Project news

Issue 7 | October 2023

iAtlantic
INTEGRATED ASSESSMENT OF ATLANTIC MARINE ECOSYSTEMS IN SPACE AND TIME

Cold-water coral reefs at 400m depth in the Lónsdjúp trough, SE of Iceland. Image courtesy GEOMAR ROV Team.

The final countdown

In this issue...

Message from Murray

In October 2023 we will be hosting the final iAtlantic General Assembly here in Edinburgh where we launched the project in June 2019. It's hard to wrap our heads around everything that's happened since then. Early 2020 saw the start of rolling lockdowns as the Covid-19 pandemic spread across the world. Labs shut and research ships returned to port, only later getting to sea under stringent pandemic controls and often operating from their home ports with little or no international participation.

It's remarkable to see how far we've come and how much of the work lost to Covid we've either rebuilt or reimagined. Huge kudos to everyone for everything you've done to make this possible. Pandemic delays meant we've already extended iAtlantic by six months and we're currently negotiating a further 4-month no-cost extension with the EC. If granted – and we believe this likely – iAtlantic will run until the end of March 2024, taking our voyage from four to nearly five years.

In this newsletter you'll find more wonderful articles on subjects as diverse as the long-term monitoring of the Lucky Strike hydrothermal vents (p4) and expeditions to cold-water coral habitats that thrive in low oxygen conditions off Angola (p6), through to lab studies on coral larvae (p10). What a great illustration of iAtlantic's breadth: we've pushed the boundaries of work at sea and driven new approaches to study deep-sea animals in the lab. All this while enhancing long-term oceanographic monitoring and adding 1 million km² of new seabed bathymetry data (p31). While roughly equivalent to twice the area of France, this still only increases the total area of Atlantic mapped at suitable resolution by 2%.

2023 has been another important year in the ocean policy world and as we enter the final months of our project we need to redouble our efforts to get our findings to policy makers. In June the UN Biodiversity Beyond National Jurisdiction 'High Seas' treaty text was adopted. The BBNJ treaty opens for signatures in September just ahead of the Edinburgh 'High Seas Treaty' symposium that iAtlantic and others are convening (6-7 October, www.high-seas-treaty.org). Several influential stakeholders from this symposium will remain for our final meeting. Check out Matt Gianni's article (p32) for other important updates on sustainable fisheries management, including work to expand understanding of species associated with Vulnerable Marine Ecosystems, and on the future regulation of deep-sea mining following the International Seabed Authority meeting in July when the two-year rule triggered by Nauru to establish mining regulations expired.

Our work is directly relevant to all these policy processes and our timing couldn't be better. Let's use our final General Assembly to share our results and discuss the important issues where our different workstreams come together with broader insights that will generate impactful research papers to add to iAtlantic's already burgeoning collection (see the back page of this edition for details). After the General Assembly we have two days free of Powerpoint to sit and write together. We've booked the beautiful St Leonard's Hall (pictured below) beneath Arthur's Seat – the extinct volcano many of us climbed during the iAtlantic kickoff meeting – for our retreat. So, if you get writer's block go climb Arthur's Seat and I guarantee that when you're back you'll be inspired to pick up a pen or bash the keyboard once again.

J Murray Roberts
iAtlantic Coordinator
20 September 2023

iAtlantic: The Results

Open meeting 9-10 October 2023
Internal project meeting 11 October 2023
iAtlantic writing retreat 12-13 October 2023
Edinburgh, UK & online

Four and a half years after the iAtlantic community gathered for the first time in Edinburgh for the project kickoff meeting, we return to Edinburgh to mark the closing stages of the project. Whilst it seems like only yesterday that we met in Florianopolis, Brazil for our previous annual meeting, a full year has passed and – rather incredibly – it's now time to wrap up our work.

To help celebrate the project's achievements and to share results with the broadest audience possible, this year we are opening up our meeting to anyone who wishes to join us, either in person or online, on 9-10 October. We have made a special effort to invite stakeholders from a range of sectors, and with that in mind the meeting programme aims to highlight the bigger-picture relevance and application of iAtlantic's research, as well as showcasing the many science results.

The open meeting is followed by an internal iAtlantic meeting to conclude final business (11 Oct), and then a 2-day writing retreat (12-13 Oct) during which project partners and close collaborators will focus on discussing, planning and drafting papers for publication in peer-reviewed journals. iAtlantic already has more than 100 papers published or under review in the scientific literature, but there are many more to come. The writing retreat presents a rare opportunity for our scientists to focus on these manuscripts (and plan for others that will emerge after the end of the project), away from the everyday distractions of working life.

For some members of the iAtlantic crowd, the project's final meeting comes hot on the heels of another important gathering in Edinburgh. A 2-day symposium on '*The High Seas Treaty: From negotiation to implementation*' will take place at Dynamic Earth in Edinburgh on 6-7 October 2023. Co-organised and co-sponsored by iAtlantic, this event aims to critically evaluate the potential challenges and opportunities for the implementation of the BBNJ Agreement For full details see www.high-seas-treaty.org

THE HIGH SEAS TREATY

FROM NEGOTIATION TO IMPLEMENTATION

A 2-day symposium in Edinburgh, UK and online
6-7 October 2023

www.high-seas-treaty.org

Momarsat 2023 : A challenging but successful cruise!

by Jozée Sarrazin & Marjolaine Matabos, Ifremer

The Momarsat 2023 cruise took place on 9-22 July 2023 aboard the French research vessel *L'Atalante* with the ROV Victor6000, visiting the Lucky Strike vent field on the northern Mid-Atlantic Ridge to carry out the yearly maintenance of the EMSO-Azores observatory. The EMSO-Azores observatory is part of Ifremer's One Ocean Network for Deep Observation action, endorsed by the UN Ocean Decade programme.

Once again, we ensured the turnover of the full platform and sensor array and started another year of data acquisition! Led by Marjolaine Matabos, the team of 18 scientists from Ifremer, CNRS (IPGP, GET, MIO), University of Western Brittany and University of the Azores worked together to achieve the substantial sampling plan that is paramount to the long-term monitoring of the vent field. Despite the delayed departure of the ship, numerous breakdowns and technical issues with the submersible and the observatory infrastructure, all objectives were achieved. This success would not have been possible without the adaptability, support and flexibility of all teams and especially the ship's crew, who had to adapt continuously to a changing programme.

Image acquisition will allow iAtlantic's mapping work to continue: a new 3D reconstruction of the Eiffel Tower edifice will complete the time-series analysis, and additional OTUS still image acquisition will fill the remaining gaps in mapping the entire vent field. In addition, this year – as part of the Deep-Rest project – we conducted new experiments: the SPIDER benthic chamber was used to examine deposition of sulphide particles on vent fauna and its impact on their biodiversity and physiology. On-board and *in situ* incubations of the *Bathymodiolus azoricus* mussel to a fluorochrome aimed to assess their growth rate. Finally, a new diffuse-flow vent site spotted to the south of the Cimendef sulphide structure appears to hold promise for future integrated multidisciplinary studies.

ROV Victor6000 encounters a Grimpotheutis *octopus at 1697 m depth.*
Image ©Victor6000/Momarsat 2023

Marine life accompanied us throughout the cruise with dolphins, sharks, tuna and whales spotted from the ship. On the seafloor at 1697m water depth, we enjoyed a rare encounter with a *Grimpotheutis* octopus (main picture).

On our return to Horta, cruise participants Jozée Sarrazin and Marjolaine Matabos, along with IMAR's Ana Colaço, were invited by the Azorean government to give a presentation alongside the exhibition of Damien Roudeau's drawings from the Momarsat 2022 cruise at the Fabrica Baleia.

Above, left: Drawings from the Momarsat 2022 cruise by the artist Damien Roudeau were shown at the Fabrica Baleia in Horta during the whole month of July. Image © J. Sarrazin/Momarsat 2023. Right: Marjolaine Matabos, Jozée Sarrazin and Ana Colaço giving a conference for the general public at the Fabrica Baleia on 30 July 2023.

Below: The Momarsat 2023 team on the RV L'Atalante *at the Lucky Strike vent field on the Mid-Atlantic Ridge. Image © Eloi de L'Estourbeillon/Momarsat 2023*

Living with little oxygen: cold-water coral reefs off Angola

by Dierk Hebbeln & Cova Orejas, MARUM/IEO

During the RV *Meteor* expedition M122 in January 2016, hitherto unknown cold-water coral (CWC) reefs were discovered thriving in the SE Atlantic Ocean off the coast of Angola (~9.7°N, 12.7°E)[1]. Whilst new CWC reefs are regularly found along the margins of the Atlantic and other oceans and seas, the Angolan reefs are special as they occur in an environment marked by hypoxic conditions in the well-developed regional oxygen minimum zone (OMZ). Video observations with a remotely operated vehicle (ROV) revealed the presence of vivid CWC reefs dominated by *Lophelia pertusa* (aka *Desmophyllum pertusum*). They colonise the slopes and summits of coral mounds up to 100 m high that are clustered over at least 50 km, running parallel to the continental slope. While dispersed live CWC colonies were found in a water depth range of 250-500 m, flourishing and well-developed reefs were restricted to 330-470 m water depth, corresponding to the centre of the OMZ with mean dissolved oxygen concentrations (DO_{conc}) of 0.9 mL L^{-1} (lowest: 0.4 mL L^{-1}).[2] The observation of a wide range of colony sizes forming the reefs – ranging from recently settled colonies with only few polyps to colonies more than 50 cm high comprising up to 20 generations of living polyps – is clear evidence of the continuous proliferation of CWC reefs off Angola over many years (Fig. 1).

In addition to the hypoxic conditions, the observed water temperatures off Angola (6.4-12.6°C) are close to the assumed upper tolerance limit for *L. pertusa*, which corresponds to temperatures found in the Mediterranean at 200 m depth and beyond[3]. Interestingly, the occasional advection of slightly better ventilated waters by internal tides corresponds to higher temperatures and vice versa[4], indicating that these two factors balance each other out to some extent. The tide-induced temperature and oxygen fluctuations imply a vertical tidal movement of around 130 m.

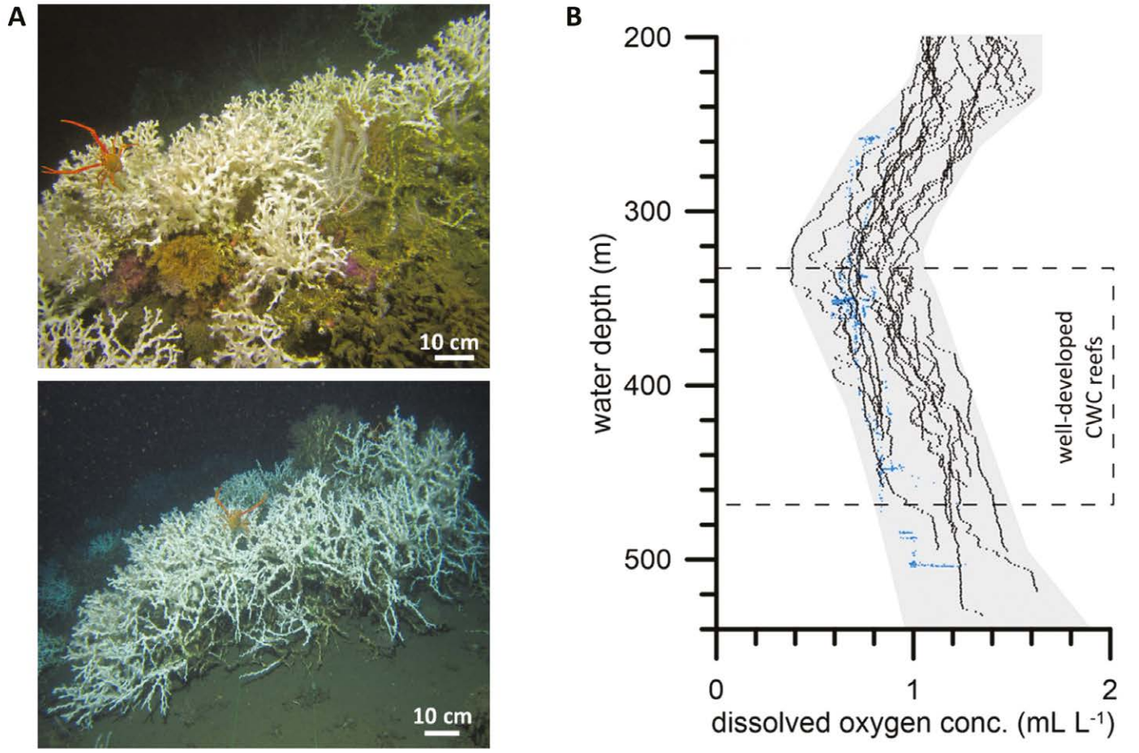

Figure 1: (A) Thriving cold-water corals observed in the center of the oxygen minimum zone (OMZ) off Angola at 350 m water depth; (B) Dissolved oxygen concentrations around the Angolan mounds obtained by CTD measurements (black dots) and ROV data (blue dots) with values mainly < 1 mL L^{-1} in the zone of well-developed cold-water coral (CWC) reefs.

