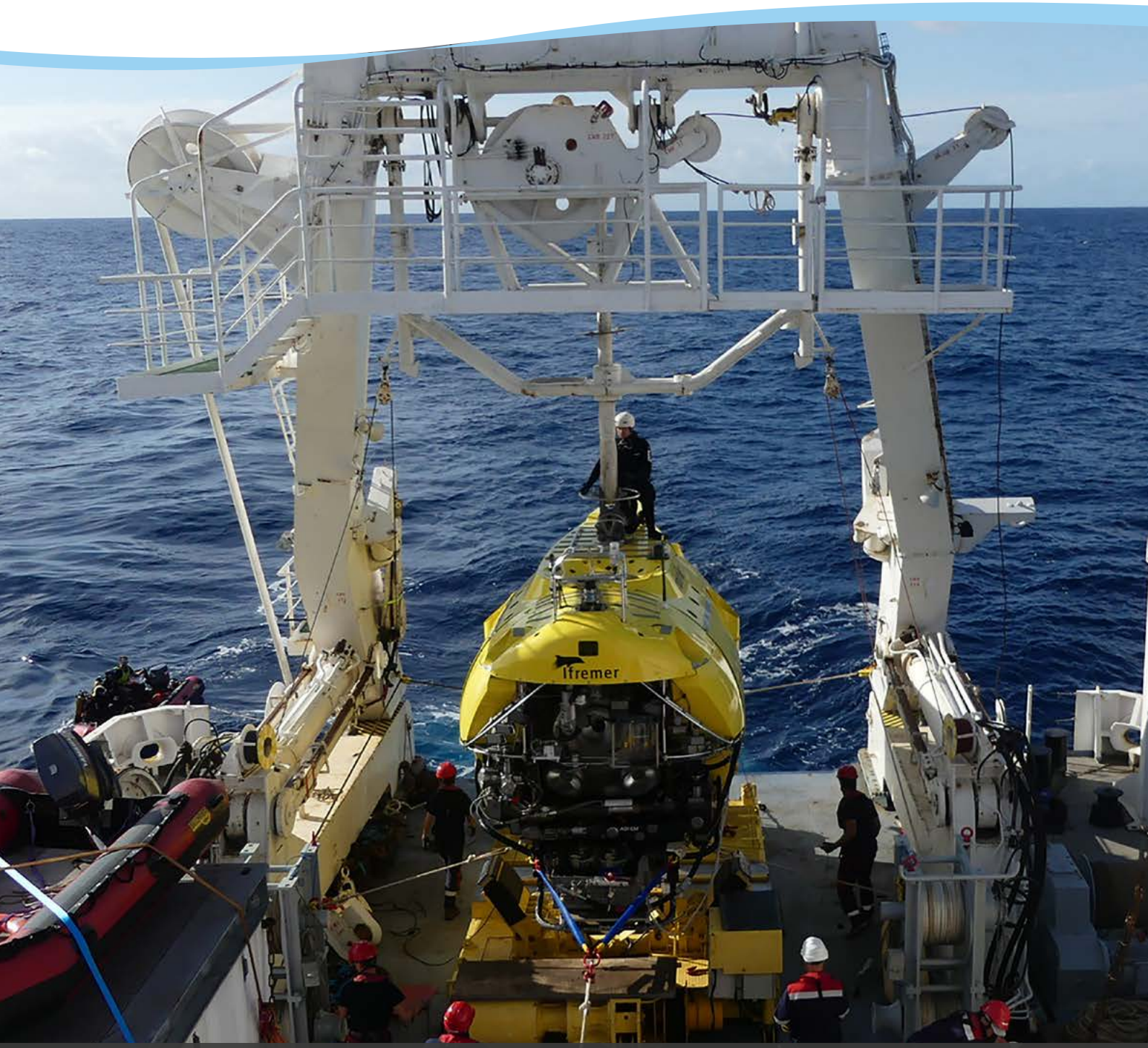
Project news

Issue 3 | June 2021

iAtlantic
INTEGRATED ASSESSMENT OF ATLANTIC MARINE ECOSYSTEMS IN SPACE AND TIME



Diving on the Mid-Atlantic Ridge

Expeditions to Lucky Strike and the Azores

Also in this issue...

Cover image: Launching the submersible Nautile *from RV* L'Atalante *at Lucky Strike, May 2021. Image courtesy : J. Sarrazin, Momarsat21 © Ifremer*

Message from Murray

We're approaching the half-way point of our iAtlantic voyage. Even in normal times this is a critical moment for any team to reflect on what's going well and what could have gone better – but thanks to the unprecedented issues created by the COVID-19 pandemic, a little reflection is more important than ever.

This newsletter gives a superb snapshot of iAtlantic and the positive forward momentum our project has maintained despite the challenges that 2020 and 2021 have thrown at us. When we designed iAtlantic we created a balance of activities to study deep- and open-ocean ecosystems at sea, to run multiple stressor experiments in the laboratory and to analyse existing datasets from a whole range of sources. All this work was grounded in an improved understanding of the Atlantic's oceanographic environment and how it is changing. In this newsletter you can see this approach in action. COVID-19 pandemic restrictions continue to create challenges, but our strategy is working.

As I write, two iAtlantic expeditions are at sea, both focussed on understanding the Mid-Atlantic Ridge. The University of the Azores is leading the iMAR expedition to the study vulnerable marine ecosystems (p4) and Ifremer, with the EMSO-Azores team, are servicing and downloading data from their seafloor observatory at the Lucky Strike vent field (p3). Experiments to study the impacts of deep-sea mining plumes combined with climate change stressors are underway (p6, 10, 12). As well as incorporating climate stressors, these experiments are looking at both seabed and water column species and the results will be hugely important to understand the wider environmental impacts of deep-sea mining in a rapidly changing ocean.

Our work in the South Atlantic is expanding in many areas. iAtlantic's physical oceanographers now have a better understanding of the strength, structure and timescales of variability in the Brazil Current – an important driver of climate variability (p14) – and we are working closely with our sister project Triatlas to enhance the SAMBA-West mooring array. Off Brazil in the 'Blue Amazon', iAtlantic has also secured access to a large deep-sea environmental dataset from Petrobras, a great example of how important it is to forge close partnerships between science and industry (p16).

iAtlantic's work is also designed to be relevant to a great range of policy and management processes. We're a project alive to the real-world issues of how human uses impact upon deep- and open-ocean marine ecosystems. We need to understand what sustainable use of marine ecosystems means, and how our results are relevant to discussions at IPBES (p21), IPCC and the ongoing negotiations at the UN to develop a new international agreement on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (BBNJ Agreement).

Working with non-traditional and local knowledge, like the remarkable time series from WhalesBermuda (p18), gives iAtlantic more resilience to the challenges of working in the COVID era. Although our flagship iMirabilis expedition can no longer operate off Namibia and South Africa the replanned iMirabilis2 cruise will set sail to Cabo Verde in July with the Autosub600 AUV, Luso ROV and deep-sea landers on board (p8) – stay tuned for updates on that and our other 2021 expeditions.

There's so much to be proud of in this newsletter and across our project. Thanks to everyone in the iAtlantic family for your great work and commitment. It's a pleasure working with you!

J Murray Roberts
iAtlantic Coordinator
Edinburgh, 25 May 2021

Welcome to NOAA's Kasey Cantwell

iAtlantic is pleased to welcome Kasey Cantwell from the National Oceans and Atmosphere Administration (NOAA) to the iAtlantic Advisory Board. Kasey takes over as the NOAA representative on the Board from Alan Leonardi, who has taken up a new role as Executive Director at the Consortium for Ocean Leadership. We're delighted that Alan remains a Board member! Kasey looks after the NOAA Okeanos Explorer shiptime programme and brings valuable expertise to the iAtlantic governance team.

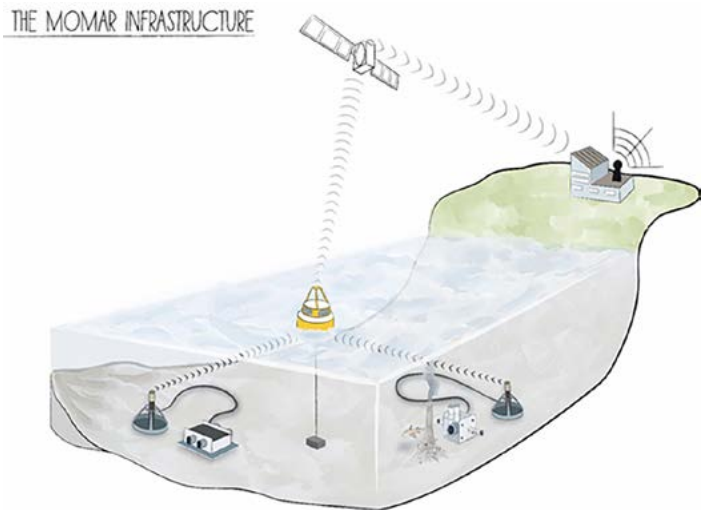
MoMARSAT 2021: collecting the first data of the second decade

By Marjolaine Matabos, Ifremer

The EMSO-Azores crew has raised the anchor and cast off again! After celebrating the observatory's 10th anniversary in 2020, this year marks the beginning of the second decade of observations of the 1700 m deep hydrothermal vent field at Lucky Strike!

EMSO-Azores is a non-cabled multidisciplinary observatory devoted to the long-term integrated study of mid-ocean ridge processes, from the subsea floor to the water column. It is part of the EMSO-ERIC European network. The observatory includes two sea-monitoring nodes (SEAMON) providing power and communication to a number of instruments deployed on the seafloor, a surface buoy insuring data transfer to land, and an oceanographic mooring. Every year, the entire array is brought to the surface where the engineering team download large volumes of data from the instruments. The sensors are then cleaned, checked, repaired if needed, set-up and calibrated for another year of observations.

If you want to know more about the research conducted at Lucky Strike and the main scientific results, check our groundbreaking results on the EMSO webpage: www.emso-fr.org/EMSO-Azores/Ground-breaking-results.



This year we are sailing on the French research vessel *L'Atalante,* having left Toulon, France on 15 May. After two COVID tests and a 10-day transit to the Mid-Atlantic Ridge off the Azores, we are in the midst of a 21-day mission dedicated to the maintenance of the observatory and its associated sampling programme, using the submerisble *Nautile*. We will return to Brest, France on 21 June after a 6-day transit. The MoMARSAT 2021 oceanographic campaign is jointly carried out by Ifremer and Institut de Physique du Globe de Paris (IPGP-CNRS/INSU).

Data acquired during this cruise will feed into iAtlantic's work on time-series of environmental variables. We will also sample vent mussel larvae and juveniles that will be kept alive onboard for on-land lab experiments. This work is conducted by our colleague Ana Colaço from the University of the Azores, as part of iAtlantic's work on multiple stressors (see p10). Ana will assess the impact of climate change on the behaviour and physiology of mussel juveniles by controlling oxygen concentrations in her experimental setup.

Finally, we are happy to once again involve external partners in the adventure! In 2020, we started a collaborative project with a local radio and a social centre in Brest. In this project, which combines media education and scientific mediation, eight budding young journalists/marine scientists will produce a radio broadcast on the deep sea, focusing on vents and deep-sea minerals. The objective is to train the kids in radio production – interview, recording, audio editing – but also introduce them to deep-sea ecosystems: their diversity, uniqueness and the societal challenges they are facing. To this end, we will organise several video interviews from the ship – not only about the science, but also the different jobs and life on board. The kids will lead the way!

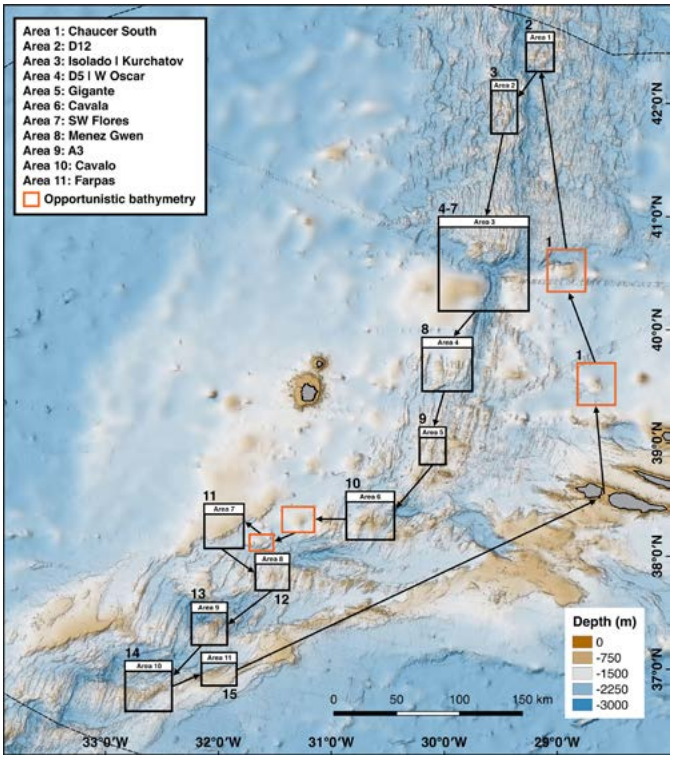
Join us and follow the adventure on our Facebook page: www.facebook.com/CampagneMomarsat

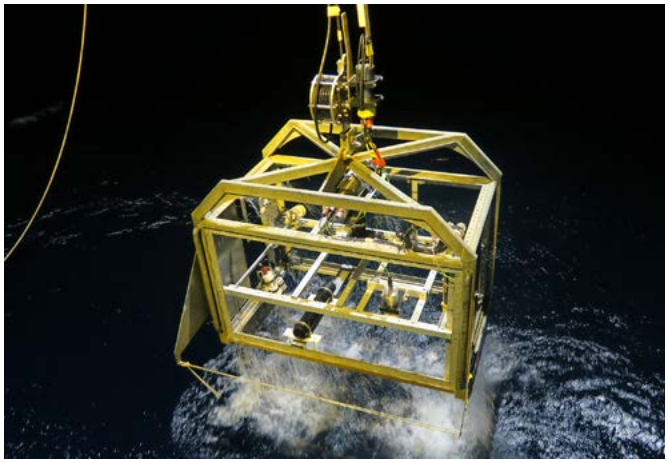
Assessing vulnerable marine ecosystems along the Mid-Atlantic Ridge

By Telmo Morato, Carlos Dominguez-Carrió & Marina Carreiro-Silva
Instituto do Mar/OKEANOS, Azores

The iMAR cruise "*Integrated assessment of the distribution of Vulnerable Marine Ecosystem along the Mid-Atlantic Ridge in the Azores region*" is currently underway aboard the Dutch research vessel *Pelagia*.

