TANGO1 Cruise report

13rd February to 19th March 2023

Executive Summary

The TANGO1 expedition ventured to accumulate new data on the 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. TANGO1 took place between February and March 2023, sampling two main locations at different spatial scales. Deploying 14 different types of gear (both traditional and modern), the TANGO1 team gathered over 4000 samples that will be brought back to Belgium for further analysis. The team focused on synchronized, transdiciplinary sampling to understand the linkages between realms (atmosphere, sea-ice, watercolumn, seafloor) and there potential responses to changes in climate-changed linked ice regime at various spatial scales.

The use of R/V *Australis* for coastal studies deemed to be extremely efficient, in terms of environmental impact (ca. 40 times less CO_2 emissions than a Polar class icebreaker) and reactivity, 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 B121 team to sample in shallow areas, not accessible to icebreaker and too far away from research stations, and which have been under sampled.

The preliminary (meta)results accumulated during TANGO1 confirm 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. TANGO1 provides a first-hand experience to carry an ambitious TANGO2 expedition. Based upon Open Science approaches, the combination of B121/TANGO1 efficiency in sampling paves the way to testing the transposability of the concept to multiply similar efforts in a coordinated fashion.

An overview of initial results is provided below:

Fine-scale bathymetry

An estimated 30 hours were spent to generate sufficient data to generate bathymetric maps All visited sampling sites were charted. The bathymetric exercise allowed reaching a very high sampling efficiency (for example for selecting preferential areas to deploy the SCUBA divers). As a side benefit, the generation charts allowed to identify and flag dangers to navigation which were immediately communicated to relevant hydrographic authorities.

Aerial mapping

A total of 16 drone flights were carried out during the TANGO1 expedition, generating large quantities of media fit for different purposes. Deployment of drones was found to be useful in terms of scouting when arriving in new work station, documenting their general setup as well as carrying out more sophisticated works including orthomosaic (2D) and photogrammetry (3D). Combined to other georeferenced layer gathered during the TANGO1 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.

Oceanography

In total, 15 CTD profiles were taken in different locations of Dodman Island and Blaiklock Island. 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 Dodman Island while another deployment (ST2) took place in Blaiklock Island. More particles were recovered at Blaiklock Island compared to Dodman Island, suggesting a significantly higher particle fluxes in Blaiklock Island.

Sea-ice works

We sampled two drifting ice floes: ICE-1 nearby Dodman Island, and ICE-2 at station 3 of Blaiklock island. Even though the ICE-1 floe was drifting, the overall aspect of it, the fact that we observed remaining landfast ice in person or by remote sensing in areas less than 30km away (Dimitrov Cove and Crates Bay respectivally), suggest it was landfast ice recenty detached. Ice floe ICE-2 was found at site 3 of Blaiklock island and was surrounded by floating glacial ice. The floe was thinner and less homogeneous than floe ICE-1 as the floe grew around a piece of glacial ice and was likely a remnant piece of landfast ice. Salinity of the floe was quite low for a first year sea ice, with an uncommon salinity profile. We hypothesize that the low salinity profile observed in Blaiklock, with salinity down to 0 at the surface, was due to rainfall washing down the ice.

Soft sediments biodiversity and biogeochemistry

The amount of samples and the storage of the samples generated for the sediment biogeochemistry part are available further in the report., In the next year the preliminary data generated during the incubations will be quality checked and the setup will be discussed with colleagues at the Ghent Marine Biology Laboratory. The samples for both the incubation measurements, the sediment environmental data, and the stable isotope analysis will be carried out. The results from the field samples will inform priorities for the upcoming campaigns and will help deciding on the feasibility of such detailed and time-consuming measurements aboard of a nimble vessel that was not originally designed to host these types of technically complex, detailed and time-consuming measurements.

Benthic habitat mapping

In Dodman Island, 6 different sites were sampled with a total of 20 recorded squares using a Remotely Operated Vehicle (ROV). When a squared-shaped pattern was not possible, the site was sampled by transects. In Blaiklock Island, our second sampling station, 3 contrasting sites were sampled as well as 3 sub-locations in one of the sites to characterize small scale heterogeneity. In total, 12 squares and 2 transects were sampled.

Back in the Laboratory, the images will be used to create photomosaics from which we will calculate biodiversity indices (α and β), evenness/dissimilarity indices (Species Richness, Shannon-Wiener, Simpson) and functional diversity (Functional Dispersion, Rao's Quadriatic Entropy). Then, to compare our results between sites, we will use multivariable correlative approaches (such as a Canonical Correspondence Analysis and NMDS analyses).

For characterizing how benthic communities respond to environmental heterogeneities, we will perform Spatial Point Process Analyses (SPPA). To build predictive models, and investigate the drivers of ecosystem responses to their changing environment, we will use Bayesian Network Inference (BNI) analysis.

Macro- and megabenthos diversity

All sample collected in the different events of Rauschert Dredge and the Amphipod Trap have been partially sorted on board of *Australis* during the expedition. Representants of the major taxa present in the catch were isolated and counted whenever time and space were available.

As agreed during the preparation of the expedition, all sorted taxa and unsorted subsamples were fixed in ethanol to be processed further thoroughly in the lab by master or PhD thesis students.

Top Predators census (TOPP)
Species encountered in the Magellanic area, Drake Passage, Dodman Island, Blaiklock Island and along the Antarctic Peninsula are enumerated hereunder with preliminary considerations. Overall, most species expected to be seen were observed during this voyage at the exception of the Antarctic Petrel (*Thalassoica antarctica*) for which not a single individual was found, which is rather unusual especially in the Bransfield Strait and South Shetland Island. Killer Whale (*Orcinus orca s.l.*) despite our intensive search remained equally out of sight during this expedition.

Sea urchins microbiota
A total of 150 urchins was processed onboard during the expedition. Due to their high abundance at all locations, there was no issue with the collection of specimens. Sizes however varied strikingly from one location to another, a variability that will be investigated into more details. Samples preserved dried and in ethanol will be analyzed upon return in Belgium for trophic niche characterization. Sexing (observation of gonad tissues) and genetic (test tissue) analyses will also be performed in Belgium as well as DNA extractions for microbiome characterization.

Underwater photography
This part of the project was a first approach in documenting the work and illustrating biodiversity during the expedition. Many improvements can be implemented and notably having dedicated dives to illustrate a maximum of the diversity encountered. The creation of a reference library for live specimens coupled with DNA barcoding effort is also considered. Such efforts are important and more and more valuable, especially in studies using metabarcoding/eDNA approaches.

Cyanobacteria
Collected cyanobacteria samples will be transported to the University of Liège and processed by Dr Annick Wilmotte from the Cyanobacterial molecular diversity and ecology laboratory, InBios Research Unit
Planned analysis include:

- microscopic observations of the diversity of photosynthetic microorganisms in the samples
- cultivation and isolation of cyanobacteria and microalgae
- molecular analysis of selected samples by amplicon sequencing of the SSU rRNA gene and Illumina technology (if diversity observations have shown the presence of cyanobacteria)

Diving
A total of 30 logged dives were performed by the team of four divers collecting a total of 828 unique samples consisting of sediment cores, photo and videos and handpicking and transect collection of megafauna specimens and macroalgae. The average dive time was 30 min, the maximum dive time was 51 min. The average depth was 19 m and the maximum

depth was 25 m. More details will be provided in the dedicated Scientific Diving Activity Report to be found on the Tango I website.

Citation of this document

Please cite this report as follows:

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Please cite the media (pictures, videos, sounds) associated to the expedition as follows:

"TANGO1 expedition, 2023. Content under Creative Commons Attribution International (CC-BY) 4.0 License."

Table of contents

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 TANGO 1 expedition. 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)** have improved our chances of success in organizing the TANGO expeditions.

The TANGO1 expedition focused on the "Southern" 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 TANGO1 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 Danis[1]

R/V *Australis* Crew
Skipper: M. Ben Wallis[2]
First mate: Ms. Annette Bombosch[2]
Stewardess: Ms. Maria Amenabar[2]

Scientific Team:
Ms. Axelle Brusselman[3]
Prof. Bruno Delille[3]
Dr. Camille Moreau[1] (BSD diver)
Dr. Francesca Pasotti[4] (ABSD diver)
M. Henri Robert[5]
Ms. Lea Katz [1] (BSD diver)
M. Marius Buydens[4]
M. Martin Dogniez[3] (BSD diver)

Affiliations :

1. Université Libre de Bruxelles
2. Ocean Expeditions
3. Université de Liège
4. Gent Universiteit
5. EMC[2]

Figure 1: The TANGO 1 Team. Top row, from left to right: Annette Bombosch, Martin Dogniez, Bruno Delille, Camille Moreau, Henri Robert. Middle row, from left to right: Ben Wallis, Marius Buydens, Francesca Pasotti, Maria Amenabar, Axelle Brusselman, Lea Katz. Bottom row: Bruno Danis

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.

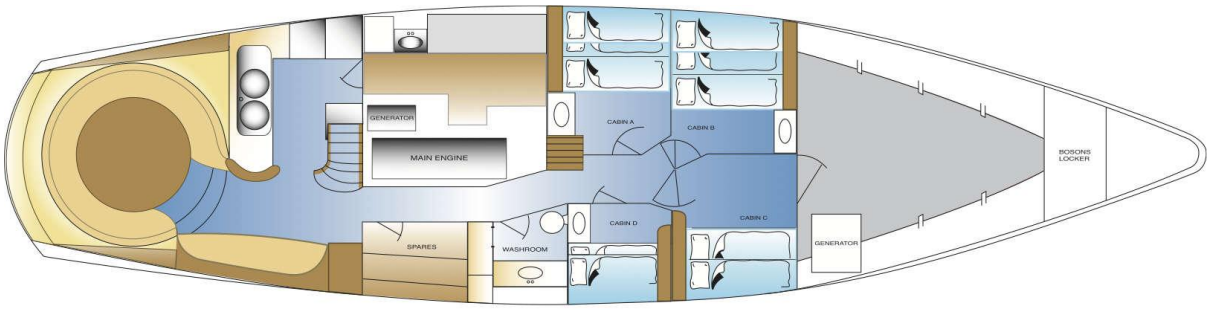

Figure 2: general layout of the cabins of R/V Australis

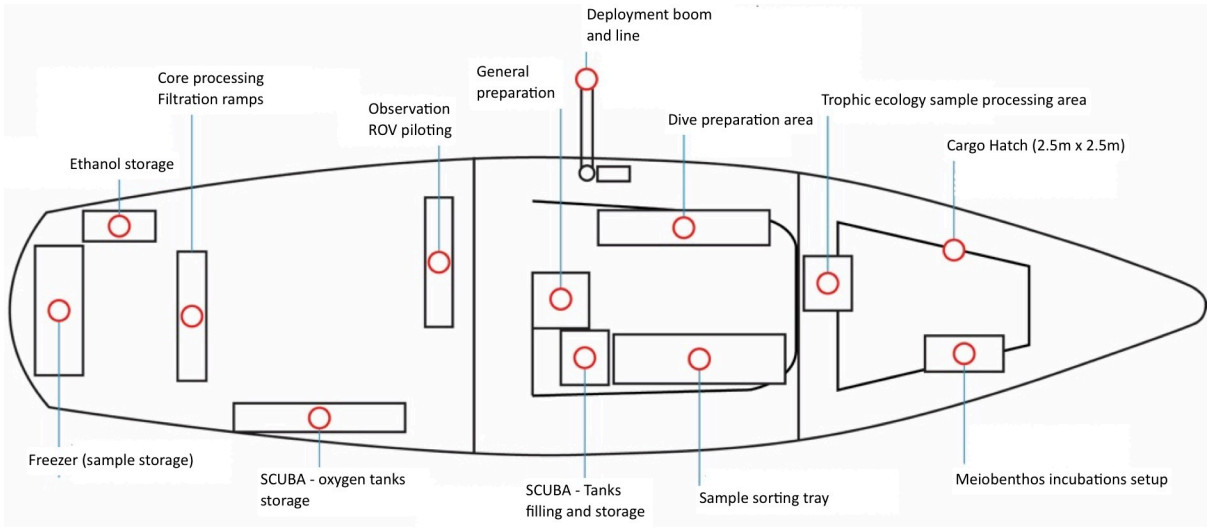

Figure 3: deck layout – deploy and working areas of R/V Australis

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 13th and March 18th, 2023. The *Australis* departed from Ushuaia (Argentina) on Feb 13rd and arrived at the first sampling station (Dodman Island) on Feb 19th after crossing the Drake passage and transiting through the Western Antarctic Peninsula. The last station was completed on March 7th and the expedition returned to Ushuaia on March 17th, via Livingstone Island (to transfer samples to RV. *Hesperides*). A total of 17 days were devoted to the sampling effort (excluding birds and marine mammals observations (TOPP project) carried out during transit).
The timing of the main sampling operations conducted during the expedition is detailed in Table 1 and Table 2. Two main stations 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 TANGO1 expedition

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
February				9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26

February/March	27	28	1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21					

Mobilisation/Demobilisation
CapeHorn/Drake transit
WAP transit
Work at sea

Table 2: station list including location and sampling dates.

Stations			*Lat (S)*	*Long (W)*	*Area (Ha)*	*Arrival*	*Departure*
MI	Dodman Island		-66,0003	-65,7774	420	18/02/2023	25/02/2023
	Ice Floe		-66,0253	-65,1077	-	25/2/2023	25/02/2023
BI	Blaiklock Island		-67,5519	-67,2148	600	26/02/2023	07/03/2023
		Site 1	-67,5519	-67,2148	310	26/02/2023	05/03/2023
		Site 2	-67,5151	-67,1000	275	05/03/2023	07/03/2023
		Site 3	-67,5052	-67,0518	15	05/03/2023	05/03/2023

Sampling Area

The sampling area focused on the West Antarctic Peninsula (WAP) and in particular in two contrasting areas: Dodman Island (Latitude: 66°S), located in the southern Grandidier Channel and Blaiklock Island (next to Jones iceshelf, Latitude: 67,5°S) to the East of Marguerite Bay.

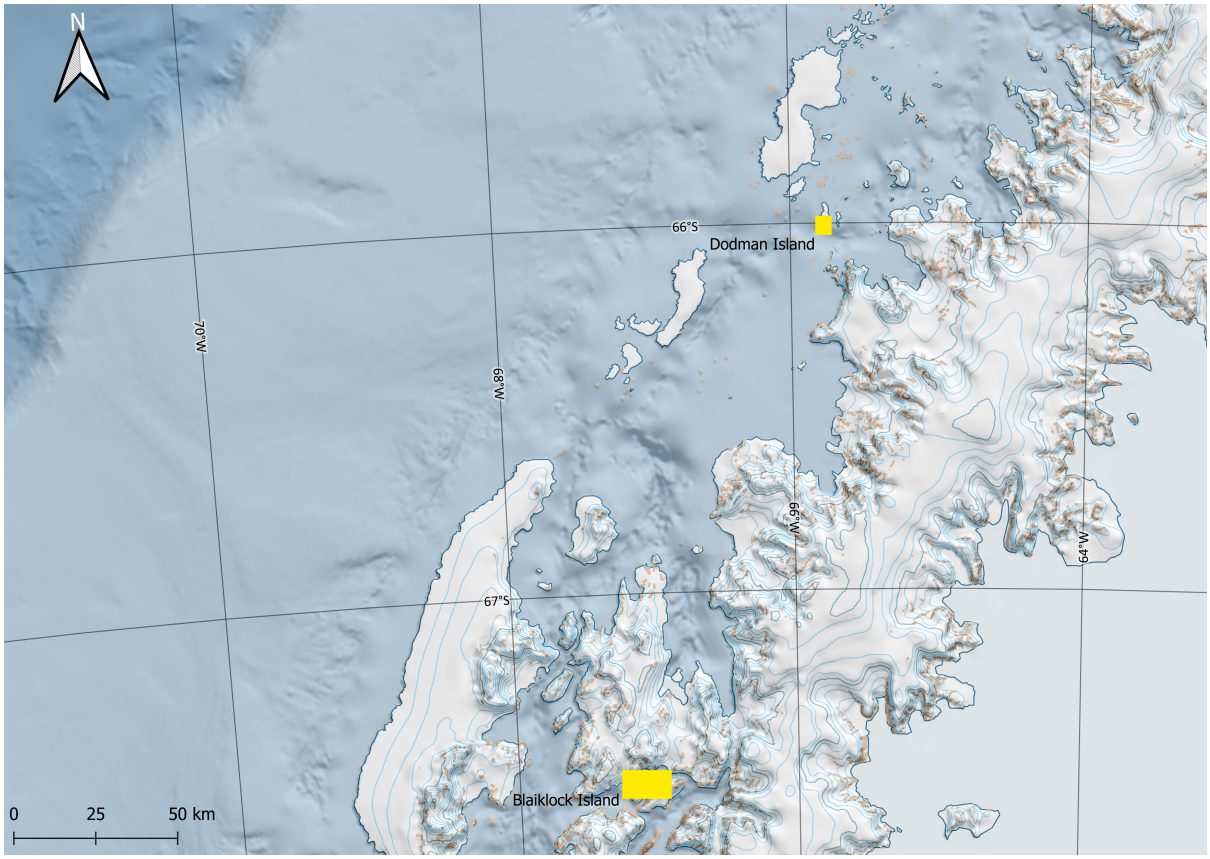

Figure 6 General map of the sampling area. Yellow rectangles represent the two sampling areas.

The expedition track reached a total mileage of 2058 nm, and is shown in

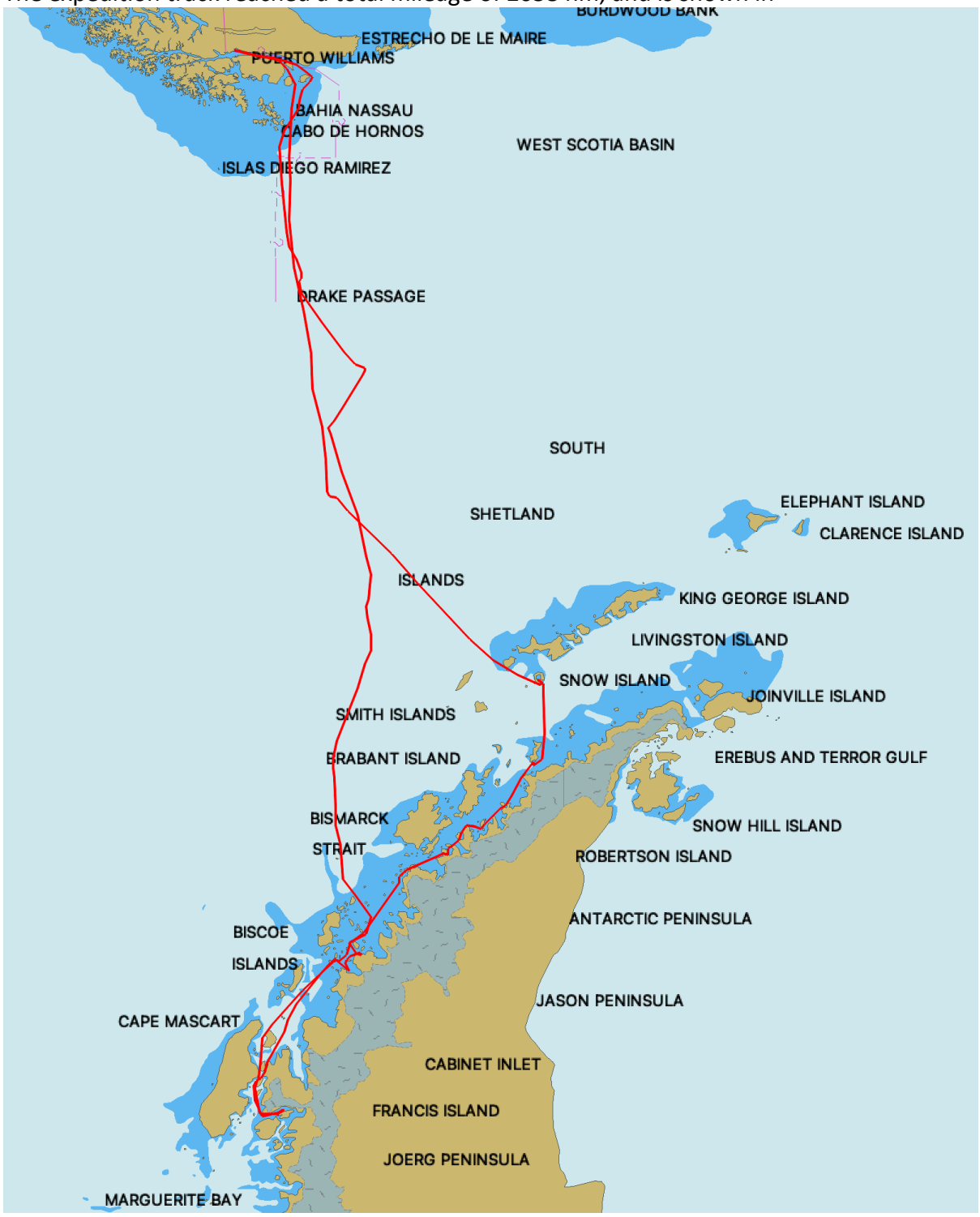

Figure 7 (full track) and

Figure 8 (sampling area).

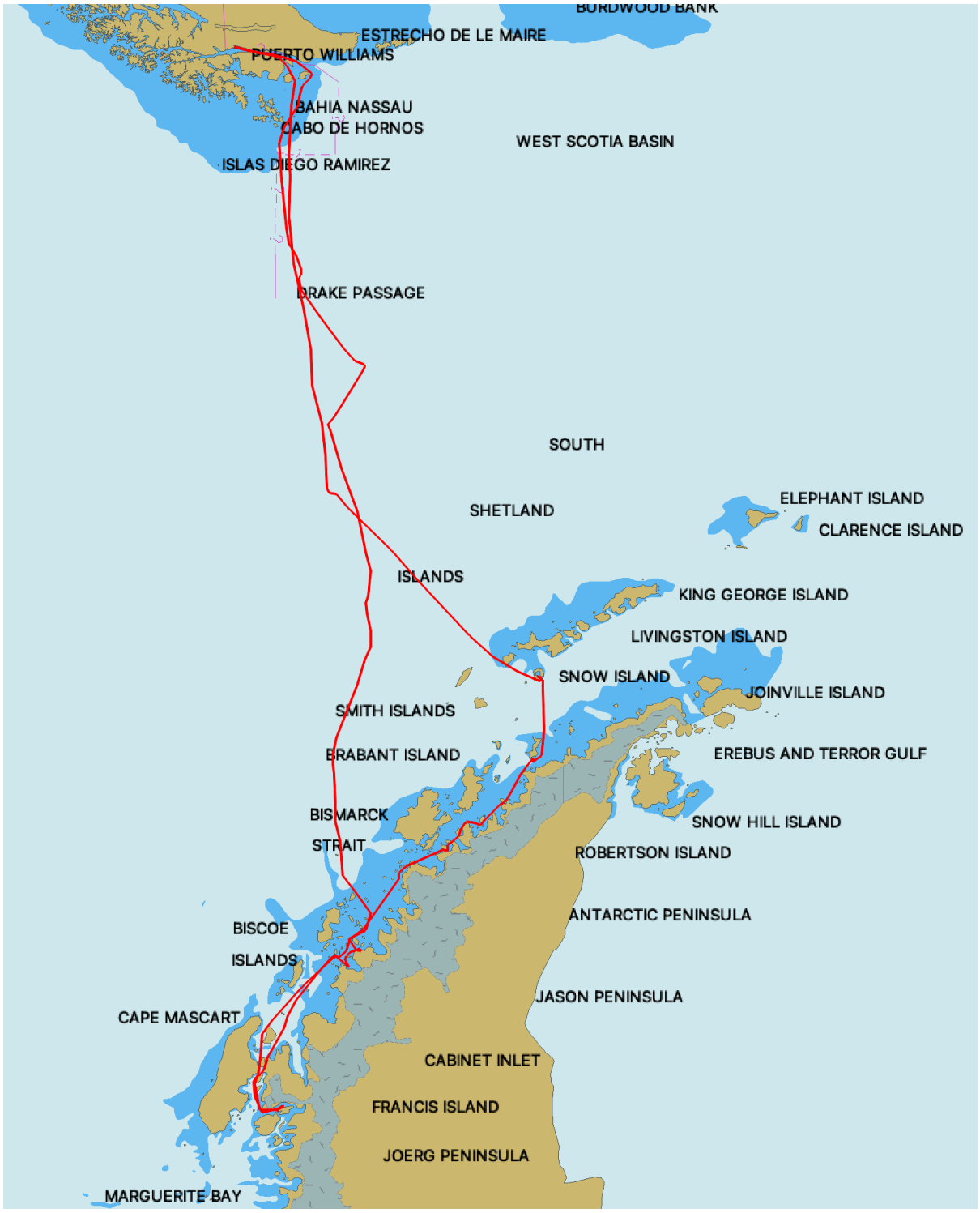

Figure 7: TANGO1 expedition track. The red rectangle corresponds to the closeup displayed in


Renaud
Island
Lavoisier Island
Ferin Head
Black Head
Cape Bellue
Watkins
Island
Matha Strait
PA
PD
ED
DARBEL
BAY
LOUBET
COAST
Mill Inlet
ADELAIDE
ISLAND
ARROWSMITH
PENINSULA
Fuchs Ice
Piedmont
Cape Northrop
Whirlwind Inlet
Choyce Point

Figure 8

Figure 8: Closeup on the TANGO1 track in the sampling areas from the WAP

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.

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.

