

TANGO2 Cruise report

13rd February to 19th March 2024



Executive Summary

The TANGO2 expedition ventured to accumulate new information and samples to delineate responses of marine ecosystems to shifts in ice regimes in the West Antarctic Peninsula (WAP), taking full advantage of a nimble sampling platform, the R/V *Australis*, a steel hulled, fully rigged motor sailor. TANGO2 took place between February and March 2024, sampling three main locations at different spatial scales. Deploying 11 different types of gear (both traditional and modern), the TANGO2 Team gathered over 4000 physical samples that will be brought back to Belgium for further analysis. The Team focused on synchronized, transdisciplinary sampling to understand the linkages between realms (atmosphere, water column, seafloor) and their potential responses to changes in climate-changed linked ice regime at various spatial scales.

Once more, the use of R/V *Australis* for coastal studies deemed to be extremely efficient, in terms of environmental impact (ca. 40 times less CO₂ emissions than a Polar class icebreaker) and agility, allowing the Team to adapt the sampling efforts in function of the weather or anchoring conditions. Fully devoted to the expedition, the ship allowed the TANGO2 team to sample in shallow areas, not accessible to icebreakers and too far away from research stations, and which have been under sampled (based on data available from the reference information system for Antarctic marine biodiversity data, [biodiversity.aq](#)). The preliminary (meta)results accumulated during TANGO2 confirm the efficiency of using a nimble research platform to study fine-scale processes in the shallow areas of uncharted regions of the West Antarctic Peninsula. TANGO2 provides a first-hand experience to carry on future expeditions taking advantage of the low cost/low environmental impact approach, coherent with environmental conservation. Based upon Open Science approach, the combination of B121/TANGO1 and now TANGO2 efficiency in designing informed, focused expeditions, paving the way to transposing the concept developed by Danis et al. (2022) to multiply similar efforts in a coordinated fashion.

An overview of initial results is provided below:

1. Concept and Sampling design

The preliminary (meta)results accumulated during TANGO2 confirm again the efficiency of using a nimble research platform to study fine-scale processes in the shallow areas of uncharted regions of the West Antarctic Peninsula. Based upon Open Science approaches, the concept tested and improved during the B121/TANGO1/TANGO2 paves the way to transposing the concept, and to multiply/coordinate similar efforts in different oceans.

2. Mapping

Despite being rather sensitive to environmental conditions (strong wind velocity, compass interference with vessel, takeoff/landing delicate from vessel), deployment of drones was found to be useful in terms of scouting when arriving in new work sites, documenting their general setup as well as carrying out more sophisticated works including orthomosaic (2D) and photogrammetry (3D).

3. Environmental parameters

A total of six incubations were performed at every substation. There was no visible difference between the stations or the bottle during the filtration. Sediment traps were deployed successfully after coordinated recovery of the sample bottle and release by divers and

surface recovery. There was less matter compared to TANGO 1 expedition but the sediments seems bigger and more stringy. The three sites seem to have a comparable quantity of particulate matter.

A total of 123 Niskin bottles were taken at the surface. These samples were taken in various environment, including active glaciers, open water and coastal environment without glacier. These samples were taken following the results of the TANGO1 expedition. It showed a potential source of methane at the top of the water column. The hypothesis is that this source come from run-off water from the glacier.

The sampling strategy of TANGO2 have been adapted to this hypothesis to sample sensitive area as glacier with a high velocity. This was done to assess the impact of melting glacier as a source of methane in the West Antarctic Peninsula.

4. Biogeochemistry

To determine the quantity and distribution of carbon present in the seafloor sediment from different sources, divers pushed 3 perspex cores into the seafloor sediment at each site, aiming for a sediment column of at least 10 cm. After retrieval, the cores were sliced and all samples were immediately stored into a -20 °C freezer.

Two types of incubations were performed: dark incubations, and light incubations, representing the light intensity on the seafloor on a partially overcast day (as measured with HOBO loggers (Scaled instruments) on CTD profiles). Oxygen consumption rates measured in the dark incubations were similar for all the investigated sites, with average rates varying around 20 mmol O₂ m⁻² d⁻¹. The exception was one of the sediment cores collected next to the wreck of the Guvernøren (Føyn harbor), which had more than double the oxygen consumption as most of the other stations.

5. Trophic analysis

*A total of 2259 samples were collected, accounting for 101 different morphospecies sampled in the 6 stations investigated. Samples collected during TANGO2 would enable to refine those obtained during TANGO1 and extend the spatial range of study. Indeed, for instance, *N. concinna*, was found in every station. This will allow comparison of rock habitat among a range of latitude but also compare potential diet differences between rock and soft sediment habitats. Biometry measurements were also taken.*

*Sampling was performed to characterize gut microsymbionts from sea urchins (*Sterechinus neumayeri*). The samples will be analysed using different methods: The samples preserved dried (Aristotle's lantern) will be analysed in ULiège once return in Belgium for trophic niche analyses, The food pellets and gut epithelium samples will be processed at ULB (DNA extraction and PCRs) and send to a sequencing company to assess the diet and microbiome composition. The gonads will be processed at ULB for sea urchin sexing, as well as in Germany for proteomics studies (MALDI-TOF), the spines will be used in Germany for genomics studies (RAD sequencing).*

6. Biodiversity inventories

All sample collected in the different events of Rauschert Dredge and the Amphipod Traps have been partially sorted by main morphotypes on board of RV Australis during the expedition. Representants of the major taxa present in the catch were isolated, identified to the lowest taxonomic level known and counted whenever time and space was available. All

sorted taxa and unsorted subsamples were labeled and fixed in ethanol to be processed further thoroughly in the laboratory.

*Regarding Top Predators (Birds and Marine Mammals), a total of 64 observation events (standard counts or punctual observations) were performed while crossing the Magellanic Area (MA), the Drake Passage (DP) and along the Antarctic Peninsula (AP). General notes on the observations for each species encountered during the voyage were taken. Remarkably, very low densities of birds during both crossings of the Drake Passage were observed compared to similar crossings performed at similar dates during previous years. Several species, although normally common or frequently observed during such transect e.g., the Southern Royal Albatross (*Diomedea epomophora*), Snow Petrel (*Pagodroma nivea*), White-headed Petrel (*Pterodroma lessonii*), Antarctic Petrel (*Thalassoica antarctica*), Kerguelen Petrel (*Lugensa brevirostris*) or Blue petrel (*Halobaena caerulea*) were absent during this voyage.*

Citation of this document

This report is under a Creative Commons Attribution International (CC-BY) 4.0 License. It is openly shared in the spirit of the Antarctic Treaty, Art. III.1.c.



Please cite this report as follows:

"Danis, B., Bayat, B., Brusselman, A., Coerper, A., De Borger, E., Delille, B., Dogniez, M., Katz, L., Moreau, C., Reade, A., Robert, H., Terrana, L., Voisin, A., Wallis, B. Report of the TANGO 2 expedition to the West Antarctic Peninsula. 106 pp."

All media (pictures, videos, sounds) are under a CC-BY 4.0 Licence, please cite the material as follows:

"TANGO2 expedition, 2024. Content under Creative Commons Attribution International (CC-BY) 4.0 License."

Table of contents

Executive Summary	2
Citation of this document	5
Table of contents	6
Background	8
Objectives of the expedition	9
Expedition members	10
Sampling platform: the R/V <i>Australis</i>	12
Calendar	14
Sampling Area	15
Melchior Islands (MI)	20
Hovgaard Islands (HI)	23
Føyn Harbor (FH)	25
Work at sea and preliminary results	28
1. Concept and Sampling design	28
2. Mapping	30
3. Environmental parameters	40
4. Biogeochemistry	42
5. Trophic analysis	54
6. Biodiversity inventories	76
Diving activities	87
Outreach activities	90
Press release	90
Social media and internet platforms	91
Collaboration and sponsors	94
Data management	95
General procedures	95
Sample (biodiversity) data	95
Media data	95
Data publication	95
Index of Tables	97
Index of Figures	98
Permits	101
Acknowledgements	102

Funding of expedition	102
Sponsorship of the expedition	102
Personal thanks	102
Annexes	103

Background

There is a dearth of knowledge about biological and habitat diversity levels found in shallow areas from the Southern Ocean, a situation opposite to that found in other oceans. These ecosystems are exposed to fast-paced changes in key environmental parameters (seawater temperature, salinity, primary production, sea-ice regimes, ice-shelf loss/collapse) and host organisms which have been facing past events shaping the function and structure of ecosystems. The present report gives a detailed account of the preliminary results of the TANGO2 expedition, which follows up on the TANGO1 expedition (Danis et al. 2023). The Southern Ocean is an extremely challenging area to carry out fieldwork for marine ecology studies as the access to our area of interest is highly dependent on environmental conditions (sea state, wind, sea ice...) but also on logistics and human factors. The decade of experience of the involved parties in organizing land-based campaigns in collaboration with the international community and the experience gained in the framework of the Belgica 121 expedition (B121) (Danis et al. 2019, 2022) have significantly improved our chances of success in organizing the TANGO expeditions.

The TANGO2 expedition focused on the northernmost part of the West Antarctic Peninsula (WAP) in an attempt to collect data and information to help the consortium address the scientific objectives laid out in the TANGO project.

Objectives of the expedition

The overarching objective of the expedition was to gather samples and data to help building a benchmark to contribute to our understanding of the drivers shaping the response of shallow benthic communities to contrasting glacial regimes in a fast-warming region of the Southern Ocean, the West Antarctic Peninsula (WAP). It is hoped that the collected samples will refine insights in the tipping points these communities might.

The objective was tackled by using a multi-faceted approach matched by the complementary competences of the scientific crew and the sampling gear.

The following specific objectives were tackled: (1) study **individual responses of selected key species**, (2) identify **species interactions** and the assessment of benthic species competition for resources (food, space) along a latitudinal gradient of different ice conditions, (3) investigate the **ecosystem responses** in terms of carbon fluxes along this same sea ice conditions latitudinal gradient and finally 4) **upscale our findings to ecosystem level**.

Concretely, the TANGO2 Team collected samples and carried out onboard experiments to understand the spatial distribution of biodiversity, the structure of trophic networks, and the energy (carbon) fluxes from the atmosphere to the sea floor.

Expedition members

Expedition leader:

Prof. Bruno Danis¹

R/V Australis Crew

Skipper: M. Ben Wallis²

First mate: M. Adam Coerper²

Stewardess: Ms. Alice Reade²

Scientific Team:

M. Anthony Voisin^{3, 7} (BSD diver)

Ms. Axelle Brusselman³

Dr. Camille Moreau¹ (BSD diver)

M. Emil De Borger⁴

M. Henri Robert⁵

Ms. Lea Katz¹ (BSD diver)

Dr. Lucas Terrana⁹ (ABSD diver)

Ms. Manon Bayat¹

M. Martin Dogniez^{3, 6} (BSD diver)

Prof. Bruno Delille³ (remote)

Affiliations :

1. Université Libre de Bruxelles
2. Ocean Expeditions
3. Université de Liège
4. Gent Universiteit
5. EMC²
6. Royal Belgian Institute of Natural Sciences
7. Université de Bretagne Occidentale
8. Musée d'Histoire naturelle & Vivarium de Tournai



Figure 1: The TANGO2 Team. Top row, from left to right: Lucas Terrana, Henri Robert, Emil De Borger, Alice Reade, Ben Wallis. Bottom row, from left to right: Lea Katz, Manon Bayat, Anthony Voisin, Axelle Brusselman, Bruno Danis, Martin Dogniez, Camille Moreau, Adam Coerper

Sampling platform: the R/V *Australis*

Research vessel AUSTRALIS is a steel hulled, fully rigged motor sailor registered as a commercial – Category 0 (zero – Unrestricted) vessel for cargo and passengers. She carries a comprehensive range of safety, operational and navigational equipment. A 180hp Gardner diesel engine powers the vessel and she is equipped with 2 zodiac tenders. She sails very well and has a powerful engine to push her along at 8+ knots when needed. The general layout of the boat is shown in Figure 2 and Figure 3.

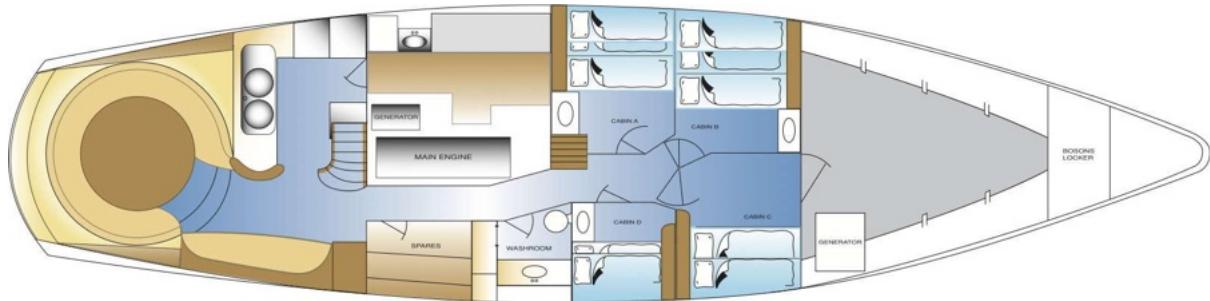


Figure 2: general layout of the cabins of R/V *Australis*

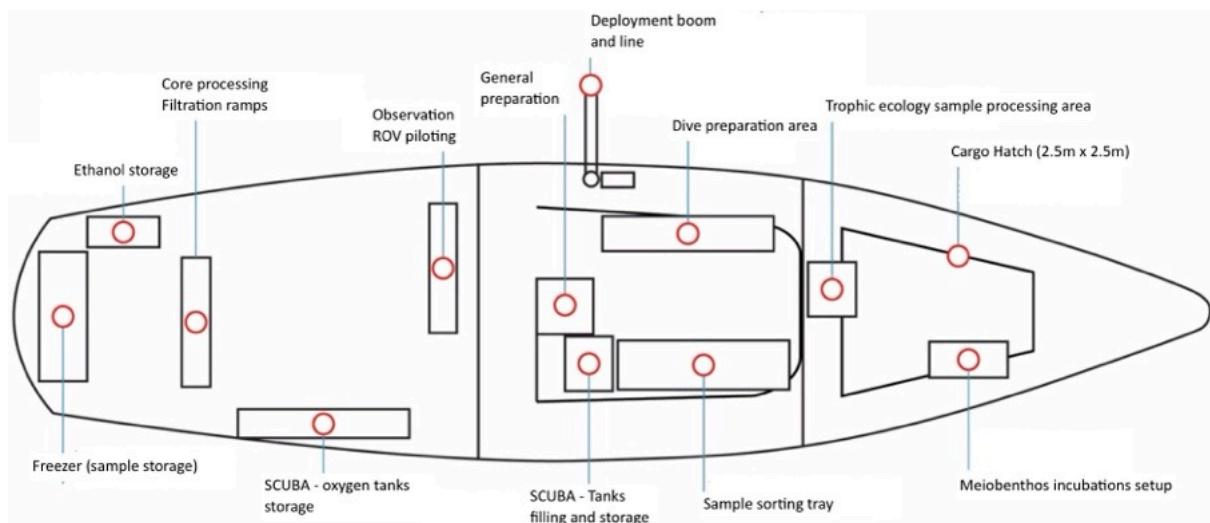


Figure 3: deck layout – deploy and working areas of R/V *Australis*

Specific equipment was added to the vessel in order to run the scientific mission and deploy the sampling gear in an efficient manner (Figure 3). This gear included for example a deploy boom and 400 m x 8 mm Dyneema deploy line (SLW 2800kg), a 2 x 0.6 m stainless steel sample sorting tray, a Van Veen benthic grab, and BAUER air compressors for diving tanks.



Figure 4: aerial view of the outdoor working space onboard Australis.



Figure 5: Sorting and processing samples on the tray on deck.

Calendar

The expedition took place between Feb 5th and March 8th, 2024. RV *Australis* departed from Ushuaia (Argentina) on Feb 7rd and arrived at the first sampling station (Melchior Islands) on

Feb 11th after transiting through the Beagle Channel, passing Cape Horn and the Drake passage towards the Western Antarctic Peninsula. The last station was completed on March 7th and the expedition returned to Ushuaia on February 27th, *via* Deception Island (to transfer samples to RV. *Hesperides*) then Snow Island. A total of 16 days were devoted to the sampling effort (excluding birds and marine mammals observations) carried out during transit time (from Ushuaia to the WAP, between the stations, and back to Ushuaia). The timing of the main sampling operations conducted during the expedition is detailed in Table 1 and Table 2. Three main sites were visited, allowing running sampling at different timescales along gradients of ice conditions at various spatial scales.

Table 1: simplified view of the overall calendar of the TANGO2 expedition

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
February							4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
February/March	26	27	28	29	1	2	3
March	4	5	6	7	8		

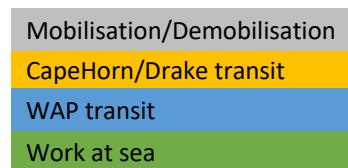


Table 2: station list including location and sampling dates.

EventID	Paren	SampleID	sampleType	Parameter	ScientificName
RD_1		152	biota		Porifera
RD_1		153	biota		Invertebrata
RD_1		154	biota		Invertebrata

Sampling Area

The sampling area focused on the West Antarctic Peninsula (WAP) in three contrasting areas: **Melchior Islands** (Latitude: 64°S), located near the center of Dallmann Bay in the Palmer Archipelago, **Hovgaard Islands** (next to Girard Bay glacier iceshelf, Latitude: 65°S) to the South of the Lemaire Channel and **Føyen Harbor**, on Enterprise Islands adjacent to the Gerlache Strait (Latitude: 64°S). The three locations were already visited during the Belgica 121 expedition (Danis et al. 2019), which provides the grounds for timewise comparisons. The maps below (Figure 6, Figure 7 and Figure 8Error! Reference source not found.) detail the distribution of the sampling effort.

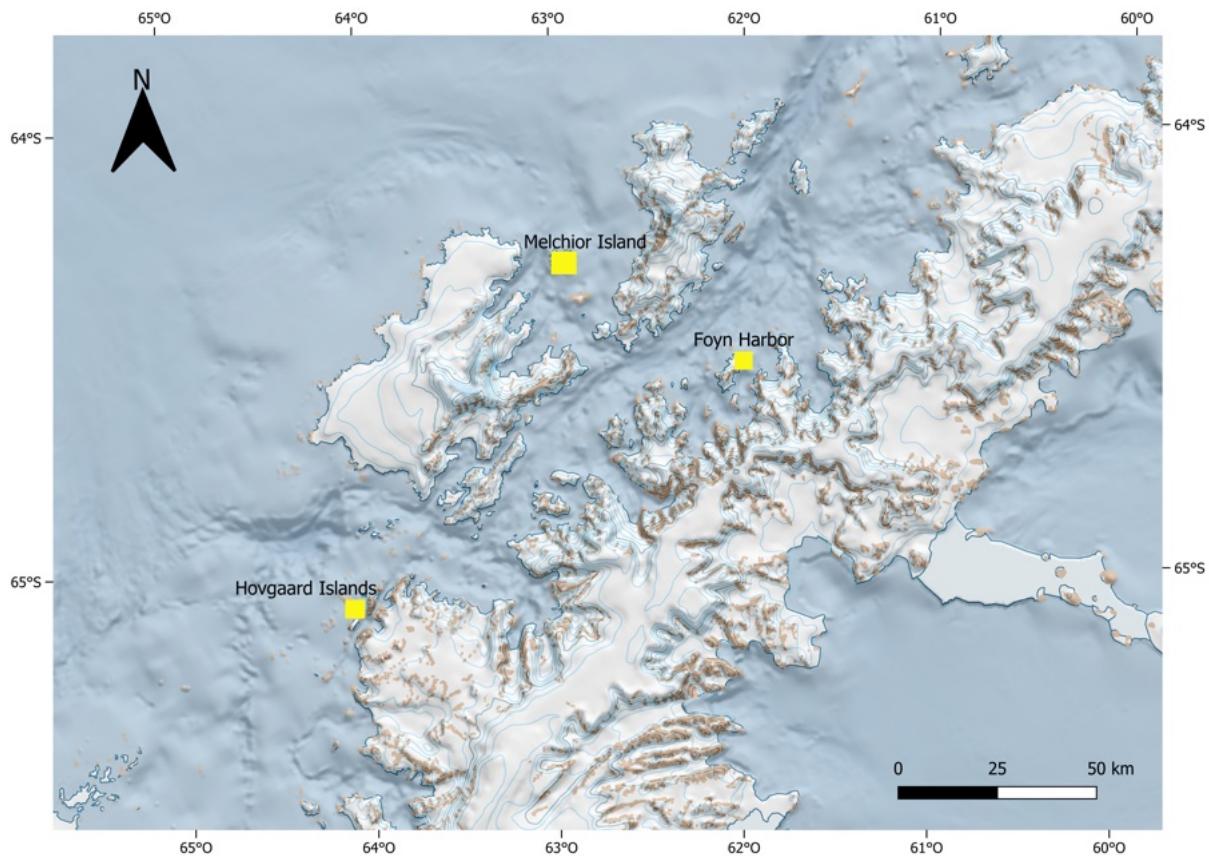


Figure 6: General map of the sampling effort during TANGO2, representing stations with full deployments.

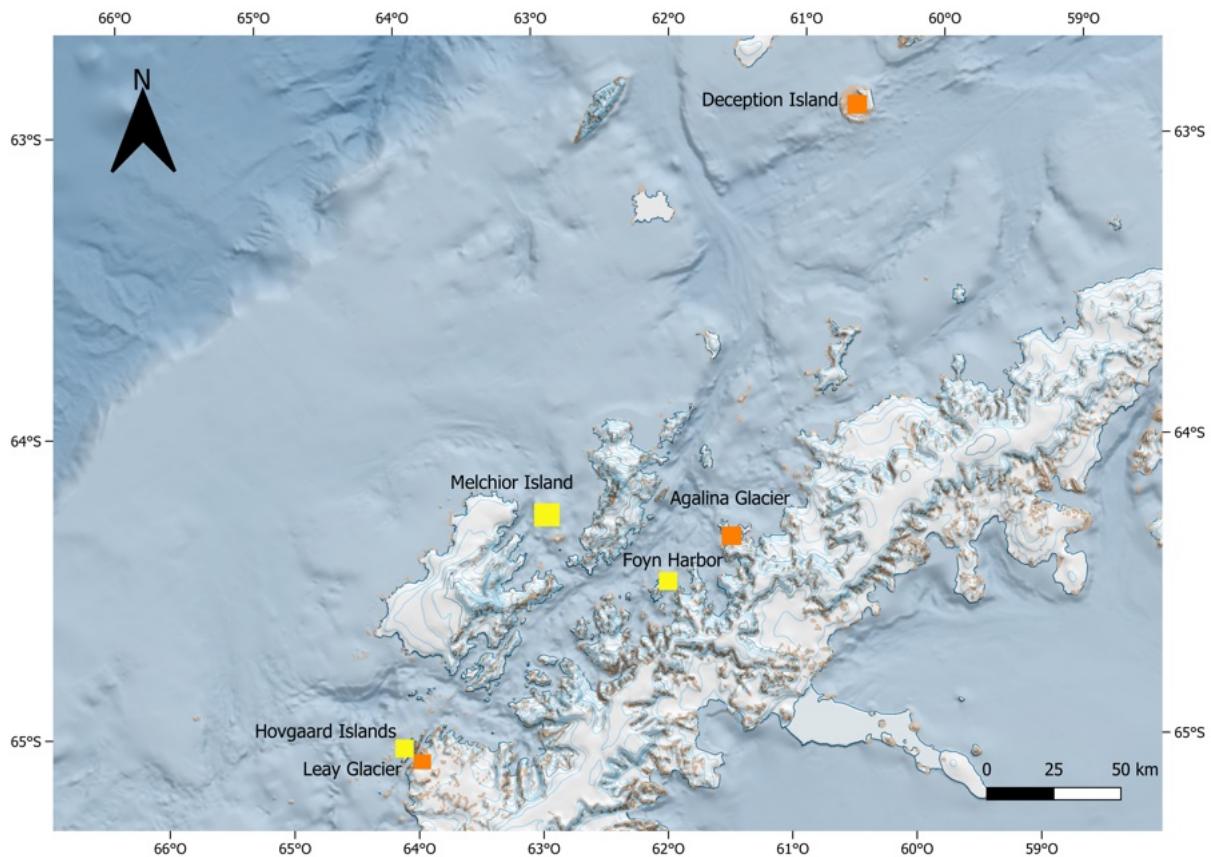


Figure 7: General map of the sampling effort during TANGO2, representing stations with full deployments (yellow) and additional oceanographic sampling (orange)

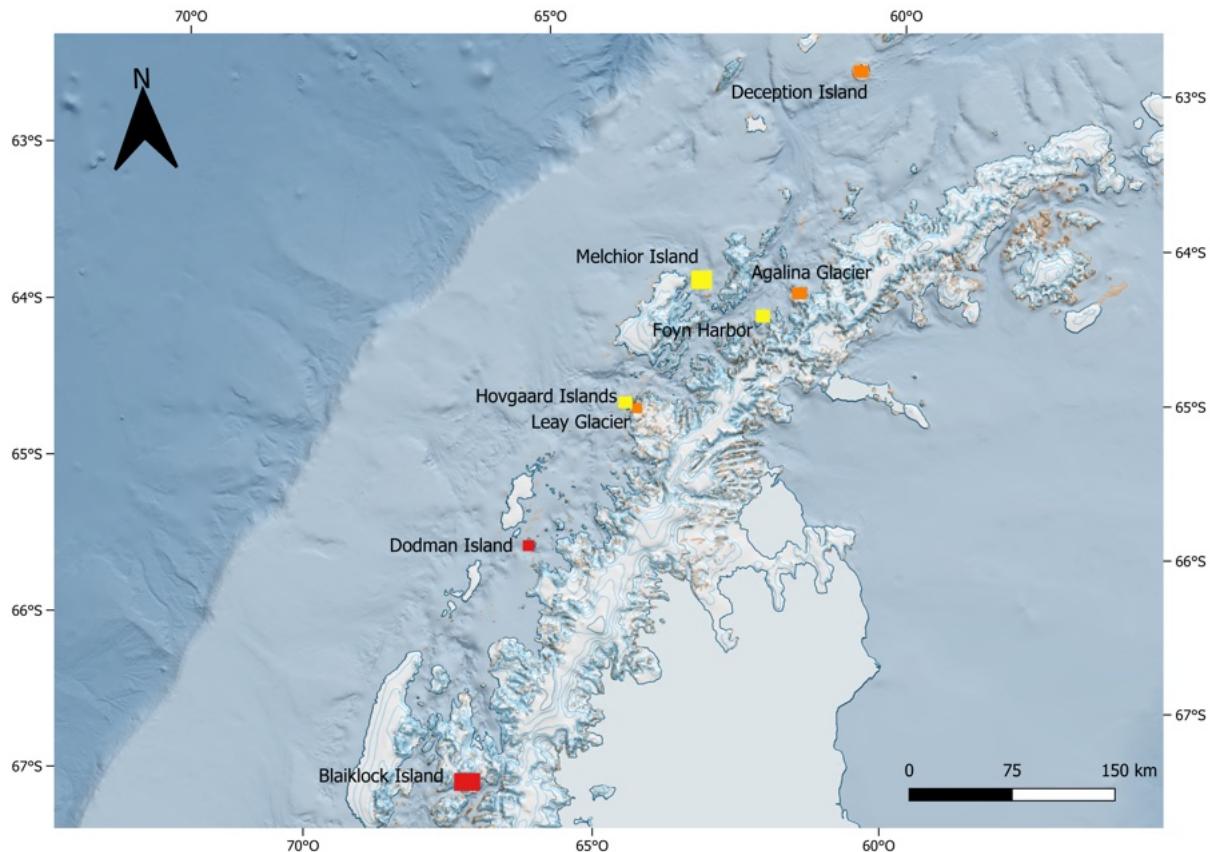


Figure 8: General map of the sampling effort during TANGO1 (Red) and TANGO2 (Yellow and Orange)

The expedition track reached a total mileage of 1546 nm (2863 km), and is shown in Figure 9 and Figure 10. The total length of the combined TANGO1 and TANGO2 transects is ca. 600 km.

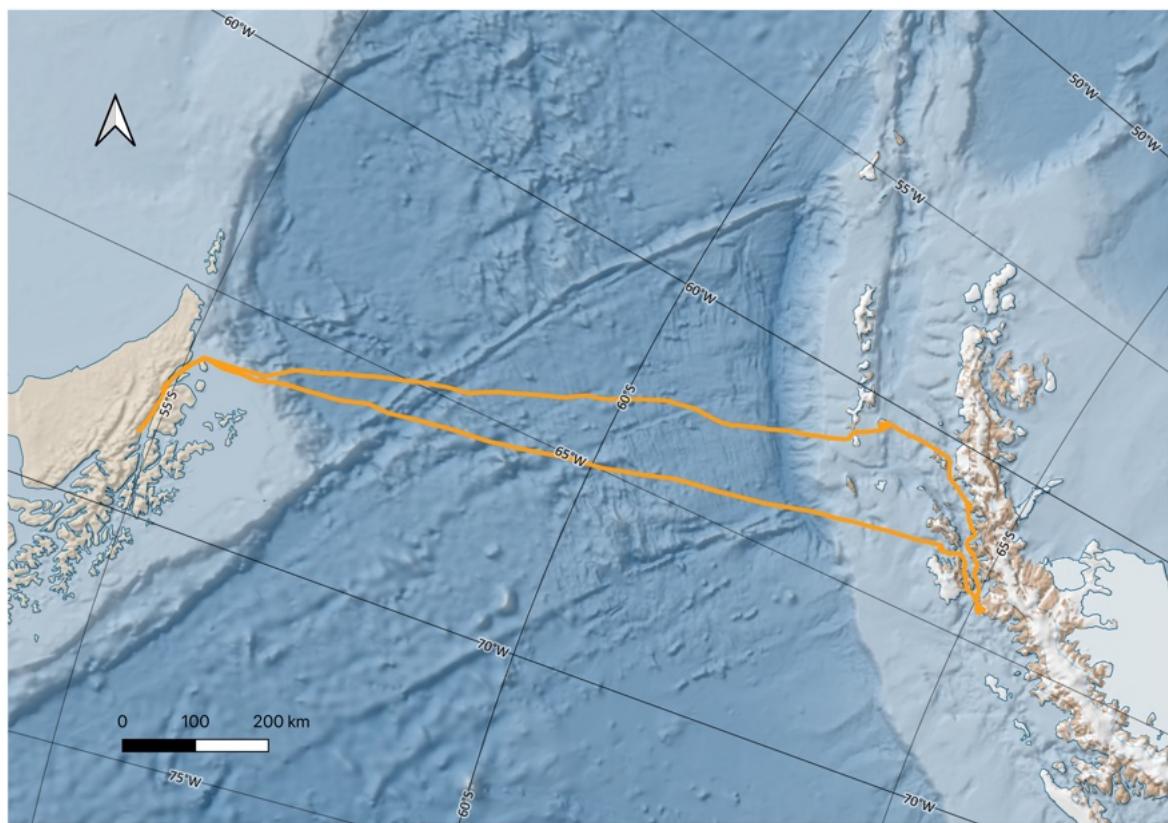


Figure 9. TANGO 2 expedition track from/to Ushuaia.

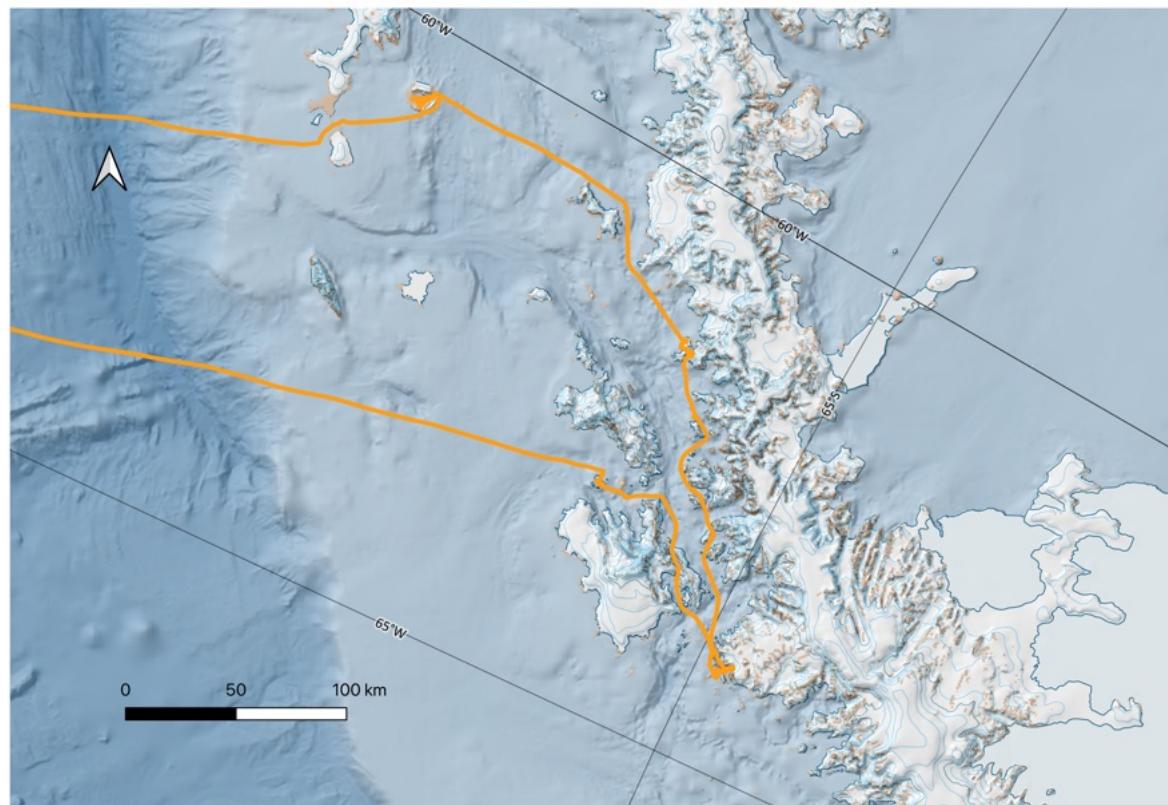


Figure 10. Close-up on the TANGO2 expedition track, focusing on the Gerlache Strait area.