The Mid-Atlantic Ridge (MAR) is the most prominent ocean seafloor feature in the Atlantic Ocean, dividing it into eastern and western deep basins. The unique setting of the Azores, at the triple junction of the European, American and African plates and in close proximity to the mid-ocean ridge, offers an exceptional opportunity to survey the role of the MAR in shaping the distribution of deep-sea megabenthic communities, in partiucular those considered as Vulnerable Marine Ecosystems (VME). The varied geomorphology and complex oceanography patterns surrounding the Azores has generated an extraordinary diversity of benthic organisms, making this area a hotspot for cold-water corals in the North Atlantic. Latitudinal gradients and dissimilarities between the deep-water coral fauna on both sides of the MAR were noted during local and wider scale studies, raising the question of whether the MAR could present a barrier to biological dispersion between the east and west Atlantic. However, there has been very little exploration on seamounts, ridges and other topographic features along the MAR.





Above: the NIOZ towed camera / hopper system. Photo courtesy Carlos Dominguez-Carrió/OKEANOS-UAç.

This iMAR cruise will evaluate the role of the MAR in shaping the latitudinal and transatlantic patterns in the biogeography, connectivity and spatial distribution patterns of deep-sea megafauna. Additionally, the cruise will: (i) map and characterise deep-sea coral and sponge communities inhabiting unexplored seamounts and ridges in the MAR in the Azores Region; (ii) identify new areas that fit the FAO's VME definition; (iii) add to the existing knowledge on the environmental drivers that determine the spatial distribution of deep-sea benthic biodiversity in the MAR, and (iv) determine the condition of benthic communities by looking at evidence of fishing damage to fauna, presence of lost fishing gear and marine litter. At each sampling location, multibeam data will be collected for seabed mapping, together with towed camera transects to identify deep-sea benthic communities, water samples for biodiversity analyses through eDNA methods, sediment samples for biodiversity analyses through faunal studies and eDNA methods, microplastics and analyses of granulometry and physical-chemical studies. Water mass properties will also be characterised by sampling seawater and measuring physico-chemical parameters.

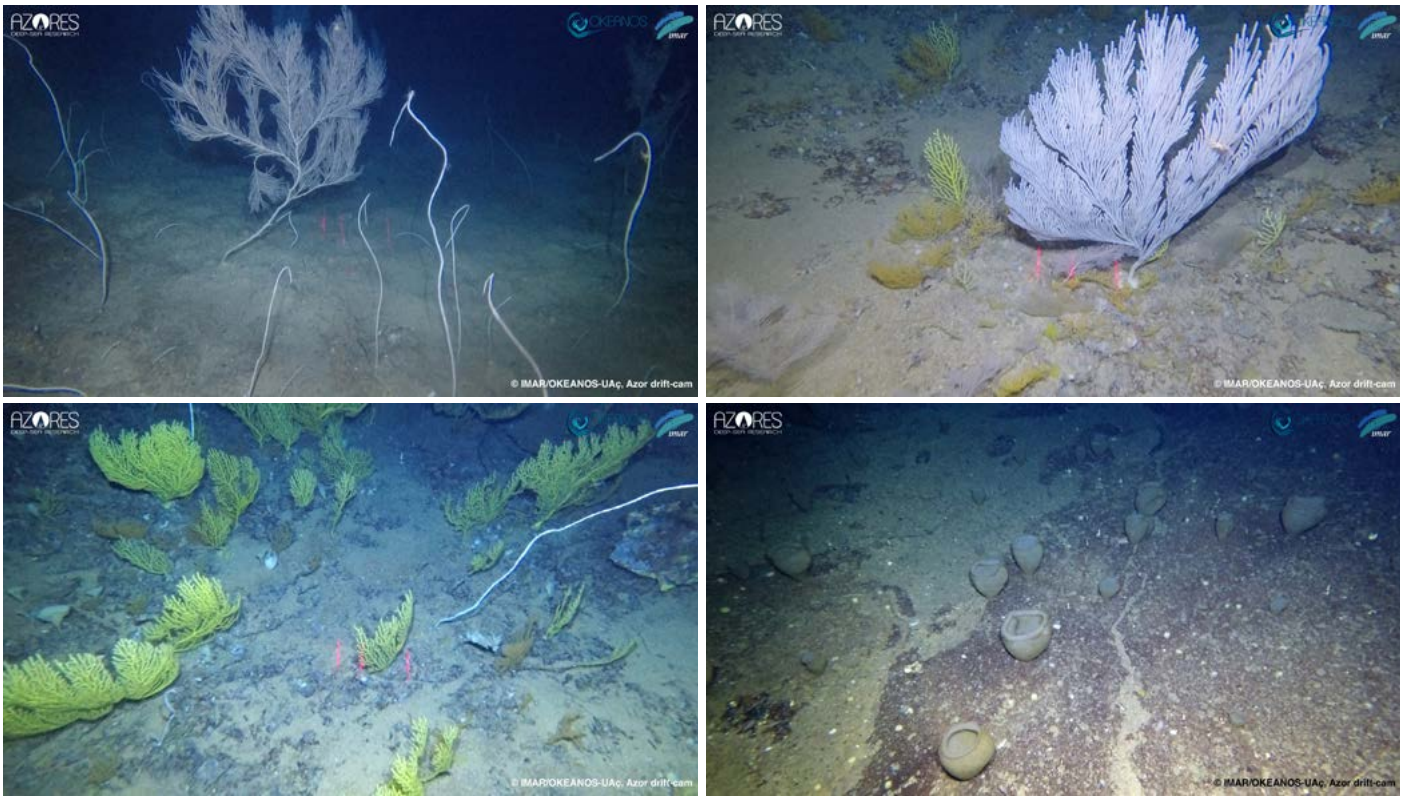
The results of this exploration will directly contribute to iAtlantic's objective to understand the factors that control the distribution, stability and vulnerability of deep-sea ecosystems and better inform sustainable management

Left: Map showing the location of the 11 survey areas along the Mid-Atlantic Ridge near the Azores.

throughout the Atlantic in an era of unprecedented global change. iMAR will enhance the predictive capabilities for detecting VMEs, and results will inform Good Environmental Status (GES) assessments, Marine Spatial Planning (MSP), as well as provide new insights on how to sustainably manage deep-sea ecosystems in the MAR. This cruise will also contribute to the SEAMAP 2030 (Mapping the Portuguese Sea) programme of the Portuguese Hydrographic Institute, to the international Seabed 2030 initiative, as well as to the United Nations Decade of Ocean Science for Sustainable Development (2021-2030).

Running from 19 May to 3 June 2021, this expedition is funded by the SEA OCEANS programme of Eurofleets+ and iAtlantic, and is led by iMAR and Okeanos from the University of the Azores (Portugal) in collaboration with the Hydrographic Institute and University of Porto (Portugal), the University of Aarhus (Denmark), the National Oceanography Center (UK), GEOMAR (Germany), the University Museum of Bergen (Norway), the PP Shirshov Institute of Oceanology (Russia), and the University of Vale do Itajaí (Brazil).

You can follow the cruise activities on Twitter: #iMARcruise2021



Azores deep-sea biodiversity - clockwise from top left: A large colony of the octocoral Callogorgia verticillata*, which can reach up to 2 m in height in the Azores; a coral garden common in the Azores deep sea, with a large colony of the octocoral* Paracalyptrophora josephinae*; A rare aggregation of glass sponges (perhaps* Asconema *sp.); A typical Azorean deep-sea community, composed of several species of cold-water corals (*Dentomuricea aff. meteor, Viminella flagellum*, and* Acanthogorgia *sp.). All images courtesy IMAR/OKEANOS-UAç, Azor drift-cam. Below: RV* Pelagia*. Image courtesy Carlos Dominguez-Carrió/OKEANOS-UAç.*

HE570: a cruise of opportunity for iAtlantic

By Leni Hauss, GEOMAR

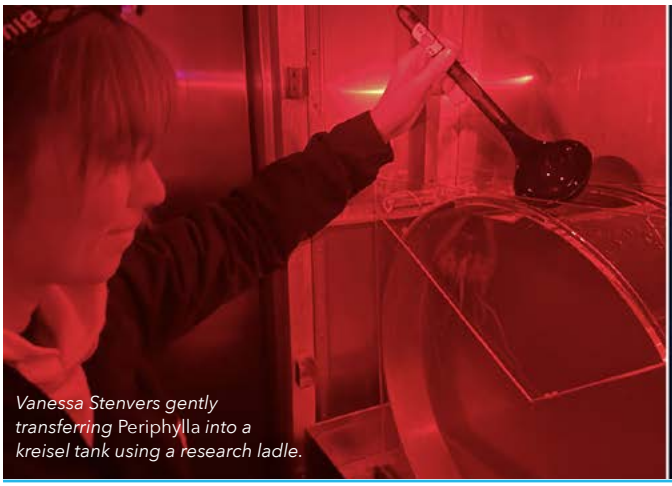
When we were planning the fieldwork for iAtlantic, the COVID-19 pandemic was not yet on the horizon. And so it seemed perfectly feasible to schedule a land-based expedition to the Lurefjord near Bergen to carry out stressor experiments with the cosmopolitan deep-sea helmet jellyfish *Periphylla periphylla*, which – along with copepods – is particularly abundant in this fjord. Our team comprised members from HWU, UWC and GEOMAR. The plan was to use GEOMAR's submersible JAGO, deployed from a local barge (Leon Pedersen's MS *Solvik*), for the gentle capture of jellyfish. Short-term incubations of the jellyfish at different temperatures were planned on board MS *Solvik*, and longer incubations in kreisel tanks at the Espegrend field station, in order to simulate exposure to a range of sediment plumes that might be generated by deep-sea mining (see p10).

At that time (in 2019), we were also planning a cruise with RV *Heincke* to Norway with the Pelagic Imaging Consortium (PIC) colleagues from GEOMAR, AWI, and HEREON (HZG), led by Klas Ove Möller and myself. All of us are working with *in situ* camera systems in the pelagic realm, and this expedition was meant to be a harmonisation exercise, as well as an attempt to simultaneously quantify the different pathways of the biological carbon pump using imaging techniques. To this end, we targeted Masfjorden and Lurefjorden because of their fundamentally different pelagic food webs. While Masfjorden is home to deep-sea lanternfish (*Benthosema glaciale*) and pearlside (*Maurolicus muelleri*), Lurefjorden is dominated by *Periphylla* jellyfish. Of course, the upcoming iAtlantic work also played a role in our choice of location, allowing another set of observations to be made a few weeks later in the year. In June 2020, our cruise proposal was approved as HE570 FjordExport.

Little did we know then that our land-based plans would have to be abandoned; the final decision on that came in January 2021 as it became clear that COVID-19 would continue to disrupt scientific seagoing plans. At the same time, however, it was decided that the HE570 expedition could go ahead as planned (Bremerhaven-Bremerhaven, preceded by hotel quarantine for all participants). Suddenly, there was a free berth on the *Heincke* because one participant could not travel to Germany (ironically, the only participant from Norway). This allowed iAtlantic PhD student Vanessa Stenvers to join the expedition, and in some last-minute preparations I packed the kreisel tanks, incubators, respiration and ammonium excretion equipment to carry out experiments on board.

During the cruise, we were able to gently catch jellies in the upper water column during the night. They were much bigger than we had expected from our literature review and "*We're gonna need a bigger kreisel*" quickly became the expedition catchphrase. We worked with them in *Heincke*'s temperature-controlled room as well as in two incubators. Since they are extremely sensitive to light, experiments were carried out in darkness (with the opportunity to watch their bioluminescence), using red headlamps during manipulation. Given the tight timeframe (after all, this study was not in the original cruise workplan), this all worked quite nicely, and we are very excited about our first results. Nevertheless, we still need to increase our sample numbers, and have requested shiptime as co-proponents of another cruise in November 2021 on RV *Alkor*.

Although we were so close to the impressive shoreline scenery, it was a true deep-sea experience to combine *in situ* observations and experiments with living animals from the deep. Every research cruise is a dive into new discoveries, and, after a year of home office, the good spirits of everyone on this cruise were a particular tonic. Many thanks to captain Haye Diecks and crew for all their great support!



