SD049

Cruise report

10/05 to 24/05/2025

PSOs Gabriele Stowasser and James Bradley

Contents

Crew

Bridge

William Whatley (Captain)

Fergus Walker (Chief Officer)

Matthew Chapman (2nd Officer)

Elizabeth Coase (3rd Officer)

Luke Kelly-Granger (3rd Officer)

Nisha Mistry (Doctor)

Catering team

Christopher Walton (Purser)

Aaron Harper (Chief Cook)

Micah Hendrickx (2nd Cook)

Nicholas Greenwood (Senior Steward)

Anita Buttle (Steward)

Desislava Fileva (Steward)

Rafal Kozak (Steward)

Deck team

David Peck (CPO Science)

Joseph Laurence (Launchman)

Donavon Crombie (AB)

Patrick McKerchar (AB)

Daeleyn Peck (AB)

Jamie Roberts (AB)

Graham Waylett (AB)

Engineers

Andris Kubulins (Chief Engineer)

Lewis Bumstead (3rd Engineer)

Christopher Henry (3rd Engineer)

Amanda Little (3rd Engineer)

Lee Eccles (4th Engineer)

Euan Telford (4th Engineer)

Robert Sutton (Deck Engineer)

Greg Dalgarno (Deck Engineer)

Maksims Moisejenko (PO Motorman)

Carlos Vargas Leon (PO Motorman)

Michael O'Reilly (CPO Motorman)

Harrison Dorgan (ETO)

Joseph Knight (ETO)

Joshua Di Leo (Engineer Cadet)

Travis Lightbown-Smith (Engineer Cadet)

Scientists

Chief Scientists	
Gabriele Stowasser (**CASS 226**)	James Bradley (**CASS 224**)
CASS 223	Liam Kelleher
CASS 226	Samantha Buzzard
	Tracey Dornan
	Siobhan Foden
	Nadine Johnston
CASS 227	Anjali Dhunna
Science Support	Jade Boughton
	Louie Bridges

Cruise overview

Cruise SD049 was a multidisciplinary cruise supporting four different CASS (Collaborative Antarctic Science Scheme) aboard the RRS Sir David Attenborough.

The Collaborative Antarctic Science Scheme provides opportunities for UK researchers to access NERC-BAS Antarctic research stations and marine science cruises for the purpose of conducting small-scale, fieldwork-based science projects that do not require logistic resources additional to those already allocated to the Antarctic field programme supported by BAS.

The cruise track taken was from the Falkland Islands (Islas Malvinas) to Rothera research station and back to Punta Arenas in Chile via the Falkland Islands (Islas Malvinas)(Fig.1).

To fulfil their objectives the 4 projects either sampled from the uncontaminated seawater supply or installed instruments to passively air sample during passage.

CASS 223: TOMATO: Transport Of nano and Microplastics Across The Ocean. This project investigated the long-range transport of nano and microplastics across the Southern Ocean, focusing on pathways, dynamics, and environmental impacts. The project utilised airborne/atmospheric particle sampling methodologies to gather nano and microplastic samples during the late-season rotation of the Research Vessel RRS SDA.

CASS 224: Winter-Air: The wintertime atmospheric ecosystem over Antarctica. This project investigated seasonal changes in the structure and function of Antarctic atmospheric microbial communities. The project collected atmospheric and underway seawater samples during the crossing of the Drake Passage and the transit down the western Antarctic Peninsula to Rothera.

CASS 226: BIOPOLE-W (III): Biogeochemical processes and ecosystem functioning in changing polar systems during the polar Winter. This project aimed to collect and analyse underway seawater samples for their biogeochemical properties during a voyage along the Antarctic Peninsula between Rothera and Punta Arenas. The measurements followed BIOPOLE protocols (SD033 and SD046) to make them directly comparable to those made in other seasons. A second element of this project was to utilize the on-board echosounding facilities to determine the spatial and vertical distribution of backscattering particles (principally small pelagic organisms) to address the hypothesis that activity levels in these communities are higher than assumed during the winter period, with consequences to the sequestration of carbon to the ocean interior. A third aspect of this project was to test the ability of a small autonomous surface vehicle (ImpYak) to map the distribution and biomass of krill aggregations in inshore waters that large research vessels are typically unable to survey.

CASS 227: How do marine diatoms end up in ice cores? This study aimed to better understand the processes and conditions that control the entrainment of wind-blown diatoms. To achieve this uncontaminated seawater, sea spray and surface air were sampled along a latitudinal transect during the transit to Rothera.

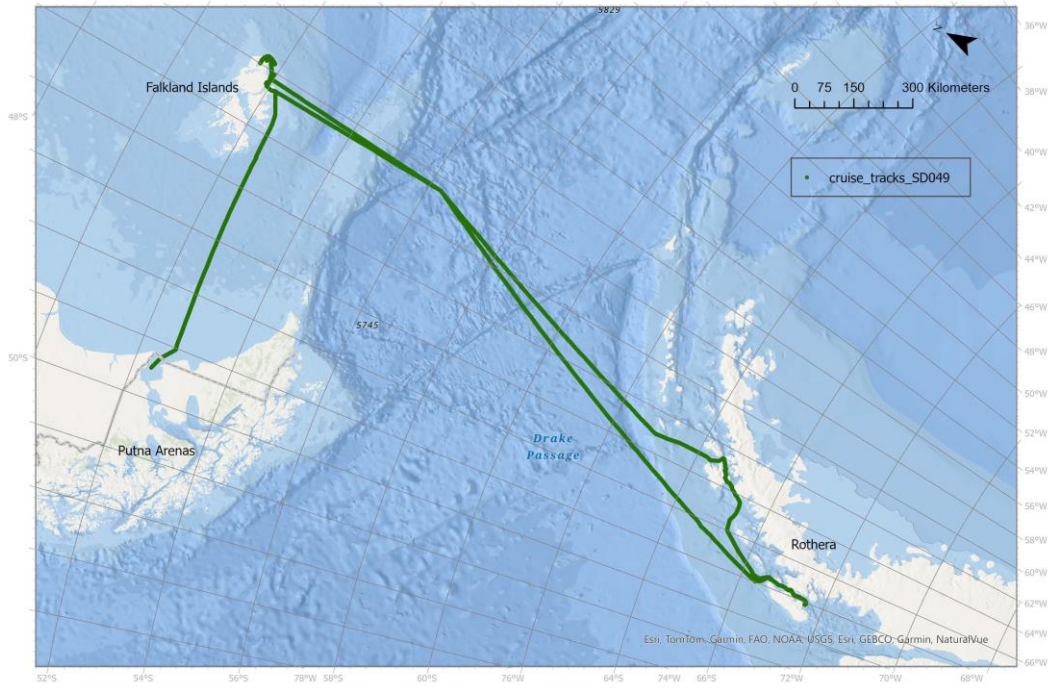

Fig 1: Map of the cruise path during SD049

PSO narrative

Author: Gabriele Stowasser

09.05.2025

The Science party joined the SDA at 12:00. After lunch, the scientists new to the ship were given a brief tour of the laboratories and the ship. At 13:00 we started mobilisation by unpacking the container and setting up the labs. At 18:00 we were picked up to spend the night in the hotel in Stanley.

10.05.2025

Pickup at 08:00 to join the SDA. Everyone continued mobilisation. The PSO and Co-PSO had an initial meeting with the captain and the chief officer to talk about requirements. A safety brief was conducted at 12:30 followed by an induction to the IT and logging systems. We then all signed our Lab SOPs and Risk assessments. The rest of the afternoon was spent setting up labs. We left East Cove at 16:00 to sail overnight to Berkeley Sound to refuel.

11.05.2025

Fuelling commenced at 08:00. As the ship needed to wait for spare parts to be delivered, we sailed overnight back to East Cove to wait for the next incoming MOD flight on the 12th. Mobilisation continued. A daily meeting with the captain and first officer was held for the first time at 17:00.

12.05.2025

A lab induction was given at 8:00 followed by a walk through the labs. Last preparations were made for the start of sampling on the 13th May. At 10:30 a fire drill including boat stations was conducted. At lunch the Captain informed us that the spare parts were not going to be delivered by the MOD flight and that we would sail in the afternoon. At 16:00 the ship left East Cove on our journey to Rothera.

13.05.2025

We crossed the Falkland Island EEZ in the morning and the underway clean sweater supply was switched on. Sampling started at 12:00 with the whole CASS226 team to familiarise everyone with the processes. All other CASS projects started their measurements on deck 10 after ships incineration processes ceased in the afternoon to avoid sample contamination. Sailing though the Drake's passage was relatively calm.

14.05.2025-15.05.2025

We continued our journey to Rothera outside the island chain. Sampling continued for all CASS teams on board.

16.05.2025

We arrived alongside at Rothera at 08:00 and were cleared for shore at 11:00. The Impyak box was lifted ashore and Tracey Dornan with the help of Siobhan Foden, Liam Kelleher and Gabriele Stowasser worked on the set-up of the instrument all day. James Bradley (CASS224) collected snow and ice samples around Rothera station for his work. All air sampling and underway seawater sampling was stopped.

17.05.2025

Team Biopole III (CASS226) set out on Terror (the SDA's cargo tender) to sample zooplankton and water samples and test the ImpYak. We had a successful trip collecting samples from 2 stations (glacier front and open water) by deploying a handheld Mini-Bongo, CTD and Niskin bottle and successfully ran a mission with the ImpYak. Other SSPs went on a walk around the Point and were given a tour of the station. In the evening the ship's crew and SSPs went for a party to Rothera station.

18.05.2025

All passengers leaving Rothera had joined the ship by 09:00. The ship left it's mooring at 10:30 and we proceeded to a sampling station in South Cove where we again collected zooplankton and water samples from the aft of the SDA. The ship left for it's journey North at 11:30. Air and water sampling resumed. CASS 226 (BIOPOLE 3) increased their frequency of sampling to maximise samples from areas close to the continent from 4 times to 6 times per day. Our journey took us through the Lemair and Neumayer Channels. In Lemaire we had another chance to collect Zooplankton and CTD data.

19.05.2025

Our journey continued through Schollart channel and we left the Antarctic island chain behind at approx. 20:00 and entered the Drake's Passage. The BIOPOLE team continued to measure at a high frequency rate. At 19:30 all CASS teams presented their work in 5-min. presentations to all crew and passengers on board.

20.05.2025

We continued our journey through the Drake's Passage. The BIOPOLE team reduced their sampling rate in the morning (after 10:00) on leaving the continental shelf. Air and water sampling resumed as before.

21.05.2025

All CASS projects finished sampling on reaching the EEZ zone of the Falkland Islands (Islas Malvinas). The ship turned into Mare Harbour (Falkland Islands, Islas Malvinas) to collect cargo destined for the last call to Rothera research station.

21.05 – 23.05. 2025

Demob of cruise SD049 and arrival in Punta Arenas, Chile.

1. CASS 223 TOMATO

Liam Kelleher (University of Birmingham)

Atmospheric Microplastics

The project is titled "**TOMATO: Transport Of Microplastics Across The Ocean** – a study of long-range transport across the southern ocean," and is recorded as CASS-223. It is a collaboration between the British Antarctic Survey (Clara Manno) and the University of Birmingham (Liam Kelleher and Stefan Krause).

1.1 Introduction

Nano and microplastic (NMP) pollution pose significant threats to polar ecosystems, yet understanding its distribution and impacts remains limited. These small anthropogenic materials, including polymer fragments and fibers, have been shown to cross the "physical" barriers that isolate Antarctica. Several studies have demonstrated this for the Antarctic Circumpolar Current (Johnston et al., 2023; Jones-Williams, 2022), with one study showing airborne transport across the Polar Front (Chen et al., 2023). Recent polar studies and the SCAR Plastics in Polar Environments emphasize the need for further research to understand the impact and levels of NMP in Antarctica. The significance of airborne NMP in this context is paramount, given the predominant emphasis bas been on marine ecosystems in polar research (Aves et al., 2022).

Our study will focus on the transport of NMP across the Polar Front during the 2025 late-season SDA rotation. We will utilize proven polar research sampling equipment to collect samples for analysis at the University of Birmingham post-trip. This entails the analysis of rubber material, which constitutes up to 50% of the global NMP abundance (Jarlskog et al., 2020), yet has remained understudied until recent analytical advancements. This project aligns with the objectives of the Collaborative Antarctic Science Scheme (CASS) and will generate the first NMP dataset for airborne NMP in the Southern Ocean.

1.2 Instrumentation

We made use of the deck 10 railing to mount the “NanoTank” sampler, a liquid trap that creates a vacuum to pull airborne particles into the sampler. The NanoTank was filled with 20% ethanol solution to a volume of 500 ml to prevent freezing. A vacuum line was taken from the aerosol lab through the deck access and to the sampler mount. The photos below highlight the mounting (Fig 1.1 left), the vacuum system with back-ups (Fig 1.1 centre) and the internal of the NanoTank sampler (Fig 1.1 right).

