SiCLING Rothera Fieldwork Report

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British Antarctic Survey

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Natural Environment Research Council

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Personnel

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Scientific background

The polar regions are experiencing the most rapid climate change observed on Earth. Marine ecosystems are already responding to – and amplifying – environmental change, with important implications for carbon burial and important natural resources such as fisheries. One important type of microalgae, which form the basis of these polar ecosystems and an important conduit for carbon flow from the surface to the seafloor, are diatoms. Diatoms build their microscopic shells from silica, and so dissolved silicon (DSi) is a critical nutrient for their growth. We need a better understanding of how climate-sensitive processes within polar environments impact silicon cycling, and their consequences for regional and global systems.

SiCLING will explore novel hypotheses linking silicon and metal cycling within glacial sediments in Arctic and Antarctic fjords, resulting in a step-change in our understanding of silicon mobility and bioavailability in fjords, high-latitude nutrient balance, and the flow of nutrients into the polar coastal ocean and beyond. Our recent work has shown that glaciers are a substantial source of both dissolved silicon (DSi) and reactive particles of silica, termed ASi. However, the processes by which DSi and ASi escape glaciated fjords are under scrutiny; these processes have profound implications for the supply of DSi to coastal and open ocean ecosystems in the polar regions, and ultimately how this system will respond and change in the future. We have shown that, whilst the coastal shelf waters are very low in DSi, the interaction between shelf sediments and bottom waters is an important conduit for this critical nutrient into the overlying water column. Further inland, nearer the glaciers, our new data indicate that the DSi within the sediments themselves have a unique geochemical and isotopic fingerprint – and this fingerprint appears to be the same wherever we look: in the Arctic, Antarctic and in mid-latitude glaciated mountain regions like Chilean Patagonia. Given the extent and the nature of this signal, we propose that there is an important and ubiquitous – but yet unknown – mechanism that controls the release of DSi into fjords and then into the coastal ocean, acting as an effective trap of this important nutrient. We propose that this mechanism is likely not entirely biological, but relates to the interactions between silicon and another important element for life: iron. Iron is also released in large quantities from glacial weathering, and the iron released is highly reactive with the capability of mopping up significant quantities of DSi. This mechanism is likely to be climate sensitive (because of the glacial meltwater source and temperature/salinity effects), and understanding the underlying processes will be crucial for predicting future change especially in the context of accelerating polar warming and land-ice melting. SiCLING will be the first project to focus specifically on these previously overlooked links between dynamic silicon and iron cycling in the polar regions, incorporating cutting-edge analysis of field and laboratory samples and advanced geochemical modelling.

The Rothera component of this project centres around the Antarctic case study investigating the particle-water interactions in Ryder Bay, off Adelaide Island, West Antarctic Peninsula.

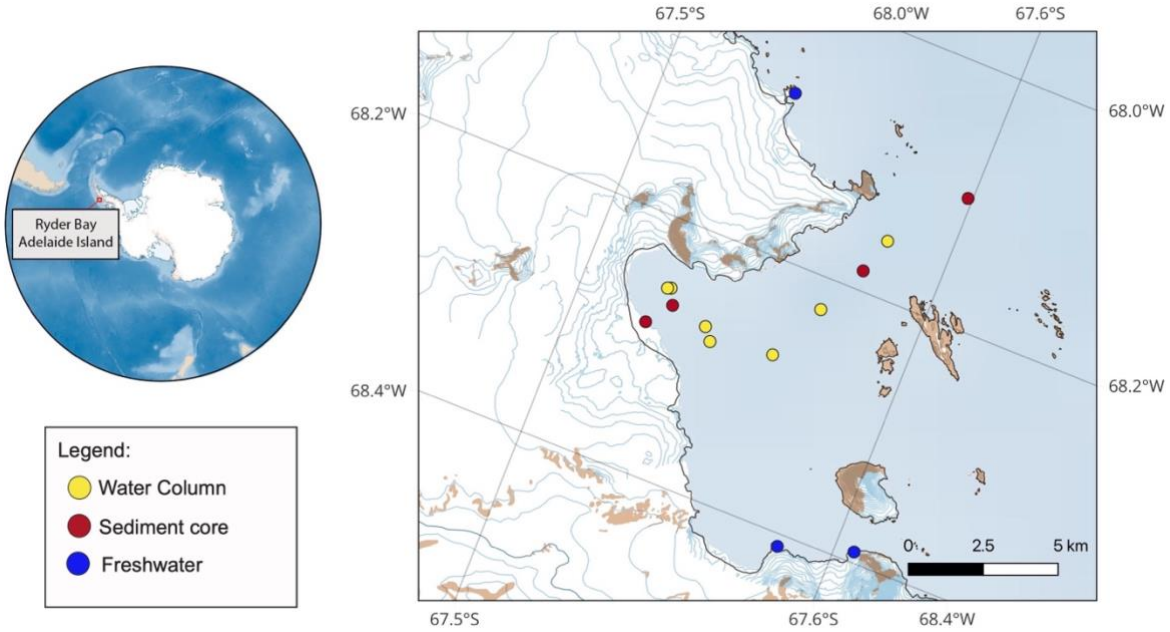


Figure 1: Map showing the location of all samples collected during the SiCLING campaign in Ryder Bay, Adelaide Island, Antarctica. Water column sites with CTD profiles. Figure made in QGIS using the Antarctic Polar Stereographic projection (EPSG:3031) and Quantarctica basemaps (Matsuoka et al., 2021[1]).

[1] Matsuoka, K., Skoglund, A., Roth, G., de Pomereu, J., Griffiths, H., Headland, R., ... & Melvær, Y. (2021). Quantarctica, an integrated mapping environment for Antarctica, the Southern Ocean, and sub-Antarctic islands. Environmental Modelling & Software, 140, 105015

Water column sampling

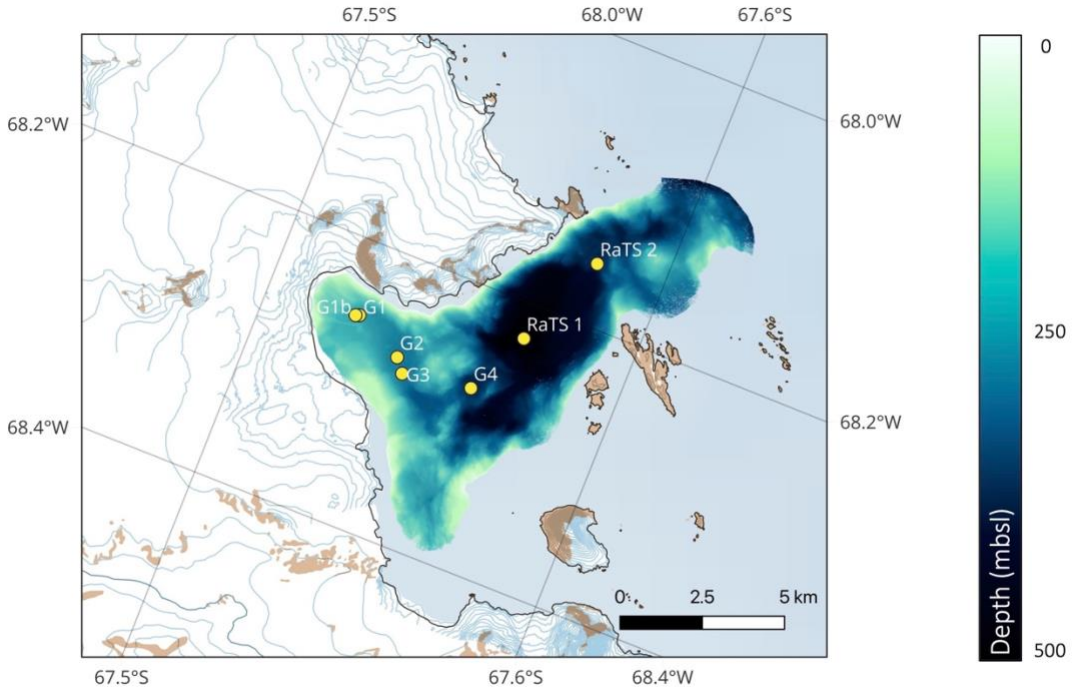


Figure 2: Map of water column sampling sites where CTD and Niskin bottles were deployed. Bathymetry from Retallick et al., 2021[2].

Sampling strategy

The aims of the water column work were to:

1) Collect particles from the deep turbidity maxima into Sheldon Cove for analysis;
2) Collect particles from 15m water depth during the summer bloom to represent a biological/diatom "endmember";
3) Collect ancillary samples from the same depths to aid interpretation;
4) Collect near surface samples to support the NERC BIOPOLE project.

Sampling locations (Fig. 2) were selected based on distance from the glacier in combination with information from a Slocum glider (unit 982) deployed in Ryder Bay for most of the field campaign. Near real time data from the glider were processed by Hugh Venables and used to find the most likely locations of strong, deep high turbidity layers. CTD casts with turbidity sensors were also used where possible to pick out depths for sampling.

