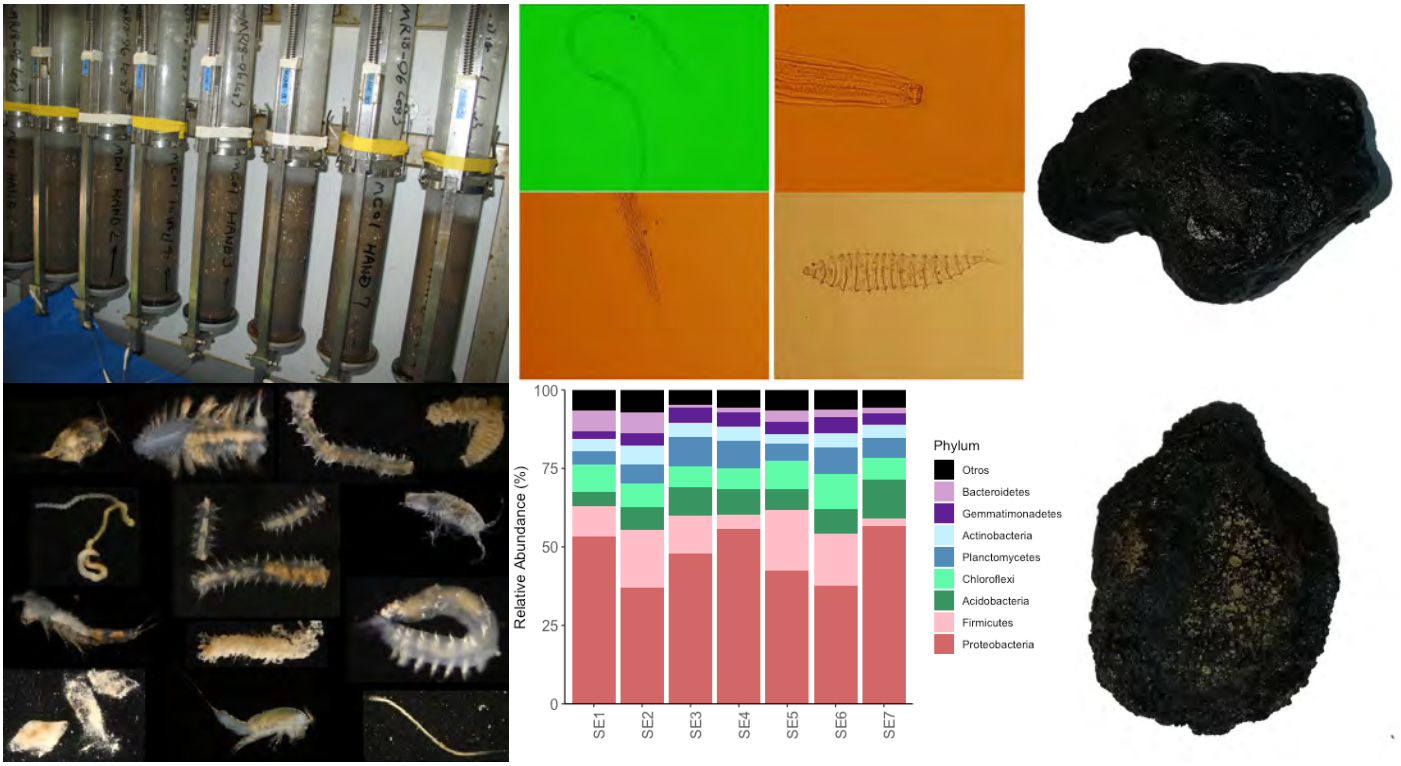

Figure 2 (top left). Sediment cores obtained from Atacama Trench at 7742 m depth (Photo by Eulogio Soto). Figure 3 (top middle). Nematodes found at study site. Clockwise, *Halalaimus* sp., *Metasphaerolaimus* sp., *Monhystrella* sp. and *Desmoscolex* sp. (Photo by Joseph Horacek). Figure 4 (bottom left). Representative soft-bottom macrofauna from sediment cores (Photo by Charlotte Seid). Figure 5 (bottom middle). Relative abundance (%) of bacteria in the sediments at phylum level (SE: Sampling station). Figure 6. (right) Manganese crusts and nodules associated with SE Pacific seamounts (top: site SPG5; bottom: site SPG2,) (Photo by Eduardo Quiroga).

Cloroflexi, Plactinomycetes, Actinobacteria and Gemmatimonadetes.

Manganese crusts and nodules were collected at SPG 2 and SPG5 (Figure 6), some of them containing possible evidence of invertebrates (cnidarians, bryozoans) on their surfaces. The geological characterization of these minerals is in progress.

The oxide-reduction potential (ORP) in sediments ranged from 409 mV to 572 mV, while pH ranged from 7,23 to 7,43. Gran size, organic content, isotopes and others geochemical parameters are being analysed.

Results are expected to improve our knowledge and understanding of biodiversity, biogeography and geochemistry of seafloor from one of the most unexplored regions in the world.

Authors thank the funds provided by The Pew Charitable Trusts. However funding is highly required and necessary for samples analysis, shipment and results outreach.

The project is led by Dr. Eulogio Soto and Dr. Eduardo Quiroga. Contact details: eulogio.soto@uv.cl and eduardo.quiroga@pucv.cl

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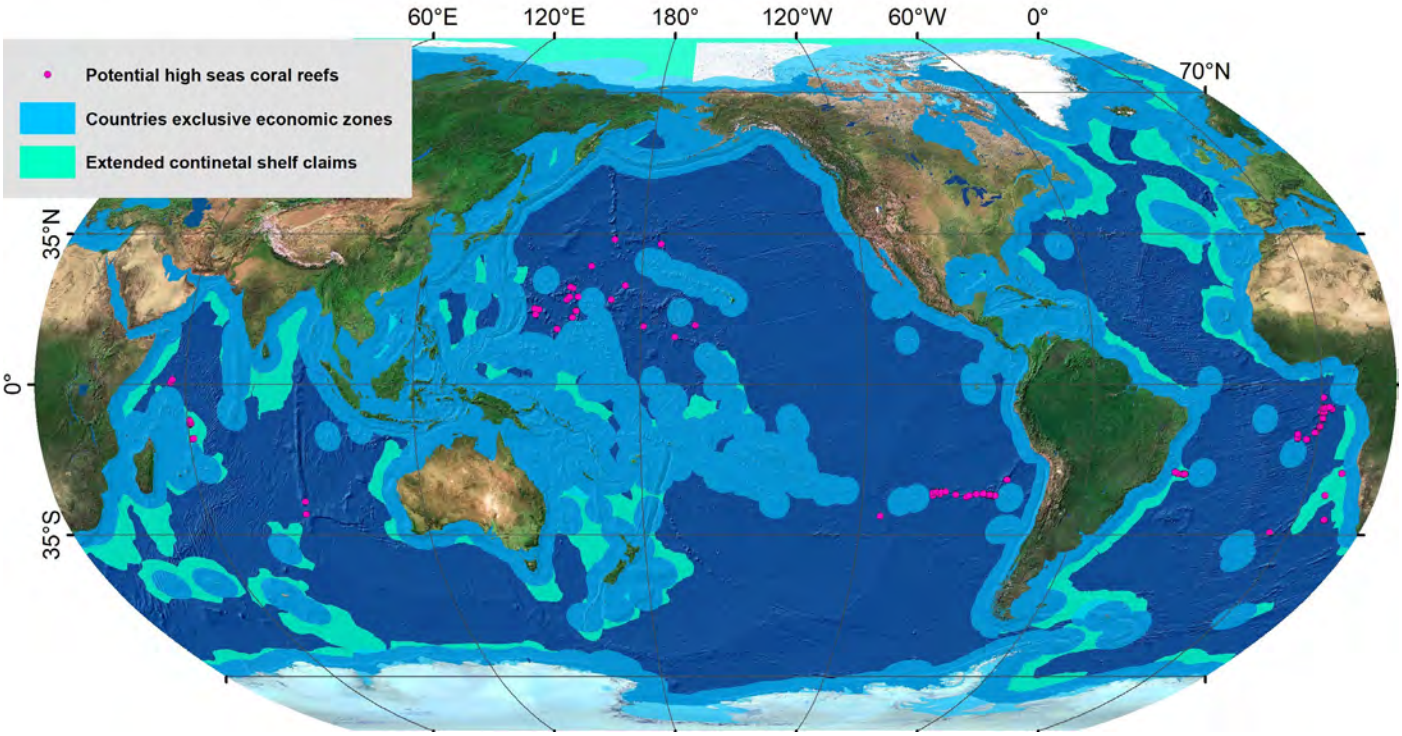
Coral Reefs on the High Seas Coalition: Supporting the establishment of the first marine conservation areas to protect mesophotic coral reefs on the high seas

Daniel Wagner

Conservation International

In May 2019, a group of experts in ocean science, policy, law, and communications convened in Denver, Colorado to launch the Coral Reefs on the High Seas Coalition, a global alliance of partners that seeks to support the establishment of the first large-scale marine conservation areas that would protect coral reefs in marine areas beyond national



Potential mesophotic coral reefs on the high seas based on the global distribution data of seamounts and knolls (Yesson *et al.* 2011).

jurisdiction. Specifically, the coalition seeks to support high seas conservation efforts by generating the scientific evidence base and developing the strategic communications that are necessary to advance international awareness and action for these unique and fragile ecosystems.

Marine areas beyond national jurisdictions, commonly known as the high seas, cover over 61% of the global oceans by area and over 73% by volume. These vast ocean areas provide many vital ecosystem services that are critical for sustaining life on our planet. Yet, only 1.2% of the high seas currently lie within marine protected areas, in large part due to the patchwork of a legal framework that is currently in place to protect the high seas, as well as the lack of awareness that important ecosystems exist within these remote ocean areas.

Coral reefs have been heralded as the rainforests of the sea due to their remarkably high levels of biodiversity, and as a result, have a long history of protection in the exclusive economic zones (EEZ) of many countries. While most people assume that coral reefs only exist in shallow and nearshore waters, deeper extensions of tropical coral reefs, known as mesophotic coral ecosystems, have been documented down to depths of 150m in many remote locations, including on the high seas. Global seamount inventories, available seafloor mapping data, and habitat suitability models suggest that there are several seafloor areas in the high seas that are suitable for mesophotic coral reefs, with almost none of these having been explored scientifically.

The Coral Reefs on the High Seas Coalition will work with several partners over the next two years to conduct scientific exploration of high seas coral reefs, link research results into protected area design, raise political support, and advance international policy for these irreplaceable ecosystems. Planned coalition activities include several research expeditions, the first of which will explore mesophotic reefs on seamounts around Rapa Nui (Easter Island) early in 2020. For more information contact dwagner@conservation.org.

Coral reef off Salas y Gomez Island in the Chilean EEZ explored by a National Geographic expedition in 2011. Over 20 seamounts with summits shallow enough to host MCEs exist in high seas waters around the Salas y Gomez and Nazca Ridges. The Coral Reef of the High Seas Coalition will work with several partners to explore such areas in the next two years. (Photo courtesy of Enric Sala, National Geographic Society).

The Deep-Ocean Stewardship Initiative (DOSI): Recent Highlights

Maria Baker[1], UK & Harriett Harden-Davies[2]

[1]University of Southampton, [2]University of Wollongong, Australia

The funding awards from Arcadia Fund, Benioff, JM Kaplan and others over the past year to the Deep-Ocean Stewardship Initiative have enabled continued and coordinated involvement of a wide variety of experts, predominantly deep-sea scientists, to engage with national and international policy processes in a way that is unique and essential at this critical time for the future of ocean biodiversity. DOSI continues to expand its network membership, with an increase of 100+ new members in the past year to 715 (from 50 different countries and from a variety of disciplines – with around 70% scientists). Over the past few months, comprehensive terms of reference and guidance documentation have been produced, approved and circulated, our internal and external communications have improved, and our Core Team and an ever-growing number of working group members have been even more engaged in numerous DOSI activities (Box 1).

Box 1: DOSI 2019-20 Highlights

- DOSI Governance documentation finalised and online
- Improved DOSI communications including new website and Instagram
- Increased membership
- BBNJ IGC1,2 & 3 – 7 policy briefs, 10 side-events, numerous interventions & side-meetings
- BBNJ stakeholder commentary submissions
- BBNJ-related workshops x 6
- ISA – 3 policy briefs, 2 side-events, numerous interventions and side-meetings
- ISA stakeholder commentary submissions
- Deep seabed mining-related workshops x 9
- New publications x 9
- DOSI Day (Monterey, USA)
- DOSI Special Session at DSBS
- Capacity development activities
- Further funding secured for DOSI
- Numerous outreach activities
- Engagement with the UN Decade

As a recap, the main thrust of our work concerns advancing science in policy, our current main focus being providing expert input to both the negotiations for a new UN treaty on Biodiversity Beyond National Jurisdictions (BBNJ) and the International Seabed Authority (ISA) mining regulations. DOSI is now a well-established UN observer and attends many events related to these issues, continuing to coordinate targeted scientific input to aid the formation of these high-level regulations. DOSI contributions come in the form of

policy briefs, peer-reviewed papers, reports, books, meeting and workshop participation, UN and ISA side-events, interventions and presentations. DOSI members continuously work hard to build relationships across disciplines and sectors in order to establish a broad knowledge among all stakeholders of the key science/environmental issues and the latest scientific results that may influence the management of the deep ocean. During the last year, DOSI has also continued to raise awareness of climate change in the deep sea and is planning for and promoting the deep ocean as a key component of the upcoming UN Decade of Ocean Science for Sustainable Development.

Again this year, we have been successful in leveraging funds for DOSI activities to organize stakeholder workshops, produce technical reports, and to increase participation (including for developing-nation and early-career scientists) in relevant meetings. Communication of important deep-sea research and stewardship matters across and beyond the network is an integral part of our work and, with a further increase in membership from a variety of stakeholders, and an injection of funding from Synchronicity Earth to improve and develop our communications strategy, we are now reaching further afield. We continue to pay close attention to our policy engagement strategy, to ensure that our activities are policy relevant without being policy prescriptive, and take care not to stray towards advocacy.