Vanessa Stenvers gently transferring Periphylla *into a kreisel tank using a research ladle.*

In situ *video observation (by Henk-Jan Hoving's PELAGIOS) of* Periphylla periphylla *in Lurefjorden.*

Using sound to quantify the fish biodiversity in sponge grounds

By Laurence De Clippele, University of Edinburgh

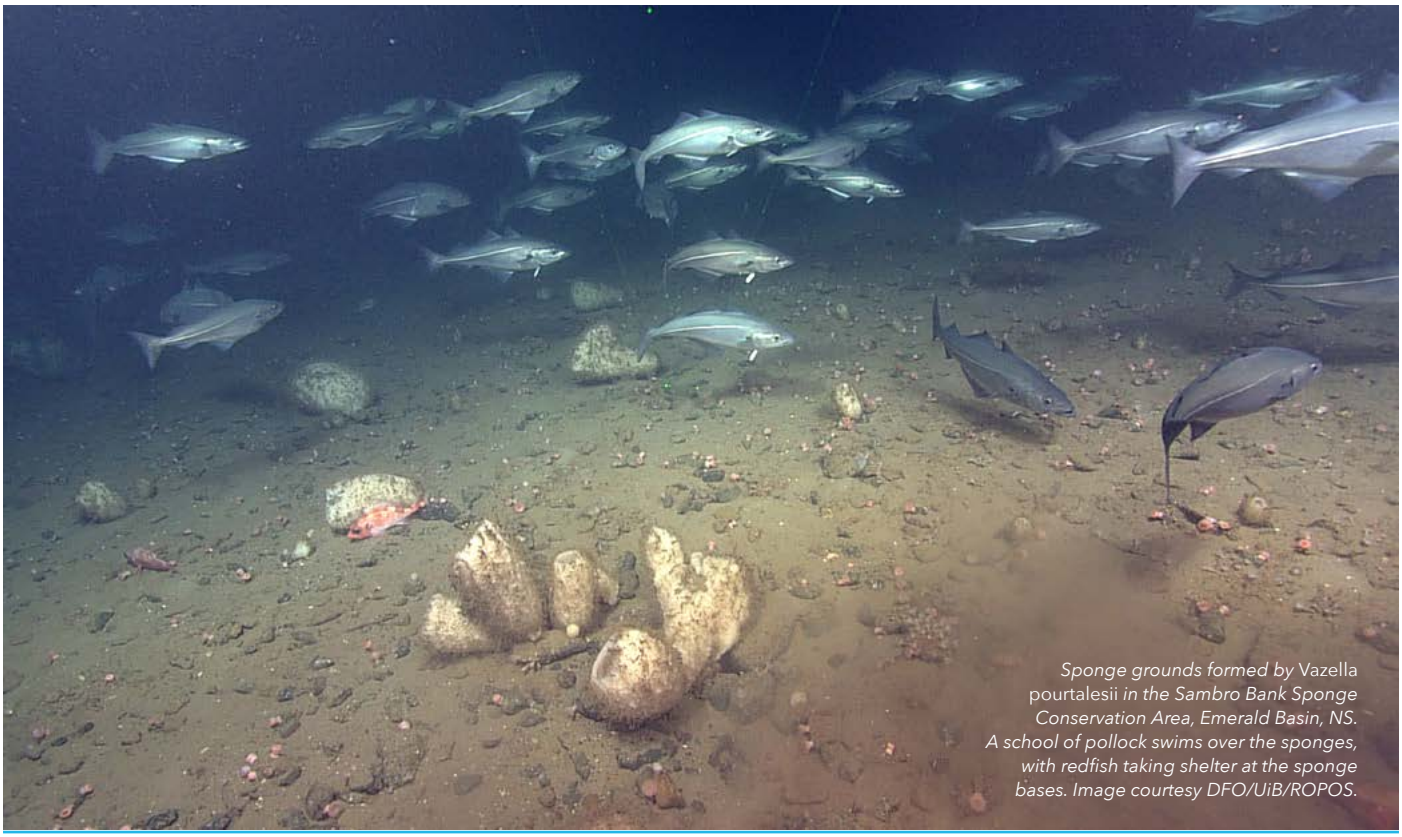
Vazella pourtalesii is a relatively large sponge (up to 50 cm) that can form dense biogenic habitats and locally enhances invertebrate biodiversity. Fourteen fish species in trawl catches have been found to be significantly associated with these sponge grounds, including commercially important silver hake, redfish, haddock and northern shortfin squid. Since fish may use these sponge grounds for feeding, spawning, and nursery areas there is a need to collect more information on fish use of this key benthic habitat in order to support decision-making following an ecosystem approach.

Passive acoustic monitoring (PAM) is a novel approach that uses long-term underwater sound recordings to study animal behaviours, weather-related and geophysical sound sources and the impact that humans have on the overall soundscape. In recent years, PAM has also been used as a method to assess the health and biodiversity of marine ecosystems. However, this research has predominantly been in coastal and relatively shallow ecosystems.

To increase our knowledge of the soundscape in open ocean ecosystems, the CCGS *Hudson* – an offshore oceanographic and hydrographic survey vessel operated by the Canadian Coast Guard – will depart on a mission in September 2021 to study the soundscape of sponge grounds formed by *Vazella pourtalesii* in the Sambro Bank Sponge Conservation Area on the Scotian Shelf. Landers with sound recorders, cameras, Acoustic Doppler Current Profilers, sediment traps and Ocean Tracking Network (OTN) acoustic receivers will be deployed in three locations: a "high density", a "low density", and a "dead" *Vazella* sponge site.

The landers will be recovered in the spring of 2022 after recording data for ~10 months. During this time the pollock are expected to have spawned, along with other key species. The data collected will allow us to study spatial and temporal changes in the biodiversity and the geophysical environment at these sponge grounds, which can ultimately be used to identify important areas for enhanced protection and inform ecosystem management decision-making.

The project is a collaboration between the Department of Fisheries and Oceans Canada, the University of Edinburgh, the Ocean Tracking Network (OTN), the University of Liverpool, Aarhus University and the iAtlantic project.



Sponge grounds formed by Vazella pourtalesii *in the Sambro Bank Sponge Conservation Area, Emerald Basin, NS. A school of pollock swims over the sponges, with redfish taking shelter at the sponge bases. Image courtesy DFO/UiB/ROPOS.*

iMirabilis2: Bringing deep-sea discovery and training to your desktop!

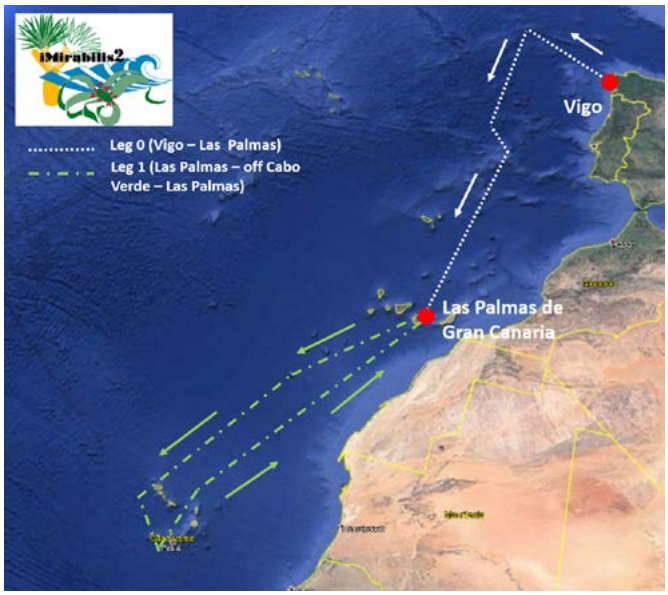
RV Sarmiento de Gamboa - *the research vessel that will be home to the iMirabilis2 expedition this summer. Image courtesy EMEPC.*

Named after the long-lived *Welwitschia mirabilis* plant found in western Africa, the iMirabilis2 expedition is a six-week mission to explore the deep-sea ecosystems of the Atlantic Ocean around Cabo Verde. During this time, the scientists on board will use state-of-the-art equipment to undertake a number of experiments and surveys that will reveal information about the inhabitants and physical conditions in the water column and at the seafloor. In addition, a large part of the expedition's activities will be dedicated to training and skills development for early career marine scientists.

The mission will take place on the Spanish research vessel *Sarmiento de Gamboa*, and is split into two legs, which have different objectives and involve different teams of people. As many will know, planning this expedition has been extremely complicated due to the immense volume of science we have planned, but also due to the COVID-19 crisis, which has forced us to reschedule and then re-plan everything several times!

Leg 0: Investigating seafloor spreading features

After leaving port in Vigo on 23 July 2021, the ship will sail a roundabout route southwards to Las Palmas in the Canary Islands. This journey will take about a week, and during this time scientists from EMEPC and other research institutions will undertake surveying and sampling of some of the geological features on the seafloor using the ROV *Luso*. At the same time, some of scientists on the ship will undergo intensive training in the use of ROV technology. Also on board will be a small team of seabird ecologists from the NGO Projecto Vito in Cabo Verde, who will use this time at sea to observe seabirds. This expedition is an excellent opportunity for them to get hands-on training and experience in seabird surveying and census techniques, as well as collecting valuable new data on seabird abundance and distribution in this area of the Atlantic.



Above: The planned route for the iMirabilis2 expedition.

Leg 1: Investigating deep-sea ecosystems around Cabo Verde

RV *Sarmiento de Gamboa* will reach Las Palmas in the Canary Islands on 30 July, where most of the Leg 0 team will disembark, and new team members will join the ship for the main phase of the expedition. The ship will depart port again on 31 July and head further south-west, where cruise leaders Cova Orejas, Veerle Huvenne and Andrew Sweetman will direct operations to discover and investigate what lies in the deep Atlantic waters around Cabo Verde. Data collected during this cruise will contribute to many aspects of iAtlantic's work, from understanding better the distribution of seafloor habitats across the Atlantic basin, to undertaking scientific detective work to reveal past environmental conditions in the deep ocean - this will help us understand trends and changes in the ocean and how they affect ecosystems. On board, ROV *Luso*, Autosub6000, benthic landers and a range of other sampling gear and experimental kit will be deployed during what will be a very intensive few weeks' work.

Everyone is invited

Capacity building has always been at the heart of the iMirabilis2 expedition. From the very start, the ethos for this mission was to maximise every opportunity to exchange knowledge, teach new skills, build capacity, and share experiences. Unfortunately, COVID has forced us to re-plan a lot of our activities, but we are delighted that Kelsey Barnhill – an iAtlantic Fellow from University of Edinburgh – will be our eyes and ears on the ship for both legs of the expedition. Her role on the expedition is to make sure we can share as much of the action as possible with everyone back at home. The iMirabilis2 expedition will have a dedicated area on the iAtlantic website, where learning materials, explainers and videos of the work at sea will be available, along with a daily blog from the team on board the ship. We are currently busy pulling all the background material together, which will be available in the coming weeks. Of course, you will also be able to follow all the action via our Twitter feed too.

#iAtlanticEU #iMirabilis2

Right, top: The remotely operated vehicle (ROV) Luso *(image courtesy EMEPC); middle: the autonomous underwater vehicle (AUV)* Autosub6000 *(image courtesy NOC) - both of which will be used udring the expedition. Bottom: University of Edinburgh's Kelsey Barnhill, who will be reporting and sharing experiences from the ship for the duration of the iMirabilis2 expedition.*

Join us for a special iAtlantic Follow the Fellows webinar about the iMirabilis2 expedition: Tuesday 9 June, 15:00 BST

Joining details at www.iatlantic.eu/events-calendar/webinar-programme

Assessing multiple stressor impacts on deep-sea fauna

IMAR-UAz: Marina Carreiro-Silva, Inês Martins, António Godinho, Sandra Marques, Mariana Cruz, Ana Colaço
IEO/AWI: Melanie Fähse, Covadonga Orejas, Jürgen Laudien
GEOMAR/HWU: Vanessa Stenvers, Helena Hauss, Henk-Jan Hoving, Andrew Sweetman

Environmental disturbance resulting from prospective deep-sea mineral resource extraction, bottom trawling, and other anthropogenic activities such as coastal development, can impact deep-sea biota through the generation of sediment plumes that disperse across vast areas of the ocean. Suspended sediments can affect benthic and pelagic fauna by impairing processes associated with feeding and respiration, among others, which can lead to altered communities and loss of biodiversity. The potential release of metals during mining of deposits such as seafloor massive sulphides (SMS), can further affect the physiology of organisms and bio-accumulate through the food web.

Impacts from these human activities will occur in parallel with climate change effects in the oceans, which include ocean warming, acidification and, in some regions, decreasing dissolved oxygen concentrations and reduced levels of food supply and quality to the seafloor. Thus, climate change may act as an added stressor to those already imposed as a result of human activities, potentially reducing the resilience (i.e. the capacity to recover from a disturbance) of species and ecosystems to direct human impacts. To address this issue, iAtlantic is conducting a series of *ex situ* studies to examine the effects of different climate and man-made stressors on key deep pelagic and benthic organisms, in order to understand and predict how and where multiple stressors could drastically impact ecosystem functions and services. These include regulatory services such as the global carbon cycle, as well as supporting services such as the generation and connectivity of habitats with unique or high biological diversity. iAtlantic studies will produce data that can be incorporated into standards and guidelines, policy regulation, monitoring programmes, and adaptive management for deep-sea industries and activities – for example, the International Seabed Authority (ISA)'s developing deep-sea mineral exploitation regulations, and regional fisheries organisations' management of fishing activity.

IMAR-Az is conducting experiments on cold-water corals (CWC) to test the cumulative impacts of predicted ocean acidification and reduced food supply, as well as sediment plumes generated during extraction of SMS. The octocoral species *Dentomuricea aff. meteor* and *Viminella flagellum* are used as model species because of their habitat-forming role in the coral gardens of the Azores. This experiment builds on a series of previous experimental studies conducted by IMAR-UAz through satellite projects to iAtlantic, which focus on the impacts of deep-sea mining on these octocoral model species. Results of these related studies are used to select the mining scenarios to combine with climate change simulations in iAtlantic.