[2] Retallick, K., Van Landeghem, K., Fremand, A., Howard, F., Sands, C., Roman-Gonzalez, A., Barnes, D., Jenkins, S., Munoz-Ramirez, C., & Scourse, J. (2021). Seafloor bathymetry of Sheldon Cove, Börgen Bay and Marian Cove, merged and gridded from EM122 multibeam echosounder data collected for the project NE/P003087/1 (2017-2020) (Version 1.0) [Data set]. NERC EDS UK Polar Data Centre. https://doi.org/10.5285/1b4ab7bc-4272-4b16-a642-565e40544b0a

CTD Operations

A total of 5 successful CTD casts were undertaken using the BAS Rothera Station CTD frame in collaboration with the Rothera Time Series program (RaTS). The unit consists of a SeaBird SBE 19+ V2 CTD (a pumped system, Table 1), and additional sensors for chlorophyll fluorescence, turbidity, oxygen, pH and photosynthetically active radiation (PAR).

A total of 4 successful CTD casts were undertaken using the RBR Concerto configured to measure at 6Hz. The unit consists of a non-pumped CTD, and sensors for chlorophyll fluorescence and turbidity. There is a wifi connection allowing near-real-time reading of data.

The deepest cast was 500m, and the shallowest cast was 200m (Table 2).

Seabird CTD Instrument payload and configuration

The following sensors were installed on the Seabird CTD frame:

Parameter	Serial number
Temperature	19-8321
Conductivity	19-8321
Pressure (strain gauge)	870 psia S/N 12009020
Fluorometer	FLNTURT-8490
Photosynthetically active radiation (PAR)	PARLOG-2320
Oxygen	4460
pH	1731

Table 1: Sensors used on the Seabird 19+v2

The serial number of the RBR Concerto used was 66055.

CTD operation

The CTD casts (Table 2) were carried out from the RIB *Erebus*. The frame was lowered and raised using a hand-winch system at approximately 0.5m/s. The CTD was lowered in a continuous movement, but rate of recovery likely varied.

An initial soak of 5 minutes at 5m water depth was carried out for the Seabird pumped system (or 3 minutes for the RBR), before winching the frame to the surface and lowering to the depth of interest, measured using markings on the winch cable.

Issues and trouble shooting

- The following issues were identified relating to the use of the RBR Concerto for reactive water column sampling (i.e., immediate identification of high turbidity layers for Niskin sampling):

- The RBR can be slow to reconnect after deployment in the cold; recommend to warm unit and be patient with reconnection;
- There is no means of determining wire out, so sampling depths based on pre-labelled markings on the winch rope and calibrating winch turns to wire out;
- The batteries in the RBR can be drained rapidly in the cold; dead batteries meant that a CTD was not carried out at site 13 (the unit had been left on the boat too long whilst there were launch delays and the battery was flat on arrival at the sampling station); recommendation is to keep unit warm and plan to have spare batteries readily available.

- There were issues with the PAR sensor on the new RaTS SeaBird unit, resulting in low values post-processing. No issues had been observed during the previous deployment on the KANG-GLAC cruise in August 2024. The PAR sensor was checked for corrosion, with no clear sign of any issues, and checked against another sensor from the RRS *Sir David Attenborough*, again without any clear sign as to why the processed values are so low. Further investigations are underway.

- A Chlorophyll offset of + 0.05 is recommended with SBE19+v2 data (Abrahamsen, pers com).

- As noted above, there were some issues with the RBR calibration for chlorophyll and turbidity. The chlorophyll constants were incorrectly entered into calibration file (confirmed with NOC) and have to be corrected offline; there is an offset in turbidity assessed by comparison with Seabird CTD and glider data.

Stn	**Date**	**Depth (m)**	**Lat (N)**	**Lon (E)**	**CTD Unit**	**Name**
001	24/12/2024	500	-67.570	-68.225	Seabird	RaTS site 1 (Ev2623)
002	30/12/2024	300	-67.581	-68.156	Seabird	RaTS site 2 (Ev2625)
003	04/01/2025	200	-67.526	-68.253	RBR	G1
004	06/01/2025	500	-67.570	-68.225	Seabird	RaTS site 1 (Ev2627)
007	08/01/2025	200	-67.562	-68.272	RBR	G4
009	13/01/2025	200	-67.543	68.281	RBR	G3
010	14/01/2025	500	-67.570	-68.225	Seabird	RaTS site 1 **(Ev2629)**
011	15/01/2025	200	-67.540	-68.271	RBR	G2
013	18/01/2025	N/A	-67.525	-68.254	RBR - failed	G1b
015	20/01/2025	500	-67.570	-68.225	Seabird	RaTS site 1 (Ev2631)

Table 2: CTD cast summary

CTD data processing

Standard processing of the Seabird raw data was completed using Sea-Bird Data Processing software, according to RaTS protocols.

The Seasave Instrument Configuration file used for all casts was 19-8321.xmlcon.


```
<?xml version="1.0" encoding="UTF-8"?>
<SBE_InstrumentConfiguration SB_ConfigCTD_FileVersion="7.26.4.0" >
 <Instrument Type="11" >
  <Name>SBE 19plus V2 Seacat CTD</Name>
  <PressureSensorType>1</PressureSensorType>
  <ExternalVoltageChannels>5</ExternalVoltageChannels>
  <Mode>0</Mode>
  <!-- Serial RS-232 Sensor: 0 = None. -->
  <SerialRS232C_Sensor>0</SerialRS232C_Sensor>
  <SampleIntervalSeconds>10</SampleIntervalSeconds>
  <ScansToAverage>1</ScansToAverage>
  <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
  <ScanTimeAdded>0</ScanTimeAdded>
  <NmeaPositionDataAdded>0</NmeaPositionDataAdded>
  <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
  <NmeaTimeAdded>0</NmeaTimeAdded>
  <NmeaDeviceConnectedToPC>0</NmeaDeviceConnectedToPC>
  <SensorArray Size="8" >
   <Sensor index="0" SensorID="58" >
    <TemperatureSensor SensorID="58" >
     <SerialNumber>8321</SerialNumber>
     <CalibrationDate>20-Aug-23</CalibrationDate>
     <A0>1.26182334e-003</A0>
     <A1>2.72907202e-004</A1>
     <A2>-1.04079255e-006</A2>
     <A3>1.78471802e-007</A3>
     <Slope>1.00000000</Slope>
     <Offset>0.0000</Offset>
    </TemperatureSensor>
   </Sensor>
   <Sensor index="1" SensorID="3" >
    <ConductivitySensor SensorID="3" >
     <SerialNumber>8321</SerialNumber>
     <CalibrationDate>20-Aug-23</CalibrationDate>
     <UseG_J>1</UseG_J>
     <!-- Cell const and series R are applicable only for wide range sensors. -->
     <SeriesR>0.0000</SeriesR>
     <CellConst>2000.0000</CellConst>
     <ConductivityType>0</ConductivityType>
     <Coefficients equation="0" >
```

```
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <M>0.0</M>
      <CPcor>-9.57000000e-008</CPcor>
    </Coefficients>
    <Coefficients equation="1" >
      <G>-1.01190622e+000</G>
      <H>1.18124635e-001</H>
      <I>-2.12855718e-004</I>
      <J>2.86174735e-005</J>
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
<Sensor index="2" SensorID="46" >
  <PressureSensor SensorID="46" >
    <SerialNumber>8321</SerialNumber>
    <CalibrationDate>16-Aug-23</CalibrationDate>
    <PA0>-2.82649398e-001</PA0>
    <PA1>2.64369342e-003</PA1>
    <PA2>9.11782104e-012</PA2>
    <PTEMPA0>-4.95480830e+001</PTEMPA0>
    <PTEMPA1>5.64914135e+001</PTEMPA1>
    <PTEMPA2>-4.36666300e-001</PTEMPA2>
    <PTCA0>5.23910664e+005</PTCA0>
    <PTCA1>-9.99605337e+000</PTCA1>
    <PTCA2>2.15792273e-001</PTCA2>
    <PTCB0>2.51113750e+001</PTCB0>
    <PTCB1>-7.25000000e-004</PTCB1>
    <PTCB2>0.00000000e+000</PTCB2>
    <Offset>0.000000</Offset>
  </PressureSensor>
</Sensor>
<Sensor index="3" SensorID="38" >
  <OxygenSensor SensorID="38" >
    <SerialNumber>4460</SerialNumber>
    <CalibrationDate>12-Sep-23</CalibrationDate>
    <Use2007Equation>1</Use2007Equation>
    <CalibrationCoefficients equation="0" >
      <!-- Coefficients for Owens-Millard equation. -->
```

```
      <Boc>0.0000</Boc>
      <Soc>0.0000e+000</Soc>
      <offset>0.0000</offset>
      <Pcor>0.00e+000</Pcor>
      <Tcor>0.0000</Tcor>
      <Tau>0.0</Tau>
    </CalibrationCoefficients>
    <CalibrationCoefficients equation="1" >
      <!-- Coefficients for Sea-Bird equation - SBE calibration in 2007 and later. -->
      <Soc>5.3464e-001</Soc>
      <offset>-0.5114</offset>
      <A>-3.8116e-003</A>
      <B> 1.5035e-004</B>
      <C>-2.5320e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 0.0000</Tau20>
      <H1>-3.3000e-002</H1>
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
  </OxygenSensor>
</Sensor>
<Sensor index="4" SensorID="43" >
  <pH_Sensor SensorID="43" >
    <SerialNumber>1731</SerialNumber>
    <CalibrationDate>01-Sep-23</CalibrationDate>
    <Slope>4.6340</Slope>
    <Offset>2.5440</Offset>
  </pH_Sensor>
</Sensor>
<Sensor index="5" SensorID="20" >
  <FluoroWetlabECO_AFL_FL_Sensor SensorID="20" >
    <SerialNumber>FLNTURT-8490</SerialNumber>
    <CalibrationDate>7-Sept-2023</CalibrationDate>
    <ScaleFactor>6.00000000e+000</ScaleFactor>
    <!-- Dark output -->
    <Vblank>0.0760</Vblank>
  </FluoroWetlabECO_AFL_FL_Sensor>
</Sensor>
<Sensor index="6" SensorID="67" >
  <TurbidityMeter SensorID="67" >
    <SerialNumber>FLNTURT-8490</SerialNumber>
    <CalibrationDate>7-Sept-2023</CalibrationDate>
    <ScaleFactor>2.000000</ScaleFactor>
```

```
      <!-- Dark output -->
      <DarkVoltage>0.058000</DarkVoltage>
     </TurbidityMeter>
    </Sensor>
    <Sensor index="7" SensorID="42" >
     <PAR_BiosphericalLicorChelseaSensor SensorID="42" >
      <SerialNumber>PARLOGICSW-2320</SerialNumber>
      <CalibrationDate>14-Aug-2023</CalibrationDate>
      <M>0.80668800</M>
      <B>1.00815000</B>
      <CalibrationConstant>1000000000.00000000</CalibrationConstant>
      <Multiplier>1.00000000</Multiplier>
      <Offset>0.00000000</Offset>
     </PAR_BiosphericalLicorChelseaSensor>
    </Sensor>
   </SensorArray>
  </Instrument>
</SBE_InstrumentConfiguration>
```


