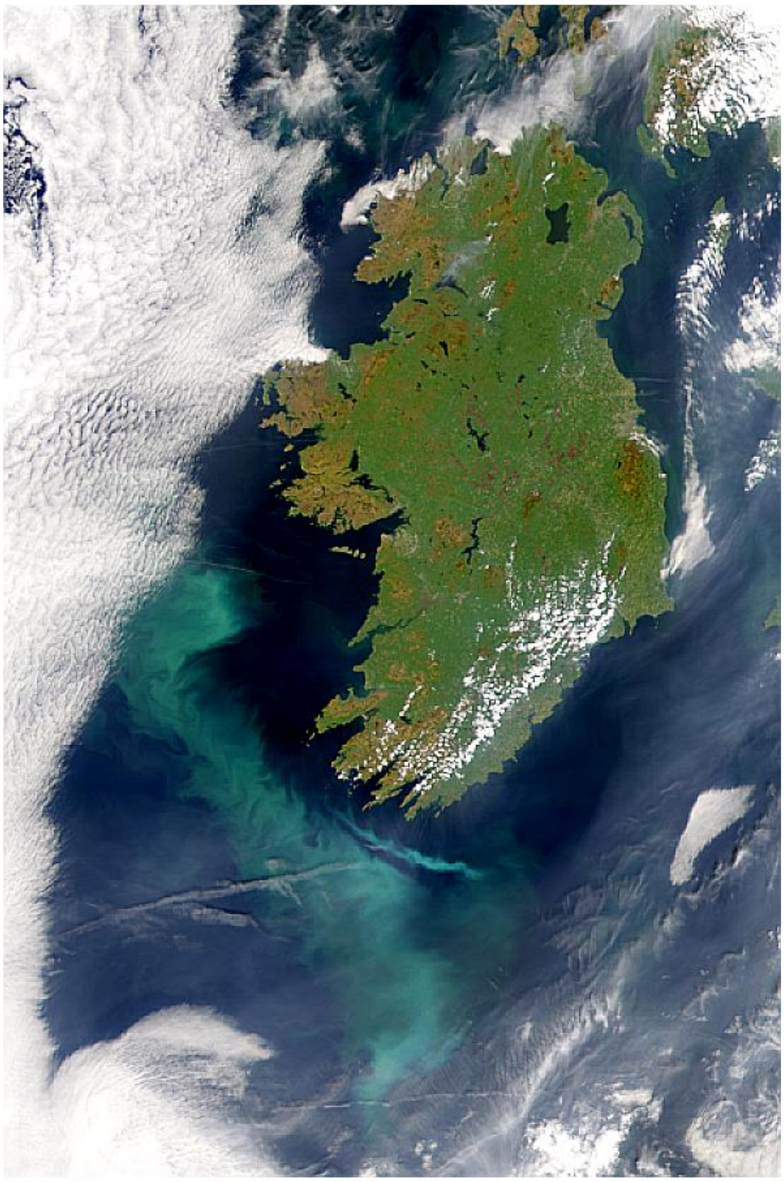
DY195 Cruise Report



RRS Discovery

24th May – 27th June 2025

Chief Scientist: Thomas Bell, Plymouth Marine Laboratory

PML | Plymouth Marine Laboratory

University of York

MANCHESTER 1824
The University of Manchester

UNIVERSITY OF LEEDS

University of Essex

ICM Institut de Ciències del Mar

CSIC
Consejo Superior de Investigaciones Científicas

University of Gothenburg

UCIrvine
University of California · Irvine

University of Lincoln

Foras na Mara
Marine Institute

Contents:

1 Introduction

The overarching aim of the CARES and COCO-VOC projects is to understand the controls on sulfur gases and other volatile carbon compounds in the marine environment. The DY195 goal was to investigate air-sea gas exchange in the international waters West of Ireland, specifically the biogeochemical processes that influence seawater concentrations, the resultant air-sea fluxes and the chemical and physical processes that determine the fate of these gases in the marine atmosphere. The knowledge gained from the observations made during DY195 will enable a thorough assessment of the global impact of marine sulfur and volatile organic compounds (VOCs).

2 Projects and Funding

CARES (NERC, NE/W009277/1)

COCO-VOC (NERC, NE/Z000335/1)

OceanCarbon4Climate (OC4C, European Space Agency)

GOOSE project (Spanish Research Agency, PID2022-140872NB-I00)

3 Acknowledgements

Thank you to Captain Stewart Mackay, the officers and crew, for facilitating our science in such a positive and supportive manner. Communication is key when working together, particularly when the work and the people are not necessarily familiar to each other. The 'can do' attitude of the entire ship's company made a huge difference when trying to achieve the sometimes challenging (and certainly non-routine!) task of scientific observations at sea. Thank you for taking every request seriously and helping to think of ways to resolve issues, all while acting professionally and ensuring a safe working environment. It made a huge difference to what we were able to achieve during DY195.

Thank you to Dougal Mountifield, Paul Henderson, Martin Weeks, Finn Sougioultzoglou, Dan Phillips and Jez Evans for always keeping positive, and being key liaison persons between ourselves, the ship and, during mobilization/demobilization, the shore. All of you have been a reassuring presence, always on hand to help sort out the various practical and digital challenges.

A big thank you to NEODAAS, who provided processed satellite information every day from before the campaign even began. Some of this information and the insights provided were very helpful. Thank you also to the various scientists and technical support shoreside who gave useful advice to the teams on the ship, helping bring instruments back to life.

Finally, a big thank you to all the Scientists on board from the Chief Scientist. The spirit of cooperation and sense of "Team" was evident in this group right from the start, which made life on board a pleasant experience and difficult decisions so much easier. I also want to point out that everyone, but particularly the early career scientists (which is most of you!) conducted themselves very well. I hope that the dedication you have shown will pay off with excellent data and deserved success.

DY195 Cruise Photo

4 Cruise Overview

The cruise began and finished in Southampton. The original plan was to work in Irish waters. Despite applying for and getting Diplomatic Clearance to work within the Irish Exclusive Economic Zone (EEZ), we fell foul of the relatively new Irish Maritime Area Regulatory Authority scheme (https://www.maritimeregulator.ie/our-work/maritime-usage-licences/licensing-of-maritime-usages/), which requires an additional license to sample Irish waters. We were not aware of the scheme in time to be able to make the application. This resulted in our study area being moved West, and a loss of two days of science as part of the transit to/from this region.

During the cruise we tried to target waters with a range of plankton type and productivity. We were guided by remote sensing images (when available) but often the area is covered in cloud. We successfully targeted multiple locations (>10 stations) over a latitude span of 48.2°N to 53.5°N, from low to high chlorophyll and seawater sulfur (DMS) concentrations (although often not at the same time). At each station, measurements were made of the biological community structure, the vertical structure and composition in the upper water column, the biological transformation rates of sulfur and volatile organic compound (VOC) gases, the impact of light and ozone deposition on seawater and the resultant trace gas production.

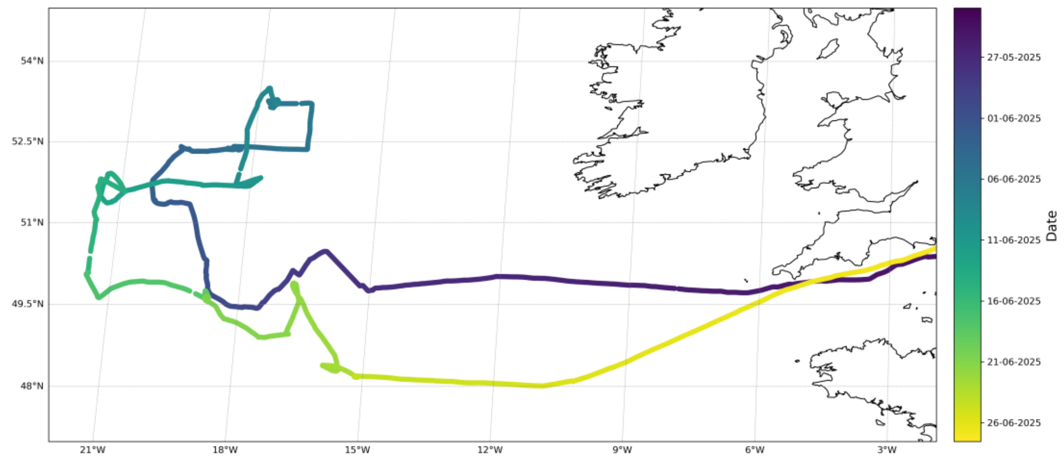


Figure 1: Cruise track during DY195.

4.1 Surface seawater sampling approaches

A particular concern for DY195 was the potential for fouling of the trace gas concentrations in the seawater intake used for continuous underway measurements. Previous work has demonstrated that plankton can colonise the pipework within the ship and perturb underway measurements of oxygen (Juranek et al., 2010). This has led to improved practice on RRS Discovery, by soaking the majority of the pipework (all but the first inaccessible metres) with cleaning fluid before every research campaign. However, repeat cleaning during a research trip is challenging, and previous observations have demonstrated that seawater dimethylsulfide (DMS) measurements can become contaminated by a factor of two, simply due to passing through an intense plankton bloom (Bell et al., 2015).

PFA (perfluoroalkoxy alkane) tubing was purchased specifically for DY195 and connected to the Towed Fish pump that has historically been used to collect seawater for trace metal-free observations. The Towed Fish was kept in close proximity to the ship, and as close to the air-sea interface as practicable, depending on sea state and ship movements. Typically, periods when the ship speed was <3 knots enabled a sampling depth of ~2 m. Sampling depth was similar to the underway system (6 m) when in transit, and ship speed was limited to 7 knots whenever the Towed Fish was in the water. Differences in trace gas concentrations could be seen between seawater pumped through the Towed Fish and the Underway from the very beginning of the cruise. The Towed Fish tubing was cleaned multiple times during the campaign.

The Towed Fish pump was also configured to switch to pump seawater from a near surface sampler (metal float with PFA tubing suspended ~30 cm below the sea surface). This was deployed while on station, with repeat switches back and forth from the Towed Fish every 30-60 minutes. The near surface sampler was rinsed with pure milliQ water after each usage.

Garret screen sampling involved dipping a metal mesh onto and through the surface of the ocean. Interfacial water is retained by the surface tension between the mesh squares when retrieved. Each dip collects a few hundred mL of seawater and repeat dips were used to collect ~10 L per sampling activity, typically taking over an hour to complete. Further detail can be found in Section 7.1.6 Garret screen deployment for Microlayer sampling.

References:

Bell, T. G., De Bruyn, W., Marandino, C. A., Miller, S. D., Law, C. S., Smith, M. J., and Saltzman, E. S.: Dimethylsulfide gas transfer coefficients from algal blooms in the Southern Ocean, Atm Chem Phys, 15, 1783-1794, 10.5194/acp-15-1783-2015, 2015.

Juranek, L. W., Hamme, R. C., Kaiser, J., Wanninkhof, R., and Quay, P. D.: Evidence of O_2 consumption in underway seawater lines: Implications for air-sea O_2 and CO_2 fluxes, Geophysical Research Letters, 37, art. no.-L01601, 10.1029/2009gl040423, 2010.

4.2 Typical schedule of activities

In general, activities followed a three-day rolling cycle. Rolling Day 1 involved a pre-dawn (0400 hrs.) CTD to collect seawater for incubations (VOCs or sulfur), followed by afternoon Garrett screen sampling for the microlayer and near surface sampling. Rolling Day 2 typically involved microlayer and near surface sampling in the morning, followed by a CTD profile to measure seawater concentrations in the upper mixed layer. Rolling Day 3 involved a CTD at 0400 hrs. to make a second set of incubations (VOCs or sulfur) before setting out to survey a wider area, towing the Scanfish to characterise from the near surface down to below the mixed layer. Scanfish surveys were timed to finish in time to begin the rolling cycle again at 0400 hrs. the following day.

Figure 2: Garret screen sampling.

Throughout the entire cruise, atmospheric observations were being collected by instrumentation contained within the ship's Meteorological Laboratory and three containers installed on the foredeck. Inlets were either mounted on poles a few metres above the top of the containers (typically for measurements requiring a short inlet tube to minimize signal loss), or on top of the foremast (typically for the air-sea flux observations, which require minimal air flow distortion). The foremast inlets were suspended and ran directly between the foremast and the containers. In addition, radiosonde balloons were launched twice a day from the aft deck (see Appendices, Table G: List of radiosonde launch dates, times, locations and altitudes reached).

Figure 3: View from the foremast towards the ship's bridge. Showing the containers with the majority of the atmospheric instrumentation and the inlet sampling tubing which can be seen running from the rail of the foremast to the port side of the middle container.

To avoid sampling contamination (from the ship stack or other sources such as the galley, paint store, etc.), it was crucial to keep the relative wind direction within a relatively tight sector (typically we specified that relative winds should remain within +/-60°). In addition, periods of light winds (<5 kts) meant that it was necessary for the ship to create its own wind by moving slowly forwards. For the vast majority of time, the ship's officers were able to achieve this request, designing creative solutions in order to get to target locations while keeping the winds in sector. This effort has resulted in a highly successful cruise that was able to balance the dual requirements for atmospheric concentration, air-sea fluxes and seawater composition measurements.

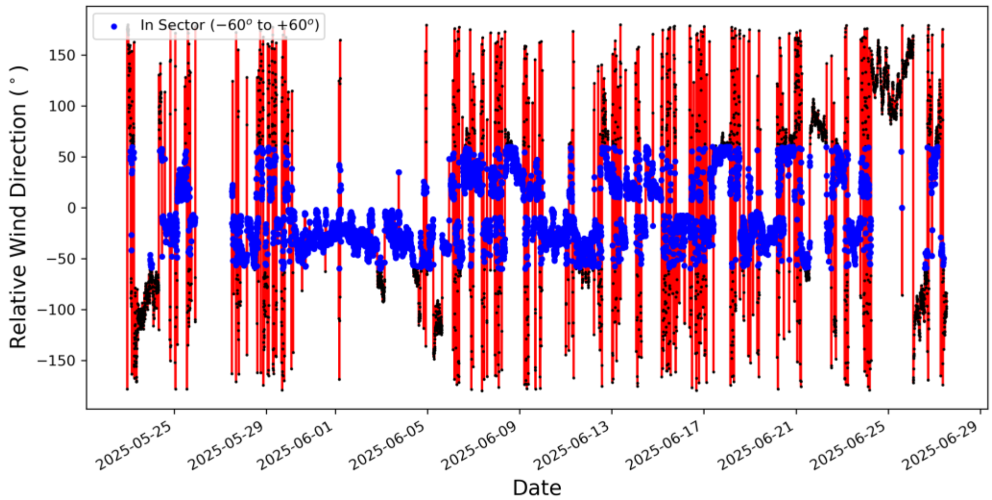


Figure 4: Relative wind direction throughout DY195. 0° is when winds were straight onto the bow, with negative relative wind direction being when wind was coming from the port side. Blue points = winds within sector (+/-60°).

4.3 Scanfish

Scanfish was towed behind the ship multiple times during DY195, undulating between the surface and 150 m depth. Data sections will be used to characterize the mixed layer depth and fluorescence concentration at the base of the mixed layer (below the region of photochemical quenching). Figure 5 gives an estimate of where the Scanfish data were collected.

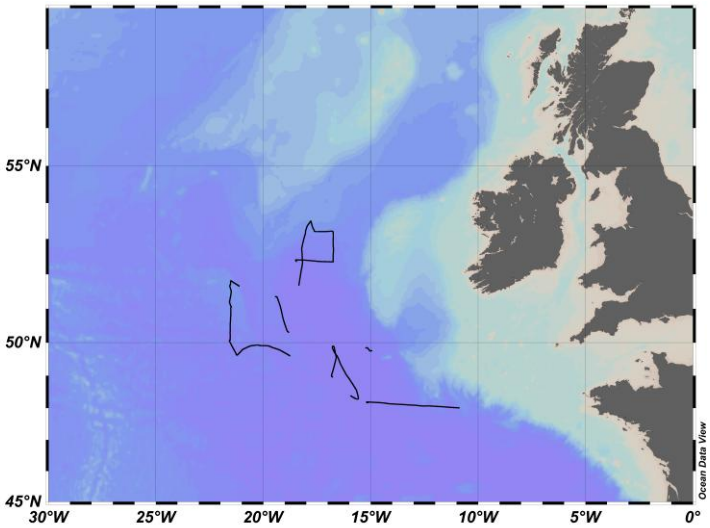
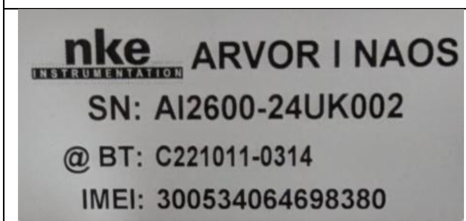


Figure 5: Map showing Scanfish deployments.

4.4 Argo float deployments

Two Argo floats were successfully deployed for the Met Office during DY195 in international waters close to the Irish EEZ (see Table 1). A CTD (Lat: 49.761951, Long: 14.927971 W, 27th May 2025, Event #3 in the Bridge Log, see Appendices, Table H: Bridge Event Log) down to 1000 m was performed just prior to their deployment (Lat: 49.761896 N, Long: 14.928642 W).

Table 1: Float Identification with time of removal and deployment

Float Identification	Time of Magnet Removal (UTC)	Time of Deployment (UTC)
	16:42	16:53
	16:41	16:55

4.5 DY195 Participants

4.5.1 Science Party

Table 2: Names and institutes of all science party aboard DY195

Person	Institute
Alicia Guadalupe Talavera Caro	University of Essex, UK
Charlotte Stapleton	University of York, UK
Eve Grant	University of York, UK
Félix Sari Doré	University of Gothenburg, Sweden
Frances Hopkins	Plymouth Marine Laboratory
Glen Tarran	Plymouth Marine Laboratory
Hyunjin An	University of York, UK
Ian Blackwell	University of Lincoln, UK
Irene Monreal-Campos	Plymouth Marine Laboratory
Isobel Thistlethwaite	University of York, UK
Ken Hagiya	University of British Columbia, Canada
Jared Novelly	University of California, Irvine, USA
Jaynise Pérez Valentín	University of Washington, USA
Jolynn Moll	Irish Marine Institute, Ireland
Lide Jansen Van Vuuren	Institut de Ciències del Mar, Spain
Lisa Whalley	NCAS, University of Leeds, UK
Liz Deschaseaux	Institut de Ciències del Mar, Spain
Loren Temple	Plymouth Marine Laboratory
Marvin Shaw	University of York, UK
Midhun George	University of Leeds, UK
Mingxi Yang	Plymouth Marine Laboratory
Rongrong Wu	University of Manchester, UK
Tom Bell	Plymouth Marine Laboratory

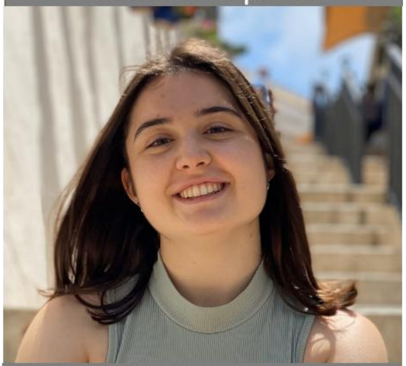

Tom Bell


Ming-Xi Yang


Frances Hopkins


Glen Tarran


Loren Temple


Irene Monreal


Ian W Blackwell


Jared Novelly


Lisa Kniveton


Midhun George


Eve Grant


Hyunjin An

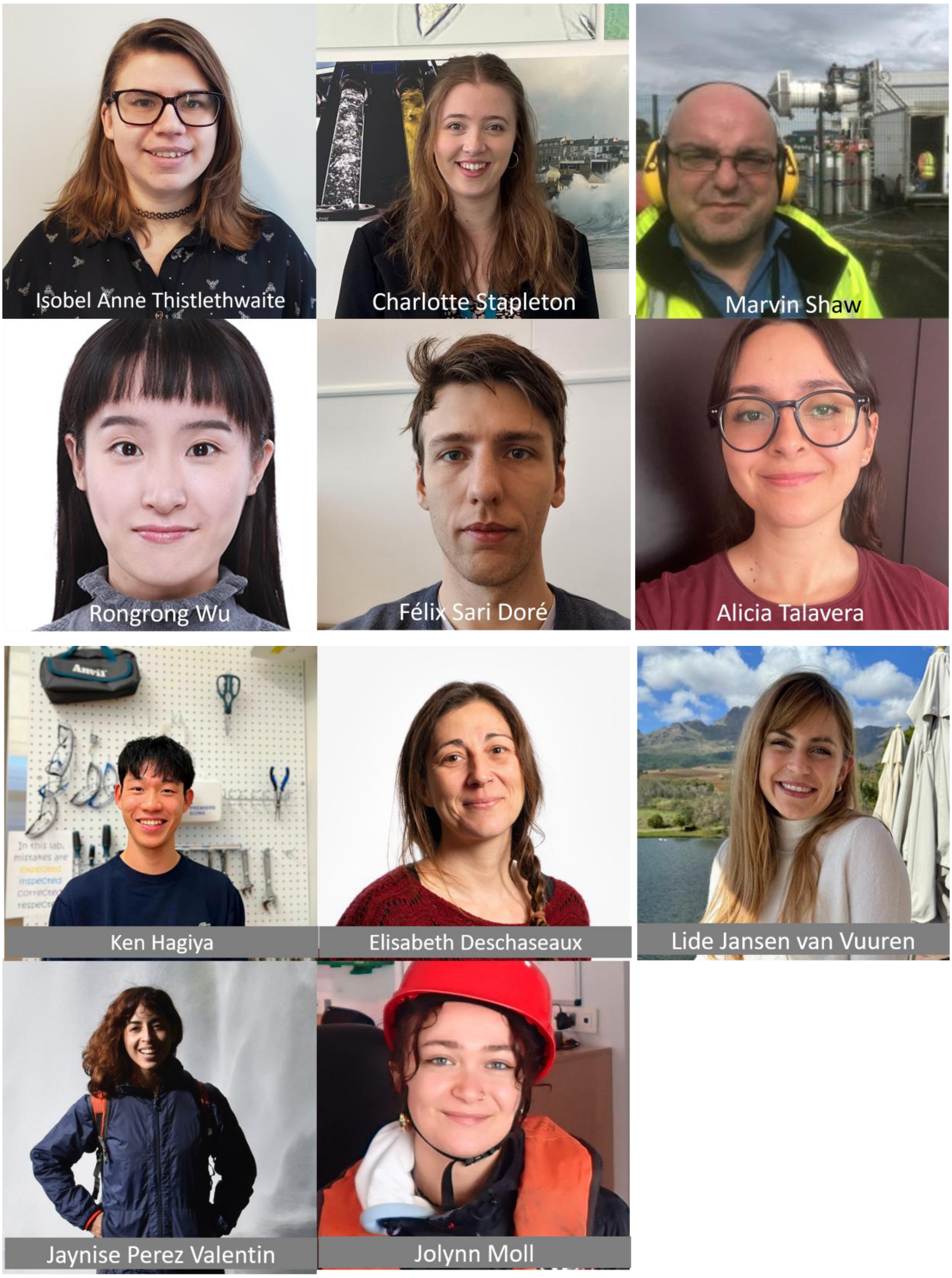


Figure 6: Photos of Science Party aboard DY195.

4.5.2 National Marine Facilities (NMF) Personnel

Table 3: NMF personnel involved in DY195.

Family Name	Given Names	Rank or Rating
EVANS	JEREMY MARSHALL	Project Manager
MOUNTIFIELD	DOUGAL	STech
HENDERSON	PAUL ROBERT	Tech
SOUGIOULTZOGLOU	FINNEGAN	Tech
WEEKS	MARTIN	Tech
PHILLIPS	DANIEL PERRY	Tech

4.5.3 Ship's Personnel

Table 4: Ship's personnel aboard DY195

Family Name	Given Names	Rank or Rating
MACKAY	STEWART MACDONALD	Master
MAHON	ANDREW	C/O
STRINGFELLOW	GRAHAM ROBERT	2/O
BROWN	JONATHAN ROBERT	3/O
MC COY	GARRY THOMAS	C/E
HAY	DEREK BRIAN	2/E
GHEISARI-MIANDOAB	JONATHAN	3/E
FOWLER	BENJAMIN JOHN	3/E
MURDOCH	ALASTAIR MCLEAN	ETO
WARWICKER	NATHANAEL BENJAMIN	Deck Cadet
HEMPSTEAD	ASHLEY STEPHEN	Eng Cadet
BULLIMORE	GRAHAM	Purser
SMITH	STEPHEN JOHN	CPOS

COOK	STUART CLIVE	CPOD
BURKE	TERRY	POS
RILEY	KEVIN PETER	POD
WRIGHT	MARTIN KARL	SG1A
STALKER	LUKE	SG1A
PEPPIN	CHRISTOPHER	SG1A
QUENAULT	PAUL LEE	ERPO
LYNCH	PETER ANTHONY	H/Chef
BURGESS	NEIL ROBERT	Chef
ANDERSON	PAUL	Steward
LUSK	ANN-MARIE LOUISE	A/Steward

5 Cruise Diary

Table 5: Cruise Diary for DY195

Date	Activities
24/05/2025	Departed Southampton at 0830hrs. Everyone gradually getting operational during day while heading West. Deployed sea snake in the afternoon.
25/05/2025	Clocks set back from BST to UTC (BST-1) overnight. Sea state worsened overnight and throughout day. Transited across a coccolithophore bloom, seeing high (~15 nM DMS). Slowed ship from 10 to 7 knots to spend more time in UK waters and make life more comfortable for those on board as the weather worsened. Recovered sea snake and turned off underway data acquisition before entering Irish EEZ at approximately 2300hrs.
26/05/2025	Sea state worsened today, slowed progress considerably. ETA at shakedown station delayed until later tomorrow. Problems identified with Earth faults caused power to scientific instruments to be turned off with no warning. Eventually, meant that Manchester and NMF containers had to be powered off completely, along with the high-volume aerosol sampler. Manchester container problem seems associated with container electrics (not instruments) and ETOs happy to proceed without change. NMF container problem was isolated to the UCI instrument. Further investigation identified that the problem could be removed when the instrument was powered directly via a 110 VAC supply, eliminating the transformers. Aerosol sampler will be investigated tomorrow.
27/05/2025	Continued (slow, due to conditions) westward progress toward edge of Irish EEZ, arriving at just after 1200hrs. Successful balloon launch followed by CTD wire tensioning, CTD to 1000m. During these activities, shakedown activities took place for microlayer sampling and near surface sampling. All of the above had their challenges but everyone adapted well and had a successful day. Sea state improved over the afternoon. Aerosol sampler investigations were initially concerning but eventually a problem with the wiring was found and fixed, meaning all electrical Earth faults have been found/addressed. Sea snake, towed fish and scan fish were successfully deployed from after dinner until approx. 2100hrs. Ship then continued to transit with a course over ground of 320°, slowing for another successful radiosonde release at midnight.
28/05/2025	Stopped transiting just before 0400hrs for Station 1 (50° 28.18N, 16° 03.662W), sulfur incubation CTD. Oil residue observed on deck during sampling, likely from grease used on new CTD wire. Relatively low Chl (~1ug/L) and DMS (few nM) levels. Sea state has improved, with lower wind speeds. Slow (2+ kts) steaming into wind followed, with a balloon release at midday. Winds picked up during the afternoon, making microlayer sampling impossible (25+ kts). Near surface sampler deployed for 2 hrs – difficult to keep away from the ship, but otherwise successful. Continued slowly into the wind over the afternoon/evening. Containers generally back operational following electrical disruptions.

	UCI CIMS measuring SO_2 (concentrations at least). Some problems with LIF SO_2, but hopefully fixable.
29/05/2025	Slow steaming overnight into wind, with balloon release making it to 8 km. Ship made planned stop at 1030hrs to do maintenance. Used this opportunity to make further refinements to the microlayer sampling approach. Decision taken to use crane rather than pole to push screen away from ship. Successful. Balloon release at midday. Post-lunch CTD for concentration profiles and concurrent microlayer and near surface sampling. Deep water (1000 m) is proving a successful blank so this will be collected routinely. During CTD, slicks were observed coming from winch wire, which were floating past the microlayer and near surface sampling activities further aft. Based on this, we will now switch activities around to decouple CTD and microlayer/near surface sampling activities. Any towed fish sampling during CTDs should also be treated cautiously. For future cruises interested in VOCs, the Trace Metal free winch would be highly preferable. Weather forecast is for strong winds and large waves tomorrow, making the deployment of scan fish risky and limited in use.
30/05/2025	First 0400hrs incubation CTD for VOC compounds today. Steamed into weather slowly while winds and sea state built throughout the day. Sped up slightly to discharge grey waste and food waste (1033hrs-1200hrs). Tried to take advantage of the winds not increasing too quickly and stopped to try to collect microlayer water at about 1400hrs. Wind speeds already too high though so this was aborted. Also collected a second CTD (no Niskins fired) down to 150 m at ~1700hrs for a pre-storm reference MLD. Wind gradually swung around so heading changed from due South to due West over the course of the day. Expect a bumpy ride tonight (3.5 m swell) but hope to still be able to deploy the CTD in the morning.
31/05/2025	Midnight sonde failed – could not get a GPS fix (likely due to sea state). Successful 0400hrs CTD for sulfur incubations. Engineers had to investigate a fault in the dirty power - starboard (Leeds) container temporarily turned off, but no major issues so quickly back on. Successful midday sonde, but too much wind/waves for successful deployment of either microlayer or near surface sampler. Manchester Aerosol Mass Spec. has a problem that has resulted in two blown filaments. The instrument is currently not operational –there is the possibility of a fix, but it is not definite that anything will be possible whilst at sea. Continued slow steaming into weather throughout afternoon and overnight.
01/06/2025	Underway sensors cleaned during the 0400hrs incubation CTD. Scanfish deployed and successfully steamed Northward at ~7 kts with winds in sector and all fish/snakes deployed. Finished Scanfish at 1500hrs, having travelled approximately 60 miles. Microlayer sample collected successfully at 1600hrs! After microlayer sample collected, continued moving without Scanfish, albeit at a slower speed because wind was increasingly coming from the West and we need to keep it in sector).

	Midnight sonde was only partially successful – collided with A frame and then only made it to ~500 m before descending again (probably got a puncture).
02/06/2025	No early morning CTD so gradual progress made North by keeping winds in sector but on the port side to help push the ship's course over ground Northward. 1130hrs microlayer and near surface sampling aborted due to wind/sea state. Continued moving but then stopped at ~1230hrs to clean the towed fish tubing. 1330hrs CTD for depth profiles. Wind had shifted to be more northerly by this point so steamed North at ~5 knot, aiming for a higher chlorophyll patch seen from days-old satellite imagery. Updated imagery came through late in the day, enabling an adjustment to heading and speed at ~1930hrs. Steamed at ~7.5 knots at bearing of 45° (compromising some atmospheric obs. as relative winds were about -80°, e.g. could be seen in the CO_2 and CO measurements on the containers) until higher chlorophyll (fluorescence) signals were seen in the water. Passed through these and tried to head East into larger bloom on satellite imagery. Only partially successful.
03/06/2025	Incubation CTD at 0400hrs in moderate chlorophyll levels. Initially headed Northward into winds at 2 kts. However, subsequent analysis of satellite imagery and data from previous night suggested we needed to be further South and East. Ship then held heading into wind using DP and drifted with the winds back toward the South and East. Successful microlayer and near surface sample collected, and radiosonde released. Otherwise persisted with heading into wind while drifting South and increasingly East for the rest of the day and overnight.
04/06/2025	Drifted approximately 35 nm overnight, moving through the high chlorophyll waters. No significant DMS levels observed, however. Large swell arrived from the North during the night, making life difficult aboard and disrupting sleep. Stopped to collect microlayer and near surface samples, followed by CTD for surface profiles of trace gas concentrations. After CTD had a period with winds out of sector for atmospheric observations. This made life more comfortable, but spikes were seen in NOx, particles, CO, CO2 and kOH. Changed heading so that we were (just) back in atmospheric sector. Continued to drift East throughout afternoon. Shortly after dinner, headed West for a few miles so that the ship will drift back toward the CTD profile location for tomorrow's early morning incubations CTD.
05/06/2025	0400hrs incubations CTD was immediately followed by the deployment of Scanfish and transit to the East at 7 kts. Winds were from the West so atmospheric sampling was shut down from 0600hrs until 1500hrs when we turned North. At approximately 2200hrs the ship turned to head West toward a patch of high chlorophyll in recent satellite imagery. Seawater measurements were made on the ship's underway system and on the towed fish, as well as sample collection every hour for the duration of the transit. High xylene levels were observed in the water from approximately 1100hrs, persisting in the towed fish tubing for up to 24hrs. Throughout the duration of the Scanfish deployment, over 200 CTD, fluorescence and

	oxygen profiles were collected from the surface down to 150 m. Unfortunately, after extensive search of the spare's boxes, the Aerosol Mass Spec. failure is not fixable, and it will not be possible to run the instrument for the rest of the trip.
06/06/2025	Scanfish was recovered at 0245hrs as we approached the location identified for the incubation CTD at 0400hrs. Very high chlorophyll levels (>6 mg/m^3) and moderate DMS levels 4-5 nM. Headed into the wind throughout the day, stopping to do microlayer and near surface sampling at 1330hrs. At approximately 1800hrs, allowed the ship to drift back in the direction of the early morning CTD, before steaming into the wind and repositioning ready to sit in that location for tomorrow's sampling activities.
07/06/2025	Stayed with bow into wind and broadly on location throughout day while doing microlayer and near surface sampling in the morning, followed by a concentration profile CTD in the afternoon. It has been identified that the sonde laptop has been going to sleep at some point after balloon release, leading to disconnection with the sonde. Problem resolved so should get profiles to greater height from now on.
08/06/2025	Early morning CTD still in high productivity waters. Once on deck, Scanfish deployed and headed North with Westerly winds in sector (now determined to be relative winds +/- 60°). Some instruments (particle counts, carbon monoxide) picking up signals from Canadian wildfires. Traversed across high chlorophyll waters and then turned to head South (again, keeping winds in sector). Destination was an area of suspected low chlorophyll identified from a few-day old satellite imagery. Entered the low chlorophyll waters a few hours before getting onto station, so well-positioned for the next Station / set of incubation and profile CTDs.
09/06/2025	Scanfish recovered during approach to CTD station location. 0400hrs incubation CTD in low chlorophyll water. Held position with bow into wind, and then later allowed wind to push us to the East. No microlayer sample collected as the winds were too high. Continued moving with the winds while pointing bow into wind throughout afternoon and evening. Evening BBQ on the back deck.
10/06/2025	Continued to move East and then North with wind overnight until successful microlayer and near surface sampling at 1130hrs. Immediately followed this with a concentration profile CTD in the same location. Cleaned towed fish tubing before heading back (at a few knots) toward position occupied by ship at 1530hrs on the 9th of June. Chlorophyll levels were low as experienced previously. Once on location, held position with bow into wind in preparation for morning CTD.
11/06/2025	0400hrs CTD completed before heading Westward (with winds kept in sector) into incoming 4 m swell from a storm that should pass us to the South. No Scanfish deployment as waves predicted to be too large for recovery. Instead, steamed West, stopping every ~15 miles to do a quick CTD for physics (no water sampling). Continued this approach throughout day. Fresh satellite imagery revealed the productivity we were moving through (finally!) and enabled us to set a target in higher

	chlorophyll waters that was achievable with winds in sector. Last few CTDs were more challenging to do with winds in sector so some out of sector measurements may have occurred throughout the latter part of the day.
12/06/2025	Completed transect and arrived on station shortly before the 0400hrs CTD. Some noises observed in CTD winch, which will be investigated throughout the course of the day. Ship was situated in a large region with high chlorophyll levels. Satellite imagery from approximately 1-week prior shows lower chlorophyll and suggests that the bloom is developing rather than declining. Wind speeds and sea state reduced throughout day. Low pressure system passed ship around lunchtime. Ship pointed bow into wind and moved forward at ~2kts until microlayer and near surface sampling at 1330 hrs. CTD winch was realigned and then tested, causing a break during microlayer sampling to avoid any contamination from the winch wire grease. Slight (30 min) delay in completion of sampling. After sampling, continued keeping wind in sector and moving forward for remainder of afternoon and throughout evening. When wind speeds dropped particularly low, increased speed to limit contamination from the ship. Winch noise resolved by realignment, so no delays expected.
13/06/2025	Moving at 2 kts overnight into the wind resulted in movement North out of the high chlorophyll patch. Turned to the Northeast to keep winds in sector and, shortly after this, stopped and remained stationary with bow into wind until the microlayer, near surface and CTD sampling sequence began at 1130 hrs. Once the sampling sequence was completed, turned to keep the winds (now coming from the West) on the starboard side of the ship and gently moved South and East back toward the location of the CTD conducted on the 12th of June. In contrast to previous days (weeks!), the weather was sunny, with lower wind speeds and only minor swell. Wind speed increased slightly throughout the day, but the conditions are overall much improved.
14/06/2025	Back in high chlorophyll waters for the 0400hrs CTD. Scanfish deployed but then had to be retrieved as it had stopped communicating. Waited and tested on deck for a short while (continued steaming). After breakfast, redeployed successfully and then steamed continuously throughout the day and night. Some adjustments were made to the planned transect to accommodate difference between speed over ground and speed through the water (Scanfish is quite specific as to its optimum speed). Majority of day was spent moving through very high chlorophyll waters that the previous two incubation CTDs were located in (now identified as a coherent patch of water within an anti-cyclonic eddy). After dinner a specific target was identified a bit further South and the ship stopped slaloming and went directly toward the waypoint in time for the morning incubation CTD.
15/06/2025	Overnight we continued our Scanfish transit out of the eddy and into the intermediate chlorophyll waters to the South. DMS levels went up significantly in the ocean and atmosphere, with concentrations at the

	0400 hrs (sulfur) incubation CTD >10 nM in seawater and >1.5 ppb in air. Held bow into the wind and sat on station until breakfast. Spent approx. 1.5 hrs moving forward into the wind (to measure seawater concentrations that were driving the fluxes observed when on station) and then back to the original station location (keeping winds over the bow the whole time). Arrived back onto station in time for 1330hrs microlayer and near surface sampling. Held position throughout the evening and overnight.
16/06/2025	Shallow atmospheric boundary layer formed overnight, with heavy rainfall in the early hours. Atmospheric DMS concentrations increased to 2 ppb, and seawater levels stayed constant. Microlayer sampling at 1130 hrs abandoned as wind speeds too high. By the 1330 hrs, the stronger winds had eroded the shallow (12 m) mixed layer observed in the CTD yesterday. Microlayer sampling attempted a second time after the CTD, but still too windy. Held position with bow into wind throughout the evening and night until the morning CTD.
17/06/2025	Incubation CTD for VOCs was conducted at 0400 hrs. Scanfish then deployed and we began to steam. Initially headed South into the wind and then turned East when the winds became favourable, heading toward a patch of water identified from satellite imagery. Currents and fluorescence suggest an anticyclonic eddy bringing nutrients to the surface in the middle of the eddy, stimulating a bloom of plankton. The winds were predicted to change throughout the day, becoming stronger and shifting around to be more from the West. In anticipation of this, we kept winds within sector for atmospheric measurements (initially 45° off the starboard bow and then 55°) while making as much progress North as possible. Then, as the winds changed, the ship was able to keep them in sector throughout the night for timely arrival at the next station.
18/06/2025	Arrived at station slightly early (approx. 0230 hrs) so recovered Scanfish and were in a good position for the 0400 hrs CTD. Scanfish recovery may have put winds out of sector briefly. After the CTD, had to move astern to avoid another container ship that was going to move across our position. Stayed on location until approximately 0930hrs. Then continued to keep winds in sector while moving astern (North) until the microlayer and near surface sampling at 1330hrs. After microlayer sampling was complete, started moving slowly forward at ~2 kts into the wind. Persisted with this movement throughout the evening and night following the winds as they switched to come more directly from the East. Continued switching between near surface and raised towed fish inlets throughout the afternoon. The diaphragm split on the pump for the near surface sampler / towed fish at ~1830 hrs, so switched to underway water supply while replacement pump was setup. Switched back to towed fish water supply with replacement pump at 2006 hrs.
19/06/2025	Held position throughout the night and the morning with bow into the wind. Conducted microlayer and near surface sampling at 1130hrs followed by CTD profile at 1330hrs. Coccolithophores still present in the water column – both cell concentrations and seawater DMS levels had

	doubled since yesterday. Manchester container's inlet was lowered after lunch to sort the funnel out (tape was coming off). Then held position throughout the afternoon and evening.
20/06/2025	Incubation CTD at 0400 hrs. Coccolithophore cell numbers have increased again. Scanfish put into water, but barrel rolled during deployment. The roll snapped the termination. Recovered to deck for re-termination. New plan formulated – held position on station for a few hours, then headed East with bow into wind. Maintained a southeasterly heading until approximately 1700hrs. Conducted a CTD (sensors only) and then turned to head directly East toward the centre of another eddy containing intermediate levels of chlorophyll. Marine Facilities team spent day replacing a Scanfish flap (possible cause of fault) and re-terminating cable.
21/06/2025	Unfortunately ended up in patchy waters, and ultimately in a patch of lower-than-ideal fluorescence. Aborted kinetics experiment and did a VOC incubation instead using the 0400hrs CTD water. Began Scanfish tow, heading North for ~11 hours. Turned earlier than planned to head South toward a low chlorophyll eddy for the final Station.
22/06/2025	Early turn yesterday meant we intentionally overshot the station location and then turned back to the North to arrive back at the desired location for 1000hrs. Microlayer and near surface sampling were followed by deep CTD for a 2000 m profile. Cleaned towed fish sampling line before steaming at 7 kts to the East (winds out of sector). After 2 hrs, turned into wind and moved astern (East and slightly South) at ~2 kts in time to arrive at desired location for final science station (# 12).
23/06/2025	Successful 0400 hrs incubation CTD. Kept within 2 miles of location with bow into wind. Near surface sampler put out in the morning and regular (30 min) switching between Towed fish and near surface throughout the day. Cruise photo taken after lunch, followed by final microlayer. Stayed on station for remainder of day/evening in preparation for final 0400 hrs CTD tomorrow.
23/06/2025	Successful 0400 hrs incubation CTD. Kept within 2 miles of location with bow into wind. Near surface sampler put out in the morning and regular (30 min) switching between Towed fish and near surface throughout the day. Cruise photo taken after lunch, followed by final microlayer. Stayed on station for remainder of day/evening in preparation for final early morning CTD tomorrow.
24/06/2025	0400 hrs CTD for incubations. Then started to Scanfish and head East toward home, keeping South to avoid crossing into Irish waters. Winds were generally from West and so out of sector (approximately 120°). Waters very warm and low chlorophyll, with a deep chlorophyll maximum.
25/06/2025	Finished Scanfish tow at 0830hrs and continued transit at 7 kts with the Towed Fish deployed. Turned to head to the Northeast and crossed the shelf break, with the expected increase in chlorophyll encountered in late afternoon/evening. Recovered the Towed Fish at 2200hrs to enable the

	remainder of the transit home to be at 10 kts. Any instruments remaining on were switched to the nontoxic seawater supply.
26/06/2025	Continued transit down the channel. Turned off the nontoxic seawater supply at about 1500hrs and recovered the sea snake to deck shortly afterwards.
27/06/2025	Arrived in port at Southampton at about 0930 hrs to begin demobilisation.

6 Ship Scientific Systems (SSS) Report

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Ship Scientific Systems (SSS) is responsible for operating and managing the Ship's scientific information technology infrastructure, data acquisition, compilation and delivery, and the suite of ship-fitted instruments and sensors in support of the Marine Facilities Programme (MFP).

The main objectives for SSS in the service of the science party on this cruise were:

1. Acquire underway data and metadata, including sea-surface EOV, meteorological EOV, atmospheric and seawater pCO_2, wave characteristics, position, attitude and time, and seafloor depth.
2. Provide services for monitoring data streams and displaying data.
3. Provide services for recording metadata and events.
4. Provide basic IT support.

All times in this report are in UTC.

Note that a few biases were identified after the cruise data collection was completed. METOCEAN data should be checked to see if corrections have been applied. The data provided by NMF SSS requires the following corrections:

Tair_C_corr = 100 * (Tair_C + 40) / 99.32 - 40

RH%_corr = (RH% / 99.32) * 100

Pres_mb_corr = (Pres_mb - 800) / 0.9932 + 800

6.1.1 Summary

A summary of the progress made against objectives is shown below.

[X] Objectives, [X] completed, [X] partially completed, [X] not completed.

Table 6: Summary of progress against objectives

Target	Outcomes	Objective met?
Acquire underway data and metadata, including sea-surface EOV, meteorological EOV, atmospheric and seawater pCO2, wave characteristics, position, attitude and time, and seafloor depth.	Completed	Yes
Provide services for monitoring data streams and displaying data.	Completed	Yes
Provide services for recording metadata and events.	Completed	Yes
Provide basic IT support	Completed	Yes

6.1.2 Scientific computer systems

Underway data acquisition: Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired. A Public network folder was also available for scientists to share files.

A copy of these two drives is written to the end-of-cruise disks that are provided to the Principal Scientist and the designated data centre.