Notwithstanding the unexpected discovery of *L. pertusa* and *Madrepora oculata* living off Angola under hypoxic conditions with DO_{conc} of mostly <1.0 mL L^{-1}, it is even more astonishing that the most prolific and well-developed CWC reefs occur directly in the centre of the Angolan OMZ[2] – despite the extreme setting, the largest known (so far) *M. oculata* colonies have been observed here. Of exceptional note is a large framework of around 1 m in height and 2.5 m in length[5], which exceeds the size of large colonies previously reported in the Mediterranean Sea (Fig. 2). A detailed size assessment reveals that the Angolan *M. oculata* colonies are the largest documented to date. Hypoxic conditions and high temperatures are energetically challenging for the metabolism of most marine species, but can be compensated for by high food availability. The Angolan margin is part of the highly productive Eastern Boundary Current Upwelling System, where a significant portion of the high net primary productivity is exported to deeper waters and remineralised, creating the extensive OMZ. At the same time, these low DO_{conc} levels cause a slowdown in further remineralisation, resulting in enhanced water column fluorescence – which in turn points to an increased availability of relatively fresh organic matter within the centre of the OMZ where the most prolific CWC reefs occur.

Figure 2: Extraordinary large Madrepora oculata *framework of 1.2 m height observed on the Scary mound off Angola. Blue arrow indicates the* Lophelia pertusa *colonies in the vicinity of the large* M. oculata *framework. (ROV images: MARUM; taken from Orejas et al. 2021[5])*

A comparison of DO_{conc} with ambient temperature and site-specific net primary productivity, used as a proxy for the food supply, indeed reveals that the occurrence of CWC under low oxygen conditions (e.g. off Angola and Mauritania) is bound to a high food supply. This highlights that the presumed negative effects of hypoxic conditions and high temperatures on the growth of *L. pertusa* can seemingly be compensated by significantly enhanced food supply[2] or by using alternative metabolic pathways[6].

To gain more insight in how these CWCs can cope with low oxygen conditions, a short-term (10-day) laboratory experiment was conducted on board RV *Meteor*. The respiration rates of Angolan *L. pertusa* specimens were analysed under in situ low DO_{conc} as well as under saturated DO_{conc}[6]. Results show that in both experiments *L. pertusa* displayed the same respiration rates, which were in the same order of magnitude as those of the species living under normoxic conditions in other areas. This novel result highlights that low oxygen conditions are not a limiting factor for the distribution of *L. pertusa*, nor for *M. oculata* or other associated benthic fauna, and suggests acclimation or local-regional adaptation to hypoxic conditions.

Known as biodiversity hotspots in the deep sea, CWC reefs can provide space, shelter and food and thus attract many other organisms. The thriving reefs of Angola display much less biodiversity compared to that known from other CWC reefs, e.g., in the North Atlantic[1,7], probably due to the hypoxic conditions of the area. Nevertheless, compared to the surrounding soft bottom environment, biodiversity is high in these coral mound settings, including large aggregations

of hexactinellid sponges (*Aphrocallistes* sp., *Sympagella* sp.). In addition, species new to science such as the hydrozoan *Rosalinda nowaldi* sp. nov.[8], the gastropod *Talassia rugosa* sp. nov.[9], and the amphipods *Aeginella corallina* sp. nov.[10] and *Dautzenbergia concavipalma* sp. nov.[11] have been discovered here.As well as taxonomic diversity, the functional diversity of the Angola CWC ecosystems has been investigated using stable carbon and nitrogen isotopes. Despite the availability of fresh phytodetritus, the CWCs predominantly feed on a higher trophic level, probably zooplankton[12] (Fig. 3). Other associated organisms, echinoderms and the polychaete *Eunice norvegica* occupy the same trophic guild, pointing to predatory feeding behavior on CWCs and sponges. In the case of the latter, which has the highest $\delta^{15}N$ signature, this highlights the role of the associated microbiome in helping to cope with the hypoxic conditions, but this aspect remains under investigation.

Studying the long-term development of the Angolan CWC has documented their almost continuous presence throughout the last c. 35 kyr, covering cold glacial as well as warm interglacial periods. However, the record shows some variations in mound development, with recurring short intervals (< 3,000 years) of increased mound formation (i.e., reef growth) interspersed with periods where reef formation significantly slowed down or even temporarily stagnated[7]. The almost continuous presence of CWC off Angola under dramatically changing climate conditions from the last glacial period to the present-day interglacial conditions of the Holocene is in contrast to most other CWC sites known from the Atlantic, which almost exclusively reveal occurrence patterns of the CWC paced by large-scale, i.e., glacial/interglacial, climate variability. So far, a pattern similar to that observed off Angola has only been found off Brazil, highlighting the specific role of the South Atlantic for the basin-wide development of CWC under changing global climates.

The discovery of thriving CWC reefs under hypoxic conditions in the OMZ off Angola sheds new light on the adaptive capacities of the two main reef-forming CWC species *L. pertusa* and *M. oculata*. In particular, the widespread occurrence of *L. pertusa* within regional oxygen minima challenges the empirical approach used to assess the lower limit of *L. pertusa*'s oxygen tolerance. With *L. pertusa* preferring ambient oxygen minima, the DO_{conc} obtained at such sites cannot provide any information about *L. pertusa*'s capability to cope with lower concentrations. However, some information about this capability is provided by lab experiments with specimens collected in the NE Atlantic (~6 mL L^{-1}) and the NW Atlantic (~2.8 mL L^{-1}). In both experiments, *L. pertusa* could not withstand DO_{conc} conditions of less than 40-50 % of the ambient values. Consequently, the range of low DO_{conc} tolerated by *L. pertusa* might depend on the conditions the corals are acclimatised to, pointing to a possible genotypic adaptive capacity of *L. pertusa*. Thus, although on a global scale its tolerable limits appear to cover DO_{conc} of <1 to >6 mL L^{-1}, much smaller ranges probably define these limits on regional scales.

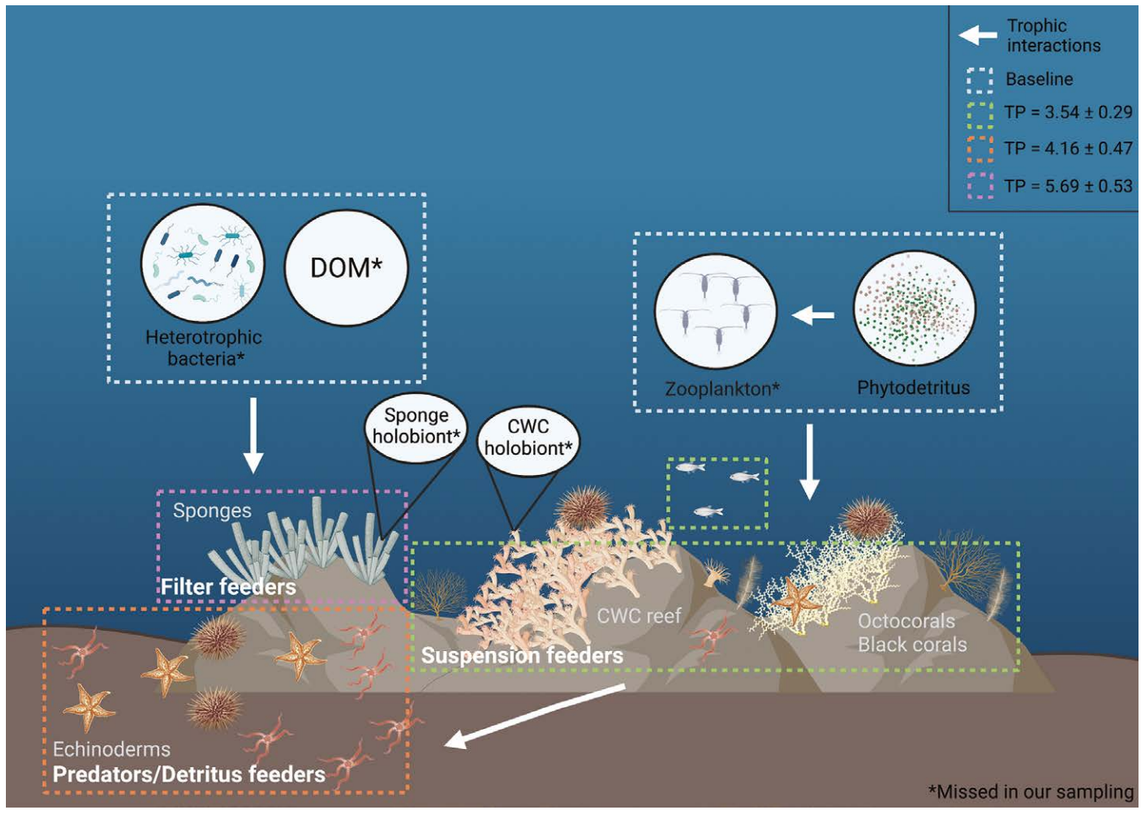

Figure 3: Ideal representation of the trophic web for the Angolan cold-water coral (CWC) reefs investigated by Vinha et al. (2023)[12]. The trophic groups included in the schematic are based on the results of the carbon and nitrogen stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses. In the upper corner right the mean trophic position (TP) (± Standard Deviation) is indicated for each trophic group using different colour patterns, as well as the proposed food sources. The schematic was created with BioRender.com Image courtesy Vinha et al. 2023[12]

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Workshop: FAIR data publications with PANGAEA

PANGAEA – Data Publisher for Earth & Environmental Science – invites you to the next edition of their PANGAEA Community Workshop series. In focus this time: "FAIR data publications with PANGAEA".

The series comprises user-oriented theoretical and practical trainings on the services offered by PANGAEA and various aspects of modern research data management. They place special emphasis on sustainable publication and long-term archival of scientific data, including various methods to access and re-use those valuable resources.

This two-day, four-hour workshop focuses on preparing and submitting data to PANGAEA in accordance to requirements for FAIR and sustainable data publishing. In a combination of theoretical units and hands-on exercises, this workshop is dedicated to best practices in data management, recommended steps to prepare your data to support a smooth publication process, and a behind-the-scenes look at related PANGAEA workflows and services.

When: 16-17 November 2023, 10:30 - 12:30 CET

Where: Online (via Zoom - registration required)

How: Registration will open on 4 October and close on 1 November.

More: https://pad.gwdg.de/s/x_5olfQ8h

PANGAEA. Community Workshops

Lophelia's early adventures in the deep: A picnic of microplastics and an odyssey through acidified and trawled marine waters

by Anaïs Sire de Vilar[1,2], Marina Carreiro e Silva[1,2], Maria Rakka[3], Susanna M. Strömberg[4], Christopher Kim Pham[1,2], João Miguel Pereira[1,2] & Ann I. Larsson[4]*

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Female gamete clouds during spawning of the cold-water coral Lophelia pertusa. *Image © A.Sire de Vilar*

A series of lab experiments have shed light on how cold-water coral larvae respond to threats such as ocean acidification, sedimentation and microplastic pollution

In the remote depths of the ocean lies a mysterious realm. Among its inhabitants are cold-water corals (CWCs): these organisms play a vital role as engineers of the seafloor, constructing reefs or gardens that provide habitats and breeding sites for a diverse range of other deep-sea species.

Despite their importance, these valuable CWC reefs are facing an escalating threat due to the combined effects of climate change and anthropogenic activities. Although the impacts of these threats on adult corals have received significant attention in recent years, a notable gap persists in our understanding of their early life stages. This gap is particularly concerning given that larval dispersal is the key to maintaining connectivity between populations and ensuring the persistence of species in a rapidly evolving ocean.

To address our lack of understanding of how the early life stages of CWC respond to various threats, a series of pilot research studies were carried out at the Tjärnö Marine Laboratory in Sweden as a collaborative research effort between IMAR/OKEANOS and UGOT.

The CWC *Lophelia pertusa* (also known as *Desmophyllum pertusum)* was chosen as a model species due to its widespread distribution and its essential role in deep-sea ecosystems by providing habitats, sustenance, and breeding grounds for numerous other deep-sea species. Additionally, the coral research group at the Tjärnö Marine Laboratory has successfully maintained this species for several years under controlled aquarium conditions. Here, successful *ex situ* spawning, leading to the acquisition of *L. pertusa's* larvae, has paved the way for a series of small-scale *ex situ* experiments, shedding light on stressors and their impacts.

Within the framework of the iAtlantic project, we investigated the combined impacts of ocean acidification (OA) and sediment plumes from bottom trawling, as well as the potential consequences of microplastic (MP) pollution on the early life stages of *L. pertusa*.