The different stations were selected in shallow areas that differ in terms of environmental settings with a special attention to existing gradients of exposure to ice-related constraints (such as different values in change velocities).

A series of bathymetric maps were generated using the *Australis* single beam echosounder system and a portable system on Zodiacs and are displayed below, for each visited station (see [Bathymetry](#) section below for details). Additional maps are provided in the description of the work at sea to visualize the spatial and temporal distribution of the sampling effort carried out during the expedition.

[Melchior Islands \(MI\)](#)

Location: Palmer Archipelago. North of Gerlache Strait. Open to Drake Passage.

Settings:

- protected inner bay. muddy bottom with gravels and dropstones
- low glacier activity and ice disturbance
- no penguin colony
- regularly visited by tourists: usual boat anchorage. kayak and zodiac tours. no landing

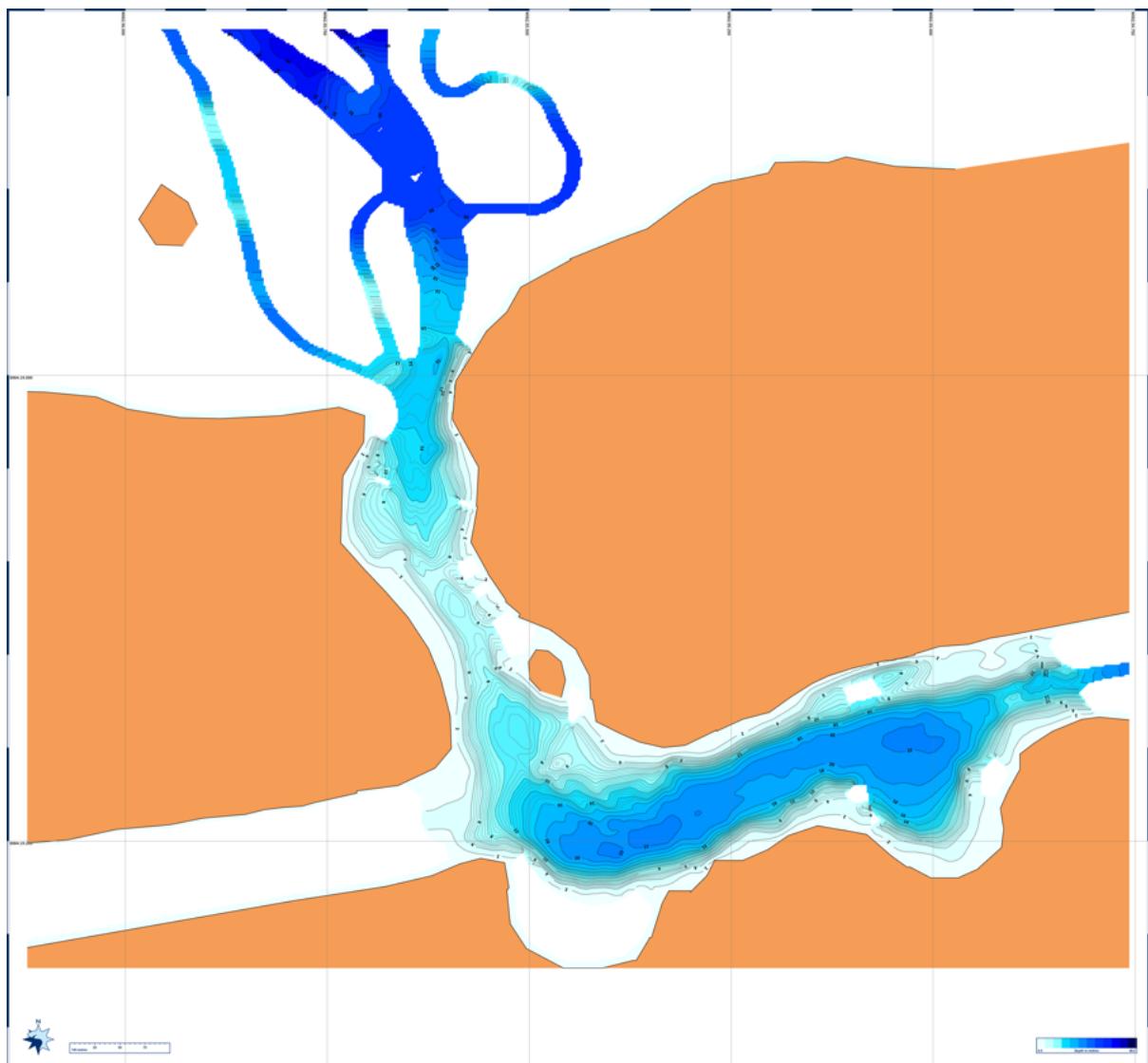


Figure 11. Melchior Islands (North Omega). Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

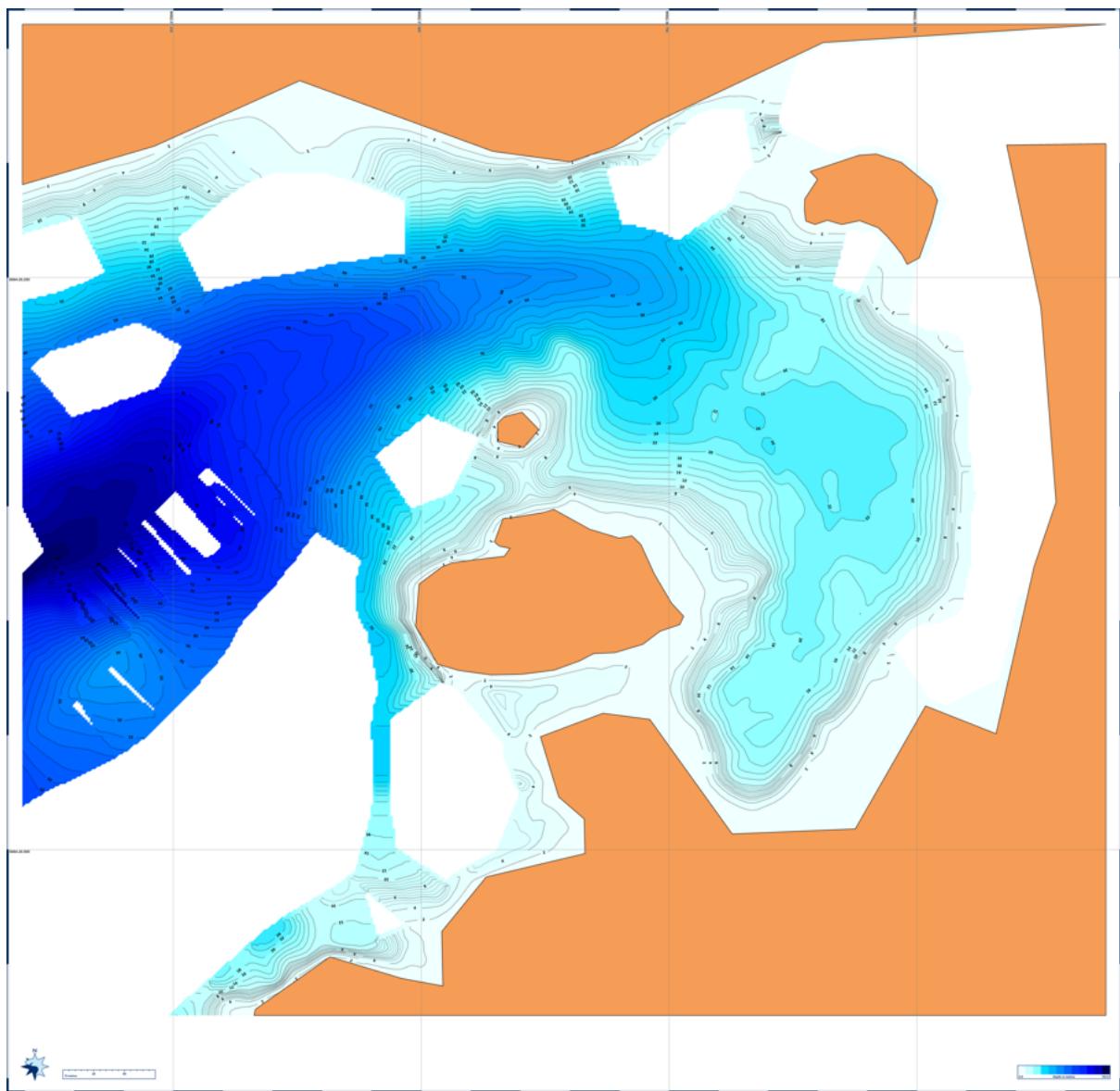


Figure 12: Melchior Islands (South Omega). Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

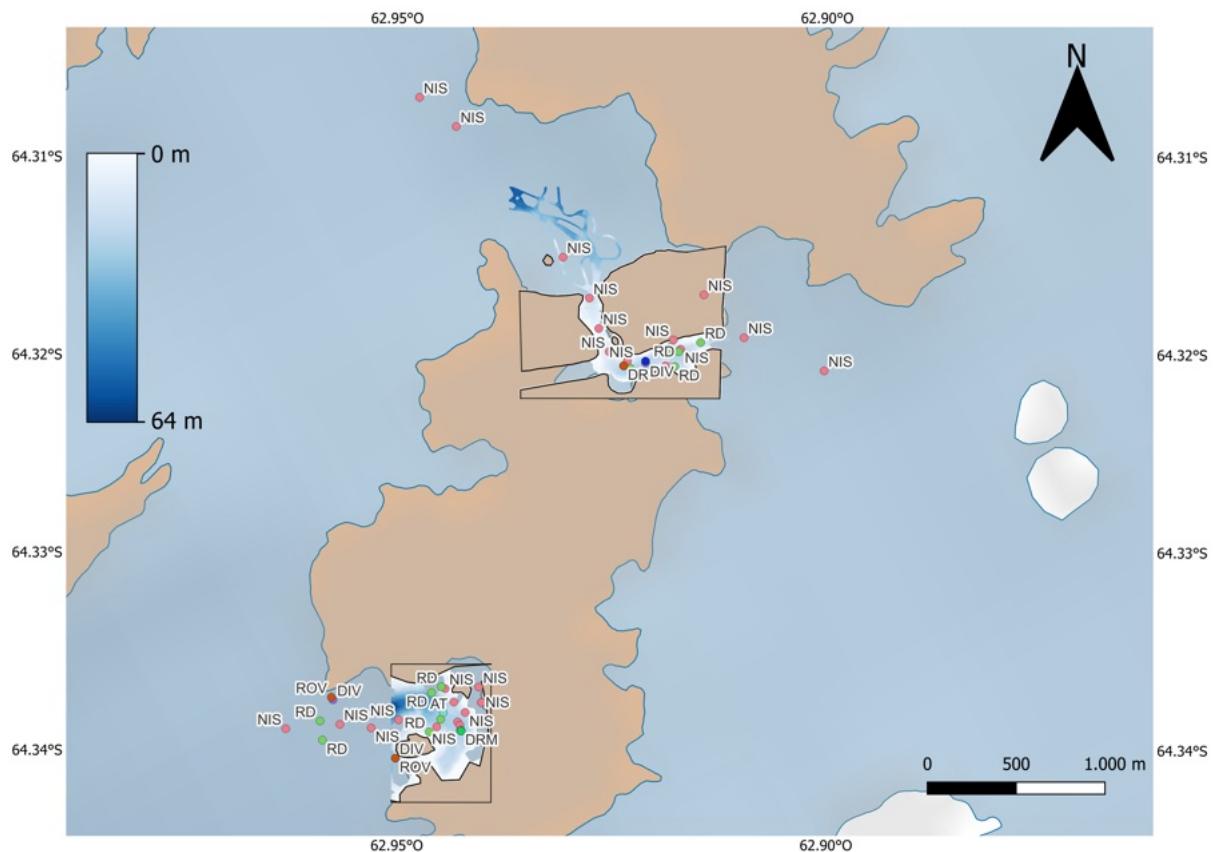


Figure 13. Melchior Islands total sampling area. All the deployment events are displayed on the map

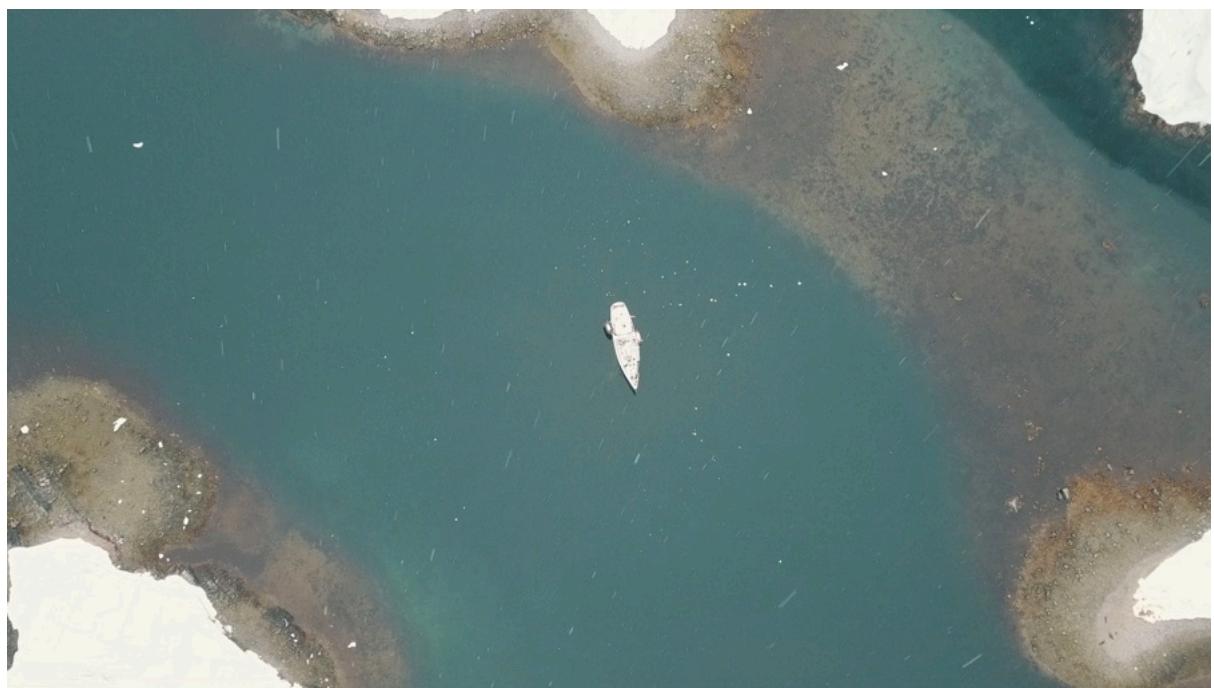


Figure 14: Aerial view of the anchorage in Melchior Island (alt.: 250m). Australis used for scale (75' - 23m)

Hovgaard Islands (HI)

Location: Wilhelm Archipelago. South of Gerlache Strait. open to Drake Passage and Antarctic Coastal Current influence

Settings:

- highly protected and almost enclosed inner bay
- no glacier activity nor direct ice influence
- no penguin colony
- low visit level but renown anchorage site: 30 boats a year

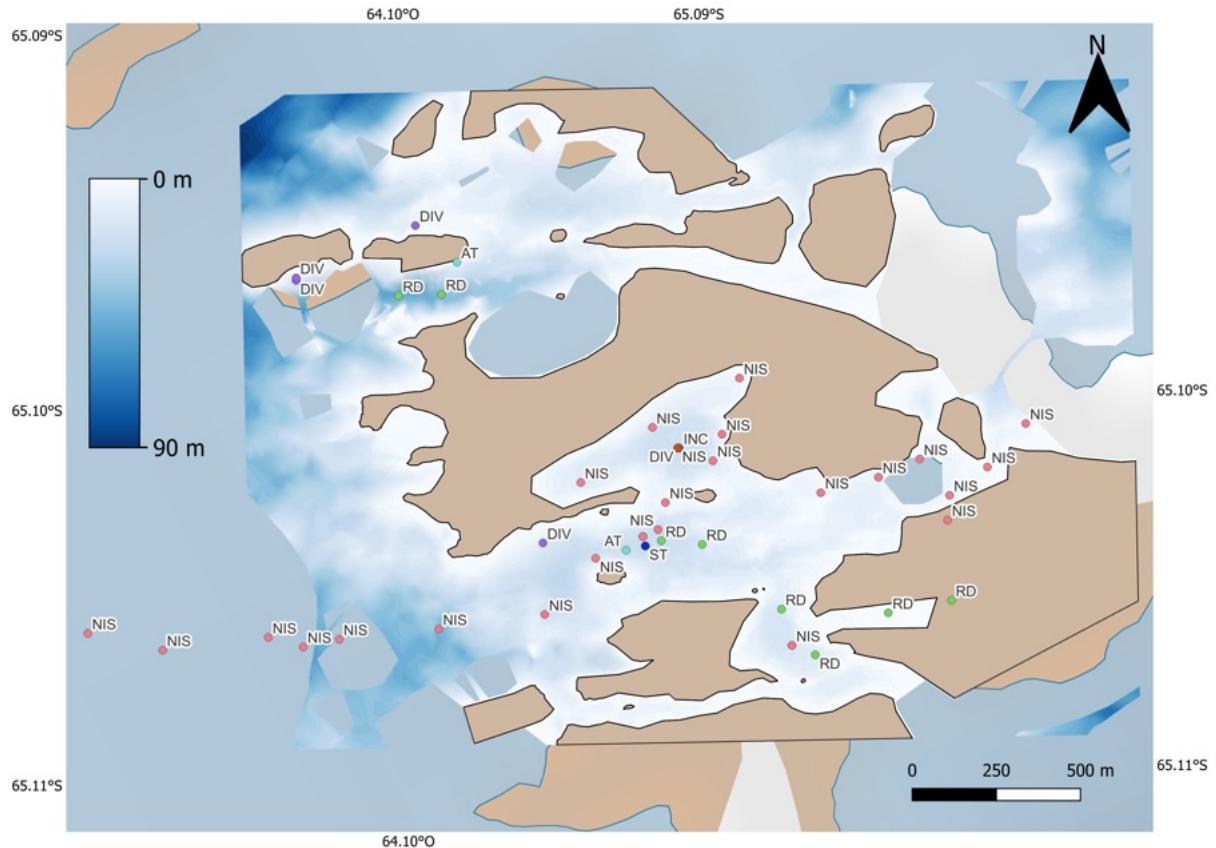


Figure 15. Total sampling area and different sampling site at Hovgaard Islands



Figure 16: Aerial view of the anchorage in Hovgaard Islands (alt. 500m). Australis used for scale (75' - 23m).

Føyn Harbor (FH)

Location: between Nansen Island and Enterprise Island NE Gerlache Strait, off Bancroft Bay
Settings:

- highly protected and almost enclosed inner bay
- no glacier activity nor direct ice influence
- no penguin colony
- low visit level but renown anchorage site, especially near the wreck of a whaling factory ship (Guvernøren).

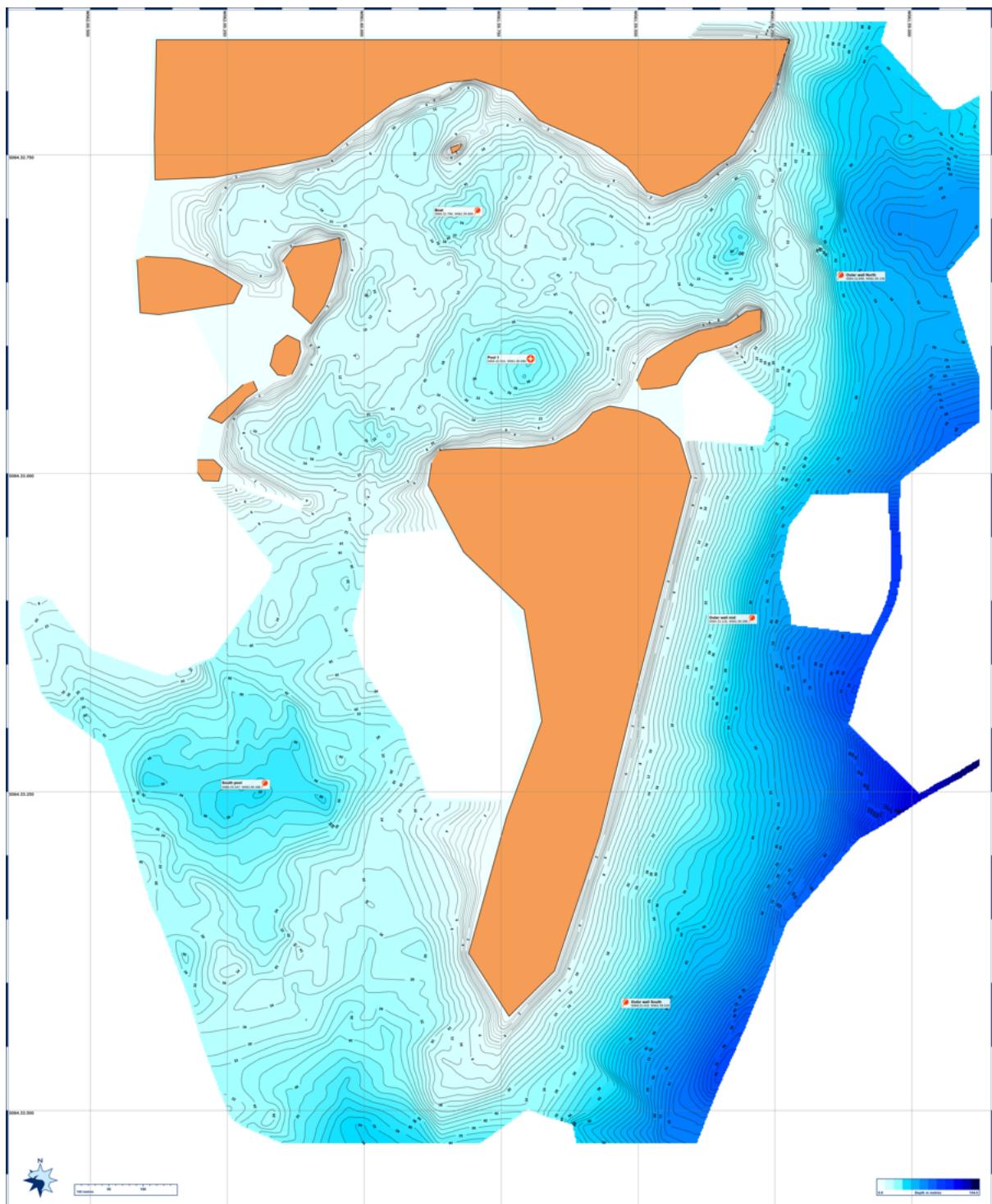


Figure 17: Føyn Harbor. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

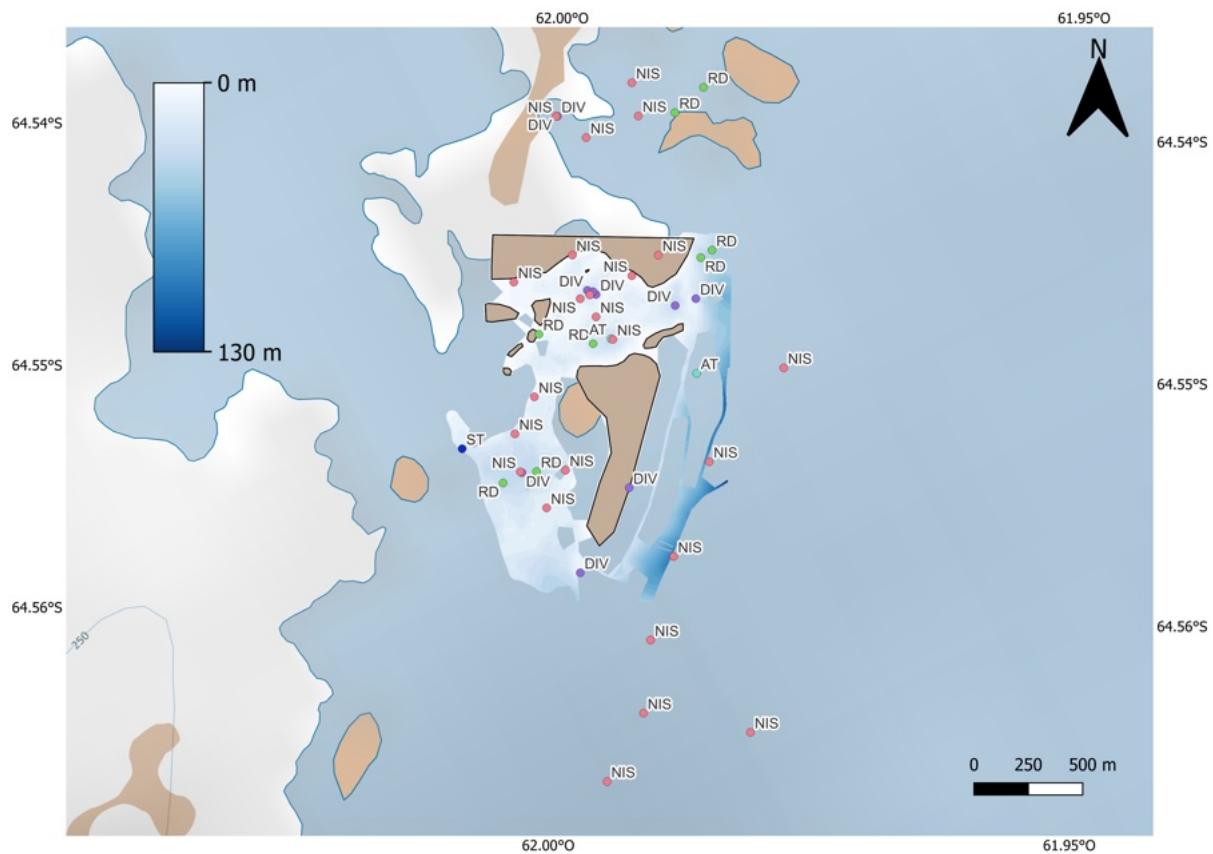


Figure 18: Sampling site bathymetry and all events at Føyn Harbor

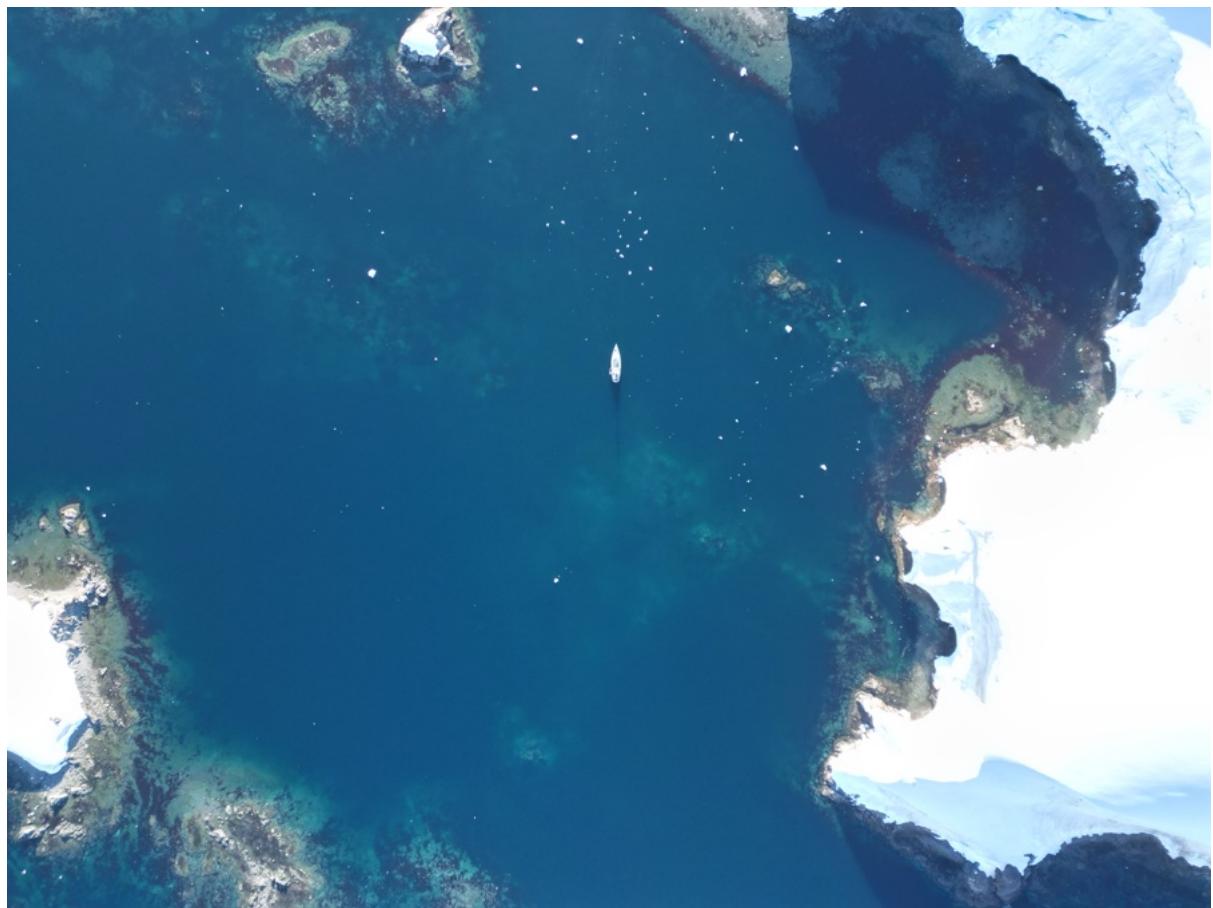


Figure 19: Aerial view of the anchorage in Føyn Harbor (alt. 500m). Australis used for scale (75' - 23m).

Work at sea and preliminary results

1. Concept and Sampling design

Bruno Danis

Context

Concerted efforts in documenting the Southern Ocean biodiversity has shown that the sampling intensity varies considerably with the considered geographic location (Griffiths & Danis 2011, De Broyer et al. 2014). Key elements in the distribution of sampling intensity are the locations of the various national bases and the routes of major research icebreakers. In fact, much of the sampling, tagging, and observing of animals has been done in the nearby coastal areas around the research bases. Based upon the knowledge gained during the B121 and TANGO1 expeditions (Danis et al. 2022, 2023), the TANGO2 expedition focused its sampling efforts on areas displaying gradients in ice conditions.

In the framework of TANGO2, we took advantage of the baseline information (bathymetry, ice conditions, geomorphology,...) acquired during the B121 expedition. This allowed the consortium to decide on the candidate stations for TANGO2, to best optimize the potential to meet TANGO objectives. To meet these needs, effectiveness, agility, operability were at the center of the strategic decisions taken during the expedition. To finalize the selection of the final sampling sites, special attention was devoted to opt for a nested design to allow taking into account multiple spatial scales, to feed information to the upscaling workpackage (WP4) of the TANGO project.

Methods

Available information was ground-truthed and/or refined by carrying out scouting sessions using Australis, two tenders (Bombard C3 and C4), DJI MavicPro2 and DJI Mavic Mini Pro3 drones, BlueROV ROV, and SCUBA divers.

This approach allowed for swift identification of suitable sampling stations, as well as anchorage fit for the deployment of the research gear, ensuring maximal efficiency for finding stations, and secure deployment of gear and SCUBA divers.