They say a picture paints a thousand words…. If you prefer words (7436 of them to be precise), see the full DOSI Annual Report to Arcadia Fund online. If not, above are a few pictures from some of our DOSI team in action (which may be preferable).

Meetings & Workshops

5th International Symposium on the Ocean in a High-CO_2 World

7 - 10 September 2020

Lima, Perú

Universidad Nacional Pedro Ruiz Gallo

The 5th Symposium on the Ocean in a High-CO2 World will take place in Lima, Peru from 7-10 September 2020. The Symposium is the place to share cutting-edge science in a rapidly developing frontier of research dealing with the science of ocean acidification and related stressors. The Symposium will feature keynote talks by some of the leading experts in the field, as well as special events on ocean acidification and aquaculture, carbonate chemistry and the Latin American Ocean Acidification Network (LAOCA). As with past symposia in this series, we anticipate GOA-ON to play an important role in presenting advancements in ocean acidification research.

For more information on the Symposium themes, abstract submissions and meeting details, please visit the Symposium website at http://www.highco2-lima.org.

Key dates:

6 March 2020: abstract submission deadline

15 April 2020: abstract and travel support applicants notified

5 June 2020: early registration closes

21 August 2020: registration closes

7 September 2020: on-site registration

Into the spotlight: Deep-sea inactive sulfide ecosystems

Cindy Lee Van Dover

(on behalf of the workshop participants)

Duke University, USA

Active hydrothermal vents in the deep sea are valued for their dense communities of strange organisms that rely on chemicals spewing from the seafloor for their sustenance. Every vent eventually becomes inactive. For decades, ecosystems associated with inactive vents were largely by-passed by the scientific community. Now that metal-rich massive sulfides of inactive vents have attracted the attention of an emergent deep-sea mining industry, there is a need to understand what organisms live in this habitat, and whether any of these organisms are endemic, are especially adapted to the inactive sulfide environment, or are particularly vulnerable. It was thus both timely and useful to discuss current environmental research on inactive sulfide ecosystems and to anticipate and prioritize research that may be undertaken to inform the regulation and monitoring of mining activities. To this end, the Global Ocean Biodiversity

Initiative (GOBI) partnered with the National University of Ireland (Galway) and the Pew Charitable Trusts to convene a workshop on ***Scientific Considerations for Environmental Management of Inactive Polymetallic Sulfide (PMS) Ecosystems.***

Thirty scientists from 15 countries met in Galway, Ireland in October 2019 to discuss definitions of inactive sulfide ecosystems, potential upside and downside environmental risks specific to mining inactive sulfide ecosystems, and environmental management needs specific to inactive sulfide ecosystems. A key challenge identified by participants is the paucity of scientific knowledge regarding the biodiversity and ecological characteristics of these ecosystems. Workshop participants will present their findings in both a scientific manuscript and in a science brief for the stakeholders of deep-sea mining, including the International Seabed Authority, the agency responsible for sustainable management of mining in Areas Beyond National Jurisdiction.

Deep reef ecosystems of the Western Indian Ocean: addressing the big unknown

Paris Stefanoudis[1,2], Sheena Talma[1], Kaveh Samimi-Namin[1,2] and Lucy Woodall[1,2]

[1]Nekton Foundation, UK, [2]University of Oxford, UK

Between 31.07.2018-09.08.2018 Nekton, in collaboration with the South African Institute of Aquatic Biodiversity (SAIAB), held a taxonomic workshop in Grahamstown in order to assess the biodiversity of the little known fauna and flora collected during two recent Western Indian Ocean (WIO) expeditions, the 2018 Wild Oceans Comoros deep reef survey, and the 2019 First Descent: Seychelles expedition.

During the first week a team of experts focused on identifying ~500 benthic specimens. Representing sponges (Dr Toufiek Samaai, Liesl Janson, Robyn Payne, *Department of Environmental Affairs, South Africa* and *University of Western Cape*), octocorals (Dr Monika Bryce, *Western Australia Museum*), hydroids (Dr Carlos Moura, *University of Azores*) and brittle stars (Dr Jennifer Olbers, *Ezemvelo KZN Wildlife*) groups. The second week was dedicated to training a number of early career researchers from the WIO (Seychelles, South Africa, Comoros) about the taxonomy of the major benthic groups found in those waters. The training involved hands-on practicals in the laboratory and lectures given by the experts present there, as well as by others who joined remotely, thus covering additional groups such as sea stars (Dr Chris Mah, *Smithsonian National Museum of Natural History*), black corals (Dr Daniel Wagner, *National Oceanic and Atmospheric Administration*), hard corals (Rowana Walton, *Nekton*) and octocorals (sampling and phylogenetics; Dr Kaveh Samimi-Namin, *Nekton / University of Oxford*, and Prof. Catherine McFadden, *Harvey Mudd College*). There was also a strong focus on identifying organisms from underwater imagery from footage brought by the participants, and address the challenges associated with that.

Figure 1 (top left). The sponge and octocoral team. From left to right: Liesl Janson, Lucy Woodall, Monika Bryce, Toufiek Samaai and Robyn Payne. Figure 2 (top right). During one of the hands-on practical sessions in the laboratory. Figure 3 (bottom). Group photo of all workshop participants in front of SAIAB.

It was two really productive weeks in SAIAB, which strengthened collaborations amongst scientists from the WIO and will help accelerate the analysis of the data collected during the Comoros and Seychelles expeditions. We are particularly thankful to SAIAB for being such excellent hosts and providing assistance with all associated logistics.

Additional post-workshop examination for some of the specimens is still ongoing, and involves further collaborations for example; sea urchins (Zoleka Filander, *Department of Environmental Affairs, South Africa*), crinoids (Dr Charles Messing, *Nova Southeastern University*), crabs (Dr Paul Clark, *Natural History Museum London*), shrimps (Dr Sammy De Grave, *Oxford Museum of Natural History*), and bryozoans (Dr Wayne Florence, *Iziko South African Museum*).

We are looking forward to holding similar taxonomic workshops over the next two years, following Nekton's future WIO expeditions in 2020-2021.

Deepwater Shark and Ray Red List Assessment Workshop

In November 2019, IUCN Species Survival Commission Shark Specialist Group (SSG) members and experts came together in Vancouver, Canada to assess the extinction risk of deepwater shark and ray species. Included in the assessment were gulper sharks, sleeper sharks, catsharks, and skates, amongst others. This was part of the global reassessment of all sharks, rays, and chimaeras for the IUCN Red List of Threatened Species being undertaken through the Global Shark Trends Project which is funded by the Shark Conservation Fund. The previous published assessments provided much of the taxonomic, distributional, and biological information so the focus of the workshop was on deepwater fisheries and population trends. Over five days, the workshop participants examined and discussed the analyses of population trend data and overlap with fisheries for each of the species and reached consensus for IUCN Red List categories. Following review and consultation with the SSG member network (~170 experts), the final assessments will be submitted for publication on the IUCN Red List of Threatened Species.

Meeting Announcement: The 16th Deep-Sea Biology Symposium

Moriaki Yasuhara

Deep-Sea Biology Society Conferences Officer, conferences@dsbsoc.org

The 16th Deep-Sea Biology Symposium will be held in Shizuoka City, Japan, during 7–12 November 2021.
The conference venue is MARINART: https://www.japanmeetings.org/plan-your-event/venue-search/detail.html?id=334
http://www.fieja.jp/shimizu-marinart/341.html
This conference will be co-organized by JAMSTEC, Shizuoka City, Tokai University, and the University of Hong Kong.

The conference venue MARINART is located at Shimizu Port: https://www.visit-shizuoka.com/en/spots/detail.php?kanko=522

Shimizu Port is an important international port in Japan (http://www.fieja.jp/shimizu-port/2968.html) with a beautiful view of Mt. Fuji (https://www.visit-shizuoka.com/en/gokuraku/content.php?t=23), and faces Suruga Bay, a unique deep-sea embayment (http://www.pref.shizuoka.jp/kensetsu/ke-410/surugabay/en/index.html).

We are looking forward to seeing many of you in Japan in two years' time.

7th International Symposium on Chemosynthesis-Based Ecosystems (CBE7)

23-28 August 2020, Brazil https://www.cbe7.com/

Dear Lovers of Chemosynthesis-Related Science,

We would like to remind you that the 7th International Symposium on Chemosynthesis-Based Ecosystems (CBE7) will be held between **23-28 August 2020** in Brazil. CBE7 represents the 7th iteration of a successful symposium series, that has already taken place in Europe (Portugal, France), North America (United States and Canada), and Asia (Japan). It is the premier meeting for scientists, explorers, managers, policymakers, industry specialists and students to exchange ideas and share knowledge of advances on chemosynthesis-based ecosystems.

We are looking forward to offering you and spending with you a very productive and pleasant week at Casa Grande Hotel Resort & Spa (more info: http://www.casagrandehotel.com.br/language/en/) located in Guarujá, on the north coast of São Paulo state.

Registrations and abstracts submission will open in **late January**. Please check our website for more information: https://www.cbe7.com/
BEM-VINDOS!

Organizing Committee: Camila Signori, Cristina Nakayama, Maurício Shimabukuro, Paulo Sumida & Vivian Pellizari
Oceanographic Institute, University of São Paulo Contact: cbe7brazil@gmail.com

The call for abstracts for the upcoming International Marine Conservation Congress in Kiel Germany from 24-27 August 2020 is now open. Please consider submitting to the below session focused on the deep sea!

Human Impacts and Stewardship in the Deep Ocean

The deep sea is the largest ecosystem on the planet, covering approximately 60% of the Earth's surface, most of which is unexplored and not yet understood. It harbors high biodiversity and provides services that are essential to the functioning of our planet. The deep sea also has a wealth of resources, including mineral deposits, fish and invertebrates as food sources, oil and gas, and novel biological compounds that, through technological developments, are increasingly being exploited. This combined with marine pollution, fishing, and climate change, as well as synergistic effects of these disturbances, are already having significant impacts in the highly-vulnerable deep ocean. As such, stewardship of deep-sea habitats and associated communities should be a priority. This includes gaining a better understanding of the deep sea worldwide, effectively managing deep-ocean resources, and mitigating potential impacts. While this is a challenge as the majority of these habitats are located on the high seas or in developing countries where the capacity and legal basis for intervention either do not exist or are nascent and under-equipped, the progress of several major multilateral negotiations, such as BBNJ, is heartening. Stakeholders such as the scientific community, industry, states, intergovernmental organizations, and NGOs must work together to make science matter and implement effective management and conservation actions for deep-sea ecosystems.

Please contact Diva Amon (divaamon@gmail.com), Andrew Thaler (andrew@blackbeardbiologic.com) or Angelo Villagomez (avillagomez@pewtrusts.org) for more information.

The Deep Sea at the UN

Aria Ritz Finkelstein

Woods Hole Oceanographic Institution Marine Policy Center

Late August 2019, the third in a series of four sessions on high seas biodiversity met at the United Nations for two weeks. The hope is that these meetings will culminate in an international legally-binding instrument (IBLI) to regulate the conservation and sustainable use of biodiversity beyond national jurisdiction (BBNJ) under the law of the sea convention (UNCLOS). It is too soon to say with certainty whether the negotiations will be successful in reaching an agreement, or to what extent such an agreement will be effective. Working through the details of the text is painstaking, and there are several points that might prove to be intractable. But, there are reasons for optimism. The delegates have approached the talks with a spirit of collaboration, and the talks have been fueled by the understanding that urgent action to protect the high seas is necessary. As representatives of WHOI's marine policy center, Dr. Porter Hoagland and I have participated in one of the preparatory meetings and two of the three sessions that have already happened.

The ILBI has the potential to define a management framework for almost half of the world's surface, but, surprisingly, the BBNJ talks have stayed largely out of the public consciousness. And, among those who are aware of them, there

is still great confusion as to their potential impacts. Perhaps this lack of clarity is not surprising—the talks encompass a number of complex issues, and any ILBI will relate to complex layers of institutional acronym upon acronym. For example, some have claimed that the talks might result in an outright ban on high seas fishing; while some ecologists would advocate for such a ban, it's simply not currently on the table at the BBNJ talks. What is more likely is that a resulting ILBI will work to fill existing legal gaps and to coordinate between different frameworks and sectoral, regional, and global bodies.

One conspicuous gap in the talks is attention to the entirety of the water column and especially to the mesopelagic zone. While we have highlighted the ocean's mesopelagic zone, or the twilight zone, in informal conversations and in a couple of interventions in the General Assembly, the talks have focused mainly on the surface waters and the seabed. Why does this matter? The twilight zone is that part of the sea defined by the depth between the point at which only a tiny amount of light reaches to that under which no light reaches. Scientists have only begun to discover the multitude of bizarre, fascinating creatures that inhabit it. What is already clear is that these organisms play an enormous role in regulating biogeochemical cycles, especially in actively transporting carbon to the sea floor, but we still have much to learn about their specific contributions.

Ensuring the sustainable use and conservation of the twilight zone is a point that all elements of the ILBI should address. The talks encompass four areas: Area based management tools including marine protected areas (ABMTs), environmental impact assessments (EIAs), marine genetic resources (MGRs), and capacity building and technology transfer (CB&TT), and there is a role for all of them to play in making sure we do not overexploit the twilight zone and that our use of it is equitable. The ILBI should support ABMTs in protecting vertical ecological linkages, not just horizontal ones; EIAs should consider the impacts of BBNJ uses, even those that take place on the surface or the seabed, on the entire water column; the twilight zone represents huge untapped potential for the discovery of MGRs, and the ILBI should recognize these as the common heritage of mankind so that not only the wealthiest, most industrialized states have access to them; and an ILBI should include a framework for states, including developing nations, to contribute to twilight zone research and conservation. Finally, given how much we have yet to learn about the twilight zone and its role in supporting life on earth, an ILBI should enshrine a precautionary principle for exploiting it.