The first study investigated the cumulative effect of acidification (OA) and the natural benthic sediment (NS) generated during bottom trawling on the embryo and larvae biological responses. Our first objective was to investigate these threats on mortality, abnormality of coral embryos, specifically during their development from the 2-cell stage to the blastula stage over a 48-hour period. Our second

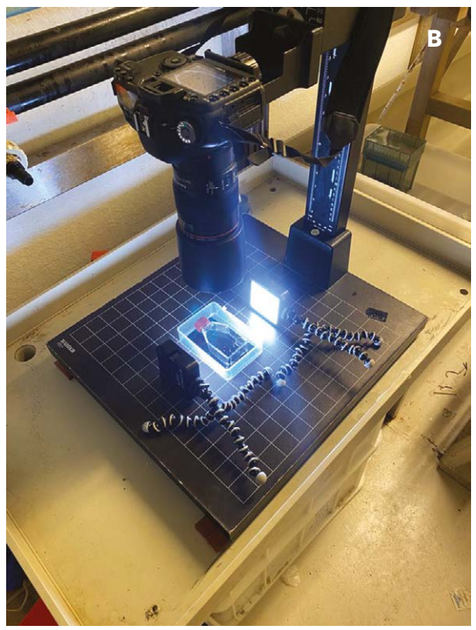


Figure 1: Experimental setup

A: Plankton wheel used to maintain the natural benthic sediments (NS) and microplastics (MP) in continuous suspension inside the experimental flasks.

B: Measuring larval swimming speed. The flasks containing the larvae are illuminated using lateral light and a black background, with a camera mounted on a tripod.

Images © A.Sire de Vilar

iAtlantic

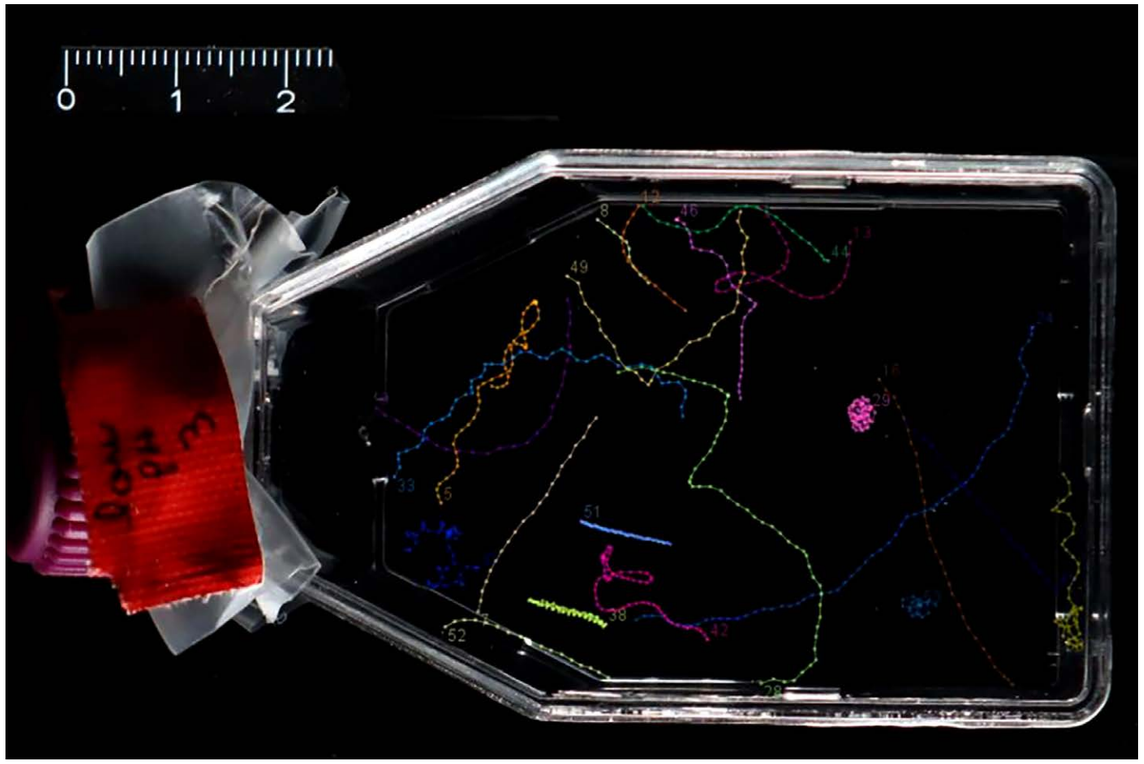


Figure 2: Larval swimming track within the flask with the investigated stress treatment. Each line, color-coded, represents the trajectory of an individual larva. Tracking was carried out using ImageJ software and the MtrackJ plugin. Image © A.Sire de Vilar

objective was to assess the impact of these stressors on survival, abnormalities and swimming speed of 12 day-old larvae, under both short-term exposure (24-48 hours) and long-term exposure (1 week), in order to determine whether significant differences in treatment effects emerged over time.

This study was carried out through a series of four experimental treatments, including a scenario reflecting the IPCC RCP8.5 prediction (elevated pH level projected for the end of the century: pCO_2 1000 µatm; low pHT: 7.63), and a control mimicking present-day pCO_2/pH condition (pCO_2 400 µatm; ambient pHT: 8.01). Additionally, these treatments were paired with or without the introduction of natural benthic sediments (NS) at a concentration of 5 mg/mL to simulate the effects of bottom trawling. These sediments, sized at ≤ 63 µm, were collected at around 130 m depth near a regularly trawled area of soft bottom seafloor, close to the reef site of Säcken in the Northern Koster-fjord, Sweden.

The second study evaluated the impact of microplastic (MP) pollution, using 6 µm yellow green fluorescent polystyrene microbeads (catalog no: 17156, Polysciences) on 4-5 week-old larvae. These beads emit fluorescence when exposed to UV light, facilitating their observation under a microscope. The first objective was to differentiate the effects of pristine MP (i.e., not altered after fabrication) and conditioned MP (i.e. with a biofilm, altered/modified by the environment to mimic environmental conditions).

The larvae were exposed to three treatments: no MP, 1000 pristine MP/mL and 1000 biofouled MP/mL. Larval survival, abnormalities, ingestion behaviour and swimming speed were examined after 24h exposure. The second objective was to investigate the larvae's feeding behaviour on MP during a 15-min exposure, comparing the effects of pristine MP with and without the presence of food (fine fraction of copepods) to see if the presence of food could induce the ingestion of MP (based on the assumption that larvae possess the ability to distinguish between edible and non-edible particles).

All experiments were conducted using 75 mL culture flasks, with each flask containing the specific stressors treatment along with a predefined number of larvae or embryos. For the entire duration of the experiments, these flasks were attached to a plankton wheel rotating at a speed of 45 seconds per turn to guarantee the uniform suspension of the particles throughout the experiment (Fig. 1). The experiments took place within a temperature-controlled cold room set at 8°C.

The results of the first study showed that embryo survival rates were consistently above 70% across all treatments, with no significant differences, along with no notable differences in terms of abnormalities or developmental disruptions between treatments. This robustness during these initial stages, up to the blastula stage, may be attributed to a combination of adaptive mechanisms and developmental plasticity. Similarly, the size of the embryos remained constant. However there were instances of smaller embryos with varying proportions among replicates, highlighting greater variability within replicates than across treatments and underscoring the challenge of deducing any effect of the treatment. This could potentially arise from factors such as parasites or other uncontrolled variables. The observation of small embryos stems from a phenomenon known as blastomere division where embryos split into distinct parts, potentially leading to twins of unequal sizes that can develop independently. If one part is too small, it may face developmental issues due to limited yolk reserves, while the larger part could also struggle to sustain optimal growth after splitting, impacting their long-term viability.

Regarding the larvae, their survival rates remained stable (70-80%) over time without significant differences. However, in the short-term experiment (48h) a notable occurrence of larval abnormalities (protrusions and lumps) was observed. The nature of these anomalies exhibited substantial variability from one replicate to another, rendering any meaningful comparison between treatments impractical. Also, when larvae within a flask displayed bad health, this was consistent across the majority of larvae within that particular flask. This phenomenon raises the possibility of underlying factors, such as parasitism, influencing the health of all the larvae. Another finding was the relationship between larval health and swimming speed. Larvae in good condition demonstrated significantly higher swimming speeds compared to the larvae in bad condition. Additionally, the larvae in poor health exhibited a notable reduction in the surrounding cilia, a phenomenon potentially linked to cilia consumption by parasites. Furthermore, these larvae exhibited clusters of cells adhering to their bodies, indicating the possibility of cell shedding, perhaps in response to stress or parasitic influence. The accumulation of these shed cells into clusters, coupled with the reduced presence of cilia, appears to impede the natural movement of the larvae, which likely contributes to the observed decrease in their swimming speed. Significant variations in swimming speed were observed between different batches of larvae, within the same batch, and in individual larva, highlighting the diverse responses that different larvae can exhibit.

In order to understand the effects of the treatments on larval swimming speed, comparisons were conducted exclusively among the flasks with larvae in good condition (Fig. 2). Results showed that larvae in good condition exposed to high pCO_2 and NS (individually or in combination) exhibited a notable decrease in swimming speed but only after a week of exposure. Reduction in swimming speed could stem from the direct influence of pH on acid-base balance, potentially leading to decreased larval metabolism. The individual effects of NS on water density and viscosity may also contribute to increased hydrodynamic resistance, and the clogging of larvae with sediment could further exacerbate the decline in swimming speed. This decline in swimming speed could carry ecological implications, potentially affecting larval dispersion, connectivity and vulnerability to predators.

The results of the second study revealed high survival rates (>70%) across all microplastic treatments after 24 hours with no significant differences. There were no notable abnormalities or non-entanglement with MPs. However, these findings could be attributed to the perfect spherical shape of the microbeads used in the study, preventing them from attaching to cilia and causing harm to the larvae. In natural environments, irregular and sharp-edged microplastics can pose risks by causing damage and entangling organisms, potentially leading to deformities and increased mortality. This highlights the importance of microplastic physical attributes, such as shape and aggregation, when assessing their effects on larval coral ecology and coral reef ecosystems.

Regarding swimming speed, larvae exposed to pristine MPs displayed decreased swimming velocity compared to the control group, whilst larvae exposed to biofouled MPs showed no significant differences from the control. This divergence may arise from biofouled MP aggregation, limiting encounters during larval swimming. The lack of statistical significance between the control and the biofouled MP treatment could also potentially be influenced by the limited number of replicates, particularly considering the large variability seen within and among individual larvae.

Concerning MP ingestion, we speculated that biofouled MP might have been ingested due to its biofilm coating containing similar prey to plankton consumed by larvae and potentially secreting attractive chemicals. However, no ingestion was observed after 24 hours exposure with MP and without food. Caution is needed in interpreting the absence of ingestion as biofouled MPs tended to aggregate, affecting their concentration and consequently their availability to the larvae.

However, after the introduction of food (fine fractions of copepods), the larvae displayed feeding behaviour involving the ingestion of MPs along with the food (Fig. 3). Shortly after ingestion (less than 15 minutes), the larvae expelled the ingested MPs, which were aggregated within a mucus matrix. These results suggest that CWC larvae are capable of distinguishing nutritious food from non-nutritive particles, which could be linked to their suspension feeding mode using cilia or mucus. This behavior could also be attributed to strong chemotaxis evolved in response to nutrient-poor deep-sea habitats. Moreover, the rapid regurgitation of ingested MPs may serve as a defense mechanism against non-nutritive or undesirable particles. Additionally, the larvae's simple digestive system could prevent the retention of microplastics, that potentially explain their rapid expulsion.

