Project news

Issue 4 | January 2022

iAtlantic
INTEGRATED ASSESSMENT OF ATLANTIC MARINE ECOSYSTEMS IN SPACE AND TIME

Preparing the multicorer for deployment during the IceDivA2 expedition in the North Atlantic, November 2021. Image courtesy Viola Siegler, SGN.

Marine science in action!

In this issue...

Message from Murray

Welcome to our latest iAtlantic newsletter and after two years since the start of the COVID19 pandemic I think "Marine Science in Action!" is a perfect summary of iAtlantic's ethos.

After heroic efforts from all our partners throughout 2020 and 2021 to reorganise and replan iAtlantic's work we should all be incredibly proud of the results we're gathering. In this newsletter you can see examples from across the project that capture the pioneering work of our teams at sea and how we're working to get these findings straight to policy makers and other stakeholders working to ensure sustainable development in the deep and open Atlantic Ocean. Here are just a couple of examples to whet your appetites.

Last year our partners at Senckenberg grabbed the chance to bid into Germany's emergency pandemic call for expeditions on board the RV Sonne*, and in late 2021 ran the IceDivA2 expedition extending their earlier IceDivA expedition further west into the Atlantic. Despite battling 14 m high waves and Force 11 storms they adapted their plan not only to achieve most of their stations but also to run a fantastic UN Ocean Decade satellite event live from the ship.*

2021 also saw the successful completion of iAtlantic's flagship expedition, iMirabilis2. Sadly, it was impossible for us to run iMirabilis as originally planned all the way from Spain to South Africa, but after a year of intense replanning the shorter iMirabilis2 expedition was completed around Cabo Verde in August. In this newsletter you can see some stunning images from the ROV dives – I will never forget seeing the beauty of the Cadamosto seamount with my own eyes. Truly a once in a lifetime experience.

And just as our sea-goers have been busy, those working at the science/policy interface have done wonderful work for iAtlantic. Early November saw the pivotal COP26 UN Climate

South Atlantic waters offshore Cape Town, South Africa.
Image courtesy Ben Wild

Change Conference in Glasgow. In this newsletter you can read more about our activities at COP26 – from ocean/climate briefings, TV reports and public events to new films and textiles inspired by climate change.

As we enter the last two years of iAtlantic there are many important opportunities on the horizon. As Vikki Gunn and colleagues explain, 2022 is the new 'super year' for the oceans and we need to be ready to get our latest results into the discussions that will shape deep and open ocean governance and management for generations to come.

Much of iAtlantic's work relates closely to the UN's biodiversity beyond national jurisdiction (BBNJ) negotiations – remember this new agreement is being built around four pillars of marine genetic resources, environmental impact assessments, area-based management tools including MPAs, and capacity building and technology transfer. Please read the article on the following page and think about how your work relates to the BBNJ negotiations and other policy processes.

Despite all the downsides of the last two years I'm so proud of the work we're doing. They say life is all about the right timing. Despite everything the last two years have thrown at us iAtlantic is delivering exciting, relevant deep and open ocean research at the very best time. Let's make the most of our good timing throughout 2022 and 2023.

J Murray Roberts
iAtlantic Coordinator
Edinburgh, 31 January 2022

2022: Finally, the "Super Year" for the ocean?

by Vikki Gunn and the iAtlantic WP6 team

Two years ago, 2020 was widely heralded as the "Super Year" for the ocean with a string of landmark international policy meetings in the calendar for the months ahead, all aiming to accelerate progress towards better management and more sustainable practices in our ocean. 2020 was anticipated to mark the culmination of an inter-related suite of long-running international efforts: the CBD Aichi Biodiversity Targets were expected to come to fruition, and after more than a decade of deliberations and discussion there was a cautious anticipation that the UN's Biodiversity Beyond National Jurisdiction (BBNJ) process would result in an international legally binding treaty on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction. International enthusiasm for generating and using knowledge for the good of the marine environment was captured by the UN's Decade of Ocean Science for Sustainable Development 2021-2030, due to officially launch at the UN Ocean Conference planned for June 2020, and recognition of the vital importance of the ocean in the climate change agenda was a major theme for the UNFCCC Climate Change Conference (COP26), scheduled to take place in November 2020.

Two years later, and emerging (we hope) from the tail-end of a global pandemic that forced most international policy processes to a standstill, or to be kept alive by some form of interim virtual/hybrid efforts, 2022 offers a cautious but tantalisingly exciting prospect of a return to business. The fourth session of negotiations on the BBNJ treaty will potentially resume in March, the Convention on Biological Diversity (CBD) will convene its long-awaited COP15 meeting in April (more about that below), and early preparations are underway for the postponed UN Ocean Conference, now set to take place in Lisbon in June-July. Of course, not all activity ceased during those intervening two Covid years: the UN Ocean Decade is in full swing with a string of virtual events marking its launch and more than 360 endorsed Decade Actions in their portfolio, and the COP26 climate summit took place in Glasgow in November 2021, resulting in stronger recognition of the ocean's role in global climate, the establishment of an annual Ocean and Climate Dialogue, and a variety of ambitious pledges and commitments toward ocean-based climate action.

For those of us working in the shady area between marine scientific research, policy development and ocean governance, 2022 is looking to be a very busy year – which offers all sorts of exciting opportunities for iAtlantic to contribute knowledge, data and expertise in support of a range of processes and initiatives.

Assuming Covid-related restrictions allow an in-person meeting to go ahead, the fourth and (perhaps) final session to negotiate the international BBNJ treaty is scheduled to take place in New York in March. These negotiations are structured around four 'pillars' of the draft treaty: marine genetic resources, environmental impact assessments, area-based management tools including MPAs, and capacity building and technology transfer. Surrounding these thematic sections are a number of cross-cutting issues that represent the functioning and management of the treaty. A number of intersessional online meetings have taken place over the past two years to maintain momentum and further explore topics related to these elements of the draft treaty, but there is no doubt that there is a lot to do in the two weeks that the Parties meet to try and finalise the agreement and further sessions may be required.

In April-May 2022, Parties to the CBD will come together in China at the COP15 conference to debate and decide on a number of iAtlantic-relevant issues. The headline item is the anticipated adoption of the Post-2020 Global Biodiversity Framework (GBF), successor to the Aichi Biodiversity Targets which expired in 2020. The GBF is a stepping-stone along the path to the CBD's 2050 Vision of "Living in harmony with nature", with the intention to undertake a substantive assessment of progress in 2030. The details of targets and indicators are still being finessed, but the importance of land-water-marine synergies is recognised and there is an expectation that marine biodiversity elements of the GBF will be strengthened further.

Of more direct and immediate relevance to iAtlantic at COP15 is the final consideration of areas in the North Atlantic that are described as meeting the criteria for ecologically or biologically significant marine areas (EBSAs). Seventeen of these areas were put forward following a technical workshop in September 2019; these have been through the initial scrutiny of the CBD's scientific and technical body and now await final consideration by CBD Parties. Also on the COP15 agenda is a debate on how the process governing the description, identification and modification of EBSAs should or could evolve. The outcome of this discussion will have important implications for marine conservation going forward.

The UN Ocean Conference in June-July has an overarching theme of "Science and Innovation" with a focus on partnerships and solutions. iAtlantic is planning a strong presence at this conference, which will take place in Lisbon, including the hosting of our first iAtlantic Stakeholder Dialogue event. We will convene three of these Dialogue events through the

course of the project, which are intended to provide a forum where iAtlantic results will be presented, ideas exchanged, and relevant issues discussed with stakeholders from governments, intergovernmental and regional authorities, industry, civil society and the wider scientific community.

The fisheries agenda for 2022 is also looking incredibly busy, offering a number of opportunities for iAtlantic to contribute expertise to ongoing processes. On the international stage, the UN General Assembly is set to undertake a review of the implementation of the resolutions committing States to manage bottom fisheries on the high seas to prevent significant adverse impacts on Vulnerable Marine Ecosystems (VMEs), protect biodiversity in the marine environment, minimise bycatch and to sustainably manage deep-sea fisheries on target fish stocks. The review process will begin with a stakeholder workshop in August, followed by several rounds of consultation with interested States and culminating in a review by UNGA negotiators during the informal negotiations in November on the annual UNGA fisheries resolution that will be adopted in December.

Efforts to find common ground between Regional Fisheries Management Organisations and Regional Seas Programmes continue, with the third Sustainable Ocean Initiative Global Dialogue scheduled for the autumn. Also at a regional level, the annual consideration, deliberation and debate over whether to protect additional areas of the high seas will take place at NEAFC, NAFO and SEAFO for the areas they manage, especially if the science community can present new information on potential VMEs through their national government or the relevant Scientific Committees. VME-relevant information can also be channelled through the ongoing ICES process, which provides advice to the EU and NEAFC on areas where VMEs are known or likely to occur and are at risk from bottom trawling and/or other types of bottom fishing in EU waters and the high seas of the NE Atlantic. This year also sees the first steps in the implementation of national and EU level negotiations on designating areas for protection from deep-sea bottom fishing in EU waters – the process for such designations was established by the EU deep-sea fisheries regulation in 2016 but only this year will begin to be implemented.

The International Seabed Authority continues to develop its Regional Environmental Management Plan (REMP) for the Mid-Atlantic Ridge in the North Atlantic. The culmination of a three-year process involving scientific experts from around the world, the draft REMP is currently being developed by the ISA's Legal and Technical Commission and is anticipated to be released in spring 2022.

Of course, much activity is happening elsewhere at regional and national levels. The North Atlantic Current and Evlanov Sea-basin (NACES) MPA was designated by the OSPAR Commission in October 2021, giving protection to an area of almost 600,000 km^2. The MPA is designated primarily for the protection of seabirds; the area represents a major foraging hotspot and is estimated to be used by up to five million birds throughout the year that migrate from colonies in both North and South Atlantic countries. However, the seafloor was not included in the MPA designation, and a two-year process is now underway to gather and review evidence to determine whether the MPA designation should be expanded to include seafloor features and associated benthic and mesopelagic ecosystems. Scientific evidence of vertical connectivity and bentho-pelagic coupling would be a welcome contribution to this process. **Please contact vikki.gunn@seascapeconsultants.co.uk if you have a contribution to make in this respect.**

In South Africa, colleagues are deeply engaged in the National Biodiversity Assessment, part of a five-year cycle to monitor and assess progress against their National Biodiversity Strategic Action Plan, and the first National Coastal and Marine Spatial Biodiversity Plan for the coast and ocean around the South African mainland was developed along with proposed sea use guidelines in late 2021. These efforts contribute to and will be advanced through support by the regional prioritisation work undertaken in iAtlantic as part of the systematic conservation planning exercise in WP5. Work continues in the Azores to expand and strengthen the network of MPAs in the region, with the stakeholder engagement process well underway. The overall goals and objectives of the systematic conservation approach have been approved by the Government of the Azores and relevant stakeholders, and the task of scenario planning will begin in the coming weeks. Further south in the Atlantic, iAtlantic scientists are working closely with NGO partners in Cabo Verde to explore how new data collected during last year's iMirabilis2 expedition may help build a case for protecting biodiversity in the region.

So, much to look forward to in 2022! Ironically, in many ways the hiatus in policy processes over the past two years puts iAtlantic in a stronger position to be able to contribute knowledge to support the dialogue and debate taking place in the months to come – despite having to overcome our own challenges brought by the pandemic, our science is more developed and we are closer to producing tangible results that have enormous relevance for the wider stakeholder community. The WP6 team are always happy to hear from you if you have results or data that you feel are important contributions to policy development (or if you have a question!) and of course we are in regular contact with the WP leaders on the latest developments across the project. We plan to have an iAtlantic presence at all the key policy and governance meetings in 2022 (travel restrictions permitting), and are excited to finally be able to share iAtlantic's work and results in a non-virtual setting!

Tobias Fischer

IceDivA2 "goes west" of the Mid-Atlantic Ridge!

by James Taylor and the IceDiVA2 team

RV Sonne *leaving the harbour in Emden*

IceDivA2 (**Ice**landic marine animals meets **Div**ersity along latitudinal gradients in the deep sea of the **A**tlantic Ocean **2**) took place between 5 November and 9 December 2021, and aimed to investigate the connectivity and biodiversity within key marine benthic abyssal habitats and their overlaying planktonic communities. IceDivA2 built on the work completed during the first IceDivA expedition during January 2021 east of the Mid-Atlantic Ridge (MAR), an expedition connecting the IceAGE (Icelandic marine Animals: Genetics and Ecology) and DIVA (Latitudinal Gradients in BioDIVersity in the deep Atlantic) projects. In a rare case of positive momentum in a Covid-19 influenced world, IceDivA2 repsonded to the second emergency pandemic shiptime call for the use of the German Research Vessel *Sonne* by proposing to "go west" to close the remaining gap in our knowledge of the deep-sea benthic and planktonic communities - this time to the west of the MAR.

