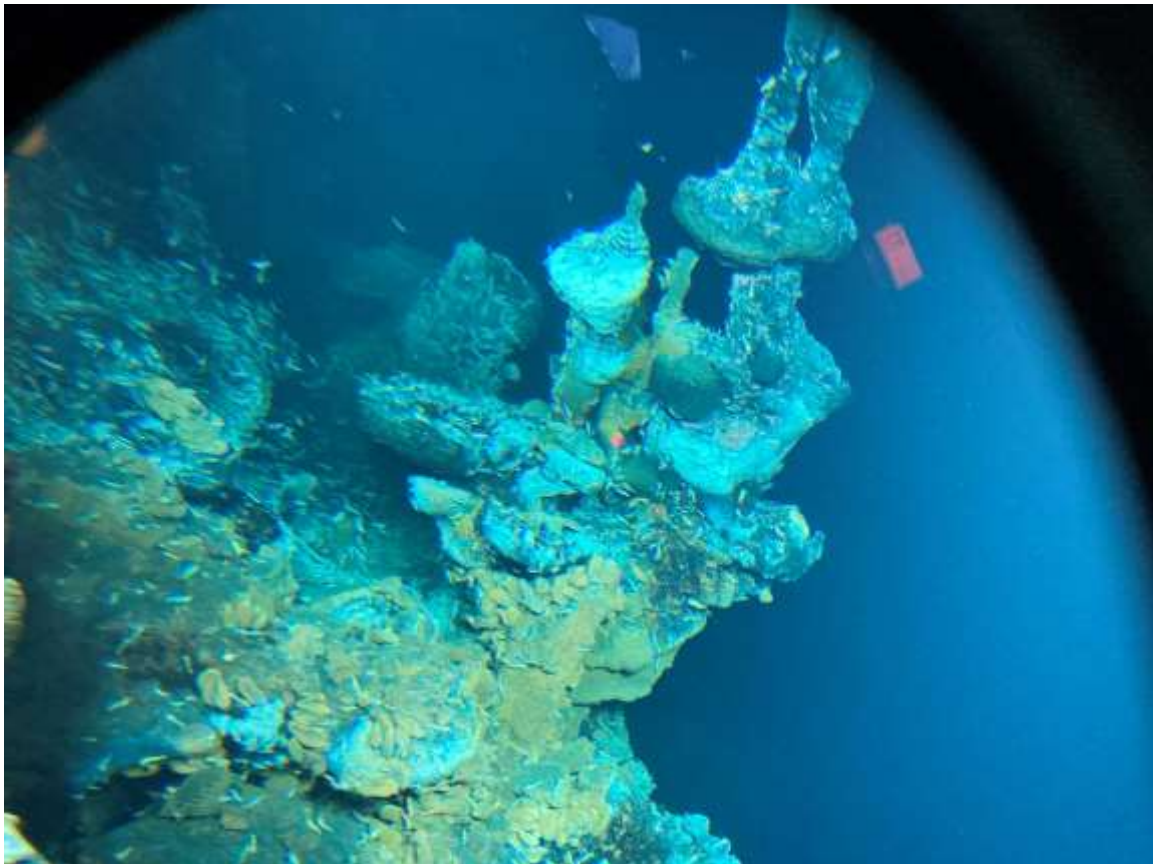




Conservation and restoration of marine ecosystems in the context of deep-sea mining

DEEP REST – Fifth Newsletter



View from the Nautilie porthole of the active sulphide edifice Les Ruches visited during the Bicosse 3 cruise. Photos credit J. Sarrazin/Ifremer.

October 2023 – March 2024



Editorial – Dear all. Thanks for those who contributed to the Newsletter. It is great to have photos and updates from you. We're almost halfway through our project! Many cruises have been completed, data accumulated and experiments carried out, but the most exciting part is yet to come: data analysis and synthesis of results. We still have a lot of work to do to ensure that DEEP REST's objectives are met and that results can be shared and used to develop sustainable, environmentally-friendly management strategies and restoration scenarios for our ecosystems of interest. Moreover, the development of a fair and equitable governance of deep-sea environments and their resources appears to be an absolute priority for the benefit of mankind. Progress are made with the signature of the BBNJ and the engagement of many countries in a moratorium against deep-sea mining. The next meeting will be intense: we will focus on our deadlines and deliverables and will start to think about what the legacy of our project might be for the future. Looking forward to seeing you May 14-16 in Faro! –Jozée

