



# AZORES DEESEA RESEARCH

**OCEANX 2023 CRUISE REPORT: EXPLORATION AND MAPPING OF  
DEEP-SEA BIODIVERSITY IN THE AZORES**

AJUSTE DIRETO N.º 11/DRPM/2022 - CARACTERIZAÇÃO DOS HABITATS DE PROFUNDIDADE, COM VISTA AO SEU MAPEAMENTO  
ATÉ AO LIMITE EXTERIOR DA SUBÁREA DOS AÇORES DA ZONA ECONÓMICA EXCLUSIVA PORTUGUESA

## OCEANX 2023 CRUISE REPORT: EXPLORATION AND MAPPING OF DEEP-SEA BIODIVERSITY IN THE AZORES ON BOARD THE RV OCEANXPLORER

**Autores:** Telmo Morato, Guilherme Gonçalves, Laura Neves de Sousa\*, Filipe Porteiro, Manuela Ramos, Teresa Cerqueira, João Balsa, Gal-la Edery, Carlos Dominguez-Carrió, Marina Carreiro-Silva

Instituto de Investigação em Ciências do Mar - Okeanos, Universidade dos Açores, Horta, Portugal

\*Instituto Hidrográfico, Marinha Portuguesa, Lisboa, Portugal

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**Authors:** Telmo Morato, Guilherme Gonçalves, Laura Neves de Sousa\*, Filipe Porteiro, Manuela Ramos, Teresa Cerqueira, João Balsa, Gal·la Edery, Carlos Dominguez-Carrió, Marina Carreiro-Silva

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### 1 RESUMO EM PORTUGUÊS

A campanha OceanXplorer 2023 (OCX\_2023) é a continuação da nossa estratégia de longo prazo para mapear a biodiversidade do mar profundo dos Açores e identificar áreas que se enquadrem nos critérios de Ecossistemas Marinhos Vulneráveis (VMEs). Tirando partido da nossa rede de contactos internacionais, conseguimos estabelecer uma parceria com a OceanX, uma iniciativa sem fins lucrativos da Dalio Philanthropies que “dá vida à ciência através de histórias cativantes”. A OceanX é proprietária do NI OceanXplorer que está equipado com a melhor e mais avançada tecnologia de exploração dos oceanos, incluindo dois submarinos com capacidade de mergulho até aos 1000m de profundidade e um ROV com capacidade de trabalho até aos 6000m. Nesta missão, pretendemos explorar áreas emblemáticas e pouco exploradas, mas, principalmente, tirar partido das capacidades do navio para recolha de amostras biológicas de espécimes do mar profundo para identificação taxonómica. Tal como noutros cruzeiros MapGES, os objectivos foram (i) mapear as comunidades bentónicas que habitam montes submarinos, cordilheiras e encostas insulares inexplorados, (ii) identificar novas áreas que se enquadrem na definição de Ecossistema Marinho Vulnerável da FAO, e (iii) determinar os padrões de distribuição da biodiversidade bentónica de profundidade nos Açores. Para além disto, a recolha de amostras biológicas de espécies pouco conhecidas ou não identificadas observadas nas imagens de vídeo seria também um dos objetivos principais desta missão. Os resultados deste cruzeiro somaram-se aos anteriores para identificar os drivers ambientais que determinam a distribuição espacial da biodiversidade bentónica de profundidade nos Açores. Ele também fornece informações valiosas no contexto do Bom Estado Ambiental (GES), Ordenamento do Espaço Marinho (MSP) e novos dados que ajudem à gestão sustentável dos ecossistemas do mar profundo.

A campanha a bordo do RV OceanXplorer foi composta por uma expedição destinada a visitar algumas áreas de bancos e montes submarinos mais emblemáticos dos Açores, nomeadamente os bancos Dom João de Castro e Princesa Alice. Ao todo, foram realizados 11 mergulhos de ROV e 7 de Submarino, em 5 áreas de amostragem distintas, percorrendo cerca de 19 km de fundo e produzindo 84:30 horas de imagens de vídeo.

#### **Esta campanha teve diversos destaques principais:**

No mar profundo, a missão mostrou que bancos muito explorados pela pesca demersal albergam, ainda, refúgios com um elevado valor natural e ecológico. Apesar dos dados não estarem ainda analisados com detalhe, os mergulhos de submarino e de ROV revelaram algumas descobertas surpreendentes:

1. Durante o OCX 2023 visitámos 7 áreas diferentes e cartografámos 3.840 km<sup>2</sup> de fundos marinhos, dos quais 630 km<sup>2</sup> são informação nova a incluir em bases de dados oficiais portuguesas. Pudemos participar em 8

mergulhos submarinos tripulados e 12 mergulhos com veículos operados remotamente, que produziram 84:30 horas de vídeo em alto mar, mais de 19 km de fundo e 268 amostras biológicas. Também foram realizadas 27 estações de análise de massas de água, nas quais foram coletadas 157 amostras para análise de DNA ambiental e outros parâmetros.

2. Grandes colónias de corais negros (*Leiopathes* sp.), possivelmente com mais de 1000 anos de idade, que se encontram “penduradas” em paredes íngremes do banco Princesa Alice. É possível que antes da pesca demersal explorar este banco, este corais negros arborescentes e vulneráveis à pesca fossem muito mais abundantes e de maior dimensão e idade. Estes corais possuem um crescimento muito lento e podem viver milhares de anos.
3. Uma das maiores e mais densas florestas da gorgónia *Callogorgia verticillata* encontrada nos Açores. Esta floresta de gorgónias, encontrada no monte submarino Dom João de Castro, é caracterizada por colónias em forma de leque cujos ramos emplumados lembram folhas de palmeira.
4. Densas agregações das maiores espécies de esponjas que habitam o mar profundo dos Açores (por ex., *Characella pachastrelloides*, *Haliclona magna*), no banco Princesa Alice. As esponjas têm um papel estruturante no mar profundo, aumentando a produtividade do ecossistema e criando habitat para outras espécies.
5. Um dos poucos (e pequenos) recifes de corais duros, de *Lophelia* e *Madrepora*, conhecidos nos Açores, a cerca de 850 m de profundidade, na zona dos Capelinhos, a oeste do Faial. Os recifes de corais duros possuem um papel importante nos ciclos biogeoquímicos do mar profundo, mas são muito vulneráveis à acidificação dos oceanos. Conhecer melhor a sua distribuição e a sua suscetibilidade às alterações climáticas são linhas de investigação prioritárias para o futuro.
6. Numa das áreas exploradas com sondas multifeixe, foi encontrado um canhão (ou desfiladeiro) desconhecido com cerca de 15 km de comprimento, 340 m de largura e com escarpas de cerca de 100 m de altura. Os canhões ou desfiladeiros dos Açores são habitats bastante desconhecidos e onde se poderão localizar ecossistemas únicos.
7. A expedição OceanX 2023 permitiu identificar que grande parte das comunidades bentónicas, incluindo corais e esponjas, observadas num dos principais bancos de pesca demersal dos Açores se encontram, ainda, em bom estado ambiental e possuem um elevado valor natural e ecológico. Foram, contudo, observadas algumas colónias de corais de grande longevidade com visíveis impactos da pesca. Estas observações in loco corroboram conclusão de estudos anteriores que sugerem que pesca de profundidade bem regulamentada e baseada em artes de linha e anzol (preferencialmente linha de mão) poderá contribuir para a exploração sustentável do mar profundo.
8. A utilização dos equipamentos sofisticados de exploração do mar profundo que o RV OceanXplorer dispõe, desde submarinos tripulados a um ROV que desce até aos 6000 m, permitiu recolher 232 amostra biológicas de organismos que vemos nas imagens, mas que ainda não estão identificados e que poderão ser mesmo novas espécies para a ciência.
9. Em resumo, foram encontradas áreas que se enquadram na definição de Ecossistemas Marinhos Vulneráveis, e compilou-se informação científica valiosa para o desenvolvimento de políticas que promovam a preservação do património natural, garantindo o uso sustentável do mar profundo e minimizando os impactos negativos nestes ecossistemas tão vulneráveis.

## 2 SUMMARY OF THE OCEANX 2023 CRUISE

### 2.1 MAIN OBJECTIVES

The Azores Exclusive Economic Zone (EEZ) is characterized by a complex marine seafloor, home to a large number of seamounts, ridges, trenches and abyssal plains. This variety of landscapes host rich (deep-sea) benthic habitats, where hydrothermal vents, coral gardens and sponge grounds are commonly observed. These benthic habitats are, however, exposed to anthropogenic pressures, which can put their long-term preservation at risk. Identifying areas of ecological relevance, such as those that fit the FAO criteria for defining Vulnerable Marine Ecosystems (VME), is currently of upmost importance to implement efficient management measures that would ensure the protection of the natural heritage in commitment with a sustainable use of marine resources. Recognizing this urgency, the Regional Government of the Azores, signed a memorandum of understanding over the “Blue Azores” Program, focused on promoting the conservation and sustainable use of resources, by declaring 30% of the Exclusive Economic Zone of the Azores as marine protected areas of which 10% should be strictly protected.

With the development of the Azor drift-cam, a cost-effective video platform designed to conduct rapid appraisals of deep-sea benthic habitats down to 1,000 m depth, and partnerships with the international scientific community, the amount of information regarding the composition and spatial distribution of benthic communities in the Azores was significantly enlarged over the last four years. However, the catalogue of the deep-sea benthic species of the Azores has been produced mostly based on the Azor drift-cam videos, which contains a large number of unidentified species, some of which could be new to science. In order to fill this knowledge gap, there is a need to collect biological samples of cold water-corals and sponges to make species identification from videos possible and, thus, better understanding the deep-sea biodiversity in the Azores. Having the possibility to build a true partnership with OceanX to continue deep-sea exploration in the Azores and collect biological samples of unknown species, could significantly contribute to the ongoing efforts to improve the understanding of deep-sea biodiversity in the Azores.

The OceanX 2023 (OCX 2023) is the continuation of our long-term strategy to map deep-sea biodiversity and identify Vulnerable Marine Ecosystems (VMEs) in the Azores. In this cruise, we operated from the RV OceanExplorer and planned to visit some unexplored areas such as the geomorphological structures around the Princesa Alice bank and Dom João de Castro seamount, as well as other areas near the slopes of Pico and Faial islands. As in the MapGES cruises, the objectives were to (i) map benthic communities inhabiting unexplored seamounts, ridges and island slopes, (ii) identify new areas that fit the FAO Vulnerable Marine Ecosystem definition, (iii) determine distribution patterns of deep-sea benthic biodiversity in the Azores, and (iv) determine the condition of benthic communities by looking at evidence of fishing damage to fauna, presence of lost fishing gear and marine litter. Moreover, this cruise aimed to collect biological samples of poorly known or unidentified species observed on video footage. The results of these explorations will directly contribute to the Regional Government of the Azores efforts to declare 30% of the Azores EEZ as marine protected areas of which 10% should be strictly protected. The results of this cruise added to the previous contributions to identify the environmental drivers that determine the spatial distribution of deep-sea benthic biodiversity in the Azores. It also provides valuable information in the context of Good Environmental Status (GES), Marine Spatial Planning (MSP) and new insights on how to sustainably manage deep-sea ecosystems.

## 2.2 *METHODOLOGY*

### 2.2.1 *Activity 1. Collection of video images of the seabed*

We performed several underwater video transects using the vehicles available in the RV OceanXplorer. These assets included the Argus ROV Chimaera, rated to 6000 meters depth, and equipped with several cameras and 7-function manipulator for high-dexterity sampling, and the Triton submersibles Nadir and Neptuno rated to 1000 meters and with similar sampling capabilities as the ROV Chimaera. In each of the areas or geomorphological structures to be explored, we carried out video transects from a depth of about 1 000 m to the shallowest depth of each structure. The objective was to obtain underwater images to characterize the biodiversity along the entire bathymetric gradient and substrate types of each structure and to collect as many samples of unknown species as possible. The video transects were planned according to the bathymetry data recorded for planning purposes, so that the vehicles would move from deeper to shallower areas. This methodology allows the collected images to always have the best possible quality, maximizing the area of incidence of light and avoiding its dissipation in the water column (in the case of descending transects). The transects carried out with both the ROV and the submersibles were planned to last approximately 5 to 6 hours in the seafloor, with the lasers on, at a transect speed over the benthic habitats between 0.2 to 0.5 knots, and at the closest distance to the seabed as possible to facilitate the identification of the organisms observed. The vehicles were equipped with a small CTD, which recorded environmental data every 1-2 seconds. ADCP data was also collected during the dives for the characterization of the current flows. Biological samples collected at different sites followed the taxonomic priorities of the group (mostly un-identified CWC and sponge species). During ROV and submersible surveys seawater samples were also collected at key sites using mounted Niskin bottles, to characterize the biogeochemistry of water masses (pH, TA, DIC, POM) associated with coral and sponge communities of interest. Water collected could also be used to obtain samples for eDNA analysis. Some push cores were also collected.

### 2.2.2 *Activity 2. Water column; physical, chemical and biological characterization*

Since in-situ data of water-mass characteristics is very scarce, one of the goals of the cruise is to collect information that can contribute to the understanding of the water masses distribution in the Azores. Vertical CTD/Rosette profiles could be conducted at each of the video stations at a seabed depth of about 1,000 m in order to measure physical and chemical seawater properties that characterize the dominant water masses described for the Azores: 0-150m, Mixed layer and seasonal thermocline; 150-550 m, North Atlantic Central Water (NACW); 500-1500 m, Mediterranean Outflow Water (MOW) / Subarctic Intermediate Water (SAIW, west of MAR). The North Atlantic Deep Water (NADW; >1500 m) will not be targeted during this cruise. One open-ocean control station should also be considered. The CTD and the additional sensors will collect data on conductivity, temperature, depth, fluorescence, turbidity, photosynthetically active radiation (PAR), and Dissolved Oxygen (DO). Water samples on Niskin bottles were collected at each suggested water depth: 1000 m, close to the bottom, 20-30 m above the seabed; 800 m, MOW; 400m, NACW; 75 m chlorophyll-a max (detected first Chl-a max and sample that depth); 5 m, close to the surface. On deck, water samples were collected from the different Niskin bottles, namely one 100 ml beaker filled with seawater from each Niskin bottle for measuring pH with a portable probe (3 replicates from each depth); four vials (12 ml) from the last Niskin bottle of each depth strata frozen at -20°C for measuring inorganic nutrients (NO<sub>3</sub>, NO<sub>2</sub>, NH<sub>4</sub>, PO<sub>4</sub>, Si) (4 replicates from each depth); one 4 L sterilized bottle from each Niskin bottle for filtering eDNA (3 replicates from each depth). Water samples for eDNA analyses were filtered onboard using water pumps on a dedicated wet lab.

### **2.2.3 Activity 3. MB bathymetry**

Accurate knowledge of seabed characteristics is crucial in order to effectively plan the biological surveys and to better understand the ecological processes that are observed in the video images. Considerable effort has been placed in the last few years in collecting accurate bathymetric data in the Azores region and, therefore, most areas to be visited have already been surveyed with MB. Nevertheless, we suggested conducting surveys in all 3 main areas to improve coverage or complement existing data (Princess Alice bank, D. João de Castro bank and SE Pico area). Additionally, opportunistic MB surveys were conducted during the transits. Water column logging data was also saved. The collection of backscatter data from the MB surveys was also saved in order to interpret the sediment properties of the seabed. Sound Velocity Profiles (SVP) were acquired before each survey or transit. Sound velocity profiles should be extended using climate profiles (e.g. sound speed manager). For beam guidance should be used probe sound speed. For quality control purposes it was important to perform checklines and check roll calibration to check if there were any calibration problems.

### **2.2.4 Activity 4. Science Communication**

In order to achieve our communication goals, our media team onboard Ocean Explorer was in permanent contact with the OKEANOS institute media team on land to organize social media posts about the mission. Several science communication activities were organized during the cruise, including full photo and video coverage of the scientific activities. Besides the social media posts, our team worked on a more detailed and specific coverage of the Deep Sea Research group activities, for a documentary on which there will be a sequence dedicated to the OceanX 2023 cruise and the results obtained by the research group. The scientific activities filmed included: planning the dive transects with Ocean X crew at the bridge, monitoring the ROV and submarine dives at the mission control room, CTD samples collection, diving on the submarines for biologic samples collection, storage and cataloguing the collected samples at the wet laboratory, bathymetry planning and bathymetric data processing.

### **2.2.5 Vessel**

RV OceanXplorer

### **2.2.6 Dates**

**Leg 1:** 24<sup>th</sup> August to 8<sup>th</sup> September

## **2.3 SCIENTIFIC TEAM**

Telmo Morato (chief scientist), Carlos Dominguez-Carrió, Laura Neves de Sousa, Guilherme Gonçalves, Manuela Ramos, João Balsa, Teresa Cerqueira, Gal·la Ederly, Marina Carreiro-Silva, Filipe Porteiro





Figure 1. Scientific team on the RV OceanXplorer that participated in OceanX 2023 cruise.

#### 2.4 STATISTICS

During the OXR 2023 cruise onboard the RV OceanXplorer we were able to work for 12 days, transited for 1,080 km, visited 7 different areas, and mapped 3,840 km<sup>2</sup> of seabed, of which 630 km<sup>2</sup> is new information to be included in official Portuguese databases. We were able to participate in 8 manned submarine dives and 12 remotely operated vehicle dives, which produced 84:30 hours of deep sea video, over 19 km of bottom, and 268 biological samples. We also performed 27 stations for analysis of water masses, in which 157 samples were collected for analysis of environmental DNA and other parameters.

#### 2.5 CRUISE SUMMARY

During the OXR 2023 survey we visited several areas in the central group of the Azores, namely D. João de Castro seamount and Princesa Alice bank and the slopes of Faial Capelinhos, Pico S Lajes, and Pico Ponta da Ilha (Table 1). Taking advantage of the technological assets onboard RV OceanXplorer, namely the ROV Chimaera and the Submersibles Neptune and Nadir, we were able to conduct 8 manned submarine dives and 12 remotely operated vehicle dives, one ROV D. João de Castro seamount, 3 SUB and 3 ROV dives in Capelinhos, 5 SUB and 6 ROV dives in Princesa Alice (Princesa Alice, Princesa Alice W, Bourée E), and one ROV dive in Pico S Lajes and another one in Ponta da Ilha N. From the 20 ROV and SUB dives, 19 were successful. In general both the ROV and the submersible dives covered a much smaller linear distance (average 952 m) per hour of survey (206 m·h<sup>-1</sup>) when compared to the Azores drift-cam. One of the reasons for the shorter distances was the need to collect biological samples to clarify the taxonomic identification of several organisms. During these dives, we were able to collect 268 biological samples belonging to approximately 197 different morphotypes. It is likely that this sampling effort will help solving about 100 taxonomic questions. After each ROV or submersible dive we performed a CTD cast to measure water masses properties and collect water samples for more detailed analyses. From the 27 CTD stations, 15 were specifically conducted to address deep-sea related questions, while the other stations were performed to address the Pelagic team objectives. From these 15 dedicated CTD casts, we obtained 157 water samples for different types of analyses.