Recent studies conducted as part of the JPIOceans2/MiningImpact2 (Mining2/0005/2017) project compared the differential impacts of sediment plumes generated during potential mining activities for the extraction of nodules in the Clarion-Clipperton Fracture Zone (CCFZ) in the NE equatorial Pacific Ocean, and SMS from a hydrothermal vent field in the Azores in the NE Atlantic. Over a period of four weeks, corals were exposed to suspended sediments from nodule fields, hydrothermal polymetallic sulphide particles, and a control treatment with no sediment addition (Fig. 1a). Sediment concentrations were selected based on plume dispersal models for close-field and far-field scenarios. Sediments from the CCZ were obtained from abyssal depths of 4000 m in the Belgian polymetallic nodule exploration contract area. SMS particles were obtained by grinding up fragments of dead sulphide chimneys from the Lucky Strike hydrothermal vent field on the Mid-Atlantic Ridge. Preliminary results showed high sensitivity to SMS particles compared with nodule field sediments.

Another study, undertaken within the IMPACTOR project (ACORES-01-0145-FEDER-000122), assessed the effects of metal toxicity associated with SMS particles and the reduced seawater pH predicted under ocean acidification scenarios. A set of short-term aquaria experiments exposed *D. meteor* and *V. flagellum* to acute copper (Cu) concentrations (found to be the main metal that is remobilised from polymetallic sulfide particles in solution) under reduced pH conditions (1000 µatm/pH 7.73). Preliminary results showed reduced physiological capacity of corals to cope with Cu intoxication under reduced pH when compared with when compared with ambient pH conditions. Each species seems to trigger distinct cellular responses to overcome Cu exposure, reduced pH and the cumulative effect of both, indicating species-specific sensitivities to metal toxicity.

IEO and AWI have conducted experiments to explore the potential impacts of sedimentation resulting from close-to-shore activities on the juvenile stages of the cup coral *Caryophyllia huinayensis*, a CWC species which is present in high densities on the steep slopes of Chilean fjords such as Comau Fjord. The distribution of this small cup coral, frequently found in the shelter of overhangs, suggests

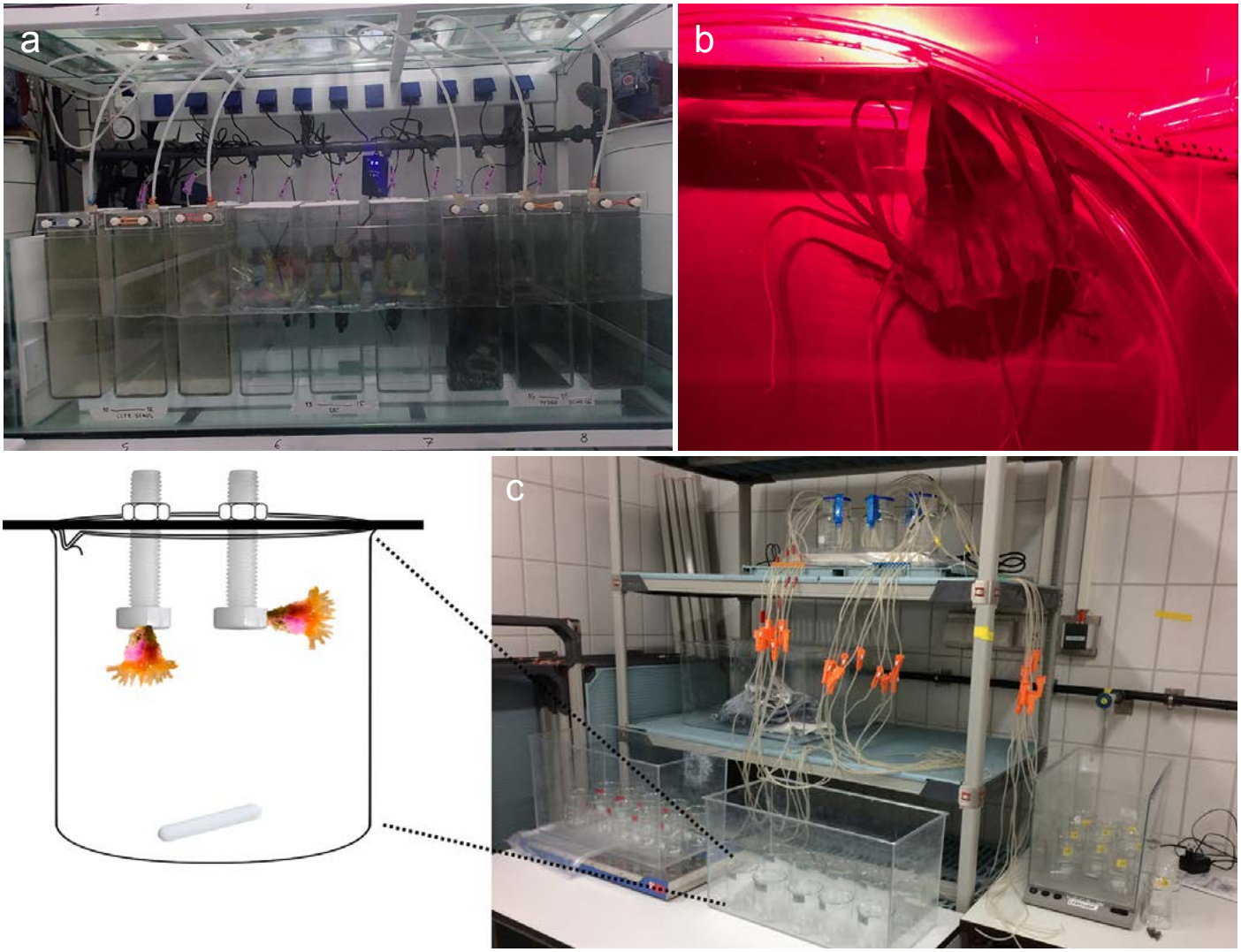


Figure 1: Experimental set-up used in the different sedimentation experiments at (a) IMAR-UAz using the octocoral Dentomuricea aff. meteor, *(b) GEOMAR/HWU using the helmet jellyfish* Periphylla periphylla, and *(c) IEO/AWI using the cup coral* Caryophyllia huinayensis.

a natural sensitivity to sedimentation, but data on the susceptibility of this coral species to sediment load is lacking. Understanding the capabilities of CWC recruits to cope with anthropogenic impacts is important, as their viability is the guarantee for the population's future. To shed light in these aspects, a three-month aquaria experiment was conducted at the AWI (Fig. 1c) using three sediment loads: i) the current natural sediment concentration in Comau Fjord; ii) 100- fold higher values expected from local construction and coastal erosion, and iii) and 1000-fold higher values. Response variables measured included polyp activity, and variation in coral mass and in calyx dimensions. Under high turbidity, polyp activity was clearly reduced, therefore significantly affecting prey capture effectiveness and thus nutrition. This is also confirmed by the significantly lower growth rate, measured under the highest sediment load. Respiration measurements are currently being conducted in order to explore the potential effects of this mid-term *ex situ* experiment in the physiological performance of the corals.

GEOMAR and HWU have assessed how pelagic fauna is impacted by global warming and mining-related sediment plumes by conducting experiments with the deep-sea helmet jellyfish *Periphylla periphylla*. This particular scyphomedusa was chosen for its circum-global distribution, its occurrence from the surface down to 4000 m water depth, and because of its high abundance in several Norwegian fjords. The original idea was to conduct these experiments via a land-based expedition near Bergen, Norway, and to collect jellies using GEOMAR's submersible JAGO. Unfortunately, this plan had to be abandoned because of the COVID-19 pandemic, and was replaced by ship-based efforts. Using RV *Heincke* in March 2021 (p6), helmet jellyfish were collected with nets from the Lurefjord, Norway. Since these deep-sea jellyfish possess a pigment that becomes toxic to them when exposed to bright light, experiments were conducted in the dark and the necessary stressor manipulations (temperature and sediment treatment) were done under red light (Fig. 1b). GEOMAR/HWU plans to repeat these experiments later in the year. This study will be one of the first to document species-specific tolerances of a large gelatinous zooplankton species towards human-induced stressors in the deep ocean.

How to study the effects of multiple stressors on a cold-water coral? Setting up an aquarium facility from scratch

By Cristina Gutiérrez-Zárate[1,2], Alfredo Veiga[3], Andrea Gori[2], Juancho Movilla[1], Elisa F. Guallart[1], Marta Álvarez[1] & Covadonga Orejas[1]

[1]Spanish Institute of Oceanography (IEO) [2]Universitat de Barcelona [3]Aquarium Finisterrae

The current available knowledge on the consequences of global change for deep benthic marine ecosystems is still very limited. Some of the main stressors arising from global change are ocean warming, acidification and deoxygenation. These stressors do not act separately but their interactions are almost completely unknown, therefore there is a need to investigate the combined effects of these stressors to achieve a more accurate understanding of the possible consequences of global change on the structure and functioning of deep-sea benthic ecosystems.

In iAtlantic, our aim is to study the ecophysiological response of the yellow scleractinian *Dendrophyllia cornigera*, a cold-water coral with a wide geographical and bathymetric distribution that plays an important role in providing habitat to other species. Although past ecophysiological studies have explored how global change would impact this species, they focused on the effects of one isolated stressor (warming or acidification), so we planned an experimental design that would allow the study of the possible interactions of different stressors under a global change scenario. This methodological approach determines the experimental design and implies an extraordinarily complex aquarium setup. It simulates the IPCC scenarios in a much more realistic way, since the environmental variables do not act independently or in isolation, but jointly. Understanding these interactions will contribute to the assessment of the response of the benthic communities to global change.

The selected scenarios used in the study that determine the values of the stressors are current *in situ* values vs the IPCC projection under the RCP 8.5 "business as usual" scenario for the deep North Atlantic in 2081-2100. The selected stressors, based on these projections, are: warming (as increase of temperature), acidification (as increase of dissolved carbon dioxide and therefore decrease of pH) and deoxygenation (as decrease of dissolved oxygen). Consequently, the study of these combined effects leads to a factorial analysis with eight different treatments, with three replicates of each treatment, with a total number of 24 experimental aquaria.

The facility for this experiment belongs to the Aquarium Finisterrae (A Coruña, NW Spain), which was already equipped with an open life support system where seawater is pumped from 17 m water depth, filtered by a series of equipment (sand and biological filters, skimmer, filter cartridges up to 0.35 µm) and cooled to 10°C by an industrial chiller. The filtered and chilled water is stored in an isothermal 1500 L tank and goes through a UV lamp and, by gravity, it reaches the treatment tanks (Fig. 1).

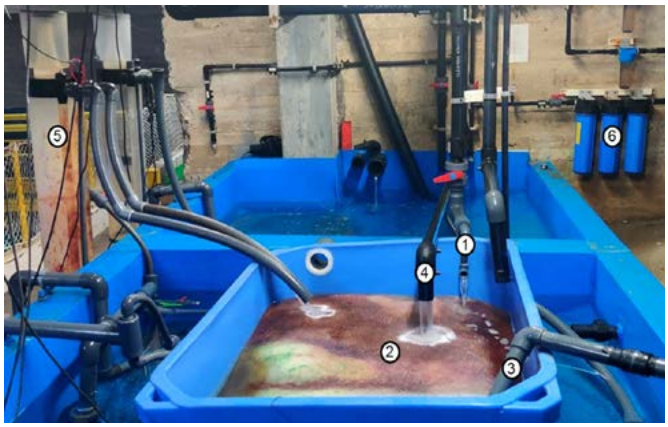


Figure 1: Filtration and chilling system: (1) continuous supply of pre-filtered seawater; (2) 1000L bio-filter; (3) 10°C water input from chiller; (4) water overflow from isothermal storage tank; (5) skimmer; (6) cartridge filters.

Inside the facility, eight 80L treatment tanks were installed, each containing pH, dissolved oxygen and temperature probes, nitrogen and carbon dioxide tubes and a heater. Sets of three 5L experimental aquaria are connected to each treatment tank and placed inside water baths that keep the temperature stable. The water renewal rate is about four times per hour and the water overflows, filling the water bath and reaching a drain line. All of the tanks have a recirculating pump that homogenises and keeps a constant current inside. Treatments with different pH and dissolved oxygen values were labelled with different colours, and divided on both sides depending on temperature values: current *in situ* scenario on the left and global change scenario on the right (Fig. 2).

After finishing the aquaria installation, the next step was the controller setup, which is connected to the pH and dissolved oxygen probes from all of the treatment tanks. We installed nitrogen and carbon dioxide bottles and their respective gas lines to allow the gas circulation from the

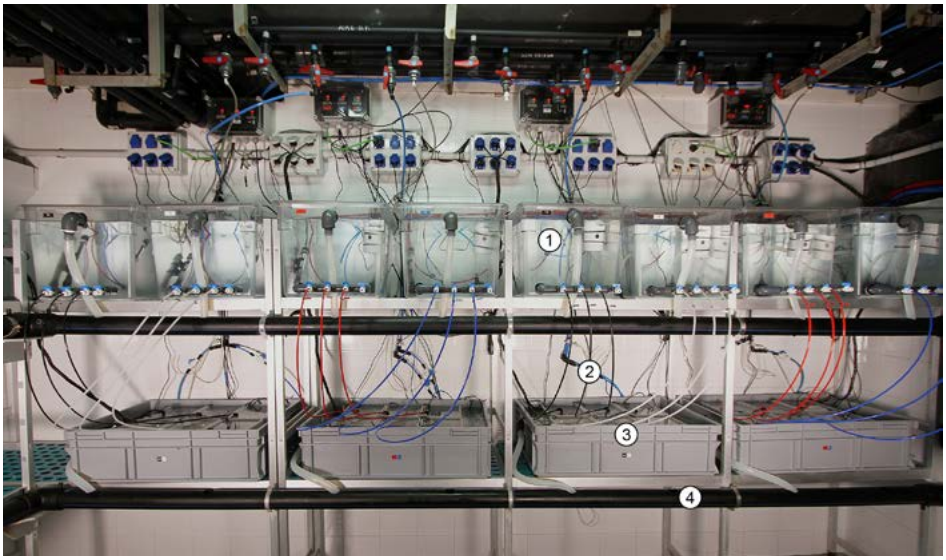


Figure 2 (left image) - Aquaria setup: (1) treatment tanks; (2) polyethylene tubes that connect water from treatment tanks to the experimental aquaria; (3) warming bath containing experimental aquaria; (4) drain line. Figure 3 (right image) - Controller setup: (1) controllers with every pH and dissolved oxygen probe from treatment tanks connected behind; (2) solenoid valves; (3) needle valves to control the gas flow; (4) gas tubes for each treatment tank (red for carbon dioxide and blue for nitrogen).

bottles to the solenoid valves, and then their circulation to their respective treatment tanks. When the measured values from the probes are above a certain threshold, the controller (Profilux 4) activates a specific solenoid valve that allows the circulation and bubbling of carbon dioxide and nitrogen in the treatment tank, to reduce the pH and dissolved oxygen concentration, respectively. Additionally, we installed a temperature controller (Raspberry Pi) that activates heaters inside the tanks once the PT100 probes register lower values than the desired treatment temperature (Fig. 3).