A pH calibration was carried out previously on the KANG-GLAC cruise, and will be repeated later on in the Antarctic field season.

Note that the following offsets are suggested for the Seabird unit data (Abrahamsen, pers com):

```
condoffset1fcn = @(press,temp,cond,stano,gtime) -0.005;
tempoffset1fcn = @(press,temp,cond,stano,gtime) 0;
oxygenoffset1fcn = @(press,temp,oxygen,stano,gtime) 0;
phcalfcn = @(pH_orig,temp) ((pH_orig-7).*4.6340.*(temp+273.15).*1.98416e-4+2.5440-
2.6512)./(3.4905*(temp+273.15).*1.98416e-4)+7;
fluoroffsetfcn = @(fluor) 0.05;
```

Rapid processing of the raw RBR data was carried out on the boat by exporting to an .xls file using the RBR software Ruskin, and plotting up depth vs. turbidity on a ruggedised laptop. This allowed estimates of where to sample in the water column to find turbidity peaks.

Processing of the raw RBR data was completed using RBR Data Processing software with additional processing using MATLAB code to i) extract the downcast only and manually remove the soak; ii) bin data; iii) update the chlorophyll calibration (given error from previous calibration file); iv) apply a dark correction offset of -1.3932 NTU to the turbidity data; and v) save the data as a .csv file. See Fig. 3-6.

Comparison between two casts (close in space and time) show good agreement between the RBR Concerto and SeaBird units (Fig. 7).