**Table 1. Areas surveyed with video platforms during the Legs of OXR 2023 cruise, with information on the amount of underwater terrain explored and time of filming accomplished.**

Leg	Dates	Areas explored	Dives (n)	Dist. (m)	Bottom time (h)
1	24/08/2023-08/09/2023	Dom João de Castro seamount and Princesa Alice bank (Princesa Alice, Princesa Alice W, Bourée E) and South slopes of Faial and Pico islands	19	19.040	84:30

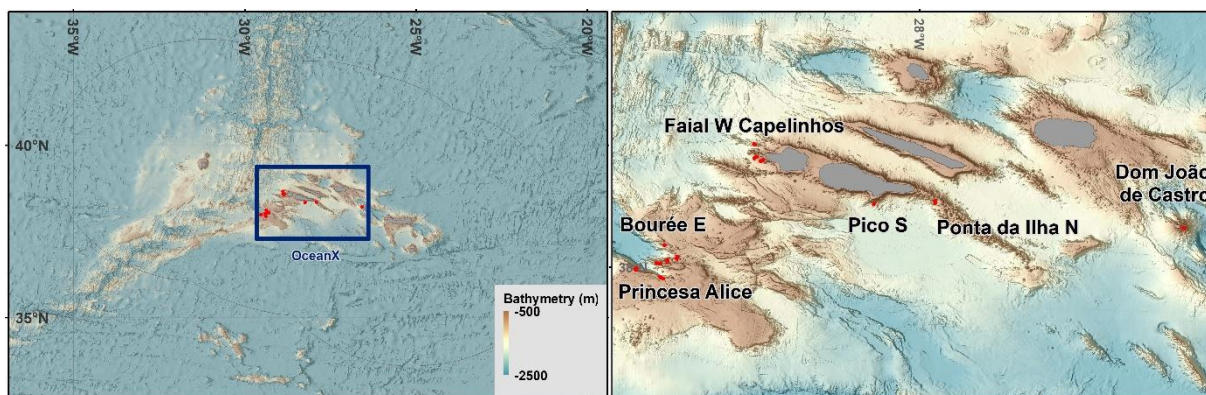


Figure 2. Location of the stations (red points) conducted during the OceanXplorer 2023 cruise.

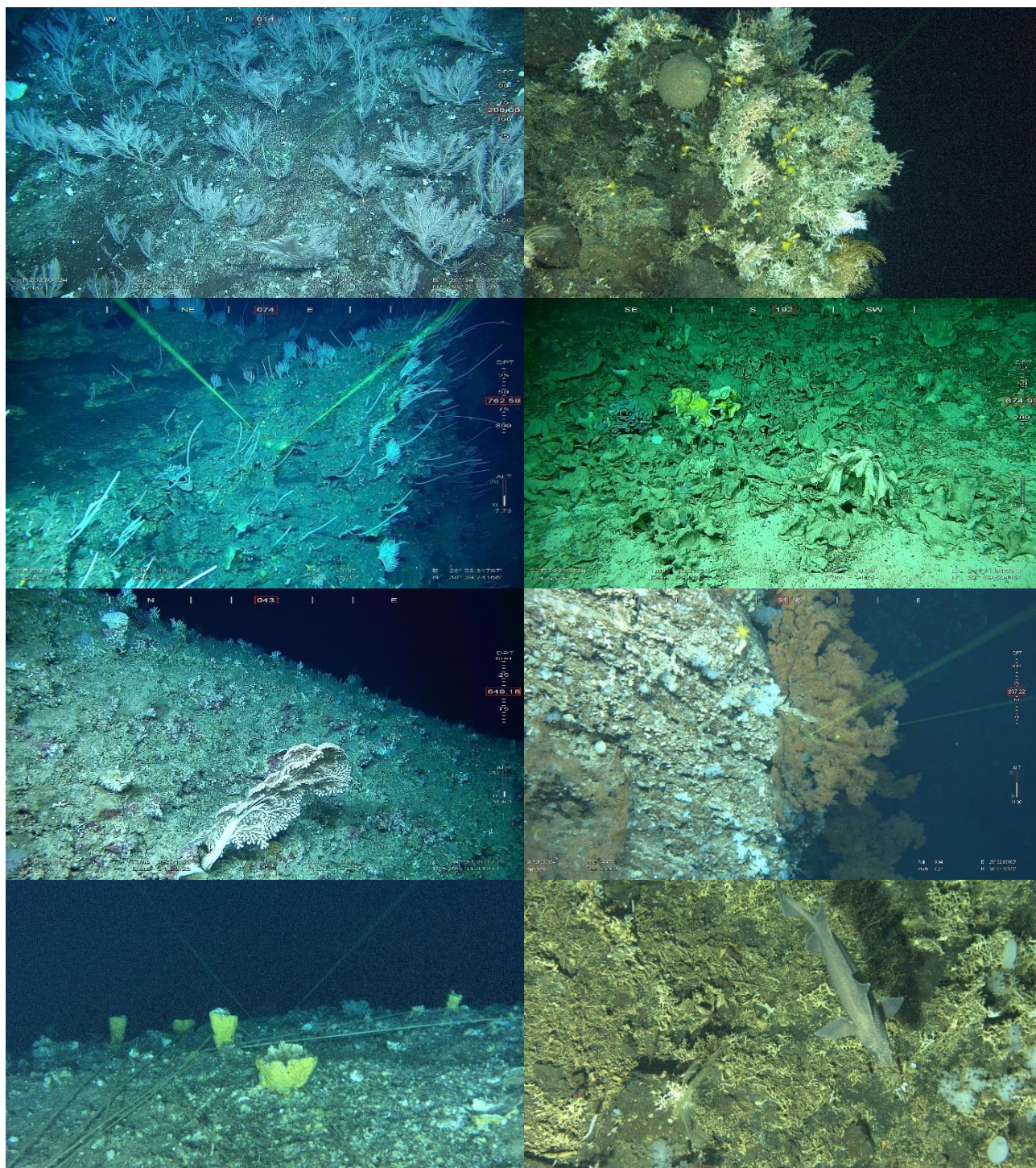


Figure 3. Highlights taken from the footage recorded during the OceanXplorer 2023 cruise onboard the RV OceanXplorer. (a) One of the densest *Callogorgia verticillata* gardens recorded in the Azores; (b) *Lophelia pertusa* and *Madrepora occulata* reef discovered south of Faial island; (c) *Narella versluysi* and *N. bellissima* aggregation; (d) Vast field of soft sediments covered in dead Lithistid sponges; (e) Large *Paragorgia johnsoni* colony on a steep slope of a ridge; (f) Outcrop covered with large, very long-lived *Leiopathes expansa* colonies; (g) Massives *Characella* spp. with several lost bottom longlines stretched across the seafloor; (h) Rare sighting of a sailfin roughshark *Oxynotus paradoxus*.

## 2.6 MAIN ACHIEVEMENTS

The deep-sea component of the OceanX 2023 expedition revealed that **banks and seamounts heavily exploited by bottom longline fishing are still home deep-sea benthic communities with a high natural and ecological value.**

1. During the OXR 2023 we visited 7 different areas, and mapped 3,840 km<sup>2</sup> of seabed, of which 630 km<sup>2</sup> is new information to be included in official Portuguese databases. We were able to participate in 8 manned submarine dives and 12 remotely operated vehicle dives, which produced 84:30 hours of deep sea video, over 19 km of bottom, and 268 biological samples. We also performed 27 stations for analysis of water masses, in which 157 samples were collected for analysis of environmental DNA and other parameters.
2. We observed many benthic communities, some of them quite special. One of the highlights of this campaign was the big basalt outcrops found at around 800 m depth that were densely colonized by many colonies of the black coral *Leipathes expansa*. Most of the colonies observed were visually healthy, particularly large, probably older than 1.000 years, and with a lot of associated biodiversity. It is possible that before demersal fishing exploited this bank, these arborescent black corals, vulnerable to fishing, were even much more abundant, larger and older. These corals are very slow growing and can live for thousands of years.
3. We also discovered one of the few hard coral reefs known in the Azores composed by the lace corals *Lophelia pertusa* and *Madrepora oculata*. This small reef was observed at around 850 m depth on the Capelinhos area, west of Faial. Hard coral reefs play an important role in the biogeochemical cycles of the deep sea, but are very vulnerable to ocean acidification. Some portions of this reef were not alive, forming a compact coral framework to which many other associated species were attached. A better understanding of their distribution and their susceptibility to climate change are priority lines of research for the future.
4. We also discovered one of the largest and densest coral garden dominated by the primnoid *Callogorgia verticillata* found in the Azores. This gorgonian forest, found on the Dom João de Castro seamount, is characterized by fan-shaped colonies whose feathery branches resemble palm leaves. Most of the colonies observed were smaller than usual, but possibly the densest aggregation of this species observed so far.
5. We observed dense aggregations of the largest species of sponges that inhabit the deep sea of the Azores (e.g., *Characella pachastrelloides*, *Haliclona magna*), on the Princesa Alice bank. Sponges play a structuring role in the deep sea, increasing ecosystem productivity and creating habitat for other species.
6. In one of the areas explored with multibeam probes, an unknown canyon (or gorge) of about 15 km long, 340 m wide and with cliffs about 100 m high was found. The canyons and gorges of the Azores are fairly unknown habitats where unique ecosystems can be found.
7. The OceanX 2023 expedition made it possible to identify that a large part of the benthic communities, including corals and sponges, observed in one of the Azores' main demersal fishing grounds are still in good environmental condition and have a high natural and ecological value. However, some long-lived coral colonies with visible fishing impacts were observed. These *in situ* observations corroborate the conclusions of previous studies which suggest that well-regulated deep-sea fishing based on hook-and-line gear (preferably handlines) could contribute to a sustainable exploitation of the deep sea.
8. The manned submarines and the ROV available on the RV OceanXplorer, allowed collecting 268 biological samples belonging to approximately 197 different morphotypes. It is likely that this sampling effort will help solving about 100 taxonomic questions, and some samples could even reveal new species to science.
9. In summary, we found areas that fit the definition of Vulnerable Marine Ecosystems, and compiled valuable scientific information to inform policies that promote the preservation of the natural heritage, guaranteeing the sustainable use of the deep sea and minimizing the negative impacts on these vulnerable ecosystems.

### 3 STATIONS SURVEYED DURING OCEANX 2023 CRUISE ONBOARD THE RV OCEANXPLORER

During the OceanX 2023 cruise onboard the RV OceanXplorer we performed a total of 47 stations (excluding one ROV dive aborted – St035) of MB, CTD and video surveys, in 7 sampling areas. Here we present a compilation of all the stations surveyed during this cruise (Table 2).

**Table 2. Metadata of the stations surveyed during OceanX 2023 cruise onboard the RV OceanXplorer.**

Station	Instrument	Location	Date	Time Start	Time End	Lat Start	Long Start	Lat End	Long End	Depth Start	Depth End
St001	MB	Faial-DJC	24/08/2023	22:40	07:38	38.2766	-27.9880	38.2107	-26.5775	1700	250
St002	CTD	D Joao Castro	25/08/2023	07:47	07:56	38.2125	-26.5780	-	-	210	-
St003	ROV	D Joao Castro	25/08/2023	09:30	15:43	38.2063	-26.5743	38.2135	-26.5743	360	227
St004	CTD	D Joao Castro	25/08/2023	16:24	16:48	38.2088	-26.5731	-	-	290	-
St005	CTD	D Joao Castro	25/08/2023	17:45	18:57	38.2224	-26.5361	-	-	1034	-
St006	MB	DJC-Faial	25/08/2023	19:56	07:30	38.2058	-26.5765	38.5706	-28.8417	215	715
St007	MB	Faial W, Capelinhos	26/08/2023	09:00	09:30	38.5719	-28.8597	38.5753	-28.8308	905	420
St008	SUB	Faial W, Capelinhos	26/08/2023	10:07	17:20	38.5713	-28.8593	-	-	820	479
St009	ROV	Faial W, Capelinhos	26/08/2023	11:31	15:56	38.5720	-28.8600	38.5764	-28.8496	832	570
St010	CTD	Faial W, Capelinhos	26/08/2023	18:39	19:35	38.5720	-28.8601	-	-	800	-
St011	MB	Faial W, Capelinhos	26/08/2023	20:17	02:00	38.5717	-28.8729	38.6319	-28.9255	901	1450
St012	CTD	Faial W, Capelinhos	27/08/2023	06:23	07:28	38.6051	-28.9150	-	-	1200	-
St013	SUB	Faial W, Capelinhos	27/08/2023	13:31	16:40	38.5870	-28.8915	38.5962	-28.8767	926	397
St014	ROV	Faial W, Capelinhos	27/08/2023	11:29	15:40	38.5902	-28.8916	38.5937	-28.8859	873	688
St015	CTD	Faial W, Capelinhos	27/08/2023	18:25	19:29	38.5874	-28.8916	-	-	918	-
St016	MB	Faial W, Capelinhos	27/08/2023	20:15	21:18	38.6151	-28.8985	38.6711	-28.9464	750	1343
St017	SUB	Faial W, Capelinhos	28/08/2023	09:49	16:35	38.6642	-28.8939	38.6607	-28.8907	964	817
St018	ROV	Faial W, Capelinhos	28/08/2023	10:52	15:50	38.6641	-28.8917	38.6624	-28.8867	820	710
St019	CTD	Faial W, Capelinhos	28/08/2023	19:27	20:39	38.6635	-28.8952	-	-	1002	-
St020	MB	Faial-PAL	29/08/2023	20:33	05:00	38.6143	-28.8747	38.0082	29.5492	456	870
St021	CTD	Princesa Alice	29/08/2023	06:19	08:51	38.0455	-29.5065	-	-	1500	-
St022	SUB	Princesa Alice	29/08/2023	10:04	16:37	37.9943	-29.5265	37.9846	-29.5318	936	344
St023	ROV	Princesa Alice	29/08/2023	11:23	16:03	37.9947	-29.5293	37.9891	-29.5349	870	373
St024	CTD	Princesa Alice	29/08/2023	18:01	18:47	37.9942	-29.5273	-	-	880	-
St025	MB	Princesa Alice	29/08/2023	20:25	23:55	37.9210	-29.6277	38.0353	-29.5088	786	2375
St026	SUB	Princesa Alice	30/08/2023	09:18	16:20	38.0561	-29.9706	38.0448	-29.9777	831	523
St027	ROV	Princesa Alice	30/08/2023	10:25	15:49	38.0559	-29.9763	38.0492	-29.9806	812	551
St028	CTD	Princesa Alice	30/08/2023	17:52	18:49	38.0597	-29.3192	-	-	1083	-
St029	MB	Princesa Alice	31/08/2023	00:40	07:00	37.9903	-29.5114	38.0223	-29.4197	1088	912
St030	SUB	Princesa Alice	31/08/2023	09:12	16:36	38.0214	-29.4185	38.0221	-29.3970	924	528
St031	ROV	Princesa Alice	31/08/2023	10:31	16:03	38.0239	-29.4163	38.0213	-29.4026	722	615
St032	CTD	Princesa Alice	31/08/2023	19:00	20:06	38.0235	-29.4220	-	-	1008	-
St033	MB	Princesa Alice	31/08/2023	20:41	00:30	37.9917	-29.3828	37.9043	-29.0497	1097	1377
St034	SUB	Princesa Alice	01/09/2023	09:48	12:15	38.1183	-29.3773	38.1214	-29.3757	960	957
St035*	ROV	Princesa Alice	01/09/2023	10:34	11:36	38.1169	-29.3753	38.1171	-29.3753	935	963
St036	ROV	Princesa Alice	01/09/2023	12:51	16:11	38.1169	-29.3781	38.1215	-29.3760	997	747
St037	CTD	Princesa Alice	01/09/2023	18:15	19:02	38.1163	-29.3667	-	-	1000	-
St038	MB	Princesa Alice	01/09/2023	20:00	03:09	38.1018	-29.3611	37.7948	-28.1292	882	514
St039	SUB	Princesa Alice	02/09/2023	09:19	16:38	37.9492	-29.4001	37.9399	-29.3841	836	413
St040	CTD	Princesa Alice	02/09/2023	18:02	19:06	37.9492	-28.6033	-	-	800	-
St041	MB	Princesa Alice	02/09/2023	19:58	04:21	37.9319	-29.3685	37.8524	-29.2518	538	384
St042	ROV	Princesa Alice	03/09/2023	08:13	14:44	38.0412	-29.3629	38.0311	-29.3583	887	487
St043	CTD	Princesa Alice	03/09/2023	15:23	16:26	38.0412	-29.3630	-	-	850	-
St044	CTD	Pico S Lajes	06/09/2023	18:16	19:13	38.3382	-28.2480	-	-	900	-
St045	ROV	Pico S Lajes	06/09/2023	19:13	23:37	38.3382	-28.2480	38.3451	-28.2437	1085	789
St046	ROV	Ponta da Ilha N	07/09/2023	17:59	22:26	38.3453	-27.9153	38.3577	-27.9186	839	400
St047	MB	Pico S Lajes	08/09/2023	22:56	02:22	38.3577	-27.9189	38.2459	-28.1537	429	1775

\*Aborted dive

#### 4 CRUISE DIARY OF OCEANX 2023 CRUISE

##### 24 August 2023

We started the first day of the mission by packing all our gear during the morning and bringing it to the RV OceanXplorer at around 11:00. After everyone having tested negative for COVID-19 on board, we had lunch on land and returned to the vessel at around 14:00. Telmo and Jorge gave a quick interview to RTP and RDP, explained the main goals of the mission and the assets available on the vessel. We did the familiarization and safety briefings around the vessel and left Horta harbour at 18:00. The weather forecast for the next 3-4 days showed moderate to strong winds blowing from ENE with the swell peaking up to 2.5m. With this forecast it seemed very unlikely that we would be able to work in Princesa Alice before the 30<sup>th</sup> of August. With this weather, it would not be possible to deploy the 14m long RV Metal shark, making the pelagic work unlikely to happen. We had several meetings in the Mission Control room with the OceanX scientists and on the Bridge with the Captain and agreed on a plan. Since the pelagic team needed to stay in Princesa Alice bank for 3-4 days and considering the reduced number of working days caused by the bad weather, we decided to try to work in D. João de Castro before heading to PAL. We started transiting to D. João de Castro seamount and performed St001 of the Cruise: a MB survey.



Figure 4. Photos of the first day of the OceanX 2023 cruise.

