DY098 CRUISE REPORT

Polar Ocean Ecosystem Time Series – Western Core Box

02 JAN 2019 – 10 FEB 2019

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1. Introduction

Cruise DY098 is the 23rd occupation of the Polar Ocean Ecosystem Time Series Western Core Box (POETS-WCB). The main deliverable of the POETS-WCB is a consistent unique time series of mesoscale distribution and abundance of Antarctic krill and an understanding of their physical environment within the region of South Georgia, South Atlantic (1996 – current). These data are required to understand the long-term variability in krill biomass at South Georgia and the influences from climatic variability, fishing pressure and predation.

South Georgia is an area of high regional biodiversity, supporting large numbers of endemic and range-edge species. The pelagic ecosystem in this region is extremely productive with intense phytoplankton blooms supporting a rich food web that includes zooplankton, in particular large densities of Antarctic krill, and vertebrate predators (penguins, seals and whales).

The British Antarctic Survey (BAS) have undertaken cruises to monitor krill biomass as part of the ongoing assessment of the status of the marine ecosystem in the south-west Atlantic sector of the Southern Ocean. In addition to an annual acoustic assessment of krill in an area to the north-west of South Georgia called the Western Core Box (WCB), BAS maintains moorings both on the South Georgia shelf and in the open ocean region of the Scotia Sea. The open ocean sustained observations in the area are carried out as part of the SCOOBIES (SCotia sea Open-Ocean BIological laboratoriES) programme, a NERC National Capability Science (Single) funding (NC-SS) project with a primary purpose to consider the flux of carbon to deep ocean layers as well as monitoring ocean chemistry parameters, particular in relation to ocean acidification. This moored instrumentation complements the WCB surveys by providing year round temporal sampling of environmental conditions and acoustic backscatter.

An additional 14 days were added to DY098 to contribute to the 2019 Large Scale Survey of krill density and distribution in the South Atlantic, surveying the South Sandwich Islands. Led by Norway with contributions from UK, USA, Korea, China and Ukraine it will be used to inform CCAMLR of the current Antarctic krill status, pertinent to managing the Antarctic marine ecosystem.

The cruise consists of the following:

1.1. POETS - WCB survey

1. Acoustic survey during daylight hours using multi-frequency (38, 70, 120 & 200 kHz) Simrad EK60 echosounder. Two transects to be run each day during a four day period.

2. Regular deployments of XBTs (Expendable bathythermographs) along transects during day.

3. Deployment of the CTD at minimum of two stations per night during survey.

4. Continuous operation of underway data logging system (bathymetry, location, sea surface temperature, sea currents, etc.).

5. Net sampling (RMT8 and other zooplankton/micronekton nets) at night-time stations plus target fishing during both night and day to ground-truth acoustic data.

6. Acoustic calibration using standard sphere techniques will be undertaken in one of the deep-water harbours on the North coast of South Georgia (Stromness Harbour is the preferred location).

7. Recover WCB mooring. Download data, refurbish and replace batteries. Redeploy mooring.

1.2. POETS – SCOOBIES (SCotia sea Open-Ocean BIological laboratoriES)

Mooring recovery, refurbishment and redeployment

1. Recover two deep-water moorings (SW and NW of South Georgia). Download data, refurbish and replace batteries. Redeploy moorings during cruise.

2. Net sampling (RMT8, MOCNESS and other zooplankton nets) over 24 hour periods at mooring stations.

1.3. 2019 Large Scale South Sandwich Island krill survey

1. Acoustic survey during daylight hours using multi-frequency (38, 70, 120 & 200 kHz) Simrad EK60 echosounder. Two transects to be run each day during a four day period.

2. Deployment of the CTD at two stations per 24 hour period during survey.

3. Continuous operation of underway data logging system (bathymetry, location, sea surface temperature, sea currents, etc.).

4. Net sampling (RMT8 and other zooplankton/micronekton nets) at two stations per 24 hour period plus occasional target fishing during to ground-truth acoustic data.

1.4. Cruise track

DY098 set off from Stanley, Falkland Islands (02/01/2019) and returned there (10/02/2019) (Figure 1)

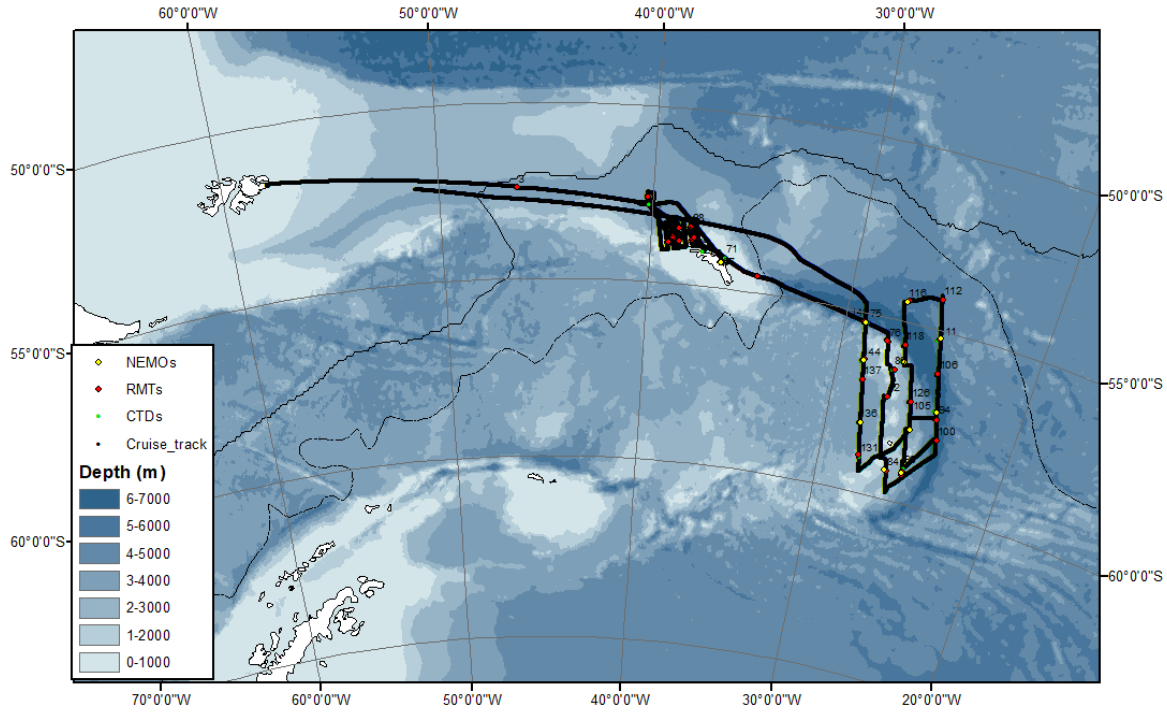

Figure 1 DY098 cruise track, with event numbers listed

1.5. Personnel

List of all personnel on cruise (Table 1) and cruise photograph (Figure 2).

Surname	Forename	Position	Institute
GAULD	PHILIP	Master	NOC
MAHON	ANDREW	C/O	NOC
MORROW	DECLAN	2/O	NOC
WILLCOX	SIMON	3/O	NOC
LEWTAS	ANDREW	C/E	NOC
HAY	DEREK	2/E	NOC
HAMILTON	JOHN	3/E	NOC
LONGWORTH	TAYLOR	3/E	NOC
LAVERSUCH	CONRAD	ETO	NOC
BULLIMORE	GRAHAM	Purser	NOC
SMITH	STEPHEN	CPOS	NOC
COOK	STUART	CPOD	NOC
PEPPIN	CHRISTOPHER	POD	NOC
CRABB	GARY	SG1A	NOC
MACKENZIE	DAVID	SG1A	NOC
STIVEY	MARK	SG1A	NOC
PARIS	RYAN	SG1A	NOC
CONTEH	BRIAN	ERPO	NOC
KEIGHLEY	CHRISTOPHER	Head Chef	NOC
SHANNON	PAUL	Chef	NOC
BRADBURY	JANE	Stwd	NOC
MASON	KEVIN	A/Stwd	NOC
FIELDING	SOPHIE	PSO	BAS
STOWASSER	GABRIELE	Scientist	BAS
ASHURST	DANIEL	AME Engineer	BAS
APELAND	BJOERG	AME Engineer	BAS
ARIZA	ALEJANDRO	Scientist	BAS
BAINES	MICHAEL	Scientist	BAS

CORNWELL	LOUISE	Scientist	PML
HULBERT	ALYSA	Scientist	BAS
JONES-WILLIAMS	KIRSTIE	Scientist	BAS/University of Exeter
LACEY	CLAIRE	Scientist	BAS
LANGAN	EMMA	Scientist	UEA/BAS
MANNO	CLARA	Scientist	BAS
REICHELT	MAREN	Scientist	BAS
McRAE	EUAN DAVID	Scientist	BAS/University of Strathclyde
PERRY	FRANCES	Scientist	PML/BAS
PINDER	SIMON	Scientist	BAS
ROWLANDS	EMILY	Scientist	University of Exeter/BAS
SACCOMANDI	FLAVIA	Scientist	ISPRA
SILVESTRI	CECILIA	Scientist	ISPRA
SLOMSKA	ANGELIKA	Scientist	University of Gdansk
SORENSEN	MEGAN	Scientist	University of Sheffield
PHILIP	KEATING	Medic	SSI Energy
WYNAR	JOHN	Tech	NOC
LEADBEATER	ANDREW	STO	NOC
CHEESEMAN	DEAN	Tech	NOC
HARKER	NICHOLAS	Tech	NOC
MOORE	ANDREW	SST	NOC

Table 1 List of all personnel on cruise

Figure 2 Cruise photograph

1.6. Acknowledgements

This cruise is part of a long term commitment by the BAS Ecosystems programme to investigate the ecology of the Scotia Sea ecosystem and understand the variability and change occurring in the region. In addition the group undertook a large scale survey of the pelagic ecosystem around the South Sandwich Islands.

This cruise included a stay at King Edward Point whilst supporting a medical incident, lots of fog, and some epic icebergs (B15). We thanks the ship's officers and crew for their enthusiastic and expert support. We are grateful for their professionalism and helpful attitude.

We thanks the scientific bosun, NMF and AME technical and engineering support for bringing all our equipment back this year, as well as redeploying our two long term moorings!

The cruise was extended for three days, many thanks to the NOC and BAS logistics teams who enabled this to happen, ensured that we got home, and apologies to all for the changes to timetables!

1.7. Station summary

Summary of station names, activities and associated event numbers by date (Table 2). The WCB and P4 components of the cruise were undertaken between 04/01/2019 and 23/01/2019. During this time that vessel answered a medical support request and as a result spent 9 days in the vicinity of KEP. Equipment testing was carried out during this period, as well as calibration of acoustic instruments. On resuming science the vessel headed to the South Sandwich Islands to complete the survey there. Once there it completed as much of the transects it could, whilst balancing fog, icebergs and weather.

Date	Event No.	Station	Activities
04/01/2019	1-3	Test	RMT, CTD
05/01/2019	4-7	P3	Mooring, CTD, Bongo
06-11/01/2019	8-51	WCB	Acoustic transects, CTDs, XBTs, RMT8s, Bongos
12-13/01/2019	52-55	P3	Mooring deployed, RMT, acoustics
14-22/01/2019	56-69	KEP	Tests, sediment trap, WBAT, acoustic calibration, MOCNESS, RMT8+1
23/01/2019	70	WCB mooring	Mooring deployed
24-25/01/2019	71-75	South Georgia	Transit and fishing
26/01 – 07/02/2019	76-148	South Sandwich Island	Acoustic transects, RMT8+1, Bongo, NEMO, CTDs

Table 2 Station summary

2. CTD and XBT

2.1. CTD deployments

A Conductivity-Temperature-Depth (CTD) unit was used to vertically profile the water column at P3, within the WCB and within the South Sandwich Island survey. Full depth casts were undertaken at P3. The WCB CTDs were to within 10m of the seabed or 1000m, whichever deeper and the South Sandwich Island CTD were to a maximum depth of 1500m (except for one to 3000m). CTD stations locations and water depths are summarised in Table 3.

Water bottles were fired at selected depths at selected stations for water samples, these were collected for POM, DOM, chlorophyll a, salinity, eDNA and lugols samples (Section 3).

Time	Latitude	Longitude	Event No.	Station	Water Depth (m)	Max CTD depth (m)	CTD No.
04/01/2019 17:19	-52.428175	-46.346225	3	Test	3046		Test CTD 001 deployed
04/01/2019 17:45	-52.428162	-46.346317	3	Test	3045	1000	Test CTD 001 at 1000m
04/01/2019 18:12	-52.428158	-46.346246	3	Test	3046		Test CTD 001 recovered
05/01/2019 20:00	-52.810968	-40.169134	5	P3	3048		CTD 002 deployed
05/01/2019 21:09	-52.814533	-40.172027	5	P3	3043	3040	CTD 002 max wire out 3040m
05/01/2019 22:25	-52.820212	-40.176395	5	P3	3799		CTD 002 recovered
06/01/2019 22:39	-53.786181	-38.582364	15	WCB2.2S	212		CTD 003 deployed
06/01/2019 22:53	-53.786176	-38.582365	15	WCB2.2S	212	193	CTD 003 max wire out 193m
06/01/2019 23:04	-53.786179	-38.582355	15	WCB2.2S	212		CTD 003 recovered
07/01/2019 02:32	-53.432685	-38.694902	17	WCB2.2N	3045		CTD 004 deployed
07/01/2019 02:57	-53.432671	-38.694936	17	WCB2.2N	3037	1000	CTD 004 max wire out 1000m
07/01/2019 03:33	-53.432672	-38.694958	17	WCB2.2N	3042		CTD 004 recovered
09/01/2019 04:40	-53.846638	-39.144198	29	WCB1.2S	294		CTD 005 deployed
09/01/2019 04:52	-53.846668	-39.144184	29	WCB1.2S	295	283	CTD 005 max wire out 283m
09/01/2019 05:00	-53.846652	-39.144187	29	WCB1.2S	295		CTD 005 recovered
09/01/2019 23:57	-53.7196	-37.968865	37	WCB3.2S	143		CTD 006 deployed

10/01/2019 00:09	-53.828875	-39.093605	37	WCB3.2S	597	128	CTD 006 max wire out 128m
10/01/2019 00:14	-53.719586	-37.968908	37	WCB3.2S	143		CTD 006 recovered
10/01/2019 05:14	-53.361136	-38.080648	38	WCB3.2N	3000		CTD 007 deployed
10/01/2019 05:41	-53.361101	-38.080621	38	WCB3.2N	2669	1000	CTD 007 max wire out 1000m
10/01/2019 06:03	-53.36111	-38.080666	38	WCB3.2N	3006		CTD 007 recovered
11/01/2019 15:24	-54.020879	-37.411211	49	Rosita	114		CTD 008 deployed
11/01/2019 15:37	-54.020882	-37.41121	49	Rosita	113	112	CTD 008 max wire out 112m
11/01/2019 15:49	-54.020883	-37.411214	49	Rosita	113		CTD 008 recovered
12/01/2019 13:42	-52.800003	-40.158521	52	P3	3801		CTD 009 deployed
12/01/2019 14:56	-52.800606	-40.158135	52	P3	3801	3750	CTD 009 max wire out 3750m
12/01/2019 16:22	-52.801381	-40.1578	52	P3	3799		CTD 009 recovered
15/01/2019 16:32	-54.285405	-36.464192	56	KEP	145		CTD 010 deployed
15/01/2019 16:40	-54.285404	-36.464193	56	KEP	145	128	CTD 010 max wire out 128m
15/01/2019 16:56	-54.285403	-36.464195	56	KEP	145		CTD 010 recovered
20/01/2019 20:10	-54.266022	-36.443725	67	KEP	266		CTD 011 deployed
20/01/2019 20:23	-54.266012	-36.44373	67	KEP	266	247	CTD 011 max wire out 247m
20/01/2019 20:33	-54.266016	-36.443725	67	KEP	266		CTD 011 recovered
24/01/2019 12:51	-54.124879	-36.290299	71		285		CTD 012 deployed
24/01/2019 13:02	-54.124873	-36.290284	71		285	250	CTD 012 max wire out 250m
24/01/2019 13:19	-54.124837	-36.290337	71		285		CTD 012 recovered
26/01/2019 02:39	-55.276846	-28.834796	75		5001		CTD 013 deployed
26/01/2019 03:13	-55.277952	-28.832505	75		6036	1500	CTD 013 max wire out 1500m
26/01/2019 03:58	-55.277952	-28.832505	75		6036		CTD 013 recovered

26/01/2019 13:16	-55.663048	-27.662596	76		1245		CTD 014 deployed
26/01/2019 13:43	-55.663071	-27.662642	76		1248	1217	CTD 014 max depth 1217m
26/01/2019 14:22	-55.66305	-27.66262	76		1247		CTD 014 recovered
27/01/2019 02:43	-56.41208	-27.087453	80		1842		CTD 015 deployed
27/01/2019 03:19	-56.412106	-27.087458	80		1842	1500	CTD 015 max depth 1500m
27/01/2019 04:07	-56.412134	-27.087478	80		1842		CTD 015 recovered
27/01/2019 13:11	-57.187341	-27.06062	82		2359		CTD 016 deployed
27/01/2019 13:48	-57.187311	-27.060574	82		2359	1500	CTD 016 max depth 1500m
27/01/2019 14:28	-57.187393	-27.060558	82		2359		CTD 016 recovered
28/01/2019 14:02	-59.211263	-26.149746	84		2170		CTD 017 deployed
28/01/2019 14:43	-59.211266	-26.149747	84		2169	1500	CTD 017 max depth 1500m
28/01/2019 15:24	-59.211272	-26.149699	84		2171		CTD 017 recovered
30/01/2019 01:19	-57.449335	-24.208529	94		6535		CTD 018 deployed
30/01/2019 02:17	-57.449392	-24.208385	94		6544	3000	CTD 018 max depth 3000m
30/01/2019 03:43	-57.449473	-24.208501	94		6536		CTD 018 recovered
31/01/2019 02:30	-59.031632	-25.253628	98		2767		CTD 019 deployed
31/01/2019 03:05	-59.031718	-25.25369	98		2768	1500	CTD 019 max depth 1500m
31/01/2019 03:47	-59.03172	-25.253691	98		2768		CTD 019 recovered
31/01/2019 13:39	-58.022124	-23.960438	100		4546		CTD 020 deployed
31/01/2019 14:13	-58.022107	-23.960388	100		6117	1500	CTD 020 max depth 1500m
31/01/2019 14:53	-58.022084	-23.960424	100		6119		CTD 020 recovered
01/02/2019 02:50	-57.256812	-24.476507	105		5508		CTD 021 deployed
01/02/2019 03:06	-57.256806	-24.476496	105		5518	400	CTD 021 max depth 400m

01/02/2019 03:27	-57.256808	-24.476493	105		5508		CTD 021 recovered
01/02/2019 13:14	-56.190115	-24.776429	106		7336		CTD 022 deployed
01/02/2019 13:45	-56.190115	-24.776417	106		7337	1500	CTD 022 max depth 1500m
01/02/2019 14:22	-56.190071	-24.776457	106		7336		CTD 022 recovered
02/02/2019 02:22	-55.288959	-25.263444	111		6052		CTD 023 deployed
02/02/2019 02:49	-55.288955	-25.263435	111		4951	1500	CTD 023 max depth 1500m
02/02/2019 03:28	-55.28895	-25.263441	111		4952		CTD 023 recovered
02/02/2019 13:28	-54.130912	-25.564621	112		4964		CTD 024 deployed
02/02/2019 13:58	-54.130919	-25.564626	112		4964	1500	CTD 024 max depth 1500m
02/02/2019 14:41	-54.130922	-25.564609	112		4964		CTD 024 recovered
03/02/2019 01:31	-54.433021	-27.176344	116		5352		CTD 025 deployed
03/02/2019 02:02	-54.434687	-27.173324	116		5363	1500	CTD 025 max depth 1500m
03/02/2019 02:41	-54.437096	-27.169042	116		5375		CTD 025 recovered
03/02/2019 13:07	-55.646727	-26.768167	118		5960		CTD 026 deployed
03/02/2019 13:35	-55.646721	-26.768196	118		5960	1500	CTD 026 max depth 1500m
03/02/2019 14:13	-55.646721	-26.768175	118		5961		CTD 026 recovered
04/02/2019 02:28	-56.108967	-26.740852	125		2486		CTD 027 deployed
04/02/2019 02:57	-56.10879	-26.74088	125		2485	1500	CTD 027 max depth 1500m
04/02/2019 03:31	-56.108788	-26.740863	125		2485		CTD 027 recovered
04/02/2019 13:10	-57.159429	-25.796516	126		3462		CTD 028 deployed
04/02/2019 13:40	-57.159426	-25.796518	126		3462	1500	CTD 028 max depth 1500m
04/02/2019 14:19	-57.159425	-25.796513	126		3462		CTD 028 recovered
05/02/2019 13:09	-59.015972	-27.761129	131		2997		CTD 029 deployed

05/02/2019 13:45	-59.015971	-27.761054	131		2996	1500	CTD 029 max depth 1500m
05/02/2019 14:25	-59.015975	-27.761057	131		2996		CTD 029 recovered
06/02/2019 01:30	-58.091509	-28.232429	136		3365		CTD 030 deployed
06/02/2019 02:01	-58.091539	-28.232466	136		3364	1500	CTD 030 max depth 1500m
06/02/2019 02:41	-58.091519	-28.23241	136		3364		CTD 030 recovered
06/02/2019 13:11	-56.871801	-28.492096	137		4522		CTD 031 deployed
06/02/2019 13:40	-56.872015	-28.492057	137		3401	1500	CTD 031 max depth 1500m
06/02/2019 14:16	-56.872022	-28.492054	137		3400		CTD 031 recovered
07/02/2019 01:19	-56.36396	-28.775801	144		3137		CTD 032 deployed
07/02/2019 01:51	-56.363955	-28.775808	144		3137	1500	CTD 032 max depth 1500
07/02/2019 02:31	-56.36395	-28.775809	144		3139		CTD 032 recovered
07/02/2019 13:11	-55.265677	-28.979731	146		3007		CTD 033 deployed
07/02/2019 13:42	-55.265652	-28.979698	146		4742	1500	CTD 033 max depth 1500
07/02/2019 14:22	-55.265598	-28.979703	146		4740		CTD 033 recovered

Table 3 CTD events, stations, depths and numbers from DY098

2.2. NMF CTD Operations report – *John Wynar Sensors and Moorings group NOC*

2.2.1. Overview

There were 33 CTD casts made all using the stainless steel system. Log sheets were scanned and included with the data from this cruise.

The configuration file used was DY098_1182_SS.xmlcon and is included in the configuration section below.

CTD1 was used for all casts. The wire was terminated at the start of the cruise; an insulation figure of > 999MΩ o/c was initially obtained and a s/c value of 70Ω. Swivel s/n: 1246-1 was used for casts 1-10 inclusive and no faults occurred. Swivel s/n: 1246-2 was used for casts 10 and 11 but failed at the start of cast 12. Swivel 1246-1 was used for the remainder of the expedition. 1246-2 was measured for continuity and insulation but no fault could be found. Hence further internal inspection is required.

2.2.2. Sensor Failures

There were no sensor failures. However there was an anomalous behaviour of the altimeter at shallow depths from later casts. Benthos unit s/n: 59494 would give consistent values of approximately 10m above bottom (~ 0.5V) for the first 2 to 300m after the start of the deployment

and then behave normally for the remainder of the cast. Unfortunately there was no opportunity to check its behaviour near the sea-bed. All cables were inspected, cleaned and finally substituted but at no stage was there any change in the behaviour of the output. When the altimeter was exchanged for unit s/n: 62679 for cast 25 there was still no change in recorded output. Hence it can be deduced that this behaviour is not associated with the instrument or cabling. Incidentally, the fluorimeter which shared the same Y cable showed no such behaviour.

NB: Re-playing earlier casts it was observed that this anomalous behaviour was present but for a shorter period just after the "soak" at the start of the downcast. The bottom tracking capability of the altimeter appeared unaffected during these deployments.

2.2.3. LADCP Configuration

The TRDI WHM 300kHz LADCP (s/n:1855) was deployed in a downward-looking orientation on the CTD frame. Battery voltage could not be monitored as the cable was diode protected. The instrument was configured to ping as fast as possible, use 25 bins, a zero blanking distance and a depth cell size of 8m thus yielding a range of approximately 200m in ideal conditions. The ambiguity velocity was set to 400 cms-1 and ensemble time of 1.3 seconds.

Master command file (DY98_com_file.cmd)

```
CR1                 ; retrieve parameters (1 = On)
RN DY098            ; cruise name DY098
WM15                ; sets some defaults for lowered ADCP
CF11101             ; flow control
EA00000             ; heading alignment (-179.99 to 180 deg)
ES35                ; salinity (0 to 40)
EX00100             ; coordinate transformation (none: leave in beam coordinates)
EZ0011101           ; sensor source: internal heading, pitch, tilt, temp
TB00:00:02.80       ; time interval per burst of pings (hh:mm:ss)
TC2                 ; two ensembles per burst
TE00:00:01.30       ; time per ensemble (hh:mm:ss)
TP00:00.00          ; minimum time between pings (mm:ss)
LP1                 ; single ping per ensemble
LN25                ; number of depth cells
LS0800              ; size of depth cells (cm)
LF0                 ; blank after transmit
LW1                 ; narrow band
LV400               ; ambiguity velocity (cm/s radial)
SA011               ; synchronise before ensemble
SM0                 ; RDS3 mode select (0 = off [single instrument])
SB0                 ; disable hardware-break detection on channel B
CK                  ; keep parameters as user defaults
CS                  ; start pinging
```

2.2.4. CTD Data Processing

Basic post-processing of the CTD cast data was done to guidelines established with BODC (ref. Moncoiffe 7th July 2010).

2.2.5. Salinity measurement

A Guildline Autosal 8400B salinometer, s/n: 68426, was used for salinity measurements. The salinometer was sited in the Salinometer lab. Initially, the bath temperature was set at 21°C, the ambient temperature being approximately 20°C. A bespoke program written in Labview called "Autosal" was used as the data recording program for salinity values.

Salinity samples were taken and analysed from most casts except the first test cast, and the results tabulated in a spreadsheet SALFORM_SS.xlsx.

2.2.6. Configuration files

Configuration file used for the stainless system:

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY098\Data\Seasave Setup Files\DY098_1182_SS.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : Yes
NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature
Serial number : 03P-5835
Calibrated on : 10-FEB-2017
G : 4.37871334e-003
H : 6.72990980e-004
I : 2.74310529e-005
J : 2.07304902e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity
Serial number : 04C-3054
Calibrated on : 31-AUG-2016
G : -9.81052501e+000
H : 1.42335408e+000
I : -3.68037907e-004
J : 9.42658320e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008

Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
Serial number : 129735
Calibrated on : 3-NOV-2017
C1 : -6.064446e+004
C2 : 6.966022e-002
C3 : 1.971200e-002
D1 : 2.882500e-002
D2 : 0.000000e+000
T1 : 3.029594e+001
T2 : -6.713680e-005
T3 : 4.165390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 0.99982000
Offset : -1.48930
AD590M : 1.279180e-002
AD590B : -8.821250e+000

4) Frequency 3, Temperature, 2
Serial number : 03P-5838
Calibrated on : 10-FEB-2017
G : 4.34196239e-003
H : 6.69268068e-004
I : 2.67944163e-005
J : 2.14786223e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2
Serial number : 04C-3874
Calibrated on : 14 June 2018
G : -1.05061165e+001
H : 1.39034506e+000
I : -1.35095160e-003
J : 1.64034401e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43
Serial number : 43-2831
Calibrated on : 29-APR-2017
Equation : Sea-Bird

Soc : 4.69000e-001
Offset : -4.95700e-001
A : -4.72720e-003
B : 2.37530e-004
C : -3.46640e-006
E : 3.60000e-002
Tau20 : 1.07000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Fluorometer, Chelsea Aqua 3
Serial number : 88-2615-126
Calibrated on : 16-AUG-2018
VB : 0.593340
V1 : 2.105980
Vacetone : 0.756140
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Altimeter
Serial number : 59494
Calibrated on : 25-MAR-2013
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor
Serial number : 70520
Calibrated on : 24-Jan-2017
M : 1.00000000
B : 0.00000000
Calibration constant : 16835016800.00000000
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : -0.06092372

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2
Serial number : 70510
Calibrated on : 24-JAN-2017
M : 1.00000000
B : 0.00000000
Calibration constant : 20449897800.00000000
Conversion units : umol photons/m^2/sec

Multiplier : 1.00000000
Offset : -0.04979765

12) A/D voltage 6, OBS, WET Labs, ECO-BB
Serial number : 1055
Calibrated on : 30-MAR-2016
ScaleFactor : 0.003648
Dark output : 0.041600

13) A/D voltage 7, Transmissometer, WET Labs C-Star
Serial number : CST-1602DR
Calibrated on : 24-MAY-2016
M : 21.2319
B : -0.1040
Path length : 0.250

Scan length : 45

Pump Control
This setting is only applicable to a custom build of the SBE 9plus.
Enable pump on / pump off commands: NO

Data Acquisition:
Archive data: YES
Delay archiving: NO
Data archive: C:\Users\sandm\Documents\Cruises\DY098\Data\CTD Raw Data\DY098_EV056_CTD10.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 20

Instrument port configuration:
Port = COM4
Baud rate = 19200
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 36
Port: COM5
Enable remote firing: NO
Firing sequence: User input
Tone for bottle fire confirmation uses PC sound card.

Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship: RRS Discovery

prompt 1 = Cruise: DY098
prompt 2 = Cast:
prompt 3 = Station:
prompt 4 = Julian Day:
prompt 5 = Date:
prompt 6 = Time:
prompt 7 = Latitude:
prompt 8 = Longitude:
prompt 9 = Depth (uncorr m):
prompt 10 = Principal Scientist: S Fielding
prompt 11 = Operator: J Wynar

TCP/IP - port numbers:

Data acquisition:
Data port: 49163
Status port: 49165
Command port: 49164

Remote bottle firing:
Command port: 49167
Status port: 49168

Remote data publishing:
Converted data port: 49161
Raw data port: 49160

Miscellaneous data for calculations

Depth, Average Sound Velocity, and TEOS-10
Latitude when NMEA is not available: 55.000
Longitude when NMEA is not available: 0.000

Average Sound Velocity
Minimum pressure [db]: 20.000
Minimum salinity [psu]: 20.000
Pressure window size [db]: 20.000
Time window size [s]: 60.000

Descent and Acceleration
Window size [s]: 2.000

Plume Anomaly
Theta-B: 0.000
Salinity-B 0.000
Theta-Z / Salinity-Z 0.000
Reference pressure [db] 0.000

Oxygen
Window size [s]: 2.000
Apply hysteresis correction: 1
Apply Tau correction: 1

Potential Temperature Anomaly
A0: 0.000
A1: 0.000
A1 Multiplier: Salinity

Serial Data Output:
  Output data to serial port: NO

Mark Variables:
  No variables are selected.

Shared File Output:
  Output data to shared file: NO

TCP/IP Output:
  Raw data:
    Output raw data to socket: NO
    XML wrapper and settings: NO
    Seconds between raw data updates: 0.000
  Converted data:
    Output converted data to socket: NO
    XML format: NO

SBE 11plus Deck Unit Alarms
  Enable minimum pressure alarm: NO
  Enable maximum pressure alarm: NO
  Enable altimeter alarm: NO

SBE 14 Remote Display
  Enable SBE 14 Remote Display: NO

PC Alarms
  Enable minimum pressure alarm: NO
  Enable maximum pressure alarm: NO
  Enable altimeter alarm: NO
  Enable bottom contact alarm: NO
  Alarm uses PC sound card.

Options:
  Prompt to save program setup changes: YES
  Automatically save program setup changes on exit: NO
  Confirm instrument configuration change: YES
  Confirm display setup changes: YES
  Confirm output file overwrite: YES
  Check scan length: YES
  Compare serial numbers: YES
  Maximized plot may cover Seasave: NO

2.2. BAS CTD processing *Sophie Fielding*

CTDs were processed according to BODC standard steps (Recommended steps for basic processing of SBE-911 CTD data) and also using standard protocols that BAS scientists have used for the WCB survey as detailed below.

The following steps use the SBE data-processing software:

Data conversion - input files (DY098_EVnnn_CTDmm.hex, DY098_Evnnn_CTDmm.XMLCON), output files (DY098_EVnnn_CTDmmdc.cnv)

Align CTD – input files (DY098_EVnnn_CTDmmdc_a.cnv), output files (DY098_EVnnn_CTDmmdc_a.cnv)

Wild edit – input files ((DY098_EVnnn_CTDmmdc_a.cnv), output files (DY098_EVnnn_CTDmmdc_aw.cnv)

Cell thermal mass – input files (DY098_EVnnn_CTDmmdc_aw.cnv), output files (DY098_EVnnn_CTDmmdc_awctm.cnv)

The following matlab scripts were then used to process the CTD files.

ctdread.m Reads in DY098_EVnnn_CTDmmdc_awctm.cnv. Outputs DY098ctdnnn.cal

editctd.m Reads in DY098ctdnnn.cal. Manual edit of CTD file to remove start and end data when CTD out of water and any spikes. Outputs file DY098ctdnnn.edt

Interpol.m Reads in DY098ctdnnn.edt. Interpolate any missing data. Output DY098ctdnnn.int

Salcalapp.m Reads in DY098ctdnnn.int. Calculates density (sig0, sig2 sig4). Output DY098ctdnnn.var

Splitcast.m Reads in DY098ctdnnn.var. Splits up cast and down cast. Output DY098ctdnnn.var.up and DY098ctdnnn.var.dn.

Fallrate.m Reads in DY098ctdnnn.var.dn. Removes data from periods where CTD above a pressure it has already sampled. Output DY098ctdnnn.var.dn

Gridctd.m Reads in DY098ctdnnn.var.dn. Grids data into 2dB depth intervals. Output DY098ctdnnn.2db.mat.

Fill-to-surf.m Reads in DY098ctdnnn.2db.mat. Fills in surface values if CTD doesn't reach surface, user input to determine which ones. Output file DY098ctdnnn.2db.mat

Ctdplot.m Reads in DY098ctdnnn.2db.mat files and creates overview plots saved in /images folder

Makebot Reads in DY098ctdnnn.2db.mat. Extracts median and standard deviation of variables at the depth/time of each bottle firing. Output file DY098botnnn.1st

2.3. XBT deployment *Alysa Hulbert, Euan McRae, Andrew Moore, Nicholas Harker*

Expendable bathythermographs (XBTs) were used to vertically profile the temperature through the water column on transects in the Western Core Box. In order to reduce environmental impact, there were a reduced number of deployments on this cruise with only two XBTs being deployed on 5 of the transects (W1.1, W2.1, W3.1, W4.1 and W4.2, Table 4). On each occasion the probe was launched at a pre-defined location which has been done on previous surveys in the Western Core Box. The selected stations were latitudinally equivalent of the CTD stations on W1.2, W2.2 and W3.2.

The XBTs were deployed from the aft port side of the vessel. Each deployment was made using a launcher in which the expendable probe was mounted before deployment. When the probe was locked in position, an electrical connection was made between the probe and recorder. An operator

then confirmed that the ship-based recording programme was ready for launch. Following the launch of the probe, copper wire de-reeled from inside the launch canister as well as inside the probe to compensate for ship movement. As the probe descended through the water column, depth temperature data were recorded and displayed in real time. When the probe reached the sea floor (if shallower than the length of the wire), the wire was cut.

XBT Software/Version: WinMK21 v3.0.3 Lockheed Martin Sippican Inc. See Appendix 1 NMF ship systems cruise report for details.

Time	Latitude	Longitude	Event No.	Station	Water Depth (m)	Surface Salinity (TSG)	Surface temp (deg, TSG)	Sound velocity (m/s)	Wind speed	Comment
07/01/2019 10:16	-53.5227	-39.5505	19	WCB1.1N	3179.8	33.7472	4.1423	1465.604	10.863	
07/01/2019 12:33	-53.8776	-39.4446	20	WCB1.1S	308.6	33.7404	3.8431	1464.345	13.443	
08/01/2019 08:54	-53.4625	-38.9835	23	WCB2.1N	3060.02	33.7945	4.1037	1465.504	12.117	
08/01/2019 11:21	-53.816	-38.8744	24	WCB2.1S	451.21	33.7487	3.7597	1464.005	10.834	Failed
09/01/2019 10:53	-53.7538	-38.2762	32	WCB3.1S	211.99	33.7282	3.7437	1463.912	19.467	
09/01/2019 13:34	-53.4041	-38.3907	33	WCB3.1N	2928.75	33.8032	4.2954	1466.312	13.596	
10/01/2019 10:10	-53.6945	-37.648	40	WCB4.1N	124.74	33.7436	3.711	1463.794	4.781	
10/01/2019 12:46	-53.6927	-37.7871	41	WCB4.1S	116.83	33.741	3.8455	1464.356	12.984	
10/01/2019 15:56	-53.6761	-37.6543	43	WCB4.2S	137.2	33.7386	3.8663	1464.44	11.627	
10/01/2019 18:27	-53.3142	-37.7764	44	WCB4.2N	2698.93	33.751	4.5516	1467.304	13.046	

Table 4 WCB XBT locations

3. Sampling from NISKIN and underway water

3.1. Phytoplankton sampling from Niskin bottles *Alysa Hulbert and Euan McRae*

3.1.1. Motivation

Phytoplankton samples were obtained from the CTD to assess the phytoplankton biomass and composition within the South Sandwich Islands region (Table 5). Such samples will allow us to look for correlation between phytoplankton metrics and Antarctic krill density. Finally, the results of this analysis can be compared with that of Emma Langan's eDNA analyses to ensure consistency between methods.

3.1.2. Method (*Filters*):

Collect seawater samples from standard depths of 400m, 200m, 100m, 50m, 5m and Chl Max (unless one of the standard depths is Chl max), wearing nitrile gloves throughout. Water samples come from 20l Niskin bottles attached to the CTD. Either filter immediately or chill until filtration. Working from the depth with the lowest Chl concentration up to Chl max, filter 2 separate samples of 100ml through a glass fibre filter and then remove the filter and wrap in tinfoil, avoiding direct contact with the filter at all times. Place wrapped filter inside a bag labelled with important identifying details and place all bags in freezer at -20°C. Chlorophyll a fluorescence of the samples will be analysed at British Antarctic Survey, Cambridge.

3.1.3. Method (*Lugol's*):

Collect seawater samples in 200ml amber bottles from standard depths of 400m, 200m, 100m, 50m, 5m and Chl Max (unless one of the standard depths is Chl max), wearing nitrile gloves throughout. Water samples come from 20l Niskin bottles attached to the CTD. Either add Lugol's Iodine immediately or chill until able to do so. Ensure correct PPE is used at all times: nitrile gloves, safety glasses, lab coat and non-slip mat. Discard a small amount of seawater sample from each sample bottle to allow space and add 2ml of Lugol's Iodine. Seal lid securely and tape lid shut to minimise risk of leaking and then store in a dark place. Taxonomic diversity of the samples will be analysed at British Antarctic Survey, Cambridge.

Event Number	Lugol's done?	Chl Max (m)	Notes
5	No	30	Sample from Western Core Box used to test method. No sample was taken from 400m.
75	No	77	
76	Yes	20	
80	No	63	
82	Yes	44	
84	Yes	65	
94	Yes	41	Lugol's prepared approx. 12 hours after collection but stored in cold and dark until then.
98	Yes	22	
100	Yes	37	

105	Yes	N/A	No Chl Max identified. Chl profile approx. uniform throughout top 100m.
106	Yes	28	
111	Yes	28	
112	Yes	38	
116	Yes	33	No sample available from 50m due to Niskin bottle misfire.
118	Yes	67	
125	Yes	23	
126	Yes	28	
131	Yes	78	
136	Yes	60	
137	Yes	68	
144	Yes	70	400m and 200m samples filtered approx. 12 hours before other depths.
146	Yes	34	

Table 5 Lugols and chlorophyll sampling from DY098 CTDs

3.2. Ship-Seq: DNA sequencing of polar microbes onboard research vessels *Emma Langan and Clara Manno*

3.2.1. Introduction

Polar ecosystems are under significant threat from climate change and we don't yet have a good understanding of how phytoplankton and other microbes will be affected, or what knock-on effects this will have. To understand this, and to create models for further research, we need to develop a better picture of which species are present where, and understand more about their life cycles, interactions, and responses to changing conditions. To help achieve this, we undertook metagenomic DNA sequencing of polar ocean samples.

DNA sequencing samples from polar oceans has been difficult because it takes months for the samples to get back to the lab, with unquantifiable loss of diversity occurring during storage. This is particularly problematic with metagenomic samples, where the inability of some species to live successfully in culture, and DNA degradation rates can introduce biases to the species found. To counter this problem, we used Oxford Nanopore MinION sequencing *in situ*, removing the need for sample storage and cell culturing prior to sequencing. We also performed real-time analysis to determine which species are present, using NanoOK. This experiment was a proof-of-concept test of real-time *in situ* MinION sequencing onboard research vessels, it has shown that the technology can be used in this environment and has allowed us to see where developments are still required.

3.2.2. Methods

Samples taken are summarised in Table 6.

3.2.2.1. CTD – samples 1-12

12 seawater samples were collected from the chlorophyll maxima using the CTD at stations detailed in table 1. 100 litres of seawater were collected from the CTD in 10 or 20 litre carboys, rinsed with

seawater from the Niskin bottle being used for collection. These carboys were placed in the 2 ℃ cold room until filtration could take place (night collections were filtered the following day as the process took approximately 10 hours). For filtration, 142 mm cellulose acetate filters with 0.45 μm pore size were used in a Sartorius pressure filter holder (filtration stand). A peristaltic pump was connected to the filtration stand to pump the water from the carboys through the filter until the filter had clogged (tube connectors would no longer stay attached, or the pump could not pump water through). The filter was then removed from the stand and cut into 8 pieces (except samples 1 and 2 where the filters were cut into 4 pieces) and either frozen at -80 ℃ or used immediately for DNA extraction (vials 9.5-9.8). For samples 1, 2, and 4, two filters were used to filter all of the seawater collected; for all other collections, one filter was used, and excess seawater discarded.

3.2.2.2. Underway pump – samples 13-20

8 seawater samples were collected from the underway pump between -54.742235, -29.110777 and -52.21580000, -52.16901500, from 21:00 7/02/2019 to 16:30 11/02/2019, detailed in table 1. Samples were collected on 142 mm cellulose acetate filters with 0.2 μm pore size using a pressure filter holder. The filter was placed in the filter stand which was attached to the seawater tap with jubilee clips, and the tap turned on at a flow of approximately 1l/min through the filter stand for 3 hours. (4 hours for sample 14, the first underway pump sample). The filter was then removed from the stand and cut into 8 pieces which were placed into 2 ml Eppendorf tubes and either frozen at -80 ℃ or used immediately for DNA sequencing (vials 16.5-16.8).

Sample number	Vial numbers	Location	Event no	Depth (m)	Lat/Long	Date	Time	Filter size (μm)	Filter no	Volume (l)
1	1.1-1.8	P3	5	30	-52.8, -40.2	5/1/19	20:00	0.45	1 - 1-4 2 - 5-8	35, 45
2	2.1-2.8	WCB 2.2	15	20	-53.8, -38.6	6/1/19	23:00	0.45	3 - 1-4 4 - 5-8	35, 40
3	3.1-3.8	Rosita	49	50	-54.0, -37.4	11/1/19	12:00	0.45	5 - 1-8	80
4	4.1-5.8	KEP	56	8	-54.3, -36.4	15/1/19	13:00	0.45	6 - 4.1-8 7 - 5.1-8	30, 30
5	6.1-6.8	SSI transect 1	75	80	-55.3, -28.8	26/1/19	00:39	0.45	8 - 6.1-8	90
6	7.1-7.8	SSI transect 2	80	65	-56.4, -27.1	27/1/19	00:42	0.45	9 - 7.1-8	65
7	8.1-8.8	SSI transect 3	94	42	-57.4, -24.2	30/1/19	01:19	0.45	10 - 8.1-8	90
8	9.1-9.8	SSI transect 4	98	22	-59.0, -25.3	31/1/19	02:30	0.45	11 - 9.1-8	15
9	10.1-10.8	SSI transect 5	111	28	-55.2, -25.2	02/02/19	01:30	0.45	12 - 10.1-8	65
10	11.1-11.8	SSI transect 6	116	33	-54.3, -27.1	03/03/19	01:30	0.45	13 - 11.1-8	100
11	12.1-12.8	SSI transect 7	136	63	-58.1, -28.2	06/02/19	01:30	0.45	14 - 12.1-8	90
12	13.1-13.8	SSI transect 8	144	59	-56.2, -28.4	07/02/19	01:30	0.45	15 - 13.1-8	100
13	14.1-14-8	Underway 1	N/A	N/A	-54.7, -29.1 -54.5, -29.8	07/02/19 08/02/19	21:00 01:00	0.2	16 - 14.1-8	~180 (~1l/min)
14	15.1-15.8	Underway 2	N/A	N/A	-53.8, -32.6 -54.5, -29.8	08/02/19 08/02/19	15:00 18:00	0.2	17 - 15.1-8	~180 (~1l/min)
15	16.1-16.8	Underway 3	N/A	N/A	-53.4, -34.8 -53.3, -35.5	09/02/19 09/02/19	00:00 03:00	0.2	18 - 16.1-8	~180 (~1l/min)
16	17.1-17.8	Underway 4	N/A	N/A	-53.2, -38.6	09/02/19	15:00	0.2	19 - 17.1-8	~180

					-53.1, -39.5	09/02/19	18:00			(~1l/min)
17	18.1-18.8	Underway 5	N/A	N/A	-53.0, -41.6 -52.5, -42.4	10/02/19 10/02/19	00:00 03:00	0.2	20 - 18.1-8	~180 (~1l/min)
18	19.1-19.8	Underway 6	N/A	N/A	-52.8, -44.7 -52.8, -45.2	10/02/19 10/02/19	12:00 15:00	0.2	21 - 19.1-8	~180 (~1l/min))
19	20.1-20.8	Underway 7	N/A	N/A	-52.7, -42.7 -52.6, -48.5	10/02/19 11/02/19	23:00 02:00	0.2	22 - 20.1-8	~180 (~1l/min)
20	21.1-21.8	Underway 8	N/A	N/A	-52.3, -51.4 -52.2, -52.2	11/02/19 11/02/19	13:30 16:30	0.2	23 21.1-8	~180 (~1l/min)

Table 6 CTD and underway DNA samples

3.2.3. DNA extraction and sequencing

Four phenol:chloroform, mercaptoethanol, CTAB DNA extractions were carried out using vials 1.5-1.6, 3.5-3.8, 9.5-9.8, and 16.5-16.8 as follows.

In a fume hood, 4 x 1/8 of a 142mm filter containing phytoplankton from CTD or underway pump samples were placed in 4 x 2 ml Eppendorfs containing 1.5 ml CTAB, 150 µl 2-mercaptoethanol and 15 µl 10% SDS. These were placed in a thermomixer with 2ml tube attachment at 65 ℃ for 4 hours. In a fume hood, 1 ml of the incubated CTAB mixture was added to 6 clean 2 ml Eppendorf tubes, the used tubes containing the filter were discarded, and 1 ml of phenol:chloroform:isoamyl alcohol (25:24:1) was added to each tube. This mixture was centrifuged in a microfuge until clear phase separation was present (around 30 minutes). In a fume hood, the upper phase was removed to 4 clean 2 ml Eppendorf tubes and the lower phase discarded, and 750 µl (2/3 vol) -20 ℃ isopropanol was added to each tube and left to sit for 15 minutes. This mixture was then centrifuged until a pellet was formed (>1hr). In a fume hood, the supernatant was discarded and the pellet was washed with 70% EtOH. The pellet was then allowed to airdry before resuspension in 50 µl low TE buffer. The sample was either immediately used for DNA library preparation for Nanopore MinION sequencing or frozen at -80 ℃. The DNA samples are summarised in **Error! Reference source not found.** below:

Sample Name	Location	Vials used	Date	Size (µm)	Volume DNA Stored	Mean DNA (µg)	Frozen before sequencing?	DNA conc	Fate
1.1	P3	1.5 - 1.6	08/01/2019	0.45	47 µl x3	8.5	Yes	9.6	Frozen -80
1.2								6.7	Frozen -80
1.3								10.0	Frozen -80
1.4								8.0	MinION
2.1	Rosita	3.5-3.8	23/01/2019	0.45	48 µl x3	1.82	Yes	2.9	Frozen -80
2.2								0.745	Frozen -80
2.3								0.75	Frozen -80
2.4								2.92	MinION
3.1	SSI transit 4	9.5-9.8	01/02/2019	0.45	50 µl x 3	2.19	No	Unknown	Frozen -80
3.2								2.19	MinION
3.3								Unknown	Frozen -80

3.4								Unknown	Frozen -80
4.1	Underway 3	16.5-16.8	09/02/2019	0.2	50 µl x 2	2.1	No	Unknown	Frozen -80
4.2								Unknown	Frozen -80
4.3								1.55	Discarded
4.4								2.65	MinION

Table 7 DNA samples and fate

DNA library preparation and Nanopore MinION sequencing was carried out according to Oxford Nanopore Technologies protocol 1D Genomic DNA by Ligation (SQK-LSK109) – Version GDE_9063_v109_revB_23May2018 - see 3.2.4. Oxford Nanopore Technologies library preparation and MinION sequencing protocol. The optional DNA shearing step (Covaris g-tube) was omitted. An offline version of MinKNOW 1.15.6 (Bream version 1.15.10.20 and GUI version 2.2.16), was provided upon request by Oxford Nanopore Technologies to prevent problems when there was no internet connection.

Real-time analysis of the Nanopore MinION data was performed using NanoOKReporter version 1.27, a network cable was used to connect 2 laptops and a shared folder was created which both could read/write to. Laptop 1 ran MinKNOW and was connected to the MinION, and laptop 2 ran NanoOKReporter. A script was used to copy the sequencing data from the MinKNOW working folder on laptop 1 to the shared folder where a script processed the data and sent it to NanoOKReporter. The NanoOKReporter GUI was used for real-time reporting of which species were present. Data was stored on 2 external 1TB hard-drives, with one copy from the shared folder and one from the MinKNOW working folder of Laptop 1.

3.2.4. Oxford Nanopore Technologies library preparation and MinION sequencing protocol

1D Genomic DNA by Ligation (SQK-LSK109)

Version: GDE_9063_v109_revB_23May2018
Last update: 03/09/2018

Oxford NANOPORE Technologies

Flow Cell Number: ..... DNA Samples: .....

Before start checklist

Materials

- ☐ 1 µg (or 100-200 fmol) high molecular weight genomic DNA
- ☐ Ligation Sequencing Kit (SQK-LSK109)
- ☐ Flow Cell Priming Kit (EXP-FLP001)

Consumables

- ☐ Agencourt AMPure XP beads
- ☐ NEBNext FFPE Repair Mix (M6630)
- ☐ NEBNext End repair / dA-tailing Module (E7546)
- ☐ NEBNext Quick Ligation Module (E6056)
- ☐ 1.5 ml Eppendorf DNA LoBind tubes
- ☐ 0.2 ml thin-walled PCR tubes
- ☐ Nuclease-free water (e.g. ThermoFisher, cat # AM9937)
- ☐ Freshly prepared 70% ethanol in nuclease-free water

Equipment

- ☐ Hula mixer (gentle rotator mixer)
- ☐ Magnetic separator, suitable for 1.5 ml Eppendorf tubes
- ☐ Microfuge
- ☐ Vortex mixer
- ☐ Thermal cycler
- ☐ Ice bucket with ice
- ☐ Timer
- ☐ Pipettes and pipette tips P2, P10, P20, P100, P200, P1000