Dodman Island (DI)

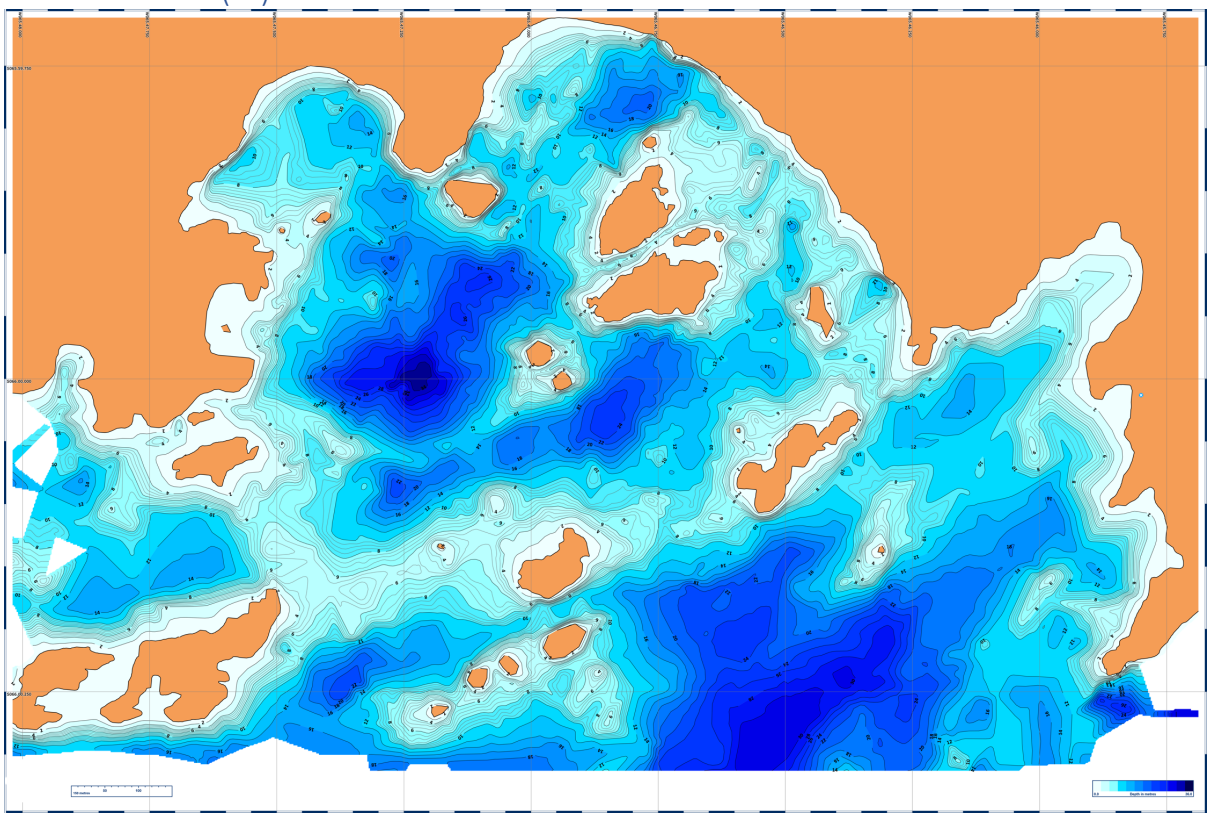

Figure 9: Dodman Island inner bay. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

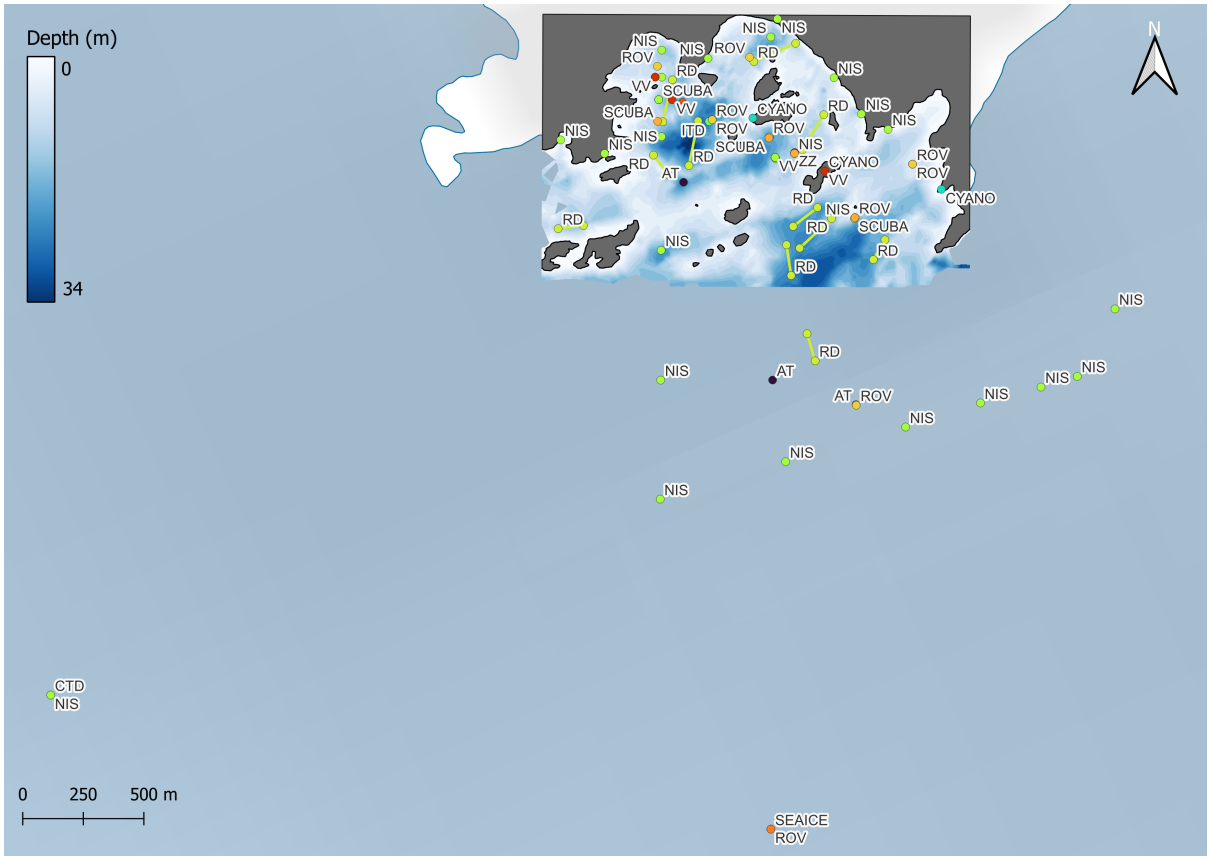

Figure 10 Dodman Island total sampling area. All the deployment events are displayed on the map.

Figure 11: Aerial view of the anchorage in Dodman Island (alt.: 500m). Australis used for scale (75' - 23m)

Location: South of Grandidier Channel, between Graham Land and Renaud Island.
Settings:

- protected inner bay. various qualities of seafloor (muddy with gravels and dropstones), including pools at ca. 20m depth.
- highly variable habitats over a small surface
- high glacier activity and ice disturbance
- no penguin colony

Grandidier Channel: ice floe

Remark: only sea-ice and oceanography works were performed at this location. See dedicated sections for details.
Location: South of Grandidier Channel.
Settings: second year icefloe drifting in the channel (2-3 nm away from Dodman Island)

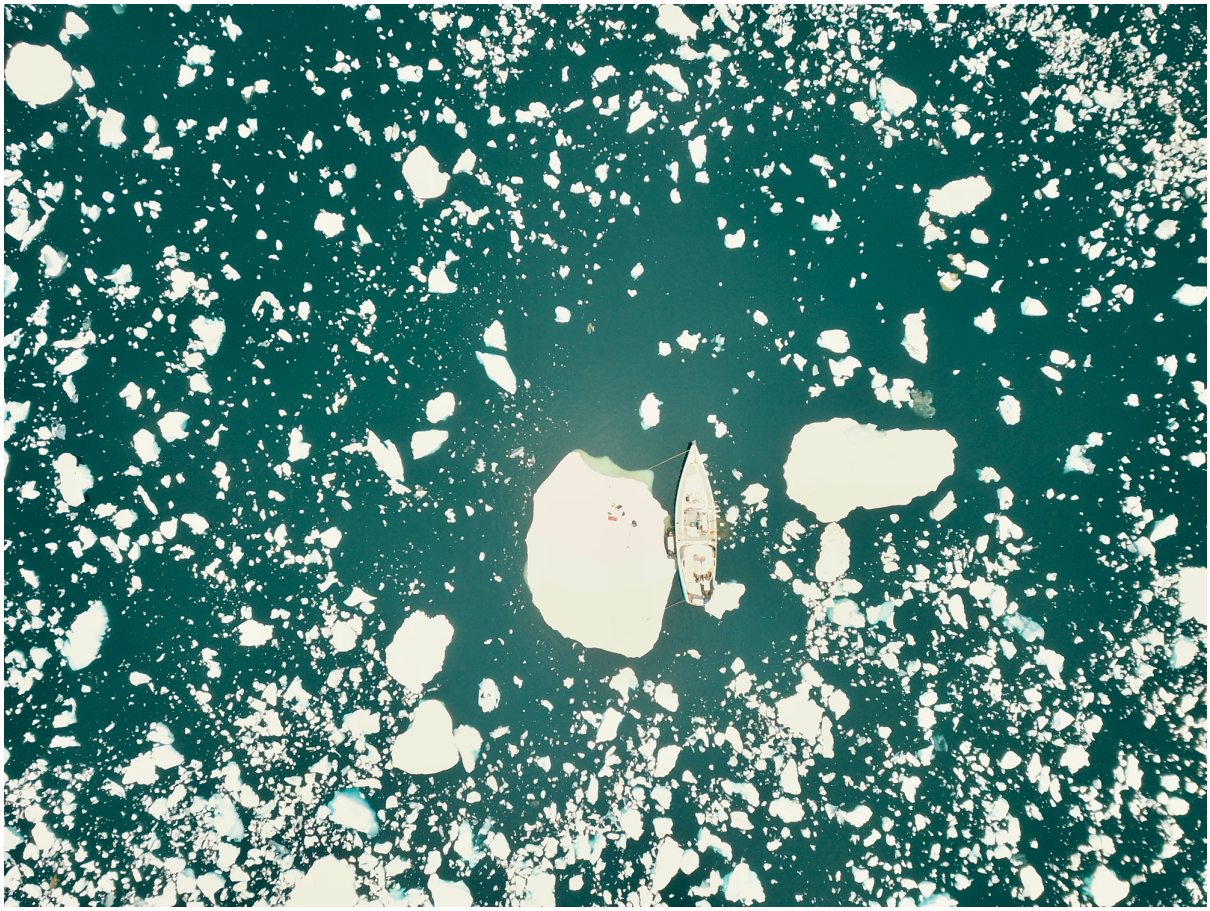

Figure 12: Aerial view of the ice floe sampled for glaciology studies. Australis used for scale (75' - 23m)

Blaiklock Island (BI)

Figure 13 Total sampling area and different sampling site at Blaiklock Island

Location: East of Marguerite Bay. Enclosed fjord system including a recently (2003) collapsed ice shelf (Jones ice shelf, Fox & Vaughan (2005)).
Spatial scale: work carried out in 4 distinct sites (Site 1, Site 2, Site 3, Site 4) along a gradient of influence from the Jones ice shelf. Site 4 is a shallow structure found in the middle of the channel leading to Jone's Ice Shelf

Blaiklock Island (BI), Site 1

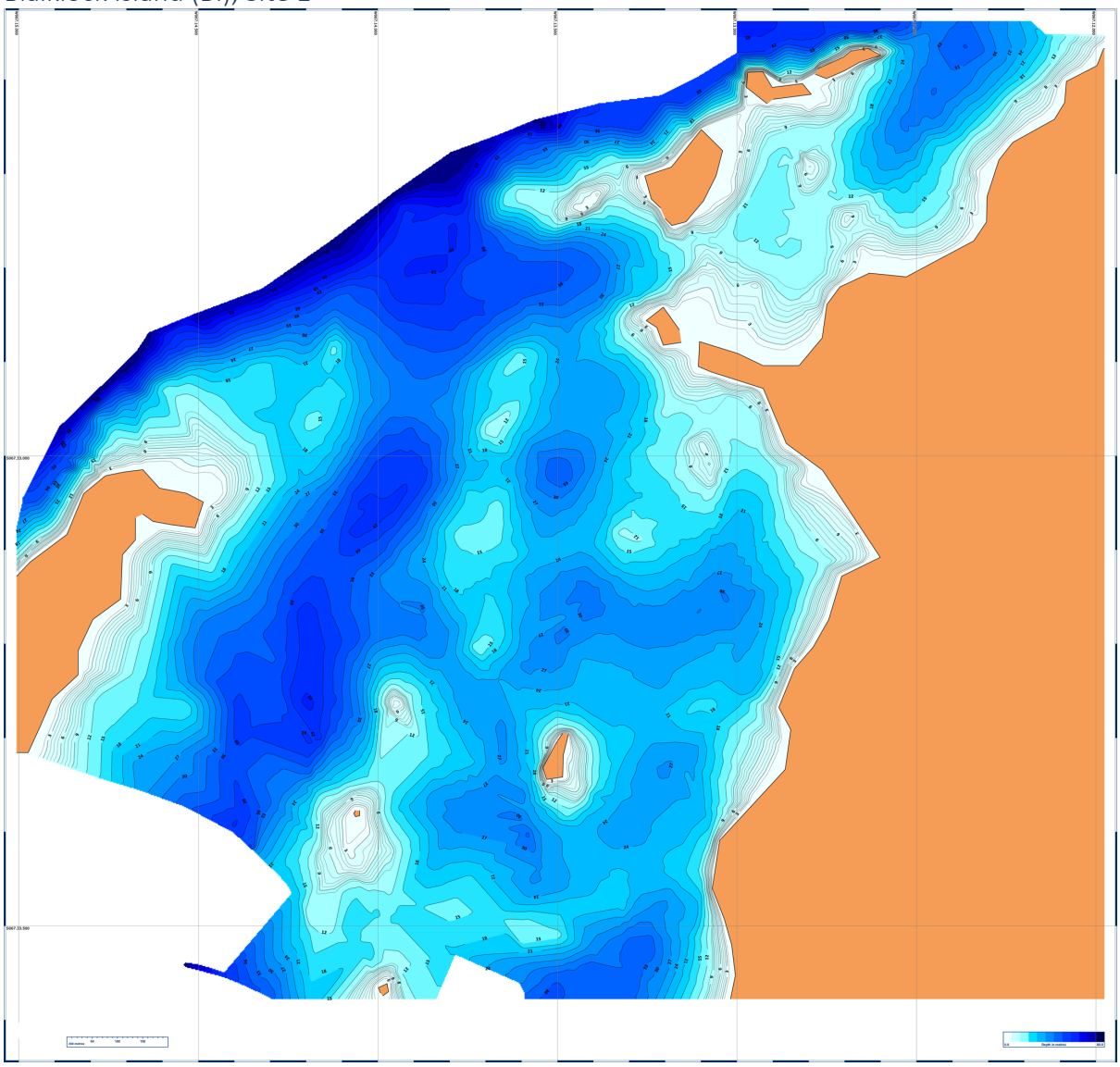

Figure 14: Blaiklock Island, Site 1. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

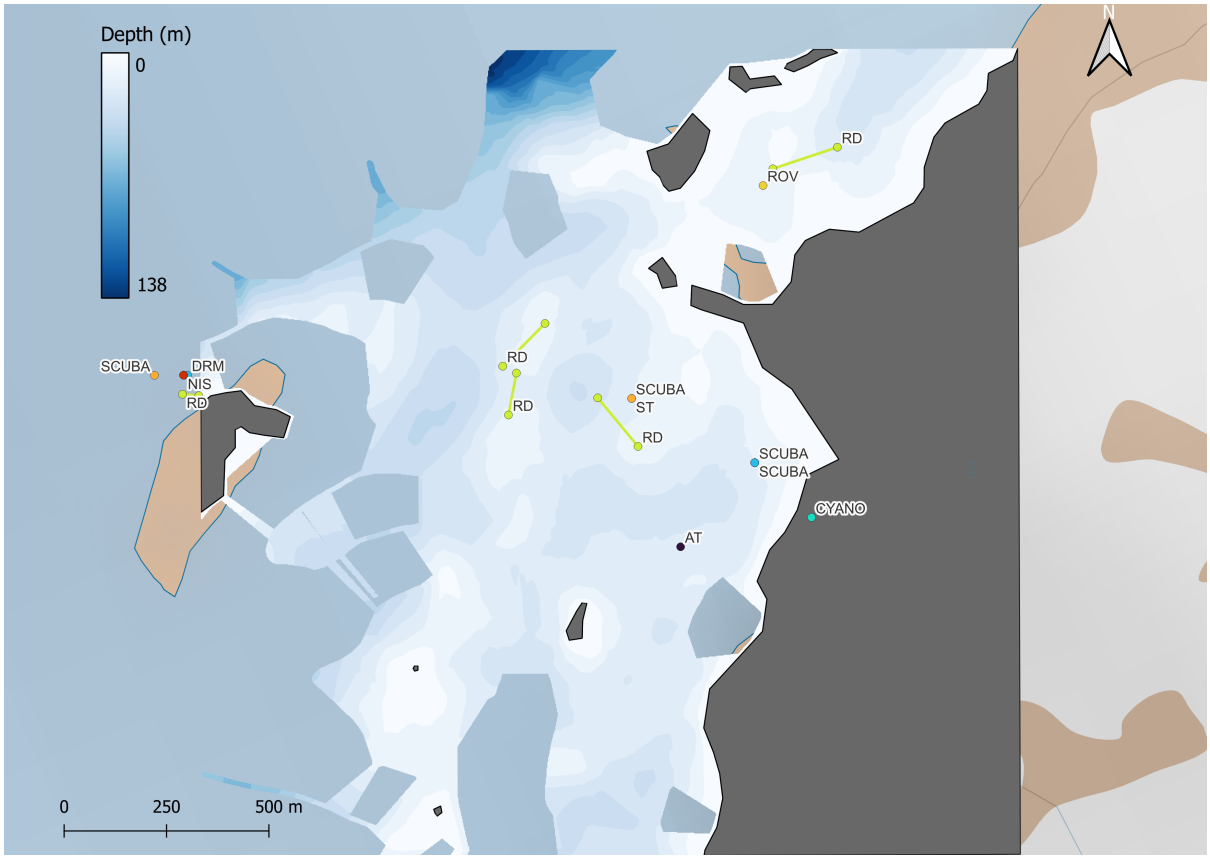

Figure 15 Sampling site 1 bathymetry and all events at Blaiklock Island

Figure 16: Aerial view of the anchorage in Site 1 (alt. 500m). Australis used for scale (75' - 23m).

Site 1 settings:

- gradient of exposure to glaciers, 3 sub-stations considered
- protected inner bay. muddy bottom with gravels and dropstones
- from moderate to high glacier activity and ice disturbance
- no penguin colony

Blaiklock Island (BI), Site 2

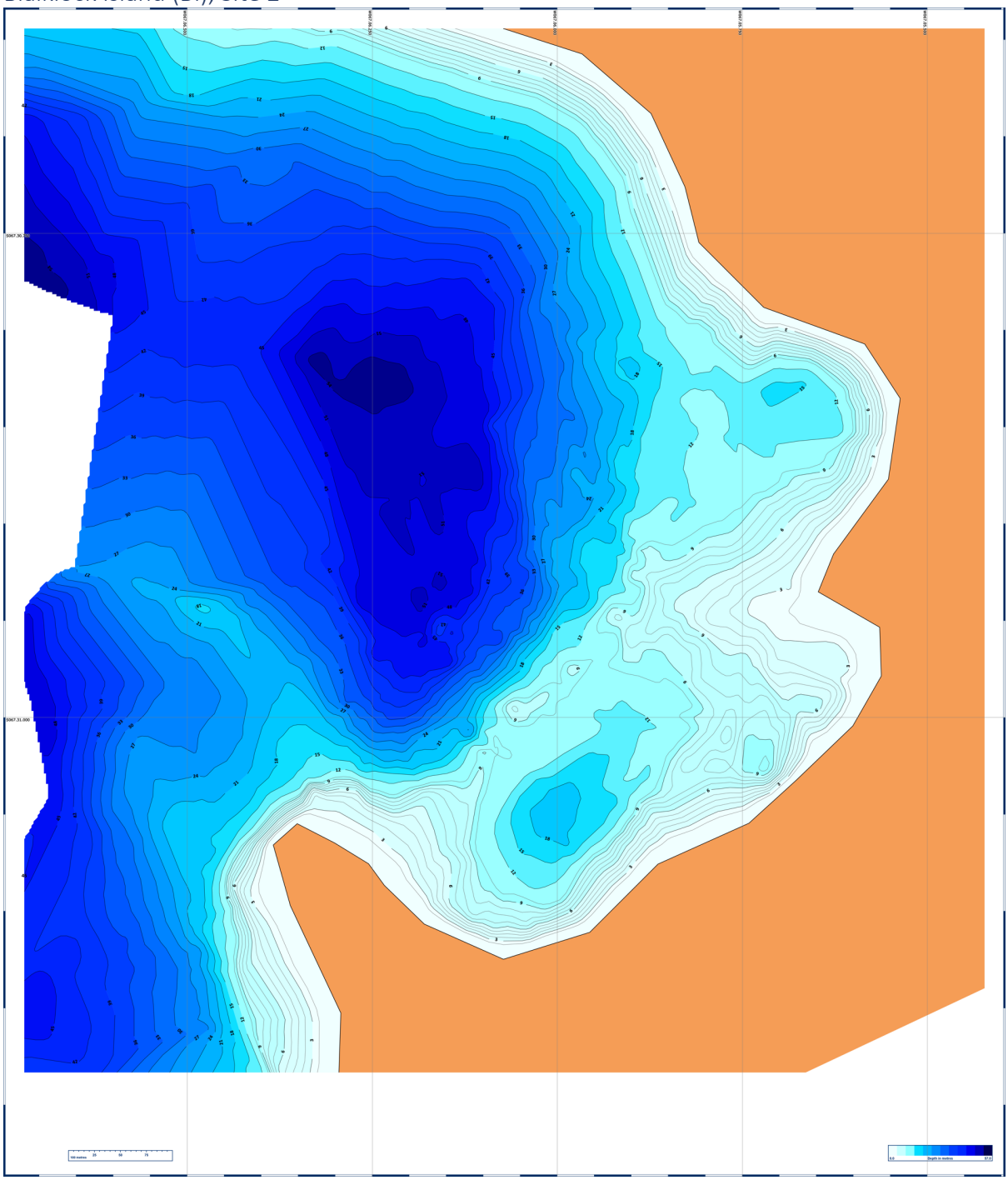

Figure 17: Blaiklock Island, Site 2. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

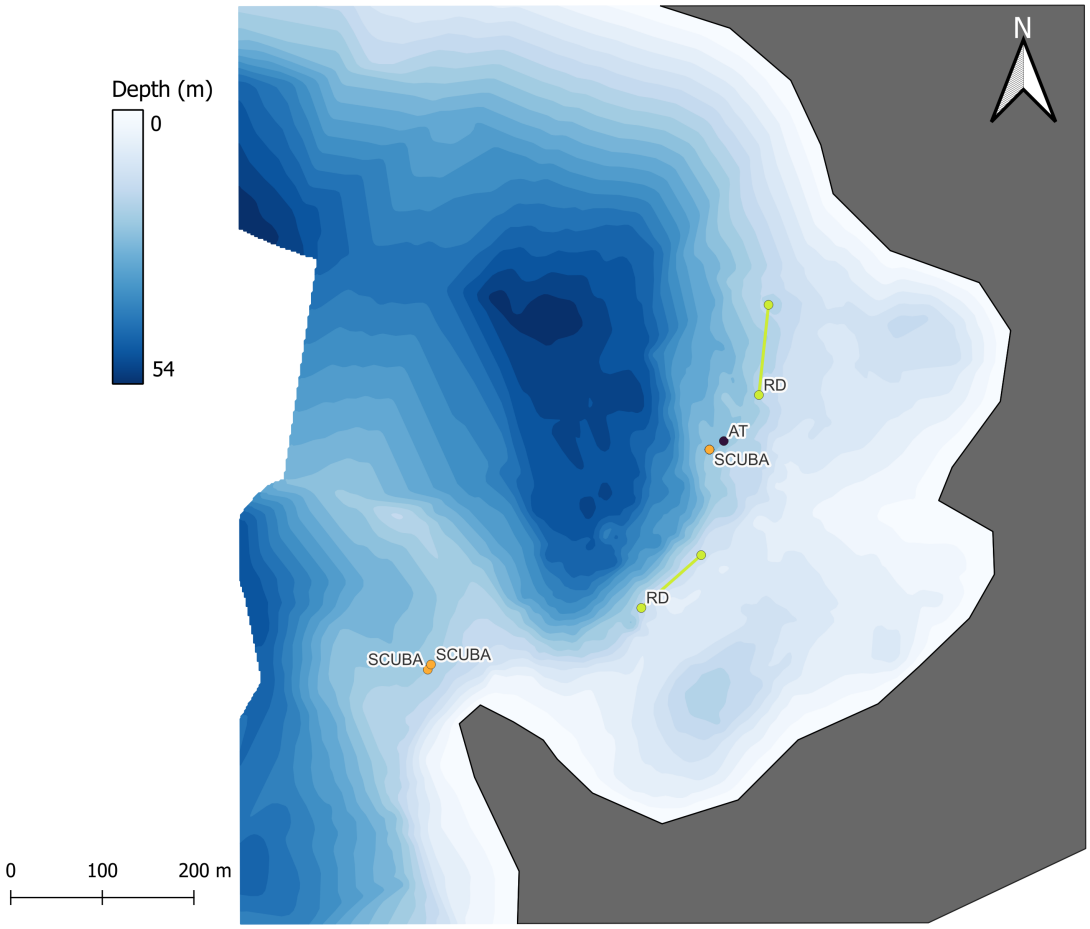

Figure 18 Sampling site 2 bathymetry and all events at Blaiklock Island

Figure 19: Aerial view of the anchorage in Site 2 (alt. 500m). Australis used for scale (75' - 23m).

Site 2 settings:

- halfway between Site 1 and 3, protected bay
- protected inner bay. muddy bottom with gravels and dropstones
- from moderate to high glacier activity and ice disturbance
- no penguin colony
- additional -shallow- site visited outside the bay

Blaiklock Island (BI), Site 3

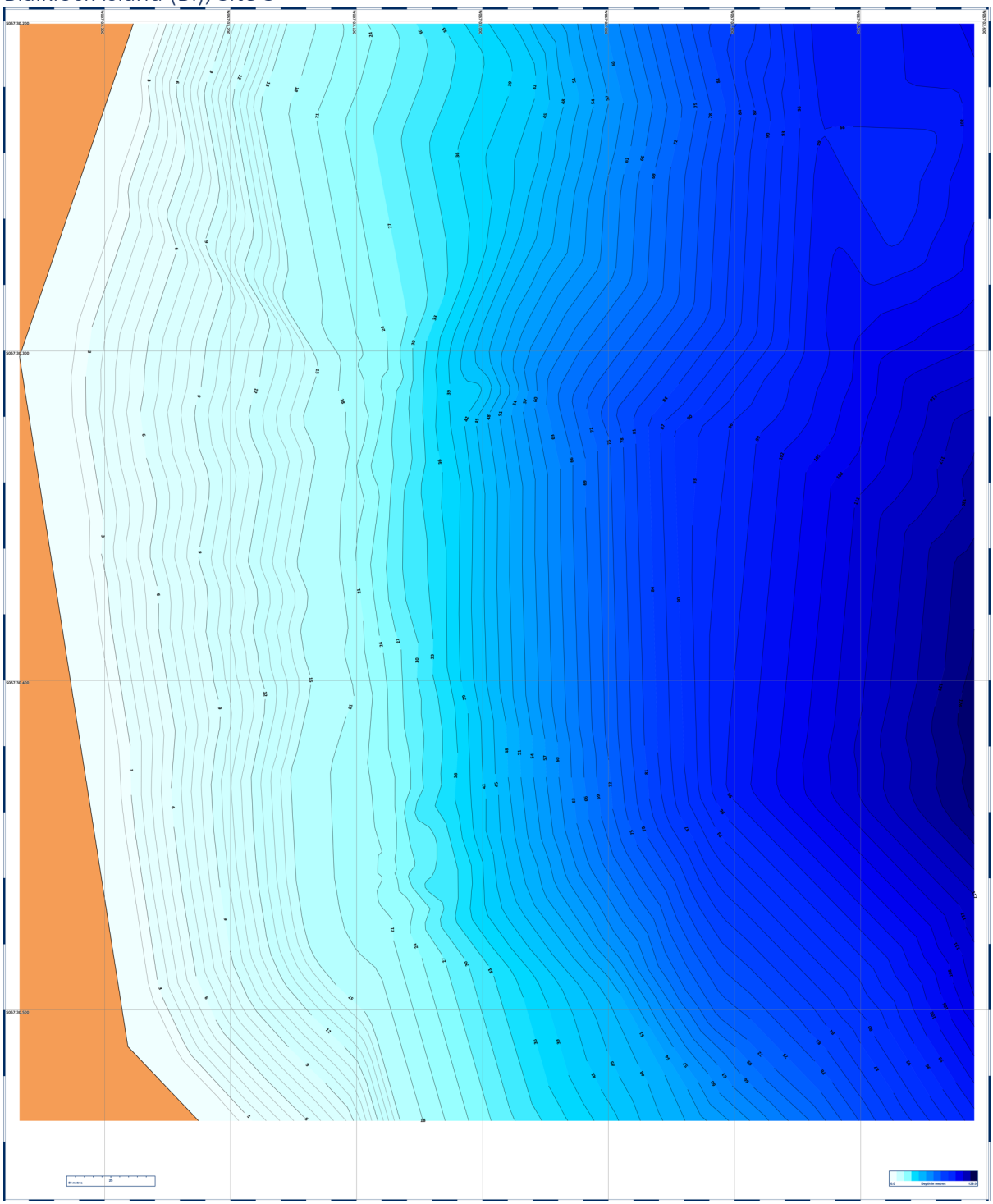

Figure 20: Blaiklock Island, Site 3. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

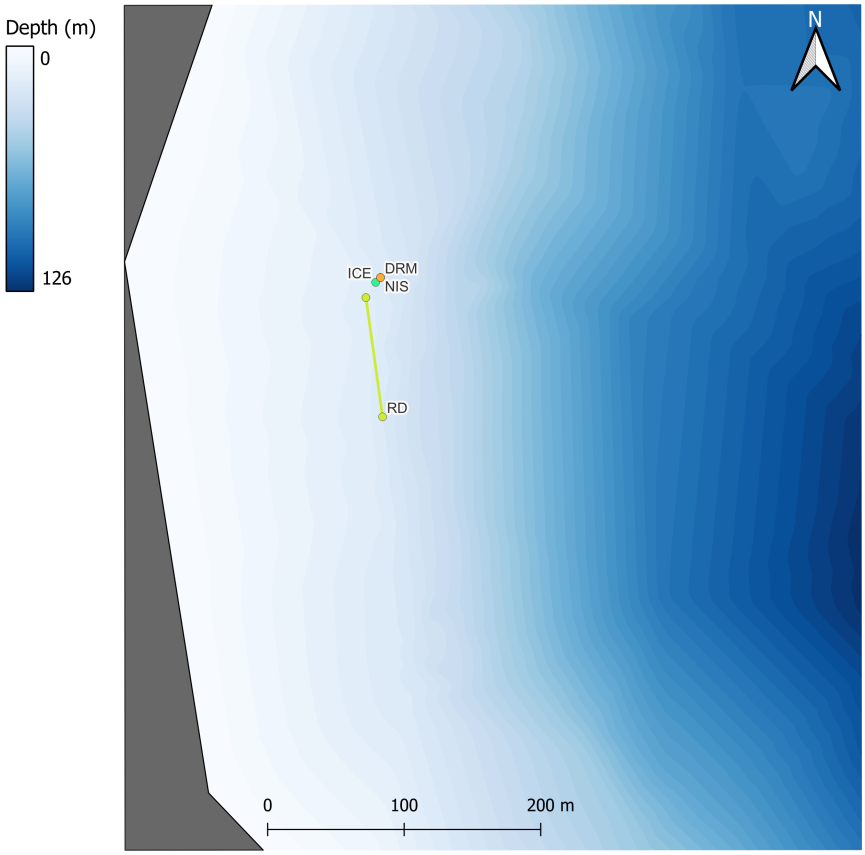

Figure 21 Sampling site 3 bathymetry and all events at Blaiklock Island

Figure 22: Aerial view of the anchorage in Site 3 (alt. 250m). Australis used for scale (75' - 23m)