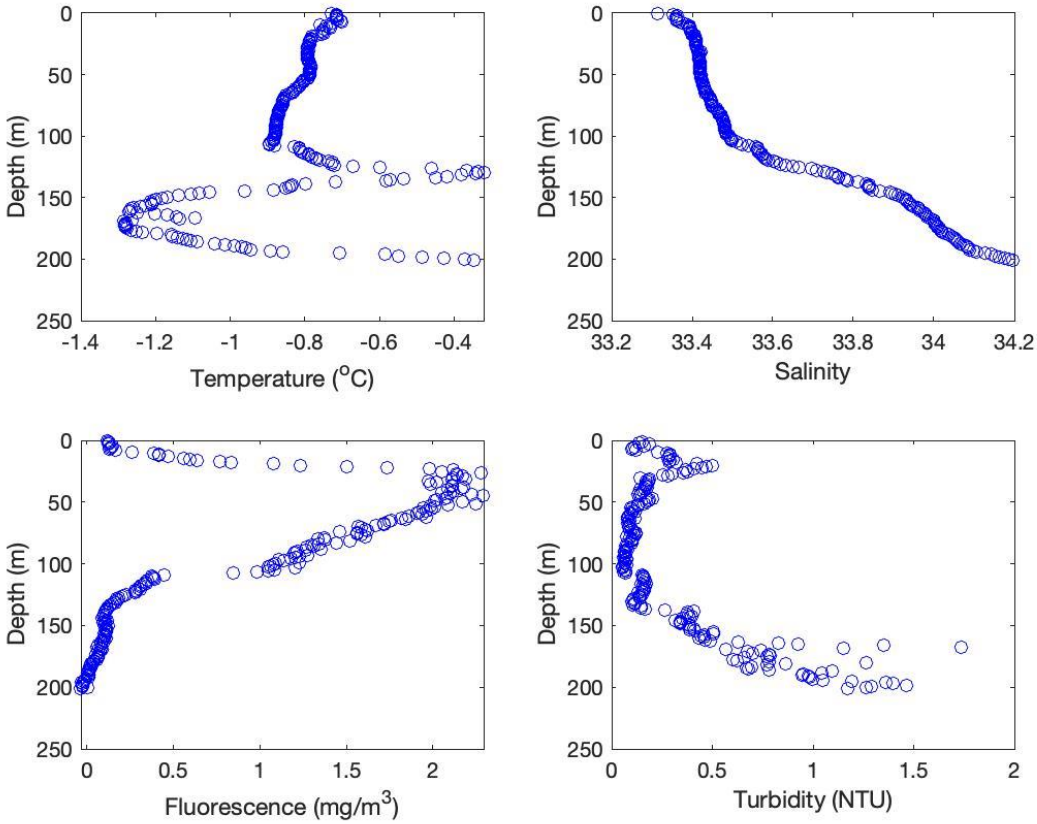


Figure 3: RBR Concerto CTD cast 003 – 4th January 2025

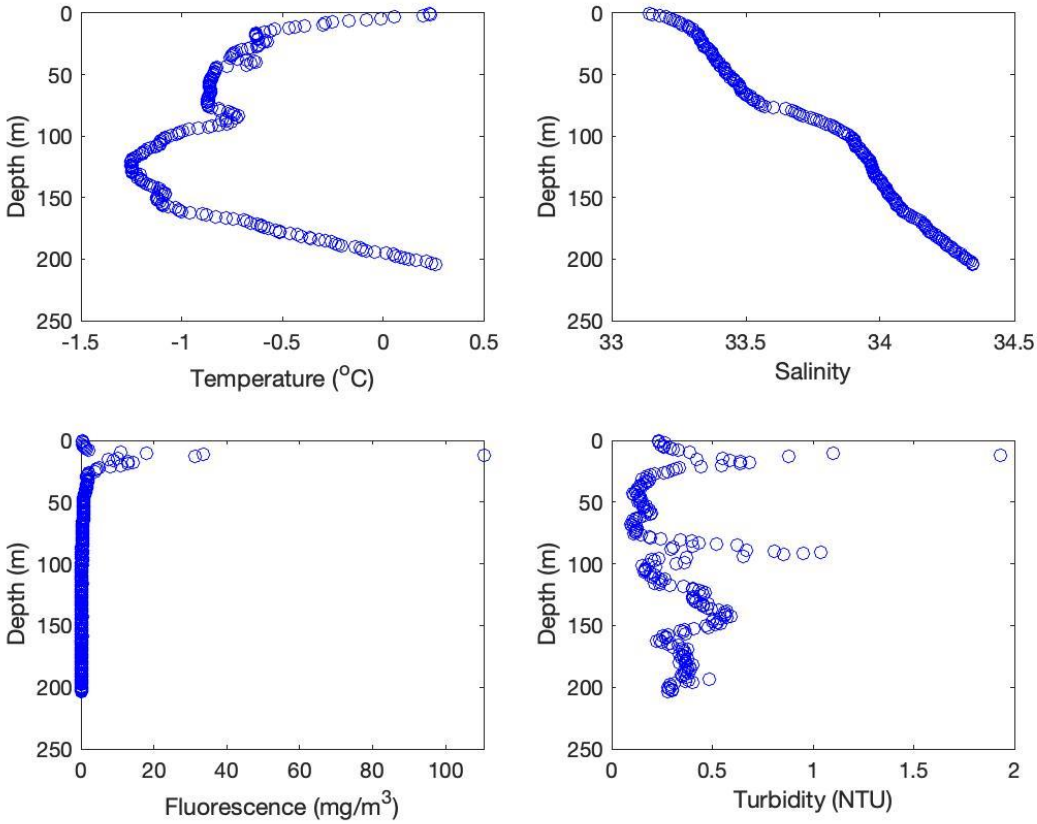


Figure 4: RBR Concerto CTD cast 007 – 8th January 2025

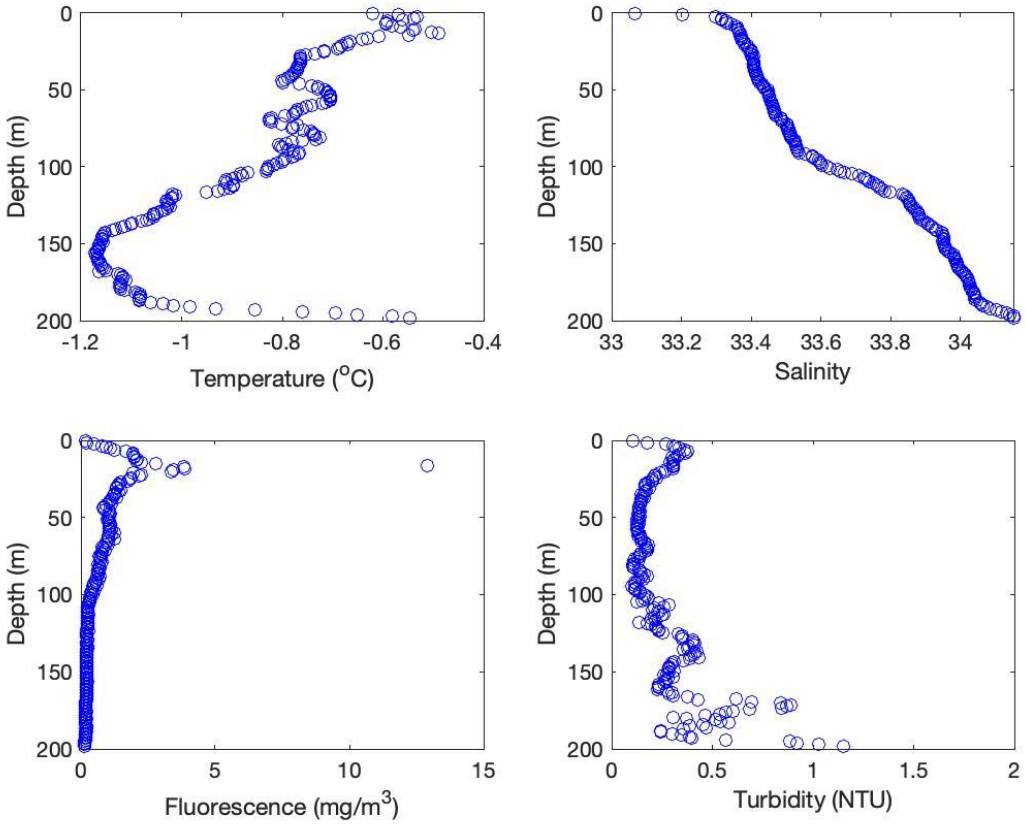


Figure 5: RBR Concerto CTD cast 009 – 13th January 2025

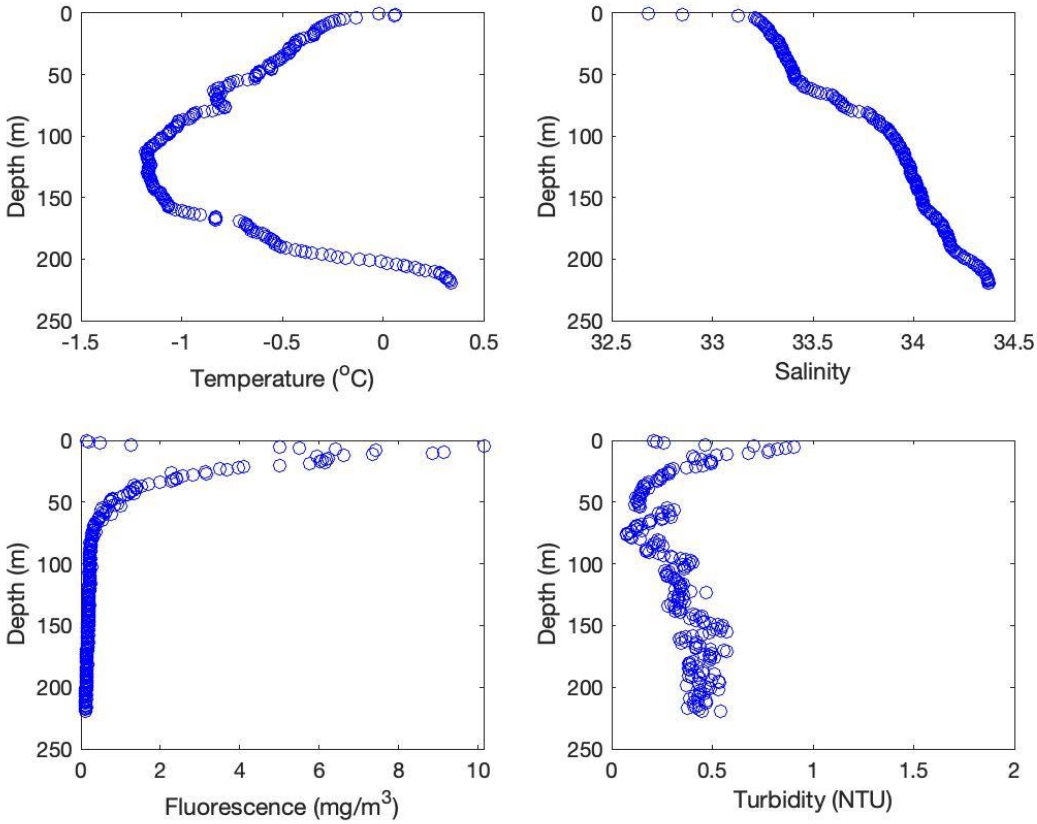


Figure 6: RBR Concerto CTD cast 011 – 15th January 2025

MATLAB code for post-processing of RBR data:

```
% Processing RBR Concerto data
% K Hendry Jan 2025
% Rothera Research Station

close all
clear all

warning('off','MATLAB:interp1:NaNinY')
fileName=input('Input file name = ','s');
fileName = num2str(fileName);
fullFileName = strcat(fileName,'.xlsx');

fprintf(1, 'Now reading %s\n', fileName);
[~,sheet_name]=xlsfinfo(fullFileName);
for k=1:numel(sheet_name)
```

```
  [~,~,data{k}]=xlsread(fullFileName,sheet_name{k})
end

a = data{1,4};

% File structure as follows:

% 1. 'Time'
% 2. 'Conductivity'
% 3. 'Temperature'
% 4. 'Pressure'
% 5. 'Chlorophyll a'
% 6. 'Turbidity'
% 7. 'Sea pressure'
% 8. 'Depth'
% 9. 'Salinity'
% 10. 'Speed of sound'
% 11. 'Specific conductivity'
% 12. 'Density anomaly'

b = a(:,2);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
conductivity = cell2mat(b);
b = a(:,3);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
temperature = cell2mat(b);
b = a(:,4);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
pressure = cell2mat(b);
b = a(:,5);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
chl = cell2mat(b);
```

```
b = a(:,6);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
turbidity = cell2mat(b);
b = a(:,8);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
depth = cell2mat(b);
b = a(:,9);
numind = cellfun(@isnumeric, b(:,1));
b(~numind,1) = {NaN};
salinity = cell2mat(b);

ctd_data = [pressure depth temperature conductivity salinity chl turbidity];

% Delete rows by hand


% Binning and saving processed CTD data from RBR Concerto
% K Hendry Jan 2025
% Rothera Research Station

% Run RBR_Rothera_050125.m first, and delete unwanted rows to get a
% ctd_data matrix

% DO NOT CLEAR ANY VARIABLES

% Save .csv of all data

pressure = ctd_data(:,1);
depth = ctd_data(:,2);
temperature = ctd_data(:,3);
conductivity = ctd_data(:,4);
salinity = ctd_data(:,5);
chla_vr = (ctd_data(:,6)-475.77)/-652.409 % calculate voltage ratios
chl = chla_vr*-631.895 + 462.937 % re-calibrate chlorophyll using two-points only
```

```
turbidity = ctd_data(:,7)-1.3932; % Correct for strange dark offset

%% Making .csv

Pressure_db = pressure; Pressure_db = array2table(Pressure_db);
Depth_m = depth; Depth_m = array2table(Depth_m);
Temp_deg_C = temperature; Temp_deg_C = array2table(Temp_deg_C);
Cond_S_per_m = conductivity; Cond_S_per_m = array2table(Cond_S_per_m);
Salinity = salinity; Salinity = array2table(Salinity);
Fl_mg_per_m3 = chl; Fl_mg_per_m3 = array2table(Fl_mg_per_m3);
Turbidity_NTU = turbidity; Turbidity_NTU = array2table(Turbidity_NTU);

T = [Pressure_db Depth_m Temp_deg_C Cond_S_per_m Salinity Fl_mg_per_m3 Turbidity_NTU];
T.Properties.VariableNames = {'Pressure_db' 'Depth_m' 'Temp_deg_C' 'Cond_S_per_m' 'Salinity'
'Fl_mg_per_m3' 'Turbidity_NTU'};

% Save csv
save_name = strcat(fileName,'_all.csv');
save(save_name)
writetable(T,save_name,'Delimiter',',','QuoteStrings',true);

% Once data all extracted and deleted

% Bin by pressure

ipress  = fix(pressure)-min(fix(pressure))+1;   % Create Integer Subscript Of Pressures
vblm = ctd_data(:,2:end);                       % Rest Of Data
[ipressu, ia, ic] = unique(ipress);             % Unique Pressures & Indices
for k1 = 1:size(ipressu,1)
   pressmean(k1,:) = [mean(vblm(ic==k1,:))];    % Means By Metre
end
ctd_data_bin = [ipressu+min(fix(pressure))-1 pressmean];      % Depth = Col #1


%% Making .csv of binned data
```

```
pressure = ctd_data_bin(:,1);
depth = ctd_data_bin(:,2);
temperature = ctd_data_bin(:,3);
conductivity = ctd_data_bin(:,4);
salinity = ctd_data_bin(:,5);
chla_vr = (ctd_data_bin(:,6)-475.77)/-652.409 % calculate voltage ratios
chl = chla_vr*-631.895 + 462.937 % re-calibrate chlorophyll using two-points only
turbidity = ctd_data_bin(:,7)-1.3932;

% Plot up data

figure
subplot(2,2,1)
plot(temperature,depth,'bo')
xlabel('Temperature (^oC)')
ylabel('Depth (m)')
set(gca, 'YDir','reverse')

subplot(2,2,2)
plot(salinity,depth,'bo')
xlabel('Salinity')
ylabel('Depth (m)')
set(gca, 'YDir','reverse')

subplot(2,2,3)
plot(chl,depth,'bo')
xlabel('Fluorescence (mg/m^3)')
ylabel('Depth (m)')
set(gca, 'YDir','reverse')

subplot(2,2,4)
plot(turbidity,depth,'bo')
xlabel('Turbidity (NTU)')
ylabel('Depth (m)')
set(gca, 'YDir','reverse')
xlim([0 2])
```

```
saveas(gcf,fileName,'jpeg')

Pressure_db = pressure; Pressure_db = array2table(Pressure_db);
Depth_m = depth; Depth_m = array2table(Depth_m);
Temp_deg_C = temperature; Temp_deg_C = array2table(Temp_deg_C);
Cond_S_per_m = conductivity; Cond_S_per_m = array2table(Cond_S_per_m);
Salinity = salinity; Salinity = array2table(Salinity);
Fl_mg_per_m3 = chl; Fl_mg_per_m3 = array2table(Fl_mg_per_m3);
Turbidity_NTU = turbidity; Turbidity_NTU = array2table(Turbidity_NTU);

T = [Pressure_db Depth_m Temp_deg_C Cond_S_per_m Salinity Fl_mg_per_m3 Turbidity_NTU];
T.Properties.VariableNames = {'Pressure_db' 'Depth_m' 'Temp_deg_C' 'Cond_S_per_m' 'Salinity'
'Fl_mg_per_m3' 'Turbidity_NTU'};

% Save csv
save_name = strcat(fileName,'_bin.csv');
save(save_name)
writetable(T,save_name,'Delimiter',',','QuoteStrings',true);
```