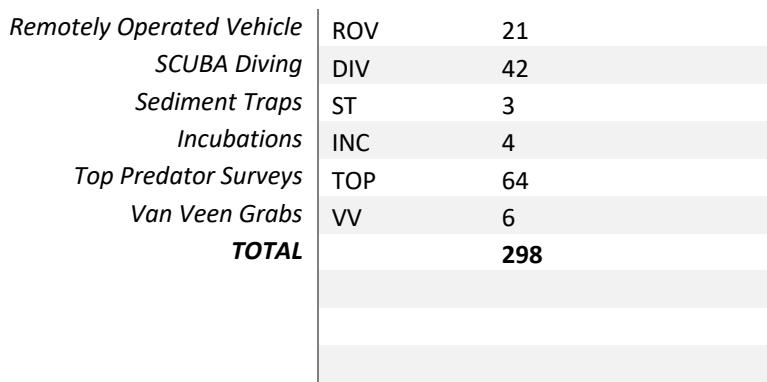
Results

Out of the total ship time devoted to the expedition (27 days), steaming from Ushuaia to the WAP (entrance via Melchior Islands) took 4 days. Time steaming back from Enterprise Island to Ushuaia was 7 days, including additional oceanographic sampling in Leah and Agalina Glaciers, in Deception Island and the drop-off of the samples at the Gabriel de Castilla Base (ES).

During the 18 operational days, 11 different types of deployment were carried out, reaching a total of 298 deployments (see Table 3).

Table 3: List of gear deployed during the TANGO 2 expedition.

Gear	Abbreviation	Deployments
<i>Amphipod Trap</i>	AT	6
<i>Niskin bottle</i>	NIS	130
<i>Drone - mapping</i>	DRM	11
<i>Intertidal</i>	ITD	2
<i>Rauschert Dredge</i>	RD	15



As shown in Table 3, a total of 298 Deployments, were carried out (over 10 per day on average). The samples collected included physical (seawater, sediments, ice, organisms, fragments of organisms, etc.) and virtual samples (in the form of media or data files). A total of approximately 4300 samples (virtual and physical) were collected during the expedition. The samples will allow to proceed with the analysis carried out in the framework of 14 sub-projects, listed in the Table of contents.

Perspectives

The preliminary (meta)results accumulated during TANGO2 confirm again the efficiency of using a nimble research platform to study fine-scale processes in the shallow areas of unchartered regions of the West Antarctic Peninsula. Based upon Open Science approaches, the concept tested and improved during the B121/TANGO1/TANGO2 paves the way to transposing the concept, and to multiply similar efforts in different oceans.

References

- Danis, Bruno, Ben Wallis, Charlène Guillaumot, Camille Moreau, Francesca Pasotti, Franz M. Heindler, Henri Robert, Henrik Christiansen, Quentin Jossart, and Thomas Saucède. "Nimble Vessel Cruises as a Complementary Platform for Southern Ocean Biodiversity Research: Concept and Preliminary Results from the Belgica 121 Expedition." *Antarctic Science*, June 14, 2022, 1–7. <https://doi.org/10.1017/S0954102022000165>.
- De Broyer C., Koubbi P., Griffiths H.J., Raymond B., Udekem d'Acoz C. d', Van de Putte A.P., Danis B., David B., Grant S., Gutt J., Held C., Hosie G., Huettmann F., Post A., Ropert-Coudert Y. (eds.), 2014. Biogeographic Atlas of the Southern Ocean. Scientific Committee on Antarctic Research, Cambridge, XII + 498 pp
- Griffiths, Huw J., Bruno Danis, and Andrew Clarke. "Quantifying Antarctic Marine Biodiversity: The SCAR-MarBIN Data Portal." *Deep Sea Research Part II: Topical Studies in Oceanography* 58, no. 1–2 (January 2011): 18–29. <https://doi.org/10.1016/j.dsr2.2010.10.008>.

2. Mapping

Aerial mapping

Bruno Danis

Context

Recent advances in drone technology allow for an easy deployments of aerial drones to complement georeferenced data gathered during scientific expeditions. On top of taking images at relatively high altitudes and gaining an overview of the setup at a sampling station, aerial drones can be used to build high resolution georeferenced orthomosaic pictures, using dedicated software, which result in data layers that can be used in combination with other spatially explicit data layers in a Geographic Information System.

Methods

The drone (DJI MavicPro2) was deployed when weather conditions allowed (wind velocity <10kts, good visibility). Two types of observations were carried out: aerial survey imagery (event ID: "DR") consisted in flying the drone at high altitude (500m) and manually taking high resolution images of the general setup of the different working areas. The second type of operation (event ID: "DRM") consisted in flying the drone after programming an automated flight (using the Flight app v4.129.0, running on an Apple iPhone 14 Pro smartphone, connected to the drone's remote control) to cover the area at an altitude of 60m. The programmed flight results in a sequence of georeferenced pictures taken along the path of the drone. The resulting images (resolution: 4000x3000 pixels) are processed using the Agisoft Metashape v1.6.2 to obtain orthomosaic pictures (GeoTIFF format) for further analysis in a GIS software.

Results

A total of 42 drone flights were carried out, including 11 drone mapping flights, representing a total of 3,77 hours of flight for a total distance of 25,1 km. 90 Gb of data were compiled. An example of a (pre)processed image resulting of the DRM_11 deployment (Føyn Harbor) is shown in Figure 21. The processing of images will be finalized out when back in BIOMAR (ULB).

The Mavic 2 Pro drone was lost at sea in Girard Bay (close to Lemaire Channel), during the Niskin deployments. The drone could not be recovered due to the water depth at that point (>250m).



Figure 20: Aerial view (alt. 500m) shot by the drone in Føyn Harbor (RV Australis in the center).



Figure 21: Example of an orthomosaic image obtained by aligning 335 images shot (139300 tie points) by the drone (DRM_11) in Føyen Harbor

Perspectives

Despite being rather sensitive to environmental conditions (strong wind velocity, compass interference with vessel, takeoff/landing delicate from vessel), deployment of drones was found to be useful in terms of scouting when arriving in new work sites, documenting their general setup as well as carrying out more sophisticated works including orthomosaic (2D) and photogrammetry (3D).

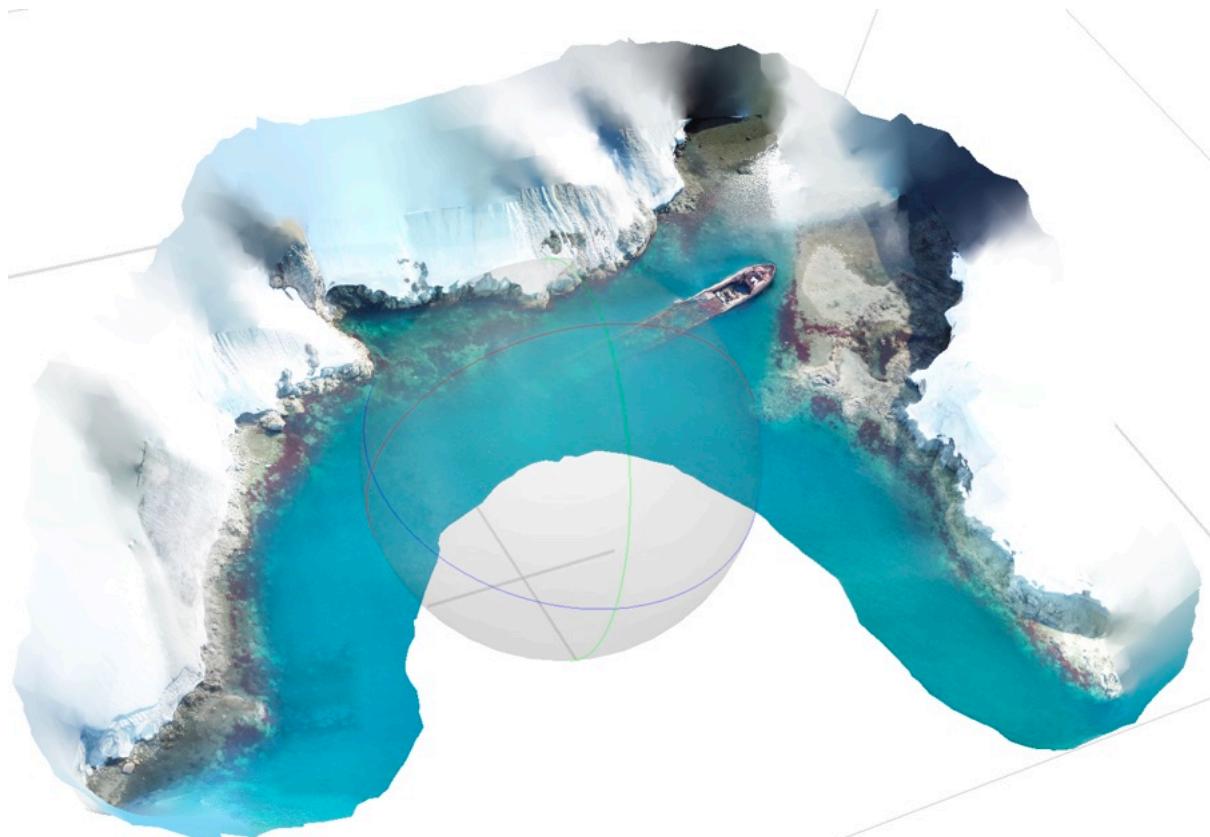


Figure 22: example of 3D reconstruction using the drone imagery from Figure 21 (generated using Agisoft Metashape Professional V 2.0.1)

Combined to other georeferenced layer gathered during the expedition (ROV imagery, bathymetry, etc...) the aerial imagery has a promising potential in terms of geospatial analysis at a scale matching the distribution of the sampling efforts. This avenue deserves to be further explored during the next expeditions.

Bathymetric surveys

Ben Wallis, Bruno Danis

Context

Large portion of the waters in the West Antarctic Peninsula are uncharted, and precise bathymetric charts are a pre-requisite to conduct oceanographic research in this region at spatial scales relevant to the TANGO project. Most available data is concentrated along the routes of oceanographic/logistic or tourist vessels, but there are massive gaps in the data available for shallow areas. In the framework of both TANGO expeditions, a special effort was devoted to generate fine-scale bathymetric charts for our sampling areas before and during sampling operations as time allowed. This information, as already determined in the framework of the B121 concept-expedition, is absolutely crucial to organize the sampling effort at each station, and for an efficient deployment of the gear.

Methods

Bathymetric charts were generated using the ReefMaster v2.0 software. Two main types of instruments were used to generate the data:

1. the RV *Australis* onboard single beam echosounder (Furuno FCV 295)

2. a portable echosounder (Hummingbird Helix 5) mounted on the Bombard C4 tender, for the shallowest areas

The shapefiles were used in combination with other data layers to generate the maps in the rest of the report.

Results

An estimated 40 hours were spent on both platforms to generate sufficient data to generate maps using the ReefMaster 2.0 software (as GIS/ESRI shapefiles).

All visited sampling sites (see

EventID	Paren	SampleID	sampleType	Parameter	ScientificName
RD_1		152	biota		Porifera
RD_1		153	biota		Invertebrata
RD_1		154	biota		Invertebrata

Sampling Area section above for details and examples) were charted using the described approach.

On top of the picture available in the present report, the bathymetric data has been generated in Shapefile format, which will allow the use and integration in Geographic Information Systems (GIS).

Perspectives

The bathymetric exercise allowed generating indispensable charts for reaching a very high sampling efficiency (for example for selecting preferential areas to deploy the SCUBA divers). We recommend that this approach is done systematically during future expeditions onboard RV Australis, and valorized as a significant contribution to the SCAR community of marine researchers.

As a side benefit, the generation of bathymetric chart helps identifying and flag dangers to navigation to be immediately communicated to IAATO (and forwarded to the relevant hydrographic authorities), as it was the case during the TANGO1 expedition.

Benthic Mapping

Lea Katz

Context

The Western Antarctic Peninsula (WAP) is one of earth's region where we witness the most dramatic environmental changes, with the warming of the upper water column, changes in the yearly extent of sea ice, intensification of ice-related processes such as glacier retreats and ice shelves collapsing, and changes in local primary production (Turner et al. 2013, Ducklow et al. 2013). How these changes impact the marine ecosystem and its processes is still largely unknown.

This project aims to study the impact of climate change-related processes on benthic communities by using the environmental gradients between the Northern and the Southern part of the peninsula as proxies of climate change scenarios. The goals of this project include providing a baseline of knowledge on biodiversity in the WAP, with a focus on benthic communities, studying their spatial heterogeneity and understanding how these communities respond to environmental differences at different spatial scales.

Results from TANGO1

In the Southern WAP, which was the area sampled during TANGO1, we found a very high small-scale heterogeneity (at the scale of a bay) in the benthic communities of Dodman Island (Figure 23).

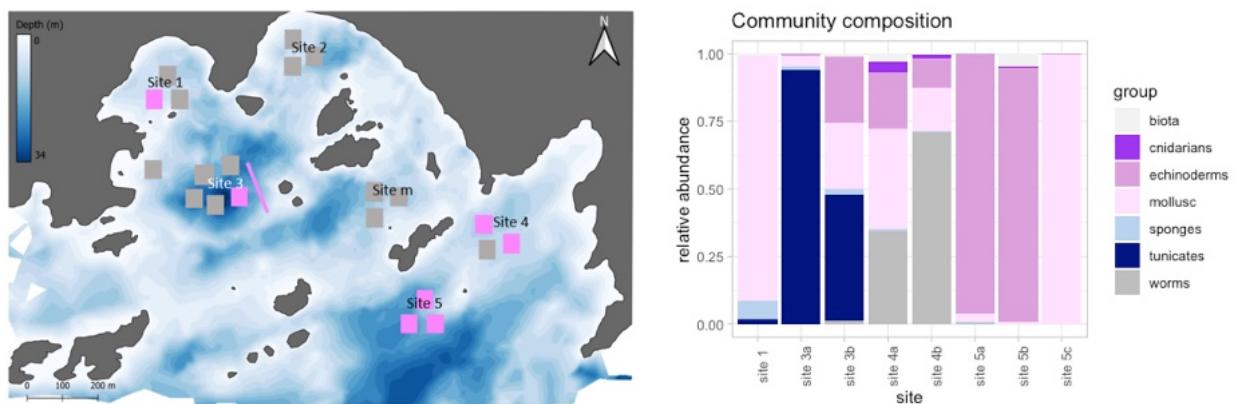


Figure 23: Spatial heterogeneity in Dodman Island (TANGO1 sampling station, 2023)

Methods

For TANGO2, 3 different sampling stations were chosen for their contrasting oceanography. There were more stations than TANGO1, but less sub-sites. Indeed, this allows to study different scales of environmental heterogeneities (intermediate and large scale), and with the previous expedition (TANGO1), an even larger scale (North VS South Peninsula).

The sampling method differed slightly from the one of TANGO1, where we used square-shaped areas to perform spatial analysis (SPPA). After analysis, the number of sessile species lacked to perform SPPA on our squares. This expedition, the sampling protocol was adapted to optimize time/coverage of the stations, using transects instead of squares and only perform a square-shaped sampling when the number of sessile animals was high enough (which was the case for 1 sampling site).

A small affordable Remotely Operated Vehicle (ROV), the BlueROV2 from BlueRobotics, was equipped with a downward looking GoPro (HERO10), a single-beam sonar and a pair of lasers. The ROV was deployed from the Australis itself or from a Bombard C4 tender. With a person managing the tether to assist the pilot.

GPS coordinates were taken on the surface using a handheld GPS (Garmin Oregon 600), then the ROV headed straight downwards until reaching the bottom. It was then flown at a constant altitude above the seafloor (1 meter), with a known bearing, for approx. 15 minutes at a pace of 0,1m/s, resulting in transects between 90-110 meters, depending on the geomorphological characteristics of the site. Then, it was brought back straight upwards to the surface and a second GPS point was recorded. If, for weather or logistic reasons, it was not possible to retrieve the second GPS point, it was calculated afterwards using distance and bearing. In total, 44 transects were performed successfully, resulting in 398 GB of data or approx. 24 hours of video footage.

Table 4: overview of the sampling effort (intensity and location) using the ROV during TANGO2

Sampling station	transects	lon min	lon max	lat min	lat max
Melchior Is.	16	-64.3812	-64.3192	-62.9584	-62.9167
Hovgaard Is.	13	-65.1086	-65.095	-64.0929	-64.0745
Foyn Harbor	15	-64.556	-64.5457	-62.0064	-61.9889

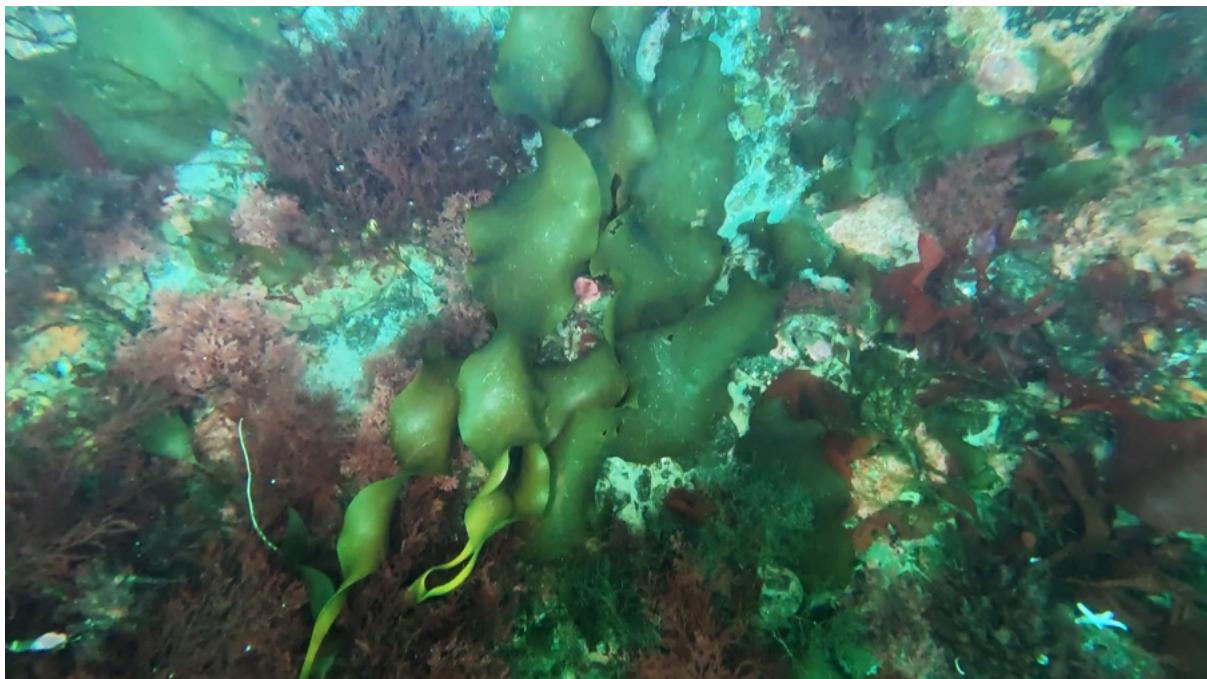


Figure 24: Melchior Is. South Omega, outer bay (ROV_10, 31m)



Figure 25: Hovgaard Is., south pool (ROV_15, 14m)



Figure 26: Hovgaard Is., outer pool, "tombant" (ROV_13, 25m)



Figure 27: Hovgaard Is., channel (ROV_14, 20m)



Figure 28: Føyn Harbor, « Enterprise Island » (ROV_20, 25m)

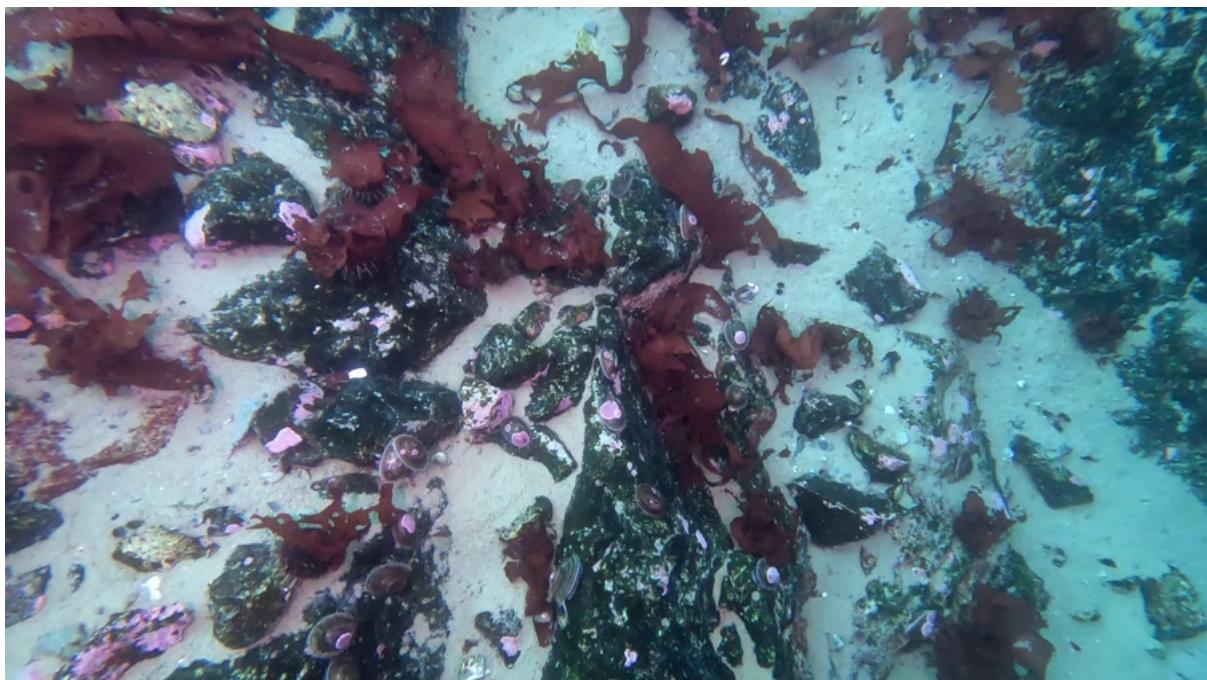


Figure 29: Føyn Harbor, "boat pool" (ROV_16, 15m)

General Observations

From a first look at the videos, there is a very high heterogeneity between stations and between the station's sub-sites. In general, there is much more algae abundance and diversity in Melchior Islands, but more sessile filter feeding animals in Hovgaard Island and Føyn Harbor.

Due to some technical issues, some transects had to be repeated or carried out by divers.

Perspectives

Back in the lab, still images will be extracted from the videos and resulting images will be used for annotation. Each individual as well as algae cover and sediment type will be marked up on

BIIGLE (Langenkämper et al. 2017) using a CATAMI-inspired label tree (Althaus et al. 2013), using morphotypes rather than species (Figure 30), as most groups require live specimens to identify up to the species level.



Figure 30: annotated image from TANGO1, from BIIGLE.

Then, abundance data will be used to calculate biodiversity indexes, compare dominant morphotypes and functional groups between stations.

Finally, to understand what underlying processes shape the heterogeneity in the benthic communities Bayesian Network Inference (BNI) analysis will be performed on different spatial scales, integrating all environmental parameters measured by the different TANGO2 parties. Performing BNI on this type of data allows for a naïve approach on how the different “nodes” in our network are connected to each other, regardless of their nature (taxonomic and/or functional groups, substrate, depth, water characteristics, etc.). Causal relationships between each node will be statistically inferred using Banjo v2.2.0. Then, we can simulate the removal of a taxa or changes in an environmental variable and see how this affects the other nodes in the network.

References

- Turner, J., Barrand, N.E., Bracegirdle, T.J., Convey, P., Hodgson, D.A., Jarvis, M., Jenkins, A., Marshall, G., Meredith, M.P., Roscoe, H., Shanklin, J. (2014) *Antarctic climate change and the environment: an update*. Polar Record 50 (254): 237–259. doi:10.1017/S0032247413000296
- Ducklow, H.W., W.R. Fraser, M.P. Meredith, S.E. Stammerjohn, S.C. Doney, D.G. Martinson, S.F. Sailley, O.M. Schofield, D.K. Steinberg, H.J. Venables, and C.D. Amsler. (2013). West Antarctic Peninsula: An ice-dependent coastal marine ecosystem in transition. Oceanography 26(3):190–203, <https://doi.org/10.5670/oceanog.2013.62>.
- Althaus F., Hill N., Edwards L., Ferrari R., et al. (2013). *CATAMI Classification Scheme for scoring marine biota and substrata in underwater imagery – A pictorial guide to the Collaborative and Annotation Tools for Analysis of Marine Imagery and Video (CATAMI) classification scheme*.
- Langenkämper, D., Zurowietz, M., Schoening, T., & Nattkemper, T. W. (2017). *Biigle 2.0-browsing and annotating large marine image collections*. Frontiers in Marine Science, 4, 83. doi: 10.3389/fmars.2017.00083

3. Environmental parameters

Axelle Brusselman

Context

In order to gain a better understanding of the environment we are studying, but also to be able to characterize it, we have analyzed environmental parameters. These parameters enable us to characterize the water column and therefore to discriminate between the different sites using physical criteria. This gives us an overall view of the environment and enables us to understand the interactions between the individuals that make up the environment and the environment itself. It helps us also to highlight some processes that occur in coastal environments.

Method

Vertical salinity and temperature profiles were performed using ODDI sensors. HOBO sensors were used for light profiles. These profiles were done on every TANGO 2 sites. The sensors were attached to a 2.5L Niskin bottle (see Figure 31) during the sampling of biogeochemistry parameters of the water column.



Figure 31. Details of the HOBO light and ODDI CTD sensors setup on the 2.5L Niskin. The ODDI sensor is secured in the yellow plastic tube.

Attention has been paid to condition the ODDI sensor in cold seawater for at least 10 min before the CTD profile, then to let the sensor for 3 min at the surface before going down slowly to perform the CTD profile.

Results

In total, 8 CTD and light profiles have been taken. All the sites were investigated.

The temperature varies in function of site and depth with a range between -1.1°C at Melchior South (site full of brash ice) and 3.1°C at Melchior North (see Figure 32).

For the light, the intensity at the surface could reach up to 20000 Lux on a sunny day and fall to 15000 Lux on foggy day. The intensity falls fast and is comprise between 0 and 1000 at 10m depth (see Figure 33).

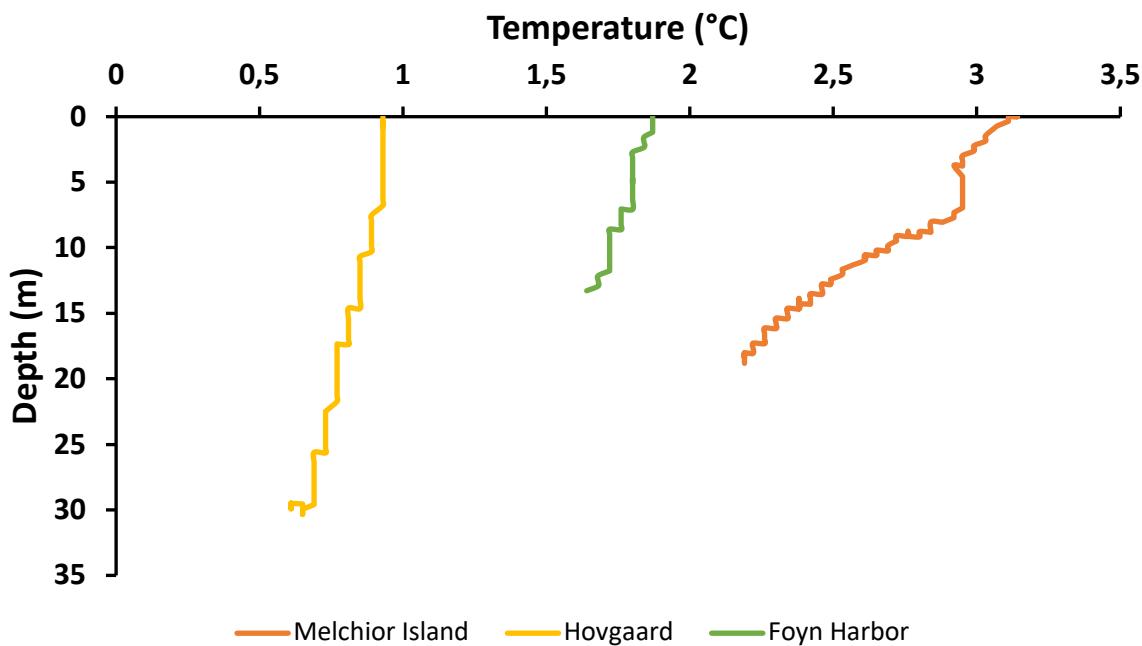


Figure 32. Temperature profiles at the three main stations of TANGO2

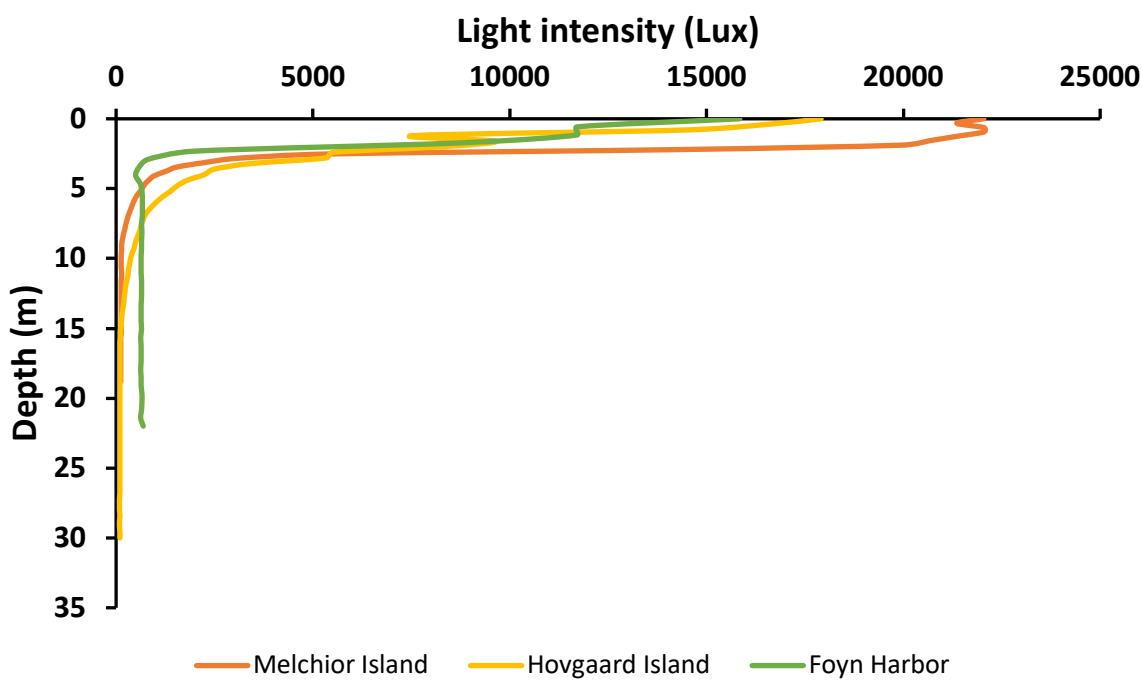


Figure 33. Light intensity profiles at the three main stations of TANGO2

4. Biogeochemistry

Context

TANGO aims to follow the sources and sinks of carbon across the sea ice-water column-benthic continuum and the fate of the carbon in the food web. The biogeochemistry effort was designed to document carbon fluxes in the water column and at the air-sea interface, while carbon fluxes at the sea floor were measured at a part of the soft bottom incubation. We also investigated the vertical export and the primary production. We consider carbon fluxes at large, including methane fluxes. In addition, we measured N₂O to complete the survey of greenhouse gases.

Collection of samples for the measurement of partial pressure of CH₄ and N₂O (pCH₄ and pN₂O) carried out as the general TANGO strategy (i.e. at TANGO sampling sites) were extended with additional transects carried out in and out of Deception Island.

Biogeochemical parameters

Method

Biogeochemical parameters were sampled by water collection with a 2.5L General Oceanic Niskin bottle at three depths: (0m, 6m and 1m from the bottom). Two entire profiles minimum were done at every station.

The measured parameters are presented in Table 5.

Table 5. Parameters to be measured in the water column

Parameter	Instrument	Laboratory
Salinity	Guilgline 8400B Autosal	University of Liège
Pigments (including Chl a)	HPLC	University of Liège
Particulate organic carbon (POC), particulate organic nitrogen (PON), particulate organic sulphur (POS), δ ¹³ C of POC, δ ¹⁵ N of PON, δ ³⁴ S of POS	Mass spectroscopy	University of Liège
CH ₄ and N ₂ O concentration	Gas Chromatography	University of Liège
¹³ CH ₄	Cavity ring-down spectroscopy	University of Liège
Nutrients		Max Plank Institute of Chemistry
Total alkalinity (TA)	Gran titration (open cell)	University of Liège
Dissolved inorganic carbon (DIC)	Airica DIC analyzer (Marianda)	University of Liège

Dissolved organic carbon (DOC)		University of Liège
Total suspended matter (TSM)	Weight	University of Liège
Fatty acid		Brest University
Environmental DNA (eDNA)		RBINS

After sampling, all the parameters had a treatment on board as follows:



Figure 34. Filtration setup at the back of the Australis

Salinity were collected by filling up one brown 100ml glass vial with a headspace.