Experimental approaches to explore colonisation dynamics and restoration potential in different hydrothermal contexts at the Mid-Atlantic Ridge: preliminary results of the Deep Seeds experiment

Florence Pradillon & Jozée Sarrazin, Ifremer Deep Sea Lab, Brest

Colonisation experiments with the small modules *Deep Seeds* were recovered last November 2023 during the BICOSE 3 cruise (<http://dx.doi.org/10.17600/18002399>) that explored known and new hydrothermal areas within the French SMS exploration licence along the Mid-Atlantic Ridge (MAR). These experiments, deployed in the summer 2022 (Hermine 2 cruise, <https://doi.org/10.17600/18001851>) at and around the TAG vent field, remained on the seafloor for almost 15 months in different hydrothermal contexts. While two sets were deployed on the active mound within areas exposed to hydrothermal fluids, three others were positioned on ancient mounds with none to faint fluids detected. However, these last three experiments were all deployed away from detectable hydrothermal influence.

This was the first large scale colonisation experiment conducted with the newly developed standardised modules *Deep Seeds* in deep-sea hydrothermal context (another study is currently conducted in cold-water corals ecosystems in a canyon along the Brittany coast). *Deep Seeds* were designed to allow the concomitant evaluation of the arrival of sinking particles and organisms trapped in small tube traps as well as the recruitment of organisms on colonisation plates made of slate or wood (oak). Each device were equipped with autonomous temperature probes (iButtons) that recorded local temperatures during the

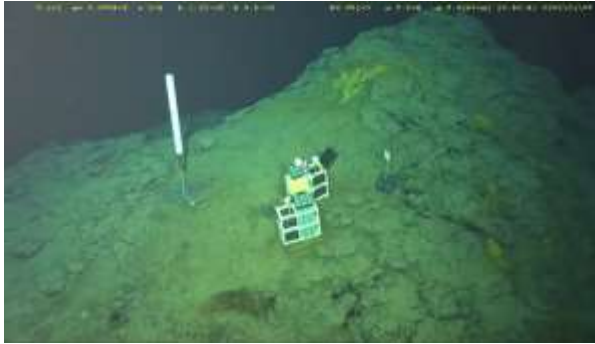
whole deployment duration. At each of the five study sites, two *Deep-seeds* (1 with slates, 1 with wood) and a pile of three basalt plates were deployed, along with a tilt current meter to document main current regimes at the position of the experiment (Fig 1).

Deep Seeds and their associated current-meters were recovered at each deployment site using specifically designed collection boxes that minimized washing off and losses of organisms during the ascent to the surface. Just before recovery, the local water mass was characterized using water *in situ* analysers such as Chemini and water sampler such as PIF that collected water for later chemical analyses (Fig 4). On board, each device was imaged, and organisms were carefully collected from each colonisation substratum. Small portions of the substratum were first aseptically collected for later analyses of microbial communities. Then organisms were washed off the substratum and sorted into different size fractions before being conditioned in ethanol or formalin. Substratum were also preserved for later examination of strongly attached or boring organisms.

Deep-seeds deployed in the most active area of TAG Active Mound near a swarm of *Rimicaris* shrimps had fallen during the deployment period, and a small sulphide chimney had even grown within the structure (Fig 5). Fauna collected was typically that found in shrimp swarms, i.e. mostly shrimps. At the area with anemones, characterized by a quite significant hydrothermal influence that drove iron precipitations (Fig 6), wood and slate plates were slightly colonised by few organisms. Most tube traps were clogged with material, which reflect a rather high biological activity and particle load locally.

In the three sets deployed at ancient mounds, results were quite different. As expected, all wood plates were colonised with wood-boring bivalves which were completely absent from experiments within hydrothermal activity. Surprisingly, colonisation levels were very different between the three sites, although the experiment duration was the same and environmental settings appeared similar (Figs 3, 4). Current-meter data demonstrated quite different local current regimes at the different mounds where *Deep Seeds* were deployed, which probably reflects the position of the deployment site relative to the local topography created by each mound. These differences may have strongly influence the arrival of colonists, explaining the drastically different colonisation levels observed among *Deep Seeds* at different mounds.