The designated data centre for this cruise is: British Oceanographic Data Centre

List of logged ship-fitted scientific systems:

`/Ship_Systems/`*[Keywords]*`_Ship_fitted_information_sheet.docx`

The Ship Systems portion of the cruise disk is split into three directories: Data, Metadata and Documentation (Table 7). The data acquisition systems used on this cruise are detailed in 8. The data and data description documents are filed per system in the *Data* and *Metadata* directories respectively within Ship Systems folder on the cruise data disk.

Table 7: Directories aboard ship

<table>
<tr><th>Directory</th><th>Explanation</th></tr>
<tr><td>Data</td><td>Folder: <code>/Ship_Systems/Data/</code>
Purpose: All raw and processed datasets, including structured metadata.
Examples.
Raw sensor time series data (.txt)
Structured sensor metadata (.json)
Processed sensor time series data (.nc)
Example file formats: .txt, .nc,.csv,. json,. all, .raw, .log</td></tr>
<tr><td>Metadata</td><td>Folder: <code>/Ship_Systems/Metadata/</code>
Purpose: All non-structured metadata. This helps to explain some of the datasets.
Examples;
Data description documentation (.docx)
Sensor calibration documentation (.pdf).
Ship survey documentation (.pdf).
Example file formats: .docx, .pdf</td></tr>
<tr><td>Documentation</td><td>Folder: <code>/Ship_Systems/Documentation/</code>
Purpose: All non-metadata documentation. As an example, PDF documentation for sensor operation.
Examples;
Instrument manuals (.pdf).
Example file formats: .docx, .pdf</td></tr>
</table>

Table 8: Data acquisition systems used on this cruise.

Data acquisition system	Usage	Data products	Directory system name
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	`/TechSAS/`
NMF RVDAS	Continuous	ASCII Raw NMEA NetCDF (Testing)	`/RVDAS/`
Kongsberg EA640	Continuous	None, redirected to Techsas/RVDAS RAM	
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	`/Acoustics/ADCP/`
Rutter WAMOS	Continuous	None, redirected to Techsas/RVDAS RAM	

Data description documents per system:

`/Ship_Systems/Metadata/[systemName]/`

Data directories per system:

`/Ship_Systems/Data/[systemName]/`

6.1.3 Significant acquisition events and gaps

On this cruise, the RVDAS event logger was used with CSV records of events saved to the cruise data directory (Table 9).

Path and pattern to event log CSV files:

`/Ship_Systems/Data/RVDAS/Event_logs/[logName]/*.csv`

Table 9: Summary of main events

Time start	Time end*	Event
2025-05-20 09:00:00		Main acquisition started.
2025-05-24 07:30:00		RRS Discovery departed GBSOU.
2025-05-27 12:40:00		Reached science site.
2025-06-25 14:20:00		Departed science site.
2025-06-27 10:30:00		RRS Discovery arrived GBSOU.
2025-05-27 15:00:00		Main acquisition stopped.

Table 10: Summary of data gaps

Date start	Date end	Event
2025-05-25 22:02:30	2025-05-27 12:40:00	Passage through Irish EEZ. All scientific acquisition stopped.

6.1.4 Internet provision

Satellite communications were provided with Starlink, OneWeb, VSat and Iridium Certus.

The ship operated with bandwidth controls to prioritise business use.

6.1.5 Data acquisition systems

NMF operated two central acquisition systems; TechSAS and RVDAS.

TechSAS

TechSAS (Technical and Scientific Acquisition System) is a central acquisition system developed by the oceanographic institute Ifremer. TechSAS has been used on the RRS James Cook and RRS Discovery since ~2007/2013 and is currently the primary acquisition system.

TechSAS produced two file types; NetCDF and NMEA (ASCII);

Table 11: Summary of file types and systems

File type	Explanation
NetCDF	Data: `/Ship_Systems/Data/TechSAS/NetCDF/[SENSOR]/` Filename format: `YYYYMMDD-HHMMSS-[SENSOR]-[SENSOR].[SENSOR]` Source: Written in real time by system. Data description: `/Ship_Systems/Metadata/Techsas/Data_Description` Collection: All data at acquisition resolution. Purpose: Standard NetCDF format with global attribute metadata, variable metadata and 1D variable timeseries data.
NMEA	Data: `/Ship_Systems/Data/TechSAS/NMEA/[SENSOR]/` Filename format: `YYYYMMDD-HHMMSS-[SENSOR].[SENSOR]` Source: Written in real time by system. Data description: `/Ship_Systems/Metadata/Techsas/Data_Description` Collection: All data at acquisition resolution. Purpose: ASCII data format with pseudo-NMEA data sentences in 1D timeseries.

System	Quick reference
Primary GPS	NetCDF: `/Ship_Systems/Data/TechSAS/NetCDF/GPS/YYYYMMDD-HHMMSS-[TYPE]-POSMV_GPS.gps` NMEA: `/Ship_Systems/Data/TechSAS/NMEA/mvpos/YYYYMMDD-HHMMSS-POSMV_GPS.mvpos` Data description: `/Ship_Systems/Metadata/TechSAS/Data_Description/Posmv Data Description.docx`
Biogeochemical, meteorological and solar irradiance sensors	NetCDF: `/Ship_Systems/Data/TechSAS/NetCDF/SURFMETV3/YYYYMMDD-HHMMSS-[TYPE]-SURFMET.SURFMETv3`

	NMEA: /Ship_Systems/Data/TechSAS/NMEA/surfm/YYYYMMDD-HHMMSS-SURFMET.surfm Data description: /Ship_Systems/Metadata/TechSAS/Data_Description/Surfmet Data Description_v5_DY.docx
Thermosalinograph	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/SURFMETV3/YYYYMMDD-HHMMSS-[TYPE]-SURFMET.SURFMETv3 NMEA: /Ship_Systems/Data/TechSAS/NMEA/surfm/YYYYMMDD-HHMMSS-SURFMET.surfm Data description: /Ship_Systems/Metadata/TechSAS/Data_Description/Surfmet Data Description_v5_DY.docx
Windsonic	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/SURFMETV3/YYYYMMDD-HHMMSS-WINDSONIC-WINDSONIC.WINDSONIC NMEA: /Ship_Systems/Data/TechSAS/NMEA/winds/YYYYMMDD-HHMMSS-WINDSONIC.winds Data description: /Ship_Systems/Metadata/TechSAS/Data_Description/Windsonic Data Description.docx

RVDAS (Research Vessel Data Acquisition System) is a central acquisition system developed by NMF and the British Antarctic Survey. RVDAS has been used since ~2018 and is currently the common data acquisition format across the NERC research ships RRS Discovery, RRS James Cook and RRS Sir David Attenborough.

RVDAS produced one real-time data file (raw ASCII), one real-time PostgreSQL database, one post-cruise PostgreSQL dump, six post-processed data files (NetCDF and CSV), structured metadata files (JSON) and event log files (CSV).

Table 12: Summary of file type

File type	Explanation
Raw text	Data: /Ship_Systems/Data/RVDAS/Raw_TXT/ Filename format: [Keywords]_[SENSOR]_YYYY_MM_DD.nmea.txt Source: Written in real time by acquisition module (v2.7.0). Data description: /Ship_Systems/Data/RVDAS/Sensor_metadata/

	Collection: All data at acquisition resolution. Purpose: ASCII data format with NMEA-0183 standardised or pseudo-NMEA data sentences in 1D timeseries. Status: Production data product.
PostgreSQL database	Data: Only available onboard ship. Source: Written in real time by database module (v1.0.0). Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Collection: All data at acquisition resolution. Purpose: Advanced querying of timeseries data on ship. Status: Production data product.
Sensor metadata	Data: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Filename format: `[SENSOR]_[SHIP]_YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json` Source: Written on demand by metadata module (v1.0.0). Collection: Manual entries of structured sensor and acquisition metadata. Status: Production data product.
Event logs	Data: `/Ship_Systems/Data/RVDAS/Event_logs/[LOG TYPE]/` Filename format: `[LOG TYPE].csv` Source: Written in real time by eventlogging module (v1.0.0). Collection: Entries of acquisition and science event history. Status: Production data product.
NetCDF (Raw)	Data: `/Ship_Systems/Data/RVDAS/Database_NetCDF/Raw/` Filename format: `metocean-`[Keywords]`-[SENSOR]_[SENTENCE]-raw-YYYMMDD-HHMMSS.nc` Source: Written by NetCDF module (v1.0.0) as post-processing from database. Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Collection: All data at acquisition frequency. Status: Work-in-progress data product.
NetCDF (SAMOS)	Data: `/Ship_Systems/Data/RVDAS/Database_NetCDF/SAMOS/` Filename format: `samos_YYYYMMDD-HHMMSS.nc`

	Source: Written by NetCDF module (v1.0.0) as post-processing from database. Collection: SAMOS data variables at 1 min resolution (bin averaged). Data description: `https://samos.coaps.fsu.edu/html/documentation.php` Status: Work-in-progress data product.
NetCDF (METOCEAN)	Data: `/Ship_Systems/Data/RVDAS/Database_NetCDF/METOCEAN/` Filename format: `metocean_YYYYMMDD-HHMMSS.nc` Source: Written by NetCDF module (v1.0.0) as post-processing from database. Collection: All data at 5 min resolution (bin averaged). Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Status: Work-in-progress data product.
CSV (Raw)	Data: `/Ship_Systems/Data/RVDAS/Database_CSV/Raw/` Filename format: `metocean-[Keywords]-[SENSOR]_[SENTENCE]-raw-YYMMDD-HHMMSS.csv` Source: Written by NetCDF module (v1.0.0) as post-processing from database. Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Collection: All data at acquisition frequency. Status: Work-in-progress data product.
CSV (SAMOS)	Data: `/Ship_Systems/Data/RVDAS/Database_CSV/SAMOS/` Filename format: `samos_YYYYMMDD-HHMMSS.csv` Source: Written by NetCDF module (v1.0.0) as post-processing from database. Collection: SAMOS data variables at 1 min resolution (bin averaged). Data description: `https://samos.coaps.fsu.edu/html/documentation.php` Status: Work-in-progress data product.
CSV (METOCEAN)	Data: `/Ship_Systems/Data/RVDAS/Database_CSV/METOCEAN/` Filename format: `metocean_YYYYMMDD-HHMMSS.csv`

	Source: Written by NetCDF module (v1.0.0) as post-processing from database. Collection: All data at 5 min resolution (bin averaged). Column header format: `[VARIABLE]-[SENSOR]_[SENTENCE]` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/` Status: Work-in-progress data product.

System	Quick reference
Primary GPS	Raw data: `/Ship_Systems/Data/RVDAS/Raw_TXT/`[Keywords]`_POSMV_YYYY_MM_DD.nmea.txt` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/posmv-[SHIP]-YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json`
Seawater biogeochemical sensors	Raw data: `/Ship_Systems/Data/RVDAS/Raw_TXT/`[Keywords]`_NUDAMUWY_YYYY_MM_DD.nmea.txt` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/nudamuwy-[SHIP]-YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json`
Meteorological sensors	Raw data: `/Ship_Systems/Data/RVDAS/Raw_TXT/`[Keywords]`_NUDAMMET_YYYY_MM_DD.nmea.txt` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/nudammet-[SHIP]-YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json`
Solar irradiance sensors	Raw data: `/Ship_Systems/Data/RVDAS/Raw_TXT/`[Keywords]`_NUDAMLGT_YYYY_MM_DD.nmea.txt` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/nudamlgt-[SHIP]-YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json`
Windsonic	Raw data: `/Ship_Systems/Data/RVDAS/Raw_TXT/`[Keywords]`_WINDSONIC_YYYY_MM_DD.nmea.txt` Data description: `/Ship_Systems/Data/RVDAS/Sensor_metadata/windsonic-[SHIP]-YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json`

6.1.6 Instrumentation

Coordinate reference

Path to ship survey files:

`/Ship_Systems/Documentation/Vessel_Survey`

Origin (RRS Discovery)

All coordinates, unless otherwise specified, use the following convention:
Central reference point (0,0,0) at Frame 44, centreline, main deck with sense (X+ fwd, Y+ stbd, Z+ down). This CRP is at (32.4m, 0m, -7.4m) with respect to the ship's absolute stern, centreline, baseline.

The ship's survey (Parker Maritime, 2013) defines two systems of reference point using two different central reference points (CRPs):

1. (0,0,0) at Frame 0 (aft-most frame, 6m forward from stern), centreline (centre of keel), baseline (ship's bottom-most longitudinal).
2. (0,0,0) at ship's centre of gravity (CG), Frame 44 (26.4m forward from Frame 0 at 0.6m framespacing), centreline (centre of keel), main deck (7.4m up from baseline).

The survey coordinate sense is X is positive forward, Y positive starboard, and Z positive down. The coordinate order in the survey is (Y,X,Z), but unless otherwise noted, all coordinates are given elsewhere as (X,Y,Z).

For all scientific purposes, unless otherwise stated, the coordinate system is referenced using the second system, with the CRP at the CG.

Primary scientific position and attitude system

The translations and rotations provided by this system (Applanix PosMV) have the following convention:

1. Roll positive port up,
2. Pitch positive bow up,
3. Heading true positive to starboard,
4. Heave positive up.

Table 13: Position, attitude and time

System	Navigation (Position, attitude, time)		
Data product(s)	NMEA (mvpos, mvatt, spatt, sppos, cnpos): `/Ship_Systems/Data/TechSAS/NMEA/` NetCDF (GPS): `/Ship_Systems/Data/TechSAS/NetCDF/` Raw NMEA (POSMV, SEAPATH, CNAV): `/Ship_Systems/Data/RVDAS/Raw_TXT` Raw & processed NetCDF (POSMV, SEAPATH, CNAV): `/Ship_Systems/Data/RVDAS/Database_NetCDF` Raw NMEA (POSMV, SEAPATH, CNAV): `/Ship_Systems/Data/RVDAS/Database_CSV`		

Data description	`/Ship_Systems/Data/RVDAS/Sensor_metadata`
	`/Ship_Systems/Metadata/Techsas/Data_Description`
	~~/Ship_Systems/Metadata/RVDAS/Data_Description~~		

Other documentation	`/Ship_Systems/Documentation/GPS_and_Attitude`		
Component	Purpose	Outputs	Headline Specifications
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 0.15 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	RTCM to primary and secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	

6.1.7 Ocean and atmosphere monitoring systems

Table 14: SURFMET

System	SURFMET (Surface water and atmospheric monitoring)	
Data product(s)	NMEA (surfm, sbe38, sbe45, winds): /Ship_Systems/Data/TechSAS/NMEA/ NetCDF (SURFMETV3, SBE38, TSG, WINDSONIC): /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA (NUDAM***, SF***, SBE38DK, SBE45, WINDSONIC): /Ship_Systems/Data/RVDAS/Raw_TXT Raw & processed NetCDF (NUDAM***, SF***, SBE38DK, SBE45, WINDSONIC): /Ship_Systems/Data/RVDAS/Database_NetCDF Raw NMEA (NUDAM***, SBE38DK, SBE45, WINDSONIC): /Ship_Systems/Data/RVDAS/Database_CSV	
Data description	/Ship_Systems/Data/RVDAS/Sensor_metadata /Ship_Systems/Metadata/Techsas/Data_Description ~~/Ship_Systems/Metadata/RVDAS/Data_Description~~	
Other documentation	/Ship_Systems/Documentation/SURFMET	
Calibration info	See [Keywords]_Surfmet__sensor_information_sheet.docx for calibration information for each sensor. Calibration documents: /Ship_Systems/Metadata/SURFMET/Calibration_Files	
Component	**Purpose**	**Outputs**
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet.	Serial to Interface Box.
Drop keel temperature probe (SBE38)	Measure temperature of water flush to hull at the drop keel.	Serial to Interface Box.
Thermosalinograph (SBE45)	Measure temp. and conductivity at sampling board. Salinity is calculated.	Serial to Interface Box.
Interface Box (SBE90402)	Signals management.	Serial to Moxa.

Debubbler	Reduces bubbles through instruments.	None.
Transmissometer (CST)	Measure of transmittance.	Analogue to NUDAM.
Fluorometer (WS3S)	Measure of fluorescence.	Analogue to NUDAM.
Air temperature and humidity probe (HMP45A, HMP155)	Temperature and humidity at met. platform.	Analogue to NUDAM.
Ambient light sensors (PAR, SKE510; TIR, CMP6)	Ambient light at met. platform.	Analogue to NUDAM.
Barometer (PTB110, PTB210)	Atmospheric pressure at met. platform.	Analogue to NUDAM.
Anemometer (Windsonic)	Wind speed and direction at met. platform.	Serial to Moxa.
NUDAM	A/D converter.	Serial NMEA to Moxa.
Moxa	Serial to UDP converter.	UDP NMEA to Surfmet VM.
Surfmet Virtual Machine	Data management.	UDP NMEA to TechSAS, RVDAS.

Table 15: Calibration functions (the calibration function below refers to both TechSAS and RVDAS data products).

Component	Calibrated product steps
SBE38: Temperature (°C)	No calibration to apply because the residuals are below uncertainty.
SBE45: Temperature (°C)	No calibration to apply because the residuals are below uncertainty.
SBE45: Conductivity (S m^{-1})	No calibration to apply because the residuals are below uncertainty.
HMP155: Temperature (°C)	
HMP155: Relative humidity (%)	No calibration to apply because the residuals are below uncertainty.
PTB110 / PTB210: Pressure (hPa)	No calibration to apply because the residuals are below uncertainty.

Windsonic: Wind speed (m s^{-1})	No calibration to apply.
Windsonic: Wind direction (m s^{-1})	

Table 16: Calibration functions (the calibration functions below refer to the TechSAS data products only)

Component	Calibrated product steps	
	TechSAS NetCDF	TechSAS NMEA
CST: Transmission (%)	$\text{Product} = (\text{Data} - V_{\text{dark}})/(V_{\text{ref}} - V_{\text{dark}})$. Here product has units % and data, V_{dark} and V_{ref} have units V.	
WS3S: Fluorescence (µg L^{-1})	$\text{Product} = \text{Coefficient} \times (\text{Data} - \text{Offset})$. Here product has units µg L^{-1}, coefficient has units µg L^{-1} V^{-1}, and data and offset have units V.	
SKE510: PAR (W m^{-2})	$\text{Product} = \text{Data} \times \left(\frac{10^6}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units 10^{-5} V, the 10^6 scalar has units µV V^{-1}, and coefficient has units µV m^2 W^{-1}.	$\text{Product} = \text{Data} \times \left(\frac{10}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units W m^2, the 10 scalar has units µV m^2 W^{-1}, and coefficient has units µV m^2 W^{-1}.
CMP6: TIR (W m^{-2})	$\text{Product} = \text{Data} \times \left(\frac{10^6}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units 10^{-5} V, the 10^6 scalar has units µV V^{-1}, and coefficient has units µV m^2 W^{-1}.	$\text{Product} = \text{Data} \times \left(\frac{10}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units W m^2, the 10 scalar has units µV m^2 W^{-1}, and coefficient has units µV m^2 W^{-1}.

Table 17: Calibration functions (the calibration functions below refer to the RVDAS data products only)

Component	Calibrated product steps	
	RVDAS raw text	RVDAS NetCDF & CSV
CST: Transmission (%)	$\text{Product} = (\text{Data} - V_{\text{dark}})/(V_{\text{ref}} - V_{\text{dark}})$. Here product has units % and data, V_{dark} and V_{ref} have units V.	
WS3S: Fluorescence (µg L^{-1})	$\text{Product} = \text{Coefficient} \times (\text{Data} - \text{Offset})$. Here product has units µg L^{-1}, coefficient has units µg L^{-1} V^{-1}, and data and offset have units V.	
SKE510: PAR (W m^{-2})	$\text{Product} = \text{Data} \times \left(\frac{1000}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units mV, the 1000	$\text{Product} = \text{Data} \times \left(\frac{10}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units W m^2, the 10 scalar has

	scalar has units μV mV^{-1}, and coefficient has units μV m^2 W^{-1}.	units μV m^2 W^{-1}, and coefficient has units μV m^2 W^{-1}.
CMP6: TIR (W m^{-2})	$\text{Product} = \text{Data} \times \left(\frac{1000}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units mV, the 1000 scalar has units μV mV^{-1}, and coefficient has units μV m^2 W^{-1}.	$\text{Product} = \text{Data} \times \left(\frac{10}{\text{Coefficient}}\right)$. Here product has units W m^2, data has units W m^2, the 10 scalar has units μV m^2 W^{-1}, and coefficient has units μV m^2 W^{-1}.

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port, and whilst alongside. Please see the separate information sheet for details of the sensors used and whether their recorded data have calibrations applied or not.

Table 18: Summary of data gaps

Date start	Date end	Event
2025-05-25 22:02:30	2025-05-27 12:40:00	Passage through Irish EEZ. Acquisition stopped.

Table 19: Surface water sampling board maintenance

Date	Event	Fluorometer signal (V)	Transmissometer signal (V)
2025-06-01 ~04:27	Pre-cleaning freshwater rinse	0.0748±0.0003	4.2855±0.0013
2025-06-01 ~05:25	Post-cleaning freshwater rinse	0.0580±0.0002	3.7426±0.2769
2025-06-06 ~10:26	Pre-cleaning freshwater rinse	0.0594±0.0003	4.3790±0.0041
2025-06-06 ~10:53	Post-cleaning freshwater rinse	0.0584±0.0005	4.2407±0.1588
2025-06-15 ~14:01	Pre-cleaning freshwater rinse	0.0594±0.0003	3.7295±0.0574
2025-06-15 ~16:29	Post-cleaning freshwater rinse	0.0573±0.0002	4.3607±0.0330

2025-06-21 ~12:15	Pre-cleaning freshwater rinse	0.0587±0.0003	2.2897±0.3270
2025-06-21 ~12:54	Post-cleaning freshwater rinse	0.0574±0.0002	3.4942±0.4950

The sampling board pipework was cleaned prior to the cruise.

6.1.8 TSG-Autosal comparison

Water samples were taken daily (~12:00 UTC) from the underway sampling board to be analysed by the onboard Autosal (both by D. Phillips). The comparison between the SBE45 TSG and the Autosal can be found here:

Path to TSG vs Autosal:

`/Ship_Systems/Data/SURFMET/TSG-Autosal analysis/`

Figure 7 shows the regression before and after the conductivity ratio was adjusted for the residual between the standard conductivity solutions at the beginning and end of sample analysis. The standard conductivity solution residuals were linearly interpolated to the timestamp of each Autosal analysis. Further analysis should be done to determine an adjustment for the TSG data relative to the adjusted Autosal data.

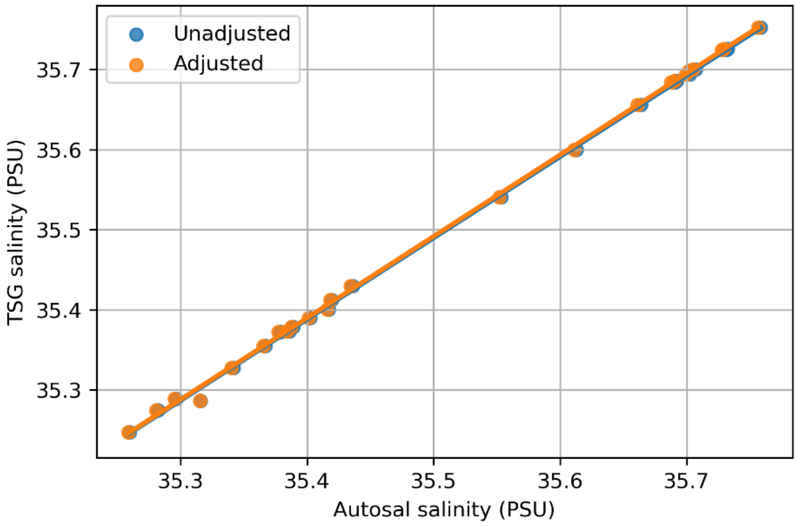

Figure 7: Regression plot (before and after conductivity ratio was adjusted).

Table 20: Wave Radar

System	WAMOS Wave Radar	
Data product(s)	NMEA (wamos): `/Ship_Systems/Data/TechSAS/NMEA/` NetCDF: `/Ship_Systems/Data/TechSAS/NetCDF/NC` Raw NMEA (WAMOS): `/Ship_Systems/Data/RVDAS/Raw_TXT` Raw & processed NetCDF (WAMOS): `/Ship_Systems/Data/RVDAS/Database_NetCDF` Raw NMEA (WAMOS): `/Ship_Systems/Data/RVDAS/Database_CSV`	

Data description	~~/Ship_Systems/Metadata/WAMOS~~
	`/Ship_Systems/Data/RVDAS/Sensor_metadata`
	`/Ship_Systems/Metadata/Techsas/Data_Description`
	~~/Ship_Systems/Metadata/RVDAS/Data_Description~~	

Other documentation	`/Ship_Systems/Documentation/WAMOS`	
Component	Purpose	Outputs
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.

Table 21: Summary of data gaps

Date start	Date end	Event
2025-05-25 22:02:30	2025-05-27 12:40:00	Passage through Irish EEZ. Acquisition stopped.

6.1.9 pCO_2 system

System	pCO_2 system
Data product(s)	Raw: `/Ship_Systems/Data/pCO2/Raw` Processed: `/Ship_Systems/Data/pCO2/Processed`

Data description	/Ship_Systems/Metadata/pCO2/Data_Description /Ship_Systems/Data/RVDAS/Sensor_metadata	
Other documentation	/Ship_Systems/Documentation/pCO2	
Component	Purpose	Outputs
General Oceanics' model 8060 dry enclosure	Brains of pCO_2 system. Controls electronics and merges data streams.	Data product sentence to file and via UDP to central acquisition.
General Oceanics' model 8060 wet enclosure	Controls seawater and atmospheric gas samples to gas analyser.	
General Oceanics' model 8060 deck enclosure	Measure deck pressure.	Deck pressure via serial to dry enclosure.
LI-COR 7815 gas analyser	Measure dry mixing ratio of CO_2 (xCO_2)	xCO_2 via ethernet to dry enclosure.
Aanderaa 4835 oxygen optode	Dissolved O_2 sensor.	Measured O_2 concentration, O_2 saturation and sensor temperature to dry enclosure.
External SURFMET sensors	Send additional valuable data for merge.	Data via UDP to dry enclosure.
NMF data reduction script.	Process raw data product into higher-level data products (i.e. pCO_2/fCO_2).	Additional data products to cruise disk.

Table 22: Summary of data gaps

Date start	Date end	Event
2025-05-25 22:02:30	2025-05-27 12:40:00	Passage through Irish EEZ. Acquisition stopped.

The LI-COR 7815 gas analyser sampled reference gases on an automated ~21-hour cycle.

Path to gas calibration certificates:

/Ship_Systems/Metadata/pCO2/Calibration/

Table 23: Standard known concentrations

Standard	Known conc. (ppm)	Source	Scale / traceability
STD1	0	BOC	n/a
STD2	249.788±0.012	ICOS (2023-04-27)	WMO-CO2-X2007-EXTENDED
STD3	403.081±0.014	ICOS (2021-01-21)	WMO-CO2-X2007-EXTENDED
STD4	812.918±0.030	ICOS (2023-04-27)	WMO-CO2-X2007-EXTENDED

A post-processor "data reduction script" developed by NMF was used to process the raw instrument data into reduced calibrated datasets. The processor was configured to run automatically daily at 00:10 and the output files were stored in the directory `/Ship_Systems/Data/pCO2/Processed/ Rough processed (daily)/YYYY-MM-DD/`. At the end of the cruise, the SST ran the script manually to produce the final data products, which were stored in the directory `/Ship_Systems/Data/pCO2/Processed/Final product/`.

For the calculation of pCO_2 and fCO_2, the equations from Pierrot et al. (2009)[1] were used. Seawater pCO_2/fCO_2 calculation used equation 6 with the wet equilibrator pCO_2/fCO_2 values of equations 4 and 1 respectively. Atmospheric pCO_2 and fCO_2 used equation 4 and equation 1, respectively, with sea surface temperature substituted for equilibrator temperature. Table 24 shows the data sources of each variable.

Table 24: Data sources of variables

Variable	Data source
$equT$	Primary equilibrator thermometer. Data file variable '`EquTemp`'.
x_{CO_2}	Drift-corrected dry mixing ratio. Drift-corrected dry mixing ratio was calculated by cross-linearly interpolating the routine gas standard checks (~21 hr) to the data file variable '`CO2ppm`'.

[1] *Pierrot et al. (2009) Recommendations for autonomous underway pCO2 measuring systems and data-reduction routines. https://doi.org/10.1016/j.dsr2.2008.12.005.*

P_{equ}	Sum of the equilibrator differential pressure sensor and the wet box enclosure pressure sensor. Data file variables '`EquPress`' and '`DruckLabPress`' respectively.
P_{atm}	Deck box enclosure PTB210 pressure sensor. Data file variable '`Deck_Press`'. If the deck box enclosure PTB210 pressure sensor data was not unavailable, the mast-mounted PTB210 pressure sensor was used (external data). Data file variable '`air_pressure`'.
SSS	Underway SBE45 thermosalinograph (external data). Data file variable '`salinity`'.
SST	Hull-mounted SBE38 thermometer (external data). Data file variable '`hull_temperature`'. If the hull-mounted SBE38 thermometer data was not unavailable, the inlet-mounted SBE38 thermometer was used (external data). Data file variable '`inlet_temperature`'.

The data reduction script produced the following core data products:

Table 25: Core data products

File type	Explanation
Calibration data	Filename format: `YYYY-MM-DD_YYYY-MM-DD_calibration_data.csv` Data description: `/Ship_Systems/Metadata/pCO2/Data_Description/` Purpose: Time series of calibration events with regression statistics and residual data. Status: Production data product.
Seawater data	Filename format: `YYYY-MM-DD_YYYY-MM-DD_seawater_data.csv` Data description: `/Ship_Systems/Metadata/pCO2/Data_Description/` Purpose: Time series of equilibrator measurements (seawater) with drift-corrected xCO_2, and calculated pCO_2 and fCO_2. Dataset is reduced to geophysical data only. Status: Production data product.

Atmospheric data	Filename format: YYYY-MM-DD_YYYY-MM-DD_atmospheric_data.csv Data description: /Ship_Systems/Metadata/pCO2/Data_Description/ Purpose: Time series of atmospheric measurements with drift-corrected xCO_2, and calculated pCO_2 and fCO_2. Dataset is reduced to geophysical data only. Status: Production data product.

The data reduction script produced the following optional data products:

Table 26: Optional data products

File type	Explanation
System health data	Filename format: YYYY-MM-DD_YYYY-MM-DD_system_health_data.csv Data description: /Ship_Systems/Metadata/pCO2/Data_Description/ Purpose: Time series of all diagnostic measurements and processed flags. Status: Work-in-progress data product.

6.1.10 Hydroacoustic Systems

System	Acoustics
Data product(s)	NMEA (eadep, emdep): /Ship_Systems/Data/TechSAS/NMEA NetCDF (EA640, DEPTH): /Ship_Systems/Data/TechSAS/NetCDF Raw NMEA (EA640): /Ship_Systems/Data/RVDAS/Raw_TXT Raw & processed NetCDF (EA640): /Ship_Systems/Data/RVDAS/Database_NetCDF Raw NMEA (EA640): /Ship_Systems/Data/RVDAS/Database_CSV
Data description	/Ship_Systems/Metadata/Acoustics /Ship_Systems/Data/RVDAS/Sensor_metadata /Ship_Systems/Metadata/Techsas/Data_Description

	~~/Ship_Systems/Metadata/RVDAS/Data_Description~~	
Other documentation	/Ship_Systems/Documentation/Acoustics	
Component	Purpose	Operation and Outputs
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	Continuous, free running NMEA over serial, raw files
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	Unused, known failure (via UHDAS)
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	Continuous, free running (via UHDAS)

Equipment-specific comments

ADCPs

Path of ADCP data on the cruise datastore:

/Ship_Systems/Data/Acoustics/ADCP

Attribute	Value
Acquisition software	UHDAS
Frequencies used	150 kHz
Running mode	Free-running (untriggered)

6.1.11 METOCEAN CSV headers

The column names have the structure [variable]-[sensor]_[sentence]. To locate the metadata, navigate to /Ship_Systems/Data/RVDAS/Sensor_metadata/ and find the file in the format [SENSOR]_[SHIP]_YYYY-MM-DDTHHMMSSZ-YYYY-MM-DDTHHMMSSZ.json. Inside the file, there is a list of dictionaries "sentences" that have a key-value pair of "name": "[sentence]". Each sentence value has a list of dictionaries "fields" that have a key-value pair of "fieldNumber": "[variable]". This inner dictionary contains the required metadata. Note that this is a work-in-progress dataset.

The SEAPATH system (secondary GPS) was not provided in Table 27 because this was inoperative during DY195. The FUGRO and PHINS systems (quaternary and quinary GPS systems) were not provided in Table 27 because the data can be found in the primary and tertiary GPS systems (POSMV and CNAV respectively).

Note that a few biases were identified after the cruise data collection was completed. METOCEAN data should be checked to see if corrections have been applied. The data provided by NMF SSS requires the following corrections:

Tair_C_corr = 100 * (Tair_C + 40) / 99.32 - 40

RH%_corr = (RH% / 99.32) * 100

Pres_mb_corr = (Pres_mb - 800) / 0.9932 + 800

Table 27: METOCEAN CSV headers

Column name	Explanation
time	Start timestamp of the averaging period.
utctime-cnav_gngga	UTC timestamp from CNAV. Format is HHMMSS.S.
latitude-cnav_gngga	Latitude position from CNAV. Format is DDMM.MMMM.
longitude-cnav_gngga	Longitude position from CNAV. Format is DDMM.MMMM.
ggaqual-cnav_gngga	GPS quality flag from CNAV.
numsat-cnav_gngga	Number of satellites used in GPS fix by CNAV.
hdop-cnav_gngga	Horizontal dilution of precision from CNAV.
altitude-cnav_gngga	Altitude position from CNAV. Unit is m.
geoidaltitude-cnav_gngga	Altitude (geoid) position from CNAV. Unit is m.
diffcage-cnav_gngga	Age of differential correction from CNAV. Unit is s.
dgnssrefid-cnav_gngga	Reference station for differential correction used by CNAV.
rms-cnav_gngst	RMS value of the pseudorange residuals from CNAV.
majoraxis-cnav_gngst	Error ellipse, semi-major axis, 1-sigma error from CNAV. Unit is m.
minoraxis-cnav_gngst	Error ellipse, semi-minor axis, 1-sigma error from CNAV. Unit is m.
orientation-cnav_gngst	Error ellipse orientation (true). Unit is °.
laterr-cnav_gngst	Standard deviation in latitude position from CNAV. Unit is m.
lonerr-cnav_gngst	Standard deviation in longitude position from CNAV. Unit is m.
alterr-cnav_gngst	Standard deviation in altitude position from CNAV. Unit is m.
courseoverground-cnav_gnvtg	Vessel course over ground (true) from CNAV. Unit is °.
magnetictrack-cnav_gnvtg	Vessel course over ground (magnetic) from CNAV. Unit is °.
speedknots-cnav_gnvtg	Vessel speed over ground from CNAV. Unit is kn.
speedkmph-cnav_gnvtg	Vessel speed over ground from CNAV. Unit is kph.
waterdepthfeetfromsurface-ea640_sddbs	Seafloor depth below water surface from EA640. Unit is feet.
waterdepthmetrefromsurface-ea640_sddbs	Seafloor depth below water surface from EA640. Unit is m.

waterdepthfathomfromsurface-ea640_sddbs	Seafloor depth below water surface from EA640. Unit is fathoms.
waterdepthmetretransducer-ea640_sddpt	Seafloor depth below transducer from EA640. Unit is m.
transduceroffset-ea640_sddpt	Transducer – surface offset in EA640. Unit is m.
humidity-envtemp_wimhu	Relative humidity of the controlled environment laboratory. Unit is %.
airtemperature-envtemp_wimta	Temperature of the controlled environment laboratory. Unit is °C.
flow-nudamuwy_sfuwy	Flow rate in seawater sensors. Unit is L min^{-1}.
fluo-nudamuwy_sfuwy	Raw fluorescence sensor signal. Unit is V.
trans-nudamuwy_sfuwy	Raw transmission sensor signal. Unit is V.
ppar-nudamlgt_sflgt	Photosynthetically available radiation sensor (port). Unit is W m^{-2}.
spar-nudamlgt_sflgt	Photosynthetically available radiation sensor (starboard). Unit is W m^{-2}.
ptir-nudamlgt_sflgt	Total irradiance sensor (port). Unit is W m^{-2}.
stir-nudamlgt_sflgt	Total irradiance sensor (starboard). Unit is W m^{-2}.
airtemp-nudammet_sfmet	Atmospheric temperature. Unit is °C.
humidity-nudammet_sfmet	Atmospheric relative humidity. Unit is %.
press-nudammet_sfmet	Atmospheric pressure. Unit is hPa.
windspeed-windsonic_iimwv	Wind speed. Unit is m s^{-1}.
winddirection-windsonic_iimwv	Wind direction. Unit is °.
tension-winch_winch	Tension on winch cable. Unit is t.
cableout-winch_winch	Cable length deployed from winch. Unit is m s^{-1}.
rate-winch_winch	Cable deploy rate. Unit is m s^{-1}. Positive values are cable paying out.
backtension-winch_winch	Back tension on winch cable. Unit is t.
rollangle-winch_winch	Roll angle of cable. Unit is °.
utctime-posmv_gpgga	UTC timestamp from POSMV. Format is HHMMSS.S.
latitude-posmv_gpgga	Latitude position from POSMV. Format is DDMM.MMMM.
longitude-posmv_gpgga	Longitude position from POSMV. Format is DDMM.MMMM.
ggaqual-posmv_gpgga	GPS quality flag from POSMV.
numsat-posmv_gpgga	Number of satellites used in GPS fix by POSMV.
hdop-posmv_gpgga	Horizontal dilution of precision from POSMV.
altitude-posmv_gpgga	Altitude position from POSMV. Unit is m.
diffcage-posmv_gpgga	Age of differential correction from POSMV. Unit is s.
dgnssrefid-posmv_gpgga	Reference station for differential correction used by POSMV.
latitude-posmv_gpgll	Latitude position from POSMV. Format is DDMM.MMMM.
longitude-posmv_gpgll	Longitude position from POSMV. Format is DDMM.MMMM.
semimajor-posmv_gpgst	Error ellipse, semi-major axis, 1-sigma error from POSMV. Unit is m.
semiminor-posmv_gpgst	Error ellipse, semi-minor axis, 1-sigma error from POSMV. Unit is m.
ellipseorient-posmv_gpgst	Error ellipse orientation (true). Unit is °.
standarddeviationoflatitude-posmv_gpgst	Standard deviation in latitude position from POSMV. Unit is m.
standarddeviationoflongitude-posmv_gpgst	Standard deviation in longitude position from POSMV. Unit is m.

standarddeviationofheight-posmv_gpgst	Standard deviation in altitude position from POSMV. Unit is m.
headingtrue-posmv_gphdt	Vessel heading (true) from POSMV. Unit is °.
latitude-posmv_gprmc	Latitude position from POSMV. Format is DDMM.MMM.
longitude-posmv_gprmc	Longitude position from POSMV. Format is DDMM.MMM.
speedknots-posmv_gprmc	Vessel speed over ground from POSMV. Unit is kn.
trackmadegood-posmv_gprmc	Vessel course over ground (true) from POSMV. Unit is °.
coursetrue-posmv_gpvtg	Vessel course over ground (true) from POSMV. Unit is °.
speedknots-posmv_gpvtg	Vessel speed over ground from POSMV. Unit is kn.
speedkmph-posmv_gpvtg	Vessel speed over ground from POSMV. Unit is kph.
day-posmv_gpzda	Calendar day from POSMV. Format is DD.
month-posmv_gpzda	Calendar month from POSMV. Format is MM.
year-posmv_gpzda	Calendar year from POSMV. Format is YYYY.
heading-posmv_pashr	Vessel course over ground (magnetic) from CNAV. Unit is °.
roll-posmv_pashr	Vessel roll from POSMV. Unit is °. Positive is port side up.
pitch-posmv_pashr	Vessel pitch from POSMV. Unit is °. Positive is bow up.
heave-posmv_pashr	Vessel heave from POSMV. Unit is m. Positive is motion up.
rollaccuracy-posmv_pashr	Vessel roll accuracy from POSMV. Unit is °.
pitchaccuracy-posmv_pashr	Vessel pitch accuracy from POSMV. Unit is °.
headingaccuracy-posmv_pashr	Vessel heave accuracy from POSMV. Unit is m.
temph-sbe45_nanan	Housing temperature of thermosalinograph. Unit is °C.
conductivity-sbe45_nanan	Conductivity of seawater from thermosalinograph. Unit is S m^{-1}.
tempr-sbe45_nanan	Remote temperature from thermosalinograph (at seawater inlet). Unit is °C.
salinity-sbe45_nanan	Derived salinity from thermosalinograph. Unit is PSU.
soundvelocity-sbe45_nanan	Derived sound velocity from thermosalinograph. Unit is PSU.
tempdk-sbe38dk_sbe38	Temperature of seawater measured from dropkeel sensor. Unit is °C.
headingtrue-shipsgyro_hehdt	Vessel heading (true) from SHIPSGYRO. Unit is °.
rateofturn-shipsgyro_tirot	Rate of turn from SHIPSGYRO. Unit is ° min^{-1}. Negative values are turns to port.
watertemperatureincelsius-skipperlog_vdmtw	Temperature of SKIPPERLOG transducer. Unit is °C.
longitudinalwaterspeed-skipperlog_vdvbw	Bow–stern vessel speed through water from SKIPPERLOG. Unit is kn. Negative values are astern.
transversewaterspeed-skipperlog_vdvbw	Port–starboard vessel speed through water from SKIPPERLOG. Unit is kn. Negative values are to port.
longitudinalgroundspeed-skipperlog_vdvbw	Bow–stern vessel speed over ground from SKIPPERLOG. Unit is kn. Negative values are astern.
transversegroundspeed-skipperlog_vdvbw	Port–starboard vessel speed over ground from SKIPPERLOG. Unit is kn. Negative values are to port.
hs-wamos_pwam	Significant wave height from WAMOS. Units is m.
tm2-wamos_pwam	Wave period from WAMOS. Units is s.
pdir-wamos_pwam	Wave peak direction from WAMOS. Unit is °.
tp-wamos_pwam	Wave peak period from WAMOS. Unit is s.

lp-wamos_pwam	Wave peak wavelength from WAMOS. Unit is m.
dp1-wamos_pwam	Direction of swell system from WAMOS.
tp1-wamos_pwam	Period of swell system from WAMOS. Unit is s.
lp1-wamos_pwam	Wavelength of swell system from WAMOS. Unit is m.
dp2-wamos_pwam	Direction of wind sea system from WAMOS.
tp2-wamos_pwam	Period of wind sea system from WAMOS. Unit is s.
lp2-wamos_pwam	Wavelength of wind sea system from WAMOS. Unit is m.
currentdir-wamos_pwam	Surface current direction from WAMOS. Unit is °.
currentspeed-wamos_pwam	Surface current speed from WAMOS. Unit is m s^{-1}.

7 Science Reports

7.1 Seawater observations

7.1.1 Measurements of dimethyl sulfide (DMS), methanethiol (MeSH) and volatile organic compound (VOC) concentrations in surface seawater and depth profiles

Lead: Frances Hopkins (fhop@pml.ac.uk), Plymouth Marine Laboratory, Plymouth, UK

Motivation

We measured the concentrations of dimethylsulfide (DMS), methanethiol (MeSH), and a range of volatile organic compounds (VOCs) in surface seawater. Samples were primarily taken from the towed fish and the near surface sampler, with some measurements earlier in the cruise from the ship's underway supply before it was established that an enhanced level of DMS and MeSH was present in the underway supply. Discrete samples were also collected from Niskin bottles collected during daily CTD depth profiles.

Methods

A segmented flow coil equilibration (SFCE) system was coupled to a Ionicon proton transfer reaction-quad-MS (PTR-Quad-ms, or Quad in short) to measure these compounds, as described in detail by Wohl et al. (2019). Briefly, seawater is pumped into the deck laboratory on RRS Discovery through 3/8" PFA (perfluoroalkoxy alkane) tubing, into a rapidly overflowing 5000 mL Duran flask secured in the sink. For the SFCE system, water is nominally extracted from the bottom the glass sampling bottle with a peristaltic pump at 100 ml/min (via a ~0.5 m long ¼'' Teflon tube and a ~15 cm long Pumpsil soft tube). To analyse discrete samples collected in glass sample bottles taken from the Niskins, the ¼" Teflon tube was simply transferred into the sample bottle.

Carrier air (100 sccm zero air) joins the sample water at a Teflon 'tee' piece, naturally forming distinct segments of water and air. These segments travel in the same direction through 10 m of ¼'' PFA coil (during which time gas exchange occurs) and are then separated in an air-water separator (fashioned out of a ½'' Teflon 'tee' piece). The sample air leaves the separator from the top and goes towards the Quad, while the sampled water is drained from the bottom of the separator into the sink.