INSTRUCTIONS	NOTES/OBSERVATIONS
Preparing input DNA	
☐ Record the quality, quantity and size of the DNA. IMPORTANT Criteria for input DNA ☐ Purity as measured using Nanodrop - OD 260/280 of 1.8 and OD 260/230 of 2.0-2.2 ☐ Average fragment size, as measured by pulse-field, or low percentage agarose gel analysis >30 kb ☐ Input mass, as measured by Qubit - 1 µg, or 100-200 fmol for short-fragment libraries ☐ No detergents or surfactants in the buffer	
Prepare the DNA in Nuclease-free water. ☐ Transfer 1 µg genomic DNA into a DNA LoBind tube ☐ Adjust the volume to 48 µl with Nuclease-free water ☐ Mix thoroughly by inversion avoiding unwanted shearing ☐ Spin down briefly in a microfuge	
Check your flow cell	
☐ Set up the MinION, flow cell and host computer Once successfully plugged in, you will see a light and hear the fan.	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
Open the MinKNOW GUI from the desktop icon and establish a local or remote connection. ☐ If running a MinION on the same host computer, plug the MinION into the computer. ☐ If running a MinION on a remote computer, first enter the name or IP address of the remote host under Connect to a remote computer (if running from the Connection page), or Connections (if running from the homepage) and click Connect. ☐ Choose the flow cell type from the selector box. Then mark the flow cell as "Selected": Click "Check flow cells" at the bottom of the screen. ☐ R9.4.1 FLO-MIN106 ☐ R9.5.1 FLO-MIN107 ☐ Click "Start test". ☐ Check the number of active pores available for the experiment, reported in the System History panel when the check is complete.	
Flow cell check complete.	
DNA fragmentation (optional, for lower inputs)	
OPTIONAL Covaris g-TUBE ☐ Transfer the genomic DNA sample in 49 µl to the Covaris g-TUBE. Spin the g-TUBE for 1 minute at RT at the speed for the fragment size required. ☐ Spin the g-TUBE for 1 minute ☐ Remove and check all the DNA has passed through the g-TUBE ☐ If DNA remains in the upper chamber, spin again for 1 minute at the same speed Invert the g-TUBE and spin again for 1 minute to collect the fragmented DNA. ☐ Remove g-TUBE, invert the tube and replace into the centrifuge ☐ Spin the g-TUBE for 1 minute ☐ Remove and check the DNA has passed into the lower chamber ☐ If DNA remains in the upper chamber, spin again for 1 minute ☐ Remove g-TUBE ☐ Transfer the 49 µl fragmented DNA to a clean 1.5 ml Eppendorf DNA LoBind tube.	
Analyse 1 µl of the fragmented DNA for fragment size, quantity and quality.	
48 µl of fragmented DNA is taken into the next step.	
DNA repair and end-prep	
☐ Thaw DNA CS (DCS) at RT, spin down, mix by pipetting, and place on ice. ☐ Prepare the NEBNext FFPE DNA Repair Mix and NEBNext End repair / dA-tailing Module reagents in accordance with manufacturer's instructions, and place on ice.	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
In a 0.2 ml thin-walled PCR tube, mix the following: ☐ 1 µl DNA CS ☐ 47 µl DNA ☐ 3.5 µl NEBNext FFPE DNA Repair Buffer ☐ 2 µl NEBNext FFPE DNA Repair Mix ☐ 3.5 µl Ultra II End-prep reaction buffer ☐ 3 µl Ultra II End-prep enzyme mix ☐ Mix gently by flicking the tube, and spin down. ☐ Using a thermal cycler, incubate at 20° C for 5 minutes and 65° C for 5 mins.	
IMPORTANT ☐ AMPure XP bead clean-up	
☐ Prepare the AMPure XP beads for use; resuspend by vortexing. ☐ Transfer the DNA sample to a clean 1.5 ml Eppendorf DNA LoBind tube. ☐ Add 60 µl of resuspended AMPure XP beads to the end-prep reaction and mix by pipetting. ☐ Incubate on a Hula mixer (rotator mixer) for 5 minutes at RT. ☐ Prepare 500 µl of fresh 70% ethanol in Nuclease-free water. ☐ Spin down the sample and pellet on a magnet. Keep the tube on the magnet, and pipette off the supernatant. ☐ Keep on magnet, wash beads with 200 µl of freshly prepared 70% ethanol without disturbing the pellet. Remove the 70% ethanol using a pipette and discard. ☐ Repeat the previous step. ☐ Spin down and place the tube back on the magnet. Pipette off any residual ethanol. Allow to dry for ~30 seconds, but do not dry the pellet to the point of cracking. ☐ Remove the tube from the magnetic rack and resuspend the pellet in 61 µl Nuclease-free water. Incubate for 2 minutes at RT. ☐ Pellet the beads on a magnet until the eluate is clear and colourless. ☐ Remove and retain 61 µl of eluate into a clean 1.5 ml Eppendorf DNA LoBind tube.	
Take forward the repaired and end-prepped DNA into the adapter ligation step. However, at this point it is also possible to store the sample at 4° C overnight.	
Adapter ligation and clean-up	
IMPORTANT ☐ Although the recommended 3rd party ligase is supplied with its own buffer, the ligation efficiency of Adapter Mix (AMX) is higher when using Ligation Buffer supplied within SQK-LSK109.	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
☐ Spin down Adapter Mix (AMX) and T4 Ligase from the NEBNext Quick Ligation Module (E6056), and place on ice. ☐ Thaw Ligation Buffer (LNB) at RT, spin down and mix by pipetting. Due to viscosity, vortexing this buffer is ineffective. Place on ice immediately after thawing and mixing. ☐ Thaw the Elution Buffer (EB) at RT, mix by vortexing, spin down and place on ice. IMPORTANT ☐ Depending on the wash buffer used in this section, the clean-up step after adapter ligation is designed to either enrich for long DNA fragments, or purify all fragments equally. ☐ To enrich for DNA fragments of 3 kb or longer, thaw one tube of L Fragment Buffer (LFB) at RT, mix by vortexing, spin down and place on ice. ☐ To retain DNA fragments shorter than 3 kb, thaw one tube of S Fragment Buffer (SFB) at RT, mix by vortexing, spin down and place on ice. In a 1.5 ml Eppendorf DNA LoBind tube, mix in the following order: ☐ 60 µl DNA sample from the previous step ☐ 25 µl Ligation Buffer (LNB) ☐ 10 µl NEBNext Quick T4 DNA Ligase ☐ 5 µl Adapter Mix (AMX) ☐ Mix gently by flicking the tube, and spin down. ☐ Incubate the reaction for 10 minutes at RT. IMPORTANT ☐ If you have omitted the AMPure purification step after DNA repair and end-prep, incubating the ligation reaction for longer than 10 minutes is not recommended. ☐ Prepare the AMPure XP beads for use; resuspend by vortexing. ☐ Add 40 µl of resuspended AMPure XP beads to the reaction and mix by pipetting. ☐ Incubate on a Hula mixer (rotator mixer) for 5 minutes at RT. ☐ Spin down the sample and pellet on a magnet. Keep the tube on the magnet, and pipette off the supernatant. ☐ Wash the beads by adding either 250 µl L Fragment Buffer (LFB) or 250 µl S Fragment Buffer (SFB). Flick the beads to resuspend, then return the tube to the magnetic rack and allow the beads to pellet. Remove the supernatant using a pipette and discard. ☐ Repeat the previous step. ☐ Spin down and place the tube back on the magnet. Pipette off any residual supernatant. Allow to dry for ~30 seconds, but do not dry the pellet to the point of cracking. ☐ Remove the tube from the magnetic rack and resuspend pellet in 15 µl Elution Buffer (EB). Incubate for 10 minutes at RT. ☐ Pellet the beads on a magnet until the eluate is clear and colourless.	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
Remove and retain 15 µl of eluate into a clean 1.5 ml Eppendorf DNA LoBind tube. ☐ Remove and retain the eluate which contains the DNA library in a clean 1.5 ml Eppendorf DNA LoBind tube ☐ Dispose of the pelleted beads	
The prepared library is used for loading into the flow cell. Store the library on ice until ready to load.	
Priming and loading the SpotON flow cell	
IMPORTANT ☐ Please note that the Sequencing Tether (SQT) tube will NOT be used in this protocol. It is provided in the kit for potential future product compatibility.	
☐ Thaw the Sequencing Buffer (SQB), Loading Beads (LB), Flush Tether (FLT) and one tube of Flush Buffer (FLB) at RT before placing the tubes on ice as soon as thawing is complete.	
☐ Mix the Sequencing Buffer (SQB) and Flush Buffer (FLB) tubes by vortexing, spin down and return to ice.	
☐ Spin down the Flush Tether (FLT) tube, mix by pipetting, and return to ice.	
☐ Open the lid of the nanopore sequencing device and slide the flow cell's priming port cover clockwise so that the priming port is visible.	
IMPORTANT ☐ Care must be taken when drawing back buffer from the flow cell. The array of pores must be covered by buffer at all times. Removing more than 20-30 µl risks damaging the pores in the array.	
After opening the priming port, check for small bubble under the cover. Draw back a small volume to remove any bubble (a few µls): ☐ Set a P1000 pipette to 200 µl ☐ Insert the tip into the priming port ☐ Turn the wheel until the dial shows 220-230 µl, or until you can see a small volume of buffer entering the pipette tip	
☐ Prepare the flow cell priming mix: add 30 µl of thawed and mixed Flush Tether (FLT) directly to the tube of thawed and mixed Flush Buffer (FLB), and mix by pipetting up and down.	
☐ Load 800 µl of the priming mix into the flow cell via the priming port, avoiding the introduction of air bubbles. Wait for 5 minutes.	
☐ Thoroughly mix the contents of the LB tube by pipetting.	
IMPORTANT ☐ The Loading Beads (LB) tube contains a suspension of beads. These beads settle very quickly. It is vital that they are mixed immediately before use.	
In a new tube, prepare the library for loading as follows: ☐ 37.5 µl Sequencing Buffer (SQB) ☐ 25.5 µl Loading Beads (LB), mixed immediately before use ☐ 12 µl DNA library	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
Complete the flow cell priming: ☐ Gently lift the SpotON sample port cover to make the SpotON sample port accessible. ☐ Load 200 µl of the priming mix into the flow cell via the priming port (not the SpotON sample port), avoiding the introduction of air bubbles. ☐ Mix the prepared library gently by pipetting up and down just prior to loading. ☐ Add 75 µl of sample to the flow cell via the SpotON sample port in a dropwise fashion. Ensure each drop flows into the port before adding the next. ☐ Gently replace the SpotON sample port cover, making sure the bung enters the SpotON port, close the priming port and replace the MinION lid.	
Starting a sequencing run	
☐ Double–click the MinKNOW icon located on the desktop to open the MinKNOW GUI. ☐ If your MinION was disconnected from the computer, plug it back in. ☐ Choose the flow cell type from the selector box. Then mark the flow cell as "Selected". ☐ Click the "New Experiment" button at the bottom left of the GUI. On the New experiment popup screen, select the running parameters for your experiment from the individual tabs. ☐ Output settings - FASTQ: The number of basecalls that MinKNOW will write in a single file. By default this is set to 4000 ☐ Output settings - FAST5: The number of files that MinKNOW will write to a single folder. By default this is set to 4000 ☐ Click "Start run". Allow the script to run to completion. ☐ The MinKNOW Experiment page will indicate the progression of the script; this can be accessed through the "Experiment" tab that will appear at the top right of the screen ☐ Monitor messages in the Message panel in the MinKNOW GUI The basecalled read files are stored in :\data\reads	
Progression of MinKNOW protocol script	
The running experiment screen Experiment summary information	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
Check the number of active pores reported in the MUX scan are similar (within 10-15%) to those reported at the end of the Flow Cell Check ☐ If there is a significant reduction in the numbers, restart MinKNOW. ☐ If the numbers are still significantly different, close down the host computer and reboot. ☐ When the numbers are similar to those reported at the end of the Flow Cell Check, restart the experiment on the Connection page. There is no need to load any additional library after restart. ☐ Stopping the experiment is achieved by clicking "Stop run" button at the top of the screen. Data acquisition will stop, but the software will continue basecalling unless the user clicks the "Stop basecalling" button. ☐ Check that the temperature has reached 34° C. Check pore occupancy in the channel panel at the top of the experimental view. ☐ A good library will be indicated by a higher proportion of light green channels in Sequencing than are in Pore. The combination of Sequencing and Pore indicates the number of active pores at any point in time. A low proportion of Sequencing channels will reduce the throughput of the run. ☐ Recovering indicates channels that may become available for sequencing again. A high proportion of this may indicate additional clean up steps are required during your library preparation. ☐ Inactive indicates channels that are no longer available for sequencing. A high proportion of these as soon as the run begins may indicate an osmotic imbalance. ☐ Unclassified are channels that have not yet been assigned one of the above classifications ☐ Monitor the pore occupancy Duty time plots ☐ Monitor the development of the read length histogram. Cumulative throughput ☐ the number of reads that have been sequenced and basecalled; and whether the reads have passed of failed the quality filters Trace viewer	
Further analysis with EPI2ME (optional)	
OPTIONAL ☐ Open the Desktop Agent using the desktop shortcut. ☐ Click on the New Workflow tab in the Desktop Agent and select the workflow to be used in the analysis. ☐ Select the workflow parameters. ☐ Check the correct settings are selected in the Desktop Agent. ☐ Click "Start Run" to start data analysis. ☐ Follow the progression of upload and download of read files in the Desktop Agent.	

Flow Cell Number: ..... DNA Samples: .....

INSTRUCTIONS	NOTES/OBSERVATIONS
Click on VIEW REPORT. ☐ Click on VIEW REPORT to navigate to the EPI2ME website, this can be done at any point during data exchange ☐ Return to the Desktop Agent to see progression of the exchange ☐ When the upload and download numbers are the same, the data exchange is complete. The processed reads will be in downloads folder in the selected location on the host computer.	
Close down MinKNOW and the Desktop Agent	
☐ Quit Desktop Agent using the close x. ☐ Quit MinKNOW by closing down the web GUI. ☐ Disconnect the MinION.	
Prepare the flow cell for re-use or return to Oxford Nanopore.	
☐ If you would like to reuse the flow cell, follow the Wash Kit instructions and store the washed flow cell at 2-8 °C, OR ☐ Follow the returns procedure by washing out the MinION Flow Cell ready to send back to Oxford Nanopore.	

3.3. Isotopic characterization of particulate and dissolved organic matter *Flavia Saccomandi and Cecilia Silvestri*

3.3.1. Introduction

The amount of carbon contained within ocean natural Dissolved Organic Matter (DOM) is comparable in size to atmospheric CO2, and therefore represents a major global reservoir, capable of altering atmospheric CO2 levels if the balance of sources and sinks is substantially altered. Photochemical degradation of DOM induces CO2 emission to the atmosphere from waters and in particular, direct oxidation of DOM to CO2 dominates at low temperatures while conversion of DOM to intermediate Particulate Organic Carbon (POC) prior to oxidation to CO2 dominates at high temperatures (Porcal et al., 2015). In particular, the High Molecular Weight fraction of Dissolved Organic Matter (HMW-DOM) in seawater, usually bio-refractory, can be photo-chemically degraded. A large amount (90%) of the global marine Dissolved Organic Carbon (DOC) is bio-refractory and aged of 4000–6000 years with a lifespan from months to millennia (Lechtenfeld et al., 2014).

Moreover, ocean acidification could induce DOM transformation processes. Three recent mesocosms studies (Yamada et al., 2013; Riebesell et al., 2013; Zark et al., 2015) have examined the effects of ocean acidification on DOM transformation processes. Yamada et al. (2013) and Zark et al. (2015) did not find a significant effect of increased CO2 concentration on the short-term decomposition of labile DOM; Riebesell et al. (2013) in Svalbard (Norway) found that the combination of increasing dissolved CO2 and nutrients input triggered a synergistic effect inducing an increase in the DOC fraction.

In order to deepen the knowledge of biogeochemical processes that produce, accumulate, and recycle DOM and taking into account that this knowledge may be broadly comparable across a range of environmental settings, we propose to participate to British Antarctic Survey to study spatial distribution of HMW-DOM, its isotopic features and the potential effects of ocean acidification on it.

3.3.2. Material and methods

During the cruise, 75 water samples sampled were taken for isotopic (δ13C, δ15N and δ34S) characterization of particulate and dissolved organic matter. Some of them were concentrated by ultrafiltration system on board in order to obtain high molecular dissolved organic substances (HMW-DOM) and back to the lab in Italy. HMW-DOM samples will be isotopically characterized too. Each sample of water (5 L) was collected from CTD (**Error! Reference source not found.**) and/or s ubmerged pump (**Error! Reference source not found.**) mounted on ship.

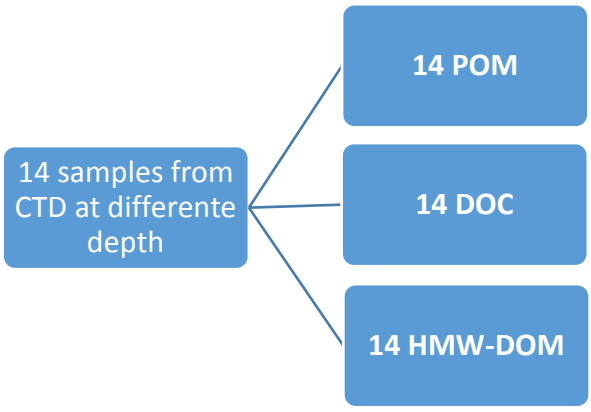

Figure 3 Samples collected with CTD at different depth

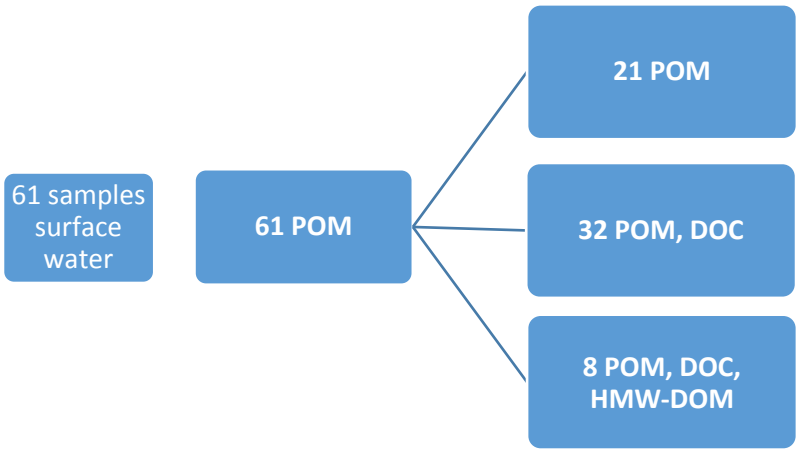

Figure 4 Samples collected from underway water (submerged pump)

The sampling points are showed in Figure 5, and samples are recorded in Table 8, Table 9, Table 10 and Table 11.

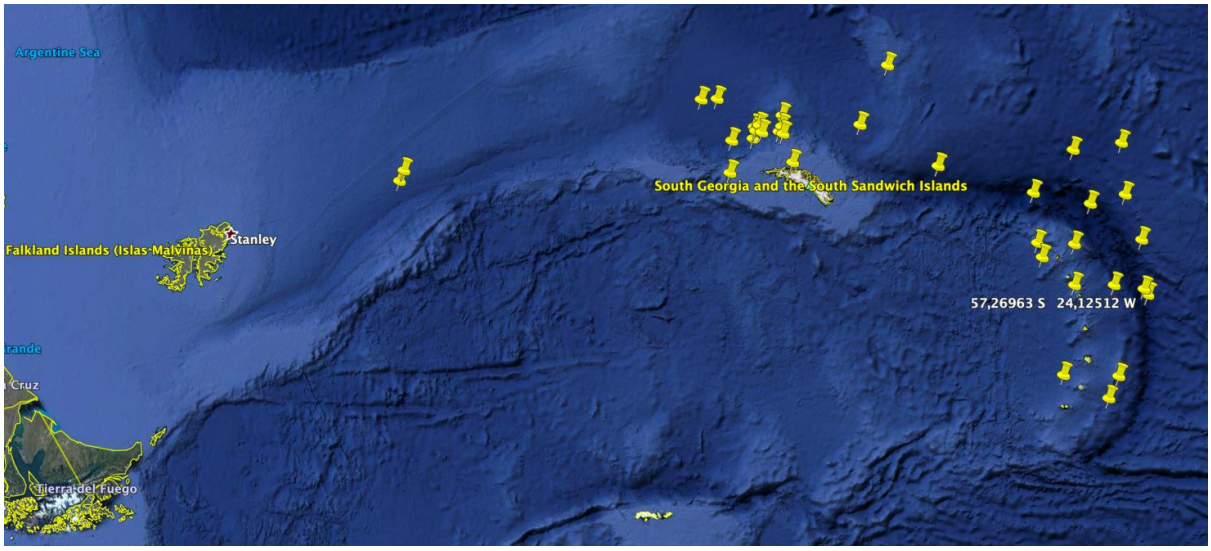

Figure 5 DOM Sampling area and locations

A portion of 100 ml of each sample was temporary disposed in dark bottles and then an aliquot of 20 ml and filter through 0,45 µm pore diameter filtered for Dissolved Organic Carbon (DOC) analysis. The samples (5 L) were filtered through 0,45 µm Millipore filters previously combusted for 1 h at 450 °C for Particulate Organic Matter (POM) analysis. A portion (3 L) of the filtered sample was put in the ultrafiltration cell (350 ml capacity) that was pressured with nitrogen at 3 atm; the sample was then re-added to the cell up to end of the volume to be processed. When the sample is transferred totally to the cell and reduced to 50/70 ml, the concentration step is finished (High HMW-DOM analysis).

3.3.3. References

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DATA (dd/mm/yyyy)	Sample Time (local)	Observer	Station name	LAT	LON	ID SAMPLE	DOC		POM		
							ID Bottle	Volume filtered (mL)	ID Bottle	Volume filtered (L)	ID filter
03/01/2019	15:54:00	Cecilia/Flavia	Test	52°37.272 S	51°33.24180 W	01SW_Test	01SW_Test-DOC	20	01SW_Test	5	01SW_Test-POM
05/01/2019	15:00:00	Cecilia/Flavia	P3	52°48.37380 S	40°10.17780 W	01P3_SW	02SW_P3-DOC	20	02SW_P3	5	02SW_P3-POM
07/01/2019	09:00:00	Cecilia/Flavia	WCB 1.1	53°46.40670 S	39°28.52790 W	12SW_WCB1.1	12SW_WCB1.1-DOC	20	12SW_WCB1.1	5	12SW_WCB1.1-POM
07/01/2019	12:10:00	Cecilia/Flavia	WCB 1.2N	54°1.29330 S	39°5.39508 W	13SW_WCB1.2N	13SW_WCB1.2N-DOC	20	13SW_WCB1.2N	5	13SW_WCB1.2N-POM
08/01/2019	08:30:00	Cecilia/Flavia	WCB 2.1S	53°49.81626 S	38°52.20450 W	14SW_WCB2.1S	14SW_WCB2.1S-DOC	20	14SW_WCB2.1S	5	14SW_WCB2.1S-POM
08/01/2019	13:20:00	Cecilia/Flavia	WBC 2.2	53°34.55772 S	38°38.99046 W	15SW_WCB2.2	15SW_WCB2.2-DOC	20	15SW_WCB2.2	5	15SW_WCB2.2-POM
09/01/2019	08:35:00	Cecilia/Flavia	WCB3.1-XBT1	53°39.61626 S	38°18.41778 W	16SW_WCB3.1-XBT1	16SW_WCB3.1-XBT1-DOC	20	16SW_WCB3.1-XBT1	5	16SW_WCB3.1-XBT1-POM
09/01/2019	10:30:00	Cecilia/Flavia	WCB1-XTB2	53°24.03612 S	38°23.51598 W	17SW_WCB3.1-XBT2	17SW_WCB3.1-XBT2-DOC	20	17SW_WCB3.1-XBT2	5	17SW_WCB3.1-XBT2-POM
09/01/2019	19:00:00	Cecilia/Flavia	WCB3.2-CTD1	53°44.03736 S	37°57.39582 W	18SW_WCB3.2-CTD1	18SW_WCB3.2-CTD1-DOC	20	18SW_WCB3.2-CTD1	5	18SW_WCB3.2-CTD1-POM
10/01/2019	08:50:00	Cecilia/Flavia	WCB4.1S	53°33.88662 S	37°45.76010 W	19SW_WCB4.1N	19SW_WCB4.1N-DOC	20	19SW_WCB4.1N	5	19SW_WCB4.1N-POM
10/01/2019	10:45:00	Cecilia/Flavia	WCB4.1N	53°49.56072 S	37°44.54034 W	20SW_WCB4.1N	20SW_WCB4.1N-DOC	20	20SW_WCB4.1N	5	20SW_WCB4.1N-POM
11/01/2019	10:10:00	Cecilia/Flavia	Rosita Arbour	54°1.24572 S	37°2466840 W	21SW_Rosita Arbour	21SW_Rosita Arbour-DOC	20	21SW_Rosita Arbour	5	21SW_Rosita Arbour-POM
11/01/2019	16:45:00	Cecilia/Flavia	Rosita Arbour	54°1.24572 S	37°2466840 W	22SW_Rosita Arbour			22SW_Rosita Arbour	5	22SW_Rosita Arbour-POM
12/01/2019	08:50:00	Cecilia/Flavia	SGP3	52°53.37000 S	39°54.80082 W	23SW_SGP3	23SW_SGP3-DOC	20	23SW_SGP3	5	23SW_SGP3-POM
15/01/2019	16:54:00	Cecilia/Flavia	DY098-EV056_CTD10 KEP (Hope Point)	54°17.17124 S	36°27.85220 W	24SW_KEP	24SW_KEP-DOC	20	24SW_KEP	5	24SW_KEP-POM
25/01/2019	10:00:00	Cecilia/Flavia	SouthGeorgia-SandwichIslands	54°51.92784 S	32°03.69696 W	25SW_SGSI	25SW_SGSI-DOC	20	25SW_SGSI	5	25SW_SGSI-POM
26/01/2019	11:18:00	Cecilia/Flavia	DY098-EV076-CTDK14	55°39.782 S	27°39.757 W	26SI_CTD1	26SI_CTD1-DOC	20	26SI_CTD1	5	26SI_CTD1-POM
26/01/2019	11:00:00	Cecilia/Flavia	DY098-EV076_submerged pump	55°39.78384 S	27°39.75648 W	27SW_SI			27SW_SI	5	27SW_SI-POM
27/01/2019	01:56:00	Cecilia/Flavia	DY098-EV080_CTD15	56°24.725 S	27°05.250 W	28SI_CTD2			28SI_CTD2	5	28SI_CTD2-POM
27/01/2019	12:10:00	Cecilia/Flavia	DY098-EV082_submerged pump	57°11.239 S	27°03.636 W	29SW_SI	29SW_SI-DOC	20	29SW_SI	5	29SW_SI-POM
27/01/2019	12:21:00	Cecilia/Flavia	DY098-EV082_CTD16	57°11.239 S	27°03.636 W	30SI_CTD3			30SI_CTD3	5	30SI_CTD3-POM
28/01/2019	12:10:00	Cecilia/Flavia	DY098-EV084_submerged pump	59°12.680 S	26°08.990 W	31SW_SI	31SW_SI-DOC	20	31SW_SI	5	31SW_SI-POM
28/01/2019	12:14:00	Cecilia/Flavia	DY098-EV084_CTD17	59°12.680 S	26°08.990 W	32SI_CTD4			32SI_CTD4	5	32SI_CTD4-POM
28/01/2019	21:30:00	Cecilia/Flavia	Antartide_submerged pump	59°49.39956 S	25°53.55036 W	33SW_SI_Antartide	33SW_SI_Antartide-DOC	20	33SW_SI_Antartide	5	33SW_SI_Antartide-POM
30/01/2019	00:15:00	Cecilia/Flavia	DY098-EV094_CTD18_submerged pump	57°26.963 S	24°12.512 W	34SW_SI	34SW_SI-DOC	20	34SW_SI	5	34SW_SI-POM

31/01/2019	00:00:00	Cecilia/Flavia	DY098-EV98_CTD19_surbmergen pump	59°01.900 S	25°15.220 W	40SW_SI			40SW_SI	5	40SW_SI-POM
31/01/2019	01:40:00	Cecilia/Flavia	DY098-EV98_CTD19	59°01.900 S	25°15.220 W	41SI_CTD6	41SI_CTD6-DOC	20	41SI_CTD6	5	41SI_CTD6-POM
01/02/2019	01:08:00	Cecilia/Flavia	DY098EV105_CTD21_submerged pump	57°15.408 S	24°28.591 W	42SW_SI			42SW_SI	5	42SW_SI-POM
01/02/2019	01:15:00	Cecilia/Flavia	DY098EV105_CTD21	57°15.408 S	24°28.591 W	43SI_CTD7			43SI_CTD7	5	43SI_CTD7-POM
01/02/2019	23:30:00	Cecilia/Flavia	DY098EV106_CTD22_submerged pump	56°11.407 S	24°46.586 W	44SW_SI			44SW_SI	5	44SW_SI-POM
01/02/2019	00:11:00	Cecilia/Flavia	DY098EV106_CTD22	56°11.407 S	24°46.586 W	45SI_CTD8			45SI_CTD8	5	45SI_CTD8-POM
02/02/2019	00:15:00	Cecilia/Flavia	DY098EV111_CTD23_submerged pump	55°17.338 S	25°15.406 W	46SW_SI			46SW_SI	5	46SW_SI_POM
02/02/2019	01:15:00	Cecilia/Flavia	DY098EV111_CTD23	55°17.338 S	25°15.406 W	47SI_CDT9	47SI_CDT9-DOC	20	47SI_CDT9	5	47SI_CDT9-POM
02/02/2019	11:30:00	Cecilia/Flavia	DY098EV112_CTD24_submerged pump	54°07.855 S	25°33.878 W	48SW_SI			48SW_SI	5	48SW_SI-POM
02/02/2019	12:00:00	Cecilia/Flavia	Bianco			03_Bianco			03_Bianco	5	03_Bianco-POM
02/02/2019	12:25:00	Cecilia/Flavia	DY098EV111_CTD23	54°07.855 S	25°33.878 W	49SI_CTD10			49SI_CTD10	5	49SI_CTD10-POM
02/02/2019	23:40:00	Cecilia/Flavia	DY098EV116_CTD25-submerged pump	54°25.289 S	27°10.370 W	50SW_SI	50SW_SI-DOC	20	50SW_SI	5	50SW_SI-POM
03/02/2019	00:26:00	Cecilia/Flavia	DY098EV116_CTD25	54°25.289 S	27°10.370 W	51SI_CTD11	51SI_CTD11-DOC		51SI_CTD11	5	51SI_CTD11-POM
03/02/2019	11:15:00	Cecilia/Flavia	DY098EV118_CTD26-submerged pump	55°38803 S	26°46.090 W	52SW_SI	52SW_SI-DOC		52SW_SI	5	52SW_SI-POM
03/02/2019	11:59:00	Cecilia/Flavia	DY098EV118_CTD26	55°38803 S	26°46.090 W	53SI_CTD12	53SI_CTD12-DOC		53SI_CTD12	5	53SI_CTD12-POM
04/02/2019	11:00:00	Cecilia/Flavia	DY098EV126_CTD28-submerged pump	57°09.566 S	25°47.791 W	54SW_SI			54SW_SI	5	54SW_SI-POM
04/02/2019	12:05:00	Cecilia/Flavia	DY098EV126_CTD28	57°09.566 S	25°47.791 W	55SI_CTD13			55SI_CTD13	5	55SI_CTD13-POM
04/02/2019	12:15:00	Cecilia/Flavia	DY098EV126_CTD28	57°09.566 S	25°47.791 W	56SI_CTD13			56SI_CTD13	5	56SI_CTD13-POM
05/02/2019	11:10:00	Cecilia/Flavia	DY098EV131_CTD29-submerged pump	59°00.959 S	27°45.6620 W	57SW_SI			57SW_SI	5	57SW_SI-POM
05/02/2019	14:10:00	Cecilia/Flavia	DY098EV131_CTD29	59°00.959 S	27°45.6620 W	58SI_CTD14			58SI_CTD14	5	58SI_CTD14-POM
05/02/2019	14:16:00	Cecilia/Flavia	DY098EV131_CTD29	59°00.959 S	27°45.6620 W	59SI_CTD14			59SI_CTD14	5	59SI_CTD14-POM
05/02/2019	23:20:00	Cecilia/Flavia	DY098EV136_CTD30-submerged pump	58°05.491 S	28°13.948 W	60SW_SI	60SW_SI-DOC	20	60SW_SI	5	60SW_SI-POM
06/02/2019	00:25:00	Cecilia/Flavia	DY098EV136_CTD30	58°05.491 S	28°13.948 W	61SI_CTD15			61SI_CTD15	5	61SI_CTD15-POM
06/02/2019	00:31:00	Cecilia/Flavia	DY098EV136_CTD30	58°05.491 S	28°13.948 W	62SI_CTD15			62SI_CTD15	5	62SI_CTD15-POM
06/02/2019	11:20:00	Cecilia/Flavia	DY098EV137_CTD31-submerged pump	56°52.310 S	28°29.530 W	63SW_SI			63SW_SI	5	63SW_SI-POM
06/02/2019	12:05:00	Cecilia/Flavia	DY098EV137_CTD31	56°52.310 S	28°29.530 W	64SI_CTD16			64SI_CTD16	5	64SI_CTD16
06/02/2019	12:11:00	Cecilia/Flavia	DY098EV137_CTD31	56°52.310 S	28°29.530 W	65SI_CTD16			65SI_CTD16	5	65SI_CTD16-POM
06/02/2019	23:30:00	Cecilia/Flavia	DY098EV144_CTD32-submergen pump	56°21.839 S	28°46.548 W	66SW_SI			66SW_SI	5	66SW_SI-POM