Site 3 settings:

- inside Jones iceshelf area
- protected inner bay. muddy bottom with gravels and dropstones
- high glacier activity and ice disturbance, recently freed from ice
- no penguin colony

Blaiklock Island (BI), Site 4

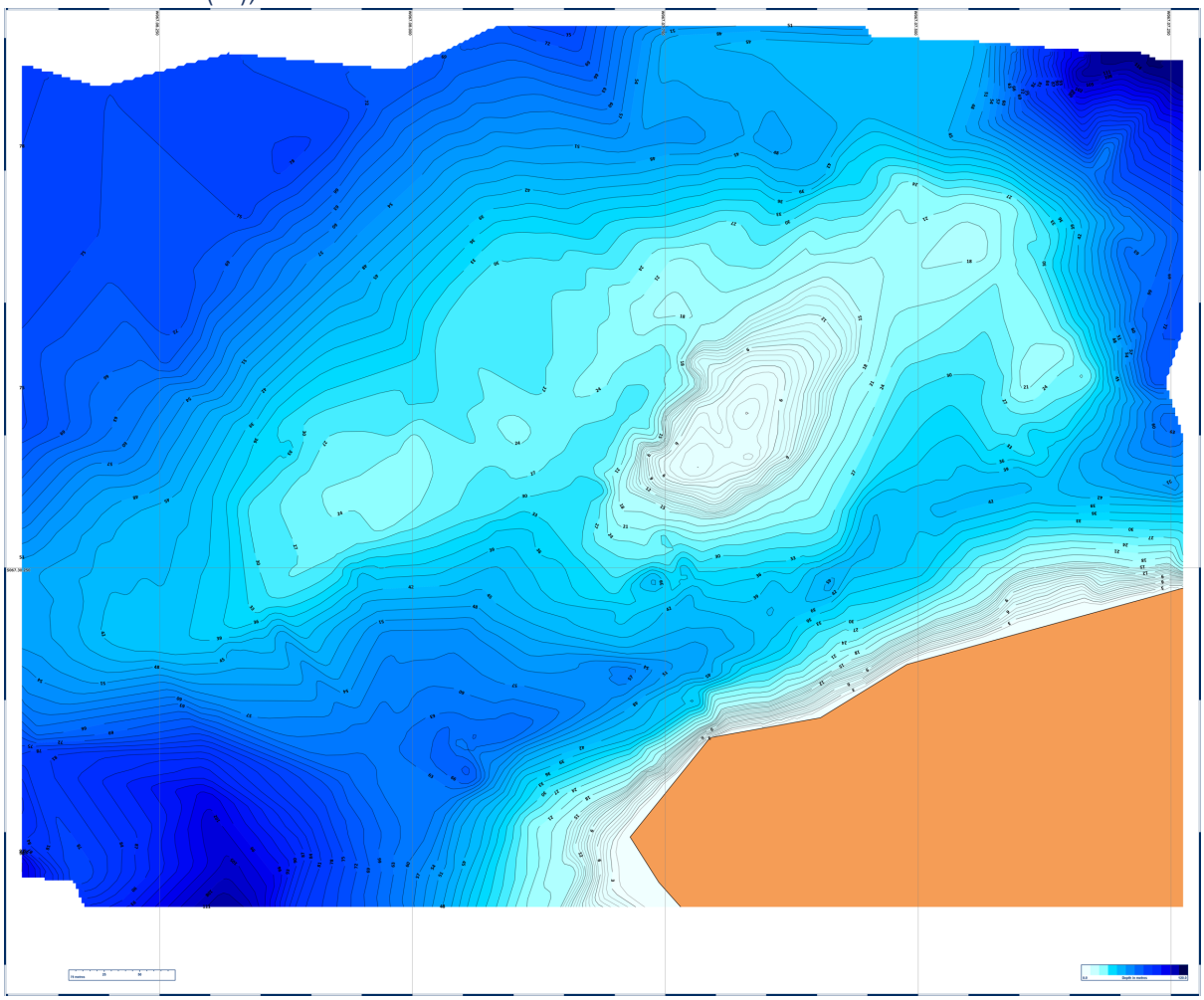

Figure 23: Blaiklock Island, Site 4. Bathymetric chart is courtesy of Ben Wallis (Ocean Expeditions).

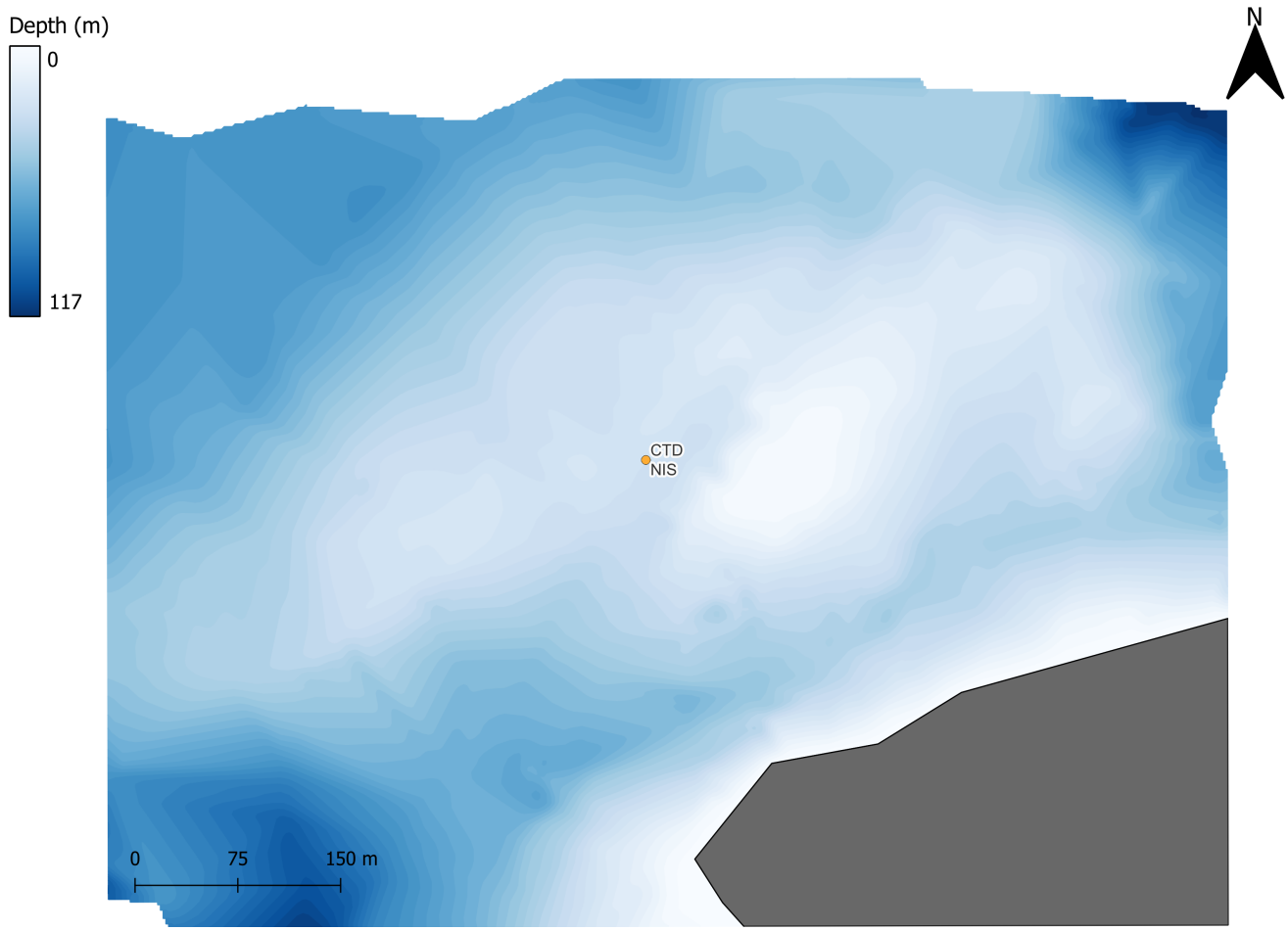

Figure 24 Sampling site 4 bathymetry and all events at Blaiklock Island

Figure 25: Aerial view of the anchorage in Site 4 (alt. 250m). Australis used for scale (75' - 23m)

Site 4 settings:

- inside channel leading to Jones iceshelf
- shallow mount directly exposed to ice
- high glacier activity and ice disturbance, recently freed from ice
- no penguin colony

Data management

In the framework of the TANGO1 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 TANGO 1 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 TANGO1 team: Bruno Danis, Henri Robert, Bruno Delille, 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.

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.
Aerial footage was shot by Bruno Danis using a DJI MavicPro2 drone, 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 TANGO1 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).

Work at sea and preliminary results

1. Sampling design and efficiency

Bruno Danis & Ben Wallis

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 expedition (Danis et al. 2022), the TANGO1 expedition focused its sampling efforts on areas displaying gradients in (sea)ice conditions.

In the framework of TANGO1, the main challenge was to precisely determine an area that would be suitable for establishing baseline information, displaying sea-ice gradients at various (but workable) spatial scale, in unchartered areas. To meet these needs, effectiveness, agility, operability were at the center of the strategic decisions taken during the expedition.

In terms of design, the chosen strategy was to take advantage of the agility of RV *Australis* to explore areas in pre-selected regions (south of the Grandidier Channel and vicinity of Marguerite Bay). The decision on the final sampling areas was based upon combination of upfront Sentinel-1 and Sentinel-2 satellite imagery analysis (performed by Axelle Brusselman) and ground-truthing using RV *Australis* and fine-scale local knowledge of the skipper (Ben Wallis, Ocean Expeditions). To finalize the selection of the final sampling sites, special attention was devoted to opt for a hierarchical design to allow taking into account multiple spatial scales, to feed information to the upscaling workpackage (WP4) of the TANGO project.

Methods

Satellite imagery (Sentinel-1 and Sentinel-2) was used upfront, before the expedition, to try and identify areas which would fill all requirements for sampling, including sea-ice. Two candidates were identified, Dimitrov Cove and Crate's Bay (Graham Land). These two candidate stations were first visited for visual scouting onboard Australis.

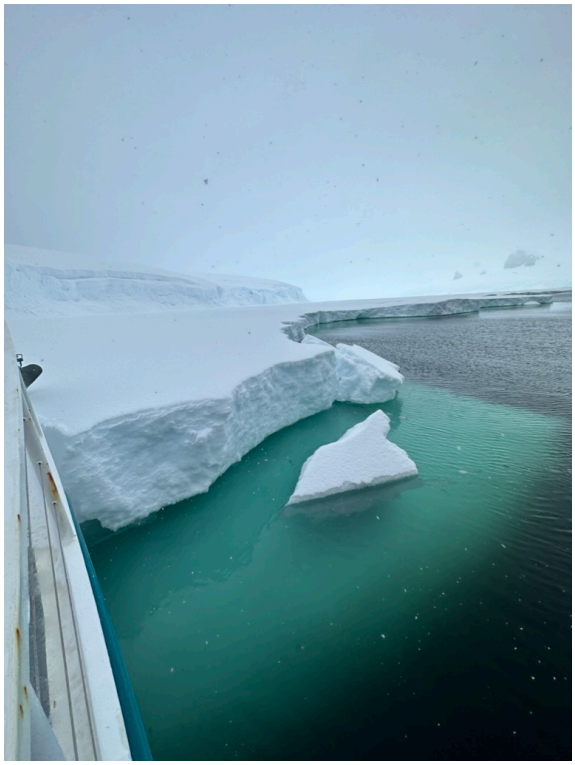

Figure 26: Bow docking in Dimitrov Cove.

The pre-selected area were unchartered, and the bathymetric measurements (depth > 80m) carried out onboard *Australis* proved the measured depths to be unworkable for most envisioned operations, including sea-ice works. A similar situation was found in Crate's Bay, which was visited directly after. Decision was taken to visit Dodman Island, in the vicinity of Dimitrov Cove and Crate's Bay, and which appeared to meet the logistical and scientific requirements for deploying all gear.
All visited areas for work were always scouted first to gather precise aerial/underwater imagery as well as bathymetry data. Scouting was carried out by using Australis, two tenders (Bombard C3 and C4), MavicPro2 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, ice floes and to carry out gear deployments in a secure fashion.

Results

Out of the total shiptime devoted to the expedition (28 days), steaming from Ushuaia to the WAP (entrance via Pitt Islands) took 4 days. Steaming from Dodman Island to Blaiklock Island took 1 day. Time steaming back from Blaiklock to Ushuaia was 10 days, including the drop-off of the samples at the Gabriel de Castilla Base in Deception Island.
Time spent on search for suitable TANGO1 stations was limited to 2 days.
During the 16 operational days, 14 different types of gear were deployed, reaching a total of 174 deployments (see Table 3).

Table 3: List of gear deployed during the TANGO 1 expedition.

Gear	*Abbreviation*	*Deployments*
Amphipod Trap	AT	5
Bathymetric surveys	BATHY	5

CTD casts	CTD	13
Cyanobacteria sampling	CYANO	5
Drone - aerial imaging	DR	5
Drone - mapping	DRM	11
Intertidal	ITD	3
Niskin bottle	NIS	42
Rauschert Dredge	RD	22
Remotely Operated Vehicle	ROV	22
SCUBA Diving	SCUBA	30
Sea Ice Works	SEAICE	2
Sediment Trap	ST	2
Van Veen Grab	VV	7
TOTAL		**174**

As shown in Table 3, a total of 174 Deployments, were caried 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 4000 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 TANGO1 confirm 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. TANGO1 provides a first-hand experience to carry an ambitious TANGO2 expedition. Based upon Open Science approaches, the combination of B121/TANGO1 efficiency in sampling paves the way to testing the transposability of the concept to multiply similar efforts in a coordinated fashion.

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2. Fine-scale bathymetry

Ben Wallis, Annette Bombosch, Bruno Danis

Context

Large portion of the waters in the West Antarctic Peninsula are unchartered, and precise bathymetric charts are a pre-requisite to conduct oceanographic research in this region. 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 the TANGO1 expedition, 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 expedition, is absolutely crucial to organize the sampling effort at each station.

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 30 hours were spent on both platforms to generate sufficient data to generate maps using the ReefMaster 2.0 software (as GIS shapefiles).
All visited sampling sites (see 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 (including TANGO2), and valorized as a significant contribution to the SCAR community of marine researchers.
As a side benefit, the generation of bathymetric chart allowed to identify and flag dangers to navigation which were immediately communicated to IAATO (and forwarded to the relevant hydrographic authorities).

3. 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 iPhone 14 pro, 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) will be processed using the Agisoft Metashape v1.6.2 to obtain orthomosaic pictures usable in a GIS software.

Results

A total of 16 drone flights were carried out during the TANGO1 expedition, including 5 DR events and 11 DRM events. A total of 6h26 minutes of flight were cumulated for a total distance of 51829 m in 52 flights. 98 Gb of data were compiled.
An example of a (pre)processed image resulting of the DRM_1 deployment is shown in Figure 28.
The rest of the process will be carried out when back in the Laboratory.

Figure 27: Aerial view (alt. 500m) shot by the drone (DR_1) in Dodman Island (RV Australis in red circle).

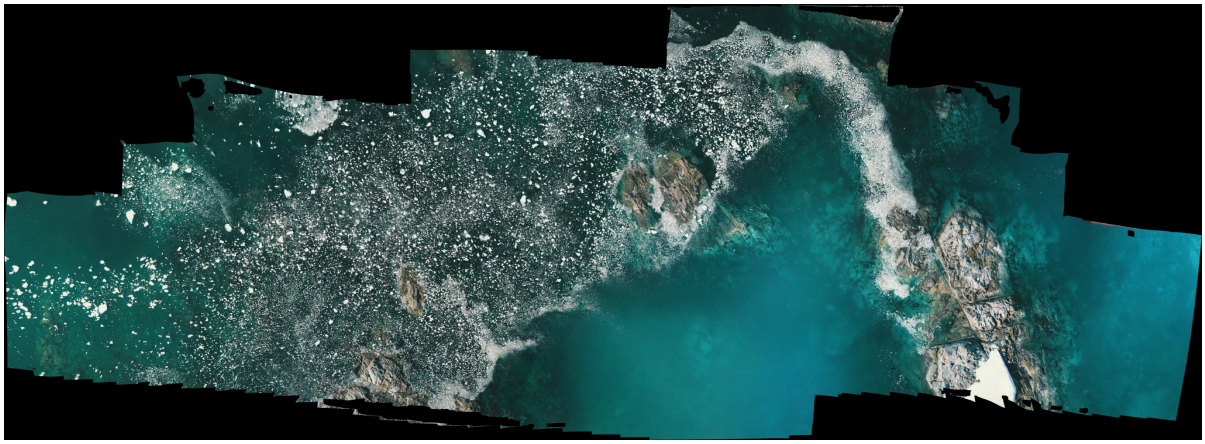


Figure 28: Orthomosaic image obtained by aligning 668 images shot by the drone (DRM_1) in Dodman Island (partial result)

Perspectives

Despite being 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 station, documenting their general setup as well as carrying out more sophisticated works including orthomosaic (2D) and photogrammetry (3D). Combined to other georeferenced layer gathered during the TANGO1 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 TANGO2.

4. Oceanography

Bruno Delille, Axelle Brusselman, Martin Dogniez

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 oceanography 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 (section **Error! Reference source not found.**). We consider carbon fluxes at large, including methane fluxes. In addition, we measured N_2O to complete the survey of greenhouse gases.

Collection of samples for the measurement of partial pressure of CH_4 and N_2O (pCH_4 and pN_2O) carried out as the general TANGO strategy (i.e. at TANGO sampling sites) were extended with additional transects carried out in Dodman island and "in transit" sampling. Transects were designed to identify potential sources of CH_4 or N_2O related to sub-glacial streams. The TANGO survey will be complemented by the simultaneous collection of samples at other locations in the WAP as part of the SONATINA piggyback project funded by the FRS-FNRS. This will allow us to derive a quasi-synoptic view of surface pCH_4 and pN_2O in the Western Antarctic Peninsula in summer and assess related air-sea CH_4 and N_2O exchange over an extended area. Surface seawater sample collection was performed simultaneously in the northern part of the peninsula onboard the *RV Hesperides* during the PolarChange survey by Odile Crabeck and Sofia Muller (University of Liège) and 30 km south of Blaiklock Island, around the Horseshoe Island in the frame of the project "Antarctic ecosystems Modeling using IBMs and machine learning techniques" at the Horseshoe Island /Turkish Scientific Research Camp onboard the *RV Betanzos* by Pablo Araujo. All water collection followed the same protocol and will be measured at the same laboratory (University of Liège).

Methods

We carried out 3 sampling strategies that involve seawater collection:

1) CTD/Niskin profile

Vertical salinity and temperature profiles were performed using ODDI sensors for depth, salinity, temperature, and HOBO light sensor from the surface to the bottom at all TANGO sites.

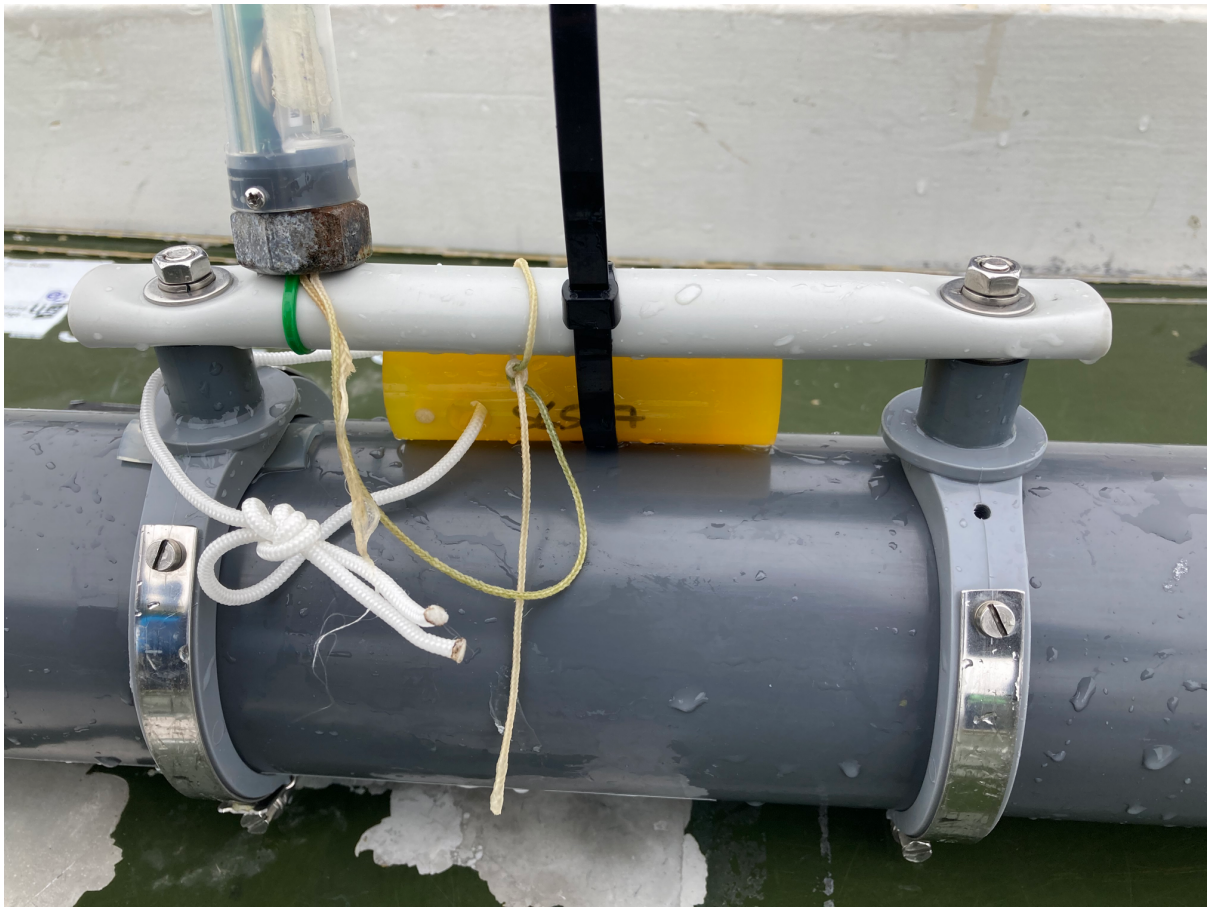


Figure 29 Details of the HOBO light and ODDI CTD sensors setup on the 2.5L Niskin. The ODDI sensor is secured in the yellow plastic tube.

These CTD profiles were completed by water collection with a 2.5L General Oceanic Niskin bottle at three depths: (0m, 6m and 1m from the bottom). 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.

Measured parameters are presented in Table 4.

Table 4 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), $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS	Mass spectroscopy	University of Liège

CH_4 and N_2O 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 analzer (Marianda)	University of Liège
Total suspended matter (TSM)	Weight	University of Liège
Fatty acid		Brest University
Environmental DNA (eDNA)		RBINS

2) Niskin sampling at 2m from the bottom to complement organism analysis.
   Seawater was collected for:
   With the same analyses as mention before:

- Salinity
- CH_4 and N_2O concentration
- $\delta^{13}C$ of CH_4
- Nutrients
- TA and DIC

   3 replicates:

- Pigments (including Chl a) - to be measured by HPLC at the University of Liège
- POC, PON, POS, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS
- Total suspended matter (TSM) (weight)
- Fatty acid
- Environmental DNA (eDNA) to be measured by Martin Dogniez at RBINS

3) Water collection at the surface to measure the partial pressure of CH_4 (pCH_4) and pN_2O
   Seawater was collecter for:

- Salinity
- CH_4 and N_2O concentration
- $\delta^{13}C$ of CH_4

In addition, we measured vertical fluxes of carbon using a sediment trap (Figure 31). One sediment trap was deployed at the two main sites (Dodman and Blaiklock) Island for about 7 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 30: 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, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS
- TSM (weight)

TANGO mooring

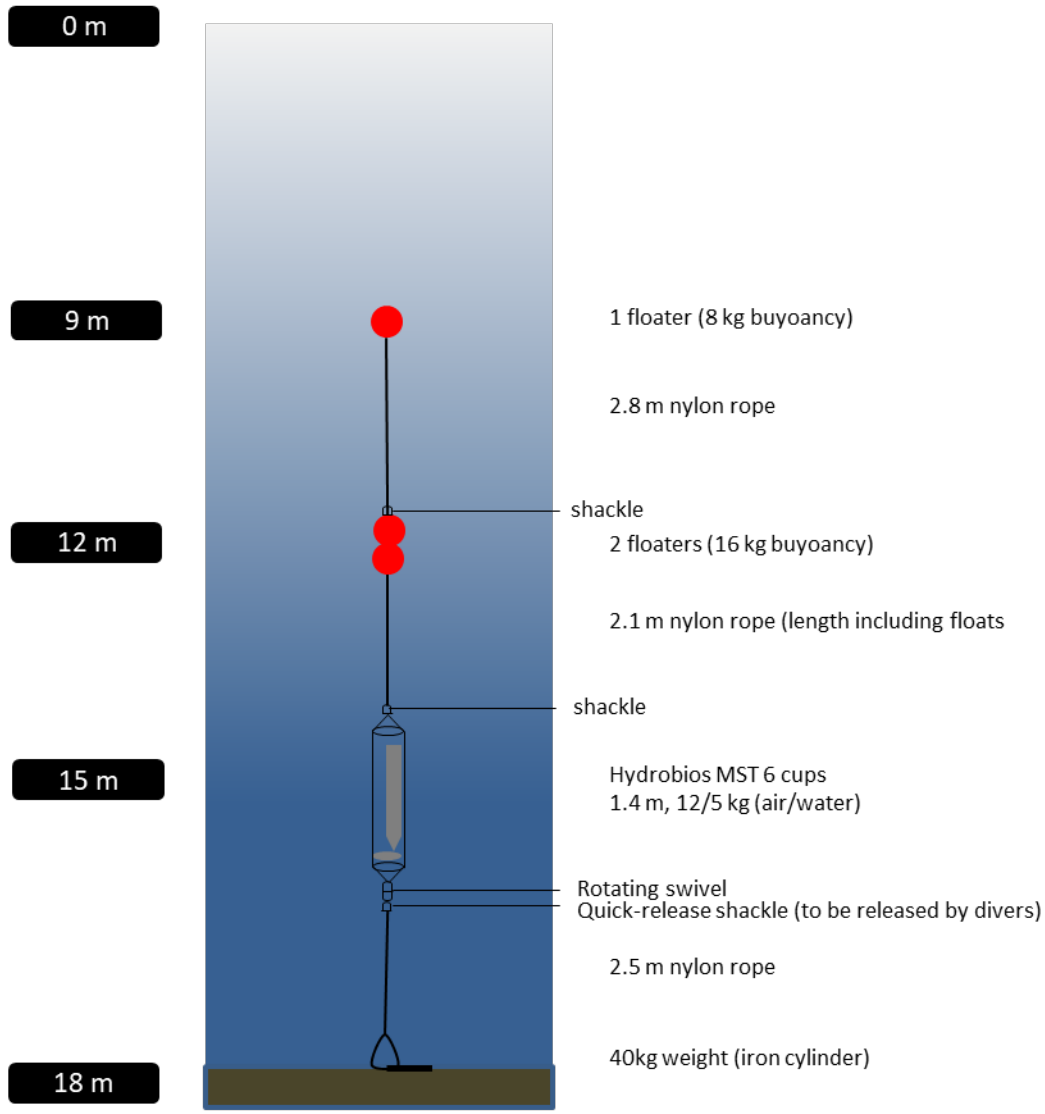


Figure 31 Sediment trap sketch

On ship sample treatment:

Figure 32 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 $HgCl_2$ solution just after sample collection.
CH_4/N_2O concentration and $\delta^{13}C$ of CH_4 were collected in 60ml serum glass vials without bubbles, with an isobutyl stopper and aluminium cap (crimped), and the adding 60 µl of saturated $HgCl_2$ solution just after sample collection. Two bottles were collected for CH_4/N_2O concentration and 2 bottles for $\delta^{13}C$ of CH_4
Pigments (seawater)were collected by filtering 1L of seawater on 25mm GF/F glass fibre for pigment analysis. Filters were stored in cryovials in a liquid nitrogen container, then in a -80°C fridge on the *RV Hesperides*.
Pigments (sediment trap) were collected by filtering the content of the sediment trap on 47 mm GF/F glass fibre filters 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, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS for vertical profiles were collected by filtering 1L of seawater on 25mm pre-combusted (12 hours at 450°C) GF/F glass fibre filters. Filters were stored in petri dishes and dried at 60°C for at least 12 hours.
POC, PON, POS, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS to complement organisms analysiswere collected by filtering 2L of seawater on 47mm pre-combusted (12 hours at 450°C) and pre-weighted GF/F glass fibre filters. Filters were stored in aluminium 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 fibre filters. Filters were stored in aluminium 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 fibre 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

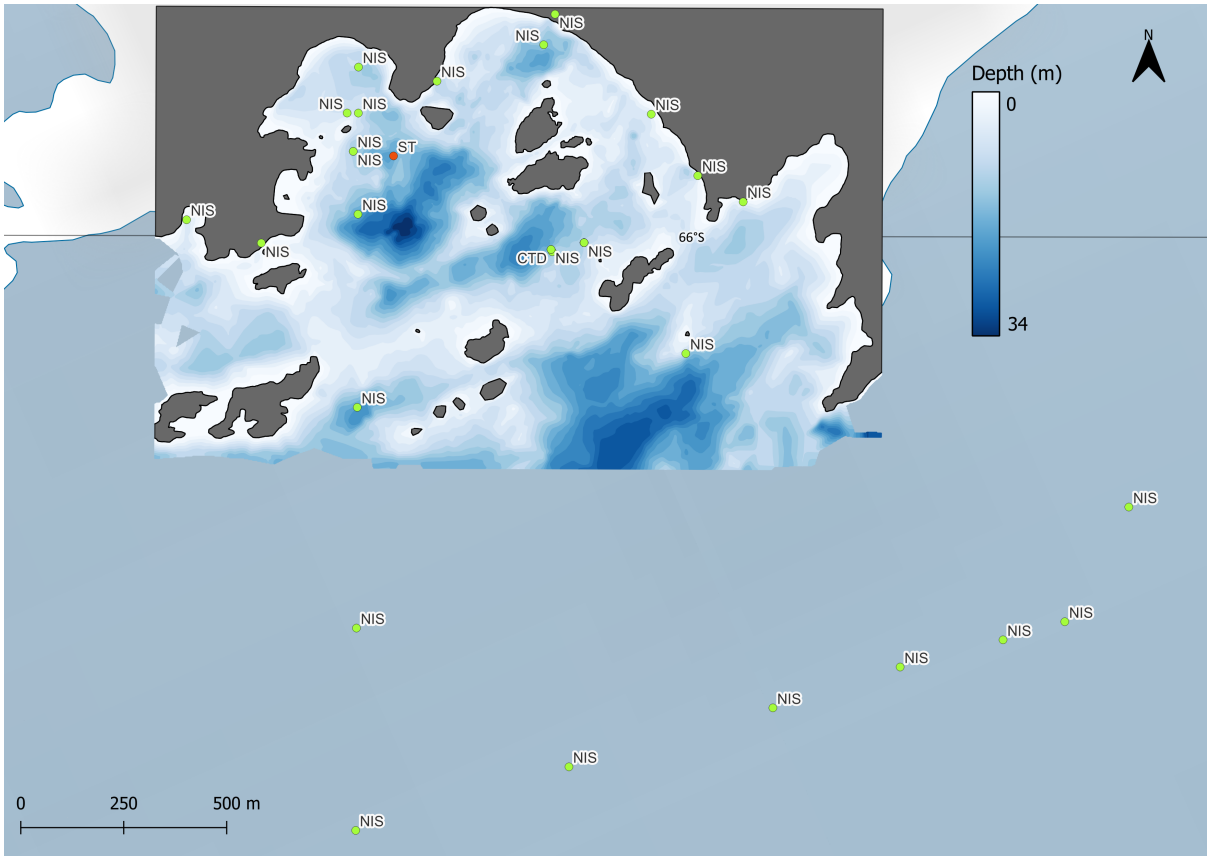


Figure 33 Map of Dodman Island with the localisation of the Niskin, CTD and sediment trap deployments

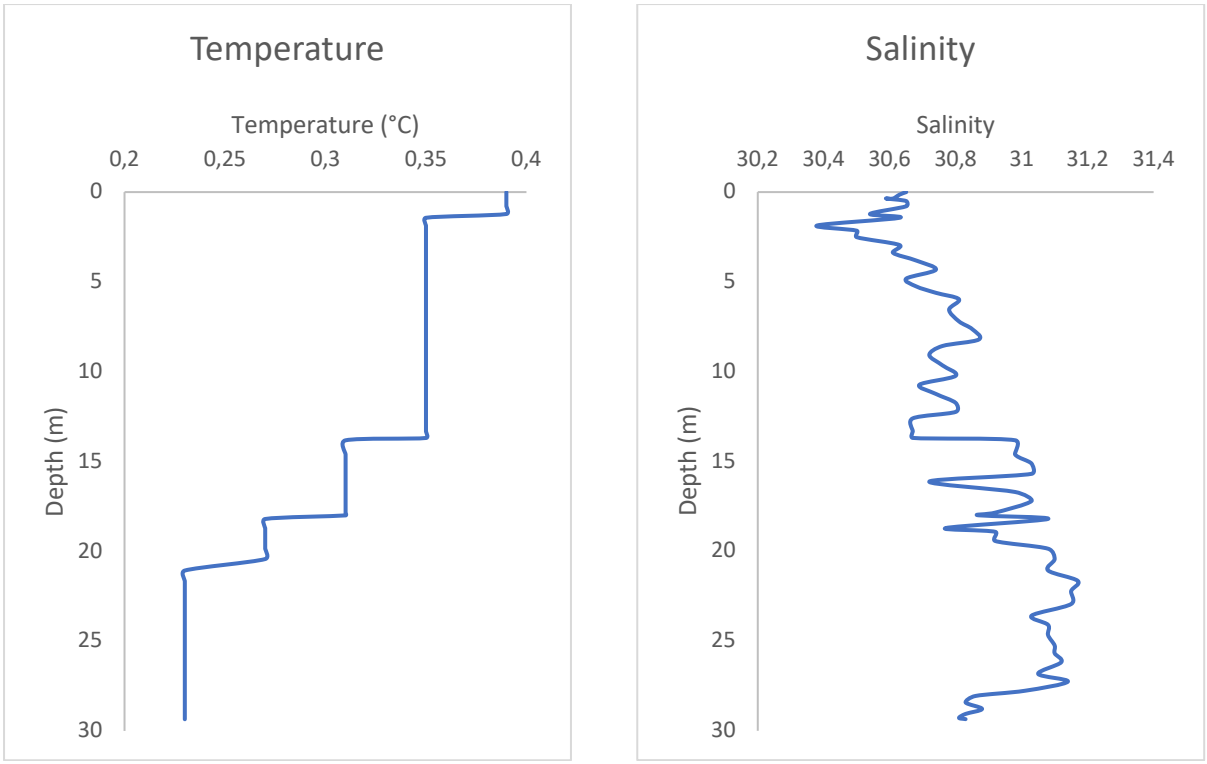


Figure 34 Temperature and salinity CTD 11 profile from Blaiklock site 3 on the 5 March 2023

In total, 15 CTD profiles were taken in different locations of Dodman Island and Blaiklock Island. After some tests with a temperature probe and a conductometer to check the accuracy of the CTD measurements, the temperature measurements seemed to be accurate but the salinity measurements are too low. A calibration with the salinity samples that were taken at the same time and will be analyzed with the Guilgline 8400B Autosal is needed.

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 Dodman Island (65.998430°S 65.787609°W from 19/02/2022 11:45 to 28/02/2022 11:25 at 18 m deep) while another deployment (ST2) took place in Blaiklock Island site 1 (67°33.0346’ S 67°13.3317’ W from 2/03/2023 9:15 to 07/03/2023 17:15 at 18.4 m deep)

Figure 35 Sample bottle recovered from the sediment trap: Left ST1 at Dodman island, Right ST2 at Blaiklock Island site 1

More particles were obviously recovered at Blaiklock Island compared to Dodman Island, even though longer deployment in Dodman Island (9 days) compared to Blaiklock (5.4 days) (Figure 35). This suggests significantly higher particle fluxes in Blaiklock Island compared to Dodman Island.

5. Sea-ice works

Bruno Delille, Axelle Brusselman

Context

Sea ice work was designed to complement the sampling strategy of the water column, providing the same information for sea ice as for the water column to cover carbon fluxes over the benthic-pelagic-sympagic continuum.

Hence consistent physical, biological, and biogeochemistry parameters were captured for sea ice, as for the benthic and pelagic compartments, but involving different techniques. For instance, primary production in sea ice will be assessed using O2:Ar ratio rather than O_2 incubation. In addition, we collected additional cores to investigate the spatial variability of gas concentration at small scale (1 to 10 m).

Two ice floes have been sampled as close as possible to the two main sites (i.e. Dodman and Blaiklock islands). Suitable floes have been chosen according to safety concerns (large and thick enough to deploy several people on the floe), accessibility, and ice thickness of less than 2m (limitation of the gear).

On each floe, we followed a sequence of events that involved:

- Safety assessment and measurement of ice thickness
- Measurement of basic parameters (snow and ice thickness, air, snow and ice skin temperature, freeboard)
- Measurement of ice temperature vertical profile

- Collection of snow (if any) and ice cores with on-site cutting for different parameters and treatments. On-site cutting was necessary to avoid losing too much brine, a significant bias when working with warm ice and air temperature above -5°C.
- Collection of ice cores directly stored at -20°C for further analysis at home laboratories
- Deployment of an automatic chamber for measurement of air-snow CO_2 fluxes (ICE 1 only)

Table 5 Target parameters for the ice stations

TOPIC	MEASUREMENTS
Physics and inorganic chemistry	Temperature Bulk Salinity Water Stable isotopes Fabrics
Gases	N_2, O_2, Ar, CH_4, N_20, CO_2
Biology	Pigments Fatty acid (only station ice 2) eDNA (only station ice 2)
Biogeochemistry	Nutrients POC, PON, POS, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS
Carbonate System	CO_2 DIC Total Alkalinity (TA)

Methods

Ice cores were collected with an 8 cm diameter ice corer (Lichtert Industry®, Belgium) coupled to a battery-powered driller. Core was sampled along two lines in a preserved untouched area at similar snow thickness. The distance between the two cores was about 50 cm (Figure 38).

Figure 36 Ice coring during ICE 1 station

Given the high temperature of the ice (Figure 41) and the air temperature ranging between 6.1°C at ICE-1 station and -0.4°C at station ICE-2, attention has been paid to treat or to pack the ice cores as fast as possible to limit brine drainage. Typically, two people were in charge of the coring, while 2 to 3 people were treating or packing the ice cores. All cutting was done on-site just after ice collection (Figure 37) with stainless steel ice saw. All personnel were wearing laboratory gloves for ice manipulation. Archives ice cores dedicated to treatment at home laboratories were wrapped in polyethylene plastic bags and stored immediately in a cool box with cool packs at -20°C and transferred within less than one hour in a -20°C freezer.

Figure 37 Ice core packing during ice 1 station

At each ice station 12 to 14 ice cores were collected covering the full ice thickness. Details of the core collected, purpose and cutting resolution and treatment are presented in Table 6.

Table 6 Details of cores collected, purpose, cutting resolution and treatment

Core	Parameter	Resolution	Melting procedure
Physical core	Temperature Bulk salinity Water stable isotopes	10 cm from top; 10 cm in the middle; one piece with adjustable resolution in the middle	Room temperature in the dark
Pigments core	Pigments	Ice 1: 20 cm from top. Bottom 10 cm then 20 cm towards the top Ice 2: 10 cm from top, 10 cm from bottom; one adjustable resolution in the middle	Room temperature in the dark, with addition of FSW
Biogeochemical core	Nutrients POC, PON, POS, $\delta^{13}C$ of POC, $\delta^{15}N$ of PON, $\delta^{34}S$ of POS	Ice 1: 20 cm from the top. Bottom 10 cm, then 20 cm towards the top Ice 2: 20 cm from the top, 10 cm from bottom. Ice 1: 20 cm from top; 10 cm in the middle; one piece with adjustable resolution in the middle	Room temperature in the dark
Gas cores (bags method)	CH_4, N_2O	Ice 2: 10 cm from top; 10 cm in the middle; one piece with adjustable resolution in the middle	Melted in sealed vacuum bags in the dark at room temperature
Fatty acid core (Ice 2 only)	Fatty acid	60-70 cm from bottom	Room temperature in the dark
eDNA core (Ice 2 only)	eDNA	40-60 cm & 86-106 cm	Room temperature in the dark
Archive cores stored at -20°C			
Ice 1: cores Ice 1-1 to Ice 1-10, including top, medium and bottom sections	N_2, O_2, Ar, CH_4, N_20, CO2 and Fabrics	TBD	
Ice 2: cores Ice 2-1 to Ice 2-6, including Top and Bottom sections for some cores			

Air-snow CO_2 fluxes were carried out at ICE 1 using a LI8100 soil CO2 fluxes system, connected to a LI8100-104 Long Term Chamber. Observations time was set to 20 min.

Results

We sampled two drifting ice floes:

ICE-1 nearby Dodman Island (66°01.517'S, 65°46.459'W) on the 25/02/2023.

ICE-2 at station 3 of Blaiklock island (67°30,310'S 67°03.109'W on the 05/03/2023.

Even though the ICE-1 floe was drifting, the overall aspect of it, the fact that we observed remaining landfast ice in person or by remote sensing in areas less than 30km away (Dimitrov Cove and Crates Bay respectivally), suggest it was landfast ice recenty detached. The floe was flooded (freeboard -1 cm) due to a thick snow layer ranging from 40 to 45 cm. The ice thickness was 1.82 m ± 0.16 m and presented a typical second-year ice salinity profile with low salinity (<5) in the top 110 cm and a sharp increase in salinity between 7 and 8 underneath (Figure 41). The top of the ice was rotten, and an obvious internal community were observed at a depth corresponding to the summer ice growth of the previous year (around 80 to 100 cm). No obvious bottom community was observed, likely due to bottom ice ablation, as the summer melting of the floe was well advanced, as evidenced in the temperature profile mostly above -1.8°C (Figure 41)

Figure 38: Ice floe ICE-1 attached to the Australis during the ice collection.

Ice floe ICE-2 was found at site 3 of Blaiklock island (Figure 39). The floe was surrounded by floating glacial ice.

Figure 39: Ice collection during Ice 2 station

The floe was thinner and less homogeneous than floe ICE-1 as the floe grew around a piece of glacial ice. Pictures taken during the last voyage of the Australis in January show a solid continuous land-fast ice at the same location (Figure 40). Given the configuration of the cove, with narrow access and the presence of landfast ice one month ago, the floe was likely a remnant piece of landfast ice. Given that landfast ice does not appear to survive over the summer and the thickness of the floe (0.90 m ± 0.22 m), the floe was very likely landfast first-year ice. No snow was observed on top, and the freeboard was +13 cm (no flooding). Salinity of the floe was quite low for a first year sea ice, with an uncommon salinity profile. Moreover, the profile exhibit a salinity of 0 at 10 cm. While we cannot exclude flushing from snow, presence of melt ponds was not observed by Ben Wallis in the previous voyage at the same location in 12- 14 January 2023. However, it was reported heavy rain falls (i.e; one week, all day and night observed in day rock , 20nm further north, by early January 6-11 january 2023)in that area. Rain was also observed in Blaiklock from the 12 to 14 of January 2023. So we hypothesis that the low salinity profile observed in Blaiklock, with salinity down to 0 at the surface, was due to rainfall washing down the ice. Consolidation of this freshwater layer was difficult to core. When coring, the presence of a gap layer was obvious; this gap layer was significantly enriched in sympagic microalgae according to the brownish color observed around 70cm depth. Bottom community was not observed, probably due to ice ablation at the bottom. The temperature of the ice was above -1.8°C, suggesting ongoing melting (Figure 41).

Figure 40 Collecting site of ice floe ICE-2 in January 2023.

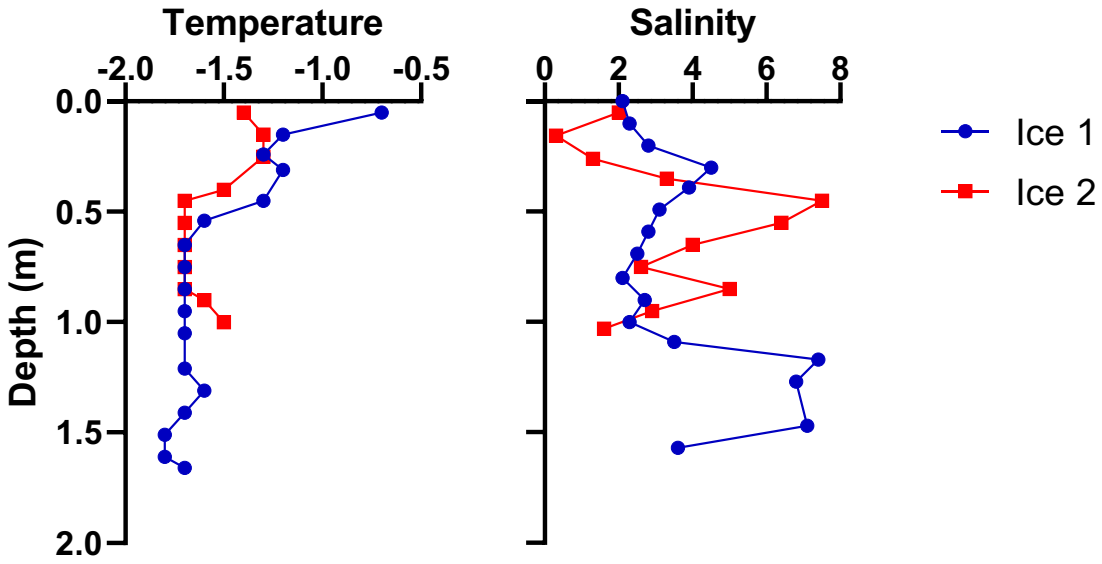


Figure 41 Ice temperature (A) and salinity (B) vertical profiles

6. Soft sediments biodiversity and biogeochemistry

Francesca Pasotti and Marius Buydens

Context

Continental sediments are key players in the overall carbon budget of the ocean ecosystems because they contain about 50% of the global marine sediment C stock (Luisetti et al. 2020). The biota inhabiting the inorganic matrix of the shallow seafloor in the euphotic zone is capable of primary production (microphytobenthos and macroalgae), of remineralization of settling organic matter (i.e. from primary production or zooplankton faecal pellets) via microbial degradation and transfer of this biomass to higher trophic levels via microbial loop or, depending on the sedimentary conditions, sequester it in the deeper layers in a process known as burial. When carbon is stored into long living organisms (in their biomass), this process is named carbon storage. Therefore, in sediments that are displaying large capacity for primary production and organic matter remineralization and which host and support abundant communities of large, long-lived filter and suspension feeder organisms, we may expect these habitats to be acting as carbon stores in these coastal ecosystems.
Due to the recent climate change, ice shelves on the West Antarctic Peninsula collapse and glaciers retreat. As a result, areas of the seafloor have become exposed to the water column dynamics and have given birth to the onset of primary production processes by both phytoplankton, macroalgae and microphytobenthos. Because of the colonization of newly ice-free areas by new assemblages of organisms as a response to the increase in local primary production after glacier or ice shelf collapse, the coastal Antarctic (and especially the Antarctic Peninsula) has been categorized as one of those habitats that is responding and will respond to climate change generating a negative feedback as new biomass is stored in higher trophic levels consumers generating a carbon storage (Peck *et al.*, 2010).

At the same time, changes in winter sea ice extent and duration have been linked to increases in shallow water benthic mortality because of the decrease in fast ice and the consequent increase in the frequency of iceberg scouring. Scouring processes generate local mortality and act as carbon release drivers, for previously immobilized carbon is now turned into decaying matter and remineralised and respired within the sediments (Barnes, 2016). Further it is possible that once the sediment assemblages have been decimated by eliminating the large long-lived organisms which typically store the primary production in their biomass, once the organic matter cannot be immobilized it will start to accumulate in the sediments and depending on the local sea bottom hydrodynamics and the infaunal bioturbation potential, the sedimentation rates and temperature shifts, we may be presented with hypoxic or anoxic sediments wherein newly produced organic matter can be buried in the deeper sediments.

The environmental and biological conditions that lead to one end (immobilization) or the other end (decay and remineralization) processes are complex. Braeckman *et al.*, (2021) observed in a shallow coastal fjord in the WAP that sediments could characterized by either a net heterotrophic or autotrophic sediment processes, or neutral one (balanced system), across different environmental conditions that are thought to be driven by El Nino/La Nina-induced glacial dynamics.

These processes have till now only been estimated and modelled from very sparse and limited observations. In coastal Antarctic local glacial dynamics can be very patchy, locally,

and regionally, and can vary from year to year also in relation to the previously mentioned El Nino/La Nina events. An in depth understanding of the sediment assemblages standing stocks both in terms of microbiota, primary producers and infauna linked to the overall biodiversity and functional diversity, and the sediment respiration rates can help inform models for estimating the role of the Antarctic shallows for blue carbon stores.

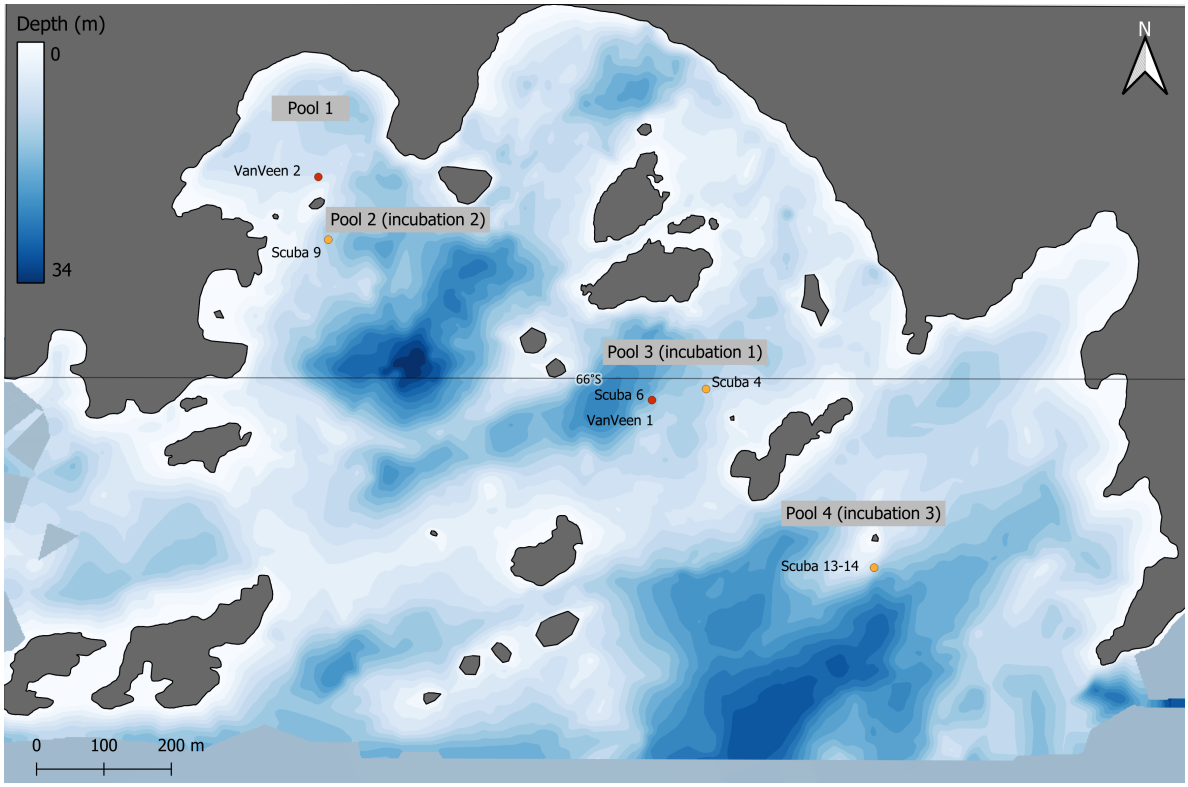


Figure 42 Overview of the sampling stations at Dodman Island in regard of the sediments

Table 7 Location where the activities took place, the event ID, the sample ID and the type of samples collected ad scope of the samples (e.g. incubation, Env = environmental replicates; SI = stable isotopes; Macro = macrofauna quantification).

Location	Event ID	Sample ID	Type of sample
Pool 1	VV_2	??	??
Pool 2	Scuba 9	#490-492	Incubation cores
		#493-499	Env + SI meio cores
		#505-506	MPB Falcon
Pool 3	VV_1	#324-326	
	Scuba 4	#200-201	Incubation cores
		#202-207	Env + SI meio cores
	Scuba 6	#257	Incubation core
		#258	1L scooping Macro
		#259	MPB falcon
Pool 4	Scuba 13	#1340-1342	Incubation cores
		#1343-1345	Env meio cores
		#1346-1349	eDNA+SI meio cores
		#1351-1353	MPB falcon
	Scuba 14	#1451	Pb 120
		#1452-1454	Macrofauna cores

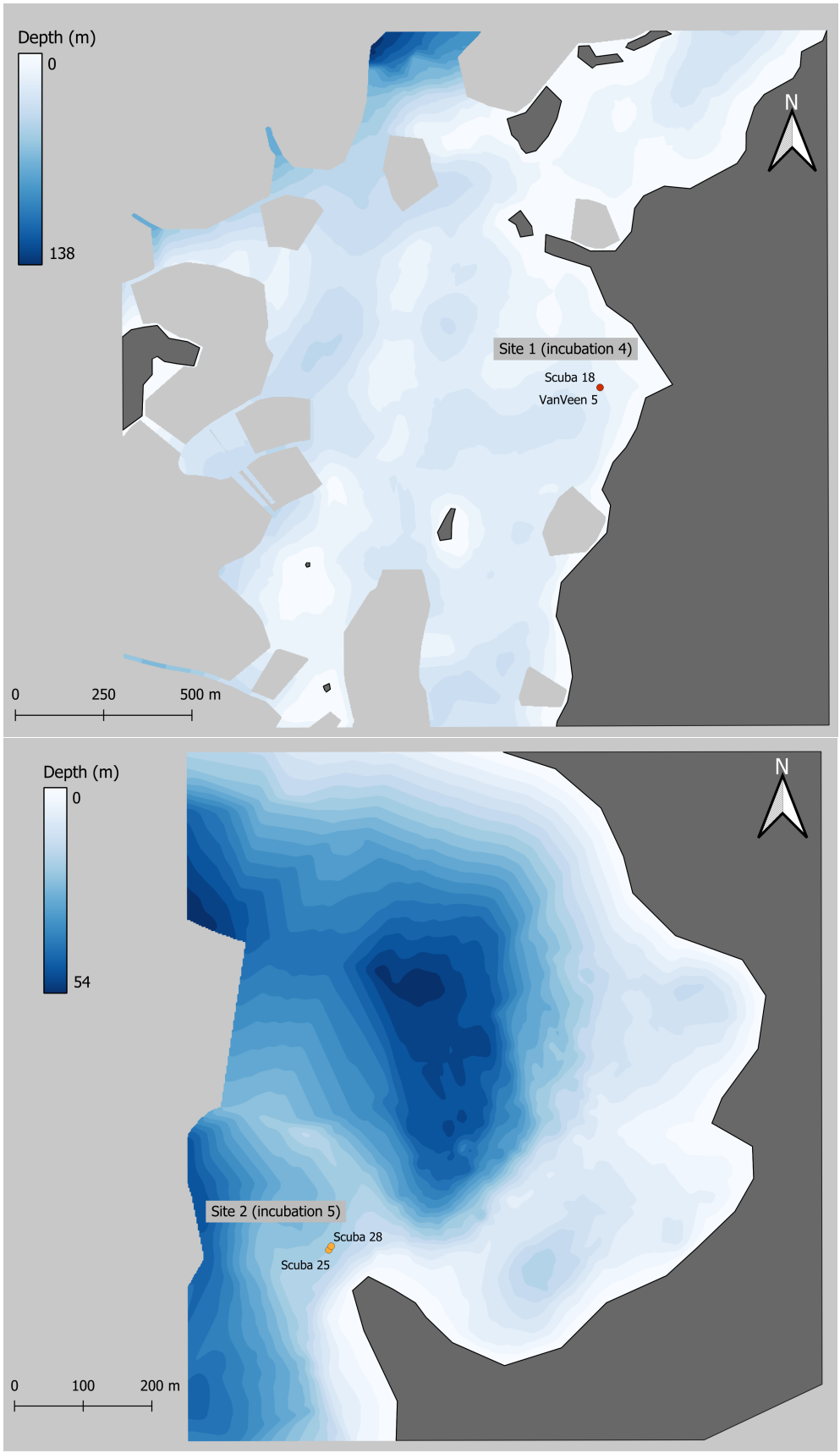


Figure 43: Map of the two site where sediment sampling was possible for the incubations. Site 1 was more to the South than Site 2 along the area of Blaicklock Island. Site 3 is not reported here since no sampling happened for soft sediment there.