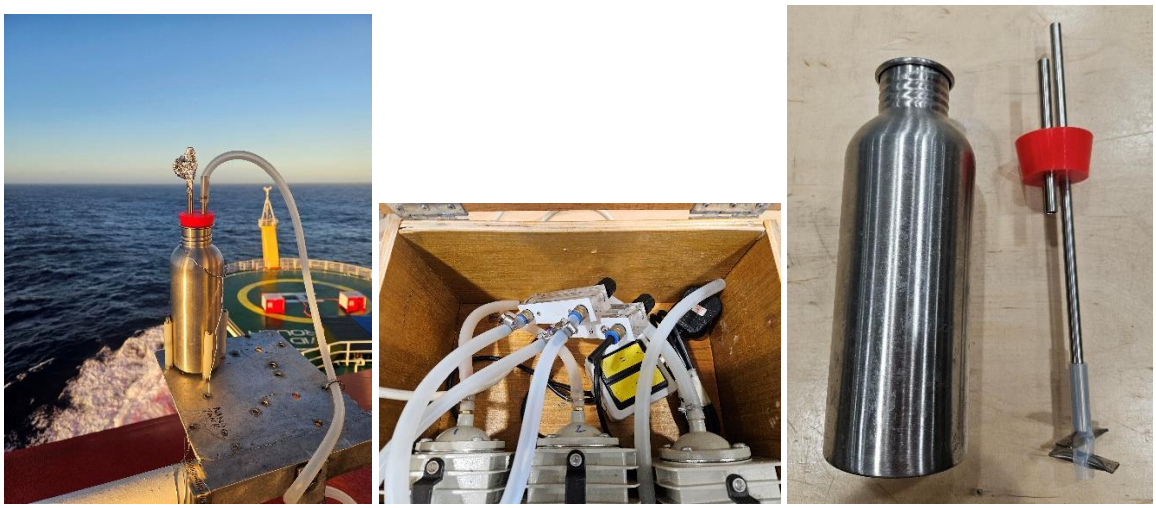

Figure 1.1: Left, NanoTank sampler mounted to deck 10 portside railing (note foil cover still on). Centre, Pump system with back-ups and flow controllers. Right, the NanoTank bottle and internal percolation system.

1.3 Lab work onboard

Preparation of the ethanol solution was completed in the wet lab fume hood. Ethanol was filter through 0.2 µm Anodisc prior to use and deionised Milli-Q water filtered at 0.22 µm was used. Sample filtering to Whatman Anodisc was completed in the aerosol lab laminar flow cabinet.

1.4 Issues Encountered

No real issues were encountered. Would plan for a more secure filtration in the aerosol lab for future visits.

Burning of ships waste may impact results, times were noted and the burning events can be accounted for.

1.5 Results

A total of 8 samples, 2 procedural reference blanks, and 1 burning event were collected. Samples were aliquoted during filtration for > 1.2 µm, 1.2 – 0.7 µm, and 0.7 – 0.2 µm to analysis for microplastic to nanoplastic levels of plastic pollution. Microplastics will be analysed with Raman spectroscopy, nanoplastics will be analysed by pyrolysis- gas-chromatography mass-spectrometry (pyGCMS).

Results will be modelled for back trajectory using FLEXPART. Wind speed and cruise route will be used to map this data.

1.6 References

Aves, A. R., Revell, L. E., Gaw, S., Ruffell, H., Schuddeboom, A., Wotherspoon, N. E., LaRue, M., and McDonald, A. J. (2022). First evidence of microplastics in Antarctic snow. The Cryosphere, 16, 2127–2145. https://doi.org/10.5194/tc-16-2127-2022.

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2. CASS 224 Project WINTER-AIR

James A. Bradley (Aix Marseille Université, Université de Toulon, CNRS, IRD, MIO, Marseille, France)

This project investigates the wintertime atmospheric microbial ecosystem over Antarctica. The project collected atmospheric samples and underway seawater samples during the crossing of the Drake Passage and the transit of the western Antarctic Peninsula to/from Rothera, as well as snow and ice from the Rothera ‘Ramp' up Wormald Ice Piedmont. DNA

will be extracted from the samples and sequenced, to evaluate the microbial community composition, function and adaptation of the habitats sampled.

2.1 INTRODUCTION

The atmosphere is the largest potential ecosystem on Earth, yet it is the least understood. Life is found across Earth's three major systems: the lithosphere (land), hydrosphere (water), and atmosphere (air). Yet several factors make life
poorly understood in the atmosphere: (i) its biomass is very low and dominated by microbes, (ii) sampling the atmospheric microbiome faces methodological challenges, and (iii) there is general low awareness of the importance and complexity of the atmosphere as an ecosystem (Womack et al. 2010; Rothschild et al., 2001). The atmosphere forms a bridge between Earth's major biomes, linking terrestrial, aquatic, marine and glacial systems via the continual exchange, transport and dispersal of microorganisms and other material, and shaping adjacent habitats via processes that are not well understood. Classically, atmospheric-dwelling microbes are thought to be passively dispersed, without performing metabolic activities or mediating ecological interactions (Rothschild et al., 2001; Finlay et al. 1999). However, recent work suggests that the atmosphere may be a true ecosystem: containing active resident and transient microbes that profoundly influence biology, chemistry, and climate globally (Womack et al. 2010).

Atmospheric microorganisms influence biodiversity, disease, and potentially climate. The continual exchange and dispersal of microbes between land and water through the atmosphere is one of four key processes controlling community ecology, together with selection, drift, and speciation (Schmidt et al. 2014). In turn, airborne dispersal drives primary succession (ecosystem formation) and influences secondary succession (ecosystem recovery following disturbance), thereby shaping adjacent habitats and contributing to the maintenance of global biodiversity (Schmidt et al. 2014). Air may also transport invasive taxa, and a range of human, animal, and plant pathogens from local to continental scales (Brown et al. 2002). Other ecosystem roles of atmospheric microbes are underexplored, though they are implicated as key ice nucleators responsible for cloud formation and precipitation (Archer

et al. 2020) and thus may play an important role in the global climate system, and they are likely sensitive to anthropogenic activities (Archer et al. 2020).

Despite its suspected importance, knowledge of the atmospheric microbiome and the structure and function of resident microbial communities remains unknown. This is especially true in Antarctica – which is one of the most important locations to study atmospheric microbes (Pearce et al., 2016) – being the most remote continent on Earth and therefore isolated from human-modified ecosystems and background contamination, and with its ecosystems sharing many of the same characteristics as the atmosphere (e.g. freezing temperatures, extreme aridity, low energy, low nutrients, high UV irradiance). Antarctica is also distinctly seasonal – with midnight sun and high biological activity in summer punctuated by winter months of total darkness and an almost complete lack of knowledge of microbial activity and processes.

The overarching aim of this project is to characterize the wintertime Antarctic atmospheric ecosystem and assess whether it exhibits seasonal changes. This information will bring us closer to knowing whether atmospheric microbial communities are structured and adapted to the atmosphere, and the relationships between airborne microbes and adjacent habitats.

This project will address two major objectives:

Objective 1: Characterize the diversity and metabolic characteristics of winter-time Antarctic atmosphere-dwelling (and adjacent habitat) microbial communities using state-of-the-art molecular techniques.

Objective 2: Compare the wintertime atmospheric ecosystem with the summer, to assess how seasonality influences the structure and function of the Antarctic atmospheric ecosystem.

2.2 METHODS

Atmospheric microbial samples and underway seawater samples were collected during the crossing of the Drake Passage and the transit of the western Antarctic Peninsula to/from Rothera. Snow and ice samples were also collected from the Rothera ‘Ramp' up Wormald Ice Piedmont (see Table 2.1).

Air sampling was carried out using portable dry air samplers (SASS 3100, Research International) mounted temporarily to the railings of the outdoor front deck space of Deck 10 (outside the Aerosol Lab). The samplers were powered by a portable battery, temporarily secured (during active sampling) to the ship deck. The sampling duration for each air sample was approximately 4 hours.

Seawater was collected directly from the uncontaminated seawater system and filtered in-line using single-use syringe-mountable Sterivex filters (0.2 µm).

Snow surface, bulk snow, and surface ice samples were collected in triplicate from the top of the Rothera ‘Ramp' up Wormald Ice Piedmont, into sterile Whirlpak bags, using an ethanol sterilized ice axe and snow shovel. Samples were refrigerated overnight, and then melted at room temperature in the dark, before being filtered by syringe through Sterivex filters (0.2 µm).

Air, seawater, snow and ice samples (i.e. filter papers) were stored frozen (-20°C) in the freezers onboard the SDA and transported to the UK at -20°C via BAS cargo for further analyses.

2.3 OUTCOMES

Table 2.1: The following samples were collected:

SampleID	Habitat	Replicates	Date_collected	Time (local Falklands)	/ Latitude	Longitude	Volume_mL
RRS Sir David Attenborough - SD049 - Antarctic Peninsula May 2025							
AN25.01	air	1	14.05.25	"10.40"	-61.66216	-63.20745	
AN25.02	seawater	3	14.05.25	"10:50"	-61.69906	-63.2443	A: 2000; B: 2000; C: 2000
AN25.03	air	1	14.05.25	"14:50"	-62.56764	-64.08611	
AN25.04	seawater	3	14.05.25	"14:55"	-62.58459	-64.10524	A: 2000; B: 2000; C: 2000
AN25.05	air	1	15.05.25	"12:35"	-66.87334	-67.6583	
AN25.06	seawater	3	15.05.25	"12:50"	-66.87334	-67.6583	A: 2000; B: 2000; C: 2000
AN25.07	air	1	15.05.25	"16:40"	-67.35972	-67.84955	
AN25.08	seawater	3	15.05.25	"19:45"	-67.58161	-68.14614	A: 2000; B: 2000; C: 2000
AN25.09	Snow (fresh)	3	16.05.25	"13:00"	67.56541° S	68.14066° W	A: 3060; B: 3300; C: 3420
AN25.10	Snow (bulk)	3	16.05.25	"13:00"	67.56541° S	68.14066° W	A: 2100; B: 1800 ; C: 2100
AN25.11	Ice surface	3	16.05.25	"13:20"	67.56731° S	68.12596° W	A: 1800 ; B: 1620; C: 1200
AN25.12	air	1	18.05.25	"13.00"	-67.44051	-67.8647	
AN25.13	air	1	18.05.25	"17.05"	-66.74334	-67.5616	
AN25.14	air	1	18.05.25	"17.02"	-66.75281	-67.56756	
AN25.15	seawater	3	18.05.25	"19:05"	-66.46226	-67.64762	A: 2000; B: 2000; C: 2000
AN25.16	air	1	19.05.25	"09.00"	-65.23051	-64.18473	
AN25.17	air	1	19.05.25	"13.25"	-64.7836	-63.52388	
AN25.18	seawater	3	19.05.25	"14.11"	-64.73565	-63.26996	A: 2000; B: 2000; C: 2000
AN25.19	air	1	20.05.25	"11.30"	-60.76376	-61.483	
AN25.20	seawater	3	20.05.25	"14.55"	-59.63375	-60.69852	A: 2000; B: 2000; C: 2000
AN25.21	air	1	20.05.25	"16.10"	-59.79545	-60.80955	

Data will be available after samples have undergone laboratory processing.

2.4 REFERENCES

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Brown et al. Aerial dispersal of pathogens on the global and continental scales and its impact on plant disease *Science.* 297 (2002).

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3. CASS 226 BIOPOLE III

3.1 Zooplankton Activity

Nadine Johnston, Gabriele Stowasser, Siobhán Foden, Tracey Dornan (BAS), Sammie Buzzard (CPOM)

3.1.1 Objectives

To determine dynamics (community composition, distribution, and abundance) of the winter zooplankton community in the Southern Ocean, and their relationships with oceanography, phytoplankton, and nutrient dynamics. The objectives and outcomes of this cruise form part of the BIOPOLE Programme. Workpackage 2 of BIOPOLE is seeking to understand the community composition, distribution (vertical and horizontal) and abundance of the zooplankton community, the proportion of the copepod *Calanoides acutus* within it, and its role in processing nutrients and sequestering carbon to the deep ocean. This cruise is focused on the zooplankton community during the winter period and complements work carried out on SD033 (BIOPOLE I) during spring (as the zooplankton community develops in tandem with the spring phytoplankton bloom) and SD046 (BIOPOLE II) during the autumn (as *C. acutus* descend to depth for winter diapause).

3.1.2 Sampling

The zooplankton community was examined through a combination of in situ mini bongo net deployments (from workboat Terror and the SDA), underway water sampling passed through a mini bongo net, and underway water sampling to pass through a Planktoscope along the cruise transect (from waters at the beginning of the Falkland Islands EEZ, down to Rothera Base, within the Ryder Bay environs, and back to the Falklands EEZ).