TA, DIC were collected by filling up two brown 100ml glass vials with a headspace and adding 100µl of saturated HgCl₂ solution just after sample collection.

CH₄/N₂O concentration and δ¹³C of CH₄ were collected in 60ml serum glass vials without bubbles, with an isobutyl stopper and aluminum cap (crimped), and the adding 60 µl of saturated HgCl₂ solution just after sample collection. Two bottles were collected for CH₄/N₂O concentration and 2 bottles for δ¹³C of CH₄.

Pigments were collected by filtering 0.8L of seawater on 25mm GF/F glass fiber for pigment analysis. Filters were stored in cryovials in a liquid nitrogen container, then in a -80°C fridge on the *RV Hesperides*.

POC, PON, POS, $\delta^{13}\text{C}$ of POC, $\delta^{15}\text{N}$ of PON, $\delta^{34}\text{S}$ of POS for vertical profiles were collected by filtering 0.8L of seawater on 25mm pre-combusted (12 hours at 450°C) GF/F glass fiber filters. Filters were stored in petri dishes and dried at 60°C for at least 12 hours.

POC, PON, POS, $\delta^{13}\text{C}$ of POC, $\delta^{15}\text{N}$ of PON, $\delta^{34}\text{S}$ of POS to complement organisms analysis were collected by filtering 2L of seawater on 47mm pre-combusted (12 hours at 450°C) and pre-weighted GF/F glass fiber filters. Filters were stored in aluminum foils and dried at 60°C for at least 12 hours.

Total suspended matter were collected by filtering 2L of seawater on 47mm pre-combusted (12 hours at 450°C) and pre-weighted GF/F glass fiber filters. Filters were stored in aluminum foils and dried at 60°C for at least 12 hours.

Fatty acid were collected by filtering 2L of seawater on 47mm pre-combusted (12 hours at 450°C) and pre-weighted GF/F glass fiber filters with the addition of hot fresh water at the end of filtration. Filters were stored in a 5 ml brown glass vial pre-filled with a 2:3 chloroform, 1:3 methanol mix. Glass vials were then stored at -20°C. Attention was paid to cleaning the tweezers with ethanol and rinsing them with filtered seawater.

At least 1L was filtered for Environmental DNA (eDNA) on dedicated filter cartridges. Water in the cartridge was removed, and 3ml preservative was added according to the protocol. Bottles and the bucket used for the filtration were cleaned with a 1% bleach solution and rinsed with filtered seawater.

Results

In term of filtration, the three sites were very similar with the same coloration on the filters. It was possible to filter between 0.8 and 1L of seawater at the bottom and around 0.6L at the top of the water column. For the three sites, it was the middle depth (6m) that clogged the fastest (around 0.5L filtered). This suggests a higher particulate matter concentration at this depth.

Filtration volumes are different from TANGO 1, where the filtrations were 1L or above most of the time and the filters clogged faster at the surface. It can be due to a water with a higher particulate matter concentration. It can also be the result of the change of equipment, we used a new pump that have less pressure than the previous one.

Primary production

Method

Primary production was measured with ^{13}C 24 hours incubations. A total of 6 incubations were performed (one per substation). All the incubation started between 6 and 7am to be as close as possible to the sunrise. The spiking solution were prepared on board by dissolving pre-weighted $\text{NaH}^{13}\text{CO}_3$ with 50ml of milliQ water.

Five liters of surface water were collected and spiked with ^{13}DIC for a ratio of 0.3ml/500ml. three liters of spiked water were then transferred in 6 PC transparent bottles of 500ml. The bottles were attached to an incubation line at three different depths (5m, 10m and 15m above bottom) with two bottles per depth and a HOBO light logger (Figure 31). The set up was placed away from the boat for 24 hours to avoid its shadow during the day.

We filled three exetainer of 12ml with spiked sea water and added saturated solution of HgCl_2 for DIC measurement. POC was performed by filtering 3*500ml of spiked water on GF/F filters.

After 24h, the incubation line was retrieved, and each bottle were filtered on GF/f filters.

Attention was paid to use specific equipment for incubation filtration to avoid contamination with natural samples. All the filters were placed in petri dishes and in Ziplock and placed at -20°C.

During the 24h hour of the incubation, a light profile was taken with the CTD to know the intensity of light at every depth.

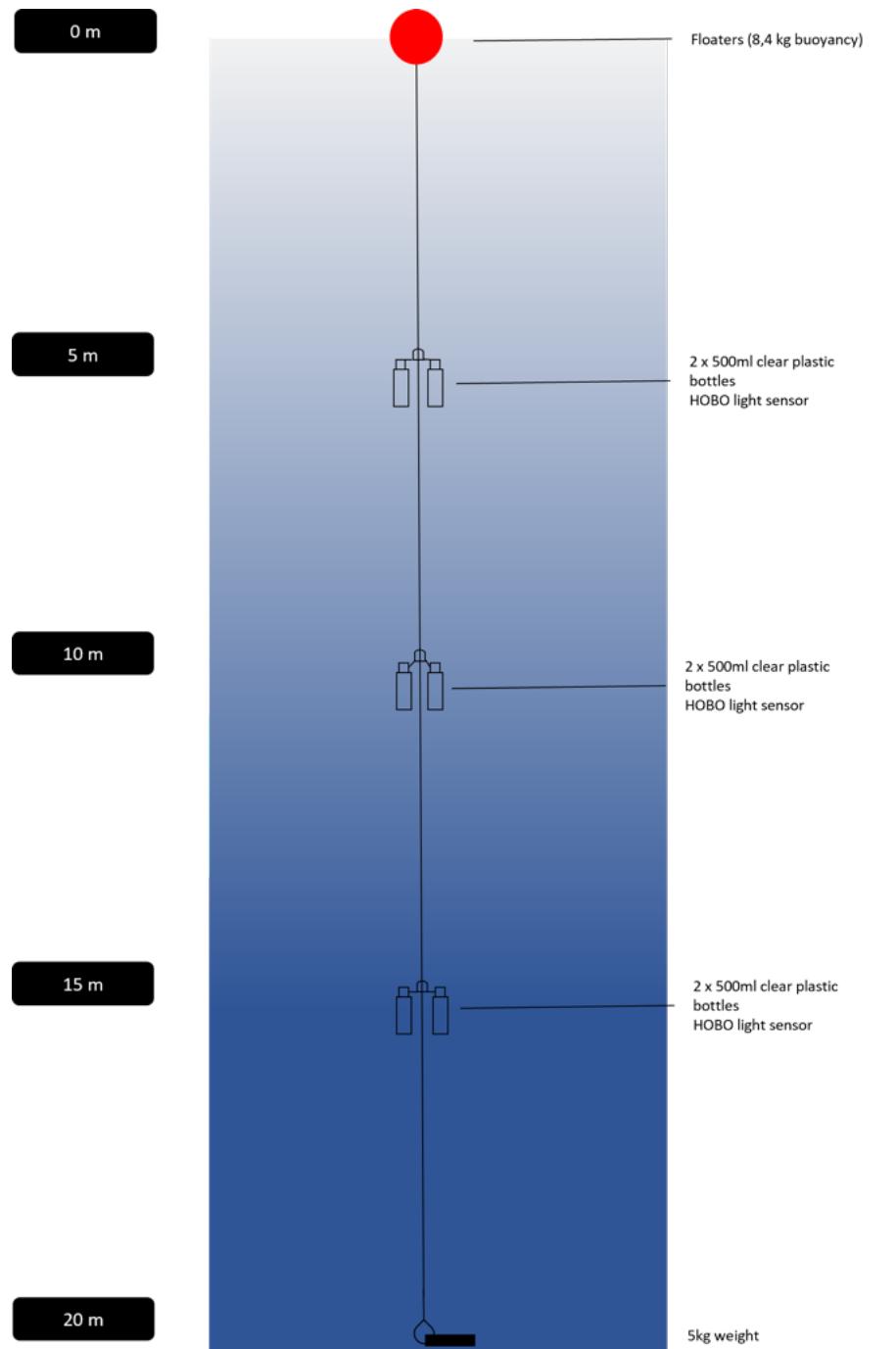


Figure 35. Incubation line sketch

Result

A total of six incubations were performed at every substation. There was no visible difference between the stations or the bottle during the filtration.

Vertical export

Method

We measured vertical fluxes of carbon using a sediment trap (Figure 37). One sediment trap was deployed at the three main sites for about 5 days on a relatively flat bottom ranging between 18 m and 20 m to allow release by divers. Only one collecting cup was used for each deployment. The cup was filled with brine prepared with filtered seawater (FSW) and the addition of NaCl to increase the salinity by 5 psu. No preservatives were added. Filtered seawater was prepared by filtering surface seawater collected close to the vessel and filtered on a Sartorius Sartroban 0.45/0.2 μ cartridge using a peristaltic pump set at 1l/min. Filtered seawater was kept in the dark at room temperature.



Figure 36. Setup for the preparation of the filtered seawater at the front of the *Australis*

To prevent mixing of the sample during the sediment trap recovery, the sample bottle was recovered by the divers before releasing the trap. We carefully divided the sample bottle in two subsamples of equal sediment content to allow two filtrations.

The content of the suspended matter will be analyzed for:

- Pigments (including Chlorophyll a)
- POC, PON, POS, $\delta^{13}\text{C}$ of POC, $\delta^{15}\text{N}$ of PON, $\delta^{34}\text{S}$ of POS
- TSM (weight)

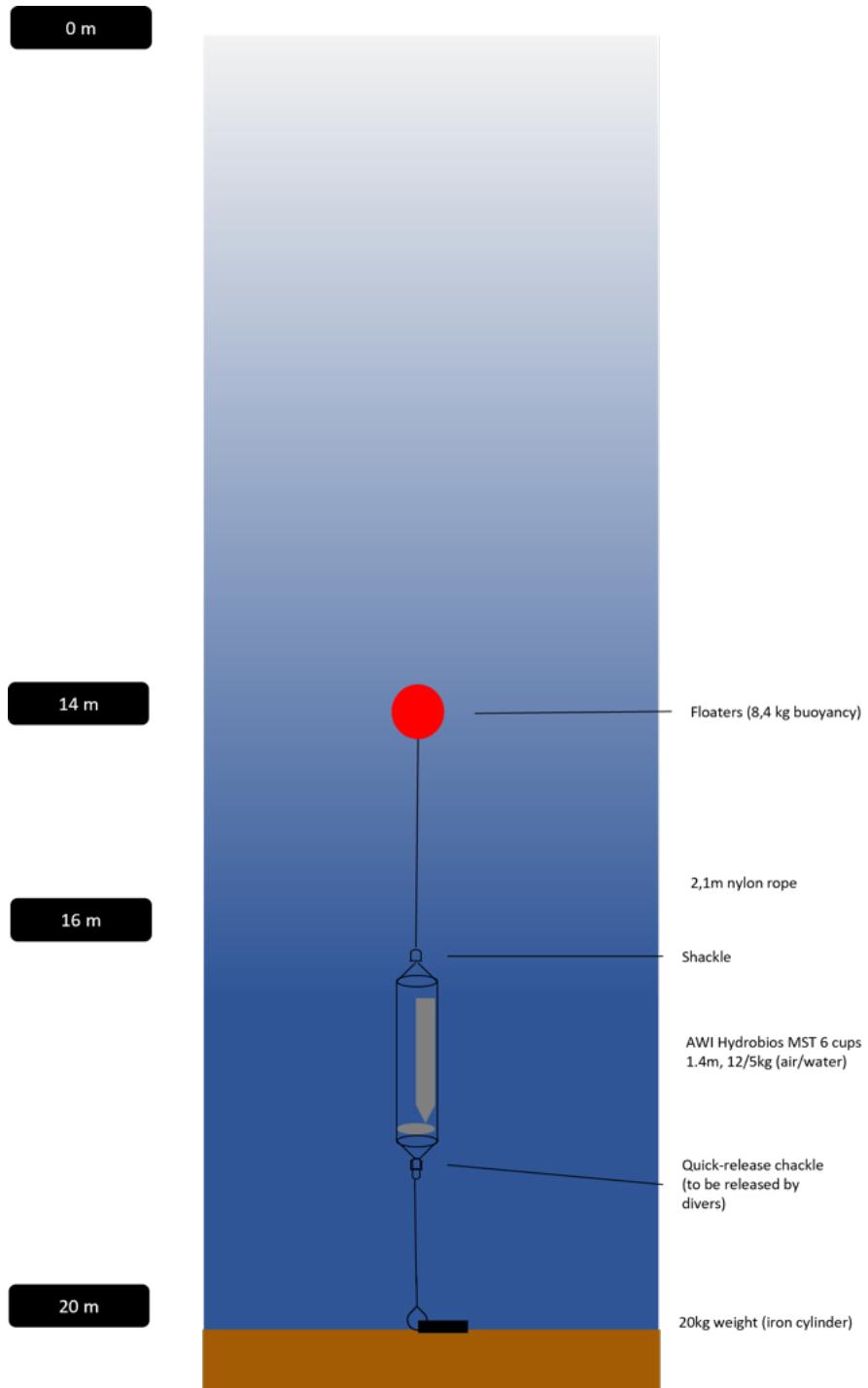


Figure 37. Sediment trap sketch

Results

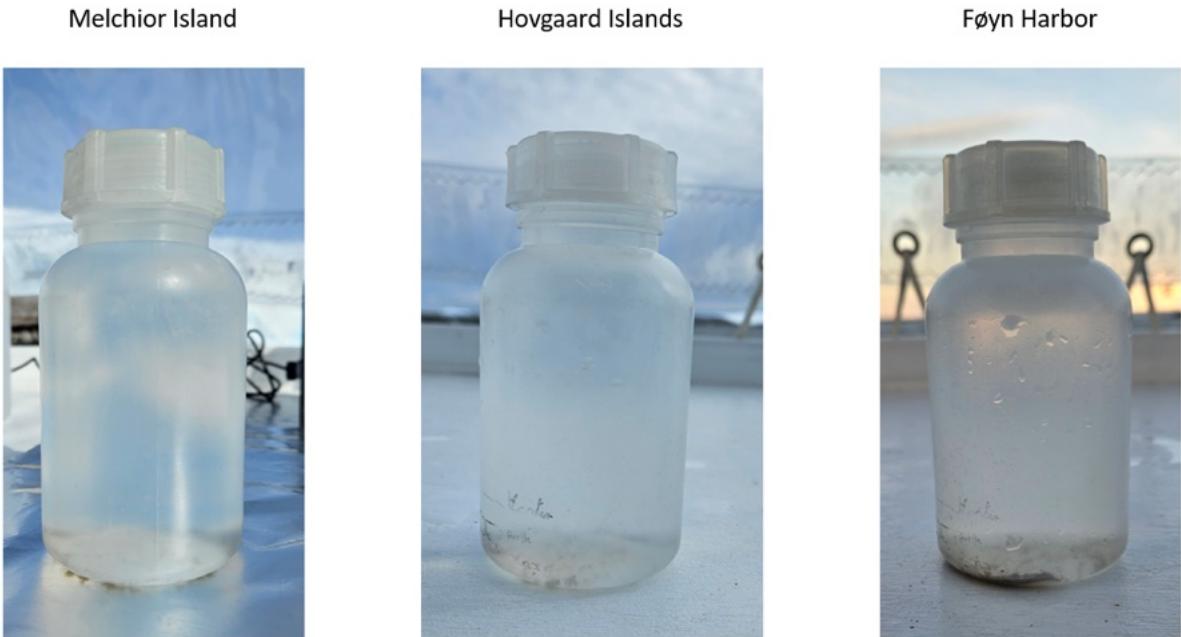


Figure 38. Overview of the vials from the sediment trap after collection, in the three deployment locations.

Sediment trap were deployed successfully after coordinated recovery of the sample bottle and release by divers and surface recovery. One sediment trap (ST1) has been deployed at Melchior Island ($64^{\circ}19.2206'S$ $62^{\circ}55.2654'W$ from 11/02/2022 12:58 to 16/02/2022 10:56 at 21 m deep). Second sediment trap deployment (ST2) took place in Hovgaard Island ($65.103909^{\circ}S$ $64.084684^{\circ}W$ from 17/02/2023 18:09 to 21/02/2023 13:54 at 22 m deep). Last sediment trap deployment (ST3) took place in Føyn Harbor ($64^{\circ}33.1909 S$ $62^{\circ}00.5342 W$ from 22/02/2023 15:17 to 26/02/2023 15:48 at 22 m deep).

There was less matter compared to TANGO 1 expedition but the sediments seems bigger and more stringy. The three sites seem to have a comparable quantity of particulate matter.

Greenhouse Gases

Method

We collected water at the surface with a 2.5L General Oceanic Niskin bottle to measure the partial pressure of CH₄ (pCH₄) and N₂O (pN₂O). The method used is the same as in the section for the water column concerning CH₄ and N₂O.

Seawater was collected for:

- Salinity
- CH₄ and N₂O concentration
- $\delta^{13}\text{C}$ of CH₄

Transects were performed at every station to have the best spatial cover of the area. Attention was paid to have samples close to the shore and other in more open water to have an assessment of the impact of bathymetry, hydrology, and glacier run-off.

We also sampled two important glaciers (Leah glacier and Agalina glacier) to assess the potential source of methane of these glaciers.

We also sampled inside and out of Deception Island, in collaboration with the Spanish station.

Results

A total of 123 Niskin bottles were taken at the surface. These samples were taken in various environment, including active glaciers (Figure 39), open water and coastal environment without glacier.

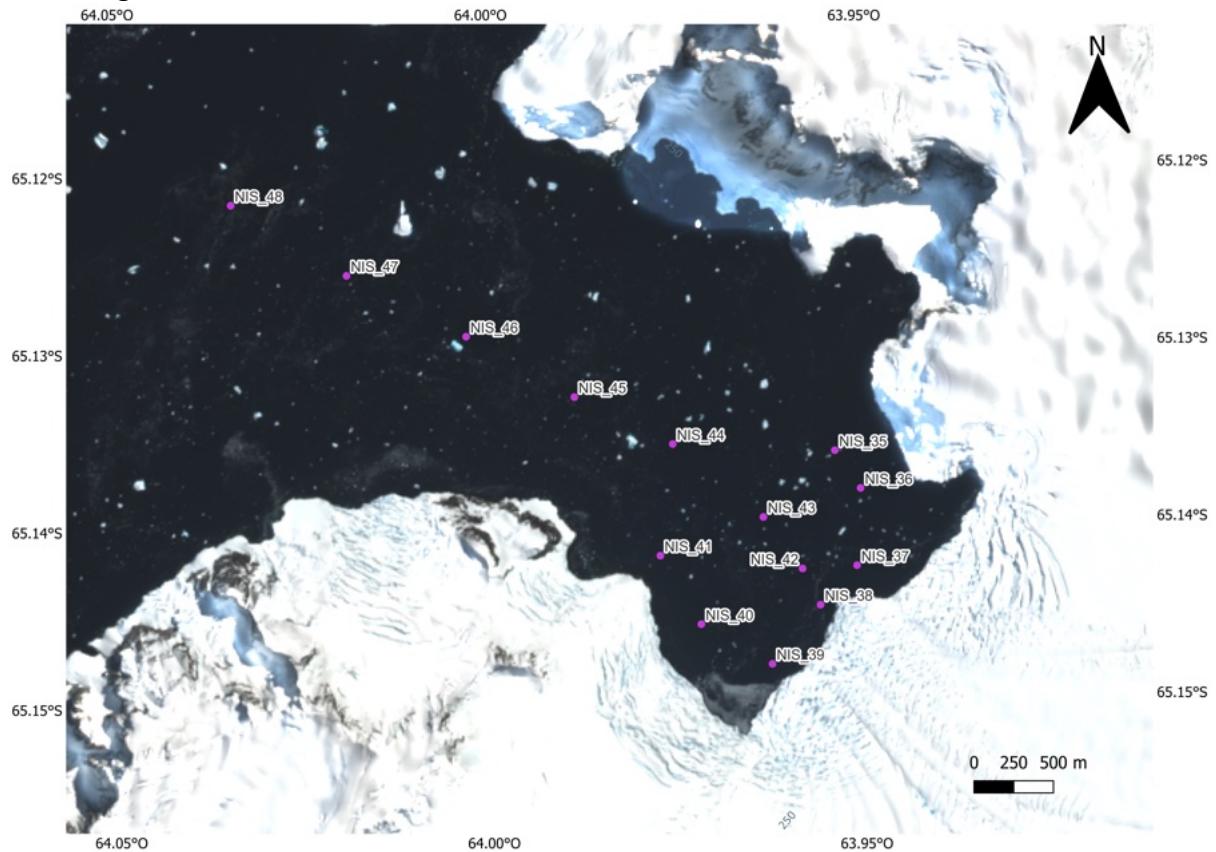


Figure 39. Sampling of surface water at Leah Glacier

These samples were taken following the results of the TANGO1 expedition. It showed a potential source of methane at the top of the water column. The hypothesis is that this source come from run-off water from the glacier.

The sampling strategy of TANGO2 have been adapted to this hypothesis to sample sensitive area as glacier with a high velocity. This was done to assess the impact of melting glacier as a source of methane in the West Antarctic Peninsula.

Sea floor

Emil De Borger

Biogeochemical parameters

To determine the quantity and distribution of carbon present in the seafloor sediment from different sources (organic matter, inorganic carbon, algal origin...), divers pushed 3 cores (perspex, Ø 3.6 cm) into the seafloor sediment at each site, aiming for a sediment column of at least 10 cm. After retrieval, the cores were sliced as follows. First, the overlying water was siphoned off, if the surface sediment consisted of a fluffy layer of detritus and/or algal matter, this was carefully siphoned off and placed into an aluminum cryo-vial as part of the first 0.5 cm of sediment. Cores were then sliced into 0.5 cm intervals for the first two centimeters, in 1 cm intervals down to 6 cm, and 2 cm intervals for the remaining sediment, all into aluminum cryo-vials. All samples were immediately stored into a -20 °C freezer.

Benthic nutrient exchange

Materials and methods

Oxygen and nutrient fluxes

To determine the consumption and/or production of oxygen (O_2), nutrients (NH_x , NO_x , PO_4 , Si), greenhouse gases (CH_4 , N_2O), and carbon (C) by the benthic community, we ran incubation experiments on intact sediment cores, sampled by divers. At each site 3 incubation cores ($\varnothing 10$ cm Perspex) were pushed into soft sediments, aiming for a sediment height of 15 – 20 cm in the cores (Table 6).

The incubation cores were immediately placed in a thermostatic bath (see Figure 40) controlled by an external chiller (LAUDA thermocirculator), set to the water temperature at the seafloor as determined by the divers (± 0.5 °C). We provided oxygen to the cores through bubbling stones, and the cores were left to acclimatize overnight until further treatment.

Incubation experiments lasted from 8 to 12 hours, depending on the sediment oxygen consumption rates, and consisted of the following steps. First a T0 sample was collected, which consisted of a 5 mL subsample, filtered through a 0.45 μm syringe filter for nutrient analysis, a 10 mL subsample injected into a headspace vial for dissolved inorganic carbon (DIC), a 30 mL subsample for alkalinity (TA), and a 60 mL subsample for greenhouse gases. Subsequently, the cores were closed with airtight transparent lids, which contained sampling ports and a Teflon stirrer to keep the water column in the cores homogenized. Through an airtight septum, we placed a rigid oxygen probe (Pyroscience Firesting optodes), to measure the oxygen concentration in the water at 30 second intervals. At time intervals of 2 – 3 hours (depending on the oxygen consumption rates), repeat measurements for nutrients (5 mL) and DIC (10 mL) were collected through sampling ports. The DIC, TA, and greenhouse gas samples were stabilized with mercury chloride ($HgCl_2$), and the nutrient sample was immediately frozen at -20 °C. Incubations lasted until most cores reached an oxygen concentrations no around 70 % of the starting concentration, after which all measurements of the T0 sample were repeated.

Two types of incubations were performed: dark incubations where the cores were kept in the dark throughout the experiment, and light incubations where the sediment surface was subjected to a light intensity of 400 lumens, representing the light intensity on the seafloor on a partially overcast day (as measured with HOBO loggers (Scaled instruments) on CTD profiles). The first incubation was the dark incubation, after which the overlying water was replaced with filtered seawater, bubbled with oxygen, and left to acclimatize again overnight until the light incubation was performed the following day.

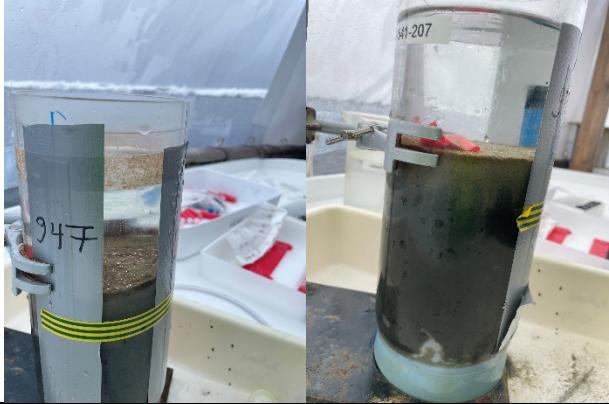
To calculate oxygen consumption rates within the cores, a linear regression line was fitted through the Firesting water column oxygen concentration data. The height of the overlying water column was used to express the oxygen consumption rates in $mmol\ O_2\ m^{-2}\ d^{-1}$.

Porewater extraction

After finishing the incubations, we extracted porewater from the sediment column in 1 cm intervals through pre-drilled holes in the cores using rhizon samplers (Rhizosphere research products), attached to 5 mL plastic syringes. The extracted porewater was split into 2 mL for DIC (2 mL headspace vials, stabilized with $HgCl_2$), and 2 – 3 mL for nutrients (5 mL scintillation vials). The nutrient samples, and DIC vials were stored at -20 °C and room temperature respectively. Finally, the contents of the cores were sieved over a 1 mm mesh

to collect the macrofaunal community present in the cores. The macrofauna were stored in Kautex jars, and preserved on ethanol.

Table 6: Representative pictures of the sediment collected on the different sampling sites, and a brief description of the main sediment characteristics.

Melchior site 1		Dive 2: cores 73, 74, 75 <ul style="list-style-type: none"> - S 64°19.233 W 62°55.412, 21 m depth - Relatively featureless sediment column. - Light beige oxidized layer transitioning relatively deep to darker anoxic sediment. - Presence of amphipods and cumaceans seen in core surface.
Melchior site 2		Dive 9: cores 946, 947, 948 <ul style="list-style-type: none"> - S 64°20.343 W 62°56.551, 23 m depth - Similar sediment column to Melchior site 1. - Very clear layer of brown diatoms in upper sediment. - Oxygen bubbles after light incubation. - Presence of amphipods and cumaceans seen in core surface.
Hovgaard site 1		Dive 14: cores 1566, 1567 <ul style="list-style-type: none"> - S 65°06.081 W 62°04.955, 20 m depth - Clear layer of brown algae / detrital matter on top of cores. - Light brown layer of sediment above dark brown/black sediment column, very strong sulfidic smell.
Hovgaard site 2		Dive 20: cores 2370, 2371, 2372

	<ul style="list-style-type: none"> - S 65°06.219 W 62°05.089, 23 m depth - Lighter sediment on top, followed by greyish sediment below. - Thin layer of brown algae / diatoms on top layer (not all cores) - Clear presence of tubeworms / faunal burrows in the cores, resulting in oxidized extensions to deeper sediment layers. - Rocks / gravels in deeper layers.
Foyn harbor site 1 	Dive 26: cores 3415, 3416, 3417 <ul style="list-style-type: none"> - S 64°32.793 W 61°59.830, 23 m depth - Light sediment column, greyish patches in deeper layers. - Presence of fluffy structure on sediment surface. - Presence of organism burrows → tubeworms and bivalves seen.
Foyn harbor – Guvernøren wreck site 	Dive 34: cores 3901, 3902 <ul style="list-style-type: none"> - S 64°32.636 W 62°00.027, 23 m depth - Rust coloured sediment, extending deep in the cores (10 – 12 cm). - Dark sediment below, possibly soot. - Particles / fragments of iron present throughout sediment column.



Figure 40: Incubation setup with sediment cores submerged in the thermostatic bath with airtight lids with stirrers and sampling ports (red ellipse, left) and oxygen optodes (green, left). The middle image shows the top of the workbench. The right image shows the interface of the pyroscience-Firesting oxygen monitoring software.

Results (preliminary)

Oxygen consumption rates measured in the dark incubations were similar for all the investigated sites, with average rates varying around $20 \text{ mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$ (Figure 41). The exception was one of the sediment cores collected next to the wreck of the Guvernøren (Føyn harbor), which had more than double the oxygen consumption as most of the other stations (Figure 41). Oxygen consumption rates varied more strongly during the light incubations between sites, with a noticeable lower net oxygen consumption in all stations, and oxygen production in some or all cores of Hovgaard site 1, and Melchior Islands site 2.

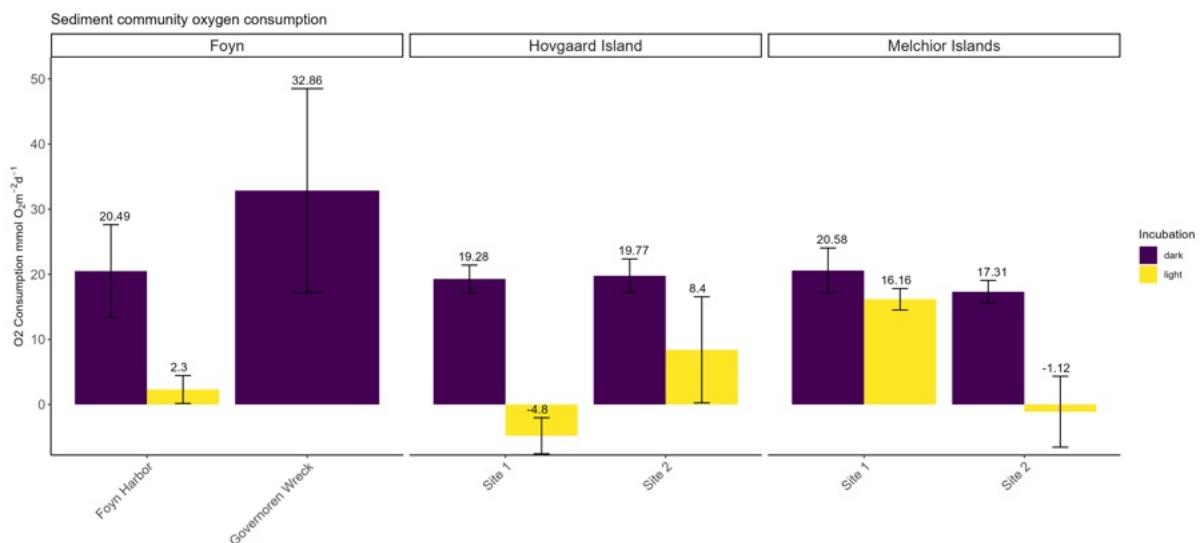


Figure 41. Measured oxygen consumption rates by the sediment community (in $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$, $\pm \text{SD}$) for the different studied sites, and dark (purple) – light (yellow) incubations performed on each set of cores. Numbers above the bars represent averages. Negative values represent oxygen production by the benthic community

5. Trophic analysis

Meiobenthos

Emil De Borger

Perspex cores (3.6 Ø cm) were pushed into the seafloor by divers, with care not to disturb the sediment column. After retrieval, the cores were sliced as follows. First, the overlying water was siphoned off, if the surface sediment consisted of a fluffy layer of detritus and/or algal matter, this was carefully siphoned off and placed in a petri-dish as part of the first 0.5 cm of sediment. Cores were sliced into 0.5 cm intervals for the first two centimeters, in 1 cm intervals down to 5 cm, and half of the following 5 cm (5-10 cm) was collected as well and stored into the same petri-dish. All petri-dishes were wrapped individually in parafilm to prevent leaks, and stored at -20°C.