Methods

A total of nine dives have been devoted to the sampling of the soft sediment communities in three different stations in Dodman Island and in two stations in Blaicklock Island.
At each station divers sampled 3 x incubation cores (perspex cores of 10 cm inner diameter) which were retrieved and placed into the incubation bath for the light/dark incubations (see farther).
To support the interpretation of the incubation measurements and be able to cover more of the local patchiness, a total of 3 x 5.6 cm inner diameter perspex cores were sampled for environmental variables (sediment grain size, pigments analysis, total organic matter (TOM) and total organic carbon content (TOC) and total nitrogen (TN); 0-1 cm, 2-3 cm, 3-4 cm ….till 9-10 cm sediment profiles) and another three for eDNA and dual stable isotopes ($\partial^{13}C$ and $\partial^{15}N$; sliced 0-1 cm, 1-2 cm, 2-5 cm sediment profile) analyses. Environmental samples were stored in Alu vials at -20°C, whereas the eDNA and stable isotopes samples were placed into Petri dishes at -20°C. Finally, where possible, the abundance and biomass of the macrobenthic infauna was estimated by collecting sediment by means of Vanveen grabs (Ponar grab PPG15, AQUATIC Biotechnology: sampling area 225 cm^2 and volume of 2.2L), measuring the total volume of the collected sediment and sieving the sediment on a 1 mm mesh size sieve. In case the substrate was filled with gravel and pebbles hindering the proper functioning of the VanVeen grab, a dedicated dive was conducted to sample a total of three incubation cores which were individually sieved on a 1 mm sieve for the macrofauna. All macrofauna sampled with these two gears, were stored at -20°C in ziplock bags, for the macrofauna collected will be both counted and analysed for dual stable isotopic signature ($\partial^{13}C$ and $\partial^{15}N$).
When possible, a large core was taken for the quantification of sedimentation rates (Pb120 analysis). The core had 10 cm inner diameter core and it was pushed into the sediment to the maximum depth reachable. The core was then sliced every 1 cm interval till the end of the sediment. The sediment slices were placed into large 14 cm petri dishes and stored at -20°C.

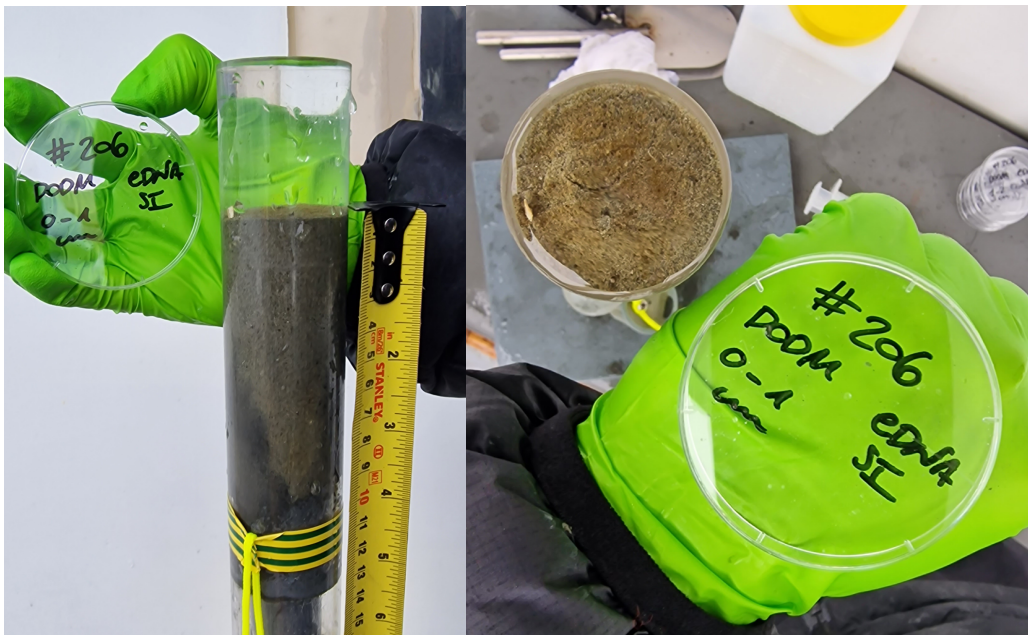


Figure 44: Smaller size perspex cores used to collect sediment for environmental variables and eDNA and stable isotope analysis.

A total of five incubations were run during the whole cruise.
Upon retrieval of the sediment cores by divers and depending on the conditions of the sediment within the cores (whether there was a lot of resuspension or not), the cores were placed in a thermostatic bath and the sediment was left to settle for a few hours/overnight. The thermostatic bath was controlled by an external chiller (LAUDA) provided of an external sensor which was continuously measuring the temperature in the bath and adjusting the chiller inner batch temperature to compensate for changes. The temperature for each incubation was set at the same sea water temperature measured in situ during the dive with a margin of error due to the chiller activity of +/-0.5°C.

Incubations were ran for twelve or more hours depending on the rate of oxygen consumption. Cores were sealed off airtight by a lid equipped with a stirrer to homogenize the overlying water column, a FireSting optode (PyroScience) to measure the change of the dissolved oxygen concentration over time and a sampling port to retrieve water samples.

At the start and ending of each incubation, water samples were taken for nutrient (nitrite, nitrate, ammonia and phosphate), dissolved inorganic carbon (DIC), alkalinity, methane and nitrous oxide. Nutrient and DIC samples were taken during the course of the incubation. Night conditions were created by covering the bath and the rate of respiration was measured during a minimum of six hours depending on the oxygen uptake rate. The same measurements were conducted in light conditions to measure potential oxygen production. The *in situ* brightness had been recorded using HOBO loggers (Scaled Instruments) during the retrieval of the sediment cores and the in situ light intensity within the cores during incubation was mimicked using lamps.

Figure 45: Incubation setup with three cores submerged in the thermostatic bath with the airtight lids operating the stirrer and hosting the optodes ports (green) and the water sampling ports (red).

After finishing each incubation, porewater samples for nutrient concentrations were taken by inserting Rhizon filters at 1 cm sediment depth intervals. Additionally, every 2 cm interval, samples were taken for DIC analysis. The cores were finally sieved to collect the present macrofauna and later adjust the measurements in light of the macrofauna present.

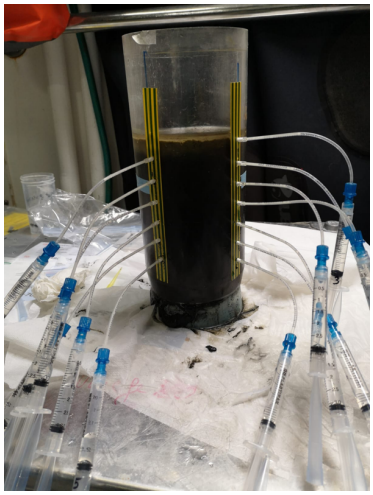
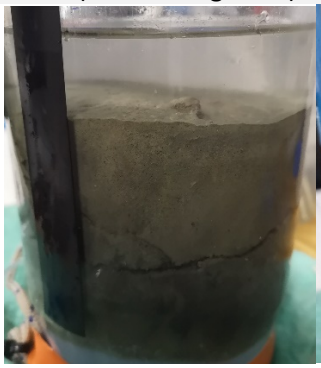
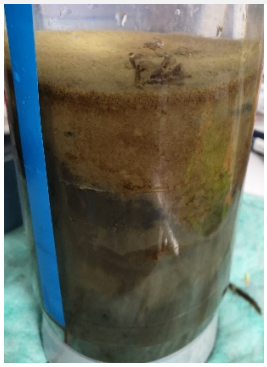


Figure 46 Incubation core with the pore water rhizon extraction ongoing.

Table 8: Illustration of the cores used for incubations

	Pool 1 (2nd incubation) (closest to glacier)	*Pool 3 (1st incubation)*	*Pool 4 (3rd incubation)*
Dodman Island			
	Highly concentrated MPB present at sediment surface. Top 5 cm sediment consisted of silty, "fluffy" subglacial sediment. Deeper layers characterized of H_2S smell, anoxic, dark appearance.	Top 0.5 – 1 cm, MPB present, oxidized. Deeper layers gravely and much sandier with dark appearance. Strong H_2S smell from 3 to 4 cm sediment depth.	Sandier sediment. Easy to retrieve undisturbed the cores. In the area large presence of *Laternula* of large size and adult age. Pretty oxic up to 8 cm sediment depth. Hypoxic (no H_2S smell) from 8 cm sediment depth onwards.
	Site 2 (Closest to glacier)		Site 1
Blaiklock Island			

One core displayed a gravel layer at 4 cm depth. (Other incubation cores not beyond 4 cm sampled). Only few pathes consisting of sand and thus able to sample. Lots of boulders and pebbles present. Area dominated by ophiura, sea urchins, Trematocarpus, large sponges and filter feeding holothurians. Sediment was not easy to retrieve and sediment got a little disturbed. Nonetheless, oxic across the first 10 cm (info from meiofauna cores).	Top 1 cm to 4 cm layer was oxic. Sandier. Site dominated by large filter feeders and Trematocarpus, lot of sea urchins of small size. Large megafauna community present. Rocky shore, not covered by snow. Very patchy distribution of gravels within the sediment layer, hence impossible core retrieval at some spots, whereas other spots, easy to take core.

Results

Results will be available after analysis. The amount of samples and the storage of the samples generated for the sediment biogeochemistry part are given in Table 9.

Table 9: Overview of samples taken for biogeochemistry during TANGO1 campaign

Material	Container	Total volume (L)	Storage	Analysis
Sediment	15 plastic containers	15	Room temperature, fixed with 8% formalin	Macrobenthos to correct oxygen consumption measurements
Water	142 glass scintillation vials	2.1	4°C fridge, fixed with $HgCl_2$	DIC fluxes
Water	27 small glass exetainers	0.01	4°C fridge, fixed with $HgCl_2$	DIC porewater
Water	142 x plastic scintillation vials	2.8	-20°C freezer	Nutrient fluxes
Water	14 x plastic containers	2.3	-20°C freezer	Back up sample overlying water, collected after incubation
Water	135 x Eppendorf tubes	0.2	-20°C freezer	Nutrient concentration porewater
Sediment	105 x aluminum tins	4	-20°C freezer to be transferred to -80°C	Pigment, TOC, TN, stable isotopes

Sediment	55 x petri dishes	2.5	-20°C freezer	Meiofauna
Sediment	21 x 14 cm diam. Petri dishes	3	-20°C freezer	Pb-210 for sedimentation rate
Sediment	20 x ziplock bags with pre-sieved macrofauna	2	-20°C freezer	Macrofauna community

Perspectives

In the next year the preliminary data generated during the incubations will be quality checked and the setup will be discussed with colleagues at the Ghent Marine Biology Laboratory. The samples for both the incubation measurements, the sediment environmental data, and the stable isotope analysis will be carried out. The results from the field samples will inform priorities for the upcoming campaigns and will help deciding on the feasibility of such detailed and time-consuming measurements aboard of a nimble vessel that was not originally designed to host these types of technically complex, detailed and time-consuming measurements.

Reference

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7. Benthic habitat mapping

Lea Katz, Bruno Danis & Camille Moreau

Context

In the Antarctic Peninsula, the air temperature has increased five times faster than the global average and the Western Antarctic Peninsula (or WAP) is one of the Earth's regions where we observe the most rapid and dramatic environmental changes with appreciable variation in the duration of the sea ice season, extended glacier retreats, ice shelves collapse, warming of the upper water column and changes in local primary production (Turner et al. 2013, Ducklow et al. 2013). As these climatic changes intensify, changes in structure and function of ecosystems are observed and expected to accelerate (Carlini et al. 2009, Pasotti et al. 2015).

Since the responses of natural ecosystems to environmental fluctuations remain poorly understood, this part of the expedition aims to provide a baseline of knowledge on biodiversity of the Western Antarctic Peninsula with a focus on benthic habitats, while attempting to answer the following questions: **(1)** How do benthic communities of the

Western Antarctic Peninsula respond to fine scale environmental heterogeneities and which parameters are discriminant? **(2)** Are there any regional patterns in the benthic community composition of the Western Antarctic Peninsula and can we model benthic distribution at such fine scales? **(3)** Can these fine scale models be extrapolated to larger scales?

At fine scale resolutions, habitat mapping using benthic imagery has emerged recently as a very promising technique to document environmental variables and biodiversity in a quantitative way (Harris & Baker 2020). Traditionally, the recording of underwater footage is handled by divers. The problem with this type of survey is that it often does not generate sufficient data because of time and monetary restrictions, and divers are limited to shallow depths for security reasons, which are prominent in the context of Antarctic expeditions. Using an underwater vehicle (remotely operated or autonomous) can circumvent these issues, while extending the surveys to deeper areas and broader surfaces (Piazza et al. 2020).

Methods

During this first expedition, images of the sea floor were collected using a Remotely Operated Vehicle (ROV). The resulting benthic imagery will be used to characterize and map the studied sites, describe macrobenthic communities, quantify their patchiness, and study spatial distribution of macrobenthic taxa along environmental gradients (sea ice, glacier activity, salinity, temperature, etc.).

The ROV used in this campaign was a BlueROV2 from BlueRobotics. It has one built-in camera, used mainly for navigation, and onboard sensors that capture synchronized data on parameters such as depth, temperature and flight data. It was also equipped with a down-looking GoPro Hero10 (settings : video, linear, 4k), a single-beam sonar (Ping sonar) and a WaterLinked GPS (an acoustic underwater positioning system). In each sampling site, the ROV was flown at constant speed (>1m/s) and altitude (approx. 1m from the bottom or more, depending on the visibility) covering square-shaped areas of 10x10m. For each site, 3 non-overlapping squares were recorded (3 replicates). All square areas were located in the same depth range as the SCUBA diving activities (max 25m), and extra transects were carried out in areas that were inaccessible for the SCUBA divers.

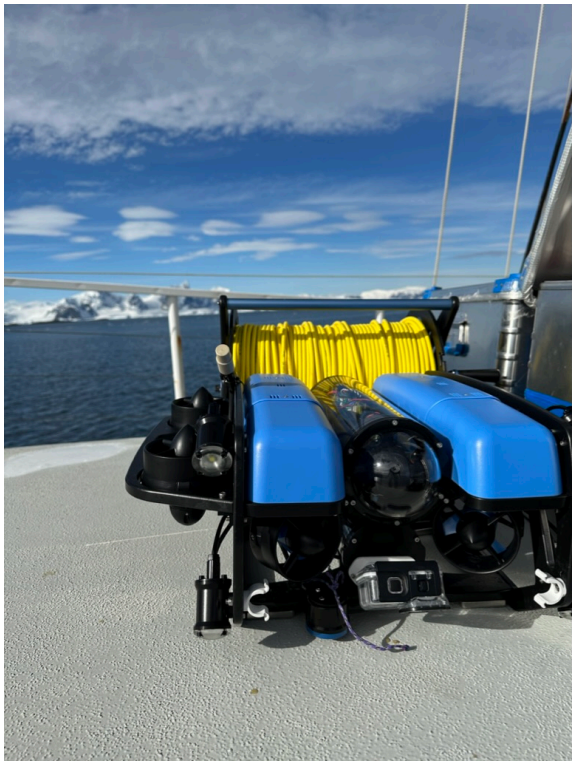

Figure 47: the BlueROV and it 200m tether. The GoPro housing is attached in the front of the ROV and pointing towards the seafloor.

- When deploying the ROV from the *Australis*, the topside control was set up in the wheelhouse, which made flying the ROV possible in all weather conditions. In shallower areas, where the *Australis* could not access, the topside was transferred to the Bombard C4 tender , but in that case, the deployment events were strongly dependent on the weather. Furthermore, the WaterLinked GPS system was not used when the ROV was deployed from the tender, but GPS coordinates (Garmin Oregon 600 GPS) were taken manually at the location of the tender anchoring.

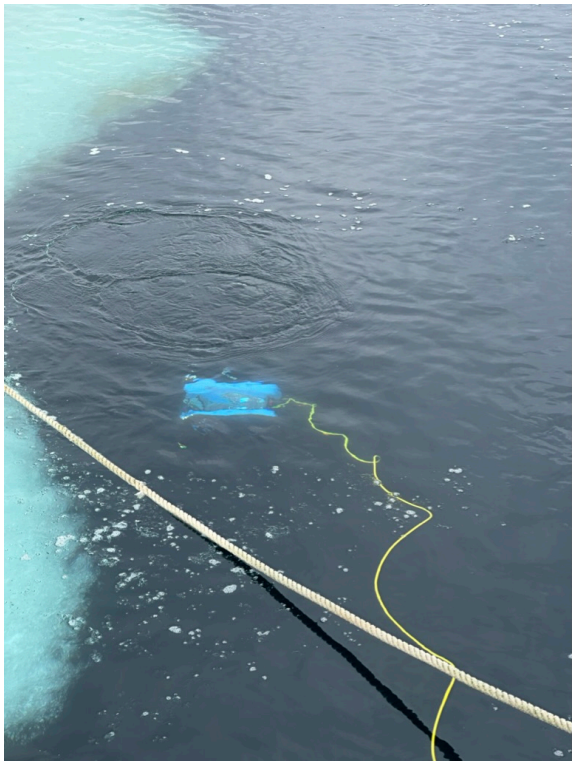

Figure 48: BlueROV preparing for a flight under a drifting icefloe (EVENT_ID: ROV_10).

Figure 49: the BlueROV making its way on the surface, before diving for habitat mapping.

Figure 50: the Australis topside setup to control the BlueROV.

Results

In Dodman Island, our first sampling station, 6 different sites were sampled with a total of 20 recorded squares. When a squared-shaped pattern was not possible (due to currents or floating ice), the site was sampled by transects to document the area nevertheless. In addition, a longer transect was performed to document the deeper area, as it is inaccessible for the SCUBA divers.

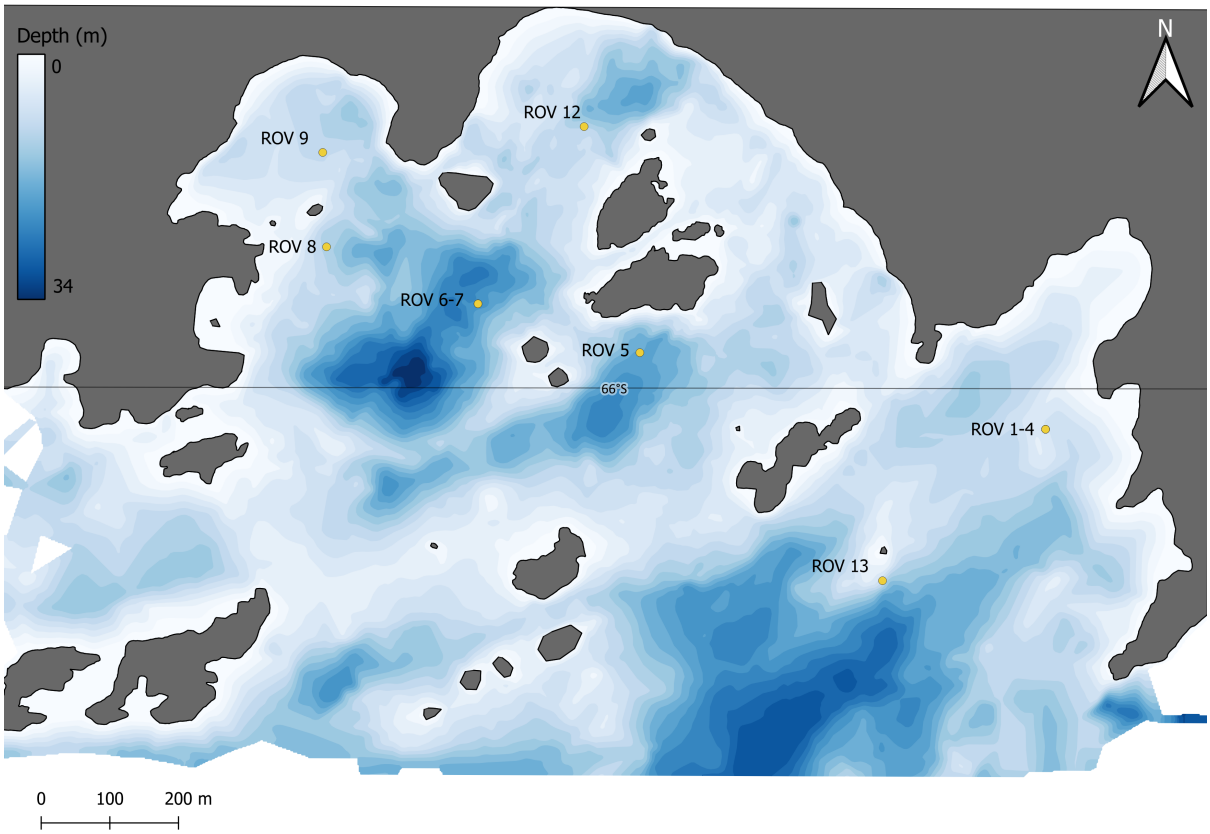

Figure 51 General map of the ROV deployments at Dodman Island

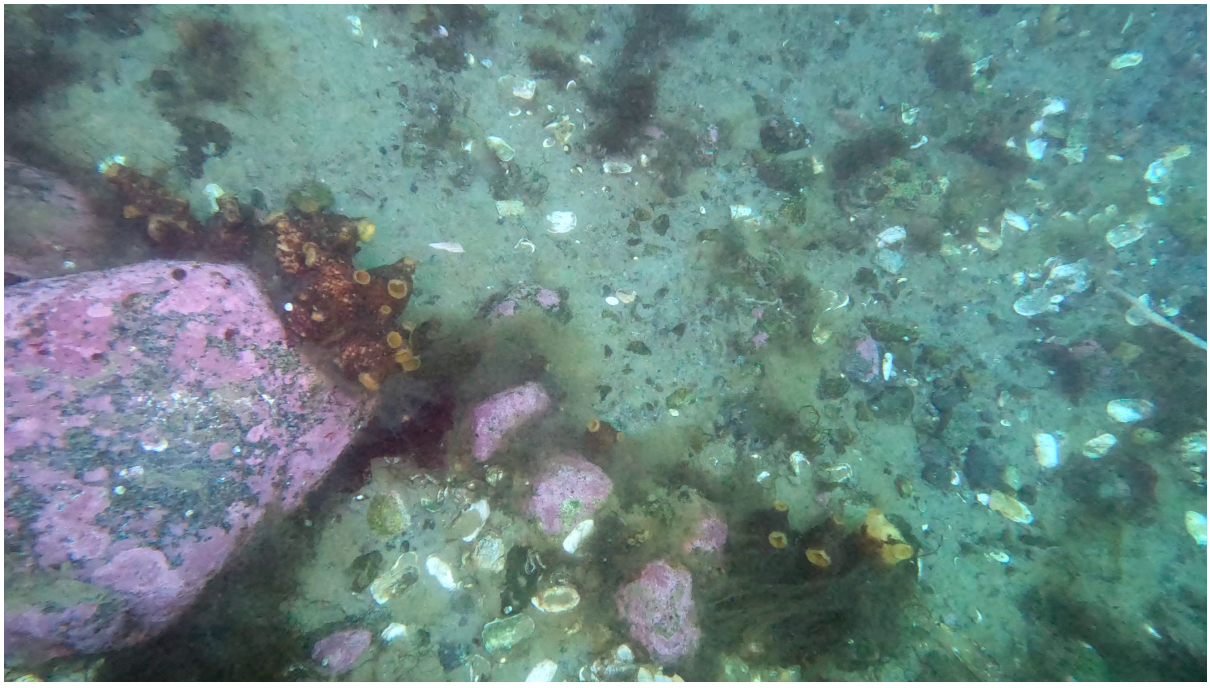

Figure 52: general view of the seafloor in Dodman Island (depth: 25m)

Figure 53: Macroalgae forest general view in Dodman Island (depth: 20m)

Figure 54: general view of the seafloor in Dodman Island, next to the glacier (depth: 18m)

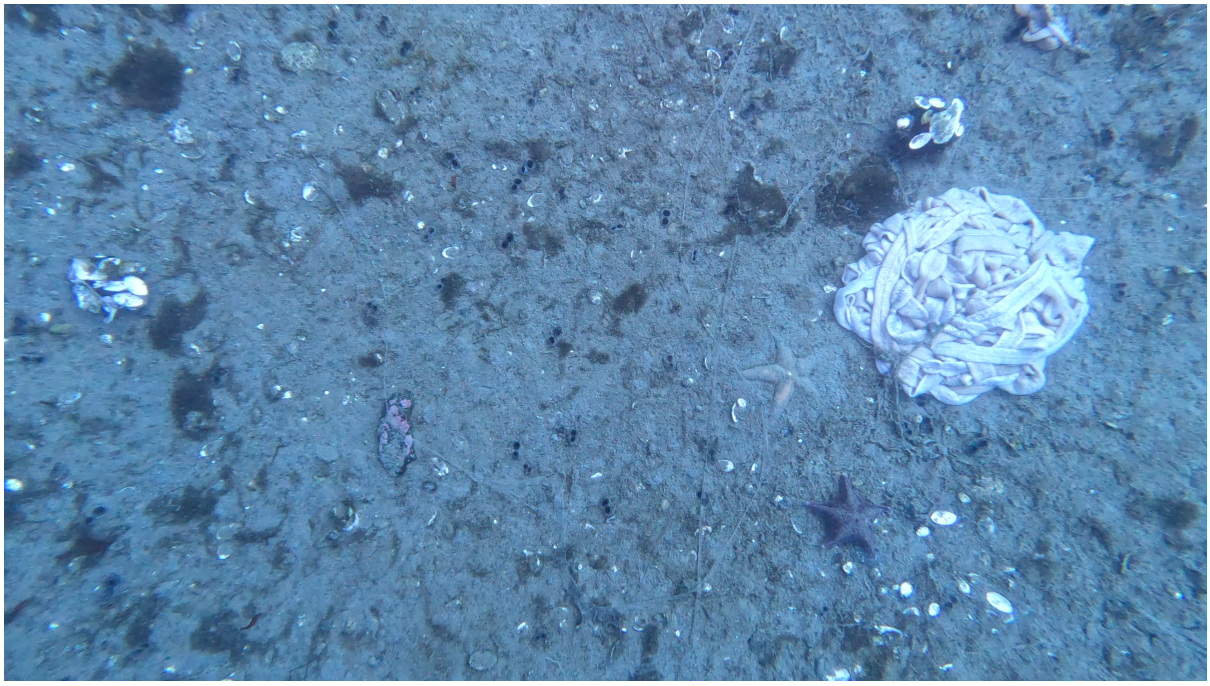

Figure 55: general view of the seafloor in Dodman Island (depth: 20m)

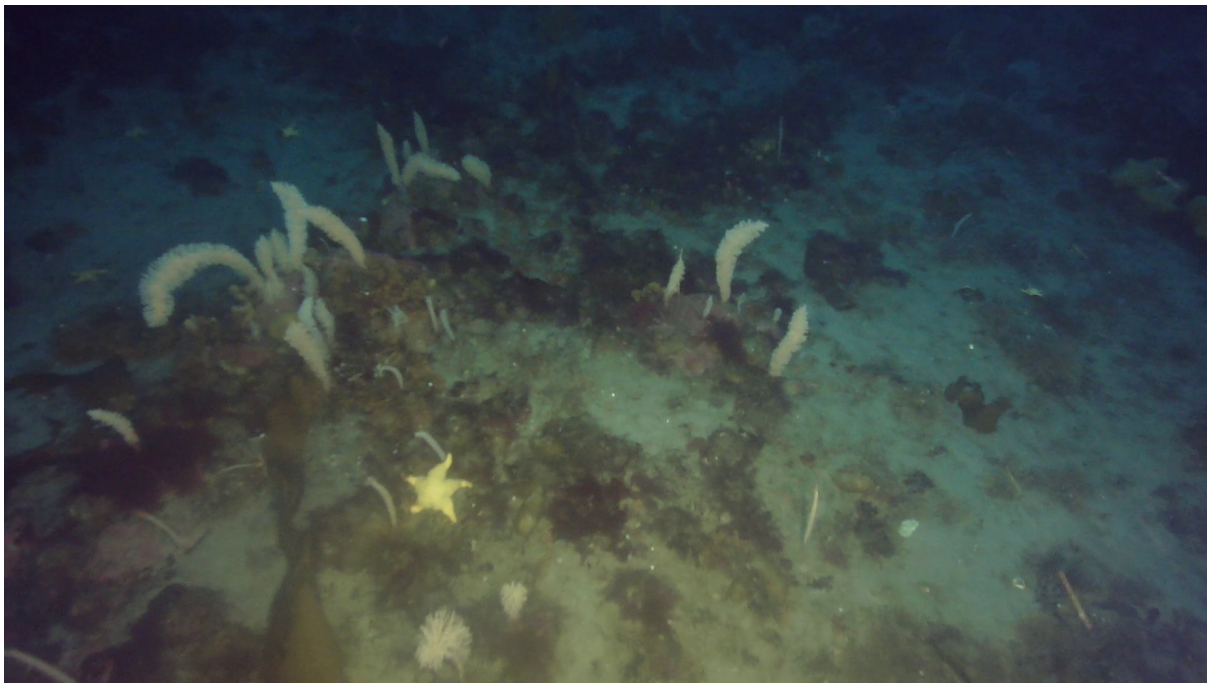

Figure 56: general view of the seafloor in Dodman Island (depth: 60 m)

In Blaiklock Island, our second sampling station, 3 contrasting sites were sampled as well as 3 sub-locations in one of the sites to characterize small scale heterogeneity. In total, 12 squares and 2 transects were sampled.