Coinciding perfectly with the beginning of the UN Ocean Decade at the start of 2021, the IceDivA project has been a proud contributor to the Challenger 150 programme, which is officially endorsed by the Decade. IceDivA2 also hosted the satellite event "A floating classroom: Deep-sea science in action towards a clean ocean" for the UN Ocean Decade's Laboratory on 'A Clean Ocean'. This event was conducted live and transmitted via satellite from the middle of the Atlantic Ocean, providing a rare insight to life on board a research vessel.

During the first IceDivA expedition the phrase "spontaneous, creative, and multi-flexible" was coined due to the testing nature of trying to conduct marine research in the North Atlantic during the winter months, with mastery of "weather chess" required. For IceDivA2 some 10 months later, this mantra was pushed to the extreme as we faced storm after storm attempting to cross the North Atlantic, the likes of which not even our captain had seen in his near two decades of experience on research vessels. Thankfully, due to the nature of our research questions we had the freedom to adapt the position of our research locations to find 3-4 days' worth of good weather as long as we located abyssal plain areas deeper than 3,000 m. This flexibility ultimately allowed us to complete 3.5 work stations out of the proposed five, despite station work being impossible for the first two weeks.

The research questions we set out to test were as follows:

1. Are there differences in species composition and diversity across a latitudinal transect of the IceDivA2 stations?
2. Are there differences in species composition and diversity Atlantic-wide?

3. Are the observed species restricted to the Atlantic deep-sea abyssal plains?
4. How does species composition and diversity vary with depth?
5. How are populations genetically connected ?
6. Are molecular taxonomic methods able to reveal cryptic diversity in North Atlantic deep-sea fauna?

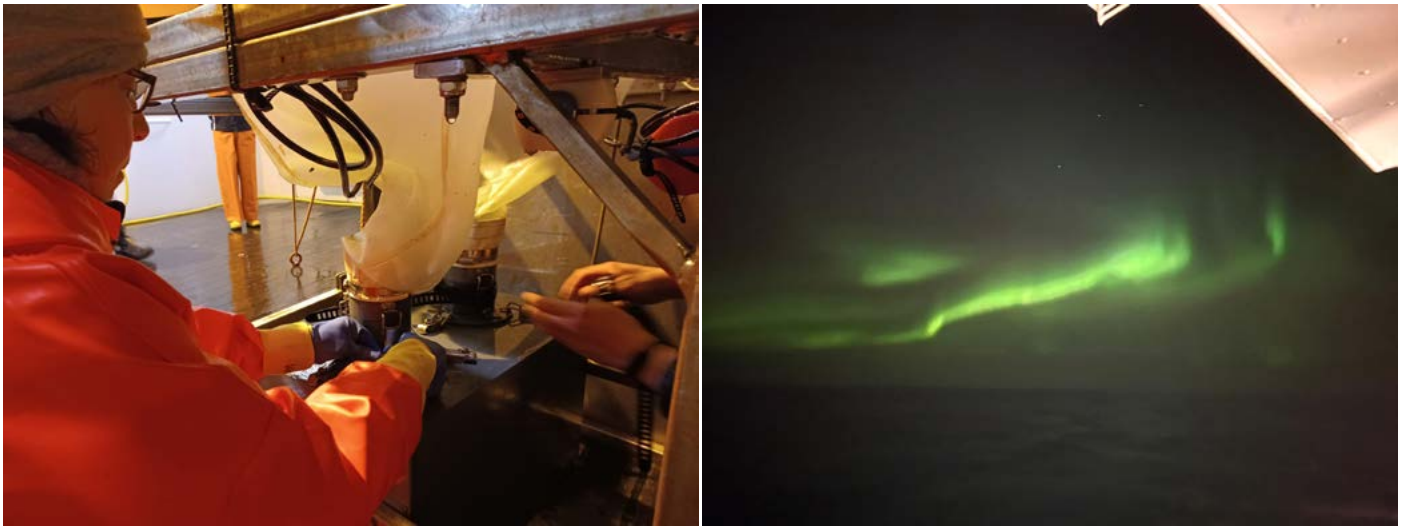
We arrived at the RV *Sonne* in Emden on 4 November, led by Chief Scientist Dr Saskia Brix and Co-chief Scientist Dr James Taylor, with all 27 scientists and 33 crew members testing negative under the current Covid-19 regulations. Preceding our departure on the 5 November we were able to set up and secure all laboratories and workstations, including two genetic labs, two sorting labs, and a photography station, for sample processing on board, as well as securing all our heavy gear.

We were battered by extreme poor weather for the first 14 days of the expedition, having to bunker down twice during our western transit across the Atlantic, once off the coast of the Faroe Islands and again off the North coast of Iceland. This route was necessary as, even on a vessel as impressive as the RV *Sonne*, waves of up to 14 m and winds up to 11 on the Beaufort scale posed a real danger. We refused to let this time be wasted however. With such an eclectic mix of knowledge on board we hosted a daily seminar series in which everybody presented previous work they had accomplished or what they were contributing on board. With a large student contingent this served as both practice in presenting, and horizon-broadening for senior scientists. We also used the time to organise and prepare the pre-recorded material for our UN Ocean Decade satellite event, a task that everybody on board enjoyed, yet underestimated. A beneficial side effect of our enforced northern route across the Polar Circle meant that for many on board we encountered our first instance of aurora borealis – the northern lights.

On Wednesday 17 November the core event of the UN Ocean Decade's Laboratory on 'A Clean Ocean' was held in Berlin with the RV *Sonne* playing host to our satellite event the following day. This really marked the turning point of our expedition, particularly in terms of weather. Even at sea we needed a dress rehearsal to ensure the smooth production of our live event, divided between the Senckenberg Museum in Frankfurt and the RV *Sonne*. This rehearsal was priceless as all gremlins in the system were worked out before the big event. Our satellite event "*Deep-sea science in Action towards a clean ocean*" brought together a range of specialists on land and at sea to discuss the issues of marine pollution and how, as marine scientists, we are helping to contribute to better practice while at sea to prevent further damage to our oceans. During the event the IceDivA "TrashMap" (see p9) was introduced, showing where litter has been found in the deep sea, with our data from the expedition already added. This map will continue to be updated based on observations from those in the iAtlantic and Challenger150 projects (https://bit.ly/3HBvSUV). For those who missed the event, it can still be viewed on YouTube at https://bit.ly/3ETxZ4v.

Following the satellite event, we were full steam ahead with the scientific programme. Our first station (our original work area 2) was in the Labrador Basin. This was our first opportunity to deploy a full quota of scientific gear, which included: CTD, EM122 multibeam surveying, Ocean Floor Observation System (OFOS), bongo net, multinet, epibenthic sledge (EBS), large box corer (GKG), Neuston catamaran, multicorer (MUC), and Agassiz trawl. We would go on to perform a full deployment of all gears at two further locations, west of the Charlie-Gibbs Fracture and west of the MAR at 37°N. For our final station we attempted to sample a nearby flat-topped seamount from work area 3, however our good weather window closed, allowing only for the deployment of the TV-MUC and EBS.

Of paramount importance prior to deploying our gear was the mapping of the seafloor using the ship-based EM122 multibeam system, which in itself gave us two highlights: mapping an underwater mountain range and the Tolkien-inspired Mount Doom (see p10). The resulting bathymetry



Above, left: Karen Jeskulke retrieving samples from the epibenthic sledge "Anna" (image courtesy Anne-Nina Lörz). Right: The aurora borealis (northern lights) seen off the coast of Iceland (image courtesy Dr Simon Gütl).

Above: Alexander Kieneke (Senckenberg am Meer) checks on the OFOS camera mounted on the 20-core multicorer. Deployed as a "TV-MUC", we were able to sample soft sediment on top of the seamount in our working area, which is geologically characterised as a spreading axis west of the MAR. Image courtesy Viola Siegler, Senckenberg am Meer.

data allowed safe deployment of the benthic gear onto soft bottom sediment, and especially for the deployment of the OFOS (see p10).

Overall, we had a very successful and productive cruise, with 80 individual gear deployments being achieved, a large majority of which were benthic deployments. We were able to sample a wide variety of fauna through our procedures, and should anyone in the iAtlantic network wish to have access to samples or would like to discuss the expedition in general they should contact either Dr. James Taylor (jtaylor@senckenberg.de) or Dr. Saskia Brix (sbrix@senckenberg.de). It was a pleasure to interact with everybody back on shore as IceDivA2 was taking place and we look forward to bringing you along with us again in the future.

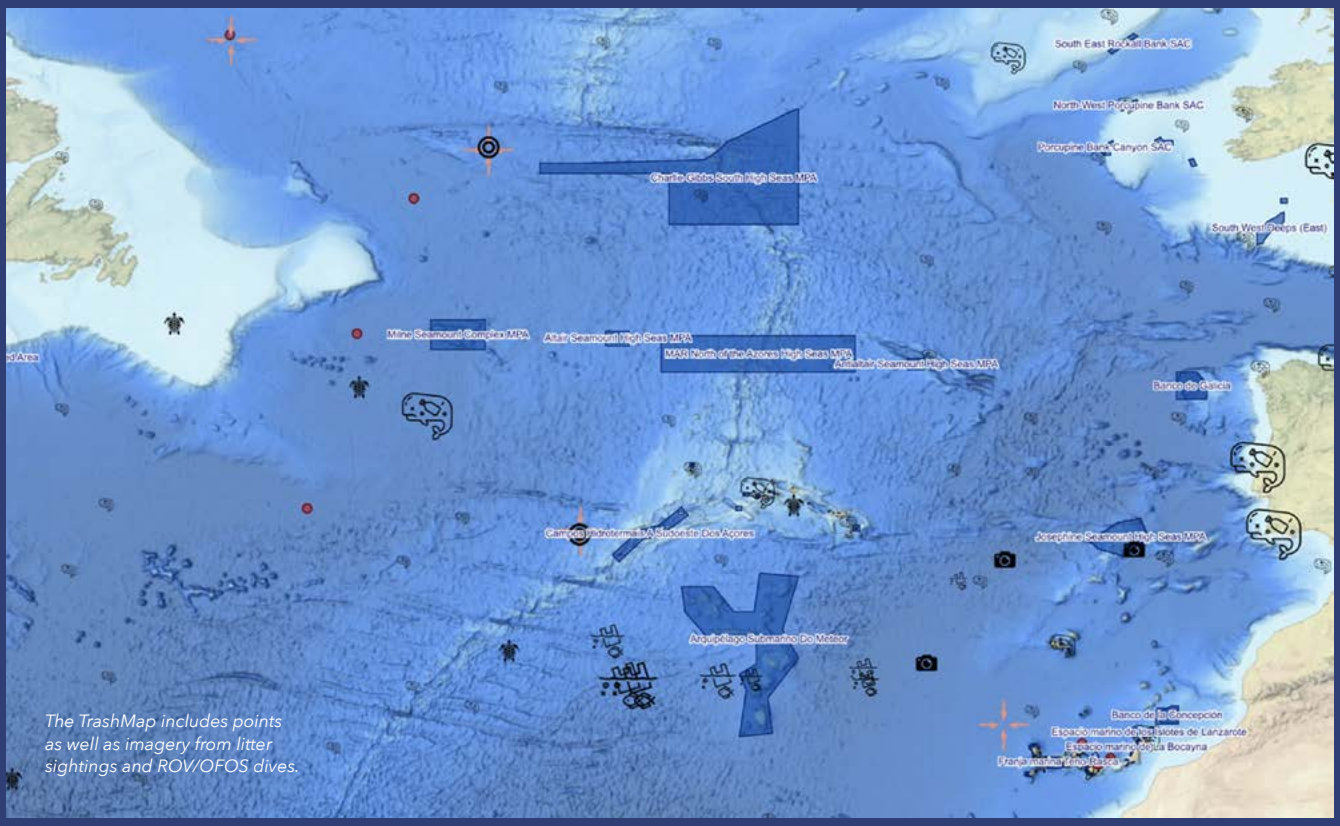
Above: The IceDivA2 team on board RV Sonne*. Top row, left to right: Vivien Hartmann, Karen Jeskulke, Nicole Gatzemeier, Sahar Khodami, Elham Kamyab, Mia Schumacher, James Taylor, Angelina Eichsteller, Katrin Linse, Frederic Bonk, Kevin Keß, Lisa Gaertner, Pedro Martinez, Denisse Galarza, Saskia Brix. Bottom row: Stefanie Kaiser, Franziska Theising, Alexander Kieneke, Anne-Nina Lörz, Tjardo Stoffers, Severin Korfhage, Tim Bierschenk, Mail Wilsenack, Anna Krug, Marco Bruhn, Jenny Neuhaus. Image courtesy Viola Siegler, Senckenberg am Meer.*

Left: Live shot from the satellite event. From left to right: Denisse Galarza, Katrin Linse, James Taylor, Saskia Brix, Pedro Martinez, Mia Schumacher, Jenny Neuhaus.