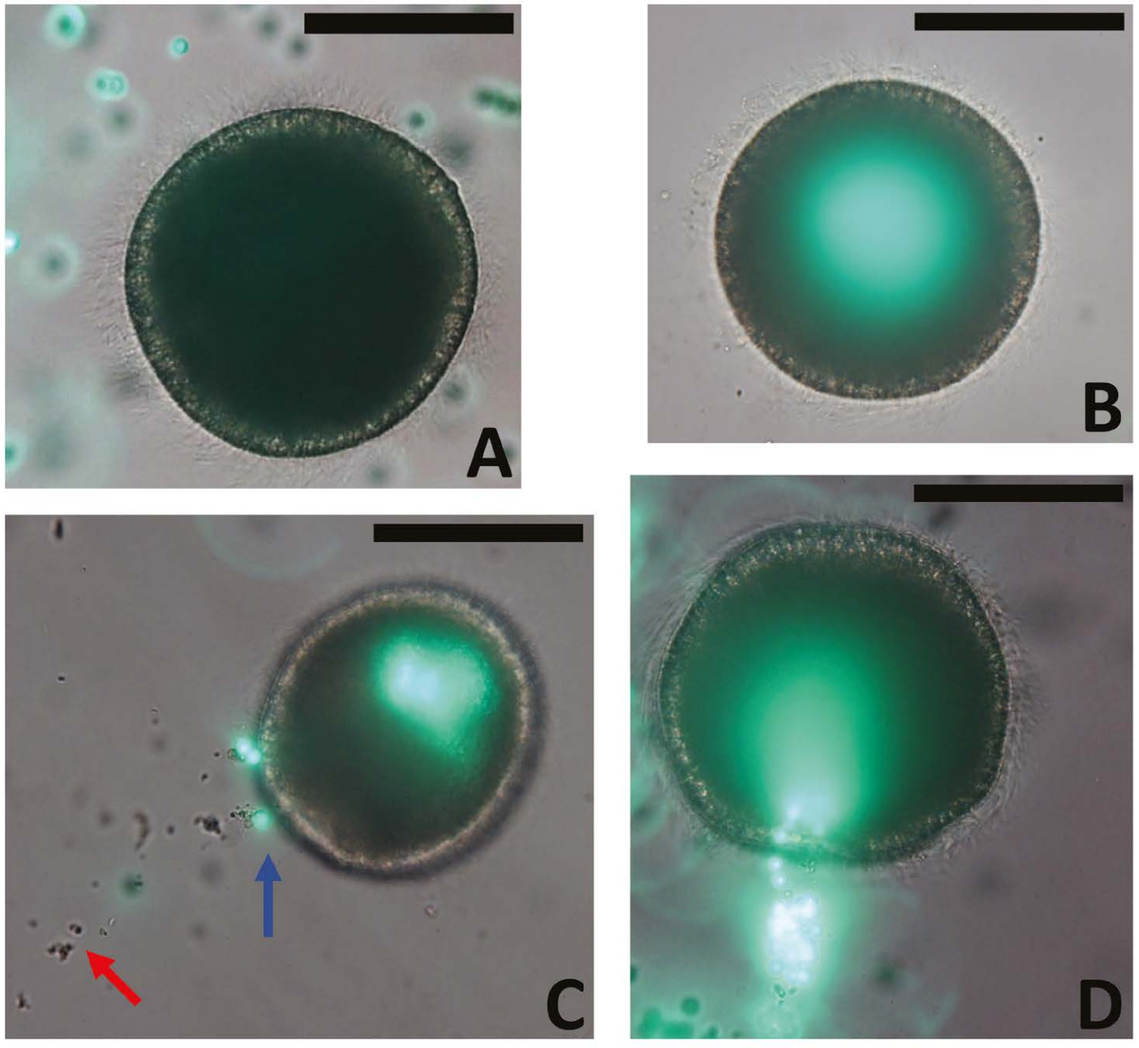


Figure 3: Larval feeding behaviour: (A): larva surrounded by MP and no ingestion observed during tratement with pristine MP; (B) larva full of MP during treatment with pristine MP + food; (C): larva producing a mucus string (red arrow) to grab and ingest particles, mouth wide open (blue arrow) sucking in the particles during treatment with pristine MP + food; (D): larva expelling the ingested MP. The MP are released within a sticky mucus during treatment with pristine MP + food. Scale bars 100 µm. Images © A.Sire de Vilar

Despite their ability to recognise non-edible particles and quickly expel microplastics, this process remains energy-consuming. With the increasing plastic pollution in oceans, prey containing microplastics could lead to higher indirect ingestion, demanding more regurgitation and energy expenditure.

This study is among the first to document the responses of early life stages of CWC to the stressors of ocean acidification and human activities. It highlights the resilience of early embryos and larvae of *L. pertusa* to various short-term stressors, while highlighting the challenges associated with intrinsic variability and embryo/larval rearing, which can be influenced by factors beyond our control. While the long-term effects remain uncertain, these findings help bridge gaps in our understanding of the early life stages of CWC and are essential for developing biodiversity conservation strategies and sustainable management for the preservation of these deep-sea coral ecosystems.

Highlights from the iAtlantic workshop 'Cold-water corals in aquaria: maintenance and experimentation'

by Marina Carreiro-Silva, Okeanos/U. Azores & Maria Rakka, Dalhousie University, Canada

The iAtlantic capacity building workshop '*Cold-water corals in aquaria: maintenance and experimentation*' took place at the John McIntyre Conference Centre at the University of Edinburgh, UK, on 3-4 June 2023. Held in collaboration with the Marine Animal Forest of the World COST Action, this event was organised to facilitate cooperation among researchers who would like to set up laboratory facilities to maintain cold-water corals (CWC) in order to advance our knowledge on their biology, eco-physiology and responses to anthropogenic and climate stressors. The workshop aimed to provide practical guidance on the maintenance of CWC in aquaria, offering an overview of the different aquaria systems, collection methods, feeding and daily care, as well as addressing a variety of techniques for ecophysiological research, and using different life stages (adult and larval stages).

The workshop brought together 38 in-person and 21 online attendants from Chile, USA, Canada, New Zealand and eight European countries, including students, young researchers, technicians and senior researchers. During the 2-day workshop, invited lecturers shared their experience on different aspects of cold-water coral research. In the first session, Alfredo Veiga from Aquarium Finnisterra and António Godinho from the Azores Deep Sea Research Group at Okeanos/U. Azores gave an overview of the best practices and basic system requirements for maintaining cold-water corals, while Bruce Shillito from Sorbonne University introduced us to innovative pressurised aquaria, which can replicate the high pressure conditions that are typically encountered in the deep sea, allowing us to study CWC under conditions closer to their natural environment. In the second session, Sebastian Hennige and Kristina Beck from the Changing Oceans Group at U. Edinburgh explained the challenges of conducting experiments with CWC under changing ocean conditions. In the same session, Sam Dupont (U. Gothenburg) talked about how to resolve potential interactions of multiple experimental factors to allow proper modelling of multiple stressors both in the lab and at the field. Andrea Gori (U. Barcelona) and Meri Bilan (U. Salento) then gave us hands-on experience on how to measure growth and metabolic responses in cold-water corals. In the last session of the day, Ann Larsson and Rhian Waller (U. Gothenburg) revealed the secrets of CWC reproduction and early life stages.

The second day of the workshop was dedicated to learning about feeding experiments with CWC using different types of chambers and stable isotope tracers, with experiences shared by Maria Rakka (Dalhousie University), Sandra Maier (Greenland Institute of Natural Resources) and Covadonga Orejas (IEO). In the last lecture of the session, Nadine Le Bris (Sorbonne University) told us about *in situ* approaches to study CWC ecophysiology. The workshop ended with a wonderful visit to St. Abbs Marine Station, where we had the opportunity to see the elaborate experimental setup that the Changing Oceans Group assembled to simultaneously simulate ocean acidification, warming and deoxygenation conditions that are forecast for future oceans, to test their impacts of the reef-building coral *Lophelia pertusa*. The beautiful scenery and good weather made it possible for the group to enjoy a walk through the village of St Abbs, try local sweets and socialise against the stunning backdrop of the Atlantic and the Scottish coastline.

The interesting conversations that arose were transferred to a Slack group created in order to build a strong community of researchers dedicated to CWC maintenance and experimentation. At the same time, the workshop organising team is putting together a series of online tutorials that will summarise some of the information provided during the workshop - these will be openly available to researchers that are interested in maintaining CWC in aquaria.

We take the opportunity to thank Vikki Gunn and Sebastian Hennige and for their support with the logistics, and all participants whose high level of participation and commitment made the workshop very productive! Thanks are also extended to the MAF World COST Action for providing travel support for 7 participants at the workshop.

Above: Kristine Beck explains the experimental setup used by UEDIN for the mutistressor experiment with reef-building coral Lophelia pertusa *at St Abbs Marine Station. Below: Sebastian Hennige gives an overview of the experimental facilities and research work conducted at St Abbs Marine Station.*

Taxonomy and Red Listing: corals under examination in Iceland workshop

By Saskia Brix[1], Severin Korfhage[1], Stefán Áki Ragnarsson[2], Steinunn H. Ólafsdóttir[2] & Laure de Montety[2]

[1]Senckenberg Research Institute, Germany; [2]Marine and Freshwater Research Institute, Iceland

The Northern Lights on display over the marine station in Sandgerði, Iceland. Image courtesy Antje Fischer

Well, how to start a story about cold-water corals in Iceland...?

Just imagine you are sitting under the blue sky in 40°C water between several Icelanders and you are asked "What are you doing here in Iceland?". This happened several times during the week when our workshop group visited the public hot springs and continued our scientific discussions while adapting to Iceland´s hot pot culture. Our answer was met with interest and curiosity.

The cold-water coral Red Listing and Taxonomy workshop took place on 10-16 September 2023 at the marine station in Sandgerði, Iceland, with the aim of addressing several aspects:

1. Training in cold-water coral taxonomy for the less experienced – including iAtlantic Fellows – covering methods for correct sample identification and preparation of slides for miscrcope examination.
2. Building capacity in carrying out global Red List assessments of cold-water corals, and at the same time...
3. ...confirming or reassessing the existing determination of corals from Icelandic waters (iAtlantic study area1).
4. Initiating a revision of the octocoral genera *Duva* Koren & Danielssen 1883, *Drifa* Danielssen 1887, *Pseudodrifa* Utinomi 1961, and *Gersemia* von Marenzeller 1878. We named this taxonomic challenge the "Cauliflower Riddle" owing to the appearance of these corals.

To achieve our goals, 23 participants from nine different nations worked together and learned from each other.

An important goal of the workshop was to build capacity for global Red List assessments of cold-water corals, to support the conservation and protection of these important species, many of which are under threat. The workshop therefore included training in the global Red List, delivered by Prof. Julia Sigwart (Senckenberg Research Institute) who chairs the IUCN Marine Invertebrate Red List Authority (MIRLA). The IUCN Red List is the world's best-known conservation tool, ensuring more targeted monitoring of Red-listed species. During the workshop, the experts completed draft assessments for 25 species for the IUCN global Red List of Threatened Species.

The taxonomy training component of the workshop provided less experienced participants the opportunity to learn from experts and to ask questions. Renowned octocoral taxonomists Catherine S. McFadden (Harvey Mudd College, USA) and Kaveh Samimi-Namim (Naturalis Biodiversity Center Leiden, The Netherlands) were invited to provide this expert training and support the participants in growing their taxonomy skills.

And what of the Cauliflower Riddle? The workshop confirmed previous taxonomic identifications and several new species were identified. Rather than undertaking a complete revision of the genera within the Cauliflower Riddle, the workshop intended to generate impetus within the cold-water coral science community to focus more attention on these genera in the future. For the protection and monitoring of these important octocorals, it is vital to be able to identify them to species level and, above all, to find out how many species occur in the region.

Above: Red Listing requires computer work and discussion between experts. During the workshop, teams of 2-3 people worked together to deal with one species. In total, 26 species underwent Red List assessment during the workshop. Image courtesy Saskia Brix.

Above left: Catherine McFadden and the workshop team scan the coral collection for specimens used for taxonomy training and confirmation. Above right: iAtlantic Fellow and workshop co-organiser Severin Korfhage introduces the audience to the Cauliflower Riddle. Images courtesy Saskia Brix/Karen Jeskulke.

Sponsored by the Senckenberg Ocean Species Alliance (SOSA), a project that supports taxonomy, conservation and fascination for marine invertebrate species, this workshop highlighted the global importance of Icelandic material for knowledge about cold-water coral species. By raising awareness about the marine biodiversity of Iceland, our workshop was included in the Biodiversity Festival organised by BIODICE (Biodiversity of Iceland).

Workshop organising team: Saskia Brix and Severin Korfhage in cooperation with Guðmundur Guðmundsson (Icelandic Institute of Natural History), Stefán Áki Ragnarsson, Steinunn H. Ólafsdóttir, Laure de Montety (Marine and Freshwater Research Institute). The workshop was supported by SOSA (Senckenberg) via Julia Sigwart as head of the Marine Invertebrate Red List Authority (MIRLA).

Follow SOSA on social media: @oceanspecies

Workshop participants outside the Sandgerði marine station. Image courtesy Sandgerði staff.

Modelling the distribution of cold-water corals around the seamounts of Cabo Verde… with a little help from iAtlantic partners in Canada

by Beatriz Vinha, University of Salento/Spanish Institute of Oceanography

Species distribution models are being developed for different study areas of iAtlantic, in a collective effort between partners to improve knowledge on the distribution of deep-sea species along the Atlantic Ocean. These predictive habitat maps provide information on the ecological requirements of species and on the potential occurrence of Vulnerable Marine Ecosystems (VME).