What are some ways deep sea biologists can contribute to the BBNJ process? First, by continuing to piece together the twilight zone's role in sustaining life on earth. Second, by working to understand the impacts of human activities on its functions. Third, by modeling predictions for how climate change might affect its biogeography and how our uses of the high seas might best prepare for these changes. Fourth, by honing their ability to communicate complex deep sea system functions with policy-makers and the general public. And, finally, and perhaps most importantly, by continuing to share discoveries of the twilight zone's awe-inspiring organisms, their magical adaptations, and their strange beauty.

Conference website: **www.wcmb2020.org**

To discover things to see and do in Auckland and New Zealand, go to **newzealand.com**

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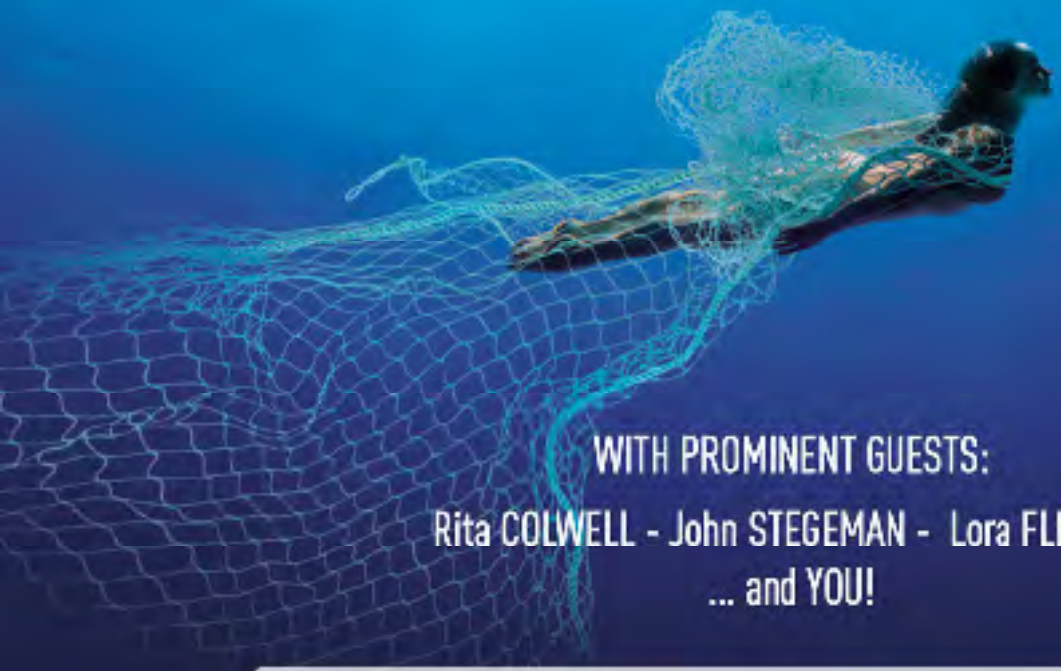

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Scientist Profiles

Henry Joseph Horacek

PhD Student

Florida State University, USA

I am a second year PhD student at Florida State University, Biological Sciences Department, under supervision of Dr. Jeroen Ingels (@Meiolab, FSU Coastal and Marine Lab) and for my dissertation I am investigating meiofaunal assemblages (density, higher taxa community composition) and meiofaunal nematode assemblages (density, abundance, diversity, community composition) as well as genetic connectivity between disparate populations of meiofaunal nematodes. In February, I was able to go on the EPIC cruise aboard the RV *Mirai* to take samples from the Atacama Trench and different seamounts in the Southeast Pacific Ocean. I also plan to take sediment samples from Apalachee Bay, Florida. Initial results indicate that the densities of meiofauna at these seamounts are much lower than is normally expected for deep-sea sediments. In 2018 I received an M.S. in Biology from Winthrop University (South Carolina, USA), and my dissertation focused on whether cryptic speciation had occurred for two different morphospecies of meiofaunal flatworms in North Carolina and Florida. I found evidence that one morphospecies (Onslow Bay, North Carolina) did not undergo cryptic speciation, and that another morphospecies comprised in fact two different cryptic species: one in Onslow Bay (North Carolina) and one in Northwest Florida.

Steven Auscavitch

PhD Candidate

Department of Biology, Temple University, Philadelphia, PA, USA

Contact: steven.auscavitch@temple.edu

Google Scholar: https://scholar.google.com/citations?user=k-Foh_4AAAAJ&hl=en

I am a fifth-year PhD candidate studying the biogeographic patterns of deep-water corals on seamounts. My dissertation research has focused on characterizing the distribution, diversity, and community structure patterns of deep-water corals at bathyal depths from exploratory ROV video datasets in the Anegada Passage (Caribbean Sea), the Phoenix Islands, and seamounts off the western margin of Costa Rica. Specifically, I am interested in identifying the role that widespread oceanic water masses have on species ranges and community similarities across large geographic areas. As water mass boundaries are among the sharpest environmental gradients at bathyal depths, understanding how benthic fauna responds to these changes can better inform about patterns of biodiversity in the deep-sea. My research has also helped improve species inventories and baseline knowledge of deep-water coral community assembly across

data deficient localities and remote features, like seamounts.

I also have an interest in investigating phylogenetic community patterns of deep-water benthic megafauna in the equatorial Pacific Ocean. As a result of recent explorations, I have been constructing a DNA barcode database of deep-sea coral collections, with the greatest diversity from octocorals, with the goal of better understanding how evolutionary processes and history influence community assembly in remote parts of the Pacific deep ocean. In addition, a number of recent collections from the central and eastern Pacific have yielded several potentially new species that would benefit from further description and systematic assessment.

I am currently seeking postdoctoral opportunities that focus on addressing questions of change in deep-sea benthic species or communities across environmental gradients using demographic and/or phylogenetic approaches.

Opportunities

ASSEMBLE Plus celebrates its successful access programme, and launches a sixth call

Georgia Bayliss-Brown[1] & Andrea Tarallo[2]

[1]AquaTT, Dublin, Ireland; [2]SZN, Italy

Members of the ASSEMBLE Plus partnership met from 9th–12th September in Naples, Italy, for almost of week of meetings as part of a project review, General Assembly and Project Implementation Committee meeting. The project's Joint Research Activities were reported to be on-track and updates on their activities featured in the ASSEMBLE Plus newsletter issued at the end of October 2019.

ASSEMBLE Plus' most notable news was in relation to its Transnational Access (TA) programme. This programme supports research projects in marine biology and ecology, providing access to facilities and research services for marine biology to researchers from academia and industry at more than 30 partner institutes. The objective of this programme is to enable researchers to carry out their own research projects, offering them free access to platforms and marine biological resources not available in their own institutes, also gaining the opportunity to establish new scientific collaborations.

Since its initiation in January 2018, the TA programme has received more than 250 project proposals from European and non-European researchers. Researchers who have been granted access to ASSEMBLE Plus marine stations have reported enthusiastic success stories.

The last call for the TA programme will close in April 2020, and on-site and remote access to our facilities will be granted until January 2021. The next deadline for submission (for access during April to September 2020) is 9 February 2020. ASSEMBLE Plus covers all access costs for your project up to 30 days. Up to two persons per project can apply for sponsorship for their travel, accommodation and meals costs.

If you are interested in learning more about the TA programme and applying, please visit assembleplus.eu/access/transnational-access or get in touch with our access officer at assembleplus_ta@embrc.eu.

You can follow updates of our project on Twitter at @ASSEMBLE_Plus

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Special Issue "Marine Mapping and Monitoring using Autonomous Underwater Vehicles (AUVs)"

A special issue of Remote Sensing (ISSN 2072-4292).

Call for manuscript submissions. Deadline: 31 May 2020

Autonomous Underwater Vehicles (AUVs) can now provide an unprecedented increase in both resolution and seafloor

coverage available for marine research. AUVs can cover large distances at high speeds or maneuver in complex terrain, and their low altitude above the seafloor enables data resolutions orders of magnitudes higher than ship-based sensors have been able to provide. Their ability to automatically map contiguous areas of interest, as well as to explore unknown territory using a range of survey approaches increases the cost-efficiency of ocean science. AUVs are also robust platforms for a variety of imaging sensors, like cameras and echosounders, as well as traditional ocean science gear like CTDs. More recent developments are incorporating novel technologies such as eDNA samplers or artificial intelligence for adaptive mission planning, increasing further the versatility of these platforms.

This Special Issue focuses on two aspects of AUVs. First are applications of these versatile platforms for mapping and monitoring the seafloor. This includes, amongst others, biological, geological, archaeological and infrastructure surveying tasks. The second focus is on the AUV platform itself: its efficient deployment to solve specific mapping or monitoring tasks, its evolving capabilities regarding sensor payload, its expected progress from the automated, (in essence pre-programmed), execution of a task towards true autonomy.

Guest Editors:

Dr. Timm Schoening
DeepSea Monitoring Group, GEOMAR Helmholtz Centre for Ocean Research Kiel, 24148 Kiel, Germany
Interests: image analysis; pattern recognition; machine learning; seafloor observation; high-performance computing; Autonomous Underwater Vehicles

Dr. Katleen Robert
School of Ocean Technology, Fisheries and Marine Institute of Memorial University, St John's, NL, A1C 5R3, Canada
Interests: seafloor and habitat mapping; cold-water corals; spatial ecology

Manuscript Submission Information here

Social Media and Science Communication Coordinator, Louisiana, USA

A Social Media & Science Communication Coordinator is sought for employment at the Louisiana Universities Marine Consortium (LUMCON). Science communication strategies at LUMCON focus on innovation and seek to catalyze change through that innovation. One of our highest priorities is experimenting with how our scientists and our brand interact with the public and our peers, rather than just following the status quo. We primarily use digital platforms to reach others, with a heavy investment in social media. LUMCON's Social Media Program is the digital version of LUMCON, which connects people, enriches communities, and transforms understanding of coasts and oceans. We are looking for someone who has a passion for all things social media and content development. Above all, we are looking for someone who has the same passion for marine science that we do.

The position will be based at the LUMCON Marine Center in Cocodrie, LA (http://lumcon.edu).
Duration and Start Date: Appointment is for 2 years, depending upon satisfactory performance, with a possibility of extension. The position is available immediately. Send a cover letter addressing each of bulleted points above, curriculum vitae or resume, three examples of science communication (e.g. blog posts, videos, articles, Facebook campaigns, etc.), and the name, address, phone and email contact for at least three individuals qualified to comment on your science communication work to hr@lumcon.edu. Review of applications will begin February 15, 2020 and continue until the position is filled.

Download a PDF description of this position.

Fisheries Oceanographer/Protistan Biologist/Sea-Going Benthic Ecologist - Assistant Professor, Scripps Institution of Oceanograpy, USA

https://apol-recruit.ucsd.edu/JPF02287
Recruitment Period Open date: October 16, 2019
Next review date: Friday, Dec 20, 2019 at 11:59pm (Pacific Time)
Apply by this date to ensure full consideration by the committee.
Final date: Friday, Dec 20, 2019 at 11:59pm (Pacific Time)
Applications will continue to be accepted until this date, but those received after the review date will only be considered if the position has not yet been filled.

PhD project on The dynamics of deep-water vertical habitats, Fisheries and Marine Institute of Memorial University

We seek a PhD student to study megabenthic species distribution (including cold-water corals) from ROV video footage to be acquired as part of a planned 2021 research expedition to the Galapagos. Cold-water corals (CWCs) represent important, though vulnerable, marine ecosystems. Yet, owing to technological limitations, CWC reefs attached to vertical cliffs have been undervalued. Using a multi-disciplinary approach, the aim of this project will be to understand the links between environmental settings, CWC habitat complexity and biodiversity of associated communities. The student will be expected to (1) reconstruct vertical coral cliffs in high resolution using laser-scanning, multibeam or structure-from-motion datasets, (2) investigate how geological characteristic, terrain characteristics and hydrodynamic patterns influence the habitat complexity created by coral skeletons, and (3) quantify how different species exploit this complexity. Required skills include a quantitative background in ecology or marine biology, and a good knowledge of a programming language (e.g. R). Previous experience acquiring or processing acoustic or video data will be considered a strong asset.

To apply, please contact Katleen Robert (Katleen.robert@mi.mun.ca) with a CV and a cover letter stating your main research interests. Please also mention how you learned about this opportunity.

Closing date: until fulfilled
Prospective start date: September 2020
Salary: 21,000 CAD (4 years)
Please visit: https://www.mi.mun.ca/graduateopportunities/

PhD Scholarship in the Law of the Sea

Purpose: The Faculty of Law, UNSW Sydney, wishes to offer a PhD Scholarship to support a student with outstanding research potential in the Law of the Sea. It is intended that the successful applicant will commence their studies in Term 2 or 3 of 2020. The Scholarship is to support a specific Faculty member and their projects (see details below).

Deadline: Monday 4 February 2020, by 10 am (AEST)

Amount: The stipendiary component of the scholarship shall be equivalent to the value of the yearly RTP Scholarship rate (for 2018, this rate is AUD $28,092 p.a.), together with Faculty top-up (AUD $5,000 p.a.). Where an international applicant is selected for a Scholarship, the Faculty will support an application for a Tuition Fee Scholarship (TFS) to meet

the cost of international tuition fees, provided the applicant meets the criteria for the award of a TFS. The award of the Scholarship will be conditional on the award of the TFS.

Tenure: Up to 3.5 years, subject to satisfactory progress.

Eligibility: Applicants may be Australian citizens, permanent residents or international. Students currently enrolled in or holding an offer to commence a full-time PhD in the UNSW Faculty of Law in 2019 may apply, provided that, by the application deadline, they shall have been enrolled for no longer than twelve months and they are not already holding or have been offered a scholarship for study at UNSW.
The Scholarship is for study on a full-time basis only, unless there are exceptional personal or medical circumstances that would require study on a part-time basis for all or part of the PhD program.
This Scholarship is not open to students already enrolled in a PhD program elsewhere.