##### 25 August 2023

During the transit to D. João de Castro seamount some bathymetry data of unsurvey areas was acquired using the OceanXplorer vessel's systems Kongsberg EM712 and EM304 (St001). This data aimed to fill the gaps

identified by the IH and contribute to the Seamap 2030 program. In addition, the deep-sea team asked to survey the south part of D. João de Castro seamount to find evidence of a reported hydrothermal vent between 150 and 250m depth. At the beginning of the day, it was identified some potential hydrothermal activity on position latitude 38.212N, longitude 026.578W using water column data from EM 304 and EK80 raw data. At around 07h30 we conducted the first CTD cast at 195m depth to verify any temperature anomalies associated to the potential vent site (St002). This information was requested by the submersible chief officer in order to evaluate if it would be safe to deploy the subs around this position. Apparently, for safety reasons the sub will not get close to areas that show a  $>5^{\circ}\text{C}$  increase in temperature.

After detecting a change in the water column based on MB data collected during the night on D. Joao de Castro, we studied the option of operating both submersibles and ROV over the preferred transect lines. However, due to swell and wind conditions, the crew informed us that operating the submersibles concomitantly with the ROV would not be possible. After another quick briefing, the line over which the ROV would be performing the transect was re-drawn, having as an end-point the position of the anomalies previously detected on the MB data, at about 180m depth. We started the ROV dive (St003) at 09h30. After having reached the bottom, we started to transit along the pre-defined path and we began to observe what would become one of the largest and densest aggregation of *Callogorgia verticillata* we have seen so far in the Azores. Probably due to their small/medium sizes, it often reached densities of roughly 10 colonies per square meter, which was quite impressive to witness. Most of the seafloor on the first half of the dive was completely dominated by this species. As we transited towards shallower sections of the dive, faunal community shifted at around 240m to a sponge-dominated one, with impressively high diversities and abundances. *Leiodermatium* sp., *Neophrissospongia nollitangere*, *Macandrewia azorica*, and many other smaller and abundant species colonized the seafloor. In fact, most of the rocky substrate was nearly 100% covered by fauna up until 180m, where another community shift took place, with some black coral colonies of the species *Leiopahtes glaberrima* colonizing the landscape. In terms of mobile fauna, *Pontinus kuhlii* and *Serranus atricauda* were among some of the fish species observed. After the ROV dive, we conducted a CTD cast (St004) close to the detected aggregation of *Callogorgia verticillata* and another CTD cast (St005) in a deeper area with about 1000m depth to collect data and water samples for water masses characterization.

After the ROV arrived on deck we prepared and stored all biological and water samples. Part of the team had the daily science & media meeting at 18:30 and the daily evening planning meeting at the bridge at 19:30. Due to bad weather forecast it was decided to look for a sheltered area to work the next day and therefore transited from D. João de Castro seamount to Baía do Varadouro (Faial). We started a MB survey at around 20:00 (St006).

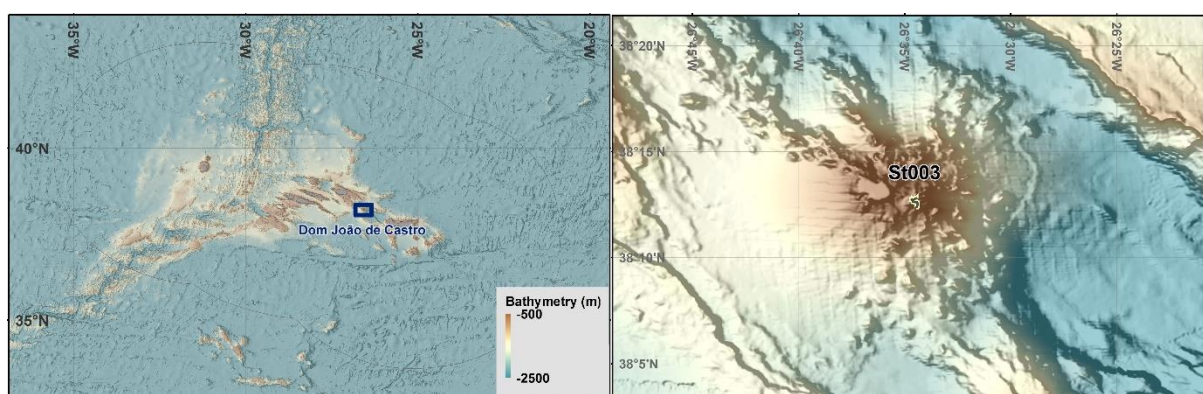


Figure 5. Map showing the ROV station conducted on the first day of the OceanX 2023 cruise.

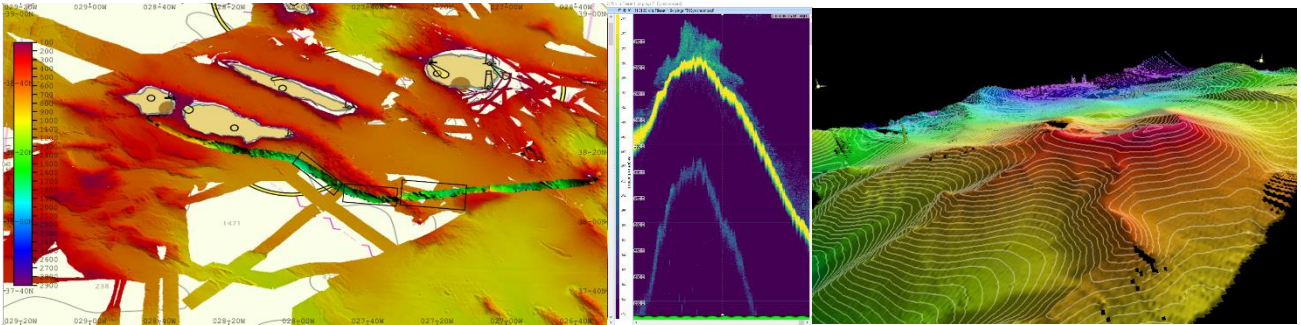


Figure 6. Bathymetry surveyed during the transit from Faial Island to Dom João de Castro seamount, anomalies detected by the EK80 at Dom João de Castro seamount, and the bathymetric data collected to plan the ROV dives.

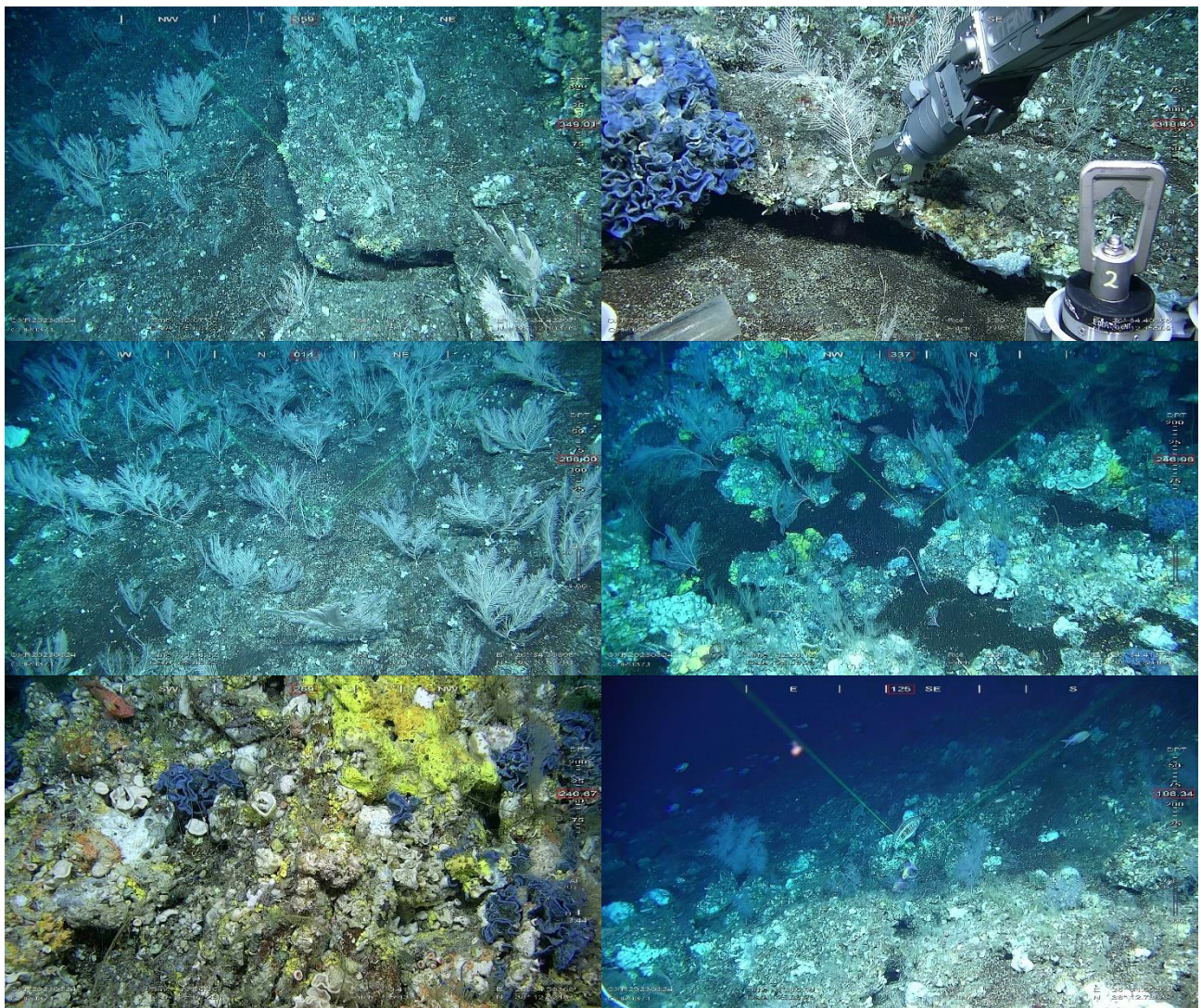


Figure 7. Screenshots taken from the ROV Chimaera video footage recorded during day 1 of the OceanX 2023 cruise in Dom João de Castro seamount.





Figure 8. Life on board OceanXplorer during the OceanX 2023 cruise.

### 26 August 2023

During the night, we performed a MB station (St006) while in transit from D. João de Castro to Faial Island, to collect data for Seabed 2030 and Seamap 2030. Most of the transit was already surveyed but there we had the opportunity to have a 40 nm line of new data using the vessels' MB system. Before deploying the ROV there was time for a quick MB survey (St007) to collect higher resolution data in the diving area. Unfortunately, the data was not saved in the hard drives because all the hydrographers were on Metal Shark, the OceanX 14m long yacht.

The weather conditions on the sheltered southwestern side of Faial island were much better. After the 07:30 bridge planning meeting, it was decided to move ahead with the submersibles and ROV dive. A Subs briefing was held on the bridge with the Captain, the Subs and ROVs team leaders. The Submersibles Neptune and Nadir were deployed at around 10:00 (St008) with Marina and Pepe Brix on the science Sub (Neptune) and Filipe Porteiro on the media Sub (Nadir). This dive aimed to explore a small structure close to Faial Novo in Capelinhos.

After the SUBs reached the seafloor, we started the deployment of the ROV Chimaera (St009) at around 11:30. The submersible dive started at 840m depth, in areas of soft bottom with a few boulders. Sponges of the species *Regadrella phoenix*, *Farrea occa*, and *Aphrocallistes beatrix* together with the xenophyophore *Syringamina* were commonly observed on soft sediments, while the octocorals *Swiftia* sp. and *Gersemmia* sp. and the solitary hard coral *Leptosammia formosa* colonized boulders. Samples of all these species were collected. At around 770m, the benthic community changed in composition to mixed assemblages of the octocorals *Narella versluysi* and small *Narella bellissima*, with the presence of the octocoral, likely of the genus *Villogorgia*, on boulders and large hydrozoans on sand patches. Towards the end of the dive, at 550-600 m, the presence of large sponges of the genus *Characella* was also noticed and successfully collected. Several fish species were also detected, such as *Helicolenus dactylopterus*, *Mora moro*, *Synaphobranchus kaupii*, *Hoplostethus mediterraneus*, a kitefin shark *Dalatia licha* and a bluntnose sixgill shark *Hexanchus griseus*. The Sub dive ended at 470m depth, at around 16:30.

The ROV transect started at around 830m depth, mostly over soft bottoms. In fact, most of the dive was dominated by this type of substrate, with lots of sediment and marine snow, typical of island slopes. Nevertheless, we got to see some interesting assemblages of glass sponges of the species *Regadrella phoenix*, *Farrea occa*, and *Aphrocallistes beatrix*, having managed to collect a sample of the latter in very good conditions. We also managed to collect a purple crinoid, a colony of a white plexaurid and a small octocoral, likely of the genus *Acanthogorgia*. Several white whip corals, possibly of the species *Narella versluysi* were also observed, together with small *Narella bellissima* colonies as well. Several fish species were also detected, such as *Helicolenus dactylopterus*, *Mora moro*, *Synaphobranchus kaupii*, *Hoplostethus mediterraneus*, a kitefin shark *Dalatia licha*, and a large ray *Dipturus intermedius*. During the morning, Telmo had an interview with the OceanX media team to explain the objective of the cruise but most importantly, why it is important to explore the deep-sea. After the ROV dive, we conducted a CTD cast (St010) at the location where the ROV dive started, at around 800m depth, collect data and water samples for eDNA and water masses characterization.

After the SUBs and the ROV arrived on deck we prepared and stored all biological and water samples. The daily science & media meeting was not held but we met at the bridge for the daily evening planning meeting at 19:30. It was decided to stay in the area for an EK80 and MB survey. Due to a tight schedule, the MB station (St011) was a little bit shorter. It was only possible to survey for approx. 2 hours in order to let the pelagic group to operate the EK80 echosounder during the night period.

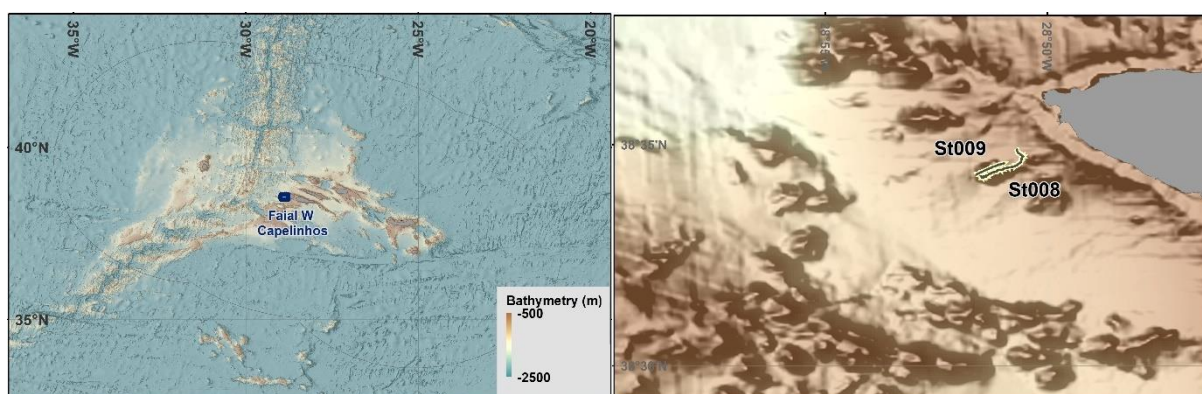


Figure 9. Map showing the ROV and Submersible stations conducted during the 26<sup>th</sup> August 2023 on the OceanX 2023 cruise.

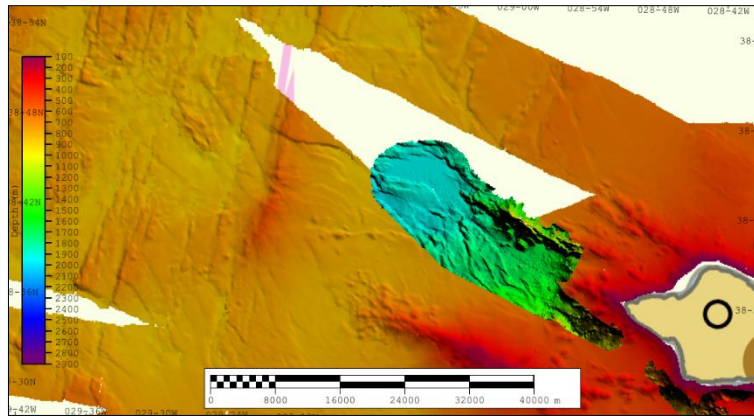


Figure 10. MB surveyed area on the 26<sup>th</sup> of August 2023.



Figure 11. Screenshots taken from the ROV Chimaera video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on the 26<sup>th</sup> of August 2023.



Figure 12. Life on board OceanXplorer during the OceanX 2023 cruise.

### 27 August 2023

The new MB data was used to have better data resolution on the ROV dive site. The 3D model was created based on IH previous data as well as the acquired data. This morning the pelagic team conducted an experiment with a new internal tag implanted in a *Remora remora* attached to the CTD structure (St012). We used the data for water masses characterization. At the 07:30 meeting at the bridge, it was decided to move forward with the submersibles and ROV dives in an area close to the old Capelinhos lighthouse where we were searching for a patch of *Lophelia* and *Madrepora* that resembles a small reef. Today, we had Telmo and Manuela in the science sub and Laura Neves de Sousa, from the Hydrographic Institute, in the media sub.

The submersibles (St013) were in the water at around 10:31 while the ROV (St014) waited for them to reach the seafloor before being launched at around 11:30. As soon as both subs arrived at bottom, at around 940m, an impressive coral reef composed of *Lophelia pertusa* and *Madrepora occulata* was observed, with most of the seafloor covered in dead coral framework. Within 20 minutes of bottom time, several samples were already collected. Composing this reef, several other species were also observed, such as *Paramuricea* and plexaurids, *Errina cf. atlantica*, *Leptosammia formosa*, as well as some glass sponges (*Regadrella phoenix* and *Farrea occa*, for instance). As the dive progressed, *Candidella imbricata* and *Narella versluysi* started to dominate the community in high abundances. After around 500m, another community shift began to take place, where *Acanthogorgia* sp. and *Errina dabneyi* composed most of the benthic faunal assemblage seen, together with more sporadic species such as *Dentomuricea* aff. *meteor* and cf. *Muriceides paucituberculata*. Several fish species were spotted throughout the dive, including *Beryx decadactylus*, *Trachyscorpia cristulata*, *Lophius piscatorius* and a large shoal of *Pagellus bogaraveo*. Deep-sea sharks of the species *Hexanchus griseus* and *Dalatias licha* were also observed, as well as rare sighting of a sailfin roughshark *Oxynotus paradoxus*. Two squids were also seen calmly hovering above the seabed. The dive ended at 16:15 at around 400 m depth.