3.1.2.1 Sampling stations

Refer to the following logs for a list of sampling stations:

- Zooplankton In Situ (TERROR)
- Zooplankton In Situ (SDA)
- Zooplankton Underway (incorrectly titled Bongo and Planktoscope)
- Zooplankton Planktoscope (incorrectly titled as Bongo and Planktoscope)

3.1.2.2 In situ mini Bongo net (+Niskin and CTD) deployments

The mini bongo was deployed at three locations in the Ryder Bay area: (1) in front of a glacier and (2) an open water site from Terror, and (3) from a coastal site from the SDA. At each of these locations an RBR CTD and a 5L Niskin was also deployed to obtain supporting environmental, nutrient and phytoplankton data. The mini bongo was also deployed together with an RBR CTD within (4) Lemaire channel from the SDA (but the Niskin was not deployed owing to time constraints).

Ryder bay deployments: At each location a mini bongo, 5L Niskin and RBR CTD were deployed in variable sequence, each to a depth of 50m using a nylon line (Figure 3.1, Tables 3.1 & 3.2). To stop it drifting, the mini bongo was weighed down with two messengers attached to the line where it was tied to the mini bongo and the net remained open (i.e. messengers were not sent down the line to open/close the net). Lat, long and time UTC was taken upon reaching 50m. The net was hauled back onto Terror and the SDA by hand. When back on deck the codend was opened into a 125mL Nalgene and rinsed with filtered seawater. Samples were then preserved in 4% formalin in the deck lab fume hood. The 5L Niskin was also weighed down with a messenger hung from the bottom to stop it drifting. Once the Niskin was recovered water was decanted into a clean 5L carboy. Samples for flow cytometry were filled

directly into sample vials and stored, and the remaining water was filtered for PIC and POC (tables 3.1 and 3.2) immediately on return to the SDA labs. Refer to section on biogeochemistry for methods and sample logs. The RBR CTD was attached to the 50m line using a woven rope secured to the body of the RBR CTD using 2x jubilee clips, making sure the woven rope was wetted before securing to ensure the rope was pliable and remained secure on deployment.

Lemaire deployment: Within Lemaire channel, the mini bongo was deployed as above, but with the RBR CTD attached to the line approximately 1m above the mini bongo (Figure 3.2, Table 3.2). The 5L Niskin was not deployed owing to time constraints, so no additional water samples were collected for nutrient, oceanographic, and phytoplankton analyses as above.

Issues encountered: The messenger on the 5L Niskin failed to trigger. The line was therefore secured to the white trigger with electrical tape to ensure the base of the messenger hit it. Without the electrical tape the line swayed away from the Niskin and the messenger did not fall directly over the trigger and hence the top and bottom lids on the Niskin failed to close.

We are immensely grateful to the Captain and the deck crew of the SDA and Terror for making in situ sampling possible on this cruise.

3.1.2.3 Underway sampling using mini bongo and planktoscope

The mini bongo was mounted above a seawater sink in the Main Lab and the underway seawater hose was secured inside the net (Figure 3.3, Table 3.3). Underway seawater was allowed to pass through the closed net for approximately 1 hr, every 6 hrs (and every 4 hrs through Lemaire Channel etc) over a 24h period along the cruise track. The flow of the seawater out of the pipe was measured regularly and recorded. Using time start and time end sampling, the volume of water sampled could be estimated. Following collection, the codend was emptied into a 125mL Nalgene and rinsed with filtered seawater. This was then preserved in 4% Formalin and stored at 4 °C for the return journey back to Cambridge.

50ml samples were collected for analyses and imaging in the Planktoscope from the UCSWL every 6 hrs (and every 4 hrs through Lemaire Channel etc) (Figure 3.3, Table 3.4). Owing to time constraints the samples were not passed through the planktoscope onboard. Instead, they were frozen at -20 °C for transport back to Cambridge and analyses thereafter.

Issues encountered: There did not appear (with the naked eye, as no microscopes were available onboard) to be many zooplankton in any of the in situ or underway samples taken.

However, acoustic imagery did seem to suggest zooplankton activity (see Section 3.3). When sailing through the Gullet, and through Lemaire the underway system had to be turned off owing to ice, impacting the frequency of sample collection.

Table 3.1: Mini Bongo, RBR CTD and 5l Niskin samples collected on workboat Terror				
Date and time	Latitude	Longitude	Sample ID	Comment
17/05/2025 18:07	67'36.122	68'15.605	POC/PIC-111/109 Filters (BIII-53/BIII-23)	5L Niskin deployment at 50m from TERROR in OPEN OCEAN site opposite glacier in Ryder Bay
17/05/2025 18:07	67'36.122	68'15.605	FCT106	FCT106 taken from TERROR 5l Niskin OPEN OCEAN site
17/05/2025 17:57	67' 36.249	68'15.727		RBR CTD deployment at 50m from TERROR in OPEN OCEAN site opposite glacier in Ryder Bay
17/05/2025 17:39	67' 36.469	68'16.027	ZOI-101	Mini bongo deployed at 50m from TERROR in OPEN OCEAN SITE opposite glacier
17/05/2025 16:28	67'33.726	68'14.679	ZOI-100	Mini Bongo deployed at 50m from TERROR at GLACIER SITE near Ryder Bay
17/05/2025 16:19	67'33.737	68'14.654		RBR CTD deployed at 50m from TERROR at GLACIER SITE near Ryder Bay
17/05/2025 16:00	67'33.676	68'14.746	POC/PIC-110/108 Filters (BIII-51/BIII-9	5L Niskin deployment at 50m from TERROR in OPEN OCEAN site opposite glacier in Ryder Bay
17/05/2025 16:00	67'33.676	68'14.746	FCT105	FCT105 sample taken from 5l Niskin on Terror at GLACIER SITE

Table 3.2: Mini Bongo, RBR CTD and 5l Niskin samples collected from SDA				
Date and time	Latitude	Latitude	Sample ID	Comment
19/05/2025 12:56	-65.147	-64.0743	ZOI-103	Mini Bongo deployment in Lemaire Channel CHANNEL SITE at 50m with RBR CTD attached to the line approx 1m above the net.
18/05/2025 14:39	-67.5716	-68.1362	POC/PIC-112/112 Filters (BIII-60/BIII 11)	5L Niskin deployed at 50m from SDA at Ryder Bay COASTAL SITE
18/05/2025 14:39	-67.5716	-68.1362	FCT-108 N	FCT-108 (flow cytometry sample) taken from 5l Niskin deployed on SDA to 50m over stern at COASTAL SITE
18/05/2025 14:28	-67.5712	-68.1362		RBR CTD deployed at 50m from SDA at Ryder Bay COASTAL SITE
18/05/2025 14:18	-67.5709	-68.1366	ZOI-102	Mini bongo deployed at 50m on SDA in Ryder Bay COASTAL SITE

Table 3.3: Zooplankton samples collected with mini-Bongo from the underway seawater system.					
Date and time	Latitude	Latitude	Flow rate	Sample ID	Comments
21/05/2025 10:21	-56.6397	-58.7110		ZOU-122	Sample end time
21/05/2025 09:20	-56.8460	-58.8463	11s per L	ZOU-122	Sample start time
21/05/2025 04:16	-57.8711	-59.5067		ZOU-121	Sample end time
21/05/2025 03:16	-58.0864	-59.6532	6s per L	ZOU-121	Sample start time
20/05/2025 23:21	-58.9227	-60.2136		ZOU-120	Sample end time
20/05/2025 22:21	-59.1306	-60.3544	6s per L	ZOU-120	Sample start time

20/05/2025 14:07	-60.8446	-61.5402		ZOU-119	Sample end time
20/05/2025 13:06	-61.0614	-61.7060	6s per L	ZOU-119	Sample start time
20/05/2025 10:07	-61.6959	-62.1637		ZOU-118	Sample end time
20/05/2025 09:07	-61.9127	-62.3298	18s per L	ZOU-118	Sample start time
20/05/2025 04:30	-62.9111	-63.0822		ZOU-117	Sample end time
20/05/2025 03:30	-63.1295	-63.0803	23s per L	ZOU-117	Sample start time
20/05/2025 02:34	-63.3371	-63.0375		ZOU-115	Sample end time
20/05/2025 01:34	-63.5553	-62.9750	22s per L	ZOU-115	Sample start time
20/05/2025 00:34	-63.7443	-62.9715		ZOU-116	Sample end time
19/05/2025 23:35	-63.9098	-62.9681	22s per L	ZOU-116	Sample start time
19/05/2025 10:20				ZOU-114	End lat/long missing
19/05/2025 09:30	-65.3419	-65.0110	22s per L	ZOU-114	Sample start time
19/05/2025 06:30	-65.3499	-66.0428		ZOU-113	Sample end time
19/05/2025 05:30	-65.4771	-66.2784	30s per L	ZOU-113	Sample start time
19/05/2025 02:34	-65.8442	-66.9534		ZOU-112	Sample end time
19/05/2025 01:32	-65.9828	-67.1716	30s per L	ZOU-112	Sample start time
18/05/2025 22:28	-66.3968	-67.7195		ZOU-111	Sample end time
18/05/2025 21:29	-66.5285	-67.5429	30s per L	ZOU-111	Sample start time
18/05/2025 17:54	-67.1500	-67.6552		ZOU-110	Sample end time
18/05/2025 17:25	-67.2239	-67.7592	30s per L	ZOU-110	Sample start time

16/05/2025 00:50	-67.5816	-68.1461		ZOU-109	Sample end time
15/05/2025 23:50	-67.5816	-68.1461	25s per L	ZOU-109	Sample start time
15/05/2025 16:36	-67.0161	-67.6443		ZOU-108	Sample end time
15/05/2025 15:35	-66.8733	-67.6583	25s per L	ZOU-108	Sample start time
15/05/2025 10:18	-66.0537	-67.6818		ZOU-107	Sample end time
15/05/2025 09:15	-65.8471	-67.4735	25s per L	ZOU-107	Sample start time
15/05/2025 04:30	-64.7978	-66.3914		ZOU-106	Sample end time
15/05/2025 03:29	-64.5805	-66.1163	33s per L	ZOU-106	Sample start time
14/05/2025 23:00	-63.6283	-65.1326		ZOU-105	Sample end time
14/05/2025 22:00	-63.4174	-64.9162	33s per L	ZOU-105	Sample start time
14/05/2025 16:46	-62.3460	-63.8473		ZOU-104	Sample end time
14/05/2025 15:30	-62.0713	-63.5953	33s per L	ZOU-104	Sample start time
14/05/2025 09:59	-60.8061	-62.4036		ZOU-103	Sample end time
14/05/2025 08:55	-60.8061	-62.4036	33s per L	ZOU-103	Sample start time
14/05/2025 04:58	-59.6600	-61.3638		ZOU-102	Sample end time
14/05/2025 03:57	-59.4347	-61.1540	33s per L	ZOU-102	Sample start time
14/05/2025 00:02	-58.5736	-60.3965		ZOU-101	Sample end time
13/05/2025 23:02	-58.3462	-60.2123	33 s per L	ZOU-101	Sample start time
13/05/2025 17:39	-57.1586	-59.1891		ZOU-100	Sample end time
13/05/2025 16:39	-56.9453	-59.0338	33 s per L	ZOU-100	Sample start time

Table 3.4: Zooplankton samples taken from the underway seawater supply for measurements in the Planktoscope			
Date and time	Latitude	Latitude	Sample number
21/05/2025 09:04	-56.9009	-58.8829	PTS-122
20/05/2025 21:21	-59.3373	-60.4899	PTS-121
20/05/2025 21:11	-59.3718	-60.5122	PTS-120
20/05/2025 13:18	-61.019	-61.6723	PTS-119
20/05/2025 09:05	-61.9202	-62.3352	PTS-118
20/05/2025 03:11	-63.2008	-63.0724	PTS-117
19/05/2025 21:19	-64.2804	-63.0278	PTS-116
19/05/2025 16:30	-64.7802	-63.4931	PTS-115
19/05/2025 09:34	-65.3431	-64.9879	PTS-114
19/05/2025 05:23	-65.4916	-66.3055	PTS-113
19/05/2025 01:28	-65.9917	-67.1854	PTS-112
18/05/2025 21:22	-66.5428	-67.5148	PTS-111
18/05/2025 17:37	-67.1971	-67.6936	PTS-110
15/05/2025 22:20	-67.5817	-68.1464	PTS-109
15/05/2025 15:07	-66.8179	-67.6051	PTS-108
15/05/2025 09:06	-65.8168	-67.4427	PTS-107
15/05/2025 03:08	-64.5046	-66.0447	PTS-106
14/05/2025 21:34	-63.3373	-64.8434	PTS-105
14/05/2025 15:06	-61.9819	-63.5163	PTS-104
14/05/2025 09:33	-60.7057	-62.3149	PTS-103
14/05/2025 03:16	-59.2852	-61.0221	PTS-102
13/05/2025 22:02	-58.1185	-60.0156	PTS-101
13/05/2025 15:39	-56.7507	-58.8758	PTS-100

Figures

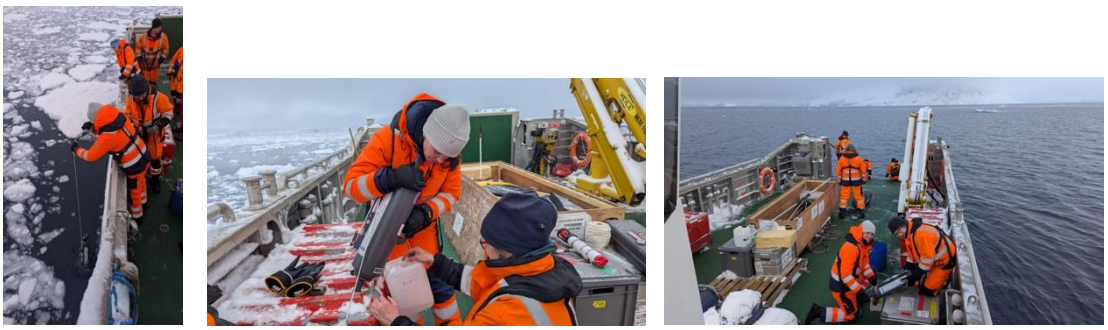

Figure 3.1: **In situ mini Bongo net (+Niskin and CTD) deployments** in Ryder Bay onboard the SDA's Terror during SD049 to collect zooplankton, nutrient and oceanographic samples.