Residency requirement: Applicants must pursue their PhD research in Sydney.External study is not permitted. The Law Faculty reserves the right to discontinue the Scholarship in the event that the successful applicant ceases to be resident in Sydney.
International applicants are responsible for securing any necessary visas to enable study based in Sydney.

Selection criteria: All applicants must possess:

- an undergraduate degree in Law or a related discipline at a 2i honours level (or equivalent); or
- a postgraduate qualification in Law or a related discipline with an average that equates to a Distinction average at UNSW (75%); or
- equivalent research or professional experience, supported by references and a detailed CV.

International applicants must also meet UNSW English language requirements.
Previous research experience, including completion of a research thesis and / or publications is strongly encouraged.
Selection will be based on (a) the applicant's academic qualifications, (b) the quality of their research proposal, (c) the applicant's prior research experience and potential, (d) the fit between the proposal and the focus areas of the Scholarship.

Details of Available Scholarship: This PhD scholarship is available to participate in a project, led by Professor Natalie Klein, addressing the enhancement of maritime security through informal lawmaking. Proposals would be particularly welcome considering informal lawmaking in different areas of the law of the sea. Preference will be given to proposals that have a multilateral or regional perspective rather than focusing on the law and policy of one particular country. Multidisciplinary perspectives on the issues being assessed are encouraged.

How to Apply: Applicants must complete the Application Form for the Law of the Sea PhD Scholarship. Application forms are available either by emailing Jenny Jarrett on j.jarrett@unsw.edu.au or to download online:

Research Fellow

Marine Biology & Ecology

Location: National Oceanography Centre Southampton
Salary: £30,942
Full Time Fixed Term (until 31/05/2022)
Closing Date: Thursday 06 February 2020
Reference: 1224520HN

Further info: https://jobs.soton.ac.uk/Vacancy.aspx?ref=1224520HN

Applications are invited for the post of Research Fellow in Marine Ecology at the University of Southampton, based at the National Oceanography Centre, Southampton on a fixed term basis until 31/05/2022. The successful candidate will investigate the implications of organism trait variability and environmental change for ecosystem functioning in marine soft sediment systems, and projections of marine ecosystem futures using hypothesis-led laboratory experiments.

Under the direction of Dr. Jasmin Godbold, research will investigate specific organism traits that make species more or less vulnerable to environmental change and quantify how variation in trait expression in surviving communities influence sediment ecosystem functioning. Funded by UKRI NERC, the position will involve direct collaboration with the Centre for Environment, Fisheries and Aquaculture Science (Cefas, Dr. Clement Garcia, Dr. Stefan Bolam and Dr. Ruth Parker) and the University of Hull (Dr. Jörg Hardege and Dr. Katharina Wollenberg-Valero) and associated stakeholders.

The successful candidate will have a PhD* or equivalent professional qualification in marine biology/ecology or related discipline and have an understanding and knowledge of the ecosystem consequences of environmental change in marine ecosystems. The successful candidate will be coordinating and conducting the fieldwork and mesocosm experiments and will be responsible for data analysis and write-up for publication, and will also be expected to contribute to the wider research environment within the research group.

*Applications will be considered from candidates who are working towards or nearing completion of a relevant PhD qualification. The title of Research Fellow will be applied upon completion of PhD. Prior to the qualification being awarded the title of Senior Research Assistant will be given

Enquiries about the post should be made by email to Dr. Jasmin Godbold, j.a.godbold@soton.ac.uk.

Pacific Community
Communauté du Pacifique

Job Title: Fisheries Molecular Geneticist
Division/Programme and Section/Project: Fisheries and Ecosystem Monitoring and Analysis (FEMA) Section, Oceanic Fisheries Programme (OFP), FAME Division
Location: Noumea
Responsible To: Principal Fisheries Scientist (Fisheries and Ecosystem Monitoring and Analysis)
Responsible For:No direct staff line-management responsibilities

Job Purpose:The purpose of the job is to undertake a programme of work that supports the fisheries and ecosystem monitoring and analysis objectives in the FAME Business Plan. This is to be achieved through the use of genetic/genomic methods and analyses and interpretation of genetic/genomic information to develop advice that supports the assessment and management of the tuna stocks and associated species in the SPC and adjacent areas.

Deadline Date: 9th February 2020 (11.30pm Noumea time)
Further Information: Link

Mary Derrickson McCurdy Visiting Scholar

The Division of Marine Science and Conservation in the Nicholas School of the Environment at Duke University invites applicants for the **Mary Derrickson McCurdy Visiting Scholar** position at its Marine Laboratory in Beaufort, North Carolina.

We seek an early-career scholar who has completed a higher degree and who wishes to undertake self-directed study and participate in faculty activities, or a scholar at any level interested in a creative interlude. Originality and collegiality—rather than any specific research area—are our primary criteria in selecting our McCurdy Scholars. The successful applicant is expected to contribute to the intellectual life of the Marine Laboratory and to engage with members of the resident faculty.

The Marine Laboratory is home to a diverse faculty of natural and social scientists, with strong ties to colleagues in the Nicholas School of the Environment on Duke's Durham campus. Division faculty are at the forefront of generating new knowledge about the science, conservation, and restoration of marine systems and in using this knowledge to inform local, state, national, and international policy. We achieve this through leadership in research, interdisciplinary collaborations, training, communication, and inclusion. We value diverse ways of knowing, understanding, and learning.

We encourage applicants from across the spectrum of Marine Science and Conservation, broadly construed, including (but not limited to) coastal/deep-sea/microbial ecology, oceanography, toxicology, coastal restoration, ocean governance, climate change, marine technology, science communication, environmental law, political ecology, fisheries management, anthropology, the Arts, economics, coastal and marine livelihoods and well-being. Support is available for salary, travel, and research for a 9-month (or longer) appointment beginning late-summer/fall 2020.

Interested individuals should apply through AcademicJobsOnline. See **Job # 15820**. A one-page cover letter, curriculum vitae, summary of research interests, pdfs of up to three publications (or evidence of other substantive contribution), and contact information for three references are required.

Further inquiries may be directed to the search committee chair, Professor Cindy Van Dover (McCurdy Scholar, 1994-1995): clv3@duke.edu. The search committee will begin reviewing applications **20 February 2020** and will continue until the position is filled.

Duke aspires to create a community built on collaboration, innovation, creativity, and belonging. Our collective success depends on the robust exchange of ideas—an exchange that is best when the rich diversity of our perspectives, backgrounds, and experiences flourishes. To achieve this exchange, it is essential that all members of the community feel secure and welcome, that the contributions of all individuals are respected, and that all voices are heard. All members of our community have a responsibility to uphold these values.
Duke University is an Affirmative Action/Equal Opportunity Employer committed to providing employment opportunity without regard to an individual's age, color, disability, genetic information, gender, gender identity, national origin, race, religion, sexual orientation, or veteran status.

PhD fellowship on marine biodiversity, climate change and conservation

A PhD fellowship is available at the Faculty of Biosciences and Aquaculture, Nord University (Bodø, Norway) as part of the establishment of a new research unit in the Ecology Research Group under the leadership of Professor Mark J. Costello. The position is for three years and will be available from 1st March 2020.

The proposed research concerns how to improve predictions of the effects of climate change on the ocean environment and biodiversity, particularly in relation to temperature and oxygen. It is envisaged this research will make use of biodiversity informatics, and may involve development of databases of biodiversity data from the literature. It may also include field studies using seasonally stratified Norwegian fjords as experimental sites, and/or field surveys to test hypotheses about the effects of temperature and oxygen on marine biodiversity. The details of the research will aim to build on both Professor Costello's and the candidates' strengths and interests.

Further information about the position can be obtained by contacting :
Professor Mark Costello (e-mail: m.costello@auckland.ac.nz)

Applications must be submitted electronically by January 27th, 2020
Further information: https://www.jobbnorge.no/en/available-jobs/job/179400/phd-fellowship-on-marine-biodiversity-climate-change-and-conservation

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Call for nominations to the 2020 GBIF Young Researchers Award

15 May 2020 deadline for nominating graduate students whose innovative research relies on biodiversity data from the GBIF network

On behalf of the network of national Participants, the GBIF Secretariat is pleased to invite nominations for the 2020 Young Researchers Award. This annual programme aims to foster and recognize innovative research and discovery in biodiversity informatics by graduate students whose master's and doctoral studies rely on GBIF-mediated data.

As in previous years, the 2020 programme will provide a pair of €5,000 prizes recognizing the work of two graduate students—preferably, one master's and one PhD candidate—nominated by GBIF Participant countries.

A jury organized by GBIF Science Committee will select two award recipients from the pool of nominees whose names are received by the GBIF Secretariat by 15 May 2020. The winners will be announced in late summer or early fall 2020. While the deadline for receipt of nominations at the GBIF Secretariat is 15 May, local deadlines do apply!

We will post national deadlines here as we receive them and post notifications through the GBIF Twitter feed using the hashtag #YoungResearchers).

Eligibility - Candidates must be enrolled in a university graduate programme to be eligible for the award. Candidates

must be either
a) citizens of a country participating in GBIF
or
b) students at an institution located in a GBIF participant country

Nominations can come from the GBIF delegation of either the candidate's country of citizenship or the country of the candidate's host institution.

For further information and deadlines see website

"The future of the ocean beyond national jurisdiction" – Call for articles

The **ICES Journal of Marine Science (ICES JMS)** strives to advance marine science by making judicious use of themed article sets (TSs). TSs are series of coordinated contributions – introduced by a synthetic overview - on a selected topic. Both individually and collectively, TSs are instrumental in focusing attention, triggering opinions and stimulating ideas, discussion and activity in specific research fields.

We invite you to participate in a TS on **"The future of the ocean beyond national jurisdiction"**.
This TS builds on the earlier one, *Biodiversity beyond national jurisdiction*.

For areas beyond national jurisdiction (ABNJ), the years 2020 and 2021 are of pivotal importance, with the conclusion of the **Intergovernmental Conference on Marine Biodiversity in Areas Beyond National Jurisdiction (BBNJ)** and the potential finalization of a mining code for exploitation of the deep seabed. Looking beyond seabed mining and the "package" of issues covered by the mandate of the BBNJ negotiations, many other major issues of relevance for ABNJ remain: addressing pollution (e.g. plastics) in ABNJ; making best use of emerging technologies for enforcement and compliance; improving performance of regional fishery management organizations; conducting science in the most remote parts of the world; etc.

The objective of this TS is to bring together forward-looking contributions related to ABNJ, and the suite of governance tools and challenges that will shape its future. Of particular interest are contributions that connect the latest scientific understanding of ABNJ with existing and emerging governance mechanisms for addressing the conservation and sustainable use of its resources and ecosystems. We welcome contributions on the following topics, among others.

Elements of the BBNJ negotiations:

- Area-based management tools (e.g. prioritizing areas in ABNJ for protection; improving coordination across existing sectoral designations such as Vulnerable Marine Ecosystems (VMEs), Particularly Sensitive Sea Areas (PSSAs), etc.)
- Marine genetic resources sourced from ABNJ (e.g. quantification of current extent of use and benefits accrued, databases of genetic sequence data, disclosure of origin of marine genetic resources)
- Environmental impact assessments and strategic environmental assessments
- Capacity building and transfer of marine technology

Other relevant issues:

- Addressing and remediating pollution (e.g. plastics)
- Issues of ecological connectivity and the implications of management of marine populations in the context of climate change related biogeographic shifts (spatial and temporal) involving ABNJ.
- Translating big data (e.g. Global Fishing Watch data and improved performance by RFMOs) into action
- Cross-cutting issues (e.g. financing and optimizing monitoring, control and surveillance)

- Resource management implications of access to new regions of the oceans (e.g. as a result of receding ice or development of mesopelagic and deep water trawling technology)

You are welcome to invite colleagues to co-author your contribution and to circulate this invitation to anyone who you think would be interested in contributing.

In addition to original research articles, contributions can take the form of a review, a "Food for Thought" essay in which you present a thought-provoking or controversial issue, or a "Quo Vadimus" essay in which you describe what you see as the future of the field, question or issue.
For further information see: https://academic.oup.com/icesjms/pages/themed_sets

The deadline for submissions is 3 April 2020. You can also submit at any time before the deadline (your article will be published online as soon as it is finalized – it will not be held back until the TS is complete). We would appreciate receiving an indication of your interest in contributing at your earliest convenience.
We hope that you will accept this invitation and look forward to hearing from you. Yours sincerely,
Robert Blasiak, Mark Gibbs, Wesley Flannery, Lori Ridgeway, Alf Håkon Hoel, Andrew Serdy and Howard Browman
Editors, ICES JMS

Special Issue "Deep-Sea Crustaceans: Biodiversity, Ecology and Conservation"

A special issue of Diversity (ISSN 1424-2818)
Call for manuscript submissions. Deadline: 31 January 2020

Prof. Marina R. Cunha
Guest Editor
Universidade de Aveiro, Aveiro, Portugal

In the 1960s, the discovery that deep-sea biodiversity is much greater than that of other ecosystems dramatically changed our perception of life on Earth and fostered a rich and lively debate of ecological and evolutionary hypotheses on global biodiversity patterns and processes. The technological advances of underwater exploration permitted direct observations and manipulative experimentation, increasing our knowledge of unique organisms and diverse seascapes of the deep sea; despite that, though, the deep sea remains largely unknown. Moreover, along with the growing pressures on deep-sea ecosystems and the services they provide, there is currently an increased awareness of the extended human footprint and the need for a robust and science-based response to the global threats imposed to this remote domain.
Crustaceans are probably the most specious group of marine organisms. They can form both monospecific swarms with high densities and highly diverse assemblages; they can be found in most habitats at all depths of the oceans; they display a variety of feeding habits and reproduction modes; and their populations constitute important resources that are, in some cases, intensively exploited. This Special Issue intends to highlight new research and advances on the knowledge of deep-sea crustaceans addressing: (i) their diversity and distribution (both pelagic and benthic); (ii) aspects of feeding ecology and life cycle; (iii) overexploitation, and other threats and conservation aspects. Other innovative aspects and breakthroughs in deep-sea crustacean biology will also be considered.