As the ROV got to the bottom, a similar faunal community was observed, with some of the same species composing it in relatively high densities, such as *Candidella imbricata*, *Errina atlantica*, *Leptosammia formosa*, several different Plexaurids and some glass sponges including *Regadrella phoenix* and *Farrea occa*. As the dive progressed towards shallower sections of the ridge, the seafloor became poorer in terms of fauna, with volcanic rubble composing most of the substrate observed until the end of the dive. This afternoon, Filipe Porteiro had an interview with the OceanX media team where he explained his area of expertise and main interest for this expedition.

After the vehicles were on deck, we conducted a CTD station (St015) close the area where the *Lophelia pertusa* and *Madrepora oculata* small reefs were observed. We started processing all the samples collected by both vehicles right away. During the 19:00 bridge meeting with the captain, the OceanX scientific crew asked to anchor the vessel in Praia do Norte Bay to proceed with the calibration of the EK80 sounder. In case it would not be possible because of weather or other constrains, we would be allowed to conduct subs and ROV dives. We started a MB survey (St016) on the potential diving area, before the pelagic team conducted an EK80 survey.

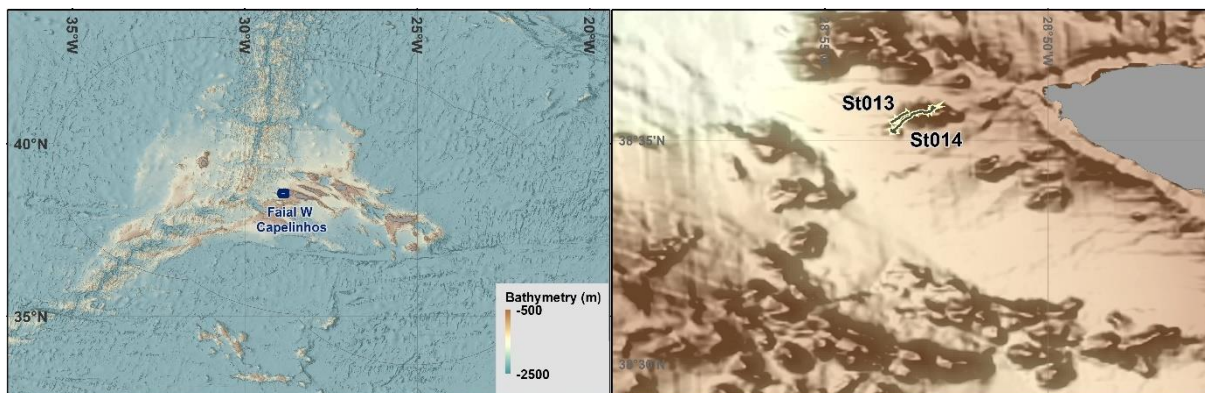


Figure 13. Map showing the ROV and Submersible stations conducted on 27<sup>th</sup> of August 2023 on the OceanX 2023 cruise.

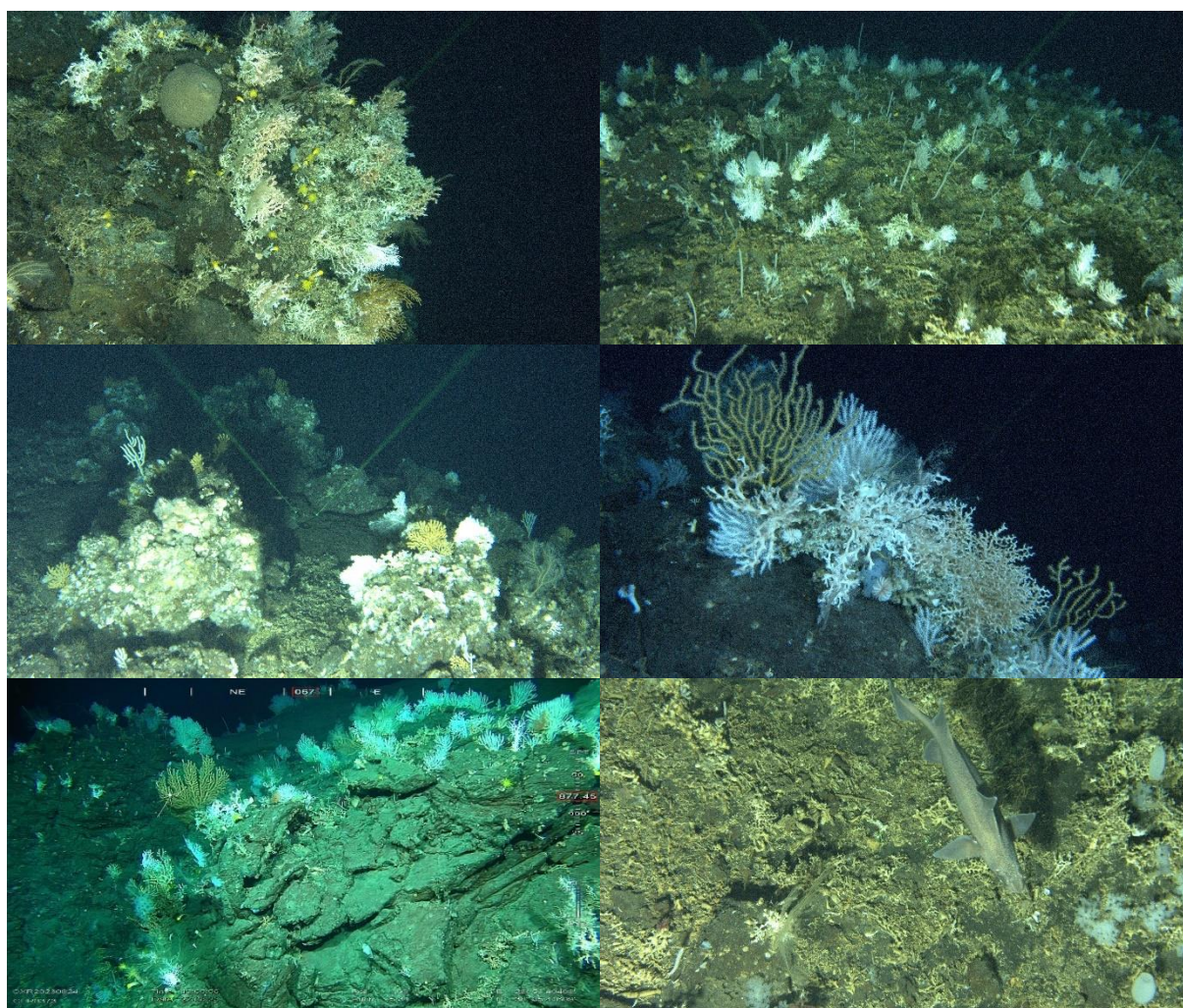


Figure 14. Screenshots taken from the ROV Chimaera and SUB Neptune video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on 27<sup>th</sup> of August 2023.



Figure 15. Life on board OceanXplorer during the OceanX 2023 cruise.

### 28 August 2023

During the early morning weather check meeting on the bridge, it was decided to cancel the EK80 calibration due to the strong currents in the area. Therefore, the alternative plan of making a dive in a small ridge located close to Praia do Norte moved forward. Today, we had Guilherme and Filipe diving in the science sub Neptune and Jorge Fontes diving in the media sub Nadir. The plan was to explore the lower and the middle parts of the steep wall with the Subs while the ROV would explore the upper part and its crest.

The submersible dive (St017) started at around 09:30 and reached the bottom at about 964 m depth at 11:00, immediately observing an impressive array of coral species, with considerable diversity. It was mostly composed by *Candidella imbricata*, *Acanella arbuscula*, *Lophelia pertusa*, several different plexaurid species and some colonies of *Leiopathes expansa*, all covering rocky and steep terrain. We promptly started sampling species that need taxonomic clarification, including some black corals, plexaurids and also a large anemone. We also collected a small branch of a large colony of the “bubble-gum” coral *Paragorgia cf. johnsoni*. After spending some time at roughly the same depth, we started to slowly transit up and along the wall in order to cover some ground on shallower areas. Unfortunately, up until 850m, the substrate observed was quite bare, which prompted us to go down again until the base of the hill, where we observed the similar faunal composition as in the beginning. An impressive black-coral colony of the genus *Bathypathes* was also observed, having been one of the highlights of the dive. We also spotted many *Mora moro*, and *Neocyttus helgae* on these deepest sections of dive. After several communication issues between the media sub and the vessel and after the control reporting back bad weather conditions, we had to cut the dive short in order to bring the subs back on deck safely.

The ROV (St018) was launched at 10:50 and surveyed mostly the top of the crest between 820 and 770m depth where the benthic communities were mostly dominated by *Narella bellissima* and *N. versluysi*, which occurred in impressive densities. *Leptopsammia formosa*, *Anthomatus sp.*, and *Acanthogorgia sp.* were also among the coral species observed. Lamellate sponges including *Poecilastra compressa* and *Desmacella grimaldi* were also a part of this community. During the transect we also observed occasional black coral colonies of the genus *Leiopathes* and *Bathypathes* and a few bird’s nest *Pheronema carpenteri*. On the edge of the cliff, we were able

to observe some colonies of *Hemicorallium tricolor*, *H. niobe* and *Errina atlantica*. When looking down the wall we couldn't see any particular large colonies of black corals or other species. The dive ended at 16:40 at 397 m depth.

During the afternoon, Marina recorded an interview with the OceanX media team where she explained her objective for the cruise including details of her research line. After the vehicles were on deck we started sorting and processing the water and the biological samples but could not finish processing them all on this day. Marina was offered a ride on the Helicopter to bring the live corals to the University's deep-sea lab. During the 19:00 Bridge meeting it was decided to transit to Princesa Alice to work on this seamount for 4 to 5 days. We also spent a large portion of the night working on the cruise log and the specimens log file. We conducted a CTD cast (St019) and started a MB survey (St020) on the way to Princesa Alice.

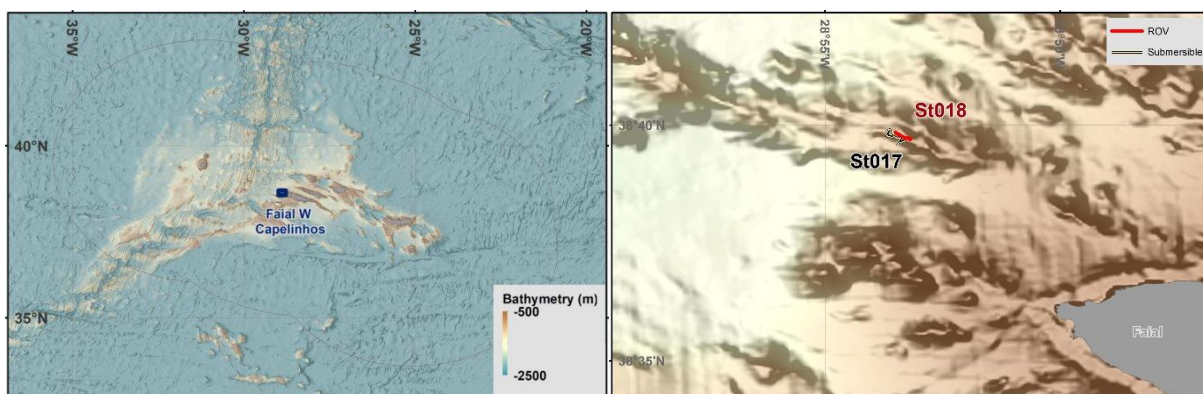


Figure 16. Map showing the ROV and Submersible stations conducted during the 28<sup>th</sup> of August 2023 on the OceanX 2023 cruise.

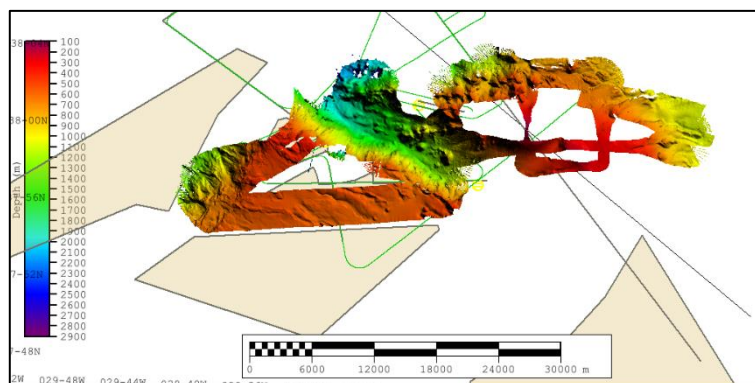


Figure 17. Map showing the station conducted during the 28<sup>th</sup> of August 2023 on the OceanX 2023 cruise with the EK80 transects.

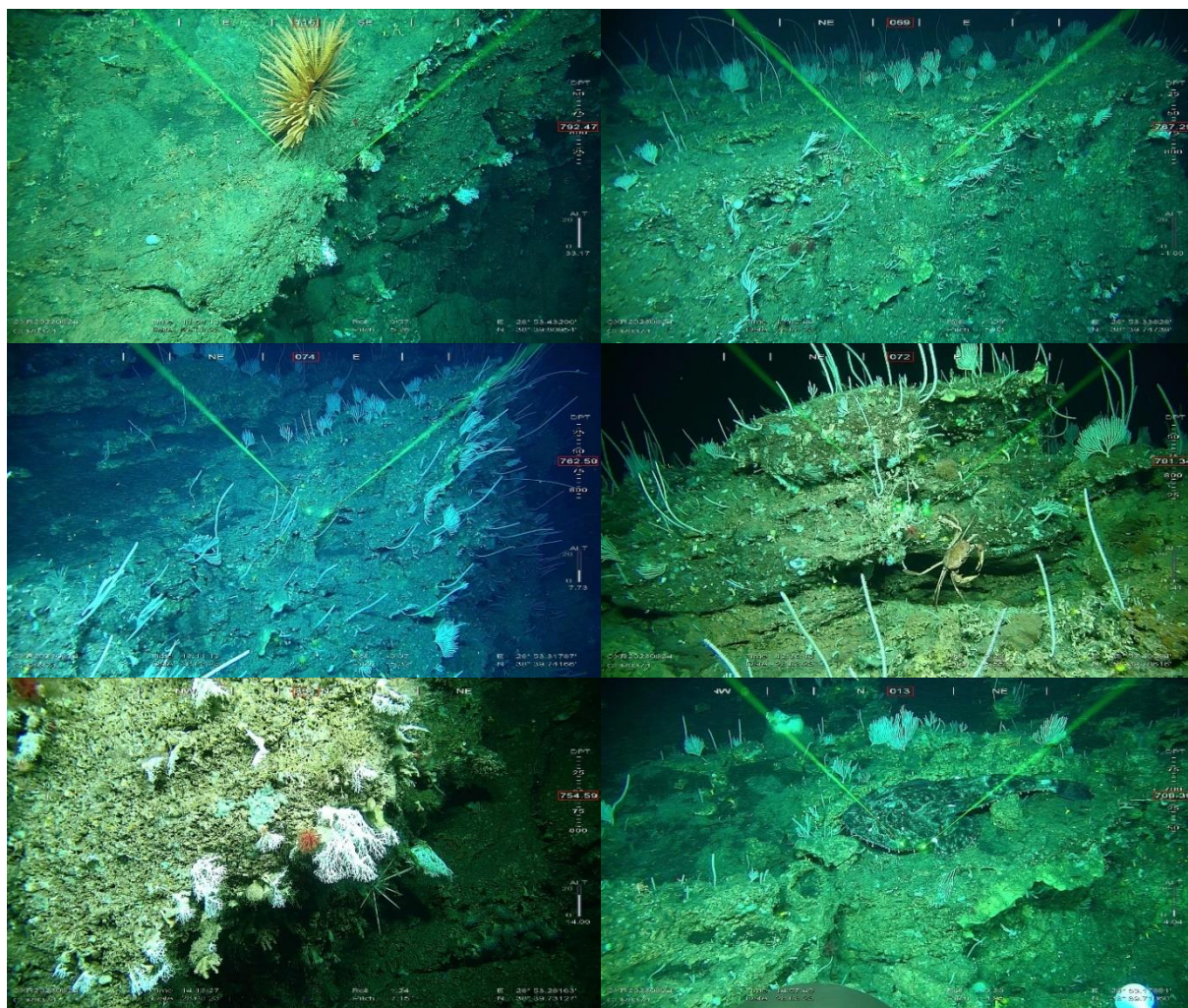


Figure 18. Screenshots taken from the ROV Chimaera video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on the 28<sup>th</sup> of August 2023.



Figure 19. Life on board OceanXplorer during the OceanX 2023 cruise.



### 29 August 2023

During the night, besides conducting the MB survey along a track line to Princesa Alice, we surveyed a small, unexplored area to help selecting the diving site for the day. The daily plan was agreed on the previous evening, so no early morning planning meeting was done. Today, we had Telmo and Manuela diving in the science Sub Neptune and Marina diving in the media sub Nadir. The plan was to explore an almost vertical cliff located southwestern of the Princesa Alice shallow peak. The Subs and the ROV would explore different locations along the wall. After the 09:00 Subs briefing in the Bridge part of the team headed to the submersibles while Filipe and Guilherme prepared for the ROV dive.

The submersible dive (St022) started at around 09:40, reaching the seafloor at 950m depth by 11:30. We landed right in front a steep wall covered with sediment in the less steep areas. Here we spotted some *Pheronema carpenteri*, a couple of *Mora moro*, and the shrimp *Aristaeopsis edwardsiana*. We started ascending the bare rock vertical with only a few sponges and some colonies of *Hemicorallium niobe* and *Pliobothrus symmetricus* and some fish *Neocyttus helgae* and *Helicolenus dactylopterus*. At around 850m depth we found an area with several colonies of black coral *Leiopathes expansa* with some associated fauna including shark eggs cages. During the first part of the dive, we collected multiple samples of different sponges, black corals and one oyster. The wall continued showing bare rock with several species of sponges (e.g., *Farrea occa*, *Regadrella phoenix*, *Asconema*, *Stylocordilla pellita*), sparse colonies of cf. *Errina atlantica* and *Leiopathes expansa*. We reached the top of the first wall at around 720 m depth where we spotted some *Pheronema carpenteri* and some *Narella bellissima* and one kite fin shark *Dalatias licha*. During the rest of the dive, we continued observing several sponges dominated communities (e.g., *Characella pachastrelloides*, *Neophrissospongia nolitangere*, *Leiodermatium* sp., *Macandrewia azorica*, among many other smaller sponges) and spotted several *Helicolenus dactylopterus*, two wreckfish, a conger eel (*Conger conger*). We reached the top of the feature at about 370 m depth where we spotted some colonies of *Callogorgia verticillata*, one crossed by a fishing line, and *Acanthogorgia* sp., and a school of *Apogon* sp. living on the crevice. The media submersible made some shoots of the science sub and then we started ascending to the surface at 16:37.