Figure 3.2: **In situ mini Bongo net (+Niskin and CTD) deployments** in Ryder Bay and Le Mer Channel onboard the SDA during SD049 to collect zooplankton samples and oceanographic variables.

Figure 3.3: **Underway sampling using mini bongo and planktoscope:** onboard the SDA during SD049 to collect zooplankton samples the Main Lab for collecting zooplankton samples via a Mini Bongo net (left) and from the Uncontaminated Sea Water Laboratory for passing through a planktoscope (right).

3.2 Physical oceanography, phytoplankton and biogeochemistry

Gabriele Stowasser, Nadine Johnston, Siobhán Foden (all BAS), Sammie Buzzard (CPOM) and Amanda Burson (BAS)

3.2.1 Oxygen isotope and salinity sampling

Samples for $\delta^{18}O$ were collected from the uncontaminated seawater supply (UCSW) to determine the proportion of meteoric water and sea ice-derived water in the samples. Both oxygen isotope and salinity samples were initially taken every 6 hours on the southbound

leg towards Rothera research station and with the frequency increased to every 4 hours when close to the Antarctic Peninsula on the way north (in line with the biogeochemistry sampling, see event log Underway_sampling_GS for sampling points).

3.2.1.1 $\delta^{18}O$

When sampling, 50 ml plastic bottles were rinsed three times, before being filled with minimal air gap from a continuously flowing UCSW tap. The bottles were then closed with plastic screw tops and sealed with parafilm. The samples were stored at +4°C once sampling was complete.

3.2.1.2 Salinometry

For salinity samples a 250ml glass bottle was rinsed three times, filled to the bottle shoulder, the neck dried with blue roll and seal the bottle with a stopper. Salinity samples were stored in crates in the salinometer lab so that the salinity samples could reach room temperature prior to measurement. The salinity samples were processed on SD050.

3.2.2 Phytoplankton

3.2.2.1 Introduction

One of the main targets of the BIOPOLE program is to understand the relationship between the availability of (inorganic) resources (ie. silica, phosphorus, nitrogen, iron and other trace metals) and subsequent productivity within polar oceans. Primary production by phytoplankton is the linking factor between inorganic geochemistry, physical mixing and zooplankton trophic levels. Photosynthetic phytoplankton transform inorganic carbon to organic carbon, thus creating the foundation to the biological carbon cycling in the world's oceans. Understanding not only the net abundance but also the community composition of phytoplankton present is important for predicting carbon transfers to upper trophic levels due to selective feeding behaviours of zooplankton (e.g. Haberman et al., 2003; Pauli et al., 2021). In addition to the relative abundances of, e.g. large diatoms verses nanoflagellates within the phytoplankton community, the biochemical composition of the phytoplankton itself (particulate organic nitrogen, phosphorus and carbon content) impacts its suitability as prey material for higher trophic levels (Meunier et al. 2016). In general, mesozooplankton

graze on larger phytoplankton cells, especially diatoms. By separating the micro- (>20 µm) particulate organic matter composition from the total phytoplankton community we can for focus on nutritional value of the phytoplankton most relevant to zooplankton.

The SD049 cruise occurred in what should fall at the beginning of the low- to non-productive winter season of the Southern Ocean. This work will complement sampling carried out on cruises SD033 (spring – start of high productivity) and SD046 (autumn – as copepods start their descent into diapausing depths) and will give us a unique opportunity to 1) determine the abundance and community composition of the phytoplankton present in surface waters and (2) measure the particulate organic carbon, nitrogen and phosphorus and pigments in the phytoplankton community in the winter.

3.2.2.2 Underway sampling

Underway uncontaminated seawater samples were collected every 6 hours on the leg south towards Rothera research station. Northwards samples were taken every 4 hours when close to coastal waters of the Antarctic peninsula and every 6 hours after leaving the Antarctic continental shelf up to the Falkland EEZ. Water was collected from the uncontaminated seawater pipe directly into flow cytometry (FCM) cryovials and Lugol's bottles and into 5l carboys for all other parameters sampled (see list below) for subsequent filtering. Water was either filtered directly or stored at 4°C for no more than 2 hours before filtering.

Samples for filtering were taken for Particulate organic carbon (POC), particulate inorganic carbon (PIC), particulate organic matter (POM), particulate organic phosphorus (POP), High performance liquid chromatography (HPLC) and Clorophyll a (Chla), from the uncontaminated seawater (UCSW) lab (see Table 3.5 for the full list of parameters and sampling stations). Tubing was fixed to one of the seawater taps for taking samples, through which water was left running continuously to ensure there was no backlog of water in the pipes to the tap. When too much ice was present the underway water system had to be switched off to avoid clogging. When it was switched back on the water was left to run for several minutes to flush the system before any samples were taken.

3.2.2.3 Filtration for POC, PIC and POP

Pre-ashed, pre-weighed 25 mm GF/F filters were placed on the filter holder and the cup twisted to secure in place. A small amount of filtered seawater was run through before adding sample water to ensure there were no leaks in the filter seal. 2 L of water was then poured from the sampling carboy into the 5 L filtration carboys (Filtration rig, Fig. 3.4). Filtration for POC/PIC and POP was carried out at a pressure of at or below 40 kPa.

Once the water had been filtered, filters were removed from the stand using forceps rinsed with filtered seawater, folded in half twice, and placed in pre-labelled plastic bags. The ID code of each sample plus the filter number were also transcribed onto filtration logsheets which were subsequently scanned and can be found in the cruise leg folder under “scanned data sheets”. Filters were then stored at -20°C until further analysis in the laboratory at BAS.

Figure 3.4: Filtration rig used on SD049

3.2.2.4 Filtering for pigments: Chlorophyll *a* and HPLC

Phytoplankton utilise photosynthetic pigments to absorb the energy from light and transform inorganic carbon into organic carbon. All phytoplankton contain chlorophyll pigments, hence the use of chlorophyll fluorescence as a proxy for biomass in CTD and satellite sensors

However, different groups of phytoplankton produce different accessory pigments (i.e. carotenoids and phycobilins) to utilise sections of the light spectra not effectively captured by chlorophyll. The presence and relative ratios of these accessory pigments to chlorophyll *a*

allow for a relatively quick assessment of the phytoplankton community composition as well as relative abundances. The analysis of these pigments is done via fluorometry (in the case of chlorophyll) and HPLC (for accessory pigments). Analysis for both will occur back in the UK but the collection of the material onboard is described here.

For chlorophyll, 2-4 L of water (depending on filter colouration) were gently (no more than 30 psi) vacuum filtered onto 25 mm pre-ashed GF/F filters. These were then folded in-half and placed inside individual small sample bags and labelled with pre-printed labels with individual sample IDs. The filters were stored in the -80˚C freezer. For HPLC samples 4 L of water were filtered onto 47mm pre-ashed GF/F filters. These were packaged and stored the same way as chlorophyll filters.

3.2.2.5 Preserving for taxonomy: Lugol's iodine and Flow Cytometry

We employed two different preservation methods for phytoplankton community composition analysis. The first is Lugol's iodine (acid) at 1% final concentration which will be used for microscopic analysis (enumeration and species identification) of cells of ~5 µm and larger. Water was collected from the uncontaminated seawater pipe directly into 125 mL opaque brown plastic bottles to the base of the neck. To this we added 3 mL of Lugol's iodine solution under the flow hood and wearing appropriate PPE. The bottle was capped, gently inverted, parafilm added around the lid and stored in the 4˚C walk-in fridge.

Flow cytometry allows for the analysis of smaller phytoplankton within the community; picoplankton and cyanobacteria (if present). Flow cytometry utilizes the combination of pigments which are excited by specific wavelengths of light via a laser then the corresponding emission wavelength post-excitation is measured using sensors for specific wavelengths as well. The excitation/emission factors combined with information related to the size and complexity of cell allows for the separation and enumeration of different groups of phytoplankton. It also allows for post-hoc enumeration of bacteria if a secondary dye (Syber green) is added prior to analysis. Analysis is conducted on the Accuri C6 Plus flow cytometer from BD instruments located in Cambridge.

For preservation, 4.5 mL of seawater (directly from the UCSW supply) was added to 5 mL cryo-vials. Then 0.5 mL of formaline-hexamine (10% w/v) was added, and the vials capped then gently inverted several times. Vials were kept in the 4˚°C fridge in the deck lab for a minimum of 30 min and maximum of 12 hrs to ensure the preservative has penetrated the cells. The vials then need to be flash-frozen in liquid nitrogen and stored in 5 mL cryovial boxes in the -80˚C freezer. There is special PPE specific to LN2 which includes a cryo-apron, cryo-gloves and eye protection. Additionally, specific training is required prior to any LN2 work and the person doing the work should always have a safety buddy present. The lab should be well ventilated and the O2 monitor working correctly.
Liquid nitrogen was generated on board using a LN2 generator and N2 compressed gas. The dewar onboard the SDA maintains the generated LN2 for multiple weeks if not opened and/or samples submerged, and it filled within a 15 hr period of initiation of LN2 generation.

3.2.2.6 POM sampling for stable isotope analysis $\delta^{13}C$ and $\delta^{15}N$

In order to establish an isotopic baseline for POM across the Atlantic sector of the Southern Ocean particulate organic matter (POM) was collected along both transects in line with the biogeochemistry sampling. POM samples were obtained through filtering water collected from the UCSW outlet. All water samples collected were processed on-board. 5L were filtered onto pre-ashed 47mm GF/F filters and the filters stored frozen at -80°C.

3.2.2.7 In situ oxygen measurements

The oxygen sensor connected to the UCSW system was not operational on this cruise. We therefore used a portable oxygen sensor (RBRduet3T.ODO) to determine dissolved oxygen. On SD046 we tested the sensor and found that it was not calibrated. It is therefore unsuitable for comparative analysis with other measurements. However, while the absolute values cannot be used for comparison we will be able to assess fluctuations in dissolved oxygen along the cruise transects in winter waters. The RBR oxygen sensor was suspended by string into a bucket with continuous UCSW flowthrough. Interruptions to the flow (i.e. switching off the water supply in icy water conditions) and data downloads were recorded into the

“Oxygen_Optode_Eventlog”. This and the downloaded oxygen data can be found in the folder “Optode data” on the SD049 leg drive.

Table 3.5: Samples collected from the Uncontaminated Seawater supply during SD049*

Parameters	Nutrients	Flow cytometry	Oxygen	Salts	Lugols	POC	PIC	POP	Chla	HPLC	POM
Water filtered (F) collected(C)	50ml C	4.5ml C	50ml C	200ml C	125ml C	2L F	2L F	2L F	2-4L F	4L F	5L F
Samples taken	24	13	25	25	23	24	24	23	24	24	24
Storage	-20°C	-80°C	+4°C	Room temp.	+4°C	-20°C	-20°C	-20°C	-80°C	-80°C	-80°C

* Not all pre-printed labels were used and sample numbers are not always in sequential order. For sample numbers and related time stamps and coordinates please see Eventlog: Underway_water_sampling_GS.