Fortunately, colonies of *D. cornigera* for the experiment were caught as bycatch before the COVID lockdown, otherwise it would be impossible to collect the organisms. To prepare the nubbins (which is our experimental unit, consisting of a coral fragment that includes one to several polyps), we cut the colonies using a rotary tool, then smoothed and cleaned any remnant tissue, and glued them to laser-cut methacrylate bases, numbered with the aid of the laser cutter. Although we needed 144 nubbins (six per aquarium), we prepared a total of 167 nubbins to have spares and be able to select the best fitting ones for the experiment (Fig. 4).

Throughout this experiment, several analyses will be performed to understand the ecophysiological response of this species to climate change. These analyses will include the measures of skeletal growth, respiration and excretion rates, measure of tissue retraction, as well as measure of skeletal density and microporosity, among others. To study the skeletal growth during the experiment and how it can be affected by the different stressors, we are using the buoyant weight technique. Since cold-water corals have a very slow growth, we need a highly precise weight balance to detect the growth patterns (Ohaus Adventurer AX124) and we designed an *ad hoc* weighing table that isolates any vibration and disturbance, allowing that required accuracy. Additionally, a parallel experiment will take place to study how different conditions can affect the ability of this coral to regenerate tissue, simulating the simultaneous impacts from physical damage due to fishing activities and global change.

This study will increase knowledge about the effect and interaction of different stressors on this species, to advance the understanding of the vulnerability of deep-sea ecosystems against global change. We hope to get back to you in a couple of months to report the first results, so we can all learn more about the fate of this species under global change scenarios.

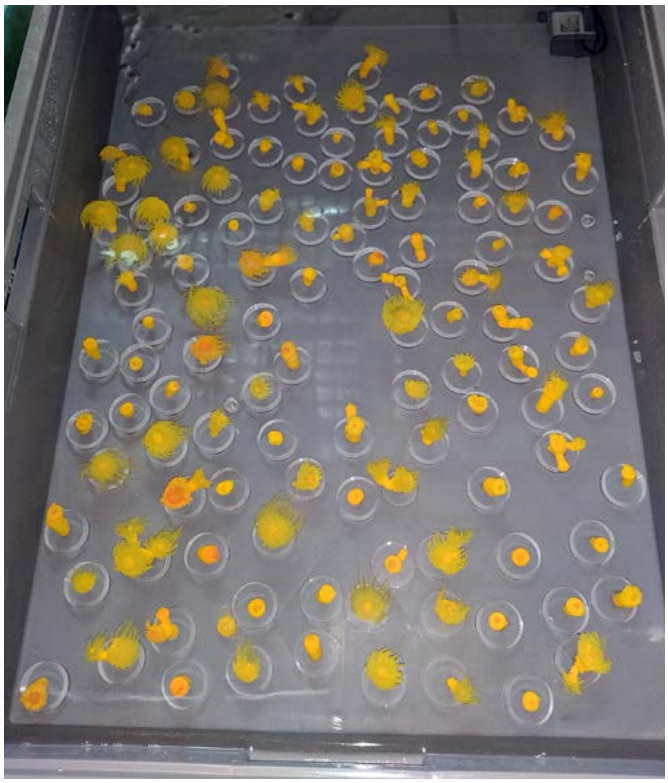


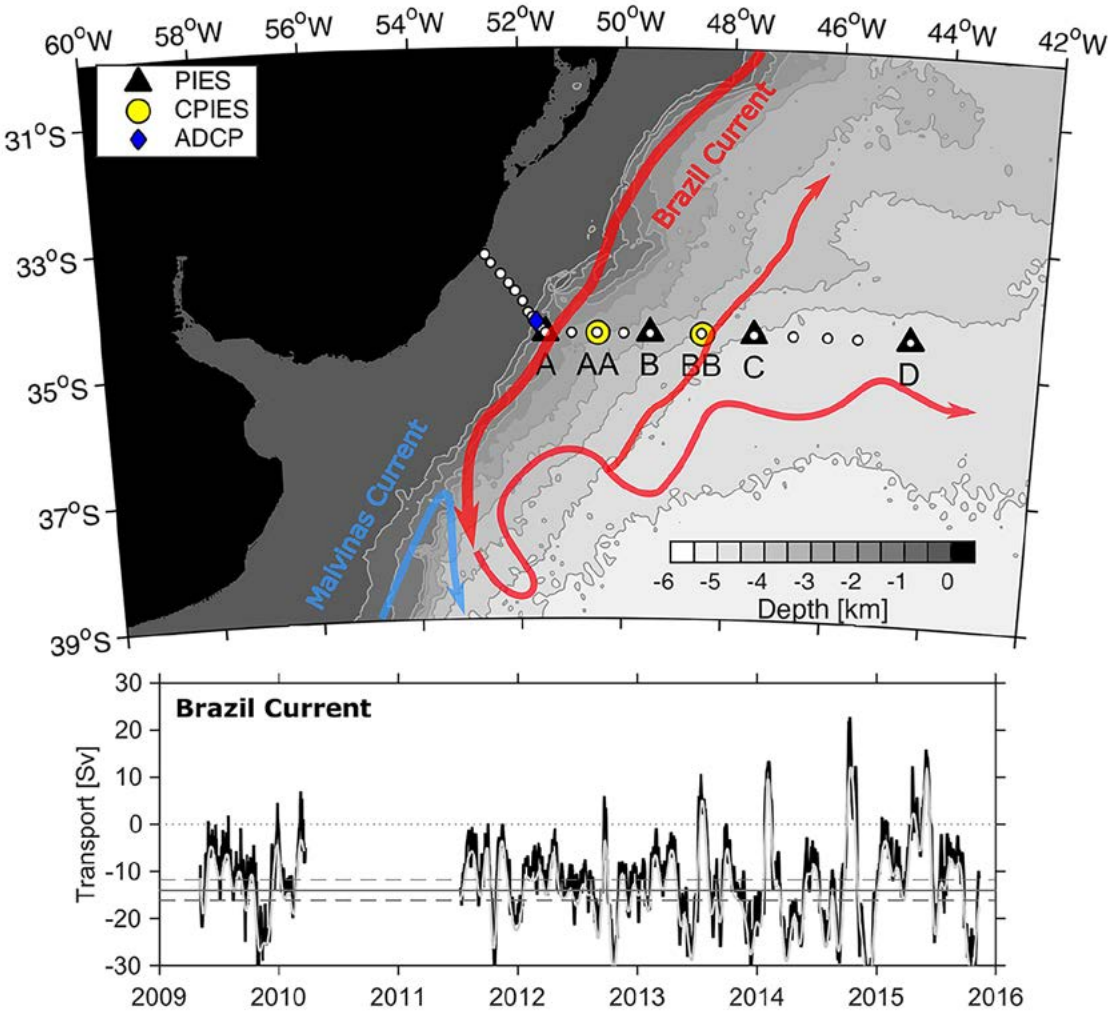
Figure 4: Some of the Dendrophyllia cornigera *nubbins prepared for the experiments in husbandry tanks.*

Multiyear Brazil Current volume transport timeseries measured at 34.5°S

By María Paz Chidichimo, CONICET and Servicio de Hidrografía Naval, Argentina

The Brazil Current – the western limb of the subtropical gyre of the South Atlantic Ocean – transports warm and salty water off the South American coast towards the pole, and is a major driver of climate variability. In this work, we present the first multiyear continuous daily time series of Brazil Current absolute volume transport obtained using more than six years of observations from a line of four pressure-recording inverted echo sounders (PIES) deployed in 2009 at 34.5°S. The array was augmented in 2012 with two current meter-equipped PIES (CPIES), and in 2013 with a moored Acoustic Doppler Current Profiler on the upper continental slope. These measurements in the southwest South Atlantic are part of the South Atlantic Meridional Overturning Circulation Basin-wide Array (SAMBA) deployed across the Atlantic at 34.5°S to measure daily variations in the AMOC. The western boundary portion of SAMBA (SAMBA-West) measures the flows of the Brazil Current in the upper ocean and the Deep Western Boundary Current below. SAMBA is part of the international South Atlantic Meridional Overturning Circulation (SAMOC) initiative, led by contributors from Argentina, Brazil, France, Germany, South Africa and the US.

These new observations allow us to analyse in unprecedented detail the strength, structure, and timescales of variability in the Brazil Current. The absolute Brazil Current transport at 34.5°S, integrated between the sea-surface and the mean-pressure of the density interface between Tropical Waters/ South Atlantic Central Water and Antarctic Intermediate Water (on average at a reference pressure of 628 ± 46 dbar from our regular hydrographic sections) has a mean strength of -14.0 Sv, a large standard deviation of 8.8 Sv, and a large peak-to-peak range of 61.7 Sv. Transport variations of 20-



Left: Configuration of the SAMBA-West array: PIES (black triangles), CPIES (yellow circles), ADCP mooring (blue diamond). White circles represent the nominal positions of the hydrographic CTD/O 2 / LADCP stations. Bathymetry (shaded background) comes from the Smith & Sandwell (2007) dataset.

*Left: Time series of 72 h low-pass-filtered absolute Brazil Current transport observed at 34.5°S during 2009-2015. The gray horizontal solid and dashed lines indicate the time-mean and time-mean plus minus two standard errors of the mean (2*SEM; 95% confidence value), respectively. Negative transports correspond to southward flow.*

30 Sv occur in periods as short as 2-3 weeks and larger variations of about 40-60 Sv occur in periods of 30-60 days, illustrating the dynamic short-term variability in the record and the necessity of continuous-in-time daily observations to avoid aliasing. Our results reveal that the largest part of the variance (~80%) in the absolute transport is concentrated at periods shorter than 150 days with a well-defined peak at 100 days. Interestingly, the baroclinic component of the Brazil Current transport accounts for the largest fraction of the absolute transport variance (85%), but the barotropic variance contribution (15%) is not negligible. The baroclinic and barotropic transports are uncorrelated, highlighting the need to measure both transport components independently in order to accurately describe the flow variability. Given the energetic high frequency transport variations, statistically significant seasonal to interannual variability and trends have yet to be detected.

The long-term PIES/CPIES array at 34.5°S has been shown to capture the majority of the variability of the Brazil Current, centered mainly in the area between 51.5°W and 49.5°W. High-resolution hydrographic section data have been used to estimate the mean related transports near the shelf/shelf-break to the west of 51.5°W (which are not currently sampled by the PIES/CPIES array) and data from the bottom moored ADCP provided important insights about upper slope and shelf velocities. Our results indicate that additional time series observations at the shelf-break between the 500 and 1000 dbar isobaths would improve the overall estimation of the Brazil Current transport by the array. Within iAtlantic, a tall dynamic height mooring additionally equipped with current meters and oxygen sensors will be deployed at the western boundary wedge at the 700 m isobath, currently not sampled by the PIES/CPIES at the SAMBA-West array. This new capacity to measure oxygen concentrations and fluxes will be used to understand the role of the Brazil Current in the oxygen budget of the subtropical South Atlantic. SAMBA-West will be further enhanced by the addition of a tall mooring at 3500 m to be deployed as part of iAtlantic's sister project TRIATLAS (see iAtlantic Newsletter, March 2020).

These new SAMBA results were recently published in Chidichimo, M. P. et al. (2021): Brazil Current volume transport variability during 2009–2015 from a long-term moored array at 34.5°S. https://doi.org/10.1029/2020JC017146.

For more information about the SAMOC initiative please visit www.aoml.noaa.gov/phod/SAMOC_international/

Also hot off the press...

Check out the latest iAtlantic publications below! For a full list of all the papers iAtlantic has produced to date, please see www.iatlantic.eu/our-work/publications

Dominguez-Carrió C., Fontes J. & Morato T. (2021) A cost-effective video system for a rapid appraisal of deep-sea benthic habitats: the Azor drift-cam. Methods in Ecology and Evolution. DOI 10.1111/2041-210x.13617

Gould W.J. & Cunningham S.A. (2021) Global-scale patterns of observed sea surface salinity intensified since the 1870s. Communications Earth & Environment. DOI 10.1038/s43247-021-00161-3

Ison S., Ison T., Marti-Puig P., Needham K., Tanner M.K. & Roberts J.M. (2021) Tourist preferences for seamount conservation in the Galapagos Marine Reserve. Frontiers in Marine Science. DOI 10.3389/fmars.2020.602767

Rakka M., Maier S.R., Van Oevelen D., Godinho A., Bilan M., Orejas C. & Carreiro-Silva M. (2021) Contrasting metabolic strategies of two co-occurring deep-sea octocorals. Scientific Reports. DOI 10.1038/s41598-021-90134-5

Wheeler A.J., Lim A., Butschek F., O'Reilly L., Harris, K. & O'Driscoll, P. (2021) The "Little MonSta" deep-sea benthic, precision deployable, multi-sensor and sampling lander array. Sensors. DOI 10.3390/s21103355

Watch this space! An iAtlantic Special Issue of *Frontiers in Marine Science* is in the wings, co-edited by Murray Roberts and Telmo Morato, on the theme of "**Managing deep-sea and open ocean ecosystems at ocean basin scale**". More details coming soon...