Cross comparison between CTD units

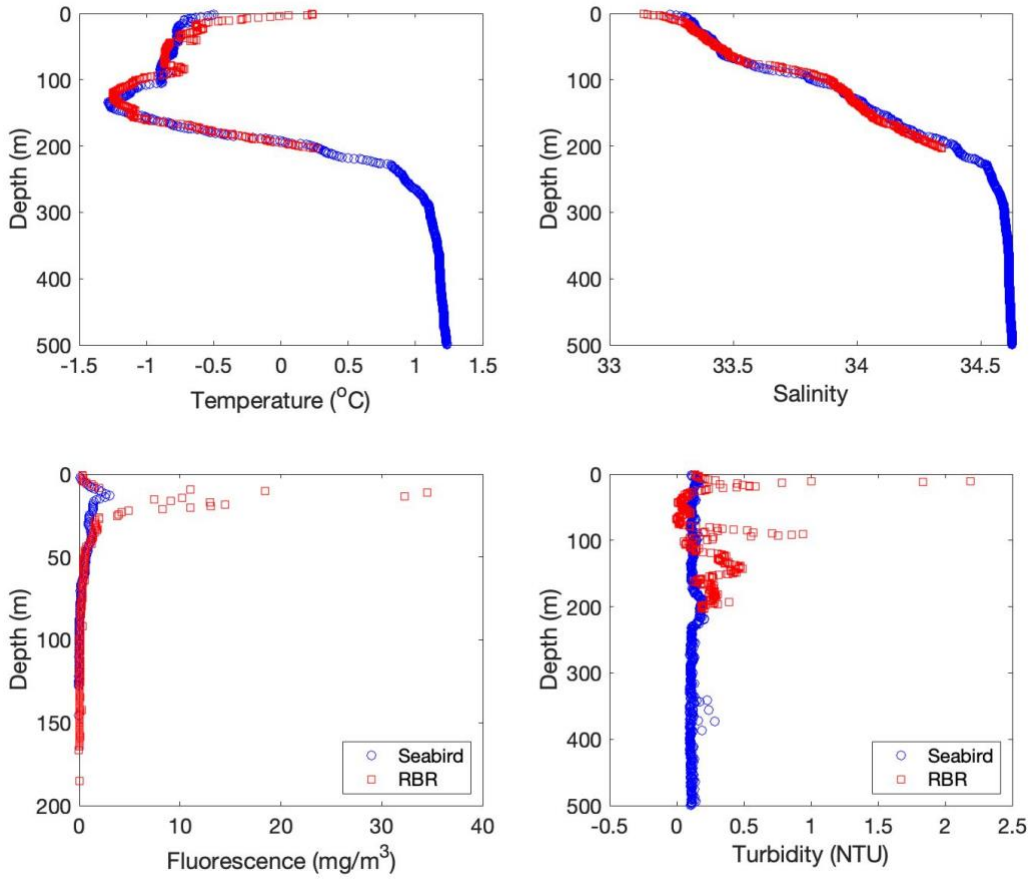


Figure 7: Comparison between Seabird 19+v2 cast (Event 2627, CTD site 1) on 6th January and RBR Concerto CTD cast 007(G4) on 8th January

Water sampling

Seawater samples were collected from 5m, mid-depth (15m) and deep waters (150 or 200m) where possible using a 10L Niksin bottle (Table 3). Deep water layers were chosen to sample high turbidity layers in the water column (Fig. 8). The valves and caps were checked before deployment. The bottle was deployed using the same winch system as for the CTD, with an added weight attached to the shackle in each case. The bottles were fired using a messenger system.

The bottles were recovered to the boat in each case, and sampled as soon as possible for nutrients, dissolved δ^{30}Si, and total alkalinity, filtering through a 0.8/0.2 μm Acrodisk filter into an acid-cleaned, rinsed plastic bottle and a rinsed 50ml centrifuge tube respectively. The nutrients samples were frozen immediately at -20°C. Unfiltered samples were then taken for oxygen isotopes in rinsed glass bottles. Phytoplankton cell count samples were subsampled and fixed with 2ml lugols and parafilmed. The remaining seawater was stored in an acid-rinsed 10L bottles in the cold and dark for later processing (processing occurred within 12 hours of sampling).

Water samples were filtered through GF/Fs for particulate organic carbon and nitrogen (POC/PON) and phosphorus (POP) under low light conditions and through 0.2 μm polycarbonate filters for reactive silica. Some samples were also filtered through GF/Fs for chlorophyll analyses under low light conditions (when not being analysed as part of the RaTS program, or deeper samples). Water was additionally filtered through 0.2 μm PES filters for particulate trace metal (and SEM) analyses using a plastic covering to minimise contamination. MilliQ 'exposure' blanks were taken for all particulate samples. Silica and metals samples were filtered under a HEPA clean box.
Samples for δ^{30}Si were acidified (0.1% v/v trace metal grade nitric acid) and parafilmed.

Stn	Date	Depth (m)	Lat (N)	Lon (E)	~Temperature (°C)	~Salinity	Name
001	24/12/2024	2	-67.570	-68.225	-0.09	33.8	RaTS site 1
001	24/12/2024	15	-67.570	-68.225	-0.25	33.8	RaTS site 1
001	24/12/2024	200	-67.570	-68.225	-0.56	34.2	RaTS site 1
002	30/12/2024	2	-67.581	-68.156	-0.44	33.4	RaTS site 2
002	30/12/2024	15	-67.581	-68.156	-0.51	33.5	RaTS site 2
002	30/12/2024	150	-67.581	-68.156	-1.11	34.1	RaTS site 2
003	04/01/2025	2	-67.526	-68.253	-0.72	33.6	G1
003	04/01/2025	15	-67.526	-68.253	-0.75	33.4	G1
003	04/01/2025	200	-67.526	-68.253	-0.38	34.2	G1
004	06/01/2025	2	-67.570	-68.225	-0.50	33.2	RaTS site 1
004	06/01/2025	15	-67.570	-68.225	-0.73	33.3	RaTS site 1
004	06/01/2025	200	-67.570	-68.225	0.19	33.4	RaTS site 1
007	08/01/2025	2	-67.5398	-68.2709	0.20	33.2	G4
007	08/01/2025	15	-67.5398	-68.2709	-0.59	33.2	G4