Further analyses are now required to characterise precisely the diversity and abundance of colonists, including microbiota, meiofauna and macrofauna. These data will then be compared with the diversity and abundance of organisms collected in the tube traps as well as with local environmental characteristics (temperature, hydrogen sulphide, iron, pH, organic matter...) and current regimes during the whole experiment in order to better understand colonization dynamics and origin in different vent active and inactive contexts.



Large view of the colonization experiment at Shimmering Mound showing the two *Deep Seeds*, with the small basalt pile on the left and the current-meter on the right.



Close view of the *Deep Seeds* with wood at the Shinkai Mound.



Close view of the *Deep Seeds* with wood at the Abyss Mound.



Chemical characterization of the water mass surrounding *Deep Seeds* before recovery at Abyss Mound



Fallen *Deep Seeds* at TAG active mound surrounded with shrimps and with a sulphide chimney growing on it.



Deep Seeds in the anemone area of TAG active mound, covered with iron precipitates.

Use of ANATOMIX beamline at the Synchrotron SOLEIL in Paris to study the reproductive biology of the deep-sea vent gastropods *Peltoispira smaragdina*

Marjolaine Matabos¹, Julia Sigwart², Catherine Borremans¹, Nicolas Gayet¹, Andre Ampuero-Leon²

¹ Deep Sea Lab Univ Brest, Ifremer, BEEP, F-29280 Plouzané, France and ² Senckenberg Research Institute and Museum, Frankfurt, Germany

From February 6th to 9th 2024, a team from Ifremer with colleagues from the Senckenberg Institute visited the synchrotron in Paris Saclay to acquire imagery data on the ANATOMIX beamline. The objective of the project was to study the reproductive biology of the vent

gastropod *Peltoispira smaragdina* from the Mid-Atlantic Ridge in contrasted environmental conditions to better understand vent species ability to maintain local populations and colonize new areas.

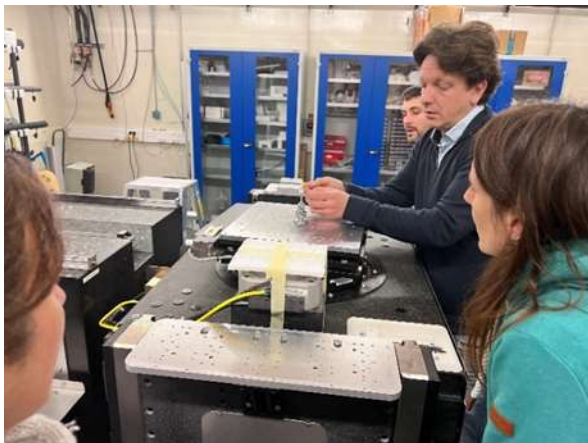


The Synchrotron building in Paris and the Anatomix beamline

The ANATOMIX (Advanced Nanotomography and Imaging with coherent X rays) line, the newest beamline of the particle accelerator synchrotron SOLEIL (www.synchrotron-soleil.fr/en), supplies X-rays in the energy ranges between 5 and 50 keV. It is dedicated to full-field radiography and tomography, with absorption and phase contrasts, and pixel sizes ranging from 20 nm to 20 μm . In 2023, the team applied to beamline time to obtain high-resolution 3D images of the gonads of *P. smaragdina*.

The main objective of the project was to study for the first time the reproduction biology of a dominant gastropod species that colonise deep-sea hydrothermal vents and more specifically to (1) describe and reconstruct the anatomy of this species; (2) characterise its reproductive biology including reproduction type, gametogenesis and fecundity and (3) determine how environmental variability affects species reproduction by comparing fecundity across different environmental sites and along a geographical gradient. The use of ANATOMIX allowed to obtain high-resolution, well contrasted, images, essential to visualise mature oocytes.

In total 80 individuals of *P. smaragdina* were imaged for their gonad morphology and egg quantification. An additional few species was also scanned for anatomical description. Images showed that the animal is able to detoxify itself and expels minerals through digestion. This support first observations, showing that this species evolves on mineral substratum where it grazes on bacterial mats.