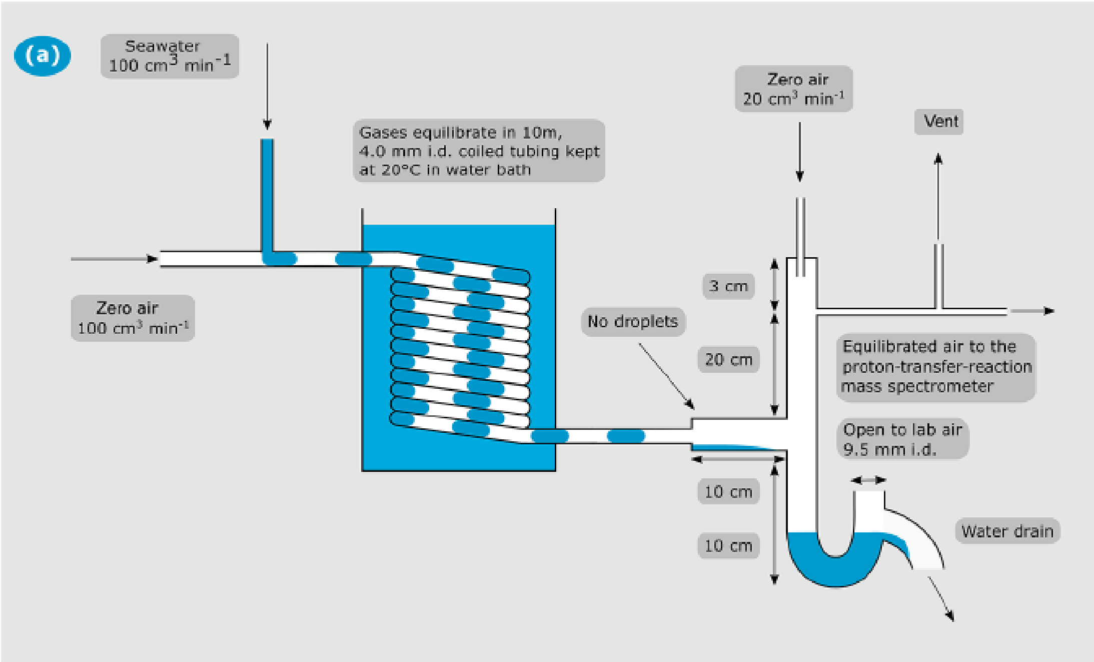

Figure 8: Schematic of the segmented flow coil equilibration (SFCE) system.

The SFCE coil is kept in a 20°C water bath to keep the temperature constant. (solubility of all gases better known at this temp and can make use of Wohl et al. (2019) humidity dependent PTR calibrations). Also, 20 sccm of zero air is added downstream of the SFCE to reduce the relative humidity of the measurement air and avoid condensation (see Figure 8).

A standalone catalyst is installed between the vent and the Quad. A 3-way solenoid valve directs equilibrated air either through the catalyst (NC) or bypassing the catalyst (NO). The solenoid valve is controlled by the valve automation program for the Quad and is programmed to trigger for 10 mins within every 60 min measurement period. The catalyst period represents the blank measurement.

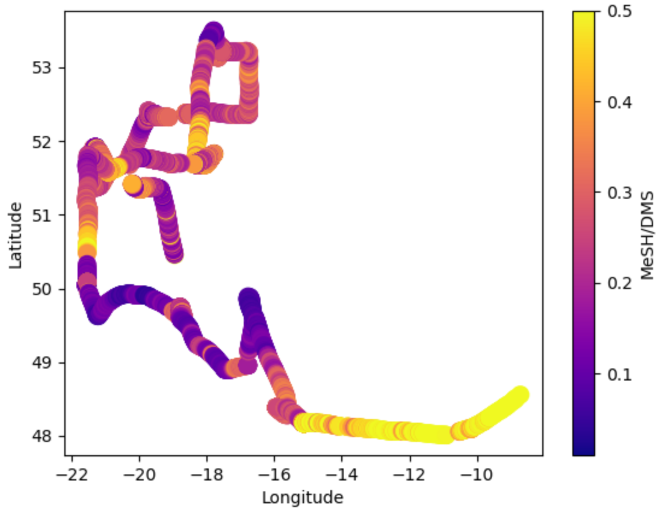

Figure 9: Ratio of methanethiol to DMS shown to illustrate where sulfur and non-sulfur VOCs were measured along the cruise track from the towed fish.

Table 28: CTD stations, Niskins sampled and depths (m) for discrete concentration measurements of DMS, MeSH and other VOCs.

Date	Station	Time (UTC)	CTD	Latitude N	Longitude W	Niskins sampled	Depths (m)
28/05/2025	1	04:00	1	50° 28.179'	16°03.662'	22, 23, 24	3, 3, 3
28/05/2025	1	15:10	2	49° 45.71664'	14°55.66736'	19, 17, 15, 13, 11, 9, 7	6, 10, 15, 25, 45, 60, 100
29/05/2025	1	13:40	3	49° 45.47268'	17° 10.81128'	21, 19, 17, 15, 13, 11, 9, 7	4, 6, 10, 20, 30, 40, 55, 70
30.5.2025	1	04:00	4	49° 45.47268'	17° 10.81128'	22, 17, 15, 13, 11, 9, 7, 5	3, 6, 10, 20, 30, 40, 55, 60
31/05/2025	2	04:00	6	49° 39.76470'	18° 36.36330'	22, 17, 15, 13, 11, 9, 7, 5	6, 10, 20, 30, 40, 45, 55, 65
01/06/2025	2	04:00	7	50° 18.58014'	18° 49.76790'	22, 17, 15, 13, 11, 9, 7, 5	6, 10, 20, 30, 40, 50, 65, 80
02/06/2025	3	13:30	8	51° 24.92922'	20° 12.13014'	22, 17, 15, 13, 11, 9, 7, 5	6, 10, 25, 40, 50, 60, 70, 100
03/06/2025	4	04:00	9	52° 20.55732'	19° 41.42256'	22, 17, 15, 13, 11, 9, 7, 5	6, 10 ,20, 30, 40, 50, 60, 100

04/06/2025	4	13:30	10	52° 21.96558'	18° 27.61686'	21, 19, 17 ,15, 13, 11, 9 ,7	6, 10, 20, 30, 40, 50, 60, 100
05/06/2025	4	04:00	11	52° 21.89178'	18° 27.82122'	22, 17, 15, 13, 11, 9, 7, 5	6, 10, 20, 30, 35, 50, 60, 100
06/06/2025	5	04:00	12	53° 12.67740'	17° 33.72096'	22, 17, 15, 13, 11, 9, 7, 5	5, 10, 20, 30, 40, 45, 55, 100
07/06/2025	5	13:30	13	53° 13.73664'	17° 31.98264'	21, 19, 17, 15, 13, 11, 9, 7	4, 10, 20, 30, 40, 50, 60, 100
08/06/2025	5	04:00	14	53° 12.64152'	17° 32.52798'	22, 17, 15, 13, 11, 9, 7, 5	4, 10, 20, 30, 40, 45, 55, 100
09/06/2025	6	04:00	15	51° 41.34108'	18° 20.27850'	22, 17, 15, 13, 11, 9, 7, 5	4, 10, 25, 40, 45, 55, 65, 100
10/06/2025	6	13:30	16	51° 49.17822'	17° 48.21708'	21, 19, 17, 15, 13, 11, 9, 7	4, 10, 20, 35, 45, 55, 75, 100
11/06/2025	6	04:00	17	51° 41.07924'	18° 20.17776'	22, 17, 15, 13, 11, 9, 7	4, 10, 20, 30, 50, 64, 70, 80
12/06/2025	7	04:00	24	51° 35.37192'	20° 54.11232'	22, 17, 15, 13, 11, 9, 7	4, 10, 15, 25, 30, 40, 50, 100
13/06/2025	7	13:30	25	51° 54.96036'	21° 17.78466'	21, 19, 17, 15, 13, 11, 9, 7	3, 10, 25, 35, 48, 60, 80, 100
14/06/2025	7	04:00	26	51° 54.71966'	20° 55.23750'	22, 17, 15, 13, 11, 9, 7	3, 10, 20, 30, 40, 50, 60, 100
15/06/2025	8	04:00	27	50° 4.95990'	21° 32.80380'	22, 17, 15, 13, 11, 9, 7	3, 10, 15, 20, 40, 50, 60, 80
16/06/2025	8	13:30	28	50° 5.10678’	21° 32.43342'	21, 19, 17, 15, 13, 11, 9, 7	3, 10, 15, 25, 35, 50, 60, 80
17/06/2025	8	04:00	29	50° 5.34936'	21° 32.3590'	22, 17, 15, 13, 11, 9, 7, 5	3, 10, 25, 30, 40, 50, 60, 80
18/06/2025	9	04:00	30	49° 36.71994’	18° 46.25814’	22, 17, 15, 13, 11, 9, 7, 5	5, 10, 20, 30, 40, 50, 80, 100

19/06/2025	9	13:30	31	49° 36.7171’	18° 46.27452'	21, 19, 17, 15, 13, 11, 9, 7	3, 10, 15, 20, 30, 40, 60, 80
20/06/2025	9	04:00	32	49° 36.71064'	18° 46.26018'	22, 17, 15, 13, 11, 9, 7, 5	3, 10, 15, 25, 35, 50, 80, 110
21/06/2025	10	04:00	36	48° 57.50814'	16° 46.76178'	22, 17, 15, 13, 11, 9, 7, 5	3, 10, 15, 20, 30, 40, 60, 80
22/06/2025	11	12:45	37	48° 23.17302’	15° 56.01036'	21, 19, 17, 15, 13, 11, 9,	5, 10, 15, 20, 30, 40, 60, 70
23/06/2025	12	04:00	38	48° 10.41054'	15° 7.33710'	22, 17, 15, 13, 11, 9, 7	3, 15, 30, 50, 60, 70, 80
24/06/2025	12	04:00	39	48° 10.32816'	15° 7.00164'	22, 17, 15, 13, 11, 9, 7	3, 15, 30, 50, 60, 70, 80

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7.1.2 Continuous seawater DMSP

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Motivation

Dimethylsulfoniopropionate (DMSP) is one of Earth's most abundant organosulfur compounds, produced in high particulate concentrations (intracellular DMSP) by marine phytoplankton. These organisms can release DMSP into their environment (dissolved or extracellular DMSP) as part of physiological processes to protect themselves against stressors such as zooplankton grazing, changes in salinity and temperature, oxidative stress and hydrostatic pressure. Measuring the oceanographic distribution of DMSP is therefore important because it plays a central role in the global carbon and sulfur cycles, serving as the main precursor for climate-active gases like dimethyl sulfide (DMS) and methanethiol (MeSH).

Oceanic DMSP concentrations are governed by phytoplankton community composition and environmental conditions, among other variables, and hence are highly variable. Typical total DMSP concentrations (DMSPt, particulate and dissolved DMSP) in the euphotic zone range from ~ 10 to 200 nM (Galí et al., 2015) but can reach higher levels during blooms of DMSP-rich phytoplankton (Kiene et al., 2019). Correlations between chlorophyll a and DMSP tend to hold only in areas where DMSP-producing phytoplankton are prevalent (Bell et al., 2010). Given the combined influence of taxonomic differences and environmental variability, predicting DMSP concentrations remains difficult but essential to disentangle phytoplankton community dynamics from other biotic and abiotic factors that regulate the fate of DMSP in seawater (Stefels et al., 2007).

Accurate measurements of DMSP, combined with ancillary environmental data, are therefore crucial for improving the parameterisation of DMSP dynamics in sulfur cycling models. Such models are critical for predicting oceanic DMS emissions and assessing their potential responses to climate change (Galí et al., 2015). Despite its importance, DMSP measurement in seawater remains limited by the discrete and therefore spatially sparse nature of traditional methods, such as purge-and-trap techniques (Turner et al., 1990) following cold alkaline hydrolysis to convert DMSP to DMS.

To overcome these limitations, this work introduces a continuous measurement technique for determining DMSPt concentrations in seawater, enabling higher-resolution observations.

Methods

In this work, a hot alkaline hydrolysis method was used to speed up the rate of conversion of DMSP into DMS. This was achieved via addition of 12 M NaOH at a flow rate of 2 ml/min into a seawater flow rate of ~ 135 ml/min which passes into a 24 m length of tubing (giving a residence time of 2.4 minutes), termed the 'reaction coil', placed inside a water bath set to 80 °C. These parameters were chosen as a result of theoretical analysis to enable complete (100 %) conversion of DMSP to DMS, which was also proved experimentally in the lab prior to the campaign. A by-pass pathway (without NaOH addition and heating) was used to allow for a measurement of DMS and hence the difference between the two pathways was proportional to DMSP. Following this, the use of a segmented flow coil equilibrator (SFCE, Charel et al., 2019) allowed for the exchange of DMS into the air-phase. Subsequent detection of DMS at m/z 63 occurred via a microCIMS instrument, as detailed in Saltzman et al., 2009, and more recently in Bell et al., 2013. A liquid internal standard of triply deuterated DMS (d3-DMS, m/z 66) was used to account for changes in instrument sensitivity. Therefore, the ratio of m/z 63:66 was proportional to the species concentration relative to the standard concentration. A diagram of this setup is given in Figure 10.

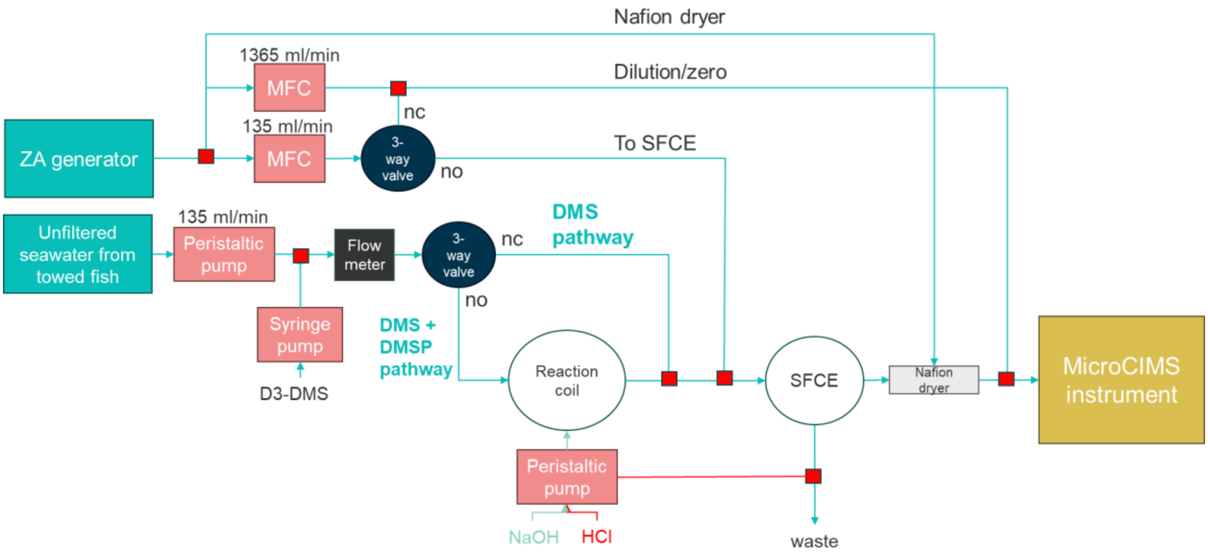

Figure 10: Schematic of the setup used to measure DMS and DMSP.

Preliminary results

A time series of preliminary DMSP concentrations compared to MeSH concentrations, measured by the PTR-Quad-MS (see Section 7.1.1 Measurements of dimethyl sulfide (DMS), methanethiol (MeSH) and volatile organic compound (VOC) concentrations in surface seawater and depth profiles) and fluorescence data is shown in Figure 11. For the DMSP and MeSH measurements, seawater was primarily sampled from the towed fish and near surface sampler, with some earlier measurements (before 12th June) made from the ship's underway supply before a contamination issue, causing elevated concentrations of DMS and MeSH, was identified. Fluorescence measurements were all taken using the ship's underway seawater supply.

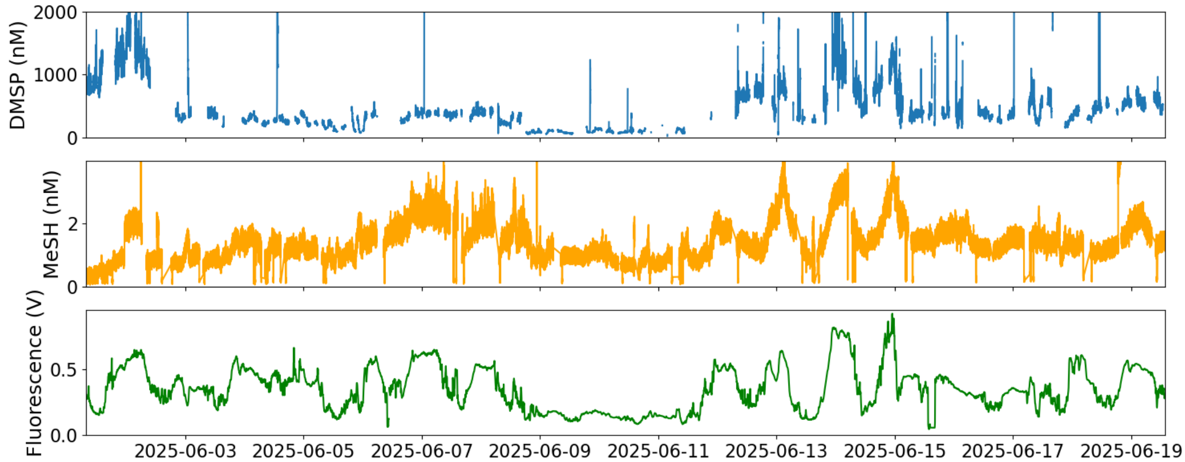

Figure 11: Time series of DMSP and MeSH concentrations and fluorescence measurements in surface seawater.

DMSP concentrations are largely within the expected range based on the literature (10 to 200 nM), however, periods of higher concentrations could be indicative of phytoplankton blooms. In terms of phytoplankton composition, those species that exhibit large DMSP:chlorophyll a ratios, such as chrysophytes and dinoflagellates (Stefels et al., 2007), may be responsible for periods where the DMSP concentrations agree well with fluorescence, for example, between 9th – 11th June and 13th – 15th June. However, it is necessary to look at ancillary measurements i.e. flow cytometry, DNA, pigments and FIRe data to aid with interpretation of these results.

It was also found that MeSH correlates better with DMSP and fluorescence than DMS and hence is plotted in Figure 11. This may provide insights into the conversion pathways of DMSP into MeSH or DMS, in addition to the loss rates of DMS and MeSH, which can be determined from the incubation experiments.

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7.1.3 Consumption rates of DMSP

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Objective

Sulfur (S) is an essential element for life, due to its role in forming biomolecules like proteins and facilitating key redox reactions and metabolic processes.

A crucial part of the marine S cycle is the large proportion of the inorganic S that is assimilated by primary producers to produce dimethylsulfoniopropionate (DMSP). Phytoplankton allocate approximately 50% of their sulfur assimilation and roughly 5% of their carbon fixation towards the synthesis of DMSP (Galí et al., 2015). Therefore, this DMSP released from microalgal biomass is a major source of energy, S, and C for osmotrophic microbes, and its biodegradation generates a cascade of derivative compounds with important ecological, biogeochemical and climatic consequences (Simó, 2004).

These influences are predominantly present in the degradation of DMSP into the climate active gas dimethylsulfide (DMS) and methanethiol (MeSH). The significant oversaturation of DMS in surface waters results in an oceanic DMS emission flux of approximately 27 Tg S per year (Hulswar et al., 2022). This, in turn, drives atmospheric DMS oxidation, which contributes to the formation and growth of sulfate and methane sulfonate aerosols (Andreae and Rosenfeld, 2008). These aerosols can cool the Earth by scattering sunlight and by promoting cloud formation, thus increasing cloud reflectivity (Charlson et al., 1987; Carslaw et al., 2013).

In an effort to better constrain DMSP transformation rates in surface waters, seawater incubations were conducted in a temperature-regulated, dark environment. Seawater was sampled during May -June 2025 (late spring/early summer) in the North Atlantic. Samples were collected for both initial dissolved DMSP ($DMSP_d$) and total DMSP ($DMSP_t$), with station information in Table 29.

Methods

During the three-day cycle implemented and described within Section 4.2 Typical schedule of activities, DMSP- consumption rate experiments were conducted during the pre-dawn sulfur incubation (Day 1), and DMSP concentrations quantified during the midday vertical profile (Day 2). On sulfur incubation days, unfiltered surface seawater was collected using a Niskin CTD Rosette and passed through a 200 µm mesh into 2x2L amber glass bottles. After sampling a T_0 timepoint for both $DMSP_t$ and $DMSP_d$, the bottles were placed at the bottom of the incubator in black bags and subsequently subsampled for $DMSP_t$ at set timepoints (T_1-T_4) throughout an 11–12-hour period. The incubator in-situ temperature was maintained at sea surface temperature using a flow-through system of underway seawater.

Subsampling for $DMSP_t$ included pipetting the seawater from the amber bottles into a 30 mL vial under a fume hood and acidifying with 100 µL of 37% HCl. For $DMSP_d$, 3 mL of seawater was gravity filtered through pre-combusted, 25 mm diameter GF/F filters into 10 mL glass vials using the small volume drip filtration method (Kiene et al., 2006). Samples were then acidified with 10 µL of 37% HCl. All vials were capped and crimped and placed in a dark environment for analysis at the ICM in Barcelona. $DMSP_{t-}$ + DMS is subsequently annotated as evolved DMS and will be determined following alkaline hydrolysis taking place after around 1-2 months.

Evolved DMS will be analyzed with a purge and trap system, which is coupled with a Shimadzu GC 14A Gas chromatograph with a flame photometric determination method.

DMSP will then be determined as the evolved DMS minus the DMS measured onsite. Samples are run in duplicate, with standard errors usually within 10% of the mean.

On days when vertical profiles were sampled, the top six to seven depths were collected in 300 mL PFA bottles and immediately processed. Subsampling was conducted for $DMSP_d$ at the uppermost depths, while $DMSP_t$ was sampled at the upper 6-7 depths. This approach facilitates an analysis of DMSP variability throughout the water column, both within and below the mixed layer depth.

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7.1.4 Estimating the total removal rates and gross production rates of climatically relevant sulfur volatile organic compounds (SVOCs) using stable isotopes in seawater incubations

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Objective

Dimethyl sulfide (DMS) and methanethiol (MeSH) are the two predominant dissolved sulfur volatile organic compounds (SVOCs) in the marine environment. They both have strong climatic relevance as their main oxidation product in the atmosphere, namely sulfur dioxide (SO_2), can alter the global radiation budget by getting further oxidised to sulfuric acid and sulfate secondary organic aerosols (SOAs). Sulfate SOAs can not only absorb and scatter incoming radiations but they are also a major source of cloud condensation nuclei (CCN) through either condensing onto pre-existing particles or forming new particles via nucleation in areas remote from land influence.

DMS and MeSH both derive from dimethyl sulfoniopropionate (DMSP), which is a phytoplankton metabolite. Although 75% of DMSP degradation leads to MeSH production and only 10% to DMS, the MeSH:DMS ratio in seawater is often 1/4 or less. This is most likely because MeSH is rapidly consumed as a source of carbon and sulfur to the microbial community, and also possibly because MeSH gets quickly removed via photo-oxidation.

To better understand the turnover of DMS and MeSH in surface seawater, and to determine the relative contribution of the microbial community and photochemistry in the cycling of these SVOCs, we conducted seawater incubations using stable deuterated isotopes (d^3-DMS and d^3-MeSH) as tracers of total removal rates in the productive waters of the North Atlantic in the late spring - early summer (May-June 2025). Gross production rates of DMS and MeSH will be deducted by also monitoring the net rates of change of the non-isotopic DMS and MeSH in these incubations.

Methods

While progressing through international waters west of the coast of Ireland, a three-day cycle was implemented to consecutively conduct a pre-dawn sulfur VOC incubation (Exp. S) on day 1, a midday vertical profile (VP) on day 2 (see Section 7.1.1 Measurements of dimethyl sulfide (DMS), methanethiol (MeSH) and volatile organic compound (VOC) concentrations in surface seawater and depth profiles), and a pre-dawn non-sulfur VOC incubation (Exp. V) on day 3 (see Section 7.1.5 Seawater incubations to determine biological consumption and production rates of volatile organic compounds (VOCs)) at each station (Table 29).

Table 29: List of CTD casts conducted during the DY195 Cruise on board the RV Discovery. VP: vertical profiles, Exp. S: sulfur VOC incubations, Exp. V: non-sulfur VOC incubations; MLD: mixed-layer depth; DCM: deep-chlorophyll maximum; SRD: solar radiation dose. Days of DMSPt and DMSPd incubations are indicated with an 'X'.

CTD	Date	Expt.	Lon. (°)	Lat. (°)	MLD (m)	DCM (m)	SRD (%)	Neutral screen	DMSPt & DMSPd sampled
CTD 1	27/05/2025	Shakedown CTD	16° 03.662'	50° 28.179'N	18	25			X
CTD 2	28/05/2025	Exp. S1	14°55.6 6736'	49° 45.71664' N	30	35	27.7	2	X
CTD 3	29/05/2025	VP1	17°10.8 1128'	49° 45.47268' N	50	25 & 35			X
CTD 4	30/05/2025	Exp. V1	17° 10.8112 8'	49° 45.47268' N	45		22	2	
CTD 6	31/05/2025	Exp. S2	18° 36.3633 0'	49° 39.76470' N	50	40		2	X
CTD 7	01/06/2025	Exp. V2	18° 49.7679 0'	50° 18.58014' N	65	60	13.4	3	
CTD 8	02/06/2025	VP2	20° 12.1301 4'W	51° 24.92922' N	53	45			X
CTD 9	03/06/2025	Exp. S3	19° 41.4225 6'W	52° 20.55732' N	38	40	19	3	X
CTD 10	04/06/2025	VP3	18° 27.6168 6'W	52° 21.96558' N	58	40			X
CTD 11	05/06/2025	Exp. V3	18° 27.8212 2'W	52° 21.89178' N	38	35	22.7	3	
CTD 12	06/06/2025	Exp. S4	17° 33.7209 6'W	53° 12.67740' N	40	35	15	3	X
CTD 13	07/06/2025	VP4	17° 31.9826 4'W	53° 13.73664' N	38	25			X
CTD 14	08/06/2025	Exp. V4	17° 32.5279 8'W	53° 12.64152' N	28		20.7	3	
CTD 15	09/06/2025	Exp. S5	18° 20.2785 0'W	51° 41.34108' N	45		30.7	2	X
CTD 16	10/06/2025	VP5	17° 48.2170 8'W	51° 49.17822' N	58	35			X
CTD 17	11/06/2025	Exp. V5	18° 20.1777 6'W	51° 41.07924' N	64		22.1	3	
CTD 24	12/06/2025	Exp. S6	20° 54.1123 2'W	51° 35.37192' N	24		27.6	2	X

CTD 25	13/06/2025	VP6	21° 17.78466'W	51° 54.96036'N	48				X
CTD 26	14/06/2025	Exp. V6	20° 55.23750'W	51° 71966'N	12 & 32		27.8	2	
CTD 27	15/06/2025	Exp. S7	21° 32.80380'W	50° 4.95990'N	15 & 45		26.2	2	X
CTD 28	16/06/2025	VP7	21° 32.43342'W	50° 5.10678'N	20		40.4	2	X
CTD 29	17/06/2025	Exp. V7	21° 32.3590'W	50° 5.34936'N	22	25	37.6	2	
CTD 30	18/06/2025	V8 Kinetic	18° 46.25814'W	49° 36.71994'N	25		26	2	
CTD 31	19/06/2025	VP8	18° 46.27452'W	49° 36.71718'N	19	13			X
CTD 32	20/06/2025	Exp. S8	18° 46.26018'W	49° 36.71064'N	15		52	1	X
CTD 36	21/06/2025	Exp. V9	16° 46.76178'W	48° 57.50814'N	8		73	1	
CTD 34	22/06/2025	VP9	15° 56.01036'W	48° 23.17302'N	18				X
CTD 38	23/06/2025	Exp. S9	15° 7.33710'W	48° 10.41054'N	22	62	80.9	1	X
CTD 39	24/06/2025	S10 Kinetic	15° 7.00164'W	48° 10.32816'N	22	60	80.9	1	X

On vertical profile (VP) days, the top eight sampled depths were collected in 300 mL PFA bottles and immediately processed using a Vocus proton transfer reaction time-of-flight mass spectrometer (PTR-ToF-MS) coupled with a segmented flow coil equilibrator (SFCE) inlet to measure VOC concentrations throughout the water column within and below the mixed layer depth (MDL).

On incubation days, surface seawater was sampled from one Niskin bottle of the CTD rosette for incubation. The first 6L of the Niskin were filtered under dark conditions by gravity filtration through 0.3 µm GF/F filters placed in parallel in two all-Teflon filter holders. Another 6L of surface seawater was sampled in the dark as unfiltered water (by using 200 µm mesh to avoid the presence of zooplankton). In parallel, six 1L PTFE bottles were sampled from the same Niskin bottle for characterization of the microbial community in triplicates at T0 and T final of the incubation (see Section 7.1.11 Abundance and Composition of Microbial Plankton Communities by Flow Cytometry).

Two 300 mL PFA bottles were also filled to the top with unfiltered seawater to determine the endogenous VOC concentration at T0. Both 6L Schott bottles were spiked with the same amount of d^3-DMS and d^3-MeSH and divided into 10 PFA bottles for the unfiltered water and 18 PFA bottles for the filtered fraction. Duplicate unfiltered and filtered PFA bottles were kept aside to quantify VOC concentrations in both fractions at T0 post-spiking. The remaining PFA bottles were placed in a flow-through on-deck incubator as follows: “unfiltered light” to assess the contribution of biotic processed combined with photochemistry and “filtered light” and “filtered dark” to assess the contribution of photochemistry alone at removing SVOCs (Figure 12). Underway seawater was used as flow-through seawater in the incubator to maintain PFA bottles at sea-surface temperature.

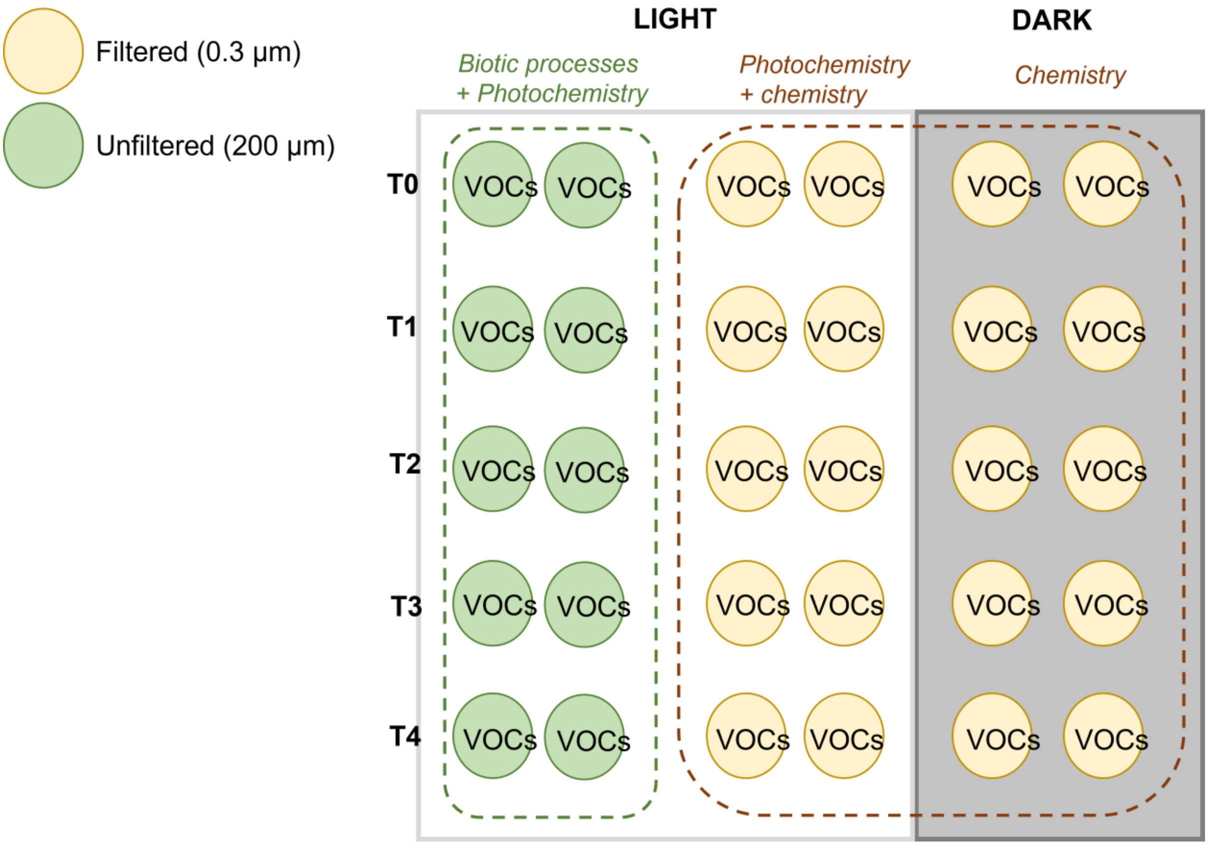

Figure 12: Experimental design of seawater incubations using stable isotopic tracers to determine the total removal rate and gross production rates of sulfur VOCs as a function of biotic processes combined with photochemistry (unfiltered seawater in the light),photochemistry alone (difference between filtered seawater under light and dark conditions) and pure chemistry (filtered seawater under dark conditions).

Natural light conditions within the MLD were mimicked in the on-deck incubator by initially calculating the solar radiation dose (SRD%), which is a function of the MLD and of the vertical attenuation coefficient of downwelling irradiance in the water column (Kd) using the following equation:

$$\mathrm{SRD}(\%) = 100 \cdot \frac{1 - e^{-K_d \cdot \mathrm{MLD}}}{K_d \cdot \mathrm{MLD}}$$

Here, irradiance at the sea surface is set to 100 to obtain SRD as a percentage of surface irradiance.

Kd in the PAR region (Kd(490)) can be estimated as a function of Chl-a (in µg/L) within the MLD as follows:

$$K_d(490) = 0.0166 + 0.08253 \cdot [\text{Chl-a}]^{0.6529}$$

Once the SRD% in the MLD was calculated, layers of neutral mesh were placed on top of the incubator to mimic the SRD that the seawater collected at the surface would have received within the MLD, knowing that every layer allows for 60% transmittance (i.e. 2 layers of neutral screen corresponds to 0.6 x 0.6 = 0.36 transmittance).

At T0, PFA bottles for endogenous VOC concentration as well as duplicate PFA bottles of spiked filtered and unfiltered seawater were processed on the SFCE-PTRMS. At each consecutive time point (T1-T4), which spanned over a 12h incubation, duplicate PFA bottles from each treatment (unfiltered light, filtered light and filtered dark) were removed from the incubator and immediately processed on the SFCE-PTRMS. At T0, a 1.8 mL subsample from each filtered and unfiltered PFA bottles was preserved with 200 µL of glutaraldehyde to determine initial phytoplankton and bacteria abundance and composition by flow cytometry, respectively (see Section 7.1.13 Collection of samples for ancillary parameters (chlorophyll *a*, photosynthetic pigments, nutrients, phytoplankton taxonomy, dissolved organic carbon, FIRE)). At T1-T4, a 1.8 mL subsample from duplicate unfiltered PFA bottles was also collected for flow cytometry to estimate the growth in phytoplankton community. At T4, a flow cytometry subsample was also taken from duplicate filtered seawater PFA bottles that were incubated in the light and in the dark to estimate the changes in the bacteria population over the course of the 12h incubation under light and dark conditions.

Total removal rates will be determined by following the degradation of the stable isotopes d^3-DMS (m/z 66) and d^3-MeSH (m/z 52) over time whilst the net rates of change (net production or net removal) will be determined by following the variation in concentration of non-isotopic DMS (m/z 63) and MeSH (m/z 49). Gross production will then be calculated by subtracting the total removal rate from the net rate of change.

A 5-point calibration was run on the PTRMS on a daily basis by using a calibration gas mix (Apel Riemer) containing acetaldehyde, methanol, acetone, isoprene, DMS, benzene, toluene, m-xylene and α-pinene at about 0.5 ppm. Each calibration point was run for a minimum of 5min. A 5-point liquid calibration was run three times over the course of the voyage on the SFCE-PTRMS using MeSH standards and once using DMS standards.

7.1.5 Seawater incubations to determine biological consumption and production rates of volatile organic compounds (VOCs)

Lead: Frances Hopkins (fhop@pml.ac.uk) [1]Plymouth Marine Laboratory, Plymouth, UK

Motivation
Marine VOCs are a key part of the dissolved organic matter (DOC) pool, serving as both products of, and substrates for, microbial activity (Halsey and Giovannoni 2023; Dixon, Beale, and Nightingale 2013). In the ocean, photosynthesis by phytoplankton drives biotic production of some VOCs, which diffuse across cell membranes into the surrounding seawater. VOCs can also be released when phytoplankton are infected by viruses or grazed. Bacteria use this supply of VOCs for energy and growth. Environmental drivers (light, mixed layer depth, nutrients) can shift the plankton community physiology or composition and are likely to alter the VOC fluxes(Halsey and Giovannoni 2023). The relative contributions of different phytoplankton groups, bacterial communities, and metabolic pathways that are responsible for VOC production and consumption remain very poorly known to date.

Here, we used incubations of unfiltered and filtered seawater, in the light and dark, with additions of VOC stable isotope tracers to quantify biological consumption rates and gross production rates of key VOCs.

Methods
Photosynthesis-related production and microbial consumption were measured in parallel light and dark experiments using unfiltered and filtered bulk surface seawater, using identical methods to those described in detail in Chapter 6.1.4 (Estimating gross removal and production rates of climatically-relevant sulfur volatile organic compounds (SVOCs) using stable isotopes in seawater incubations, Deschaseaux et al.) for sulfur rate measurements.

Filtered surface seawater was gravity-filtration directly from Niskin bottles through an inline PTFE filtration unit holding a 47 mm 0.3 μm filter, into an acid-washed and MilliQ-rinsed 5 L Duran flask (total volume when full to brim = 6 L). Flow cytometry was used to assess the effectiveness of the filtration for the removal of phytoplankton and bacteria cells (see Section 7.1.13 Collection of samples for ancillary parameters (chlorophyll a, photosynthetic pigments, nutrients, phytoplankton taxonomy, dissolved organic carbon, FIRE)). For unfiltered seawater, the surface seawater was sampled directly into a Duran flask, through a 200 μm mesh to remove large grazers that could introduce variability between replicate incubations.

The filtered and unfiltered seawater was injected with tracer concentrations (< in situ concentrations) of stable isotopes of key VOCs: d3-acetaldehyde, ^{13}C-acetone and ^{13}C-methanol. The Duran flask was gently rolled and tilted to ensure the tracers were well mixed. Seawater was then siphoned into duplicate 300 mL PFA bottles (see Figure 12 in Section 7.1.5 Seawater incubations to determine biological consumption and production rates of volatile organic compounds (VOCs)).

Samples for T0 (initial) were analysed immediately by Vocus TOF-MS (Section 7.1.5 Seawater incubations to determine biological consumption and production rates of volatile organic compounds (VOCs)), using a segmented flow coil equilibrator (Wohl et al. 2019). The remaining PFA bottles were randomly placed in a deck incubator either in the light (at light levels calculated for the mixed layer), or in the dark (placed in a black plastic bag and weighted down to bottom of incubator). At each time point (2 hours, 4 hours, 6 hours, 12 hours), bottles were randomly removed from the incubator and analysed on the TOF-MS.

Light and dark incubated samples yield net biological VOC production and consumption rates, respectively. Total biological consumption will be estimated from the decline of the isotopic tracers. Gross VOC production rates are estimated from net production and biological consumption.

To provide context and explain differences in VOC production/consumption among incubation stations, samples for nutrients and Chla concentrations, microbial abundance and community composition were taken from the same surface seawater used for the incubations. Microbial abundance was also monitored at each time point (see Section 7.1.13 Collection of samples for ancillary parameters (chlorophyll a, photosynthetic pigments, nutrients, phytoplankton taxonomy, dissolved organic carbon, FIRE)).

Table 30: Details of sampling stations for VOC incubation experiments

Date	*Station*	*CTD*	*Expt*	*Time in water (UTC)*	*Latitude N*	*Longitude W*	*Niskin*	*Depth (m)*
30/05/2025	1	4	V1	04:00	49° 45.47268'	17° 10.81128'	23	3
01/06/2025	2	7	V2	04:00	50° 18.58014'	18° 49.76790'	23	6
05/06/2025	4	11	V3	04:00	52° 21.89178'	18° 27.82122'	23	6
08/06/2025	5	14	V4	04:00	53° 12.64152'	17° 32.52798'	23	4
11/06/2025	6	17	V5	04:00	51° 41.07924'	18° 20.17776'	23	4
14/06/2025	7	26	V6	04:00	51° 54.71966'	20° 55.23750'	23	3
17/06/2025	8	28	V7	04:00	50° 5.10678'	21° 32.43342'	23	3
18/06/2025	9	30	V8 kinetics	04:00	49° 36.71994'	18° 46.25814'	23, 24	5
21/06/2025	11	36	V9	04:00	48° 57.50814'	16° 46.76178'	23	3

References

Dixon, Joanna L., Rachael Beale, and Philip D. Nightingale. 2013. 'Production of methanol, acetaldehyde, and acetone in the Atlantic Ocean', Geophysical Research Letters, 40: 4700-05.

Halsey, Kimberly H, and Stephen J Giovannoni. 2023. 'Biological controls on marine volatile organic compound emissions: A balancing act at the sea-air interface', Earth-Science Reviews, 240: 104360.

Wohl, Charel, David Capelle, Anna Jones, William T Sturges, Philip D Nightingale, Brent GT Else, and Mingxi Yang. 2019. 'Segmented flow coil equilibrator coupled to a proton-transfer-reaction mass spectrometer for measurements of a broad range of volatile organic compounds in seawater', Ocean Science, 15: 925-40.

7.1.6 Garret screen deployment for Microlayer sampling

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Objective

To deploy the Garrett screen on the RRS Discovery.

To obtain sufficient microlayer samples and volume for experiments on board

Method

An aluminium mesh Garrett screen (102 x 74 cm) was deployed off the starboard side of the aft deck, using a crane, a pulley system and two guide ropes. The pulley was held approximately 1.5 m off the side of the boat using the crane and the screen was lowered approx. 4 m to the ocean surface. The screen was lowered into the ocean and then brought back up horizontally a few seconds later. Once on the deck, the screen was turned onto a corner and the seawater drained into a suitable container (Figure 13).

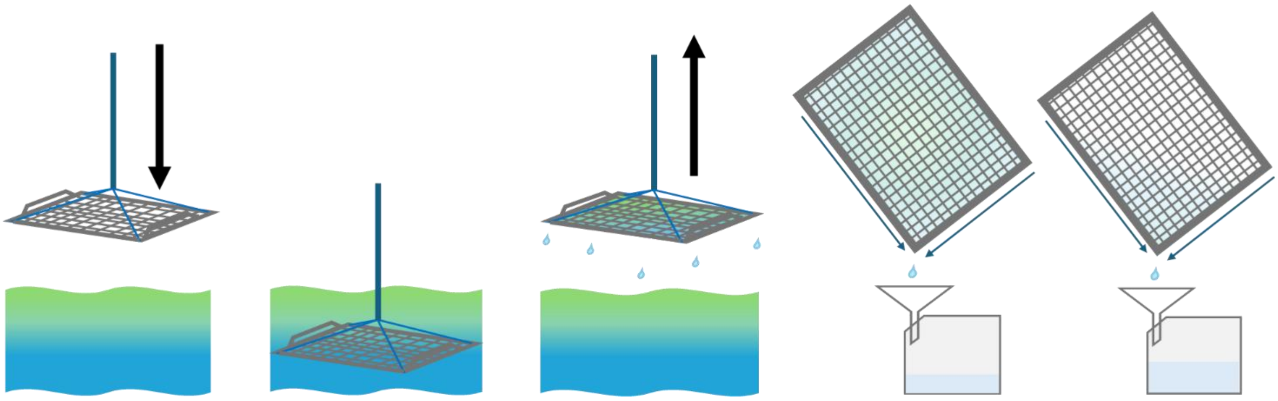

Figure 13: Schematic 1 - The Garret screen sampling process.