The IceDivA2 team sent back regular updates from RV Sonne *during the expedition. Check out the expedition blog at www.iatlantic.eu/icediva2-blog*

Introducing the TrashMap!

This map was introduced during the IceDivA2 satellite event that took place in the framework of the UN Ocean Decade 'A Clean Ocean' Laboratory. It provides information about litter sightings in the ocean, including *in situ* sampling as well as imagery from ROV and OFOS dives. The idea behind it is to raise more awareness of marine pollution, especially in the deep sea which is feared to become the world's ultimate dustbin. This map will be updated with any accessible data. For more information, please do check it out and walk yourself through the map – you will find further details of each feature when clicking on the icons. If you have litter data and would like to integrate it to the map, please feel free to get in touch with Mia Schumacher (mschumacher@geomar.de). The map is online at https://experience.arcgis.com/experience/8260b2c831de448ea905fb021cacb313



The TrashMap includes points as well as imagery from litter sightings and ROV/OFOS dives.

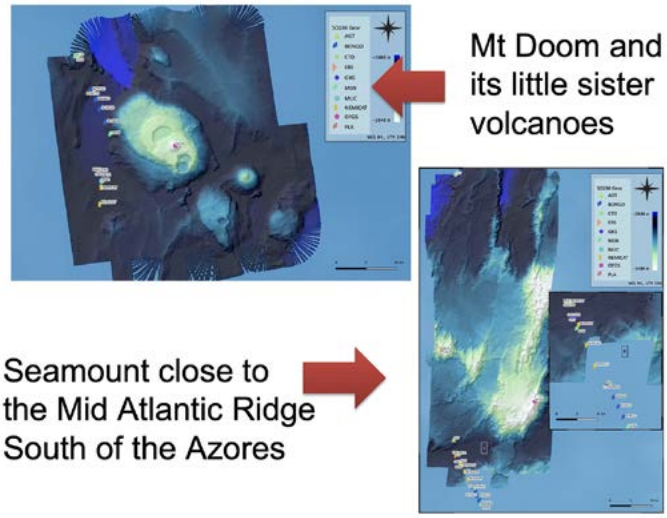
IceDivA2 from the perspective of four iAtlantic Fellows

Mia Schumacher, GEOMAR

Hi! I am a research and data scientist from GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. Primarily, I work with bathymetry data, actively mapping the seafloor during multiple cruises - including this one, IceDivA2. I love maps and also have a passion for protecting vulnerable marine areas, based on bathymetry and imagery.

During this cruise, beautiful seafloor formations were offered to us. We have discovered decent submarine calderas just north-east of the Great Bank off Newfoundland, south of the Charlie Gibbs Fracture Zone and MPA. The largest and oldest of the three volcanoes is estimated to be about 49.5 million years old. Honouring the epic fantasy tales of the great novelist J.R.R. Tolkien, we called the grand caldera 'Mount Doom'.

Further south, in the vicinity of the Azores and closer to the Mid Atlantic Ridge we have been mapping a large patch of about 2,200 km^2. This survey again revealed an impressive seamount of almost 1,000 m height and very, very steep walls. In the backscatter mosaic we could see that it was barely sedimented, in contrast to the surrounding abyssal plains.



James Taylor, Senckenberg am Meer

The bathymetry maps of both of the surveys mentioned above were used as a basis for stunning Ocean Floor Observation System (OFOS) dives. In charge of the OFOS and co-chief scientist on the IceDivA expeditions, my passion lies with observing the seafloor. I specialise in deep-sea benthic ecology and community analysis through video and image material. Recently my focus has been on the hydrothermal vent communities off the coast of Iceland, including the discovery and description of new vent fields located on the Reykjanes Ridge. This experience turned out to be particularly useful for the IceDivA2 expedition where we used the OFOS to explore the two ancient volcanic systems described above, confirming the assumptions made on the basis of the bathymetry. We also undertook three OFOS investiations of the abyssal plain, directly tackling the main research questions of the IceDivA expeditions.

All five deployments were successful and provided a stunning overview of a realm rarely seen. It is always a special moment to explore the deep in real time and see what very few have the privilege to see. We observed a myriad of life down there with clear differences in biodiversity and species composition observed between each deployment. These dives will be analysed further when the team return to land to assess and explain these differences. The highlight from our investigations had to be the exploration of the 1000 m seamount. This trip across the pinnacle of the mountain unveiled spectacular large coral and sponge gardens amongst sheer volcanic cliffs. We look forward to being able to explore such amazing habitats again in the near future.

Above: Coral and sponge aggregation seen via OFOS. Image courtesy James Taylor.

Elham Kamyab, Senckenberg am Meer

The IceDivA2 expedition brought us to amazing locations in the North Atlantic Ocean and gave me the precious chance to get to know different aspects of science and teamwork alongside outstounding researchers from different scientific backgrounds.

Following the main aim of IceDivA2 expedition, I took water and sediment samples using benthic and planktonic gear (mainly the multicorer and bongo net, pictured right) in order to analyse and compare the meiofauna biodiversity through two different methods of eDNA and metabarcoding. During the cruise, we extracted DNA of some of the samples and we are looking forward to understand more about deep-sea meiofaunal biodiversity!

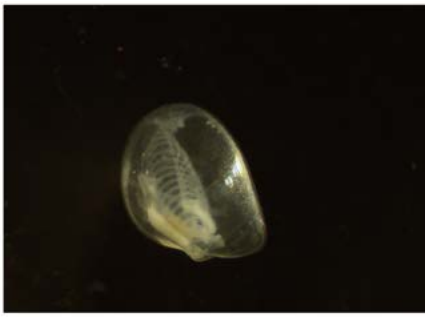
Furthermore, due to my interdisciplinary studies, I will study the bioactive compounds of deep-sea sea cucumbers collected from stations 1 and 3 of this expedition.

Above, left: bongo net (planktonic gear). Right: the multicorer (benthic gear). Images courtesy Viola Siegler, Senckenberg am Meer.

Jenny Neuhaus, Senckenberg am Meer

Five weeks at sea have passed, and the North Atlantic Ocean has shown its rough and smooth sides and once again fascinated me with its beautiful deep-sea fauna. I consider myself very lucky to have started my PhD during the IceDivA2 expedition, aiming to resolve distribution and connectivity across adjacent deep-sea basins using invertebrate taxa as surrogates.

In close collaboration with specialists on board the RV *Sonne*, I have been able to build up a database of DNA sequences of bivalve and isopod taxa, both from freshly collected material from the western basins, and from samples gathered on the eastern side on former expeditions. With this work, I intend to reveal distribution pathways seen in the light of reproduction modes and locomotion, comparing sessile with mobile taxa, and brooders with those that start off their lives as planktonic larvae before settling on the seabed. Having just started, I am looking forward to my academic journey in the Senckenberg group and the contributions to deep-sea Atlantic research it will yield.



Above, top: Processing samples in the lab on board RV Sonne. *Bottom left:* Ledella *sp.. Bottom right:* Dacrydium *sp. Images courtesy Viola Siegler, Senckenberg am Meer.*

Check out the IceDivA2 expedition blog at: www.iatlantic.eu/icediva2-blog

Unveiling the deep-sea hard-bottom megabenthic communities of Cabo Verde

by Beatriz Vinha[1], Veerle Huvenne[2], Andrea Gori[3], Kelsey Archer Barnhill[4], J Murray Roberts[4], Covadonga Orejas[5], ROV Luso Team[6] and Crew of RV Sarmiento de Gamboa[7]

[1]University of Salento; [2]National Oceanography Centre; [3]University of Barcelona; [4]University of Edinburgh; [5]Spanish Institute of Oceanography; [6]EMEPC; [7]UTM-CSIC

Fogo Island in the Cabo Verde archipelago (image courtesy Beatriz Vinha). Inset: RV Sarmeiento de Gamboa. *Image courtesy Nuno Vasco Rodrigues.*

On 31 July 2021, the Spanish RV *Sarmiento de Gamboa* set sail from Las Palmas in the Canary Islands to begin the journey south to the Cabo Verde archipelago to start Leg 1 of the iMirabilis2 expedition. This was a multidisciplinary scientific expedition aiming to explore the deep-sea ecosystems offshore Cabo Verde while relying on state-of-the-art technology to explore the deepest parts of the ocean.

Cabo Verde is a group of ten volcanic islands and five islets located off NW Africa in the equatorial eastern Atlantic Ocean. Once *Sarmiento de Gamboa* arrived at the Sotavento Islands in the archipelago, the team on board was delighted to see the cinematic volcanic panorama of Fogo and Brava Islands. There was great excitement to explore the deep sea in the area and to discover Cabo Verde's hidden biodiversity, as this is one of the most unexplored regions of the Atlantic Ocean in terms of deep-sea research.

One of the state-of-the-art pieces of equipment deployed during iMirabilis2 was the Remote Operated Vehicle (ROV) *Luso* (operated by EMEPC). Exploratory video transects using ROV Luso were designed to reveal the megabenthic communities settled on the hard slopes of Fogo and Brava Islands and at Cadamosto seamount, a seismically active seamount located west of Brava with its summit at 1,400 m water depth.

The ROV dives unveiled a fascinating underwater landscape in terms of both geology and biology, with volcanic rock and pillow lavas, and cold-water corals thriving on the seafloor. Cold-water coral communities were dominated by octocoral species from bamboo corals to golden gorgonians, in places forming extensive coral gardens. Demosponges and glass sponges, as well as different echinoderm species, were often observed in high densities.

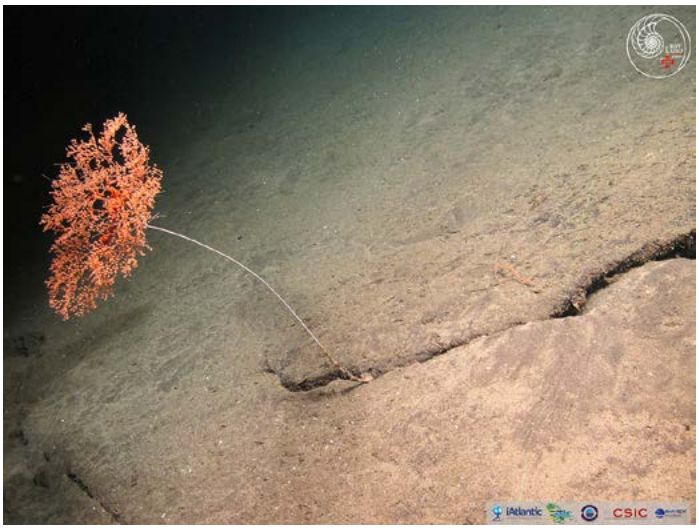
The scientific work carried out with ROV *Luso* in iMirabilis2 will allow us to characterise the megabenthic communities of Cabo Verde in the bathyal zone. The video data is being

Above, left: The ROV Luso *in action. Right: The team were treated to spectacular views of Brava Island. Both images courtesy Beatriz Vinha.*

analysed quantitatively and will provide information on species occurrence and densities in order to investigate communities' spatial patterns. These results will be interpreted under the environmental envelope of the study area and our observations will be used to predict species distribution in other parts of the archipelago. Samples of the most abundant functional groups will be used to study the trophic ecology of these communities by investigating food quality and potential species interactions.

With the outcomes from this scientific work, iAtlantic will contribute new information about deep-sea benthic megafauna of an unexplored area of the Atlantic Ocean.