Celebrating industry-science alliances in the Atlantic Ocean

Environmental data produced by Petrobras from Campos and Espírito Santo Basins is now available for ecological studies under the iAtlantic project

By Angel Perez (UNIVALI), Paulo Sumida (IOUSP), Alberto Lindner (UFSC), Ângelo Fraga Bernardino (UFES), Guarani Hollanda Cavalcanti, Priscila Reis da Silva and Ricardo Silva Varotto (Petrobras)

Brazil's "Blue Amazon" describes the 4.5 million km^2 Brazilian EEZ. The term was coined by the Brazilian Navy to raise awareness of the importance of an area that is equal to the Brazilian Amazon rainforest in both size and in importance as a provider of critical ecological services.

Nearly two-thirds of this area comprises deep-sea environments virtually unknown to Brazilians until the 1980-90s when the first research initiatives were launched in the country to explore this vast area and map its natural resources. Driven by a strong academic component, these programmes have produced significant advances, which nevertheless have become sparse and discontinuous, mostly due to the erratic availability of public resources (both financial and technological). Consequently, as opposed to the "green" Amazon, the vast majority of the Blue Amazon has remained unexplored and understudied.

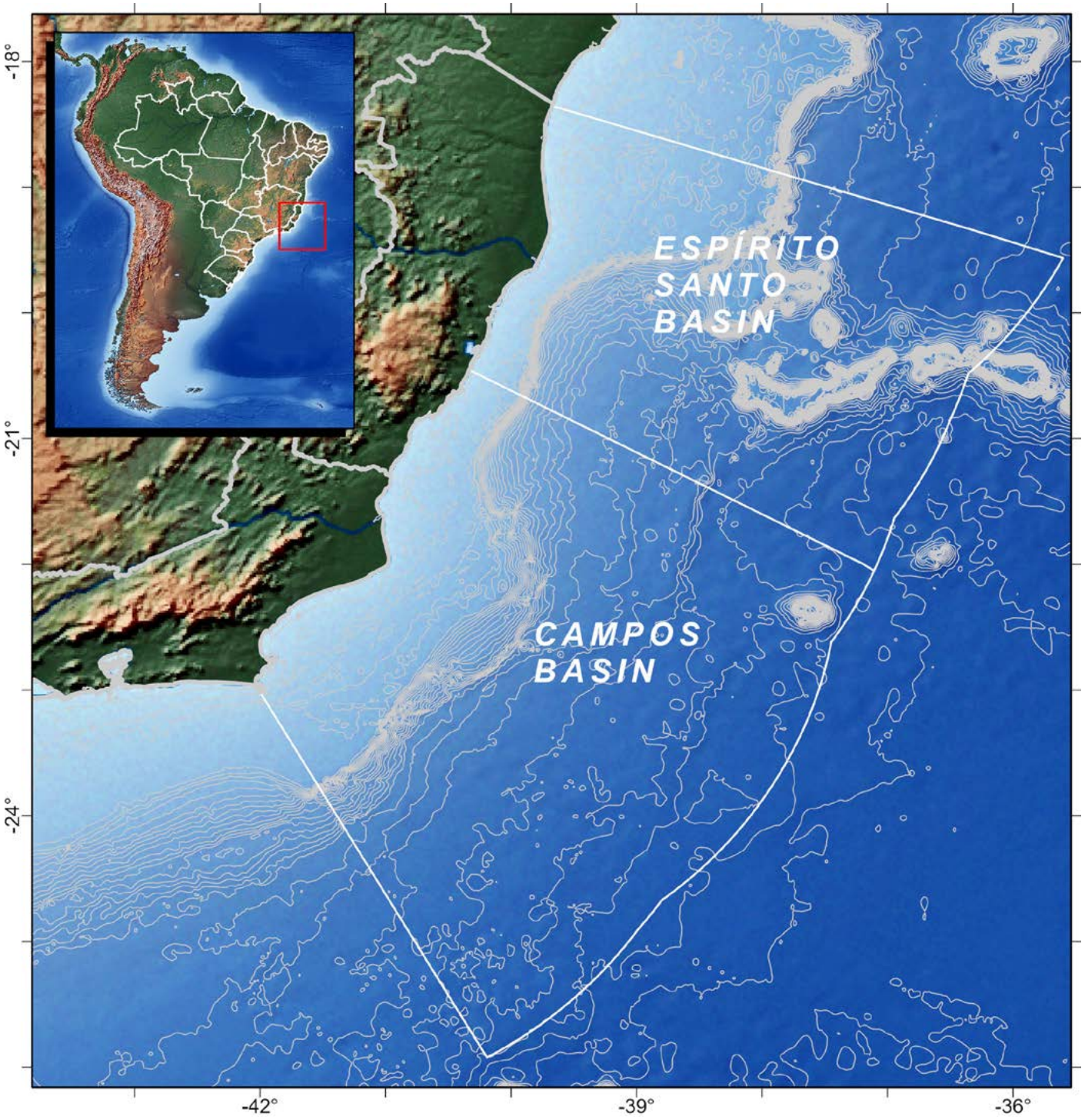
On an alternative path, however, the Brazilian national oil and gas company Petrobras established an independent research programme that explored the deep areas of the Brazilian continental margin, revealing one of the largest hydrocarbon-rich sedimentary basins of the planet. In 1984-87, the discovery of the giant Albacora and Marlim offshore oil fields in Campos Basin were milestones that stimulated not only the expansion of deep seafloor exploration, but also technological development in submarine production systems. This enterprise made Petrobras a global player in offshore hydrocarbon production, currently capable of extracting over 80% Brazil's annual oil and gas production from deep (200–2000 m) and ultra-deep (> 2000 m) oil fields. Most of this production is extracted from "pre-salt" deposits in the Campos and Santos basins, which lie in 5000–7000 m water depth, and some 3000–5000 m below the seafloor.

Throughout this resource-driven process, an extensive amount of environmental data on deep-sea ecosystems was produced, largely surpassing the capacity of the existing scientific programmes, and highlighting the potential for industry-science collaboration to enhance knowledge about the Blue Amazon. Opportunities for such an alliance emerged through the environmental licensing process carried out by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), which induced the development of environmental studies known as Regional Characterization Projects (PCRs) in the most productive basins. Throughout these studies Petrobras connected to important marine research groups at universities and research institutes in Brazil, and funded ecological descriptions of deep-sea ecosystems where most oil and gas offshore activities take place, especially in the Espírito Santo, Campos and Santos sedimentary basins on the SE Brazil margin. Such knowledge has become available via numerous scientific reports and articles. Yet many Brazilian marine scientists would agree that, through continued access and use of the accumulated raw data, much more could be learned about deep-sea ecosystems – not only in the context of the sustainable use of hydrocarbons and other deep-sea resources, but also to address pressing environmental issues such as the effects and consequences of global climate change on the ocean.

Data sharing has been a central element behind the support of the offshore oil and gas industry to iAtlantic, championed by the International Association of Oil and Gas Producers (IOGP). Since 2019, a collaborative dialogue with the iAtlantic Steering Committee, coordinated by Wendy Brown (IOGP), defined the types of data that would leverage ecological analysis and could be shared by the oil and gas companies that operate in iAtlantic's study regions. Particular emphasis was given to strengthening the established partnership between Petrobras (associated to iAtlantic through IOGP) and iAtlantic partner institutions in Brazil, focusing on collaborative use of data produced during the oil and gas environmental licensing processes for the advancement of iAtlantic tasks, goals and objectives. Early this year, these efforts resulted in Petrobras' decision to make available its extensive environmental database produced in Espírito Santo and Campos basins, where environmental licensing processes have long been concluded. It was also flagged

that sharing data produced in the Santos Basin would also be possible in the future, as the pre-salt deposit environmental licensing progresses.

In May 2021, Petrobras made an extensive database available to the iAtlantic consortium, including geological, physical, chemical and biological variables from the shelf break to the deep slope, and including both seafloor and water column samples. This dataset partially covers the two principal study regions of iAtlantic on Brazil's margin (study regions 10 and 11). Considerable effort is now underway to translate field names and metadata before it is released to the wider iAtlantic community. These are the initial steps towards using the data in a range of scientific applications that includes regional habitat suitability and species distribution modelling, but may extend much further to include multiple and fruitful studies not easily predictable at this point. It is definitely time to acknowledge all the efforts that led us to this milestone and celebrate such an opportunity to prove the value of a science- industry alliance to address the critical environmental issues in the Atlantic Ocean.



Fluke chances: the abundance of migrating whales

By Tom Grove (University of Edinburgh) and Andrew Stevenson (WhalesBermuda)

Bermuda holds a unique position in the North Atlantic for migrating humpback whales. As a mid-ocean migratory stopover, the whales seen in Bermuda have been matched to tropical breeding grounds and cold-water feeding grounds across the entire North Atlantic. At the same time, human activities in the waters around Bermuda are increasing – including large vessel traffic and whale-watching tourism – and there are plans to further develop a blue economy. Within iAtlantic, a collaboration between WhalesBermuda and the University of Edinburgh aims to provide the first abundance time series for humpback whales at this key stopover site, spanning a decade. Here, we share our research journey so far, some preliminary results, and their potential implications for marine spatial planning and species monitoring.

Counting whales in the field

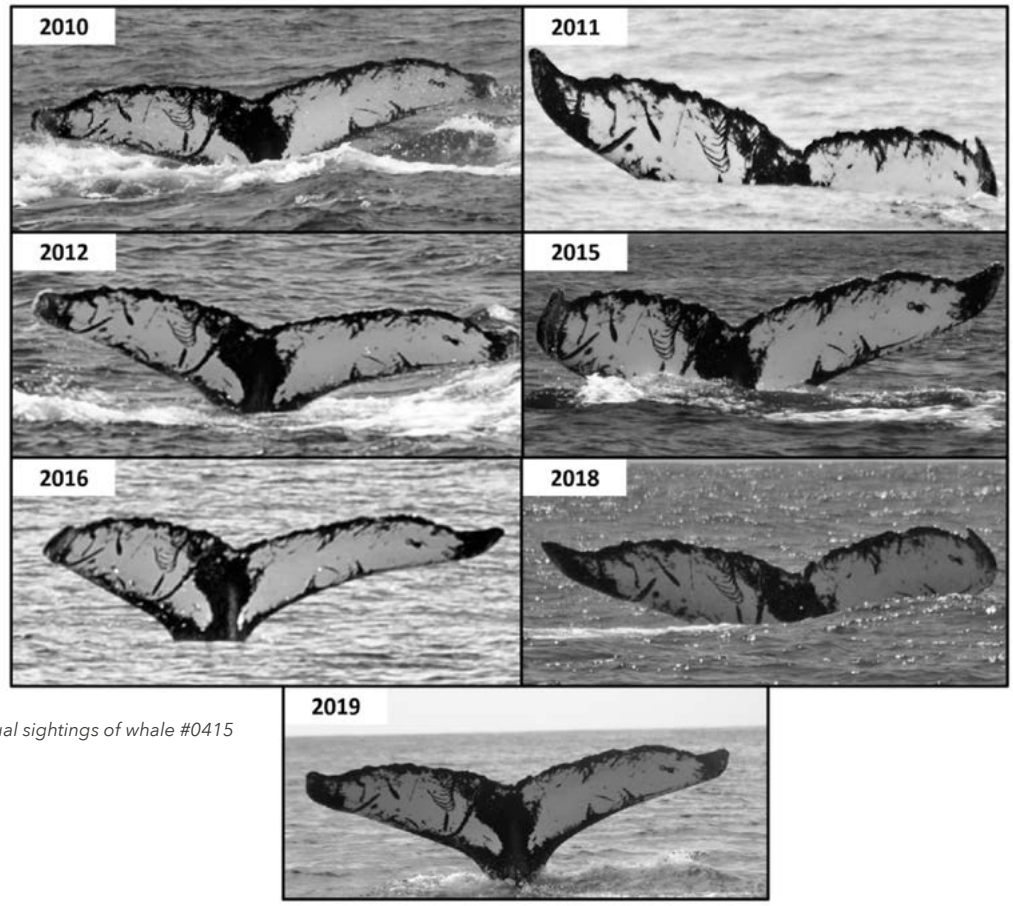
Deriving even a single abundance estimate for a cetacean species requires a huge observation effort in the field. When your study area encompasses offshore waters and strong winds can be relentless, this is especially true. Despite this, Bermuda's position in the 'middle' of the migration route for North Atlantic humpbacks provides a perfect platform to explore the pelagic habits and lives of this iconic species. WhalesBermuda, led by Andrew Stevenson, has monitored humpbacks around Bermuda annually since 2007, with plenty of discoveries and challenges.

Using a 22-foot single-engine boat, *Magical Whale*, Andrew makes use of a five-month window (January-May) when the weather is relatively benign – although storms can still prevent fieldwork for weeks at a time. Over the years, Andrew has identified and targeted 'hotspots' where sightings are most frequent. Averaging 20-30 days on the water per season, usually 11 hours per day, it is rare for him not to find a whale. The fieldwork itself is varied. For example, aerial observation with drones alludes to complex social behaviour and the potential use of sea mounts as aggregation points; and long-term acoustic deployments confirm seasonal occurrence and demonstrate singing behaviour. To estimate abundance, however, we are focusing on a single field method and dataset photo identification.