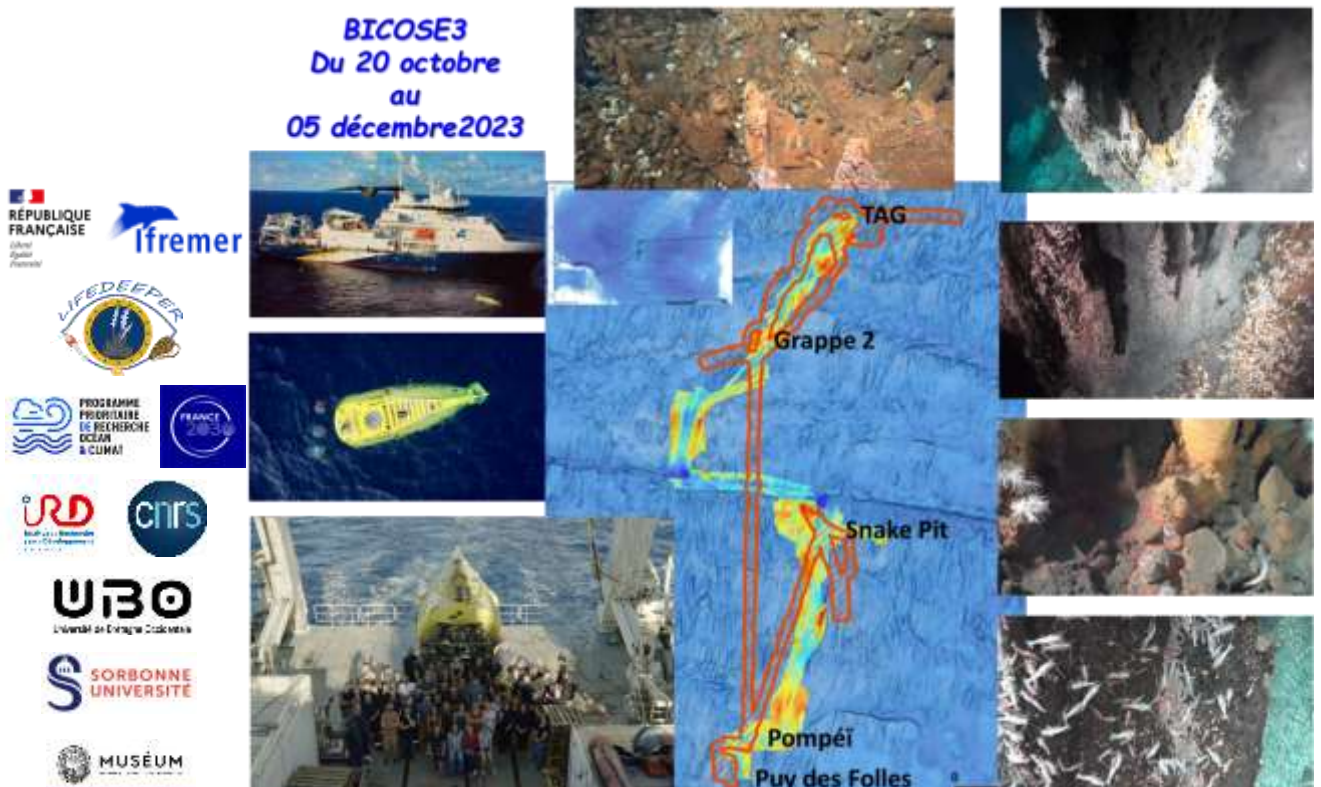
Scientists and technicians at work at the Synchrotron in Paris.



Bicose 3 cruise

October 20th-December 5th, Mid-Atlantic Ridge

Marie-Anne Cambon, chief scientist, Ifremer Brest



The aim of the BICOSE3 cruise was to explore over 800 km of the mid-Atlantic ridge between 26°N (TAG) and 21°N (Puy des Folles), in order to establish more precisely i) the functioning of the geological system underlying this hydrothermal activity, > 125,000 years for TAG ; ii) community distribution maps linking *in situ* observations and inventories using integrative taxonomy approaches; iii) the connectivity of key species taking into account all active sites; iv) the *in situ* functioning of holobionts in contrasting areas and over the life cycle (including the key symbiont acquisition stage); v) the settlement processes of new recruits and the influence of environmental conditions on this settlement using *in situ* colonization experiments deployed on active and inactive sites of different ages; vi) the sensory and acclimatization capacities of holobionts using *in vivo* approaches; vii) and finally lead to a redefinition of the notions of active and inactive sites, taking into account the gradient

between the two extremes and the distribution of biotopes and biodiversity (micro to macro) within the TAG district.