The ROV dive (St023) reached the bottom at at 11:59, having promptly collected two large sponges. It surveyed similar communities to those observed by the submersibles. The terrain was quite steep in the beginning of the transect, with large basaltic outcrops being the dominating type of substrate. An interesting array of sponge species was observed, among which *Farrea occa* and a *Pheronema carpenteri* being the most common glass sponge species seen. After going over 800m depth, the substrate shifted to sandy bottoms, only colonized by a few Foraminifera and some glass sponges *Hyalonema thomsonis*. Around 680 m we started to observe what looked like thousands of dead lithistid sponges covering the sea-floor, making an impressive sight. Towards the end of the dive, we began to see large basalt outcrops covered by a vast array of sponge species, between 600 and 400m depth, with *Characella pachastrelloides*, *Neophrissospongia nolitangere*, *Macandrewia azorica*, *Geodia* sp and many smaller sponges.

After the vehicles were back on deck and after dinner at 18:00, we started sorting and processing the water and the biological samples. During the short 19:00 bridge meeting, we agreed on a plan for the next day. We conducted a CTD cast (St024) close the areas with black corals and started a short MB survey (St025) close to the Princesa Alice summit.

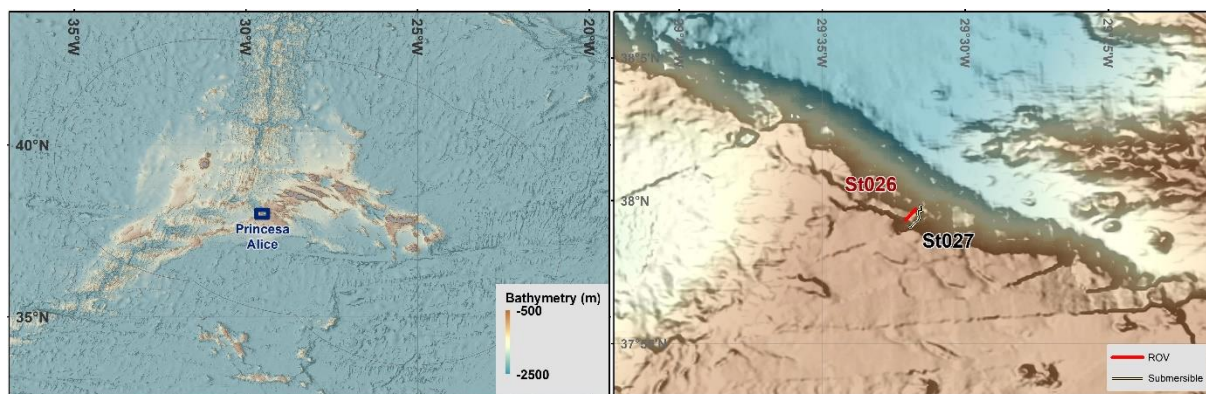


Figure 20. Map showing the ROV and Submersible stations conducted during the 29<sup>th</sup> August 2023 on the OceanX 2023 cruise.

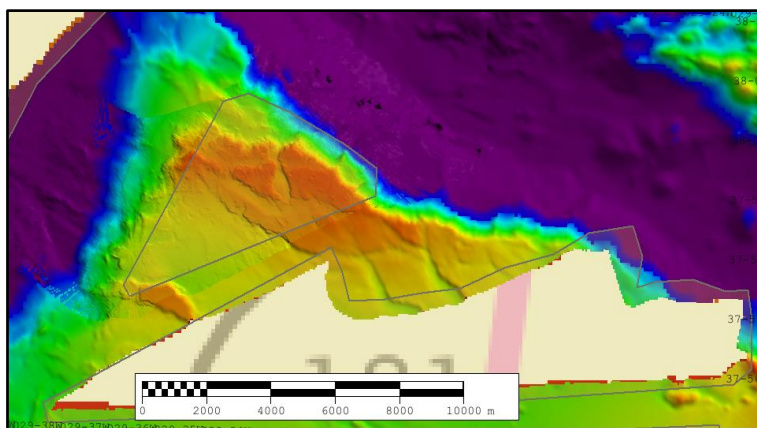


Figure 21. MB survey on the 29<sup>th</sup> August on the unsurveyed area (filled polygon) - variable resolution coverage (VRS).

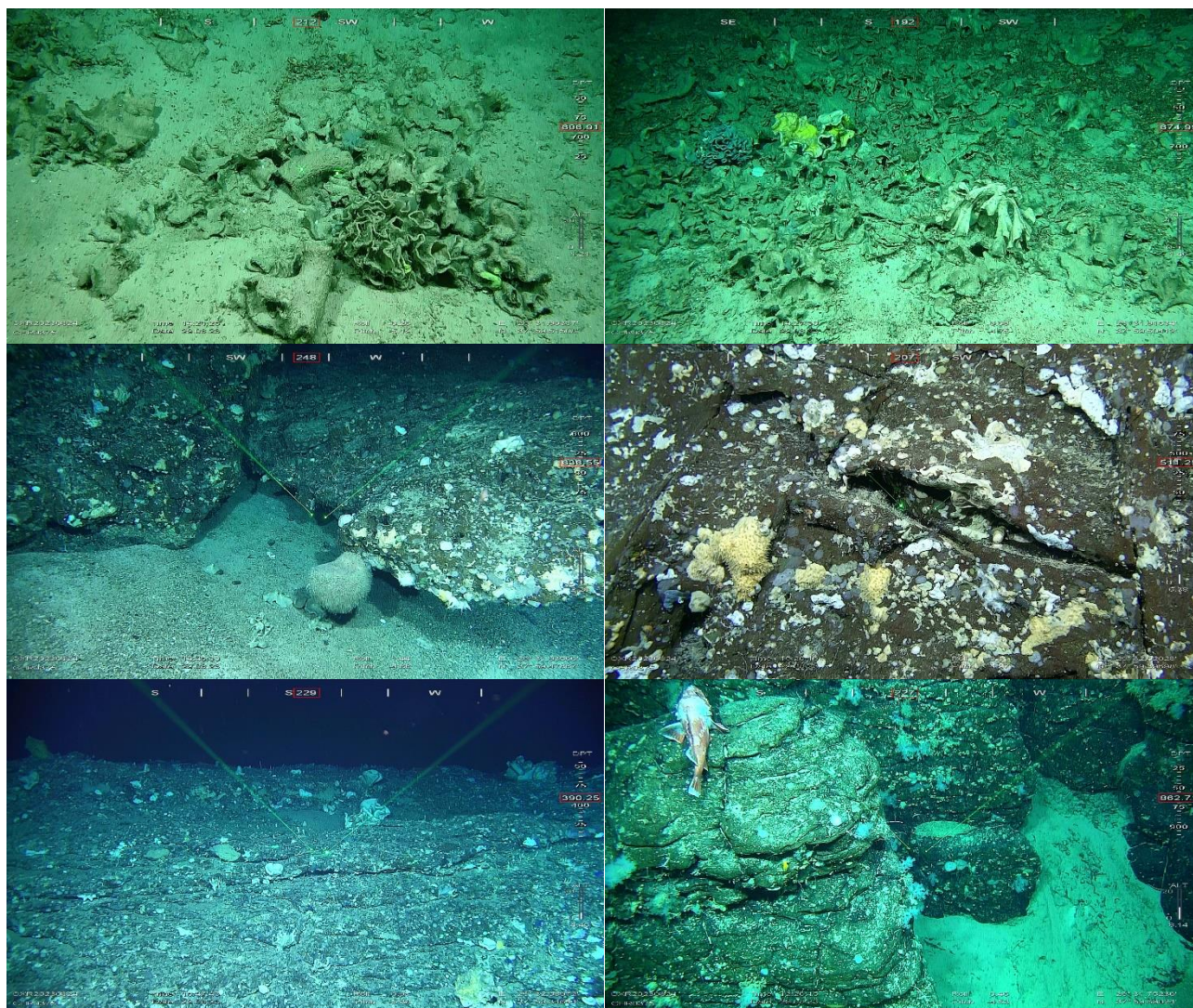


Figure 22. Screenshots taken from the ROV Chimaera video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on the 29<sup>th</sup> of August 2023.



Figure 23. Life on board OceanXplorer during the OceanX 2023 cruise.

### 30 August 2023

We started the day with the 08:30 Sub planning meeting in the Bridge, where it was decided to maintain the plan of exploring the northern flank of the Princesa Alice seamount. The Subs and the ROV would explore different locations along the small ridge like features. Today, we had Filipe and Guilherme diving in the science sub Neptune and Pedro Afonso in the media sub Nadir. The team headed to the submersibles while the rest of the team finalised identifying the samples collected in the previous day and organized the data and the report.

The submersibles (St026) were in the water at around 09:18 while the ROV (St027) was launched at 10:25, after the subs had reached the seafloor. Both vehicles would be operating in areas quite close to each other and, in fact, somewhere along the dive, we were able to see one another on the seafloor at a distance of about 50m apart. Naturally, faunal composition for both dives was quite similar. As soon as the subs reached the seafloor, a large shoal of *Hoplostethus mediterraneus* was immediately spotted and right after that, a sand-tiger shark inspected both subs. Topography-wise, the area surveyed was particularly interesting, with both submersibles going over several large hills throughout the dive, where the substrate of the peaks was consistently tall, vertical basalt walls, while their bases were composed of consolidated sedimentary rock. It was interesting to witness completely different faunal compositions associated to each substrate within a few meters of distance from each other. The start of the dive was characterized by a diverse community of mostly sponge species such as

*Farrea occa*, *Aphrocallistes beatrix* and *Asconema* sp. Up on the basalt outcrops, oysters *Neopycnodonte zibrowi* were usually spotted under overhangs, together with *Cyathidium foresti*. Three surprisingly large *Haliclona magna* were also observed at the top of the first hill. After a few hundred meters of transect covered, the birds's nest *Pheronema carpenteri* began to dominate the seafloor and after a few hundred meters more, massive specimens of the species *Characella pachastrelloides* started to be predominant and eventually dominating the faunal assemblage. Other sponge species composed the community as well, such as *Petrosia crassa*, *Macandrewia azorica* and *Desmacella grimaldii*. Near the end of the dive, we navigated over a large section of dead coral framework, mostly of *Errina dabney*. Having completed the full length of the transect sooner than expected, we ended the dive by exploring a flat top colonized by a few large colonies of *Callogorgia verticillata*. Several lost bottom longlines were also spotted on the shallower sections of the dive, as well as a large monkfish (*Lophius piscatorius*) lying on the seabed. At around 15:50, the ROV dive ended and, shortly after, both submersibles were brought back on deck.

During the afternoon, Telmo, Marina and Guilherme had interviews with Pepe Brix where they explained their role in the deep sea research group, the objectives for the cruise and their area of expertise and interests. As in previous days, as soon as the vehicles were on deck, we started sorting and processing the water and the biological samples. We also conducted a CTD cast (St028) at about 2 nm from the diving site, so that we could sample the 1000m depth water. Because one tag of the pelagic team popped up, the first MB survey was cancelled. On the daily 19:00 bridge meeting, it was agreed on a plan for the next day that included some MB tracks, diving in the western flank of Princesa Alice and a CTD at around 1000 m depth. After the CTD, we started surveying using Kongsberg EM304 and Kongsberg EM712 MBs (St029). It was surveyed a small line on our way to EK80 large scale transect. After ending collecting data with the EK80, MBs were used to have some higher resolution data on the 31<sup>st</sup> of august dive site. Quality control was ensured by performing checklines and compared with complete coverage bathymetric model made with the survey lines, the comparison came up with 98,03% for order 1a (S44 6<sup>th</sup> edition) and 99,19% for order 2. Altitude calibrations were confirmed by checking the roll value that was inserted on the SIS parameters.

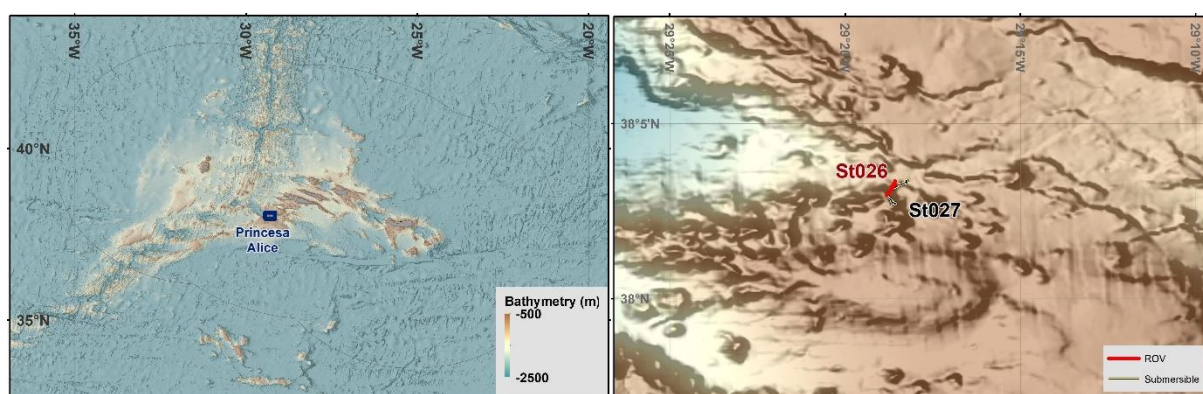


Figure 24. Map showing the ROV and Submersible stations conducted during the 30<sup>th</sup> August 2023 on the OceanX 2023 cruise.

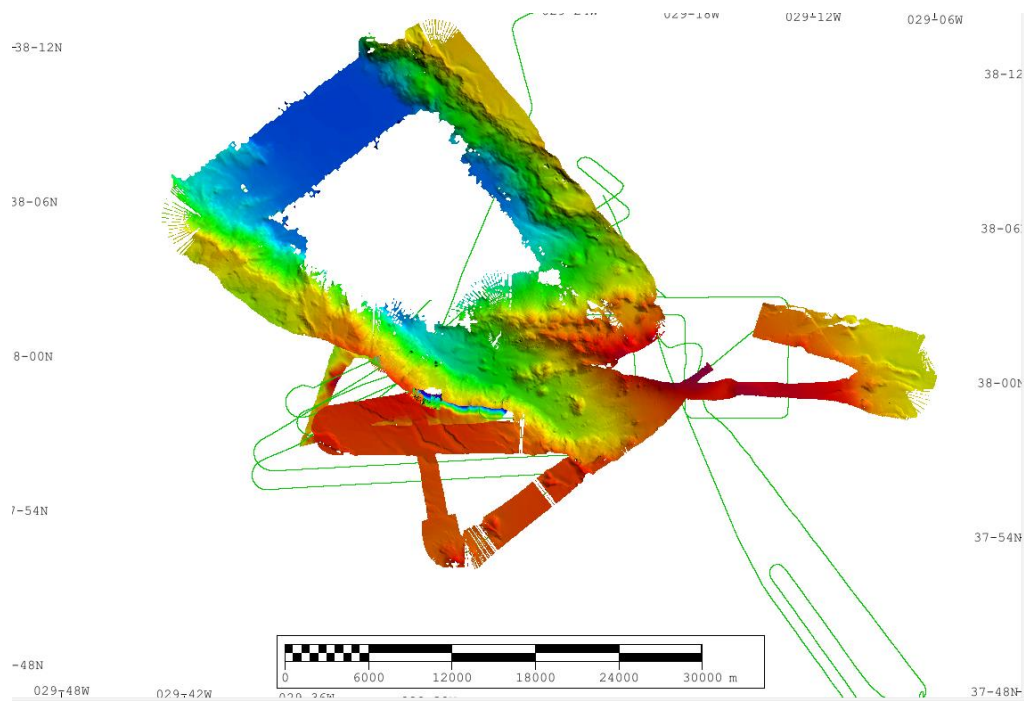


Figure 25. 30<sup>th</sup> to 31<sup>st</sup> of august MB survey (data not processed)- - variable resolution coverage (VRS).

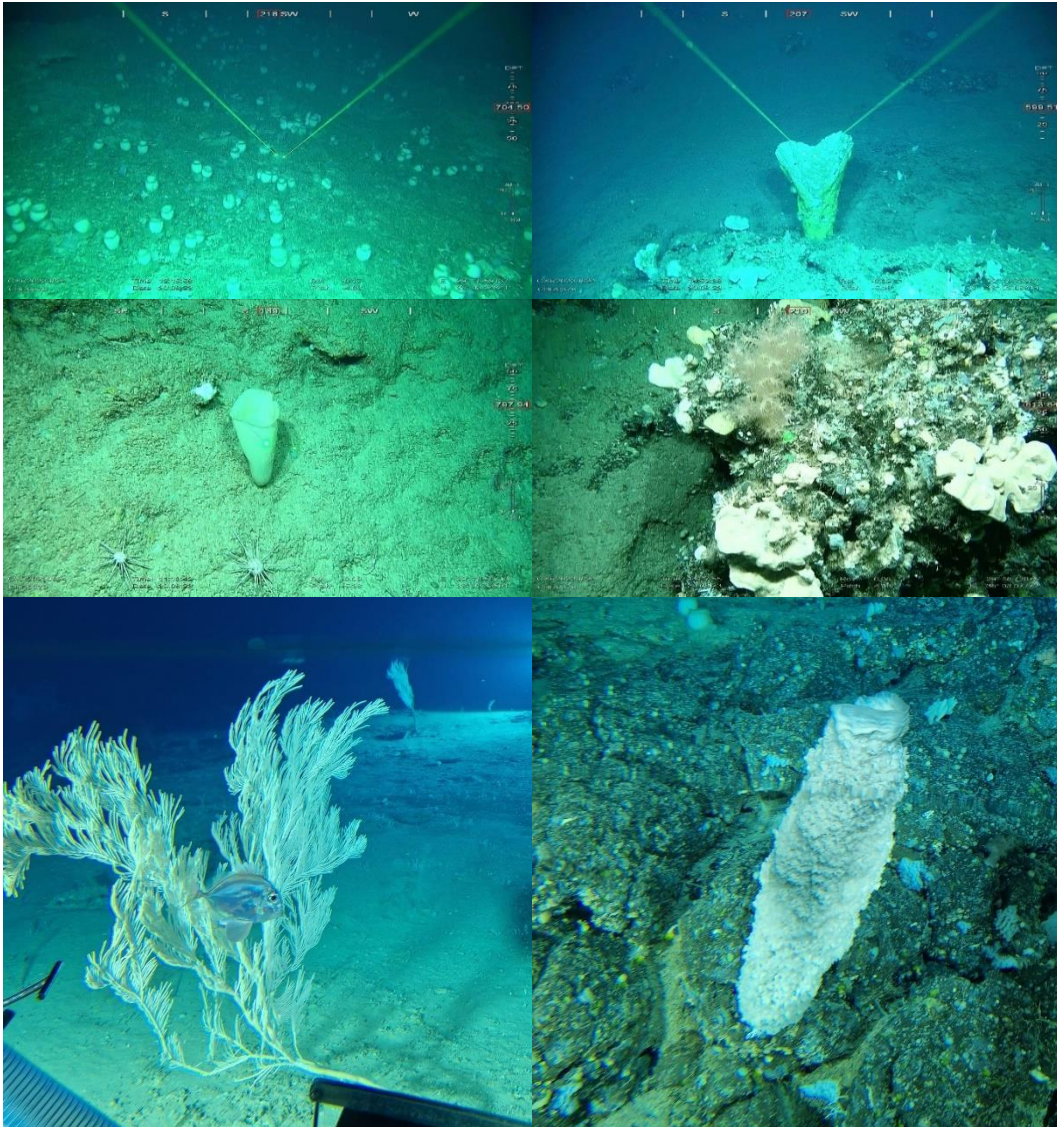


Figure 26. Screenshots taken from the video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on the 30<sup>th</sup> of August 2023.