Humpback whales have black and white pigmentation patterns on the ventral side of their tail flukes; some are inherent markings and others consist of scars from healed injuries of both natural and anthropogenic origin. Crucially, these patterns are unique to each animal, providing a convenient way to identify individuals and track their sightings around Bermuda and across the entire North Atlantic. In a single season, Andrew can obtain as many as 270 whale IDs, accumulated primarily using a digital camera, underwater cameras and even drones. Since 2007, over 1500 individual humpbacks have been identified, many of them re-sighted over multiple years.

Reconstructing abundance

We used 11 years of photo-ID sightings to reconstruct annual abundance across a decade. Working with Prof. Ruth King at the University of Edinburgh's School of Mathematics, we developed a capture-recapture model for abundance. A term



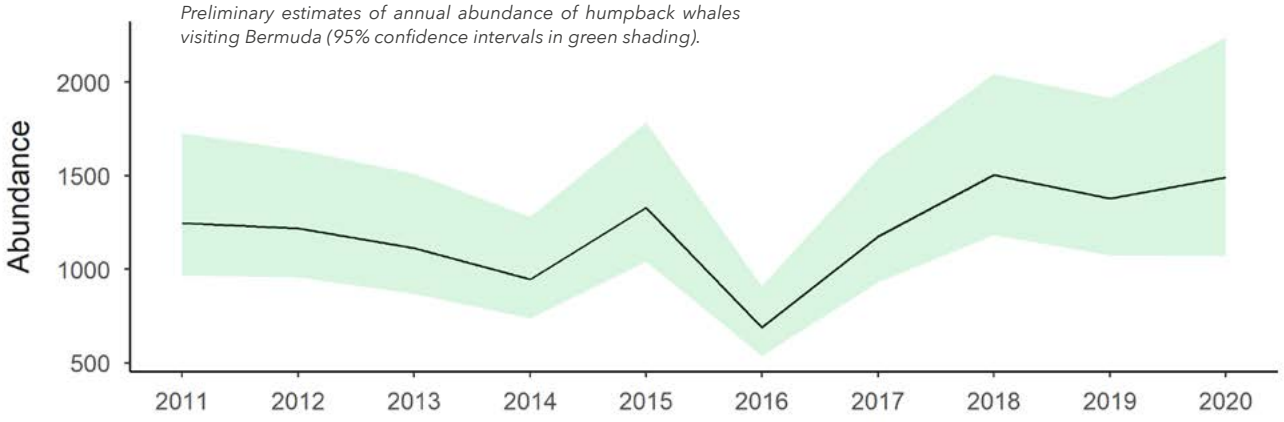
Annual sightings of whale #0415

originally applied to the process of physically capturing and releasing animals, in our system 'capture-recapture' refers to the process of sighting and re-sighting identifiable whales. By modelling these sighting patterns, we can estimate the probability of detecting an animal within the study system (whales around Bermuda), which can then be used to derive abundance estimates.

With no demographic data for humpback whales in Bermuda, we started with a simple capture-recapture model and sequentially added complexity. We accounted for inter-annual variation in the number of days of survey effort, which, as expected, influenced detection probabilities. We tested for the presence of transients – animals that only visit Bermuda once, perhaps due to shifting migration routes or simply infrequent migration by some individuals. We also considered individual detection heterogeneity, where each animal has a different probability of detection. This may arise from differences in surface behaviour, such as the propensity of a whale to show its fluke (which is very important!), or habitat use.

Whilst we are yet to publish our findings, we can share some preliminary results. The graph below shows annual abundance from 2011 to 2020, derived from our latest model. Without focusing on the details, this time series sends quite a clear message. With up to 1500+ whales visiting Bermuda annually, this small area is an important stopover

Preliminary estimates of annual abundance of humpback whales visiting Bermuda (95% confidence intervals in green shading).



for migrating North Atlantic humpback whales. As focus turns towards a blue economy in Bermudian waters and human activity increases regionally, this evidence of habitat use should encourage consideration of area-based management tools to mitigate risks from human activities around Bermuda. These tools might include Particularly Sensitive Sea Areas (PSSAs) and marine protected areas, as well as a review of existing whale-watching regulations.

More questions asked

To our knowledge, an abundance time series for humpback whales at an oceanic stopover has not been previously published. Therefore, we hope that our results can advance our understanding of North Atlantic humpback whales and scientifically confirm Bermuda's importance to the migration of this population. However, as with all science, we have ended up posing many more questions than we have answered.

For example, our preliminary abundance estimates show greater fluctuations between years than can be explained by changes in the North Atlantic population size. In part, this may be explained by variation in weather (which will influence detection probability) and within-survey effort. However, perhaps these fluctuations are also driven by shifts in migration routes, or changes in the proportion of animals that migrate each year. Understanding which processes drive changes in abundance could improve our understanding of species response to environmental change.

Zooming in from the population level, how do individual whales use Bermuda during their migration? Andrew's photo-ID dataset suggests that, generally, individuals are sighted and re-sighted at similar dates across years. Why maintain this temporal fidelity? Is it a manifestation of their social complexity? Or, given the preponderance of orca scars we see on North Atlantic humpbacks, perhaps whales aggregate at mid-ocean seamounts to migrate in protective convoys?

Finally, we know that humpback whales are marine predators and sensitive to environmental change. With Bermuda's migratory connections across the North Atlantic, could this time series contribute to ecosystem monitoring across an entire ocean basin? Exploring this 'sentinel' potential is our next challenge within iAtlantic. The continued monitoring of humpback whales around Bermuda may contribute, not only to the management of this species, but to that of entire ecosystems across the North Atlantic.

"Cetacean research cannot be measured in years, but rather in decades. I have completed only one and a half decades of this dedicated investigation and the more I find out, the more questions I have."

Andrew Stevenson

What is sustainable use of wild species?

A viewpoint from the IPBES Sustainable Use Assessment

By Jake Rice, Chair of the iAtlantic Science Council and joint-lead author of the IPBES Thematic Assessment chapter on Sustainable Use of Wild Species

Osvaldo Escobar

We live in a world that is realising that whilst our challenges are increasingly globalised, the ways to address those challenges must scale from the global down to very local. We have also come to realise that policies to address these challenges must be evidence- and knowledge-based, whereas policymaking is becoming increasingly partisan and politicised. In its efforts to address climate change, the Intergovernmental Panel on Climate Change (IPCC) demonstrated that sound and de-politicised assessments of complex issues are feasible; they can be policy-relevant without being policy-prescriptive, and can include a diverse evidence base. Where these assessments have been presented, they have been credible, and where they have been used, they have made a difference.

Led by Sir Robert Watson, a number of experts experienced in the IPCC assessments felt there were parallels with the global biodiversity crisis, which would benefit from a similar assessment process to provide non-politicised foundations for evidence- and knowledge-based decision making. This led to the foundation of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) in 2012 (Watson et al., 2018; Diaz et al., 2015). The principal feature of IPBES may not sound all that novel today: true integration across the natural sciences, economics, social sciences and governance, and across scientific knowledge systems, including knowledge systems of Indigenous and Local Communities. However, what is novel is having clear frameworks and guidance to make these aspirations operational in practice.

After a successful trial of the assessment framework, IPBES conducted four Regional Assessments of Biodiversity and Ecosystem Services (Africa, Asia-Pacific, Europe and Central Asia, and The Americas). These four Regional Assessments then formed the basis for the Global Synthesis Report. Together, these assessments have convincingly documented, on various scales, the declines in biodiversity, the key drivers of the declines, and the likely responses if alternative policies and choices were implemented. Results have already have been influential in developing the UN Sustainable Development Goals, the CBD Post-2020 Agenda, and many other global, regional, national and even sub-national uses. They were also the basis for a number of follow-up Thematic Assessments, including the Sustainable Use Assessment, for which I am co-lead author for the chapter on "Conceptualization of Sustainable Use".

What is the Sustainable Use Assessment (SUA)?

Even without efforts like the IPBES Regional Assessments and Global Synthesis, the Atlantic community is well aware of the global biodiversity crisis, the role of unsustainable use in biodiversity decline, and why it needs to be addressed. Correspondingly, it is no surprise that a thorough assessment of "Sustainable Use of Wild Species" was among the priority topics for the IPBES Thematic Assessments. In this assessment we are looking at all uses, categorised into five practices: fishing, gathering, hunting, timber harvesting, and viewing. It covers all wild species that are either used directly or are impacted by the use of other species.

For the deep ocean, fishing is by far the most relevant practice, making the very wide scope of the assessment seem excessively demanding when a more focused approach might be faster. However, the broad approach enables the full spectrum of use impacts to be assessed: direct impacts on the populations being used (extractive uses or through watching) or as a direct consequence of use of other species

(e.g. bycatch), direct impacts on the habitats where the uses take place, and all the indirect impacts of the changes in populations and habitats on ecosystem structure and function.

This is far from the first time that the sustainability of fishing has been comprehensively examined, but it has never been done on a such a large scale or with this range of expertise or diversity of perspective. The ambition of the assessment is reflected in its chapter structure: 1) Introduction and Framework, 2) Conceptualization of Sustainable Use, 3) Status and Trends, 4) Drivers, 5) Scenarios and Projections, and 6) Synthesis and Policy Options. Each of these chapters considers all five classes of practice, extends in scale from community-based to global, and considers the consequences for wild populations, ecosystems, and human communities of users, as well as the product chains for commerce, and the economic and human well-being arising from the uses.

The Sustainable Use Assessment started late in 2019, and the penultimate draft is currently out for review by Parties and registered experts. An "appropriate expert" can be credentialed in any of the natural or social sciences, or considered an expert in the context of the social organisations, local communities and Indigenous Peoples interested in the assessment. The expertise across iAtlantic is very relevant to this review and anyone from the iAtlantic community can register as individual expert reviewer online - go to www.ipbes.net/sustainable-use-wild-species-assessment/sod/registration

When the review period is over in a few weeks' time, the SUA authors must respond to every comment received, and submit the final draft before the end of 2021. Just as the IPCC assessments, Parties will meet in Plenary in early 2022 to negotiate the detail in the Summary for Policy Makers (SPM) relative to i) the soundness of the evidence presented in the assessment, and ii) the balance of the interpretation of that evidence. When finally approved, the SPM and assessment as a whole will be made public.

What have we learned from the Sustainable Use Assessment?

As with all the assessments carried out by intergovernmental agencies, specific findings can't be discussed while the assessment is in review. However, there are emergent patterns and messages that can be discussed that have important implications for us all.

- *Different human uses of nature share similar sustainability concepts:* They've all encountered very similar challenges and explored similar pathways for addressing them. There is far more to learn from other practices than our expert communities or institutional structures can process. Integrated planning and management is not a new concept, but the consequences of not doing it effectively have already plagued the planet for generations.

- *The dimensions of sustainable use are hugely complex:* Many science-policy discussions now make the point that sustainability is a much broader concept than just ensuring the health or recovery of a single target species or individual population. Life science experts stress that the supporting structure and function of the habitats and larger ecosystems in which the use occurs must also be healthy or recovering, and the policymakers talk about the "triple bottom line" of biological, economic and social outcomes. The SUA is working with a range of "dimensions of sustainability": the biological dimension can be split into populations used directly, ecosystem and habitat structures and functions changed by the direct uses, and ecosystem services for humanity altered by those changes. The economic dimension can be split into (at least) commerce, costs and revenues accompanied by the employment and livelihoods supported. The social dimension can be divided into cultural diversity, social identity, and different perceptions of human well-being, as well as the importance of inclusive governance for the true sustainability of any uses of nature.

- *Solutions are always context-specific:* Despite the desire for experts of every discipline to come up with instant solutions to advance the sustainability of how humanity interacts with nature, solutions are always context-specific, and one size never fits all. Social scientists need to understand why some approaches work effectively in one application and fail in another; economists are investigating the factors that influence how allocation of access rights make users into good stewards in some cases but more greedy in others. Ecologists are trying to understand the factors that make protected areas excellent tools for improved conservation in some cases, but in other cases deliver few substantive ecological benefits but attract high social or economic costs.

The SUA has excellent discussions of these complexities, which are presented as realities that must be considered in expert dialogues and decision-making.

It is interesting to observe how the SUA has been able to move away from an assessment that reflects whether we are data-rich or data-poor in specific topics, to a consideration of the degree in which we are knowledge-rich on a wide range of topics. Are we truly interested in knowledge, and do we know how to use it when it is provided?

Why might the SUA be of interest to iAtlantic?

In the deep ocean, much of the IPBES conceptual framework and approach of the SUA may not seem to be of central interest. In the deep sea, human uses are generally fewer, social and community dependencies have not been entrenched for generations, and decisions can be made by reasonable governance processes. But if I walk through what I have come to consider a personal line of reasoning I have taken from IPBES, you might gain some of the interest I have developed:

- Healthy biodiversity is essential for a viable future for the planet.
- It is equally true that healthy human cultural diversity is essential for a viable future for the planet.
- Human cultural diversity reflects how each culture has co-adapted with the surrounding biodiversity, adopting values that reflect the biodiversity on which the culture depends, while the biodiversity itself becomes changed through the uses made of it.
- Because the values of each culture reflect the background biodiversity to which the culture is adapted, there is no single set of values that is "right" to apply to nature unless there is some single human culture that is "right" for this planet.
- With no single set of "right" values, traditional policy-making tools such as trade-off analyses have a much more limited value than often assumed, whereas knowledge-based dialogue among those who may attach fundamentally different values to the same potential costs and benefits is the essence of finding ways for different parts of humanity to share our ecosystems and coexist, rather than to continually divide and subdivide access and usage rights.