Ultimately, our aim is to gain a holistic understanding of how these environments function, both geologically and biologically. These studies aim to respond to societal concerns about protecting and respecting these biotopes, based not only on the biodiversity they contain, but also on their key functions, enabling them to be resilient, adapt and evolve in the face of natural or anthropogenic change. This work is part of the LIFEDEEPER France 2030 project, the EU DEEP REST project and France 2030 Mission 1.

Overall, during the cruise, we carried out SMF surveys covering an acquisition area estimated at 17,000 km², 17 rock dredges, 18 USNEL cores and 17 MTB cores, 8 epibenthic sledging operations and 27 Nautilé dives for *in situ* measurements, video and sampling.



The Arctic Sunrise II – Does the ISA have ‘enforcement jurisdiction’ on the High Seas?

Shani Friedman, AMURE, University of Brest

On 28 November 2023, the Secretary-General of the International Seabed Authority (ISA) issued ‘temporary measures’ orders, in accordance with Regulation 33 (i.e. emergency orders) of the Regulations on Prospecting and Exploration for Polymetallic Nodules (Polymetallic Nodules Regulations). The measures were issued with respect to an incident involving an ISA contractor, Nauru Ocean Resources Inc. (NORI), and Greenpeace’s vessel, the Arctic Sunrise.

These measures and the overall conduct of the ISA Secretary-General raise some questions concerning the possible expansion of the ISA’s jurisdiction. There is little doubt that Greenpeace has violated the freedom of the High Seas and other rules of international law by boarding the *MV Coco* unauthorized and damaging the vessel. However, the actions taken by the ISA to address this incident do not seem to be within the scope of its jurisdiction or authority under the Polymetallic Nodules Regulations. Furthermore, the ISA exercised its jurisdiction with respect to a maritime zone or conduct that are outside its capacity altogether, thus acting *ultra vires*. The ISA essentially took upon itself what is an obligation of states – to request the intervention of the flag state.

Read the full blog post examining the measures issued by the ISA and its capacity to issue such measures: <https://www.ejiltalk.org/the-arctic-sunrise-ii-does-the-isa-have-enforcement-jurisdiction-on-the-high-seas/>

Norway's Deep-sea Valuation Survey & Norwegian Government Mining Initiative

Asif Khan & Tom Van Rensburg, University of Galway

In the global race for resource extraction, Norway positions itself at the forefront of deep-sea mining (DSM)—a venture that promises both opportunities and significant environmental challenges. In a landmark move, the Norwegian Parliament has recently passed legislation on deep-sea mining law as of January 4, 2024, paving the way for impact assessment and extraction of deep-sea minerals within its jurisdiction on the continental shelf. Norwegian jurisdiction, under UNCLOS, grants rights to explore and exploit minerals on its continental shelf, including national waters near Svalbard. To explore and extract seabed minerals reserves, companies must seek parliamentary approval for mining licenses. Norway emphasizes responsible environmental conduct amid global debate and criticism from the UK and the EU.

We have been working on developing a comprehensive choice experiment survey to capture a wide range of perspectives on DSM, focusing particularly on environmental conservation, restoration, and governance within the jurisdiction of Norway's deep-sea mining activities. The survey targets the Norwegian public and encompasses various stakeholders, such as scientists, government officials, industry representatives, and NGOs. Our objective was to assess the public preference on DSM within Norwegian jurisdiction and its environmental implications, including the management & governance of associated risks and benefits. Key themes of our survey include:

- *Conservation and Restoration*: Assessing attitudes towards DSM's ecological impacts within Norwegian maritime zones.
- *Governance and Jurisdiction*: Probing into the perceived roles and responsibilities of DSM's key decision-makers, including the legal frameworks that govern these activities.
- *Risk and Benefit Perception*: Weighing the economic advantages against environmental concerns, within the context of Norway's legal and regulatory environment.