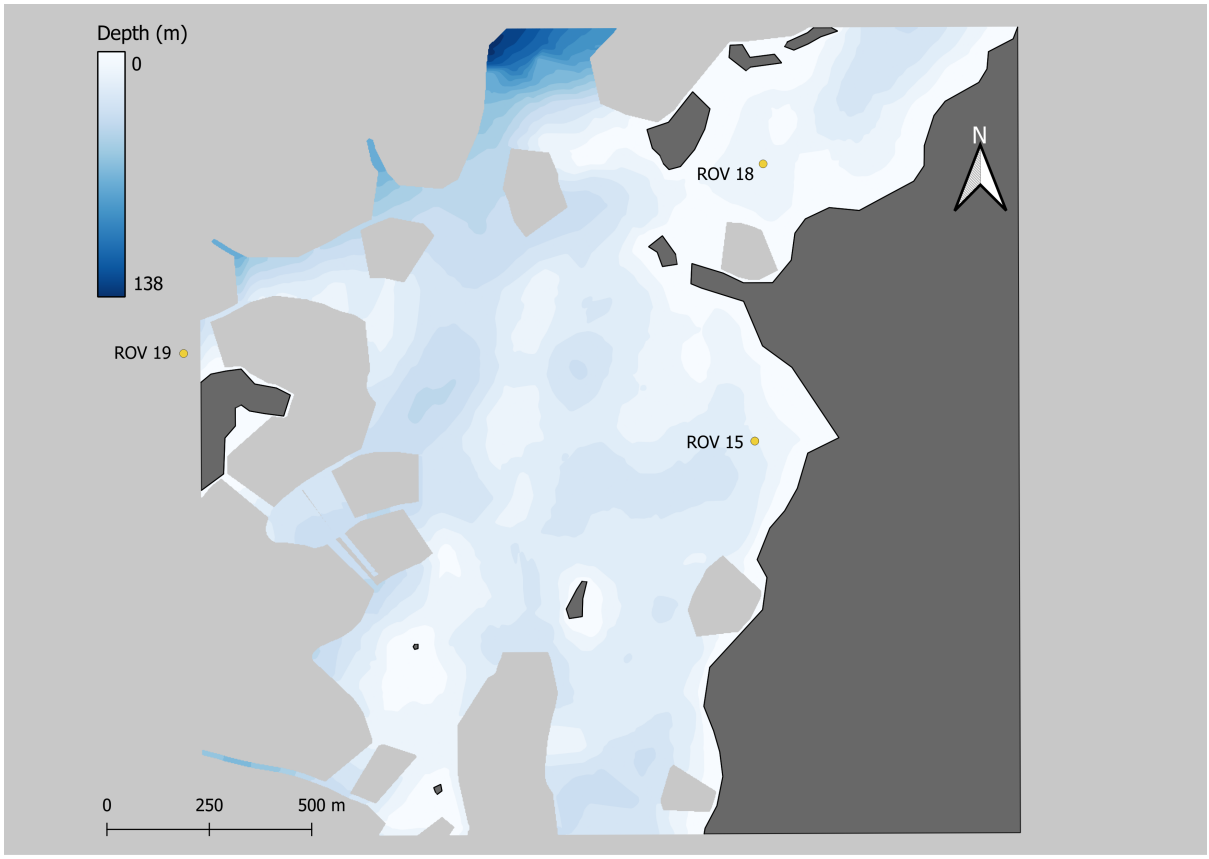

Figure 57 ROV deployment in site 1 of Blaiklock Island

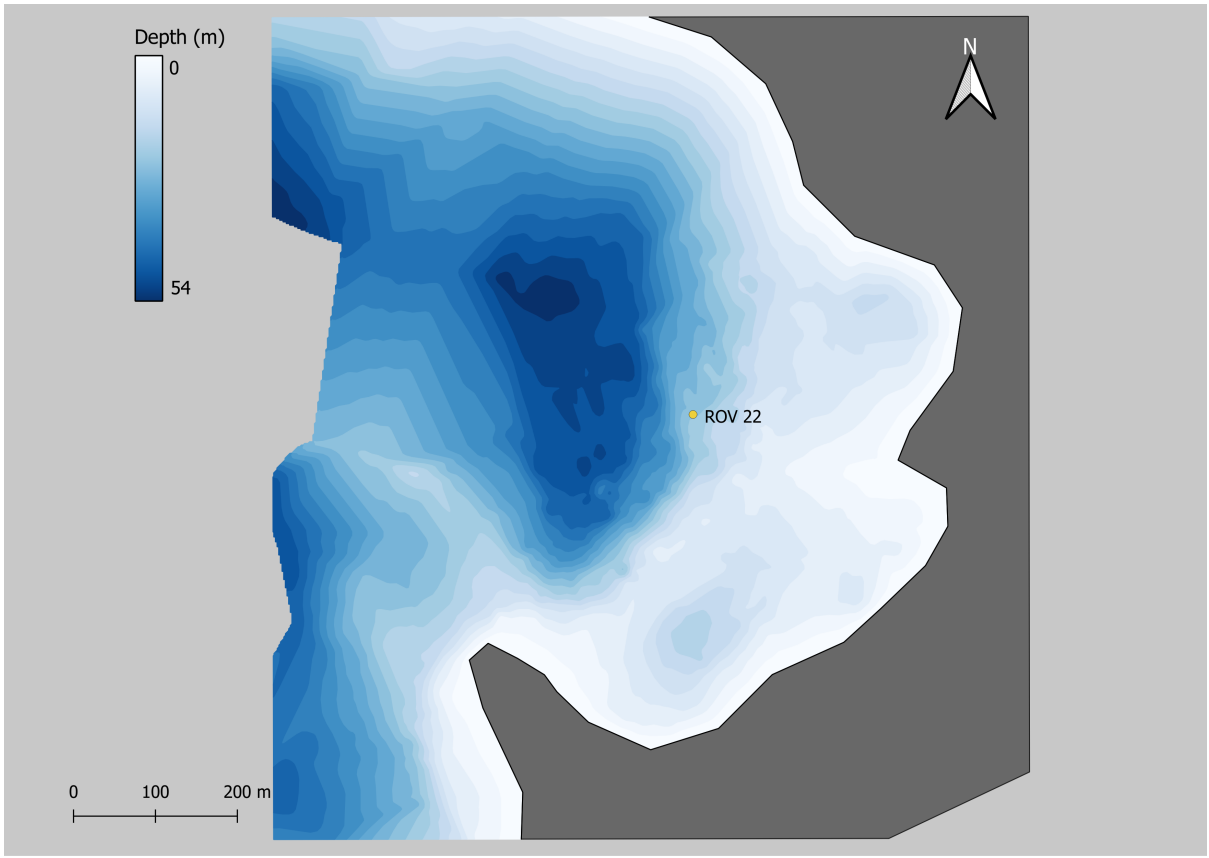

Figure 58 ROV deployment in site 2 of Blaiklock Island

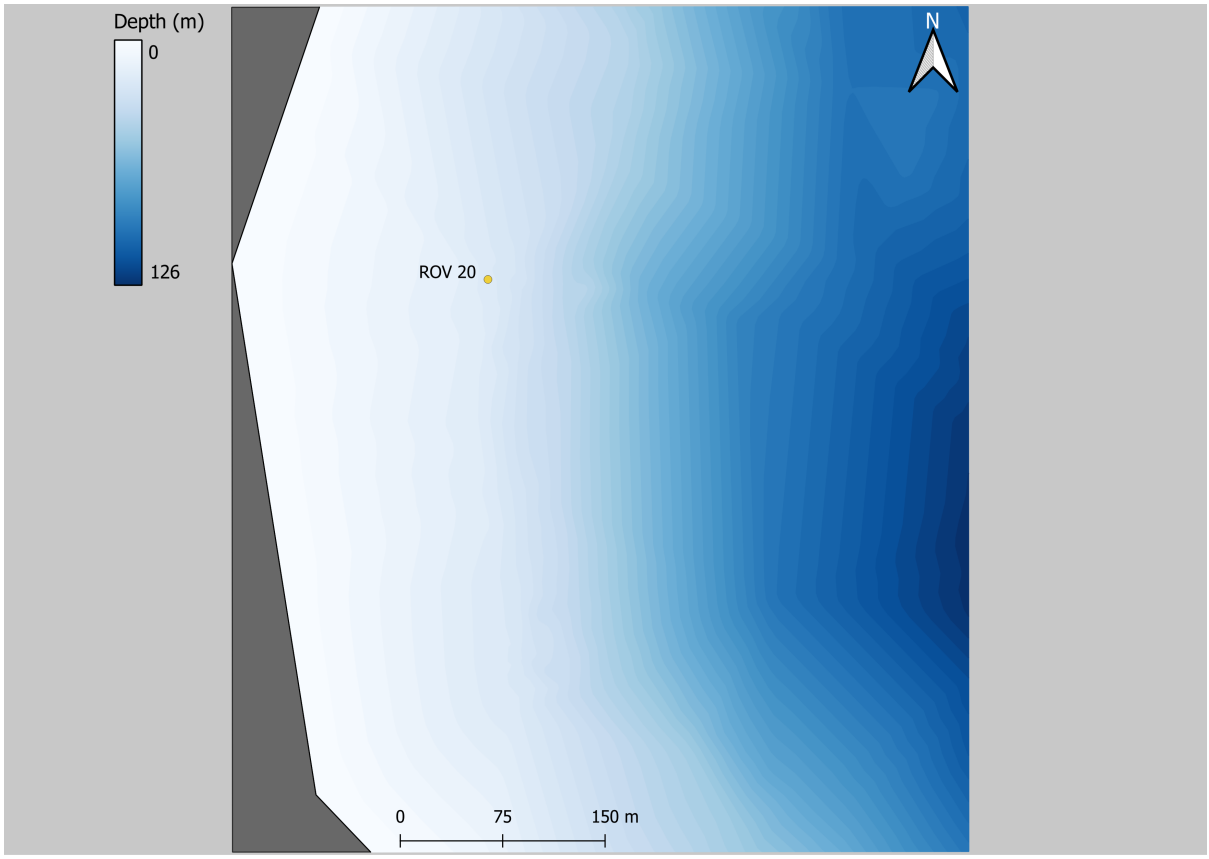

Figure 59 ROV deployment in site 3 of Blaiklock Island

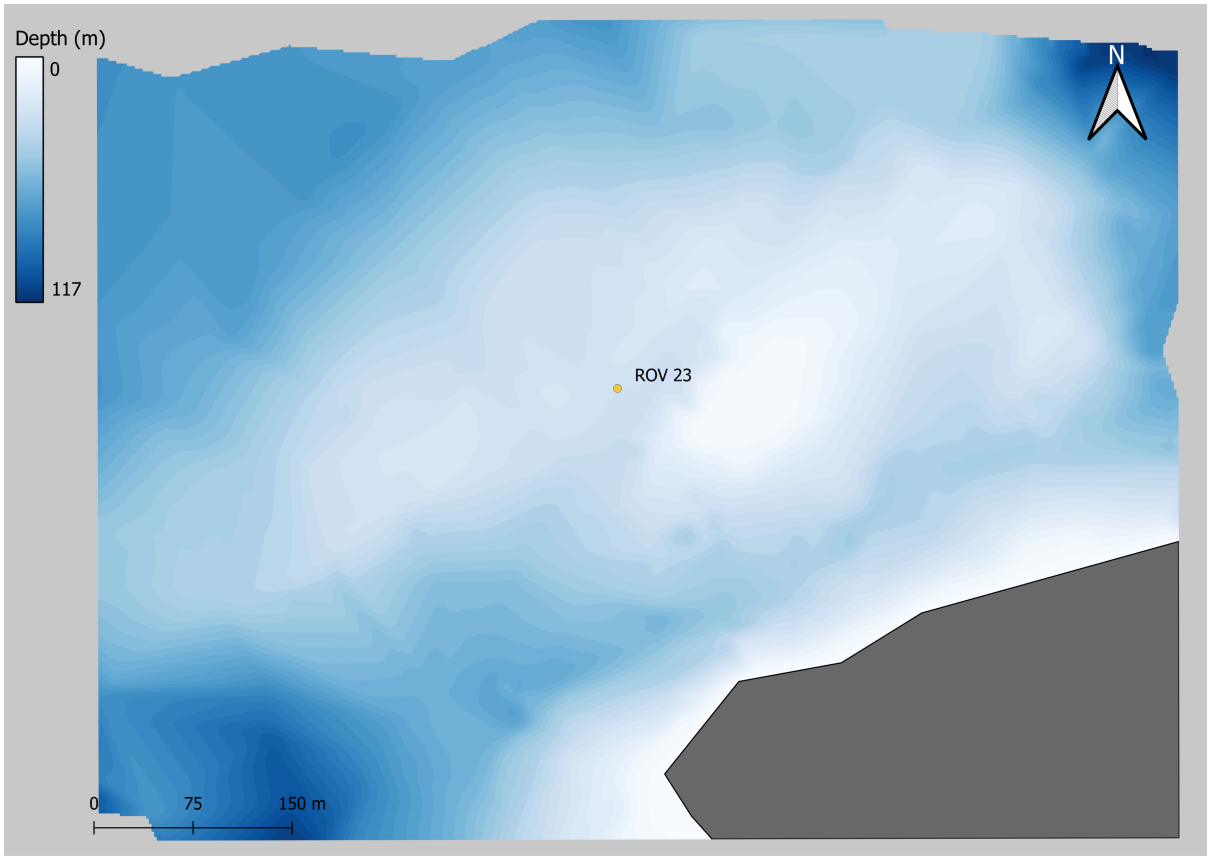

Figure 60 ROV deployment in site 4 of Blaiklock Island

Figure 61: Porifera on the seafloor in Blaiklock Island, Site 2 (depth: 20m)

Figure 62: general view of the seafloor in Blaiklock Island (Site 1B) (depth: 20 m)

Perspectives

Back in the Laboratory, the images will be used to create photomosaics of each square-shaped area and each organism will be identified and marked up.

For each site, we will characterize the community by calculating biodiversity (α and β), evenness/dissimilarity indices (Species Richness, Shannon-Wiener, Simpson) and functional diversity (Functional Dispersion, Rao's Quadriatic Entropy). Then, to compare our results between sites, we will use multivariable correlative approaches (such as a Canonical Correspondence Analysis and NMDS analyses).

For characterizing how benthic communities respond to environmental heterogeneities, we will perform Spatial Point Process Analyses (SPPA). To build predictive models, and investigate

the drivers of ecosystem responses to their changing environment, we will use Bayesian Network Inference (BNI) analysis.

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8. Macro- and megabenthos diversity

Henri Robert ,Camille Moreau, Martin Dogniez

Context

Polar regions temperature averages are observed to raise faster than anywhere else on the planet. The western part of the Antarctic Peninsula is certainly where this phenomenon is the most striking causing nearly 90% of all glaciers to retreat and melting of about 28 000 km² of floating ice shelves (36). Large areas, formerly ice covered since the last glaciation period recently emerged around islands and shallow waters providing suitable habitat for flora and fauna colonization resulting in increasing coastal productivity (35).
During the TANGO 01 expedition, selected areas presenting these characteristics were intensively surveyed from the intertidal zone to a depth of 25 meters (with occasional sampling at 50 to 60 meters with Amphipod Traps and ROV observations). Specimen and abiotic data collected during this expedition represent the first bits of knowledge about the colonizing benthic communities and a “T-zero” for a long-term biodiversity survey.

Methods

- Intertidal zones were visited…

- Baited “amphipod trap” (AT) are used to capture scavenging communities present in the area. The “home made” type of trap used during the expedition are composed of a coarse plastic mesh for protection of a 500µ fine mesh rolled around two rings of PVC pipes to produce a cylinder of 15x40 cm. Both end of the trap is equipped with a funnel with a 2 cm opening directed inward to prevent organisms to escape after penetrating the trap. The bait used consist of fresh mackerel tied inside the trap and squid enveloped is a fine mesh 15x15 cm “tea bag” for better attraction and inaccessibility of the organisms. Traps are deployed in pairs, secured together with a metal frame (see Figure 63). A 5 kg ballast weight is used to anchor the traps at 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 36 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.

Five AT event were performed during the expedition (see details on Table 10).

- At **Dodman** Island the first deployment was performed in the center of the main "pool" at a depth of about 22 meters. The second one was deployed outside the shallow working area at a depth of 40 meters to detect any community change at greater depth in a sort of a canyon leading to the main study area. The third deployment was deployed at 60 meters on a deeper plateau located at the vicinity of the second site of deployment outside of the main study area (Figure 64).
- At **Blaiklock** Island two deployments were performed at comparable depth of 20 meters at location 1 and 2. Location 3 was visited essentially for ice work with not enough time length on site for a suitable deployment and recovery (Figure 65, Figure 66).

Table 10: Location, depth and time of all Amphipod trap (AT) deployments.

EventID	Event Date	Time start (UTC-3)	Time end (UTC-3)	Latitude start	Longitude start	Latitude end	Longitude end	Station Name	Minimum depth (m)	Maximum depth (m)
AT_1	20/02/23	10:10		-66,001	-65,7875	0	0	Dodman Island		21
AT_1	21/02/23		16:30	0	0	-66,0014	-65,7875	Dodman Island		21
AT_2	24/02/23	12:00		-66,009	-65,7793	0	0	Dodman Island		50
AT_2	25/02/23		07:30	0	0	-66,0087	-65,7793	Dodman Island		50
AT_3	26/02/23	11:30		-66,01	-65,7717	0	0	Dodman Island		60
AT_3	27/02/23		17:00	0	0	-66,0096	-65,7717	Dodman Island		60
AT_4	2/03/23	13:00		-67,554	-67,2191	0	0	Blaiklock Island		24
AT_4	4/03/23		08:30	0	0	-67,5537	-67,2191	Blaiklock Island		24
AT_5	5/03/23	18:30		-67,515	-67,0996	0	0	Blaiklock Island		23
AT_5	7/03/23		09:30	0	0	-67,515	-67,0996	Blaiklock Island		23

Figure 63: Baited amphipod trap composed of coarse plastic mesh for protection doubled by 500µ fine mesh. Both sides of the cylinder are equipped with a funnel to capture organisms into the trap

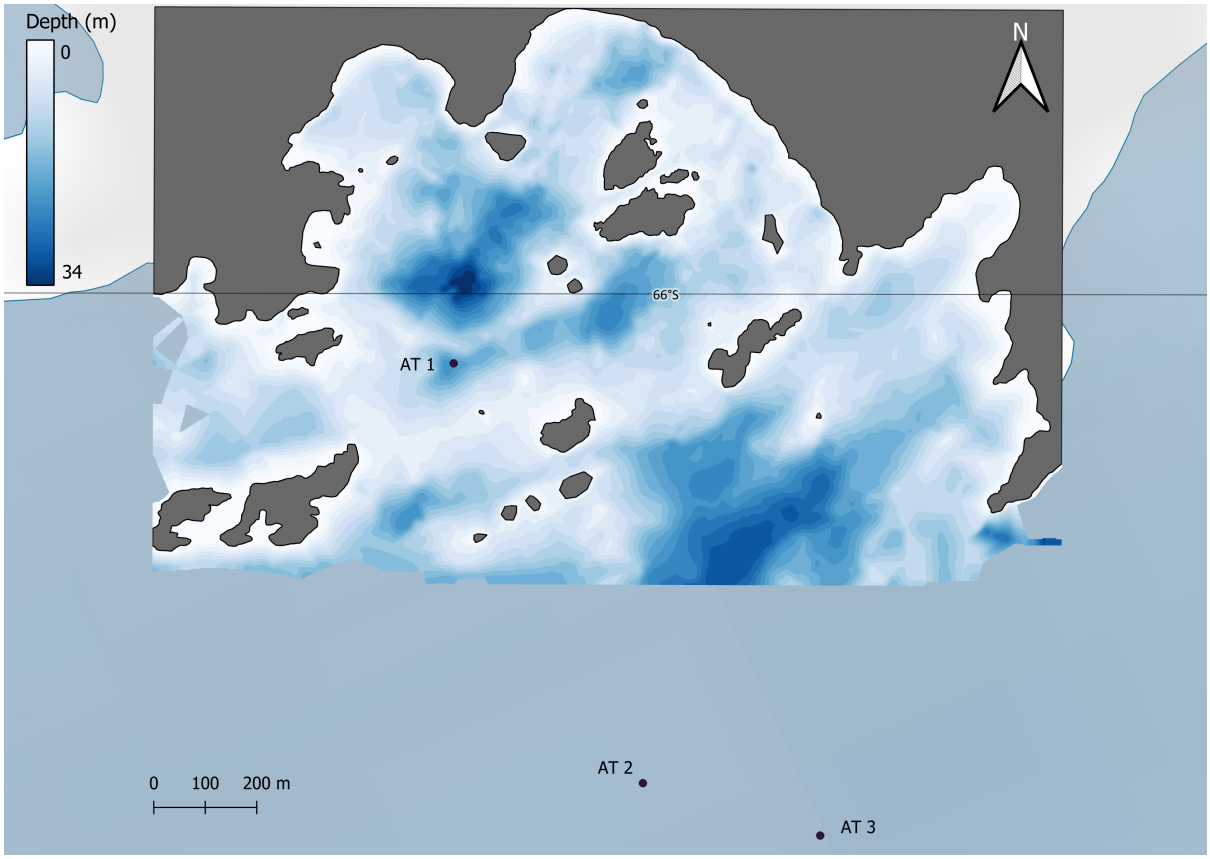

Figure 64: position of AT01, AT02, AT03 events performed at Dodman Island

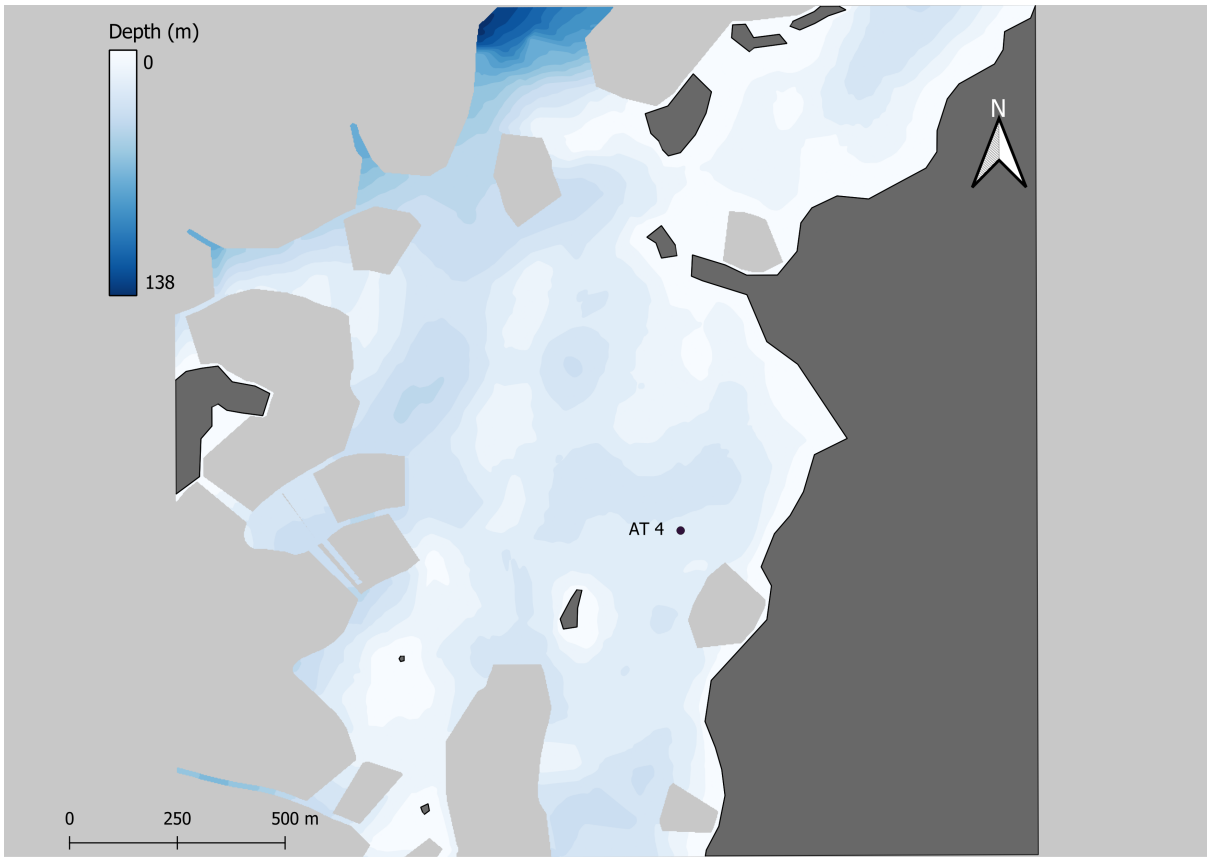

Figure 65 Localisation of AT04 deployment at site 1 at Blaiklock Island

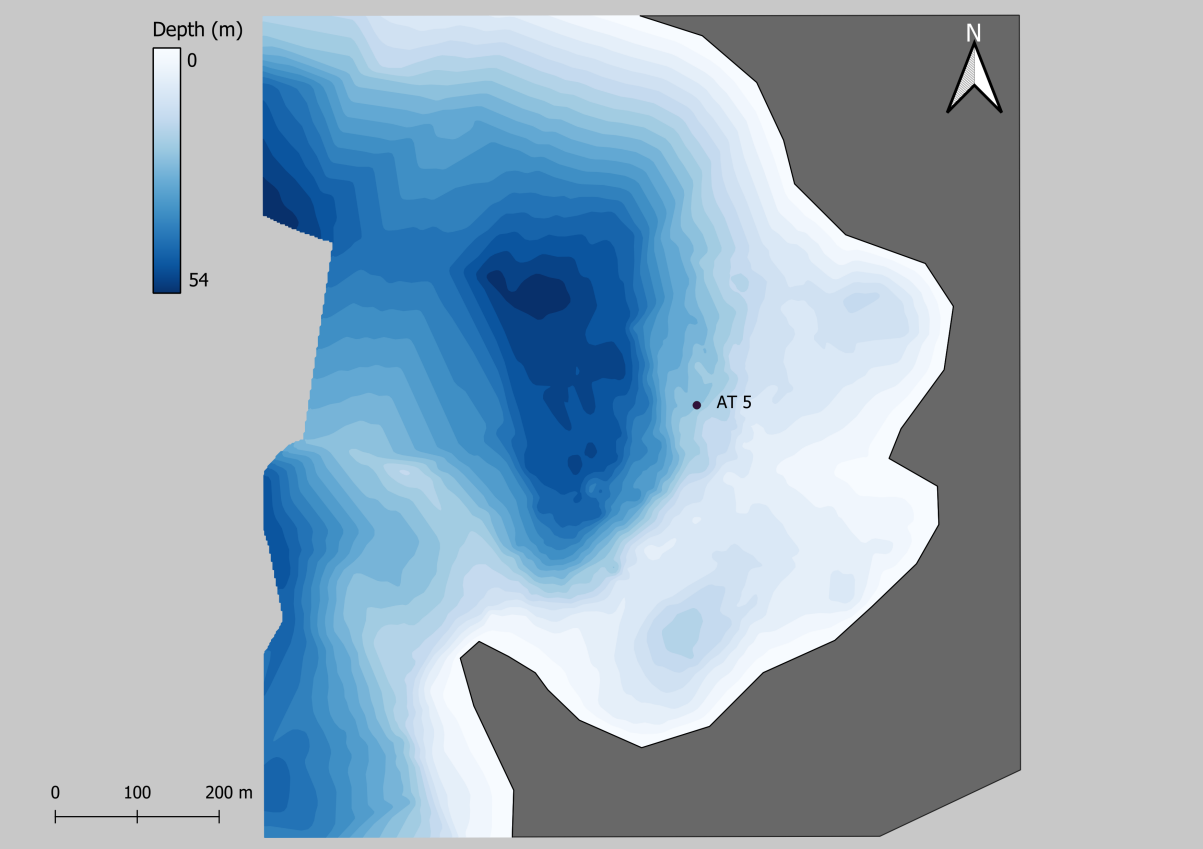

Figure 66 Localisation of AT05 deployment at site 2 at Blaiklock Island

- Samples of the general macro-benthic communities of each working area were collected using a **"Rauschert" dredge (RD)**. 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 20 cm on front of the exit of the frame. At the bottom of the dredge a large 50x70x20 cm bag of 500µ 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 67). 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 67: The Rauschert Dredge composed of a sledge-like metal frame drags the collecting megabenthic communities mesh bag (protected by rubber carpets) on the sea floor.