Read more about iMirabilis2 at: www.iatlantic.eu/imirabilis2-expedition



Above: Deep-sea benthic megafauna observed during ROV dives. Images © iMirabilis2 (IEO,CSIC)/EMPEC/iAtlantic

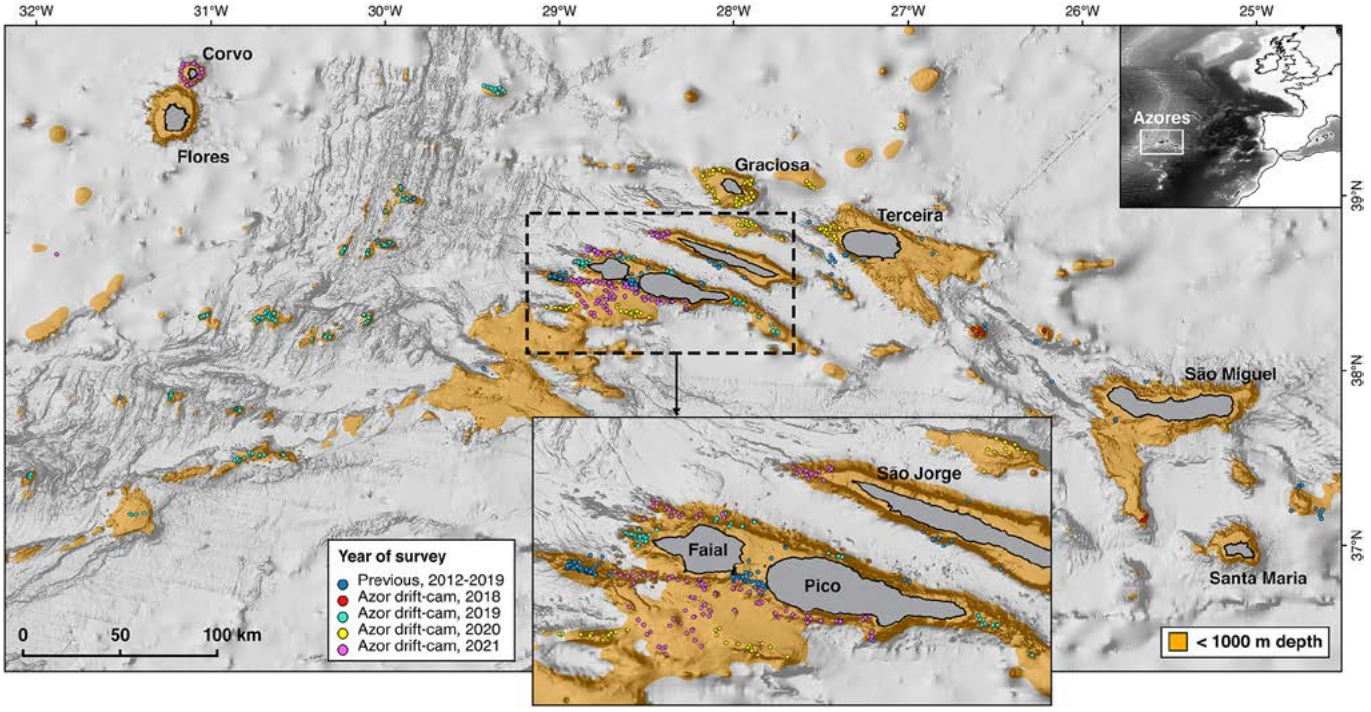
Exploring the Azores deep sea using a custom-made low-cost imaging tool: how much have we achieved with the Azor drift-cam?

by Carlos Dominguez-Carrió, Sérgio Gomes, Gerald H. Taranto, Luis Rodrigues, Manuela Ramos, Guilherme Gonçalves, Laurence Fauconnet, Marina Carreiro-Silva and Telmo Morato

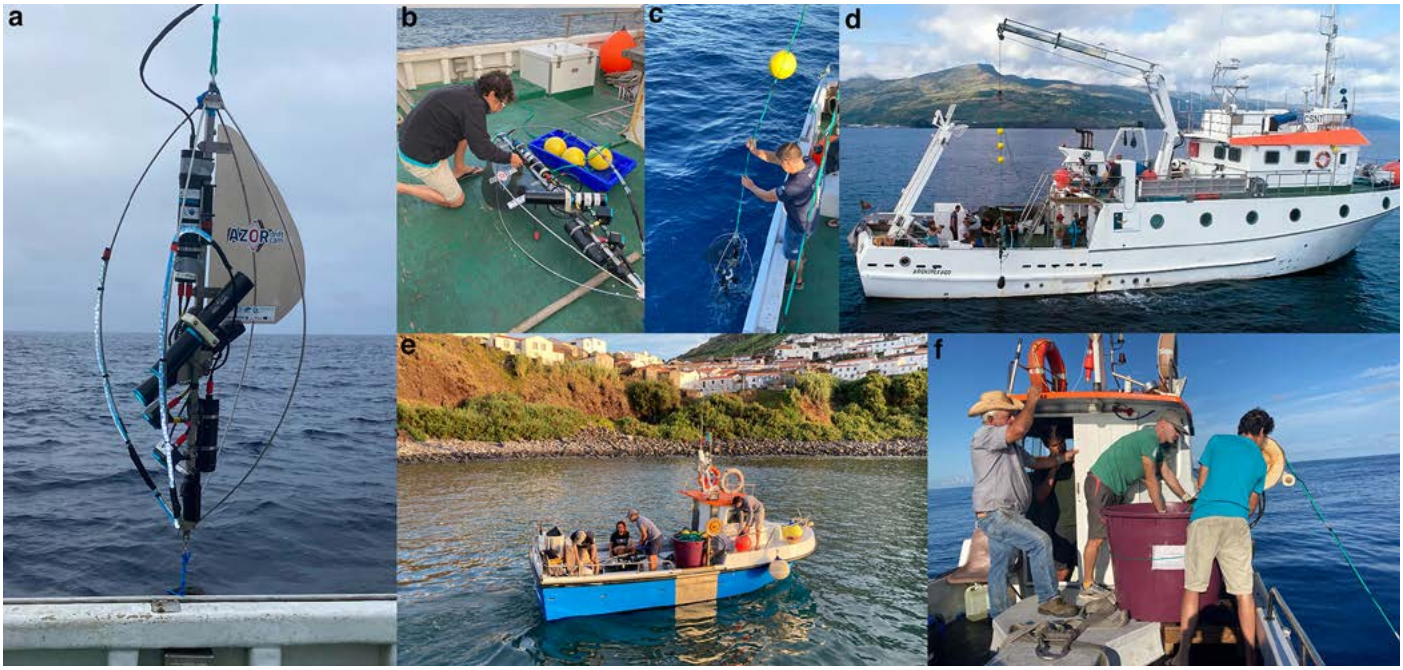
IMAR Instituto do Mar and Ocean Sciences Institute - Okeanos, University of the Azores

Deep-sea exploration has advanced immensely since the beginning of the 20th century, when manned submersibles started to be used to investigate the diversity of life dwelling at the bottom of the ocean. The development of marine technology has provided us with a series of underwater imaging tools that can gather high-quality images of the seabed thousands of metres below the surface. Although deep-sea imaging devices such as Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs) and towed camera systems have now become essential tools for the study of deep-sea benthic habitats, they still remain inaccessible to many research teams due to their elevated costs, and are generally associated with large oceanographic vessels and specialised crews in order to be fully operational.

The Azores Exclusive Economic Zone spans more than 1,300 km from east to west, and is home to around 130 seamounts with summits shallower than 1,000 m water depth. For years, local scientists and policy makers had limited access to underwater imaging devices, and deep-sea exploration mostly relied on international research vessels equipped with commercial ROVs visiting the archipelago. A large number of these scientific cruises focused on the study of hydrothermal vents, common features along the Mid-Atlantic Ridge. Most of our knowledge on the biological diversity of the deep sea was based on the study of organisms accidentally collected as fishing by-catch and from the few research cruises that actually targeted benthic habitats. The situation improved with the dives performed by the ROV



Above: Figure 1 - Location of the underwater dives performed with the Azor drift-cam during the summers of 2018 (first trials) throughout 2021 in the Azores region. The orange colour over the bathymetry corresponds to those areas with depths shallower than 1,000 m. The dark blue dots represent the location of the dives carried out in previous years using other underwater video devices (e.g., commercial ROVs, manned submersibles, towed cameras) from which we have information in our database.

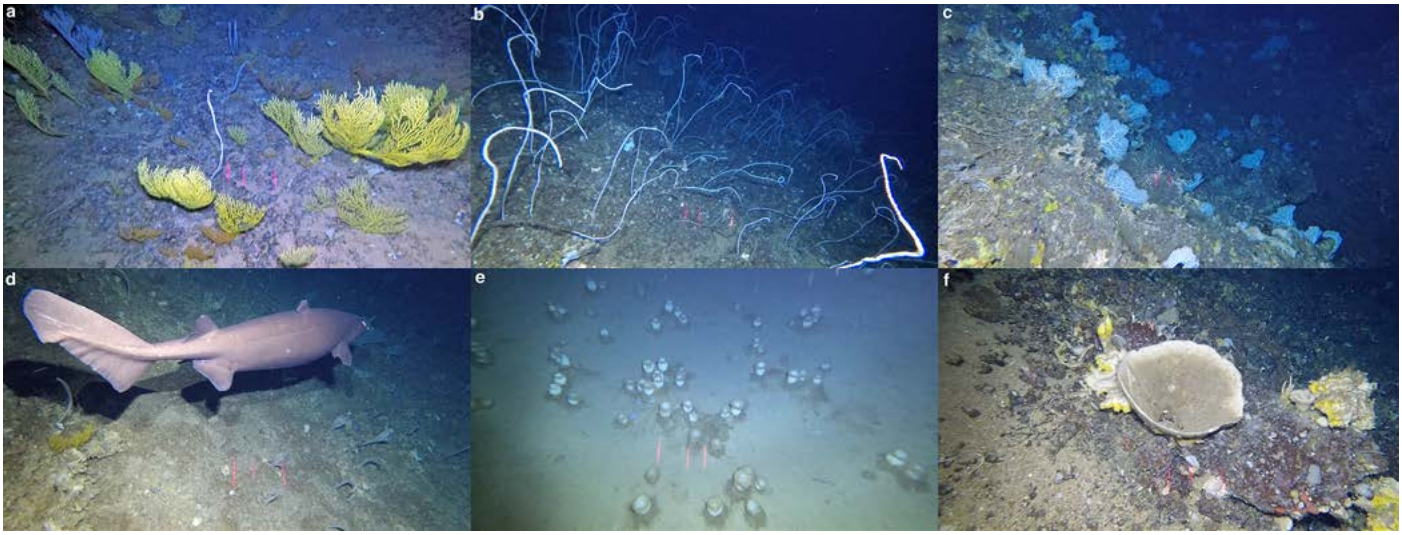


Above: Figure 2 - Images from the exploratory work done in the Azores with the Azor drift-cam over the past three years: (a) The device held with the crane of the vessel NI Arquipélago *ready to be deployed; (b-d) The team getting the system ready and deploying it over the side of the vessel to start surveying the deep sea; (e-f) Images of the survey performed on the slopes and adjacent seamounts of the island of Corvo with the Azor drift-cam deployed from a local fishing vessel.*

Luso as part of Portugal's Continental Shelf Extension Project (https://en.emepc.pt/projeto-rov-luso) and within the frame of national and international projects, such as CoralFish and the Blue Azores programme. Additionally, the Azores-based manned submersible *LULA1000* from the Rebikoff-Niggeler Foundation (https://www.rebikoff.org/) explored some slopes and seamounts around the central group of islands. Knowledge of deep-sea habitats further increased through collaborations with international institutions, such as NIOZ (Netherlands) and IEO-CSIC (Spain), with exploratory surveys using commercial ROVs and towed camera systems conducted in specific areas.

Even with all these recent efforts, the deep-sea area explored in the Azores using visual methods remained relatively small until a few years ago (blue dots in Fig. 1), and comprehensive information regarding the diversity and composition of its benthic communities was only available for a limited number of seamounts. In order to speed up deep-sea exploration in the region and better inform policymakers, in 2018 researchers at IMAR/Okeanos (University of the Azores) started to develop an affordable and easy-to-use underwater video system for a rapid appraisal of benthic habitats. A year later, following prototype testing, a low-cost video device to obtain images from the deep seafloor down to 1,000 m was completed. It was named 'Azor drift-cam', since it takes advantage of the drift of the vessel to 'fly' over the seabed. This system was developed to reflect the reality of the Azores setting, aiming to be cost-effective, cover large areas in short periods of time, perform well over rough seafloor terrain, be operational from small vessels and have high chance of escaping lost long-lines, the most common fishing gear in the region. The device is composed of off-the-shelf components, taking advantage of the powerful action cameras now available on the market. It has an oval steel structure that protects all electronic components from potential collision with rocks and from entanglement with fishing lines, reducing the likelihood of losing equipment. It has two action cameras (one of which provides a live feed to the surface), powerful LED lights, a parallel laser system for image scaling, and a temperature/depth sensor (Fig. 2a). All electronic components are battery-powered to avoid sending electricity through the cable, further decreasing the risks associated with its use. Being aware of the expensive nature of marine technology, the design and functioning of the Azor drift-cam was recently shared in an open access article in the journal *Methods in Ecology and Evolution* in order to allow other research teams interested in the field of deep-sea exploration to benefit from this technology (https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.13617).