07/02/2019	00:15:00	Cecilia/Flavia	DY098EV144_CTD32	56°21.839 S	28°46.548 W	67SI_CTD17			67SI_CTD17	5	67SI_CTD17-POM
07/02/2019	00:25:00	Cecilia/Flavia	DY098EV144_CTD32	56°21.839 S	28°46.548 W	68SI_CTD17			68SI_CTD17	5	68SI_CTD17-POM
07/02/2019	13:20:00	Cecilia/Flavia	DY098EV146_CTD33-submergen pump	55°15.941 S	28°58.783 W	69SW_SI	69SW_SI-DOC	20	69SW_SI	5	69SW_SI-POM
07/02/2019	12:08:00	Cecilia/Flavia	DY098EV146_CTD33	55°15.941 S	28°58.783 W	70SI_CTD18			70SI_CTD18	5	70SI_CTD18
07/02/2019	12:17:00	Cecilia/Flavia	DY098EV146_CTD33	55°15.941 S	28°58.783 W	71SI_CTD18			71SI_CDT18	5	71SI_CTD18-POM
08/02/2019	12:38:00	Cecilia/Flavia	DY098EV147-submerged pump	53°51.184 S	34°70.016 W	72SW_RETURN	72SW_RETURN-DOC	20	72SW_RETURN	5	72SW_RETURN-POM
09/02/2019	10:00:00	Cecilia/Flavia	DY098EV148_submerged pump	53°11.15190 S	37°38.8226 W	73SW_RETURN	73SW_RETURN-DOC	20	73SW_RETURN	5	73SW_RETURN-POM
10/02/2019	09:15:00	Cecilia/Flavia	DY098EV149_submerged pump	52°31.004 S	33°53,847 W	74SW_RETURN	74SW_RETURN-DOC	20	74SW_RETURN	5	74SW_RETURN-POM
11/02/2019	09:10:00	Cecilia/Flavia	DY098EV150_submerged pump	52°19.34754 S	51°05.47702 W	75SW_RETURN	75SW_RETURN-DOC	20	75SW_RETURN	5	75SW_RETURN-POM

Table 8 DOC and POM underway samples

DATA (dd/mm/yyyy)	Sample Time (local)	ID SAMPLE	H-DOM						T °C	Fluorescence (V)	Salinity	DO (µmol/Kg	DEPTH BOTTOM (m)	DEPTH SAMPLE (M)	Notes
			DATA Ultrafiltration	Start time	DATA Ultrafiltration	End time	Volume filtered (L)	ID bottle							
03/01/2019	15:54:00	01SW_Test		16:16		INTERROTTO	0.3		8.18	0.13	0.084				
05/01/2019	15:00:00	01P3_SW	05/01/2019	15:10	09/01/2019	11:40	3	02SW_P3-HDOM	5.07	0.512	33.73				Pressure N_2 < 3, una notte filtro andato secco
07/01/2019	09:00:00	12SW_WCB1.1							3.82	0.198	33.76				
07/01/2019	12:10:00	13SW_WCB1.2N							3.85	0.388	33.7				
08/01/2019	08:30:00	14SW_WCB2.1S							3.25	0.352	33.24				
08/01/2019	13:20:00	15SW_WCB2.2							4.19	0.32	33.21				
09/01/2019	08:35:00	16SW_WCB3.1-XBT1							3.56	0.673	33.73				
09/01/2019	10:30:00	17SW_WCB3.1-XBT2							4.21	0.398	33.8				
09/01/2019	19:00:00	18SW_WCB3.2-CTD1							3.93	0.668	33.77				
10/01/2019	08:50:00	19SW_WCB4.1N							3.77	0.260	33.69				
10/01/2019	10:45:00	20SW_WCB4.1N							3.2	0.154	33.22				
11/01/2019	10:10:00	21SW_Rosita Arbour							2.62	0.294	33.57				

11/01/2019	16:45:00	22SW_Rosita Arbour	30/01/2019	18:30	02/02/2019	09:00	2	22SW_Rosita Harbour-HDOM							campione marrone
12/01/2019	08:50:00	23SW_SGP3							5.08	0.837	33.74				
15/01/2019	16:54:00	24SW_KEP	15/01/1029	Fixed with $HgCl_2$				24SW_KEP-HDOM	3.44	0.6	32.80	320	147	5	
25/01/2019	10:00:00	25SW_SGSI							1;42	0.569	33.88				
26/01/2019	11:18:00	26SI_CTD1							0.8	2,8 µg/L	33.88	350	1244	6	
26/01/2019	11:00:00	27SW_SI							1.02	1.727	33.86				
27/01/2019	01:56:00	28SI_CTD2							0.5	1,2 µg/L	33.9	340	1842	52	
27/01/2019	12:10:00	29SW_SI							0.83	0.648	33.86				
27/01/2019	12:21:00	30SI_CTD3							0.8	1,2 µg/L	33.83	330	2359	45	
28/01/2019	12:10:00	31SW_SI							0.22	0.115	33.68				
28/01/2019	12:14:00	32SI_CTD4							-0.5	0,2 µg/L	33.9	350	2170	65	
28/01/2019	21:30:00	33SW_SI_Antartide							0.24	0.843	33.68				
30/01/2019	00:15:00	34SW_SI							1.31	0.685	33.82		6544		
31/01/2019	00:00:00	40SW_SI							1.3	2.194	33.58				
31/01/2019	01:40:00	41SI_CTD6		Fixed with $HgCl_2$				41SI_CTD6-HDOM	0.8	4,4 µg/L	33.6	350	2768	21	per il POM fatti due filtri una 2/5 l'altro 3/5
01/02/2019	01:08:00	42SW_SI							1.3	0.642	33.83				
01/02/2019	01:15:00	43SI_CTD7							-1.2	0,01 µg/L	34.2	330	5503	120	
01/02/2019	23:30:00	44SW_SI							1.3	0.64	33.83				
01/02/2019	00:11:00	45SI_CTD8							0.4	0,01 µg/L	33.9	340	7335	120	
02/02/2019	00:15:00	46SW_SI							3.23	1.286	33.92				
02/02/2019	01:15:00	47SI_CDT9							2.2	0,01 µg/L	34.4	200	4952	200	
02/02/2019	11:30:00	48SW_SI							3.54	0.544	33.91				
02/02/2019	12:00:00	03_Bianco													
02/02/2019	12:25:00	49SI_CTD10							-0.1	0,01 µg/L	34.40	290	4964	200	
02/02/2019	23:40:00	50SW_SI							3.54	1.534	33.83				
03/02/2019	00:26:00	51SI_CTD11							1.6	0,00 µg/L	34.40	200	5353	200	
03/02/2019	11:15:00	52SW_SI							1.98	0.169	33.94				
03/02/2019	11:59:00	53SI_CTD12							0.2	0,01 µg/L	34.50	250	5964	200	
04/02/2019	11:00:00	54SW_SI							1.81	0.415	33.75				

04/02/2019	12:05:00	55SI_CTD13							0.2	0,00 µg/L	34.60	210	3462	200	
04/02/2019	12:15:00	56SI_CTD13							1.4	7,00 µg/L	33.70	350	3462	28	
05/02/2019	11:10:00	57SW_SI							1.33	0.136	33.79				
05/02/2019	14:10:00	58SI_CTD14							0.3	0,00 µg/L	34.60	220	2996	200	
05/02/2019	14:16:00	59SI_CTD14							-1.4	0,60 µg/L	33.80	330	2996	78	
05/02/2019	23:20:00	60SW_SI							1.35	0.448	33.82				
06/02/2019	00:25:00	61SI_CTD15							0.4	0,00 µg/L	34.60	230	3365	200	
06/02/2019	00:31:00	62SI_CTD15							0.00	0,9 µg/L	33.90	340	3365	63	
06/02/2019	11:20:00	63SW_SI							1.23	0.156	33.87				
06/02/2019	12:05:00	64SI_CTD16							0.7	0,00 µg/L	34.60	210	3401	200	
06/02/2019	12:11:00	65SI_CTD16							-1	0,9 µg/L	34.10	340	3401	68	
06/02/2019	23:30:00	66SW_SI							1.63	0.38	33.81				
07/02/2019	00:15:00	67SI_CTD17							1.4	0,00 µg/L	34.6	190	3137	200	
07/02/2019	00:25:00	68SI_CTD17							-0.2	0,9 µg/L	34	340	3137	60	
07/02/2019	13:20:00	69SW_SI							1.62	0.205	33.91				
07/02/2019	12:08:00	70SI_CTD18							0.1	0,4 µg/L	34.5	230	4743	200	
07/02/2019	12:17:00	71SI_CTD18							1.3	0,00 µg/L	33.9	330	4743	34	
08/02/2019	12:38:00	72SW_RETURN		Fixed with $HgCl_2$					2.61	0.109	33.88				
09/02/2019	10:00:00	73SW_RETURN		Fixed with $HgCl_2$					4.92	0.85	33.83				
10/02/2019	09:15:00	74SW_RETURN		Fixed with $HgCl_2$					5.6	0.246	33.77				
11/02/2019	09:10:00	75SW_RETURN		Fixed with $HgCl_2$					7.32	0.149	34.04				

Table 9 H-DOM and temperature, salinity, dO of underway samples

DATA (dd/mm/yyyy)	Sample Time (local)	Observer	Station name	LAT	LON	WATER Deph (m)	ID SAMPLE	DEPHT Sample (m)	DOC		POM		
									ID Bottle	Volume filtered (mL)	ID Bottle	Volume filtered (L)	ID filter
05/01/2019	21:10:00	Cecilia/Flavia	DY098_EV005-CTD02	52°48.659 S	40°10.147 W	3045	07P3_2500	3042	07P3_2500-DOC	20	07P3_2500	5	07P3_2500-POM
	21:29:00	Cecilia/Flavia	DY098_EV005-CTD02				06P3_2000	2000	06P3_2000-DOC	20	06P3_2000	5	06P3_2000-POM
	21:49:00	Cecilia/Flavia	DY098_EV005-CTD02				05P3_1000	1000	05P3_1000-DOC	20	05P3_1000	5	05P3_1000-POM
	22:05:00	Cecilia/Flavia	DY098_EV005-CTD02				04P3_200	201	04P3_200-DOC	20	04P3_200	5	04P3_200-POM
	22:14:00	Cecilia/Flavia	DY098_EV005-CTD02				03P3_53	54	03P3_53-DOC	20	073P3_53	5	03P3_53-POM
06/01/2019	00:03:00	Cecilia/Flavia	DY098_EV017-CTD04	53°25.960 S	38°41.700 W	3037	08-CTD2.2N	6	08-CTD2.2N-DOC	20	08-CTD2.2N	5	08-CTD2.2N-POM
	00:18:00	Cecilia/Flavia	DY098_EV017-CTD04				09-CTD2.2N	43	09-CTD2.2N-DOC	20	09-CTD2.2N	5	09-CTD2.2N-POM
	00:23:00	Cecilia/Flavia	DY098_EV017-CTD04				10-CTD2.2N	199	10-CTD2.2N-DOC	20	10-CTD2.2N	5	10-CTD2.2N-POM
	00:31:00	Cecilia/Flavia	DY098_EV017-CTD04				11-CTD2.2N	749	11-CTD2.2N-DOC	20	11-CTD2.2N	5	11-CTD2.2N-POM
30/01/2019	01:36:00	Cecilia/Flavia	DY098-EV094_CTD18	57°26.963 S	24°12.512 W	6544	35SI-CTD5	41 (CHL MAX)	35SI-CTD5-DOC	20	35SI-CTD5	5	35SI-CTD5-POM
	01:27:00						36SI_CTD5	200	36SI_CTD5-DOC	20	36SI_CTD5	5	36SI_CTD5-POM
	01:09:00						37SI_CTD5	1000	37SI_CTD5-DOC	20	37SI_CTD5	5	37SI_CTD5-POM
	00:41:00						38SI_CTD5	2000	38SI_CTD5-DOC	20	38SI_CTD5	5	38SI_CTD5-POM
	00:20:00						39SI_CTD5	3000	39SI_CTD5-DOC	20	39SI_CTD5	5	39SI_CTD5-POM

Table 10 DOC and POM samples from the CTD

DATA (dd/mm/yyyy)	Sample Time (local)	ID SAMPLE	DEPHT Sample (m)	H-DOM						T °C	Cond (s/m)	Salinity	Oxy (umol/l)	Fluorescence (ugram/l)	Notes
				DATA Ultrafiltration	Start time	DATA Ultrafiltration	End time	Volume filtered (L)	ID bottle						
05/01/2019	21:10:00	07P3_2500	3042	09/01/2019	16:40	13/01/2019	17:20	3	07P3_2500-HDOM	0.32	3.04	34.68	201	0.0226	in un refil perso campione perché aperto il gas senza aver chiuso la cella
	21:29:00	06P3_2000	2000	14/01/2019	09:00	18/01/2019	08:00	3	06P3_2000-HDOM	0.8	3.04	34.7	192	0.0181	
	21:49:00	05P3_1000	1000	18/01/2019	13:25	22/01/2019	13:10	3	05P3_1000-HDOM	1.71	3.07	34.7	173	0.0233	
	22:05:00	04P3_200	201	22/01/2019	17:00	26/01/2019	03:00	3	04P3_200-HDOM	1.48	2.98	34.23	227	0.0249	
	22:14:00	03P3_53	54	26/01/2019	09:00					4.1	3.16	33.8	316	0.0441	SENZA LAVAGGIO FILTRO!
06/01/2019	00:03:00	08-CTD2.2N	6	DROGATI CON $HgCl_2$ (1ml/L) E REFRIGERATI SI ULTRAFILTRERANNO IN ITALIA						4.06	3.16	33.87	324.57	1.2611	
	00:18:00	09-CTD2.2N	43							3.09	3.08	33.86	327.14	1.1106	
	00:23:00	10-CTD2.2N	199							1.42	2.98	34.26	224.38	0.019	
	00:31:00	11-CTD2.2N	749							1.92	3.08	34.69	167.2	0.0106	
30/01/2019	01:36:00	35SI-CTD5	41 (CHL MAX)	DROGATI CON $HgCl_2$ (1ml/L) E REFRIGERATI SI ULTRAFILTRERANNO IN ITALIA						1		33.8	300.5	1.2	
	01:27:00	36SI_CTD5	200							-0.5		34.4	200.6	0.01	
	01:09:00	37SI_CTD5	1000							0.5		34.6			
	00:41:00	38SI_CTD5	2000							0.2		34.6			
	00:20:00	39SI_CTD5	3000							0.1		34.6			

Table 11 H-DOM and temperature and salinity from CTD samples

3.4. Survivability of marine copepod *Oithona similis* under Climate Change *Louise Cornwell*

3.4.1. Introduction

The marine cyclopoid copepod *Oithona similis* is abundant in epipelagic waters throughout the world (Figure 6). Small copepods, such as *O. similis*, are of significant importance in marine food webs, serving as major grazers of phytoplankton, as components of the microbial loop, and as prey for larger pelagic carnivores (Turner, 2004).

I investigate how the population dynamics of *O. similis* are affected by environmental variation, and whether this varies between geographic populations.

General consensus is that ubiquitous species, such as *O. similis*, will have a high physiological tolerance to environmental variation. To enhance current knowledge on the tolerance of *O. similis* to environmental variation, I aim to establish the physiological stress responses of this species under temperature and ocean acidification (OA) conditions predicted for the end of the century.

Local adaptation may result in geographically isolated populations of the same species exhibiting different physiological response mechanisms. Therefore, I compare the effect of temperature and OA on survival of *O. similis* from several locations throughout the cruise.

Understanding how different populations respond to environmental stress will improve our ability to predict how they will withstand future climate change, and the impact this will have on marine ecosystems as a whole.

My experiments measured the effect of temperature and OA, both separately and in combination, on the survival of *O. similis* populations across the Southern Ocean. I compare ambient temperature and pH conditions with those predicted for the year 2100. The results will be used to address the question of whether different geographical populations have different physiological response to environmental variation.

Figure 6 Adult female Oithona similis

3.4.2. Temperature and Ocean Acidification (OA) Experiment

Zooplankton were collected from a bongo net with a 100 or 200 µm mesh net, vertical haul from 50 m depth to the surface.

Upon collection, the sample was poured through a 100 µm sieve to retain the copepods, which were then rinsed into a beaker with filtered sea water (FSW).

Approximately 600 copepods were pipetted into a 2 L plastic container filled with seawater collected at the same site, screened through a 45 µm mesh. A 45 µm filter size was chosen in order to retain small plankton cells in the water, upon which the copepods could feed, whilst removing any large zooplankton. Care was taken to include only adult females and late copepodite (juvenile) stages in these experiments.

Copepods were acclimated for approximately 24 hours under ambient conditions in the laboratory.

3.4.2.1 Treatments:

Two fridges were used: one set at ambient (3 – 4 °C depending on location), the other at 4 °C above ambient (representing conditions predicted for the year 2100).

Three header tanks were set up: the first contained 45 µm FSW, stored at ambient temperature in the cold room (~4 °C). A 2 L sub-sample was taken from this header tank and stored in the "high temperature" fridge overnight, in order to adjust the water to the appropriate temperature. Ideally, 2 separate header tanks would have been used and stored one in each fridge, but fridge space was limited, thus this method was deemed the best alternative. The other 2 header tanks contained 45 µm FSW, which has been acidified by addition of sodium bicarbonate ($NaHCO_3$) and hydrochloric acid (HCl), to achieve a pH of 0.3 units below ambient (ambient pH ranged from 7.5 – 8.0 depending on location). Future pH levels are predicted to reach 0.3 units below current levels (Feely *et al*., 2009), hence why this pH level was chosen for the low pH treatment. One of each of the header tanks containing acidified FSW were stored in each fridge.

Thus, the experiment consisted of four treatments:

1) ambient temperature + ambient pH

2) ambient temperature + low pH

3) high temperature + ambient pH

4) high temperature + low pH

3.4.2.2. Experimental procedure:

Following acclimation, copepods were pipetted into Duran bottles (volume 350 mL) containing 45 µm FSW of either of the four treatments. Approximately 50 copepods were allocated per bottle. Each bottle was then filled to the top, sealed with parafilm, and lids screwed on. Bottles were then left in their respective fridges for 24 hours.

After 24 hours, the contents of the bottles were poured through a 45 µm mesh to capture the copepods. Copepods were then washed from the mesh into a beaker (separate beakers were used for each bottle). Each bottle was then filled with fresh FSW from its respective header tank. The number of live and dead copepods in each bottle were then counted under an Olympus microscope. Live copepods were returned to their bottle, sealed as before, and placed back in the fridge.

This process was repeated daily for 7 days.

3.4.3. Starvation Experiment

Zooplankton were collected from a bongo net with a 100 or 200 µm mesh net, vertical haul from 50 m depth to the surface.

Upon collection, the sample was poured through a 100 µm sieve to retain the copepods, which were then rinsed into a beaker with filtered sea water (FSW).

Approximately 600 copepods were individually pipetted into a 2 L plastic beaker filled with seawater that had been through a 45 µm mesh. A 45 µm filter size was chosen in order to retain small plankton cells upon which the copepods could feed, whilst removing any large zooplankton. Adults of both sexes, and late copepodite (juvenile) stages were used in this experiment.

Copepods were acclimated for approximately 24 hours under ambient conditions in a the laboratory.

3.4.3.1. Treatments:

Two fridges were used, one set at ambient (3 – 4 °C depending on location), the other at 4 °C above ambient (representing conditions predicted for the year 2100).

Three header tanks were set up: the first contained 45 µm FSW, stored at ambient temperature in the cold room (~4 °C). A 1 L sub-sample was taken from this header tank and stored in the "high temperature" fridge for ~ 1.5 hours, in order to adjust the water to the appropriate temperature. It was important the header tank for the "fed" treatments was exposed to light, to enable photosynthesis of any autotrophic phytoplankton cells. For this reason, the header tank could not be stored in a fridge, as it would have been in darkness. The other 2 header tanks, for the "starvation" treatment, contained 0.45 µm FSW (thus potential food cells removed). One of each of these header tanks were stored in each fridge.

Thus, the experiment consisted of four treatments:

1) ambient temperature + fed

2) ambient temperature + starved

3) high temperature + fed

4) high temperature + starved

3.4.3.2. Experimental procedure:

Following acclimation, copepods were pipetted into Duran bottles (volume 350 mL) containing 45 µm FSW of either of the four treatments. Approximately 50 copepods were allocated per bottle. Each bottle was then filled to the top, sealed with parafilm, and lids screwed on. Bottles were then left in their respective fridges for 24 hours.

After 24 hours, the contents of the bottles were poured through a 45 µm mesh to capture the copepods. Copepods were then washed into a beaker (separate beakers were used for each bottle). Each bottle was then filled with fresh FSW from its respective header tank. The number of live and dead copepods in each bottle were then counted under an Olympus microscope. Live copepods were returned to their bottle, sealed as before, and returned to their respective fridge.

This process was repeated daily for 7 days.

3.4.4. Transect – Temperature Size Response

Plankton samples were collected from the underway pump along a transect from near the Falkland Islands, to station P3, crossing the Polar Front. Water was filtered through a double layer filtration system, passing first through a 200 µm, then a 63 µm, mesh. Every three hours, or when clogging occurred, the mesh was replaced. Mesh of both sizes were placed in sealable bags and stored in the -80 °C freezer.

The main purpose of this was to measure the prosome length of *Oithona similis* from each sample, to deduce if body size varied with temperature (Figure 7). According to the Temperature-Size Rule

(Atkinson, 1994), body size is negatively correlated with temperature. We should therefore expect that *O. similis* prosome length will increase along the transect, as we move further south.

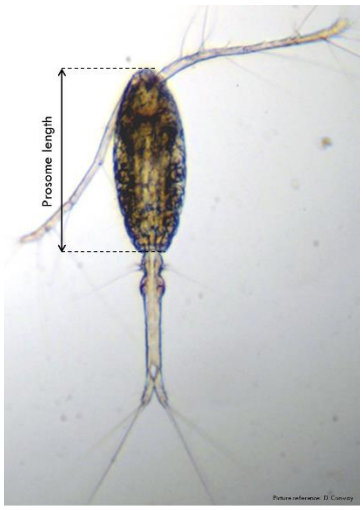

Figure 7 Adult female Oithona similis, with prosome length indicated

3.4.5. References

Atkinson D (1994) Temperature and organism size: A biological law for ectotherms? Adv Ecol Res. 25:1–58.

Feely, R.A., Doney, S.C., Cooley, S.R., 2009. Ocean acidification: Present conditions and future changes in a high-CO_2 world. Oceanography. 22(4), pp.36-47.

Turner, J. T. (2004). The importance of small planktonic copepods and their roles in pelagic marine food webs. Zool Stud. 43(2), pp.25

4. WCB and South Sandwich Islands survey acoustics EK60

4.1. Introduction

The EK60 was run throughout DY098 to collect information on the horizontal and vertical distribution of krill and to derive estimates of krill biomass for the Western Core Box and the South Sandwich Island krill density surveys.

4.2. Method/System specification

Acoustic data were collected using transducers (18, 38, 70, 120, 200, 333 kHz) fitted to the ships drop keel. The drop keel was retained during the whole survey in the raised position so that ship speed was not influenced. ER60 software (ver 2.4.3.) was used to control the echosounder. All raw data were collected to 1200 m, except during the calibration. The EK60 was operated in default settings (Table 12), although the environmental settings were updated at the start of the cruise to a temperature of 2°C and salinity of 34 PSU. The transducer settings were left at their default settings that reflected the last calibration (from DY090). Note that T5 is the 333kHz transducer and T6 the 200 kHz in the data file.

The EK60 was controlled through the k-sync along with the ADCP (75 and 150 kHz) and EA612, on a 2 second ping rate.

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2111	31185	258	890	533	125
Transducer depth (m)	6.6	6.6	6.6	6.6	6.6	6.6
Transceiver Serial No.	00907206dc83	00907206d08e	00907206b831	00907206ebdf	00907206b82f	00907206d0a4
Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024
Absorption coefficient (dB/km)	3.1312	10.2636	20.1151	29.7236	42.7959	72.3335
2-way beam angle (dB)	-17.1	-20.7	-20.5	-20.4	-20.3	-20.3
Transducer gain (dB)	23.10	25.71	27.24	26.94	26.05	25.10
Sa correction (dB)	-0.67	-0.68	-0.41	-0.37	-0.34	-0.64
3dB beam along (°)	10.93	7.07	6.45	6.63	6.92	6.71
3dB beam athwart (°)	10.89	7.17	6.65	6.67	6.63	6.76
Along offset (°)	-0.09	-0.13	-0.05	-0.16	0.06	0.03
Athwart offset (°)	-0.17	-0.10	-0.08	-0.05	-0.02	-0.11

Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024

Table 12 EK60 default settings

4.3. Calibration

The EK60 was calibrated on 15/01/2019 in Cumberland Bay, South Georgia. The ship was balanced on DP. All echosounders were stopped, and the EK60 was self-triggered at a rate of 1 ping per second. The ships own echosounder was not switched off. Each transducer was calibrated in turn, although all transducers were operating at the time. Standard ER60 calibration procedures were used and all frequencies except the 333 kHz were calibrated using a 38.1 mm tungsten carbide sphere. The 333 kHz was not calibrated, as previous attempts using a 20 mm sphere were unsuccessful due to the depths the sphere is at on Discovery versus the usable range.

Line lengths and depths for calibration are contained within the guidelines for calibrating RRS Discovery (Andrew Moore, NMF documentation), and also discussed in cruise reports DY086 and DY090.

A CTD (Event 56) was undertaken prior to the calibration (Figure 8). Temperature and salinity were averaged from the surface to 50 m (depth of the calibration sphere) and were 2.82 °C and 33.49 PSU, resulting in a sound speed constant of 1469 m/s (Kongsberg software calculation). Calibrated settings are given in Table 13.

During the calibration it became evident that the 18 kHz had a failure in one sector, and the calibration was not applied. Subsequent to DY098, and identified on the 27th January, it became clear that the 38 kHz suffered a similar fate – and data past this date are not viable.