007	08/01/2025	200	-67.5398	-68.2709	0.13	34.3	G4
009	13/01/2025	2	-67.5427	-68.28041	-0.52	33.3	G3
009	13/01/2025	170	-67.5427	-68.28041	-1.12	34.0	G3
009	13/01/2025	200	-67.5427	-68.28041	-0.54	34.2	G3
010	14/01/2025	15	-67.570	-68.225	-0.20	33.4	RaTS site 1
010	14/01/2025	40	-67.570	-68.225	-0.60	33.5	RaTS site 1
011	15/01/2025	2	-67.5398	-68.2709	0.06	33.1	G2
011	15/01/2025	160	-67.5398	-68.2709	-1.00	34.1	G2
011	15/01/2025	200	-67.5398	-68.2709	-0.12	34.3	G2
013	18/01/2025	2	-67.525	-68.254	-	-	G1b
013	18/01/2025	15	-67.525	-68.254	-	-	G1b
013	18/01/2025	100	-67.525	-68.254	-	-	G1b
015	20/01/2025	15	-67.570	-68.225	-0.21	33.3	RaTS site 1

Table 3: Water sampling events

]

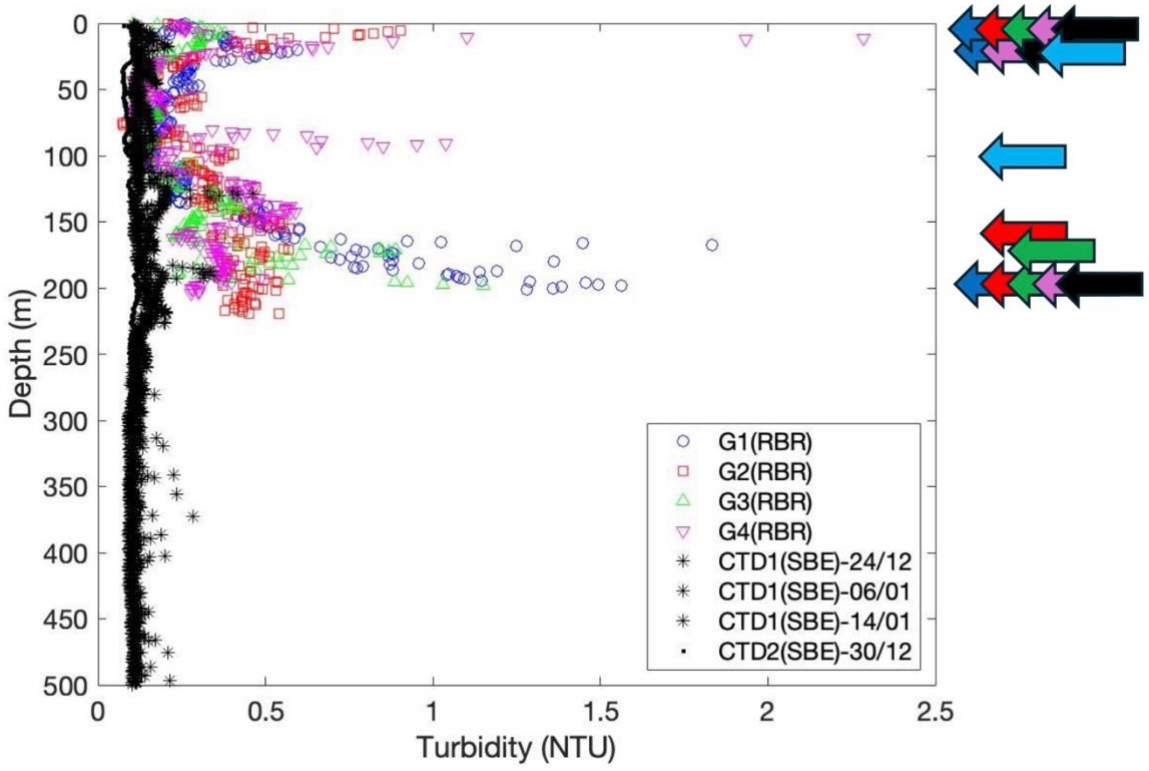


Figure 8: Sampling depths vs. turbidity plot; arrows show sampling depths for particulates, colour-coded for study site; note pale blue arrow shows G1a, where there was a strong turbidity maximum at 100m water depth in the glider data

Chlorophyll analyses

Chlorophyll assays were carried out as follows: the filters (stored in the dark for less than a week at -20°C) were added to a test tube containing 10ml 90% acetone, and left to extract at -20°C for 4 hours. The sample was then analysed using a calibrated Turner Trilogy fluorometer (calibrated as part of the RaTS program in January 2025, calibration number 41). A comparison between the old (calibration 39/40) and new calibration (calibration 41) was carried out, and they agreed well (Table 4). Blank filter measurements were below the limit of detection. Other chlorophyll data are available from the RaTS database.

Sample	Old calibration		New calibration	
	Chl conc (mg/m3)	**Phae conc (mg/m3)**	**Chl conc (mg/m3)**	**Phae conc (mg/m3)**
001 2m	0.52	0.10	0.53	0.13
002 2m	1.36	0.25	1.34	0.41
003 - 2m A			0.45	0.07
003 - 2m B			0.17	0.29
003 - 15m A			0.67	0.20
003 - 15m B			0.69	0.20
004 - 2m A			0.28	0.18
004 - 2m B			0.28	0.20
008 - 2m			0.07	0.05
008 - 15m A			3.15	0.85
008 - 15m B			3.17	1.43
009 - 2m A			0.17	0.05
009 - 2m B			0.20	0.03
011 - 2m A			0.10	0.03
011 - 2m B			0.11	0.02
013 – 2m A			0.33	0.09
013 – 2m B			0.37	0.08
013 – 15m A			5.84	0.34
013 – 15m B			5.62	0.81

Table 4: Seawater chlorophyll measurements, including a comparison between chlorophyll extractions using the old and new RaTS calibrations (30/40 vs. 41)

Freshwater sampling

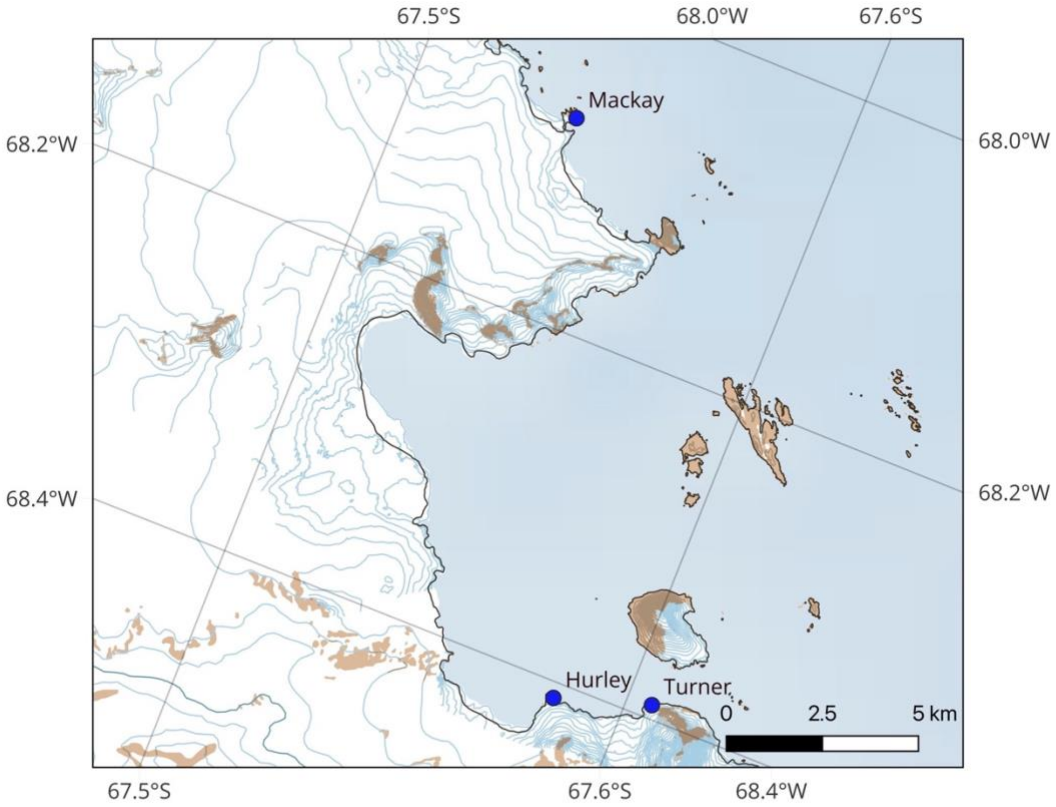


Figure 9: Map of freshwater sampling sites collected for the BIOPOLE project.

Physical properties

Temperature, conductivity, pH and dissolved oxygen were measured as part of the BIOPOLE project work by Alanna Grant.

Water sampling

Freshwater inputs were sampled in the form of dripping ice/snow on nearby access points (Fig. 9, Table 5). A cleaned funnel was used to collect the water into clean carboys. In the lab, the water was filtered for nutrients and total alkalinity using a plastic syringe, filtering through a 0.8/0.2 μm Acrodisk filter into an acid-cleaned, rinsed plastic bottle (and frozen immediately at -20°C) and a rinsed 50ml centrifuge tube respectively. A subsample was filtered for dissolved δ^{30}Si through 0.8/0.2 μm Acrodisk filters into an acid-cleaned, rinsed plastic bottle. Unfiltered samples were then taken for oxygen isotopes in rinsed glass bottles. Phytoplankton cell count samples were subsampled and fixed with 2ml lugols and parafilmed. When possible, water samples were filtered under low light conditions through

GFFs for chlorophyll particulate organic carbon and nitrogen (POC/PON) and phosphorus (POP).