In the summer of 2021, the multidisciplinary iAtlantic expedition iMirabilis2 organised by the Spanish Institute of Oceanography (IEO-CSIC) set sail on board the RV *Sarmiento de Gamboa* to explore the unknown deep-sea ecosystem of the Cabo Verde islands (NW Africa, eastern equatorial Atlantic Ocean). Dives with EMEPC's ROV *Luso* revealed pristine and diverse cold-water coral communities on Cadamosto seamount, an underwater seismically active volcano in the south-west of the archipelago. Despite the new information on the deep-sea benthic habitats of Cabo Verde revealed during the expedition, the presence of cold-water corals is barely explored on other seamounts of the archipelago. Therefore, we aim to use species distribution models to predict the presence of four cold-water coral species, which are indicators for VMEs, in five seamounts of the archipelago. This information will be fundamental to guide new research expeditions and science-based management plans in the region.

Thanks to collaborations between iAtlantic partners and the capacity-building possibilities given to early career researchers within the project, I had the opportunity to visit partners on the other side of the Atlantic, at the Bedford Institute of Oceanography (BIO) – part of Canada's Department of Fisheries and Oceans (DFO), located in Halifax, Nova Scotia.

During my five-week research visit at BIO, I had the opportunity to learn first-hand from their expertise in modelling deep-sea species in NW Atlantic and to apply this knowledge to the models being developed for Cabo Verde within my PhD thesis. We had fruitful discussions on how to overcome data-limited situations, the effect of spatial autocorrelation in species distribution models and on the different approaches for pseudo-absence data generation, in order to achieve the best possible modelling results. The results from this productive visit contributed to an iAtlantic deliverable report and form a fundamental part of my PhD thesis, with a scientific publication currently in preparation.

I am very grateful to Javier Murillo and Ellen Kenchington, and everyone I have met at BIO, for all the knowledge shared and for so warmly welcoming me in Canada, despite the cold temperatures felt at the end of the Atlantic Canadian winter.

Left: Beatriz Vinha and Javier Murillo at Bedford Institute of Oceanography, Halifax, Canada. Image courtesy B. Vinha.

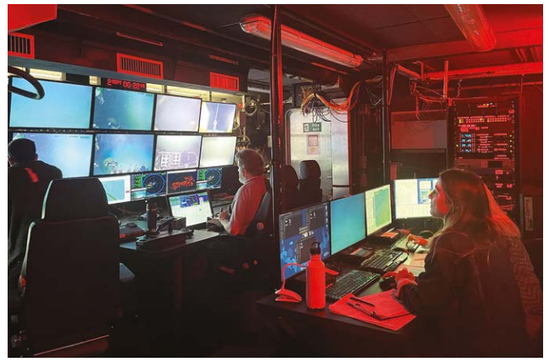
Expanding horizons

by Lisa Skein, South African National Biodiversity Institute, Nelson Mandela University

My first introduction to the iAtlantic project was in August 2022 when I joined the JC237 expedition aboard RRS *James Cook* to the Whittard Canyon and Porcupine Abyssal Plain as a scientific volunteer. As a biologist coming from a mainly rocky shore / kelp forest background, I was extremely excited to have been given the opportunity to expand my biological knowledge to the mysterious world of the deep-sea. I distinctly remember a pre-cruise afternoon tea with cruise PI Veerle Huvenne (NOC), where she explained how the cruise is all about an interdisciplinary approach to deep-sea research, working together as opposed to working in silos. This could not be more true, and so I also managed to develop a better understanding of other processes that come into play in shaping deep-sea ecosystems from the fields of oceanography, geology, sedimentology, and seafloor topography.

A few months later, iAtlantic announced that funding would be made available to support a series of small projects for South Atlantic-based researchers. This came following the unfortunate cancellation of a portion of the iMirabilis2 cruise in the South Atlantic as a result of Covid-19. Shortly after, I was approached by Veerle to see if I would be interested to take part in a short-term project on species distribution modelling (SDM) of deep-sea corals in the South-East Atlantic that would form part of iAtlantic's habitat mapping work. Not having much (any) experience with SDM, I was eager to do the work but would need to learn from scratch. And so, in January 2023, my 'SDM journey' started and over the next five months I would immerse myself in analyses with the guidance of subject expert Tabitha Pearman (NOC), Veerle, and other iAtlantic collaborators* that shared data** to enable the analyses.

The study focused on a cold-water coral, *Enallopsammia rostrata*, that is regarded as a species characteristic of a Vulnerable Marine Ecosystem and forms complex habitats for a myriad of other deep-sea animals. In addition to focusing on an ecologically important species, other aspects made this study especially valuable. It is the first study on Walvis Ridge (SE Atlantic) to generate predictive distribution maps of deep-sea animals. In addition, as is often emphasised of the South Atlantic deep sea, it takes place in a data-limited environment, and so any first maps produced serve as valuable starting points for future studies. We were also fortunate in being able to make use of hydrodynamic variables that were developed in high-resolution by Christian Mohn (Aarhus University) and others for a section of Walvis Ridge. This is not often done in predictive mapping of animals that live on the seafloor, as such high-resolution hydrodynamic information is not always readily available, although it almost always results in more accurate maps. I explored the effects of these variables on modelling outputs during a 2-week visit to the National Oceanography Centre in Southampton (UK) where Veerle, Tabitha and I processed and incorporated the hydrodynamic variables shared by Christian. During this time I also managed a short visit to Plymouth University to present some of our preliminary results to the Deep Sea Conservation Research Unit lead by Kerry Howell, where SDM/habitat mapping is also a key research focus. During this visit, I received the news that our work had been accepted for presentation at the International Symposium on Deep-Sea Corals in Edinburgh in late May 2023. The opportunity to share this important research on an international stage, with all its associated exposure, learning and networking opportunities, was definitely the highlight of the past five months' hard work.



Above: Lisa working in the ROV control room on board RRS James Cook during the JC237 expedition. Image courtesy L. Skein.

I have been fortunate to continue working in the field of SDM and bringing the work closer to home: South Africa is also a case study region in the Mission Atlantic project (an All-Atlantic sister project to iAtlantic). Annual Mobility Grants issued by Mission Atlantic to researchers and technicians working on any aspect related to Integrated Ecosystem Assessment have allowed me to extend my stay in the UK to spend more time with Kerry Howell's group at Plymouth University, where Kerry co-leads work focusing on improved deep-sea benthic maps. In working with and expanding on what I have learnt to date, we are now performing research that will help us better predict where Vulnerable Marine Ecosystems might occur in the deep-sea of the South African EEZ. This work is ongoing.

I would like to express my immense gratitude to Veerle Huvenne, Tabitha Pearman, Kerry Howell and Kerry Sink (SANBI), all of whom have invested significant effort in my work and development as an Early Career Researcher to date, especially over the last year (and still ongoing!). I also thank EU-H2020 projects iAtlantic and Mission Atlantic for providing the funding and networking platforms that made all of this a reality.

*Co-collaborators include: Covadonga Orejas (IEO), Roberto Sarralde (IEO), Christian Mohn (Aarhus University), Javier Murillo (Fisheries & Oceans Canada), Irene Perez (IEO), Patricia Garcia (TSUP Proy AGSA-MAPI Baleares).

**Data underpinning analyses were collected during three interdisciplinary research cruises to Walvis Ridge off Namibia, mobilised as collaborative efforts between the Namibian and Spanish governments and the South East Atlantic Fisheries Organisation (SEAFO).

Main image: Getting to know RRS James Cook *in port alongside NOC during mobilisation for the JC237 expedition, August 2022. Image courtesy L. Skein.*

Left, top: Lisa with fellow scientists Esther Sumner (NOC) and Susan Evans (NOC) enjoying the sunset over Whittard Canyon in the NE Atlantic. Image courtesy V. Huvenne.

Left, bottom: Presenting results from the species distribtion modelling work at the 8th International Symposium on Deep-Sea Corals in Edinburgh earlier this year. Image courtesy L.Skein.

Azor drift-cam workshop:
Building capacity in the use of low-cost imaging technology for deep-sea exploration

by Carlos Dominguez-Carrió & Telmo Morato
IMAR Instituto do Mar, University of the Azores

Responding to a capacity need identified by iAtlantic partners in Brazil and South Africa, the Azor drift-cam – a cost-effective video system for a rapid appraisal of deep-sea benthic habitats – provided the focus for an intensive 4-day training workshop in the Azores.

Hosted by IMAR-University of the Azores in the Escola do Mar facilities in Horta (Faial, Azores) on 5-8 June 2023, the main objective of the workshop was to demonstrate how to build, operate and troubleshoot the Azor drift-cam through a combination of hands-on training sessions in the classroom and a full survey at sea. Participants included resarchers from institutions in Brazil, South Africa and Europe.

The Azor drift-cam is an affordable and easy-to-use underwater video system designed by researchers at IMAR University of the Azores to make rapid appraisals of benthic habitats down to 1,000 m water depth. It should be regarded as a modular, light and easy-to-assemble video platform for the recording of high-quality underwater video images of the deep seabed, with all its components currently available for purchase in the retail market. The system aims to be cost-effective, cover large areas in short periods of time, perform well over rough seafloors, be operational from small vessels and have high chances of escaping lost long-lines, the most common fishing gear in the region. Further information on the Azor drift-cam can be found at https://deepsea.uac.pt/azor-drift-cam

Part 1: Problems and challenges in deep-sea exploration

The first session of the workshop was conceived as an introduction to the rationale behind the development of the Azor drift-cam. It started with discussions on the problems and challenges that we currently face in deep-sea exploration, and how we can proactively find cost-effective alternatives to expensive state-of-the-art marine imaging tools. Although the Azores has a long history of deep-sea exploration with large oceanographic vessels regularly visiting the region, the area explored was until recently very limited, restricting our capacity to inform management and conservation policy. This scarcity of data and the reduced availability of large oceanographic vessels drove us to develop an affordable tool that would allow us to explore the deep seabed of the Azores in a simple and cost-effective manner.

The session then reviewed the concept, rationale and guiding principles followed during the construction of the different prototypes that led to the final design of the Azor drift-cam, emphasising what can and can't be achieved when deploying this system. This was followed by an overview of the components that make up the Azor drift-cam, before finishing with a summary of how the system should be operated at sea from small- or medium-sized vessels.

Part 2: Setting up the Azor drift-cam and troubleshooting

A large part of the workshop was dedicated to showing participants each of the components that make up the Azor drift-cam, how to attach them onto the metal frame and how to connect the electronics for the live-view system to work. The group then split into two teams with the objective that, through active collaboration, each team would assemble a fully functional drift-cam replica, which were tested by connecting the live video feed into an external monitor. The idea behind this exercise was to provide all participants the knowledge needed to autonomously build a full system back in their own institutional facilities. This session also covered some general aspects of troubleshooting to give participants the capacity to find and solve the small problems that can potentially arise during deployment of the system at sea.

Part 3: Data management and processing

Using the Azor drift-cam at sea requires some knowledge of how to use specialist software. For this reason, we offered a practical session on running the software associated with the depth/temperature sensors that are attached to the system, as well as the GIS tools used to collect positioning data while the system is underwater. This included some time allocated to review the recommended settings that each of the action cameras should have. We also shared experience on how the IMAR team plans surveys, how the resulting data is stored and organised, and how the collected images can be processed in order to obtain quantitative data for benthic studies.

Above: Images from the first sessions of the workshop focused on knowing the components and the setting up the Azor drift-cam. During these hands-on sessions, participants had to work together to ensemble all parts on the metallic structure to create a fully functional replica of the Azor drift-cam.

Above: Participants took part in at-sea surveys to learn how the Azor drift-cam should be operated in real conditions.

Part 4: Surveys at sea

The training included survey time at sea to demonstrate the operation of the Azor drift-cam to collect quality video footage of the deep sea under real conditions. The group split into two teams, each going out for a half-day survey aboard a local vessel that is often used by the IMAR team to explore the local deep seabed. This practical session began at the marina, where participants were shown how to set up all the system connections and get the software up and running. Once the system was working, each team made two deployments in the Faial-Pico canal, reaching water depths of 200-300 m. With the Azor drift-cam underwater, participants were encouraged to observe the live-view feed on the monitors and provide orders to the winch operators to control the system's position with respect to the seabed. All four deployments were successful, and the images collected revealed habitats of mixed substrates dominated by a wide variety of sponges. Interestingly, we observed not only demersal fish but had the luck to spot several deep-sea sharks that passed slowly in front of the camera.

Summary

The capacity building workshop was a great success with all participants being actively involved in the preparation of the Azor drift-cam, its operation at sea, and the extraction of the recorded data. We achieved the main goal driving the development of this tool: to democratise deep-sea exploration by sharing a simple but versatile instrument that can be used aboard small vessels to explore shelf and deep-sea habitats around the world's ocean. As a bonus, we saw the first Azor drift-cam frame flying to the southern hemisphere to serve as a model for future replicas. We hope to see the Azor drift-cam exploring the deep sea off Brazil soon.