Prof. Marina R. Cunha
Special Issue Editor (Guest Editor)
Manuscript Submission Information here

Wanted

Wanted! Holothurian Specimens

Dear Colleagues,

I am a PhD student at Queen's University Belfast studying the impact of taxonomy and systematics on deep-sea biodiversity (supervisor Dr Julia Sigwart).
I am looking for comparative ***Peniagone*** and ***Psychropotes*** specimens for use in the taxonomic description of new species from the Indian Ocean. I am also looking for ***Scotoplanes*** specimens preserved in ethanol for use in a phylogenetic study.
Please contact me (ethomas07@qub.ac.uk) if you have or know of any available specimens.

Many thanks!
Elin Thomas

Email: ethomas07@qub.ac.uk
Twitter: @elinthom

Wanted

I'm looking for anyone going on on a cruise soon who might collect the octocoral *Primnoa pacifica* from a deep location (>250m). We're investigating reproductive differentiation between deep and shallow populations and are looking for polyps to be preserved for TEM analysis. We can provide methodology, chemicals, containers and shipping, and even a student to come and aid in collections and preservation if there is space.

Contact: Dr. Rhian G. Waller, rhian.waller@maine.edu

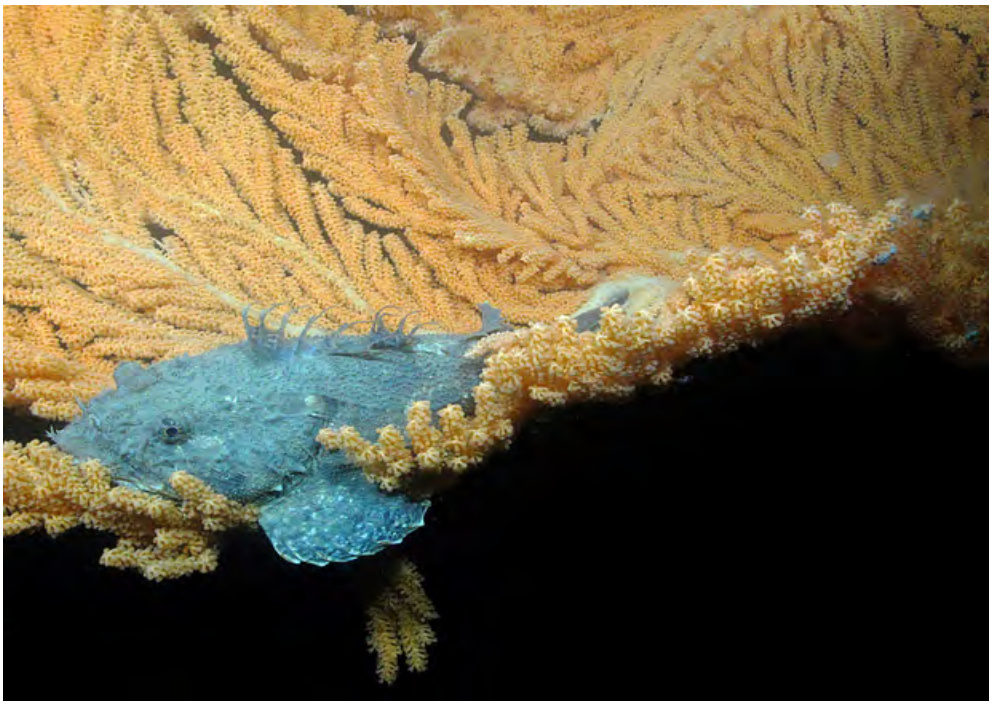

Figure 1. A sculpin taking a rest on a *Primnoa pacifica* colony in Glacier Bay National Park and Preserve. Courtesy of the Deepwater Exploration of Glacier Bay National Park expedition and UCONN-NURTEC.

We are looking for viperfish specimens (ideally with tissue samples) from all over the world to expand our knowledge on these little-known fishes.

We are Masters student Eva Paulus (University of Groningen, Netherlands) and PhD student Frederic Schedel (Bavarian State Collection of Zoology, Germany) working on the genus Chauliodus morphologically and would like to expand our efforts to genetics, as well as further developing our morphological dataset.

Do not hesitate to contact us, we are able to travel or send documentation for shipping so it's not a hassle for you.

Email: e.paulus@student.rug.nl
Tel: +49176 644 68100

Hot off the Press

Amid fields of rubble, scars, and lost gear, signs of recovery observed on seamounts on 30-to 40-year time scales

Baco, A. R., Roark, E. B., & Morgan, N. B. (2019)

Science Advances, 5(8), eaaw4513

Although the expectation of lack of resilience of seamount vulnerable marine ecosystems has become a paradigm in seamount ecology and a tenet of fisheries management, recovery has not been tested on time scales >10 years. The Northwestern Hawaiian Ridge and Emperor Seamounts have experienced the highest documented fish and invertebrate seamount fisheries takes in the world. Surveys show that, despite visible evidence of substantial historic fishing pressure, a subset of these seamounts that have been protected for >30 years showed multiple signs of recovery including corals regrowing from fragments and higher abundances of benthic megafauna than Still Trawled sites. Contrary to expectations, these results show that, with long-term protection, some recovery of seamount deep-sea coral communities may be possible on 30- to 40-year time scales. The current practice of allowing continued bottom-contact fishing at heavy trawled sites may cause damage to remnant populations, which likely play a critical role in recovery.

Link to paper: https://advances.sciencemag.org/content/5/8/eaaw4513

Habitat suitability and environmental niche comparison of cold-water coral species along the Brazilian continental margin

Barbosa, R. V., Davies, A. J., & Sumida, P. Y. G. (2019)

Deep Sea Research Part I: Oceanographic Research Papers, 103147

In face of increasing anthropogenic disturbance in the deep sea, it is a priority to better understand the regional distribution of cold-water corals (CWC). These organisms create some of the most species-rich habitats in the deep sea and, for this reason, they must be properly protected and managed. In this study, we aimed to identify suitable habitat for multiple CWC taxa off the Brazilian continental margin and compare their environmental niches. Habitat suitability models were developed using the Maxent approach, which allowed for the prediction of species distribution and for the identification of potential 'hot spot' areas that may be important for biodiversity conservation. Ecological niches were determined by a PCA-env approach, and niche similarity and equivalence were evaluated based on niche overlap using the Schoener's D metric. Potentially suitable habitat for Octocorallia covered a broad latitudinal range encompassing nearly the entire Brazilian continental margin, whereas Scleractinia had greater potentially suitable habitat in the Central and Southern areas. Scleractinian species were observed to slightly differ in their environmental niche, with non-reef-forming species being more tolerant to a wider range of environmental conditions in comparison with reef-forming species, inhabiting a wider area of the South American continental margin. Due to the high potential suitability for several CWC species, the Central and Southern parts of the Brazilian continental margin should be considered as potential areas high CWC diversity. Considering the current state of the art and strategic assessment tools, these areas are important targets for conservation, management, and environmental impact assessment. Most

reef-forming species had similar but not directly equivalent ecological niches, indicating that mapping efforts and management planning should consider CWCs at the species level.

Link to paper: https://www.sciencedirect.com/science/article/pii/S0967063719302936?via%3Dihub

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Inclusive innovation: Enhancing global participation in and benefit sharing linked to the utilization of marine genetic resources from areas beyond national jurisdiction

Collins, J. E., Harden-Davies, H., Jaspars, M., Thiele, T., Vanagt, T., & Huys, I. (2019)

Marine Policy, 109, 103696

Negotiations for a new international legally binding instrument under the United Nations Convention on the Law of the Sea for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (ABNJ) have commenced. For the new agreement to be fair and effective, it is vital that all States are able to participate in the long-term sustainable use and conservation of the ocean beyond national jurisdiction. This includes participation in marine scientific research and the utilization of marine genetic resources (MGR) through subsequent innovation processes. Open access to MGR, such as data, coupled with capacity building, can promote the equitable sharing of benefits associated with MGR. In this paper, it is hypothesized that an 'inclusive innovation' approach may facilitate participation and promote enhanced engagement in the conservation and sustainable use of biodiversity beyond national jurisdiction. A number of existing genetic resource initiatives provide examples of efforts to foster inclusivity in the innovation process, including BioBricks, Open Source Drug Discovery, GenBank and the Global Genome Biodiversity Network. An analysis of these examples enables clear identification of common elements that are adopted by such initiatives, whereby inclusive innovation either develops naturally or is promoted actively through measures for open access, capacity building, and collaboration. By empowering more States and stakeholders to participate in research and innovation processes, global potential in terms of enhanced scientific knowledge and opportunities associated with biodiversity of ABNJ can be promoted and the overall objective of the conservation and sustainable use can be best pursued.

Link to paper: https://www.sciencedirect.com/science/article/pii/S0308597X19301393

The unknown and the unexplored: insights into the Pacific deep-sea following NOAA CAPSTONE expeditions

Kennedy, B. R., Cantwell, K., Malik, M., Kelley, C., Potter, J., Elliott, K., Lobecker, E., McKenna Gray, L., Sowers, D., France, S. & Auscavitch, S. (2019)

Frontiers in Marine Science, 6, 480

In 2017, NOAA and partners wrapped up one of the largest US ocean exploration efforts ever conducted, which was a 3-year, Pacific-wide field campaign entitled CAPSTONE: Campaign to Address Pacific monument Science, Technology, and Ocean NEeds. Under the auspices of CAPSTONE, NOAA mapped 597,230 km2 of the Pacific seafloor (with ~ 61% of mapped area located within US waters), including 323 seamounts, conducted 187 remotely operated vehicle (ROV) dives totaling 891 hours of ROV benthic imaging time, and documented more than 347,000 individual organisms. This

comprehensive effort was detailed and analyzed for the first time in a recent paper published in Frontiers in Marine Science.

This article is the first comprehensive look at the dataset generated during CAPSTONE. Specifically, this study quantified the number of organisms that were unidentifiable via video, which will give researchers a benchmark for expected diversity. For example, the study found that fewer than 20% of the ROV-visualized species were able to be identified. The most abundant and highest diversity taxa across the dataset were from Cnidaria, Porifera and Echinodermata. The study further examined taxonomic assemblage patterns by depth, geographic region, and geologic feature. Within each taxa, there were multiple genera with specific distribution and abundance by depth, region, and feature. In addition to these (and other) analyses, the article contains a comprehensive documentation of the methods used by NOAA during CAPSTONE; these detailed methods are meant to be used as a guide and reference for other researchers interested in using this publicly available dataset.

Despite the incredible amount of new known and unknown information about the Pacific deep sea, CAPSTONE is far from the culminating experience the name suggests. Rather, it marks the beginning of a new era for exploration that will offer extensive opportunities via mapping, technology, analysis, and insights.

Link to paper: https://www.frontiersin.org/articles/10.3389/fmars.2019.00480/full

Response of deep-sea deposit-feeders to detrital inputs: A comparison of two abyssal time-series sites

Durden, J. M., Bett, B. J., Huffard, C. L., Pebody, C., Ruhl, H. A., & Smith Jr, K. L. (2019)

Deep-Sea Research II, doi: 10.1016/j.dsr2.2019.104677

Biological communities on the abyssal plain are largely dependent on detritus from the surface ocean as their main source of energy. Seasonal fluctuations in the deposition of that detritus cause temporal variations in the quantity and quality of food available to these communities, altering their structure and the activity of the taxa present. However, direct observations of energy acquisition in relation to detritus availability across megafaunal taxa in abyssal communities are few. We used time-lapse photography and coincident measurement of organic matter flux from water column sediment traps to examine the impact of seasonal detrital inputs on resource acquisition by the deposit feeding megafauna assemblages at two sites: Station M (Northeast Pacific, 4000 m water depth) and the Porcupine Abyssal Plain Sustained Observatory (PAP-SO, Northeast Atlantic 4850 m water depth). At Station M, studied over 18-months, the seasonal particle flux was followed by a salp deposition event. At that site, diversity in types of deposit feeding was related to seabed cover by detritus. At PAP-SO, studied over 30 months, the seasonal particle flux consisted of two peaks annually. While the two study sites were similar in mean flux (~8.0 mgC m−2 d−1), the seasonality in the flux was greater at PAP-SO. The mean overall tracking at PAP-SO was five times that of Station M (1.9 and 0.4 cm2 h−1, respectively); both are likely underestimated because tracking by some common taxa at both sites could not be quantified. At both sites, responses of deposit-feeding megafauna to the input of detritus were not consistent across the taxa studied. The numerically-dominant megafauna (e.g. echinoids, large holothurians and asteroids) did not alter their deposit feeding in relation to the seasonality in detrital supply. Taxa for which deposit feeding occurrence or rate were correlated to seasonality in particle flux were relatively uncommon (e.g. enteropneusta), known to cache food (e.g. echiurans), or to be highly selective for fresh detritus (e.g. the holothurian *Oneirophanta mutabilis*). Thus, the degree of seasonality in deposit feeding appeared to be taxon-specific and related to natural history characteristics such as feeding and foraging modes.