Station	Date	Lat (N)	Lon (E)	Notes
005	07/01/2025	-67.606	-68.392	Turner stream (FW1)
006	07/01/2025	-67.584	-68.410	Hurley stream (FW2)
008	09/01/2025	-67.539	-68.076	Chlorophyll-rich snowbank on Mackay Point (FW3)
012	17/01/2025	-67.584	-68.410	Hurley stream (FW2-2)
014	20/01/2025	-67.539	-68.076	Mackay Point (FW3-2)

Table 5: Freshwater sampling events

Chlorophyll analyses

See above for methods.

Sample	New calibration	
	Chl conc (mg/m3)	**Phae conc (mg/m3)**
FW3 A	20.22	8.24
FW3 B	17.84	12.20
FW2-2 - A	0.15	0.10
FW2-2 - B	0.15	0.10

Table 6: Freshwater chlorophyll measurements

Sediment sampling

Sampling strategy

The aims of the sediment work were to:

1) Collect sediments from near Sheldon Glacier and from the outer fjord (filling in gaps from samples already analysed from the ICEBERGSIII cruise) for solid phase extractions and porewater analyses for SiCLING;
2) Collect sediment samples to support the NERC BIOPOLE project.

Sediment sampling was carried out from the RRS Sir David Attenborough's workboat, Erebus (cruise number SD045). The A-frame was used to deploy a winch, with 1000m, 4mm, 875kg breaking strength rope spooled on. Metering sheave was initially used, but triggered the Van Veen grab during testing, and so was removed. Initial testing also revealed that 4kg weights were needed for both the grab and 8kg for the coring.

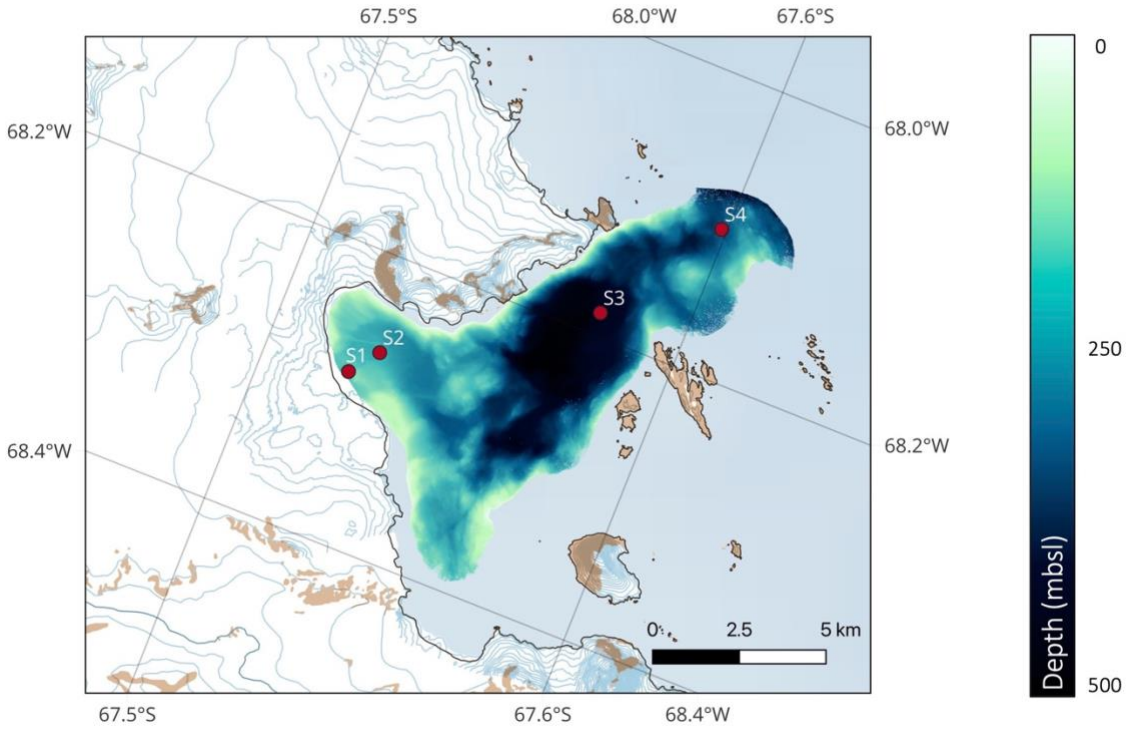


Figure 10: Map of sediment sampling sites where Van Veen grab samples and gravity cores were collected. Bathymetry from Retallick et al., 2021.

Methodology

Van Veen Grab

Sediment surface samples were collected using a Van Veen Grab on the SDA Erebus (Fig. 11). The grab was opened onto a cleaned, plastic tray and sediment was samples were scooped with a plastic scoop into clean plastic bags and stored in the dark. In the laboratory, subsamples were frozen at -20°C, and aliquots used in the core incubation study (see below).

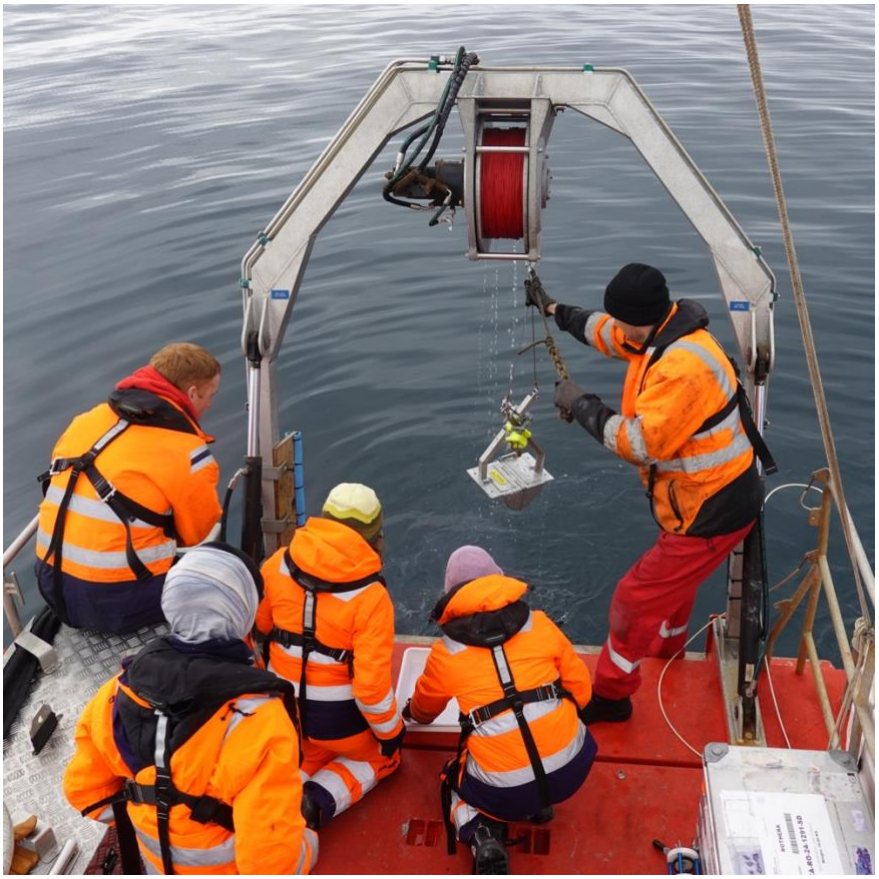


Figure 11: Recovery of Van Veen Grab (photo credit J. Oliver)

Gravity coring

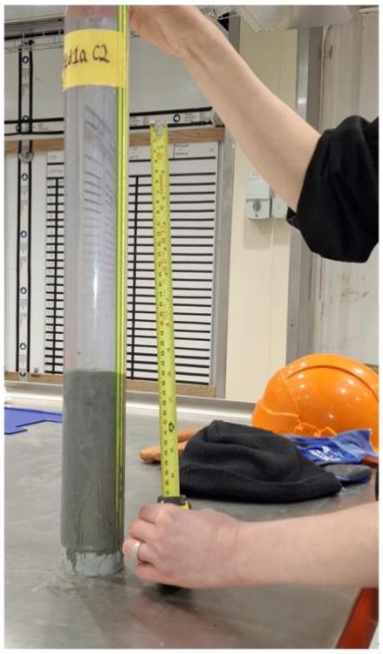
A UWITEC gravity corer (P/N 016001) was used to collect sediment cores (Fig. 12), with 2 x 4kg weights (P/N 016009). Bungs were inserted on retrieval, the cores capped and stored in the dark until processing (Fig. 13). The coring device was successful in collecting intact sediment-water interface (e.g., Fig. 14). In the lab, the first core was sliced at 1cm intervals (to 10cm) then at 2cm intervals, and samples frozen at -20°C. The second core was used for Rhizon (Rhizosphere, 0.11 µm pore size) extraction of porewaters, which were frozen at -20°C. The third core was also sliced, and put into centrifuge tubes; the porewaters were extracted with Rhizons, acidified (0.1% v/v nitric acid) and kept cool at +4°C; the remaining sediments were frozen at -20°C.