3.3 ACOUSTICS

Tracey Dornan

3.3.1 Vessel-Mounted Acoustic Doppler Current Profiler (VMADCP)

3.3.1.1 Introduction and instrumentation

The Acoustic Doppler Current Profiler (ADCP) is a hydrological instrument used to measure water current velocities using the Doppler effect. An ADCP emits an acoustic signal, and then measures the return signal as scattered by moving water, the frequency shift of the return signal can then be used to establish relative water velocity in the signal plane. A Vessel-mounted ADCPs (VMADCP) is housed in the hull of a ship and has several beams which can be used to measure the three-dimensional current field up to some hundreds of metres below the vessel. A VMADCP uses a stream of navigational data to convert relative current velocities to absolute values.

The VMADCP on the RRS Sir David Attenborough (SDA) is a Teledyne Ocean Surveyor. The Ocean Surveyor can operate on two frequencies, 150kHz and 75kHz, which is dictated by a configuration file. In good conditions, the 150kHz ADCP has a range of approximately 400m, and the 75kHz has a range of 700m with half the depth resolution. At present only one of the two frequencies can be operated at any one time, as documented in the main SD025 Polar Trials cruise and 'E&T Elec Report'.

3.3.1.2 Operation and configuration

The VMADCP is operated using the VMDAS software. See the VMDAS user guide for instructions using this software. VMDAS outputs raw ADCP data (.ENR files), short-term averages (.STA files) computed over 30-second intervals and long-term averages (.LTA files) computed over 120-second intervals.

VMDAS is configured using command files. Only the 150 kHz ADCP was run during cruise SD049, operating in water tracking mode. The ping rate was maintained at 2 seconds via the K-Sync. For the duration of the cruise, we used the command file:

os150nb_450m_wt_8mbins_thru_ksync.txt

In VMDAS, the Com Port (Program Options, Communications tab) “COM2” is used for the 150 kHz frequency. If the 75 kHz frequency is used “COM1” is required. VMADCP pings were controlled through the K-Sync software to minimise interference between different acoustic systems. For easier file management the VMDAS software was stopped and restarted daily.

The ADCP operated well throughout the cruise but crashed shortly before entering the Falkland Islands 200nm zone, and so was not restarted. The ADCP data was not processed during the cruise.

Table 3.6 150 kHz ADCP event log summary.

Date Time	Lat	Lon	Event action type	ADCP	Line No	Comment
12/05/2025 19:09	-51.9373	-58.4898	Powered up	150kHz		Not pinging
13/05/2025 13:32	-56.3449	-58.5409	Start ping	150kHz	001	thru k-sync
14/05/2025 11:09	-61.0716	-62.6448	Stop and restart	150kHz	002	Daily stop and restart ping
14/05/2025 11:21	-61.1183	-62.6873	Restart	150kHz	003	Restart at console following crash
15/05/2025 11:36	-66.3349	-67.9440	Stop and restart	150kHz	004	Daily stop and restart
16/05/2025 11:09	-67.5722	-68.1300	Stop	150kHz		Arrival at Rothera
18/05/2025 14:45	-67.5728	-68.1351	Start ping	150kHz	005	Depart Rothera
19/05/2025 12:11	-65.2089	-64.1516	Stop and restart	150kHz	006	Daily stop and restart
20/05/2025 11:12	-61.4652	-62.0006	Stop and restart	150kHz	007	Daily stop and restart
21/05/2025 10:33	-56.5993	-58.6859	ADCP crashed	150kHz	007	ADCP crashed, not restarted as approaching 200 nm limit

3.3.2 EK80

3.3.2.1 Introduction

The SDA is equipped with a six frequency Simrad EK80 scientific echosounder operating at 18, 38, 70, 120, 200 and 333 kHz. All transducers are mounted on the hull behind ice windows.

During cruise SD049, the EK80 echosounders were operated continuously on transit to and from Rothera in international waters (beyond 200nm), to collect information on the horizontal and vertical distribution of krill and micronekton (i.e., small pelagic fish). The transmission rates and intervals of all actively transmitting acoustic instruments (EK80, ADCP 150kHz, EA640) were synchronised using the K-Sync to reduce interference. Recording and pinging of the EK80 was stopped while alongside at Rothera. Recording also stopped briefly when the data volume was too full to write to disk (see Table for timings). Apart from a full hard drive the EK80 performed well throughout the cruise.

Table 3.7. EK80 event log summary.

Date Time	Lat	Lon	Event action	Comment
12/05/2025 19:08	-51.9376	-58.4853	EK80 transceivers powered up	Not pinging
13/05/2025 13:03	-56.2480	-58.4820	Start ping	Thru k-sync
16/05/2025 11:12	-67.5722	-68.1300	Stop ping and record	Arrival at Rothera
18/05/2025 19:18	-66.8890	-67.6349	Start ping	Restart ping through k-sync and record, departing Rothera
19/05/2025 03:34	-65.7110	-66.7303	EK80 stopped recording	Ran out of disk space. Deleted Biopole 3 data up to D20250226
19/05/2025 04:51	-65.5549	-66.4315	Restart ping and record	Restarted ping and recording
21/05/2025 12:22	-56.2251	-58.4770	EK80 stopped recording	Stopped at 200nm limit

3.3.2.2 Methodology

EK80 data

The EK80 was operated using Simrad EK80v. 21.15.2 software. The EK80 was switched on and as calibration was not going to be possible during the cruise all environmental settings were unchanged from those applied during SD046. The raw data files (SD-Dyyyymmdd-Thhmmss.raw) were logged to the local PC, which was backed up at the end of the cruise to the samba drive (data\cruise\sda\current\system\bioacoustic_simrad_ek80\acquisition\EK80_data). Raw data were collected to variable ranges to reduce data volume (see Table 1.8). These ranges were unchanged from the previous cruise settings.

The ping rate was maintained at 2 seconds via the K-Sync. See Table 1.8 for EK80 settings.

Table 1.8: EK80 settings applied during cruise SD049. None of the settings were changed and assumed to be the same as SD046.

Variable	**18 kHz**	**38 kHz**	**70 kHz**	**120 kHz**	**200 kHz**	**333 kHz**
Range (m)	1200	1200	1200	600	400	150
Temperature	2.8	2.8	2.8	2.8	2.8	2.8
Salinity	33.4	33.4	33.4	33.4	33.4	33.4
Mode	Active	Active	Active	Active	Active	Active
Pulse type	CW	CW	CW	CW	CW	CW
Transducer type	ES18	ES38-7	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2172	190-narrow	437	1588	666	210
WBT Serial no.	720835	721576	721579	721585	721591	721746
Transducer depth (m)	0	0	0	0	0	0
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024	1.024
Max Power (W)	1600	1000	750	225	150	50

Calibration data embedded in .raw files:

SourceCal T1

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.831 # (milliseconds) [0.001..50.000]

Frequency = 38.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 7.31 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = -0.02 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 18.000000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 7.45 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = -0.15 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 18.000000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.71972 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 20.8333333 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 26.8100 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 1000.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -20.700000 # (decibels re 1 steradian) [-99.000000..11.000000]

SourceCal T2

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.930 # (milliseconds) [0.001..50.000]

Frequency = 200.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 6.10 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = 0.19 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 6.00 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = 0.05 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.77937 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 31.2500000 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 25.2800 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 150.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -20.700000 # (decibels re 1 steradian) [-99.000000..11.000000]

SourceCal T3

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.911 # (milliseconds) [0.001..50.000]

Frequency = 70.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 7.42 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = 0.01 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 7.40 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = -0.04 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.76717 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 20.8333333 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 26.0400 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 750.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -20.700000 # (decibels re 1 steradian) [-99.000000..11.000000]

SourceCal T4

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.937 # (milliseconds) [0.001..50.000]

Frequency = 333.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 7.00 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = 0.00 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 7.00 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = 0.00 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.77919 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 41.6666667 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 25.0000 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 50.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -20.700000 # (decibels re 1 steradian) [-99.000000..11.000000]

SourceCal T5

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.397 # (milliseconds) [0.001..50.000]

Frequency = 18.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 9.96 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = -0.08 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 15.500000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 9.82 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = -0.04 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 15.500000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.52068 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 35.7142857 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 23.4400 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 1600.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -17.000000 # (decibels re 1 steradian) [-99.000000..11.000000]

SourceCal T6

AbsorptionDepth = 5.000 # (meters) [0.000..10000.000]

Acidity = 8.000 # (pH) [0.000..14.000]

EffectivePulseDuration = 0.924 # (milliseconds) [0.001..50.000]

Frequency = 120.00 # (kilohertz) [0.01..10000.00]

MajorAxis3dbBeamAngle = 6.85 # (degrees) [0.00..360.00]

MajorAxisAngleOffset = 0.08 # (degrees) [-9.99..9.99]

MajorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

MinorAxis3dbBeamAngle = 6.96 # (degrees) [0.00..360.00]

MinorAxisAngleOffset = -0.01 # (degrees) [-9.99..9.99]

MinorAxisAngleSensitivity = 23.000000 # [0.100000..100.000000]

NumberOfTransducerSegments = 4 # [1..4]

PulseCompressedEffectivePulseDuration = 0.77497 # (milliseconds) [0.00100..50.00000]

PulseDuration = 1.024 # (milliseconds) [0.001..200.000]

Salinity = 33.400 # (parts per thousand) [0.000..50.000]

SamplingFrequency = 25.0000000 # (kilohertz) [0.0100000..1000.0000000]

SoundSpeed = 1459.55 # (meters per second) [1400.00..1700.00]

Temperature = 2.800 # (degrees celsius) [-3.000..100.000]

TransceiverImpedance = 5400.0 # (ohms) [0.0..1000000.0]

TransceiverSamplingFrequency = 1500.00 # (kilohertz) [1.00..5000.00]

TransducerGain = 25.8000 # (decibels) [1.0000..99.0000]

TransducerModeActive = true # [false..true]

TransmittedPower = 225.00000 # (watts) [1.00000..30000.00000]

TvgRangeCorrection = SimradEK80 # [None, BySamples, SimradEx500, SimradEx60, BioSonics, Kaijo, PulseLength, Ex500Forced, SimradEK80, Standard]

TwoWayBeamAngle = -20.700000 # (decibels re 1 steradian) [-99.000000..11.000000]

3.3.3 ImpYak

3.3.3.1 Introduction

The ImpYak is a novel battery-powered 2.5m long autonomous surface vehicle (ASV) developed by SAMS (Scottish Association of Marin Science) robotics team (Figure). It is a modified river kayak, fitted with a hull mounted echosounder (Simrad WBTmini with

autonomous license and ES200-7CDK split beam transducer) controlled via EK Mission Planner (EKMP) software. Two impellers sit behind the transducer, with piloting controlled via ArduPilot drone software. Piloting and the echosounder are activated and controlled independently via separate radio links. During SD049 we aimed to test the ImpYak's ability to survey krill as part of the Darwin plus funded *Safeguarding Antarctic krill stocks for baleen whales* project. This was completed over 1.5 days whilst the SDA was alongside at Rothera.

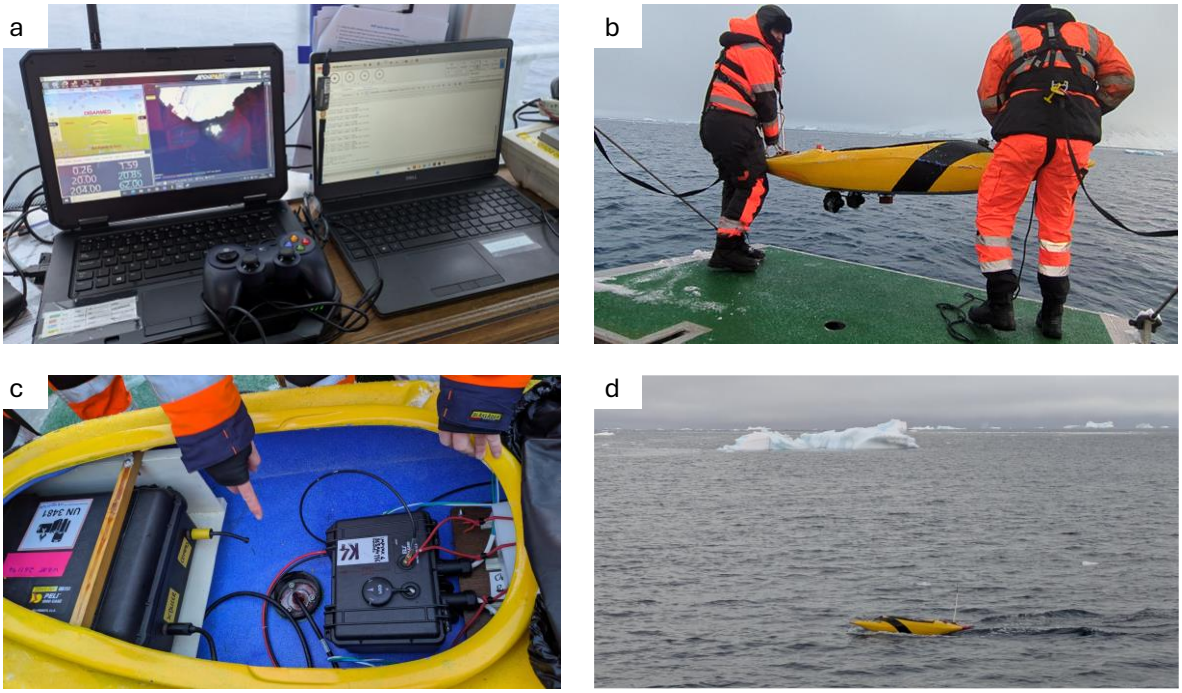

Figure 3.5. ImpYak. a) Laptop setup inside Terror showing ArduPilot software and joystick controller (left) and EKMP software (right). b) ImpYak being recovered with impellers and transducer visible on hull. c) inside the ImpYak cockpit with (L-R) WBTmini housed inside modified pelicase, 200 kHz transducer, piloting and impeller hardware in smaller pelicase, and battery board just visible to right. d) ImpYak on survey.