The new DSM law is a pivotal step for Norway, establishing a jurisdictional framework for responsible and regulated exploration of seabed mineral reserves. Our survey is designed to tap into societal and stakeholder perceptions regarding this ground breaking legislation within Norwegian maritime areas. We aim to gather valuable insights to inform future DSM policies and operational practices.

Finally, the implementation of our survey is imminent, aligning strategically with the announcement of the Norwegian Government DSM initiative. This is a critical juncture to collect and incorporate public perspectives on the topic and ensure that Norway's approach

to DSM within its jurisdiction is balanced and mindful of our shared seabed resources. The journey towards sustainable DSM is indeed a shared responsibility, and we invite all to contribute their voice to this vital dialogue.



Exploring the Depths: A unique participatory conference on biodiversity protection in the deep sea

Charline Guillou - Joëlle Richard, University of Western Brittany, AMURE

On February 13th 2024, in the auditorium of Océanopolis (Brest, France), an extraordinary participatory conference took place, captivating the audience with its innovative approach to addressing the challenges of protecting biodiversity in the deep sea.



Speakers talking to the audience after the debates ©Joëlle Richard/UBO.

Six researchers engaged in a captivating theatrical conference to kick off the new season of scientific conferences at Océanopolis, a scientific cultural centre dedicated to the ocean. Members of the DEEP REST and LIFEDEEPER research projects embraced this unconventional format to delve into the potential implications of deep-sea mining on marine ecosystems.

A dive into international negotiations

Attendees were immersed in international negotiations and prompted to ponder critical questions surrounding energy transition, marine mineral exploitation, and conservation efforts. The interactive nature of the conference allowed the audience to engage in real-time voting via smartphone devices, enhancing their involvement in the discussions. Structured as a three-act play, the participative conference featured three themed debates, each scripted and performed by pairs of experts. From an uncertain state president to a CEO advocating for deep-sea mining, and an NGO representative condemning all human activities in these fragile

areas, the experts portrayed various roles to explore diverse positions. Following the three debates, attendees were invited to engage in open discussions with the experts, who then shared their own opinions and positions.

A packed house

At 8:30 p.m., 215 individuals, including numerous students, filled the auditorium seats at Océanopolis. Each attendee received a card containing a QR code, enabling them to participate in the interactive voting process. The conference started with Thomas Leclerc shedding light on the environments of the deep sea and its regulation. The first act featured a discussion between a researcher and a hesitant state president, ultimately leading to a call for a moratorium on deep-sea mining. In the second act, amidst arguments from a CEO advocating for mining, the audience favoured the stance of an NGO representative calling for a halt to all activities in the deep sea. In the third act, the researchers embodied concerned citizens; the audience, too, expressed itself in key words at the end of their exchange, with a dominant concern for environmental destruction.

The audience's evident concern over deep-sea mineral exploitation reflects the ongoing drafting of the mining code by the ISA, which has been in progress for over 12 years. As negotiations resume in July at the ISA headquarters in Kingston, the extent to which civil society concerns will be addressed remains to be seen. In conclusion, the participatory conference succeeded in stimulating meaningful dialogue and raising awareness about the complex challenges surrounding biodiversity protection in the deep sea, emphasizing the importance of informed public engagement in shaping future policies and decisions.

At the end, the audience was encouraged to stay informed about the DEEP REST and LIFEDEEPER projects, participate in the citizen science project Deep Sea Spy, and pay close attention to the upcoming media coverage of the next General Assembly of the International Seabed Authority (ISA) meeting in July-August.