Link to paper: https://www.sciencedirect.com/science/article/pii/S0967064519301882

Fine scale assemblage structure of benthic invertebrate megafauna on the North Pacific seamount Mokumanamana

Morgan, N. B., Goode, S., Roark, E. B., & Baco-Taylor, A. (2019)

Frontiers in Marine Science, 6, 715

Changes in benthic megafaunal assemblage structure have been found across gradients of environmental variables for many deep-sea habitats, but patterns remain under-investigated on seamounts. To assess the extent of variability in benthic communities at the scale of within a single seamount, and to assess environmental drivers of assemblage changes, Mokumanamana, also known as Necker Island, a seamount in the Papahānaumokuākea Marine National Monument with no known history of human impacts, was surveyed. Replicate 1 km transects were conducted along depth contours at 50 m depth intervals from 200–700 m on three sides of Mokumanamana using the AUV *Sentry*. Megafaunal abundance and substrate parameters were obtained from 26,119 total images. The dominant megafaunal taxa were sponges, corallimorpharians, cup corals, and benthic ctenophores. Sea pens and alcyonacean octocorals were also abundant. Overall, abundance and diversity of megafauna increased with depth. Beta-diversity through species substitution with depth was very high. Beta-diversity was also high between the sides and likewise defined almost exclusively by species substitution. Crossed ANOSIM by depth and side showed community structure differed on Mokumanamana for both factors. NMDS and cluster analyses of Mokumanamana show nine assemblages that were defined by depth and reflect differences between sides of the seamount. Environmental modeling with DISTLM indicates sediment, oxygen, substrate variability and roughness, POC, and surface currents are correlated with these assemblage differences. These results suggest that microhabitats on seamounts can promote unique assemblages along depth gradients as well as on different sides of a feature, and this diversity may be easily overlooked without fine-scale sampling. These findings have implications for management and conservation of seamounts as well as future ecological studies of seamounts, as seamounts are generally sampled on much coarser spatial scales.

Link to paper: https://www.frontiersin.org/articles/10.3389/fmars.2019.00715/full

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Comparative Proteomics on Deep-sea Amphipods after in situ Copper Exposure

Kwan, Y.H., Zhang, D., Mestre, N.C., Wang, X., Lu, B., Wang, C., Qian, P-Y. & Sun, J. (2019)

Environmental Science and Technology, 53, 13981−13991

The interest in deep-sea mining increased along with the environmental concerns of these activities to the deep-sea fauna. The discovery of optimal biomarkers of deep-sea mining activities in deep-sea species is a crucial step toward the supply of important ecological information for environmental impact assessment. In this study, an in situ copper exposure experiment was performed on deep-sea scavenging amphipods. *Abyssorchomene distinctus* individuals were selected among all the exposed amphipods for molecular characterization. Copper concentration within the gut was assessed, followed by a tandem mass tag-based coupled with two-dimensional liquid chromatography–mass spectrometry/mass spectrometry (LC–MS/MS) applied to identify and quantify the protein expression changes after 48 h of exposure. 2937 proteins were identified and annotated, and 1918 proteins among all identified proteins were assigned by at least two nonambiguous peptides. The screening process was performed based on the differences in protein abundance and the specific correlation between the proteins and copper in previous studies. These differentially produced proteins include Na+/K+ ATPase, cuticle, chitinase, and proteins with unknown function. Their abundances

showed correlation with copper and had high sensitivity to indicate the copper level, being here proposed as biomarker candidates for deep-sea mining activities in the future. This is a key step in the development of environmental impact assessment of deep-sea mining activities integrating ecotoxicological data.

Link to paper: https://doi.org/10.1021/acs.est.9b04503

Low connectivity between shallow, mesophotic and rariphotic zone benthos

Stefanoudis, P. V., Rivers, M., Smith, S. R., Schneider, C. W., Wagner, D., Ford, H., Rogers, A.D. & Woodall, L. C. (2019)

Royal Society open science, 6(9), 190958

Worldwide coral reefs face catastrophic damage due to a series of anthropogenic stressors. Investigating how coral reefs ecosystems are connected, in particular across depth, will help us understand if deeper reefs harbour distinct communities. Here, we explore changes in benthic community structure across 15–300 m depths using technical

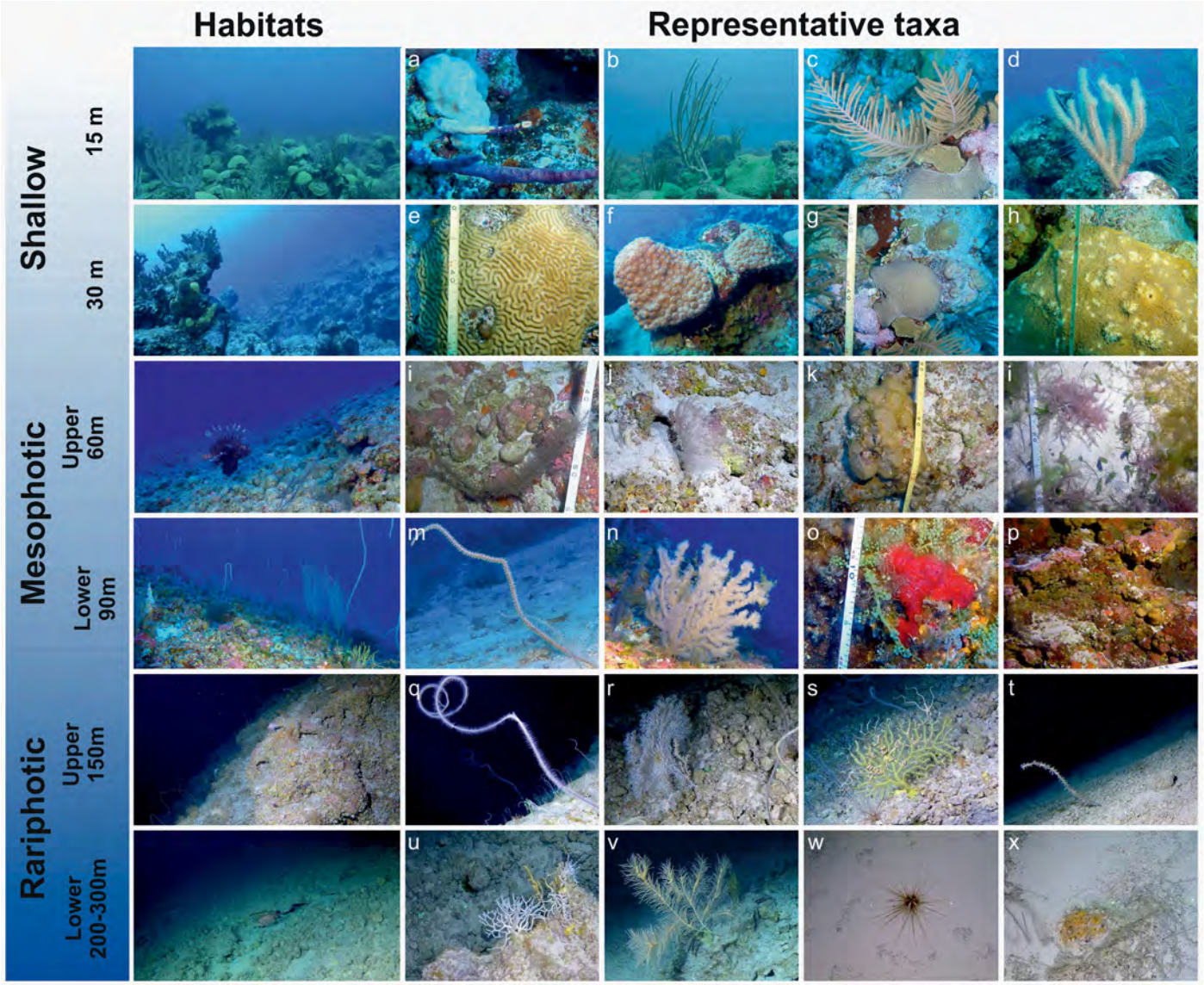


Figure 1. Benthic reef zonation in Bermuda with representative taxa. (a) *Aplysina cauliformis*, (b) *Pseudoplexaura* spp., (c) *Antillogorgia* spp., (d) *Eunicea* spp., (e) *Pseudodiploria strigosa*, (f) *Montastraea cavernosa*, (g) *Diploria labyrinthiformis*, (h) *Orbicella franksi*, (i) *Tanacetipathes tanacetum*, (j) *Antipathes atlantica*, (k) *Lobophora canariensis*, (i) *Dasya* spp., (m) *Ellisella atlantica/elongata*, (n) *Tanacetipathes hirta*, (o) red sieve encrusting sponge, cf. *Phorbas amaranthus*, (p) various encrusting sponges and crustose coralline algae, (q) *Stichopathes* spp., (r) *Hypnogorgia* sp., (s) *Placogorgia* spp., (t) *Parazoanthidae*, (u) *Madracis myriaster*, (v) *Callogorgia* spp., (w) *Coelopleurus floridanus*, (x) Yellow encrusting sponge.

divers and submersibles around Bermuda. We report high levels of floral and faunal differentiation across depth, with distinct assemblages occupying each depth surveyed, except 200–300 m, corresponding to the lower rariphotic zone. Community turnover was highest at the boundary depths of mesophotic coral ecosystems (30–150 m) driven largely by taxonomic turnover and to a lesser degree by ordered species loss (nestedness). Our work highlights the biologically unique nature of benthic communities in the mesophotic and rariphotic zones, and their limited connectivity to shallow reefs, thus emphasizing the need to manage and protect deeper reefs as distinct entities.

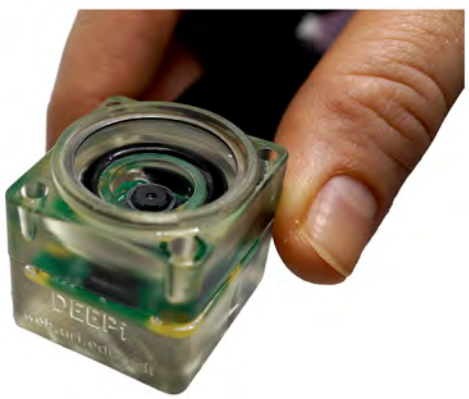
Link to paper: https://royalsocietypublishing.org/doi/10.1098/rsos.190958

DEEPi: A miniaturized, robust, and economical camera and computer system for deep-sea exploration

Phillips, B.T. *, Licht, S., Haiat, K.S., Bonney, J., Allder, J., Chaloux, N., Shomberg, R. & Noyes, T. J. (2019)

Deep Sea Research Part I: Oceanographic Research Papers, 153:103-136

*Correspondence: brennanphillips@uri.edu



Cameras are essential components to almost every underwater vehicle including ROV's, AUV's, manned submersibles, ocean observatories, and baited remote underwater video systems (BRUVs). Deep-sea cameras are traditionally expensive components, and are almost exclusively fabricated as one-atmosphere pressure housings made of aluminum, stainless steel or titanium, combined with custom-made optical viewports. In autonomous recording systems such as BRUVs and biologging animal tags, camera size and form factor directly influences the physical design of the entire system and limits the operational endurance. In this paper, we describe a novel design for DEEPi, a deep-sea imaging and control system based on the Raspberry Pi family of single-board computers. The DEEPi camera is an extremely compact remote head unit (~16 ml volume), can operate to depths of at least 5500m, and uses a photopolymer 3D-printed shell partially filled with epoxy as a pressure housing. A flat polished borosilicate glass disc serves as the optical viewport, and protects the lens assembly from pressure and water intrusion. The control computer is completely potted in epoxy and is accessible through a wifi connection. The DEEPi system is described in detail, along with example imagery from deep-sea deployments to depths of up to 1096m.

Link to paper: https://doi.org/10.1016/j.dsr.2019.103136

An atlas of protected hydrothermal vents

Menini, E., & Van Dover, C. L. (2019)

Marine Policy, 108, 103654

Active hydrothermal vents are valued worldwide because of the importance of their biodiversity and their influence on scientific discovery and insight about life on Earth and elsewhere in the Universe. There exist at least 20 areas and area networks with conservation measures for deep-sea hydrothermal vents, established by 12 countries and three Regional Fisheries Management Organisations, in six oceanic regions. Area-based management tools (ABMT) implemented by

these countries illustrate multiple categories and means of protection and management of these rare and vulnerable habitats. Some ABMTs only regulate bottom and deep-trawling fisheries activities, others manage additional activities such as mining, scientific research, and bioprospecting, while still others protect active hydrothermal vents through broad conservation interventions. This atlas summarizes the "who", "what", "when", "where" of protected hydrothermal vents worldwide and underscores recognition of the importance of hydrothermal-vent ecosystems by coastal States.

Link to paper: https://doi.org/10.1016/j.marpol.2019.103654

Abyssal fauna of polymetallic nodule exploration areas, eastern Clarion-Clipperton Zone, central Pacific Ocean: Annelida: Capitellidae, Opheliidae, Scalibregmatidae, and Travisiidae

Wiklund, H., Neal, L., Glover, A. G., Drennan, R., Rabone, M., & Dahlgren, T. G. (2019)

ZooKeys, 883, 1

This paper includes characterisation (incl DNA and imagery) of 23 species of polychaetes, with formal descriptions of 12 new taxa, and 85 records. The new taxa have been named based on a randomised list of all the crew and scientists on two large oceanographic voyages, to reflect the joint effort in collecting in this remote area.

This is the first in a series of polychaete papers we plan to publish, funding dependent, on the CCZ that we hope will greatly improve the quality of environmental work in the area related to seabed mining exploration. Current plans are that the next paper will be on the Nereidiformia followed by the Spioniformia. If you have ethanol-fixed material from the CCZ and are interested in collaboration, please do get in touch.