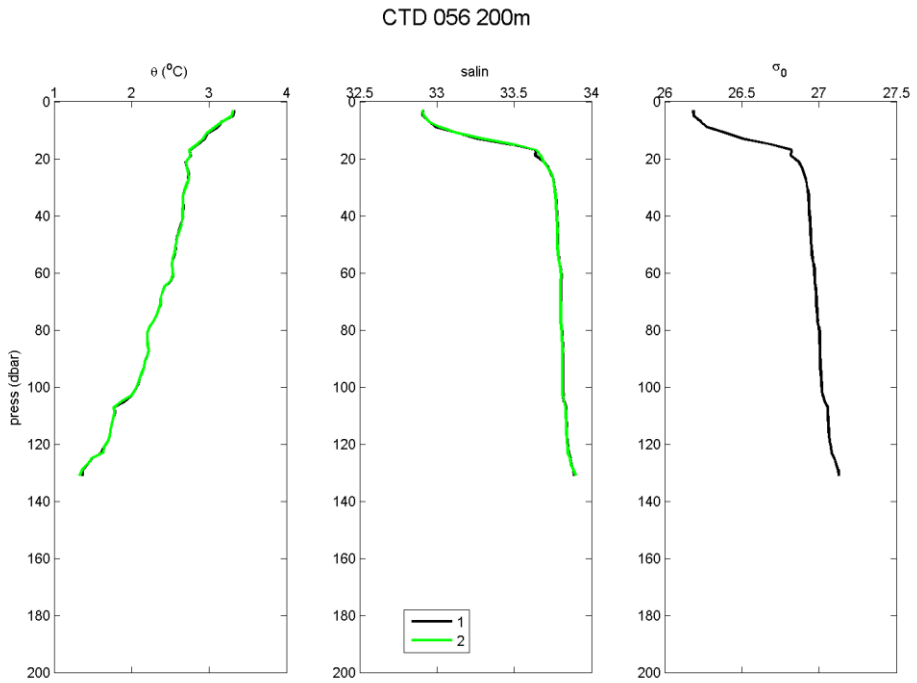

Figure 8 Calibration CTD temperature and salinity profile

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2111	31185	258	890	533	125
Transducer depth (m)	6.6	6.6	6.6	6.6	6.6	6.6
Transceiver Serial No.	00907206dc83	00907206d08e	00907206b831	00907206ebdf	00907206b82f	00907206d0a4
Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024
Absorption coefficient (dB/km)	3.1312	10.2636	20.1151	29.7236	42.7959	72.3335
2-way beam angle (dB)	-17.1	-20.7	-20.5	-20.4	-20.3	-20.3
Transducer gain (dB)	23.10	25.94	26.81	27.07	26.04	25.10
Sa correction (dB)	-0.67	-0.64	-0.33	-0.41	-0.39	-0.64
3dB beam along (°)	10.93	6.95	6.65	6.63	6.74	6.71
3dB beam athwart (°)	10.89	6.92	6.65	6.51	6.65	6.76
Along offset (°)	-0.09	-0.05	-0.06	0.01	-0.06	0.03
Athwart offset (°)	-0.17	-0.10	-0.04	-0.10	0.04	-0.11

Table 13 EK60 calibrated settings

4.4. Data Coverage

4.4.1. Acoustic transects WCB

The WCB was run in a west to east direction starting at the northern end (Table 14). Due to weather, and timing the CTDs and RMT8 nets of the WCB were undertaken out of order. The CTDs (W2.2S and W2.2N) and one stratified RMT net (W2.2S) along line 2.2 were undertaken the night before the acoustic transects commenced. Timing did not permit CTDs night of the 8th January, instead two stratified nets (W2.2N and W1.2S) were undertaken as well as a target hauls. One CTD (W1.2S) was completed the third night (09/01/2019) and one stratified RMT8 (W3.2S), again due to weather and timing. CTD stations W3.2S and W3.2N, the stratified RMT8 (W3.2N) and two target hauls were completed on the fourth night. It was intended to return to W1.2N as we headed to P3, however the weather and medivac were not conducive to it being completed. RMT8 net hauls are summarised in Table 15.

Label	Start Date	End Date	Start time (GMT	End time (GMT)	Comments
WCB1.1	07/01/2019	07/01/2019	09:06	13:47	
WCB1.2	07/01/2019	07/01/2019	15:13	21:17	Data quality poor

WCB2.1	08/01/2019	08/01/2019	07:38	12:34	
WCB2.2	08/01/2019	08/01/2019	13:45	18:31	
WCB3.1	09/01/2019	09/01/2019	09:35	14:55	Large krill swarm
WCB3.2	09/01/2019	09/01/2019	16:13	20:30	
WCB4.1	10/01/2019	10/01/2019	08:55	14:01	
WCB4.2	10/01/2019	10/01/2019	14:39	19:34	

Table 14 Start and end times of WCB acoustic transects

Date/time (GMT)	Latitude (°)	1. Longitude (°)	Event No.	Surface Temperature (°C)	Water Depth (m)	Wire Out (m)	Station	Action
06/01/2019 20:17	-53.7905	-38.5841	14	4.1566	200.25	16.42	WCB2.2S Stratified	RMT8 005 deployed. (Data from Bridge Event Log)
06/01/2019 20:19	-53.7897	-38.5851	14	4.1682	204.74	13.87	WCB2.2S Stratified	RMT8 005 1st net entered water open. Data not logged on computer.
06/01/2019 20:48	-53.7773	-38.6005	14	4.1191	228.42	220.84	WCB2.2S Stratified	RMT8 005 nets fired twice - 1st net closed. Wire out 233m. Depth 160.
06/01/2019 20:51	-53.7758	-38.6025	14	4.1169	231.01	242.73	WCB2.2S Stratified	RMT8 005 net fired - 2nd net opened. Wire out 233m. Depth 168m.
06/01/2019 21:15	-53.7652	-38.6155	14	4.2426	245.82	90.86	WCB2.2S Stratified	RMT8 005 depth sensor failed.
06/01/2019 21:27	-53.7596	-38.6226	14	4.236	252.27	10.64	WCB2.2S Stratified	RMT8 005 2nd net closed. Wire out 22m. Depth 10m.
06/01/2019 21:35	-53.7568	-38.6261	14	4.2114	255	23.95	WCB2.2S Stratified	RMT8 005 recovered. (Data from Bridge Event log)
08/01/2019 19:58	-53.4198	-38.6641	26	4.7119	3471.45	17.67	WCB2.2N stratified	RMT8 006 deployed. (Data from Bridge Event Log)
08/01/2019 20:03	-53.4209	-38.6697	26	4.7196	3479.22	9.94	WCB2.2N stratified	RMT8 006 net 1 fired at surface. Wire out 0m. Depth 0m.
08/01/2019 20:33	-53.4275	-38.7032	26	4.6499	3513.17	320.85	WCB2.2N stratified	RMT8 006 net 1 closed. Wire out 324m. Depth 201m.
08/01/2019 20:34	-53.4278	-38.7042	26	4.6312	3589.05	324.68	WCB2.2N stratified	RMT8 006 net 2 open. Wire out 326m. Depth 205m.
08/01/2019 21:04	-53.4334	-38.7369	26	4.7614	3542.21	22.91	WCB2.2N stratified	RMT8 006 net 2 closed. Wire out 22m. Depth 13m.
08/01/2019 21:13	-53.4351	-38.7466	26	4.7967	3543.27	20.55	WCB2.2N stratified	RMT8 006 recovered. (Data from Bridge Event log)
09/01/2019 00:19	-53.8385	-39.1011	27	4.3178	636.53	12.2	WCB1.2S Stratified	RMT8 007 deployed. (Data from Bridge Event Log)
09/01/2019 00:33	-53.8386	-39.108	27	4.3348	648.92	8.76	WCB1.2S Stratified	RMT8 007 in water
09/01/2019 00:36	-53.8387	-39.111	27	4.3723	221.34	17.79	WCB1.2S Stratified	RMT8 007 net 1 open. Wire out 20m. Depth 14m.
09/01/2019 01:04	-53.8372	-39.1381	27	4.3523	272.34	282.56	WCB1.2S Stratified	RMT8 007 net 1 closed. Wire out 282m. Depth 157m.
09/01/2019 01:05	-53.8371	-39.1391	27	4.35	276.04	282.56	WCB1.2S Stratified	RMT8 007 net 2 open. Wire out 282m. Depth 163m.
09/01/2019 01:34	-53.8346	-39.1696	27	4.2931	275.82	31.28	WCB1.2S Stratified	RMT8 007 net 2 closed. Wire out 15m. Depth 12m.
09/01/2019 01:35	-53.8345	-39.1705	27	4.1573	276.27	20.36	WCB1.2S Stratified	RMT8 007 recovered. (Data from Bridge Event log)
09/01/2019 03:04	-53.8371	-39.1795	28	4.1252	276.03	16.23	WCB1.2 Target Fishing	RMT8 008 deployed. (Data from Bridge Event log)
09/01/2019 03:10	-53.8327	-39.1765	28	4.0738	285.27	17.78	WCB1.2 Target Fishing	RMT8 008 in water
09/01/2019 03:12	-53.8312	-39.1755	28	4.0986	278.1	21.83	WCB1.2 Target Fishing	RMT8 008 net 1 open. Wire out 25m. Depth 21m.
09/01/2019 03:22	-53.8233	-39.1705	28	4.0732	289.79	29.73	WCB1.2 Target Fishing	RMT8 008 net 1 closed. Wire out 29m. Depth 15m.
09/01/2019 03:24	-53.8226	-39.17	28	4.0895	289.63	29.73	WCB1.2 Target Fishing	RMT8 008 net 2 open. Wire out 29m. Depth 22m.
09/01/2019 03:34	-53.8151	-39.1644	28	4.1656	285.15	12.7	WCB1.2 Target Fishing	RMT8 008 net 2 closed. Wire out 8m. Depth 10m.
09/01/2019 03:44	-53.8084	-39.1597	28	4.2667	284	14.49	WCB1.2 Target Fishing	RMT8 008 recovered. (Data from Bridge Event log)

09/01/2019 22:38	-53.7320	-37.9592	36	3.8601	150.59	14.91	WCB3.2S Stratified	RMT8 009 deployed. (Data from Bridge Event log)
09/01/2019 22:39	-53.7315	-37.9598	36	3.8625	149.34	13.29	WCB3.2S Stratified	RMT8 009 in water.
09/01/2019 22:43	-53.7299	-37.962	36	3.8086	151.12	9.72	WCB3.2S Stratified	RMT8 009 net 1 open. Wire out 14m. Depth 20m.
09/01/2019 23:00	-53.7245	-37.9681	36	3.9045	146.46	121.32	WCB3.2S Stratified	RMT8 009 net 1 closed. Wire out 121m. Depth 90m.
09/01/2019 23:00	-53.7243	-37.9683	36	3.8678	148.37	121.32	WCB3.2S Stratified	RMT8 009 net 2 open. Wire out 121m. Depth 96m.
09/01/2019 23:21	-53.7171	-37.9768	36	3.832	143.04	16.89	WCB3.2S Stratified	RMT8 009 net 1 closed. Wire out 13m. Depth 16m.
09/01/2019 23:38	-53.7147	-37.9781	36	3.8343	142.35	0	WCB3.2S Stratified	RMT8 009 recovered. (Data from Bridge Event log)
10/01/2019 22:18	-53.3447	-38.0695	46	4.398	2464.5	19.54	WCB3.2N Stratified	RMT8 010 deployed. (Data from Bridge Event log)
10/01/2019 22:22	-53.3457	-38.0727	46	4.4181	2482.4	8.32	WCB3.2N Stratified	RMT8 010 in water.
10/01/2019 22:26	-53.3467	-38.0764	46	4.441	2807.99	3.29	WCB3.2N Stratified	RMT8 010 net 1 open. Depth 5m.
10/01/2019 23:01	-53.3547	-38.1059	46	4.3929	2685.02	292.08	WCB3.2N Stratified	RMT8 010 net 1 closed. Wire out 296m. Depth 202m.
10/01/2019 23:02	-53.3549	-38.1066	46	4.4738	2688.49	296.33	WCB3.2N Stratified	RMT8 010 net 2 open. Wire out 296m. Depth 210m.
10/01/2019 23:32	-53.3616	-38.1338	46	4.4328	2788.03	10.22	WCB3.2N Stratified	RMT8 010 net 2 closed. Wire out 10m. Depth 11m.
10/01/2019 23:38	-53.3629	-38.1395	46	4.3978	2782.31	16.38	WCB3.2N Stratified	RMT8 010 recovered. (Data from Bridge Event log)
11/01/2019 04:47	-53.6536	-37.876	48	3.6979	1622.64	14.49	Target Fishing	RMT8 011 deployed. (Data from Bridge Event log)
11/01/2019 04:48	-53.6535	-37.8771	48	3.7372	1621.61	13.93	Target Fishing	RMT8 011 in water.
11/01/2019 04:56	-53.6532	-37.8843	48	3.8088	125.82	39.51	Target Fishing	RMT8 011 net 1 open. Wire out 45m. Depth 40m.
11/01/2019 04:58	-53.6531	-37.8861	48	3.7435	124.78	56.61	Target Fishing	RMT8 011 net 1 closed. Wire out 59m. Depth 42m.
11/01/2019 05:05	-53.6527	-37.8931	48	3.729	126.02	49.23	Target Fishing	RMT8 011 net 2 opened. Wire out 49m. Depth 39m.
11/01/2019 05:12	-53.6525	-37.9005	48	3.7261	125.29	17.09	Target Fishing	RMT8 011 net 2 closed. Wire out 10m. Depth 10m.
11/01/2019 05:21	-53.6521	-37.9089	48	3.6849	123.08	17.27	Target Fishing	RMT8 011 recovered. (Data from Bridge Event log)

Table 15 WCB RMT8 net hauls

4.4.2. Acoustic transects South Sandwich Islands

This component of the DY098 cruise consisted of acoustic transects, formerly undertaken during the CCAMLR 2000 acoustic krill survey. During all acoustic transects, when weather (either sea state or fog) permitted, Conductivity-Temperature-Depth stations and stratified net sampling to 200m, using a Rectangular Midwater Trawl 8+1 net (Roe and Shale, 1979) were undertaken twice a day centred around midday and midnight. In addition, at the midnight station and when weather permitted, bongo nets and a modified neuston net were used to sample small animals and for the presence of nano/microplastics. A daily plan is presented in Table 16.

Hour of Day (Local time)	Activity
04:00 – 11:00	Acoustic transects
11:00 – 12:00	CTD (1500 m or seabed-10m)
12:00 – 13:30	RMT8+1 stratified, 200m to surface
13:00 – 21:00	Acoustic transects (RMT8 target if target)
21:00 – 22:00	Neuston net (weather permitting)
22:00 – 00:00	RMT8+1 stratified, 200m to surface
00:00 – 02:00	CTD (1500 m or deeper)
02:00 – 03:00	Bongo
03:00 – 04:00	Relocate towards acoustic transect line

Table 16 South Sandwich Island Survey daily plan

Acoustic transects were labelled as SSA, SSB, SSC and Sand01 to Sand10 (Figure 9). The original plan was to undertake transects from east to west, however weather and logistical requirements resulted in the transects being undertaken out of order. Heading south, Sand06 to Sand10 were undertaken

first. This was followed by the lower end of SSA, Sand04 and Sand05, as a result of poor weather to the north. Once this had cleared SSA was undertaken south to north, until it was curtailed at the northern end by the 22 km iceberg B-15T that had fragmented but still represented a considerable barrier (https://twitter.com/nasaearth/status/1057736748594315264). SSB, Sand01 to Sand03 were run north to south, before undertaking SSC (south to north) into increasing weather. The start and end times of all transects are listed in Table 17.

A Simrad EK60 multi-frequency echo-sounder, operating at frequencies 18, 38, 70, 120, 200 and 33 kHz through split beam, hull mounted transducers was used to collect acoustic backscatter data (S_v dB re $1m^{-1}$). The 38, 70, 120 and 200 kHz transducers were calibrated using standard sphere techniques (Demer et al. 2015) in Cumberland Bay, South Georgia (15/01/2019). The calibration identified at least one failed quadrant in the 18 kHz transducer. A subsequent calibration on cruise DY100 showed at least one quadrant had failed on the 38 kHz transducer as well, this failure likely occurred January 27th.

The EK60 was controlled using a Simrad K-sync, synchronizing the EK60 at a 2 second ping rate with other acoustic instruments (EA640 bathymetric echosounder and RDI Ocean Surveryor 75 kHz ADCP). Data were collected to 1500m and stored locally as well as copied to networked storage.

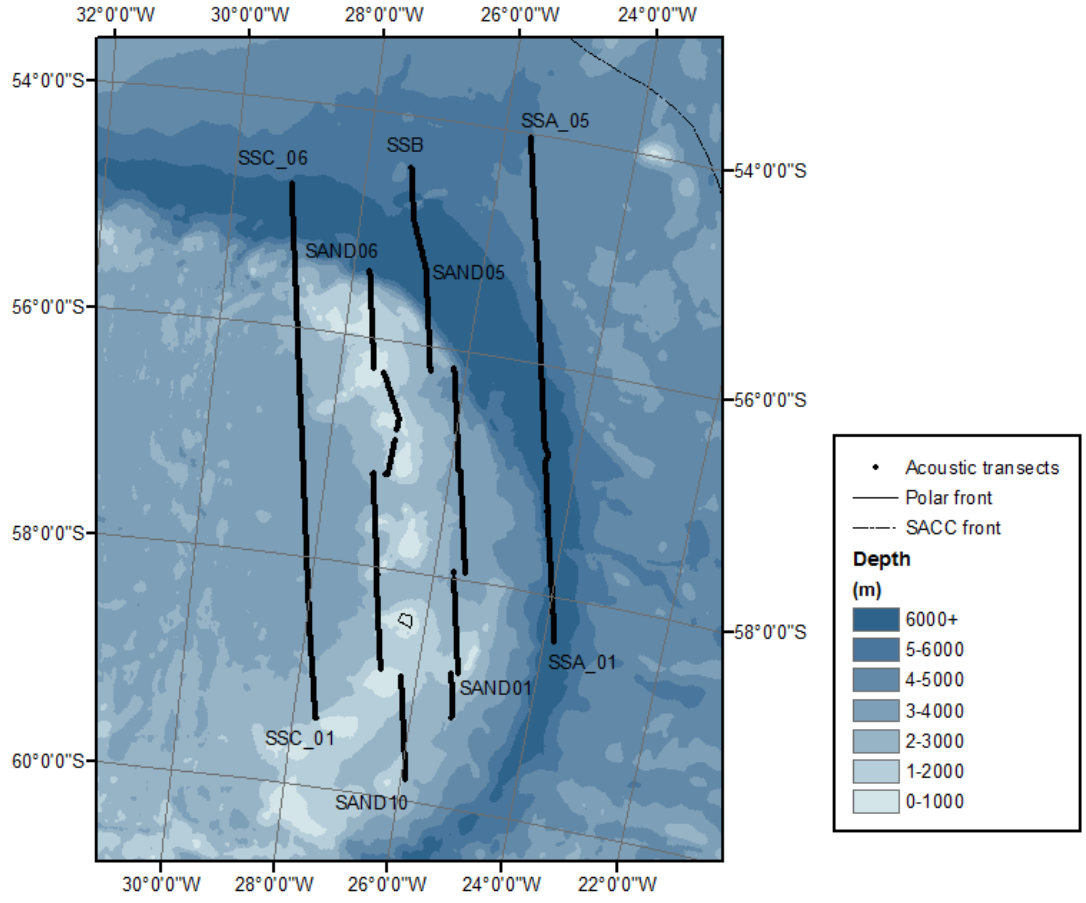

Figure 9 Acoustic transects undertaken during DY098. Transects are labelled to tally with Table 17

Transect Name	Date start	Date end	Time start (GMT)	Time end (GMT)	Comment

Sand6	26/01/2019	26/01/2019	10:58	12:40	
Sand6	26/01/2019	26/01/2019	17:35	21:55	
Sand7	26/01/2019	26/01/2019	22:24	22:50	38 kHz failure?
Sand7	27/01/2019	27/01/2019	06:15	09:27	
Sand7	27/01/2019	27/01/2019	10:34	12:50	
Sand8	27/01/2019	27/01/2019	17:33	23:00	Large krill swarm
Sand8	28/01/2019	28/01/2019	03:00	04:19	Bad data (weather)
Sand9	28/01/2019	28/01/2019	04:27	10:43	
Sand10	28/01/2019	28/01/2019	11:56	13:50	
Sand10	28/01/2019	28/01/2019	19:41	23:29	
SSA	29/01/2019	29/01/2019	15:00	20:46	Corrupt file 17:35, bad data (weather)
Sand4	30/01/2019	30/01/2019	12:47	18:10	Query 38 kHz quadrant
Sand5	30/01/2019	30/01/2019	18:43	21:40	
SSA	31/01/2019	31/01/2019	18:19	23:42	Bad data (weather)
SSA	01/02/2019	01/02/2019	05:12	12:50	08:40 detour for iceberg
SSA	01/02/2019	01/02/2019	16:55	22:55	
SSA	02/02/2019	02/02/2019	04:53	12:30	Way blocked by iceberg
SSB	03/02/2019	03/02/2019	04:22	10:59	
Sand1	03/02/2019	03/02/2019	10:59	12:51	
Sand1	03/02/2019	03/02/2019	17:30	20:30	
Sand1	04/02/2019	04/02/2019	04:34	05:19	
Sand2	04/02/2019	04/02/2019	06:39	12:06	
Sand3	04/02/2019	04/02/2019	12:14	12:54	
Sand3	04/02/2019	04/02/2019	16:30	21:14	
SSC	05/02/2019	05/02/2019	10:37	13:00	Lots of krill below 250m?
SSC	05/02/2019	05/02/2019	16:55	22:53	
SSC	06/02/2019	06/02/2019	03:55	12:54	
SSC	06/02/2019	06/02/2019	16:42	20:22	
SSC	07/02/2019	07/02/2019	05:45	12:25	
SSC	07/02/2019	07/02/2019	17:25	21:00	

Table 17 South Sandwich Island survey acoustic transects

CTD (Table 18), stratified RMT8+1 net hauls (Table 19) and RMT8 target hauls (Table 20) are listed here.

Date/Time (GMT)	Latitude (°)	Longitude (°)	Event No.	Water Depth (m)	Max CTD depth (m)	CTD No.
26/01/2019 02:39	-55.276	-28.834	75	5001		CTD 013 deployed
26/01/2019 03:13	-55.277	-28.832	75	6036	1500	CTD 013 max wire out 1500m
26/01/2019 03:58	-55.277	-28.832	75	6036		CTD 013 recovered
26/01/2019 13:16	-55.663	-27.662	76	1245		CTD 014 deployed
26/01/2019 13:43	-55.663	-27.662	76	1248	1217	CTD 014 max depth 1217m
26/01/2019 14:22	-55.663	-27.662	76	1247		CTD 014 recovered
27/01/2019 02:43	-56.412	-27.087	80	1842		CTD 015 deployed

27/01/2019 03:19	-56.412	-27.087458	80	1842	1500	CTD 015 max depth 1500m
27/01/2019 04:07	-56.412	-27.087	80	1842		CTD 015 recovered
27/01/2019 13:11	-57.187	-27.060	82	2359		CTD 016 deployed
27/01/2019 13:48	-57.187	-27.060	82	2359	1500	CTD 016 max depth 1500m
27/01/2019 14:28	-57.187	-27.060	82	2359		CTD 016 recovered
28/01/2019 14:02	-59.211	-26.149	84	2170		CTD 017 deployed
28/01/2019 14:43	-59.211	-26.149	84	2169	1500	CTD 017 max depth 1500m
28/01/2019 15:24	-59.211	-26.149	84	2171		CTD 017 recovered
30/01/2019 01:19	-57.449	-24.208	94	6535		CTD 018 deployed
30/01/2019 02:17	-57.449	-24.208	94	6544	3000	CTD 018 max depth 3000m
30/01/2019 03:43	-57.449	-24.208	94	6536		CTD 018 recovered
31/01/2019 02:30	-59.031	-25.253	98	2767		CTD 019 deployed
31/01/2019 03:05	-59.0317	-25.253	98	2768	1500	CTD 019 max depth 1500m
31/01/2019 03:47	-59.0317	-25.253	98	2768		CTD 019 recovered
31/01/2019 13:39	-58.022	-23.960	100	4546		CTD 020 deployed
31/01/2019 14:13	-58.022	-23.960	100	6117	1500	CTD 020 max depth 1500m
31/01/2019 14:53	-58.022	-23.960	100	6119		CTD 020 recovered
01/02/2019 02:50	-57.256	-24.476	105	5508		CTD 021 deployed
01/02/2019 03:06	-57.256	-24.476	105	5518	400	CTD 021 max depth 400m
01/02/2019 03:27	-57.256	-24.476	105	5508		CTD 021 recovered
01/02/2019 13:14	-56.190	-24.776	106	7336		CTD 022 deployed
01/02/2019 13:45	-56.190	-24.776	106	7337	1500	CTD 022 max depth 1500m
01/02/2019 14:22	-56.190	-24.776	106	7336		CTD 022 recovered
02/02/2019 02:22	-55.288	-25.263	111	6052		CTD 023 deployed
02/02/2019 02:49	-55.288	-25.263	111	4951	1500	CTD 023 max depth 1500m
02/02/2019 03:28	-55.288	-25.263	111	4952		CTD 023 recovered
02/02/2019 13:28	-54.130	-25.564	112	4964		CTD 024 deployed

02/02/2019 13:58	-54.130	-25.564	112	4964	1500	CTD 024 max depth 1500m
02/02/2019 14:41	-54.130	-25.564	112	4964		CTD 024 recovered
03/02/2019 01:31	-54.433	-27.176	116	5352		CTD 025 deployed
03/02/2019 02:02	-54.434	-27.173	116	5363	1500	CTD 025 max depth 1500m
03/02/2019 02:41	-54.437	-27.169	116	5375		CTD 025 recovered
03/02/2019 13:07	-55.646	-26.768	118	5960		CTD 026 deployed
03/02/2019 13:35	-55.646	-26.768	118	5960	1500	CTD 026 max depth 1500m
03/02/2019 14:13	-55.646	-26.768	118	5961		CTD 026 recovered
04/02/2019 02:28	-56.108	-26.740	125	2486		CTD 027 deployed
04/02/2019 02:57	-56.108	-26.740	125	2485	1500	CTD 027 max depth 1500m
04/02/2019 03:31	-56.108	-26.740	125	2485		CTD 027 recovered
04/02/2019 13:10	-57.159	-25.796	126	3462		CTD 028 deployed
04/02/2019 13:40	-57.159	-25.796	126	3462	1500	CTD 028 max depth 1500m
04/02/2019 14:19	-57.159	-25.796	126	3462		CTD 028 recovered
05/02/2019 13:09	-59.015	-27.761	131	2997		CTD 029 deployed
05/02/2019 13:45	-59.015	-27.761	131	2996	1500	CTD 029 max depth 1500m
05/02/2019 14:25	-59.015	-27.761	131	2996		CTD 029 recovered
06/02/2019 01:30	-58.091	-28.23	136	3365		CTD 030 deployed
06/02/2019 02:01	-58.091	-28.232	136	3364	1500	CTD 030 max depth 1500m
06/02/2019 02:41	-58.091	-28.232	136	3364		CTD 030 recovered
06/02/2019 13:11	-56.871	-28.492	137	4522		CTD 031 deployed
06/02/2019 13:40	-56.872	-28.492	137	3401	1500	CTD 031 max depth 1500m
06/02/2019 14:16	-56.872	-28.492	137	3400		CTD 031 recovered
07/02/2019 01:19	-56.363	-28.775	144	3137		CTD 032 deployed
07/02/2019 01:51	-56.363	-28.775	144	3137	1500	CTD 032 max depth 1500
07/02/2019 02:31	-56.363	-28.775	144	3139		CTD 032 recovered
07/02/2019 13:11	-55.265	-28.979	146	3007		CTD 033 deployed

07/02/2019 13:42	-55.265	-28.979	146	4742	1500	CTD 033 max depth 1500
07/02/2019 14:22	-55.265	-28.979	146	4740		CTD 033 recovered