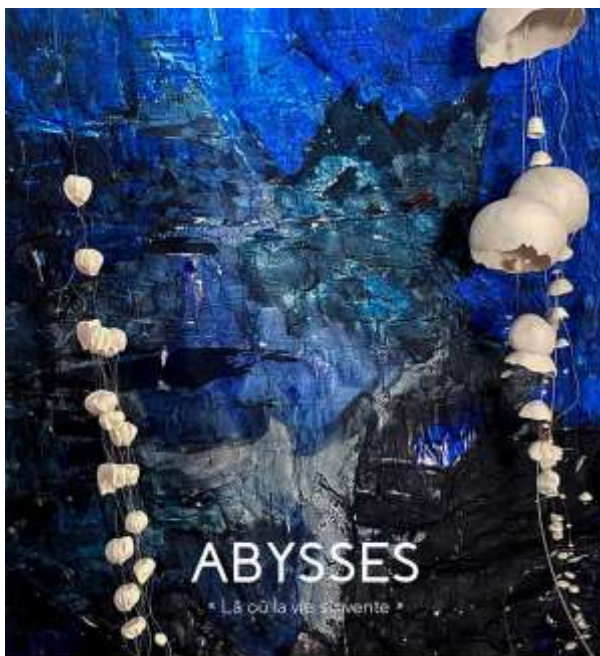


The word cloud generated during the last question to the public: what do you think of tonight's debate in two words ©Sli.do/UBO

Exhibition “Abyss: where life invents itself”

Jozée Sarrazin, Deep-Sea Lab, Ifremer

A meeting with two passionate artists -Sylvie Salmon and Valérie Ferchaud- eager to immerse themselves in the world of research on the deep seabed, took place in 2021 with Jozée Sarrazin, researcher at Ifremer. It was quickly decided that residencies offering privileged dialogue with research stakeholders were essential for them to take ownership of our scientific approaches and questions. During their two passages in the BEEP and GEOCEAN laboratories at Ifremer in 2022, the artists met more than twenty researchers, technicians, engineers and students who work on deep sea ecosystems and shared their passions. The exhibition called “*Abyss: where life invents itself*” brings a different and poetic look at this world that is still little-known and yet threatened by the exploitation of its resources, whether energy, biological or mineral.



The exhibition first took place during the Ressac Festival in Brest from March 19th to March 23rd 2024. A micro-conference on deep-sea ecosystems and their resources was given by J. Sarrazin March 21st. The exhibition was then moved to another site near Brest and will be on display until April 25th 2024.

<https://www.univ-brest.fr/festival-ressac/fr/actualite/abysses-la-ou-la-vie-s-invente>

The two artists are also now registered to the Deep-Sea Biological society

<https://dsbsoc.org/artists/valerie-ferchaud/exhibits/>

DESSA: A workshop with the street artist Teuthis

Nan Chin Chu, Hélène Leau, Jozée Sarrazin, Ifremer

This workshop called DESSA for «Deep Sea Street Art» was organized by three scientists from Ifremer for twelve Master students from the universities and engineer schools of ISBlue to explore, during one week, the theme of the deep-sea through the drawing and exhibition of deep-sea fauna, submersibles or ecosystems. Led by the street artist Teuthis, the students

imagined and exposed their large collages on the walls around the University during the second week of January and a web site was designed to promote their work and give some scientific information about them (<https://www.onedeeppocean.org/Our-actions/Citizen-Science-Ocean-Spy-Deep-Sea-Street-Art/Deep-Sea-Street-Art/Deep-Sea-Street-Art-Gallery>). You can also find the other creations there!



The project will be presented during the UN Ocean Decade Conference happening in April 2024 and post-cards were designed to promote students' drawings.

Stickers from the artist were printed and will be distributed during our annual meeting to promote deep-sea animals, tools and ecosystems during our outreach events.

Immersion Science

Riwan Leroux & William Johnson Da Silva, Ifremer

BEEP scientists were again present in this year's edition of Immersion Science, which took place March 27 at Ile Tudy, in southern Brittany. William Johnson and Riwan Leroux gave a conference about the biodiversity of the deep ocean and how to access it to 60 high-school students. In the afternoon, the students were introduced to the *Deep Sea Spy* platform, where they learned how to recognize groups of key organisms from hydrothermal vent observatories.



Post-doc Riwan Leroux giving the conference. *"I think we gave them a good idea about what it is to do research. Students were very keen to participate in imagery analyses and were given the opportunity to see what were the challenges of extracting data from imagery using annotations. They had many questions, about the specimens we brought and the scientific work. The round table in the evening was the occasion for us to give them some advice for their careers and it was really interesting to chat about their project and concerns."* - Riwan Leroux



PhD student William Johnson showing the *Deep Sea Spy* platform to the students. *"It was an exciting experience, it's always great to be able to hear from the students, and share a bit of our daily lives in science. It's fascinating to see their reactions, the questions about academic life and the whole learning process"* - William Johnson.