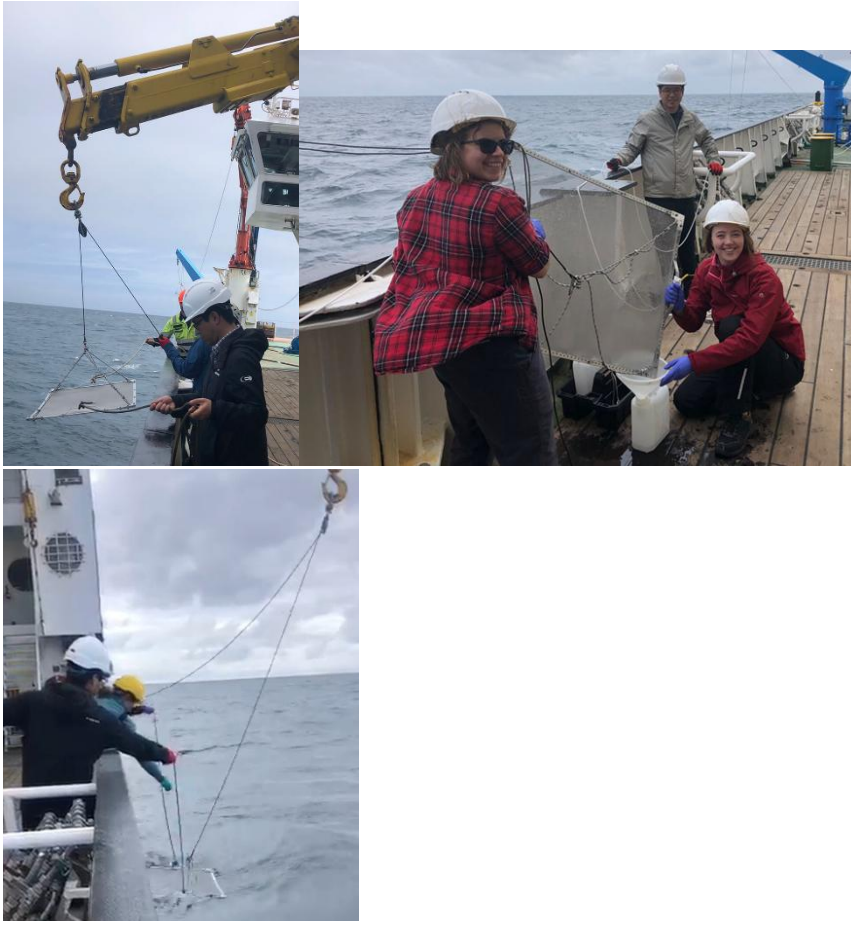

Figure 14: Pictures of the Garrett screen sampling process.

The Garrett screen was successfully deployed 14 times, the depth sampled approximately 500 µm and on average a volume of 10 L was collected. See Table 31 for details.

Table 31: Date, time, station and coordinates of microlayer sampling and the volume collected.

Date	Time	Station No.	Latitude (°N)	Longitude (°W)	Volume (L)
29/05/2025	15:00	1	49° 45.477	17° 10.81	7
01/06/2025	16:00	2	51° 21.534	19° 26.58	10
03/06/2025	13:39	4	52° 21.639	19° 33.209	5.6
04/06/2025	12:30	4	52° 21.447	18° 28.93	12
06/06/2025	14:00	5	53° 13.105	17° 45.118	12
07/06/2025	11:40	5	53° 13.64	17° 32.101	11
10/06/2025	11:42	6	51° 49.178	17° 48.217	10
12/06/2025	13:30	7	51° 23.721	21° 10.985	12
13/06/2025	11:30	7	51° 54.931	21° 18.05	12
15/06/2025	14:00	8	50° 04.902	21° 32.750	10
18/06/2025	13:30	9	49° 44.845	18° 47.208	12
19/06/2025	11:30	9	49° 36.717	18° 46.274	10
22/06/2025	11:07	11	48° 23.254	15° 55.936	9
23/06/2025	13:54	12	48° 10.658	15° 07.147	15

7.1.7 Quantification of photochemical and oxidative VOC production in near surface seawater and surface microlayer

Lead: Marvin Shaw (marvin.shaw@ york.ac.uk); National Centre for Atmospheric Science, Wolfson Atmospheric Chemistry Laboratories, University of York

Objectives

To quantify Volatile Organic Compounds (VOC) concentrations in near surface seawater compared to Surface Micro Layer (SML).

To quantify both photosensitive and oxidative abiotic VOC production rates in near surface sea water and SML and relate to dissolved organic composition.

To quantify abiotic VOC production rates in seawater used for biotic incubation studies (PML).

Method

DISCO-SFCE

The SFCE was based on the original design of Wohl et. al (2019), but with significant modifications. Here we used a 4 metre, 6mm OD quartz coil contained in an aluminium box (to keep the coil in the dark). Quartz was chosen due to its high transmission of solar radiation across a wide range of wavelengths as here we exposed the seawater in the SFCE in a timed sequence to solar radiation from a lamp (Oriel LCS 100). Similarly, either zero or ozonised air at 1ppmV (research grade air, BOC) were introduced into the seawater at a mass flowrate of 120ml/min^{-1} which produced a constant residence time in the SFCE of 15s. Ozone was generated in research grade air using a UV pen ray lamp (UVP SOG-2, fisher scientific). Seawater temperature both in and out of the SFCE, gas pressure, gas temperature and gas flowrates were measured at 10 averaged second time resolution for the entirety of the campaign. The seawater and ozone containing air were mixed and then separated for measurement using a Vocus S (Tofwerk) Proton Transfer Reaction Time of Flight mass spectrometer (PTR-TOF).

The Digital In-situ Stage Control Operator (DISCO) is a bespoke, autonomous sampling system developed at the University of York. It uses 3 x PTFE solenoid switching valves (Bukert), 3 x mass flow controllers (Alicat) a UV pen-ray based ozoniser (Fisher) and a solar lamp (Oriel) interfaced to centralised DAQ Factory based control and acquisition software (Figure 15). The software allowed continuous staged 24-hour sampling for the entirety of the campaign (controlled experimental stages and timings below).

Zero bypass (5 mins)

Ozone bypass (5mins)

Seawater (10 mins)

Illuminated seawater (15 mins)

Illuminated and ozonised seawater (10 mins)

Ozonised seawater (10 mins)

Total = 55 min cycle time

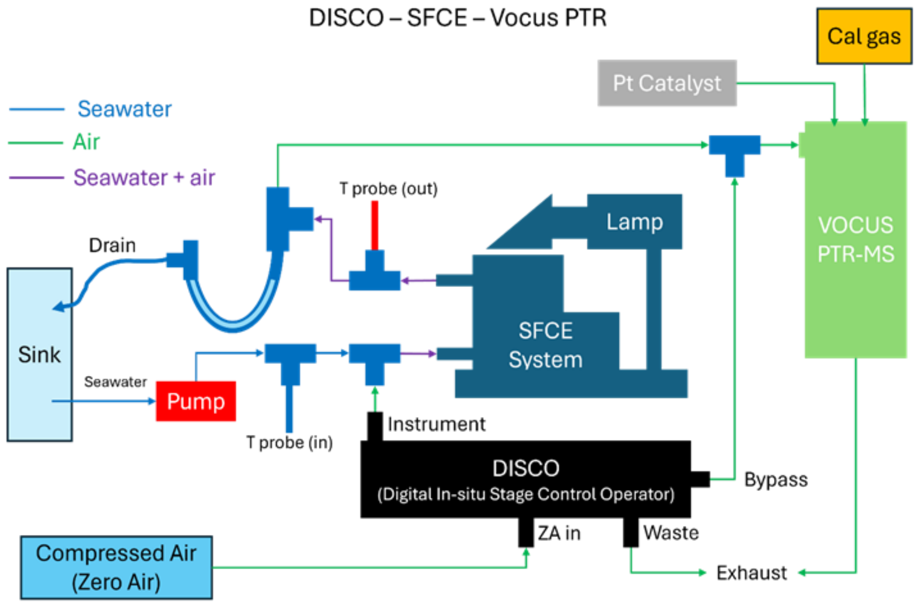

Figure 15: DISCO SFCE Flow and hardware schematic.

Online Sampling

Continuous unfiltered online seawater sampling was either carried out from the "towed fish" (2-4 metres depth) or the near surface sampler (0.5 metres depth). Seawater was pumped from the ocean through approximately 30 metres of 3/8" PFA tubing (6-10L /min^{-1}), using a pneumatically driven PTFE diaphragm pump which flushed into a 2L glass bottle in the laboratory. The PFA tubing was cleaned with 10% HCl and deionised water weekly to minimise biological contamination. Sampling from underway seawater source was not used due to elevated concentrations of both DMS and methanethiol observed on the 26th of May and subsequently for the remainder of the cruise. This was attributed to biological contamination. Discrete unfiltered SML and CTD samples were sampled directly from a dedicated 5L glass bottle. From this a peristaltic pump (Watson and Marlow, 120S) subsampled the water into a segmented flow coil equilibrator (SFCE) which was temperature controlled (20 ^{0}C) with PID controlled convective heating. The peristaltic pump tubing was 9 cm x ¼ in ID silicone (Watson and Marlow), which had to be replaced every other day. The seawater flow was measured daily and the peristatic power varied to maintain a flow of 100 mL min^{-1}. The SFCE was cleaned daily with 10% HCl.

CTD sampling

CTD samples were taken from the near surface and deep sea (1km) for comparison during biological incubation days (1 day in every 3). Sampling was directly from 5 litre glass Schott bottles. A total of 3 full CTD profiles were analysed via DISCO SFCE on the 14th, 17th and 22nd of June.

Surface Microlayer Sampling

Surface microlayer (SML) sampling was carried out at every station at least once using a Garrett screen (technique and details described herein). Typically, 10-15 litres would be sampled over a 2-hour period. A total of 5 litres would be dedicated to the DISCO-SFCE analysis. A total of 3 Garrette screen blanks were carried out during the cruise using seawater from the towed fish.

PTR-TOF

This instrument was operated at a pressure-controlled drift tube pressure of 2 mbar, temperature of 100^{0}C and an axial field gradient of 560V (E/N 140). The low mass band filter was adjusted pre-campaign to increase sensitivity at low molecular masses by adjusting BSQ RF Amp to 230V and manually adjusting the reactor exit voltage (33V) to ensure the total ion current (TIC) was between 3-5 million. Data was acquired at 1Hz within the mass range 0-500m/z. Static 2-minute zeros and calibrations (from a NPL certified gas standard) were run automatically every 3 hours to track instrument sensitivity. Following this tuning both TIC and calibrations suggest the data is of high quality, with instrument sensitivity reducing by <10% during the 5-week campaign. Therefore, no instrument or detector tuning was required during this period.

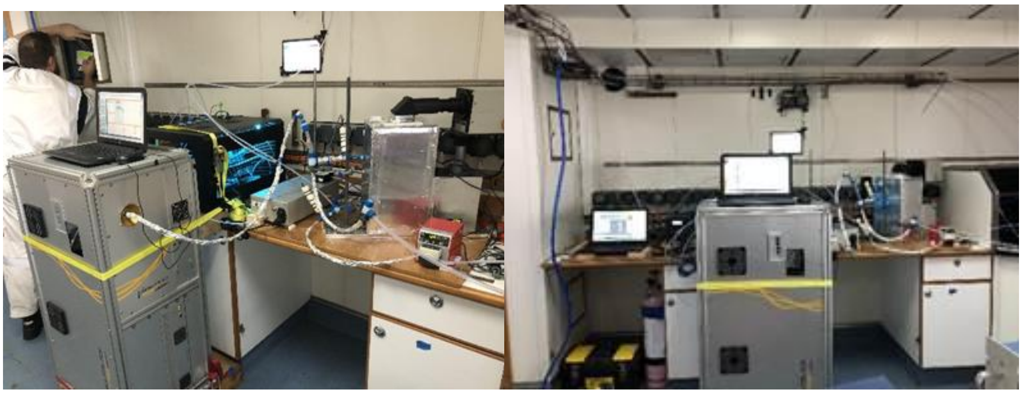

Figure 16: Images of DISCO-SFCE set up in DECK lab.

Preliminary results

Some preliminary DISCO SFCE data is shown in counts per second (cps). Figure 17 shows 1-minute averaged experimental stage separated data. Oxygenated VOCs such as nonanal, octanal and heptanal are observed at significantly higher concentrations following ozonation, suggesting that the oxidation of dissolved organic carbon (DOC) in seawater is an important formation pathway in the marine atmosphere. Dimethyl-sulfide shows very little difference between the different stages confirming its dominant formation pathway is biological with no such formation within the SFCE.

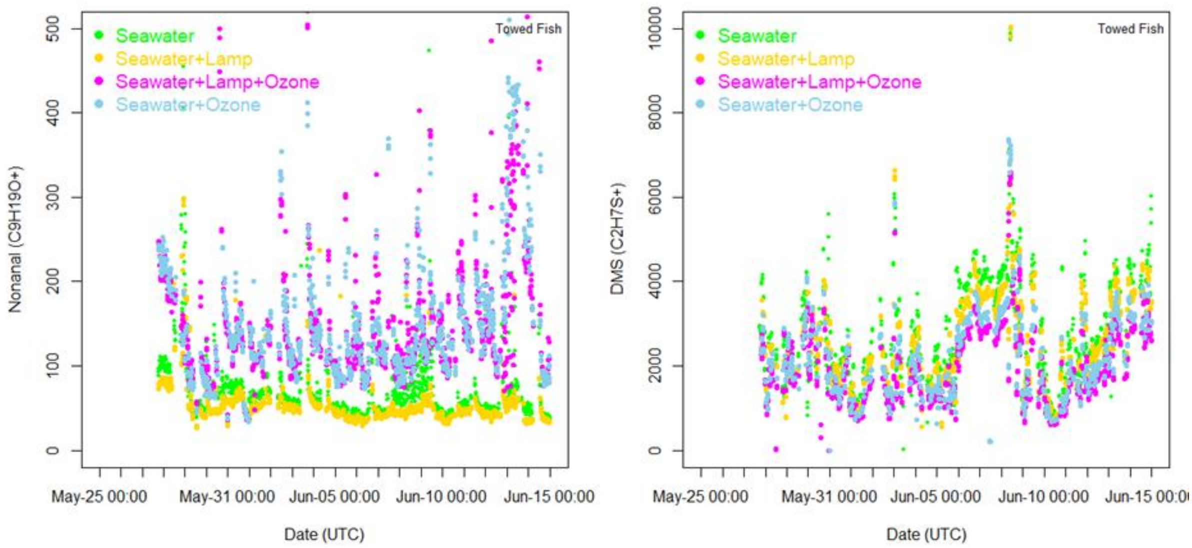

Figure 17: 1- minute averaged Towed fish DISCO SFCE data showing sequential experimental stages between the 28th of May and 15th of June.

Figure 18 shows the behaviour of a typical SML sample when exposed to 1000, 500, 250 and 160 ppb of ozone. The formation of C6-C10 OVOCs and terpenoids (possibly linalool) increased linearly with ozone concentration. This suggests an ozone/DOC heterogenous reaction which can be scaled to atmospheric concentrations of ozone to calculate oxidation formation rates. OVOCs observed in SML samples, prior to ozonation or light exposure, typically showed enrichment factors of 3-6 when compared to online near surface seawater. Figure 19 shows how nonanal concentrations change with depth during a 3 – 1000m CTD profile. Nonanal concentrations and its ozone precursors are depleted at the surface of the mixed layer but increase with depth. As expected, sea water concentrations decrease below the mixed layer but nonanal DOC oxidation precursors increase with depth to 1km.

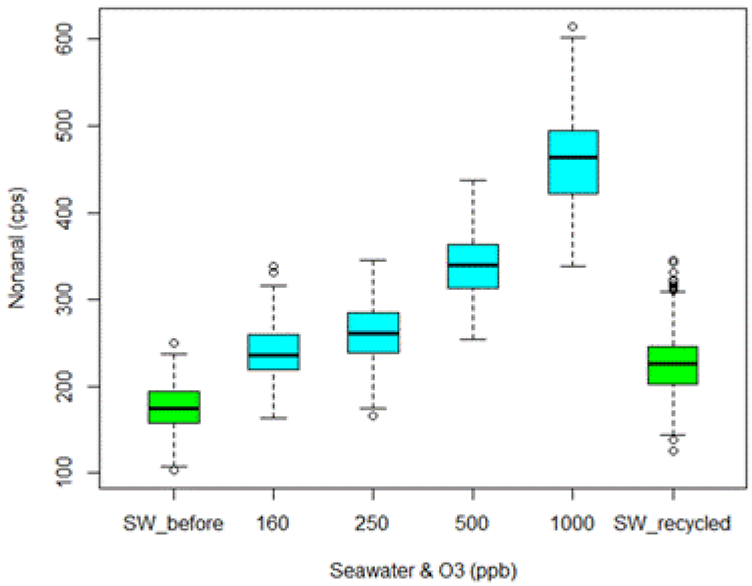

Figure 18: Box and whisker plot of Nonanal observed (cps) from ozonation of SML samples. Green boxes are observed SML concentrations before and after ozonation experiments. Error bars represent 1 standard deviation of 1Hz data.

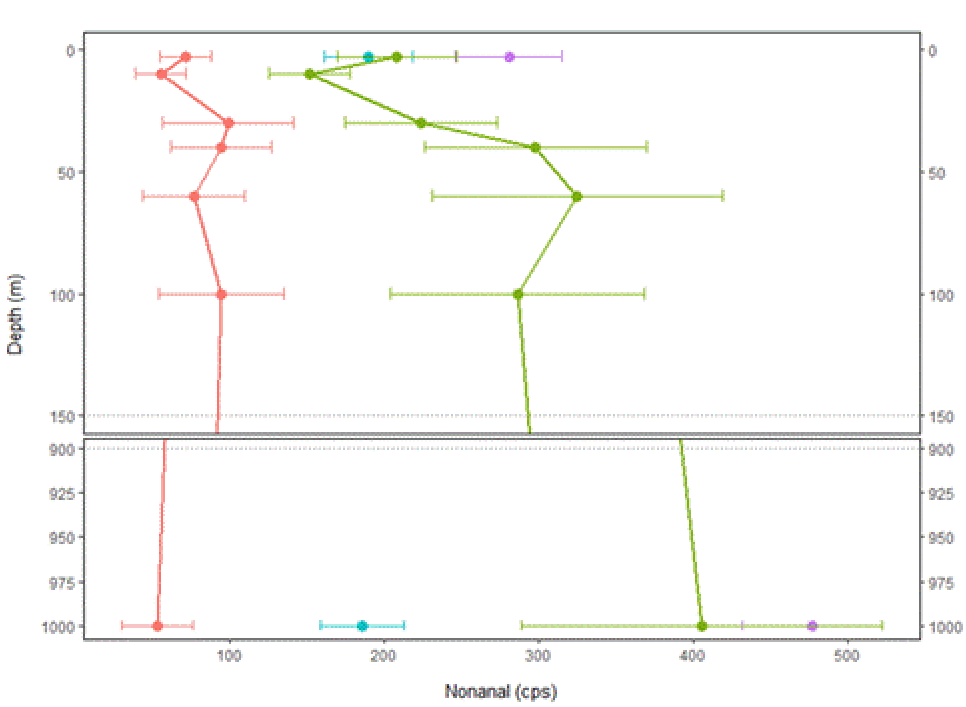

Figure 19: CTD profile of non-background subtracted Nonanal concentrations with depth. Red= seawater Green=ozonised seawater. Blue=filtered seawater, Purple = Filtered then ozonised seawater. Mixed layer depth of 32 metres. Error bars represent 1 standard deviation.

Table 32: CTD samples

Date	Lat	Lon	CTD no.	Station	Depth (m)	Time UTC

28/5/25	50° 28.179'N	16°03.662'	2	1	1000	4:00
30/5/25	49° 45.47268'N	17° 10.81128'	4	1	3	4:00
1/6/25	50° 18.58014'N	18° 49.76790'	7	2	3	4:00
3/6/25	52° 20.55732'N	19° 41.42256'W	9	4	1000	4:00
5/6/25	52° 21.89178'N	18° 27.82122'W	11	4	1000	4:00
5/6/25	52° 21.89178'N	18° 27.82122'W	11	4	3	4:00
8/6/25	53° 12.64152'N	17° 32.52798'W	14	5	3	4:00
8/6/25	53° 12.64152'N	17° 32.52798'W	14	5	1000	4:00
11/6/25	51° 41.07924'N	18° 20.17776'W	17	6	3	4:00
11/6/25	51° 41.07924'N	18° 20.17776'W	17	6	1000	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	3	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	10	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	20	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	30	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	50	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	100	4:00
14/6/25	51° 71966'N	20° 55.23750'W	26	7	1000	4:00
15/6/25	50° 4.95990'N	21° 32.80380'W	27	8	1000	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	3	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	10	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	20	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	30	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	80	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	500	4:00
17/6/25	50° 5.34936'N	21° 32.3590'W	29	8	1000	4:00
20/6/25	49° 36.71064'N	18° 46.26018'W	32	9	1000	4:00
20/6/25	49° 36.71064'N	18° 46.26018'W	36	10	1000	4:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	3	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	15	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	30	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	40	13:00

22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	60	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	100	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	1000	13:00
22/6/25	48° 23.17302'N	15° 56.01036'W	37	11	2000	13:00
24/6/25	48° 10.41054'N	15° 7.33710'W	38	12	1000	04:00

Table 33: SML Samples

Date	Time	Station	Latitude (°N)	Longitude (°W)	Volume (L)
29/05/2025	15:00	1	49° 45.477	17° 10.81	7
01/06/2025	16:00	2	51° 21.534	19° 26.58	10
03/06/2025	13:39	4	52° 21.639	19° 33.209	5.6
04/06/2025	12:30	4	52° 21.447	18° 28.93	12
06/06/2025	14:00	5	53° 13.105	17° 45.118	12
07/06/2025	11:40	5	53° 13.64	17° 32.101	11
10/06/2025	11:42	6	51° 49.178	17° 48.217	10
12/06/2025	13:30	7	51° 23.721	21° 10.985	12
13/06/2025	11:30	7	51° 54.931	21° 18.05	12
15/06/2025	14:00	8	50° 04.902	21° 32.750	10
18/06/2025	13:30	9	49° 44.845	18° 47.208	12
19/06/2025	11:30	9	49° 36.717	18° 46.274	10
22/06/2025	11:07	11	48° 23.254	15° 55.936	9
23/06/2025	13:54	12	48° 10.658	15° 07.147	15

References

Wohl, C., Capelle, D., Jones, A., Sturges, W. T., Nightingale, P. D., Else, B. G. T., and Yang, M.: Segmented flow coil equilibrator coupled to a proton-transfer-reaction mass spectrometer for measurements of a broad range of volatile organic compounds in seawater, Ocean Sci., 15, 925–940, https://doi.org/10.5194/os-15-925-2019, 2019.

7.1.8 Sample collection for SPE-DOM, iodide and surface tension measurements

Lead: Isobel Thistlethwaite (iat505@york.ac.uk); Wolfson Atmospheric Chemistry Laboratories, University of York

Objective

To collect, process and preserve seawater samples for SPE-DOM, iodide and surface tension measurements.

Method

Seawater samples were collected from the CTD rosette, the overflowing narrow necked bottle (pumped from the near surface or towed fish sampler), and the Garrett screen during the trip. Table 34, Table 35, Table 36 and Table 37 describe the date, time and location of samples taken from the four sampling methods.

<u>Unfiltered samples</u>
Surface tension (ST) – 2 x 60 mL Nalgene HDPE bottles were rinsed with a small amount of sample prior to filling with approx. 50 mL of sample each. The bottles were then shaken and immediately frozen in a -80 °C freezer for subsequent analysis back at the University of York (UoY).

<u>Filtered samples</u>
Samples were filtered using a filter rig, 0.7µm GF/F and a gentle vacuum into a 3.8 L glass Duran bottle. A small amount of sample was filtered first and used to rinse out the Duran bottle before being discarded. The GF/F filter was changed approx. every 1000 mL depending on the productivity region. All glassware and filter rigs were acid washed between samples and rinsed with milliQ three times.

SPE-DOM – 2 x 1L Nalgene HDPE bottles were rinsed with a small amount of filtered sample prior to filling with ~850 mL per bottle. The bottles were then frozen in a -20 °C freezer for analysis back at UoY.

Iodide (I) – 2 x 15 mL Falcon tubes were rinsed with a small amount of filtered sample prior to filling with ~14 mL per tube. The falcon tubes were then frozen in a -20 °C freezer for analysis back at UoY.

Table 34: Date, time, coordinates, depth and Niskin bottle of CTD samples and what ancillary samples were taken.

CTD no.	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (m)	Niskin bottle no.	Samples (ST, I, SPE)

4	30/05/2025	05:19	49° 45.47268'	17° 10.81128'	5	21	ST, I, SPE
7	01/06/2025	05:03	50° 18.58014'	18° 49.76790'	5	24	ST, I, SPE
11	05/06/2025	05:30	52° 21.89178'	18° 27.82122'	6	24	ST, I, SPE
	05/06/2025	05:30	52° 21.89178'	18° 27.82122'	1000	3+4	I, SPE
14	08/06/2025	05:20	53° 12.64152'	17° 32.52798'	5	24	ST, I, SPE
17	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	10	10	I
	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	30	13	I
	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	64	9	I
	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	70	7	I
	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	4	24	ST, I, SPE
	11/06/2025	05:45	51° 41.07924'	18° 20.17776'	1000	1	I, SPE
26	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	1000	1+4	I, SPE
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	100	5	I, SPE
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	60	7	I
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	40	11	I
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	30	13	I, SPE
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	10	17	I
	14/06/2025	05:30	51° 54.71966'	20° 55.23750'	3	22	ST, I SPE
29	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	3	22	ST, I, SPE
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	10	17	I
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	25	15	I, SPE
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	30	13	I, SPE
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	80	5	I
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	500	3	I, SPE
	17/06/2025	05:30	50° 5.34936'	21° 32.3590'	1000	1	I, SPE
37	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	5	21	ST, I, SPE
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	15	17	I
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	30	13	I
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	40	11	I, SPE
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	60	9	I, SPE
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	100	5	I, SPE
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	1000	3	I, SPE
	22/6/2025	15:30	48° 23.17302’	15° 56.01036'	2000	1	I, SPE

Table 35: Date, time and coordinates of when the NSS was sampled and what ancillary samples were taken.

Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Samples
28/05/2025	14:14	50° 19.63	16° 26.32	ST, I, SPE
29/05/2025	15:06	49° 45.472	17° 10.81	ST, I, SPE
01/06/2025	17:05	51° 21.532	19° 26.579	ST, I, SPE
03/06/2025	15:12	52° 21.995	19° 32.206	ST, I, SPE
06/06/2025	15:30	53° 13.105	17° 45.118	ST, I, SPE
07/06/2025	13:06	53° 13.720	17° 32.005	ST, I, SPE
09/06/2025	14:18	51° 41.161	18° 20.152	ST, I, SPE

10/06/2025	13:20	51° 49.18	17° 48.218	ST, I, SPE
12/06/2025	14:30	51° 23.518	21° 10.919	ST, I, SPE
13/06/2025	12:00	51° 54.931	21° 18.05	ST, I, SPE
15/06/2025	14:30	50° 04.903	21° 32.751	ST, I, SPE
16/06/2025	14:37	50° 05.099	21° 32.405	ST, I, SPE
18/06/2025	15:00	49° 44.897	18° 47.250	ST, I, SPE
19/06/2025	12:30	49° 36.430	18° 46.197	ST, I, SPE
22/06/2025	12:28	48° 23.142	15° 56.045	ST, I, SPE
23/06/2025	16:21	48° 10.803	15° 07.204	ST, I, SPE

Table 36: Date, time and coordinates of when the TF was sampled and what ancillary samples were taken.

Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Samples
28/05/2025	19:23	50° 13.12	16° 31.42	ST, I, SPE
29/05/2025	18:53	49° 41.478	17° 16.207	ST, I, SPE
30/05/2025	09:45	49° 27.215	17° 45.06	ST, I, SPE
31/05/2025	14:30	49° 54.067	18° 45.72	ST, I, SPE
02/06/2025	12:03	51° 24.957	20° 11.025	ST, I, SPE
03/06/2025	20:43	52° 19.545	19° 17.963	ST, I, SPE
04/06/2025	19:44	52° 21.963	18° 26.821	ST, I, SPE
05/06/2025	13:21	52° 21.756	17° 05.129	ST, I, SPE
06/06/2025	18:15	53° 08.688	17° 43.159	ST, I, SPE
07/06/2025	14:38	53° 13.898	17° 32.116	ST, I, SPE
08/06/2025	13:30	53° 02.098	18° 06.114	ST, I, SPE
09/06/2025	11:00	51° 41.339	18° 20.239	ST, I, SPE
12/06/2025	09:40	51° 29.292	21° 02.625	ST, I, SPE
13/06/2025	08:35	51° 54.898	21° 18.285	ST, I, SPE
14/06/2025	13:05	51° 27.081	21° 30.232	ST, I, SPE
15/06/2025	09:05	50° 04.918	21° 32.654	ST, I, SPE
16/06/2025	08:19	50° 05.101	21° 32.584	ST, I, SPE
18/06/2025	09:14	49° 38.046	18° 46.853	ST, I, SPE
20/06/2025	09:03	49° 38.968	18° 44.835	ST, I, SPE
21/06/2025	08:58	49° 19.745	16° 41.412	ST, I, SPE
23/06/2025	08:21	48° 10.322	15° 07.360	ST, I, SPE
24/06/2025	13:52	48° 07.845	13° 57.738	ST, I, SPE
25/06/2025	09:05	48° 00.770	10° 50.947	ST, I, SPE

Table 37: Date, time and coordinates of microlayer samples and what ancillary samples were taken.

Date	Time	Station No.	Latitude (°N)	Longitude (°W)	Sample
29/05/2025	15:00	1	49° 45.477	17° 10.81	ST, I, SPE
01/06/2025	16:00	2	51° 21.534	19° 26.58	ST, I, SPE
03/06/2025	13:39	4	52° 21.639	19° 33.209	ST, I

04/06/2025	12:30	4	52° 21.447	18° 28.93	ST, I, SPE
06/06/2025	14:00	5	53° 13.105	17° 45.118	ST, I, SPE
07/06/2025	11:40	5	53° 13.64	17° 32.101	ST, I
10/06/2025	11:42	6	51° 49.178	17° 48.217	ST, I, SPE
12/06/2025	13:30	7	51° 23.721	21° 10.985	ST, I, SPE
13/06/2025	11:30	7	51° 54.931	21° 18.05	ST, I, SPE
15/06/2025	14:00	8	50° 04.902	21° 32.750	ST, I, SPE
18/06/2025	13:30	9	49° 44.845	18° 47.208	ST, I, SPE
19/06/2025	11:30	9	49° 36.717	18° 46.274	ST, I, SPE
22/06/2025	11:07	11	48° 23.254	15° 55.936	ST, I, SPE
23/06/2025	13:54	12	48° 10.658	15° 07.147	ST, I, SPE

7.1.9 Coloured dissolved organic matter (CDOM) using UV-Vis spectrometry

Lead: Ming Yang (miya@pml.ac.uk); Plymouth Marine Laboratory, Plymouth, UK

Motivation

Coloured dissolved organic matter (CDOM) originates primarily from the breakdown of plant and microbial matter and its spectral characteristics influence the level and quality of solar irradiation available for primary production and surface-water photochemistry. CDOM has a strong, wavelength-dependent absorption in the ultraviolet and blue visible regions of the electromagnetic spectrum, therefore significantly affects the optical properties of seawater, particularly in the upper water column. For example, by absorbing light at these shorter wavelengths, CDOM limits the penetration of photosynthetically active radiation, thereby influencing the depth and distribution of primary production. It is also involved in controlling the steady-state concentrations of free radical species and is therefore pivotal to the photo reactivity of sea-surface waters. Therefore, CDOM is closely linked to key biogeochemical processes, including microbial degradation, photochemical reactions, and the cycling of nutrients and carbon and as such, serves as a valuable indicator of the presence and transformation of dissolved organic carbon (DOC) in aquatic environments.

Methods

A UV-Visible Spectrophotometer (VWR® P9, UV/Visible Spectrophotometer, Catalog # 634-1231) was used to make both continuous and discrete absorption measurements, a measure of CDOM concentrations. A high-resolution spectrum scanning method was used, typically over the wavelength range of 230 to 750 nm, for the seawater samples compared to a reference.

Continuous measurements

Continuous automated CDOM measurements of the underway seawater were taken using a 3 cm quartz flow through cell compared to a 3 cm quartz cuvette of reference Milli-Q. A constant flow rate was maintained through the measurement cell using a peristaltic pump and a spectrum scan between 230 to 750 nm was performed every 15 minutes. The reference Milli-Q was maintained at room temperature and hence seawater flowing into the measurement cell was first equilibrated to room temperature (by passing through a coil sat in room-temperature water) to avoid temperature-driven absorption differences.

Discrete measurements

Discrete CDOM measurements of the microlayer were taken using a longer quartz cell of path length 10 cm compared to a 10 cm quartz reference cell to observe quantify the change in absorbance due to the effect of light/ozone on VOC emissions (see Section 7.1.7 Quantification of photochemical and oxidative VOC production in near surface seawater and surface microlayer). Therefore, the reference used in these measurements was microlayer seawater that had not been exposed to light or ozone. Hence, the effects of both these processes individually on the absorption of light between 230 to 750 nm and their combined effect could be assessed.

7.1.10 Seawater Ozone Uptake

Lead: Charlotte Stapleton (cs1893@york.ac.uk); Wolfson Atmospheric Chemistry Laboratories, Department of Chemistry, University of York, York, YO10 5DD, United Kingdom

Objective

To measure ozone uptake to the ocean surface

Method

The uptake of ozone to seawater was measured using a segmented flow coiled equilibrator (SFCE) system, as shown in Figure 20. A UV ozone lamp was used to generate ~ 1000 parts per billion of ozone, which flowed through an Alicat mass flow controller set to 200 ml min^{-1}. Controlled by a 3-way solenoid valve, the air flow was either directed through a ¼ inch PFA bypass line or through the sample coil (¼ inch PFA). Seawater was continuously pumped through the sample coil at 100 ml min^{-1} controlled by a peristaltic pump. The automated solenoid valve switched between the sample coil and bypass every 5 minutes. During periods where the ozone-enriched air was combined with seawater in the sample coil, discrete alternating segments of air and water form (~ several cm in length), and the interface of these pockets enables rapid gas exchange. After passing through either the bypass or sample coil, the air flow travels through a Nafion dryer to reduce the humidity and then is directed to a Thermo 49i ozone analyser to measure the downstream ozone mixing ratio (10 s). Due to the flow requirements of the Thermo 49i analyser (1.4 lpm) being different to the flow through the coil system (0.2 lpm), a diluent flow is required by passing laboratory air through a charcoal scrubber to remove ambient ozone.

The design of the SFCE system was based on the work of Wohl et al. (2019), and similar experiments have been reported by Yang et al. (2025).

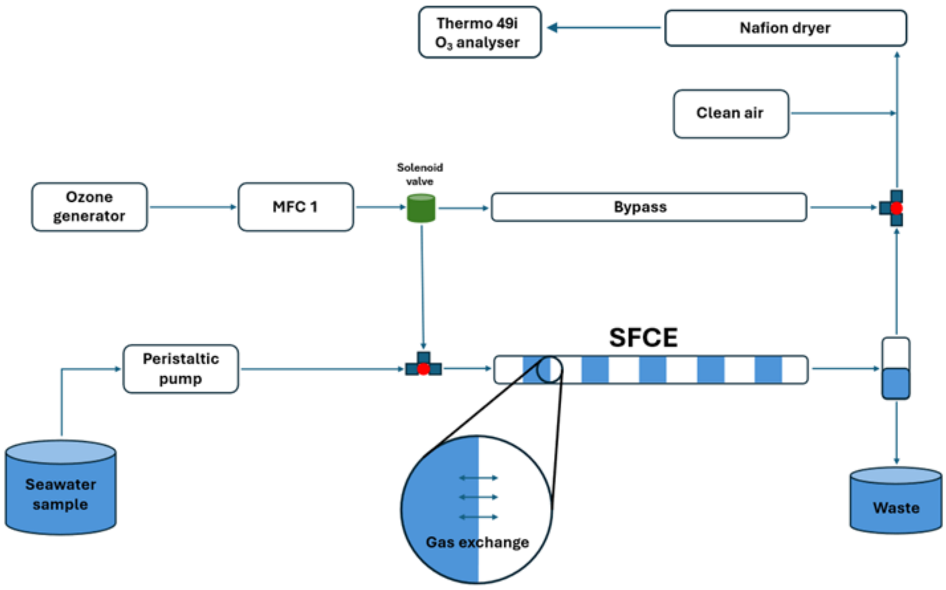

Figure 20: Schematic of the segmented flow coiled equilibrator (SFCE) system used to measure ozone uptake to seawater.

The difference between the ozone mixing ratio between the bypass and the sample coil indicates the ozone uptake occurring to the aqueous solution. However, this ozone uptake efficiency (defined as OUE) represents both the physical and chemical uptake. In order to derive the chemical component of the OUE, blank measurements of uptake to ultrapure milliQ water can be subtracted from the total OUE based on the idea that the uptake to milliQ water is purely driven by physical processes. milliQ blanks were recorded daily. In addition, other daily checks included visual inspection of the peristaltic pump tubing (Watson-Marlow 9 cm x ¼ ID silicone) for damage, and changing the bite point in the pump to ensure the flow rate through the system was constant.

Measurements were near continuous, with some discrete samples. The majority of the time, seawater from the towed fish (2 – 4m depth) was run through the sample coil, with almost daily sampling from the near surface sampler (0.5 m depth). Discrete samples of the sea-surface microlayer (sampled using a Garratt screen), and at various depths collected by the CTD were also run. As ozone reacts within the top few microns of the water column, samples of the sea-surface microlayer were particularly interesting for this research, and Table 38 displays the microlayer samples collected during the research cruise. Seawater samples collected from the CTD (Table 39) at different depths were useful to study the depth profile of ozone uptake in the water column. Figure 21 displays the depth profile of ozone uptake on 22nd June 2025, obtained from water collected from the CTD and from microlayer sampling.

Ancillary seawater samples were collected for iodide (frozen at -20°C), surface tension (frozen at -80 °C), and solid phase extraction-dissolved organic matter (SPE-DOM) (frozen at -20 °C) and will be processed at the University of York.

Table 38: Sea-surface microlayer samples collected using the Garratt screen during the cruise.

Date	Time (UTC)	Station	Latitude (°N)	Longitude (°W)	Volume (L)
29/05/2025	15:00	1	49° 45.477	17° 10.81	7
01/06/2025	16:00	2	51° 21.534	19° 26.58	10
03/06/2025	13:39	4	52° 21.639	19° 33.209	5.6
04/06/2025	12:30	4	52° 21.447	18° 28.93	12
06/06/2025	14:00	5	53° 13.105	17° 45.118	12
07/06/2025	11:40	5	53° 13.64	17° 32.101	11
10/06/2025	11:42	6	51° 49.178	17° 48.217	10
12/06/2025	13:30	7	51° 23.721	21° 10.985	12
13/06/2025	11:30	7	51° 54.931	21° 18.05	12
15/06/2025	14:00	8	50° 04.902	21° 32.750	10
18/06/2025	13:30	9	49° 44.845	18° 47.208	12
19/06/2025	11:30	9	49° 36.717	18° 46.274	10
22/06/2025	11:07	11	48° 23.254	15° 55.936	9
23/06/2025	13:54	12	48° 10.658	15° 07.147	15

Table 39: Seawater samples collected from the CTD during the cruise.

Date	Time (UTC)	CTD no.	Station	Latitude (°N)	Longitude (°W)	Niskins sampled	Depths (m)
14/06/25	05:30	26	7	51° 35.505	20° 56.946	22, 17, 13, 11, 7, 5, 1 + 4	3, 10, 30, 40, 60, 100, 1000
17/06/25	05:30	27	8	50° 03.832	21° 34.691	22, 17, 15, 13, 5, 3, 1	3, 10, 25, 30, 80, 500, 1000
22/06/25	15:30	37	11	48° 23.173	15° 56.010	21, 17, 13, 11, 9, 5, 3, 1	5, 15, 30, 40, 60, 100, 1000, 2000

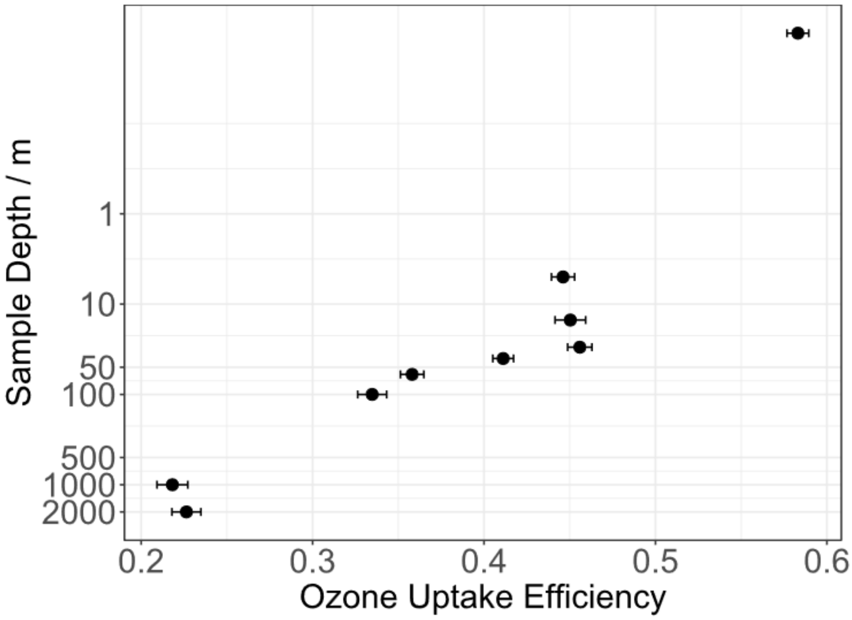

Figure 21: Depth profile of ozone uptake in the water column, with the top data point representing sea-surface microlayer sample, and the remaining data points representing samples collected from the CTD.

References

Wohl, C., Capelle, D., Jones, A., Sturges, W. T., Nightingale, P. D., Else, B. G. T., and Yang, M.: Segmented flow coil equilibrator coupled to a proton-transfer-reaction mass spectrometer for measurements of a broad range of volatile organic compounds in seawater, Ocean Sci., 15, 925–940, https://doi.org/10.5194/os-15-925-2019, 2019.

Yang, M., Phillips, D. P., Hopkins, F. E., Liss, P., Suntharalingam, P., Carpenter, L. J., et al. (2025). Marine biogeochemical control on ozone deposition over the ocean. Geophysical Research Letters, 52, e2024GL113187. https://doi.org/10.1029/2024GL113187

7.1.11 Abundance and Composition of Microbial Plankton Communities by Flow Cytometry

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NOTE: All data in this report is held by Frances Hopkins (fhop@pml.ac.uk), PML

Objective
To determine the distribution, abundance and community structure of nano- and picophytoplankton and heterotrophic bacteria from CTD casts, incubation experiments and near-surface sampling by flow cytometry.

Phytoplankton
Fresh seawater samples were collected in clean 125 mL polycarbonate bottles from a stainless steel-framed Seabird CTD system containing a 24-bottle rosette of 20 L Niskin bottles from 150 m to the surface. The depths sampled were: near surface (3-5 m), 6 m (to match the depth of the ship's uncontaminated seawater supply), 2-3 samples within the mixed layer (one of which was just above the beginning of the thermocline), mid-thermocline, subsurface chlorophyll maximum, just below the thermocline, approx. 100 m, 150 m (low VOC water).Samples were stored in a refrigerator and analysed within 2 hours of collection. Fresh samples were measured using a Becton Dickinson FACSCalibur flow cytometer which characterised and enumerated pico- and nanoeukaryote phytoplankton and prokaryote phytoplankton, based on their light scattering and autofluorescence properties. Data were saved in listmode format and analysed during the cruise. Table 40 summarises the CTD casts sampled and analysed during the cruise.

Heterotrophic bacteria
Samples for bacteria enumeration were collected in clean 125 mL polycarbonate bottles using a stainless steel-framed Seabird CTD system containing a 24-bottle rosette of 20 L Niskin bottles from 150 m to the surface, the same as for the phytoplankton. 0.5 mL samples were fixed with glutaraldehyde solution (Sigma-Aldrich, 50%, Grade 1. 0.5% final concentration, minimum of 30 mins at 4°C) within half an hour of surfacing. Samples (see below) were stained for 1 h at room temperature in the dark with the DNA stain SYBR Green I (Thermo-Fisher) in order to separate particles in suspension based on DNA content and light scattering properties. This enabled bacteria to be discriminated from other particles and enumerated. Samples were analysed flow cytometrically, within 3 hours of surfacing. Stained samples were measured using a Becton Dickinson FACSCalibur flow cytometer. Data were saved in listmode format and analysed during the cruise. Table 40 summarises the CTD casts sampled and analysed during the cruise.

Table 40: CTD casts sampled for phytoplankton and heterotrophic bacteria community structure and abundance.