Thanks to the Azor drift-cam, we have now collected a large amount of new video footage from across the whole Azores region. During the past three summers, almost 400 dives have been performed on several seamounts along the Mid-Atlantic Ridge (most of which never visited before) and on the seamounts and island slopes around the islands of Faial, Pico, São Jorge, Terceira, Graciosa and Corvo (Fig. 1). This sampling effort represents more than 300 hours of new deep-sea imagery, adding up to more than 200 linear kilometres of seabed. One of the key aspects of the system is that it can be operated from medium-sized research vessels, such as NI *Arquipélago* (Fig. 2b-d), as well as from small fishing boats (Fig. 2e,f). This versatility massively increases our capacity to survey areas close to shore at low operational cost, and benefits from the knowledge of local fishers that has been



Above: Figure 3 - Some examples highlighting the diversity of species and communities found in the Azores deep sea that have been recorded with the Azor drift-cam: (a,b) coral gardens characterised by the presence of large octocorals; (c) aggregation of the hydrocoral Errina dabneyi*; (d) a deep-sea shark on a coral garden; (e-f) sponge fields. More images recorded with the Azor drift-cam can be viewed at www.youtube.com/channel/UCrUCCk9866Ym8voq7ZwwZoQ.*

gathered through years of experience. Two full surveys have now been carried out on board fishing vessels, targeting the slopes and adjacent seamounts of the islands of Graciosa and Corvo. In both cases, the equipment was shipped to those islands using regular ferry lines, proving the capacity of the Azor drift-cam to be easily moved between areas when needed.

The images recorded over the past three years have provided a significant amount of new information regarding the composition and, especially, the spatial distribution of deep-sea benthic communities in the Azores. Several of the seamounts and island slopes explored so far are home to structurally complex assemblages, which include diverse cold-water coral gardens, sponge grounds and a wide variety of associated fish species (examples in Fig. 3). Some of the communities observed likely fulfill the criteria set by FAO to describe Vulnerable Marine Ecosystems due to their high structural complexity and functional significance of their main constituents, as well as their vulnerability to human activities and potentially slow recovery after disturbance. Our improved knowledge on the location of such diverse benthic communities, most of which had remained unknown until now, have increased our capacity to develop area-specific management plans that should lead to a more sustainable use of deep-sea natural resources and a better long-term conservation of the natural heritage of the Azores region.

The development of the Azor drift-cam was financed by the European Union Horizon 2020 Framework Programme projects ATLAS (GA No. 678760) and iAtlantic (GA No. 818123), and the PO2020 Project MapGES from the Regional Government of the Azores (Acores-01-0145-FEDER-000056).

WANTED: Your innovation stories!

As well as being a low-cost and easy-to-use system for deep-sea exploration, the Azor drift-cam is also a perfect example of scientific innovation that iAtlantic is keen to promote. With the support of iAtlantic's recently-appointed Innovation and Exploitation Manager, Theoni Massara, we will be communicating the drift-cam's innovation potential to the greater public as well as seeking ways to facilitate exploitation discussions with industry.

However, we have a keen interest in the broader aspects of innovation too: not only do we want to hear about new technology developed in the project, but also other innovative uses of project data and imagery, novel protocol development, or forward-thinking collaborations with external partners. Innovation exists in the maps and assessments developed by iAtlantic scientists, as well as in the industrial collaborations that have facilitated iAtlantic's access to new environmental datasets of interest. We are interested to hear about your participation in platforms that maximise iAtlantic's visibility outside the marine science community, as well as development of new project proposals that build on iAtlantic research. Check out the article on p25 to read how iAtlantic has collaborated with a textile designer!

These are just a few examples of "innovation" in its broadest sense; it is important that we think outside the box to really capture all the fantastic ways that iAtlantic research finds its way into the wider world and makes an impact. If you have an innovation/exploitation story to share or would like to discuss an idea, please get in touch with iAtlantic's Innovation and Exploitation Manager, Theoni Massara (theoni.massara@ed.ac.uk).

South Atlantic GAteway in the Global Conveyor Belt (SAGA)

by Cristina Arumí-Planas and Daniel Santana-Toscano

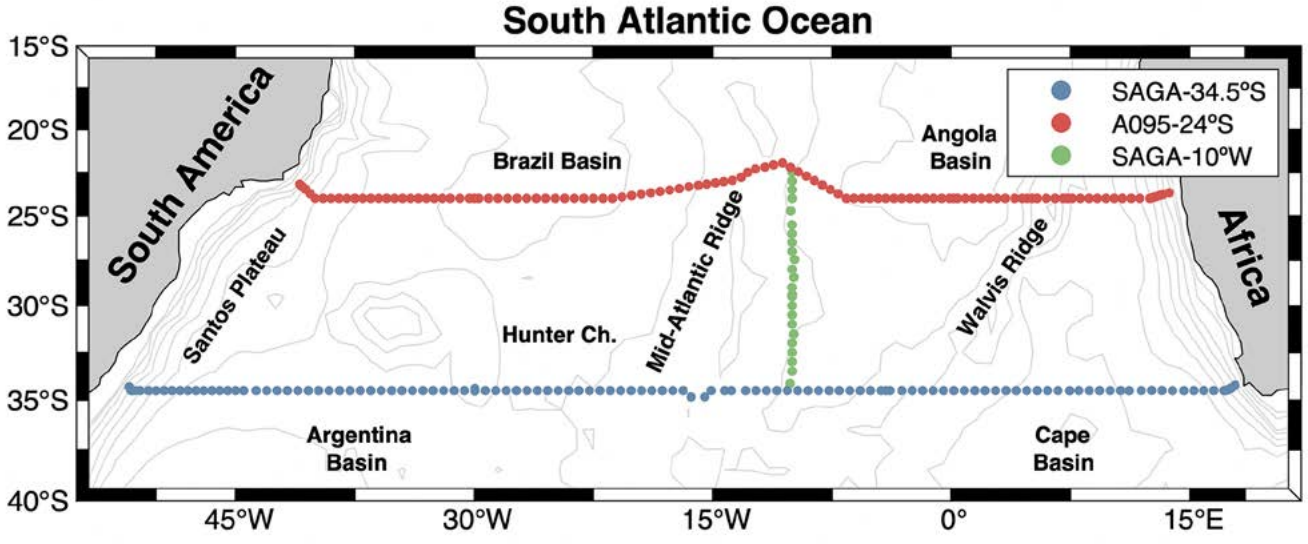
Instituto de Oceanografía y Cambio Global (IOCAG) and Instituto Español de Oceanografía (IEO), Spain

The global conveyor belt connects all the oceans through the relatively warmer surface currents and the relatively colder deep currents, transporting heat between the oceans and exchanging it with the atmosphere. The Atlantic Ocean has a significant role in controlling climate, so variations in some components of the global conveyor belt will also lead to a change in the climate. SAGA will help to characterise one of the most unknown components of the global conveyor belt found in the South Atlantic Ocean.

The Deep Western Boundary Current (DWBC) is one of the most important deep currents in the Atlantic that travels from the northern seas, where is formed, to the South Atlantic, rounding the ocean along the western edge. However, at about 20°S, a significant fraction of the flow transits eastward across the basin in the tropics and/or subtropics and flows southward along the African coast. Currently, the volume transport that passes through the oceanic ridge is unknown. The results of a southern research expedition at 10°W, together with a consecutive one at 34.5°S and the findings at the A095 section (24°S) will provide data to analyse the mass transport of the DWBC reaching the African continent. Additionally, the SAGA project aims to study the intrusion of the Indian Ocean waters through Agulhas rings and the filaments associated with the Benguela Current and eastern boundary upwelling.

The results of this study will directly contribute to iAtlantic's objective of quantifying the shallow and deep mass transports of the global conveyor belt in the South Atlantic Ocean.

Above: Cristina and Daniel with the rosette, which includes CTD, LADCPs, and Niskin bottles.



Above: Station positions for SAGA and A095 cruises carried out at nominally 34.5°S, 10°W and 24°S in the South Atlantic Ocean in 2021, 2022 and 2018 respectively.

The Deep Ocean Observing Strategy (DOOS)

What is DOOS?

The Deep Ocean Observing Strategy (DOOS) is an international, community-based group that coordinates deep ocean observing to understand the state of the global deep ocean with respect to baseline conditions, response to climate change, and response to human disturbance. It is a Global Ocean Observing System (GOOS) project and was recently endorsed as a UN Ocean Decade Programme. It is a network of networks, of which iAtlantic is one. In 2021, funding was awarded through the US National Science Foundation AccelNet programme for implementing DOOS (iDOOS).

The overarching goal of DOOS is to promote a deep ocean community that facilitates collaboration across disciplines and fields, elevates a diverse cohort of early career researchers into future leaders, and bridges scientific advancements to societal needs and challenges. In that respect it parallels many of the iAtlantic goals, but on a global scale. To that end, DOOS represents an interconnected network of deep-ocean observing, mapping, exploration and modelling programmes working together to: 1) characterise the physics, biogeochemistry and biology of the deep ocean in space and time; 2) establish a baseline required to understand changes to its habitats and services, and 3) provide the information needed to have a healthy, predicted, resilient and sustainably-managed (deep) ocean. To learn more about DOOS, please visit the website - https://deepoceanobserving.org/

While DOOS does have a global focus, we seek iAtlantic engagement for key DOOS initiatives. Several are outlined below but there are more on the way.

Azores demonstration project

One of the key thrusts of DOOS is the creation of demonstration projects that seek to demonstrate the feasibility of sustained, deep ocean observing integrated across disciplines, new technologies, and/or the impact and utilisation of deep ocean observations for industry, policy, and management. A key goal of demonstration projects is that they are designed to be scalable from local to global. While several potential projects are in early planning stages (e.g., in the Clarion Clipperton Zone), currently the most mature of these is set in the Azores archipelago. The Azores demonstration project is being developed in collaboration with the Atlantic Ocean Observation System (AtlantOS), the University of the Azores, and several other observing networks and UN Ocean Decade programmes, including Challenger 150, Marine Life 2030, MBON, and EMSO, as well as a number of iAtlantic investigators. The current focus of this project (under development) involves assessing biodiversity in deep-sea benthic communities in a changing ocean using standardised biological, biogeochemical, and physical Essential Ocean Variables and approaches taking into account water column processes, benthic-pelagic coupling, microbiology, acoustics, contaminants, geophysical controls, and atmospheric deposition. If you would like to participate in project planning, please contact Felix Janssen (felix.janssen@awi.de).

DOERs programme

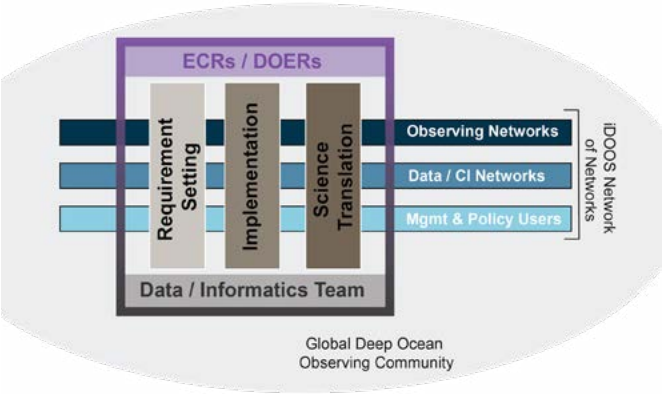
The Deep Ocean Early-career Researchers (DOERs) programme is a collaborative mentoring program designed to bring together early career researchers from across the global deep-sea community. It seeks to foster a new generation of diverse and inclusive leadership that is capable of guiding future deep-ocean observing and research. Key goals of iDOOS early career development are to advocate for and raise the profile of deep-sea early-career researchers, provide transferable skills in the areas of networking, collaboration and outreach, and cement their inclusion into and future leaders of the scientific community. Our hope is to liaise with the iAtlantic Fellows programme to collaborate on training, communication, peer support and more. iAtlantic Fellows who are interested in engaging should contact Leslie Smith (leslie.smith@youroceanconsulting.com).