Macrobenthos isotopy

Martin Dogniez & Anthony Voisin

Sampling design

Macro and mega organisms were collected by scuba diving around 20m depth. Three replicates of quadrats (40x40cm) and transects (10m) were done to collect all animal and vegetal benthic organisms (Figure 42). Moreover, opportunist collections were also done to target specific benthic organisms not found in the previously described sampling design. Depending of the organisms, scuba diving or VanVeen grabs were used to collect soft sediments infauna. Sorting and identification to the lowest taxonomic level possible were then done back to the ship with the help of field guides of the WAP marine biodiversity^{7,8,9}

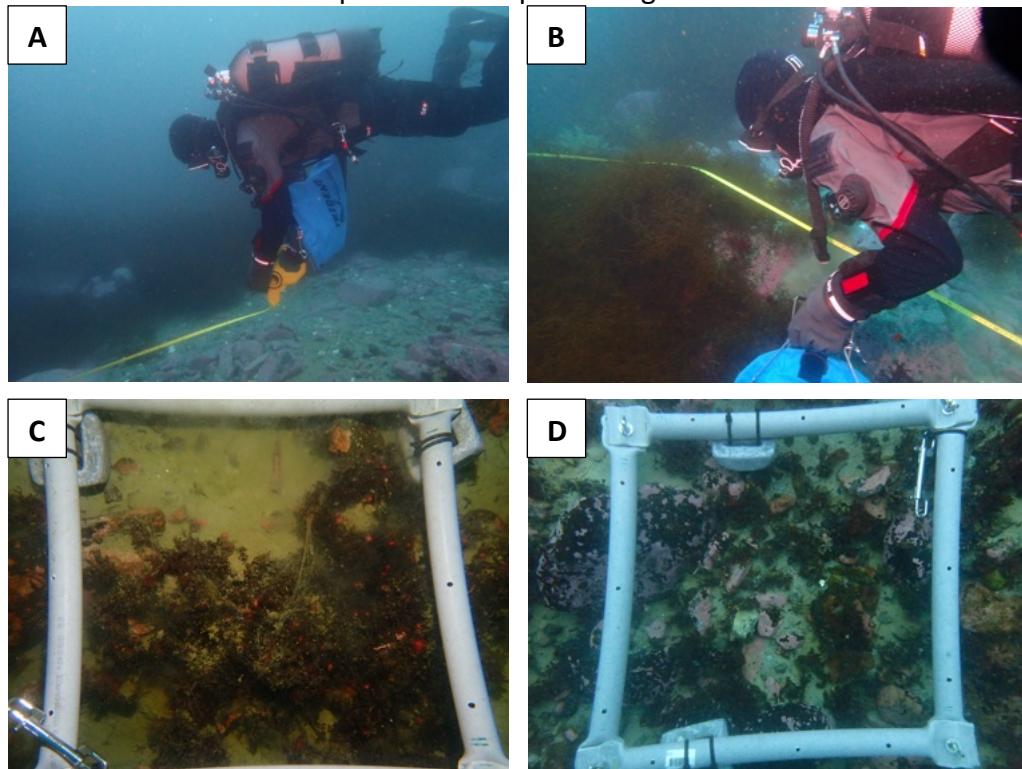


Figure 42. Transects on a bottom made of gravels and pebble (A) before picking megabenthic organisms found alongside the line (B); examples of quadrates scrapes in a muddy bottom (C) and amidst a gravelly bottom sparsely covered from algae (D)

In order to get the biomass of the organisms sampled, wet weight (ww) was measured ashore with to a portable field scale (Ohaus Navigator NV2201 with 0.1g of readability). To account for pelagic food-sources (detrital POC and phytoplankton) water samples were taken atop every station thanks to Niskin bottles (3L) deployments. In every habitat, the SPOM was collected through filtration on nine pre-weighted and burned Whatman GFF filters 47mm (2L of seawater per filter). Three of these filters were placed in 4mL ambered glass vials with CHCl₃/MeOH (2:1, v:v) solvent for subsequent fatty acid analyses, while the six remaining were dried at 60°C in an oven for at least 24H before being placed in aluminum foils for subsequent SIA and quantification of the SPOM load in the water column.

In the meantime, three dual-filter eDNA capsule (Figure 43) from Sylphium Molecular Ecology (0.45µm pore size) were used to collect the phytoplankton present in the water column (960mL of seawater filtered per capsule). These samples will allow the identification of phytoplankton communities present at every station thanks to metabarcoding. The composition of these communities will then be compared to the gut content of the benthic organisms.

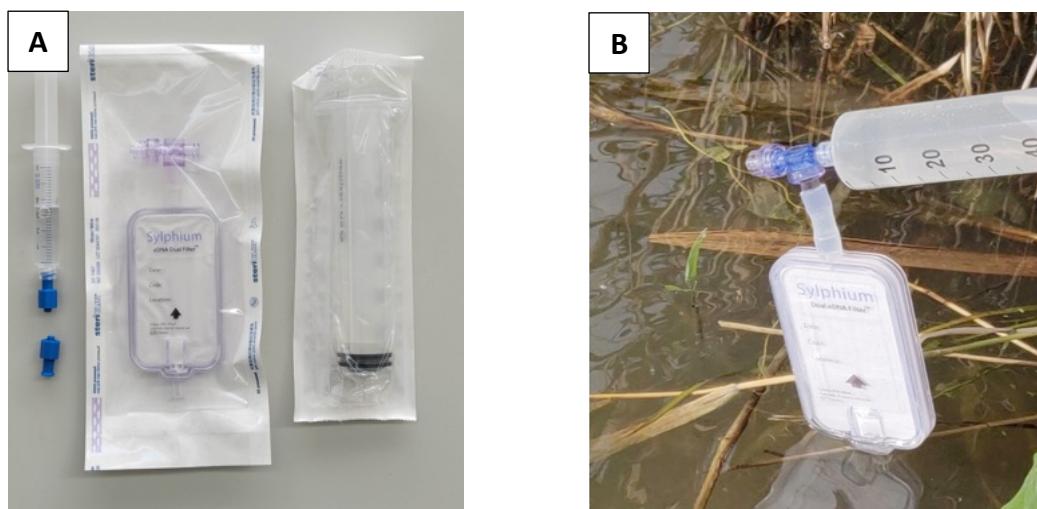


Figure 43. Views of the eDNA sampling kits from Sylphium Molecular Ecology in their full packaging (A) and used in an European stream to collect eDNA from freshwater organisms (B) (@Sylphium Molecular Ecology illustrations)

Sampling Area

Following the TANGO1 expedition in a southern part of the West Antarctic Peninsula, TANGO2 aimed a northern part around the Gerlache strait (Figure 44). Three different sites corresponding to 3 major point of entry and exit of the strait were sample. Melchior Islands was the first site studied with two station at the North and the South of Omega Island. Then different stations were done in the north of Hovgaard Island regarding the particular habitat heterogeneity observed. Finally, two stations in the south of the Enterprise Island were sample in the area of Føyn Harbor. In each site, rock bottom substrates and soft sediment environment were found and sampled. All location characteristics and coordinates are available in Table 7.

Table 7. Sites and stations sampled for macrobenthos trophic analyses of TANGO2.

Site	Station	Latitude	Longitude	Details
------	---------	----------	-----------	---------

Melchior	MI 1	-64.3206833	-62.9237667	Soft-sediment mixed with gravels and patch of algae
	MI 2	-64.3404283	-62.9501700	Rock bottom substrate with macroalgae dominance
Hovgaard	HI 1	-65.1035250	-64.0848167	Soft sediment mixed with sand, mud to gravelly dominance
	HI 2	-65.1013167	-64.1064317	Rock bottom with boulders and macroalgae forest
	HI 3	-65.106639	-64.075528	Muddy substrate mixed with gravels and patch of algae
Føyn	FH 1	-64.5467167	-61.9963250	Muddy substrate mixed with gravels and patch of algae
	FH 2	-64.5546692	-61.9928200	Rock bottom with boulders and macroalgae forest

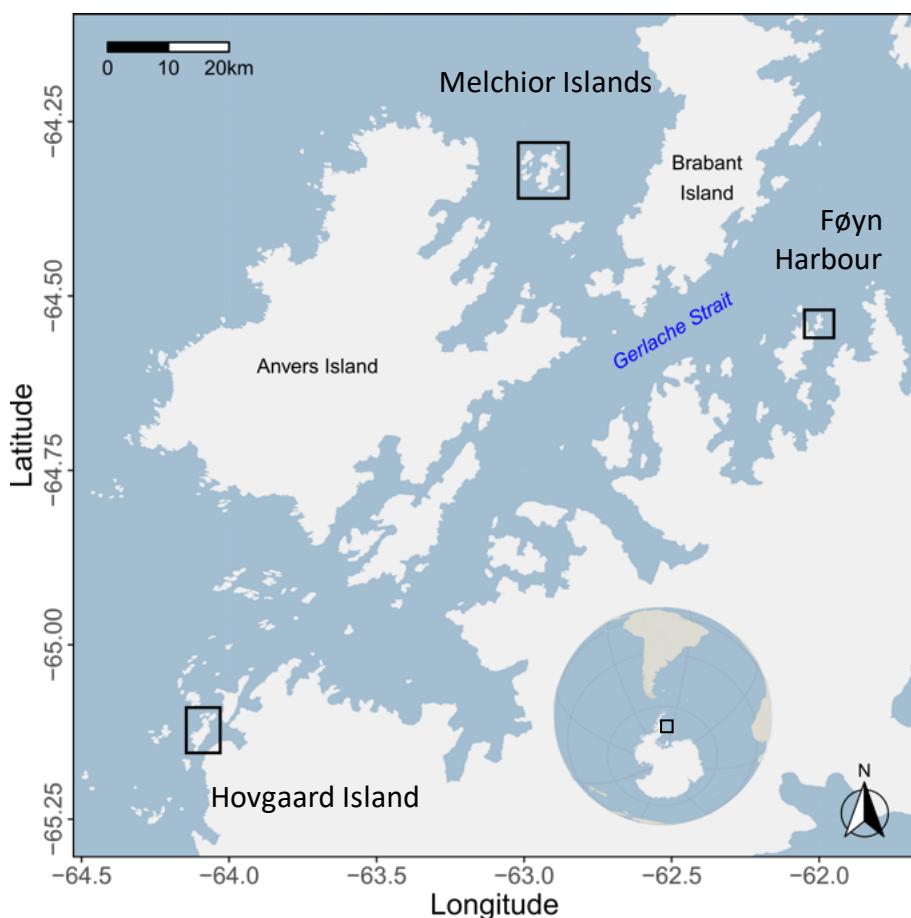


Figure 44. General view of TANGO2 sampling sites.

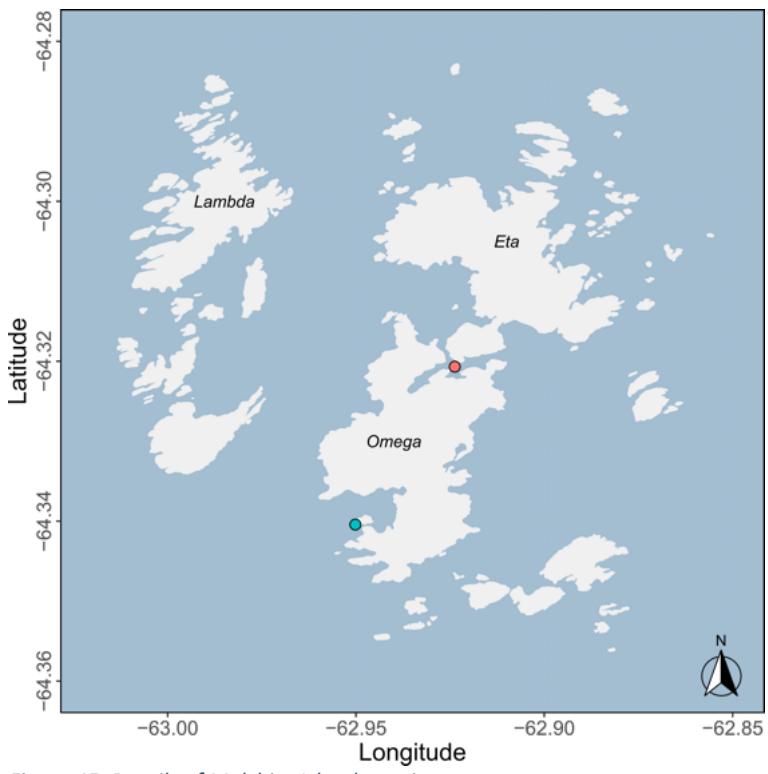


Figure 45. Details of Melchior Islands stations

MI1: North Omega



MI2: South Omega

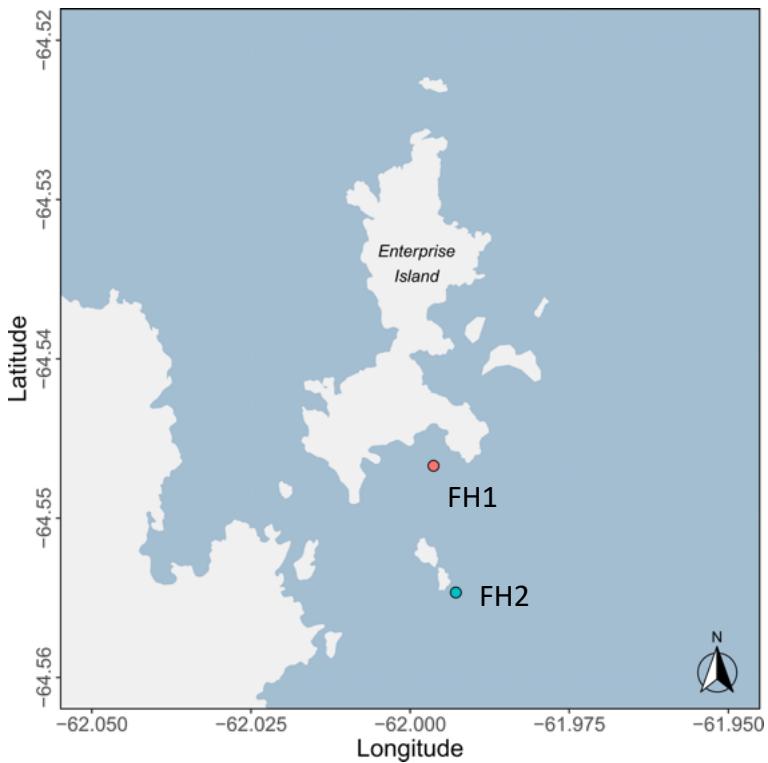


Figure 46. Details of Føyn Harbour stations.

FH1: Pool



FH2: South outer wall



MI2

MI1

Dissection and conditioning

Depending of the subsequent analyses, targeted tissues were selected depending of the organism sampled. A general view is presented in

Table 8 for stable isotope (SIA) and fatty acid (FA) analyses. After dissection, the samples for SIA were dried at 60°C at least 48h in a 4mL transparent glass vials. For FA, the tissues dissected were directly put in an ambered 4mL glass vial filled with 3mL of a solvent of CHCl₃/MeOH (2:1, v:v) and feezed at -20°C.

Table 8. Type of tissues targeted for Stable Isotope and Fatty Acid analyses

Sample	Stable Isotope	Fatty acid
Source		
SPOM	Filters dried bent	Filters dried bent in solvent
Macroalgae	Blade fragments without epiphytes	
Microphytobenthos	Part of biofilm scraped or first layer of sediments	
Microbial mat	Part of biofilm scraped or first layer of sediments	
Sediment	First layer of sediment	
Consumer		
Porifera	Body fragments	
Cnidaria	Ectoderm	
Nemertean/Annelids	Body wall	
Crustaceans		
Big	Pereopods or abdomen muscle (if clean dissection possible)	Pereopods
Small	Whole animal (may need pooling)	-
Mollusks		
Bivalves	Siphon muscle, whole if to small	Siphon muscle, whole if to small + separated gills for bigger one
Gastropods		
Shell	Whole organism	
No shell	Foot muscle	
Ascidians	Body wall without tunicate	
Echinoderms		
Asteroidae	Body wall	Vesicles podia
Echininoidea		Aristotle's lantern muscle
Holothurians		Body wall

In parallel, in HI1 and HI2 (Figure 47), additional pieces of tissues were collected for analysis of the pharmaceuticals contamination (e.g. caffeine, nicotine, antibiotics, analgesics, NSAID,...) in the invertebrate communities. After dissection, tissues were placed in 4mL glass vials and frozen at -20°C until subsequent analysis.

For mega invertebrates (> 5cm), gut content was extracted for later study through DNA metabarcoding. Before dissection, tools were cleaned with pure Ethanol and disinfected with commercial bleach, before extraction of the whole gut or parts of it. When no solid food was isolatable from the gut, the digestive tract was then stored in 5mL Eppendorfs with CTAB buffer (Sylphium Molecular Ecology technology) and preserved at 4°C. On the contrary, when solid food items were isolatable (i.e. for sea urchins mainly), these items were separated from the gut and stored in 5mL Eppendorfs with pure Ethanol before storage at -20°C.

For later more precise identification, piece of organisms was also taken for barcoding analysis. It was stored in 5mL Falcons with pure Ethanol and preserved at -20°C.

For later more precise identification and to enrich existing DNA barcode reference libraries, pieces of organisms were also taken for DNA barcoding analysis (COI and 18S rDNA markers). They were then stored in 5mL Eppendorfs with pure Ethanol and preserved at -20°C.

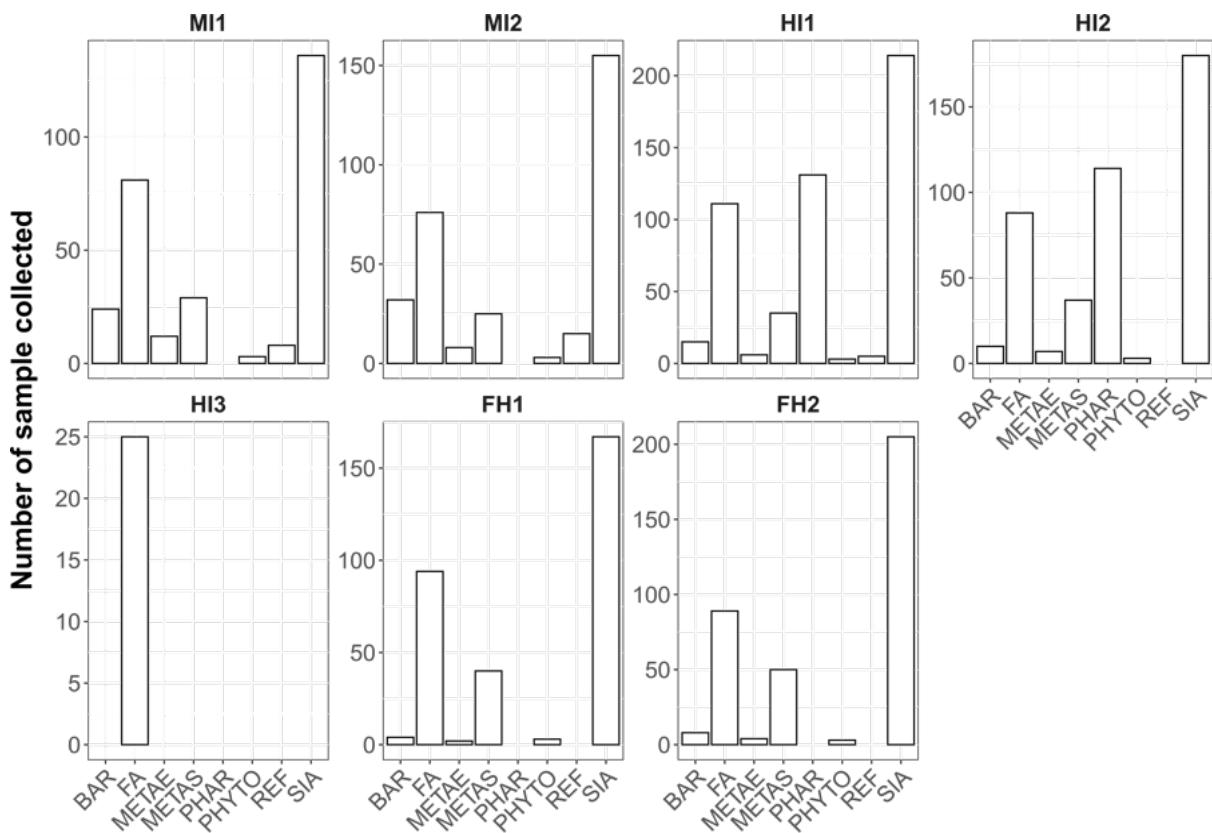


Figure 47. Number of samples collected by stations and type of analyses: (BAR = DNA barcoding, FA = Fatty Acids analysis, METAE = Metabarcoding of sea-urchin gut content, METAS = Metabarcoding of other animals' gut-content, PHYTO = eDNA collection, REF = whole frozen organisms for reference, SIA = Stable Isotopes Analysis).

A total of 2259 samples were collected, regardless of the subsequent analysis. A detailed view of the number of samples collected by analysis, among the different stations, is presented in Figure 47.

Stable Isotopes Analysis

Martin Dogniez

In each station and for every morphospecies, a maximum of respectively 6 replicates were taken for SIA. If the organism proved to be sufficiently large, pieces of tissues destined to both SIA and FA were collected on the same individual, with the objective to jointly interpret the specific information provided by the two analysis techniques. Once back in Belgium, the SI ratios of carbon, nitrogen and sulfur will be measured at ULiège through IRMS, together with their C:N ratio and total C & N content. Therefore, samples will first have to be dried once again in an oven at 60°C until all traces of moisture disappears. Then, they will be grinded into fine powder with ceramic mortar and pestle, before packing into tin cups after weighting of the material transferred in the process. Depending on the organism and the type of tissue collected, an acidification of the powder may be necessary to remove all carbonates present in the material. For the samples in question, two tin cups will have to be prepared, one for $\delta^{13}\text{C}$ and one for $\delta^{15}\text{N}$ measurements. Indeed, the acidification of the samples is likely to alter their natural $\delta^{15}\text{N}$. With the data obtained, it will then be possible to represent the six benthic communities sampled in the isotopic space, and to study some of their trophic characteristics (e.g. mean TL, SEAc but also all the traditional Layman metrics).

In short, during this sampling campaign, 101 different morphospecies have been sampled in the 6 stations investigated, for a total of 987 samples. Amongst these 6 stations, the macroalgae forest from MI2 stands-out, with the largest number of unique species not found in other sites visited ($n = 16$, Figure 48). However, interestingly enough, in terms of diversity, it is by far surpassed by the soft-bottom of HI1, with 62 morphospecies. In the future, it will be interesting to determine if the trophic characteristics from this peculiar species assemblage differ from those of other similar habitats.

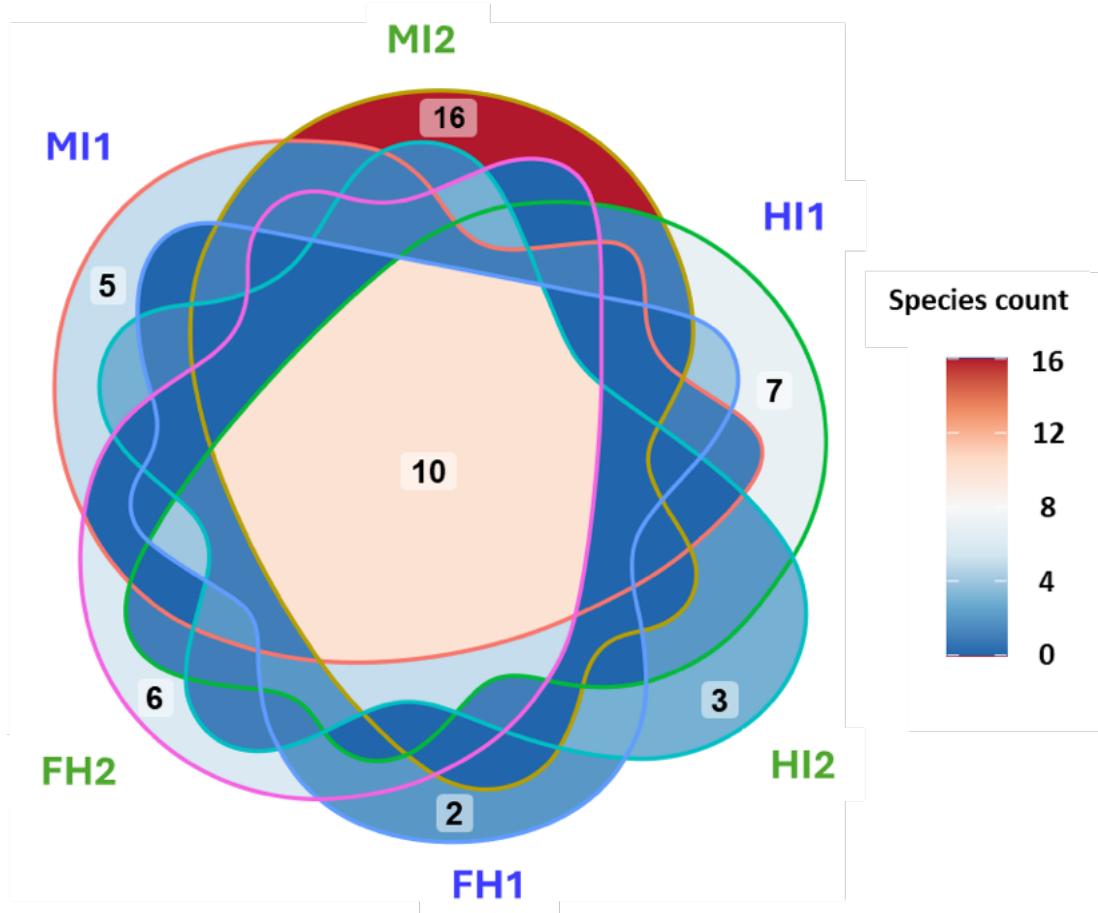


Figure 48. Venn Diagram displaying the repartition of the morphospecies sampled between the different stations of TANGO 2024, with names of macroalgae forests stations in green and of soft bottom stations in blue.

Gut Content DNA Metabarcoding

Martin Dogniez

In total, 254 gut samples (maximum n-replicates = 6) have been collected throughout the six stations, corresponding to 21 different morphospecies (1 sea urchin, 2 gastropods, 1 bivalve, 1 brachiopod, 12 sea stars, 1 arthropod, 1 sea cucumber and 3 ascidians). After repatriation to the lab, DNA extractions will be performed on these samples with a Promega Maxwell® RSC (Figure 49), using the Maxwell® RSC Fecal Microbiome DNA Kit and the Maxwell® RSC PureFood GMO and Authentication Kit for respectively the CTAB and EtOH samples. Then, the COI and 18S rDNA fragments from extracted gut-content DNA will be amplified through PCR reactions using Promega GoTaq Enviro, before purification of the PCR product with Beckman Coulter™ Agencourt AMPure XP. Finally, the obtained products will be sent to AllGenetics for library prep and sequencing on a NovaSeq PE250 platform. Ultimately, the prey sequences obtained will help, after taxonomic assignment, to refine our knowledge of the sampled organisms diet with a potentially high taxonomic resolution, giving us a snapshot of these diet that will complement the longer-term information provided by SIA for these mega-invertebrates.



Figure 49. Example of Promega Maxwell® RSC Instrument allowing to partially automate DNA extractions from samples

Pharmaceuticals analysis

Martin Dogniez

Generally speaking, the polar marine regions are considered to be better protected from pollution than other latitudes. However, recent studies have shown unsuspected levels of contamination of polar benthic communities by certain pharmaceuticals¹³. Following this observation, during this cruise, tissue samples were collected in HI1 and HI2 stations on the same organisms as SIA and FA (n-replicate = 3) to investigate potential pharmaceuticals contamination along the WAP. More specifically, these samples were collected in one soft bottom community and one macroalgae forest community, in order to investigate potential differences in pharmaceuticals accumulation and transfer across the food-web in these two different communities. Moreover, these two stations were chosen as this archipelago is a hotspot of polar tourism along the West Antarctic Peninsula.

Table 9. List of pharmaceuticals proposed for analysis in the macrobenthos samples collected in Hovgaard Island.

Analyte	Therapeutic class
Allethrin	Insecticide
Altenolol	Beta blocker
Amoxicillin	Antibiotic
Aspirin	Non-steroidal anti-inflammatory drug (NSAID)
Atrazine	Herbicide
Azamethiphos	Insecticide
Benzocaine	Anesthetic
Caffeine	Stimulant
Carbamazepine	Antiepileptic
Ciprofloxacin	Antibiotic
Citalopram	Antidepressant
Clotrimazole	Fungicide
Cypermethrin	Insecticide
Deltamethrin	Insecticide
Desmethylvenlafaxine	Antidepressant
Diclofenac	Non-steroidal anti-inflammatory drug (NSAID)
Diflubenzuron	Insecticide
Emamectic (benzonate)	Insecticide
Enrofloxacin	Antibiotic
Florfenicol	Antibiotic
Fluconazole	Fungicide
Fluoxetine	Antidepressant
Ibuprofen	Non-steroidal anti-inflammatory drug (NSAID)
Miconazole	Fungicide
Nicotine	Stimulant
Norfluoxetine	Antidepressant
Oxolinic acid	Antibiotic
Oxytetracycline	Antibiotic
Paracetamol	Analgesic and antipyretic
Praziquantel	Antiparasitic
Propranolol	Beta blocker
Simvastatin	Statin
Sulfamethoxazole	Antibiotic
Tetracycline	Antibiotic
Trimethoprim	Antibiotic

Once back in Belgium, the samples will be sent to the University of Gdansk (Poland) for measurement of the concentrations in 35 ubiquitous pharmaceuticals through HPLC-MS/MS (see full list in Table 9). Quantification will be performed after solid-liquid extraction of the components of interest from a working liquid solution containing 100mg of frozen samples homogenized with a ceramic bead-beater in 750µL of polar solvent a mixture of 250 µL of Milli-Q water and 500 µL of acetonitrile and a methanol mixture in a 1:1 ratio, v/v) and 30 µL of internal standard working solution (isotopically labelled standards of selected analytes at

a concentration of about $1 \mu\text{g.mL}^{-1}$). Afterwards, the measured concentrations will be put into perspective with the trophic characteristics of the two communities studies (e.g. mean TL, SEAc, C and N range,...).

Fatty acids

Anthony Voisin

Fatty acid analyses are done at the LipidOcean platform of the Laboratory of Environmental Marine Sciences (LEMAR), in Brest, France. The extraction of lipids is done directly on the field from the Folch's¹⁴ solvent mixture $\text{CHCl}_3/\text{MeOH}$ (2:1, v:v). When the samples came back in Europe, several biochemical processes are done at the lab. A basic saponification with KOH-MeOH (0.5M) breaks the bound between the fatty acid chains and their lipid head. Then, an acid transmethylation with $\text{MeOH-H}_2\text{SO}_4$ (3.4%, v:v) adds a methyl group to each fatty acid chain to retrieve them at the end in a hexane phase.

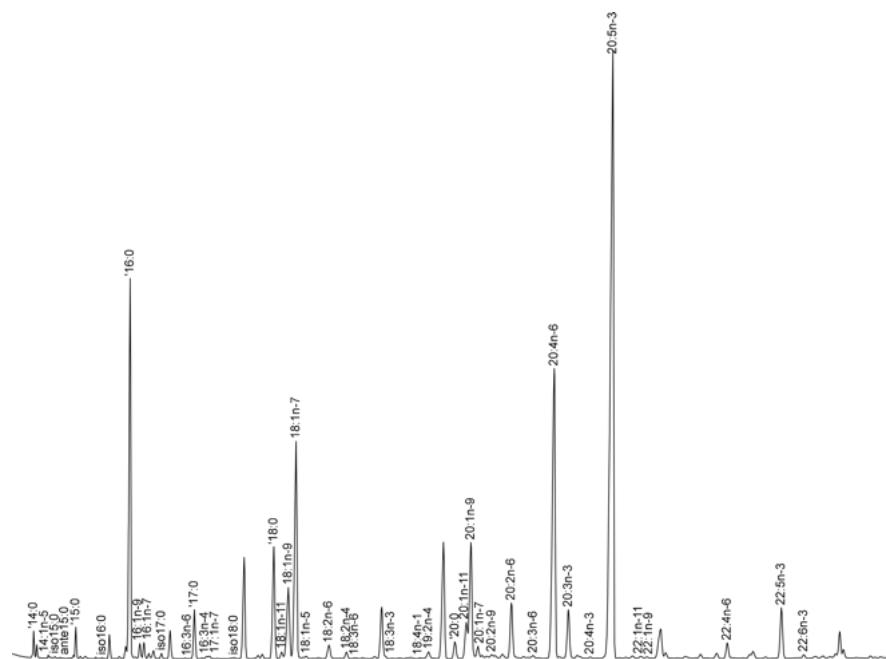


Figure 50. Example of a chromatogram after the GC-FID analysis of a benthic antarctic limpet *Nacella concinna*

Hexane fractions are then processed by Gaz Chromatography by Flame Ionization Detector (GC-FID) to get chromatograms (Figure 50). Using known standards, each pic is integrated to get the fatty acid name. Conversion of pics area in percentage is done to get the percentage of one fatty acid from the total of organism content.