DATE	STATION	CTD	TIME on deck (UTC)	LAT N	LON E	DEPTHS/*NISKIN BOTTLES*
28-05-25	1	2	04:43	50.47	-16.06	3 3 3 6 10 20 30 35 60 95 150 *21 20 19 18 16 14 12 8 6 4 2*
29-05-25	1	3	14:50	49.76	-17.18	4 6 10 20 30 40 55 70 150 *22 20 18 16 14 12 10 8 6*
30-05-25	1	4	04:50	49.43	-17.55	3 6 10 20 30 40 55 60 150 *20 18 16 14 12 10 8 6 4*

31-05-25	2	6	05:16	49.66	-18.61	6 6 10 20 30 40 45 55 65 *22 20 18 16 14 12 10 8 6*
01-06-25	2	7	04:55	50.31	-18.83	6 6 10 20 30 40 50 65 80 *22 20 18 16 14 12 10 8 6*
02-06-25	3	8	14:08	51.42	-20.20	6 10 25 40 50 60 70 100 150 *22 20 18 16 14 12 10 8 6*
03-06-25	4	9	0.21	52.34	-19.69	6 6 10 20 30 40 50 60 100 *22 20 18 16 14 12 10 8 6*
04-Jun-25	4	10	14:17	52.37	-18.46	6 6 10 20 30 40 50 60 100 *24 22 20 18 16 14 12 10 8*
05-Jun-25	4	11	05:10	52.36	-18.46	7 6 10 20 30 35 50 60 100 *22 20 18 16 14 12 10 8 6*
06-Jun-25	5	12	05:11	53.21	-17.56	5 5 10 20 30 40 45 55 100 *22 20 18 16 14 12 10 8 6*
07-Jun-25	5	13	14:11	53.23	-17.53	4 4 10 20 30 40 50 60 100 *24 22 20 18 16 14 12 10 8*
08-Jun-25	5	14	05:02	53.21	-17.54	4 4 10 20 30 40 45 55 100 *22 20 18 16 14 12 10 8 6*
09-Jun-25	6	15	05:03	51.69	-18.34	4 4 10 25 40 45 55 65 100 *22 20 18 16 14 12 10 8 6*
11-Jun-25	6	17	05:10	51.69	-18.34	4 4 10 20 30 50 64 70 80 *22 20 18 16 14 12 10 8 6*
12-Jun-25	7	24	05:08	51.59	-20.90	4 4 10 15 24 30 40 50 100 *22 20 18 16 14 12 10 8 6*
13-Jun-25	7	25	14:04	51.92	-21.30	3 3 10 25 35 48 60 80 100 *24 22 20 18 16 14 12 10 8*
14-Jun-25	7	26	05:06	51.58	-20.92	3 3 10 20 30 40 50 60 100 *22 20 18 16 14 12 10 8 6*
15-Jun-25	8	27	05:05	50.08	-21.55	3 3 10 15 20 40 50 60 80 *22 20 18 16 14 12 10 8 6*
16-Jun-25	8	28	14:12	50.09	-21.54	3 3 10 15 25 35 50 60 80 *24 22 20 18 16 14 12 10 8*
17-Jun-25	8	29	05:08	50.09	-21.54	3 3 10 25 30 40 50 60 80 *22 20 18 16 14 12 10 8 6*
18-Jun-25	9	30	05:10	49.61	-18.77	5 5 10 20 30 40 50 80 100 *22 20 18 16 14 12 10 8 6*
19-Jun-25	9	31	14:08	49.61	-18.77	3 10 15 20 30 40 60 80 100 *22 20 18 16 14 12 10 8 6*
20-Jun-25	9	32	05:06	49.61	-18.77	3 3 10 15 25 35 50 80 110 *22 20 18 16 14 12 10 8 6*
21-Jun-25	9	36	05:08	48.96	-16.78	3 3 10 15 20 30 40 60 80 *22 20 18 16 14 12 10 8 6*
22-Jun-25	11	37	14:58	48.39	-15.93	5 10 15 20 30 40 60 70 100 *22 20 18 16 14 12 10 8 6*
23-Jun-25	12	38	05:08	48.17	-15.12	3 3 15 30 50 60 70 80 100 *22 20 18 16 14 12 10 8 6*
24-Jun-25	12	39	05:11	48.17	-15.12	3 3 15 30 50 60 70 80 100 *22 20 18 16 14 12 10 8 6*

Underway sampling whilst transiting between stations

Samples were collected at 1-hour intervals from the uncontaminated seawater supply and the towed fish in the deck lab on days when the ship was transiting between stations. 1.8 mL samples were collected into 2 mL cryovials containing 50% glutaraldehyde and were left to fix in a fridge until they were analysed the following day. Samples were analysed as per phytoplankton and bacteria community structure samples in the previous section. Details of the underway sampling undertaken during the cruise can be found in the Appendices (Table D: CTD sampling stations for ancillary parameters).

Near-surface and microlayer sampling

Sampling for flow cytometry was conducted on days when the Garrett screen was being used to collect seawater from the sea surface microlayer (upper 200 µm approx.) and when the near-surface pumped seawater sampler was collecting water from a depth of approx. 0.5 m below the sea surface. Samples were collected in 15 mL centrifuge tubes; first from the Garrett screen and then from the near-surface sampler outflow and ship's underway seawater supply located in the deck laboratory. 1.8 mL sub-samples were then taken and preserved with glutaraldehyde solution (Sigma-Aldrich, 50%, Grade 1. 0.5% final concentration) and left in a fridge until analysed (within 24 h). Table 41 summarises the near-surface sampling undertaken during the cruise for analysis by flow cytometry. For full details concerning the sea surface microlayer, please refer to Section 7.1.6 Garret screen deployment for Microlayer sampling.

Table 41: Summary of dates and times of near-surface sample collection for phytoplankton and heterotrophic bacteria community structure & abundance.

Date	Time UTC
29-May-25	11:15
29-May-25	14:20
01-Jun-25	16:10
03-Jun-25	13:55
04-Jun-25	11:50
06-Jun-25	14:00
07-Jun-25	11:57
10-Jun-25	12:00
12-Jun-25	13:50
13-Jun-25	11:45
15-Jun-25	13:54
18-Jun-25	13:49
19-Jun-25	11:55
22-Jun-25	11:49
23-Jun-25	14:04

Incubation experiments

1.8 mL samples were collected into 2 mL cryovials containing 50% glutaraldehyde for all timepoints and were left to fix in a fridge until they were analysed the following day. Samples were analysed as per phytoplankton and bacteria community structure samples in the previous section. This included the analysis of samples of 0.3 µm filtered seawater used in the experiments to assess the efficiency of filters in removing phytoplankton and bacteria. For details of incubation experiments, see Section 7.1.4 Estimating the total removal rates and gross production rates of climatically relevant sulfur volatile organic compounds (SVOCs) using stable isotopes in seawater incubations. Table 42 summarises the sampling and analysis undertaken by flow cytometry for the incubation experiments.

Table 42: Summary of flow cytometry samples analysed by flow cytometry for incubation experiments. Experiment column - S = Sulfur, V = VOC, K = Kinetic

Date	Station	CTD	LAT N	LON E	Experiment
28-May-25	S1	C002	50.47	-16.06	S1
30-May-25	S1	C004	49.43	-17.55	V1
31-May-25	S2	C006	49.66	-18.61	S2
01-Jun-25	S2	C007	50.31	-18.83	V2
03-Jun-25	S4	C009	52.34	-19.69	S3
05-Jun-25	S4	C011	52.36	-18.46	V3
06-Jun-25	S5	C012	53.21	-17.56	S4
08-Jun-25	S5	C014	53.21	-17.54	V4
09-Jun-25	S6	C015	51.69	-18.34	S5
11-Jun-25	S6	C017	51.69	-18.34	V5
12-Jun-24	S7	C024	51.59	-20.90	S6
14-Jun-25	S7	C026	51.58	-20.92	V6
15-Jun-25	S8	C027	50.08	-21.55	S7
17-Jun-25	S8	C029	50.09	-21.54	V7
18-Jun-25	S9	C030	49.61	-18.77	V8K1
20-Jun-25	S9	C032	49.61	-18.77	S8
21-Jun-25	S10	C036	48.96	-16.78	V9
23-Jun-25	S12	C038	49.61	-18.77	S9
24-Jun-26	S12	C039	48.17	-15.12	V10K2

7.1.12 Filtration for DNA isolation

Lead: Alicia Guadalupe Talavera Caro (at23484@essex.ac.uk); University of Essex, Essex, United Kingdom

Objectives
Collection of seawater samples from CTD vertical profiles and SVOC/VOC incubations, along with bioaerosol samples using Tisch Environmental vacuum sampler, was conducted for subsequent DNA isolation and microbial taxonomic identification in both environments. The aim is to link phytoplankton and bacterial relative abundance to their activity in marine biogeochemical cycles across the North Atlantic.

Methods
Nalgene PPCO bottles were used for sample collection. The bottles were first rinsed with MilliQ water, then soaked in 2% (v/v) bleach for 1 hour. After bleaching, the bottles were thoroughly rinsed with MilliQ water, acid-washed with 10% (v/v) HCl, and rinsed again three times with MilliQ water.

Samples were collected for DNA isolation to analyze microbial abundance and their relationship to atmospheric measurements conducted during the campaign. Approximately 1 L of seawater was collected for DNA isolation and another 1 L for phytoplankton collection and hydrocarbon quantification. These samples were obtained from Niskin bottles deployed at various depths, ranging from the surface (typically 2–5 m) to deeper waters (100–1000 m), during both pre-dawn and noon CTD casts. The collected water was transferred into clean, pre-labeled bottles indicating volume and depth.

For filtration, a vacuum pump was used to pass the sample through a filtration tower fitted with a 0.2 μm Durapore membrane filter. Seawater was slowly pumped through the filter. After filtration, the membrane was folded using clean forceps with 70% (v/v) ethanol and transferred into a cryovial for storage at -80°C until returned to the University of Essex for DNA isolation. Each filtration unit was cleaned with ethanol and rinsed thoroughly between samples.

The same procedure was applied to SVOC/VOC incubations at both T_0 (initial time point) and Tfinal (after 12 hours). Additionally, surface microlayer (SML) and near-surface (NF) samples collected using the towed fish (see *Seawater Observations*) were included in the DNA analysis and processed immediately following sampling.

After processing samples for DNA isolation, the same filtration towers were cleaned and reused for phytoplankton collection. Pre-combusted GF/F filters were used to filter 1 L of seawater. After filtration, the filters were folded, wrapped in aluminum foil, and stored at -20°C until returned to the University of Essex for hydrocarbon analysis.

A total of 543 samples were collected from 39 CTD casts, the Garrett screen SML, and towed fish sampling, as shown in the Appendices (Table A: CTD casts sampled for phytoplankton and heterotrophic bacteria community identification, Table B: Samples from CTD casts for SVOC/VOC incubations for phytoplankton and heterotrophic bacteria identification, Table C: Samples from SML Garret screen casts for phytoplankton and heterotrophic bacteria identification).

For bioaerosols, filters were removed from the sampling plate (see *High Volume Aerosol Sample Collection*). Using sterile forceps and sterile scissors, three strips were cut from the slotted filters where the majority of particles and microorganisms had been impacted by using the pump. The strips were folded and placed in 15 mL Falcon tubes, then stored at -80°C until DNA extraction and analysis at the University of Essex.

7.1.13 Collection of samples for ancillary parameters (chlorophyll *a*, photosynthetic pigments, nutrients, phytoplankton taxonomy, dissolved organic carbon, FIRE)

Lead: Frances Hopkins (fhop@pml.ac.uk); Plymouth Marine Laboratory, Plymouth, UK

Motivation

To provide biogeochemical context for surface ocean volatile organic compound (VOC) concentrations and incubations for VOC rate measurements, a suite of ancillary samples were routinely collected. These included: a. Chlorophyll a as a measure of bulk productivity, b. photosynthetic pigments for community composition analysis and ocean colour sensor validation, c. nutrient concentrations, d. dissolved organic carbon, e. phytoplankton taxonomy by microscopy, and f. a measurement of photosynthetic efficiency. Samples were collected from Niskin bottles from CTD depth profiles, and from the towed fish seawater supply during transects (Chl a only).

Methods

Chlorophyll-a and photosynthetic pigments

Samples for chlorophyll and pigments were collected in 5 L black carbuoys directly from Niskin bottles on the CTD rosette using Tygon tubing. For Chlorophyll *a*, a measuring cylinder was used to measure out 100 mL of seawater for filtration through a 25 mm GF/F under gentle vacuum. Filters were folded with forceps and placed into a 15 mL Falcon tube and stored at -20C. For photosynthetic pigments, 2 L of seawater was filtered through 25 mm GF/F under gentle vacuum, as above. Filters were folded with forceps, placed in a 2 mL cryovial and stored at -80C. Pigment samples were collected in single samples from surface CTDs, indicated with a * in Table D: CTD sampling stations for ancillary parameters (Appendices). Samples will be analysed post-cruise.

Dissolved inorganic nutrient samples

Water samples for nutrient analysis were taken from a 24 x 20 litre bottle stainless steel framed CTD / Rosette system (Seabird). On days when incubation experiments were being conducted, triplicate near-surface samples were collected from separate Niskin bottles. On days between incubation experiments, each depth was sampled, except for 1000 m water. Samples were collected in clean (acid-washed) 60 mL HDPE (Nalgene) sample bottles, which were rinsed 3 times with sample seawater prior to filling. Sample bottles were then bagged and immediately placed in a -20°C freezer. Samples were transported back to PML on dry ice and stored in the laboratory at -20°C until analysed. Table F: CTD casts sampled for dissolved inorganic nutrients (Appendices) summarises the CTD casts sampled during the cruise and nutrient sample bottles.

Dissolved Organic Carbon/Total Organic Carbon

Whole seawater samples were collected directly from Niskin bottles on the CTD rosette into acid-washed and MilliQ rinsed 300 mL amber glass stopped bottles. Seawater was gravity filtered through pre-ashed 25 mm GF/F filters, using an acid-soaked and MilliQ rinsed glass filtration unit, directly into 40 mL glass vials, thoroughly rinsing the vial before filling to the top and adding 100 µL of 1M HCl using a pipette. Samples are stored in the fridge until later analysis. Samples will be analysed post-cruise.

Phytoplankton taxonomy

Whole seawater samples were collected in glass sample bottle pre-dosed with Lugol's iodine, and stored at room temperature. Taxonomy samples were collected in single samples from surface CTDs, indicated in Table D: CTD sampling stations for ancillary parameters (Appendices) with *. Samples will be analysed post-cruise.

FIRe

A miniFIRe – Fluorescence Induction and Relaxation instrument, was utilized to analyze the photosynthetic efficiency of phytoplankton communities, both during the sulfur incubations and in surface waters while underway. Specifically, rapid and nondestructive controlled light flashes were used to assess the physiological state of photosynthetic organisms.

Unfiltered water was subsampled into 50 mL glass cuvettes and left in a dark environment to reach homogeneity for a minimum of 15 minutes before analysis. The fluorescence yield, therefore, is measured in a dark-adapted state and is noted dimensionless. The maximum value is 0.65 in healthy algae and decreases under stress conditions.

FIRe measurements were taken at 3–4-hour intervals from 07:00 to 19:00 UTC while steaming, as well as at each time point of the sulfur incubations. For vertical profile days, three depths were subsampled: at surface, the middle of the MLD, and just below the MLD.

7.1.14 Underway fCO_{2w} and gas exchange efficiency

Lead: Mingxi Yang (miya@pml.ac.uk); Plymouth Marine Laboratory, Plymouth, UK

Objectives

In addition to the NMF General Oceanics seawater fCO_2 measurements (see Ships Scientific Systems Report), surface ocean dissolved CO_2 fugacity (fCO_{2w}) and the CO_2 gas transfer efficiency (GTE) were measured with two parallel segmented flow coil equilibrators (SFCEs) continuously on this cruise every 10 minutes. GTE is a relative measure of the impact of surfactants (e.g. derived from biogenic activities).

Methods

Measurements of GTE are made with two parallel segmented flow coil equilibration (SFCE) systems. The SFCE has been described in detail by Wohl et al. 2019 and Yang et al. 2021. Briefly, underway seawater is piped to a ~200 mL glass sampling bottle via a ~1 m long 3/8'' Teflon tube and allowed to overflow rapidly into the sink. For each SFCE system, water is extracted from the bottom the glass sampling bottle with a peristaltic pump (via a ~0.5 m long ¼'' Teflon tube and a ~20 cm long Pumpsil soft tube). Carrier air joins the sample water at a Teflon 'tee' piece, naturally forming distinct segments of water and air. These segments travel in the same direction through a length of ¼'' Teflon coil (during which time gas exchange occurs) and are then separated in an air-water separator (fashioned out of a ½'' Teflon 'tee' piece). The sample air leaves the separator from the top and goes towards the CO_2 analyser (Licor7000), while the sampled water is drained from the bottom of the separator into the sink.

Two SFCE systems are deployed in parallel and CO_2 is measured with the Licor7000 alternately every five minutes (controlled by **Solenoid valve 0**). The continuous water flow rate is set by a peristaltic pump to be about 100 mL/min for both SFCEs. The Synthetic air (essentially free of CO_2) airflow rate is set by a mass flow controller to be 25 standard cubic centimeter per minute (about 27 ml/min at room temperature), which is used by the short coil (~40 cm).

A new modification relative to Yang et al. 2021 is that a CO_2 standard (409.16 ppm) is used to equilibrate with the long coil (30 m of 1/8'' ID coil), with the flow controlled by another mass flow controller (25 sccm). The longer coil and the use of ~400 ppm CO_2 as carrier gas should make the purge effect insignificant and thus improving the accuracy of CO_2_long measurement.

The airflow rate can be verified by measuring the sample outflow of the Licor analyser, while the water flow rate can be verified with a graduated cylinder+stopwatch. The sample air is dried with a Nafion drier and filtered with a Swagelok particle filter to reduce the influence of humidity and particulates on the CO_2 measurement.

The long coil is submersed in a bucket with overflowing underway water. This is to keep the temperature as close to ambient sea surface temperature (SST) as possible. Gas equilibration should be complete within this length of tube, and measurements from this long coil thus correspond to the seawater pCO_2. The system theoretically has a response time of ca. 1 minute. In practice, since the two SFCE systems are measured alternately for five minutes each, the temporal resolution of the reported pCO_2 is every 10 minutes. These results will be compared with those from PML's underway pCO_2 system (which uses a shower-head equilibrator).

The length of the short coil is about 40 cm. This length is chosen purposely such that CO_2 does not come to full equilibration in the short coil. The short coil (straight tube) is insulated with foam to keep the temperature close to SST. Since essentially CO_2-free synthetic air is being equilibrated with seawater, we can calculate GTE as the ratio between the measured CO_2 from the short coil and the measured CO_2 from the long coil. As long as the internal turbulence within the short coil remains constant (largely a function of flow rates and physical setup), any changes in GTE should be due to changes in the measure water itself, e.g. biologically derived surfactants as well as temperature.

The two coils are washed with 10% hydrochloric acid remove any internal biological growth prior to the field deployment (this can be repeated during the cruise if needed). The Pumpsil soft tubes for the two peristaltic pumps are replaced ca. daily. Due to the constant usage and wear on the Pumpsil tubes, within a day the water flow rate may decrease by about 5-10 ml/min. The flow rates for both the long and short coils need to be measured before/after the Pumpsil tube replacement, and these flow rates are used in the corrections of GTE and pCO_2.

The Licor7000 is calibrated during the cruise by bypassing the SFCE and piping the CO_2 standard into the Licor directly. This is currently set to every 6 h, controlled by Solenoid valve 1. Note that Solenoid valve 0 is off (=0) when Solenoid valve 1 is on (=1). Additional calibration is performed by redirecting outflow from reference 'Cell A out' directly into 'Cell B in'.

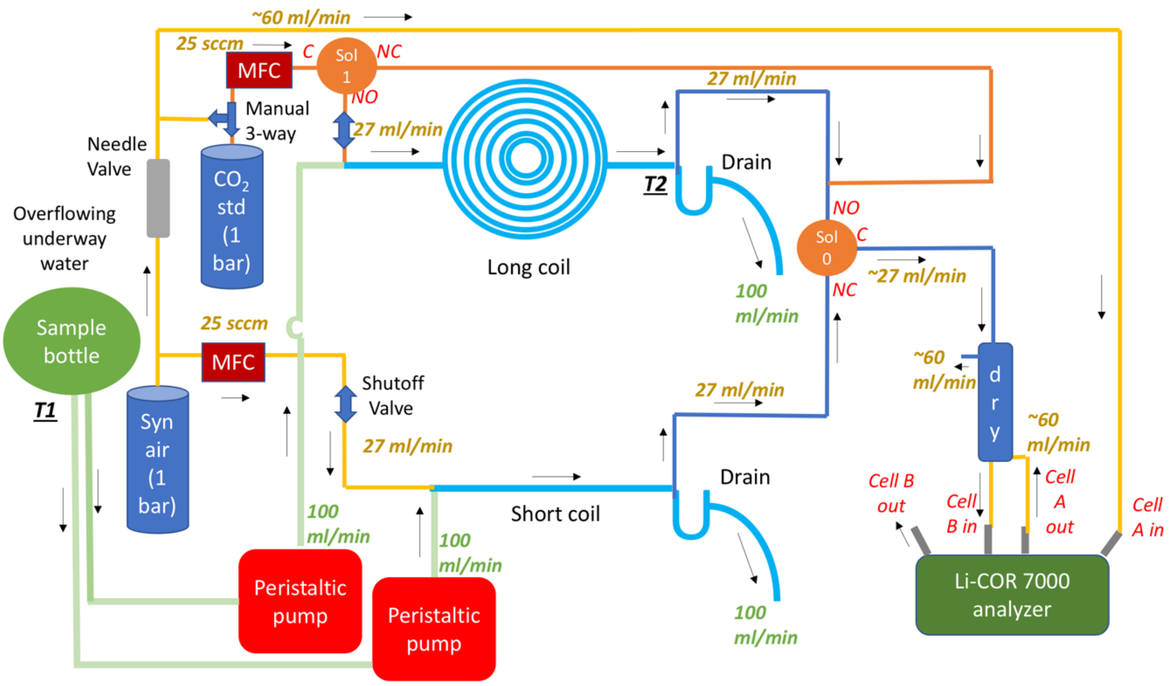

Figure 22: Detailed flow diagram.

Data output

The final data will consist of measurements of fCO_{2w} and GTE every 10 minutes. The system performed well during the cruise. The only major data gap occurred between 5th and 7th of June when I forgot to record the data on the Licor software, even though the system was running fine.

References

Wohl, C., Capelle, D., Jones, A., Sturges, W. T., Nightingale, P. D., Else, B. G. T., & Yang, M.: Segmented flow coil equilibrator coupled to a Proton Transfer Reaction Mass Spectrometer for measurements of a broad range of Volatile Organic Compounds in seawater, Ocean Sci., 1–37, 2019.

Yang, M., Smyth, T. J., Kitidis, V., Brown, I. J., Wohl, C., Yelland, M. J., et al. (2021). Natural Variability in Air–Sea Gas Transfer Efficiency of CO2. Sci. Rep. 11 (1), 1–9. doi: 10.1038/s41598-021-92947-w

7.1.15 Skin and Subsurface Temperature (ISAR, ROSR, sea snake)

Jaynise M. Pérez Valentín (jperval@uw.edu); Applied Physics Laboratory, University of Washington, USA

Introduction

Skin and sub-skin ocean temperature measurements were made using a set of infrared radiometers and towed surface thermistors, respectively. The ocean skin temperature (10-20 µm depth) was measured using two Remote Ocean Surface Radiometers (ROSRs) and two InfraRed Instruments for Sea Surface Temperature (IRISS). The set-up for these is shown in Figure 23(a). The two ROSR were mounted on a custom-built frame and were set on the rail of the fore deck on the port side of the Research Vessel (R/V) one on top of the other. A custom-built pole was attached to the frame holding a longwave sensor at the top and a high frequency relative humidity sensor. The IRISS system was also mounted on a custom-built frame with one infrared sensor pointing at the wake (IR wake) of the ship and the other pointing at the undisturbed ocean surface (IR_skin). For a period, the two sensors were pointed in the same direction (wake turned to the skin direction) for validation purposes. Figure 23(b) shows the surface thermistors towed from the back deck of the RV on the port side. High-frequency RBR and Sea Bird SBE sensors are encased on plastic hose and dragged from the movement of the ship so that the sensors float at a semi-consistent depth of around 5 cm.

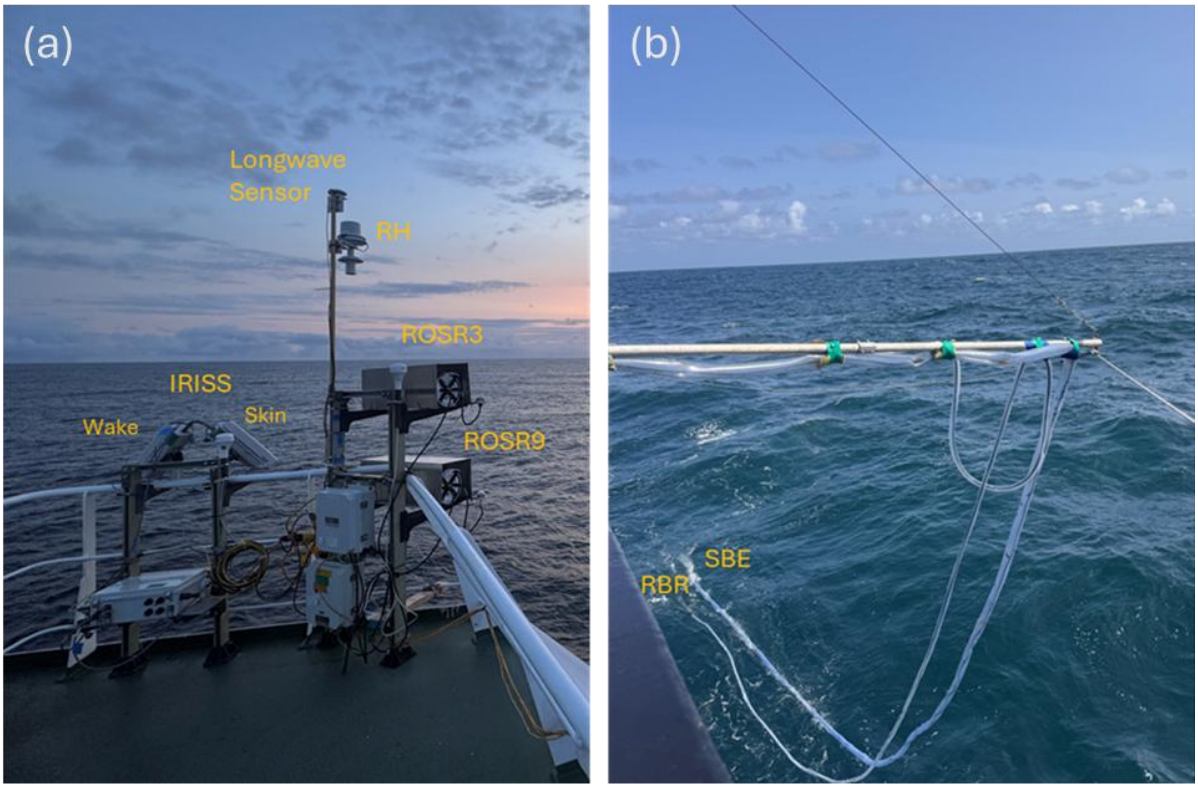

Figure 23: Instrumentation set-up. All instruments were located on the port side of the R/V (a) Instruments for skin sea surface temperature retrieval: IRISS and ROSR. Additional instruments for the calculation of the bulk heat flux measurements like a longwave sensor (pyrgerometer) and a relative humidity sensor were mounted on the frame. (b) Instruments for subskin sea sirfact temperature retrieval: Sea snakes (RBR and SBE).

Instrument specifications and calibration

<u>Calibration Procedure</u>

The radiometers and sea snake sensors were calibrated using a precision laboratory water bath equipped with a high emissivity blackbody. The bath temperature is cycled from 5 °C to 30 °C and the temperature is measured using multiple precision thermistors. The IRISS sensors are placed in a temperature-controlled housing that is held at a constant temperature.

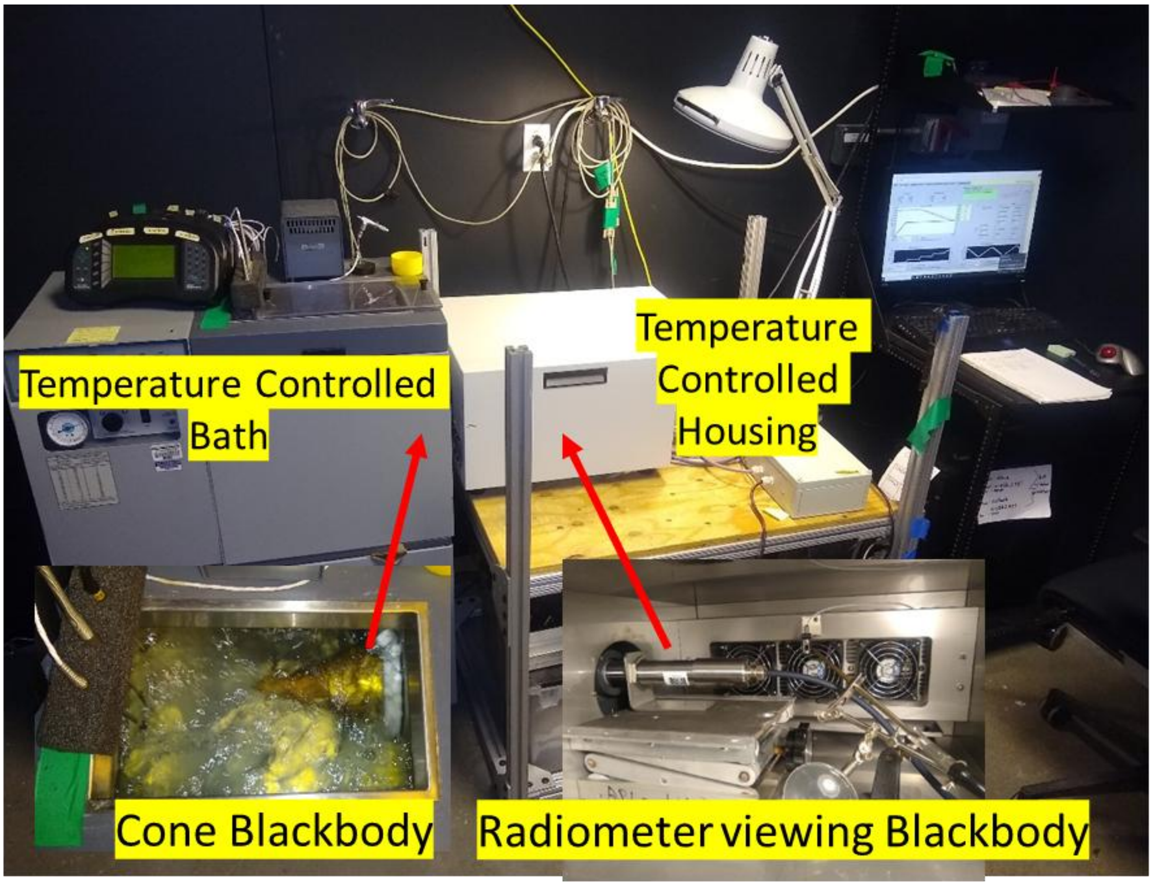

Figure 24: Laboratory calibration facility used for both the radiometers (ROSR and IRISS) and the sea snake sensors (RBR and SBE).

<u>Surface temperature thermistor (Sea-snake)</u>

The sea snake sensors continuously measure near-surface ocean temperature at ~5-10 cm depth. The temperature measured by the sea snake is representative of the ocean surface diurnal warm layer. The sea snake consists of a thermistor in a floating plastic hose dragged from the side of the ship with the thermistor sensor floating whether the ship is stationary, underway, or maneuvering. When the ship moves at relatively high-speed relative to the sea (usually over 6 knots or 3 m/s), the water measured by the sea snake is affected by the ship's wake. Depending on the ship's speed and surface conditions, waves elevate and drag the sea snakes, causing the sensors to intermittently emerge from the water into the near-surface air. This behavior was observed more frequently from the smaller RBR sensor snake than for the larger SBE sensor.

Despite the jumping, the temperature measurements are representative of the near-surface ocean, because of the greater thermal conductivity of water compared to that of air, the small fraction of time spent in the air compared to in the water (larger for the RBR than the SBE), and the long time constant of the (0.2 kg) thermally conductive sensor body (de Szoeke, 2021).

Remote Ocean Surface Radiometer (ROSR)

The ROSR provides sea surface skin temperature (0.1℃) from the reflected incoming infrared radiation by a 45-degree mirror through a small orifice, located in a scanning drum, into the Heitronics IR radiometer. The scanning drum is pointed at the sea surface at a 45-degree angle ensuring its field of view is outside of the ship's wake. It then rotates to look at the ski and into two internal black bodies for sky correction and self-calibration. The ROSR uses a pitch-roll sensor which is used to compute ocean reflectivity. A complete measurement cycle (BB1, BB2, sky, and sea surface) is done each 285 seconds. Finally, a rain sensor connected to the instrument is used to trigger the closure of the door (shutter). Therefore, no measurements are collected during the presence of precipitation.

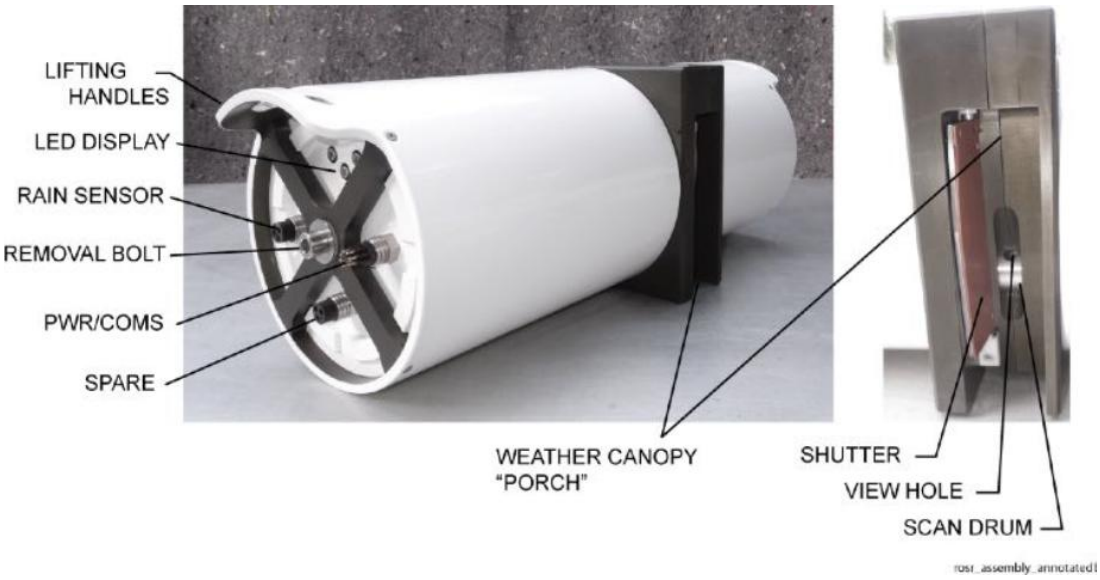

Figure 25: Photographs of ROSR showing major external components.

InfraRed Instrument for Sea Surface Temperature (IRISS)

IRISS is a new design that simplifies the skin temperature measurement by:

- Using a single ambient-temperature point blackbody for calibration
- Eliminates the need for a sky measurement by using an "optimal" absorptive waveband that allows the sky radiance to be modeled based on the ship's air temperature and relative humidity

For this cruise, we deployed two units, one looking forward of the ship at undisturbed water to measure skin temperature and the other pointed at the wake to determine if we can remotely estimate the temperature measured by the sea snake.

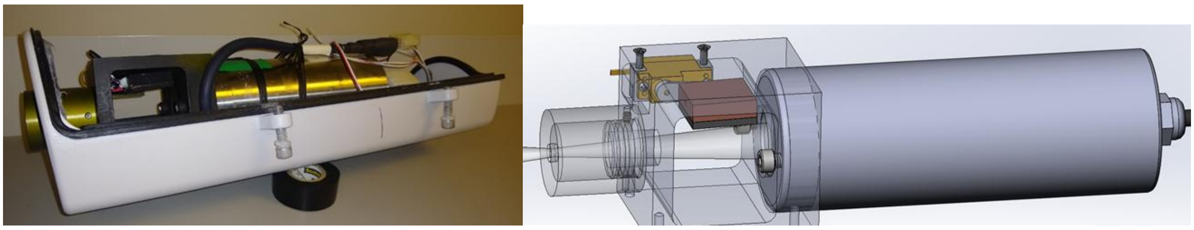

Figure 26: Photograph and schematic of the IRISS.

Supplemental Meteorological Measurements

In addition to the sea surface temperature, we measured the downwelling longwave radiation using a Kipp and Zonen model SGR3-V Pyrgeometer and relative humidity and air temperature using a Rotronics HC2A humidity sensor.

Preliminary Results

The top plot in Figure 27 shows a time series of the temperatures from the sea snake (red) and ROSR9 (black). The bottom plot in Figure 27 is the time series of the skin-bulk temperature difference dT=Tskin-Tsnake. In general, the difference dT is negative, showing a cool skin as expected. These data have not been edited for conditions that would affect the Tskin measurements. When the ship is on station the Tskin measurements may be corrupted by surface disturbance generated by the ship (hull reflections, bow thruster wake) and the sea snake data may be similarly compromised.

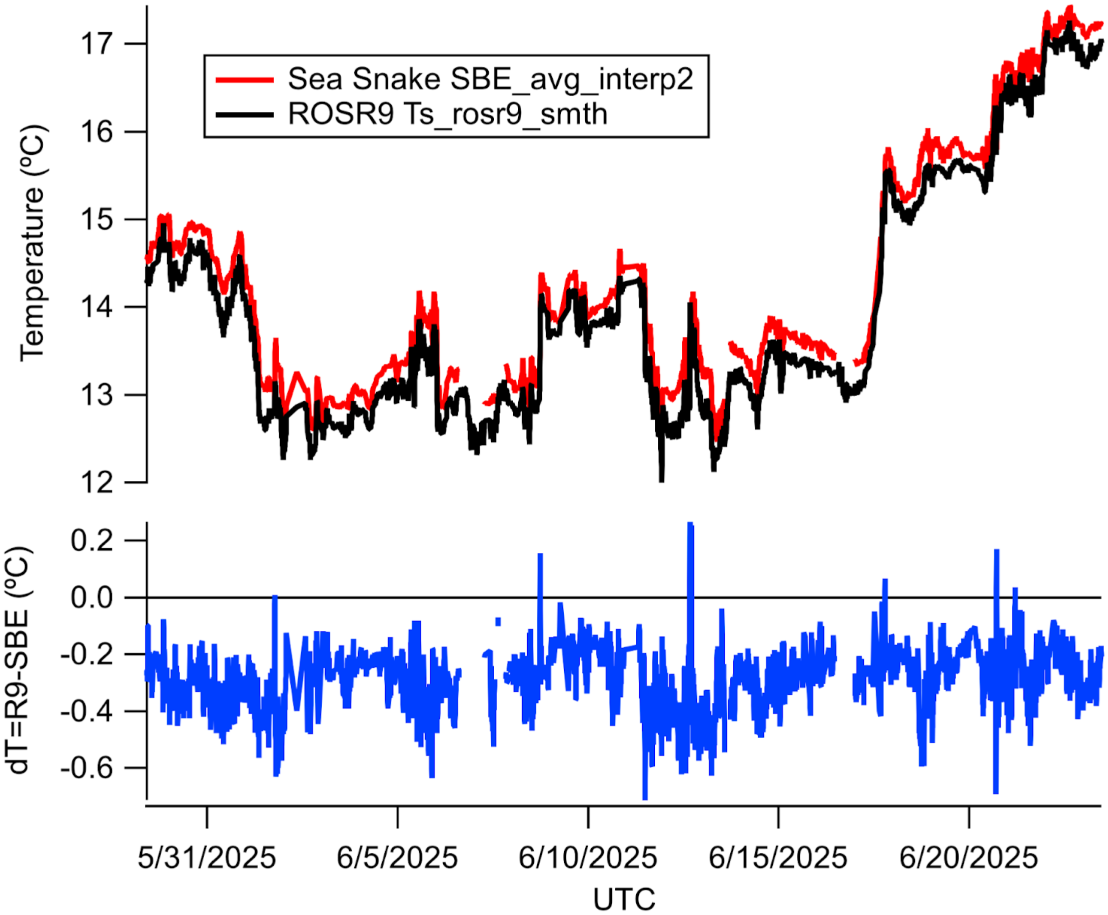

Figure 27: Time series of (top) Tskin and Tsnake and (bottom) dT=Tskin-Tsnake. In general, the data show the presence of a cool skin. These data have had minimal quality control, and we anticipate that some of the large fluctuations in dT may be reduced after further QC.

In order to compare the standard and optimal band approach, ROSR9 operated in the standard wave band of 9.6 - 11.5 microns while ROSR3 operated in the optimal wave band of 7.5 - 7.85 microns. Figure 28 is a scatter plot of the Tskin from ROSR9 vs ROSR3. In general, the measurements are well correlated with some scatter about the one-to-one line. These data have not been edited factors that can corrupt the measurements and ROSR3 has not been corrected for the path radiance between the sensor and the ship. The bias of 0.06 C° and standard deviation of 0.16 C° is within the expected range for measurements that have not been quality controlled.

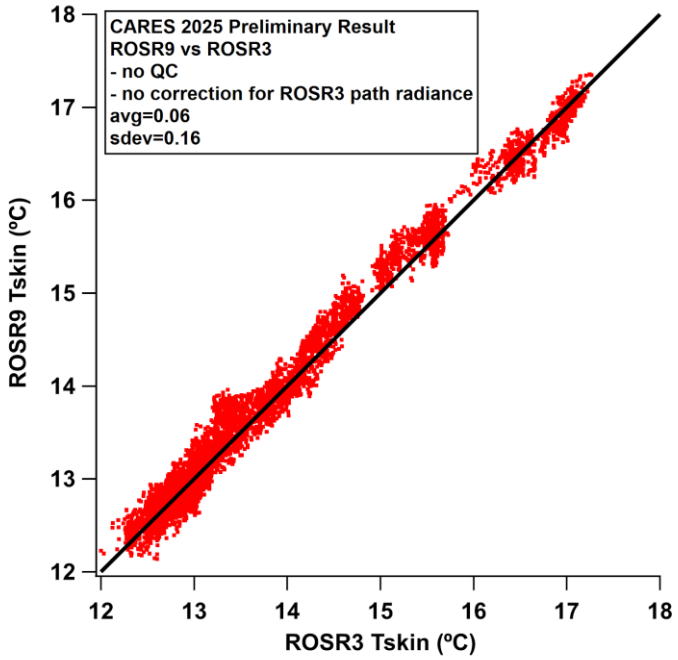

Figure 28: Scatter plot of Tskin from ROSR9 vs ROSR3.

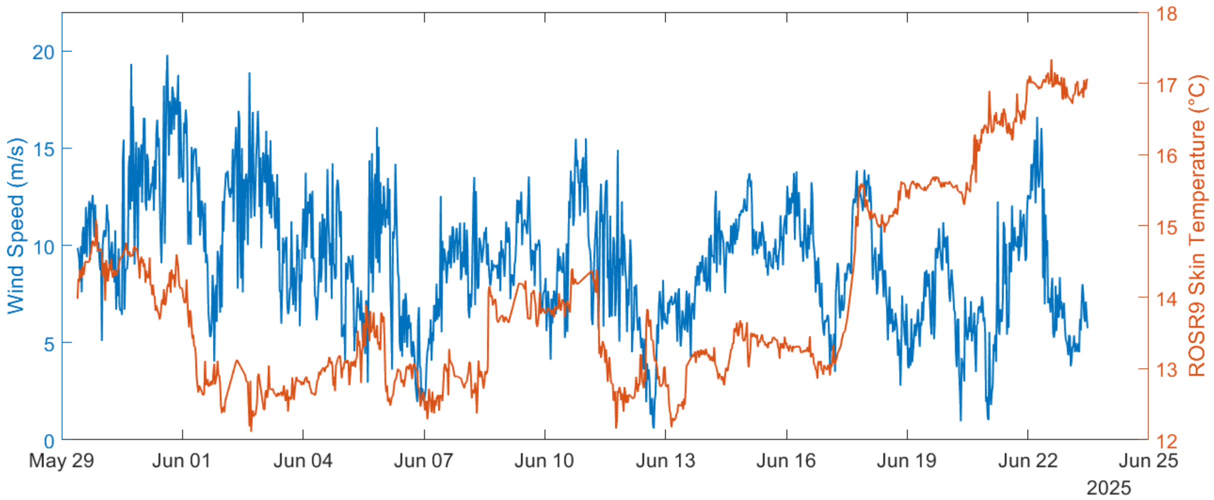

Figure 29: SSTskin from ROSR9 and wind speed (m/s) from ship's windsonic.