Vox-pop interviews

Marjolaine Matabos, Jozée Sarrazin + the contributors

We have received contributions from 5 countries and we are currently editing the video sequences so that we hope to be able to show a 22 minutes sequence during our next meeting! We still need to discuss about the messages to leave and credits to put at the end.



Raz Shauqeena Batrisyeya, University Malaysia Terengganu

Intern at Ifremer DEEP Sea Lab from March to May 2024

Bonjour and Apa Khabar! I am Raz from Malaysia, a post-grad student studying polychaete taxonomy at Universiti Malaysia Terengganu. I am currently doing a two-month internship at Ifremer's Deep Sea Lab, accompanying PhD student Alicia Veuillot in sorting the faunal samples associated with her substratum experiment from the MAR



Activities of the internship will include extracting and counting meiofauna from the 20-300 μm fraction, sorting individuals into major taxonomic groups (copepods, nematodes, halacarids...) and taking morphometric measurements on some macrofaunal taxa previously sorted.

"I am excited to delve into marine science and share my discoveries with you all!"



Conferences and symposium

Participation of DEEP REST scientists Marie-Anne Cambon and Jozée Sarrazin to the « Colloque National de la Décennie pour les sciences océaniques », a UN Decade event in Océanopolis, Brest, March 2024.

From right to left: journalist Jean-Louis Le Courvoisier and scientists Jozée Sarrazin, Marie-Anne Cambon, Clémentine Moulin and Anne Choquet.



Deep-sea biology symposium, Hong-Kong 13 to 17 January 2025

DSBS17 aims to bring together experts from around the world who have strong interest in deep-sea biological science, biodiversity conservation, deep-sea environment policy and management for better protection of biodiversity and ecosystems. Note that a session a session entitled "*Arts and Science in Deep-Sea Environmental Management*" led by Maria Baker and Jozée Sarrazin will be organized.

Presentation of the project

The DEEP REST project was presented to the Biodiversa evaluating committee in January, thanks to Ana Hilario for replacing me and to Manuel Bellanger that was there online to assist her. Comments were quite positive.

DEEP REST was also presented at the kick-off meeting of the REDRESS project (led by R. Danovaro) in March as well as the EMSO-France annual meeting in April 2024.

Small info

- The final version of the **consortium agreement** has been sent to all DEEP REST partners. Only one signature is missing. We are hoping that it will be finalized in time for our second annual meeting.
- The **data management plan** needs your inputs. Please take a few minutes to identify the data you will be using during this project.
- Post-cards of our project were designed by Charline Guillou and Joelle Richard to promote it during the UN Decade meeting in Barcelona in April 2024. They will be downloadable from our web site.

Communication tools

Web site: <https://deep-rest.ifremer.fr/> on which you can access the [Partners' dedicated area](#) (authentication requested) including templates, links to the google drive, filming protocol and useful resources and official documents

Mailing to deep-rest organization team (WP1): deep_rest@ifremer.fr

General DEEP REST mailing list: deeprestall@listes.ifremer.fr

WP leader list: deeprestwpleader@listes.ifremer.fr

Our advisory board is composed of: Samantha Smith, Luciana Genio, Ricardo Serrao Santos and Claire Armstrong. You can see their profiles on the web site and contact them directly by using their mailing list: advisory_board_deep-rest@listes.ifremer.fr. Thanks to all of them to be part of our great project!

Please cite DEEP REST in your acknowledgements (publications, conferences, activities) and add the logos (found on the web site)

This research is part of the DEEP REST project that was funded through the 2020-2021 Biodiversa and Water JPI joint call for research projects, under the BiodivRestore ERA-NET Cofund (GA N°101003777), with the EU and the following funding organisations : Agence Nationale de la Recherche (ANR-21-BIRE-0003), France, Ministry of Agriculture, Nature and

Food Quality (LNV), Netherlands, Research Foundation – Flanders (FWO), Belgium, German Federal Ministry of Research (BMBF) through VDI/VDE-IT, Germany, Environmental Protection Agency (EPA), Ireland, Fundação para a Ciência e a Tecnologia (FCT), Portugal, Fundo Regional para a Ciência e Tecnologia (FRCT), Portugal-Azores and State Research Agency (AEI), Spain.

You may add the UN Decade logo and the Challenger 150 logos as we recently had their endorsement.



-The end-