These are topics we only rarely borach in the context of the deep sea, and the marine expert community overall has been slow to engage in IPBES. But the deep sea may provide opportunities to have these discussions without quite as much overhead from entrenched historical interests. We may both learn and lead as global policymaking on sustainable use confronts how globalised this one planet Earth really is.

Get engaged with the IPBES expert review of the SUA. You may find it time well spent and knowledge well contributed.

References

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➤ **Find out more about the Sustainable Use Assessment at www.ipbes.net/sustainable-use-wild-species-assessment**

➤ **Register as an indepedent expert reviewer for the IPBES Sustainable Use Assessment at https://www.ipbes.net/sustainable-use-wild-species-assessment/sod/registration**

Building the knowledge base for managing human activities affecting marine biodiversity beyond national jurisdiction

By Kristina Gjerde, Senior High Seas Advisor to IUCN's Global Marine and Polar Programme and member of the iAtlantic Advisory Board, with contributions from Karen Kienberger and Aurelie Spadone, IUCN

The postponement in March 2020 of the fourth United Nations Intergovernmental Conference to develop a new international agreement on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (BBNJ Agreement) has spurred new ways to continue discussions and knowledge exchange – online. As a contribution to that effort, IUCN has been co-hosting a series of webinars to grow a shared understanding of some of the key scientific, technical and legal aspects of the ongoing treaty discussions and related issues.

The first webinar, Marine Genetic Resources (MGRs), outlines the importance of marine genetic diversity for the ocean and people and therefore the need to conserve and preserve biodiversity in the ocean. As the use of MGRs was not envisaged in the first draft of the BBNJ agreement there is lack of clarity on the applicable regime relating to bioprospecting and equitable use. Examples from the Seychelles and South Africa illustrate how nations can benefit from research findings in this field as well as use of these resources.

The second webinar on Environmental Impact Assessments and Strategic Environmental Assessments explored the value of best practice environmental impact assessments (EIA) and broad-scope strategic environmental assessments (SEA) for encompassing the variety of human activities affecting BBNJ and the inherent ecological sensitivities.

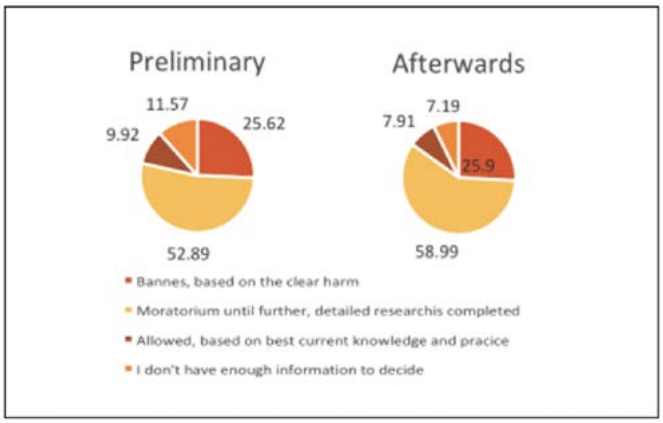
The Marine Protected Areas (MPAs) and Area-based Management Tools (ABMTs) webinar offers an overview of the management tools available to regulate human activities and conserve biodiversity in ABNJ. Traditional MPAs remain necessary to achieve the conservation objectives of the BBNJ agreement. In addition, other ABMTs are needed, including industry sector-based measures to protect particularly sensitive sea areas, vulnerable marine ecosystems and other ecologically or biologically significant marine areas from the impacts of shipping, mining, fishing, and other sectors.

Integrating Climate Change into Environmental Impact Assessments (EIAs): Building on the previous EIA/SEA webinar, this webinar brought together leading experts to explore how EIAs can and should consider climate change impacts as additional impacts to other stressors and impacts in ABNJ.

Key tools to strengthen ocean resilience via the BBNJ agreement: Building upon the publication from Yadav & Gjerde 2020, this webinar offers clear and specific tools on how to build ecological and institutional resilience in ABNJ via the BBNJ agreement.

Fishing in the Twilight Zone introduces science and ecology of the mesopelagic zone and explores potential governance challenges for sustainable development of new fisheries. The mesopelagic zone hosts significant fish stocks. These fish are unpalatable but proposals are emerging to process them into fishmeal and nutritional supplements. As this vast midwater realm plays a role in the carbon cycle and food webs, new fisheries could have global ramifications. Yet our scientific understanding is limited, and existing governance may not be ready to effectively manage mesopelagic fisheries.

The most recent webinar entitled Raising the curtain on Deep-sea Mining focused on the wider societal questions surrounding deep-sea mining. Unlike many activities that take place in the high seas above, UNCLOS deems the seabed and its mineral resources beyond national jurisdiction to be the common heritage of mankind, which requires seabed mining to be managed in a way that benefits humankind as a whole. This webinar focused on the legal, financial, institutional, and social issues. The question "*Should deep-sea mining be...*" was asked at the beginning and at the end of the webinar; poll results showed a significant increase in participants voting for the moratorium option at the end of the webinar.



The webinar series is co-hosted by IUCN and DOSI, sponsored and supported by the Swedish Government. Thanks also go to MarViva Foundation, Duke University, and the Sargasso Sea Commission.

Coming up: Making sense of ocean timeseries data

iAtlantic capacity building workshop on ocean timeseries data 13-18 June 2021

The long-anticipated iAtlantic capacity building Ocean Timeseries Workshop will take place on 15-18 June 2021. Like so many events over the past 15 months, the original plan to hold this as an in-person event in Cabo Verde was put aside, but thanks to some innovative replanning by workshop leaders Lea-Anne Henry, Marjolaine Matabos and Pierre Legendre, this workshop will convene as a four-day virtual event involving 60 participants from across the Atlantic.

Temporal change in marine ecosystems occurs over ecological to geological timescales. Exploring ocean timeseries helps us interpret past events such as regime shifts, community change and loss of species, but it also helps consider future ecosystem outcomes under climate change. Despite the multitude of approaches and methods used to collect ocean timeseries data, we can employ a common set of statistical analyses to facilitate ecosystem assessments at larger scales, e.g., over an entire region or ocean basin scale.

The purpose of this workshop is to strengthen the capacity of marine scientists who already have an understanding of statistical tests and experience in using free programming language R to employ robust statistical methods to visualise, analyse and explain drivers of change in ocean timeseries datasets in order to facilitate such ecosystem assessments.

Taught by Pierre Legendre, Professor of Quantitative Ecology at Université de Montréal, founder of Numerical Ecology, and a member of iAtlantic's Science Council, the workshop blends live online practical exercises using R, lectures, and help sessions with pre-recorded videos. The workshop sessions are scheduled to enable the workshop to run live in the mornings for participants in the western Atlantic, and during the afternoons for participants in the eastern Atlantic.

Over the four days, the workshop will cover visualisation and analysis of univariate and multivariate ocean timeseries data in, for example:

- space-time interactions;
- local contribution to beta diversity (LCBD);
- multivariate regression tree (MRT) analysis.

All available spaces on this workshop are filled and registration is now closed, but course materials and resources will be available to iAtlantic partners through the website after the workshop has finished.

Heralding a new era in global ocean cooperation

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The ocean is the largest ecosystem on Earth and is central to the survival of both humankind and nature, and yet it is massively under threat. The **High-Level Launch of the Ocean Decade as part of the First International Ocean Decade Conference** on 1 June 2021 will bring together international experts from science and research, governments and NGOs, United Nations agencies, private sector and philanthropy to protect and preserve the ocean for future generations. This virtual event will set the stage for eminent representatives from different sectors to talk about necessary measures and perspectives during a series of keynotes and panel discussions. At the end of the launch conference, procedings will be handed over the the Virtual Early Career Ocean Professionals (V.ECOPs) livestream event, in which a number of our iAtlantic Fellows are actively involved - see overleaf for details.

For more details on the UN Ocean Decade launch event, see www.oceandecade-conference.com

Join us at the UN Ocean Decade Virtual Early Career Ocean Professionals Day

Online, 1-2 June 2021

The Ocean Decade is a once-in-a-generation opportunity and the first global campaign to catalyse transformative ocean science solutions for sustainable development. The 1st International Conference to Ocean Decade on 1 June 2021 will kick-start a Decade full of new innovations, opportunities and partnerships.

The V.ECOP Day will be directly linked to the kick-off conference on 1 June, and is a 24-hour livestream event following the sun around the world, hosted by and for early career ocean professionals from around the world. The event is intended to showcase their work, activities, and contributions to the UN Decade of Ocean Science for Sustainable Development.

iAtlantic will be strongly represented at this event, with iAtlantic Fellows Christine Gaebel, Kelsey Barnhill and Kristin Burmeister featuring as session moderators and contributors. iAtlantic will also have a spot in the virtual exhibition hall to showcase the iAtlantic Fellowship, so drop in and say hello!

Conference registration is open to all: **vecop.vfairs.com**

The **All-Atlantic R&I for a Sustainable Ocean: Ministerial High-level & Stakeholders Conference**, Ponta Delgada, 2-4 June 2021, aims to bring the existing dialogue and cooperation undertaken under the All-Atlantic Ocean Research Alliance to a new level. This Conference is being co-organised by the Portuguese Presidency of the European Union Council and the European Commission.

Following the successful All-Atlantic Ocean Research fora (Brazil, 23-24 July 2018; Belgium, 6-7 February 2020, and South Africa, 3-4 December 2020), and championing the approach of Connecting-Acting-Cooperating, this conference will bring together Ministerial and other high-level representatives with marine stakeholders across the Atlantic Ocean from pole to pole, and will be a step forward in research and innovation cooperation for a sustainable Atlantic Ocean.

The All-Atlantic2021 Conference will therefore contribute to enhancing the science diplomacy efforts focused on the Atlantic, notably through the Atlantic Strategy and its 1st Action Plan (2013), the signing of the Galway and Belém Statements (respectively in 2013 and 2017) and the Administrative Arrangements between the European Commission and Cabo Verde (2018), Argentina (2018) and Morocco (2020).

The event will be the opportunity to discuss the progress made so far, to strengthen the vision Connecting-Acting-Cooperating, and to launch a Pledging Platform as a new tool to the existing cooperation. This Platform will provide a global view on the Atlantic marine R&I cooperation, enhancing stakeholder participation to co-design and invite them to participate in future actions and to monitor the progress of the cooperative efforts. Discussions on the new methodologies for ocean observation and ecosystems-based management linked to digitalisation processes represent an important innovative step towards the integration of the Ocean-Space-Climate-Food Nexus to contribute to Ocean Sustainability.

The conference's Ministerial dimension linked to the stakeholders dynamic participation and side events will contribute to leveraging the All-Atlantic R&I Cooperation through two main legacy outputs, an EU Portuguese Presidency Conference Declaration and the All-Atlantic Pledging Platform, and will provide an excellent opportunity to strengthen and contribute to the European Green Deal and to the Horizon Europe Mission on Ocean, Seas and Waters, as well as to the UN Decade of Ocean Science for Sustainable Development.

Side events

A programme of self-organised side events will take place on 2-3 June, addressing all the six priority thematic areas of the Galway and Belém Statements. This "Blue Corridor" will promote networking and dialogue, bringing together a variety of stakeholders from along and across the Atlantic Ocean. All side events aim to highlight the All-Atlantic dimension, promote synergies with other Atlantic initiatives and positively impact the All-Atlantic Ocean Research Alliance vision and ambition. Find the full side events programme online at the conference website.

www.allatlantic2021.eu AllAtlantic2021

On the agenda for iAtlantic...

iAtlantic is involved in the following AllAtlantic2021 side events and sessions:

2 June, 13:00 UTC: Atlantic Seabed Mapping and Exploration - Achievements, Challenges and Opportunities

2 June, 14:00 UTC: The Marine Biodiversity Observation Network (MBON) - Advancing Collaborative Biodiversity Observations

3 June, 13:00 UTC: Atlantic Marine Research and Innovation Ecosystem in the Azores

3 June, 13:00 UTC: Towards an All-Atlantic Data Space for the Ocean

3 June, 15:15 UTC: All-Atlantic R&I Solutions

3 June, 17:30 UTC: Rethinking citizen stewardship for our oceans and waters

iAtlantic Photo Competition

Time to get snapping!

We are excited to announce the launch of the official iAtlantic photo competition! Featuring four different themes, the photo competition provides an opportunity for the iAtlantic consortium to showcase their research activities, promote their outreach initiatives, and enhance inter-consortium relationships across the Atlantic Ocean. Photos will be chosen from the entries to feature in the upcoming iAtlantic calendar, and prizes will be allocated to the top photos for each category. The categories are:

- **iAtlantic in Action:** Submit photos of your research and training activities, you in the field, or your lab/research surroundings. Despite the disruptions to research activities over the last year, we continue to be amazed by the hard work, adaptability and perseverance of the iAtlantic Consortium. This category celebrates these achievements, both big and small.
- **iAtlantic Under the Waves:** We want to see your underwater or ocean themed photos. Whether you are a budding underwater photographer, or simply out for a walk on the beach with your phone, send us your best ocean-themed snaps.
- **iAtlantic Impact:** Do you have photos of you and your team at outreach, capacity building or policy integration activities? This category celebrates these activities which are a crucial part of iAtlantic and help enhance our impact as a project.
- **iAtlantic Insider:** Submit any funny, amusing or interesting photos of you and your team. With the ongoing pandemic demanding another year of virtual meetings, this category aims to bring back the interpersonal dimension of an in-person General Assembly.

Please email your photo submissions to the iAtlantic Project Office, along with a short description of the photo, the category that you are submitting it to, and any photo credits. The deadline for submissions is **21 September 2021** and winners will be announced at the 2021 General Assembly.

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