Table 18 South Sandwich Island survey CTD stations

Event No	Date/Time (GMT)	Latitude (°)	Longitude (°)	Net depth (m)	Action	Comment
78	26/01/2019 16:01	-55.6479	-27.7283	225	Net 1 opened	Stratified
78	26/01/2019 16:19	-55.6431	-27.7397	104	Net 1 closed	Stratified
78	26/01/2019 16:19	-55.6431	-27.7397	104	Net 2 opened	Stratified
78	26/01/2019 16:36	-55.6365	-27.7492	10	Net 2 closed	Stratified
79	27/01/2019 01:18	-56.4135	-27.0391	200	Net 1 opened	Stratified
79	27/01/2019 01:39	-56.4131	-27.0571	101	Net 1 closed	Stratified
79	27/01/2019 01:40	-56.4131	-27.058	110	Net 2 opened	Stratified
79	27/01/2019 01:56	-56.4124	-27.07	10	Net 2 closed	Stratified
83	27/01/2019 15:37	-57.2015	-27.0978	200	Net 1 opened	Stratified
83	27/01/2019 15:58	-57.21	-27.1137	100	Net 1 closed	Stratified
83	27/01/2019 15:58	-57.21	-27.1137	100	Net 2 opened	Stratified
83	27/01/2019 16:17	-57.21	-27.1137	10	Net 2 closed	Stratified
85	28/01/2019 16:21	-59.2129	-26.1792	201	Net 1 opened	Stratified
85	28/01/2019 16:41	-59.2136	-26.1931	100	Net 1 closed	Stratified
85	28/01/2019 16:42	-59.2137	-26.1939	100	Net 2 opened	Stratified
85	28/01/2019 16:57	-59.2152	-26.2075	10	Net 2 closed	Stratified
97	31/01/2019 00:46	-59.0971	-25.2899	200	Net 1 opened	Stratified
97	31/01/2019 01:06	-59.0825	-25.2893	104	Net 1 closed	Stratified
97	31/01/2019 01:07	-59.0818	-25.2894	104	Net 2 opened	Stratified
97	31/01/2019 01:23	-59.071	-25.2893	10	Net 2 closed	Stratified
101	31/01/2019 16:18	-58.0178	-24.0271	200	Net 1 opened	Stratified
101	31/01/2019 16:40	-58.0166	-24.0513	100	Net 1 closed	Stratified
101	31/01/2019 16:41	-58.0166	-24.0523	100	Net 2 opened	Stratified
101	31/01/2019 16:59	-58.0154	-24.0721	11	Net 2 closed	Stratified
103	01/02/2019 01:05	-57.263	-24.4064	200	Net 1 opened	Stratified
103	01/02/2019 01:27	-57.261	-24.4302	95	Net 1 closed	Stratified
103	01/02/2019 01:28	-57.2608	-24.4313	98	Net 2 opened	Stratified
103	01/02/2019 01:49	-57.2584	-24.4554	11	Net 2 closed	Stratified
107	01/02/2019 15:18	-56.2036	-24.8119	203	Net 1 opened	Stratified
107	01/02/2019 15:39	-56.2116	-24.8314	100	Net 1 closed	Stratified
107	01/02/2019 15:39	-56.2116	-24.8314	105	Net 2 opened	Stratified
107	01/02/2019 16:01	-56.2199	-24.8521	10	Net 2 closed	Stratified
109	02/02/2019 00:39	-55.2623	-25.2232	200	Net 1 opened	Stratified
109	02/02/2019 01:02	-55.2723	-25.2396	100	Net 1 closed	Stratified
109	02/02/2019 01:02	-55.2723	-25.2396	110	Net 2 opened	Stratified
109	02/02/2019 01:21	-55.2801	-25.2531	10	Net 2 closed	Stratified
113	02/02/2019 15:31	-54.1445	-25.5796	199	Net 1 opened	Stratified
113	02/02/2019 15:45	-54.1496	-25.5841	100	Net 1 closed	Stratified
113	02/02/2019 15:46	-54.15	-25.5844	103	Net 2 opened	Stratified
113	02/02/2019 16:02	-54.1562	-25.592	10	Net 2 closed	Stratified
114	02/02/2019 23:57	-54.4087	-27.1412	200	Net 1 opened	Stratified
114	03/02/2019 00:16	-54.4153	-27.1519	100	Net 1 closed	Stratified

114	03/02/2019 00:17	-54.4157	-27.1524	100	Net 2 opened	Stratified
114	03/02/2019 00:38	-54.4244	-27.1673	10	Net 2 closed	Stratified
119	03/02/2019 15:13	-55.6683	-26.8105	200	Net 1 opened	Stratified
119	03/02/2019 15:35	-55.6777	-26.8345	100	Net 1 closed	Stratified
119	03/02/2019 15:36	-55.6781	-26.8355	103	Net 2 opened	Stratified
119	03/02/2019 15:56	-55.6871	-26.855	8	Net 2 closed	Stratified
124	04/02/2019 01:15	-56.1027	-26.6775	200	Net 1 opened	Stratified
124	04/02/2019 01:36	-56.1048	-26.7004	100	Net 1 closed	Stratified
124	04/02/2019 01:37	-56.1049	-26.7014	100	Net 2 opened	Stratified
124	04/02/2019 01:57	-56.1069	-26.7216	10	Net 2 closed	Stratified
128	04/02/2019 15:05	-57.1652	-25.833	200	Net 1 opened	Stratified
128	04/02/2019 15:21	-57.1674	-25.8503	100	Net 1 closed	Stratified
128	04/02/2019 15:22	-57.1676	-25.8515	101	Net 2 opened	Stratified
128	04/02/2019 15:38	-57.1704	-25.8697	10	Net 2 closed	Stratified
132	05/02/2019 15:15	-58.9937	-27.7699	200	Net 1 opened	Stratified
132	05/02/2019 15:37	-58.9806	-27.776	100	Net 1 closed	Stratified
132	05/02/2019 15:37	-58.9806	-27.776	105	Net 2 opened	Stratified
132	05/02/2019 15:57	-58.9696	-27.7814	10	Net 2 closed	Stratified
134	06/02/2019 00:14	-58.0823	-28.1823	199	Net 1 opened	Stratified
134	06/02/2019 00:27	-58.0848	-28.1956	100	Net 1 closed	Stratified
134	06/02/2019 00:28	-58.085	-28.1968	101	Net 2 opened	Stratified
134	06/02/2019 00:44	-58.0882	-28.2142	22	Net 2 closed	Stratified
139	06/02/2019 15:27	-56.8792	-28.5102	202	Net 1 opened	Stratified
139	06/02/2019 15:41	-56.8811	-28.5176	100	Net 1 closed	Stratified
139	06/02/2019 15:41	-56.8811	-28.5176	97	Net 2 opened	Stratified
139	06/02/2019 15:55	-56.883	-28.5248	10	Net 2 closed	Stratified
142	06/02/2019 23:57	-56.3484	-28.7341	200	Net 1 opened	Stratified
142	07/02/2019 00:16	-56.3533	-28.7479	100	Net 1 closed	Stratified
142	07/02/2019 00:16	-56.3533	-28.7479	100	Net 2 opened	Stratified
142	07/02/2019 00:32	-56.3584	-28.7621	9	Net 2 closed	Stratified
148	07/02/2019 15:43	-55.271	-29.0275	200	Net 1 opened	Stratified
148	07/02/2019 16:03	-55.2745	-29.0467	100	Net 1 closed	Stratified
148	07/02/2019 16:03	-55.2745	-29.0467	103	Net 2 opened	Stratified
148	07/02/2019 16:23	-55.2791	-29.0672	10	Net 2 closed	Stratified

Table 19 South Sandwich Island stratified RMT8+1 net hauls

Event No	Date (dd/mm/yyyy) Time (GMT)	Latitude (°)	Longitude (°)	Net depth (m)	Action	Comment
95	30/01/2019 22:33	-59.1904	-25.2913	40	Net 1 opened	Target Fishing
95	30/01/2019 22:39	-59.1864	-25.2917	25	Net 1 closed	Target Fishing
95	30/01/2019 22:40	-59.1857	-25.2918	35	Net 2 opened	Target Fishing
95	30/01/2019 22:45	-59.1824	-25.2922	11	Net 2 closed	Target Fishing
120	03/02/2019 21:16	-56.1144	-26.6001	50	net 1 opened	Target Fishing
120	03/02/2019 21:17	-56.1148	-26.5999	48	net 1 closed	Target Fishing
120	03/02/2019 21:48	-56.1340	-26.5933	57	net 2 opened	Target Fishing
120	03/02/2019 21:50	-56.1353	-26.5929	47	net 2 closed	Target Fishing
121	03/02/2019 22:43	-56.1407	-26.5910	29	net 1 opened	Target Fishing
121	03/02/2019 22:44	-56.1400	-26.5912	27	net 1 closed	Target Fishing
121	03/02/2019 22:44	-56.1400	-26.5912	34	net 2 opened	Target Fishing

121	03/02/2019 22:45	-56.1392	-26.5915	31	net 2 closed	Target Fishing
140	06/02/2019 21:36	-56.3058	-28.6412	58	net 1 opened	Target Fishing
140	06/02/2019 22:03	-56.3147	-28.6579	64	net 1 closed	Target Fishing
140	06/02/2019 22:03	-56.3147	-28.6579	71	net 2 opened	Target Fishing
140	06/02/2019 22:16	-56.3202	-28.6680	9	net 2 closed	Target Fishing

Table 20 South Sandwich Island target RMT8 hauls

4.5. Performance of the RapidKrill software on the RRS Discovery *Alejandro Ariza, Rob Blackwell & Sophie Fielding*

RapidKrill is a Python application for processing echosounder data to derive krill distribution and biomass estimates in near real-time. The software is intended to operate onboard ships of opportunity (e.g. fishing vessels) and relay metrics to land-based scientists via periodic e-mails. The software has primarily been designed to run on small, cheap single-board computers such as the Raspberry Pi, but can also run on desktop computers.

Here we report about our experience running RapidKrill in a Raspberry Pi 3, and interfacing with the EK60 echosounder installed in the RRS Discovery.

Rapidkrill was primarily designed to interface with the echosounder PC via a network share with an Ethernet connection. This set up was not possible at the RRS Discovery since the intranet where the ship instruments are connected could not be accessed for logistical and security reasons. Instead, the instruments' data were synchronized into a public server (using Syncback Pro software) where the scientist personnel could access using an Ethernet connection. The Raspberry Pi was then connected to this public intranet, and RapidKrill was tested under these non-optimal conditions. The listening routine had to be optimized to pick the second last RAW file to be processed, because the last one was often uncompleted, still being copied from the original directory. That never happened when interfacing directly with the echosounder PC, because the EK60 only writes the file in the directory when that is complete.

Things to consider when interfacing with mirrored directories:

Probably related with a reboot or a fail in the synchronizing system, eventually part of the files already in the directory may reenter in the directory again. That made RapidKrill to crash. A condition has been added in the code to avoid RapidKrill to process the same file twice. That should prevent future crashes but could not be tested because the event did not occur again. It is still not fully understood what make that to happen, but we need to keep all possibilities in mind when coding to anticipate future problems.

The refreshing rate of the mirrored window has to be well below the rate at which the RAW files are dropped in the echosounder PC to ensure that rapidkrill can process RAW files in time. In our experience, a 25 mb RAW file is written every ~6 minutes, so everything below this should be fine. The refreshing rate was set at 3 minutes in this cruise, and worked well.

It is always preferable to interface with the actual directory where the RAW files are written by the echosounder. However, picking the penultimate RAW file seems a better listening protocol in case we face scenarios where is not allowed to connect to the instrument's intranet (common in some research ships).

Memory errors:

When RapidKrill is performing in the Raspberry Pi, and after several days listening and processing files, a memory error can occur and stop the program. This is related to the 32 bits limitation of the Raspberry Pi. A quick look in the memory usage pointed to some objects created during the reading part (PyEchoLab) as the major memory consumers. They have been set to “None”, once they are useless in the processing routine, resulting in a memory saving of about 25%. Memory errors are now much less frequent but still occurred, once a week or so. It is then necessarily to accurately profile memory usage along the full routine and tested during long periods in the Raspberry Pi so that we can debug this problem.

All errors occurred during the cruise has been copied in text files and properly documented for consultation back in land and strength the code.

5. Macrozooplankton

5.1. RMT 8 and RMT8+1 macrozooplankton sampling *Gabriele Stowasser, Sophie Fielding, Bjôrg Apeland, Daniel Ashurst, Megan Sorensen, Clara Manno, Angelika Slomska, Franki Perry, Alejandro Ariza, Kirstie Jones-Williams, Emily Rowlands*

5.1.1. Gear

The RMT8 was used to characterise the macrozooplankton community in the Western Corebox (WCB) in 200m oblique trawls and target trawls. Target trawls were undertaken on krill swarms identified from the EK60. In oblique trawls net 1 was opened near the surface (10-20m) and the net deployed to 200m (where water depth was sufficient) before closing and net 2 opened at 200m depth and closed near the surface (10-20m). The choice of deployment type depended on the task. Target hauls were made to supply the WCB team with *Euphausia superba* (Antarctic krill) for length frequency measurements and Franki Perry (PhD student at Plymouth University) with krill for reproductive studies. Krill and other zooplankton were furthermore sampled for micro- and nano-plastic incubation experiments (PhD students Kirstie Jones-Williams and Emily Rowlands, University of Exeter) as well as for a study on the trophic ecology of Southern Right Whales in South Georgia waters (PI, Jennifer Jackson, BAS). Oblique trawls within the Western Core Box were only undertaken at the CTD positions.

For fishing in the region of the South Sandwich Islands a RMT1 net was attached to the RMT8 net in order to also catch the smaller zooplankton fraction generally not caught in the RMT8. Oblique trawls were undertaken twice daily during hours of daylight and darkness respectively. The combined nets (RMT 1 and RMT8) were deployed closed to a depth of 200m. The two bottom nets (Net 1 of both RMT1 and RMT8) were opened at 200m depth and closed at 100m depth and the two top nets (Net 2 of both RMT1 and RMT 8) were opened at 100m depth and closed near the surface (~ 10m). These catches were obtained for the South Sandwich Island survey. A summary of all hauls conducted is presented in Table 21 and Table 22.

5.1.2. Catch sorting and processing

5.1.2.1. Oblique hauls WCB

For the oblique hauls the total catch of net 2 (200m – surface) was sorted and quantified. Numbers caught and total weight were obtained for each species. For some groups specific identification was not possible and identification will be verified through re-examination in the laboratory. All material collected in net 1 (surface – 200m) was preserved in 4% formalin. All data were recorded in an Excel database.

5.1.2.2. Oblique hauls SSI

For the oblique hauls in the South Sandwich region the total catches of both RMT1 nets were weighed and immediately transferred into formalin. Catches obtained from the RMT8 nets were weighed, sorted by species and quantified. After quantification these catches were also transferred into formalin for investigations on the pelagic biodiversity of the South Sandwich Island region. Where sufficient numbers were caught length-frequency measurements were taken from the small krill species *Thysanoessa* spp. and *Euphausia frigida* (see krill length-frequency, Sophie Fielding, BAS). Fish caught in RMT1 and RMT8 nets were removed and frozen at -80°C (Table 23 and Table 24) for future investigations on their trophic ecology and the impact of plastic pollution in Southern Ocean waters.

5.1.2.3. Targeted hauls

The catch of targeted hauls was sorted and quantified. Where live *E. superba* were caught samples were taken for incubation experiments. In hauls, where sufficient numbers of *E. superba* were caught, length-frequency data was collected (see chapter on krill length frequency, Sophie Fielding, BAS). Krill total length was measured on 100 fresh krill, using the standard BAS measurement from the anterior edge of the eye to the tip of the telson, with measurements rounded down to the nearest mm (Morris et al. 1988). Maturity stage was assessed using the scale of Makarov and Denys with the nomenclature described my Morris et al. (1988).

Event No	Time and Date (GMT)	Latitude	Longitude	Net depth (m)	Action	Haul type
14	06/01/2019 20:19	-53.7897	-38.5851	deployed open	net 1 open	WCB2.2S Stratified
14	06/01/2019 20:48	-53.7773	-38.6005	160	net 1 closed	WCB2.2S Stratified
14	06/01/2019 20:51	-53.7758	-38.6025	168	net 2 opened	WCB2.2S Stratified
14	06/01/2019 21:27	-53.7596	-38.6226	10	net 2 closed	WCB2.2S Stratified
26	08/01/2019 20:03	-53.4209	-38.6697	0	net 1 opened	WCB2.2N stratified
26	08/01/2019 20:33	-53.4275	-38.7032	201	net 1 closed	WCB2.2N stratified
26	08/01/2019 20:34	-53.4278	-38.7042	205	net 2 opened	WCB2.2N stratified
26	08/01/2019 21:04	-53.4334	-38.7369	13	net 2 closed	WCB2.2N stratified
27	09/01/2019 00:36	-53.8387	-39.1110	14	net 1 opened	WCB1.2S Stratified
27	09/01/2019 01:04	-53.8372	-39.1381	157	net 1 closed	WCB1.2S Stratified
27	09/01/2019 01:05	-53.8371	-39.1391	163	net 2 opened	WCB1.2S Stratified
27	09/01/2019 01:34	-53.8346	-39.1696	12	net 2 closed	WCB1.2S Stratified
28	09/01/2019 03:12	-53.8312	-39.1755	21	net 1 opened	WCB1.2 Target Fishing
28	09/01/2019 03:22	-53.8233	-39.1705	15	net 1 closed	WCB1.2 Target Fishing
28	09/01/2019 03:24	-53.8226	-39.1700	22	net 2 opened	WCB1.2 Target Fishing
28	09/01/2019 03:34	-53.8151	-39.1644	10	net 2 closed	WCB1.2 Target Fishing
36	09/01/2019 22:43	-53.7299	-37.9620	20	net 1 opened	WCB3.2S Stratified
36	09/01/2019 23:00	-53.7245	-37.9681	90	net 1 closed	WCB3.2S Stratified
36	09/01/2019 23:00	-53.7243	-37.9683	96	net 2 opened	WCB3.2S Stratified
36	09/01/2019 23:21	-53.7171	-37.9768	16	net 2 closed	WCB3.2S Stratified
46	10/01/2019 22:26	-53.3467	-38.0764	5	net 1 opened	WCB3.2N Stratified
46	10/01/2019 23:01	-53.3547	-38.1059	202	net 1 closed	WCB3.2N Stratified
46	10/01/2019 23:02	-53.3549	-38.1066	210	net 2 opened	WCB3.2N Stratified
46	10/01/2019 23:32	-53.3616	-38.1338	11	net 2 closed	WCB3.2N Stratified
48	11/01/2019 04:56	-53.6532	-37.8843	40	net 1 opened	Target Fishing
48	11/01/2019 04:58	-53.6531	-37.8861	42	net 1 closed	Target Fishing
48	11/01/2019 05:05	-53.6527	-37.8931	39	net 2 opened	Target Fishing
48	11/01/2019 05:12	-53.6525	-37.9005	10	net 2 closed	Target Fishing
55	13/01/2019 02:04	-52.6119	-40.2338	14	net 1 opened	P3 Stratified
55	13/01/2019 02:34	-52.5964	-40.2415	199	net 1 closed	P3 Stratified
55	13/01/2019 02:43	-52.5917	-40.2438	200	net 2 opened	P3 Stratified
55	13/01/2019 03:16	-52.5737	-40.2500	13	net 1 closed	P3 Stratified
72	24/01/2019 15:40	-54.2207	-36.0854	55	net 1 opened	Target Fishing
72	24/01/2019 15:46	-54.2241	-36.0906	30	net 1 closed	Target Fishing
72	24/01/2019 15:47	-54.2247	-36.0914	37	net 2 opened	Target Fishing
72	24/01/2019 15:55	-54.2294	-36.0981	13	net 2 closed	Target Fishing
73	24/01/2019 17:11	-54.2241	-36.1306	45	net 1 opened	Target Fishing
73	24/01/2019 17:13	-54.2223	-36.1313	40	net 1 closed	Target Fishing
73	24/01/2019 17:18	-54.2182	-36.1328	62	net 2 opened	Target Fishing
73	24/01/2019 17:23	-54.2142	-36.1339	42	net 2 closed	Target Fishing
74	25/01/2019 00:14	-54.5298	-34.6032	42	net 1 opened	Target Fishing

74	25/01/2019 00:24	-54.5293	-34.5963	22	net 1 closed	Target Fishing
74	25/01/2019 00:25	-54.5293	-34.5956	26	net 2 opened	Target Fishing
74	25/01/2019 00:33	-54.5290	-34.5898	13	net 2 closed	Target Fishing
95	30/01/2019 22:33	-59.1904	-25.2913	40	net 1 opened	Target Fishing
95	30/01/2019 22:39	-59.1864	-25.2917	25	net 1 closed	Target Fishing
95	30/01/2019 22:40	-59.1857	-25.2918	35	net 2 opened	Target Fishing
95	30/01/2019 22:45	-59.1824	-25.2922	11	net 2 closed	Target Fishing
120	03/02/2019 21:16	-56.1144	-26.6001	50	net 1 opened	Target Fishing
120	03/02/2019 21:17	-56.1148	-26.5999	48	net 1 closed	Target Fishing
120	03/02/2019 21:48	-56.1340	-26.5933	57	net 2 opened	Target Fishing
120	03/02/2019 21:50	-56.1353	-26.5929	47	net 2 closed	Target Fishing
121	03/02/2019 22:43	-56.1407	-26.5910	29	net 1 opened	Target Fishing
121	03/02/2019 22:44	-56.1400	-26.5912	27	net 1 closed	Target Fishing
121	03/02/2019 22:44	-56.1400	-26.5912	34	net 2 opened	Target Fishing
121	03/02/2019 22:45	-56.1392	-26.5915	31	net 2 closed	Target Fishing
140	06/02/2019 21:36	-56.3058	-28.6412	58	net 1 opened	Target Fishing
140	06/02/2019 22:03	-56.3147	-28.6579	64	net 1 closed	Target Fishing
140	06/02/2019 22:03	-56.3147	-28.6579	71	net 2 opened	Target Fishing
140	06/02/2019 22:16	-56.3202	-28.6680	9	net 2 closed	Target Fishing

Table 21 RMT8 hauls carried out in the Western Core Box and South Georgia waters on cruise DY098

Event No	Time and Date (GMT)	Latitude	Longitude	Net depth (m)	Action	Haul type
78	26/01/2019 16:19	-55.6431	-27.7397	104	Net 1 closed, net 2 opened	Stratified
78	26/01/2019 16:36	-55.6365	-27.7492	10	Net 2 closed	Stratified
79	27/01/2019 01:18	-56.4135	-27.0391	200	Net 1 opened	Stratified
79	27/01/2019 01:39	-56.4131	-27.0571	101	Net 1 closed	Stratified
79	27/01/2019 01:40	-56.4131	-27.058	110	Net 2 opened	Stratified
79	27/01/2019 01:56	-56.4124	-27.07	10	Net 2 closed	Stratified
83	27/01/2019 15:37	-57.2015	-27.0978	200	Net 1 opened	Stratified
83	27/01/2019 15:58	-57.21	-27.1137	100	Net 1 closed	Stratified
83	27/01/2019 15:58	-57.21	-27.1137	100	Net 2 opened	Stratified
83	27/01/2019 16:17	-57.21	-27.1137	10	Net 2 closed	Stratified
85	28/01/2019 16:21	-59.2129	-26.1792	201	Net 1 opened	Stratified
85	28/01/2019 16:41	-59.2136	-26.1931	100	Net 1 closed	Stratified
85	28/01/2019 16:42	-59.2137	-26.1939	100	Net 2 opened	Stratified
85	28/01/2019 16:57	-59.2152	-26.2075	?	Net 2 closed	Stratified
95	30/01/2019 22:33	-59.1904	-25.2913	40	Net 1 opened	Target Fishing
95	30/01/2019 22:39	-59.1864	-25.2917	25	Net 1 closed	Target Fishing
95	30/01/2019 22:40	-59.1857	-25.2918	35	Net 2 opened	Target Fishing
95	30/01/2019 22:45	-59.1824	-25.2922	11	Net 2 closed	Target Fishing
97	31/01/2019 00:46	-59.0971	-25.2899	200	Net 1 opened	Stratified
97	31/01/2019 01:06	-59.0825	-25.2893	104	Net 1 closed	Stratified
97	31/01/2019 01:07	-59.0818	-25.2894	104	Net 2 opened	Stratified
97	31/01/2019 01:23	-59.071	-25.2893	10	Net 2 closed	Stratified
101	31/01/2019 16:18	-58.0178	-24.0271	200	Net 1 opened	Stratified
101	31/01/2019 16:40	-58.0166	-24.0513	100	Net 1 closed	Stratified
101	31/01/2019 16:41	-58.0166	-24.0523	100	Net 2 opened	Stratified
101	31/01/2019 16:59	-58.0154	-24.0721	11	Net 2 closed	Stratified
103	01/02/2019 01:05	-57.263	-24.4064	200	Net 1 opened	Stratified
103	01/02/2019 01:27	-57.261	-24.4302	95	Net 1 closed	Stratified
103	01/02/2019 01:28	-57.2608	-24.4313	98	Net 2 opened	Stratified
103	01/02/2019 01:49	-57.2584	-24.4554	11	Net 2 closed	Stratified
107	01/02/2019 15:18	-56.2036	-24.8119	203	Net 1 opened	Stratified
107	01/02/2019 15:39	-56.2116	-24.8314	100	Net 1 closed	Stratified

107	01/02/2019 15:39	-56.2116	-24.8314	105	Net 2 opened	Stratified
107	01/02/2019 16:01	-56.2199	-24.8521	10	Net 2 closed	Stratified
109	02/02/2019 00:39	-55.2623	-25.2232	200	Net 1 opened	Stratified
109	02/02/2019 01:02	-55.2723	-25.2396	100	Net 1 closed	Stratified
109	02/02/2019 01:02	-55.2723	-25.2396	110	Net 2 opened	Stratified
109	02/02/2019 01:21	-55.2801	-25.2531	10	Net 2 closed	Stratified
113	02/02/2019 15:31	-54.1445	-25.5796	199	Net 1 opened	Stratified
113	02/02/2019 15:45	-54.1496	-25.5841	100	Net 1 closed	Stratified
113	02/02/2019 15:46	-54.15	-25.5844	103	Net 2 opened	Stratified
113	02/02/2019 16:02	-54.1562	-25.592	10	Net 2 closed	Stratified
114	02/02/2019 23:57	-54.4087	-27.1412	200	Net 1 opened	Stratified
114	03/02/2019 00:16	-54.4153	-27.1519	100	Net 1 closed	Stratified
114	03/02/2019 00:17	-54.4157	-27.1524	100	Net 2 opened	Stratified
114	03/02/2019 00:38	-54.4244	-27.1673	10	Net 2 closed	Stratified
119	03/02/2019 15:13	-55.6683	-26.8105	200	Net 1 opened	Stratified
119	03/02/2019 15:35	-55.6777	-26.8345	100	Net 1 closed	Stratified
119	03/02/2019 15:36	-55.6781	-26.8355	103	Net 2 opened	Stratified
119	03/02/2019 15:56	-55.6871	-26.855	8	Net 2 closed	Stratified
124	04/02/2019 01:15	-56.1027	-26.6775	200	Net 1 opened	Stratified
124	04/02/2019 01:36	-56.1048	-26.7004	100	Net 1 closed	Stratified
124	04/02/2019 01:37	-56.1049	-26.7014	100	Net 2 opened	Stratified
124	04/02/2019 01:57	-56.1069	-26.7216	10	Net 2 closed	Stratified
128	04/02/2019 15:05	-57.1652	-25.833	200	Net 1 opened	Stratified
128	04/02/2019 15:21	-57.1674	-25.8503	100	Net 1 closed	Stratified
128	04/02/2019 15:22	-57.1676	-25.8515	101	Net 2 opened	Stratified
128	04/02/2019 15:38	-57.1704	-25.8697	10	Net 2 closed	Stratified
132	05/02/2019 15:15	-58.9937	-27.7699	200	Net 1 opened	Stratified
132	05/02/2019 15:37	-58.9806	-27.776	100	Net 1 closed	Stratified
132	05/02/2019 15:37	-58.9806	-27.776	105	Net 2 opened	Stratified
132	05/02/2019 15:57	-58.9696	-27.7814	10	Net 2 closed	Stratified
134	06/02/2019 00:14	-58.0823	-28.1823	199	Net 1 opened	Stratified
134	06/02/2019 00:27	-58.0848	-28.1956	100	Net 1 closed	Stratified
134	06/02/2019 00:28	-58.085	-28.1968	101	Net 2 opened	Stratified
134	06/02/2019 00:44	-58.0882	-28.2142	22	Net 2 closed	Stratified
139	06/02/2019 15:27	-56.8792	-28.5102	202	Net 1 opened	Stratified
139	06/02/2019 15:41	-56.8811	-28.5176	100	Net 1 closed	Stratified
139	06/02/2019 15:41	-56.8811	-28.5176	97	Net 2 opened	Stratified
139	06/02/2019 15:55	-56.883	-28.5248	10	Net 2 closed	Stratified
142	06/02/2019 23:57	-56.3484	-28.7341	200	Net 1 opened	Stratified
142	07/02/2019 00:16	-56.3533	-28.7479	100	Net 1 closed	Stratified
142	07/02/2019 00:16	-56.3533	-28.7479	100	Net 2 opened	Stratified
142	07/02/2019 00:32	-56.3584	-28.7621	9	Net 2 closed	Stratified
148	07/02/2019 15:43	-55.271	-29.0275	200	Net 1 opened	Stratified
148	07/02/2019 16:03	-55.2745	-29.0467	100	Net 1 closed	Stratified
148	07/02/2019 16:03	-55.2745	-29.0467	103	Net 2 opened	Stratified
148	07/02/2019 16:23	-55.2791	-29.0672	10	Net 2 closed	Stratified