Table 11: location, coordinate, depth and time of all Amphipod trap (AT) deployments.

EventID	Event Date	Time start (UTC-3)	Time end (UTC-3)	Latitude start	Longitude start	Latitude end	Longitude end	Station Name	Minimum depth (m)	Maximum depth (m)
RD_01	19/02/23	10:30	11:00	-66,003	-65,774	-66,0038	-65,7769	Dodman Island	18	22
RD_02	19/02/23	16:30	17:00	-66,002	-65,7753	-66,003	-65,7775	Dodman Island	18	22
RD_03	20/02/23	17:30	17:45	-66,001	-65,787	-65,9991	-65,7862	Dodman Island	18	
RD_04	21/02/23	11:00	11:20	-66,004	-65,7702	-65,7692	-65,7692	Dodman Island	21,6	15
RD_05	21/02/23	14:30	14:50	-66,005	-65,7777	-66,7781	-66,7781	Dodman Island	23	20
RD_06	22/02/23	10:30	10:50	-66,997	-65,7811	-65,9962	-65,7773	Dodman Island	10,5	12
RD_07	22/02/23	18:00	18:30	-66,999	-65,7748	-66,0002	-65,7767	Dodman Island	10	11
RD_08	23/02/23	15:30	15:50	-66,008	-65,7755	-66,007	-65,7762	Dodman Island	38	58
RD_09	24/02/23	16:30	16:50	-65,998	-65,7885	-65,9992	-65,9992	Dodman Island	8	15
RD_10	26/02/23	14:00	14:20	-66,003	-65,7989	-66,003	-65,7966	Dodman Island	11	12
RD_11	27/02/23	14:30	14:50	-66	-65,7902	-66,0011	-65,7888	Dodman Island	9	12
RD_12	2/03/23	08:30	08:40	-67,552	-67,2215	-67,5504	-67,2238	Blaiklock Island	15*	20*
RD_13	2/03/23	13:30	13:50	-67,551	-67,2289	-67,5499	-67,2285	Blaiklock Island	15*	20*
RD_14	2/03/23	13:50	14:10	-67,55	-67,2293	-67,5488	-67,2268	Blaiklock Island	15*	20*
RD_15	3/03/23	11:00	11:20	-67,558	-67,2273	-67,5591	-67,2253	Blaiklock Island	15*	20*
RD_16	3/03/23	17:00	17:20	-67,557	-67,235	-67,5576	-67,2374	Blaiklock Island	28	34
RD_17	4/03/23	14:30	15:00	-67,55	-67,2476	-67,5504	-67,2467	Blaiklock Island	5	25
RD_18	5/03/23	14:30	14:50	-67,506	-67,0517	-67,5053	-67,052	Blaiklock Island		18
RD_19	6/03/23	08:40	09:00	-67,517	-67,1017	-67,5161	-67,1002	Blaiklock Island		14
RD_20	6/03/23	15:00	15:20	-67,515	-67,0987	-67,5137	-67,1151	Blaiklock Island		18
RD_21	7/03/23	18:00	18:20	-67,545	-67,21	-67,5454	-67,2137	Blaiklock Island		8

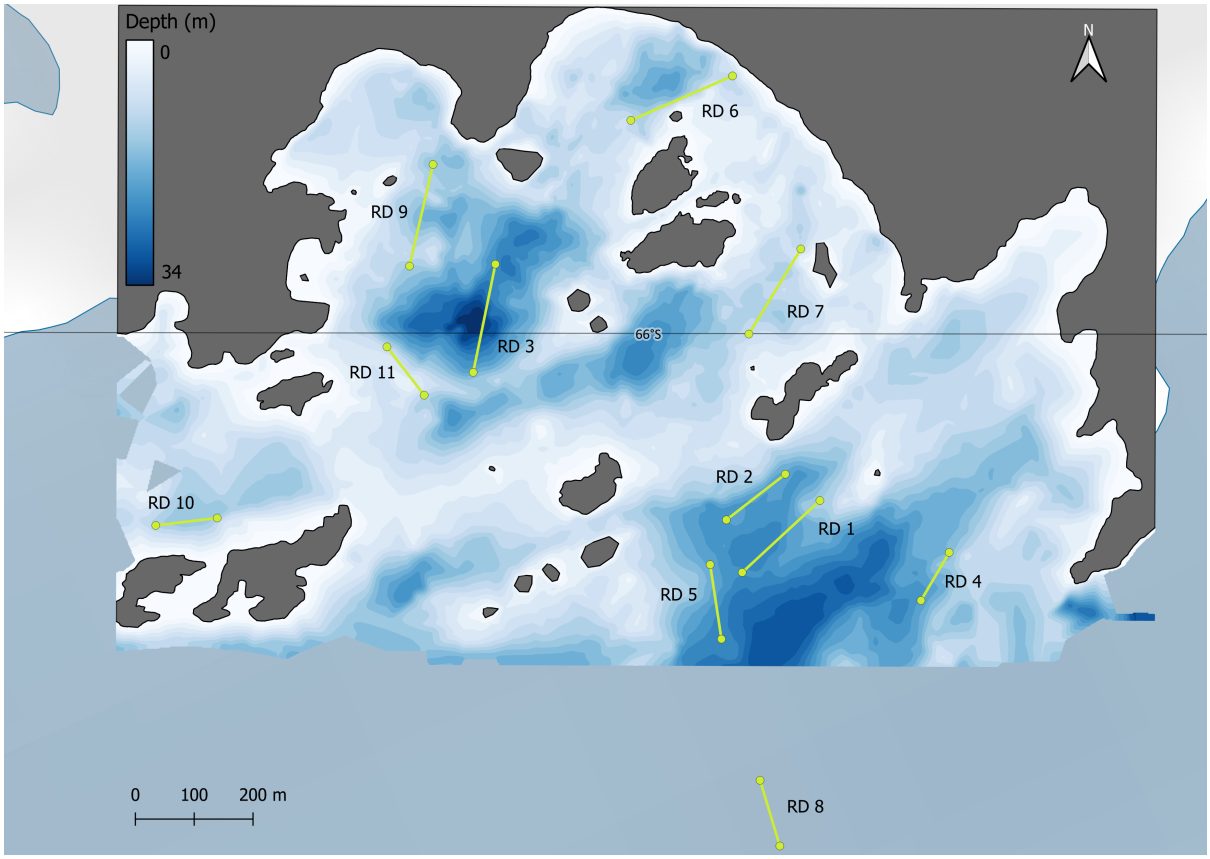

Figure 68: Rauschert Dredge deployments at Dodman Island

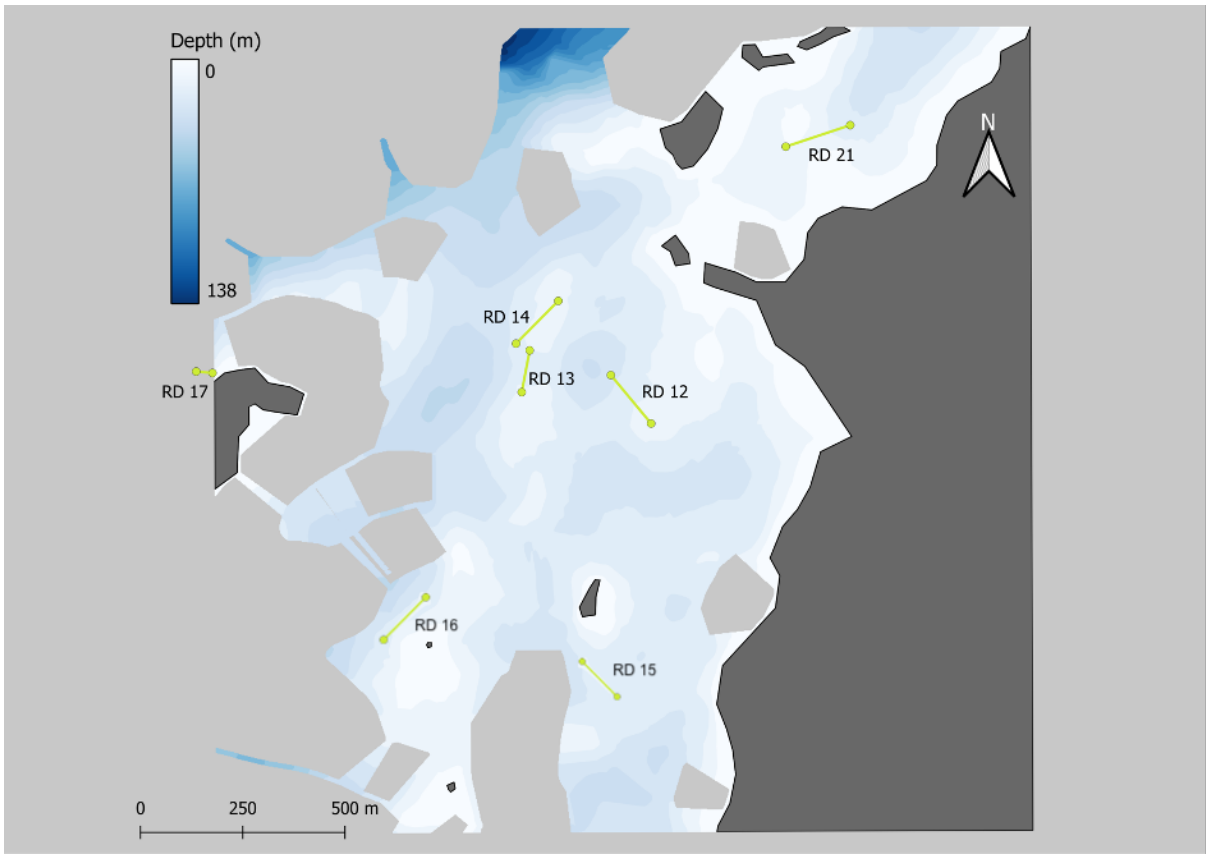

Figure 69 Rauschert Dredge deployments at site 1 at Blaiklock Island

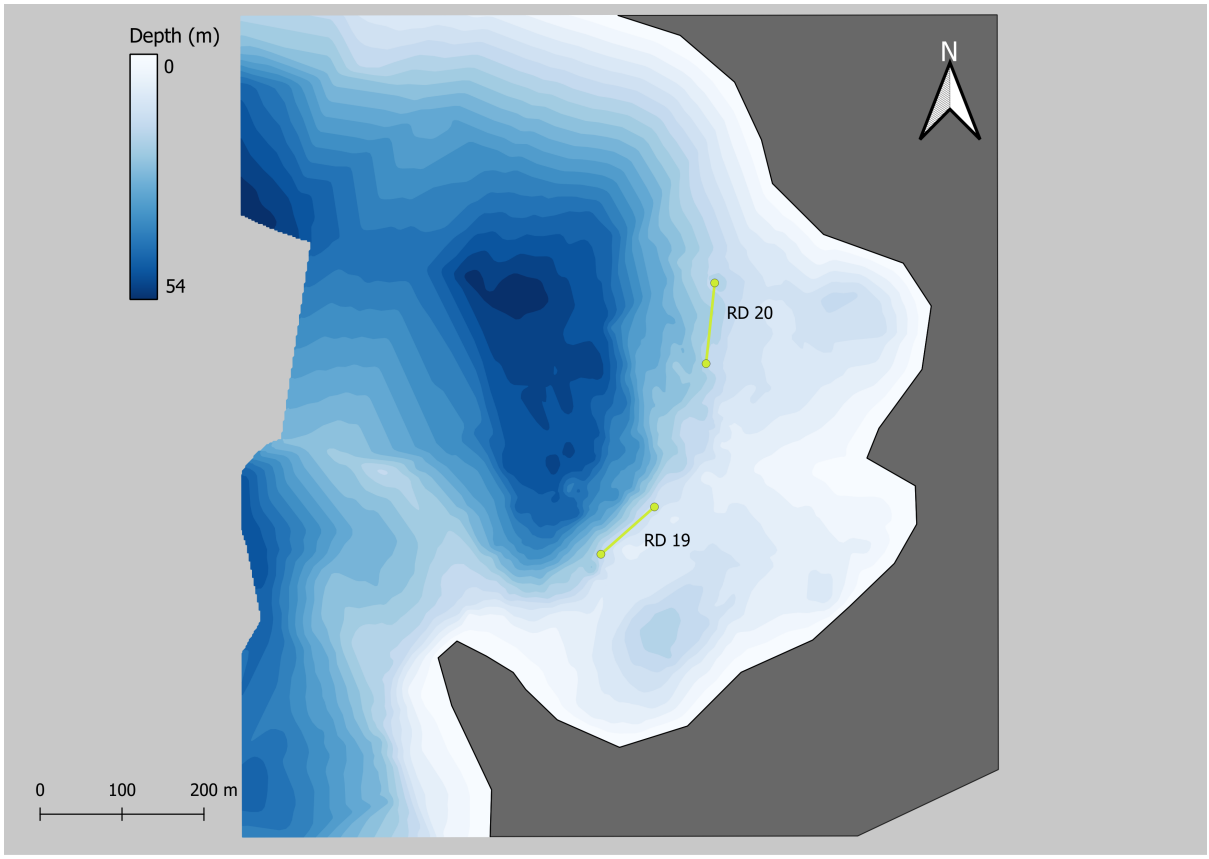

Figure 70 Rauschert Dredge deployments at site 2 at Blaiklock Island

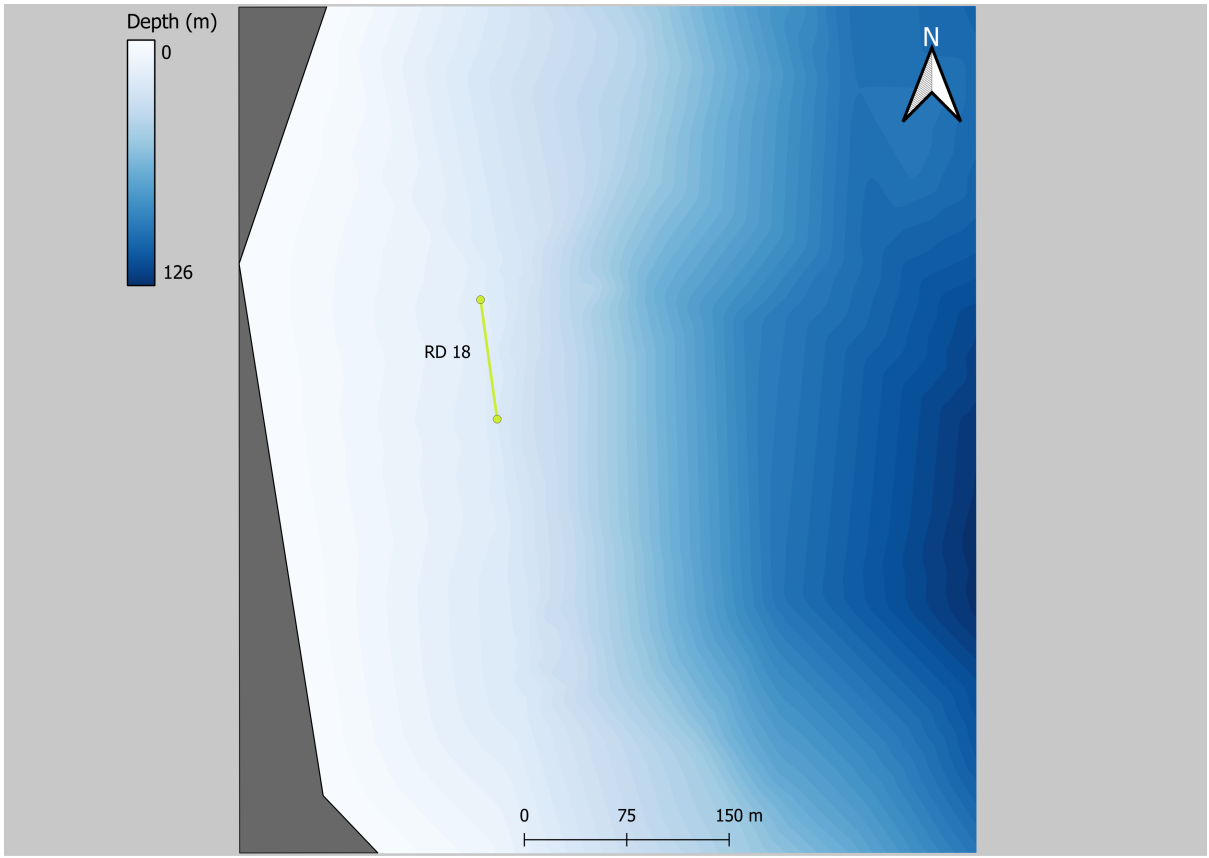

Figure 71 Rauschert Dredge deployments at site 3 at Blaiklock Island

Results and perspectives

All sample collected in the different events of RD and the AT have been partially sorted on board of Australis during the expedition. Representants of the major taxa present in the catch were isolated and counted whenever time and space were available. In the case where large number of the same species was caught in the gear, depending on necessity and/or relevance, a dominant portion was released alive in the environment (see Table 11). This occurred for species such as *Sterechinus neumayeri*, *Ophionotus victoriae* and scavenging amphipods. As agreed during the preparation of the expedition, all sorted taxa and unsorted subsamples were fixed in ethanol to be processed further thoroughly in the lab by master or PhD thesis students.

Notes on the different amphipod trap catches at the different locations (see Table 11):

- **AT1** was located at 20 m in a sheltered pool on front of an active glacier of **Dodman Island**. The species present were representative of a usual AT catch with a very large amount of scavenging amphipod feeding on the bait, being the dominant taxa attracted.
- **AT2** was located slightly outside the shallow working area of **Dodman Island** at a depth of 40 meters in a canyon-like structure in contact with the main Grandidier channel. Although the catch was not as important as the previous one, diversity increased compared to AT1 with several scavenging taxa encountered in amphipod but also in isopod with the appearance of the *Natatolana* genus.
- **AT3** was located at the vicinity of the AT2 canyon (**Dodman Island**), on a deeper plateau at 60 meters depth. Unusually, 3 unidentified sea stars were caught along with 10 individuals of Krill (*Euphausia superba*). A fair amount of amphipod and again the *Natatolana* (one individual) scavenger were present.
- **AT4** and **AT5** deployed at site 1 and 2 in the vicinity of **Blaiklock Island** at comparable depth of 20 meters. Both catches did not count many amphipod or isopod scavengers (36 and 18 individual respectively). Instead, unusually, taxa such as ophiuroids, asteroids and echinoids (*Sterechinus neumayeri* only) were well represented at both stations.

Table 12: Amphipod trap sampling preliminary data

Area	Deployment #	Sorted taxa	Total number of individuals
Dodamn Isl.	1	Amphipoda sp.	~5000 (= 1 L; 3 L released)
Dodamn Isl.	2	Amphipoda sp.	~500
		Natatolana sp.	9
		Lysianassoidea sp.	10
		Charcotia obesa	5
Dodamn Isl.	3	Asteroidea sp.	2
		Amphipoda mix.	>500
		Euphausia superba	10
		Natatolana sp.	1
Blaiklock Isl.	4	Sterechinus neumayeri	4 (12 released)
		Ophiuroids sp.	3 (27 released)
		Amphipoda mix.	33
		Isopoda mix	18
		Gasteropods mix.	3
		Polychaetes sp.	1

Blaiklock Isl.	5	Ophiuroids sp. Asteroids sp. Sterechinus neumayeri Amphipoda mix.	3 3 1 3
Total Dodman	**3**	**6**	**>6037 (3 L released)**
Total Blaiklock	**2**	**6**	**72 (39 released)**

Figure 72: Example of specimen caught in the amphipod trap (AT4) at the vicinity of Blaiklock Island (area 1). Top row: a general view of the unusually caught Ophionotus victoria (on the top left) and a general view of the catch in the sorting tray (top right). Bottom row: subsample of Sterechinus neumayeri, mix of amphipod and isopod species caught in the AT.

9. Top Predators census (TOPP)

Henri Robert

Context

The main objectives of the continuous top predator 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 species distribution patterns is therefore of high relevance and interest to identify and localize areas of high biological productivity, and potential target zones for conservation.

Of several abiotic environmental factors, salinity and water temperature were identified as the most influential for bird distribution (Longhurst, 2007). 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. Based on these considerations, the transects, conducted during the Tango expedition can be clustered into 3 main zones: Magellanic area, Drake passage, and Antarctic Peninsula.

Further research should indicate if there are clear correlations with oceanographic and biological parameters, such as water quality parameters, seafloor topography, plankton blooms, crustaceans or fish concentrations. This knowledge can then be used for the mapping of ecologically important or vulnerable areas, identification of areas of higher value for conservation and assess the effects of climate change on local populations.

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 600 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 must be stopped 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

Species encountered in the Magellanic area, Drake Passage, Dodman Island, Blaiklock Island and along the Antarctic Peninsula are enumerated hereunder with preliminary considerations. Overall, most species expected to be seen were observed during this voyage at the exception of the Antarctic Petrel (*Thalassoica antarctica*) for which not a single individual was found, which is rather unusual especially in the Bransfield Strait and South Shetland Island. Killer Whale (*Orcinus orca s.l.*) despite our intensive search remained equally out of sight during this expedition.

1- BIRDS

Diomedeidae

- Wandering Albatross (*Diomedea exulans exulans*): common in the open waters of Drake passage
- Southern Royal albatross (Diomedea epomophora): two individuals observed at the southern edge of the Patagonian continental slope
- Black-browed Albatross (*Thalassarche melanophrys*): very common in the open waters of the Southern Ocean (particularly from the channels of the Magellanic area to 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

Procellaridae

- Southern Giant petrel (*Macronectes giganteus*): circum Antarctic species. Common along the Antarctic Peninsula and the in the Drake passage
- Northern giant Petrel (*Macronectes halli*): few individuals identified at the vicinity of the Magellanic area
- Southern Fulmar (*Fulmarus glacialoides*): common species encountered along the Antarctic Peninsula and the Drake passage. One individual observed in the Beagle Channel.
- Cape Petrel (*Daption capense capense*): few specimens observed at the northern tip of the Antarctic Peninsula, near Cape Horn and during the crossing of the Drake passage
- Snow Petrel (*Pagodroma nivea*): few individuals spotted at Dodman and Blaiklock Island, as well as during the transect along the coast of Adelaide Island
- White-headed Petrel (*Pterodroma Lessonii*): one specimen observed during the crossing of the Drake passage
- Soft-plumaged Petrel (*Pterodroma mollis mollis*): species observed frequently 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
- Kerguelen Petrel (*Lugensa brevirostris*): two individuals were observed in the Drake Passage
- Sooty Shearwater (*Puffinus griseus*): common near Cape Horn and in the Beagle channel. Less abundant in the Drake Passage
- Antarctic/Slender-billed Prion (*Pachyptila sp. cf. desolata/belcheri*): very common around the continental slope of the Magellanic area. Also observed on a regular basis during the crossing of the Drake passage.

- Blue Petrel (*Halobaena caerulea*): two individuals observed during crossing of the southern part of the Drake Passage

Hydrobatidae
- Wilson's Storm Petrel (*Oceanites oceanicus)*: common in the Drake passage and along the Antarctic Peninsula (circum Antarctic).
- Black bellied Storm Petrel (*Fregetta tropica*): fairly common species observed in the Drake passage (from Snow Island – South Shetland Island, to the continental slope of Patagonia) locally even more abundant than the Wilson's Storm Petrel.

Pelecanoididae
- Common Diving Petrel (*Pelecanoides urinatrix*): few specimens observed in the drake passage.

Phalacrocoracidae
- Antarctic Shag (*Phalacrocorax brandsfieldensis*): common all along the Antarctic Peninsula.

Chionidae
- Pale-faced Sheathbill (*Chionix alba*): one specimen observed at Dodman Island (landing on Australis).

Stercorariidae
- Brown Skua (*Catharacta lonnbergi*): 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*): about one hundred individuals observed around Blaiklock Island.

Laridae
- Kelp Gull (*Larus dominicanensis*): few specimens observed at Dodman Island, along Adelaide Island and around Blaiklock Island

Sternidae
- Antarctic Tern (*Sterna vittata*): commonly encountered all along Antarctic Peninsula (present at Dodman and Blaiklock Island), during the crossing of the Bransfield Strait and in the southern part of the Drake Passage

Sphenicidae
- Gentoo Penguine (*Pygoscelis papua*): dominant and common species breeding on many locations along the Antarctic Peninsula.
- Magellanic Penguin (*Spheniscus magellanicus*): few specimens observed near Cape Horn, fairly common in the Beagle Channel.
- Chinstrap Penguin (*Pygoscelis antarctica*): Few specimens observed along the Antarctic Peninsula
- Adelie Penguin (*Pygoscelis adeliae*): few individuals observed at Dodman Island and small colonies (juveniles) observed around Blaiklock Islands.