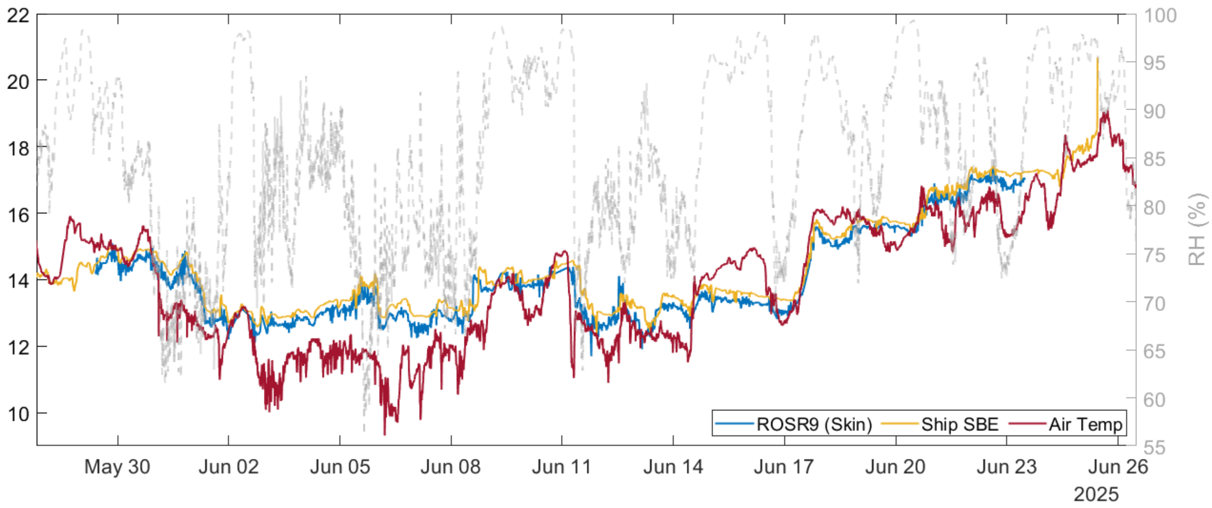

Figure 30: SSTskin from ROSR9 (blue) and SSTbulk from Ship's SBE (6m) with air temperature and relative humidity.

7.2 Atmospheric Observations

7.2.1 Atmospheric concentrations and eddy covariance air-sea trace sulfur and VOC gas fluxes using PTR-TOF-MS

Lead: Mingxi Yang (miya@pml.ac.uk); Plymouth Marine Laboratory, Plymouth, UK

Summary

A very large number of sulfur gases and volatile organic compounds (VOCs) in the atmosphere were measured with a Proton-transfer-reaction time-of-flight mass spectrometer (PTR-TOF-MS 4000 X2 with extended volatility, Ionicon) continuously at a high rate of 5Hz. This will yield the atmospheric mixing ratio of many VOCs and also enables the derivation of air-sea fluxes of the VOCs using the eddy covariance method.

Set up

The inlet for the instrument was mounted near the sonic anemometer on the Met platform (see red circle in Figure 31), and the inlet tube was made up of 30 m of ½ inch Teflon tube. A Gast 523 pump pulled the air down at a flow rate of ~ 51 standard litre per minute (monitored by a Bronkhorst mass flow meter), and the PTR-TOF-MS (itself located in the Met lab) subsampled it just outside of the Met lab at a flow rate of ~360 sccm via a few m of 1/8 inch Teflon tube via Multiple port valve (MPV) 1. A separate 1/8-inch Teflon tube subsampled at the same point and was routed through the heated catalyst and entered the instrument via PTR-TOF-MS via MPV 8. For the last two minutes of every hour, the MPV was switched from 1 to 8 for routine blanking.

Figure 31: PTR-TOF-MS inlet.

A VOC gas calibration mix was introduced to the tip of the inlet on the Met mast via a 30 m of 1/8 inch Teflon tubing, and the flow rate was regulated by a needle valve. This VOC mix was 'puffed' into the inlet about once daily (controlled by a 2-way solenoid valve), which provided not only a rough single-point calibration for the system, but also enabled the estimations of the delay (~4 s) and response times (~0.3 s) in the measurement.

For more thorough multi-point calibration, the VOC mix was piped directly into the instrument via the ICS-20 port (at 0-2 sccm) and diluted with ambient air scrubbed by the catalyst (120 sccm). The inlet flow was reduced to ~120 sccm during this measurement. The use of scrubbed ambient air ensured that the humidity level in the calibration is comparable to ambient sampling. Mass calibration is automatically performed by the instrument software every 20 s.

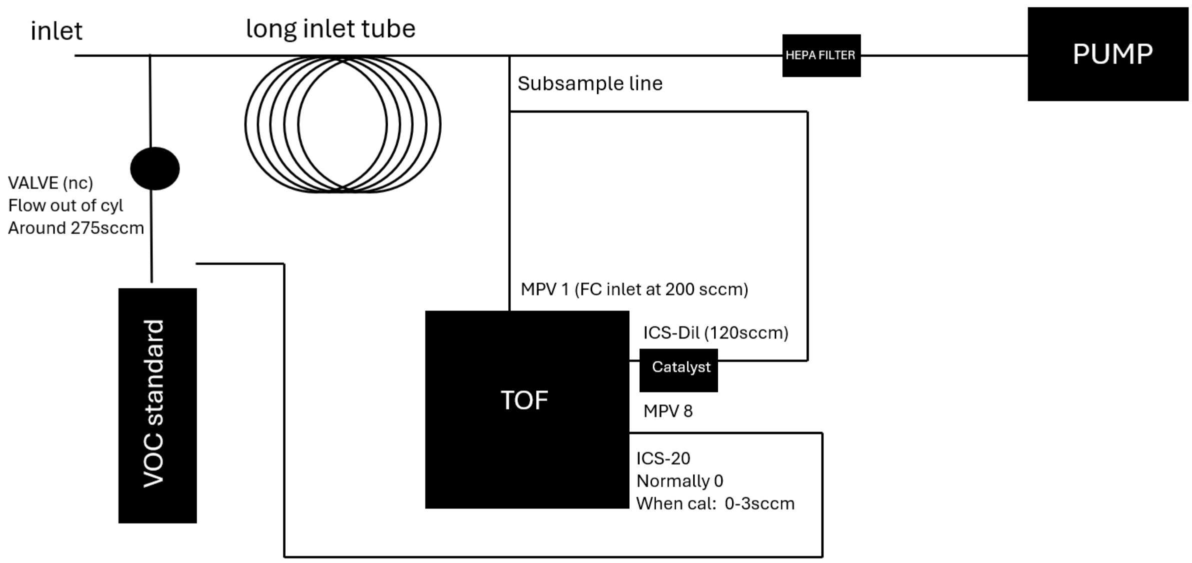

Figure 32: PTR-MS-TOF plumbing.

The data volume from the instrument is very large (about 1 GB/hour). It's necessary to stop data acquisition once a day for a full hour in order to back up data. Backing up data while trying to acquire data will freeze the data acquisition software.

Data consist of two types, traces (i.e. time series of selected compounds) and full spectra (usually averaged to reduce noise and data volume). Examples are shown below.

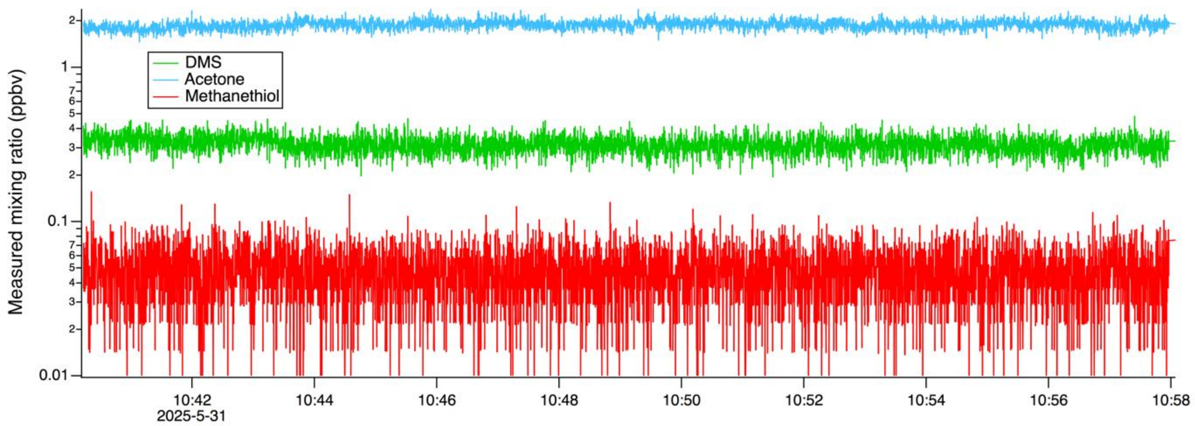

Figure 33: Example of trace data, here showing only 3 compounds.

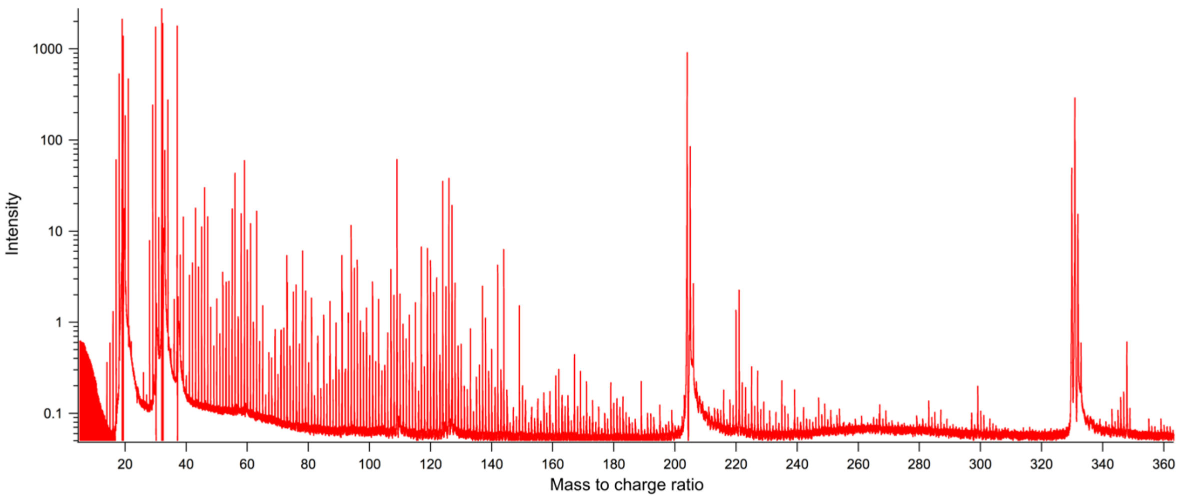

Figure 34: Example of spectrum data.

7.2.2 SO_2 concentrations (LIF)

Lead: Eve Grant (eve.grant@york.ac.uk); Wolfson Atmospheric Chemistry Laboratories, University of York

Objectives

1) Provide precise measurements of SO_2 in the North Atlantic, down to the ppt level, using LIFSO2
2) Undertake flux measurements of SO_2
3) Comparison of the LIFSO2 with the UCI CIMS, for both SO_2 concentration and SO_2 fluxes
4) Comparison of SO_2 measurements on board the Discovery with those taken at Mace Head (both using LIFSO2)

Method

SO_2 concentrations over the past 70 years have decreased steadily due to restrictions such as limiting the sulfur content in fuels. The waters around Britain fall in a region called the Sulfur Emission Control Area (SECA), where the sulfur content in fuels cannot exceed more than 0.5%. As the anthropogenic contribution has been greatly reduced, there is a need to better understand the contribution of the biogenic fraction. Previous measurements of SO_2 in marine environments observed concentrations down to the ppt level (for undisturbed marine air, Ayers et al (1998), De Bruyn et al (1998)), but the instrumentation used had long averaging times (weeks to months) or did not have the required detection limit. As such, the need for a more precise instrument that can detect SO_2 down to the low ppt level was required.

The LIFSO2 from the University of York is a field deployable laser which is capable of measuring down to such low levels. The instrument uses Laser Induced Fluorescence (LIF) to detect the SO_2 present in the atmosphere (Rollins et al (2016)). Our fundamental of 1084.5nm, produced from custom-built IR laser, is amplified and is then frequency doubled through a series of non-linear optics (NLOs). The frequency doubling of the fundamental leads to the generation of the 5^{th} harmonic at 216.9nm. At this wavelength in the SO_2 spectrum there is a strong absorption feature and is used to excite the SO_2 molecules. We then measure the red-shifted fluorescence at ~300-400nm.

The detection of SO_2 in the instrument can be broken down into two main parts; the signal cell, where we detect ambient SO_2 and the reference cell. The latter is kept at a constant SO_2 concentration. We use the reference cell to scan across the SO2 spectrum and to locate the peak of the SO_2. The instrument then "dithers" across the top of this peak to measure ambient SO_2. The reference cell is also used as a correction factor for the instrument, due to its constant concentration, so instrument drift can be accounted for.

The instrument was situated in the NMF container for the duration of the cruise (excluding the maintenance period from the 26/05-02/06/2025). The lab was kept at a constant 20°C with an air-conditioning unit, with the LIF placed out of the airflow path. The instrument inlet was positioned on the met-platform and was approximately 30m in length. A total flow rate of 19 slpm was used with a sample rate of 5Hz. Calibrations were undertaken every 2-3 hours. Regular zeros (using scrubbed compressed air supplied by a Jun-air compressor, situated in the mooring deck) were undertaken, for 5-8 minutes at a time. Calibrations at the top of the inlet were also done to account for any inlet losses (e.g. from water) and were spaced throughout the cruise.

Preliminary results

During the first week of the cruise, the instrument was non-operational due to a wiring fault and faulty regulators. Flux calculations have not yet been processed, and neither has comparison data, but we present preliminary v1 SO_2 concentration data below.

Since then, we have observed SO_2 during the duration of the cruise, with coverage of 23 days. Ambient concentrations of SO_2 have been as low as <10ppt and shown increases up to ~150ppt at times (excluding plumes). Concentrations remained low during the morning, increasing towards the early afternoon and then dropping off again later in the night. Filters at the inlet were changed regularly so as not to lead to an accumulation of sea-salt, aerosols, water etc. that may react with the SO_2.

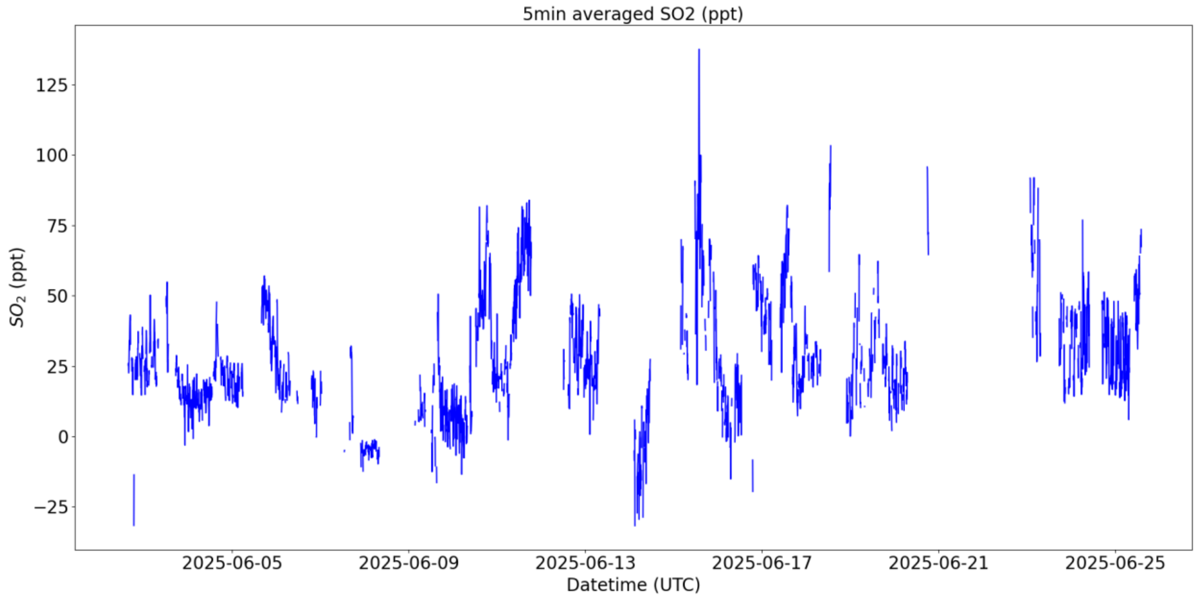

Figure 35: SO_2 concentrations during DY195 (averaged to 1min).

The instrument was also left on during the time that the atmospherics were out of sector and were sampling the ship's stack, due to the need for constant conditioning of the reference cell. This data could be used to quantify SO_2/CO_2 emission ratios for the ship. Plumes became more frequent on the 22/06/2025 due to the proximity to shipping lanes, on our return to Southampton.

Comparison tests were successful with the LIF and the CIMS and they comprised of:

- Inlet testing: as both instruments were being run on their own inlet for most of the cruise, both instruments were hooked up to each other's inlet at the same time, to sample ambient, zero air and a calibration.
- Calibration tests: comparisons of calibration standards were conducted at intervals throughout the cruise.
- Isotope testing: the CIMS uses an isotopically labelled 34SO2 standard whereas the LIF does not. Addition of the isotope whilst the LIF was on the CIMS line did not show any deviation from ambient, which was expected in the current set-up. However, it does give another avenue for further development of the LIF to try and distinguish between the two isotopes.
- Ambient air: we were able to distinguish similar trends within our data but have not gone any further than this.

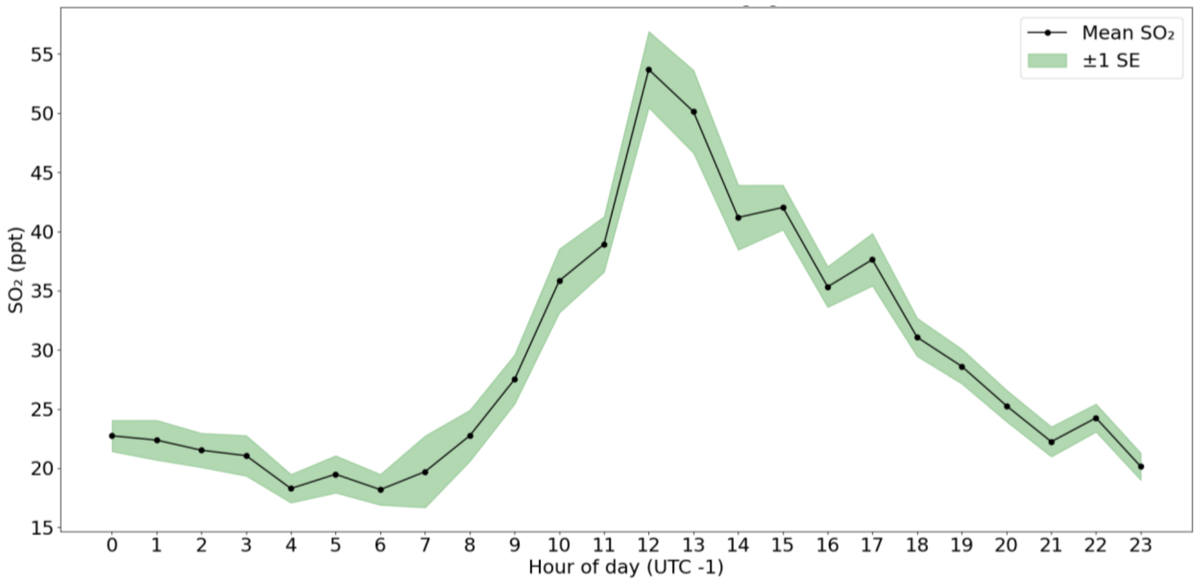

Figure 36: Diurnal cycle of SO_2 for the cruise.

7.2.3 Eddy covariance SO_2 flux measurements

Lead: Jared Novelly (jnovelly@uci.edu); Department of Earth System Science, University of California, Irvine (UCI), CA, USA

Objectives

Measurement of concentration and flux of Sulfur dioxide (SO_2) in the North Atlantic open ocean. Compare open ocean flux measurements of SO_2 to coastal flux measurements of SO_2 (Porter, 2018). Investigate the physical processes that control air-sea flux of SO_2 and soluble trace gases.

Methods

A Chemical Ionization Mass Spectrometer known as Red-CIMS is mounted within the NMF container on the foredeck. A ~25m length of 3/8th" PTFE tubing runs from the NMF container to the meteorological mast at the front of the ship. At the mast a vertical pole is mounted adjacent to a sonic anemometer. On the vertical pole is a 24" Nafion dryer is followed by a 90mm PTFE filter. The Nafion dryer reduces water vapor to reduce instrument noise and condensation in the long inlet line. The PTFE filter has a 5µm pore size removing particulates from the flow decreasing losses from particulate build up on the tubing and protecting the Nafion dryer. At the end of the tubing is a tee to introduce isotope $^{34}SO_2$ standard to measure losses from the tubing, filter and dryer.

A constant flow of 19l/min is maintained by a graphite vane pump. A sub flow of 3l/min is taken from the main flow into the system for sulfur dioxide measurements. The SO2 measurement is made using SF^-_6 ion chemistry to form ions for analysis. The system makes the measurement at 5 Hz. Periodic backgrounds are done using activated charcoal and carbonate coated glass wool in stainless steel housing. Standard addition from a 5ppm SO2 cylinder from MESA Gas is introduced to assess instrument sensitivity. Scans of the mass spectrum are done for data quality assurance.

In tandem with the CIMS operation there are two sonic anemometers mounted at the top of meteorological mast measuring the three-dimensional wind at 10Hz. This data is used to compute covariance between SO_2 concentration and wind measurements to give a flux.

Continuous measurements were made depending on instrument status. Ship heading relative to the wind impacts the ability to measure flux and concentration.

References:

Porter, J. G., De Bruyn, W., and Saltzman, E. S.: Eddy flux measurements of sulfur dioxide deposition to the sea surface, Atmos. Chem. Phys., 18, 15291–15305, https://doi.org/10.5194/acp-18-15291-2018, 2018.

7.2.4 Gas- and particle-phase DMS oxidation products and aerosol distribution

Lead: Rongrong Wu (Rongrong.wu@manchester.ac.uk); Department of Earth and Environmental Science, University of Manchester, Manchester, UK

Objectives

Marine sulfate aerosol originated from biogenic dimethyl sulfide (DMS) is the main component of natural aerosol over oceanic regions. Recent discoveries of organic sulfur molecules formed from DMS oxidation (Berndt et al., 2019; Veres et al., 2020; Ye et al., 2022) open a new window for us to explore the role of DMS in the climate system. To investigate the chemical pathways and main products of DMS oxidation, sulfur-containing species as well as other organic molecules were measured by the Vocus Time-of-Flight Chemical Ionization Mass Spectrometer (Vocus-ToF-CIMS) coupled with the Filter Inlet for Gases and Aerosols (FIGAERO), hereafter FIGAERO-CIMS, during CARES cruise.

In addition, a series of particle measuring instruments, including Scanning Mobility Particle Sizer (SMPS), Condensation particle Counter (CPC), Aerodynamic Particle Sizer (APS), Aethalometer and an Aerosol Mass Spectrometer (AMS) were deployed to characterize particle size, distributions, number concentrations, black carbon mass concentration, optical absorption coefficients and aerosol chemical composition, respectively.

Methods

The FIGAERO-CIMS utilizing Iodide (I^-) and Bromide (Br^-) as reagent ions was deployed in the container of RRS Discovery scientific ship to measure sulfur species and other organic molecules in both gas and particle phase. The FIGAERO inlet was coupled to the Ion Molecule Reaction (IMR) of the AIM reactor, which was in turn coupled to the high-resolution Vocus-ToF-CIMS (m/Δm ~ 10,000). The FIGAERO inlet was first introduced by Lopez-Hilfiker et al. (2014). It is essentially a multi-port manifold, as shown in Figure 37, which measures the trace gases while simultaneously collecting particles on a PTFE filter via a dedicated port and thereafter analyses the chemical composition of the collected particles through temperature-programmed thermal desorption (Lopez-Hilfiker et al., 2014). When in the thermal desorption mode, the PTFE filter was moved to the exclusive port for thermal desorption, while the air path of gas-phase port to the mass spectrometer was blocked by the moveable tray. A typical gas-phase sampling and filter desorption time series of ambient measurements is shown in Figure 38. The instrument was continuously cycled between gas (Figure 38, G') and particle (Figure 38, P') analysis, with periodic zeroing during gas-phase analysis. Meanwhile, the instrument switched the ionization scheme between I^- and Br^- every 5 minutes during gas analysis but remained in one mode during thermal desorption.

During the gas analysis, ambient air was sampled through a 3/8 inch OD PTFE tube that extended from the gas-phase inlet above the container at a flow rate up to 15 SLPM. The inlet outside the container was heated to 40 ˚C and that inside the container was kept at 30 ˚C. During the gas analysis, ambient air was simultaneously suck by a vacuum pump from the aerosol sampling inlet mounted along with the gas-phase inlet through a separate port at a flow rate of 3 or 4 SLPM and particles were collected onto a PTFE filter placed in this port. After about 3 hours for gas-phase analysis and particle collection, the filter was moved from collection port to the desorption port by the tray and particle-phase analysis initiated. As the particle analysis began, a mass flow controller delivered 2 SLPM of Ultra-high purity N_2 over the filter. The N_2 was delivered through the central heated tube on the manifold (Figure 38) which was ramped to 300 ˚C in 20 minutes and then held at 300 ˚C for 20 minutes during a period denoted as 'soak' in order to leave the filter at high temperature for some time so that all the organics can be desorbed and thus with no residues remaining. Finally, it cooled down to room temperature (25 ˚C) over 10 minutes. After that, it returned to gas analysis mode by sliding the tray until the filter was moved back to the collection port and unblocked the exit port used for gas-phase analysis. The operation of the FIGAERO (including temperature programming, flow setting, tray moving) was controlled automatically using the EyeON software.

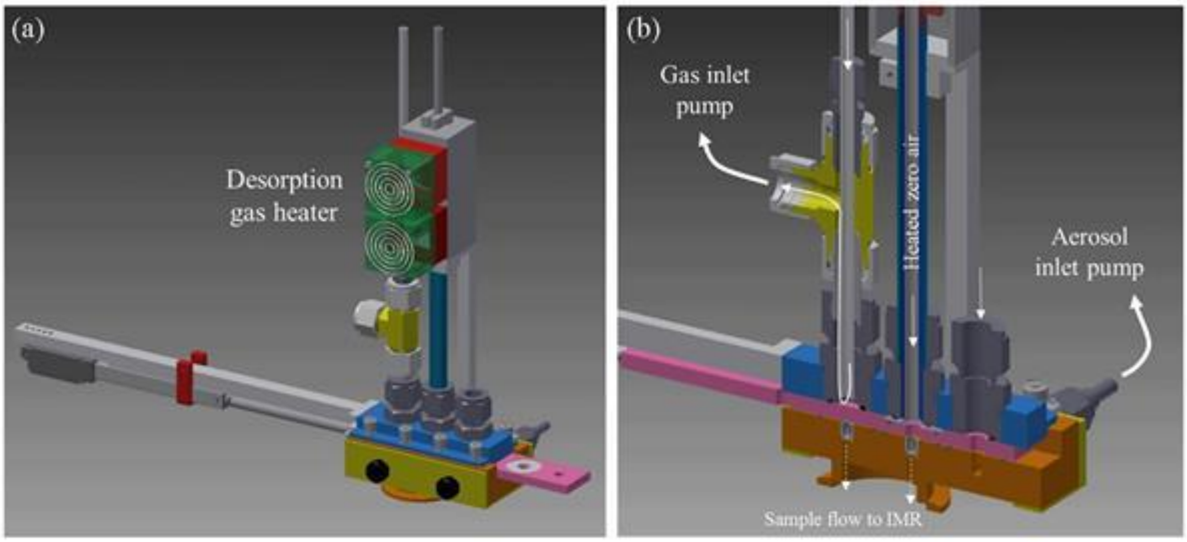

Figure 37: Schematic of the FIGAERO inlet (Adapted from Bannan et al., 2019). Panel (a) shows the full assembly with a mechanical actuator that controls gas sampling and aerosol collection or aerosol desorption. Panel (b) is a cross-sectional view that show flows for both gas and particle sampling mode. In this view the FIGAERO slide is positioned in the aerosol desorption mode, and the gas sample into the IMR is blocked.

The AMS was also deployed to retrieve the chemical composition of ambient marine aerosol. Ambient aerosol was focused into a vacuum chamber (~ 10^{-5} Torr) using aerodynamic particle beam-forming lens. Particles were then flash vaporized by impacting on the surface of a closed-end tube heated at 600 ◦C. This vaporiser was heated by applying an electric current (~ 3.5 A) to a coiled tungsten wire inside the tube. The vaporized gaseous molecules were then ionised by electron ionisation (70 eV) before being transmitted through a quadrupole to an electron multiplier for detection. Unfortunately, the tungsten wire necessary for aerosol vaporization blew shortly after departing from Southampton, and therefore the AMS was not operational for most of the campaign.

The TSI SMPS measured the size and number concentration of airborne particles ranging from 1 nm to 1000 nm. It consists of a Differential Mobility Analyser (DMA) to separate particles according to their electrical mobility. To be measured by the DMA, particles were charged by a neutralizer. After passing through the DMA, particles were counted with a CPC.

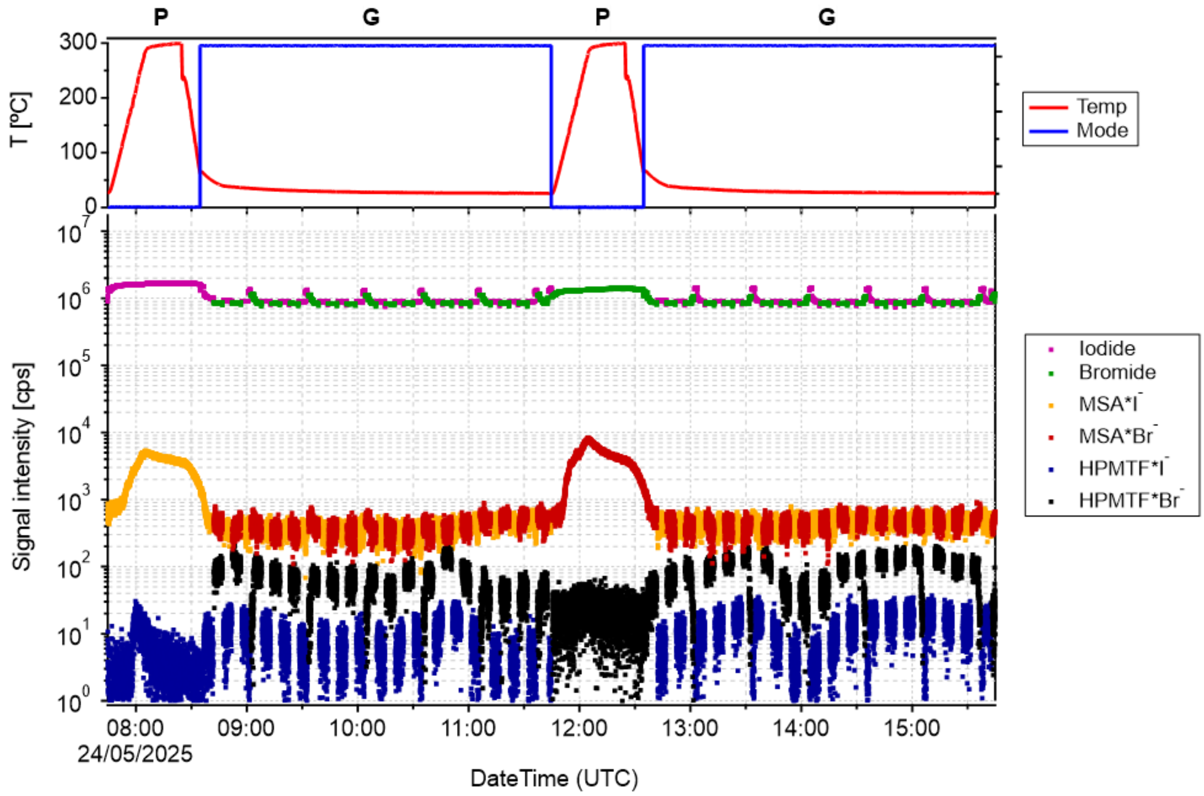

Figure 38: Ambient FIGAERO measurements on 24th May 2025. Top panel shows FIGAERO manifold operation mode (blue solid line) switching between gas-phase analysis and particle collection (high) and particle thermal desorption (low), and heating temperature (red solid line) during thermol desorption. Modes are denoted by text od 'p' for particle thermal desorption and 'G' for gas-phase analysis and particle collection. Bottom panel shows time series of selected ions during the whole operation modes.

Two TSI CPCs detected and counted aerosol particles in parallel. This was achieved by first saturating the aerosol inflow with water. Then the humified air enters the cooler, which creates a supersaturation condition where the vapor is more concentrated than it could be under given temperature. Nucleation then occurs as the supersaturated vapor condenses onto existing particles which behave as condensation nuclei and consequently particles grow to measurable sizes. The temperature difference between the heater and cooler determines the supersaturation, which determines the minimal detectable size of particles. The enlarged particles then pass through an optical system where light is scattered by particles and thus can be counted by measuring the scattered light using a photo detector. In order to study new-particle formation, one of the CPC had a cutoff of 2 nm while the other had a cutoff of 7 nm.

The TSI APS measures size distribution of particles by measuring the time particles take to travel though a known distance after being accelerated. Particles were drawn into the instrument and accelerated via a nozzle, creating a particle stream which then passed through two laser beams set in a known distance and created a detectable light-scattering pulse. Due to higher inertia, larger particles move slower than smaller particles and thus they take longer to pass through the same distance, allowing for size discrimination by measuring the time difference between the pulses produced by each particle at two laser beams. The recorded time of flight is then used to calculate particles' aerodynamic diameters.

The Magee Aethalometer uses a continuously advancing filter tap to collect particles and measure simultaneously the optical transmissions of light through a spot on the filter where particles were deposited and accumulated. The more light-absorbing particles collected accumulated on the spot, the lower the intensity of transmitted light. Consequently, the concentration of light-absorbing particles, primarily black carbon (BC) in ambient air could be derived by measuring the intensities of light transmitted through the sample spots.

Preliminary results

Particles counts and diameter

Particle number concentration from May 28th to noon of June 7th was approximately in the range of 100 to 1000 cm^{-3} (Figure 39, consistent with the typical aerosol number concentrations in clean air masses in the marine boundary layer (Spracklen et al., 2010; Byčenkienė et al., 2013; Mohrmann et al., 2018; Miyakawa et al., 2023). However, significant spikes of particle number concentration were observed, such as the 3rd and 5th of June, which are thought to correspond to periods when the instruments were sampling ship emissions instead of sampling pristine marine air due to change of cruise direction. A momentary drop in the particle number concentration was observed around the 9th of June. This was due to precipitation acting as a particle sink via wet deposition during that time. The particle concentration increased to pre-rainfall levels after June 10th.

The evolution of the particles geometric mean diameter as recorded by the APS and SMPS is presented in Figure 39B. The geometric mean diameter of particles between 0.5-20 nm monitored by the APS was generally quite low (between 0.8-1.0 nm), suggesting that most of these particles were newly formed and they didn't significantly grow probably due to a lack of condensation or reactive uptake sinks for their growth. The geometric mean diameter of larger particles measured by the SMPS varied considerably over the sampling period, from ~ 20 to 200 nm.

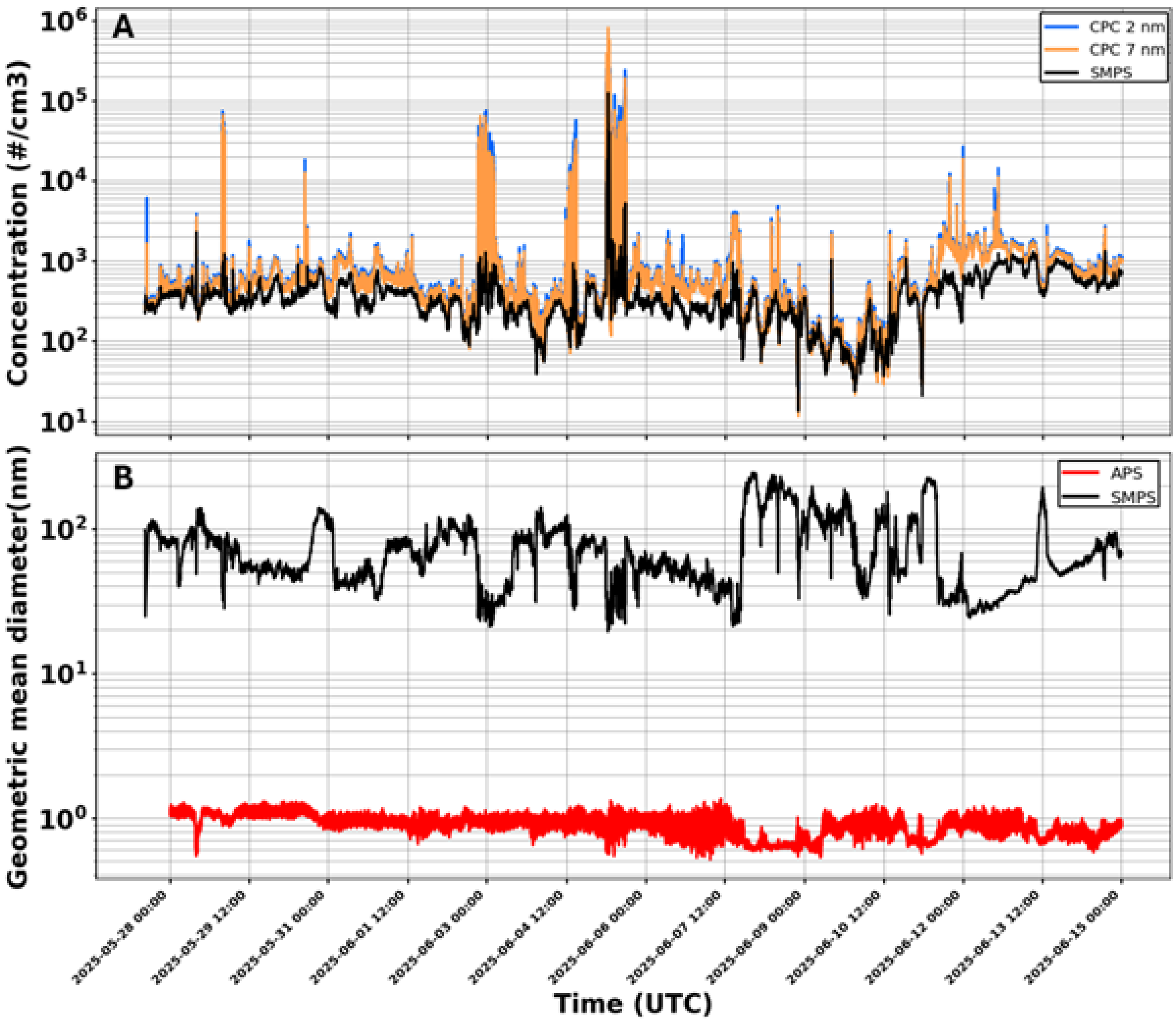

Figure 39: Ambient (A) particles concentration measured by the two CPCs (blue and orange lines for the CPCs with a 2 nm and 7 nm cutoff, respectively) and the SMPS (black line), and (B) particles geometric mean diameter measured by the APS (red line) and the SMPS (black line), and (B) particles geometric mean diameter measured by the APS (red line) and the SMPS (black line)

DMS oxidation products

Hydroperoxymethyl thioformate (HPMTF) is one of the key products formed from DMS oxidation and it plays an important role in marine aerosol formation, growth and global cloud condensation nuclei (CCN) distribution (Veres et al., 2020; Vermeuel et al., 2020). In addition, methanesulfonic acid (MSA) and sulfuric acid (H_2SO_4) are important products of DMS oxidation, which have been shown to readily produce CCN (Charlson et al., 1987; Putaud et al., 1999; Kulmala et al., 2000; Lucas and Prinn 2003; Von Glasow and Crutzen 2004). The time series of HPMTF, MSA and H_2SO_4 are shown in Figure 40. In general, HPMTF mainly exists in the gas phase, while MSA and H_2SO_4 are more in the particle phase. Diurnal structures of HPMTF can be observed on the 7th, 9th and 12th of June (Figure 40A), which is coherent with the stronger photochemical oxidation during daytime. This is seen more clearly in Figure 40D, which shows the evolution of HPMTF on June 9th. Similar increases can be seen from MSA in the iodide channel (Figure 40B). Important spikes in MSA signals can be observed during thermal desorptions of aerosol particles accumulated on the FIGAERO filter, indicating that MSA is ready to condense onto pre-existing particles or even efficient to form new particles. Similarly, H_2SO_4 was mostly present in particle-phase (Figure 40C).

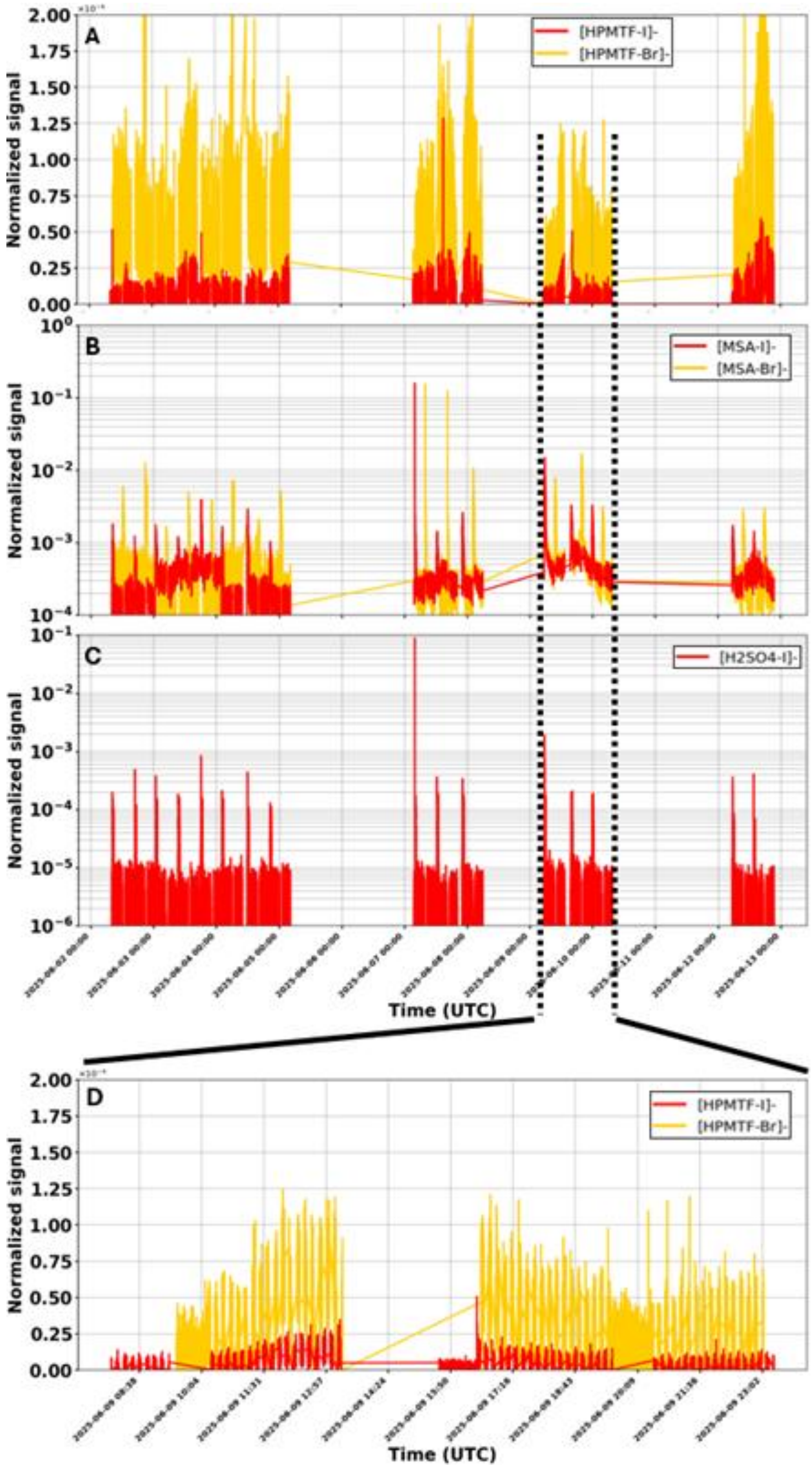

Figure 40: Ambient measurement of (A) HPMTF, (B) MSA and (C) H2SO4 using the FIGAERO-CIMS. (D) shows a closer look to the evolution of HPMTF signals on the June 9th. Iodide adduct ions are shown as red lines while the bromide adduct ions appear as yellow lines.

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7.2.5 High volume aerosol sample collection

Lead: Tom Bell (tbe@pml.ac.uk); Plymouth Marine Laboratory, Plymouth, UK

High volume (~1m^3/min) atmospheric aerosol filter samples were collected to measure important particulate sulfur compounds (e.g. MSA, sulfate) as well as other major ions in during the CARES campaign (e.g. sodium is used to calculate the non-sea salt sulfate fraction). The aerosol sampler was situated on the deck directly above the Bridge of the RRS Discovery. Conventional Whatman 41 filter substrates were used as part of a cascade impactor to discriminate between fine mode aerosol particles (< 1 µm) and coarse mode particles (>1 µm). The slotted coarse mode filters ran out during the cruise, and new ones were cut out of the fine mode filters using a template (this began on 11th June).