Paper Abstract: We present DNA taxonomy of abyssal polychaete worms from the eastern Clarion-Clipperton Zone (CCZ), central Pacific Ocean, using material collected as part of the Abyssal Baseline (ABYSSLINE) environmental survey cruises 'AB01' and 'AB02' to the UK Seabed Resources Ltd (UKSRL) polymetallic nodule exploration contract area 'UK-1', the Ocean Mineral Singapore exploration contract area 'OMS-1' and an Area of Particular Environmental Interest, 'APEI-6'. This is the fourth paper in a series to provide regional taxonomic data with previous papers reporting on Cnidaria, Echinodermata and Mollusca. Taxonomic data are presented for 23 species from 85 records within four polychaete families: Capitellidae, Opheliidae, Scalibregmatidae and Travisiidae, identified by a combination of morphological and genetic data, including molecular phylogenetic analyses. Two taxa (genetically separated from one another) morphologically matched the same known cosmopolitan species, *Ophelina abranchiata* that has a type locality in a different ocean basin and depth from where no genetic data was available. These two species were assigned the open nomenclature 'cf.' as a precautionary approach in taxon assignments to avoid over-estimating species ranges. Twelve (12) taxa are here described as new species, *Ammotrypanella keenani* sp. nov., *Ammotrypanella kersteni* sp. nov., *Ophelina curli* sp. nov., *Ophelina ganae* sp. nov., *Ophelina juhazi* sp. nov., *Ophelina martinezarbizui* sp. nov., *Ophelina meyerae* sp. nov., *Ophelina nunnallyi* sp. nov., *Oligobregma brasierae* sp. nov., *Oligobregma tani* sp. nov., *Oligobregma whaleyi* sp. nov. and *Travisia zieglerae* sp. nov. For the remaining nine taxa, we have determined them to be potentially new species, for which we make the raw data, imagery and vouchers available for future taxonomic study. The CCZ is a region undergoing intense exploration for potential deep-sea mineral extraction from polymetallic nodules. We present these data to facilitate future taxonomic and environmental impact study by making both data and voucher materials available through curated and accessible biological collections.

Link to paper: https://zookeys.pensoft.net/article/36193/

Are shallow-water shrimps proxies for hydrothermal-vent shrimps to assess the impact of deep-sea mining?

Mestre, N.C., Auguste, M., de Sá, L.C., Fonseca, T.G., Cardoso, C., Brown, A. E., Barthelemy, D., Charlemagne, N., Hauton, C., Machon, J., Ravaux, J., Shillito, B., Thatje, S. & Bebianno, M.J. (2019)

Marine Environmental Research, 151, 104771

Polymetallic seafloor massive sulphide deposits are potential targets for deep-sea mining, but high concentrations of metals (including copper - Cu) may be released during exploitation activities, potentially inducing harmful impact. To determine whether shallow-water shrimp are suitable ecotoxicological proxies for deep-sea hydrothermal vent shrimp the effects of waterborne Cu exposure (3 and 10 days at 0.4 and 4 µM concentrations) in *Palaemon elegans, Palaemon serratus*, and *Palaemon varians* were compared with *Mirocaris fortunata*. Accumulation of Cu and a set of biomarkers were analysed. Results show different responses among congeneric species indicating that it is not appropriate to use shallow-water shrimps as ecotoxicological proxies for deep-water shrimps. During the evolutionary history of these species they were likely subject to different chemical environments which may have induced different molecular/ biochemical adaptations/tolerances. Results highlight the importance of analysing effects of deep-sea mining in situ and in local species to adequately assess ecotoxicological effects under natural environmental conditions.

Link to paper: https://doi.org/10.1016/j.marenvres.2019.104771

UK deep-sea conservation: Progress, lessons learned, and actions for the future

Peter D. Chaniotis , Laura M. Robson, Anaëlle J. Lemasson, Alice L. Cornthwaite, Kerry L. Howell

Aquatic Conservation: Marine and Freshwater Ecosystems 2019; 1-19.

1. Despite a relatively long history of scientific interest fuelled by exploratory research cruises, the UK deep sea has only recently emerged as the subject of targeted and proactive conservation. Enabling legislation over the past 10 years has resulted in the designation of marine protected areas and the implementation of fisheries management areas as spatial conservation tools. This paper reflects on progress and lessons learned, recommending actions for the future.

2. Increased investment has been made to improve the evidence base for deep-sea conservation, including collaborative research surveys and use of emerging technologies. New open data portals and developments in marine habitat classification systems have been two notable steps to furthering understanding of deep-sea biodiversity and ecosystem functioning in support of conservation action.

3. There are still extensive gaps in fundamental knowledge of deep-sea ecosystems and of cause and effect. Costs of new technologies and a limited ability to share data in a timely and efficient manner across sectors are barriers to furthering understanding. In addition, whilst the concepts of natural capital and ecosystem services are considered a useful tool to support the achievement of conservation goals, practical application is challenging.

4. Continued collaborative research efforts and engagement with industry to share knowledge and resources could offer cost-effective solutions to some of these barriers. Further elaboration of the concepts of natural capital and ecosystem services will aid understanding of the costs and benefits associated with human–environment interactions and support informed decision-making in conserving the deep sea.

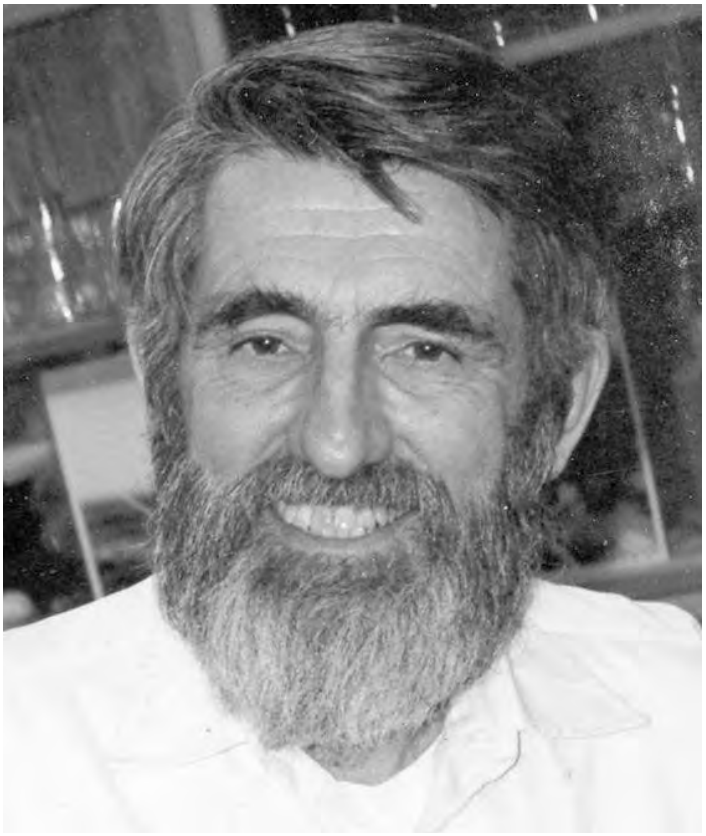
5. Whilst multiple challenges arise for deep-sea conservation, it is critical to continue ongoing conservation efforts, including exploration and collaboration, and to adopt new conservation strategies that are implemented in a systematic and holistic way and to ensure that these are adaptive to growing economic interest in this marine area.

Link to paper: https://onlinelibrary.wiley.com/doi/full/10.1002/aqc.3243

Obituaries

Rudolf (Rudi) Scheltema

27 May 1926 - 5 August 2019



The Woods Hole Oceanographic Institution announces with great sorrow the death of Scientist Emeritus Rudolf (Rudi) Scheltema on August 5 at home with generations of his family in his presence. He had many years of increasing dementia but otherwise remained healthy and happy under the home care of both sons' families. He was 93.

Rudi was born May 27, 1926 in Madison, Wisconsin. While an infant, his family returned to The Netherlands for three years before again moving, this time to the D.C. area, where his father was a research librarian. Dutch was his first language and was spoken at home.

At the age of 18, he was drafted into the U.S. Army as an infantry soldier. This was a formative period in his life and he forever afterwards held an anti-war philosophy. This was expressed in volunteer work with Veterans for Peace, the Peace Poetry Contest, and other peace promoting organizations, and beginning in the mid 1960's, membership in the Society of Friends Meeting in West Falmouth.

He received a Bachelor of Science degree from The George Washington University in 1951. He then did course work at Harvard where he met his future bride, Amélie Day Hains. After transferring to the University of North Carolina at Chapel Hill, he earned a Master of Science degree in 1954 and a Ph.D. in 1960. His thesis under the direction of Dr. Charles E. Jenner was on the effect of the substratum on the metamorphosis of intertidal gastropods.

While a graduate student, Rudi worked at the Chesapeake Biological Laboratory working on the ecology of marine fouling organisms, i.e. shipworms, with Dr. Truitt. This led to his very first scientific publications. He then spent two summers working at the Marine Biological Laboratory followed by three summers as a research fellow at WHOI.

While completing his dissertation, he spent one year as a research associate at the Oyster Research Laboratory, Rutgers University. It was here that he was involved in some of the earliest experimental studies of the mysterious so-called MSX disease of oysters that was devastating the oyster beds of Delaware and Chesapeake Bays. It was only 20 years later that the parasite causing this disease was formally described and named. It was during this year that he lived with his wife Amélie in the appropriately named small town of Bivalve, New Jersey, on the shore of Delaware Bay. After running out of cigarettes during a hurricane, they used the opportunity to stop smoking entirely.

Rudi started his full-time tenure at WHOI in 1960, where he stayed for the remainder of his scientific career, first as a research assistant and then rising through the scientific ranks to senior scientist in 1985. After a technical retirement in 1991, he remained full-time at the Institution, helping to teach graduate students and maintaining his laboratory. He declined becoming a scientist emeritus until 1996, but again, kept a full-time schedule, with cruises, until the 2010's.

His research interests started with the identification and description of larvae of bottom-dwelling organisms. He first started describing some of our very own local snails, including the Eastern Mud Snail, now called Ilyanassa obseleta, and wrote several descriptive papers with his wife as co-author. This led to his studying what factors were important

for the survival and growth of these larvae, especially for gastropods and barnacles. He led many experimental studies on what would enable these larvae to settle and then metamorphose into their adult form. He hosted a number of WHOI Summer Fellows who were tasked with such experiments and several ended up as his co-authors on scientific publications. Throughout his career, he was very active in the WHOI Education Program and mentored many undergraduate and graduate students. He said that working with young people kept him young.

In addition to his enthusiasm in working with students, Rudi included numerous administrative assistants from the Biology Department at WHIOI, friends, and family members in his research cruises to share the experience of working on a scientific expedition and his love of science. Early in his career at WHOI, he managed to sneak a female colleague past the bureaucracy and onto one of his cruises at a time when female scientists were prohibited from going to sea, much to the chagrin of the WHOI administration.

Rudi discovered that some larvae could survive in the water column for weeks and even months and still have the capability of settling and metamorphosing into their adult forms. To collect such planktonic larvae in ocean basins, he joined and/or led dozens of research cruises in the North and South Atlantic, North and South Pacific, in the Mediterranean Sea, and in Antarctica to take plankton tows that would collect the larvae that could subsequently be studied in the laboratory. He often sent colleagues and students out on ships of opportunity to collect samples for him.

His last series of cruises were five cruises to Antarctica studying the transport of larvae across the Drake Passage and gene flow between the tip of South America and the Antarctic Peninsula. As a boy, Rudi had read “The Last Continent of Adventure” (Walter B. Hayward, 1930) when only small sections of the Antarctic coastline had been mapped. This inspired him to someday go to Antarctica and these voyages fulfilled that lifetime goal. He celebrated his 80th birthday on his last voyage on Deception Island, Antarctica, with his shipmates on May 27, 2006. In August of that year, he was honored with a special symposium at the 7th International Larval Biology Meetings in Coos Bay, Oregon.

In addition, over the span of his career, he participated in five deep-sea dives in the Atlantic and Pacific Oceans in Alvin as well as two dives in the Bahamas in the Johnson Sea Link. The author or co-author of more than 70 scientific publications, Rudi presented at numerous conferences all around the world, traveled extensively to meet with his hundreds of colleagues, and spent one year as a Fulbright Scholar in Queensland, Australia. One experience that stood out for him was his participation on ad hoc committees of the National Academy of Science, National Research Council, on the “Ecological Effects of a Sea Level Canal” in 1969 in Woods Hole and 1977 in Washington, D.C. He was adamantly opposed to using nuclear detonations to build such a Panama Canal. In addition, he recognized that a sea level canal would have huge currents due to the difference in sea level of the Atlantic and Pacific Oceans and that the possibility of invasive species transiting the canal would be certain and preventing such dispersal would be difficult and expensive.

Basically, a humble man, Rudi was very pleased that a word that he invented became part of the lexicon of scientists working on dispersal of long-distance larvae. This word, from the Greek for ‘far-wandering’ was teleplanos (in Greek, ΤΕΛΕΠΛΑΝΟΣ or τελεπλανος), and could be used as an adjective as in ‘teleplanic’ larvae. He was famous among his friends and scientific colleagues for the Christmas cards that he sent each year that featured an original drawing by him of benthic larvae and a few sentences explaining what they were and where he had collected them.

Rudi was predeceased by his wife Amélie, who died in 2015. He leaves their two sons, Charles and Konrad; Konrad’s wife, Nicole; Charles’ spouse, Anne Marie Tupper; three grandchildren, Evan, Oliver, and Teodoor (Teo), and foster daughter, Zada Clark. A memorial service will be held at some time in the future.

Information for this obituary is from the Scheltema Family.

Deep-Sea Biology Society Business

The following text is the letter of the President of the Deep-Sea Biology which has been sent to the membership in December 2019. If you would like to learn more about the Society and it's role please visit https://dsbsoc.org/

President's Letter, December 2019

Dear Deep-Sea Biology Colleagues,

I am very happy to write to you all from a cold and frosty London, a city which seems to change remarkably little from year to year despite the increasing machinations of its politicians. Perhaps this is a reflection that leadership can have less impact than one might think versus the power of the collective. This has perhaps been a relatively quiet 6 months for the leadership of the Deep-Sea Biology Society, as we start to build on the extensive efforts over the past 3 years to establish the Society in its new legal framework with a sound financial model. However, there are some important things to announce and report on, which you can read about in the following sections. One important point to note is that the Society was set-up for you - the deep-sea biology community - and the Trustees are always very keen to hear from the membership any feedback on our activities and suggestions for the future. There are now dsbsoc.org email addresses for all the Trustees, please do get in touch.