2- MARINE MAMMALS

Otariidae

- Antarctic Fur Seal (*Arctocephalus gazelle*): common along the Antarctic Peninsula as far south as the northern tip of Adelaide Island
- South American Sea Lion (*Otaria flavescens*): common in the beagle channel

Phocidae

- Leopard Seal (*Hydrurga leptonyx*): several specimens observed around Blaiklock Island.
- Weddell Seal (*Leptonychotes weddellii*): few individuals observed at Blaiklock Island and along Adelaide Island
- Crabeater Seal (*Lobodon carcinophaga*): common along the Antarctic Peninsula with few hundred individuals observed around Blaiklock and Adelaide Island

Delphinidae

- Hourglass Dolphin (*Lagenorhynchus australis*): few specimens observed during the crossing of the Drake passage
- Dusky Dolphin (*Lagenorhynchus obscurus*): common in the Beagle Channel
- Long-finned Pilot whale (*Globicephala melas*): 4 individuals observed (along with Hourglass Dolphins) at the vicinity of the Antarctic Peninsula's continental slope

Balaenopteridae

- Antarctic Minke Whale (*Balaenoptera bonaerensis*): common along the Antarctic Penisula. Few individuals observed as far south as Blaiklock Island.
- Humpback Whale (*Megaptera novaeangliae*): common and dominant cetacean observed along the Antarctic Peninsula. Few specimen observed in the Beagle channel.
- Fin whale (*Balaenoptera physalus*): one specimen identified south of Snow Island (Western South Shetland Islands)

*Table 13: Checklist of birds and marine mammals observed during the TANGO 01 expedition. MA = **M**agellanic **A**rea; DP= **D**rake **P**assage; DI = **D**odman **I**sland; BI = **B**laiklock **I**sland; AP = Transects along the **A**ntarctic **P**eninsula. Abundance index are given as follow: I= one observation or rare species; II= fairly abundant species; III= dominant species*

Vernacular name	Latin name	LOCATION				
		MA	DP	DI	BI	AP
Black-browed Albatross	*Thalassarche melanophrys*	III	III			I
Southern Royal Albatross	*Diomedea epomophora*		I			
Wandering Albatross	*Diomedea exulans*		I			
Grey-headed Albatross	*Thalassarche chrysostoma*		I			
Light-mantled Albatross	*Phoebetria palpebrata*		I			
Soft-plumage Petrel	*Pterodroma mollis*		II			
Cape Petrel	*Daption capense*					I
Snow Petrel	*Pagodroma nivea*			I	I	
Antarctic Petrel	*Pterodroma incerta*					
Kerguelen Petrel	*Lugensa brevirostris*					
Southern Fulmar	*Fulmarus glacialoides*		I		I	II
Southern Giant Petrel	*Macronectes giganteus*	I	III		II	III
Sooty Shearwater	*Puffinus griseus*	III	I			
White-shinned Petrel	*Procellaria aequinoctialis*	I	II			
Blue Petrel	*Halobaena caerulea*		I			
Antarctic Prion	*Pachyptila desolata*		III			
Slender-billed Prion	*Pachyptila belcheri*		III			
Diving Petrel sp.	*Pelecanoides sp.*	I	II			
Wilson's Storm Petrel	*Oceanites oceanicus*	I	II	II	II	III
Black-bellied Storm Petrel	*Fregetta tropica*		II			
Kelp Gull	*Larus dominicanus*	II	II	II	I	III
Antarctic Tern	*Sterna vittata*		II	I	II	III
Skua sp. (cf. South polar or Brown)	*Catharacta sp. (cf. lonnbergi or maccormicki)*		I	II	III	III
Gentoo Penguin	*Pygoscelis papua*					III
Adelie Penguin	*Pygoscelis adeliae*			I	II	
Antarctic Shag	*Phalacrocorax brandsfieldensis*			III	II	III
Snowy Sheathbill	*Chionis albus*			I		
Humpback Whale	*Megaptera novaeangliae*		I	I	II	III
Minke Whale	*Balaenoptera bonaerensis*				II	I
Hourglass Dolphins	*Lagenorhynchus cruciger*		II			
Long-finned Pilot Whale	*Globicephala melas*		I			
Crabeater Seal	*Lobodon carcinophaga*			I	III	II
Weddell Seal	*Leptonychotes weddellii*				I	I
Leopard Seal	*Hydrurga leptonyx*				II	I
South American Sea Lion	*Otaria flavescens*					
Ant. Fur Seal	*Arctocephalus gazella*		I	II		II

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10. Sea urchins microbiota

Bruno Danis, Camille Moreau, Lea Katz, Martin Dogniez, Manon Bayat

Context

Climate change is strongly impacting Antarctica, and especially in the Western Antarctic Peninsula (WAP). Many types of biological responses are expected to occur in relation to ongoing environmental changes, including shifts in feeding behaviour of species, species interactions and energy flows 1-3. The acclimation to these ecological changes plays an essential role in the survival of species, as it consists of direct responses of organisms to changes, occurring on a much shorter scale than adaptation processes 4. Trophic plasticity and shifts in gut microbiome might be two overlooked, and potentially linked, acclimation mechanisms to rapid ecological changes.

Therefore, using a benthic keystone species of the WAP as biological models, this project aims to investigate:
• The trophic plasticity of the sea urchin *Sterechinus neumayeri* and how it is shaped by ecological factors
• The variability of its gut microbiomes (gut tissues and content), and the influence of ecological factors
• The relationships between trophic plasticity, gut microbiome variability and ecological factors

The ambition of the present project is to consider these questions using multidisciplinary (i.e., integrative trophic markers, metabarcoding) and multiscale approaches, by considering different hierarchical levels of biological organisation (from host microbiome to populations) and different spatial scales (representing diverse environments). Altogether, these three objectives will provide novel insights into how benthic keystone species could acclimate to fast-changing (decadal) ecological conditions.

Methods

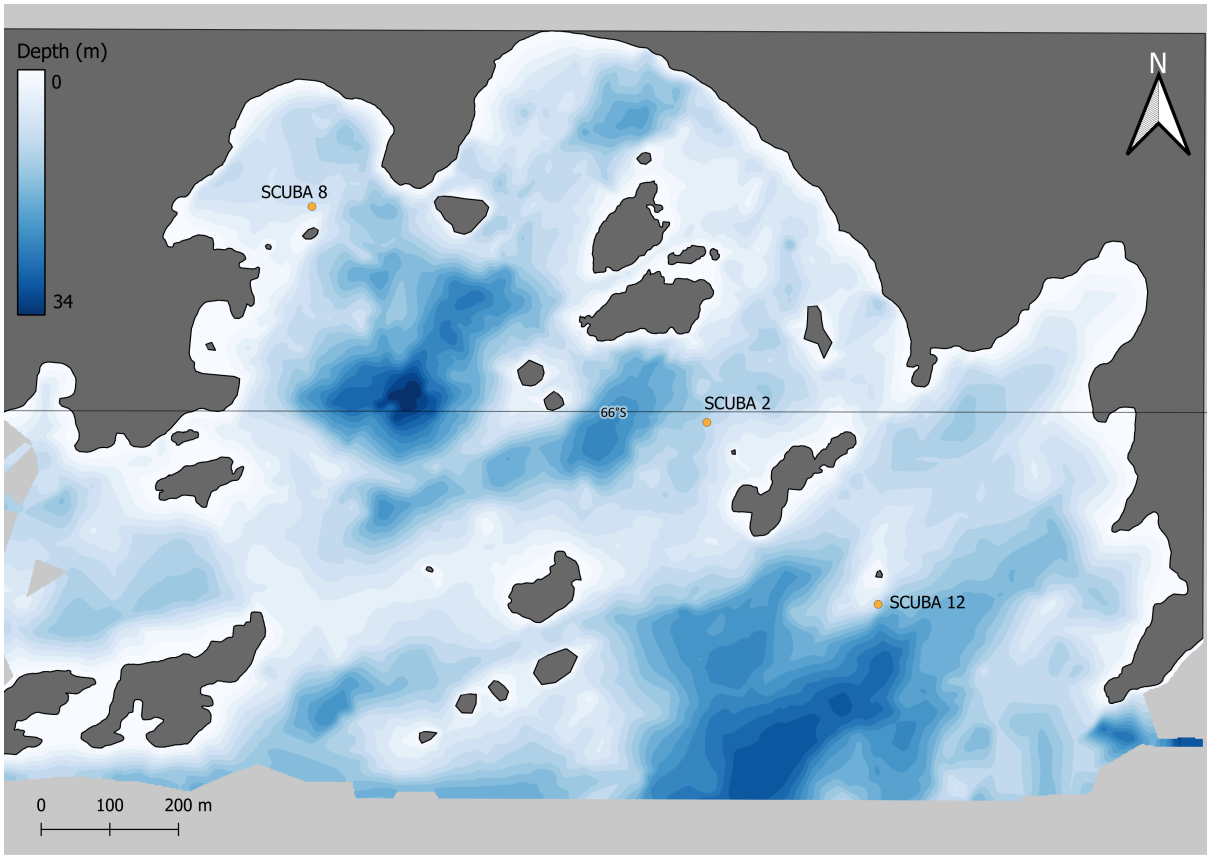

Figure 73 Location of the dives dedicated to urchins' retrieval at Dodman Island

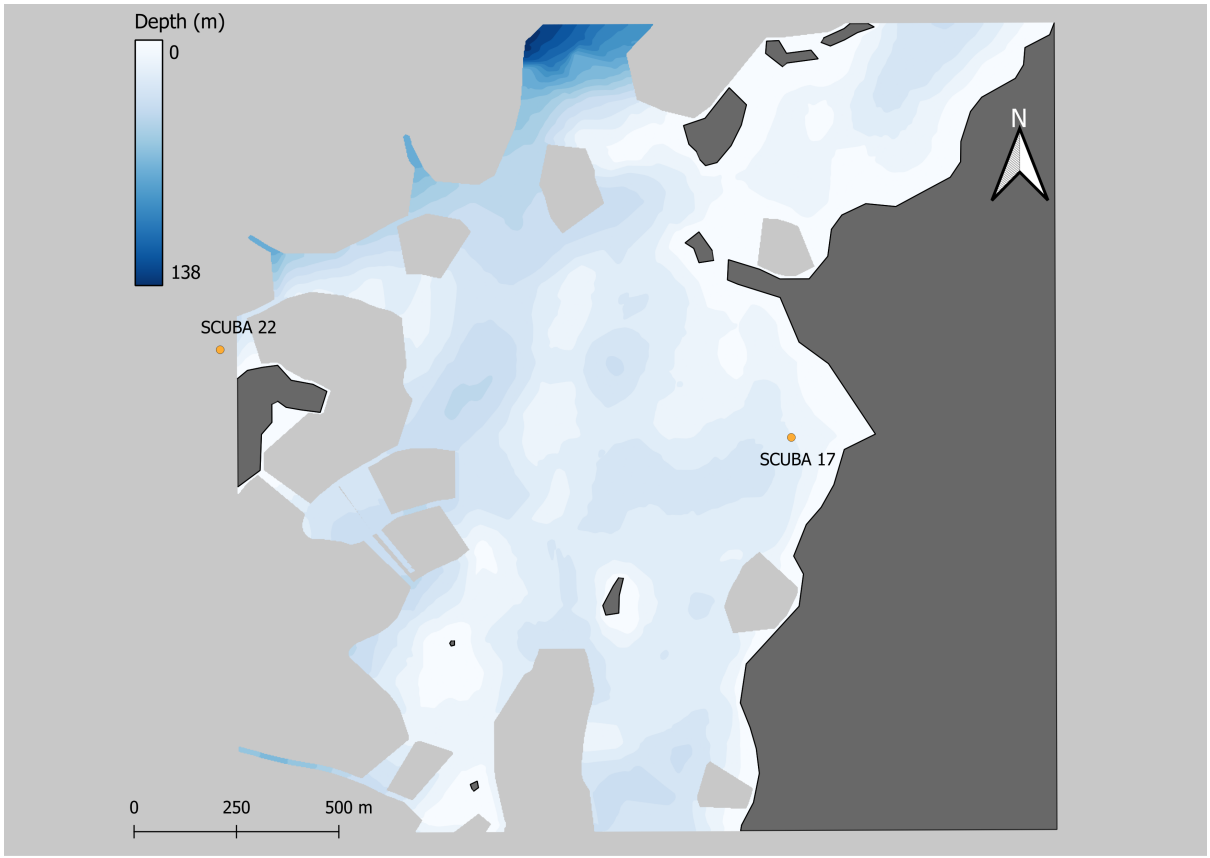

Figure 74 Location of the dives dedicated to urchins' retrieval at site 1 at Blaiklock Island

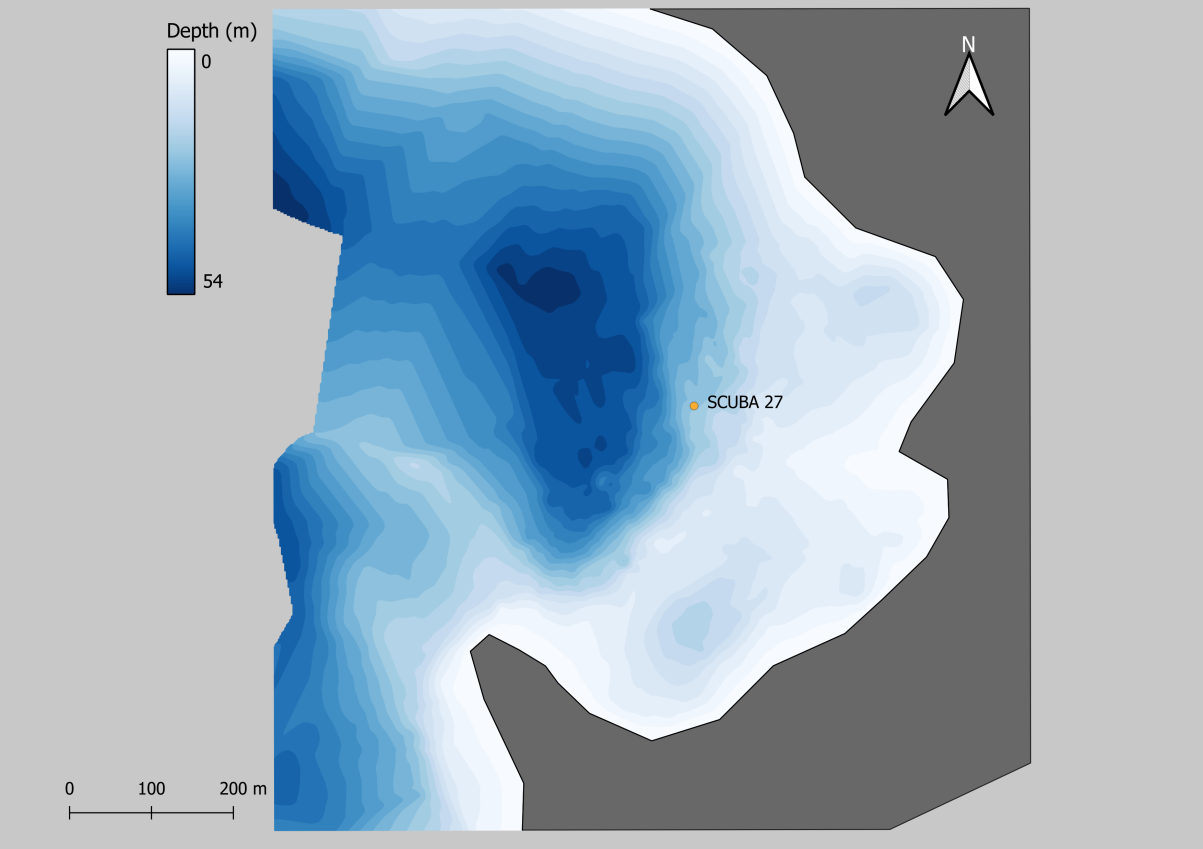

Figure 75 Location of the dives dedicated to urchins' retrieval at site 2 at Blaiklock Island

Specimens of the sea urchin *Sterechinus neumayeri* were collected by divers at 6 different locations (Figure 73, Figure 74, Figure 75) at a depth of around 15m. Twenty-five specimens were then measured (ambitus and height) and dissected for future analyses. Gonad and test tissues were preserved in 96% ethanol for sexing and genetics analyses. Gut content (consisting of pellets) and gut epitheliums were preserved in RNA later for microbiome studies. The Aristotle lantern was extracted and dried at 60°C for isotopic analyses.
For the characterisation of the microbiome, potential ambient sources of microbiome were also collected:

Sediment: Five samples of sediments were collected at each sampling location and preserved in RNA later.

Water: Bottom water was collected using a Niskin bottle. Five ambient water replicates of 1 liter 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 seven morphotypes of algae were found. Five replicates for each alga were preserved in RNA later.

Results

A total of 150 urchins was processed onboard during the expedition. Due to their high abundance at all locations, there was no issue with the collection of specimens. Sizes

however varied from one location to another, a variability that will be investigated into more details (Figure 76).

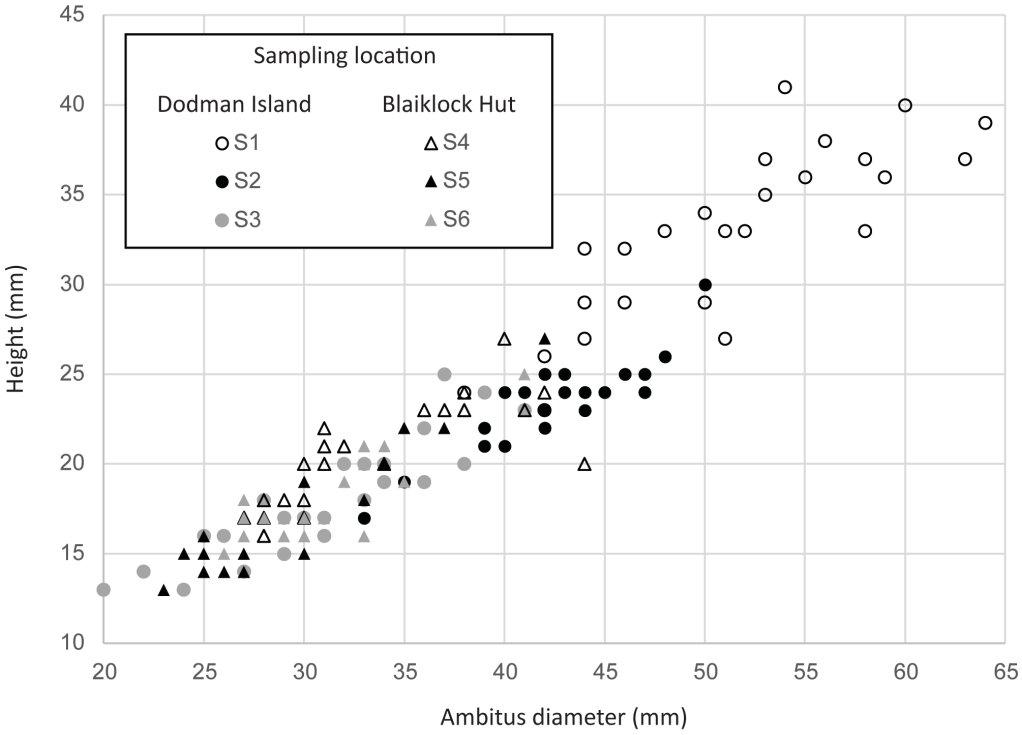

Figure 76: Size comparison (Ambitus diameter (mm) / Height (mm)) for Sterechinus neumayeri collected

Samples were preserved as follow:

150 Aristotle lanterns (dry)
150 gut contents (RNA later)
150 gut epitheliums (RNA later)
150 gonad tissue (Ethanol 96%)
150 test tissue (Ethanol 96%)
115 samples of algae (RNA later)
30 samples of sediment (RNA later)
30 samples of water (filters in RNA later)

Perspectives

Samples preserved dried and in ethanol will be analyzed upon return in Belgium for trophic niche characterization. Sexing (observation of gonad tissues) and genetic (test tissue) analyses will also be performed in Belgium. DNA extractions for microbiome characterization will be performed in Punta Arenas straight after the expedition to ensure the best DNA quality possible.

The Western Antarctic Peninsula benthic communities seem to be an ideal ecological model to investigate fundamental mechanisms underlying how trophic plasticity and gut microbiome shifts shape species responses to a fast-changing environment. Indeed, different rates of warming and consequent sea-ice loss are observed between the North and the South

of the Peninsula. For these reasons, the same project is planned for the next TANGO expedition in the northern part of the West Antarctic Peninsula.

References

1. Bae, H. et al. Sci Rep. 11, 241 (2021)
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11. Underwater photography

Camille Moreau and Lea Katz

Context

Despite the democratization of affordable equipment, underwater photography and macrophotography remain poorly used in marine sciences in the Southern Ocean. The added value of live specimens' pictures to illustrate biodiversity can however not be neglected, especially for "soft" taxa that lose morphological characters once outside the water. Underwater picture, coupled with quadrats or transects can also be used for analytical work (e.g. abundance or surface estimations). Finally, a visual support can be a powerful tool to communicate and illustrate scientific and/or naturalist work to a wider audience.

Methods

This work was conducted when possible, during some of the dives that allowed a photographic work in parallel of the main task. Pictures were taken using a camera Olympus TG-6 with a casing Olympus PT-059 and a diving lamp (Hi-max spot video light V24). The underwater mode was used by default, only switching from landscape, macro or microscope options.

Results

The camera was used during 17 dives, allowing to shoot a total of around 1000 pictures.

Figure 77: Glyptonotus antarcticus (Dodman Island)

Figure 78: Sterechinus neumayeri (Blaiklock Island, Site 1C)

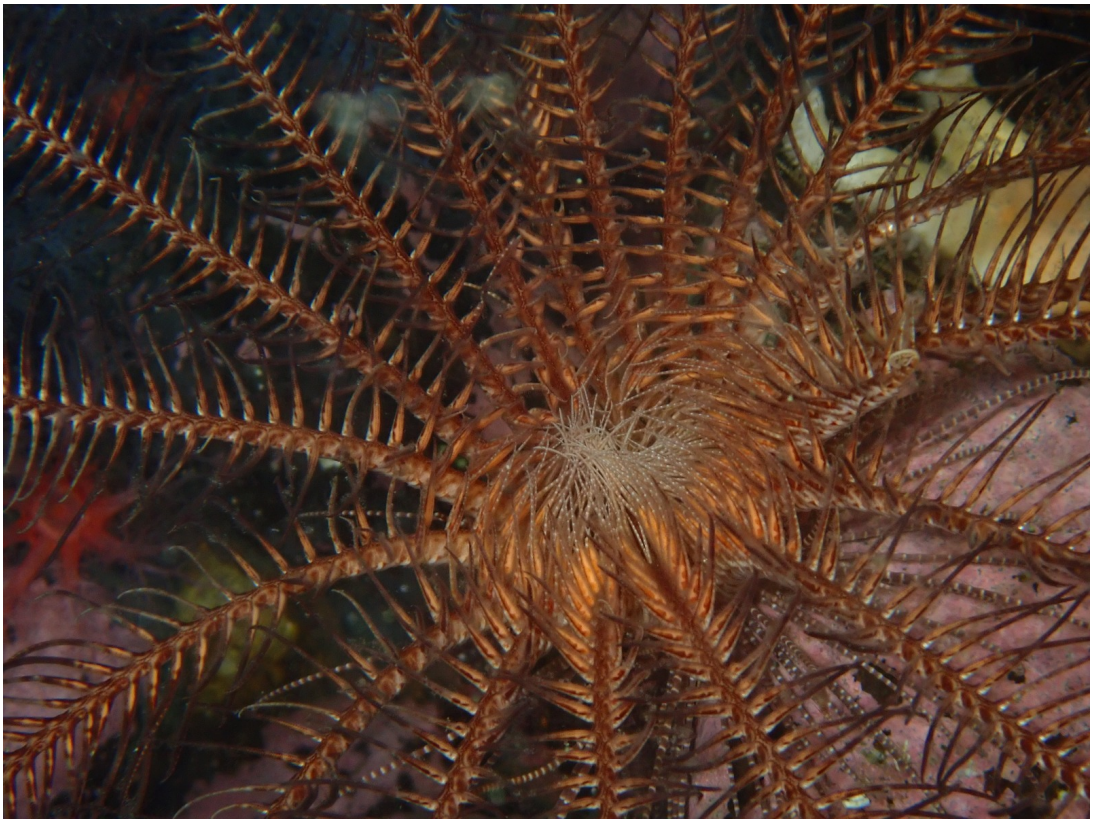

Figure 79: Promachocrinus kerguelensis (Blaiklock Island, Site 1C)

Figure 80 Benthic community of Blaiklock Island (site 1A)

Perspectives

This part of the project was a first approach in documenting the work and illustrating biodiversity during the expedition. Many improvements can be implemented and notably having dedicated dives to illustrate a maximum of the diversity encountered. The creation of a reference library for live specimens coupled with DNA barcoding effort is also considered. Such efforts are important and more and more valuable, especially in studies using metabarcoding/eDNA approaches.

Another improvement could also be the installation of a photographic bench onboard to photograph specimens collected by other gears (e.g. Rauschert Dredge, Amphipod trap, Intertidal).

Sharing the images, by organizing an exhibition could also be a good way to communicate about our work while including a wide audience. Small projects during the “Printemps des Sciences” or in collaboration with the Association for Polar Early Career Scientists are considered.

12. Cyanobacteria

Axelle Brusselman, Bruno Delille

Context

The collection of samples for the determination of eukaryotic microalgae is an opportunistic add-on to the TANGO survey carried out in collaboration with Prof Annick Wilmotte from the University of Liège. Prof Wilmotte has long-lived expertise in documenting cyanobacteria in Antarctica biofilms.

Glacial falls around Dolman Island presented obvious colored patches that are presumably related to algae growth at the surface. The patches are located on particular sides of the ice cliffs depending on the insulation and ice ablation. Patches presented different colours, red, brown and greenish, extending from the top to the bottom at sea level. By carrying parallel collection of colored ice and intertidal biofilm, we expect to link the seeding of the algae to sea spray. That would complement the work on sea aerosols carried out on the *RV Hesperides* further north during the PolarChanges survey.

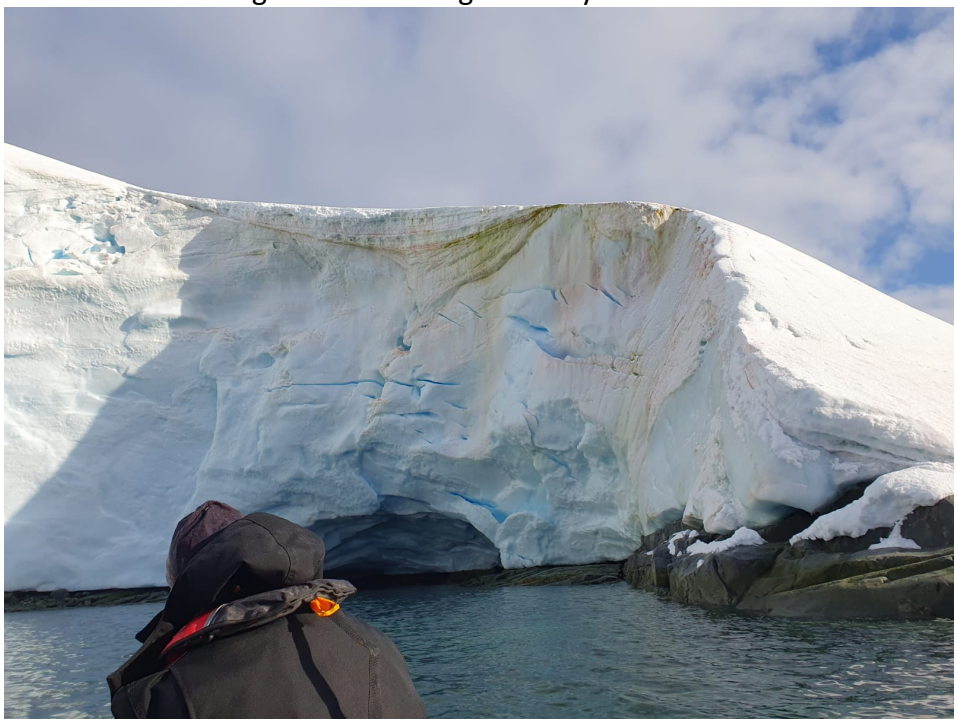

Figure 81 Colored algae patches on ice cliffs on Dodman island

Methods

We collected both colored ice and biofilms covering intertidal rocks at three locations around Dodman island and only biofilms covering intertidal rocks at one location at Blaiklock Island, paying attention to discriminating different colors. Intertidal rock biofilm was collected with a metal spoon previously disinfected with ethanol and stored in 50 ml Falcon tubes. Ice samples were sawed, and colored patches were not touched before storage in Ziplock bags. All samples were stored at -20°C within one hour after collection.

Figure 82 Collection of colored glacial ice

Figure 83 Glacial ice algea and intertidal rocks biofilms located at the same spot. Note the different colorations of algae patches.

Figure 84 Collection of intertidal rock biofilm

Results

We collected six ice samples and six intertidal samples at Dodman Island and two intertidal samples at Blaiklock Island..

Perspectives

The samples will be transported to the University of Liège and processed by Dr Annick Wilmotte from the Cyanobacterial molecular diversity and ecology laboratory, InBios Research Unit (https://www.inbios.uliege.be/cms/c_9942774/en/inbios-cyanobacterial-molecular-diversity-and-ecology).

Planned analysis are:

- microscopic observations of the diversity of photosynthetic microorganisms in the samples
- cultivation and isolation of cyanobacteria and microalgae
- molecular analysis of selected samples by amplicon sequencing of the SSU rRNA gene and Illumina technology (if diversity observations have shown the presence of cyanobacteria)

Diving activities

Francesca Pasotti, Lea Katz, Camille Moreau, Martin Dogniez

Every morning the dive leader Francesca Pasotti, the chief scientist Bruno Danis and the dive team would have a dive meeting discussing the tasks of the day and assigning the dive teams.
A total of 30 logged dives were performed by the team of four divers collecting a total of 828 unique samples consisting of sediment cores, photo and videos and handpicking and transect collection of megafauna specimens and macroalgae. The average dive time was 30 min, the maximum dive time was 51 min. The average depth was 19 m and the maximum depth was 25 m. On average, most divers took one dive per day, sometime two dives per diver did take place, but with always a minimum of 3h surface interval.
Divers dove only when feeling in good conditions, and never reported extreme fatigue. Nonetheless, two days off took place on the 25/02/2023 and on the 1/03/2023 due to other tasks priorities. No accidents were recorded, although the high humidity in the air caused towards the end of the cruise the second stages to freeze and create free air low during the dive. For the next campaigns the use of water vapor filters on the tank taps is highly recommended. More details will be provided in the dedicated Scientific Diving Activity Report to be found on the Tango I website.

Table 14: Dive records for the different participants

Diver name	***Total number of dives***	***Total time***
Francesca Pasotti (ABSD)	14	06:03
Camille Moreau (BSD)	17	09:17
Martin Dogniez (BSD)	18	09:07
Lea Katz (BSD)	10	05:30

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