Additional DOOS efforts

Our recently funded "implementing DOOS" project has many other initiatives beyond the Azores and DOERs programme that may be of interest to members of the iAtlantic community. The project is divided into three thematic working groups, each with its own tasks:

1. **Requirement setting**: creating deep-ocean focused EOV specifications and pathways of communication and collaboration between observers and modellers;
2. **Implementation**: demonstration projects and technology development, including low-cost sensor development;
3. **Science translation**: translation of data/science outputs for policy makers and building deep-ocean observing capacity globally.

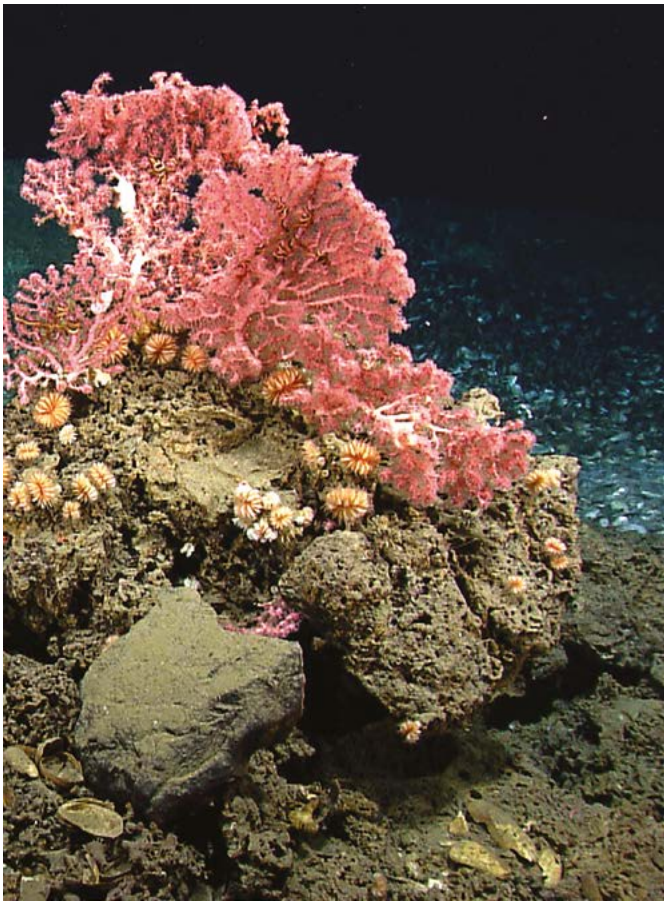
Please contact us at info@deepoceanobserving.org if you are interested in joining any of these DOOS efforts.



Introducing the Marine Animal Forest of the World COST Action

By Cova Orejas, IEO-CSIC

The term Marine Animal Forests was used for the first time by Alfred Russel Wallace in his book "The Malay Archipelago" in 1869. In recent years the concept of Marine Animal Forests (MAFs) has been developed and are described as animal assemblages in shallow, mesophotic and deep sea ecosystems, mainly composed of suspension-feeding organisms such as sponges, gorgonians, hard corals, bryozoans, bivalves and others. These animals form canopies akin to trees, shrubs or even meadows on land, creating underwater forests. As the Aichi Biodiversity Targets have proved impossible to achieve by 2020, there is an urgent need for networks to join forces to work together towards a common objective: preserve our natural capital. These submerged forests are hotspots of biodiversity, acting as refugia and nurseries for many species, including fish and crustaceans of commercial interest, thus providing ecosystem services which are essential for hundreds of million people worldwide.



Above: Sponges, corals and other benthic animals thrive in Atlantic waters off the north-eastern coast of the US. Image courtesy NOAA Stepping Stones Expedition 2021.

The Marine Animal Forests of the World COST Action (MAF WORLD; CA20102) is being developed with the aim to generate – particularly in this UN Decade of Ocean Science for Sustainable Development – robust scientific knowledge for a better understanding of the distribution, characteristics and functionality of MAFs, providing the fundamental basis for the sustainable management and conservation of these ecosystems around the world. MAFs are threatened by increasing anthropogenic pressures, notably fisheries activities, oil exploration and climate change; an in-depth analysis of these ecosystems, development of common investigative protocols and scientific consensus on the most appropriate tools to study and understand MAFs' role will inform management, restoration and conservation initiatives.

The MAF WORLD network aims to help develop the necessary instruments to support common future policies for the conservation and sustainable use of these benthic ecosystems in coastal and open-ocean waters. The network aims to establish a cross-sectoral platform for partners across academia, policy making and civil society, offering inclusive spaces for a transdisciplinary dialogues. This ambitious programme is structured into eight working groups which incorporate all necessary expertise to achieve the overarching aim of the action: biological and ecological studies, habitat mapping, analysis of threats and impacts, ecosystem services, social sciences, conservation and restoration as well as historical ecology.

MAF WORLD kicked off in October 2021 and will run for four years, comprising a large network of scientists from different disciplines. As a COST action, the project welcomes any researchers and citizens interested in joining the project as it is an open forum. Proposals for actions and activities to be carried out in collaboration between MAF WORLD and iAtlantic are more than welcome! If you are interested in joining the MAF WORLD network, please contact Cova Orejas (cova.orejas@ieo.es).

MAF WORLD

iAtlantic at COP26

A round-up of our activities at the COP26 climate conference held in Glasgow, 31 October – 13 November 2021

UN CLIMATE CHANGE CONFERENCE UK 2021

Climate Science Showcase, Dynamic Earth

On Saturday 6 November, iAtlantic teamed up with the Dynamic Earth centre in Edinburgh to bring the latest in ocean-climate science to members of the public and a range of stakeholders. Timed to coincide with the COP26 conference in Glasgow, a daytime Climate Science Showcase brought exhibits and hands-on activities to more than 1,400 members of the public, in order to demonstrate the fundamental role that science plays in understanding Earth's climate system.

iAtlantic partners Heriot-Watt University, Scottish Association for Marine Science, University of Edinburgh, Seascape Consultants and close colleagues at Whale Wise and St Abbs Marine Station pulled out all the stops to contribute exciting and interactive displays for the public to learn more about deep-ocean science, and see some of the tools used by scientists to understand how the ocean is affected by climate change. Alongside many other exhibitors from Scotland's climate science research teams, the iAtlantic team had a busy day interacting with families and local residents. A montage of the day's events can be viewed at https://youtu.be/czfdiHIXooM

Following a very busy day of public engagement, the exhibition area at Dynamic Earth was reconfigured for a special iAtlantic evening event for invited guests from a range of stakeholder organisations, including delegates from COP26 (see article on p22).

Above: The iAtlantic team at work during the Climate Science Showcase at Dynamic Earth. Images: Vikki Gunn.

COP26 Virtual Ocean Pavilion

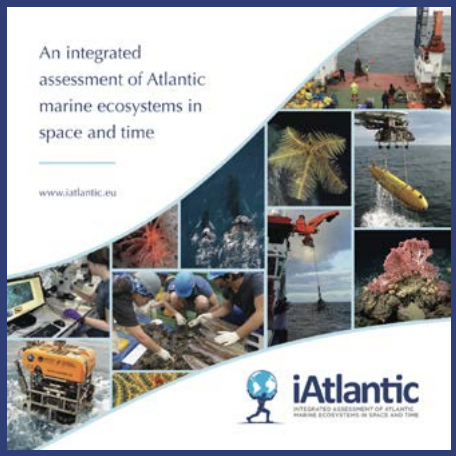
A number of iAtlantic partners attended or participated in events at or associated with the COP26 Climate Change Conference in Glasgow. The project also had a strong online presence via the Ocean Pavilion, founded and coordinated by the Global Ocean Forum, Plymouth Marine Laboratory, the Ocean Policy Research Institute (OPRI) of the Sasakawa Peace Foundation, the Oceano Azul Foundation, and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, with over 25 international partners, including iAtlantic.

The first ever dedicated Ocean Pavilion at a climate change COP was convened this year to raise the visibility of the ocean and showcase why the ocean matters in climate negotiations. Free to access, it featured an overview of the ocean events at the COP26 itself as well as hosting its own live events with more than 60 international speakers. A range of exhibition booths, a treasure trove, interviews with party representatives and a wealth of online resources attracted around 3,000 registrations.

iAtlantic scientist Dr Telmo Morato (IMAR/University of the Azores) participated as an invited speaker in a expert panel session session on "Ocean and Adaptation and Resilience", moderated by Dr Peter Ricketts from Acadia University in Canada. In his presentation, Telmo highlighted iAtlantic's collaborative approaches to the assessment of resilience and health of deep-sea and open-ocean ecosystems across the Atlantic Ocean.

iAtlantic research was also showcased via a virtual exhibiton booth (pictured below), with daily online chat sessions hosted by iAtlantic Fellows and the Project Office team.

The pavilion and its resources, including on demand videos of the live events, will continue to be accessible free of charge until March 2022 at https://cop26oceanpavilion.vfairs.com/



New iAtlantic brochure

A new 12-page brochure explaining the aims and objectives of iAtlantic research is now available for partners to distribute at conferences and events. Featuring stunning imagery from across the project and our collaborative partners, the brochure outlines the methods used in the project and how results will be used to promote sustainable management of Atlantic Ocean resources.

Copies are available from the Project Office (please give us plenty of notice!) and the PDF version is available to download from the Resources page of the project website: www.iatlantic.eu/resources. We also have a new series of freestanding project banners for use at major events and conferences.

An evening dip into the deep ocean at Dynamic Earth

Humpback whale © Andrew Stevenson, Whales Bermuda

Following a very busy day of public engagement at Dynamic Earth's Climate Science Showcase (p20), the exhibition area at Dynamic Earth was reconfigured for a special iAtlantic evening event for invited guests from a range of stakeholder organisations, including delegates from COP26. Convened as part of the Scottish Government's marine programme events for COP26, the event aimed to highlight the critical role of the ocean in the climate debate.

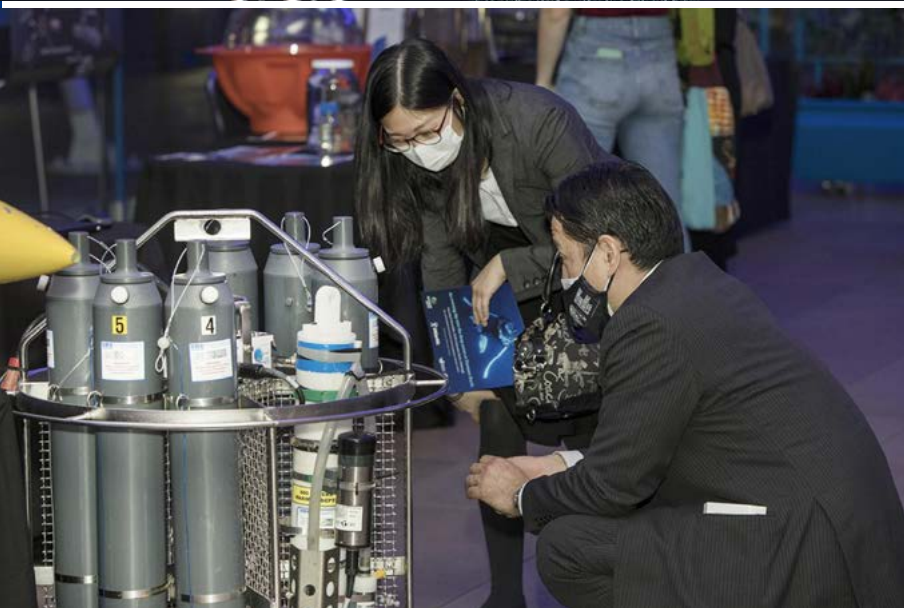
Guests arrived at Dynamic Earth to the spectacular sight of the *Gaia* globe suspended from the ceiling in semi-darkness and lit up in blue. *Gaia* is a touring artwork by UK artist Luke Jerram, measuring seven metres in diameter and created from 120dpi detailed NASA imagery of the Earth's surface. The installation aims to create a sense of the Overview Effect, which was first described by author Frank White in 1987. Common features of the experience for astronauts are a feeling of awe for the planet, a profound understanding of the interconnection of all life, and a renewed sense of responsibility for taking care of the environment.