3.3.3.2 Pre-Deployment

Batteries for the ImpYak power and the WBTmini were charged prior to arrival at Rothera. With the WBT connected to the batteries a mission plan with nine pre-programmed 'run steps' was uploaded to the WBT via serial cable, the WBT set to 'sleep', and interactive mode tested via the WBT radio link. Batteries must remain connected to ensure that the WBT clock does not reset to the default date time of 01.01.2014 00:00.

We arrived at Rothera on the 16.05.25 and following instructions in the SAMS ImpYak manual, we attempted to calibrate the ImpYak's GPS in the afternoon. This proved to be challenging and when we contacted SAMS for advice, we were informed that this would not be necessary, so we spent the remainder of the evening ensuring good communications with the ArduPilot software over serial link were established.

3.3.3.3 Deployment

On the 17.05.25 the ImpYak was taken out into Ryder Bay onboard SDA support vessel *Terror*. The ImpYak was housed in its transport case until we were ready to deploy. Whilst onboard *Terror* but prior to ImpYak deployment, the ArduPilot (drone piloting software) and Simrad EKMP echosounder software were opened and communications established. The ImpYak was deployed by SDA crew from the lowered ramp on the aft deck of *Terror* (Figure b). When ImpYak was in the water, *Terror* piloted a short distance away from the ImpYak, and ImpYak response to manual piloting commands were tested. While the manual controls worked as intended, manual piloting was challenging as the ImpYak has considerable momentum and the speed was not easy to control manually, and so 'manual control' should only be used to quick deployment and recovery.

There was a lot of brash ice around, limiting the ability to deploy the ImpYak on an autonomous grid and so two tests were conducted using the following echosounder settings:

Parameter	**Setting**
Beam type	Split 3
Ping interval (seconds)	5
Power (W)	75
Pulse type	CW
Pulse duration (ms)	1.024
Ramping	FAST
Range (m)	200
Mode	Active

Test 1 – stationary data collection

The ImpYak was deployed stationary on ACRO mode within an area of ice and allowed to ping and collect data:

17:42 EK80 ping on

18:00 EK80 ping stopped

ImpYak recovered

Test 2 – survey data collection

To test the ability of the ImpYak to collect acoustic data whilst following a survey grid, we attempted to drop markers at 4 corners of a square by piloting the ImpYak and dropping pins in the ArduPilot plan page. This did not work as the vessel/ImpYak/ice were drifting, making defining sensible points near impossible.

We relocated *Terror* to a relatively ice-free location. As brash ice was moving rapidly, we initially mapped 4 corners of a grid using *Terror*, with the ImpYak onboard dropping markers in the ArduPilot *Plan* page. A simple grid was defined and ImpYak was launched. Initially we received a Gyro error and so ImpYak had to be recovered. Once onboard we restarted the piloting software, ensured that GPS/Gyros were good and relaunched. After a couple of false starts when the WBT was out of radio link range, the WBT was set to ping and the ImpYak set on Auto to follow the grid. As it was getting dark, we allowed the ImpYak to make its way to the start of the grid, follow the first grid line and make its first turn, before picking it back up and returning to the SDA.

3.3.3.4 Summary

The ImpYak was successfully deployed, remotely controlled and was able to follow the survey grid as expected. Data quality appears to be better when the ImpYak is stationary but noisy when underway. We had some issues with radio link communications with the WBT during Test 2. These comms issues persisted until recovery, with the ImpYak having to be very close to the vessel/laptop for radio comms to work. From the data recorded it looks as though commands were getting through, but the real-time data was not necessarily being fed back via the EKMP software, making it difficult to determine if the echosounder had stopped

pinging. Given that the comms had worked well on Test 1, while the ImpYak was a little further away from *Terror*, it may be that the cold was affecting some part of the system but this is speculation as it is not clear what was causing the issue.

Future consideration and action points

Communications:

It is vital to establish comms with the ImpYak Ardupilot when it is still on the boat to ensure Gyro is OK.

ACTION: Further investigation is required by SAMS to understand why the echosounder comms were not feeding through well from the WBT radio link on Test 2.

Noise:

While the acoustic data is yet to be analysed, initial inspection indicates that it was especially noisy at times, with signal to noise ratio likely to be beyond the capacity of data cleaning. Noise is likely to be a combination of bubble sweep down under the hull, and cavitation from the impellers.

ACTION: Noise sources and reduction should be investigated with further on water trials back at SAMS.

Charging batteries:

The ImpYak power batteries took several hours to reach fully charged capacity, and the same again to reduce to 50% storage capacity for transport. For safety batteries were charged in the main lab, which had a good exit route to the aft deck should the batteries experience thermal run-away. While 2 batteries could be charged simultaneously this meant that there always had to be someone present in the lab which interfered with the ability to complete other tasks. While this may not be a problem on cruises with large scientific crew, it was a challenge for such a small team.

ACTION: Need to consider charging times/locations and whether discharging to 50% is essential for transport.

Practicalities:

The ImpYak was being piloted and the echosounders controlled by a single person using 2 laptops as these have two separate operating systems. This setup was unwieldy, and a mental challenge, particularly on a vessel at sea in the snow.

ACTION: Some consideration should be given on how to streamline control of piloting and WBT operation by SAMS given that the pilot and acoustician are likely to be the same person.

Route planning:

We were forced to map a route on the fly as there was a considerable amount of ice around. The protocol suggests marking points by piloting the ImpYak out and dropping pins on the *Plan* page, but this does not work on the featureless and shifting open ocean.

ACTION: Update the ImpYak manual to reflect that making a survey grid using the ImpYak whilst at sea is unfeasible. Survey grids should either be predefined and loaded, or if route planning on the fly is essential (e.g., due to the presence of ice or other hazards) a grid can be outlined using a mothership with the ImpYak onboard.

3.4. eDNA

Tracey Dornan

3.4.1 Introduction

The ability to convert active acoustic data into biologically meaningful results requires ancillary data on the organisms present in the water column. Environmental DNA is a technique that involves analysing trace DNA in the environment released by organisms through mucus, faeces, skin cells etc. The aim of this project was to assess the ability to use underway water samples to detect the presence of organisms that may contribute to acoustic signals and assess if there are differences between day and night samples.

3.4.2 Method

Initial method adapted from SD046

The initial aim was to follow the eDNA protocol used during SD046 to see if results from the underway system were comparable to those collected using bottles on the CTD rosette. Briefly, this involved sampling 1 x 4L MilliQ control and 3 x 4L uncontaminated sea water (UCSW) replicates per sample station. To simulate a CTD sampling event both MilliQ and UCSW were initially collected in a sterilised carboy. To allow for rinsing water 6L MilliQ water (control) was collected using a pre-filter into the 20L carboy, 2 x 2L Nalgene were triple rinsed with this water and a 4L sample retained and filtered through Sterivex. Using the same carboy and prefilters 16L of UCSW was collected, 6 x 2L Nalgene triple rinsed with this UCSW, then

12L of sample retained and filtered through Sterivex. 0.367ml of ATL buffer was then to be added to each sample (in SD046 RNAlater was used).

However, this method proved to be too slow for the time available as

1) the peristaltic pump was pumping very slowly (slower than SD046), resulting in just one MilliQ control (3.5L) and 1 single replicate of a sample (1.2L) being treated in this way on route to Rothera (sample ID eDNA_UCSW_100_C1S1).

2) As a carboy was being used to homogenise the sample and replicate the conditions of a CTD, the time required to bleach, rinse and dry all equipment (~6 hours per sample), was not achievable in the available time.

Final method – Rothera to Stanley

To fit with available time, the method was changed to collect eDNA samples directly from the UCSW supply in the General Purpose lab. Tubing was initially sterilised in a 25% Domestos bleach solution and MilliQ, and triple rinsed in MilliQ before being fitted to the UCSW tap and left in-situ for the remainder of the cruise. UCSW was allowed to run through the tubing continuously until it was switched off for ice. Following this UCSW was flushed through the tubing for a few minutes prior to sampling. Sterivex filters were attached directly to the UCSW tubing (Figure). Three x 2L replicates were taken sequentially at each sampling station, except when the UCSW had to be turned off early because of ice (Event 102). Only one set of replicates (Event 101 prior to arrival at Rothera) were treated with 0.367ml of ATL buffer. All subsequent samples between Rothera and Stanley were frozen at -20°C as this would leave us more options for processing back at Cambridge.

While the aim was to take day and night samples, two additional target samples (3 replicates each) were taken when marks assumed to be krill were visible on the echosounder. Replicates were kept on ice in a 4°C fridge before being transferred to the -20°C freezer within an hour of sampling (Figure).

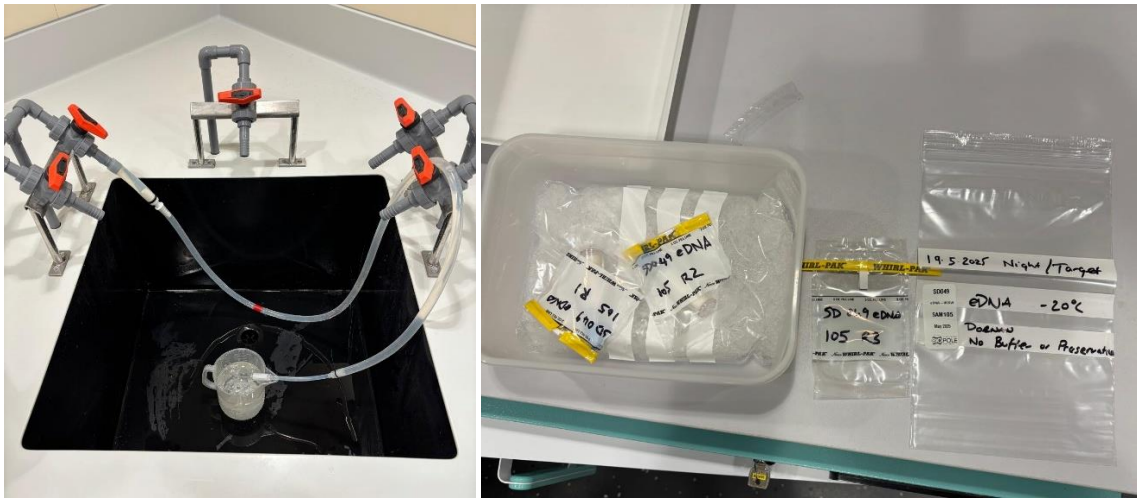

Figure 3.6. Left: eDNA sampling directly from uncontaminated seawater systems in the General Purpose lab. Tubing remained in-situ for the duration of the cruise. Water from the Sterivex was collected in a measuring jug to ensure a 2L volume was filtered. The Sterivex was monitored throughout to ensure that neither inlet or outlet came into contact with seawater or non-sterile surfaces. Right: Sterivex replicates packed in individual whirlpak bags labelled with eDNA event number and replicate number (1-3). These were kept on ice in a 4°C fridge, prior to being grouped in a Ziplock bag and stored at -20°C within an hour of sampling.

Each eDNA sampling station of 3 replicates taken directly from the UCSW system and frozen took just 1 hour to run in total (~15mins per Sterivex, plus 15mins prep set up time). The direct sampling method was simple, considerably reduced sterilisation time, the amount of bleach bath required, reduced waste and potentially risk of contamination as less equipment was needed.

3.4.3 eDNA event summary

Events 102-108 from Rothera to Stanley consisted of two target stations (Events 104 and 105) and the remainder day and night non-target samples. See
Table for a summary of all events.

Table 3.9: eDNA sample locations and comments. All samlpe IDs are prefaceed with eDNA_UCSW_EventNo_ControlsReplicate e.g., C1S1 = 1 control and 1 replicate sample, S1 = Sample replicate 1, S2 = Sample replicate 2. TARGET indicates sampling when marks on echosounder. Samples taken fron 18/05/2025 onwards did not have any ATL buffer added to the samples but were frozen at -20°C within 1 hour of sampling.