Table 22 RMT8+1 hauls carried out during the South Sandwich Island survey

Project: Fish abundance and trophic ecology studies (Sophie Fielding, Gabriele Stowasser)		
Species	**Event-Net**	**N Sampled**
Bathylagus spp.	97-1	6
Bathylagus spp.	103-1	6
Bathylagus spp.	109-1	2
Bathylagus spp.	109-2	2
Bathylagus spp.	114-1	4
Bathylagus spp.	124-2	7
Teuthoidea spp.	78-1	1
Teuthoidea spp.	113-2	1
Teuthoidea spp.	114-1	1
Teuthoidea spp.	114-2	2
Electrona antarctica	78-1	2
Electrona antarctica	79-1	1
Electrona antarctica	79-2	8
Electrona antarctica	97-1	23
Electrona antarctica	97-2	14
Electrona antarctica	103-1	21
Electrona antarctica	103-2	19
Electrona antarctica	109-1	3
Electrona antarctica	109-2	19
Electrona antarctica	114-2	18
Electrona antarctica	124-1	18
Electrona antarctica	124-2	6
Electrona antarctica	134-1	2
Electrona antarctica	134-2	2
Electrona antarctica	142-1	2
Electrona antarctica	142-2	1
Electrona carlsbergi	114-1	6
Euphausia superba	78-1	7
Euphausia superba	79-1	2
Euphausia superba	79-2	25
Euphausia superba	103-1	10
Euphausia superba	103-2	14
Euphausia superba	120-1+2	100
Euphausia superba	121-1	100
Euphausia superba	128-2	11
Euphausia superba	142-1	25
Euphausia superba	148-2	26
Euphausia superba	97-2	15
Fish larva	79-2	1
Fish larva	97-2	1
Fish larva	101-1	1
Fish larva	103-1	1
fish larvae	78-2	1
fish larvae	83-1	2
fish larvae	83-2	1
fish larvae	85-1	2

Fish larvae	97-1	3
Fish larvae	107-2	5
Fish larvae	113-1	1
Fish larvae	114-1	1
Fish larvae	114-2	2
Fish larvae	119-1	7
Fish larvae	124-2	9
Fish larvae	128-1	2
Fish larvae	128-2	2
Gymnoscopelus braueri	78-1	2
Gymnoscopelus braueri	79-1	9
Gymnoscopelus braueri	97-1	14
Gymnoscopelus braueri	97-2	4
Gymnoscopelus braueri	103-1	25
Gymnoscopelus braueri	103-2	19
Gymnoscopelus braueri	109-1	8
Gymnoscopelus braueri	109-2	16
Gymnoscopelus braueri	114-1	5
Gymnoscopelus braueri	114-2	9
Gymnoscopelus braueri	124-1	18
Gymnoscopelus braueri	124-2	11
Gymnoscopelus braueri	134-2	4
Gymnoscopelus braueri	142-1	7
Gymnoscopelus fraseri	142-1	1
Gymnoscopelus nicholsi	97-1	2
Icefish larva	78-1	3
Icefish larva	79-1	1
Icefish larva	97-1	11
Krefftichthys anderssoni	114-1	2
Krefftichthys anderssoni	132-2	1
Leptocephalus sp.	78-2	1
Leptocephalus sp.	103-2	1
Myctophidae	119-2	1
Notolepis coatsi	97-1	1
Paradiplospinus gracilis	97-1	1
Paradiplospinus gracilis	97-2	1
Paradiplospinus gracilis	103-2	1
Protomyctophum bolini	78-1	5
Protomyctophum bolini	79-1	1
Protomyctophum choriodon	109-1	2
Protomyctophum choriodon	109-2	1
Protomyctophum choriodon	114-1	1
Protomyctophum choriodon	114-2	2
Protomyctophum choriodon	124-1	1
Protomyctophum choriodon	124-2	1
Protomyctophum choriodon	128-2	1
Protomyctophum spp.	78-1	1
Protomyctophum spp.	97-1	1
Protomyctophum spp.	109-1	13
Protomyctophum spp.	114-1	6

Protomyctophum spp.	128-2	2	
Protomyctophum tenisoni	109-1	3	
Psychroteuthis glacialis	119-1	1	
Psychroteuthis glacialis	124-2	1	
Psychroteuthis glacialis	128-1	1	
Psychroteuthis glacialis	128-2	1	
Slosarczykovia circumanatarctica	109-1	1	
Slosarczykovia circumanatarctica	114-1	1	
Squid paralarva	97-2	1	
Squid paralarva	103-1	1	
Squid paralarva	124-2	1	
Squid paralarva	128-2	1	
Squid paralarva	142-1	1	
Squid paralarva	83-1	1	
Squid paralarva	85-1	2	
Squid paralarva	97-1	1	
Squid paralarva	101-1	1	
Squid paralarva	107-1	2	
Squid paralarva	107-2	1	
Squid paralarva	113-2	1	
Project: Pan-antarctic Salp distribution study (Angelika Slomska)			
Species	**Event-Net**	**Formalin/frozen N**	
Salpa thompsoni	46-1	39	
Salpa thompsoni	55-2	100	9
Salpa thompsoni	74-1	47	4
Salpa thompsoni	78-1	12	
Salpa thompsoni	78-2	12	5
Salpa thompsoni	79-1	88	4
Salpa thompsoni	79-2	112	23
Salpa thompsoni	95-2	91	1
Salpa thompsoni	97-1	114	10
Salpa thompsoni	103-1	85	
Salpa thompsoni	103-2	83	11
Salpa thompsoni	109-1		4
Salpa thompsoni	109-2		2
Salpa thompsoni	113-1		3
Salpa thompsoni	114-1		4
Salpa thompsoni	114-2		10
Salpa thompsoni	124-1	100	
Salpa thompsoni	124-2	59	7
Salpa thompsoni	148-1		1

Table 23 Organisms sampled and preserved from RMT8 nets in the South Sandwich Island area during cruise DY098

Fish abundance and trophic ecology studies (Sophie Fielding, Gabriele Stowasser		
Species	**Event-Net**	**N Sampled**
Electrona antarctica	97-1	1
Electrona antarctica	103-2	1
Electrona antarctica	109-2	1
Electrona antarctica	114-2	2
Electrona antarctica	124-2	2
Fish larva	109-2	1
Fish larva	114-2	3
Gymnoscopelus braueri	97-1	2
Gymnoscopelus braueri	103-1	3
Gymnoscopelus braueri	103-2	1
Gymnoscopelus braueri	109-1	1
Gymnoscopelus braueri	124-1	2
Gymnoscopelus braueri	124-2	2

Table 24 Fish species sampled and preserved from RMT1 nets in the South Sandwich Island area during cruise DY098

5.2. Krill length frequency *Sophie Fielding*

5.2.1. Introduction

Antarctic krill (*Euphausia superba*) were sampled to determine the variation in the structure of the population around South Georgia and the South Sandwich Islands and to provide parameters required in the target strength model for krill biomass estimation. In addition samples of *Thysanoessa* sp and *Euphausia* sp were also measured from RMT8+1 stratified samples around the South Sandwich Islands.

5.2.2. Method

Krill total length was measured, using the standard BAS measurement from the anterior edge of the eye to the tip of the telson, with measurements rounded down to the nearest millimetre (Morris et al. 1988). Maturity stage of Antarctic krill was assessed using the scale of Makarov and Denys with the nomenclature described by Morris et al. (1988). Samples are summarised in Table 25.

Euphausia superba			
Event No.	Net	Number measured	Mean length (mm)
14	2	102	37.02
28	1	105	38.36
28	2	99	49.98
73	1	99	32.54
74	2	100	31.55
74	1	100	31.57
78	1	7	52.29

79	1	2	54.5
79	2	24	41.13
93		3	50.33
97	1	4	42.5
97	2	18	45.56
103	2	13	45.31
103	1	46	43.46
109	1	2	45.50
114	1	2	47.00
120	1	100	36.36
121	1	102	45.23
121	2	80	45.33
124	2	58	49.98
132	2	2	20
134	1	2	51.5
134	2	3	48
142	1	84	37.45
142	2	45	39.69
148	2	30	54.3
148	1	5	53.8
Thysanoessa sp			
78	2	106	
85	2	27	
85	1	59	
113	1	76	
114	2	81	
114	1	103	
119	1	35	
119	2	93	
128	2	103	
132	2	49	
134	1	83	
139	2	100	
139	1	101	
140	2	105	
148	2	103	
Euphausia triacantha			
78			
114	2	53	
Euphausia frigida			
113	1	46	
114	2	103	
114	1	8	
128	2	101	
134	1	21	

Table 25 Krill length frequencies measured during DY098

5.3. Antarctic krill density *Alejandro Ariza*

5.3.1. Introduction

Active acoustic technics are widely used to study zooplankton abundance and distribution in ocean ecosystems. The WCB itself, it is an acoustic grid survey designed to assess krill stocks in the vicinity of the South Georgia Islands. Scientific echosounders transmit sound waves into the water and a backscatter is created when those waves find a target with acoustic impedance different from the surrounding water. This impedance depends on the target's size, shape, and on material properties such as density or sound speed, variables that allow us to estimate the "Target Strength". This is a *condition sine qua non*, to accurately convert the acoustic backscatter into biomass (Simmonds and MacLennan, 2005).

Having accurate scattering models proved essential for the case of *E. superba*. Demer and Conti (2003) showed that its stock assessment might vary by a factor of 2.5 when the model was improved by updated parameters. This experiment was designed to collect body density measurements of *E. superba* in order to improve the scattering models and the acoustic-based biomass estimates in the areas of South Georgia and the South Sandwich Islands.

5.3.2. Methods

Two different methods were used to measure krill body density:

1) Titration method.- Involves placing the animal in a beaker with a known volume of ambient seawater. A hypersaline sewater solution is then titrated into the beaker until the animal reach neutral buoyancy, that is, when the solution density in the beaker equals that of the animal (Warren and Smith, 2007; Smith, Ressler and Warren, 2010; Becker and Warren, 2014). The temperature and salinity of the ambient and the hypersaline seawater solutions were used to calculate the solution density using the CSIRO MATLAB Seawater Library. With this measurements, the density of the animal is calculated with the following equation:

$$\rho_k = \frac{\rho_{sw} v_{sw} + \rho_{hs} * v_{hs}}{v_{sw} + v_{hs}}$$

where ρ_{sw} is the density of seawater, v_{sw} is the volume of seawater water used initially to hold the organism, ρ_{hs} is the density of the hypersaline solution, and v_{hs} and is the volume of solution used in the titration.

2) The Weight Bridge method.- Krill density (ρ_k) is calculated based on body weight (w_k) and volume (v_k) measurements performed on board:

$$\rho_k = \frac{w_k}{v_k}$$

Weight measurements were possible by using a custom made balance (Figure 10), with two plates equipped with sensors able to measure the weight's inertia momentum due to the ship's movement. Each sensor transmits the data to a PC, where along-time inertia waves are displayed, in blue and red for each plate. Reference weights must be added in one side, and the animal weight can be deducted when the red and blue channels overlapped.

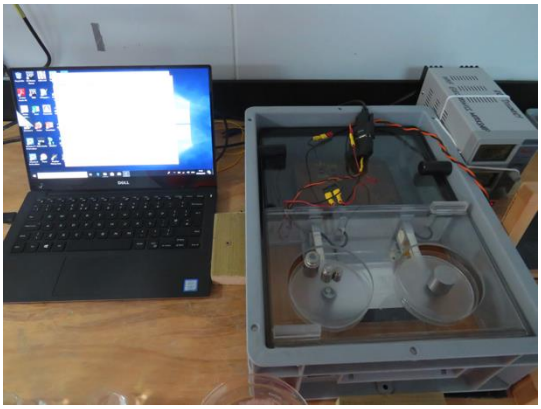

Figure 10 Weight bridge system for measuring krill body weight and calculate body density

Krill was not measured standalone, but inside a bottle with a known weight and volume. With the following steps, body density can be calculated:

- Fill bottle to brim with water and weigh (W_1)
- Remove ~2ml of water using a syringe and weigh (W_2)
- Add krill to bottle and weigh (W_3)
- Fill bottle to brim with water and weigh (W_4)

Density of water (σ_w) used is calculated as:

$$\sigma_w = \frac{(W_1 - W_b)}{V_b}$$

Weight of krill (W_k) is calculated as:

$$W_k = W_3 - W_2$$

Weight of liquid (W_l) added is calculated as:

$$W_l = W_4 - W_k - W_b$$

Volume of liquid (V_l) in bottle is calculated as:

$$V_l = \frac{W_l}{\sigma_w}$$

Volume of krill (V_k) is calculated as:

$$V_k = V_b - V_l$$

Density of krill (σ_k) is calculated as:

$$\sigma_k = \frac{W_k}{V_k}$$

5.3.3. Results

The titration and the weight bridge experiments were run in parallel to evaluate performance and for intercomparison purposes, in case one of the methods stands out the other. Both methods provided body densities within the range of values reported in previous literature (Warren and Smith, 2007; Smith, Ressler and Warren, 2010; Becker and Warren, 2014). Whoever, while the weight method

provided a wide range of values, appreciably sensible to the length of the specimen measured, the titration one seemed to give similar results, no matter the specimen measured (Figure 11). We found no relationships between the weight bridge and the titration method (Figure 12).

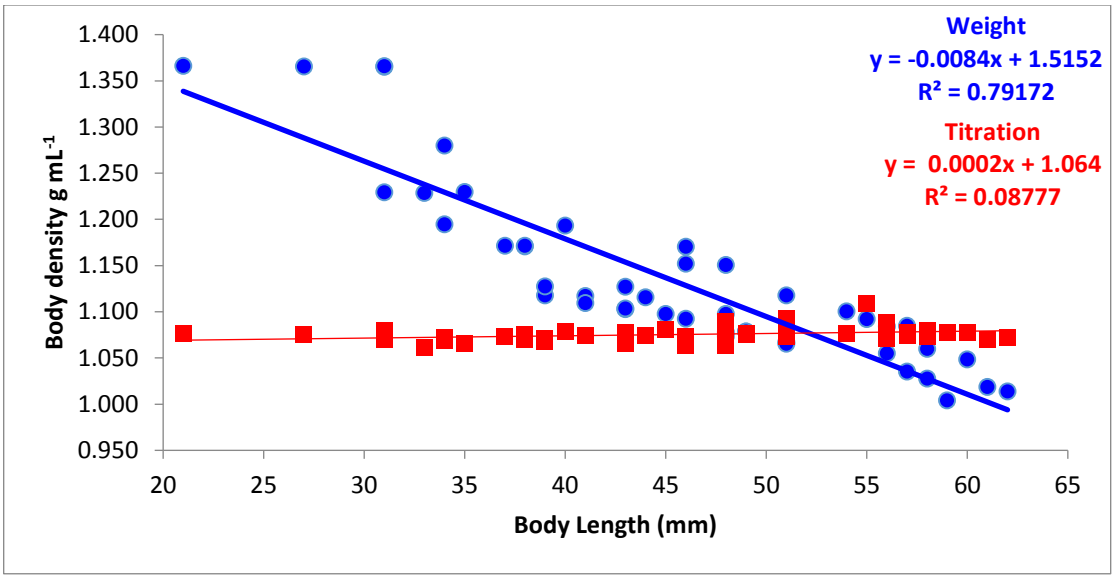

Figure 11 Krill density vs length, estimated with the weight bridge and the titration methods

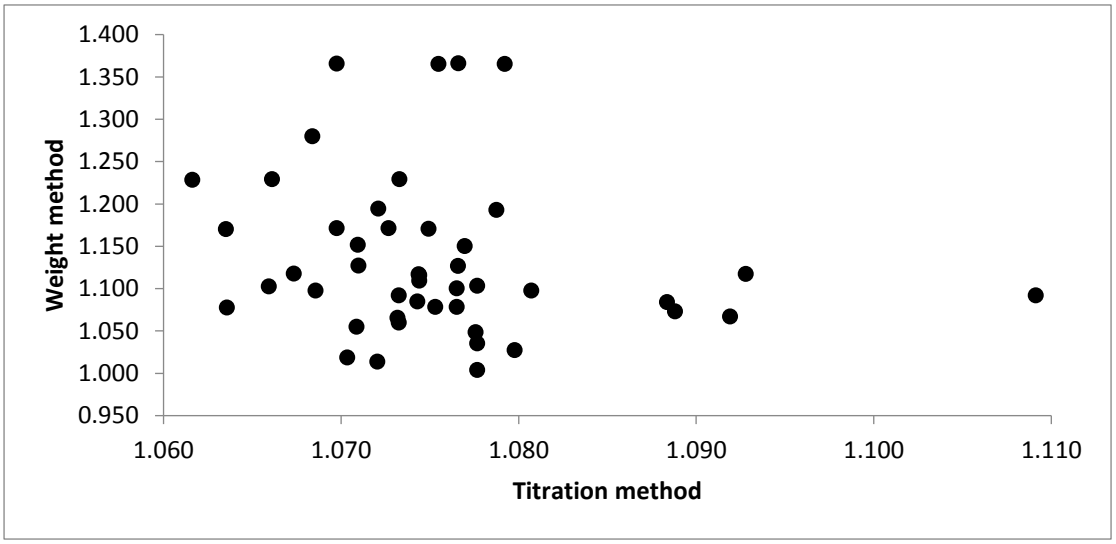

Figure 12 Krill body density measured with the weight bridge method and the titration method

The random results with the titration method might be due to several sources of error identified during this first test on board the RRS Discovery:

- The magnetic stirrer used to mix the beaker's solution creates a vortex pulling the animal down in the bottom and therefore affecting its buoyancy. It also makes the animal to move erratically around the beaker, making difficult to tell whether or not is neutrally buoyant.
- If the magnetic stirrer is not used, the solution is not mixed properly —or not quick enough— . That results in more hypersaline solution titrated before the animal reaches the neutral buoyancy, overestimating its density.

- Bubbles already present in the animal, or those coming from the burette's jet of water make the animal to float earlier.
- If a larger beaker with a larger volume of seawater is used to prevent the effects from the vortex or the jets, the amount of hypersaline solution to add turns impossible with the burettes present in the ship.
- Density calculations require an accurate knowledge of the salinity a temperature of the solutions. This needs to be done with instruments we did not have at the time when the experiments were run.

The following actions can be taken to improve the performance of the weight bridge method:

- The vibration-suppressing pad, underneath the box containing the balance, should be also extended sideways around the box: the wooden blocks holding the box in place when the sea gets rough may transmit vibrations to the system.
- Implement a maximizing window button in the software, to check the along-time inertia plot in full screen. Sometimes it is difficult to tell whether or not the two channels are overlapped. This action and the one above will improve accuracy, especially when the channels exhibit weight differences below 0.1 grams.
- Get more bottles with a wide neck, so that the larger specimens can be fitted in.

In conclusion, the weight balance method seemed a much better technique to perform on board ships. It is simpler to set up, less time-consuming and much more sensitive to measurements than the titration method. It provided declining density values as the specimen got larger, which is in well agreement with other studies.

5.3.4. References

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5.4. Where are they now? Right whales in the South Georgia marine ecosystem

Jennifer Jackson (PI, BAS), Gabi Stowasser, Megan Sorensen et al.

5.4.1. Introduction

Great whales have been subject to centuries of global hunting, first from small boats close to shore, and more recently by offshore factory ships which hunted and processed whales out in the ocean and were responsible for the most intense phase of exploitation of the world's whale stocks. While 20th century whaling rapidly decimated most of the lunge-feeding whales particularly humpback, blue, fin and sei whales, the destruction wrought by a similarly intense fishery for right whales up until the 1850s is not so well known. Right whales were one of the first large whales to be hunted because they are slow moving, calve in sheltered bays and have high fidelity to these calving areas. What catch records exist, suggest this fishery was incredibly intense on their calving grounds and their more accessible offshore aggregations.

In the Southwest Atlantic, right whales were exploited on their coastal calving grounds in Argentina and Brazil; whaling off Brazil began in 1602 and continued until commercial whaling became illegal in 1986. After nearly 400 years of hunting, southern right whales are now calving in these waters again, and for the first time in more than two centuries, they are regularly sighted on their associated high latitude feeding grounds off South Georgia, where they feed on Antarctic krill. Their principal calving ground off Península Valdés is one of the best-studied whale calving grounds in the world, with 40 years of data collection providing estimates of annual abundance and reproductive rates of known individuals through time. Consequently this is the only right whale population for which a direct relationship between high latitude environmental variability and calving ground reproductive success has been uncovered, indicating that climate and food availability off South Georgia influences right whale reproductive rates.

At present almost nothing is known about southern right whale ecology and habitat use on their South Georgia feeding ground, although this area is (i) a significant Southern Ocean krill and biodiversity hotspot, (ii) an area which has experienced significant climate fluctuation, influencing the population dynamics of other well studied krill predators, and (iii) one of the four principal areas where the Antarctic krill fishery operates. No baseline studies of any whale populations foraging in this important ecosystem have been conducted to date, although sightings data and observations from tourist vessels show increasing numbers of whales feeding in this ecosystem. For right whales, such surveys are long overdue and necessary in order to conduct an assessment of whale recovery from four centuries of exploitation (i.e. number and distribution of whales using this feeding ground), and to understand how regional South Georgia climate and habitat influence lower latitude population trends for this population (i.e. linking high latitude sightings, feeding, health status and foraging tracks with life history data available from the calving grounds).

We propose to conduct the first baseline survey of right whales feeding in South Georgia waters spanning 8 weeks of surveys during the austral summer. This survey will commence a crucial program of population monitoring for this species, to understand the population identity, dynamics, abundance and habitat use of right whales feeding in these waters, and link their foraging ecology, health and reproductive status with the low latitude calving grounds off Argentina and Brazil.

As part of this project the aim on the Western Core Box Cruise was the sampling of potential prey species for stable isotope analysis. Invertebrate and fish species collected from RMT8 and BONGO hauls are listed in Table 26.

Species	**Event**	**Net**	**Numbers sampled**
Chaetognatha spp.	46	2	30
Electrona antarctica	46	1	1
Electrona antarctica	46	2	1
Electrona antarctica	55	1	7
Electrona antarctica	55	2	2
Electrona carlsbergi	55	1	2
Electrona carlsbergi	55	2	4
Eucalanus spp.	46	2	?
Euphausia frigida	46	2	2
Euphausia superba	14	2	20
Euphausia superba	28	1	20
Euphausia superba	73	1	20
Euphausia superba	73	1	100
Euphausia superba	74	2	100
Euphausia triacantha	26	2	26
Euphausia triacantha	27	2	10
Euphausia triacantha	46	2	20
Euphausia vallentini	26	2	6
fish larvae	26	2	3
Fish larvae	46	2	3
fish larvae	55	2	2
Fish larvae	73	2	2
Gymnoscopelus bolini	27	1	6
Gymnoscopelus braueri	55	1	4
Gymnoscopelus fraseri	46	2	4
Gymnoscopelus fraseri	55	1	3
Gymnoscopelus fraseri	55	2	2
Gymnoscopelus nicholsi	27	1	2
Gymnoscopelus nicholsi	27	2	1
Gymnoscopelus nicholsi	55	2	2
Gymnoscopelus piabilis	55	1	2
Primno macropa	14	2	7
Primno macropa	26	2	?
Protomyctophum bolini	55	1	3
Protomyctophum bolini	55	2	4
Protomyctophum choriodon	27	2	1
Protomyctophum sp.	55	1	1
Rhincalanus gigas	58	BONGO	50-60
Salpa thompsoni	46	2	18
Slosarczykovia circumantarctica	55	2	1
Squid paralarvae	26	2	5
Squid paralarvae	46	2	2
Themisto gaudichaudii	14	2	20
Themisto gaudichaudii	26	2	20
Themisto gaudichaudii	46	2	20
Thysanoessa spp.	26	2	20
Thysanoessa spp.	46	2	20

Tomopteris spp.	26	2	3
* all samples where no specific net type is indicated derive from RMT8 catches			

Table 26 Invertebrate and fish species sampled from RMT8 and BONGO catches for stable isotope analysis during DY098*

The use of stable isotopes as dietary tracers is based on the principle that isotopic concentrations of consumer diets can be related to those of consumer tissues in a predictable fashion. It has been extensively applied in the investigation of trophic relationships in various marine ecosystems and has been used to determine feeding migrations in numerous species. The stepwise enrichment of both carbon and nitrogen in a predator relative to its prey suggests that the predator will reflect the isotopic composition in the prey and isotope values can be used to identify the trophic position of species in the food web investigated. Additionally $\delta^{13}C$ values can successfully be used to identify carbon pathways and sources of primary productivity. Isotopic measurements of potential prey species will be put into context with isotopic measurements of whale biopsy samples, collected later in the season in the same waters.

In order to establish an isotopic baseline for the depth horizons where zooplankton samples originated from corresponding particulate organic matter (POM) was collected. Further POM samples were collected in the South Sandwich Island region in correspondence with the sampling regime of Cecilia Silvestri and Flavia Saccomandi (ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale, Roma, Italy, Section 3.3) for a future collaboration on baseline stable isotope measurements of POM in the Southern Ocean. POM samples were obtained through filtering waters collected by Niskin bottles deployed via a CTD rosette. Water was taken from various depths at each station (Table 27). All water samples collected from Niskin bottles were processed on-board. Depending on the density of particles varying volumes of seawater per depth were filtered onto 47mm GF/F filters and the filters stored frozen at -80°C.

Station	Event	sample depths
P3	5	50m, 200m, 1000m, 2000m, 3042m
WCB 2.2N	17	5m, 25m, Chlmax (42m), 75m, 125m, 200m, 450m, 750m
P3	52	5m, 25m, Chlmax (33m), 75m, 125m, 200m, 450m, 750m
In East Cumberland Bay	56	5m
Shelf Cumberland Bay	71	5m, 25m, Chlmax (44m), 75m, 125m, 200m
SSI	76	5m
SSI	82	5m, Chlmax (44m)
SSI	84	5m, Chlmax (65m)
SSI	94	5m, Chlmax (41m), 200m, 450m, 1000m, 2000m, 3000m
SSI	106	5m, Chlmax (28m), Thermocline (121m)
SSI	112	5m, Chlmax (38m), 200m
SSI	118	5m, Chlmax (67m), 200m
SSI	131	5m, Chlmax (78m), 200m
SSI	137	5m, Chlmax (68m), 200m
SSI	146	5m, Chlmax (50m), 200m

Table 27 POM samples collected for stable isotope analysis on DY098

5.5. The historical demography of Salpa thompsoni as a response for previous climate change episodes *Angelika Słomska, Geraint Tarling, Clara Manno, William Goodall-Copestake*

5.5.1. Introduction

The study of phylogeography defines genetic diversity between populations of individuals of the same species within their geographic range, so allowing their evolutionary history to be inferred. Such knowledge not only provides information about contemporary levels of biodiversity but also indicates how Antarctic key species may respond to projected climate changes. *Salpa thompsoni* (Tunicata: Thaliacea) appear to show the opposite response to most Antarctic fauna in that their numbers are increasing with ocean warming [1], which highlights the importance of these tunicates as a special case for further study, because their importance in Antarctic marine ecosystems is likely to increase with time [2-3]. Salps have a number of important traits including repackaging of small particles into rapidly sinking pellets, complex life cycles, and high levels of adaptability to variable environmental conditions [4-6], but little is known about their evolutionary relationships and the structure of their population at the Pan-Antarctic scale. According to the latest molecular studies [6-8], *S. thompsoni* has proved to be an exceptional species with which to examine the evolution of life history traits and it can be a model organism for investigations into genomic evolution.

The need for information about population structure is most acute for ecologically key species that are likely to be heavily influenced by climate change. *Salpa thompsoni* plays a key role in the Antarctic marine ecosystem and is believed to be related to environmental factors (Figure 13) and positively impacted the projected warming global climate.