Regarding the first preliminary results from TANGO1 expedition, significant spatial differences were found for the circum-polar benthic limpet *Nacella concinna*. The content of a bacterial biomarker¹⁵ ($18:1\text{n-7}$) was significantly more abundant in sedimentary habitats. These stations were also those likely to experience greater ice-related disturbances (e.g. glacier melting, iceberg scouring, sea ice cover change). On the other hand, in other rocky-dominated stations, higher content of $20:4\text{n-6}$ was observed which is consistent with a diet based on macroalgae¹⁵. We might assume that *N. concinna* tends to turn to other sources when one is missing, such as microbial film when macroalgae abundances are low.

With this in mind, samples collected during TANGO2 would enable to refine this previous observation and extend the spatial range of study. Indeed, for instance, *N. concinna*, was found in every station. This will allow comparison of rock habitat among a range of latitude but also compare potential diet differences between rock and soft sediment habitats. Biometry measurement was also taken (Figure 51).

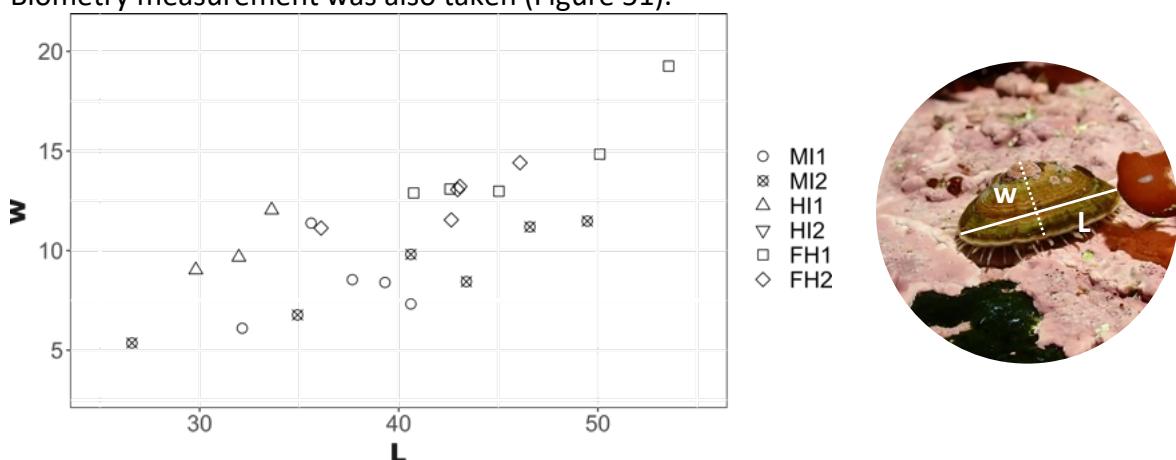


Figure 51. Biometry of *N. concinna* shells sampled during the TANGO2 expedition. L: antero-posterior length; w: apex high.

Moreover, during opportunist underwater collection, two species were targeted. Firstly, the bivalve *Laternula elliptica* is a burrowing bivalve that can reach under several centimeter under the sediment. It is known as a filter feeding organism by letting its siphon just above the surface¹⁶. Secondly, *Yoldia eightsii* is another filter feeding bivalve living in the first centimeters of the sediment¹⁷. These two species were found in every soft sediment for the tree location visited during TANGO2. Regarding, the environmental differences that can be found among Melchior Islands, Hovgaard Island and Føyn Harbour, we might expect differences in diet of this organisms. Indeed, ice disturbance dynamics are different and may alters the different primary production that those organisms rely on.

Moreover, *L. elliptica* was also found in FH2 a macroalgae dominated environment with sediment characterized by coarse sand and gravels. Then, we might also be able to compare trophic habits of this species in two type of sedimentary environment. For almost every station, shells biometry measurements (Figure 52) were done. For individuals of FH2, unfortunate events broke the shells during the travel back. Different kind of tissues were sampled with gills and siphon muscle. The aim will be to compare the lipid content of these tissues corresponding to different kind of lipids storage.

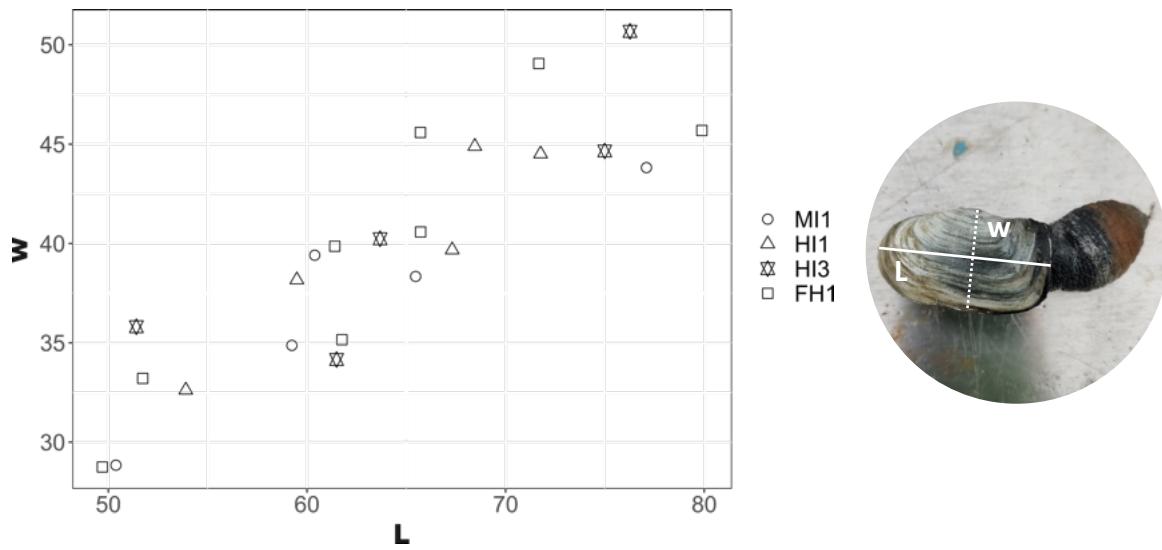


Figure 52. Biometry of *L. elliptica* shells sampled during the TANGO2 expedition. L: antero-posterior length; w: dorso-ventral length.

References

- 1 - Ducklow, H. et al. Oceanography 26, 190–203 (2013)
- 2 - Norkko, A. et al. Ecology 88, 2810–2820 (2007)
- 3 - Norkko, A. et al. Polar Biol. 27, (2004)
- 4 - Iken, K. et al. Antarct. Sci. 9, 386–391 (1997)
- 5 - Arntz, W. E. et al. Sci. Mar. 69, 237–269 (2005)
- 6 - Moline, M. A. et al. Glob. Change Biol. 10, 1973–1980 (2004)
- 7 - Schories, D. & Kohlberg, G. Dirk Schories Publications, 1-348 (2016)
- 8 - Watts, J. Jamie Watts Publications, 1-328 (2021)
- 9 - Bruegemann, P. Underwater field guide to ross Island & mcmurdo sound, Antarctica. Vol I-VIII, 1-935 (2021)
- 10 - Siegert, M. et al. Front. Environ. Sci., 7, 102. (2019)
- 11 - Danis, B. et al. Report of the TANGO 1 expedition. 106 pp. (2023)
- 12 - Stammerjohn, S. E. et al. Deep Sea Research Part II: Topical Studies in Oceanography, 55(18-19), 2041-2058. (2008)
- 13- Sokołowski, A. et al. , Sci.Tot.Env., Vol. 909 (2024)
- 14 - Couturier, L. I. et al. ICES Journal of Marine Science, 77(7-8), 2375-2395. (2020)
- 15 - Kelly, J. R., & Scheibling, R. E. Mar Ecol Prog Ser, 446, 1-22 (2012)
- 16 - Ahn, I. Y. Memoirs of National Institute of Polar Research. Special issue, 50, 1-10 (1994).
- 17 - Davenport, J. P Roy Soc Long B Bio, 232, 431-442 (1988)

Trophic plasticity

[Manon Bayat](#)

Context

Climate change is strongly challenging Antarctic ecosystems, especially in the Western Antarctic Peninsula (WAP), where sea-ice dynamics are altered with various intensities along a latitudinal gradient (i.e. stronger impact in the north). Many types of biological responses are expected to occur in relation to these environmental changes, including shifts in feeding behaviour of species, species interactions and energy flows (1-3). The potential acclimation

to these changes plays an essential role in the survival of organisms and communities. Trophic plasticity and shifts in gut microbiome, are two overlooked, and potentially linked, acclimation mechanisms to rapid changes (4–6). Displaying a large trophic plasticity by showing a diverse diet, habitat use and/or foraging modes would allow species to cope with undergoing perturbations (4,7). Other mechanisms such as gut microbiome shifts might also constitute a fast and direct response to ecological modifications, by adopting bacterial communities better suited to cope with the new environment (5–10). In most macroorganisms, gut tissue and gut content microbiomes are taxonomically diverse (11–13), and fundamental to their host. They allow digestion, nutrient assimilation, resistance to pathogens, and might play an important role in dietary preferences (10,14). Through those essential functions, gut microbiome strongly influences its host health (11,15,16). Shifts in the gut microbiome have already been observed in fish species facing changes in their environments or colonising new habitats (15–17). Marine invertebrates are poorly studied on the matter with only few examples in sponges, snails, cephalopods and mollusks (18–21).

The WAP benthic communities are an ideal model to investigate fundamental mechanisms underlying how trophic plasticity and gut microbiome shifts shape species responses to a fast-changing environment. In this region, one benthic keystone species has been selected as our model: *Sterechinus neumayeri*, endemic to Antarctica and abundant in coastal waters (22).

Using *Sterechinus neumayeri* (Figure 53), this project aims to investigate:

Its trophic plasticity and how it is shaped by ecological factors,
The variability of its gut microbiomes (gut tissues and gut content), and the influence of ecological factors on these ones,
The interplay between trophic plasticity, gut microbiome variability and ecological factors.



Figure 53. Specimen of *S. neumayeri* in its natural habitat

Methods

Specimens of the sea urchin *Sterechinus neumayeri* were collected by divers at 7 different stations in Melchior Islands, Hovgaard Islands, Føyn Harbor, Enterprise Island and Deception Island (Figure 54, Figure 55), the last two regions are not displayed). Each site presented diverse habitats (from sediment to rocky bottom), and depths varying between 5 to 30

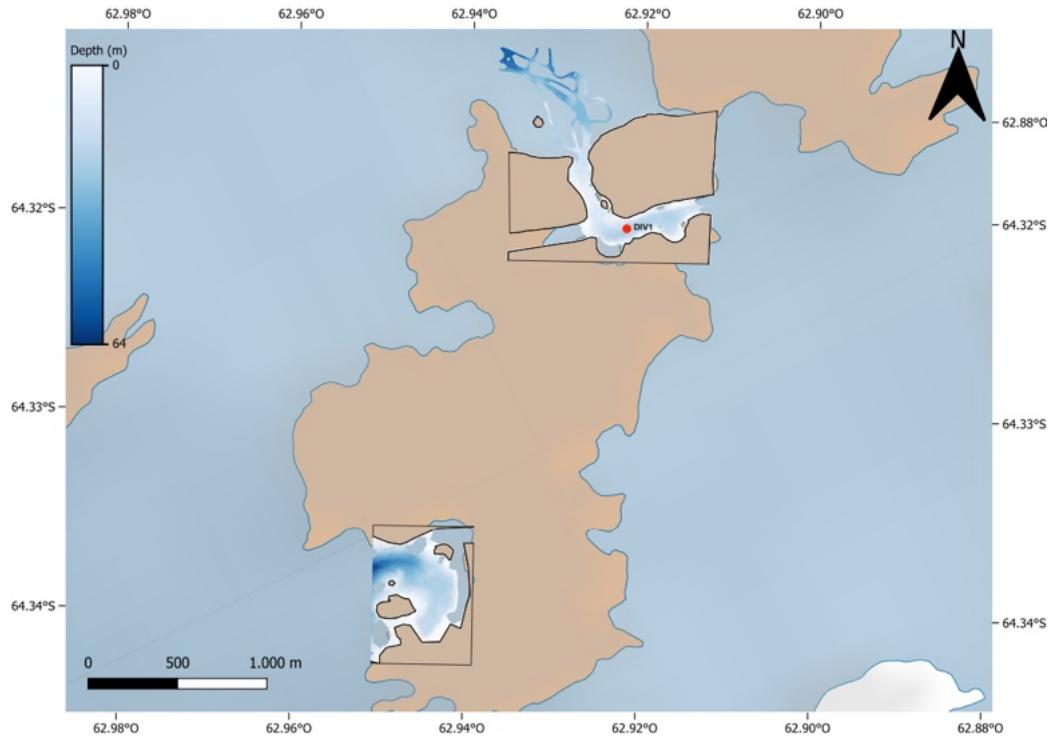


Figure 55. Sampling site bathymetry of Melchior Island and location of the diving event for sea urchin collection

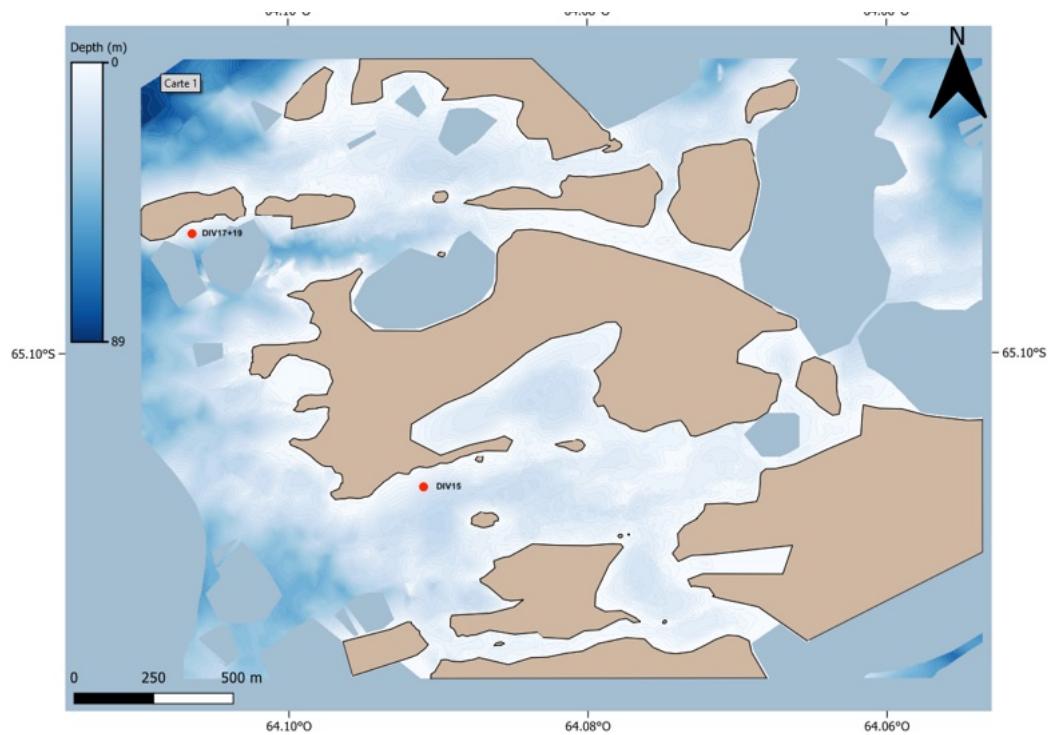


Figure 54. Sampling site bathymetry of Hovgaard Islands and location of the diving events for sea urchin collection

meters (Table 11).

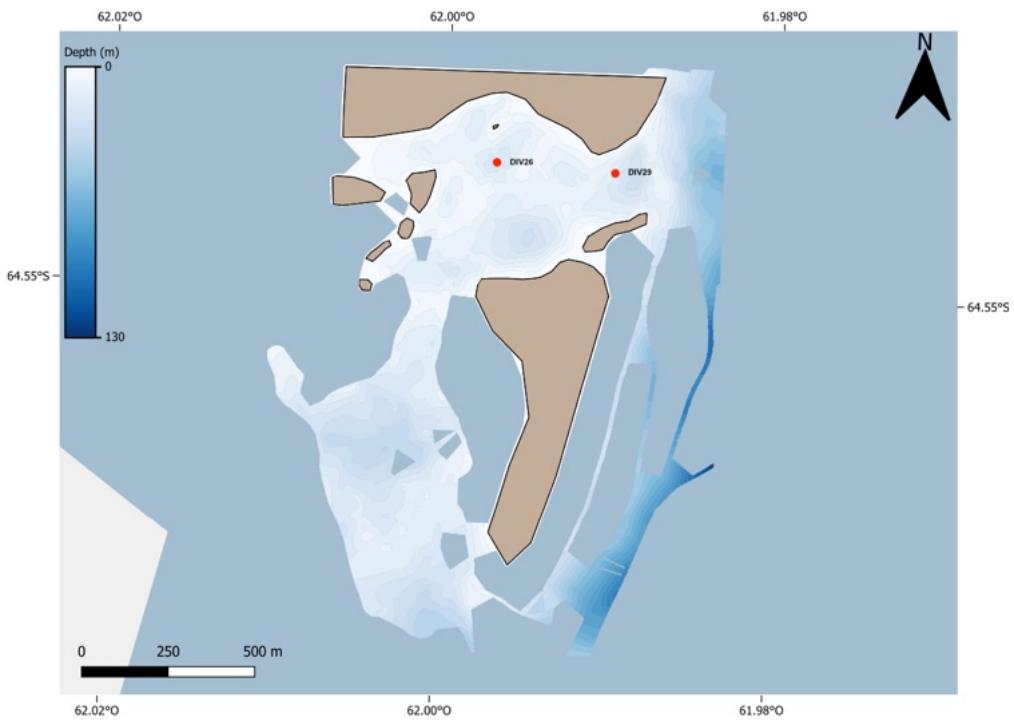


Figure 56. Sampling site bathymetry of Føyn Harbor and location of the diving events for sea urchin collection

At each of the seven station, 15 to 30 sea urchins were collected by scuba diving (Table 11), measured (ambitus and height) and dissected for future analyses. Different body parts were sampled from each sea urchin, and for different purposes (Table 10).

Table 10. The different body parts collected from each sea urchin, their preservation, and purposes.

Tissue	Preservation	Analyses	Aim
Food pellets	RNA later	Metabarcoding (COI, 18S, 16S)	Diet and microbiome
Gut epithelium	RNA later	Metabarcoding (16S)	Microbiome
Spines	Ethanol 96%	RAD-Seq	Population genetics
Gonads	Ethanol 96%	Histology	Sexing
Aristotle's lantern	Dried at 60°C	Stable isotopes	Trophic niche

For the characterisation of the environmental microbiome, ambient sources of microbiome were also collected at each station (Table 11):

Sediment: Five samples of sediments were collected at the collection site of the sea urchins and preserved in RNA later.

Water: Bottom water, where the sea urchins were sampled, was collected using a Niskin bottle. Five ambient water replicates of 500 ml were filtered using a peristaltic pump and a Nuclepore 0.22µl filter. Filters were then preserved in RNA later.

Algae: Depending on each location, one to five morphotypes of algae were collected at close proximity of the urchins' specimens sampled, and five replicates for each alga morphotype were preserved in RNA later.

*Table 11. Overview of the sampling effort
(location, event ID, type and number of samples,
bathymetry) for all the sites visited during*

Region	Sites (sub-region)	Date	Event ID	GPS Coordinates	Site #	# Urchins	# Algae (MT)	# Sediment (rep)	# Water (rep)	Bathy†
Meichior Islands	First site (North Omega)	11/02/2024	DIV1	64°19'235, 62°55'418	Site 7	30	4	5	/	
	First site (North Omega)	12/02/2024	NIS2	64°19'235, 62°55'418	Site 7	/	/	/	/	5
	Second site (South Omega)	14/02/2024 morning	DIV8	64°20'4257, 62°57'0102	/	no urchins	/	/	/	
	Second site (South Omega)	14/02/2024 afternoon	DIV10	64°20'2488, 62°57'4466	/	no urchins	/	/	/	
Hovgaard Island	First site (boat)	18/02/2024 morning	DIV15	65°10'6638, 64°07'5528	Site 8	29	4	5	/	
	First site (boat)	19/02/2024 afternoon	NIS64	65°10'6638, 64°07'5528	Site 8	/	/	/	/	5
	Second site	18/02/2024 morning	DIV16	65°06'2195, 64°07'081	/	no urchins	/	/	/	
	Third site (drop-off)	18/02/2024 afternoon	DIV17	65°05'7952, 64°06'3859	Site 9	2	4	5	/	
	Third site (drop-off)	19/02/2024 morning	DIV19	65°05'7915, 64°05'930	Site 9	15 + 2	1	/	/	
	Third site (drop-off)	19/02/2024 afternoon	NIS66	65°10'6638, 64°07'5528	Site 9	/	/	/	/	5
	Foyn Harbor	22/02/2024 afternoon	DIV26	64°32'793, 61°59'830	Site 10	30	5	5	/	
	First site (boat)	23/02/2024 morning	NIS78	64°32'793, 61°59'830	Site 10	/	/	/	/	5
	Second site	23/02/2024 afternoon	DIV29	64°33'.49305, 61°59'.8420	Site 11	15	4	5	/	
	Second site	24/02/2024 afternoon	NIS95	64°33'.49305, 61°59'.8420	Site 11	/	/	/	/	5
Enterprise Island (close to Foyn Harbor, Gouvernen wreck)	Third site	25/02/2024 morning	DIV33	64°32'.363, 62°00'.021	Site 12	30	5	5	/	10
	Third site	26/02/2024 morning	NIS97	64°32'.363, 62°00'.021	Site 12	/	/	/	/	5
	First site (boat)	28/02/2024 morning	DIV41	62°55.5990, 60°41.1860	Site 13	30	5	5	/	15
Deception Islands ("bonus")	First site (boat)	28/02/2024 morning	NIS120	62°55.5990, 60°41.1860	Site 13	/	/	/	/	5

Results

Globally, 184 sea urchins' specimens were collected in the seven stations visited. Their abundance varied from one site to another and the potential variables influencing their presence will be investigated.

The total number of samples collected during TANGO2 are:

Food pellets: 184

Gut epithelium: 184

Spines: 184

Gonads: 184

Aristotle's lantern: 184

Sediment: 35

Water: 35

Algae: 160

The sizes of the sea urchins also varied between the different sites, variability that will be assessed and investigated in this current project (Figure 57).

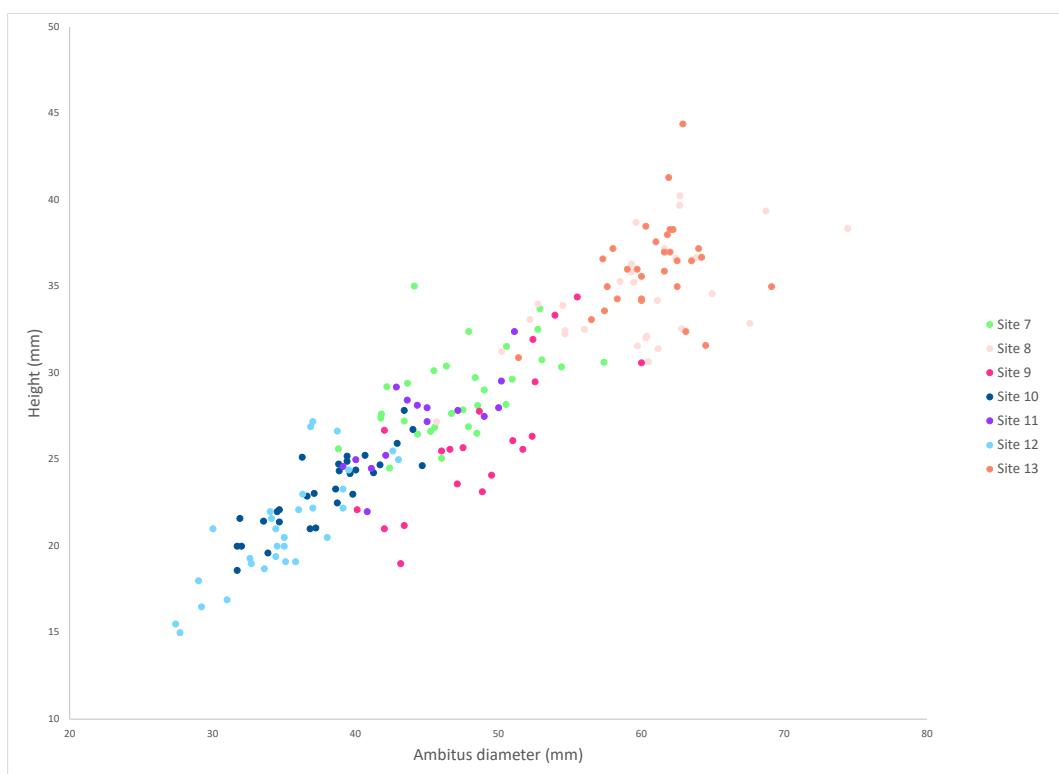


Figure 57. Size comparison (Ambitus diameter (mm) / Height (mm)) for the *Sterechinus neumayeri* specimens collected.

Perspectives

The samples will be analysed using different methods:

The samples preserved dried (Aristotle's lantern) will be analysed in ULiège once return in Belgium for trophic niche analyses,

The food pellets and gut epithelium samples will be processed at ULB (DNA extraction and PCRs) and send to a sequencing company to assess the diet and microbiome composition,

The gonads will be processed at ULB for sea urchin sexing, as well as in Germany for proteomics studies (MALDI-TOF),

The spines will be used in Germany for genomics studies (RAD sequencing).

References

1. Bae H, Ahn IY, Park J, Song SJ, Noh J, Kim H, et al. Shift in polar benthic community structure in a fast retreating glacial area of Marian Cove, West Antarctica. *Sci Rep.* déc 2021;11(1):241.
2. Caputi SS, Careddu G, Calizza E, Fiorentino F, Maccapani D, Rossi L, et al. Seasonal Food Web Dynamics in the Antarctic Benthos of Tethys Bay (Ross Sea): Implications for Biodiversity Persistence Under Different Seasonal Sea-Ice Coverage. *Front Mar Sci.* 11 déc 2020;7:594454.
3. Cardona L, Lloret-Lloret E, Moles J, Avila C. Latitudinal changes in the trophic structure of benthic coastal food webs along the Antarctic Peninsula. *Marine Environmental Research.* mai 2021;167:105290.
4. Michel LN, David B, Dubois P, Lepoint G, De Ridder C. Trophic plasticity of Antarctic echinoids under contrasted environmental conditions. *Polar Biol.* mai 2016;39(5):913-23.
5. Voolstra CR, Ziegler M. Adapting with Microbial Help: Microbiome Flexibility Facilitates Rapid Responses to Environmental Change. *BioEssays.* juill 2020;42(7):2000004.
6. Rennison DJ, Rudman SM, Schluter D. Parallel changes in gut microbiome composition and function during colonization, local adaptation and ecological speciation. *Proc R Soc B.* 4 déc 2019;286(1916):20191911.
7. Amundrud SL, Clay-Smith SA, Flynn BL, Higgins KE, Reich MS, Wiens DRH, et al. Drought alters the trophic role of an opportunistic generalist in an aquatic ecosystem. *Oecologia.* mars 2019;189(3):733-44.
8. Rudman SM, Greenblum S, Hughes RC, Rajpurohit S, Kiratli O, Lowder DB, et al. Microbiome composition shapes rapid genomic adaptation of *Drosophila melanogaster*. *Proc Natl Acad Sci USA.* oct 2019;116(40):20025-32.
9. Chen CY, Chen PC, Weng FCH, Shaw GTW, Wang D. Habitat and indigenous gut microbes contribute to the plasticity of gut microbiome in oriental river prawn during rapid environmental change. *Jadha SB, éditeur. PLoS ONE.* 17 juill 2017;12(7):e0181427.
10. Uren Webster TM, Rodriguez-Barreto D, Castaldo G, Gough P, Consuegra S, Garcia de Leaniz C. Environmental plasticity and colonisation history in the Atlantic salmon microbiome: A translocation experiment. *Mol Ecol.* mars 2020;29(5):886-98.
11. Tropini C, Earle KA, Huang KC, Sonnenburg JL. The Gut Microbiome: Connecting Spatial Organization to Function. *Cell Host & Microbe.* 12 avr 2017;21(4):433-42.

12. Schwob G, Cabrol L, Poulin E, Orlando J. Characterization of the Gut Microbiota of the Antarctic Heart Urchin (Spatangoida) *Abatus agassizii*. *Front Microbiol.* 28 févr 2020;11:308.
13. Hakim JA, Koo H, Dennis LN, Kumar R, Ptacek T, Morrow CD, et al. An abundance of Epsilonproteobacteria revealed in the gut microbiome of the laboratory cultured sea urchin, *Lytechinus variegatus*. *Frontiers in Microbiology [Internet]*. 2015 [cité 27 janv 2023];6. Disponible sur: <https://www.frontiersin.org/articles/10.3389/fmicb.2015.01047>
14. Apprill A. Marine Animal Microbiomes: Toward Understanding Host–Microbiome Interactions in a Changing Ocean. *Front Mar Sci.* 18 juill 2017;4:222.
15. Morris MT, Hauton C, Baylay AJ, Peruzza L, Targett TE, Ciotti BJ. Spatial variation in the gastrointestinal microbiome, diet, and nutritional condition of a juvenile flatfish among coastal habitats. *Marine Environmental Research.* août 2021;170:105413.
16. Curtis MD, Morrow CD, McClintock JB. Impacts of near-future ocean warming on microbial community composition of the stomach of the soft-bottom sea star *Luidia clathrata* (Say) (Echinodermata: Asteroidea) [Internet]. In Review; 2021 mars [cité 12 juill 2022]. Disponible sur: <https://www.researchsquare.com/article/rs-306104/v1>
17. Jones J, DiBattista JD, Stat M, Bunce M, Boyce MC, Fairclough DV, et al. The Microbiome of the Gastrointestinal Tract of a Range-Shifting Marine Herbivorous Fish. *Front Microbiol.* 28 août 2018;9:2000.
18. Griffiths SM, Antwis RE, Lenzi L, Lucaci A, Behringer DC, Butler IV MJ, et al. Host genetics and geography influence microbiome composition in the sponge *Ircinia campana*. *Journal of Animal Ecology.* 2019;88(11):1684-95.
19. Pita L, López-Legentil S, Erwin PM. Biogeography and Host Fidelity of Bacterial Communities in *Ircinia* spp. from the Bahamas. *Microbial Ecology.* 1 août 2013;66(2):437-47.
20. Panova MAZ, Varfolomeeva MA, Gafarova ER, Maltseva AL, Mikhailova NA, Granovitch AI. First insights into the gut microbiomes and the diet of the *Littorina* snail ecotypes, a recently emerged marine evolutionary model. *Evolutionary Applications.* 2023;16(2):365-78.
21. Kang W, Kim PS, Tak EJ, Sung H, Shin NR, Hyun DW, et al. Host phylogeny, habitat, and diet are main drivers of the cephalopod and mollusk gut microbiome. *anim microbiome.* 8 mai 2022;4(1):30.
22. Díaz A, Féral JP, David B, Saucède T, Poulin E. Evolutionary pathways among shallow and deep-sea echinoids of the genus *Sterechinus* in the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography.* 1 janv 2011;58(1):205-11.

6. Biodiversity inventories

Macrofauna

Camille Moreau, Henri Robert, Emil De Borger

Baited “amphipod trap” (AT) are used to capture scavenging communities present in the selected areas. The “homemade” type of trap used during the expedition are composed of a coarse plastic mesh for protection of a 500 μ fine mesh rolled around two rings of PVC pipes to produce a cylinder of 15x40 cm. Both end of the trap are equipped with a funnel with a 2 cm opening directed inward to prevent organisms to escape after penetrating the trap. The bait used consists of mackerel tied inside the trap. Traps are deployed in pairs, secured together with a metal frame (see Figure 58). A 5kg ballast weight is used to anchor the traps on ground level. The system holds to a rope equipped with a sailing buoy floating at the surface for easy spotting and recovery of the trap. The device is deployed for a minimum of 24 hours and maximum 48 hours. Longer deployment may allow scavengers to completely consume the bait, roam around and eventually escape from the trap. Shorter deployment time may not provide enough time for detection of the bait by the scavenger.



Figure 58. Baited amphipod trap composed of coarse plastic mesh for protection doubled by 500 μ fine mesh. Both sides of the cylinder are equipped with a funnel to capture organisms into the trap.

At each sampling station, AT were deployed at two different locations bringing the deployment total to 6 AT for the TANGO2 expedition (see Table 12).

Table 12. Indicate the coordinate, depth and time of the AT deployment during the TANGO2 expedition.