Date Time (UCT)	Lat	Lon	ID	Comment
13/05/2025 22:36	-58.41977	-60.26788	100_C1S1	Issues with the pump. Stopped processing after 1hr.

				Only 3.5L MilliQ filtered and 1 replicate of 1.2L of seawater sample.
15/05/2025 16:40	-67.02644	-67.65024	101_S1	New Direct Sample from UCSW method applied. Sterivex attached directly to UCSW in General Purpose lab. Sampling time 16 mins. 0.367ml of ATL buffer. Freeze at -20C
15/05/2025 16:51	-67.05163	-67.67707	101_S2	New Direct Sample from UCSW method applied. Sterivex attached directly to UCSW in General Purpose lab 0.367ml of ATL buffer. Freeze at -20C
15/05/2025 17:12	-67.10369	-67.70686	101_S3	New Direct Sample from UCSW method applied. Sterivex attached directly to UCSW in General Purpose lab 0.367ml of ATL buffer. Freeze at -20C
18/05/2025 17:15	-67.24535	-67.80717	102_S1	DAY. Direct Sample from UCSW, -20C storage only
18/05/2025 17:36	-67.19952	-67.69845	102_S2	DAY. Direct Sample from UCSW, -20C storage only
18/05/2025 22:28	-66.39682	-67.71948	103_S1	NIGHT. Direct Sample from UCSW, -20C storage only
18/05/2025 22:50	-66.34141	-67.70354	103_S2	NIGHT. Direct Sample from UCSW, -20C storage only
18/05/2025 23:05	-66.3035	-67.67783	103_S3	NIGHT. Direct Sample from UCSW, -20C storage only
19/05/2025 17:46	-64.70969	-63.09364	104_S1	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 18:01	-64.68294	-63.01366	104_S2	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 18:15	-64.65947	-62.93548	104_S3	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 21:19	-64.28042	-63.02782	105_S1	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 21:34	-64.24237	-62.99881	105_S2	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 21:49	-64.20294	-62.97722	105_S3	TARGET. Direct Sample from UCSW, -20C storage only
19/05/2025 23:31	-63.92065	-62.96828	106_S1	NIGHT. Direct Sample from UCSW, -20C storage only

19/05/2025 23:46	-63.8792	-62.96781	106_S2	NIGHT. Direct Sample from UCSW, -20C storage only
20/05/2025 00:00	-63.84021	-62.96836	106_S3	NIGHT. Direct Sample from UCSW, -20C storage only
20/05/2025 16:54	-60.25941	-61.13198	107_S1	DAY. Direct Sample from UCSW, -20C storage only
20/05/2025 17:10	-60.20414	-61.096	107_S2	DAY. Direct Sample from UCSW, -20C storage only
20/05/2025 17:24	-60.15658	-61.06478	107_S3	DAY. Direct Sample from UCSW, -20C storage only
20/05/2025 22:40	-59.06511	-60.30942	108_S1	NIGHT. Direct Sample from UCSW, -20C storage only
20/05/2025 22:55	-59.01341	-60.27439	108_S2	NIGHT. Direct Sample from UCSW, -20C storage only
20/05/2025 23:09	-58.96457	-60.24172	108_S3	NIGHT. Direct Sample from UCSW, -20C storage only

4.CASS 227 How do marine diatoms end up in ice cores?

Anjali Dhunna[1,2] and Claire Allen[1] ([1] British Antarctic Survey, [2] Royal Holloway University of London)

4.1 Introduction/Background

The presence of diatom microfossils in glacier ice and ice cores has been documented from numerous sites in Antarctica, as well as from sites in Greenland, the Andes and the Altai mountains. In places where marine diatoms are found in ice, entrainment from the ocean is attributed to surface winds with transport and deposition relying on higher altitude winds to carry them to high elevation ice cores sites. However, very little is known about the conditions that promote entrainment and initial transport of diatoms (Figure 4.1), particularly over the Southern Ocean.

Recent analysis of diatom microfossils preserved in Antarctic Peninsula ice cores have revealed their potential as a proxy for winds over the Southern Ocean. Sea spray is considered the main vector for ejecting diatoms from the surface ocean into surface winds but how varying sea state, wind speeds and diatom productivity in the surface waters affect the entrainment are totally unconstrained. The CASS227 project is designed to provide the first

quantitative data on entrained diatoms in sea spray and surface air over the ocean. These data will be considered within the context of surface water diatom assemblages and contemporaneous physical conditions (sea state, sea surface temperatures, sea surface salinity, sea ice cover, primary productivity, wind speed & wind direction) to identify which factors have the greatest influence on diatom entrainment from the Southern Ocean.

4.2 Objectives

To quantify the number and composition of diatoms entrained from the sea surface into low altitude air masses on a latitudinal transect across the polar front.

1. Underway sea-water sampling:

To produce a latitudinal transect of diatom assemblages from surface waters as a source for wind-blown diatoms

2. Underway sea-spray sampling

To understand how sea states affect the entrainment of wind-blown diatoms and how the composition of diatoms captured in the sea spray relate to the source waters and the wind-blown assemblage.

3. Underway air sampling

To resolve the number and composition of diatoms making it into the air masses above the range of sea spray.

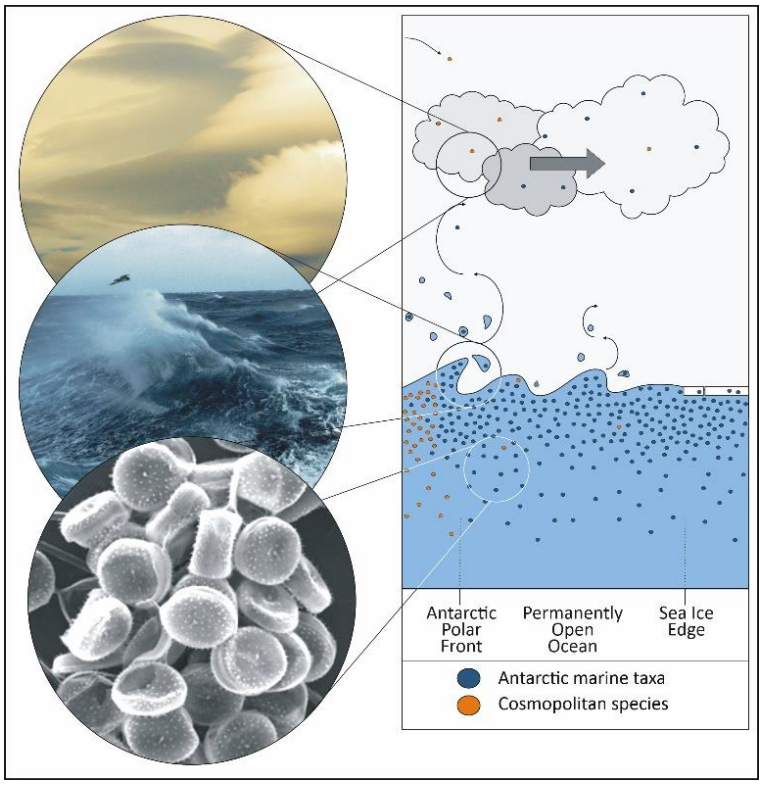

Figure 4.1: Schematic of marine diatom entrainment.

Based on analyses of ice cores from sites where high snow accumulation rates permit the seasonal variability of diatoms to be resolved, highest concentrations occur during austral summer and autumn which make the timing of SDA049 particularly relevant.

4.3 Pre-Cruise set up

4.3.1 Laboratory

Set up of filter housing, filter manifold and tubing went smoothly following the instructions and notes provided (see Acid Lugols fixation and filtration for Marine Diatoms SOP). The filter equipment was set up on the allocated bench in the main lab (Figure 4.2). The only difficulty was setting up the vacuum pump and carboy where the carboy can be secured to the ship during transit, but within range of the filtering set up. Given the location in the labs that was allocated, ensuring the carboy was secured was tricky as there were no distinct table legs to attach. However, a makeshift 'leg extender' was made on a nearby leg as the bungee hooks would not fit through the provided gaps. The modified assembly (Figure 4.3) was sufficient for the cruise as it was secure, and the vacuum system continued to work.

Spare parts and consumables were placed in the draws and cupboards below the filtering station and were easily accessible throughout the lab work period.

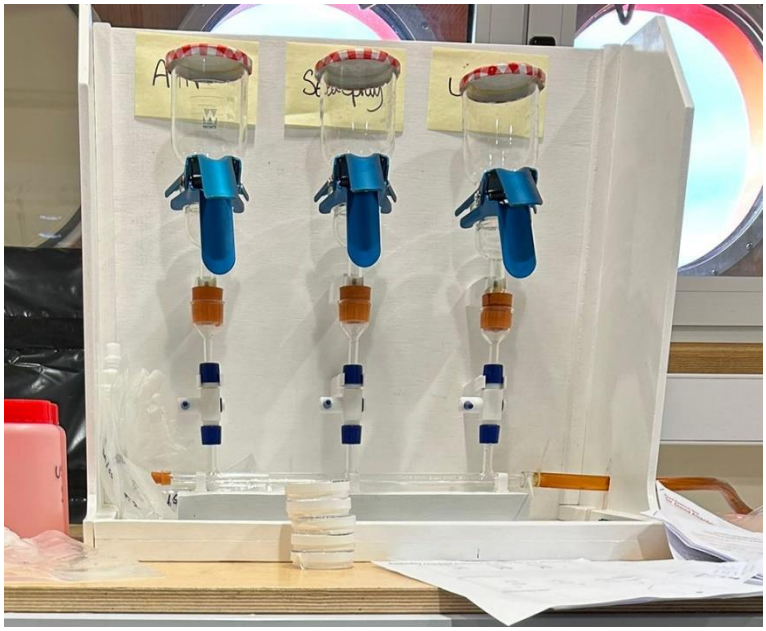

Figure 4.2: Filter equipment set up in main lab.

Figure 4.3: Modified assembly and securing of carboy

4.3.2 Sample locations

The sea spray sampler (see Installation of passive air/sea spray sample equipment SOP) was set up on deck 5 port side to avoid catching sea spray caused by the ship's movements (Figure 4.4). Pre-southbound travel it was discussed that the starboard side would be preferred, but upon discussions with the bridge that the winds were more on the port side it negated the initial plans. Alongside this, despite deck 5 portside being a smoking area, it has less traffic going through it so there would be less risk of contamination from people smoking within the vicinity.

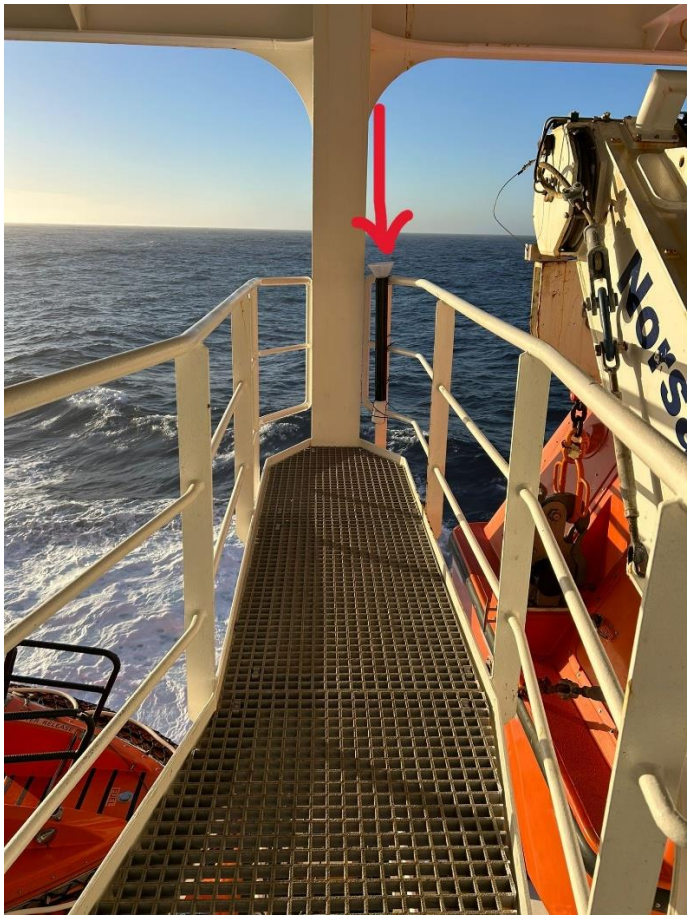

Figure 4.4: Sea spray sampler in deployed position on port side of deck 5.