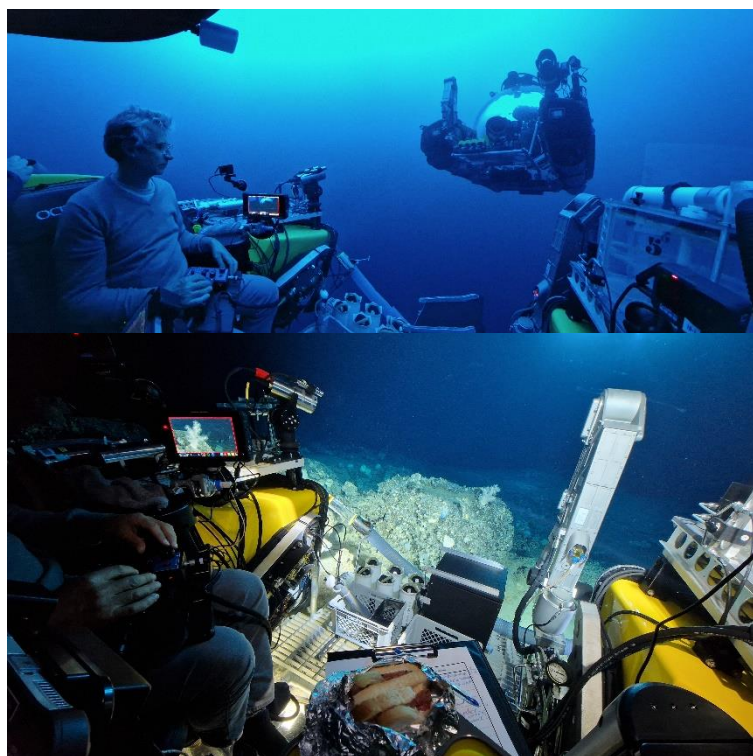


Figure 27. Life on board OceanXplorer during the OceanX 2023 cruise.

### 31 August 2023

As in the previous days we started with the 08:30 Subs planning meeting in the Bridge, where we revisited the diving lines designed in the previous evening. Since the media team was not using their seats in the Nadir submersible, we sent Pepe and Telmo in the media sub and Marina and Manuela in the science sub. The Subs and the ROV would explore different locations along a feature located west of Princesa Alice. The team headed to the submersibles while Guilherme and Filipe headed to the control room to get ready for the ROV dive.

The Submersible dives (St030), started at around 9:30 and reached the seafloor at 920 m depth at around 10:30. We landed on a rocky bottom covered with sand. After exploring around the area, we found a patch of 10+ colonies of black coral *Leiopathes expansa*, one medium-sized *Paragorgia johnsoni*, patches of *Leptopsammia formosa*, *Errina dabneyi*, *Hemicorallium niobe*, *Acanella arbuscula*, *Pliobothrus symmetricus*, and some Paramuricea and plexaurid species. In the media sub, we took this opportunity to take some footages of some of these corals and to fire two neuston bottles. During most of the dive we transited over soft bottoms with gentle slopes and dense patches of *Pheronema carpenteri*, with several other sponge species such as *Regadrella phoenix*, *Farrea occa*, and *Asconema*, and some sea-urchins *Cidaris cidaris*. Throughout the dive we observed several fish species, including the usual *Mora moro*, *Helicolenus dactylopterus*, *Hoplostethus mediterraneus*, and *Chaunax pictus* and one shrimp *Aristaeopsis edwardsiana*. In the upper part of the slope, at about 750m depth we began to observe large *Characella pachastrelloides* and *Haliclona magna*, along with some *Echinus melo*. The dive finished at about 550 m depth on the top of a very narrow ridge with very large *C. pachastrelloides* and many *Errina dabneyi* colonies.

In the ROV dive (St031), we observed similar fauna to that observed by the subs. The transect started at around 11:02, but before we got to the bottom, we briefly spotted on one of the ROV's cameras at around at 450m depth a large thresher shark. Already on the bottom, at 720m depth, we saw some *Pheronema carpenteri* aggregations covering mixed substrate, with occasional lamellate *Desmacella grimaldii* and small *Narella*



*bellissima* colonies as well. As the dive progressed, some larger sponges were observed, mainly of the species *Characella pachastrelloides*. Most of the dive was performed on top of the ridge, with relatively low fauna abundances. At around 640 m depth we started to observe dead coral framework, mainly composed of *Errina dabneyi*, with some alive colonies as well. We took occasional detours from the top of the ridge to also get a look at the hill on its southside, which looked similarly barren in terms of fauna composition to its top. Also noteworthy is the very strong current going North, which made operating the ROV along the ridge a very difficult task for the pilots. After about a quarter of the transect covered, we started to observe large *Narella versluysi* colonies, but due the strong currents mentioned, the pilots had to travel through mid-water over this section to get to a more uphill one where navigation would be easier. After this we got to see more *Errina dabneyi* framework, most of it dead, covering large sections of the top of the hill and, a few hundred meters ahead, a few impressive colonies of the “bubble-gum” coral, *Paragorgia johnsoni* were observed on the south side of the hill. The dive ended at around 15:40.

Today, the boat stopped for 30 minutes for a quick swim and dive competition. After a quick rest we started sorting and processing the water and the biological samples collected by the subs and ROV. At 19:00 we conducted a CTD cast (St032) close to the start of the subs station at 1000m depth. On the daily 19:00 bridge meeting, it was agreed on a plan for the next day that, as usual, included some MB tracks, submersible and ROV dives in the northwestern of Princesa Alice and a CTD at around 1000 m depth. Right after the CTD, we started the MB survey (St033) south of Princesa Alice. During the night time, the Kongsberg EM 712 stopped working, troubleshooting led to power supply malfunction.

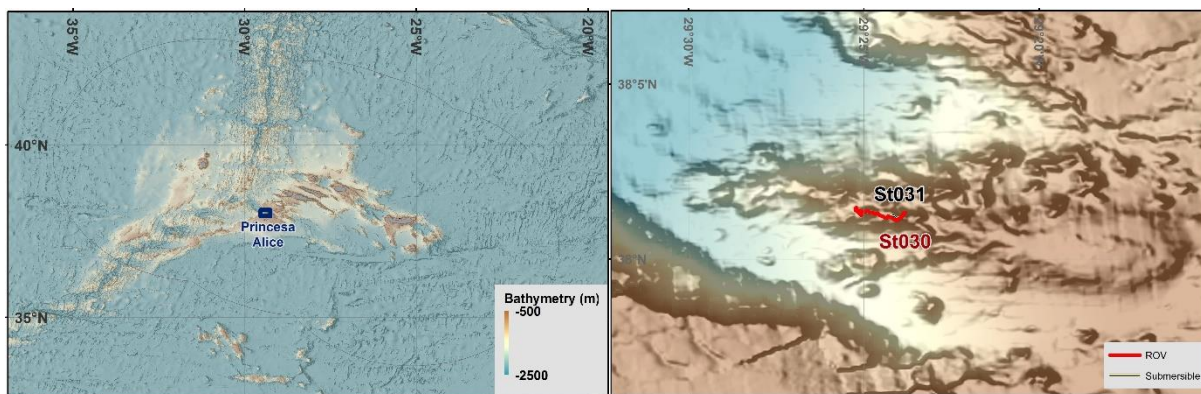


Figure 28. Map showing the ROV and Submersible stations conducted during the 31<sup>st</sup> August 2023 on the OceanX 2023 cruise.

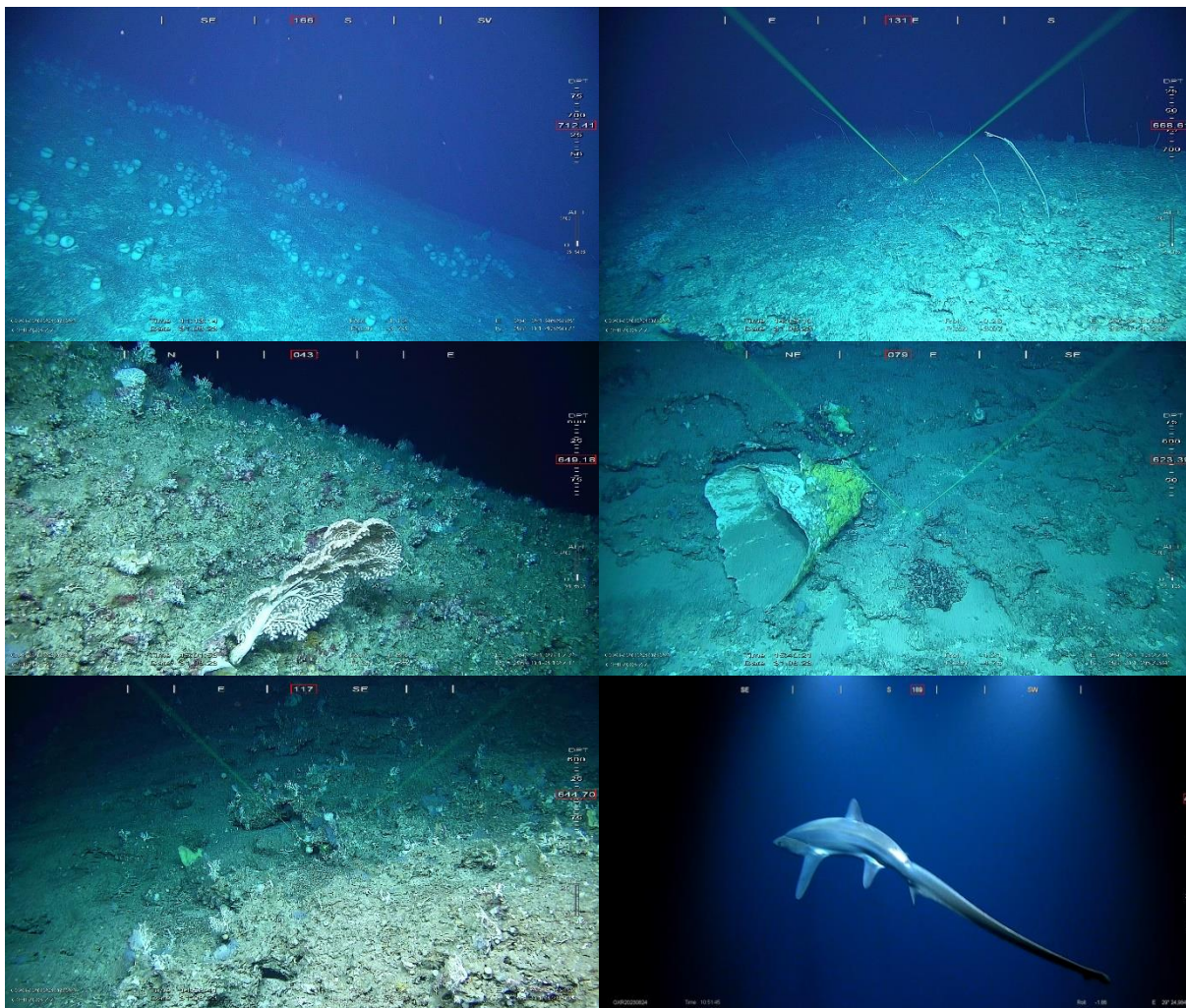


Figure 29. Screenshots taken from the video footages recorded from the ROV and Submersible dives during the OceanX 2023 cruise on the 31<sup>st</sup> of August 2023.

### 01 September 2023

After having gathered for the usual morning briefing regarding the submarine operations, Filipe and Guilherme headed to the science submersible Neptune, while Bruno Macena took the vacant spot on the media submersible. Telmo, Marina and Manuela took their seats on the mission control room and got ready for the ROV dive.

The submersible dive (St034) started to descend at around 09:50 down until 960m depth. During the descent, the Neptune pilot noticed an issue with the pump that fills the main tank with air. As we got to the bottom, two main shut downs of the system were made, but no success in getting the pump system working. We aborted the dive and were back on deck at around 12:30, while Nadir – the media submersible – resumed following the planned transect. As Neptune was ascending, it was requested that the ROV got back on deck to make the Sub recovery easier.

After Neptune was recovered, the ROV dive (St036) started at around 12:50 and started the transect at 13:25 at 997m. The first section of the dive was quite barren, with occasional large basalt vertical walls and outcrops only colonized by a few glass sponges of the species *Farrea occa*, some Brachipods and a few *Leptosammia formosa*. We also hovered over lots of dead bivalves, possibly belonging to the species *Acesta excavata*, having collected a sample. However, one of the biggest highlights of the mission came a few hundred meters along the

transect, where we started to see large vertical walls covered in surprisingly large and lush black coral colonies of the species *Leiopathes expansa*. They looked extremely long-lived, probably several thousand years old, densely covering large extensions of these outcrops with lots of associated biodiversity. It was extremely rewarding to be able to witness this amazing community for quite some time. The peaks of these large rocks were often colonized by aggregations of the bird's nest *Pheronema carpenteri*. After this section, we covered an extensive, flat and sedimentary area colonized by the glass sponges *Hyalonema thomsonis* and *Pheronema carpenteri*. Unfortunately, due to the delays in the morning, we were not able to get to the end of the transect, where the topography of the seabed looked more interesting. The ROV got off bottom and ended the dive at around 15:58. As the ROV was being brought back on deck, the umbilical cable broke, leaving the vehicle drifting at the surface. The crew decided to get the media submersible Nadir safely back first, and then rescue the ROV. We managed to collect 5 samples during the ROV dive.

After the CTD cast (St037) was concluded, the MB survey (St038) started around 20:00 when we began the transit to SW of Princesa Alice seamount.

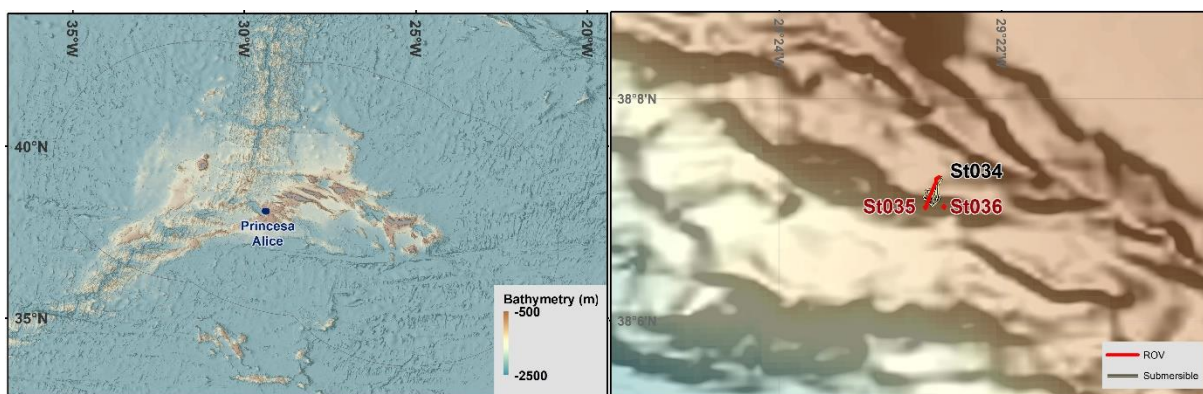


Figure 30. Map showing the ROV and Submersible stations conducted during the 1<sup>st</sup> September 2023 on the OceanX 2023 cruise.

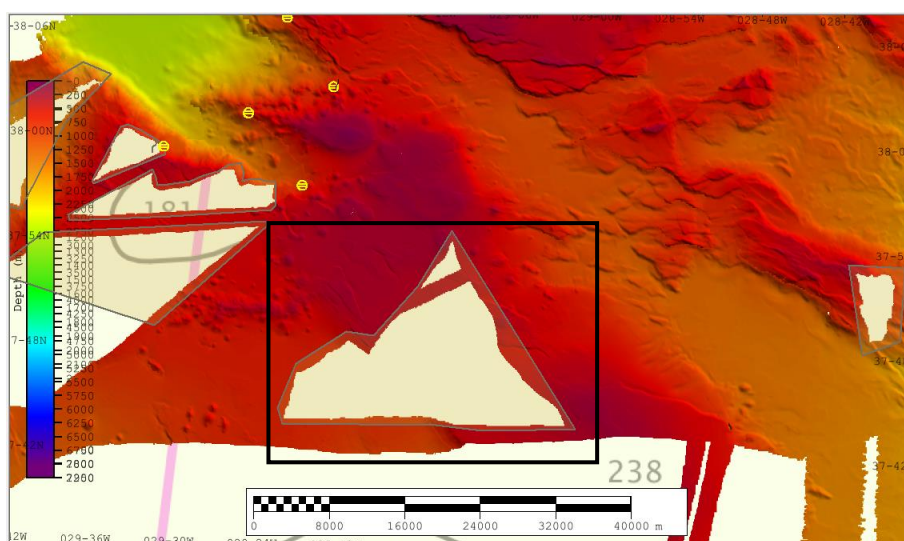


Figure 31. Unserved area on SE of Princesa Alice seamount.

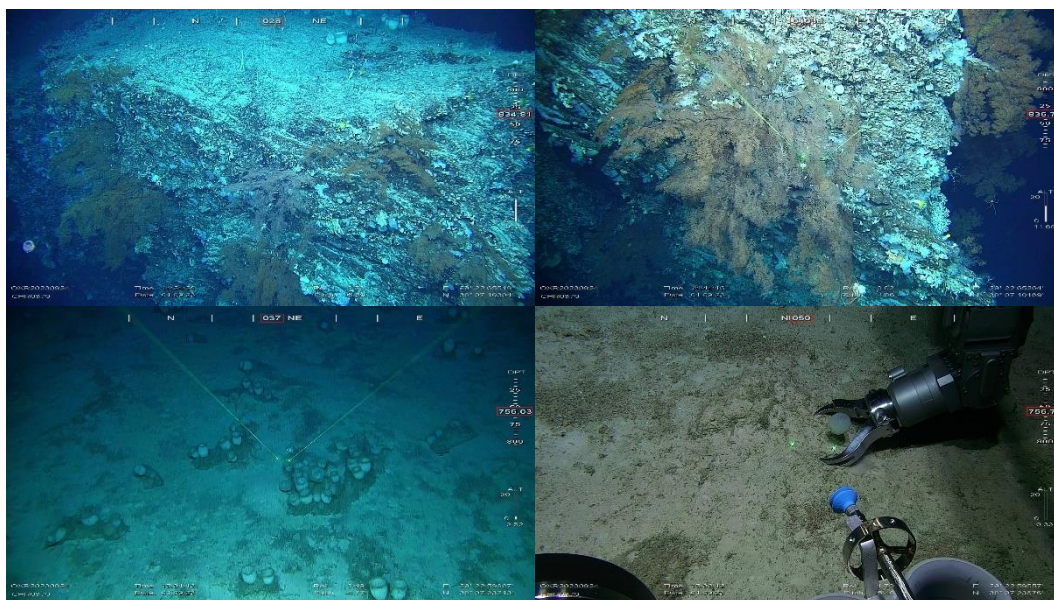


Figure 32. Screenshots taken from the video footages recorded from the ROV dive during the OceanX 2023 cruise on the 1<sup>st</sup> of September 2023.