Event ID	Station Name	Date start	Date stop	Time start (UTC-3)	Time end (UTC-3)	Duration (H)	Lat start (dec min)	Long Start (dec min)	Dept Max (m)
AT_1	Melchior Island, North Omega	2024-02-11	2024-02-13	17:30	17:00	47,5	64°19,240	62°55,250	22
AT_2	Melchior Island, South Omega	2024-02-14	2024-02-16	17:30	15:30	46	64°20,288	62°56,675	20,5
AT_3	Hovgaard Islands	2024-02-17	2024-02-19	17:45	16:00	46,25	65°06,240	64°51,540	22
AT_4	Hovgaard Islands	2024-02-20	2024-02-21	17:45	18:30	24,75	65°05,831	64°05,775	40
AT_5	Føyn Harbor	2024-02-22	2024-02-24	17:30	13:00	43,5	64°32,912	61°59,689	32

AT_6	Føyn Harbor	2024-02-24	2024-02-26	16:30	13:00	44,5	64°32,994	61°59,192	50
------	-------------	------------	------------	-------	-------	------	-----------	-----------	----

- At **Melchior Islands** the two AT were deployed at similar depth of 20 to 22 meters. The first one was deployed in the main channel between the Island Omega and Epsilon. The second trap was deployed in the middle of the cove's entrance, at the exit of the underwater canyon.
- At **Hovgaard Islands**, the first trap was deployed in the main channel at 22 meter depth while the second one was deployed at the northern, deeper cove (extensively prospected by divers) with a depth of 40 meters surrounded by underwater cliffs on the southern and northern sides of the cove. The second deployment allowed detection of community change at greater depth in rocky, canyon like environment.
- Deployments at **Føyn Harbour** were performed at the southern slope of the "south pool" at a depth of 32 meters. The second deployment was located on a deeper small plateau emerging from the outer steep slope of the study area, in the main channel at a depth of 50 meters.

A “Rauschert” dredge (RD) was used at each working area to sample the general macrobenthic communities. This small dredge designed by Biologist Martin Rauschert (AWI) several decades ago is an excellent tool (widely used in the scientific benthic research community) to capture a large diversity of specimen of all taxa and keep them in a good shape for further identification and processing. The dredge consists of a 50x50x20 cm double sided sledge-like metal frame that slides on the sea floor (on either side). Organisms are lifted from the sediment surface by a chain that scrapes the seabed under the dredge’s frame. At the bottom of the dredge a large 50x70x20 cm bag of 500 μ mesh is attached to collect all the floating organisms lifted by the chain. This collecting bag is protected by a coarse nylon 1 cm mesh size bag to support the weight of the sample collected. Both bags are protected on top and at the bottom by a rubber carpet that covers the whole surface of the collecting bag (see Figure 59). The RD is usually deployed from a zodiac but can also be deployed from the deck of Australis. The RD is being held and hauled by a rope of at least 1.5 times the length of the depth of deployment. A distance of 100 meter is travelled to the end point of deployment at very low speed that allows the dredge to sweep the sea floor without floating above the ground. At the end point the rope is pulled by hand until the RD reaches the water surface. The whole device containing the samples in its bags is placed in a bucket for further processing on the ship’s deck.



Figure 59. The Rauschert Dredge (RD composed of a sledge-like metal frame drags the collecting megabenthic communities mesh bag (protected by rubber carpets) on the sea floor.

A total of 15 RD was deployed during the TANGO2 expedition at each station's point of interest (deeper "pools", canyons, channel slope, plateau). The list of each RD deployment with information about transects position, depth and time is presented in Table 13.

Table 13. Rauschert Dredge deployment list deployed during the TANGO2 expedition

Event ID	Station Name	Date	Time start (UTC-3)	Lat start (dec min)	Long Start (dec min)	Lat Stop (dec min)	Long Stop (dec min)	Dept Min (m)	Dept Max (m)
RD_01	Melchior Island, North Omega	2024-02-12	13:30	64°19,242	62°55,372	64°19,199	62°55,421	5	20
RD_02	Melchior Island, North Omega	2024-02-13	08:30	64°19,192	62°55,034	64°19,237	62°55,062	8	22
RD_03	Melchior Island, North Omega	2024-02-14	08:20	64°19,198	62°55,115	64°19,164	62°54,881	18	22
RD_04	Melchior Island, South Omega	2024-02-15	08:30	64°20,308	62°56,694	64°20,346	62°56,774	15	22
RD_05	Melchior Island, South Omega	2024-02-15	17:30	64°20,371	62°57,520	64°20,313	62°57,537	20	100
RD_06	Melchior Island, South Omega	2024-02-16	08:30	64°20,227	62°56758	64°20,209	62°56,689	5	35
RD_07	Hovgaard Islands	2024-02-18	08:20	65°06,227	64°05,020	65°06,234	64°04,865	18	23
RD_08	Hovgaard Islands	2024-02-19	08:20	65°06,569	64°04,469	65°06,414	64°04,444	15	22
RD_09	Hovgaard Islands	2024-02-20	08:15	65°06,331	64°03,923	65°06,349	64°04,164	8	12
RD_10	Hovgaard Islands	2024-02-21	09:20	65°05,827	64°05,999	65°05,826	64°05,836	44	49,5
RD_11	Føyn Harbor	2024-02-22	15:30	64°32,925	61°59,791	64°32,904	61°59,662	28	32

RD_12	Føyn Harbor	2024-02-23	08:15	64°33,274	62°00,295	64°33,244	62°00,104	30	40
RD_13	Føyn Harbor	2024-02-24	08:20	64°32,792	61°59,896	64°32,779	61°59,787	17	22
RD_14	Føyn Harbor	2024-02-25	08:30	64°32,688	61°59,117	64°32,707	61°59,181	35	50
RD_15	Føyn Harbor	2025-02-26	08:20	64°32,285	61°59,182	64°32,349	61°59,344	14	45

Results

All sample collected in the different events of RD and the AT have been partially sorted by main morphotypes on board of Australis during the expedition. Representants of the major taxa present in the catch were isolated, identified to the lowest taxonomic level known and counted whenever time and space was available. In the case where large number of the same species was caught in the gear, depending on necessity and/or relevance, a subsample was collected while a dominant portion was released alive in their environment. This occurred for species such as *Sterechinus neumayeri*, *Parborlasia corrugatus*, *Ophionotus victoriae*, *Glyptonotus antarcticus* and scavenging amphipods. All sorted taxa and unsorted subsamples were labeled and fixed in ethanol to be processed further thoroughly in the laboratory.

The content of the different **AT and RD** (scientific name of the different taxa identified and individual count) is presented on Table 14 and Table 15. Note that AT 01 and 03 were totally clogged by large number of *Parborlasia corrugatus* which obviously had a negative impact on the catch of scavenging amphipod.

Table 14. Amphipod trap sampling preliminary data - TANGO2 expedition

Event ID	Scientific Name	Individual Count	Remark
AT_01	Amphipoda	465	
	<i>Parborlasia corrugatus</i>	62	Not collected
AT_02	Amphipoda	500	7000 individuals not collected
	Lysianassoidea	15	
	Lysianassoidea	15	
	Asteroidea	1	
	Undetermined	2	
	Gastropoda	3	
	Polyplacophora	2	
	Ascidia	1	
AT_03	<i>Parborlasia corrugatus</i>	7	Not collected
	Amphipoda	300	
	<i>Charcotia obesa</i>	1	
AT_04	<i>Parborlasia corrugatus</i>	118	Not collected
	Undetermined		
AT_05	Amphipoda	1500	Subsample. 20000 ind. released
	Amphipoda	25	
	<i>Glyptonotus antarcticus</i>	1	Not collected (released)
AT_06	Amphipoda mix	300	3000 <i>Charcotia obesa</i> released

Table 15 Rauschert Dredge sampling preliminary data - TANGO2 expedition. The complete list of taxa identified within each catch is presented in Annex.

Event ID	Catch content	Individual Count
RD_01	13 taxa + Invertebrata unsorted lot	341
RD_02	12 taxa + Invertebrata unsorted lot	147
RD_03	9 taxa + Invertebrata unsorted lot	205
RD_04	12 taxa + Invertebrata unsorted lot	359
RD_05	13 taxa + Invertebrata unsorted lot	136
RD_06	12 taxa + Invertebrata unsorted lot	349
RD_07	12 taxa + Invertebrata unsorted lot	239
RD_08	9 taxa + Invertebrata unsorted lot	1105
RD_09	4 taxa + Invertebrata unsorted lot	257
RD_10	9 taxa + Invertebrata unsorted lot	94
RD_11	6 taxa + Invertebrata unsorted lot	198
RD_12	11 taxa + Invertebrata unsorted lot	292
RD_13	8 taxa + Invertebrata unsorted lot	124
RD_14	12 taxa + Invertebrata unsorted lot	281
RD_15	10 taxa + Invertebrata unsorted lot	251
TOTAL =		4127

Top predators

Henri Robert

Context

The main objectives of the continuous top predators inventories are, on one hand, to contribute to a better understanding of the mechanisms influencing the quantitative at sea distribution of seabirds and marine mammals in polar marine ecosystems (water masses, fronts, pack ice, ice edge and eddies) and, on the other hand, to detect spatial and temporal evolutions in these distributions with special attention to possible consequences of anthropogenic activity and global climatic changes. As seabirds and marine mammals constitute the upper trophic level in the food chain, their distribution reflects the abundance of prey, like zooplankton, krill, nekton and small fish, and is thereby an indicator for the ecology and biological production of the whole water column.

Improved knowledge of this distribution patterns is therefore of high relevance and interest to identify and localize areas of high biological productivity, and to observe temporal changes due to anthropogenic influences and global change.

Of several abiotic environmental factors, salinity and water temperature were identified as the most influential for bird distribution. Through monitoring across latitudes areas of strong variations called transition zones which potentially correspond to borders between water systems or fronts indicating ecological discontinuities, were identified (Longhurst, 2007). Based on these fronts, the transects, conducted during the Tango expedition can be divided into 3 main zones: Magellanic area, Drake Passage, the Antarctic Peninsula.

Further research should indicate correlations between oceanographic and biological parameters, such as water quality, abiotic parameters, seafloor topography, plankton blooms, crustaceans or fish concentrations. This knowledge can then be used for the mapping of ecologically important or vulnerable areas and used as tools for conservation.

Methods

Continuous monitoring of birds and marine mammals (species identification and headcount) is performed from the bridge or a spot offering the best visibility on deck. Bird/mammal standard counts are 30 min non-stop observation with binoculars for identification (if required) and age/sex determination when possible. A 300 mm tele objective camera is used for documentation and identification of species that pose identification issues in the field (e.g. *Catharacta* spp., *Pachyptila* spp.). GPS ship position and climatic conditions are recorded at each start and end position of counts. Counts are performed during daylight (from dawn to dusk), while visibility permitting (counts are interrupted when visibility is poor due to heavy fog or precipitation) to avoid bias in animal detection and subsequent false population estimates.

Equipment used for the survey:

- Binoculars Leica Ultravid 10*32
- 600 mm Long lense SONY camera (XR10iv)
- Garmin Oregon 600 GPS

Results

During the TANGO2 expedition, a total of 64 observation events (standard counts or punctual observations) were performed while crossing the Magellanic Area (MA), the Drake Passage (DP) and along the Antarctic Peninsula (AP). General notes on the observations for each species encountered during the voyage are listed hereunder. Table 16 presents the relative abundance of each species in the three different areas prospected (MA, DP, AP).

It is worth mentioning that the observers found very low densities of birds during both crossings of the Drake Passage compared to similar crossings performed at similar dates during previous years. Several species, although normally common or frequently observed during such transect e.g., the Southern Royal Albatross (*Diomedea epomophora*), Snow Petrel (*Pagodroma nivea*), White-headed Petrel (*Pterodroma lessonii*), Antarctic Petrel (*Thalassica antarctica*), Kerguelen Petrel (*Lugensa brevirostris*) or Blue petrel (*Halobaena caerulea*) have not been observed at all on this voyage.

1- BIRDS

Diomedidae

- Wandering Albatross (*Diomedea exulans exulans*): common in the Drake passage.
- Black-browed Albatross (*Thalassarche melanophrys*): very common in the open waters of the Southern Ocean (particularly in the channels of the Magellanic area and the Drake passage).

- Grey-headed Albatross (*Thalassarche chrysostoma*): few specimens sighted south of Cape Horn and in the Drake passage.
- Light-mantled Sooty Albatross (*Phoebetria palpebrata*): few specimens sighted in the Drake passage.

Procellariidae

- Southern Giant petrel (*Macronectes giganteus*): circum Antarctic species. Common in the Gerlache strait and the Drake passage.
- Northern Giant Petrel (*Macronectes halli*): rare individual identified south of the Magellanic area. Most individuals of this species might have been identified as Southern G.P. (indistinguishable at distance).
- Southern Fulmar (*Fulmarus glacialisoides*): Few specimens sighted in the Gerlache strait, and very few in the southern part of the Drake passage.
- Cape Petrel (*Daption capense capense*): few specimen observed North of the South Shetland Islands and during the crossing of the Drake passage
- Soft-plumaged Petrel (*Pterodroma mollis mollis*): commonly observed during the crossing of the Drake passage.
- Grey Petrel (*Procellaria cinerea*): one individual was observed during the crossing of the Drake passage.
- White-chinned Petrel (*Procellaria aequinoctialis*): common species in the Magellanic area and the northern part of the Drake passage.
- Sooty Shearwater (*Puffinus griseus*): common near Cape Horn and in the Beagle channel (where aggregations of several thousand individuals can be encountered). Some individuals were also observed during the crossing of the Drake Passage.
- Great Shearwater (*Puffinus gravis*): one individual observed at the vicinity of Cape Horn.
- Antarctic/Slender-billed Prion (*Pachyptila sp. cf. desolata/belcheri*): these two species are virtually unidentifiable at sea due to their morphologic resemblance. Few individuals were observed in the Drake passage (much fewer number than expected on these crossings).

Hydrobatidae

- Wilson's Storm Petrel (*Oceanites oceanicus*): common in the Drake passage and the Gerlache strait (circum Antarctic species).
- Black bellied Storm Petrel (*Fregetta tropica*): common specimens observed mostly in the southern part of the Drake passage.

Pelecanoididae

- Common Diving Petrel (*Pelecanoides urinatrix*): frequently observed during the crossing of the Drake passage.
- Magellanic Diving-petrel (*Pelecanoides magellani*): several individuals observed at the vicinity of Cape Horn.

Phalacrocoracidae

- Antarctic Shag (*Phalacrocorax bransfieldensis*): common all along the Gerlache strait.
- Imperial Shag (*Phalacrocorax atriceps*): common in the Beagle channel and the Magellanic area.
- Rock Shag (*Phalacrocorax magellanicus*): one individual observed in the Beagle channel.

- Neotropic Cormorant (*Phalacrocorax brasiliensis*): two individuals observed in the Beagle channel.

Chionidae

- Snowy Sheathbill (*Chionis albus*): few specimens observed on Gentoo colonies along the Gerlache Strait.

Stercorariidae

- Brown Skua (*Catharacta lönbergi*): commonly observed in the Gerlache Strait, north of Lemaire Channel (confusion with South Polar Skua likely in the Gerlache strait).
- South Polar Skua (*Catharacta maccormicki*): few specimens observed south of the Lemaire Channel.
- Chilean Skua (*Catharacta chilensis*): common species of the Magellanic area, observed frequently but in small numbers in the Beagle channel.

Laridae

- Kelp Gull (*Larus dominicanensis*): few specimens observed near Gentoo Penguin colonies along the Gerlache Strait; common in the Beagle channel.

Sternidae

- Antarctic Tern (*Sterna vittata*): commonly encountered all along the Gerlache Strait and Lemaire Channel.
- South American Tern (*Sterna hirundinacea*): common in the Beagle channel.

Sphenicidae

- Gentoo Penguin (*Pygoscelis papua*): dominant and common species breeding on many locations along the Western Antarctic Peninsula.
- Magellanic Penguin (*Spheniscus magellanicus*): few specimens observed in the Beagle Channel.
- Chinstrap Penguin (*Pygoscelis antarctica*): few individuals observed north of the Gerlache Strait.
- Adelie Penguin (*Pygoscelis adeliae*): rare encounter along the Gerlache Strait.

Anatidae

- Flightless Steamer Duck (*Tachyeres pteneres*): few individuals observed in the Beagle channel.
- Upland Goose (*Chloephaga picta*): few individuals observed along the shores of the Beagle channel.

2- MARINE MAMMALS

Otariidae

- Antarctic Fur Seal (*Arctocephalus gazelle*): common in the Gerlache strait.
- Southern Elephant Seal (*Mirounga leonida*): few individuals observed on small island near Föyn Harbour.
- South American Sea Lion (*Otaria flavescens*): common in the Beagle channel.

Phocidae

- Leopard Seal (*Hydrurga leptonyx*): several specimens observed at the vicinity of most Gentoo Penguin colonies.
- Weddell Seal (*Leptonychotes weddellii*): several individuals observed at Mechior and Hovgaard Islands.
- Crabeater Seal (*Lobodon carcinophaga*): common along the Gerlache strait.

Delphinidae

- Hourglass Dolphin (*Lagenorhynchus cruciger*): species observed nearly every day during the Drake passage crossings with pods of few individuals bow riding the Australis for a few minutes.
- Dusky Dolphin (*Lagenorhynchus obscurus*): common at the entrance of the Beagle Channel.
- Peale's Dolphin (*Lagenorhynchus australis*): two different small groups observed between Cape Horn and the entrance of the Beagle Channel.
- Killer Whale (*Orcinus Orca*): a pod of 8 (type B2) killer whale was observed at a kill site (probably a seal or fur seal) in the Gerlache Strait, north of Cape Renard.
- Southern Bottlenose Whale (*Hyperoodon planifrons*): two individuals observed at very short distance in the Drake passage.

Balaenopteridae

- Antarctic Minke Whale (*Balaenoptera bonaerensis*): common along the Western Antarctic Peninsula. Few individuals observed in the Beagle Channel.
- Fin Whale (*Balaenoptera physalus*): one individual observed in the southern part of the Drake passage.
- Humpback Whale (*Megaptera novaeangliae*): common and dominant cetacean observed along the Western Antarctic Peninsula, particularly abundant at the northern entrance of Graham passage and Marguerite Bay.
- Southern Right Whale (*Eubalaena australis*) one individual observed at short distance during the crossing of the Bransfield Strait.
- Dwarf Minke Whale (*Balaenoptera acutorostrata*): one individual observed in the Neumayer channel.

Table 16. present the species list of marine birds and mammals observed during the TANGO 2 expedition. For each species and every area prospected (MA=Magellanic Area; DP=Drake Passage; AP=Antarctic Peninsula), an abundance index is given (I= one observation or rare species; II= fairly abundant species; III= dominant species).

Vernacular name	Latin name	Location		
		MA	DP	AP
Black-browed Albatross	<i>Thalassarche melanophrys</i>	III	III	I
Wandering Albatross	<i>Diomedea exulans</i>		II	
Grey-headed Albatross	<i>Thalassarche chrysostoma</i>		II	
Light-mantled Albatross	<i>Phoebetria palpebrata</i>	I		
Soft-plumage Petrel	<i>Pterodroma mollis</i>		II	
Cape Petrel	<i>Daption capense</i>	I	I	
Southern Fulmar	<i>Fulmarus glacialisoides</i>	I		II

Southern Giant Petrel	<i>Macronectes giganteus</i>	I	III	III
Northern Giant Petrel	<i>Macronectes halli</i>	I	I	
Sooty Shearwater	<i>Puffinus griseus</i>	III	I	
White-chinned Petrel	<i>Procellaria aequinoctialis</i>	I	II	
Grey Petrel	<i>Procellaria cinerea</i>		I	
Great Shearwater	<i>Puffinus gravis</i>	I		
Antarctic Prion	<i>Pachyptila desolata</i>		II	
Slender-billed Prion	<i>Pachyptila belcheri</i>		II	
Common Diving Petrel	<i>Pelecanoides urinatrix</i>	I	II	
Magellanic Diving Petrel	<i>Pelecanoides magellani</i>	I		
Wilson's Storm Petrel	<i>Oceanites oceanicus</i>	I	II	III
Black-bellied Storm Petrel	<i>Fregetta tropica</i>		II	I
Kelp Gull	<i>Larus dominicanus</i>	II	I	III
Flightless Steamer Duck	<i>Tachyeres pteneres</i>	II		
Upland Goose	<i>Chloephaga picta</i>	II		
Antarctic Tern	<i>Sterna vittata</i>		II	III
South American Tern	<i>Sterna hirundinacea</i>	II		
Chilean Skua	<i>Catharacta chilensis</i>	II		
Brown Skua	<i>Catharacta lönbergi</i>		I	III
South polar Skua	<i>Catharacta maccormicki</i>			I
Magellanic Penguin	<i>Spheniscus magellanicus</i>	II		
Gentoo Penguin	<i>Pygoscelis papua</i>			III
Adelie Penguin	<i>Pygoscelis adeliae</i>			I
Chinstrap Penguin	<i>Pygoscelis antarctica</i>			II
Antarctic Shag	<i>Phalacrocorax bransfieldensis</i>			III
Imperial Shag	<i>Phalacrocorax atriceps</i>	III		
Rock Shag	<i>Phalacrocorax magellanicus</i>	I		
Neotropic Cormorant	<i>Phalacrocorax brasiliensis</i>	I		
Snowy Sheathbill	<i>Chionis albus</i>			I
Humpback Whale	<i>Megaptera novaeangliae</i>	I	II	III
Antarctic Minke Whale	<i>Balaenoptera bonaerensis</i>		I	II
Dwarf Minke Whale	<i>Balaenoptera acutorostrata</i>			I
Fin Whale	<i>Balaenoptera physalus</i>		I	
Southern Right Whale	<i>Eubalaena australis</i>			I
Killer Whale (type B2)	<i>Orcinus Orca</i>			I
Southern Bottlenose Whale	<i>Hyperoodon planifrons</i>		I	
Dusky Dolphins	<i>Lagenorhynchus obscurus</i>	III		
Peale's Dolphins	<i>Lagenorhynchus australis</i>	II		
Hourglass Dolphins	<i>Lagenorhynchus cruciger</i>		II	
Crabeater Seal	<i>Lobodon carcinophaga</i>			II
Weddell Seal	<i>Leptonychotes weddellii</i>			II
Leopard Seal	<i>Hydrurga leptonyx</i>			II
Southern Elephant Seal	<i>Mirounga Leonida</i>			I

South American Sea Lion	<i>Otaria flavescens</i>	III		
Antarctic Fur Seal	<i>Arctocephalus gazella</i>	I	II	

Diving activities

Lucas Terrana

During the 17 effective working days of the expedition, from 11th of February to 27th of February 2024, a total of 42 logged dives have been performed, out of which 14 have been made from the Australis Vessel, and 28 from zodiacs. The average dive time was **42 minutes** for an average depth of **23 meters**. The longest dive was 57 minutes, the deepest dive was 36 meters. In total, 94 jumps into water have been made. Average temperature was 1°C.

When two dives were made by the same diver the same day, a minimum of **4 hours of surface interval** was always respected.

For the safety, there was always a 15L tank filled at 200 bar attached to a rope with a marker at 5m and mounted with two regulators, two direct systems and a gauge which was available onboard or directly on the zodiac as a safety tank. A 5L pure oxygen was also always available with adequate masks. When two zodiacs had to go out at the same time for two different dives, it was always the zodiac going to the farest site which brought the safety equipment, while the other was <100m from the Australis where other safety equipment could be found (B50 oxygen).

There was only one tethered dive due to the presence of brash ice on site, the 41 others were made without a tether, with a maximum of 3 divers per team.

A single dive has been aborted due to the presence of a leopard seal next to the divers, spotted by the safety team on the zodiac. This was a non-tethered dive, and the recall signal worked efficiently (engine accelerations on top of the bubbles). Thanks to the strictly non-mandatory decompression dives, the divers could join the surface within less than 3 minutes (depth around 22 m when it occurred).

Zero accident nor minor incident happened during all the dives: no freezing, no diver lost underwater, no gear failure, ...

No dive was aborted due to the cold: the divers had an efficient thermal protection (heating systems and proper undersuits).

A strict 24 hours pause –or more– was respected for each diver after 5 to 6 consecutive days of diving, depending on the tasks and the diver's fitness.

In the end, **all the scientific tasks have always been accomplished successfully without any exception.**

Total number of dives in each station:

- Melchior Islands: 13 dives
- Hovgaard: 12 dives
- Foyn Harbor: 15 dives
- Deception Island: 2 dives

Total number of divers for each diver:

- Lucas TERRANA – 25 dives
- Camille MOREAU — 24 dives
- Martin DOIGNIEZ – 20 dives
- Anthony VOISIN – 14 dives
- Lea KATZ – 11 dives

Regarding the breathed gas, before departure all the 6 tanks were completely emptied and one was chosen randomly for a visual inspection which revealed no rust nor moisture.

Prior to the first filling, both the cartridge of the electric compressor BAUER POSEIDON and the thermic compressor COLTRI were changed according to the respective manufacturer's references on the 6th of February. The snorkel of the compressor was always placed around 2.5 meters above the deck during the filling.

All the fillings have been performed with a second filtration device UNDERSEA.

A single tank was first filled and air quality checked with a KITAGAWA air quality kit for carbon monoxide, carbon dioxide, oil vapors, and moisture.

It revealed **none of these gas or pollutants**, but moisture was above the recommended value with $>160 \text{ mg/m}^3$. Moisture was inevitable as all the precautions possible were taken: two filtration devices, a long-snorkel directed towards the boat to avoid rain/snow entering in it, and the drain of the compressor every 10 minutes of filling time. Moisture was most likely due to the ambient moisture in the harbour in Ushuaia.

During the cruise, the cartridge was changed after 37 hours of running time and 62 tanks filled on the 21st of February. A second air quality test was performed which **revealed no pollutants and a level of moisture inferior to the previous one** with $<100 \text{ mg/m}^3$, but still higher than the value in the Royal Decree 28th April 2017.

At the end, a total of 55 hours of filling time and 98 tanks were filled. Every filling event has been written in a "compressor logbook".

The complete logbook of the dives and the compressor logbook are found in the Appendixes.

Table 17 Summary of diving activities during TANG02

DATE	EVENT	SITE	LATITUDE	LONGITUDE	MAX.DEPTH (m)	RUNTIME (min)	TASK	DIVE LEAD	DIVER 2	DIVER 3	From	Tether
11-02-24	DIV-01	Melchior Islands - North Omega	64°19.233 S	62°55.412 W	21	42	Sea urchin collection + photo/video	Martin DOIGNIEZ	Lea KATZ	Anthony VOISIN	Australis vessel	No
11-02-24	DIV-02	Melchior Islands - North Omega	64°19.233 S	62°55.412 W	21	46	Sediment cores	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
12-02-24	DIV-03	Melchior Islands - North Omega	64°19.241 S	62°55.241 W	20	46	Quadrats	Martin DOIGNIEZ	Anthony VOISIN	-	Australis vessel	No
12-02-24	DIV-04	Melchior Islands - North Omega	64°19.241 S	62°55.426 W	22	52	Photo/video shots + handpicking	Lucas TERRANA	Lea KATZ	Camille MOREAU	Australis vessel	No
13-02-24	DIV-05	Melchior Islands - North Omega	64°19.241 S	62°55.426 W	21	56	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	Australis vessel	No
13-02-24	DIV-06	Melchior Islands - North Omega	64°19.256 S	62°55.378 W	23	55	ROV Leak check + ROV transect + photos	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
13-02-24	DIV-07	Melchior Islands - North Omega	64°19.256 S	62°55.378 W	21	45	Sediment cores + search/recovery	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
14-02-24	DIV-08	Melchior Islands - South Omega	64°20.425 S	62°57.010 W	29	39	Sea urchin collection	Martin DOIGNIEZ	Lea KATZ	-	RIB	No
14-02-24	DIV-09	Melchior Islands - South Omega	64°20.343 S	62°56.551 W	23	35	Sediment cores	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
14-02-24	DIV-10	Melchior Islands - South Omega	64°20.248 S	62°57.446 W	30	44	Sea urchin collection + photo/video	Martin DOIGNIEZ	Lucas TERRANA	Camille MOREAU	RIB	No
15-02-24	DIV-11	Melchior Islands - South Omega	64°20.339 S	62°56.553 W	19	36	Quadrats	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	Yes
16-02-24	DIV-12	Melchior Islands - South Omega	64°20.339 S	62°56.553 W	20	50	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
16-02-24	DIV-13	Melchior Islands - North Omega	64°19.220 S	62°55.265 W	20	10	Retrieval of sediment trap	Lucas TERRANA	Camille MOREAU	-	RIB	No
17-02-24	DIV-14	Hovgaard - Anchor pool	65°06.081 S	64°04.955 W	20	37	Sediment cores + sea urchin collection	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
18-02-24	DIV-15	Hovgaard - Channel	65°06.219 S	64°05.089 W	20	36	Quadrats	Martin DOIGNIEZ	Camille MOREAU	-	RIB	No
18-02-24	DIV-16	Hovgaard - Pool Belgica121	65°10.663 S	64°07.552 W	15	47	Sea urchin collection + photo/video	Lucas TERRANA	Lea KATZ	-	RIB	No
18-02-24	DIV-17	Hovgaard - Drop-off	65°05.795 S	64°06.385 W	32	46	Sea urchin collection + exploration drop-off	Lucas TERRANA	Camille MOREAU	-	RIB	No
19-02-24	DIV-18	Hovgaard - Channel	65°06.226 S	64°05.046 W	20	52	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
19-02-24	DIV-19	Hovgaard	65°05.791 S	64°05.930 W	31	50	Sea urchin collection + photo/video	Lucas TERRANA	Lea KATZ	Camille MOREAU	RIB	No
19-02-24	DIV-20	Hovgaard	65°06.219 S	64°05.089 W	23	37	Sediment cores	Lucas TERRANA	Camille MOREAU	-	Australis vessel	No
20-02-24	DIV-21	Hovgaard	65°05.795 S	64°06.385 W	31	42	Photo/video shots + handpicking	Camille MOREAU	Lea KATZ	-	RIB	No
20-02-24	DIV-22	Hovgaard	65°05.795 S	64°06.985 W	23	37	Quadrats	Martin DOIGNIEZ	Lucas TERRANA	-	RIB	No
20-02-24	DIV-23	Hovgaard	65°05.795 S	64°06.986 W	30	38	Photo/video shots + handpicking	Lucas TERRANA	Martin DOIGNIEZ	Camille MOREAU	RIB	No
21-02-24	DIV-24	Hovgaard	65°06.079 S	64°04.945 W	19	47	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
21-02-24	DIV-25	Hovgaard	65°06.2345 S	64°51.081 W	22	26	Retrieval of sediment trap + cores	Lucas TERRANA	-	-	RIB	No
22-02-24	DIV-26	Foyn Harbor - Anchorage	64°32.793 S	61°59.830 W	23	40	Sediment cores + sea urchin collection	Lucas TERRANA	Camille MOREAU	Anthony VOISIN	Australis vessel	No
23-02-24	DIV-27	Foyn Harbor - Anchorage	64°32.803 S	61°59.779 W	25	41	Quadrats	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
23-02-24	DIV-28	Foyn Harbor - Outer Wall North	64°32.809 S	61°59.202 W	32	44	Exploration and photo/video + sea urchins	Lucas TERRANA	Camille MOREAU	Lea KATZ	RIB	No
23-02-24	DIV-29	Foyn Harbor - South tip	64°33.493 S	61°59.892 W	36	48	Sea urchins + exploration	Lucas TERRANA	Camille MOREAU	Martin DOIGNIEZ	RIB	No
24-02-24	DIV-30	Foyn Harbor - Anchorage	64°32.796 S	61°59.797 W	25	42	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	Australis vessel	No
24-02-24	DIV-31	Foyn Harbor - Outer Wall South	64°33.247 S	62°00.188 W	30	42	ROV transect	Lucas TERRANA	Camille MOREAU	-	RIB	No
24-02-24	DIV-32	Foyn Harbor	64°32.827 S	61°59.323 W	35	25	Sediment cores	Lucas TERRANA	Camille MOREAU	-	RIB	No
25-02-24	DIV-33	Foyn Harbor - Outer Wall South	64°33.247 S	62°00.188 W	21	48	Quadrats	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
25-02-24	DIV-34	Foyn Harbor - Governoren Wreck	64°32.636 S	62°00.027 W	23	56	Photo/video + sediment cores	Lucas TERRANA	Lea KATZ	Camille MOREAU	RIB	No
25-02-24	DIV-35	Foyn Harbor - Governoren Wreck	64°32.636 S	62°00.027 W	23	57	Photo/video shots	Lucas TERRANA	Camille MOREAU	-	RIB	No
25-02-24	DIV-36	Foyn Harbor - Governoren Wreck	64°32.636 S	62°00.027 W	23	41	Exploration	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
26-02-24	DIV-37	Foyn Harbor - Outer Wall South	64°33.280 S	61°59.596 W	23	43	Transects	Martin DOIGNIEZ	Anthony VOISIN	-	RIB	No
26-02-24	DIV-38	Foyn Harbor - Governoren Wreck	64°32.636 S	62°00.027 W	22	47	Photo/video shots	Lucas TERRANA	Lea KATZ	Camille MOREAU	RIB	No
26-02-24	DIV-39	Foyn Harbor - Governoren Wreck	64°32.636 S	62°00.027 W	16	55	Photo/video shots	Lucas TERRANA	Martin DOIGNIEZ	-	RIB	No
26-02-24	DIV-40	Foyn Harbor - Sediment trap	64°33.190 S	62°00.534 W	22	38	Retival of sediment trap + photos	Camille MOREAU	Lea KATZ	-	RIB	No
27-02-24	DIV-41	Deception Islands - Telefon Bay	62°55.599 S	60°41.186 W	19	41	Photo/video	Camille MOREAU	Lea KATZ	-	Australis vessel	No
27-02-24	DIV-42	Deception Islands - Telefon Bay	62°55.599 S	60°41.186 W	19	31	Sea urchin collection	Lucas TERRANA	Martin DOIGNIEZ	Anthony VOISIN	Australis vessel	No

Outreach activities

Lea Katz, Anthony Voisin

A wide range of communication tools have been put in place to share the activities of the TANGO2 scientific campaign with the general public. The various universities involved in the project were able to contact their communications departments to publish articles on the expedition's activities. In addition, various internet platforms were regularly updated during the expedition (e.g. facebook, instagram, Polarstep). Finally, thanks to a research effort, collaborations have been set up with brands of diving equipment to improve the performance of planned scientific diving activities.