2020 is an important year for the Society as we will complete the work of the start-up grant we received from the Lounsbery Foundation, and move to a new financial model. Our regular annual income will now come entirely from our membership fees, donations and surplus from conferences, which is entirely re-invested in the community through our awards and grants. With the rise in our membership, and two successful meetings behind us (that both generated a small surplus) we are pleased to be able to offer almost the same funding for Awards in 2020 as in previous years (when they were supported by Lounsbery). We are also actively seeking new development funds to support our activities. With our focus on supporting early-careers, students and scientists from developing nations, coupled with a well-organised system of efficient, transparent and accountable system of funding awards we are attractive to organisations or donors that wish to donate even small amounts of funding, e.g to give students career-changing conference opportunities. With our network of Trustees operating on a voluntary basis, we can also distribute funds without any overhead costs, unlike large institutions.

Our Annual General Meeting (AGM) for 2020 will be held alongside the 7th International Symposium on Chemosynthesis-Based Ecosystems (CBE7), which will be held in Guarujá, Brazil between 23-28 August 2020 (p30, this issue). As usual, the AGM will be held on the Wednesday evening of the Symposium, and is an opportunity for all Members to come along and contribute to discussions on the future support of our discipline as well as a nice networking event. CBE7 is sure to be a fantastic conference in a great venue, so please do register as soon as the registrations open, which is currently planned for January. Keep an eye on your emails for news on this.

I am also delighted to formally confirm the dates for the 16th Deep-Sea Biology Symposium which will be held in Shizuoka City, Japan from 8-12 November 2021 (p30, this issue). This is our major tri-ennial conference and will be the first time it has been held in Asia. The meeting is supported by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and the chair of the Local Organising Committee is Dr Katsunori Fujikura. Serving on the Trustees of the Society as Officer for the conference is Dr Moriaki Yasuhara. This is sure to be a fantastic symposium so please hold those dates in your diaries.

I am thrilled to welcome Illysa Inglesias from the University of California as the new Student Officer, who will take assume duties in early 2020. I would like to thank Zoleka Filander for her hard work on this role over the last year and wish her all the best in her future research.

In the Society news below, you can read more about our Meetings, Awards, Student activities, Early-career activities, Mentoring, Communications, Membership and Finances. For now I am very happy to wish everyone a very happy holiday season and best wishes for the New Year.

Adrian Glover, President (president@dsbsoc.org)

Meetings

Report on the 7th International Symposium on Deep-Sea Corals

Santiago Herrera

Memberships Officer, membership@dsbsoc.org

The 7th International Symposium on Deep-Sea Corals (ISDSC7) took place at the Intercontinental Hotel in Cartagena de Indias, Colombia, between July 29 - August 2, 2019. The symposium had 169 attendees, representing more than 23 countries. The latest advances in deep-sea coral and sponge science and management worldwide were presented in 81 talks and 66 posters. The abstracts and program for the conference are available at https://deepseacoral2019.weebly.com/program.html. Lunches, snacks, drinks, a banquet, and on-site child care services were available for symposium participants at no extra cost.

This was the first time that the symposium was organized with support from the Deep-Sea Biology Society. Santiago Herrera from Lehigh University, the DSBS membership officer, was also the lead organizer of the symposium. Juan Sanchez from the Universidad de los Andes, and Luisa Dueñas from the Universidad Nacional de Colombia, were the co-organizers. The entire Society leadership was also involved facilitating logistics and leading activities during the meeting. This work included the management of finances and contracts, coordination and execution of Society side-events, management and evaluation of student and early-career awards, development of software and technology for program organization and management of sessions, in addition to individual intellectual contributions.

In total, 20 travel awards were made to participants in need by the Society in collaboration with organizers and sponsors. Overall, more than 20% of the participants received some form of financial assistance from the Society or the organizing committee. The Society held its AGM, as well as student and early-career events sponsored by the Society. The Society also presented awards to the best student and early-career talks and posters. Thanks to the several sponsoring organizations, the symposium ended with a positive net economic balance. All of this balance was given by the organizers to the Society with the intent of supporting future community-led meetings and activities.

Deep-Sea Biology Society Awards and Prizes

Rachel Jeffreys

Awards Officer, awards@dsbsoc.org

Report on Calls to Date

Paper of the Year

The Society is delighted to announce that Karen Wishner and co-authors have been awarded the paper of the year for 2019. The winning article is entitled: Ocean deoxygenation and zooplankton: Very small oxygen differences matter, and was published in Science Advances and can be found here: https://advances.sciencemag.org/content/4/12/eaau5180/tab-pdf

Dive Deeper Bursaries

The Society are pleased to announce that we have awarded two Dive Deeper research bursaries this year. These were awarded to Laetitia Gunton (Australian Museum, Australia) and Arunima Sen (Nord University, Norway). Laetitia will be working with historic annelid collections held in Austrialian museums in order to better understand deep-sea annelid connectivity around Australia. The bursary will enable her to visit Museums Victoria in order to work alongside Dr. Wilson to identify annelid specimens from western Australia using their morphological characteristics and obtain samples for molecular analysis. Arunima will visit Dr. Stefane Hourdez at IFREMER, in order to gain valuable training in bioinformatics, which will allow her to gain a comprehensive view of the symbiotic community of Arctic seep frenulates. This bursary will allow her to work alongside Dr. Hourdez in order to process bioinformatics data obtained previously from illumina sequencing of the trophosomes of Arctic seep frenulates.

7th International Symposium of Deep-Sea Corals

The trustees of the Deep-Sea Biology Society and organisers of ISDSC7 were delighted to award 20 travel awards to both early career and graduate student researchers to attend the conference in Cartagena, Colombia August 2019. The awardees were announced in the last issue of Deep-Sea Life and can be found here: https://dsbsoc.org/conferences-meetings/7th-isdsc-travel-awardees/

The trustees of the Deep-Sea Biology Society and organisers of ISDSC7 were delighted to present awards for the best oral and poster presentations to both early career researchers and graduate students. The awardees are as follows:

Best Early Career Oral Presentation

- WINNER: Barbara de Moura Neves (Fisheries and Oceans Canada)
- RUNNER UP: Laurence de Clippele (University of Edinburgh, UK)

Best Graduate Student Oral Presentation

- WINNER: Ana Navarro Campoy (Universidad Católica del Norte, Chile)
- RUNNER UP: Martjn Bart (University of Amsterdam, Netherlands)

Best Early Career Poster Presentation

- WINNER: Giovanni Chimienti (University of Bari Aldo Moro, Italy)
- RUNNER UP: Andia Chaves Fonnegra (Florida Atlantic University, USA)

Best Graduate Student Poster Presentation

- WINNER: Keir Macartney (University of New Hampshire, USA)
- RUNNER UP: Guillem Corbera Pascual (University of Southampton, UK)

Lounsbery Workshop Award

ISDSC7 was followed up by a Deep-Sea Coral Taxonomy Workshop in December 2-4 at the Makuriwa Museum in INVEMAR, Santa Marta, Colombia. The workshop was led by Luisa Dueñas and Cristina Cedeño, and supported by the Lounsbery Workshop Award from the society. The workshop was mainly a hands-on experience, focused on the study of octocorals and black corals, with the participation of Phil Alderslade (CSIRO, Australia), Tina Molodtsova (P.P. Shirshov Institute of Oceanology RAS, Russia), Odalisca Breedy (Universidad de Costa Rica, Costa Rica), and Juan A. Sánchez (Universidad de Los Andes), as international taxonomic experts. They workshop had 24 participants from 9 countries, including the 4 international expert deep-sea coral taxonomists. Participants included undergraduate students, graduate students, and early-career researchers. This workshop provided a unique opportunity to train the

next generation of deep-sea coral taxonomists, build local taxonomic capacity in Colombia and Latin America broadly, and advance in the knowledge of deep-sea coral biodiversity in the Caribbean region through the identification of dozens of museum specimens, some of which will be described as new species.

Forthcoming Calls in 2020

We are pleased to announce a new award, which will enable researchers to apply for funds to join a research expedition. More details will follow soon.

In the coming year we will also have the following awards open for applications:

- Paper of the Year
- Dive Deeper (2 bursaries)
- Travel awards for the 7th Chemosynthetic Ecosystems Conference to be held in Guaruji, Brazil (August 2020). We will also be awarding prizes for the best presentations at this conference.

All terms and conditions for our awards can be found on our website here: http://dsbsoc.org/grants-awards/society-awards/

Deep-Sea Biology Society Students

Zoleka Filander

Student Officer, students@dsbsoc.org

This year's student mixer event, hosted at the 7th International Symposium on Deep-Sea Corals (29 July – 2 August, Colombia), exemplifies the continuous efforts of the Society to support students at meetings that align with Deep-Sea Research. The event itself took a more casual and interactive approach, ensuring students get to hear the experiences of experts within the field of Deep-Sea Coral research. The 29 student participants had the opportunity to gain valuable insights from ten experts within academia and the public sector. Another student event is planned to take place at the 7th Chemosynthetic-Based Ecosystem meeting in Brazil (2020), and aims to align the interests of students with those of post-doctoral fellows.

In addition to these support orientated activities, the Society further participated at the Western Indian Ocean Early Career Scientists Network (WIO-ECSN) special session (5th July, Mauritius), in order to evaluate the number of active deep-sea researchers (if any) in the region. An invite to attend this meeting was leveraged through existing relations of the Deep-Sea Society student representative with WIO-ECSN, and aimed to increase membership in under-represented region (one of which is the Western Indian Ocean).

Student opportunities are still being communicated through the students mailing list. New developments include; the

Above: Awardees for the Best Student and Early Career Presentations during ISDSC7.

launch of showcasing student research on the Deep-Sea Biology Society website, in order to (i) promote networking within student members and non-members (ii) demonstrate the diversity of research and skills developed within the field (iii) initiate future collaborations within student researchers within the field. This development was initiated through a collaborative effort between the Society's Student Representative and Communications Officer, which we hope to trial for a year.

If you have any suggestions on how the Society can better support students, please contact the student officer on students@dsbsoc.org

Deep-Sea Biology Society Early-Career Support

Andrea Quattrini

Early Career Officer, early_career@dsbsoc.org

An early-career webinar series was established this year. So far we have had three webinars focusing on: 1) Time management and work-life balance, 2) Effective broader impacts and outreach and 3) Academic job preparation. Several senior and early career scientists provided advice on the above topics during 1-2 hour discussions. We thank everyone for their participation! Tips for academic job preparation with example statements are available on request from the Early Career Officer. Next up is a webinar on effective proposal writing, TBA soon, and a plan for 2020 activities will follow.

Other activities included a well-attended Early Career Mixer event during the ISDSC7 in Colombia.

Deep-Sea Biology Society Mentoring

Rachel Jeffreys

Awards Officer, awards@dsbsoc.org

The mentoring mentoring network was set up as a space to provide advice and support for both graduate and early career researchers. It consists of groups of scientists at various stages in their careers, from graduate scientists to professors. The groups meet every 4-8 weeks via an online platform and discuss a variety of topics including but not limited to: paper writing, work-life balance, job applications and career progression.

I am delighted to announce that after a successful year piloting the mentoring network with three groups we have now progressed to 11 groups with ~80 scientists. These groups have been in place since the summer and I hope that you are all finding the network useful. If you are interested in joining the network please do get in touch. Similarly if you already participate in the network and have any suggestions or ideas please let me know.

Deep-Sea Biology Society Communications

Paris Stefanoudis

Communications Officer, communications@dsbsoc.org

If you have not been able to attend the very successful ISDSC7 in Colombia earlier this year, you can find more about it by browsing the travel award reports from Society members. These travel grants were awarded to researchers from all career levels in order to help them present their work there. You can read the travel award reports here.

We have been continuously updating the Society's website and social media with content derived from Deep-Sea Life 13, as part of the integration of the communication aspects of the Deep-Sea Biology Society, INDEEP and DOSI, and will continue to do so over the next six months with content from the current Deep-Sea Life issue. You can see some examples on our website using the tag "Deep-Sea Life". You can also access all previous Deep-Sea Life issues on the Society's website and of course on the INDEEP website.

We are witnessing a continuous growth on our Twitter account, which now stands at well over 5,000 followers, up ~60% from this point last year. We are committed to strengthen our social media presence in the coming months even more, so as to ensure that we stay connected with the growing community of deep-sea biologists around the world. You can follow us here.

Finally, if you want us to spread the word about upcoming events, courses, new papers etc. that will be of interest to the wider deep-sea biology community please direct message us on our Twitter Account or contact our Communications Officer at communications@dsbsoc.org.

Deep-Sea Biology Society Membership

Santiago Herrera

Memberships Officer, membership@dsbsoc.org

Current membership levels are double what they were this same time of the year two years ago. This is a strong indicator that the Society continues to grow at a healthy pace. As membership grows, the services that the Society offers to the community also increase in number and scope.

Deep-Sea Biology Society Finances

Chris Yesson

Treasurer, treasurer@dsbsoc.org

The society has filed its first set of accounts with the UK Charity Commission, covering the period of July 2017 until December 2018. Accounts are available at https://tinyurl.com/tnwrjyj. Moving forwards the society will file in sync with the calendar year, but for these first accounts we were required to cover the period from our official charity registration in July 2017.

Membership income for 2019 remains solid, although is down from the 2018 high that was driven by the registrations (including membership option) for the 15th Deep-Sea Biology Symposium. Membership income remains our main regular income stream that enables the Society to carry out its core activities. Our grant from the Lounsbery Foundation comes to an end in 2019, this has been used to fund travel, dive-deeper awards and workshop awards. The Society earned a modest profit from supporting ISDSC7. The society took on the up-front costs of venue hire, and we used our payment platform to handle registrations. The Society's support enabled us to fund extra travel awards and funded mentoring and student events at the conference. This was a successful pilot that could be a model for future conference support from the Society.