## 02 September 2023

The MB continued as the night started and it was possible to map some interesting seafloor features (see image below) that weren't surveyed so far. The water column from Kongsberg EM 304 was recorded as well and it was possible to see some echoes correlated with some pelagic activity. In EK80 data we had a lot of backscatter as well which reinforces the presence of a huge amount of life in this area. The different depths and underwater walls, with slopes with almost 200 m as well as the water column data collected suggest that this can become a very interesting site regarding the pelagic studies.

Early in the morning, Telmo Morato left the cruise and João Balsa joined the team. During the morning briefing, it was decided that both submersibles would be operating along the ridge over which we drew our transect line. Marina and Manuela went on the science submersible Neptune, while Laura and Dya (from the pelagic team) took the seats on the media Sub Nadir. The ROV stayed on deck for the whole day while the crew attempted to repair it for the next day.

The submersibles (St039) were on water at around 09:30 and started the transect at around 10:40 at a depth of 980m on a flat *Pheronema carpenteri* meadow, with high density clusters together with other hexactinellids (*Regadrella*, *Asconema*, *Farrea* and *Aphrocallistes*). At 777 m depth, we collected a Hydrozoan belonging to the family Tubulariidae and a small lithistid sponge Cf. *Macandrewia* found at this site for comparative purposes. A very steep cliff arose at 800 m, showing walls densely covered with several species of encrusting sponges and large aggregations of the "living fossil" community of *Neopycnodonte zibrowii* with *Cyathidium foresti* and Brachiopods. Going up the hill, the stipitate sponge *Stylocordyla pellita* appeared on consolidated sedimentary rock areas together with *Pleurocorallium jonhsoni*. Along the transect, another cliff showed up, again with *Neopycnodonte/Cyathidium* community. Two small plexaurids (Cf. *Villogorgia sp.*, Cf. *Swiftia sp.*) and a yellow sponge Cf. *Spongosorites sp.* were collected from this wall. On the upper part of the ridge, dense patches of *Errina dabney* colonized by hydrozoan epiphyts were observed as well. Later down the transect line, a very strong current rendered sampling activities much more difficult. Despite this, we could take some fragments of lamellate sponges Cf. *Desmacella grimaldi* and Cf. *Poecillastra compressa*, to be confirmed. The rocks were patched with the barnacle Cf. *Balanomorpha sp.*, bordering them in straight lines, turning out easy to be quickly

detached by the SUB arm jaw. Some fishing lines were encountered at the *Errina dabney* location, but many more lost lines were found next, within the massive *Characella pachastrelloides* aggregation field with all sorts of morphologies (vase shape, conical, tubular, etc). Before the end of the transect, we had the chance to collect the sponge morphotype named Tubular at 433 m depth. Fishing lines were more abundant at the end of transect, crossing the *Characella pachastrelloides* field in all directions. During the transect, *Helicolenus dactylopterus* and some elasmobranchs e.g. *Dipturus sp.*, *Hexanchus griseus* and a camouflaged *Lophius piscatorius* were also spotted. It also came as a big surprise when we observed a large sunfish, who calmly inspected us at around 500m depth. Strong bottom currents also rendered the submersibles' navigation particularly difficult. The dive ended at 16:02 at 413 m depth. The CTD was deployed (St040) near the position where the *Pheronema carpenteri* field was detected, at around 800 m depth. At 19:58, the MB survey (St041) was initiated, until 04:21.

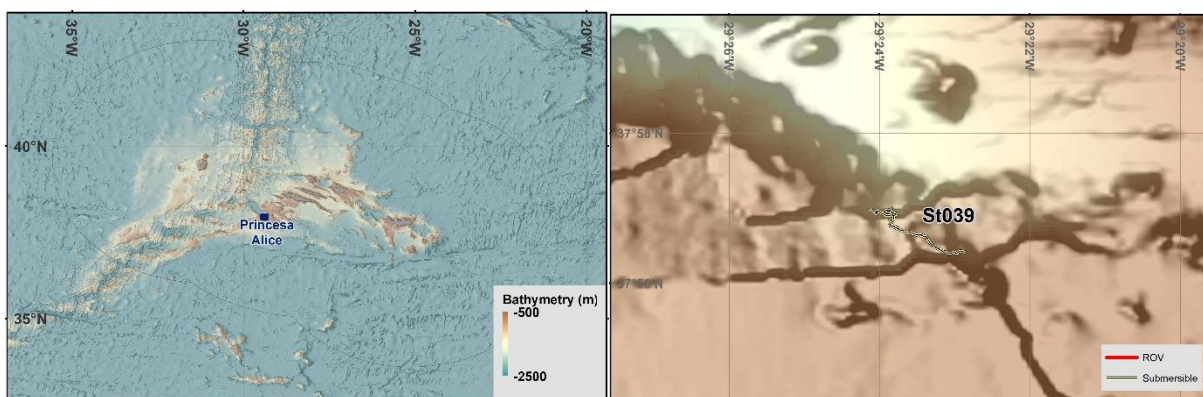


Figure 33. Map showing the Submersible station conducted during the 2<sup>nd</sup> September 2023 on the OceanX 2023 cruise.

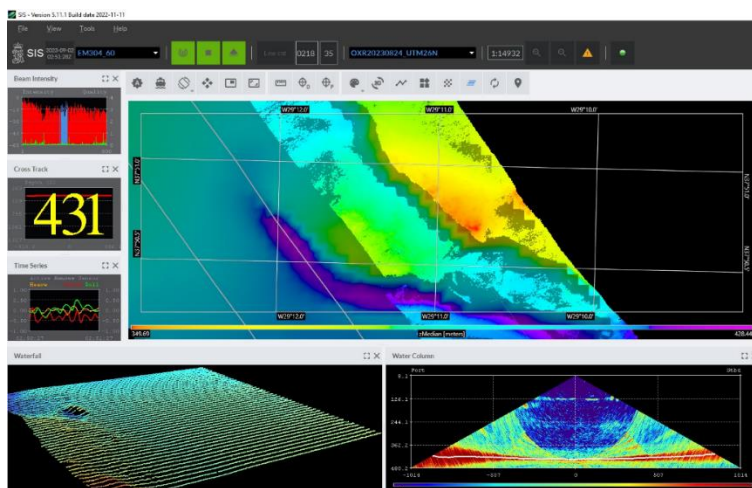


Figure 34. Screenshot from Seafloor Information System (SIS 5) software showing the acquired data on the 2<sup>nd</sup> September (water column data on the bottom right).

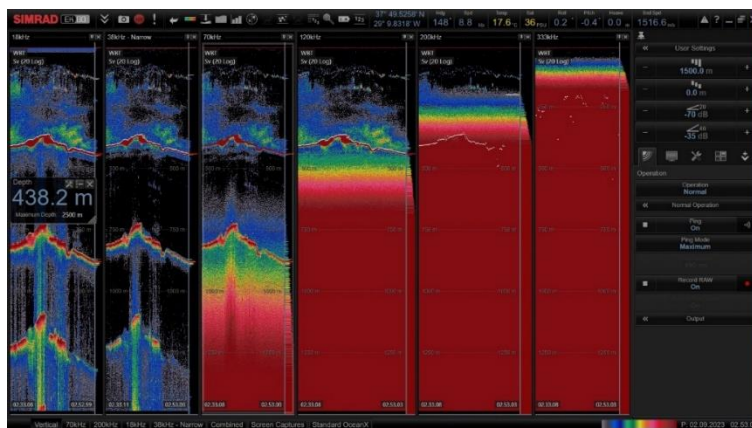


Figure 35. Screenshot taken from EK80

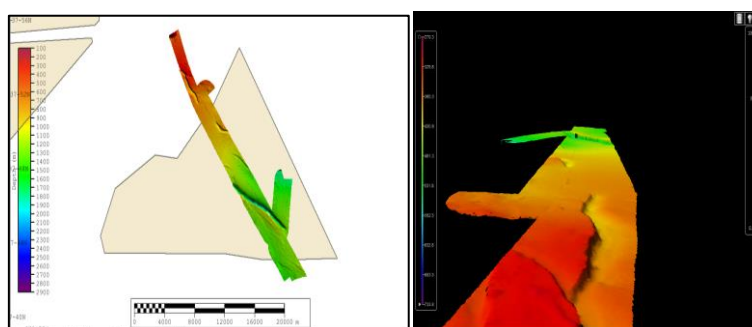


Figure 36. Area of MB survey on the night of the 2<sup>nd</sup> to the 3<sup>rd</sup> September

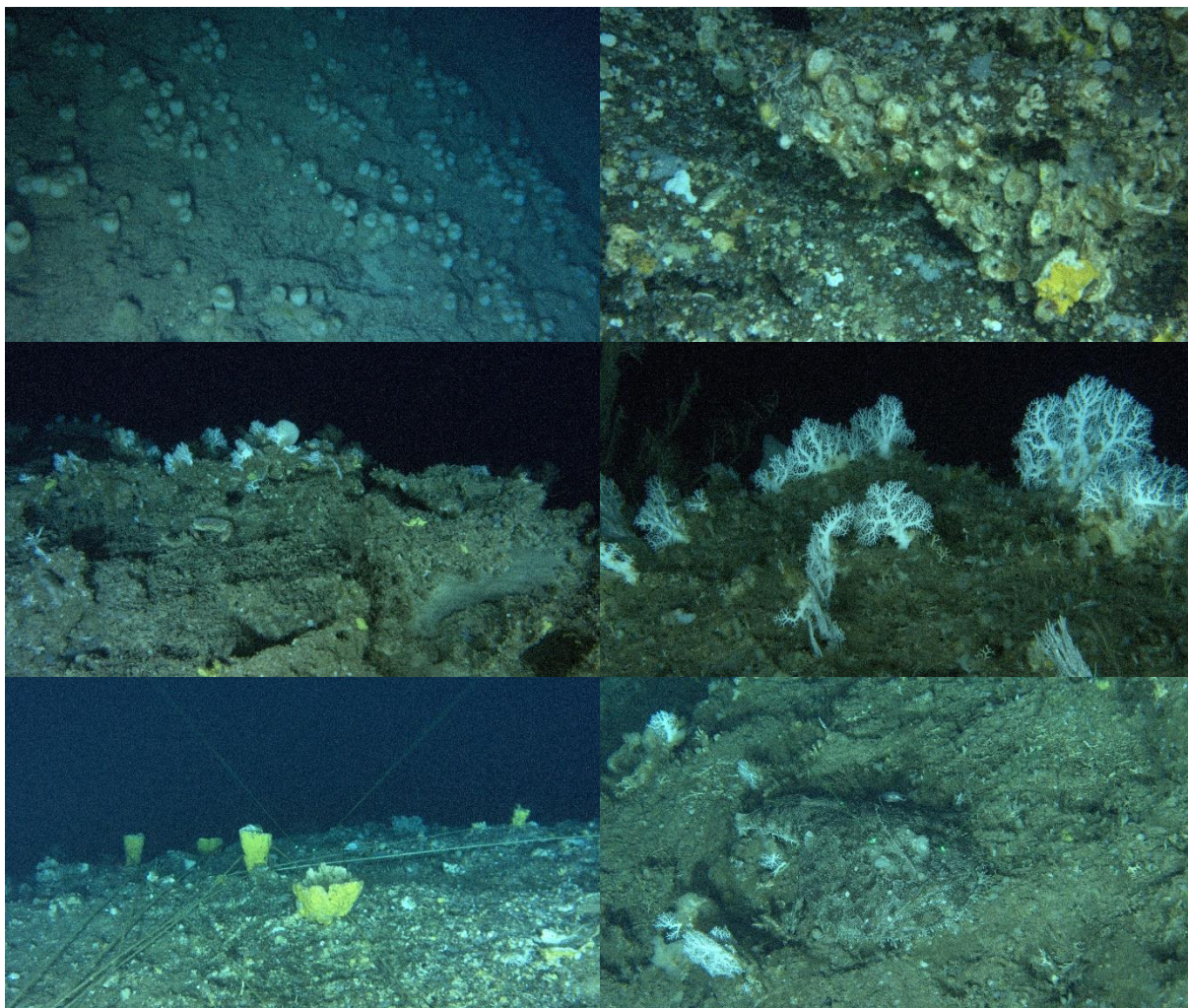


Figure 37. Screenshots taken from the video footages recorded from the Submersible dives during the OceanX 2023 cruise on the 2<sup>nd</sup> September 2023.

### 03 September 2023

After the OXR crew assessed the weather forecast early in the morning for the rest of the day and the next few days, it was decided that submersible operations would not be carried out due to safety reasons. The swell was expected to increase significantly by the end of the day, after which any eventual rescue operations would not be possible to be carried out. For this reason, ROV operations could begin sooner than expected, at around 08:20.

The ROV pilots performed the last few tests on the vehicle and the descent started at around 08:25 (St042) and got to the bottom at around 08:40 and 900m depth. We promptly observed a black scabbard fish and an arrowhead dog-fish from the genus *Deania*. We started the transect at around 08:53, with relatively barren mixed substrate of rock and sand, only colonized by a few *Pliobothrus symmetricus* and glass sponges *Farrea occa*. Above the 870m depth we started to observe some bird's nest *Pheronema carpenteri*, with increasing densities up to 690 m reaching abundances between 1-10 individuals m<sup>2</sup>. At 750 m depth, Cf. *Errina dabney* was occasionally observed, as well as a small colony of *Lophelia pertusa* and several sponge species (*Desmacella grimaldi*, *P. bitorquis*). Some samples were taken at this depth (*Lophelia pertusa*, *Errina dabneyi*, *Desmacella grimaldii*, Porifera digitate). The community shifted to massive sponges Cf. *Characella spp* and *Narella spp.* at around 690 m. A sponge community composed by massives *Characella pachastrelloides*, *Petrosia crassa*, *Geodia*

*cf. megastrella*, *Macandrewia azorica*, *Leiodermatium spp.* and *Phakellia ventilabrum* took place at 650 m and continued until 560 m, with the substrate alternating between sections of soft grounds and basaltic outcrops. Diversity got lower as we covered shallower areas at around 530 m depth. Up until the end of the transect, community remained practically the same, with low abundances. The dive ended at 14:26 at 504 m depth and, after the ROV was back on deck, we performed a CTD cast (St043) at 850 m depth. We started to process the samples collected and, at around 18:30 we joined the OCX crew for a barbecue dinner outside, while transiting to Horta harbour, where we would stay for two nights due to bad weather forecasts.

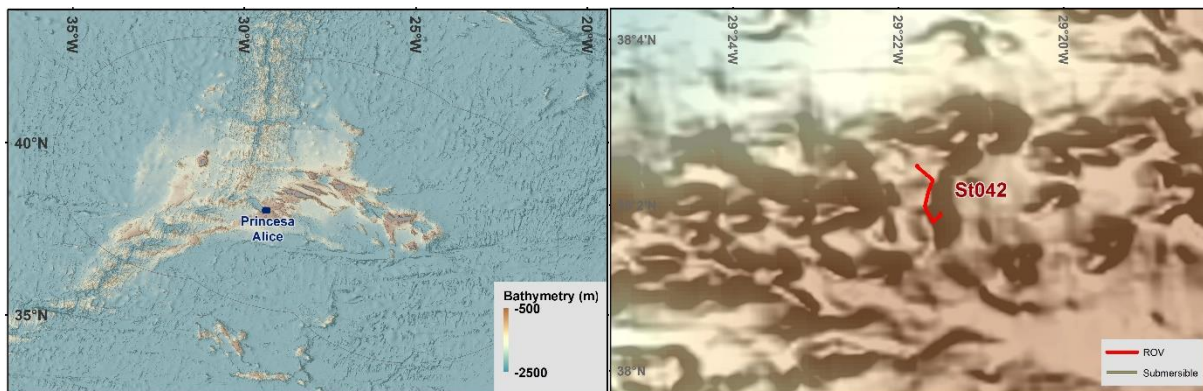


Figure 38. Map showing the ROV station conducted during the 3<sup>rd</sup> September 2023 on the OceanX 2023 cruise.

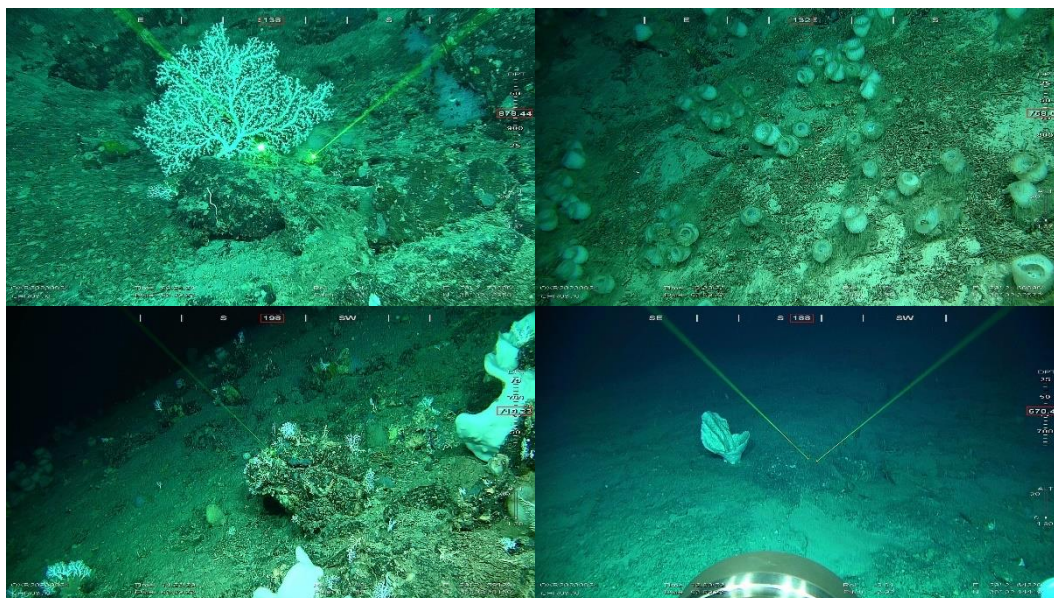


Figure 39. Screenshots taken from the video footages recorded from the ROV dive during the OceanX 2023 cruise on the 3<sup>rd</sup> of September 2023.