The aerosol sampler was automatically turned off when there was a risk of contamination from the ship's stack. A data feed from the ship's anemometer was monitored for relative wind direction and wind speed. Thresholds were used to determine when the sampler should be turned on/off, with input data averaged to avoid the power to the sampler being turned on/off too rapidly. Some thresholds were adjusted after preliminary analysis of other data (e.g. CO_2 and particle number concentration from the containers) during the cruise. The relative wind direction thresholds were initially set to collect sample between 275° and 85° but were adjusted to 300° and 60° on 4th June. Data averaging was also adjusted on the same day, smoothing input data over 30 seconds (60 seconds prior to 4th June). The wind speed threshold was 1.5 m/sec throughout the cruise.

Filter samples were changed daily, and the period of sampling depended on the amount of time that winds were out of sector (typically <1 hr per day). Filters were changed in a laminar flow cabinet and subsequently frozen.

All subsequent analysis of aerosol filters will take place at NOAA/PMEL (the contact for this work is Becky Alexander, based at University of Washington; beckya@uw.edu). A number of exposure blanks (filter put into cassette holder, but pump not turned on) were conducted during the cruise. A log of all samples and blanks collected is shown in Table 43.

Table 43: Aerosol sampling log

Sample number	Name of Persons	Elapsed Time On (HH:MM)	Sampler Date and Time Power ON:	Sampler Date and Time Power OFF:	Elapsed Time On (HH:MM)	Notes
DY195_1	Alicia and Jolynn	224.54	29/05/25 10:15	30/05/25 09:50	248.08	
DY195_2	Alicia and Jolynn	248.08	30/05/25 10:30	31/05/25 09:49	271.22	
DY195_3	Alicia and Jolynn	271.22	31/05/25 10:30	01/06/25 09:48	294.47	

DY195_4	Alicia and Jolynn	294.47	01/06/25 10:10	02/06/25 09:48	318.13	
DY195_5	Alicia and Jolynn	318.13	02/06/25 10:17	03/06/25 10:10	338.21	
DY195_6	Alicia and Jolynn	338.21	03/06/25 10:37	04/06/25 10:03	361.68	
DY195_7	Alicia and Jolynn	361.68	04/06/25 10:32	05/06/25 10:05	377.13	
DY195_8	Alicia and Jolynn	377.13	05/06/25 10:30	07/06/25 09:40	395.77	
DY195_9	Alicia and Jolynn	395.77	07/06/25 10:20	08/06/25 10:00	440.41	
DY195_B1	Alicia and Jolynn	440.41	08/06/25 10:10 (not powered on)	08/06/25 10:30	440.41	The filter was left on Monkey Island between 10:10 and 10:30, it was not powered on during this time. It was treated as usual, for use as a comparison for possible contamination
DY195_10	Alicia and Jolynn	440.41	09/06/25 10:05	10/06/25 09:52	464.27	
DY195_11	Alicia and Jolynn	464.27	10/06/25 10:17	11/06/25 10:02	487.84	
DY195_12	Alicia and Jolynn	487.84	11/06/25 10:03	11/06/25 10:30	507.33	
DY195_13	Alicia and Jolynn	507.33	12/06/25 10:20	13/06/25 10:00	527.28	
DY195_14	Alicia and Jolynn	527.28	13/06/25 10:30	14/06/25 10:10	550:90	
DY195_15	Alicia and Jolynn	550:90	14/06/25 10:40	15/06/25 10:03	573.94	
DY195_16	Alicia and Jolynn	573.94	15/06/25 10:35	16/06/25 09:57	597.25	

DY195_17	Alicia and Jolynn	597.25	16/06/25 10:20	17/06/25 10:08	621.05	
DY195_18	Alicia and Jolynn	621.05	17/06/25 10:35	18/06/25 09:50	640.01	
DY195_19	Alicia and Jolynn	640.01	18/06/25 10:18	19/06/25 09:57	663.66	
DY195_20	Alicia and Jolynn	663.66	19/06/25 10:15	20/06/25 10:00	686.32	
DY195_21	Alicia and Jolynn	686.32	20/06/25 10:35	21/06/25 10:01	687.25	
DY195_22	Alicia and Jolynn	687.25	21/06/25 10:15	22/06/25 09:35	687.25	Exposure blank 0 hours on
DY195_23	Alicia and Jolynn	687.25	22/06/25 10:00	24/06/25 10:14	704.89	Was running for 2 days straight. It was not on properly first day; had ran 0 hours (22nd-23rd)
DY195_24	Alicia and Jolynn	706.89	24/06/25 10:30	25/06/25 09:55	706.89	Exposure blank 0 hours on

7.2.6 Detection of atmospheric selenium

Lead: Ken Hagiya (khagiya@chem.ubc.ca); *Department of Chemistry, University of British Columbia, Vancouver, Canada*

Objectives

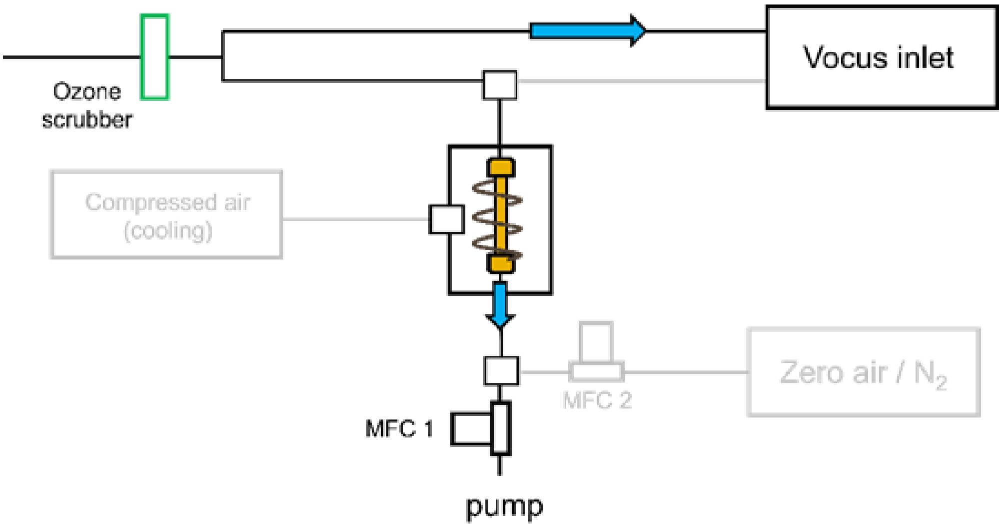
- To perform the world's first rapid detection of atmospheric selenium
- Deploy a prototype thermal-desorption pre-concentrator unit attached to the Vocus S PTR-ToF MS
- Simultaneously detect trace atmospheric VOC's that are below the limit of detection of any other analytical instrument onboard.

Motivation

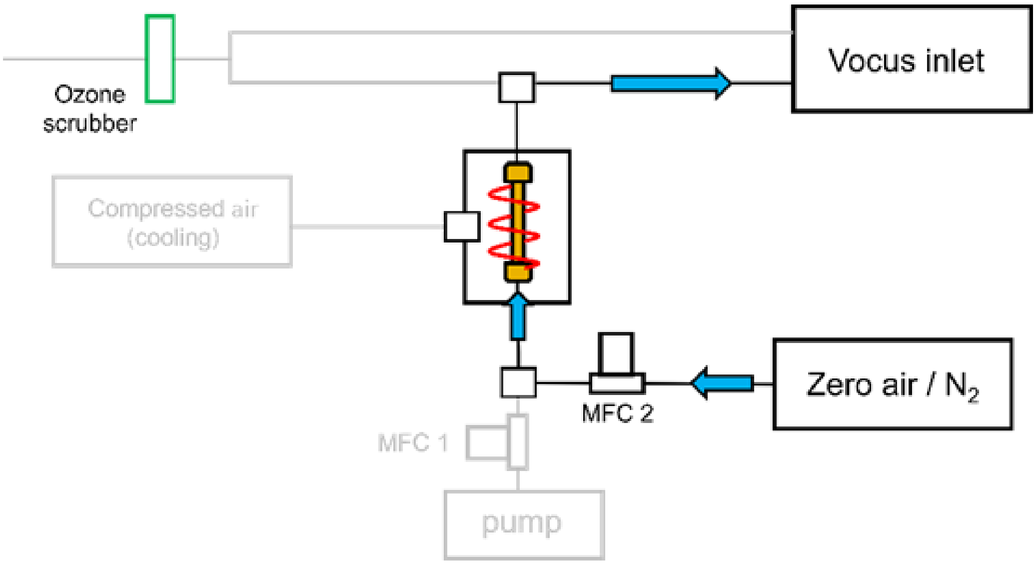
An automatic thermal-desorption pre-concentrator was developed at the University of British Columbia (UBC) to be used in conjunction with the Vocus S proton-transfer time-of-flight mass-spectrometer. The combined systems are hereby called the TD-Vocus. Briefly, the detection of volatile organic compounds (VOC's) at exceedingly low mixing ratios (e.g. ppq levels) have posed challenges due to lying below the limit of detection of most analytical instruments. Traditionally, sorbent tubes containing adsorbent material (i.e. Tenax, Carbograph) have been used to preconcentrate ambient air, stored at low temperatures, and the contents desorbed into an analytical instrument. However, this method suffers from low time resolution, and the storing of sorbent tubes for extended periods of time may lead to degradation and/or unwanted reactions taking place. A preconcentration event followed by rapid detection is needed to study dynamic chemical systems in the low ppq regime.

Methods

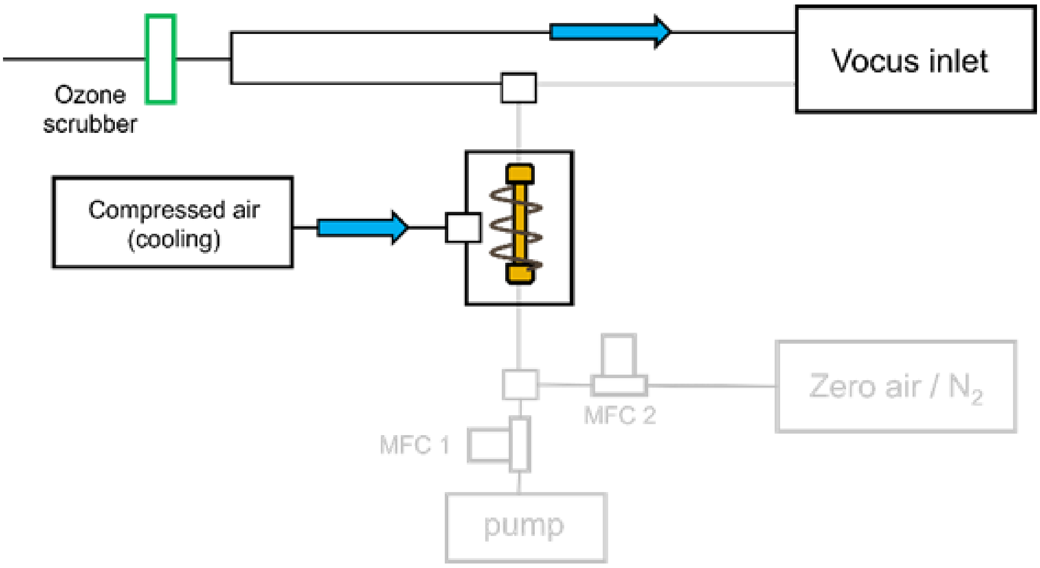
Thermal desorption unit: The following are schematics of the three steps within TD-Vocus. Blue arrows indicate air flow, mass flow controllers (MFC) regulate air flow, an inductive coil provides heating, and valves direct air flow.



***Step 1**: 2-4L of ambient air is concentrated in the sorbent tube at room temperature. The Vocus simultaneously samples ambient air*



***Step 2**: VOCs in the sorbent tube are desorbed into the Vocus at 200 °C using a stream of N_2.*



***Step 3**: Compressed air cools the sorbent tube back to room temperature to being the next cycle. For DY 195, a small desktop fan was used instead for cooling.*

Sorbent tubes were manufactured at the Max Planck Institute, Mainz, and is a ¼ in siliconized steel tube filled with a hybrid of Tenax and Carbograph. During the adsorbent phase, the sorbent tube sampled air at 0.2 LPM for 10-20 minutes, followed by desorption using N_2 into the Vocus at 0.1 LPM for 3 minutes. Every other thermal desorption event, a sorbent tube zero was done by repeating the above two steps but by sampling zero air. The sorbent tube was replaced after 150 such cycles

Container set-up: The TD-Vocus was secured in the Manchester container and connected to a heated gas-phase inlet sticking a few metres above the container. The container's interior temperature was regulated at 21 °C by an air-conditioning unit. For an internal standard, a cylinder (1000 bars) of d6-acetone (99.9%; Sigma-Aldrich) in an N_2 matrix was continuously flowed into the Vocus at 1 sccm to track PTR ion chemistry and as a qualitative indicator for sorbent tube lifetime. A PTFE filter was placed before both the TD and Vocus inlets. In addition, an oxidant scrubber was placed before the TD inlet. Oxidant scrubbers were prepared by soaking a 47mm quartz filter (2.2 µm pore size; Whatman) in a 1:10 solution of $Na_2S_2O_3 \cdot 5H_2O$ (≥ 99.0%; VWR): milliQ water then dried under air. During sorbent tube sampling periods, ambient air was also measured by the Vocus.

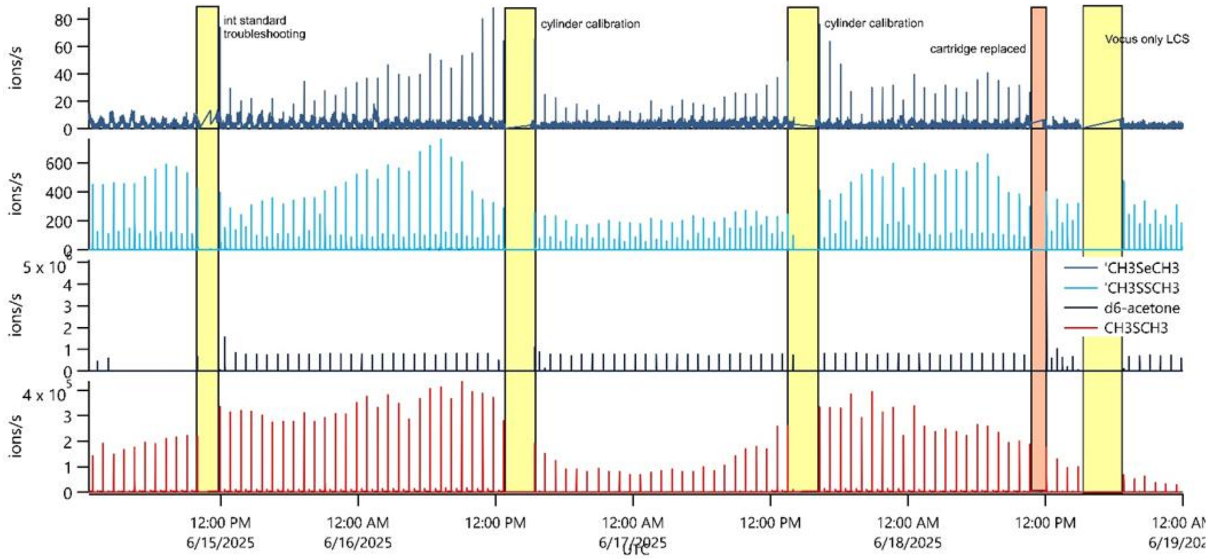
Figure 41: (Left) colleagues Paul Heine and Nathan Pennie. (Right) The gas-phase inlet.

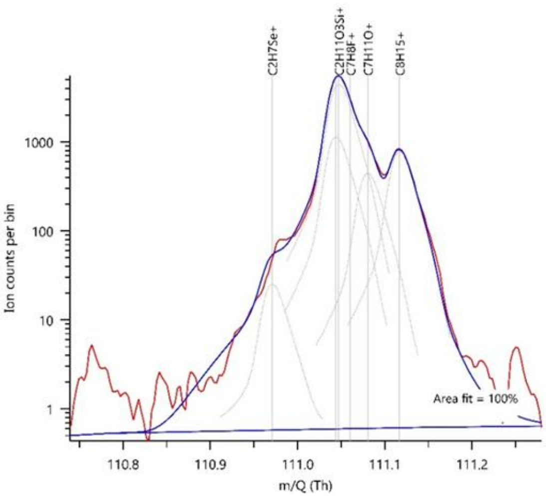
My colleagues Paul Heine and Nathan Pennie (Figure 41 (Left)) developed the TD-Vocus and stood proudly beside the instrument during mobilization. To the front and back of the TD-Vocus are Manchester's AMS and FIGAERO, respectively. (Figure 41 (right)) The gas-phase inlet is an insulated ¼ in. PFA tubing that sticks several metres above the Manchester container. A plastic funnel prevents water ingression into the tube.

Vocus PTR-ToF MS: The Vocus S PTR-ToF MS (TOFWERK AG / Aerodyne Research, Inc) uses a reagent ion source of H_3O^+ set at a flow of 20 mL min^{-1}. An incoming stream of sampled air at 0.1L min^{-1} is reacted with H_3O^+ in a focusing ion-molecule reactor (FIMR). The FIMR was heated to 100 °C and kept at 2.5 mbar. The Vocus outputs a high-resolution mass spectrum from 7 – 497 m/z with time resolution 1 Hz and a mass resolving power of m/Δm = 5000.

Calibrations: Every few days, a cylinder calibration of the Vocus was performed. We borrowed the cylinder provided by PML containing 20 VOCs in an N_2 matrix. In addition, calibrations of dimethyl sulfide (DMS), dimethyl selenide (DMSe), dimethyl disulfide (DMDS), and dimethyl diselenide (DMDSe) were performed using a liquid calibration system (LCS). The LCS operates by preparing a standard solution containing the calibrants, which is volatilized at 120 °C with a liquid flow of 20 µL/min and subsequently diluted by N_2 ranging from 0.5 to 2 LPM.

Preliminary Results





Points of collaboration

Detection of single-chain aldehydes in the atmosphere via thermal desorption is of interest to Hyunjin and Marvin. Their sensitivities can be estimated from the cylinder calibrations, and further lab work is required to understand aldehyde behaviour and retention within the cartridges.

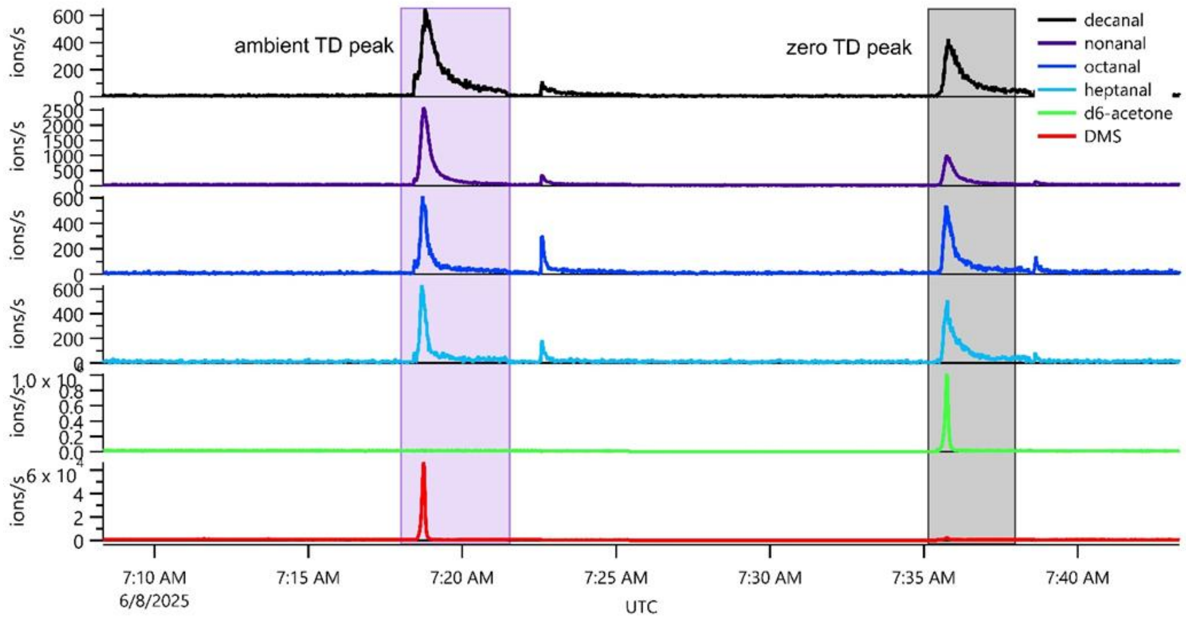


Figure 42: Time series of aldehydes decanal, nonanal, octanal and heptanal.

Acknowledgement

I would first like to acknowledge the captain and crew of *RRS Discovery* for ensuring a safe, enjoyable, and fruitful scientific campaign. DY 195 would not be possible without the tireless work of principal scientists Thomas Bell, Ming-Xi Yang, and Jez Evans. Full credit goes to Paul Heine and Nathan Pennie, as well as the mechanical and electrical departments at UBC, for developing the thermal desorption unit. I am further indebted to my supervisor, Dr. Nadine Borduas-Dedekind, for providing me with this opportunity and for her amazing support along the way. Finally, warm thanks to my colleagues Ayomide Akande and Bingying Zhao for their remote support with instrument operation and data analysis.

Appendices

Table A: CTD casts sampled for phytoplankton and heterotrophic bacteria community identification

sample id	#	equipment	station number	station info	date of sampling	depth of sample (m)	amount filtered - DNA (ml)
A-P-1-1	001	towed fish	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	1	1000
A-P-6-1	002	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	6	1000
A-P-10-1	003	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	10	1000
A-P-20-1	004	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	20	1000
A-P-30-1	005	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	30	1000
A-P-40-1	006	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	40	1000
A-P-100-1	007	CTD 02	1	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	150	1000
A-P-1-2	008	towed fish	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	1	1000
A-P-3-2	009	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	3	1000
A-P-6-2	010	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	6	1000
A-P-10-2	011	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	10	1000
A-P-20-2	012	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	20	1000
A-P-30-2	013	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	30	1000
A-P-40-2	014	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	40	1000
A-P-100-2	015	CTD 03	1	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	100	1000
A-P-1-3	016	towed fish	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	1	1000
A-P-4-3	017	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	4	1000
A-P-6-3	018	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	6	1000
A-P-10-3	019	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	10	1000
A-P-20-3	020	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	20	1000

A-P-30-3	021	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	30	1000
A-P-40-3	022	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	40	1000
A-P-100-3	023	CTD 4	1	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	150	1000
B-P-1-1	024	towed fish	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	1	1000
B-P-6-1	025	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	6	1000
B-P-10-1	026	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	10	1000
B-P-20-1	027	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	20	1000
B-P-30-1	028	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	30	1000
B-P-40-1	029	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	40	1000
B-P-55-1	030	CTD 6	2	Station **2** 29 39.76470'N; 018 36.36330'W	31/05/2025	55	1000
B-P-1-2	031	towed fish	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	1	1000
B-P-6-2	032	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	6	1000
B-P-10-2	033	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	10	1000
B-P-20-2	034	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	20	1000
B-P-30-2	035	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	30	1000
B-P-40-2	036	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	40	1000
B-P-50-2	037	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	50	1000
B-P-150-2	038	CTD 07	2	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	150	1000
B-P-6-3	040	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	6	1000
B-P-10-3	041	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	10	1000
B-P-25-3	042	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	25	1000
B-P-40-3	043	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	40	1000
B-P-50-3	044	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	50	1000
B-P-60-3	045	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	60	1000

B-P-100-3	046	CTD 8	3	Station **3** 51 24.92922'N; 020 12.13014'W	2/6/2025	100	1000
C-P-1-1	047	towed fish	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	1	1000
C-P-6-1	048	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	6	1000
C-P-10-1	049	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	10	1000
C-P-20-1	050	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	20	1000
C-P-30-1	051	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	30	1000
C-P-40-1	052	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	40	1000
C-P-50-1	053	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	50	1000
C-P-100-1	054	CTD 9	4	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	100	1000
C-P-1-2	055	towed fish	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	1	1000
C-P-6-2	056	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	6	200
C-P-10-2	057	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	10	1000
C-P-20-2	058	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	20	1000
C-P-30-2	059	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	30	1000
C-P-40-2	060	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	40	1000
C-P-50-2	061	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	50	1000
C-P-100-2	062	CTD 10	4	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	100	1000
C-P-6-3	063	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	6	1000
C-P-10-3	064	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	10	1000
C-P-20-3	065	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	20	1000
C-P-35-3	066	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	35	1000
C-P-50-3	067	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	50	1000
C-P-60-3	068	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	60	1000

C-P-100-3	069	CTD 11	4	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	100	1000
D-P-1-1	070	towed fish	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	1	1000
D-P-5-1	071	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	5	1000
D-P-10-1	072	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	10	1000
D-P-20-1	073	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	20	1000
D-P-30-1	074	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	30	1000
D-P-40-1	075	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	40	1000
D-P-55-1	076	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	55	1000
D-P-100-1	077	CTD 12	5	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	100	1000
D-P-1-2	078	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	1	1000
D-P-4-2	079	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	4	1000
D-P-10-2	080	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	10	1000
D-P-20-2	081	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	20	1000
D-P-30-2	082	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	30	1000
D-P-40-2	083	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	40	1000
D-P-50-2	084	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	50	1000
D-P-100-2	085	CTD 13	5	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	100	1000
D-P-4-3	086	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	4	1000
D-P-10-3	087	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	10	1000
D-P-20-3	088	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	20	1000
D-P-30-3	089	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	30	1000
D-P-40-3	090	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	40	1000
D-P-55-3	091	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	55	1000

D-P-100-3	092	CTD 14	5	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	100	1000
E-P-1-1	093	towed fish	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	0.3	1000
E-P-4-1	094	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	4	1000
E-P-10-1	095	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	10	1000
E-P-25-1	096	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	25	1000
E-P-40-1	097	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	40	1000
E-P-45-1	098	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	45	1000
E-P-55-1	099	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	55	1000
E-P-100-1	100	CTD 15	6	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	100	1000
E-P-4-2	101	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	4	1000
E-P-10-2	102	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	10	1000
E-P-20-2	103	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	20	1000
E-P-35-2	104	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	35	1000
E-P-45-2	105	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	45	1000
E-P-55-2	106	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	55	1000
E-P-100-8	107	CTD 16	6	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	100	1000
E-P-4-3	108	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	4	1000
E-P-10-3	109	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	10	1000
E-P-20-3	110	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	20	1000
E-P-30-3	111	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	30	1000
E-P-50-3	112	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	50	1000
E-P-64-3	113	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	64	1000
E-P-80-3	114	CTD 17	6	Station **6** 51 41.07924'N; 018 20.17776'W	11/6/2025	80	1000

G-P-4-1	115	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	4	1000
G-P-10-1	116	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	10	1000
G-P-25-1	117	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	25	1000
G-P-30-1	118	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	30	1000
G-P-40-1	119	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	40	1000
G-P-50-1	120	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	50	1000
G-P-100-1	121	CTD 24	7	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	100	1000
G-P-1-2	122	towed fish	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	1	1000
G-P-3-2	123	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	3	1000
G-P-10-2	124	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	10	1000
G-P-25-2	125	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	25	1000
G-P-35-2	126	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	35	1000
G-P-48-2	127	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	48	1000
G-P-60-2	128	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	60	1000
G-P-100-2	129	CTD 25	7	Station **7** 51 54.96036'N; 021 17.78466'W	13/06/2025	100	1000
G-P-3-3	130	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	3	1000
G-P-10-3	131	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	10	1000
G-P-20-3	132	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	20	1000
G-P-30-3	133	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	30	1000
G-P-40-3	134	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	40	1000
G-P-50-3	135	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	50	1000
G-P-100-3	136	CTD 26	7	Station **7** 51 34.71966'N; 020 55.23750'W	14/06/2025	100	1000
H-P-3-1	137	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	3	1000

H-P-10-1	138	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	10	1000
H-P-20-1	139	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	20	1000
H-P-40-1	140	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	40	1000
H-P-50-1	141	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	50	1000
H-P-60-1	142	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	60	1000
H-P-80-1	143	CTD 27	8	Station **8** 50 4.94990'N; 021 32.80380'W	15/06/2025	80	1000
H-P-1-2	144	towed fish	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	1	1000
H-P-3-2	145	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	3	1000
H-P-10-2	146	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	10	1000
H-P-15-2	147	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	15	1000
H-P-25-2	148	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	25	1000
H-P-35-2	149	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	35	1000
H-P-50-2	150	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	50	1000
H-P-80-2	151	CTD 28	8	Station **8** 50 5.09796'N; 021 32.4066'W	16/06/2025	80	1000
H-P-3-3	152	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	3	1000
H-P-10-3	153	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	10	1000
H-P-25-3	154	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	25	1000
H-P-30-3	155	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	30	1000
H-P-40-3	156	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	40	1000
H-P-50-3	157	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	50	1000
H-P-80-3	158	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	80	1000
H-P-1000-3	159	CTD 29	8	Station **8** 50 5.32878'N; 021 32.33724'W	17/06/2025	80	1000
I-P-1-1	160	towed fish	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	1	1000
I-P-5-1	161	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	5	1000

I-P-10-1	162	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	10	1000
I-P-20-1	163	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	20	1000
I-P-30-1	164	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	30	1000
I-P-40-1	165	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	40	1000
I-P-50-1	166	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	50	1000
I-P-100-1	167	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	100	1000
I-P-1000-1	168	CTD 30	9	Station **9** 49 40.184'N; 018 49.260'W	18/06/2025	1000	1000
I-P-1-2	169	towed fish	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	1	1000
I-P-3-2	170	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	3	1000
I-P-15-2	171	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	15	1000
I-P-20-2	172	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	20	1000
I-P-30-2	173	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	30	1000
I-P-40-2	174	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	40	1000
I-P-100-2	175	CTD 31	9	Station **9** 49 36.71694'N; 018 46.2742'W	19/06/2025	100	1000
I-P-3-3	176	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	3	1000
I-P-10-3	177	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	10	1000
I-P-15-3	178	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	15	1000
I-P-25-3	179	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	25	1000
I-P-35-3	180	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	35	1000
I-P-50-3	181	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	50	1000
I-P-100-3	182	CTD 32	9	Station **9** 49 36.71074'N; 018 46.26018'W	20/06/2025	110	1000
J-P-3-1	183	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	3	1000

J-P-10-1	184	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	10	1000
J-P-15-1	185	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	15	1000
J-P-20-1	186	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	20	1000
J-P-30-1	187	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	30	1000
J-P-40-1	188	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	40	1000
J-P-60-1	189	CTD 36	10	Station **10** 48 57.50814'N; 016 46.76178'W	21/06/2025	60	1000
K-P-1-1	190	towed fish	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	1	1000
K-P-5-1	191	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	5	1000
K-P-10-1	192	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	10	1000
K-P-15-1	193	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	15	1000
K-P-20-1	194	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	20	1000
K-P-30-1	195	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	30	1000
K-P-40-1	196	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	40	1000
K-P-100-1	197	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	100	1000
K-P-1000-1	198	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	1000	1000
K-P-2000-1	199	CTD 37	11	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	2000	1000

L-P-3-1	200	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	3	1000
L-P-15-1	201	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	15	1000
L-P-30-1	202	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	30	1000
L-P-50-1	203	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	50	1000
L-P-60-1	204	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	60	1000
L-P-80-1	205	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	80	1000
L-P-100-1	206	CTD 38	12	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	100	1000
L-P-3-2	207	CTD 39	12	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	3	1000
L-P-15-2	208	CTD 40	13	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	15	1000
L-P-30-2	209	CTD 41	14	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	30	1000
L-P-50-2	210	CTD 42	15	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	50	1000
L-P-60-2	211	CTD 43	16	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	60	1000
L-P-70-2	212	CTD 44	17	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	70	1000
L-P-100-2	213	CTD 45	18	Station **12** 48 10.32816'N; 015 7.00164'W	24/06/2025	100	1000

Table B: Samples from CTD casts for SVOC/VOC incubations for phytoplankton and heterotrophic bacteria identification

sample id	#	sample box	station code	station info	date of sampling	incubation	Time point
A-S-0-1	001	7A	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	T0
A-S-0-2	002	8A	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	T0
A-S-0-3	003	10A	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	T0
A-S-U-1	004	1B	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	TUltimate
A-S-U-2	005	2B	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	TUltimate
A-S-U-3	006	3B	A	Station **1** 50 28.179'N; 016 03.635'W	28/05/2025	SULFUR VOC	TUltimate
A-V-0-1	007	9C	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	T0
A-V-0-2	008	10C	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	T0
A-V-0-3	009	1D	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	T0
A-V-U-1	010	3D	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	TUltimate
A-V-U-2	011	4D	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	TUltimate
A-V-U-3	012	5D	A	Station **1** 49 25.95312'N; 017 33.06486'W	30/05/2025	VOC	TUltimate
B-S-0-1	013	2E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	T0
B-S-0-2	014	3E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	T0
B-S-0-3	015	4E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	T0
B-S-U-1	016	6E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	TUltimate
B-S-U-2	017	7E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	TUltimate
B-S-U-3	018	8E	B	Station **2** 49 45.71664'N; 014 55.67736'W	31/05/2025	SULFUR VOC	TUltimate
B-V-0-1	019	5F	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	T0
B-V-0-2	020	6F	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	T0

B-V-0-3	021	7F	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	T0
B-V-U-1	022	10F	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	TUltima te
B-V-U-2	023	1G	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	TUltima te
B-V-U-3	024	2G	B	Station **2** 49 45.71664'N; 014 55.67736'W	1/6/2025	VOC	TUltima te
C-S-0-1	025	6H	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	T0
C-S-0-2	026	7H	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	T0
C-S-0-3	027	8H	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	T0
C-S-U-1	028	1I	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	TUltima te
C-S-U-2	029	2I	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	TUltima te
C-S-U-3	030	3I	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	SVOC	TUltima te
C-V-0-1	031	1A	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	T0
C-V-0-2	032	10J	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	T0
C-V-0-3	033	9J	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	T0
C-V-U-1	034	2A	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	TUltima te
C-V-U-2	035	3A	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	TUltima te
C-V-U-3	036	4A	C	Station **4** 52 21.89178'N; 018 27.82122'W	5/6/2025	VOC	TUltima te
D-S-0-1	037	1B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	T0
D-S-0-2	038	2B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	T0
D-S-0-3	039	3B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	T0
D-S-U-1	040	4B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	TUltima te

D-S-U-2	041	5B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	TUltima te
D-S-U-3	042	6B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	SVOC	TUltima te
D-V-0-1	043	4D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	T0
D-V-0-2	044	5D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	T0
D-V-0-3	045	6D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	T0
D-V-U-1	046	7D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	TUltima te
D-V-U-2	047	8D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	TUltima te
D-V-U-3	048	9D	D	Station **5** 53 12.64152'N; 017 32.52795'W	8/6/2025	VOC	TUltima te
E-S-0-1	049	6E	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	T0
E-S-0-2	050	7E	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	T0
E-S-0-3	051	8E	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	T0
E-S-U-1	052	9E	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	TUltima te
E-S-U-2	053	10E	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	TUltima te
E-S-U-3	054	1F	E	Station **6** 51 41.34108'N; 018 20.227850'W	9/6/2025	SVOC	TUltima te
E-V-0-1	055	7G	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	T0
E-V-0-2	056	8G	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	T0
E-V-0-3	057	9G	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	T0
E-V-U-1	058	10G	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	TUltima te
E-V-U-2	059	1H	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	TUltima te
E-V-U-3	060	2H	E	Station **6** 51 41.07924'N; 018 20.17776'W	########	VOC	TUltima te

G-S-0-1	061	9H	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	T0
G-S-0-2	062	10H	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	T0
G-S-0-3	063	1I	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	T0
G-S-U-1	064	2I	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	TUltima te
G-S-U-2	065	3I	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	TUltima te
G-S-U-3	066	4I	G	Station **7** 51 35.37192'N; 020 54.11232'W	########	SVOC	TUltima te
G-V-0-1	067	10J	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	T0
G-V-0-2	068	1A	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	T0
G-V-0-3	069	2A	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	T0
G-V-U-1	070	3A	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	TUltima te
G-V-U-2	071	4A	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	TUltima te
G-V-U-3	072	5A	G	Station **7** 51 54.96036'N; 021 17.78466'W	14/6/2025	VOC	TUltima te
H-S-0-1	073	2B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	T0
H-S-0-2	074	3B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	T0
H-S-0-3	075	4B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	T0
H-S-U-1	076	6B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	TUltima te
H-S-U-2	077	7B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	TUltima te
H-S-U-3	078	8B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	SVOC	TUltima te
H-V-0-1	079	4D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	T0
H-V-0-2	080	5D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	T0

H-V-0-3	081	6D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	T0
H-V-U-1	082	7D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	TUltima te
H-V-U-2	083	8D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	TUltima te
H-V-U-3	084	9D	H	Station **8** 50 5.32878'N; 021 32.33724'W	17/6/2025	VOC	TUltima te
I-S-0-1	085	4G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	T0
I-S-0-2	086	5G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	T0
I-S-0-3	087	6G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	T0
I-S-U-1	088	7G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	TUltima te
I-S-U-2	089	8G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	TUltima te
I-S-U-3	090	9G	I	Station **9** 49 36.71074'N; 018 46.26018'W	20/6/2025	SVOC	TUltima te
J-V-0-1	091	6H	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	T0
J-V-0-2	092	7H	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	T0
J-V-0-3	093	8H	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	T0
J-V-U-1	094	X	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	TUltima te
J-V-U-2	095	9H	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	TUltima te
J-V-U-3	096	10H	J	Station **10** 48 57.50814'N; 016 46.76178'W	21/6/2025	VOC	TUltima te
L-S-0-1	097	8J	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	T0
L-S-0-2	098	9J	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	T0
L-S-0-3	099	10J	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	T0
L-S-0-4	100	1A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	T0

L-S-U-1	101	2A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	TUltimate
L-S-U-2	102	3A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	TUltimate
L-S-U-3	103	4A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	TUltimate
L-S-U-4	104	5A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/6/2025	SVOC	TUltimate

Table C: Samples from SML Garret screen casts for phytoplankton and heterotrophic bacteria identification

sample id	#	sample box	station code	station info	date of sampling	day on station	amount filtered (ml)
A-M-1	001	2C	A	Station 1 49 45.47268'N; 17 10.811128 W	29/05/2025	2	10ml
B-M-1	002	9F	B	Station **2** 50 18.58014'N; 018 49.76790'W	1/6/2025	3	30ml
C-M-1	003	10H	C	Station **4** 52 20.55732'N; 019 41.42256'W	3/6/2025	1	15ml
C-M-2	004	4I	C	Station **4** 52 22.010'N; 019 27.429'W	4/6/2025	2	200 ml
D-M-1	005	8B	D	Station **5** 53 12.67740'N; 017 33.72096'W	6/6/2025	1	100ml
D-M-2	006	7C	D	Station **5** 52 13.73664'N; 017 31.98264'W	7/6/2025	2	200ml
E-M-2	007	10F	E	Station 6 51 49.17822'N; 017 48.21708'W	10/6/2025	2	1000 ml
G-M-1	008	5I	G	Station **7** 51 35.37192'N; 020 54.11232'W	12/6/2025	1	100 ml
H-M-1	009	5B	H	Station **8** 50 4.94990'N; 021 32.80380'W	15/6/2025	1	100 ml
I-M-1	010	8E	I	Station **9** 49 40.184'N; 018 49.260'W	18/6/2025	1	10 ml
I-M-2	011	7F	I	Station **9** 49 36.71694'N; 018 46.2742'W	19/6/2025	2	1000 ml
K-M-1	012	1J	K	Station **11** 48 23.17302'N; 015 56.01036'W	22/06/2025	1	10 ml
L-M-1	013	6A	L	Station **12** 48 10.41054'N; 015 7.33710'W	23/06/2025	1	1000ml

Table D: CTD sampling stations for ancillary parameters

Note: *Indicates from which Niskin bottles photosynthetic pigments and phytoplankton taxonomy were taken.

Date	Station	Time (UTC)	CTD	Latitude N	Longitude W	Niskins sampled	Depths (m)
28/05/2025	1	04:00	1	50° 28.179'	16°03.662'	19*, 20, 21	3
28/05/2025	1	15:10	2	49° 45.71664'	14°55.66736'	20*, 18, 16, 14, 12, 10, 8	6, 10, 15, 25, 45, 60, 100
29/05/2025	1	13:40	3	49° 45.47268'	17° 10.81128'	20*, 18, 16, 14, 12, 10, 8	6, 10, 15, 25, 45, 60, 100
30/5/2025	1	04:00	4	49° 45.47268'	17° 10.81128'	19*, 20, 21	4
31/05/2025	2	04:00	6	49° 39.76470'	18° 36.36330'	19*, 20, 21	4
01/06/2025	2	04:00	7	50° 18.58014'	18° 49.76790'	19*, 20, 21	4
02/06/2025	3	13:30	8	51° 24.92922'	20° 12.13014'	22*, 20, 18, 16, 14, 12, 10, 8	6, 10, 25, 40, 50, 60, 70, 100
03/06/2025	4	04:00	9	52° 20.55732'	19° 41.42256'	21*, 20, 19, 18, 16, 14, 12, 10, 8, 6	6, 10, 20, 30, 40, 50, 60, 100
04/06/2025	4	13:30	10	52° 21.96558'	18° 27.61686'	22*, 20, 18, 16, 14, 12, 10, 8, 6	6, 10, 20, 30, 40, 50, 60, 100, 150
05/06/2025	4	04:00	11	52° 21.89178'	18° 27.82122'	21*, 20, 19, 18, 16, 14, 12, 10, 8, 6	6, 6, 6, 10, 20, 30, 35, 50, 60, 100
06/06/2025	5	04:00	12	53° 12.67740'	17° 33.72096'	21*, 20, 19, 18, 16, 14, 12, 10, 8, 6	5, 5, 5, 10, 20, 30, 40, 45, 55, 100
07/06/2025	5	13:30	13	53° 13.73664'	17° 31.98264'	22*, 20, 18, 16, 14, 12, 10, 8	4, 10, 20, 30, 40, 50, 60, 100
08/06/2025	5	04:00	14	53° 12.64152'	17° 32.52798'	21*, 20, 19, 18, 16, 14, 12, 10, 8, 6	4, 10, 20, 30, 40, 45, 55, 100
09/06/2025	6	04:00	15	51° 41.34108'	18° 20.27850'	21*, 20, 19, 18, 16, 14, 12, 10	4, 4, 4, 10, 25, 40, 45, 55
10/06/2025	6	13:30	16	51° 49.17822'	17° 48.21708'	22*, 20, 18, 16, 14, 12, 10, 8	4, 10, 20, 35, 45, 55, 75, 100

11/06/2025	6	04:00	17	51° 41.07924'	18° 20.17776'	21*, 20, 19, 18, 16, 14, 12	4, 4, 4, 10, 20, 30, 50
12/06/2025	7	04:00	24	51° 35.37192'	20° 54.11232'	21*, 20, 19, 18, 16, 14, 12	4, 4, 4, 10, 15, 25, 30
13/06/2025	7	13:30	25	51° 54.96036'	21° 17.78466'	22*, 20, 18, 16, 14, 12, 10, 8	3, 10, 25, 35, 48, 60, 80, 100
14/06/2025	7	04:00	26	51° 54.71966'	20° 55.23750'	21*, 20, 19, 18, 16, 14, 12	3, 3, 3, 10, 20, 30, 40
15/06/2025	8	04:00	27	50° 4.95990'	21° 32.80380'	21* 20, 19, 18, 16, 14, 12	3, 3, 3, 10, 15, 20, 40
16/06/2025	8	13:30	28	50° 5.10678’	21° 32.43342'	22*, 20, 18, 16, 14, 12, 10, 8	3, 3, 3, 10, 15, 25, 35, 50
17/06/2025	8	04:00	29	50° 5.34936'	21° 32.3590'	21*, 20, 19, 18, 16, 14, 12, 10	3, 3, 3, 10, 25, 30, 40, 50
18/06/2025	9	04:00	30	49° 36.71994’	18° 46.25814’	21*, 20, 19, 18, 16, 14	5, 5, 5, 10, 20, 30
19/06/2025	9	13:30	31	49° 36.7171’	18° 46.27452'	22*, 20, 18, 16, 14, 12, 10, 8	3, 10, 15, 20, 30, 40, 50, 60, 80
20/06/2025	9	04:00	32	49° 36.71064’	18° 46.26018’	21*, 20, 19, 18, 16, 14, 12	3, 3, 3, 10, 15, 25, 35
21/06/2025	10	04:00	36	48° 57.50814'	16° 46.76178'	21*, 20, 19, 18, 16, 14, 12	3, 3, 3, 10, 15, 20, 30
22/06/2025	11	13:00	37	48° 23.17302'	15° 56.01036'	22*, 20, 18, 16, 14, 12, 10	5, 10, 15, 20, 30, 40, 60
23/06/2025	11	04:00	38	48° 10.41054'	15° 7.33710'	21*, 20, 19, 18, 16, 14, 12, 10, 8, 6	3, 3, 3, 15, 30, 50, 60, 70, 80, 100
24/06/2025	11	04:00	39				

Table E: Locations and time of sampling for flow cytometry and Chlorophyll a samples during transits between stations

Note: Flow cytometry samples were collected from both the ship's underway and the towed fish, whilst Chlorophyll samples were taken from the ship's underway supply only.