Figure 12: Gravity core set-up (photo credit J. Oliver)

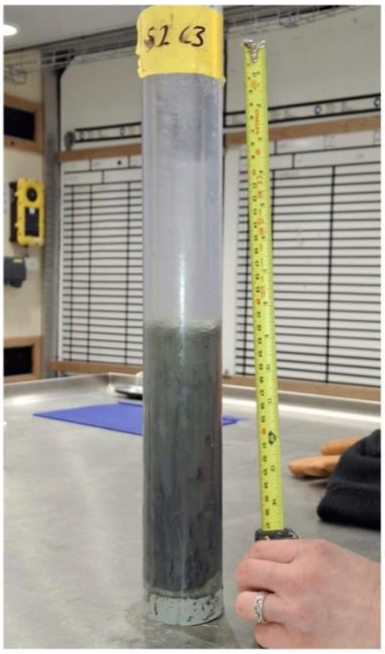
St.	**Date**	**Activity**	**Lat (N)**	**Lon (E)**	**Water depth**
016	22/01/2025	Sediment grab (Sediment 1)	-67.5226	68.2847	220m water depth
016	22/01/2025	Sediment core (Sediment 1)	-67.5226	68.2847	220m water depth
016	22/01/2025	Sediment core (Sediment 1)	-67.5226	68.2847	220m water depth
016	22/01/2025	Sediment core (Sediment 1)	-67.5226	68.2847	220m water depth
017	22/01/2025	Sediment grab (Sediment 2)	-67.5283	68.265	240m water depth
017	22/01/2025	Sediment core (Sediment 2)	-67.5283	68.265	240m water depth
017	22/01/2025	Sediment core (Sediment 2)	-67.5283	68.265	240m water depth

017	22/01/2025	Sediment core (Sediment 2)	-67.5283	68.265	240m water depth
018	23/01/2025	Sediment grab (Sediment 3)	-67.5775	68.184	320m water depth
018	23/01/2025	Sediment core (Sediment 3)	-67.5775	68.184	320m water depth
018	23/01/2025	Sediment core (Sediment 3)	-67.5775	68.184	320m water depth
018	23/01/2025	Sediment core (Sediment 3)	-67.5775	68.184	320m water depth
019	23/01/2025	Sediment grab (Sediment 4)	-67.5986	68.1014	340m water depth
019	23/01/2025	Sediment core (Sediment 4)	-67.5986	68.1014	340m water depth
019	23/01/2025	Sediment core (Sediment 4)	-67.5986	68.1014	340m water depth
019	23/01/2025	Sediment core (Sediment 4)	-67.5986	68.1014	340m water depth

Table 7: Sediment sampling events





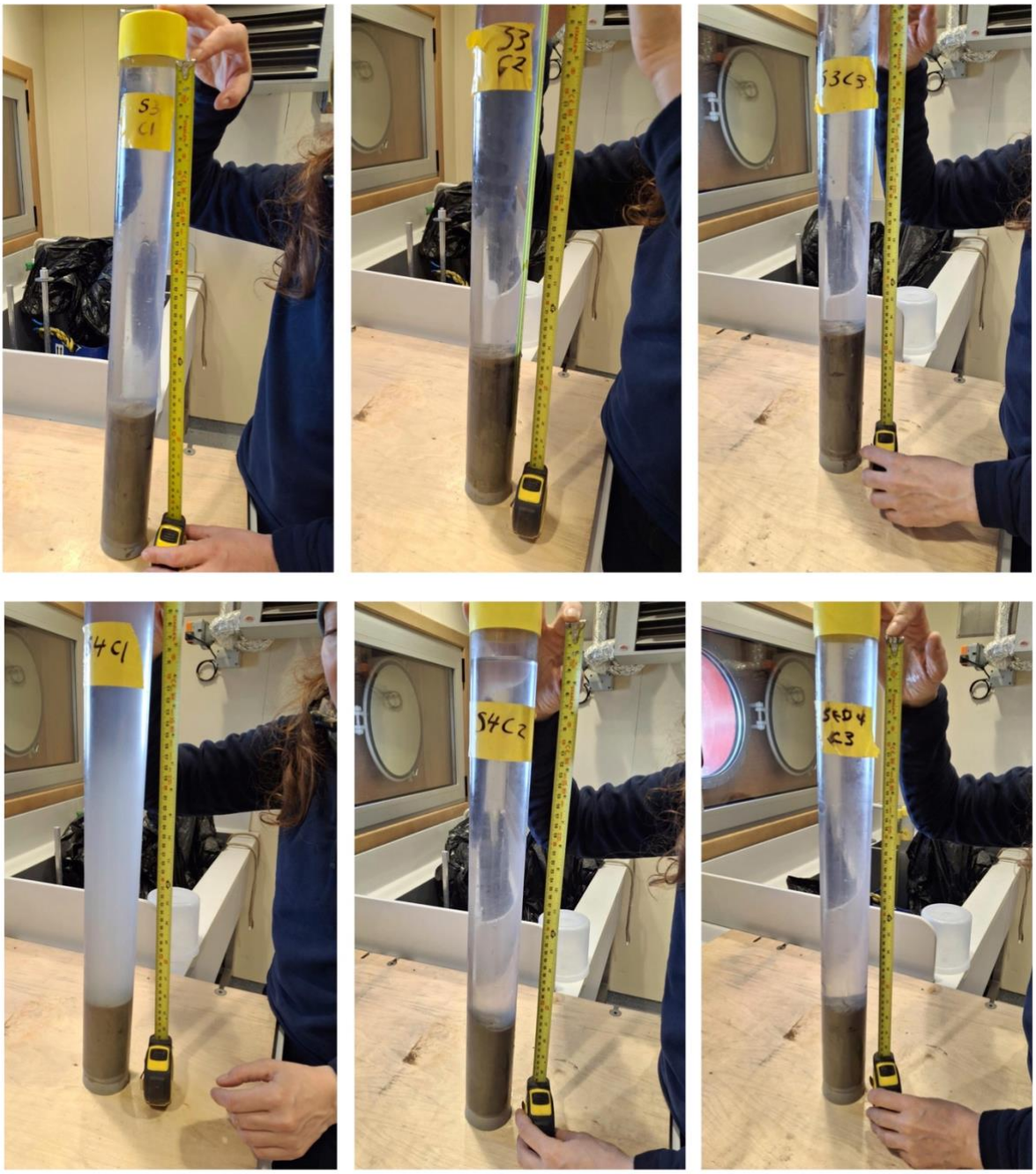


Figure 13: Sediment core photos

Figure 14: Close up of phytodetrital fluff layer, from Sediment 3 site

Incubation experiments

Sediment incubation experiments were carried out on sediments collected at sites Sediment1 and 4 (Table 6, 7). The following protocol was used.

1. Use vinyl gloves at all times.
2. Prepare 1 x 250 mL bottle with of filtered site bottom water (filtered through 0.8/0.2 μm Acrodisk filters) and sediment (Solid:solution g L-1 ~10).
3. Prepare 1 x 250 mL bottle with of 50% filtered site bottom water and 50% Milli-Q, and sediment (Solid:solution g L-1 ~10).
4. Add stir bar and use stir plate to keep in constant movement to ensure suspension, before pulling sample.
5. Pipette 10 mL of each solution into 15x15ml centrifuge tubes.

2 replicates for δ^{30}Si and metals
1 replicate for alkalinity
1 replicate for nutrients
3 time points (1 hour, 3 days, 6 days)
2 salinities (SW + 50%SW/50%MQ)
3 SW blanks (one per time interval)
3 SW/MQ blanks (one per time interval)

6. Shake daily to resuspend sediment. Vent daily to oxygenate.

7. At each sampling event, use a small syringe to remove the supernatant and filter through a 0.8/0.2 Acrodisk filters into vials: 7ml into 8ml vials (isotopes and metals), 7ml into centrifuge tubes (alkalinity) and 3ml into nutrient vials.

8. Acidify the 8ml vial samples with concentrated trace metal clean nitric acid (0.1% v/v), seal tightly, parafilm, and store under cool, dark conditions.
9. Freeze the nutrient vials at -20°C.
10. Parafilm alkalinity samples and store at +4°C.

Experiment	Location	Started	Day 3	Day 6
1	Sediment 1	22/1/2025	25/1/2025	28/1/2025
2	Sediment 2	23/1/2025	26/1/2025	29/1/2025

Table 8: Sediment incubation experiments

Station	Date collected	Date of extraction	Sample type	#	Notes
Sediment 1	22/01/2025	22/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	1 hour after experiment (100% seawater and 50% seawater)
Sediment 2	23/01/2025	23/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	1 hour after experiment (100% seawater and 50% seawater)
Sediment 1	22/01/2025	25/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	3 days after experiment (100% seawater and 50% seawater)
Sediment 2	23/01/2025	26/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	3 days after experiment (100% seawater and 50% seawater)
Sediment 1	22/01/2025	28/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	6 days after experiment (100% seawater and 50% seawater)
Sediment 2	23/01/2025	29/01/2025	Blank Alkalinity Nutrients $d^{30}Si$ Trace metals	2 2 2 2 2	6 days after experiment (100% seawater and 50% seawater)

Table 9: Incubation samples