Workshop participants with the two fully functional replicas of the Azor drift-cam that they assembled. Image courtesy Pepe Brix.

And the view from the other side...

iAtlantic Fellows Renata Arantes and Marcos Barros share their thoughts and reflections on the Drift-cam workshop

Renata Arantes is a postdoctoral researcher at Universidade Federal de Santa Catarina (UFSC), Brazil, working mostly on deep-water coral taxonomy and identification, species distribution and deep-sea coral habitat characterisation in the iAtlantic target areas off Brazil.

Capacity building initiatives between institutions across the Atlantic Ocean transcend geographical boundaries, serving as crucial channels for the exchange of knowledge, expertise, and experiences. In the iAtlantic context, such initiatives play a fundamental role in bridging gaps between researchers, institutions and regions. They facilitate the sharing of diverse perspectives and innovative approaches, enhancing our collective understanding of complex ecosystems.

The workshop went beyond the realms of theories and practical applications, immersing participants in a transformative experience. The assembly of a diverse cohort from a range of countires around the Atlantic cultivated an environment ripe for the sharing of insights and experiences. These interactions extended beyond scheduled sessions, affording an informal yet invaluable platform for networking.

For me, the workshop was an inspiring interchange of experiences. Collaborating with international peers, each bringing their own distinct expertise, proved to be profoundly transformative. The innovative drift-cam technology showcased during the workshop opened new horizons in the exploration of deep-sea habitats, especially in unexplored areas of the South Atlantic. In exchange, I shared my knowledge in taxonomy and organism recognition through imagery, revealing potential synergies capable of redefining the trajectories of our research endeavours. This eye-opening experience showed us just how much we can achieve when researchers from different Atlantic regions join forces. Looking ahead, I'm excited about the chance for more collaborations and even more meaningful sharing of experiences.

Marcos Barros is a postdoctoral researcher based jointly at Ifremer, France and UNIVALI, Brazil. He works on describing and understanding distribution of cold-water corals in the Lampaul Canyon (NE Atlantic) and the Vitoria-Trinidad seamount chain (SW Atlantic) using advanced imaging techniques.

The Azor-drift cam workshop was rich in information of excellent quality. The workshop covered everything from assembly of the entire camera system, as well as providing additional information in case of any offshore issues, assembly techniques, component checking, and component repair, pre-field and planning, field practice, loading and data backup. In addition, the cost information for all Azor drift-cam system components was shared, as well as extra guidance on where to find each component with the best cost-benefit ratio and exchange of professional contacts.

As a researcher, I believe that the Azor drift-cam workshop was a milestone in my profession, in particular for the quantity and quality of the information given in it. It is well known that deep-sea research is expensive and out of reach for the majority of the academic community, being a privilege of just a few. Unfortunately, despite the excellence of Brazilian deep-sea research, we know that collection of data in these environments is still scarce. The northern region of Brazil, for example, even with technological advances and development of research in specific areas such as the mouth of the Amazon River, is still a disadvantaged region when it comes to researching deep-sea environments. In this context, the Azor drift-cam system would be a powerful tool to address this imbalance. As a researcher in northern Brazil, I intend to use this tool to improve the development of local marine research.

Are humpback whales on a collision course in Bermuda?

by Lea-Anne Henry and Catherine Hay, University of Edinburgh

In September 2022, the Government of Bermuda released its draft Blue Economy Strategy and Marine Spatial Plan (MSP) for public feedback on the Bermuda Ocean Prosperity Programme (BOPP). The strategy and complementary marine spatial plan seek to increase economic opportunities in tourism, fisheries, renewable energy, aquaculture and expanding sustainable marine tourism while managing and conserving Bermuda's marine resources to maintain or improve ocean health.

The wider Sargasso Sea, including the exclusive economic zone (EEZ) of Bermuda, is a key study region in the iAtlantic project. A unique opportunity exists for the project to input to Bermuda's MSP process and initiate dialogues with relevant stakeholders. iAtlantic scientists at University of Edinburgh, researchers at Bermuda's Institute of Ocean Sciences, and the research charity Whales Bermuda have combined expertise to analyse trends in deep- and open-ocean ecosystems from picoplankton to humpback whales that are relevant in this context. The team has revealed continuous increases in the numbers of humpback whales over the last decades (Grove et al., 2023) and identified key areas for humpback vocalisations (Narganes Homfeldt et al., 2022), alongside punctuated rapid shifts in plankton communities in relation to changing ocean states that signal impacts of climate change.

Since 2012, numbers of of North Atlantic humpback whales (*Megaptera novaeangliae*) have been increasing around Bermuda. This magnificent rebound in the numbers of these whales is a positive sign of the ocean's ability to recover, however the growth in marine sectors that are being called for by BOPP will pose new threats to cetaceans (whales and dolphins) around Bermuda, especially if their numbers increase and human activities continue to expand and intensify.

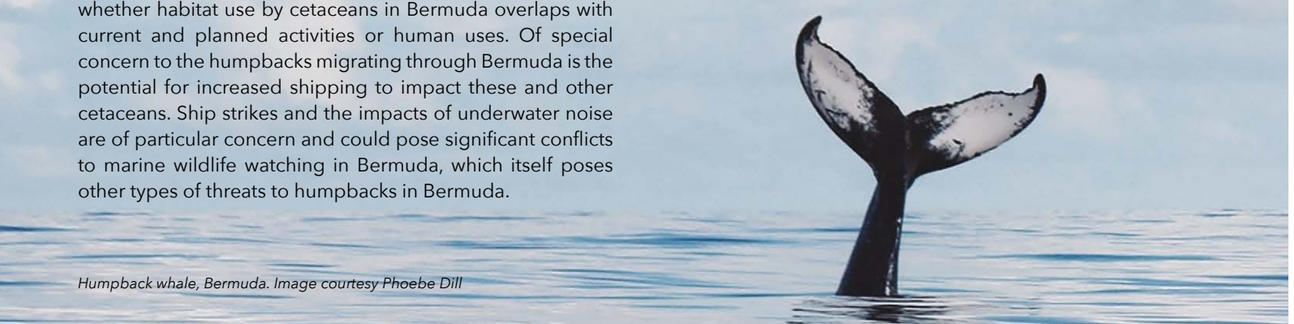
Can Bermuda sustainably implement its strategy and marine spatial plan, or are humpback whales around Bermuda on a collision course?

The current MSP contains insufficient information to evaluate whether habitat use by cetaceans in Bermuda overlaps with current and planned activities or human uses. Of special concern to the humpbacks migrating through Bermuda is the potential for increased shipping to impact these and other cetaceans. Ship strikes and the impacts of underwater noise are of particular concern and could pose significant conflicts to marine wildlife watching in Bermuda, which itself poses other types of threats to humpbacks in Bermuda.

From April to August 2023, the University of Edinburgh led a unique pilot project to assess whether existing conservation and management measures in Bermuda could sufficiently protect cetaceans both now and under future MSP scenarios. A highly targeted secondary element of this project was to then work through the International Maritime Organization (IMO) criteria for implementing a Particularly Sensitive Sea Area (PSSA) in Bermuda's EEZ to examine the extent to which there is robust scientific evidence to meet these criteria and thus whether any Associated Protective Measures (APM) such as restricted vessel speeds or re-routing shipping lanes might be effective.

The project combined social science, geosciences, and participatory Geographical Information Systems (GIS) research to create a new interactive geodatabase for users to visualise and analyse potential overlaps between cetaceans, human activities, and conservation management measures including marine protected areas. Following IMO Resolution A.982(24) that sets out guidelines for designating a PSSA, the project also began building the evidence base to demonstrate the extent to which ecological, socioeconomic, scientific and vulnerability criteria for a PSSA could be met. The GIS data compilation was launched in April 2023, collating existing information from the BOPP and online resources, including peer-reviewed publications and social media fora.

In June 2023, iAtlantic Research Project Assistant Catherine Hay from the University of Edinburgh travelled to Bermuda to undertake a series of in-person interviews with a wider variety of stakeholders including the Government of Bermuda and officials from the BOPP, but also sport fishermen, whale-watching operators, and researchers including iAtlantic partner Andrew Stevenson from Whales Bermuda. Andrew unlocked his private data collection of humpback whale fluke images, sightings data, and habitat use datasets to support this pilot project and provided much-needed local knowledge on cetacean habitat use as well.



Humpback whale, Bermuda. Image courtesy Phoebe Dill

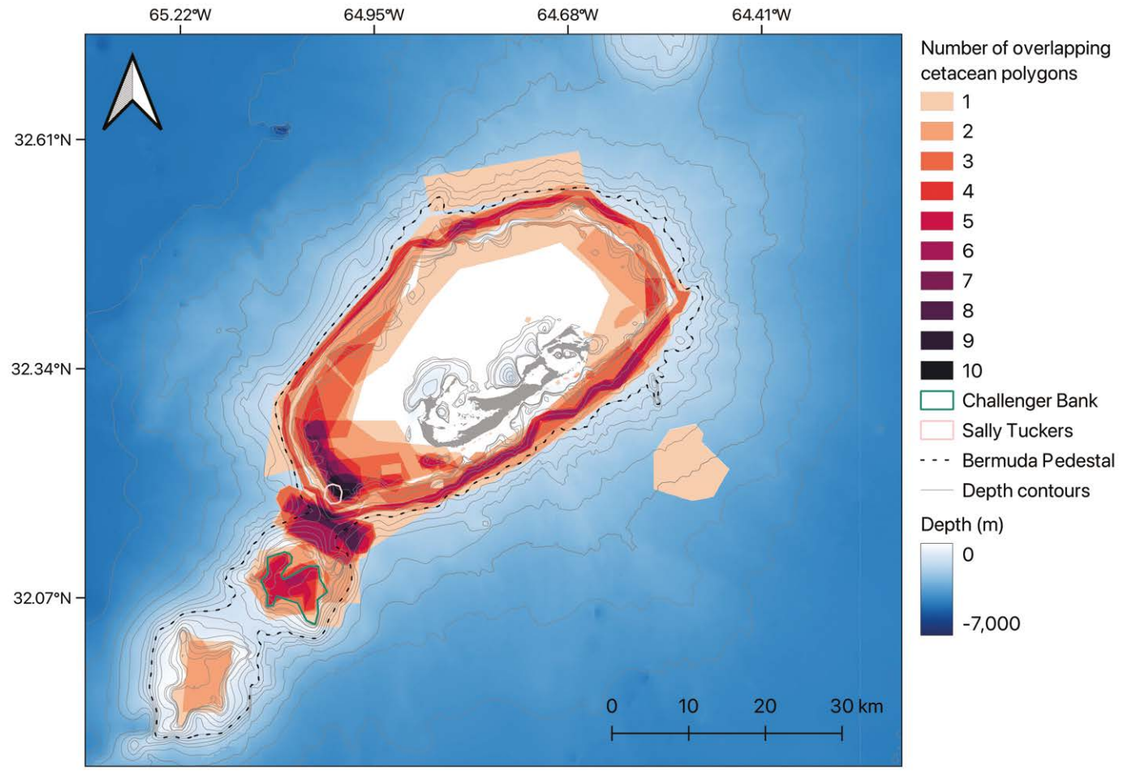


Figure 1: Areas around Bermuda showing the concentration of cetacean encounters. The area with the highest concentration of polygons is the region known as 'Sally Tuckers' to the southwest of the Bermuda Platform. The canyon between Sally Tuckers and the seamount, Challenger Bank, are both important for cetaceans, with depths reaching several thousand metres. Both Sally Tuckers and Challenger Bank were previously demonstrated by iAtlantic researchers to also be key vocalisation grounds for migrating humpbacks.

Catherine also met directly with the Government of Bermuda's Department of Marine Ports and Services and Department of Conservation Services. They discussed the future of shipping within Bermuda and whether threats to cetaceans are likely to increase following the establishment of Bermuda's new Marine Spatial Plan, and whether new area-based management tools such as PSSAs might be viable options in the future considering Bermuda's strategy to grow its blue economy.

Central to Catherine's research was the use of participatory GIS as a research method, using the SeaSketch GIS tool. This allowed participants to easily create a GIS layer that approximates an area of ocean space that they identified as being important for their use or to cetaceans. Through this approach, the project became highly accessible, more understandable to the general public, and gave a much stronger sense of participation and involvement. All these layers are new and never seen before, thus representing a real innovation to existing knowledge that informed Bermuda's MSP.