[Press release](#)

Université Libre de Bruxelles : <https://sciences.ulb.be/la-recherche/actualites/lantarctique-en-voilier-pour-observer-les-reponses-des-ecosystemes-de-locean-austral-aux-changements-climatiques>

Faculté des Sciences → Accueil → La Recherche → Actualités

L'Antarctique en voilier pour observer les réponses des écosystèmes de l'océan Austral aux changements climatiques



PUBLIÉ LE 22 JANVIER 2024 – MIS À JOUR LE 12 FÉVRIER 2024



Une expédition belge, menée par le Prof. Bruno Danis, a mis le cap sur l'Antarctique pour la deuxième étape du projet TANGO. Leur objectif : contribuer à notre compréhension des réponses des écosystèmes aux changements environnementaux en cours dans l'océan Austral. Et la mission se déroulera... en voilier !

[changements-climatiques](#)

Université de Liège : https://www.sciences.uliege.be/cms/c_12365803/fr/l-expedition-scientifique-tango-2-met-le-cap-sur-l-antarctique

EXPÉDITION SCIENTIFIQUE

L'expédition scientifique TANGO 2 met le cap sur l'Antarctique

3 février 2024

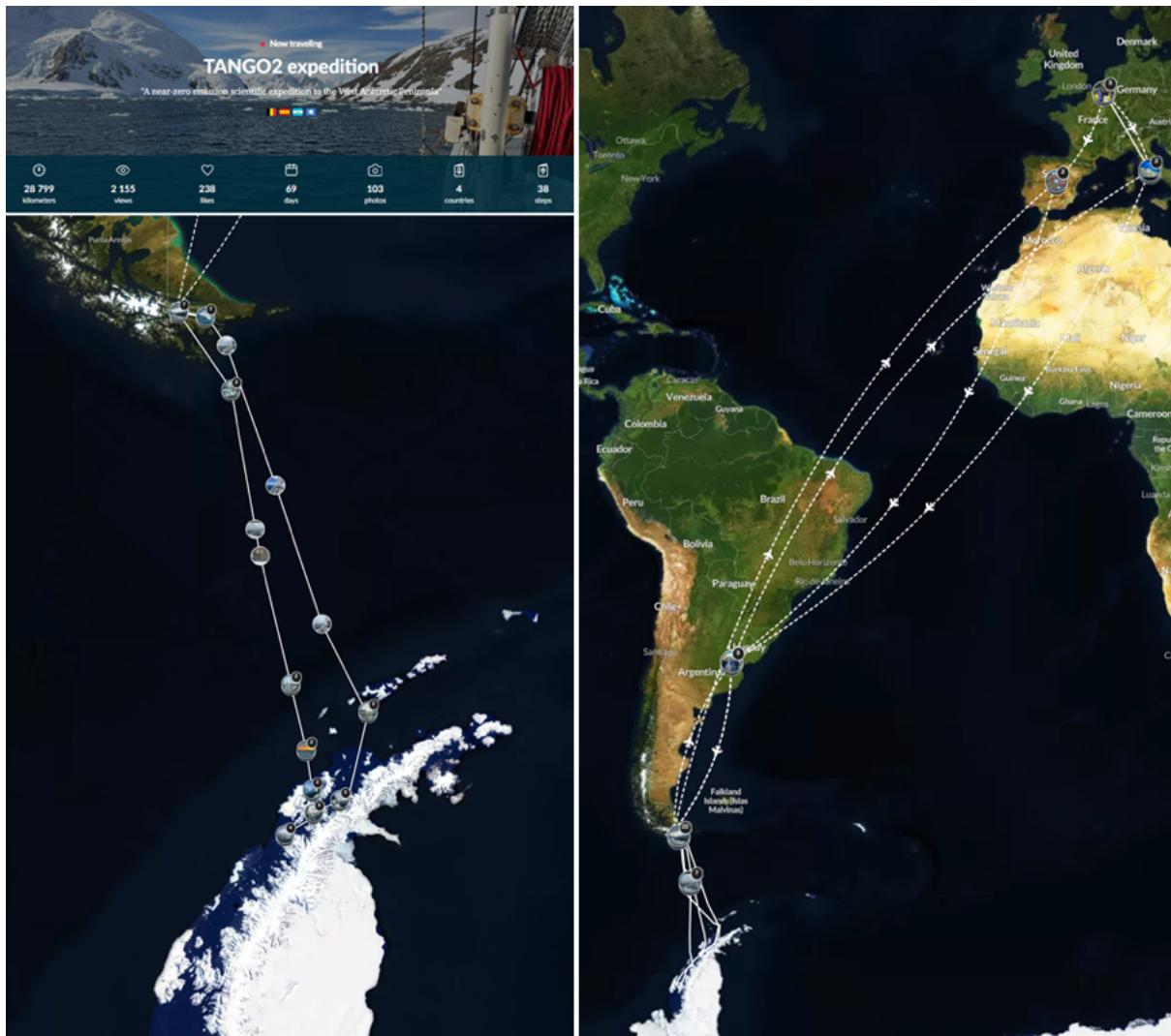


Délimiter les réponses des écosystèmes de l'océan Austral au changement climatique, c'est l'objectif de la mission scientifique TANGO 2 qui va démarrer d'Ushuaïa (Argentine) pour rejoindre la péninsule Antarctique ... en voilier ! Cette mission embarque des chercheurs de l'ULB, de l'UGent ainsi que trois doctorants de l'Université de Liège : Axelle Brusselman, Martin Dogniez et Anthony Voisin. Ceux-ci vont procéder à des prélèvements à partir du bateau et en plongée en vue d'étudier les émissions de gaz à effets de serre, la production primaire planctonique et les réseaux alimentaires benthiques.

Social media and internet platforms

The PolarStep website was used to create a step to step sharing travel. Different pictures and descriptions of every step were done:

<https://www.polarsteps.com/BrunoDanis/9745764-tango2>

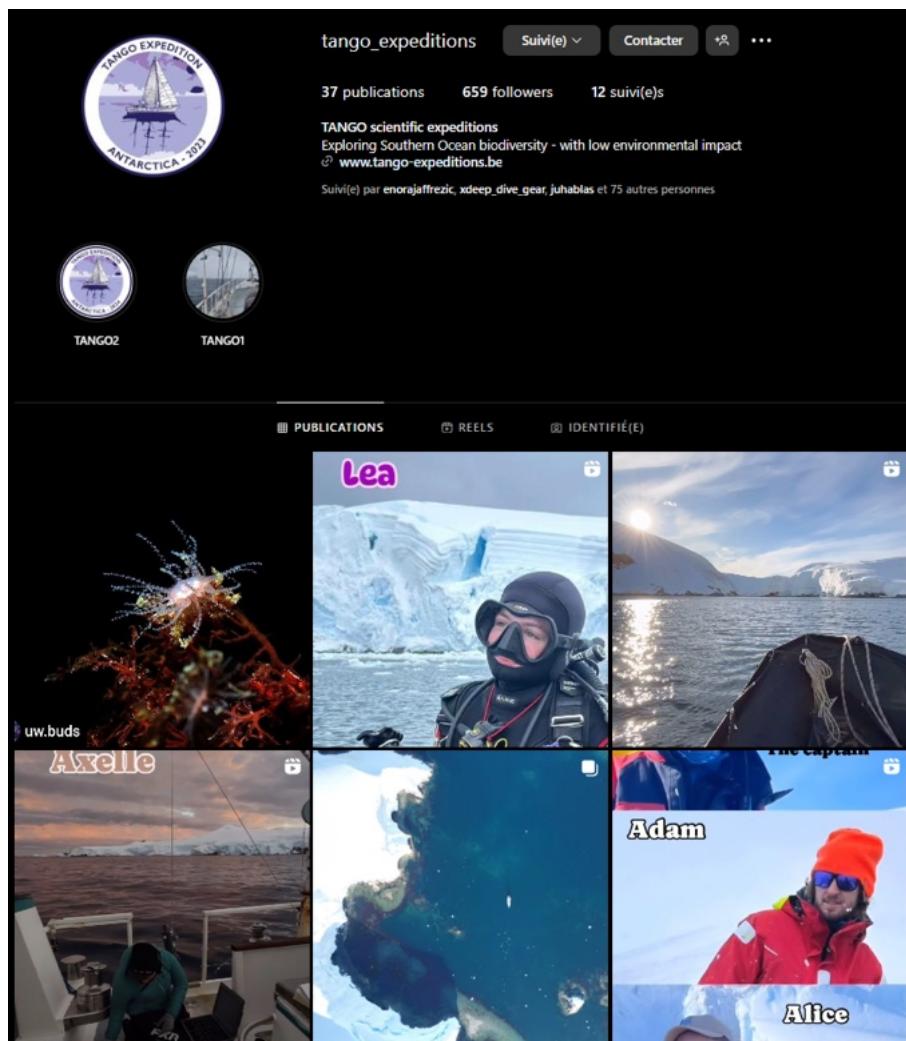


Otherwise, an instagram account was regularly updated (@tango_expeditions).

https://www.instagram.com/tango_expeditions/

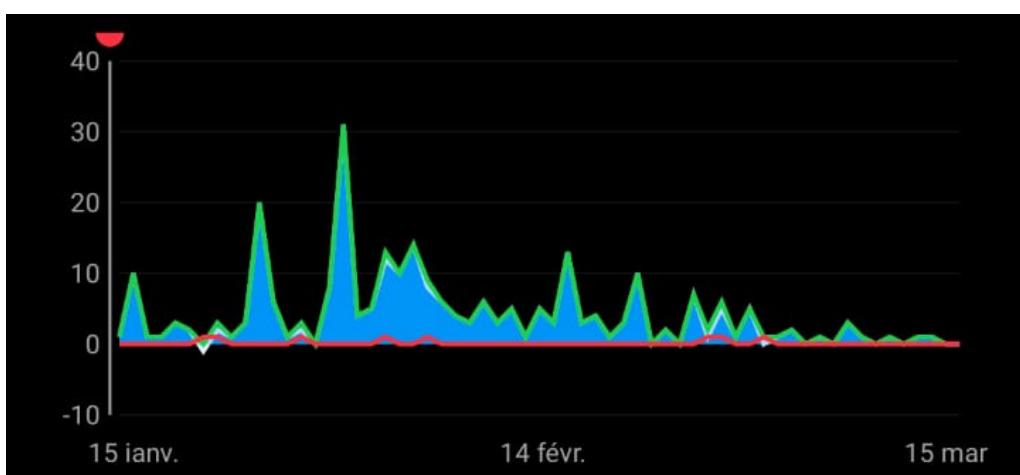
Over the period from January 15 to March 15, 2024, corresponding to the expedition's main period of activity, a total of 11,495 accounts were affected by the publications of the @tango_expeditions account. This number of affected accounts corresponds to the number of unique accounts that have seen the content at least once, including in ads, including publications, stories, reels, videos and directs. As for the number of impressions received by the instagram account, this figure stands at 39,212, corresponding to the total number of views of the content published during this period. These impressions can account for several views of the same account, differentiating it from the previous figure counting the number of accounts affected.

Among the number of accounts affected, the vast majority correspond to accounts that do not follow the instagram account @tango_expeditions with over 11k accounts. This is due in particular to the collaborative posts made with our collaborators and sponsors. Reels and posts in collaboration with XDEEP (@xdeep_dive_gear) and BigBlue (@bigblueeurope) have extended the reach of the @tango_expeditions account.



In terms of the audience reached by the account, 55.5% of followers are women and 44.4% men, the most popular age range is 25-34 at 48.7%, and the top country is Belgium at 62%, followed by Chile at 10.3% and France at 6.8%.

The number of followers increased significantly during the campaign. A total of 246 new followers have been added during the January 15 to March 15, 2024 time period. On April 12th, 2024, the instagram account had 659 followers.



Collaboration and sponsors

The diving team was supported by the XDEEP® Exploration Support Program (<https://exploration.xdeep.eu/>) through the provision of specific diving equipment. Custom Made buoyancy control devices, masks, fins, bolt snaps and surface marker buoy were provided to help with the scientific tasks during the expedition.



BigBlue Dive Lights™, through their european branch, provided lighting systems to help with the video and photography acquisition. The following models were provided: CB11000PB-RC, VL10000PB-RC and CB7200PB.



Data management

Bruno Danis

In the framework of the TANGO2 expedition, data was aggregated and organized to ensure optimal use in the future for data publication in authoritative repositories and sample management. A series of data types were collected pertaining to navigation, weather conditions and sampling efforts (both biological and oceanographic).

General procedures

- Logbooks: hard copies of logbooks were completed on a daily basis by the TANGO2 team. Data was organized in 3 different logbooks: sample, events, diving. Logbooks were digitized and backed up on a regular basis.
- Spreadsheets: data from the logbooks was entered in dedicated spreadsheet on a daily basis by members of the TANGO2 Team: Bruno Danis, Henri Robert, Axelle Brusselman, Camille Moreau and Lea Katz. A quality control (QC) was performed on-the-fly and feedback was given to the researchers on an *adhoc* basis.
- Backup procedures: digital data and samples were backed up on a daily basis on 2 computers and 2 external hard drives. An additional backup was made on remote systems (Dropbox).

Sample (biodiversity) data

Sample data was gathered in MS Excel spreadsheets, specially prepared for the expedition. The structure of the spreadsheet is based upon the Darwin Core (DwC) standard, expanded for specific data, events and sample management needs.

A template of the spreadsheet is provided in annex for future use by other users.

Media data

Large amounts of video data were gathered in the framework of the expedition, both for outreach and research purposes.

Underwater footage was shot by Lea Katz using a Remotely Operated Vehicle (BlueROV2). The footage was used essentially for habitat mapping, exploration and dive site confirmation purposes. Underwater imagery was shot by the divers Team (Lucas Terrana, Lea Katz, Camille Moreau, Martin Dogniez and Anthony Voisin).

Aerial footage was shot by Bruno Danis, Camille Moreau and Henri Robert using DJI MavicPro2, DJI Mavic Mini Pro3 drones, for mapping, photogrammetry and documentation purposes.

Additional footage (photo, video and sounds) were recorded by members of the team and shared at the end of the expedition. For more details, see the dedicated section below.

Data publication

In the spirit of the Antarctic Treaty, Art. 3.1.c, the data emerging from the TANGO2 sampling efforts will be made openly and freely available, in the best possible time limits and will follow the standards, policies and norms of behavior as established by the Scientific Committee on Antarctic Research (SCAR). In particular, raw biodiversity data will be shared using dedicated, community-driven platforms such as the biodiversity.aq initiative.

Processed data will be made available through scientific publications and through the TANGO expeditions website (www.tango-expeditions.be)

Index of Tables

Table 1: simplified view of the overall calendar of the TANGO2 expedition.....	15
Table 2: station list including location and sampling dates.....	15
Table 3: List of gear deployed during the TANGO 2 expedition.	28
Table 4: overview of the sampling effort (intensity and location) using the ROV during TANGO2	35
Table 5. Parameters to be measured in the water column	42
Table 6: Representative pictures of the sediment collected on the different sampling sites, and a brief description of the main sediment characteristics.	51
Table 7. Sites and stations sampled for macrobenthos trophic analyses of TANGO2.....	55
Table 8. Type of tissues targeted for Stable Isotope and Fatty Acid analyses.....	58
Table 9. List of pharmaceuticals proposed for analysis in the macrobenthos samples collected in Hovgaard Island.	64
Table 10. The different body parts collected from each sea urchin, their preservation, and purposes.	70
Table 11. Overview of the sampling effort (location, event ID, type and number of samples, bathymetry) for all the sites visited during TANGO. (DIV = diving event, NIS = Niskin event).	72
Table 12. Indicate the coordinate, depth and time of the AT deployment during the TANGO2 expedition.....	76
Table 13. Rauschert Dredge deployment list deployed during the TANGO2 expedition	78
Table 14. Amphipod trap sampling preliminary data - TANGO2 expedition	79
Table 15 Rauschert Dredge sampling preliminary data - TANGO2 expedition. The complete list of taxa identified within each catch is presented in Annex.	80
Table 16. present the species list of marine birds and mammals observed during the TANGO 2 expedition. For each species and every area prospected (MA=Magellanic Area; DP=Drake Passage; AP=Antarctic Peninsula), an abundance index is given (I = one observation or rare species; II = fairly abundant species; III = dominant species).....	84
Table 17 Summary of diving activities during TANGO2	89
Table 19: Results of the Rauschert Dredge catches per deployment (Event). Taxa identified are enumerated with individual count per taxa.....	103

Index of Figures

Figure 1: The TANGO2 Team. Top row, from left to right: Lucas Terrana, Henri Robert, Emil De Borger, Alice Reade, Ben Wallis. Bottom row, from left to right: Lea Katz, Manon Bayat, Anthony Voisin, Axelle Brusselman, Bruno Danis, Martin Dogniez, Camille Moreau, Adam Coerper	11
Figure 2: general layout of the cabins of R/V Australis	12
Figure 3: deck layout – deploy and working areas of R/V Australis	12
Figure 4: aerial view of the outdoor working space onboard Australis.....	13
Figure 5: Sorting and processing samples on the tray on deck.	14
Figure 6: General map of the sampling effort during TANGO2, representing stations with full deployments.....	16
Figure 7: General map of the sampling effort during TANGO2, representing stations with full deployments (yellow) and additional oceanographic sampling (orange)	17
Figure 8: General map of the sampling effort during TANGO1 (Red) and TANGO2 (Yellow and Orange).....	18
Figure 9. TANGO 2 expedition track from/to Ushuaia.....	19
Figure 10. Close-up on the TANGO2 expedition track, focusing on the Gerlache Strait area.	19
Figure 11. Melchior Islands (North Omega). Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).....	21
Figure 12: Melchior Islands (South Omega). Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).....	22
Figure 13. Melchior Islands total sampling area. All the deployment events are displayed on the map	23
Figure 14: Aerial view of the anchorage in Melchior Island (alt.: 250m). Australis used for scale (75' - 23m)	23
Figure 15. Total sampling area and different sampling site at Hovgaard Islands	24
Figure 16: Aerial view of the anchorage in Hovgaard Islands (alt. 500m). Australis used for scale (75' - 23m).	25
Figure 17: Føyn Harbor. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions)..	26
Figure 18: Sampling site bathymetry and all events at Føyn Harbor.....	27
Figure 19: Aerial view of the anchorage in Føyn Harbor (alt. 500m). Australis used for scale (75' - 23m).	27
Figure 20: Aerial view (alt. 500m) shot by the drone in Føyn Harbor (RV Australis in the center).	31
Figure 21: Example of an orthomosaic image obtained by aligning 335 images shot (139300 tie points) by the drone (DRM_11) in Føyn Harbor	32
Figure 22: example of 3D reconstruction using the drone imagery from Figure 21 (generated using Agisoft Metashape Professional V 2.0.1)	33
Figure 23: Spatial heterogeneity in Dodman Island (TANGO1 sampling station, 2023).....	35
Figure 24: Melchior Is. South Omega, outer bay (ROV_10, 31m).....	36
Figure 25: Hovgaard Is., south pool (ROV_15, 14m)	36
Figure 26: Hovgaard Is., outer pool, “tombant” (ROV_13, 25m).....	37
Figure 27: Hovgaard Is., channel (ROV_14, 20m)	37
Figure 28: Foyn Harbor, « Enterprise Island » (ROV_20, 25m).....	38
Figure 29: Føyn Harbor, “boat pool” (ROV_16, 15m).....	38
Figure 30: annotated image from TANGO1, from BIIGLE.....	39

Figure 31. Details of the HOBO light and ODDI CTD sensors setup on the 2.5L Niskin. The ODDI sensor is secured in the yellow plastic tube.....	40
Figure 32. Temperature profiles at the three main stations of TANGO2	41
Figure 33. Light intensity profiles at the three main stations of TANGO2.....	41
Figure 34. Filtration setup at the back of the Australis	43
Figure 35. Incubation line sketch.....	45
Figure 36. Setup for the preparation of the filtered seawater at the front of the Australis ..	46
Figure 37. Sediment trap sketch.....	47
Figure 38. Overview of the vials from the sediment trap after collection, in the three deployment locations.....	48
Figure 39. Sampling of surface water at Leah Glacier	49
Figure 40: Incubation setup with sediment cores submerged in the thermostatic bath with airtight lids with stirrers and sampling ports (red ellipse, left) and oxygen optodes (green, left). The middle image shows the top of the workbench. The right image shows the interface of the pyroscience-Firesting oxygen monitoring software.	53
Figure 41. Measured oxygen consumption rates by the sediment community (in mmol O ₂ m ⁻² d ⁻¹ , ± SD) for the different studied sites, and dark (purple) – light (yellow) incubations performed on each set of cores. Numbers above the bars represent averages. Negative values represent oxygen production by the benthic community.....	53
Figure 42. Transects on a bottom made of gravels and pebble (A) before picking megabenthic organisms found alongside the line (B); examples of quadrates scrapes in a muddy bottom (C) and amidst a gravelly bottom sparsely covered from algae (D)	54
Figure 43. Views of the eDNA sampling kits from Sylphium Molecular Ecology in their full packaging (A) and used in an European stream to collect eDNA from freshwater organisms (B) (@Sylphium Molecular Ecology illustrations)	55
Figure 44. General view of TANGO2 sampling sites.	56
Figure 45. Details of Melchior Islands stations	57
Figure 46. Details of Føyn Harbour stations.	57
Figure 47. Number of samples collected by stations and type of analyses: (BAR = DNA barcoding, FA = Fatty Acids analysis, METAE = Metabarcoding of sea-urchin gut content, METAS = Metabarcoding of other animals' gut-content, PHYTO = eDNA collection, REF = whole frozen organisms for reference, SIA = Stable Isotopes Analysis).....	59
Figure 48. Venn Diagram displaying the repartition of the morphospecies sampled between the different stations of TANGO 2024, with names of macroalgae forests stations in green and of soft bottom stations in blue.	61
Figure 49. Example of Promega Maxwell® RSC Instrument allowing to partially automate DNA extractions from samples.....	62
Figure 50. Example of a chromatogram after the GC-FID analysis of a benthic antarctic limpet <i>Nacella concinna</i>	65
Figure 51. Biometry of <i>N. concinna</i> shells sampled during the TANGO2 expedition. L: antero-posterior length; w: apex high.....	66
Figure 52. Biometry of <i>L. elliptica</i> shells sampled during the TANGO2 expedition. L: antero-posterior length; w: dorso-ventral length.	67
Figure 53. Specimen of <i>S. neumayeri</i> in its natural habitat.....	68
Figure 54. Sampling site bathymetry of Hovgaard Islands and location of the diving events for sea urchin collection	69

Figure 55. Sampling site bathymetry of Melchior Island and location of the diving event for sea urchin collection.....	69
Figure 56. Sampling site bathymetry of Føyn Harbor and location of the diving events for sea urchin collection	70
Figure 57. Size comparison (Ambitus diameter (mm) / Height (mm)) for the <i>Sterechinus neumayeri</i> specimens collected.	73
Figure 58. Baited amphipod trap composed of coarse plastic mesh for protection doubled by 500 μ fine mesh. Both sides of the cylinder are equipped with a funnel to capture organisms into the trap.	76
Figure 59. The Raushert Dredge (RD composed of a sledge-like metal frame drags the collecting megabenthic communities mesh bag (protected by rubber carpets) on the sea floor.	78

Permits

The TANGO2 expedition operated under PERMIT Nr 2023/02 issued by the Belgian government in November 2023, and signed by the Minister for Climate, Environment, Sustainable Development and the Green Deal.

RV Australis operated under the Commonwealth of Australia, Antarctic Marine Living Resources Conservation Act 1981, AMLRC Permit 23-24. This permit was delivered to Ben Wallis – Ocean Expeditions .

Acknowledgements

The TANGO2 expedition was funded through various channels, as detailed below. The TANGO2 team has also benefited from a lot of support, time and expertise from the international networks it has been collaborating with since a long time as well as new partners.

Funding of expedition

The Belgian Science Policy Office (BELSPO): the bulk of the funding of the expedition was channeled through the TANGO project funded by BELSPO (contract n°B2/212/P1/TANGO: Estimating Tipping points in habitability of ANtarctic benthic ecosystems under GLObal future climate change scenarios. Promoter: Ann VanReusel, Universiteit Gent).

The Fund for Scientific Research – FNRS, has funded part of the travel expenses for ULB and ULiège participants (Bruno Danis, Camille Moreau, Lea Katz, Martin Dogniez). The Research Foundation – Flanders (FWO) funded part of the travel expenses for the UGent participant (Emil De Borger)

Sponsorship of the expedition

The diving team was supported by X-Deep and BigBlue through a communication program. The sponsorship materialized in the shape of high-end equipment which was given to the divers (Lucas Terrana, Camille Moreau, Lea Katz, Anthony Voisin and Martin Dogniez).

Personal thanks

The TANGO2 Team would like to thank the following persons who have been pivotal in the success of the expedition, from a logistic, diplomatic, funding or scientific point of view:

Alain Noro (Royal Belgian Institute of Natural Sciences)

Candice Marabotti (Cellule bien-être au travail, ULB)

Club de plongée EPSM Bruxelles

Coli Whewell (Managing partner, GRYIO)

Dive Factory

Frédéric Goethals

Gilles Lepoint (Université de Liège)

Isa Schon (Royal Belgian Institute of Natural Sciences)

Isabelle Mazzara (Directrice Générale, Université Libre de Bruxelles)

Jose Manuel Fernandez (Jefe Juan Carlos station)

Loïc Michel (Université de Liège)

Maaike Van Cauwenberghe (Belgian Science Policy Office)

Magali Huret

Manuel Daloso (RV Hesperides)

Marius Gilbert (Vice-Recteur à la Recherche, Université Libre de Bruxelles)

Michel Van Camp (Royal Belgian Institute of Natural Sciences)

Nils Verstappen (SPF Environment)

Stephanie Langerock (SPF Santé Publique - FOD Volksgezondheid))

Yi Ming Gan (Royal Belgian Institute of Natural Sciences)

Annexes

Table 18: Results of the Rauschert Dredge catches per deployment (Event). Taxa identified are enumerated with individual count per taxa

Event ID	Scientific Name	Individual Count	Remark
RD_01	Porifera	15	
	Unsorted lot		
	Unsorted lot		
	Algae	1	
	Algae	5	
	Algae	1	
	Bivalvia	15	
	Bivalvia	7	
	Amphipoda	150	
	Amphipoda	30	
	Isopoda	30	
	Cumacea	18	
	Polychaeta	6	
	Undetermined	10	
RD_02	Asteroidea	2	
	Gastropoda	30	
	Sterechinus neumayeri	21	Not collected
	Unsorted lot		
	Unsorted lot		
	Amphipoda	50	
	Gastropoda	35	
	Terebellidae	7	
	Porifera	2	
	Asteroidea	6	
	Undetermined	5	
	Isopoda	12	
	Cumacea	7	
	Mollusca	1	Probably Opistobranchia
RD_03	Ophiuroidea	2	
	Polychaeta	6	
	Undetermined	14	
	Unsorted lot		
	Unsorted lot		
	Amphipoda	150	
	Isopoda	15	
	Undetermined	7	
	Polychaeta	4	
	Doris kerguelensis	1	
RD_04	Asteroidea	1	
	Amphipoda	200	
	Amphipoda	8	
	Gastropoda	80	
	Undetermined	50	

	Porifera	3	
	Algae	1	
	Platyhelminthes	3	
	Cumacea	5	
	Ophiuroidea	3	
	Isopoda	5	
RD_05	Undetermined	1	cfr Lacunaria
	Bryozoa		
	Euphausia superba	10	
	Unsorted lot		
	Amphipoda	80	
	Isopoda	2	
	Undetermined	5	
	Echinoidea	2	
	Gastropoda	20	
	Pycnogonida	3	
	Ascidia	1	
	Unsorted lot		
	Undetermined	5	
	Aegires albus	1	
	Foramnifera	6	
RD_06	Unsorted lot		
	Asteroidea	4	
	Amphipoda	200	
	Amphipoda	50	
	Undetermined	30	
	Gastropoda	30	
	Ascidia	2	
	Porifera	3	
	Bryozoa	5	
	Cumacea	2	
	Isopoda	20	
RD_07	Pycnogonida	1	
	Bivalvia	2	
	Unsorted lot		
	Unsorted lot		
	Unsorted lot		
	Brachiopoda	2	
	Amphipoda	150	
	Porifera	3	
	Bivalvia	4	
	Polychaeta	2	
	Undetermined	35	
	Cumacea	25	
	Isopoda	1	
RD_08	Gastropoda	2	
	Bivalvia	4	
	Gastropoda	12	
	Undetermined	2	
	Undetermined	1	
	Bivalvia	100	Shells only
	Amphipoda	750	Subsample

	Unsorted lot		
	Undetermined	10	
	Porifera	3	
	Gastropoda	11	
	Isopoda	5	
	Undetermined	1	
RD_09	Unsorted lot		
RD_09	Amphipoda	250	
RD_09	Undetermined	5	
RD_09	Porifera	1	
RD_09	<i>Glyptonotus antarcticus</i>	1	
RD_10	Unsorted lot		
RD_10	<i>Odontaster validus</i>	3	5 individuals released
RD_10	Amphipoda	50	
RD_10	Munnidae	5	
RD_10	Mysidacea	3	
RD_10	Cumacea	3	
RD_10	Leptostraca	1	
RD_10	Gastropoda	12	
RD_10	Undetermined	15	
RD_10	Bryozoa	2	
RD_11	Unsorted lot		
RD_11	Amphipoda	150	
RD_11	Bivalvia	6	
RD_11	Isopoda	2	
RD_11	Leptostraca	7	
RD_11	Gastropoda	8	
RD_11	Cumacea	4	
RD_11	Undetermined	1	
RD_11	Undetermined	20	
RD_12	Echinodermata	3	Subsample. Released 18 <i>S. antarcticus</i> & 6 <i>O. victoriae</i>
RD_12	Unsorted lot		
RD_12	Amphipoda	100	
RD_12	Amphipoda	120	
RD_12	Euphausia	5	<i>E. superba</i>
RD_12	Gastropoda	25	
RD_12	<i>Glyptonotus antarcticus</i>	1	1 individual released
RD_12	Ascidia	4	
RD_12	Isopoda	2	
RD_12	Cumacea	12	
RD_12	Bivalvia	18	
RD_12	Undetermined	1	
RD_12	Undetermined	1	
RD_13	Unsorted lot		
RD_13	Amphipoda	80	
RD_13	Isopoda	8	
RD_13	Mollusca	12	
RD_13	Cumacea	11	
RD_13	Polychaeta	1	
RD_13	Undetermined	6	
RD_13	<i>Sterechinus</i>	2	Released
RD_13	<i>Glyptonotus</i>	4	3 released, 1 used for gut content
RD_14	Unsorted lot		
RD_14	Amphipoda	100	

	Gastropoda	100	
	Bryozoa		
	Cnidaria	1	
	Porifera	6	
	Tunicata	1	
	Isopoda	35	
	Undetermined	30	
	Asteroidea	2	1 O. validus, released
	Cumacea	3	
	Mysidacea	1	
	Glyptonotus antarcticus	2	Released
RD_15	Unsorted lot		
	Isopoda	35	
	Amphipoda	50	
	Amphipoda	50	
	Euphausia superba	50	
	Porifera	3	
	Mollusca	35	
	Ascidia	3	
	Leptostraca	2	
	Cumacea	7	
	Worm	15	
	Echiniphimedia sp	1	cfr E. hodgsoni