After a welcome from Dynamic Earth's Scientific Director, Hermione Cockburn, the evening's formal programme commenced downstairs in the Planetarium. Chief Scientific Advisor for Scotland, Prof. Julie Fitzpatrick, opened proceedings with an address that highlighted the huge importance of international scientific collaboration in delivering the research needed to tackle the climate crisis. A series of visual treats followed, including the premiere screening of the new "Cold-Water Corals in a Changing Ocean" film, and a series of talks from iAtlantic scientists Murray Roberts, Lea-Anne Henry, Stuart Cunningham and Daniela Diz, who showcased some of the cutting-edge aspects of iAtlantic's research. The programme finale came courtesy of another premiere screening – this time of the new planetarium show that has been developed by University of Edinburgh in partnership with Dynamic Earth: 'The Final Frontier for Climate Change'. Narrated live by Murray Roberts (iAtlantic) and Alastair Bruce (Dynamic Earth), the show incorporates stunning visualisations of cold-water corals and how climate change will affect their ability to thrive – or even survive – in the ocean of the future. The show includes some breathtaking projections of global ocean circulation that left many (including hardened oceanographers) rather awestruck! This performance comprised highlights of a longer planetarium show that will form part of Dynamic Earth's new 'Discovering the Deep' exhibition that opens to the public in spring 2022.

Guests were led back upstairs to the exhibition hall where they were treated to some light refreshment in the glow of the *Gaia* globe, whilst enjoying the iAtlantic science exhibition and talking with members of the project team.

Our sincere thanks to Prof. Fitzpatrick and Marine Scotland for their support of the event, our co-hosts Dynamic Earth, and to our team of iAtlantic exhibitors and speakers who gave up their weekend to do such an amazing job!

Right: Guests enjoy the presentations, iAtlantic exhibits and networking at the special COP26 evening event at Dynamic Earth. Images © iAtlantic.



Cold-water corals in a changing ocean

Sir David Attenborough highlights how vulnerable cold-water corals are to rapidly changing ocean conditions in a new film released during COP26

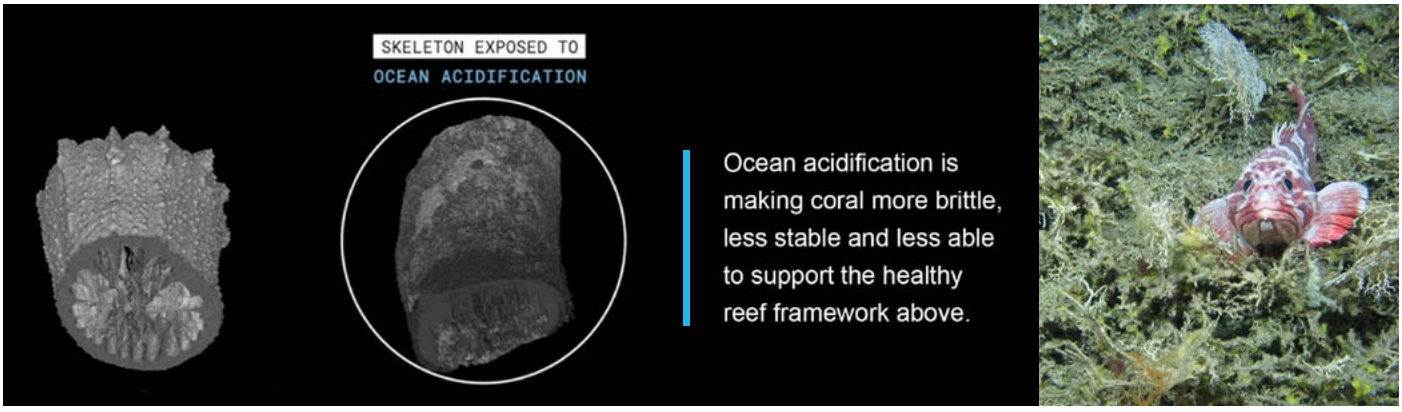
As a contribution to COP26, scientists at University of Edinburgh produced a short film explaining how cold-water corals are particularly vulnerable to the rapid acidification of the oceans caused by carbon dioxide emissions – a largely hidden impact of fossil fuel use. Narrated by Sir David Attenborough and featuring research from the iAtlantic and One Ocean Hub projects, this film also highlights the central role of the ocean when considering climate change impacts and mitigation.

Cold-water corals can form complex deep-sea reefs in many parts of the world, where the calcifying coral, *Lophelia pertusa*, creates its skeleton from the carbonate mineral aragonite. Ocean acidification, caused by carbon dioxide emissions dissolving into the ocean, is causing the aragonite saturation horizon (the depth at which dead corals start to dissolve) to become shallower and shallower, leaving many reefs in water that is corrosive to their skeletons. These reefs are supported entirely by dead coral skeletons, and as they corrode the entire reef structure becomes unstable.

A research team led by the University of Edinburgh has exposed *L. pertusa* to present and predicted future ocean conditions. Sebastian Hennige (right) said "By carrying out this study with both live and dead corals, we can now understand how ocean acidification will affect deep-sea coral reefs. By using detailed synchrotron imaging techniques, we are looking at the microstructure of the coral and discovering that dead coral skeletons become porous. This means that the vast, load-bearing structure of these reefs could crumble, causing the collapse of these precious ecosystems."

While over the last 20 years huge efforts have been made to conserve cold-water corals by creating protected areas, many of these areas are in places that will become too acidic for corals before the end of the 21st century. iAtlantic Coordinator Murray Roberts (University of Edinburgh) says "We should think of cold-water corals like canaries in a coal mine when it comes to understanding the implications of ocean acidification. They are early warning indicators that we've got a problem and the only solution is to reduce our carbon dioxide emissions as quickly as possible, minimise the other stressors and work to restore corals in areas where they used to flourish."

Check out the film via the iAtlantic YouTube channel at youtu.be/s4iPY-9mGVg



Science is beautiful: merging marine research with textile design

By Jessica Gianotti, Crùbag

Jessica Giannotti, founder of Crùbag (right) merges marine science with art and textiles to reveal the unseen beauty of the ocean and to communicate climate change science from the ocean perspective.

Years ago, as a student of marine science, I often saw something unique, a hidden world, a mystery. Learning and working on projects that involved looking down the microscope, looking at images taken by unmanned vehicles and robots in the deep sea, around seamounts or under the sea ice in polar regions opened a new world to me. There were images of beautiful diatoms, deep-sea fish, cold-water corals and quirky worms in the sediments. Large-scale planetary processes were fascinating too. Studying seawater formation, seafloor spreading and ocean currents, how they help shape our climate and the interconnectivity of it all was humbling and breathtaking.

This access to science, hidden beauty and knowledge was a huge privilege. I wanted to share this privilege and sense of awe with people but wasn't sure how. Then one day, while having coffee with a friend in the small Scottish town of Oban, I saw at least seven people wearing scarves with butterflies and flowers. They were lovely, but I wondered why butterflies and flowers and not phytoplankton? Then it clicked and I realised that textiles are the perfect medium to communicate marine science to the general public. This became my mission: to materialise the world of marine science in a tangible and artful way. Textiles are the ideal canvas – you can touch the fabric, reveal the ocean's unseen natural beauty, and share the science story behind the designs. People can wear their values and become ocean ambassadors and science communicators. The idea of Crùbag was born.

Crùbag was founded in 2013 after completing my studies in marine science at the Scottish Association for Marine Science (SAMS). In our studio, an old teaching laboratory based at SAMS, we create colourful textiles and sustainable fashion accessories that merge marine science and art. Our designs reveal the hidden ocean, those inaccessible and unseen patterns in nature that can only be seen and understood with the help of marine scientists and their microscopes, research vessels and fieldwork. Crùbag is a bridge between science and people and brings marine science into the cultural fabric of society. Together, we all celebrate our colourful planet and hope to bring joy, wellbeing and a deeper connection with nature.

To do that, we collaborate with marine scientists and research institutions to produce textile collections inspired by their exciting work. We use research images and the ocean as inspiration and foundation to develop directional print designs and ethical fashion accessories. We spread ocean literacy and link our collections to knowledge-based campaigns as platforms to discuss some of the biggest environmental issues of our time.

Marine science is beautiful. Our mission is to shine a light on the windows of wonder that scientists are opening on the natural world and share the passion and love we have for the sea with creativity and beautiful, bold designs.

In November 2021 we had the opportunity to be part of Dynamic Earth's Climate Science Showcase (see p20) and to soft-launch our new Climate Change Collection. We also joined the *Evening dip into the deep ocean* event (p22). We were delighted and grateful to be part of this collective effort to raise awareness about COP26 and climate change, inspire others to love and to celebrate our planet and highlight the importance of marine science in a changing planet.

The idea for the Climate Change Collection came last summer over a cup of tea with Prof. Stuart Cunningham (SAMS). He told me: "Jessica, the climate problem is an ocean problem". That quote stayed with me and made an impact. I then replied: "OK let's do a collection about it. Are you in?" He smiled and said: "Yes, let's do it!"

The new Climate Change Collection is a colourful collection of organic silk scarves inspired by climate change science from the ocean perspective. All scarves are paired with a graphics-rich booklet sharing the science stories behind it. The themes of the collection are:

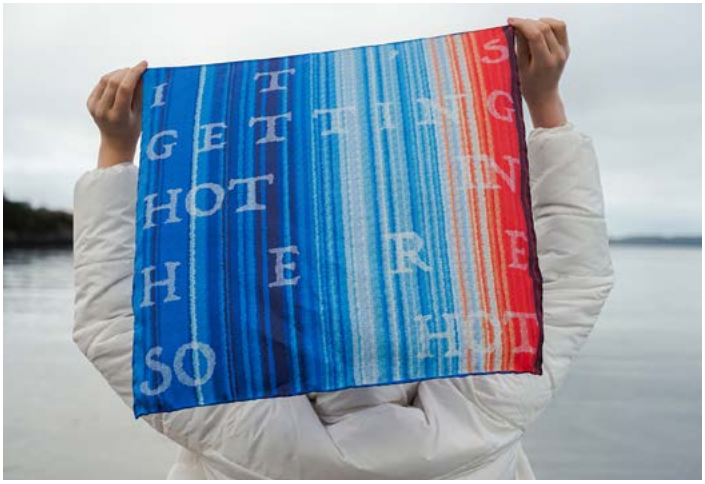
- Our Global Ocean
- Biodiversity & Habitat Loss in a Time of Rapid Climate Change,
- Climate Change, Ocean Acidification & Cold-Water Corals
- Tropical Coral Reefs & Climate Change
- Arctic Fjords connecting Ice with Ocean, Arctic Sea Ice & Primary Productivity
- Project Snowfall & Climate Change, Antarctica: A Vision for the Future
- Blue Carbon & The Zooplankton Plastic Pump
- Penguin Planet
- The Unseen Beauty of Nature

The Ocean Acidification & Cold-Water Corals theme, for example, highlights the issue of coralporosis. Murray Roberts and his team at the University of Edinburgh have been studying cold-water corals for over 20 years. More recently, they focused their research on the impact of ocean acidification on cold-water coral ecosystems, discovering that the dead coral foundations of the reefs are becoming more porous, akin to osteoporosis in humans. Evidence of this porosity can be seen by eye with very detailed 3D scans of coral skeletons showing how the skeletons will change in future ocean conditions (see image on p24).

Crùbag developed this collection in collaboration with scientists from the Scottish Association for Marine Science, The University of Edinburgh, Newcastle University and British Antarctic Survey. People hear about climate change all the time. The question is: how can we make climate change more relevant to people without overwhelming them? The aim of this collection is to demystify climate change and share clear case studies of how climate change is impacting our planet from the ocean perspective. Each story is a science theme focusing on a unique angle, thus making climate change tangible and accessible. Fashion can be a powerful platform for science-based activism.

Each scarf (such as the one pictured above) is finished by hand with care and love and comes with a special Climate Change Collection booklet, sharing the science stories and images that inspired the collection. We give 10% of our profits to support important climate change research and towards our community engagement activities. The scarves were designed and made in the UK using GOTS certified organic silk. We launched an initial range of scarves from the collection. From January until March, we will continue to add more designs and articles from the booklet as blog posts on our website. Discover the Climate Change Collection here.

You can read and download the entire Climate Change Collection booklet here



Snippets...

DOSI Task Force on conservation of deep ocean biodiversity

This new Task Force, set up under the Deep Ocean Stewardship Initiatve (DOSI), focuses on the conservation of biodiversity and identification of nature-based solutions to the biodiversity crisis. The Task Force will seek to proactively address and communicate the science directly relevant to conservation issues, such as that of biodiversity conservation or designing effective MPAs.

The Task Force will incorporate knowledge, conservation issues and solutions across the many existing DOSI Working Groups into broadly applicable actions that can then be modified as needed by individual Working Groups.

The new Task Force welcomes those interested in joining the discussion - for more details see www.dosi-project.org/topics/biodiversity-task-force/

POGO shipboard training scheme

The Partnership for Observation of the Global Ocean (POGO) offers a shipboard training fellowship programme which is designed to promote training and capacity development, leading towards a global observation scheme for the ocean.