A total of 55 polygons were drawn on SeaSketch by eight cetacean experts including researchers, the whale-watching industry, and boat charter operators. The polygons demonstrate areas where people have previously encountered humpback whales, but also Cuvier's beaked whales (*Ziphius cavirostris*), sperm whales (*Physeter macrocephalus*) and bottlenose dolphins (*Tursiops truncatus*). Interviews also helped to uncover the range of habitat use and behaviours exhibited by cetaceans in these polygons, to give further context to each polygon. Overlap analysis demonstrated that Sally Tucker's and Challenger Bank consistently rank highest in terms of where cetaceans are encountered around Bermuda (Fig. 1).

With regards to shipping and marine traffic more generally, Automatic Identification System (AIS) data are transmitted by satellite from registered vessels of all sorts (e.g., fishing vessels, cargo ships, cruise liners, recreational craft) to show their position for safety and navigation purposes. No AIS pings were transmitted in the blue area in the West of the Pedestal (Fig. 2), which exists within an Area to be Avoided (ATBA) where the IMO has already restricted vessel traffic.

However, everywhere else in this region experiences some level of shipping traffic, posing serious threats to cetaceans.

Besides shipping, other marine sectors such as sport fishing, marine tourism and potential offshore wind sites also showed overlap with areas identified by local experts as habitats where cetaceans are encountered. Bermuda's Marine Mammal Sanctuary offers no management or protection measure to conserve cetaceans, but its Protected Species Act 2003 does make it an offense to disturb or harass humpback or sperm whales. It remains to be tested to what extent the BOPP can ensure marine tourism expands sustainably, and this includes the lucrative whale-watching industry in Bermuda especially over the winter months from January to March. The MSP currently has no plans for MPAs for cetaceans either, so it appears that until now, limited protective measures and area-based management tools (ABMTs) have been implemented for cetacean conservation in Bermuda.

This pilot project undetook a series of fresh semi-structured interviews with officials in the IMO, from the Government of Bermuda, the tourism industry and research institutes. While shipping likely creates the largest population level pressure on cetaceans, the potential for misconduct of recreational boat users harassing humpback whales was also noted by many participants as potentially causing smaller-scale issues. Two nearshore seamounts were also highlighted by experts as being key feeding grounds for multiple cetacean species as well as an important stopover for migrating humpback whales.

Through this pilot project, iAtlantic has been able to secure new information from local people and governmental authorities that demonstrate a significant and unmitigated risk to cetaceans in Bermuda resulting from human activities, particularly if marine traffic continues to increase due to implementation of an ambitious blue economy strategy such as that outlined by the BOPP. Combined with pressures from marine wildlife watching, recreational boat users and – for now, at least – an increasing number of humpback whales migrating through Bermuda's EEZ, cetaceans require new measures including ABMTs to support their protection and conservation that cannot be met simply through the Protected Species Act or Marine Mammal Sanctuary designation. Early information from the pilot project also suggests that all IMO criteria for a PSSA could be met, however a more comprehensive evidence base to establish the area would meet ecological, socioeconomic, scientific and vulnerability criteria is needed.

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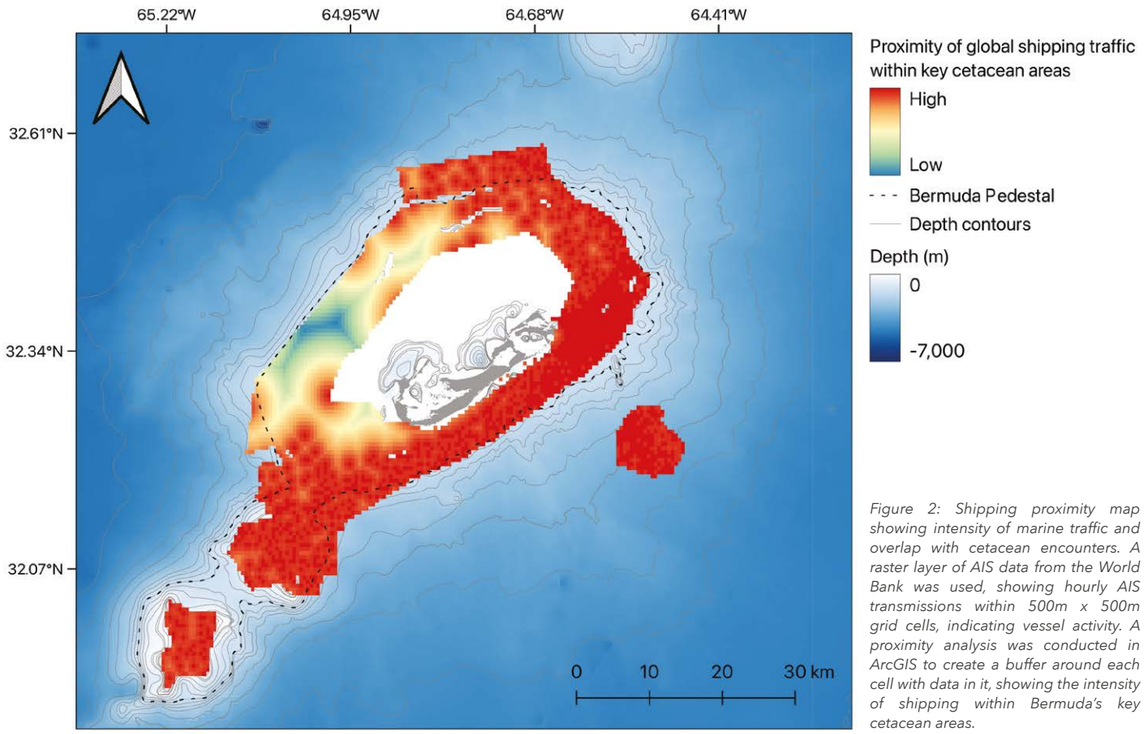

Figure 2: Shipping proximity map showing intensity of marine traffic and overlap with cetacean encounters. A raster layer of AIS data from the World Bank was used, showing hourly AIS transmissions within 500m x 500m grid cells, indicating vessel activity. A proximity analysis was conducted in ArcGIS to create a buffer around each cell with data in it, showing the intensity of shipping within Bermuda's key cetacean areas.

Trawling the archives: the hunt for lost bathymetry data

by Colin Devey, GEOMAR

One of the major barriers to assessing and protecting seafloor ecosystems in the Atlantic is a lack of data, not just on the species present but also on their environment, from water depth to chemistry of the bottom waters. A major task of iAtlantic's seafloor mapping team was to make inroads into changing this situation. Focus here was firmly on bathymetry data: the starting point of most seafloor habitat maps and a data resource that is often found hidden away in legacy or confidential datasets. With only 18% of Atlantic bathymetry mapped at a fit-for-purpose resolution at the start of the project (Woelfl et al., 2019), this was a field in which a major impact could be made for minimal expenditure.

Over the course of iAtlantic, about 100 legacy datasets generated by scientists outside iAtlantic were identified, the owners contacted and datasets acquired, resulting in 500 GB of data unlocked and published in the FAIR (Findable, Accessible, Interoperable, Reusable) data repository PANGAEA, with further data publications still in the pipeline. Overall, this resulted in the addition of 571,634km^2 of bathymetry data from the Atlantic being added to the global, publicly accessible record.

A similar volume of data was contributed directly to the Pangaea archive by the iAtlantic community, including a major contribution from oil giant Petrobras, who provided 200,000km^2 of survey data to the project. New bathymetry data were collected during iAtlantic field campaigns and associated expeditions (e.g. iMirabilis2 and ICEAge/IceDIVa expeditions), leading to a total of 'new' data made freely available to all by iAtlantic of over 1 million km^2, an area similar to that covered by countries like Egypt, Tanzania, Bolivia or Columbia, twice the area of France and 2.5 times the area of Germany.

The fact that this huge effort increased the total area of the Atlantic mapped at a suitable resolution by only 2% shows the scale of the problem that Atlantic ecosystem mapping continues to face and which hampers our attempts to understand and protect the ocean on our doorstep.

Reference:

Woelfl et al. (2019) Seafloor Mapping – The Challenge of a Truly Global Ocean Bathymetry. Frontiers, DOI 10.3389/fmars.2019.00283

Bespoke support and troubleshooting at the iAtlantic bathymetry data clinic

iAtlantic scienitists working with bathymetry data were offered a unique opportunity to troubleshoot processing problems and receive bespoke support and coaching from experts via an online bathymetry 'clinic'.

The training event, run on 29-30 August 2023 by Boris Dorschel at AWI, was designed as a hands-on workshop to address problems arising from the full range of bathymetry-related activities, from data generation and processing to data analyses and products.

The programme included a short introduction on bathymetric data collection and processing, some examples of using this type of data for scientific applications, followed by a question and answer session for specific problems with bathymetric datasets. Participants were invited to contact the trainers in advance of the session with details of the paticular issues they needed help with, so that the appropriate advice could be offered.

Deliberately designed to accommodate a small number of people so that individual problems could be addressed in a bespoke manner for the benefit of all participants, the clinic attracted researchers from Argentina, west Africa and Europe.

iAtlantic's bathymetry experts remain on hand to assist with troubleshooting and provide support.
Contact boris.dorschel@awi.de

International agreements seek to strengthen protection for marine ecosystems and biodiversity

by Matthew Gianni

Over the past nine months there have been major developments in international law and policy related to deep-sea fisheries, deep-sea mining and international ocean governance, with a strong emphasis on enhancing the conservation and protection of marine biodiversity

In December 2022, the UN General Assembly (UNGA) Resolution 77/118 (the annual 'sustainable fisheries' resolution) reaffirmed the commitment of States individually and through regional fisheries management organisations "*to protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water coral ecosystems... recognising the immense importance and value of deep-sea ecosystems and the biodiversity they contain, as documented in the first [UN] World Ocean Assessment*".

As such, the UNGA "*recognised the need for further progress with regard to obtaining more biological information on the species that comprise vulnerable marine ecosystems, including their associated and dependent species, the assessment of significant adverse impacts on vulnerable marine ecosystems, and protecting and conserving biodiversity, including beyond vulnerable marine ecosystems*"; to improve "*data availability, especially with regard to baseline data and the spatial distribution and connectivity of vulnerable marine ecosystems, including their associated and dependent species*" and committing States to apply the precautionary approach and conduct impact assessments for "*significant adverse impacts on vulnerable marine ecosystems, including their associated and dependent species*".

These provisions were adopted following a UNGA review of the implementation of the deep-sea fisheries and Vulnerable Marine Ecosystems (VME) protection measures adopted by UNGA since 2006 (UNGA Resolution 61/105 and subsequent resolutions). They were in part a response to the approach taken by a number of regional fisheries management organisations to identify, assess and manage impacts of deep-sea fisheries on so-called 'VME indicator taxa' only, and not the full suite of species that comprise VMEs.

Specifically addressing the importance of scientific research, the new resolution stressed the importance of marine scientific research for the sustainable management of deep-sea fisheries and "*to protect marine ecosystems, including the prevention of significant adverse impacts on vulnerable marine ecosystems*". It also urges States to "*strengthen the science-policy interface in order to further improve the application of the ecosystem approach to fisheries management and to address uncertainties and changes such as those related to the impacts of climate change in support of the development of adaptive fisheries management strategies*". In a similar vein, the resolution calls on States to "*take into account the potential impacts of climate change and ocean acidification in taking measures to manage deep-sea fisheries and protect vulnerable marine ecosystems, including by identifying areas, based on scientific information, where deep-water species and vulnerable marine ecosystems are likely to better survive such impacts, and establishing measures to support their resilience*".

Based on proposals from the European Union and United States, the May 2023 meeting of the UN Fish Stocks 'Resumed Review Conference' reinforced the importance of the 2022 UNGA resolution by calling on States to "*strengthen the implementation of long-term conservation and management measures for deep-sea fisheries and vulnerable marine ecosystems, including their associated and dependent species in accordance with relevant General Assembly resolutions*", including through the use of the precautionary approach. This was one of a series of recommendations by the Conference designed to strengthen the implementation of key conservation obligations in international law contained in the UN Fish Stocks Agreement. It is important to recognise that the precautionary approach to fisheries management under the UN Fish Socks Agreement requires States to "*be more cautious when information is uncertain, unreliable or inadequate*" and that "*the absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures*", to give effect to the obligations to "*protect biodiversity in the marine environment*" and "*protect habitats of special concern*" amongst others (UN Fish Stocks Agreement, Articles 5 & 6).

Delegates applaud the final adoption of the BBNJ treaty at the Further Resumed 5th session of the BBNJ Intergovernmental Conference on 19 June 2023, held at UN headquarters in New York. Image courtesy IISD/ENB - Pam Chasek

Also in December 2022, the 15th Conference of Parties (COP15) to the Convention on Biological Diversity adopted the Global Biodiversity Framework, reaffirming international commitments to halting and reversing biodiversity loss. In addition, COP15 adopted a decision on coastal and marine biodiversity (CBD/COP/DEC/15/24) which calls on States "*to ensure that, before deep seabed mineral exploitation activities take place, the impacts on the marine environment and biodiversity are sufficiently researched and the risks understood*" and that deep-sea mining activities "*do not cause harmful effects to the marine environment and biodiversity*".