The passive air filter that was set up on deck 10. Due to two other CASS projects working on the same deck, which are more susceptible to contamination than CASS-227, it was tricky to determine a suitable location to set up the filter. On a previous cruise, the filter had been set up on the Starboard side; however, the microbe project was set up on this side. This project required minimal human exposure within that side of the deck. Due to the sensitive nature of this project, and upon conversation with the other CASS project on Port side, it was agreed that the passive air filter would also be set up on Port side (Figure 4.4); the filtration of CASS223 was stopped over the period I changed my filters after informing the project lead when such events were happening. From my understanding there were no issues that arose from this compromise from either of the parties involved.

Figure 4.4: Position of passive air sampler on port side of deck 10.

4.4 During cruise

4.4.1 Underway seawater sampling

The UCSW sampling (Table 4.1) was planned for approximately every 6 hours (targeting 6am, 12pm, 6pm and 12am (ship time, not UTC). To comply with rest hours, AD was scheduled to collect the 6am, 12pm and 6pm samples, and a member of the BIOPOLE III team collected the 12am sample. On occasions when target timings were missed (due to the USW being switched off in ice-covered waters), samples were taken at the earliest opportunity. UCSW samples of 350 ml were collected at the same time, or as near as possible to the BIOPOLE III UCSW samples – to align as many complimentary data as possible for future comparison. Immediately following sample collection, ~3 ml of acid lugols was added and the sample agitated to ensure the lugols solution was fully homogenised into the seawater. The sample was either filtered immediately or put into a chemical cabinet to be processed at a more convenient time, i.e. the midnight sample.

Table 4.1: Uncontaminated Seawater Supply (USS) samples – filtered.

Sample ID	Date Collected	Time Collected	Sample Source	Latitude	Longitude
USS_1	13/05/2025	15:03:00	USCW Tap	-56.63576	-58.77547
USS_2	13/05/2025	21:00:00	USCW Tap	-57.89124	-59.81255
USS_3	14/05/2025	03:15:00	USCW Tap	-59.27913	-61.01709
USS_4	14/05/2025	09:33:00	USCW Tap	-60.70563	-62.31479
USS_5	14/05/2025	15:15:00	USCW Tap	-62.01568	-63.54623
USS_6	14/05/2025	21:07:00	USCW Tap	-63.25374	-64.76399
USS_7	15/05/2025	03:05:00	USCW Tap	-64.49054	-66.03175
USS_8	15/05/2025	09:45:00	USCW Tap	-65.94766	-67.57179
USS_9	15/05/2025	14:50:00	USCW Tap	-66.77650	-67.57030
USS_10	15/05/2025	21:53:00	USCW Tap	-67.60130	-68.04430
USS_11	18/05/2025	15:04:00	USCW Tap	-67.57220	-68.13000
USS_12	18/05/2025	21:01:00	USCW Tap	-66.59220	-67.45350
USS_13	19/05/2025	03:02:00	USCW Tap	-65.78240	-66.85240
USS_14	19/05/2025	16:25:00	USCW Tap	-64.78360	-63.52390
USS_15	19/05/2025	21:05:00	USCW Tap	-64.31410	-63.03980
USS_16	20/05/2025	03:13:00	USCW Tap	-63.19330	-63.07300
USS_17	20/05/2025	11:28:00	USCW Tap	-61.40970	-61.96200
USS_18	20/05/2025	15:04:00	USCW Tap	-60.64160	-61.40330
USS_19	20/05/2025	21:08:00	USCW Tap	-59.38210	-60.51900
USS_20	21/05/2025	03:05:00	USCW Tap	-58.12600	-59.67660

4.4.2 Passive air sampling

The passive air sampling (Table 4.2) filters were changed every ~12 hours as conditions permitted. There were occasions where this was delayed due to severe weather (very strong winds and icy surfaces) which made filter changes unsafe. To avoid contamination of the filter unit during collection and deployment to and from deck 10, a red-lidded, wide-mouthed bottle was used to cover the filter unit (amended from the sample bag suggested in the original SOP) as it was more stable and ensured the set up stayed upright. This was particularly handy when travelling with the unit in rough seas, as well as putting the filter down to change

the set up outside. Between each unit change the bottle was rinsed with Milli-Q water to avoid contamination.

During the cruise, a total of 8 filters were deployed during the transits for an average duration of ~14 hours. An additional filter was deployed for the duration of the Rothera visit (~69 hours). After collection, each filter was treated with acid lugols solution, then rinsed with ~500ml of Milli-Q water to remove salts and excess acid lugols.

Table 4.2: Passive Air Samples (PAS) - filtered

Sample ID	Date deployed	Time deployed	Date collected	Time collected	Total Time	Latitude	Longitude	Latitude	Longitude
PAS_1	13/05/2025	21:49:00	14/05/2025	11:12:00	13:23:00	-58.06962	-59.97237	-61.08309	-62.65530
PAS_2	14/05/2025	11:12:00	14/05/2025	22:52:00	11:40:00	-61.08309	-62.65530	-63.60041	-65.10128
PAS_3	14/05/2025	22:52:00	15/05/2025	15:11:00	16:19:00	-63.60041	-65.10128	-66.82458	-67.61352
PAS_4	15/05/2025	15:11:00	18/05/2025	12:55:00	69:44:00	-66.81660	-67.60350	-67.57220	-68.13000
PAS_5	18/05/2025	12:55:00	18/05/2025	22:10:00	9:15:00	-67.57220	-68.13000	-66.43860	-67.68270
PAS_6	18/05/2025	22:10:00	19/05/2025	12:21:00	14:11:00	-66.43860	-67.68270	-65.19320	-64.13380
PAS_7	19/05/2025	12:21:00	20/05/2025	00:19:00	11:58:00	-65.19320	-64.13380	-63.78650	-62.96970
PAS_8	20/05/2025	00:19:00	20/05/2025	12:20:00	12:01:00	-63.78650	-62.96970	-61.22470	-61.83060
PAS_9	20/05/2025	12:20:00	21/05/2025	12:20:00	24:00:00	-61.22471	-61.83055	-56.23253	-58.47764

4.4.3 Sea spray sampling

The location of the sea spray sampling equipment meant that access for deployment and retrieval of the samples was frequently restricted due to adverse weather or deck conditions. During the cruise, the sea spray collecting equipment was deployed 3 times for an average of 40 hours with a further deployment of nearly 67 hours while docked at Rothera (Table 4.3). In each case there were only a few drops of water evident in the sample bottle at the time of collection. Before removing the sample bottle, the funnel and tubing were rinsed with 500 ml MilliQ to ensure any droplets and residues of evaporated sea spray within the equipment were added to the sample bottle. Following the in-situ rinse, the sample bottle was removed, capped and carried to the lab to be treated with acid lugols, then filtered and rinsed with ~500ml MilliQ water in the same way as the seawater samples.

Table 4.3: Sea Spray Samples (SSS) - filtered

Sample ID	Date deployed	Time deployed	Date collected	Time collected	Total Time	Latitude	Longitude	Latitude	Longitude
SSS_1	13/05/2025	13:08:00	15/05/2025	11:29:00	46:21:00	-56.26598	-58.48253	-66.30692	-67.91813
SSS_2	15/05/2025	14:59:00	18/05/2025	09:50:00	66:51:00	-66.79930	-67.58680	-67.57220	-68.13000
SSS_3	18/05/2025	09:50:00	19/05/2025	21:30:00	35:40:00	-67.57220	-68.13000	-64.25250	-63.00870
SSS_4	19/05/2025	21:30:00	21/05/2025	12:30:00	39:00:00	-64.25250	-63.00870	-56.20060	-58.47510

4.4.4 Additional samples

In addition to the samples collected and processed during the SDA049 cruise, a further 9 sea water samples and 5 air filters collected and frozen during the transit from Rothera to Punta Arenas in January (SDA045; BIOBOL SD-C-24-5603) were processed. Sea water samples were left to defrost in a cool, dark place (+4 °C fridge) for 8-12 hours, treated with acid lugols and rinsed with ~500ml Milli-Q. Filter papers were removed from the freezer, treated with acid lugols and then rinsed with ~500ml Milli-Q.

4.5 Post-filtering storage

After rinsing, filters were placed in pre-labelled plastic 55 mm petri dishes with one or two discrete glue dots used to secure the filter to the base. Once in place, the petri dish lids were left loosely in place to prevent contamination from settling aerosols, while allowing air exchange until the filter was completely dry. Once dry, the petri-dishes were sealed closed using para-film and placed upright in an appropriate storage container for return to the UK.

5. Data Systems Summary

Petra ten Hoopen, Alex Tate, Gabriele Stowasser

5.1 Data storage and access

Data management support for this cruise has been provided fully remotely because only a reduced science support team was present onboard during the cruise. It has been noted that

while presence of a data manager enables a smoother run of the cruise, the remote data support was sufficient to carry out planned scientific activities and did not have a fundamental negative impact on the success of the cruise.

The following data management (DM) tasks were carried out to support SD049 scientific activities:

- DM presentation before mobilisation, covering topics such as data systems currently available onboard, underway sampling logging, data directory structure and access to data during and after the cruise
- A follow-up Q&A meeting with the Principal Scientist before mobilisation
- Creation & update of event logs in the onboard web interface before and during the cruise
- Creation & update of cruise track map during and after the cruise
- Data requests and queries during and after the cruise
- Web access to the cruise archive after the cruise
- Assistance with the Cruise Summary Report
- Contribution to the DM section of the full cruise report

It would be beneficial to develop within UK PDC standard operating procedures for remote data management support to assist scientific parties during CASS cruises with small-scale, fieldwork-based science projects that do not require logistic resources additional to those already allocated to the Antarctic field programme supported by BAS. This would enable more flexible and consistent assistance with cruise data management tasks, ready to be provided irrespective of last-minute funding calls, ship time opportunities or data support staff availability.

5.1.1 Event logging

Events are processes and actions related to scientific instruments recording and deployments. Event logs provide essential context to scientific data collected on the ship. Acquired information is used for data discovery. Events are logged using a web-based event logger that has been integrated with the SDA underway data streams from the RVDAS PostgreSQL

database, where each event can be annotated with relevant underway data (e.g. position, water depth, wind speed, air temperature etc.) based on matching timestamps. Users can also define variables of *boolean*, *integer* or *string* type to record additional relevant information. More information about the web event logger is available in the document */work/data_management/event_logs/Digital_Event_Logging.docx.*

Briefly, each event log should include at the minimum a timestamp, event number, latitude and longitude for each sample taken or deployment made.

The SDA event logging system was used during the SD049 to provide an overview of instrument recording and record details of sampling. On cruises using deployments of instruments over the side all scientific deployments would be assigned consecutive event numbers by the bridge officers on the watch and documented in the digital Bridge Event Log. Since only underway and air samples were collected on this cruise no Bridge Event Log was created but individual Science Event Logs. These were maintained to record sampling events and relate them to relevant underway sensor data. It should be noted that these logs are for data discovery purposes only and are not intended as a source for accurate data analysis. Table 5.1 below lists the event logs created on SD049.

Table (5.1) Event logs created during SD049

Event log name	*Event log description*
ADCP	*Daily starts and stops of the ADCP*
BONGO_and_Zooplanktoscope	*Underway Bongo Zooplankton sampling*
BONGO and Zooplantoscope (1)	*Underway Planktoscope sampling*
BRADLEY_WINTER_AIR_PROJECT_LOG	*Air sampling events CASS224*
CASS223_Tomato_Microplastics	*Air sampling events microplastics CASS223*
CASS227_Air_SeaSpray_USS	*Air and sea spray sampling events CASS227*
EK80	*Status of the EK80 echosounder*
Oxygen_Optode_Eventlog	*Starts and stops of the oxygen optode*
SDA_Underway_Systems	*Starts and stops of the underway water system*

Underway_water_sampling_GS_02	*Biogeochemistry and physical oceanography underway water sampling events*

A recently added function of duplicating existing event logs was very useful and frequently used. Edits of the created logs were carried out from a command line using the utils scripts at sdl-eventlog-s1.sda.bas.ac.uk.

To standardise the digital event logs for more automated processing as well as archiving in the scientific equipment deployment database (the UK PDC Marine Metadata Portal), a number of terms from two NERC Vocabulary Server terminologies were used to record event processes (http://vocab.nerc.ac.uk/collection/EL2/current/accepted/) and event actions (http://vocab.nerc.ac.uk/collection/EL1/current/accepted/).

At the end of the cruise, the event logs were downloaded from the web-interface into .csv files. The Science logs are available in the sub-directory:*/work/data_management/event_logs*

5.2 Underway water sampling

Underway water sampling has been recorded by all those sampling underway water for biogeochemistry using a paper sample log.

A digital event log has been created in the SDA web event logger called "*Underway_water_sampling_GS*".

The paper logs were scanned and then digitised using the web logger by the biogeochemistry team. The scanned paper logs are in the folder:

cruises/SD049/work/scientific_work_areas/Scanned data sheets