Date	Time (GMT)	Transit	Latitude N	Longitude E
01-Jun-25	06:03	1	50.36	-18.90
01-Jun-25	07:00	1	50.46	-18.95
01-Jun-25	08:00	1	50.57	-19.01
01-Jun-25	09:00	1	50.67	-19.06
01-Jun-25	10:00	1	50.78	-19.11
01-Jun-25	11:00	1	50.72	-19.14
01-Jun-25	12:00	1	51.01	-19.19
01-Jun-25	12:59	1	51.01	-19.23
01-Jun-25	14:00	1	51.23	-19.30
01-Jun-25	15:00	1	51.34	-19.36
01-Jun-25	18:12	1	51.36	-19.45
01-Jun-25	09:08	1	51.38	-19.57
01-Jun-25	20:00	1	51.37	-19.66
01-Jun-25	21:08	1	51.37	-19.70
01-Jun-25	22:00	1	51.37	-19.74
01-Jun-25	23:00	1	51.38	-19.78
02-Jun-25	00:00	1	51.39	-19.81
02-Jun-25	04:00	2	51.35	-19.94
02-Jun-25	05:00	2	51.35	-19.97
02-Jun-25	06:00	2	51.35	-20.02
02-Jun-25	07:00	2	51.35	-20.08
02-Jun-25	08:00	2	51.36	-20.13
02-Jun-25	09:00	2	51.38	-20.16
02-Jun-25	10:00	2	51.40	-20.19
02-Jun-25	11:00	2	51.42	-20.19
02-Jun-25	16:00	2	51.51	-20.25
02-Jun-25	17:00	2	51.58	-20.27
02-Jun-25	18:00	2	51.66	-20.29
02-Jun-25	19:00	2	51.74	-20.30
02-Jun-25	20:00	2	51.82	-20.26
02-Jun-25	21:00	2	51.93	-20.15
02-Jun-25	22:00	2	52.03	-20.04
02-Jun-25	23:10	2	52.15	-19.94
03-Jun-25	00:05	2	52.05	-19.88
05-Jun-25	06:00	3	52.40	-18.50
05-Jun-25	07:00	3	52.41	-18.32
05-Jun-25	08:00	3	52.41	-18.12
05-Jun-25	09:00	3	52.40	-17.92

05-Jun-25	10:09	3	52.39	-17.69
05-Jun-25	11:00	3	52.38	-17.53
05-Jun-25	12:00	3	52.37	-17.34
05-Jun-25	13:00	3	52.36	-17.32
05-Jun-25	14:00	3	52.36	-16.97
05-Jun-25	15:00	3	52.36	-16.78
05-Jun-25	16:00	3	52.45	-16.75
05-Jun-25	17:04	3	52.57	-16.75
05-Jun-25	18:08	3	52.69	-16.74
05-Jun-25	19:00	3	52.80	-16.75
05-Jun-25	20:00	3	52.92	-16.75
05-Jun-25	21:06	3	53.04	-16.75
05-Jun-25	22:07	3	53.17	-16.75
05-Jun-25	23:04	3	53.22	-16.86
06-Jun-25	00:24	3	53.21	-17.07
08-Jun-25	06:00	4	53.23	-17.63
08-Jun-25	07:00	4	53.32	-17.70
08-Jun-25	08:00	4	53.43	-17.76
08-Jun-25	09:00	4	53.48	-17.83
08-Jun-25	10:00	4	53.44	-17.93
08-Jun-25	11:00	4	53.30	-18.00
08-Jun-25	12:00	4	53.19	-18.04
08-Jun-25	13:00	4	53.09	-18.08
08-Jun-25	14:00	4	52.98	-18.12
08-Jun-25	15:00	4	52.88	-18.16
08-Jun-25	16:00	4	52.78	-18.20
08-Jun-25	17:00	4	52.67	-18.21
08-Jun-25	18:00	4	52.56	-18.20
08-Jun-25	19:05	4	52.45	-18.19
08-Jun-25	20:00	4	52.36	-18.18
08-Jun-25	21:00	4	52.27	-18.19
08-Jun-25	21:56	4	52.19	-18.21
08-Jun-25	23:02	4	52.08	-18.25
08-Jun-25	23:57	4	52.00	-18.27
11-Jun-25	06:00	5	51.69	-18.44
11-Jun-25	07:00	5	51.69	-18.62
11-Jun-25	08:00	5	51.70	-18.74
11-Jun-25	09:00	5	51.70	-18.84
11-Jun-25	10:00	5	51.70	-19.01
11-Jun-25	11:00	5	51.70	-19.13
11-Jun-25	12:00	5	51.72	-19.25
11-Jun-25	13:00	5	51.73	-19.40
11-Jun-25	14:00	5	51.74	-19.52
11-Jun-25	15:00	5	51.75	-19.61

11-Jun-25	16:00	5	51.76	-19.76
11-Jun-25	17:00	5	51.77	-19.91
11-Jun-25	18:00	5	51.78	-19.94
11-Jun-25	19:00	5	51.77	-20.08
11-Jun-25	20:00	5	51.73	-20.25
11-Jun-25	21:00	5	51.72	-20.31
11-Jun-25	22:00	5	51.68	-20.48
11-Jun-25	23:00	5	51.64	-20.66
11-Jun-25	23:57	5	51.63	-20.69
14-Jun-25	06:00	6	51.60	-20.98
14-Jun-25	07:00	6	51.62	-21.02
14-Jun-25	08:00	6	51.65	-21.09
14-Jun-25	09:00	6	51.69	-21.20
14-Jun-25	10:00	6	51.74	-21.33
14-Jun-25	11:00	6	51.80	-21.46
14-Jun-25	12:00	6	51.75	-21.53
14-Jun-25	13:00	6	51.66	-21.56
14-Jun-25	14:00	6	51.54	-21.51
14-Jun-25	15:00	6	51.43	-21.51
14-Jun-25	16:00	6	51.33	-21.54
14-Jun-25	17:04	6	51.22	-21.57
14-Jun-25	17:59	6	51.13	-21.54
14-Jun-25	19:02	6	51.03	-21.51
14-Jun-25	19:59	6	50.93	-21.51
14-Jun-25	20:58	6	50.82	-21.51
14-Jun-25	22:01	6	50.70	-21.53
14-Jun-25	23:00	6	50.59	-21.54
14-Jun-25	23:56	6	50.40	-21.54
17-Jun-25	06:00	7	50.05	-21.58
17-Jun-25	07:00	7	49.94	-21.50
17-Jun-25	08:00	7	49.84	-21.42
17-Jun-25	09:00	7	49.74	-21.33
17-Jun-25	10:00	7	49.63	-21.24
17-Jun-25	11:00	7	49.69	-21.11
17-Jun-25	12:00	7	49.77	-21.00
17-Jun-25	13:00	7	49.83	-20.86
17-Jun-25	14:00	7	49.88	-20.70
17-Jun-25	15:00	7	49.91	-20.53
17-Jun-25	16:00	7	49.92	-20.36
17-Jun-25	17:00	7	49.92	-20.19
17-Jun-25	18:00	7	49.91	-20.03
17-Jun-25	19:06	7	49.91	-19.86
17-Jun-25	20:00	7	49.89	-19.71
17-Jun-25	21:00	7	49.85	-19.57

17-Jun-25	22:00	7	49.82	-19.42
17-Jun-25	23:00	7	49.79	-19.27
18-Jun-25	00:00	7	49.74	-19.13
20-Jun-25	06:00	7	49.62	-18.77
21-Jun-25	06:00	8	48.99	-16.83
21-Jun-25	07:00	8	49.10	-16.79
21-Jun-25	08:00	8	49.21	-16.74
21-Jun-25	09:00	8	49.34	-16.69
21-Jun-25	10:00	8	49.45	-16.64
21-Jun-25	11:00	8	49.56	-16.61
21-Jun-25	12:00	8	49.67	-16.64
21-Jun-25	13:00	8	49.78	-16.68
21-Jun-25	14:00	8	49.88	-16.73
21-Jun-25	15:00	8	49.83	-16.77
21-Jun-25	16:00	8	49.72	-16.70
21-Jun-25	17:00	8	49.64	-16.63
21-Jun-25	18:00	8	0.00	0.00
21-Jun-25	19:00	8	0.00	0.00
21-Jun-25	20:00	8	0.00	0.00
21-Jun-25	21:04	8	49.29	-16.36
21-Jun-25	22:04	8	49.20	-16.28
21-Jun-25	23:00	8	49.13	-16.22
22-Jun-25	00:00	8	49.04	-16.14
22-Jun-25	04:00	8	48.69	-15.79
22-Jun-25	05:00	8	48.62	-15.70
22-Jun-25	06:00	8	48.49	-15.64
22-Jun-25	07:00	8	48.38	-15.59
22-Jun-25	08:00	8	48.28	-15.62
22-Jun-25	09:00	8	48.32	-15.76
24-Jun-25	06:00	9	48.17	-15.18
24-Jun-25	07:00	9	48.19	-15.08
24-Jun-25	08:00	9	48.18	-14.92
24-Jun-25	09:00	9	48.18	-14.76
24-Jun-25	10:00	9	48.17	-14.59
24-Jun-25	11:00	9	48.16	-14.42
24-Jun-25	12:00	9	48.14	-14.27
24-Jun-25	13:00	9	48.13	-14.11
24-Jun-25	14:00	9	48.13	-13.94
24-Jun-25	15:00	9	48.12	-13.77
24-Jun-25	16:00	9	48.12	-13.61
24-Jun-25	18:15	9	48.10	-13.25
24-Jun-25	19:04	9	48.10	-13.11
24-Jun-25	20:00	9	48.09	-12.95
24-Jun-25	21:04	9	48.08	-12.77

24-Jun-25	22:09	9	48.07	-12.59
24-Jun-25	23:02	9	48.07	-12.44
25-Jun-25	00:05	9	48.07	-12.27

Table F: CTD casts sampled for dissolved inorganic nutrients

Date	STN	CTD	TIME on deck (UTC)	LAT N	LON E	Niskin	Depth (m)	Nutrient bottle
28-May-25	1	2	04:43	50.47	-16.06	19-21	6	1-3
29-May-25	1	3	14:50	49.76	-17.18	6-22 evens	4-150	4-12
30-May-25	1	4	04:50	49.43	-17.55	6-20 evens	3-150	13-21
31-May-25	2	6	05:16	49.66	-18.61	19-21	6	22-24
01-Jun-25	2	7	04:55	50.31	-18.83	19-21	6	25-27
02-Jun-25	3	8	14:08	51.42	-20.20	6-22 evens	6-150	28-36
03-Jun-25	4	9	05:06	52.34	-19.69	19-21	6	37-39
04-Jun-25	4	10	14:17	52.37	-18.46	8-24 evens	6	40-48
05-Jun-25	4	11	05:10	52.36	-18.46	19-21	6	49-51
06-Jun-25	5	12	05:11	53.21	-17.56	19-21	5	52-54
07-Jun-25	5	13	14:11	53.23	-17.53	8-24 evens	4-100	55-63
08-Jun-25	5	14	05:02	53.21	-17.54	19-21	4	64-66
09-Jun-25	6	15	05:03	51.69	-18.34	19-21	5	67-69
10-Jun-25	6	16	14:04	51.82	-17.81	8-24 evens	4-100	70-78
11-Jun-25	6	17	05:10	51.69	-18.34	19-21	4	79-81
12-Jun-25	7	24	05:08	51.59	-20.90	19-21	4	82-84
13-Jun-25	7	25	14:04	51.92	-21.30	8-24 evens	3-100	85-93
14-Jun-25	7	26	05:06	51.58	-20.92	19-21	3	94-96
15-Jun-25	8	27	05:05	50.08	-21.55	19-21	3	97-99
16-Jun-25	8	28	14:12	50.09	-21.54	8-24 evens	3-80	100-108
17-Jun-25	8	29	05:08	50.09	-21.54	19-21	3	109-111
18-Jun-25	9	30	05:10	49.61	-18.77	19-21	3	112-114
19-Jun-25	9	31	14:08	49.61	-18.77	8-22 evens	3-100	115-123
20-Jun-25	9	32	05:06	49.61	-18.77	19-21	3	124-126
21-Jun-25	9	36	05:08	48.96	-16.78	19-21	3	127-129
22-Jun-25	11	37	14:58	48.39	-15.93	6-22 evens	5-100	130-138
23-Jun-25	12	38	05:08	48.17	-15.12	19-21	3	139-141
24-Jun-25	12	39	05:11	48.17	-15.12	19-21	3	142-144

Table G: List of radiosonde launch dates, times, locations and altitudes reached

Number	Date	Time (UTC)	Latitude	Longitude	Max Altitude (m)
1	27/05/2025	12:43:50	49.770777	-14.913513	3531
2	28/05/2025	00:00:43	50.075467	-15.539312	1673
3	28/05/2025	12:01:40	50.355923	-16.37048	1382
4	28/05/2025	23:57:42	50.051977	-16.67457	8079
5	29/05/2025	12:01:26	49.781315	-17.114847	1827
6	29/05/2025	23:57:41	49.539662	-17.424228	1812
7	30/05/2025	12:00:39	49.458537	-17.842	1814
8	30/05/2025	Failed			
9	31/05/2025	12:00:27	49.860743	-18.745862	1711
10	31/05/2025	23:54:31	50.193088	-18.818058	587
11	01/06/2025	12:04:56	51.016962	-19.189063	2201
12	01/06/2025	23:57:01	51.388627	-19.808153	2048
13	02/06/2025	11:56:51	51.415363	-20.181137	503
14	02/06/2025	23:59:17	52.216725	-19.876925	1821
15	03/06/2025	11:55:03	52.372508	-19.62131	1840
16	03/06/2025	23:59:31	52.323198	-19.11234	1538
17	04/06/2025	11:54:07	52.357098	-18.482385	1515
18	04/06/2025	23:53:02	52.378908	-18.591317	1118

19	05/06/2025	12:00:56	52.367235	-17.335527	2820
20	06/06/2025	00:11:19	53.212197	-17.034828	4838
21	06/06/2025	11:55:32	53.258488	-17.774507	6506
22	07/06/2025	00:09:29	53.222002	-17.540285	4809
23	07/06/2025	11:53:00	53.22752	-17.53443	5962
24	07/06/2025	23:57:46	53.207117	-17.544462	1632
25	08/06/2025	12:01:45	53.190852	-18.035755	7854
26	08/06/2025	23:51:12	52.00938	-18.265155	2466
27	09/06/2025	12:01:26	51.688323	-18.335607	6059
28	09/06/2025	23:55:28	51.68115	-18.030383	9759
29	10/06/2025	11:53:56	51.820482	-17.802823	10558
30	10/06/2025	23:53:41	51.68785	-18.334062	750
31	11/06/2025	12:00:07	51.719852	-19.243935	9074
32	11/06/2025	23:48:30	51.633993	-20.688023	6032
33	12/06/2025	11:53:45	51.421538	-21.117132	9120
34	12/06/2025	23:56:58	51.680785	-21.446403	6746
35	13/06/2025	11:56:04	51.91583	-21.297908	6861
36	13/06/2025	23:57:19	51.65149	-20.979918	2032

37	14/06/2025	12:00:54	51.749165	-21.526387	7415
38	14/06/2025	23:51:46	50.488353	-21.543272	4937
39	15/06/2025	11:58:13	50.041247	-21.578718	2690
40	15/06/2025	23:50:39	50.084953	-21.546965	1398
41	16/06/25	11:58:17	50.086443	-21.541012	5386
42	16/06/25	23:57:45	50.088472	-21.538562	9396
43	17/06/25	12:09:06	49.786658	-20.981823	2120
44	17/06/25	23:59:44	49.745093	-19.139607	9163
45	18/06/25	12:02:33	49.705113	-18.790607	4905
46	18/06/25	23:57:19	49.615372	-18.785213	8525
47	19/06/25	12:01:45	49.611788	-18.771577	3479
48	19/06/25	23:57:40	49.61177	-18.771322	8858
49	20/06/25	11:59:29	49.572313	-18.755805	9273
50	21/06/25	00:00:47	48.906167	-17.26089	8304
51	21/06/25	failed			
52	21/06/25	23:55:46	49.042598	-16.150148	4781
53	22/06/25	11:59:08	48.387233	-15.932217	10245
54	22/06/25	23:57:04	48.22935	-15.249887	8831
55	23/06/25	12:04:23	48.177702	-15.120302	7459

56	24/06/25	00:01:33	48.171362	-15.116302	8287
57	24/06/25	12:13:12	48.14456	-14.228748	5468
58	25/06/25	00:00:22	48.068053	-12.284508	6936

Table H: Bridge Event Log

Date and Time (UTC)	Entry #	Event	Category	Comment	Latitude (°)	Longitude (°)	Heading (°)	Ground Speed (kts)	Relative Wind Direction (°)	Relative Wind Speed (m/s)
2025-05-21T12:20:07.000Z	0			log started	50.891685	-1.394694	306.6	0		
2025-05-24T17:04:00.000Z	26	1	Tow	Seasnake deployed	50.3358	-2.379541	252.9	8.1		
2025-05-25T21:59:00.000Z	27	1	Tow	Seasnake recovered	49.828216	-8.427126	276.5	6.8		
2025-05-25T22:06:00.000Z	28	2	Pass	All science recording paused, enter Irish EEZ	49.828836	-8.451898	266	8.8		
2025-05-27T15:15:00.000Z	29	3	Stat	CTD Deployed	49.761951	-14.927971	255.9	0.9		
2025-05-27T16:29:00.000Z	30	3	Stat	CTD Recovered	49.761941	-14.927969	257.2	0.4		
2025-05-27T16:56:00.000Z	33	4	Moor	2 Argo floats deployed	49.761896	-14.928642	257.4	1		
2025-05-27T17:26:00.000Z	31	5	Tow	Trace metal fish deployed	49.763836	-14.934163	255.4	0.7		
2025-05-27T18:41:00.000Z	34	6	Gli	Scanfish deployed	49.760998	-14.95643	256.1	1		
2025-05-27T19:00:00.000Z	32	7	Tow	Seasnake deployed	49.758754	-14.968874	256.5	4.2		
2025-05-27T21:22:00.000Z	35	8	Gli	Scanfish recovered	49.842175	-15.229433	266.8	1.1		
2025-05-28T00:01:00.000Z	36	9	Gli	Balloon radiosonde released	50.075834	-15.540075	319.2	6.5		
2025-05-28T04:00:00.000Z	37	9	Stat	CTD deployed	50.46963	-16.060629	272.3	0.4		
2025-05-28T04:13:00.000Z	38	10	Stat	CTD Max. wire 150m	50.46966	-16.060612	266	0.5		
2025-05-28T04:44:00.000Z	39	10	Stat	CTD Recovered	50.469656	-16.060623	NaN	NaN	NaN	
2025-05-28T13:31:00.000Z	40	11	Stat	Deploying Microlayer	NaN	NaN	NaN	0.4	NaN	
2025-05-28T15:31:00.000Z	41	11	Stat	FInished with Microlayer, off DP	NaN	NaN	230.8	NaN	NaN	NaN
2025-05-28T23:57:00.000Z	52	12	Stat	Balloon Radiosonde released	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-29T13:36:00.000Z	53	13	Stat	CTD Deployed	NaN	NaN	NaN	NaN	NaN	NaN

2025-05-29T13:44:00.000Z	54	14	Stat	Garrat screen deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-29T14:51:00.000Z	55	15	Stat	CTD Recovered	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-29T15:32:00.000Z	56	16	Stat	Near surface sampler recovered	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-29T23:59:52.000Z	1	17	Pass	Balloon deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T03:45:22.000Z	2	18	Stat	On stn for CTD	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T04:00:40.000Z	3	18	Stat	CTD outboard	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T04:08:30.000Z	4	18	Stat	Max wire @ 150m	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T04:51:24.000Z	5	18	Stat	CTD recovered to deck	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T12:02:00.000Z	42	19	Stat	Balloon Radiosonde released	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T13:27:00.000Z	43	20	Stat	Begin Microlayer sampling	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T13:50:00.000Z	44	20	Stat	End of sampling, Off DP	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T16:08:00.000Z	45	21	Stat	CTD Deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T16:16:00.000Z	46	21	Stat	CTD Max. Wire 150m	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-30T16:24:00.000Z	47	21	Stat	CTD Recovered	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T00:00:00.000Z	48	22	Stat	Balloon Radiosonde released	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T03:47:10.000Z	6	23	Stat	On Stn for CTD	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T04:03:20.000Z	7	23	Stat	CTD deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T04:26:47.000Z	8	23	Stat	Max wire @ 1000m	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T05:17:51.000Z	9	23	Stat	CTD recovered to deck	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T13:45:00.000Z	49	24	Stat	Stopped for near surface sampling	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T14:25:00.000Z	50	25	Pass	Resume passage	NaN	NaN	NaN	NaN	NaN	NaN
2025-05-31T23:59:00.000Z	51	26	Stat	Balloon Radiosonde released	NaN	NaN	NaN	NaN	NaN	NaN

2025-06-01T03:45:16.000Z	10	27	Stat	On stn for CTD	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T04:09:00.000Z	11	27	Stat	CTD deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T04:17:15.000Z	12	27	Stat	Max wire @ 150m	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T04:57:04.000Z	13	27	Stat	CTD recovered to deck	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T05:16:16.000Z	14	28	Pass	Scan fish deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T15:39:00.000Z	57	28	Gli	Scanfish recovered	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-01T23:58:00.000Z	58	29	Stat	Balloon deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-02T11:26:00.000Z	59	30	Stat	Vessel stopped for near surface science	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-02T13:20:00.000Z	60	31	Stat	CTD Deployed	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-02T14:09:00.000Z	61	31	Stat	CTD Recovered	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-02T23:59:00.000Z	62	32	Stat	Balloon Released	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-03T03:38:14.000Z	15	33	Stat	On stn for CTD assessing conditions	NaN	NaN	NaN	NaN		
2025-06-03T03:56:57.000Z	16	33	Stat	CTD deployed	NaN	NaN	294.5	0.6		
2025-06-03T04:19:58.000Z	17	33	Stat	Max wire @ 1000m	52.34284	NaN	NaN	NaN		
2025-06-03T05:07:57.000Z	18	33	Stat	CTD recovered to deck	52.342405	-19.690169	NaN	0.2	NaN	
2025-06-03T05:20:19.000Z	19	33	Pass	Vessel moving off stn	52.342161	-19.68954	296.7	0.6		
2025-06-03T11:55:00.000Z	63	34	Stat	Balloon Radiosonde released	52.372498	-19.621604	312.4	1.6		
2025-06-03T13:35:00.000Z	64	35	Stat	Near surface sampling and garrat screen	NaN	-19.55374	313	NaN	NaN	NaN
2025-06-03T23:59:00.000Z	65	36	Stat	Balloon Radiosonde deployed	NaN	NaN	NaN	NaN	NaN	
2025-06-04T11:30:00.000Z	66	37	Stat	Vessel in DP for near surface samples	52.354439	-18.489407	335.2	1.3	289.8	12.35
2025-06-04T13:34:00.000Z	67	38	Stat	CTD Deployed	52.366079	-18.460345	333.9	NaN	294.8	11.05
2025-06-04T14:09:00.000Z	68	38	Stat	CTD Recovered	52.366402	-18.459217	335.2	0.5	289.3	12.05
2025-06-04T21:05:00.000Z	69	39	Pass	Start pumping grey water	52.36536	-18.478179	271.8	4.8	11.3	13.48

2025-06-04T21:45:00.000Z	70	39	Pass	Stop pumping grey water	52.36538	-18.532179	272.6	2.8	24.3	13.76
2025-06-04T23:59:00.000Z	71	40	Pass	Balloon radiosonde deployed	NaN	-18.590643	329.7	1.3	304.3	6.63
2025-06-05T03:45:04.000Z	20	41	Stat	On Stn for CTD	52.364982	NaN	327.9	0.8	330.3	10.33
2025-06-05T03:58:03.000Z	21	41	Stat	CTD deployed	52.364875	-18.463644	329.1	0.3	NaN	8.99
2025-06-05T04:21:08.000Z	22	41	Stat	Max wire @ 1000m	52.36482	-18.463775	327.2	0.6	332.3	8.49
2025-06-05T05:12:00.000Z	23	41	Stat	CTD recovered to deck	NaN	-18.464243	331.2	NaN	NaN	NaN
2025-06-05T05:27:00.000Z	24	42	Pass	Building up spd to 3kts for scan fish deployment	NaN	NaN	326.7	1.4	338	9.02
2025-06-05T05:32:20.000Z	25	42	Pass	Scan fish deployed	52.369956	NaN	322.9	3.3	341.7	9.1
2025-06-05T08:52:00.000Z	72	43	Pass	Start discharge grey and black water	52.399913	-17.944529	96.5	7.3	241	NaN
2025-06-05T09:45:00.000Z	73	43	Pass	End of discharge	52.390109	-17.769911	94.8	7.3	240	7.83
2025-06-05T15:10:00.000Z	75	44	Pass	Inititate turn to 000deg at 10deg/min	52.360155	-16.750188	28.1	NaN	302.5	8.05
2025-06-05T22:23:58.000Z	74	45	Pass	Commence turn to 270 at 10deg/min	53.200093	-16.749804	343.4	7	328.8	14.53
2025-06-06T00:12:33.000Z	76	46	Pass	Balloon radiosonde deployed	53.212293	NaN	265.4	5.7	29	13.08
2025-06-06T02:46:32.000Z	77	47	Pass	Reducing spd to 4kts for scan fish recovery	53.209258	-17.451391	270.5	5.1	4.7	11.55
2025-06-06T03:09:21.000Z	78	47	Pass	Scan fish recovered to deck	NaN	-17.484461	274.5	1.7	121.5	12.12
2025-06-06T03:48:59.000Z	79	48	Stat	On stn for CTD	53.211477	-17.561868	NaN	0.4	180.7	7.16
2025-06-06T04:00:19.000Z	80	48	Stat	CTD deployed	53.211225	-17.56206	NaN	NaN	NaN	NaN
2025-06-06T04:22:18.000Z	81	48	Stat	Max wire @ 1000m	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-06T05:12:46.000Z	82	48	Stat	CTD recovered to deck	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-06T05:21:57.000Z	83	48	Stat	V/L proceeding off stn head to wind @ 2kts	NaN	NaN	NaN	NaN	NaN	NaN

2025-06-06T13:36:23.000Z	84	49	Stat	v/l stopped in DP, deploying near surface equipment	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-06T15:31:23.000Z	85	49	Pass	Near surface equipment recovered, V/L off DP	NaN	NaN	NaN	NaN	31.3	4.38
2025-06-06T18:31:39.000Z	86	50	Pass	Vessel in DP, drifting back towards CTD site	NaN	-17.720343	245.7	1.2	NaN	3.1
2025-06-06T21:52:33.000Z	87	50	Pass	Vessel on station awaiting 11:30 for microlayer ops	53.216084	-17.562532	18.1	NaN	330.2	3.56
2025-06-07T00:09:54.000Z	88	51	Pass	Ballon released	53.222134	-17.540454	329.6	NaN	16	2.4
2025-06-07T11:35:51.000Z	90	52	Pass	Microlayer and Near surface sampler	53.227309	-17.535057	304.3	NaN	333.5	9.21
2025-06-07T11:56:51.000Z	89	53	Pass	Balloon Release	53.227643	-17.53466	NaN	0.8	354	8.77
2025-06-07T13:34:16.000Z	91	54	Stat	CTD 150 m	53.228789	NaN	289.3	0.4	349.8	NaN
2025-06-07T23:57:00.000Z	92	54	Stat	Balloon Deployed	53.206946	-17.545205	299.1	0.8	NaN	9.22
2025-06-08T03:47:35.000Z	93	55	Stat	On stn for CTD	53.210685	-17.542137	272.4	0.1	NaN	8.74
2025-06-08T03:54:37.000Z	94	55	Stat	CTD deployed	53.21069	-17.542151	271.3	NaN	240.2	6.5
2025-06-08T04:15:37.000Z	95	55	Stat	Max wire @ 1000m	53.210691	-17.542141	269.7	NaN	63.2	8.69
2025-06-08T05:03:37.000Z	96	55	Stat	CTD recovered to deck	53.210684	-17.542136	272.4	NaN	16	10.76
2025-06-08T05:15:39.000Z	97	56	Pass	Building up spd to 3Kts for scan fish deployment	53.210453	NaN	273.2	0.6	180.5	8.66
2025-06-08T05:20:14.000Z	98	56	Pass	Scan fish deployed	53.210774	NaN	273.6	3.3	355.5	12.02
2025-06-08T08:39:24.000Z	99		Pass	Commence grey water pumping	53.498193	NaN	306.4	5.8	345.3	12.13
2025-06-08T12:02:27.000Z	100	57	Pass	Balloon away	53.189324	NaN	190.3	6.4	73	NaN
2025-06-08T23:52:33.000Z	101	58	Pass	Balloon released	52.007244	-18.265774	193.8	5.5	36.5	9.85
2025-06-09T03:00:04.000Z	102	59	Pass	Reducing speed for scan fish recovery	NaN	-18.341361	191.5	6.5	26.2	9.68

2025-06-09T03:21:52.000Z	103	59	Pass	Scan fish recovered to deck	NaN	-18.344741	201	1.7	21.7	8.82
2025-06-09T03:46:36.000Z	104	60	Stat	On stn for CTD	NaN	-18.338249	231.1	0.3	2.2	9.29
2025-06-09T03:55:27.000Z	105	60	Stat	CTD deployed	NaN	-18.338168	230.4	0.2	1.7	10.02
2025-06-09T04:17:02.000Z	106	60	Stat	Max wire @ 1000m	NaN	-18.337519	232	0.3	8.8	10.45
2025-06-09T05:04:58.000Z	107	60	Stat	CTD recovered to deck	NaN	-18.337013	232.6	0.1	NaN	8.63
2025-06-09T12:02:20.000Z	108	61	Stat	Balloon away	51.687964	-18.336304	226	0.7	NaN	11.07
2025-06-09T23:59:38.000Z	109	62	Pass	Balloon away	51.681695	-18.029362	272.4	0.9	NaN	7.42
2025-06-11T17:16:04.000Z	110	62	Stat	CTD 150 m	51.776397	-19.920557	268.4	NaN	298.2	8.09
2025-06-11T20:38:44.000Z	111	63	Stat	CTD 150 m	51.716826	-20.308535	270.2	0.4	289.2	8.26
2025-06-11T23:31:42.000Z	112	64	Stat	CTD 150 m	51.63413	-20.688187	277.5	1	292	9.06
2025-06-11T23:49:52.000Z	113	65	Stat	Balloon away	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-12T03:39:04.000Z	114	66	Stat	On stn for CTD	NaN	NaN	NaN	NaN	NaN	NaN
2025-06-12T03:59:15.000Z	115	66	Stat	CTD deployed	NaN	NaN	NaN	NaN	NaN	4.75
2025-06-12T04:21:01.000Z	116	66	Stat	Max wire @ 1000m	51.589509	-20.901872	NaN	0.5	303.3	6.46
2025-06-12T05:09:27.000Z	117	66	Stat	CTD recovered to deck	NaN	-20.901851	269.6	0.2	308.8	NaN
2025-06-12T05:18:12.000Z	118	66	Pass	Moving off stn heading into wind a best as possible @ 2kts	51.587906	-20.901876	269.2	0.8	314.3	4.75
2025-06-12T12:00:46.000Z	119	67	Pass	Balloon released	51.41821	NaN	249.6	2.1	38.5	3.79
2025-06-12T13:28:03.000Z	120	68	Stat	Near surface gear deployed	NaN	-21.183033	253.6	0.6	NaN	2.72
2025-06-12T23:57:48.000Z	121	69	Pass	Balloon away	51.681634	-21.446123	2.9	2.5	17.8	NaN
2025-06-13T07:34:08.000Z	122	70	Stat	On DP. Atmospherics continuing	51.914983	-21.304683	347.8	NaN	11.8	7.69
2025-06-13T11:22:34.000Z	123	71	Stat	Deploying shallow water gear	NaN	-21.300723	347.5	0.4	329	NaN
2025-06-14T00:03:15.000Z	124	72	Pass	Balloon released	51.647919	-20.977213	288	2.5	15.7	8.97
2025-06-14T02:26:47.000Z	125	73	Stat	V/L on stn ready for 04:00 CTD	NaN	-20.919854	292.8	0.3	NaN	8.9

2025-06-14T03:58:14.000Z	126	73	Stat	CTD deployed	51.578654	NaN	295.5	0.3	6.6	NaN
2025-06-14T04:20:48.000Z	127	73	Stat	Max wire @1000m	51.579003	-20.92035	296.2	0.2	234.2	8.92
2025-06-14T05:07:51.000Z	128	73	Stat	CTD recovered to deck	NaN	-20.919641	295.2	0.2	65.3	8.98
2025-06-14T05:24:24.000Z	129	74	Pass	Commence moving ahead to 3kts for Scan Fish deployment	NaN	-20.919691	300.6	0.2	240	9.63
2025-06-14T05:32:11.000Z	130	74	Pass	Scan fish deployed	51.582286	NaN	304.3	2.9	352	NaN
2025-06-14T05:53:23.000Z	131	74	Pass	Vessel up to 7kts STW	51.597585	-20.963305	302.6	NaN	298	12.45
2025-06-14T06:07:05.000Z	132	74	Pass	Reducing speed to 3 kts: informed needed to recover scan fish	51.610782	NaN	301.8	6.1	NaN	13.19
2025-06-14T06:29:07.000Z	133	74	Pass	Scan fish recovered to deck; holding posn awaiting instructions	NaN	NaN	301.7	0.2	179	8.56
2025-06-14T07:29:02.000Z	134	75	Surv	vessel proceeding along track until scanfish ready to deploy	NaN	-21.015508	306.2	NaN	350.3	10.53
2025-06-14T08:25:38.000Z	135	76	Surv	Commence Scan Fish deployment	51.667532	-21.139536	308.7	2.1	343.7	10.04
2025-06-14T23:58:41.000Z	136	77	Pass	Balloon away	50.474355	NaN	177.3	7.1	21.2	12.06
2025-06-15T03:04:01.000Z	137	78	Surv	Commence recovery of scan fish	50.11729	-21.547888	188.2	6.1	9.3	13.55
2025-06-15T03:26:04.000Z	138	79	Surv	Scan fish recoverd to deck	NaN	-21.547229	188.6	1.6	9	11.57
2025-06-15T03:45:02.000Z	139	80	Stat	On Stn for CTD	50.082651	-21.546688	NaN	0.2	2.2	9.01
2025-06-15T03:53:08.000Z	140	80	Stat	CTD deployed	50.082676	-21.546785	201	0.1	62	10.25
2025-06-15T04:15:00.000Z	141	80	Stat	Max wire @ 1000m	50.082466	-21.545959	201.3	0.1	5.7	10.17
2025-06-15T05:07:12.000Z	142	80	Stat	CTD recovered to deck	50.082488	NaN	203.2	0.2	297.7	10.92
2025-06-15T11:59:10.000Z	143	81	Stat	Balloon away	50.041666	-21.578605	207.6	NaN	351	9.46
2025-06-16T13:34:54.000Z	144	82	Stat	CTD Deployed	50.085211	-21.53982	305	0.3	332	10.64

2025-06-17T00:02:01.000Z	145	83	Stat	Balloon away	50.088511	-21.539152	258.9	0.4	354	5.32
2025-06-17T03:31:10.000Z	146	84	Stat	On stn for CTD	50.089342	-21.539493	239.1	0.4	352.8	4.73
2025-06-17T03:56:59.000Z	147	84	Stat	CTD deployed	50.089135	-21.53932	239.8	0.3	335.3	4.86
2025-06-17T04:18:19.000Z	148	84	Stat	max wire @ 1000m	50.089006	-21.539165	235.2	0.4	331.5	5.21
2025-06-17T05:10:04.000Z	149	84	Stat	CTD recovered to deck	50.088744	-21.538887	235.1	0.3	334.7	5.09
2025-06-17T05:23:00.000Z	150	85	Surv	Moving off stn; proceeding up to 3kts for scan fish deployment	50.088566	-21.538666	229	0.4	326.3	5.45
2025-06-17T05:31:16.000Z	151	85	Surv	Scan fish deployed	50.084287	-21.544979	229.3	3.1	334.5	7.08
2025-06-17T05:49:46.000Z	152	85	Surv	Vessel @ 7kts STW	50.065017	-21.576605	226.3	6.7	349.3	9.5
2025-06-17T12:10:23.000Z	153	86	Pass	Balloon away	49.788101	-20.978886	55.6	6.5	57	8.64
2025-06-18T00:01:52.000Z	154	87	Pass	Balloon released	49.743268	-19.134841	133	6	58.2	14.68
2025-06-18T02:31:15.000Z	155	88	Surv	Commence recovery of scan fish	49.616832	-18.797976	126.4	5.9	60.3	12.47
2025-06-18T02:55:39.000Z	156	88	Surv	Scan fish recovered to deck	49.602619	-18.7674	130.4	1.4	66	10.43
2025-06-18T03:45:16.000Z	157	89	Stat	On Stn for CTD	49.612018	-18.771388	185.2	0.4	298.7	8.98
2025-06-18T03:57:21.000Z	158	89	Stat	CTD deployed	49.611996	-18.771044	186	0.5	64.7	8.99
2025-06-18T04:20:57.000Z	159	89	Stat	Max wire @ 1000m	49.611897	-18.769724	186.8	0.3	120.2	9.33
2025-06-18T05:12:37.000Z	160	89	Stat	CTD recovered to deck	49.611996	-18.770838	187.3	0.2	59.7	8.96
2025-06-18T23:59:19.000Z	161	90	Pass	Balloon Away	49.615204	-18.784393	103.7	0.9	8.5	5
2025-06-19T13:27:27.000Z	162	91	Stat	CTD Deployed	49.611951	-18.771248	61.6	0.1	333.2	7.21
2025-06-19T14:11:24.000Z	163	91	Stat	CTD recovered to deck	49.611948	-18.77123	60.3	0.1	323.8	6.63
2025-06-20T00:04:09.000Z	164	92	Stat	Balloon deployed	49.611895	-18.771163	40.3	0.2	338.5	9.88
2025-06-20T03:58:11.000Z	165	93	Stat	CTD deployed	49.611848	-18.771005	8.2	0.3	176.5	6.58
2025-06-20T04:20:22.000Z	166	93	Stat	Max wire 1000m	49.611848	-18.771002	9.1	0.2	61.3	6.43
2025-06-20T05:07:49.000Z	167	93	Stat	CTD recovered to deck	49.611845	-18.770997	7.3	0.2	7.5	5.12
2025-06-20T05:22:02.000Z	168	94	Stat	Delaying SCAN FISH deployment for	49.612025	-18.772744	7.1	0.2	5.3	4.43

				approx. 30mins due to traffic in vicinity						
2025-06-20T05:52:19.000Z	169	95	Surv	Building up speed to 3 Kts STW	49.612089	-18.77308	13.1	0.6	355	4.23
2025-06-20T05:58:03.000Z	170	95	Surv	Scan fish deployed	49.615314	-18.772912	17	2.8	295	5.95
2025-06-20T06:05:32.000Z	171	95	Surv	Scan fish spinning in water reducing spd to 3kts for recovery	49.621774	-18.770872	16.8	4.3	355.2	7.18
2025-06-20T06:21:29.000Z	172	95	Surv	Scan fish recovered to deck; found twist in wire	49.627791	-18.770565	24.4	0.3	352	5.34
2025-06-20T06:51:23.000Z	173	96	Stat	Streaming fish wire off A Frame	49.628656	-18.773075	27.8	0.3	297.3	5.56
2025-06-20T07:10:37.000Z	174	96	Stat	Clump weight recoverd to deck	49.629468	-18.775197	32.5	0.3	13.3	3.8
2025-06-20T16:57:58.000Z	175	97	Stat	CTD Deployed	49.216811	-18.192255	198.1	0.2	351.2	3.55
2025-06-21T00:51:47.000Z	176	98	Stat	On Stn for CTD	48.92453	-17.127558	260.3	0.2	348	5.12
2025-06-21T00:55:04.000Z	177	98	Stat	CTD deployed	48.924534	-17.127561	259.6	0.1	350.5	5.07
2025-06-21T01:00:38.000Z	178	98	Stat	Max wire @ 150m	48.924541	-17.127564	258.9	0.1	119.8	5.11
2025-06-21T01:08:47.000Z	179	98	Stat	CTD recovered to deck	48.924545	-17.127564	259.1	0.1	356.7	5.14
2025-06-21T03:36:12.000Z	180	99	Stat	On stn for 04:00 CTD	48.958475	-16.779368	251.5	0.1	297.7	5.23
2025-06-21T04:08:00.000Z	181	99	Pass	CTD deployed	48.958398	-16.779346	271.2	0.1	356.5	4.41
2025-06-21T04:23:59.000Z	182	99	Stat	Max wire @ 1000m	48.958396	-16.779353	272.3	0.2	357.2	4.55
2025-06-21T05:09:45.000Z	183	99	Stat	CTD recovered to deck	48.958386	-16.779351	274.4	0.3	238	3.83
2025-06-21T05:29:35.000Z	184	100	Surv	Commence building up spd to 3kts STW	48.959751	-16.779416	308.5	0.6	358.7	7.13
2025-06-21T05:36:05.000Z	185	100	Surv	Scan fish deployed	48.963188	-16.784911	307.6	3.2	4.3	8.79
2025-06-21T05:57:22.000Z	186	100	Surv	Vessel @ 7kts STW	48.982904	-16.821637	307.6	6.9	5.2	12.23
2025-06-22T00:02:31.000Z	187	101	Pass	Balloon Away	49.0327	-16.141732	157.5	5.8	75.7	13.11
2025-06-22T10:02:21.000Z	188	100	Tow	Commence scan fish recovery	48.374015	-15.90027	290.7	5.7	328	12.47

2025-06-22T13:09:10.000Z	189	102	Stat	CTD deployed	48.38621	-15.9335	306.4	0.3	12.2	7.52
2025-06-22T15:01:43.000Z	190	102	Stat	CTD recovered to deck	48.386561	-15.934105	302.7	0.4	15.8	7.64
2025-06-22T23:58:16.000Z	191	103	Pass	Balloon deployed	48.228784	-15.24891	284.1	2.9	41.3	5.27
2025-06-23T03:32:54.000Z	192	104	Stat	On Stn for CTD	48.173502	-15.122282	293.1	0.1	5.2	5.36
2025-06-23T03:58:34.000Z	193	104	Stat	CTD deployed	48.173494	-15.122267	295.4	0.5	238	5.46
2025-06-23T04:21:24.000Z	194	104	Stat	Max wire 1000m	48.173505	-15.122296	294.1	0.3	5.5	5.76
2025-06-23T05:09:12.000Z	195	104	Stat	CTD recovered to deck	48.173505	-15.122275	293	0.4	356.7	4.87
2025-06-23T09:22:00.000Z	196	105	Stat	Near Surface Sampling Deployed	48.171387	-15.122913	282.8	0.3	320.3	6.64
2025-06-23T12:07:00.000Z	197	106	Stat	Balloon Away	48.17769	-15.120519	283.5	0.3	320.8	7.03
2025-06-23T13:39:33.000Z	198	107	Stat	Microlayer commence	48.178974	-15.119717	253.1	0.6	333.5	8.86
2025-06-23T15:37:14.000Z	199	108	Stat	Microlayer complete	48.179455	-15.11983	253.9	0.1	328.2	9.13
2025-06-24T04:02:15.000Z	200	109	Stat	CTD deployed	48.172089	-15.116692	270.8	0.2	9.8	9.23
2025-06-24T04:25:12.000Z	201	109	Stat	Max wire @ 1000m	48.17239	-15.116682	270	0.5	296.3	7.1
2025-06-24T05:13:02.000Z	202	109	Stat	CTD recovered to deck	48.173127	-15.116677	268.1	0.1	348	7.83
2025-06-24T05:30:31.000Z	203	110	Surv	Commence moving ahead at 3kts for scanfish deployment	48.172899	-15.116825	270	1.1	356.7	8.54
2025-06-24T05:35:01.000Z	204	110	Surv	Scanfish deployed	48.172566	-15.121555	268.2	3.2	351.7	9.45
2025-06-24T05:55:35.000Z	205	110	Surv	Vessel up 7kts STW	48.16979	-15.166769	269.6	6.9	348.2	10.86
2025-06-25T00:01:27.000Z	206	111	Pass	Balloon deployed	48.068076	-12.281197	91.4	7	131.3	2.86
2025-06-25T08:46:38.000Z	207	112	Surv	Scanfish Recovered	48.009578	-10.887666	93.4	2.1	109	6.31
2025-06-25T12:00:26.000Z	209	113	Pass	Balloon Away	48.074514	-10.403358	79	6.6	116.3	6.43
2025-06-25T13:39:45.000Z	208	114	Stat	CTD Deployed	48.093229	-10.178314	236.9	0.2	346.2	7.38
2025-06-25T13:46:25.000Z	210	115	Stat	Max Wire 150 m	48.093213	-10.178296	238.8	0.4	337.5	8.29
2025-06-25T14:22:16.000Z	211	116	Stat	CTD on deck	48.092509	-10.177685	238.7	0.2	347.7	8.82