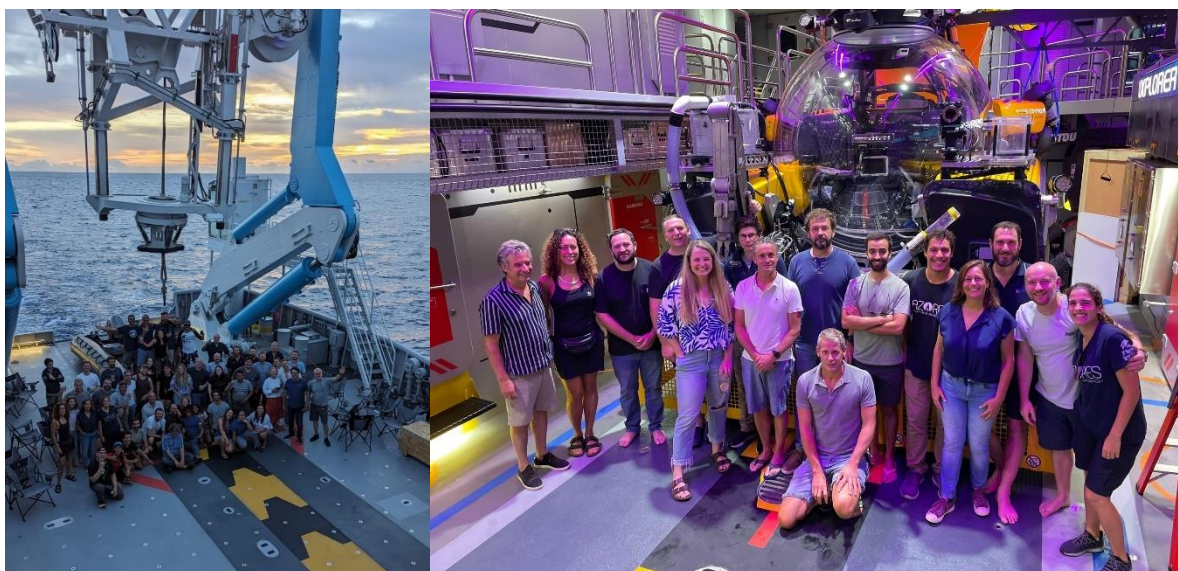


Figure 40. Life on board OceanXplorer during the OceanX 2023 cruise.

#### 04-05 September 2023

On the morning of the 4<sup>th</sup>, we moored in Horta and started to unload most of our collected samples, storing them in the Deep Sea Lab. Marina and Filipe left the cruise during the day and Teresa and Gal'la joined the team. Given that it would only be possible to leave Horta harbour on the morning of the 6<sup>th</sup>, we were able to spend some time ashore, including the OCX crew members.

On the 5<sup>th</sup>, at 15:00 a briefing was held to welcome the new media and science team on board and to plan the schedule for all the activities for the next few days. The new science team would be using both submersibles during the day to study bioluminescence, performing vertical transects. Given that our ROV transects are horizontal, it would not be possible to operate both vehicles simultaneously. This led to a shift on our ROV station schedule, only being possible to start the operations after the submersible dives were done, at around 17:00 and until 23:00. The CTD would be deployed prior to the ROV dive. After a consensus was reached between all teams, we started to plan possible transects for the two remaining ROV dives. We were interested in performing the dive in the area “Ponta da Ilha N”, however, given that this area would most likely be too exposed to the bad weather, we planned an alternative route just south of Lajes, in case our plan A would not be carried out. At the end of the day, our team gathered for a short meeting to discuss the plan for the next day.

#### 06 September 2023

On the morning of the 6<sup>th</sup>, we left the harbour at around 06:30 and headed to South of Pico. While waiting for our activities to start, we took the time to update reports, log sheets and preparing material for the processing of the samples. We deployed the CTD cast (St044) at around 18:15 at the start point of our upcoming ROV transect. The CTD was launched one hour later than planned, due to a delay in the activities of the other scientific team onboard. In the lab, the water filtration for eDNA analysis took longer than usual due to electric problems on two of the three vacuum filtration pumps. One member of the OCX crew tried to fix them, but only succeeding in one, which significantly prolonged the time it took to process the samples.

The ROV dive (St045) started at 1087m depth at 19:43 on a flat sedimentary area. We quickly started covering an upslope section of the transect, with its substrate mostly composed of coral rubble and colonized by several glass sponges such as *Farrea occa*, *Hertwigia falcifera* and *cf. Phakellia robusta*. Several coral species were also observed at this depth such as *Leiopathes expansa*, *Bathypathes* sp., *Candidella imbricata*, *Acanella arbuscula* and *Leptopsammia formosa*.

Above the 1000m depth, the slope started to increase, as well as the frequency of basalt outcrops. *Candidella imbricata* began to dominate the community, with occasional patches of relatively high densities. However, long sections of uncolonized coral rubble were quite frequent as well. We also started to observe large fields of the bird's nest *Pheronema carpenteri* that often covered the tops of large basalt rocks. Towards the end of the dive, at around 800m depth, *Narella versluysi* and *Narella bellissima* started to appear as well in high densities. We ended the dive at 22:59 at 798m depth and processed most of the samples afterwards, leaving some for the morning of the next day.

After the ROV dive an EK80 transect was conducted in the south part of the island. Due to the delays that occurred during the operations and in order to keep up with the schedule for the next day, no MB survey was performed.

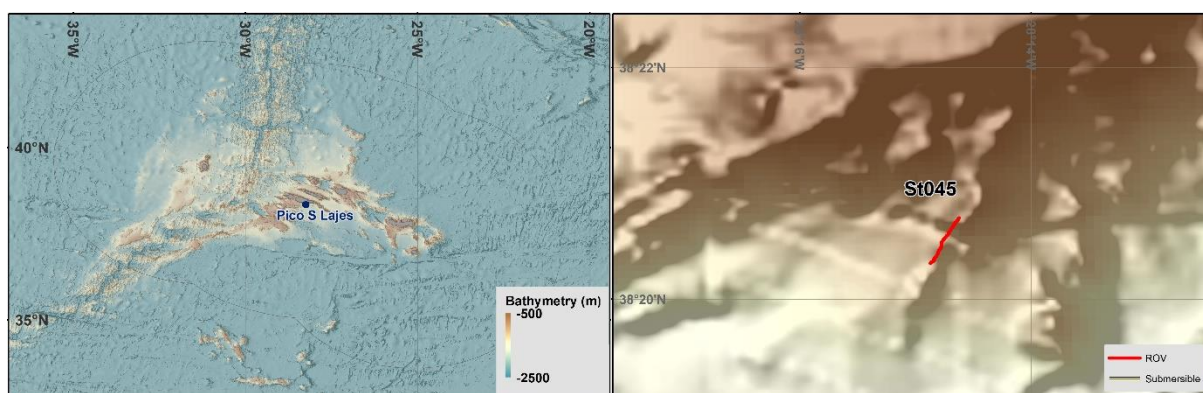


Figure 41. Map showing the ROV station conducted during the 6<sup>th</sup> September 2023 on the OceanX 2023 cruise.

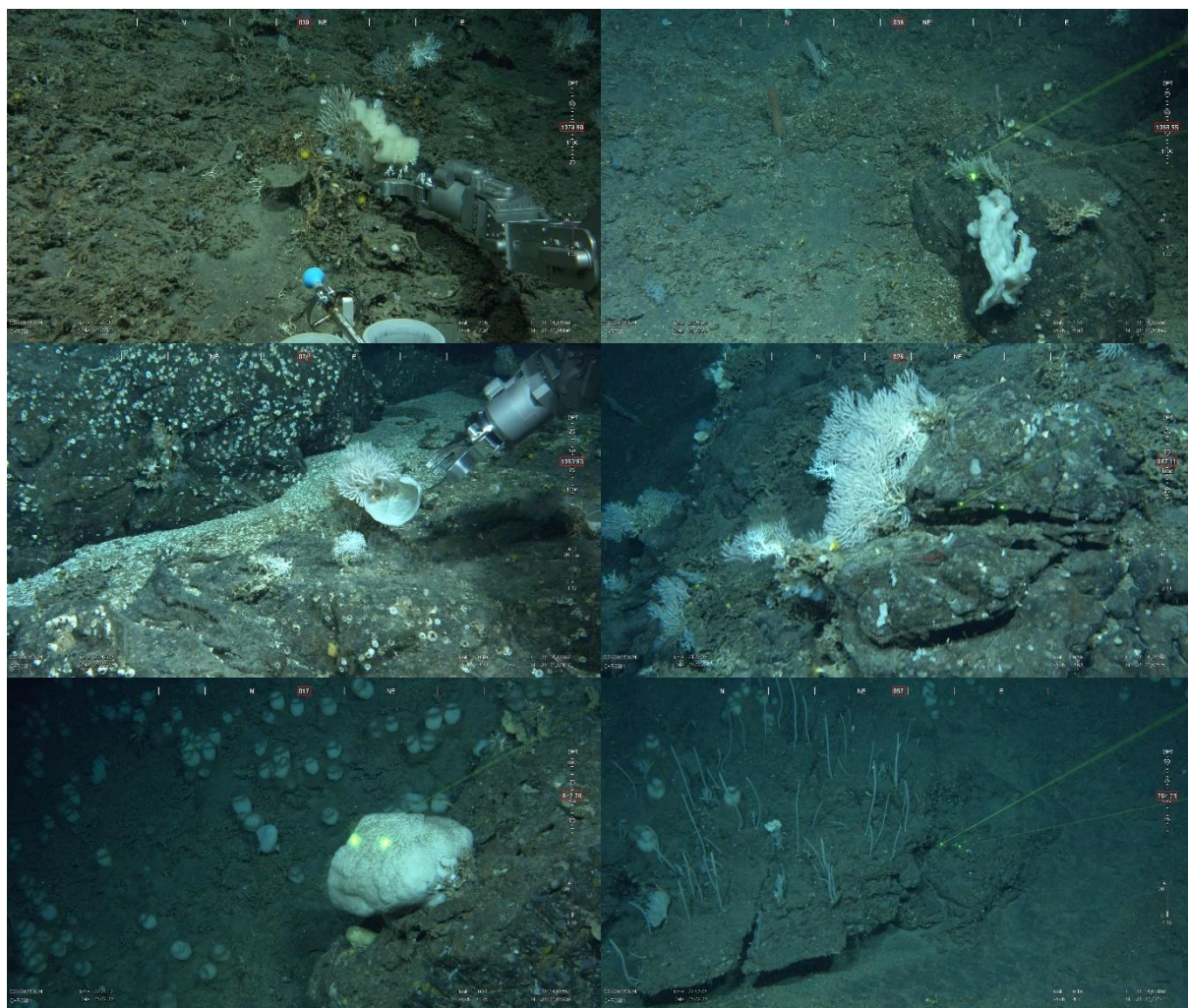


Figure 42. Screenshots taken from the video footages recorded from the ROV dive during the OceanX 2023 cruise on the 6<sup>th</sup> of September 2023.

### 07 September 2023

During the morning, João Balsa left the vessel in order to catch a plane to S. Miguel island, where he would join the RV Arquipélago for its upcoming leg. With only one pump for water filtration working properly, it was decided to cancel the CTD cast that was planned for the day and only use the water samples from the ROV dive. This shift in the schedule opened up the possibility of beginning the ROV dive sooner, in the “Ponta da Ilha N” area. Since the weather improved significantly compared to the day before, it would be possible to perform a transect slightly more offshore than previously expected. As soon as the other scientific team’s vehicles were back on deck, we immediately transited to the start point of the transect.

The dive (St046) started at 17:59 at around 839 m depth on a flat sedimentary bottom only poorly colonized by some glass sponges *Pheronema carpenteri* and *Regadrella phoenix*. As we began to cover more upslope sections of the transect at around 850m, patches of the bird’s nest sponge and became more common and abundant until 750m depth, along with several other glass sponges. A strong bottom current was observed and several *Hoplostethus mediterraneus* were also quite common at these depths, as well as a large *Molva macrophthalmia* with a distinctive bite wound on its back. The substrate began to shift to a basalt dominated one from the 715m mark, where we began to observe *Macandrewia azorica* in relatively high abundances, together with some *Sytlocordilla pellita*, *Desmacella grimaldii* and massives *Characella pachastrelloides*. Coral rubble dominated

vast areas of the substrate from 630m depth, where occasional basalt boulders were also colonized by some *Errina dabneyi*, some soft corals and small encrusting sponges. But around 550m depth, massive sponges from the genus *Geodia* and *Characella* began to dominate the community in high densities, together with several other sponge species such as *Macandrewia azorica*, *Petrosia crassa* and many other abundant, non-identified smaller sponges, some of which we were able to sample. In fact, we probably observed some of the largest *Characella* sp. specimens recorded in the area so far, displaying a diverse array of morphologies. We ended the dive at 22:15 at around 400m depth.

The MB survey (St047) was conducted during the night, in an unsurveyed area southeast of Pico island. The ship left the survey area at 02:22 in order to be in the waiting station on the 8<sup>th</sup> at 06:00, for the ship's EK80 calibration.

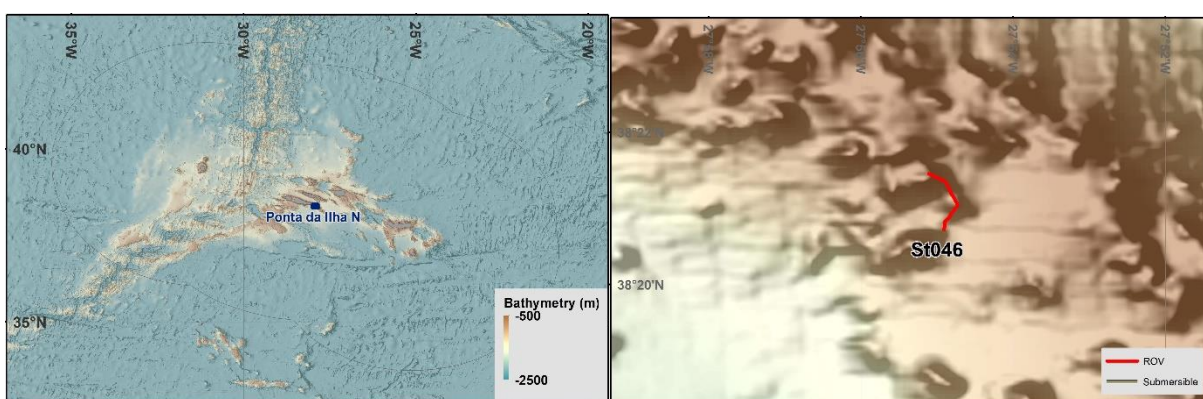


Figure 43. Map showing the ROV station conducted during the 7<sup>th</sup> September 2023 on the OceanX 2023 cruise.

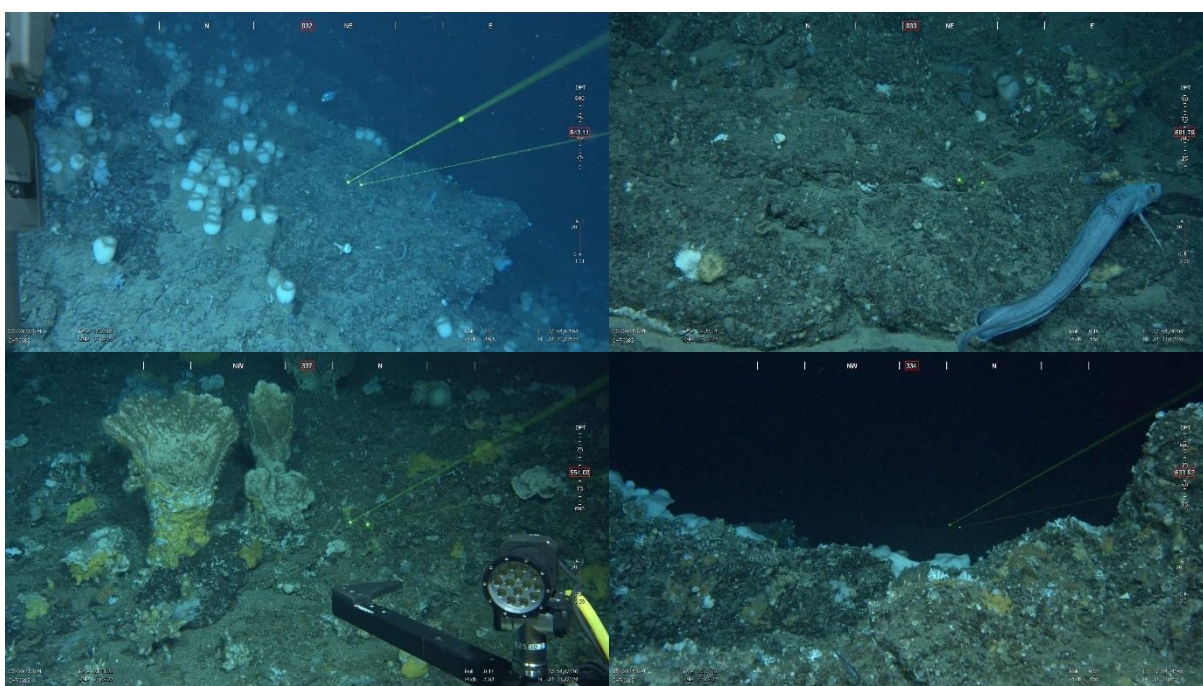


Figure 44. Screenshots taken from the video footages recorded from the ROV dive during the OceanX 2023 cruise on the 7<sup>th</sup> of September 2023.

**08 September 2023**

The calibration took longer than expected, and we were only able to unload all our equipment later in the evening. We left the OceanX 2023 cruise at around 16:20.

## **5 ACKNOWLEDGEMENTS**

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AJUSTE DIRETO N.º 11/DRPM/2022 - CARACTERIZAÇÃO DOS HABITATS DE PROFUNDIDADE, COM VISTA AO SEU MAPEAMENTO ATÉ AO LIMITE EXTERIOR DA SUBÁREA DOS AÇORES DA ZONA ECONÓMICA EXCLUSIVA PORTUGUESA

**Reference:** Morato, T., G. Gonçalves, L. Neves de Sousa, F. Porteiro, M. Ramos, T. Cerqueira, J. Balsa, G. Edery, C. Dominguez-Carrió, M. Carreiro-Silva (2023). OceanX 2023 cruise report: Exploration and mapping of deep-sea biodiversity in the Azores on board the RV OceanXplorer. Instituto de Investigação em Ciências do Mar - Okeanos, Universidade dos Açores, Horta, Portugal. 42pp. DOI: [10.5281/zenodo.10810581](https://doi.org/10.5281/zenodo.10810581)