POGO's open call for applications is targeted to early career scientists, technicians, postgraduate students (PhD or MSc) and postdocs involved in oceanographic work at centres in developing countries and countries with economies in transition who wish to gain seagoing research experience. Once registered to POGO's scheme, candidates will be shortlisted for seagoing opportunites according to their suitability for placements that become avaiable.

The scheme offers funding for successful candidates to spend up to a month at the host institution ahead of joining the research expedition. More details at www.oceantrainingpartnership.org/opencall2022

The Data We Need for the Ocean We Want

International Ocean Data Conference 2022: Sopot, Poland 14-16 February 2022 (hybrid event)

The Conference has three main objectives: (i) to consider regional and global strategies and policy needed to achieve the digital ecosystem; (ii) to discuss existing and required technological developments and their implementation; and (iii) to identify future directions in ocean data and information management.

Registration for virtual partcipation is open until 11 February 2022. More details at oceandataconference.org

First All-Atlantic newsletter

The All Atlantic Ocean Research Alliance has released its first newsletter, bringing together highlights from across the All Atlantic project portfolio and wider community. The scope of the newsletter is to promote relevant news and work, and highlight, through projects' successful cooperation activities, the importance of cooperation among projects all working in and for the Atlantic. It is also intended to be call to action for all Atlantic stakeholders to engage with existing activities to "work together to one end".
Read more at: https://mailchi.mp/71a1b7543e29/aanchor-newsletter-issue-6100422

All-Atlantic Talks Podcast

A brand-new podcast series dedicated to the All-Atlantic Ocean Research Alliance and its many partners around the Atlantic Ocean is now online.

The All-Atlantic Talks Podcast series discusses the All-Atlantic Ocean Research Alliance values and ambitions, exploring collaboration efforts around the Alliance's priority themes and diving into rich discussions with our guests. The first episode discusses the role of science diplomacy with the Co-Chairs of the Belém Statement on Atlantic Research Cooperation.

allatlanticocean.org/view/news/all-atlantic-talks

Good reads

A selection of the latest iAtlantic publications

High-resolution vertical habitat mapping of a deep-sea cliff offshore Greenland

Van Audenhaege et al. (2021), Frontiers in Marine Science, DOI: 10.3389/fmars.2021.669372

Recently, several studies have pictured the high diversity of benthic communities at deep-sea vertical environments. In this study, Van Audenhaege et al. reconstructed in high-resolution the terrain of a deep-sea wall of a glacial trough (Greenland, Labrador Sea) using sonar front-mounted on a ROV. Based on multivariate analyses, they performed an unsupervised clustering to delineate regions with dissimilar geomorphology. Regional ecological relevance is discussed based on the benthic communities compiled from ROV images. In a poorly-visited environment, this innovative and cost-effective workflow reveals the importance of combining high-resolution terrain knowledge for objective dive planning with groundtruthing imagery and accurate ROV navigation.

Measuring sound at a cold-water coral reef to assess the impact of COVID-19 on noise pollution

De Clippele and Risch (2021), Frontiers in Marine Science, DOI: 10.3389/fmars.2021.674702

This study compared noise levels at the cold-water coral Tisler reef, before and after the onset of the COVID-19 pandemic. A hydrophone was deployed from 29 January until 26 May 2020 to measure variation in the acoustic landscape at the Tisler reef. From 15 March, COVID-19 lockdown measures stopped passenger vessel traffic between Norway and Sweden and caused overall noise levels to significantly lower 8.94 ± 0.88 dB during the day and 1.94 ± 0.11 dB during the night. Since there was no ferry traffic during the night, the drop in noise levels at night was driven by seasonal changes.

Sensitivity of a cold-water coral reef to interannual variability in regional oceanography

Kazanidis et al. (2021), Diversity and Distributions, DOI: 10.1111/ddi.13363

Little is known about how the North Atlantic Oscillation affects cold-water coral reef (CWCR) benthos over ecological timescales, hindering CWCR conservation. This gap is profound for macrofauna, a key component for ecosystem functioning. This study in the Mingulay Reef Complex showed that interannual changes in bottom temperature, salinity and the North Atlantic Oscillation explained nearly twice as much variability than spatial changes in topography and hydrography. There were significant differences in community composition, diversity, and function across temperature interannual variability. Considering the warming of North Atlantic by 2100, the study suggests the establishment of monitoring programmes, supporting an advanced understanding of CWCRs and their conservation.

Hidden structural heterogeneity enhances marine hotspots' biodiversity

Kazanidis et al. (2021), Coral Reefs, DOI: 10.1007/s00338-021-02114-w

The key role of 'habitat cascades' (successive habitat formation by organisms) in enhancing biodiversity in tropical rainforests and shallow-water ecosystems was recently shown. The role of habitat cascades in the deep sea, however, is unknown. Here, the role of macrofauna in enhancing structural heterogeneity and biodiversity in cold-water coral reefs (CWCRs) was explored. The findings suggest that bivalves, tunicates and empty polychaete tubes increase habitat heterogeneity and biodiversity through habitat cascades, in a similar way that epiphytes do in tropical rainforests. Most of the studied habitat suppliers are calcified and likely susceptible to ocean acidification. This indicates climate change impacts on biodiversity and health of CWCRs may potentially be more severe than previously thought.

Madrepora oculata forms large frameworks in hypoxic waters off Angola (SE Atlantic)

Orejas et al. (2021), Scientific Reports, DOI: 10.1038/s41598-021-94579-6

This research presents insight into the recently discovered cold-water coral mounds off Angola, providing the first quantitative study of the cold-water coral communities of the south-west African margin, specifically the Angolan coral mounds. These cold water coral communities were analysed using underwater video records, including novel information on the occurrence, spatial distribution and size of the cold-water coral *Madrepora oculata*, which was detected in four of the six analysed coral mounds. The population structure of the species was investigated for each mound as well as for the whole study area, revealing a particularly large specimen of *M. oculata* reaching 125 cm, the largest height documented for the species. CTD and oxygen sensors revealed that *M. oculata* colonies in the Angolan mounds live under hypoxic conditions, but the high primary productivity of the site guarantees abundant food supply which may help compensate for the otherwise harmful low oxygen levels, suggesting adaptation of the species to the local environmental conditions.

Distribution of megabenthic communities under contrasting settings in deep-sea cold seeps near NW Atlantic canyons

Cleland et al. (2021), Frontiers in Marine Science, DOI: 10.3389/fmars.2021.692851

Cold seeps support fragile communities of high biodiversity and are often found in areas with high commercial interest. Protecting them from human impacts requires an advanced understanding of the drivers shaping biodiversity. Image analysis in a relatively shallow site near Baltimore Canyon (~400 m depth) and the much deeper Norfolk Canyon (~1500 m) showed sharp differences

Check out the full list at www.iatlantic.eu/our-work/publications

in megabenthos. Hard habitats in and around cold seeps had higher values of density and biodiversity than soft habitats. Drivers of biodiversity could also be related to differences in chemical compound fluxes and megafaunal life history traits between the sites. This study underscores the importance of discovery science to inform spatial management of human activities in the deep and open ocean.

Human impacts on deep-sea sponge grounds: Applying environmental omics to monitoring

Vad et al. (2021), Advances in Marine Biology, DOI: 10.1016/bs.amb.2021.08.004

This paper discusses the use of omics as a future tool for sponge ground monitoring. While metagenomics and (meta) transcriptomics studies have improved our understanding of sponge biology, metabolomics analysis has so far mostly been used to identify natural products. The sponge metabolome, therefore, remains vastly unknown while the exometabolome, the fraction of the metabolome released into the seawater, has only just started to be investigated. Yet, sponge exometabolites could constitute perfect biomarkers of sponge health as compounds can be measured in seawater, bypassing the need for physical samples. Within sponge grounds, the description of a shared sponge exometabolome could even lead to the identification of biomarkers of overall ecosystem health.

Exceptional 20th century shifts in deep-sea ecosystems are spatially heterogeneous and associated with local surface ocean variability

O'Brien et al. (2021), Frontiers in Marine Science, DOI: 10.3389/fmars.2021.663009

O'Brien and colleagues analysed accumulation rates of benthic foraminifera in North Atlantic marine sediment cores, to investigate whether anomalous ocean circulation changes during the Industrial Era affected the deep-sea benthos. The study found contrasting patterns of changes in benthic foraminifera abundances, with the largest magnitude changes occurring at sites where concomitant surface ocean changes had occurred. The authors hypothesize that these shifts in the deep-sea benthos were caused by changes in surface ocean frontal activity altering food supply to the seafloor. These findings provide new knowledge regarding environmental controls on benthic foraminifera and deep-sea ecology more broadly.

Biomass mapping for an improved understanding of the contribution of cold-water coral carbonate mounds to C and N cycling

De Clippele et al. (2021), Frontiers in Marine Science,DOI: 10.3389/fmars.2021.721062

This study applied a novel and user-friendly approach combining biological, environmental, and ecosystem function data of the Logachev cold-water coral carbonate mound province to predictively map coral framework (bio)mass. This approach allowed for a more accurate representation and quantification of cold-water coral reef ecosystem functions such as Carbon and Nitrogen stock and turnover by accounting for the spatial heterogeneity. The calculated nutrient cycling capacity of the area indicates that climate-induced changes in primary production, local hydrodynamical food supply and the dissolution of particle-baffling coral framework could have severe implications for the survival and functioning of cold-water coral reefs.

Dense cold-water coral garden of *Paragorgia johnsoni* suggests the importance of the Mid-Atlantic Ridge for deep-sea biodiversity

Morato et al. (2021), Ecology and Evolution, DOI: 10.1002/ece3.8319

This paper describes the densest, near-natural, and novel octocoral garden composed of large red and white colonies of *Paragorgia johnsoni*, discovered on the slopes of a small ridge-like structure located on the Mid-Atlantic Ridge, in the Azores (545-595 m depth). The colonies were observed on both sides of the ridge, with concave fan-shaped structures oriented towards the deep, likely facing the prevailing upwelling currents to maximise food intake. These observations suggest a close relationship between octocoral structure and ambient currents and may inspire future deep-sea research to narrow knowledge gaps of biophysical connections along mid-ocean ridges.

Systematic conservation planning at an ocean basin scale: Identifying a viable network of deep-sea protected areas in the North Atlantic and the Mediterranean.

Combes et al. (2021), Frontiers in Marine Science, DOI: 10.3389/fmars.2021.611358

This study applied systematic conservation planning approaches to inform the identification of priority areas for management and conservation in the deep North Atlantic, with a special focus on the conservation of vulnerable marine ecosystems (VMEs) and key deep-water demersal fish species. Results show that continental margin slopes, the Mid-Atlantic Ridge, and large and productive deep shelves appeared as priority areas. Although several knowledge gaps related to the deep Atlantic Ocean still exist, this prioritisation can inform a coherent network of MPAs for VME conservation in the North Atlantic that could be updated as new data is gathered.

In the calendar

iAtlantic meetings

10-14 October 2022: iAtlantic General Asembly 2022, Brazil (hybrid event; venue TBC)

iAtlantic webinars

16 February 2022: "Ecosystem relevant variation and oceanographic trends from present day to 2070" by Kristin Burmeister (SAMS) and colleagues

16 March 2022: "Revealing the hidden diversity and function of deep pelagic metazoans" By Henk-Jan Hoving (GEOMAR)

More speakers wanted! Please contact vikki.gunn@seascapeconsultants.co.uk

UN Ocean Decade Laboratories

The UN Ocean Decade Laboratory series continues in 2022 wth a further four events on the calendar:

9-11 March 2022: A healthy and resilient ocean - A healthy and resilient ocean where marine ecosystems are mapped and protected

5-7 April 2022: A safe ocean - A safe ocean where people are protected from ocean hazards.

10-12 May 2022: An accessible ocean - An accessible ocean with good governance, open access to data, information and technologies

31 May - 2 June 2022: A productive ocean - A sustainably harvested and productive ocean ensuring the provision of food supply

Conferences and workshops

14-16 February 2022: International Ocean Data Conference 2022, Sopot, Poland/online

24 February - 4 March 2022: Ocean Sciences Meeting 2022, online only

27 June - 1 July 2022: UN Ocean Conference, Lisbon

5-7 April 2022: All Atlantic Ocean Research Forum: scientific pre-event, Brasilia (details TBC)

26-28 April 2022: 4th Symposium on decadal variability of the North Atlantic and its marine ecosystem

23-27 May 2022: All-Atlantic Ocean Research Forum, Washington DC (details TBC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818123 (iAtlantic). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.