In a similar vein, an increasing number of States are now calling for a moratorium or 'precautionary pause' on deep-sea mining at the International Seabed Authority (ISA), with many citing a lack of sufficient baseline and scientific information to assess the potential risks to deep-sea species, ecosystems, and biodiversity. Brazil, for example, announced its position in support of "*a precautionary pause in deep sea mining in areas beyond national jurisdiction, for a minimum period of ten years*" at the July 2023 meeting of the ISA Council, stating its concern over potential 'loss and damage to marine biodiversity' as well as impacts on seabed carbon sequestration and other risks. A number of other countries cited similar concerns: Italy, for example, stated that a regulatory framework for deep-sea mining should be based on science, the precautionary principle, and the ecosystem approach which "*prevents harm to the marine environment*".

The meeting of the ISA Council in July came at a critical moment given that the deadline under the so-called 'two-year rule' triggered by Nauru on behalf of the The Metals Company expired the same month. When Nauru triggered this rule in July 2021, the ISA Secretary-General along with UK, Norway, Mexico, Nauru and several others repeatedly argued for the adoption of the mining regulations by July 2023 to meet the 2-year deadline, in some cases claiming that the Council was under a legal obligation to do so.

However, they failed to convince the other members of the Council to agree. Instead, the decision adopted by the ISA Council on 21 July 2023 stated that the Council only "*intends to*" (not "*commits to*") continue negotiations to develop rules and regulations for deep-sea mining "*with a view to*" adopting them at some point in 2025. This is not a deadline, only a timeline. Moreover, the Council agreed that there should be no deep-sea mining before regulations are adopted by the Council, though it did not entirely close the 2-year rule loophole which allows a country to apply for an exploitation license or contract in the absence of the formal adoption of regulations (ISA Council Decisions ISBA/28/C/24 & ISBA/28/C/25). Nonetheless, Council did agree to continue to meet three times a year through the end of 2024 - though there are many elements of the draft negotiating text that are far from agreed. Amongst these are issues related to the content, conduct and review of environmental impact assessments, standards and guidelines for environmental performance, requirements for test mining, the development of regional environment management plans, and whether and how mitigation, remediation, offsetting and/or factoring the cost of 'externalities' into the royalty regime could potentially compensate for biodiversity loss and harm to the marine environment in light of the obligation to ensure effective protection for the marine environment from the harmful effects of seabed mining activities (UNCLOS Art. 145).

The ISA Assembly, the 'supreme' body of the ISA, also met in July 2023. Chile, France, Palau, Vanuatu and Costa Rica put forward a proposal to debate whether the Assembly should adopt a General Policy for the protection of the marine environment in light of the concerns expressed by many States. The debate was blocked for several days by China, Nauru and Mexico but in the end all countries agreed to consider discussing this as part of the Assembly agenda in 2024. At the same time, the Assembly rejected a proposal from the ISA's Secretary-General to adopt a new 5-year strategic plan for the ISA that would prioritise the adoption of mining regulations. Instead, the Assembly agreed to a proposal from Germany to first initiate a systematic review of the way in which the ISA operates before agreeing to any new strategic plan. This too will be discussed at the 2024 Assembly meeting.

Finally, after many years of negotiation, the new UN treaty for the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction (known as the BBNJ Agreement) was adopted in June 2023 and opened for signature in September. The Agreement – the third UNCLOS implementing agreement – establishes *inter alia* that Parties shall be guided by a set of principles and approaches including those that that build "*ecosystem resilience, including to adverse effects of climate change and ocean acidification, and also maintains and restores ecosystem integrity, including the carbon cycling services that underpin the role of the ocean in climate*" (Article 7).

In addition to the above, the UNGA has designated 2020-2030 both the Decade of Ocean Science and the Decade of Ecosystem Restoration. The implementation of work programmes for these two initiatives involve the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the UN Environment Programme (UNEP) and the UN Food and Agriculture Organization (FAO). And in 2025 the United Nations Ocean Conference, jointly hosted by France and Costa Rica, will take place in Nice to review the implementation of UN Sustainable Development Goal 14 on oceans, including the commitment under Target 2 to "*sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration*". The relevance of this target to deep-sea conservation is likely to be a prominent feature of the conference.

These developments underscore the increasing emphasis placed by States on the conservation, protection, and sustainable use of marine biodiversity in areas of the global ocean beyond national jurisdiction within the twin context of a precautionary approach and ecosystem approach. As a result, there is likely to be increasing demand for comprehensive scientific information on deep-sea species and ecosystems at local, regional and basin-wide scales, such as the new knowledge that iAtlantic is providing. More information on the knowns and unknowns regarding the status of marine biodiversity in the deep-sea and open ocean, along with assessments of current and potential future impacts of deep-sea fishing, deep-sea mining, those related to climate change and the cumulative impacts of anthropogenic stressors, will be crucial.

Ocean Governance: Insights into Ongoing Policy Process and Lessons for Early Career Professionals

iAtlantic joined as a co-host of the recent '*Introduction to Ocean Governance: Insights into Ongoing Policy Process and Lessons for Early Career Professionals*' short course co-organised by the COBRA (Crustal Ocean Biosphere Research Accellerator) network and Research Institute for Sustainability (RIFS). The online event (2 half days; 6-7 September 2023) provided a general introduction to ocean governance for scientists and other stakeholders, focusing on key policy processes and ongoing discussions in selected policy fields relevant to ocean science. Topics covered in the event included the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), fisheries including key global and regional processes, deep-sea mining and the International Seabed Authority, and the global agreement covering biodiversity in areas beyond national jurisdiction (the BBNJ Agreement). In addition, the event offered insights into policy engagement, scientific outreach, and opportunities for early career professionals. The event included presentations from a diverse group of policy experts and an interactive group session to explore opportunities for participants to engage in these processes. More than 200 people registered for the event from around the world, representing a diverse range of backgrounds and expertise.

From iAtlantic, Ben Boteler (TMG) co-hosted the event, with WP6 team members David Johnson, Matt Gianni and Vikki Gunn providing presentations, answering questions and participating in the online discussions afterwards.

A recording of the course will be available from the COBRA website in due course.

COBRA
CRUSTAL OCEAN BIOSPHERE RESEARCH ACCELERATOR

Collectively working towards better ocean health in the NE Atlantic

David Johnson, Seascape Consultants

The Oslo and Paris Convention (OSPAR) is the Regional Seas Convention for the protection of the marine environment of the North-East Atlantic. The Convention (and its five Annexes) has been signed and ratified by 15 Contracting Parties and the European Union. The North-East Atlantic Environment Strategy 2020-2030 was adopted on 1 October 2021, focusing on tackling biodiversity loss, pollution and climate change. The equivalent organisation in the South East Atlantic is the Abidjan Convention, but no regional seas organisations exist yet for the north-west or south-west Atlantic. OSPAR and the Abidjan Convention work together within the framework of UNEP's Programme of Regional Seas and Action Plans, which covers 18 regions of the world's ocean (UNEP, 2014).

On World Ocean Day (8 June 2023), iAtlantic's policy team had the opportunity to present an overview of the project's highlights and emerging results to the sixth meeting under the 'Collective Arrangement' established between the North-East Atlantic Fisheries Commission (NEAFC) and the OSPAR Commission (OSPAR Agreement 2014-09). The Collective Arrangement is a formal agreement between the two legally competent authorities responsible for managing activities in the area beyond national jurisdiction in the NE Atlantic. Ironically, this initiative was conceived by iAtlantic's David Johnson (and others!) during his time as Executive Secretary of OSPAR (see NEAFC & OSPAR, 2015). The idea is to promote multilateral dialogue through information exchange at a regional level on common issues such as fisheries management, environmental protection interests, measures of joint relevance, as well as global targets and obligations. This can support policy coherence and a holistic ecosystem approach. The majority of Parties to the two conventions overlap but responsibilities often fall to different national ministries. Conservation of deep-sea elasmobranchs is one example of a common issue under consideration.

The Collective Arrangement meeting also provided information on a number of iAtlantic-relevant policy initiatives that may provide a opportunity for future collaborative work with the marine science community:

- The OSPAR Commission meeting (Oslo, June 2023) agreed to extend the scope of the North Atlantic Current and Evlanov Sea basin (NACES) marine protected area (MPA) to include the seabed and a number of additional species and habitats, such as coral gardens and deep-sea sharks. NACES – OSPAR's largest high seas MPA – was originally designated in 2021 with the goal of protecting, conserving, maintaining and restoring seabird populations and marine biodiversity; the addition of later evidence describing its benthic component (including data contributed by iAtlantic) supported its extension.
- The Quality Status Report (QSR) is OSPAR's flagship holistic assessment. The QSR 2023 covers the period 2009-2021 and reflects a comprehensive monitoring and assessment process. It provides an updated analysis underpinned by over 130 assessments involving 450 experts, including experts from iAtlantic.
- OSPAR's Data and Information System (ODIMS) publishes a range of different data compilations reflecting the varied work of the different OSPAR committees.

iAtlantic representatives have been invited to the forthcoming OSPAR Arctic Workshop in mid-October 2023 to facilitate discussion among experts and stakeholders. The workshop will consider the knowledge and evidence base collected by OSPAR's Arctic Outcomes Working Group, which is intended to help to inform how OSPAR can enhance protection of the Arctic marine environment in its maritime area.

iAtlantic's David Johnson and Vikki Gunn (and a giant puffin) at OSPAR HQ.

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Good reads

A selection of the latest iAtlantic publications

Full iAtlantic publication list | Zenodo open access archive

A blueprint for integrating scientific approaches and international communities to assess basin-wide ocean ecosystem status. Roberts et al. (2023) *Nature Comms Earth & Environment*, DOI: 10.1038/s43247-022-00645-w

Energetic overturning flows, dynamic interocean exchanges, and ocean warming observed in the South Atlantic. Chidichimo et al. (2023) *Nature Comms Earth & Environment*, DOI: 10.1038/s43247-022-00644-x

Inclusive science in the South Atlantic. Perez et al. (2023) *Nature Comms Earth & Environment*, DOI: 10.1038/s43247-022-00646-9

Climate change impacts on ocean circulation relevant to the UK and Ireland. McCarthy et al. (2023) *MCCIP Science Review 2023*, DOI: 10.14465/2023.reu05.cir

Benthic biogeographic patterns on the deep Brazilian margin. Yepes Gaurisas et al. (2023) *PeerJ*, DOI: 10.7717/peerj.14585

First in-situ observation of sponge response and recovery to an industrial sedimentation event. Durden et al. (2023) *Marine Pollution Bulletin*, DOI: 10.1016/j.marpolbul.2023.114870

Coupling large-spatial scale larval dispersal modelling with barcoding to refine the amphi-Atlantic connectivity hypothesis in deep-sea seep mussels. Portanier et al. (2023) *Frontiers in Marine Science*, DOI: 10.3389/fmars.2023.1122124

Habitat suitability models of a critically endangered cold-water coral, *Isidella Elongata*, in the Mallorca Channel. Standaert et al. (2023) *Thalassas*, DOI: 10.1007/s41208-023-00531-y

Natural hypoxic conditions do not affect the respiration rates of the cold-water coral *Desmophyllum pertusum* (*Lophelia pertusa*) living in the Angola margin (Southeastern Atlantic Ocean). Gori et al. (2023) *Deep Sea Research Part I*, DOI: 10.1016/j.dsr.2023.104052

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Underwater 3D reconstruction from video or still imagery: Matisse and 3DMetrics processing and exploitation software. Arnaubec et al. (2023) *Journal of Marine Science and Engineering*, DOI: 10.3390/jmse11050985

Ship-to-shore training for active deep-sea capacity development. Archer Barnhill et al. (2023) *ICES Journal of Marine Science*, DOI: 10.1093/icesjms/fsad088

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Smoothed particle hydrodynamics for modelling cold-water coral habitats in changing oceans. Georgoulas et al. (2023) *Journal of Sea Research*, DOI: 10.1016/j.seares.2023.102358

Challenges in avoiding deep-water shark bycatch in Azorean hook-and-line fisheries. Fauconnet et al. (2023) *ICES Journal of Marine Science*, DOI: 10.1093/icesjms/fsac178

Eiffel Tower: A deep-sea underwater dataset for long-term visual localization. Boittiauxet al. (2023) *The International Journal of Robotics Research*, DOI: 10.1177/0278364923117732

On the paradox of thriving cold-water coral reefs in the food-limited deep sea. Maier et al. (2023) *Biological Reviews,* DOI: 10.1111/brv.12976

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iAtlantic
INTEGRATED ASSESSMENT OF ATLANTIC MARINE ECOSYSTEMS IN SPACE AND TIME