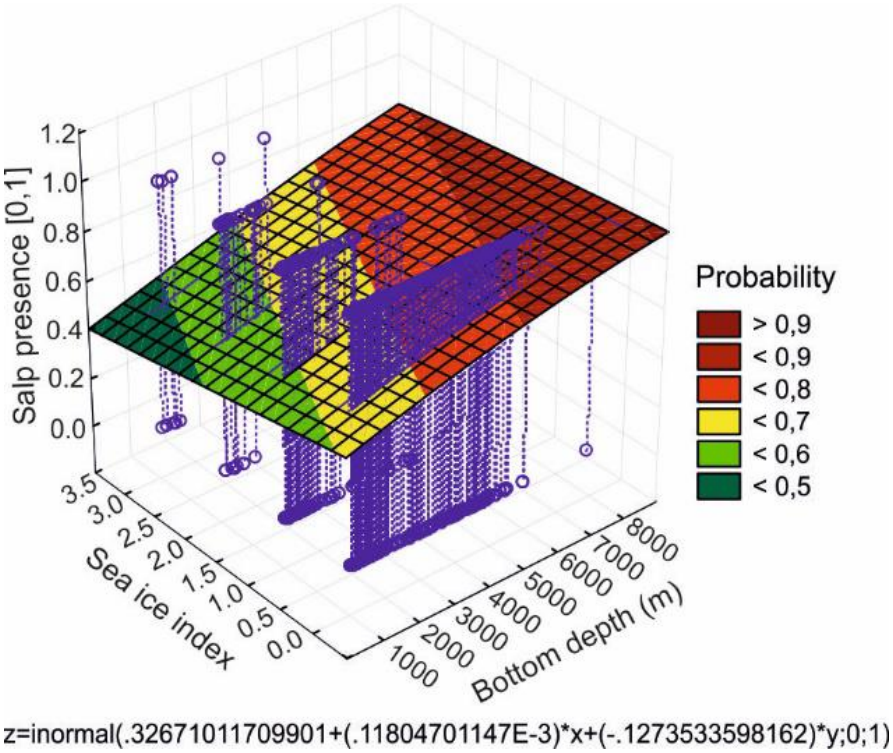

Figure 13 Linear regression model shows S.thompsoni occurrence probability with presence of such environmental factors like: degree of ice cover (0-3), sea surface temperature ([-2] -4 ° C); salp presence probability presented in the zero-one system, where 1 is the highest and 0 is the lowest chance for salp (Słomska et al. – in revision).

5.5.2. Research methodology

5.5.2.1. Zooplankton sampling

Salps were collected from the water column using mainly RMT 8 net. These equipments present mechanisms which allow to open and close the nets at different depths. Salps samples were split according to different purposes: for morphological and

population analyses they had been preserved in 4% formaldehyde, while the samples for molecular analyses had been frozen in (– 80).

The study of the development of *Salpa thompsoni* will be conducted following the guidelines of Foxton (1961) and Daponte et al. (2001), which included the determination of both size and exact stage of the development of specimens. Up to 100 *S. thompsoni* oozooid samples will be considered for genetic use and up to 1100 *S. thompsoni* had been used for the population structure analysis. They were identified following the description in Foxton (1961). By reconstructing the demographic trajectory of *S. thompsoni*, it will be possible to place the short term changes in salp numbers observed in ecological studies into a longer term evolutionary context.

5.5.2.2. Population demography analyses

Salps exhibit two developmental strategies different in the presence of internal fertilization (Figure 14). Therefore, two forms of mature organisms can be distinguished: (1) a sexually reproducing, viviparous blastozooid and (2) an oozooid which reproduces asexually by budding juveniles on its reproductive organs. Those organs are called stolons and are responsible for producing numerous buds, which are organized into three groups of varying size (BI – first block, BII – second block, BIII – third block) (Loeb *et al.* 2012). In addition to qualitative, morphometric and population analyses, all forms of salps were isolated from samples.

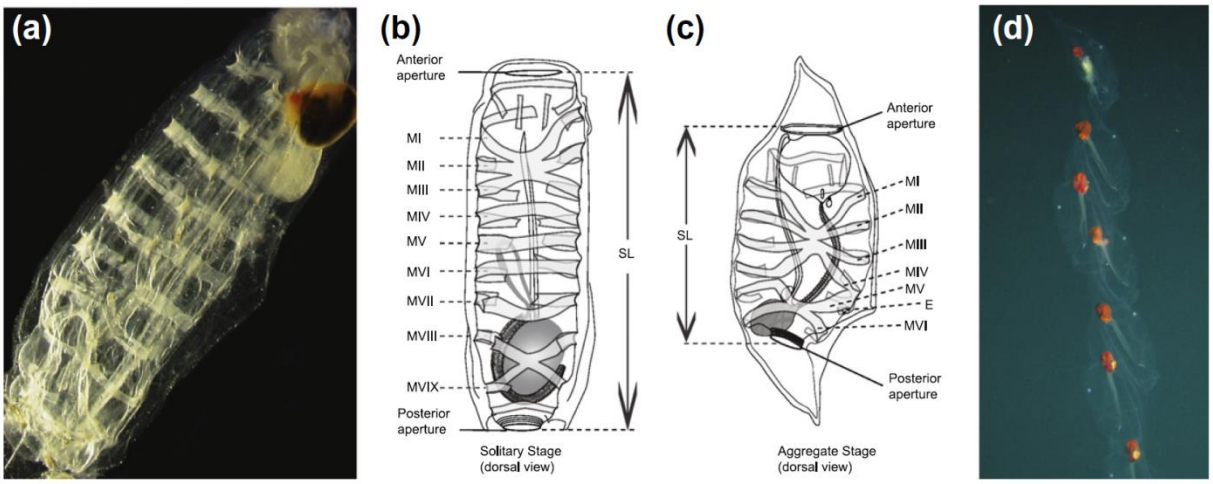

Figure 14 Two reproductive forms of Salpa thompsoni: the (a) solitary (asexual, oozooid) and (b) aggregate chain (sexual, blastozooid) form. Line drawings indicate body muscle bands (M), embryonic solitary form in the blastozooid (E) and standard body length measurements (after Loeb and Santora, 2012).

The study of the development of *Salpa thompsoni* was conducted following the guidelines of Daponte *et al.* (2001), which included the determination of both size and exact stage of the development of specimens. All the measurements followed the criteria listed below:

1) blastozooids – the length of the whole body from the oral to the atrial aperture – L (OA) (Oral−Atrial Length) – was measured, as was the length of the whole body from the dorsal appendix to the ventral appendix – L (T) (total length); the size of embryo – L (em) (embryo length) was also determined (Daponte *et al*. 2001). Assessment of blastozooid embryo development was performed using a 6−stage scale (Stage), namely 0, I, II, III, IV and V, which takes into account the size, the shape and the presence of placental scars (SCR) on embryos (Figure 15);

2) oozooids – the length of the whole body from the oral to the atrial aperture L (OA) was measured, and the stolon's level of development was evaluated with an additional measurement of each block length (B). Young buds (blastozooids) developing on reproductive stolon blocks were counted and simultaneously the oozooid stage of development was determined. The following characteristics of oozooids were selected after Daponte *et al.* (2001) for the determination of their development: the presence of scar, the number of blocks and buds on a stolon, and the length of the block (Figure 16).

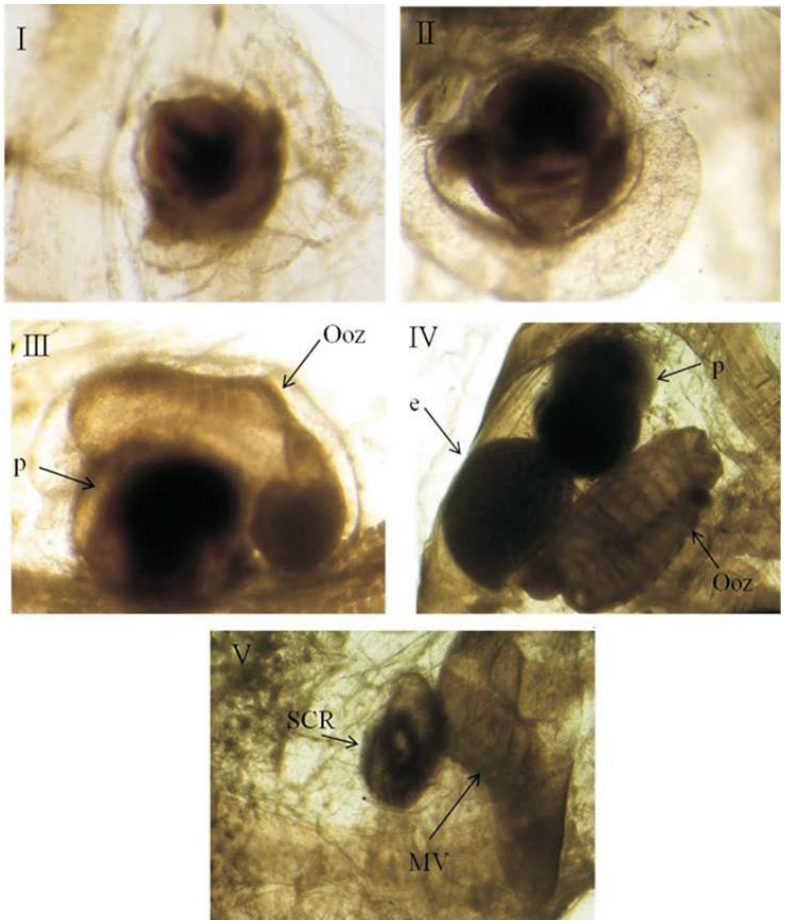

Figure 15 Developmental stages of the blastozooid Salpa thompsoni: I–V – various stages of development, e – embryonic tissue, p – placenta, Ooz – embryonic oozooid, SCR – placental scar, MV – the fifth muscular band (Słomska et al. 2015).

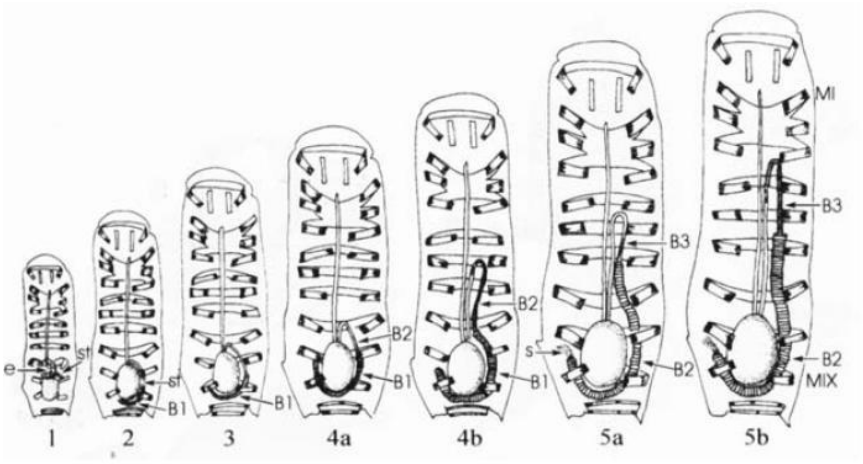

Figure 16 Developmental stages of the Salpa thompsoni oozooids, morphology of the reproductive stolon with several blocks of blastozooid buds (B1, B2, B3).

55 salps samples had been collected from different part of Atlantic Sector of the Southern Ocean. To qualitative, morphometric and genetic analyses, both forms (blastozooids and oozooids) of salps were collected. *S.thompsoni* samples were divided to each reproductive form (blastozooid and oozooid) and preserved separately. 17 samples containing around 100 salps were preserved for population analyses, including both reproductive form of salps and presumably cryptic species within *Salpa thompsoni* population. Greatest number of salps (with dominance of blastozooids and small number of oozooids) were observed within the Scotia Sea area especially around the South Sandwich Island (Event 79,93,95,103,124) (Table 28). Organisms have been assigned to the lowest possible taxonomic resolution and their life cycle and stage of the development has been classified.

Event	N sampled	Net	Storage
55	109	2	formalin (100)/ frozen (9)
74	51	1	Formalin (47)/frozen (4)
78	12	1	formalin
78	17	2	formalin(12)/frozen (5)
79	92	1	(4) frozen ; formalin (88)
79	135	2	formalin (112)/ frozen (23)
95	92	2	formalin (91)/frozen (1)
97	124	1	formalin (114)/ frozen (10)
103	85	1	formalin
103	94	2	83 formalin/ 11 frozen (-80)
109	4	1	Frozen
109	12	2	Frozen
113	1	1	Frozen
114	4	1	Frozen (-80)
114	11	2	frozen (-80)
124	100	1	formalin

124	66	2	formalin (59); frozen (7)
46	46	1	formalin

Table 28 Summary of salps caught and preserved

5.5.3. Genetic Population Structure

To learn more about the genetic diversity of this species, we explored the genetic diversity and population structure of *S. thompsoni* in the Southern Ocean by increasing the size of a previous salp mtDNA dataset encompassing samples from individuals caught off South Georgia, the Antarctic Peninsula, and Polar Front area (Figure 17). The DNA sequences obtained revealed interpopulation diversity consistent with previous work - average haplotype diversity (h) and nucleotide diversity (π) were 0.7198-0.9346 and 0.0099, respectively. However, population genetic structure assessed with AMOVA analysis revealed statistically significant differences (φST = 0.37748 with P value= 0.0000). This structure may be due to the presence of cryptic species among *S. thompsoni*'s populations or may have resulted due to the dynamic nature of its mitochondrial genome.

Figure 17 Neighbor-Joining Tree for unique S.thompsoni sequences with comparison of other salp species. Specific sequences marked on different color. Red: S.thompsoni samples from summer season between 2016/2017(E_98), blue: results obtained by Goodall-Copestake (2017) (E_146, E_187).

The main aim of my project is to infer the historical processes that may be responsible for the contemporary population structure of *Salpa thompsoni,* and reconstruct the most plausible scenario of their evolution, using the most advanced genetics methods. Pan-Antarctic population genomic analysis will determine gene diversity levels, identify any new types of mutation that have emerged over time, and reveal the evolutionary dynamics of Antarctic salps. My results will be compared with estimates of Pan-Antarctic population structure obtained for other Antarctic species to explore how different components have responded to the same environmental factors.

5.5.4. References

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5.6. Upper temperature limit for egg hatch success in Antarctic krill *Franki Perry*

5.6.1.Introduction

Antarctic krill, *Euphausia superba* (hereafter krill) are pivotal to the ecosystem function in the Southern Ocean. Within the Southern Ocean their population centre is found in the south-west Atlantic sector (Atkinson et al. 2008). This region is currently the only area in which the krill fishery has been active for the past two decades (Grant et al. 2013) and is also the area undergoing the most rapid changes due to climate change (Maksym et al. 2012). To better understand Antarctic krill population dynamics, better predict how they may change in a changing environment, and how competition between the fishery and other krill predators may function over small scales we must better grasp variation in reproductive output from individual females and the success with which their eggs hatch. Furthermore understanding why eggs may fail to hatch and what environmental factors influence will be able to help us predict successful spawning. This knowledge can be imputed into models to predict reproductive output and how this may fluctuate on multiyear time scales.

5.6.2. Objectives

Temperature is a key environmental factor when considering the developmental success of many marine invertebrates. Antarctic krill is a cold water stenotherm with a distribution that is limited to the Southern Ocean, and which is concentrated in the south-west Atlantic sector. The rapid climate change occurring in this region is causing a pole wards contraction of their range (Atkinson et al. 2019). The central role krill play in the Southern Ocean ecosystem means that changes in their distribution will affect community structure and biodiversity. In order to project future distributions and abundances models must be able to parameterise krill life history traits accurately. Embryonic development has been tested under a range of environmental conditions. However, the upper temperature tolerance of embryonic development has not been clarified. With increasing temperatures occurring across krill habitat, now is a particularly pertinent time to understand the upper temperature limit of embryonic development.

To achieve this aim I collected and incubated gravid female Antarctic krill individually until they release eggs. Eggs, once checked for fertilisation, were incubated at three temperatures. Based on prior research the temperatures at which embryonic development was tested were; 0.5 °C, 3.0 °C and 5.0 °C. These temperatures represent a control (0.5 °C), an upper range limit (3.0 °C) and destruction (5.0 °C). Prior literature stated that 'krill embryonic development is inhibited at 4.0 °C' (George & Stromberg 1985). However, once reading into this study you see that this was not tested experimentally it was discovered after an aquarium was 'accidentally raised to 4.5 °C. Other studies that have systematically tested the effect of temperature on embryonic development times have not tested higher than 2.4 °C (Yoshida et al. 2004; Ross et al. 1988). Therefore, my aim during DY098 is to test the developmental success of krill embryos at 3.0 °C and 5.0 °C in an attempt to determine:

- If all embryonic development is inhibited at 4.0 °C
- How embryonic development decreases from optimum temperatures to 5.0 °C

5.6.3. Materials and methods

During the cruise I collected krill from either targeted or non-target trawls using the RMT8 net. Once the krill had been removed from the nets and transferred to white sample buckets in the wet lab I used a small sieve to gently check the gender of the adult krill as well as attempt to determine if the female had any spermatophores attached. Any krill that fitted the criteria (ie. Gravid females with visible spermatophores (F3)) were transferred directly to a 500ml Nalgene pot. These Nalgene containers were then transferred to the krill hotel (aka The Krilton, Figure 18

Figure 18 The Krilton, Krill hotel

The Krilton was a large 360l tub, within which there were a number of pieces of guttering all placed vertically. These pieces of guttering were just larger than the diameter of the Nalgene pots, and were tall enough to allow five Nalgene tubs to be stacked on top of each other. The Krilton had an inlet and an outlet to allow water to flow through the space. During DY098 the Krilton was located in the main hanger. Due to the constant flow of water through the aquarium it was impossible to have it in the controlled temperature (CT) lab. The drains in the lab were unsuitable for the quantities of water that may have over flowed in foul weather. During the setup of the Krilton I found that the temperature of the underway water going into the aquaria was a couple of degrees

warmer than ambient. It was decided that this was because the water was being taken onto the ship and then, due to low water demand, was in the ship long enough to warm up before it was directed into the Krilton. Therefore, to ensure that the temperature in the Krilton was maintained at ambient sea surface temperatures the underway water was run from two other taps constantly for the duration of the experiment. This meant that the water spent as little time on board the ship warming up before being run through the Krilton.

All of the Nalgene pots, and guttering contained a large number of holes to ensure good water flow to the krill, without allowing them to escape. The negative buoyancy of the krill eggs means that in natural conditions they would sink away from the females. In the Nalgene pots this wasn't possible and it has been noted that females will predate on their own eggs if given the chance. Therefore, a combination of transparent acrylic discs and 1mm mesh were employed to create a false bottom in the Nalgenes so that the eggs could sink out of the reach of the females, see Figure 19. The top of the aquaria was covered first with a foam baffle and then with a wooden lid, both of which were tied down. This meant the krill were kept in darkness, except for when they were being checked. The krill in the hotel were then be monitored at midday and midnight for the length of the experiment. During these checks every krill was checked to see if she had produced eggs, moulted or died. Dead krill were removed, as were moults and frozen in the -80°C fridge. After this time period the female was removed from the Nalgene, weighed and measured and placed in the -80°C fridge.

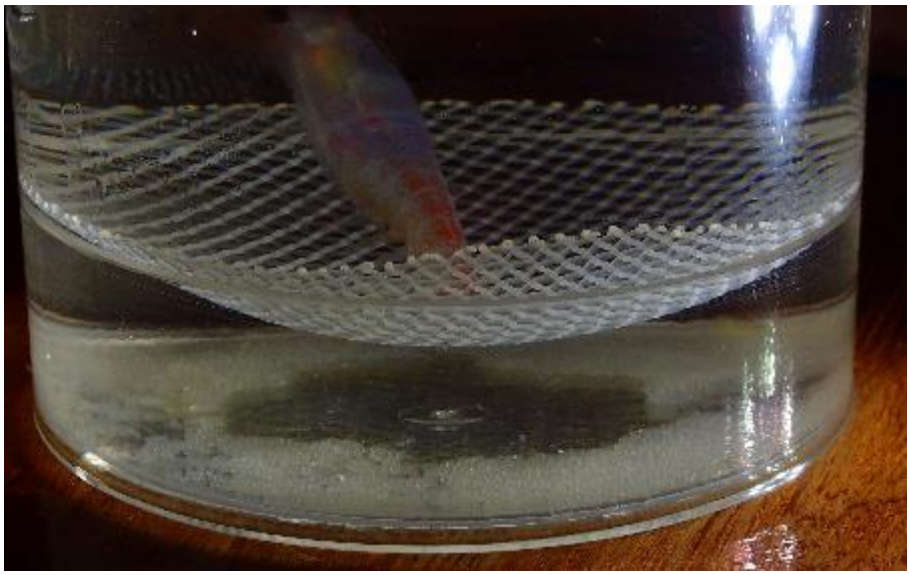

Figure 19 An example of the method used to keep the females separate from their neutrally buoyant eggs.

At this point the eggs were checked to determine if they had been successfully fertilised. If the eggs were fertile and there were at least 500 I would set up the incubation experiment. For each batch of eggs, I would take 30 eggs and fix them as T_o in 4% formalin. This was the method of preservation used for fixing all of the temperature experiment eggs, as it would allow for analysis of the embryonic development in the eggs once the samples are returned to Plymouth Marine Laboratory. Once the T_o sample had been taken I would transfer ~ 60 eggs to nine prepared 250ml Duran bottle containing 0.22µm filtered seawater. Table 29 shows the experimental set up and how the eggs were distributed between the nine Durans.

	0.5 °C	**3.0 °C**	**5.0 °C**
Day 1 -2	60	60	60

Day 3-4	60	60	60
Day 5-6	60	60	60

Table 29 Number of eggs in each of the nine Duran bottles, and how the eggs were distributed at the three different temperatures being tested.

The pH of the filtered seawater in the bottles was taken before the eggs were added to the bottles. The pH was then taken again at day 6 of the experiment to determine if the packing density of the developing embryos had had an effect of the pH of the water. The instrument used to do this was a Metrohm 826 pH mobile which was re-calibrated on each day of use. In order to maintain the required temperatures three scientific fridges were used. The fridge used for the control temperature 0.5 ^{o}C was an LMS cooled incubator and for both 3.0 ^{o}C and 5.0 ^{o}C temperatures Liebherr mediline (7082 271-00) was used. I sampled the eggs from each female at each temperature once every 24 hours, either at midnight or at midday depending at what time the female had spawned. All samples were collected in the CT lab (maintained at 2 ^{o}C) to ensure that temperatures were maintained as well as possible.

Any remaining eggs from the spawn were frozen at -80 ^{o}C along with the female to allow for later analysis if required. Before the female was frozen she was measured using the AT measurement and weighed. The two sampling locations during DY098 (South Georgia and the South Sandwich Islands) meant that I could replicate my experiment multipul times with females caught in both locations. In total I was able to collect four replicates of the experiment from females caught around South Georgia and a further ten times with females caught off the South Sandwich Islands. Further details of the gravid females used for the temperature experiments are in Table 30.

female.no.	length.mm	weight.g	location	event.number	spawn.date	midday.midnight	notes
1a			-80	28	09/01/2019	midday	Trashed. Fridge turned off.
2a			-80	28	09/01/2019	midday	Trashed. Fridge turned off.
3a			-80	28	10/01/2019	midnight	Trashed. Fridge turned off.
4a			-80	28	10/01/2019	midnight	Trashed. Fridge turned off.
5a			-80	28	10/01/2019	midnight	Trashed. Fridge turned off.
6a			-80	28	10/01/2019	midnight	Trashed. Fridge turned off.
7a	58	1.95	-80	28	11/01/2019	midday	Trashed. Fridge turned off.
1b	58	1.8	-80	28	12/01/2019	midday	Eggs developing.
2b	60	1.8	-80	28	12/01/2019	midday	Eggs not developing.
3b	55	1.65	-80	28	12/01/2019	midday	Eggs not developing.
4b	58	1.95	-80	28	12/01/2019	midday	Eggs not developing.
5b	59	1.95	-80	28	12/01/2019	midday	Eggs not developing.
6b	57	1.65	-80	28	12/01/2019	midday	Eggs not developing.
7b	55	1.55	-80	28	12/01/2019	midday	Eggs developing.
2c	60	2.1	-80	28	15/01/2019	midday	Eggs developing.
3c	57	1.85	-80	28	17/01/2019	midday	Eggs developing.
4c	58	1.7	-80	78	28/01/2019	midday	Eggs developing.
5c	56	1.65	-80	78	29/01/2019	midday	Eggs developing.
6c	52	1.25	-80	78	30/01/2019	midnight	Eggs developing.
7c	58	1.85	-80	78	03/02/2019	midday	Eggs developing.
2d	55	1.45	-80	103	04/02/2019	midnight	Eggs developing.
3d	54	1.5	-80	103	05/02/2019	midday	Eggs developing.

4d	52	1.35	-80	120	05/02/2019	midday	Eggs developing.
5d	57	1.65	-80	120	05/02/2019	midday	Eggs developing.
6d	56	1.6	-80	121	05/02/2019	midday	Eggs developing.
2e	60	1.85	-80	120	06/02/2019	midday	Eggs developing.

Table 30 Details of the gravid females used for temperature experiments

6. Micro and nanoplastics in the marine environment

6.1.The impact of nanoplastic and ocean acidification on Antarctic Zooplankton *Emily Rowlands*

Impacts of ocean acidification (OA) and plastic on zooplankton function have been acknowledged (Manno et al., 2016; Cole et al., 2016), however nanoplastics (NP) which are believed to be the most hazardous of the plastics, have a different impact on zooplankton than larger plastics. Their smaller size enables uptake and translocation into tissues whilst their high surface curvature and large surface area maximises interactions with the surrounding medium. The impact of these smallest plastic particulates is still poorly explored and though nanoplastics have not yet been detected in-situ in the Southern Ocean, like other plastic forms, their presence is believed to be ubiquitous. Additionally, The Southern Ocean (SO) has been highlighted as potential sponge for plastic debris and is particularly affected by OA due to naturally high CO_2 ocean uptake. The synergistic NP and OA stress in the SO however, is totally unknown.

Understanding the impact of these anthropogenic stressors on the keystone species supporting the Antarctic marine food web is critical. Antarctic krill (*Euphausia superba*) are pivotal to the Antarctic marine ecosystem and during the cruise, incubation experiments focused primarily on the embryonic development and hatch success rate of *E.superba* eggs. Incubation experiments explored both the individual impact of NP, plus the synergistic impact of NP and OA utilising spherical, aminated (NP-NH_2), yellow-green fluorescent nanoparticles of two sizes (0.16µm and 0.050µm), in a temperature controlled laboratory environment (2°C). A further incubation experiment focused on Antarctic Pteropods (*Limacina helicina Antarctica*), a marine calcifier pivotal not only for trophic transfer in the Antarctic marine food web but also for the SO biogeochemistry, contributing significantly to the carbon flux. Ribbons of *L.helicina* eggs were incubated with aminated (NP-NH_2), yellow-green fluorescent nanoparticles (0.050µm).

On board RRS discovery, krill were collected from either targeted or non-targeted trawls using the RMT net. Krill were moved from the nets into plastic sample buckets from which they were carefully and individually removed using metal sieves/spoons to determine gender. Identified females were further examined for spermatophores. Gravid female krill appearing healthy were moved to the krill hotel (see section 5.6) prior to their eggs been used in incubation experiments. *L.helicina* were collected via the BONGO net, deployed using a 200µm mesh and with a net depth of 50m. Pteropods were then held in incubation tanks at a temperature of 2.4°C (see section 6.2) before egg ribbons were extracted.

6.1.1. Antarctic krill egg incubation experiments

Once a gravid female spawned, a subsample of eggs was examined under the microscope to check suitability for incubation experiments i.e. successful fertilisation, lack of malformations and normality in terms of shape. All microscope work took place in the cold room to minimise the impact of temperature variance on eggs whilst examination occurred. When not being examined, eggs were refrigerated at 0.5°C.

Plastic stocks for incubation experiments were prepared in the clean lab/salinometer room within a laminar flow to minimise contamination. For 0.16µm NP spheres, antimicrobial solutions were removed during NP stock preparation whilst for 0.050µm NP particulates, the original stock contained no antimicrobials and therefore no additional stock preparation was required.

For all egg incubation experiments, a final plastic concentration of 2.5µg/ml was utilised, chosen based on toxicity and sub-lethal effects observed on exposures of zooplankton to PSNPs in Bergami *et al*., (2017) and Manfra *et al*., (2017), and in line with the NP exposures during past cruises (JR16003 – incubation of juvenile *E.superba* / JR17003 – incubation of adult *E.superba*). All egg incubation experiments were carried out in multiwells containing 6 x 10ml wells. Approximately 20 eggs were transferred to each well using a soft-tipped pipette. The total liquid volume in each well was 8ml. All treatments contained magnesium chloride to act as an antibacterial agent and prevent egg degradation.

6.1.1.1. Krill egg incubation (0.16µm NP plastic, OA and synergy)

During the first incubation experiment (Figure 20), eggs from a single female (subsequently frozen at -80◦C) were incubated with three treatments: 0.16µm NP spheres, in OA conditions (PH 7.7), plus with the synergistic impact of NP (0.16µm) and OA (PH 7.7). Three multiwells also contained only 0.22µm filtered seawater as a control and all other treatments were carried out in triplicate.

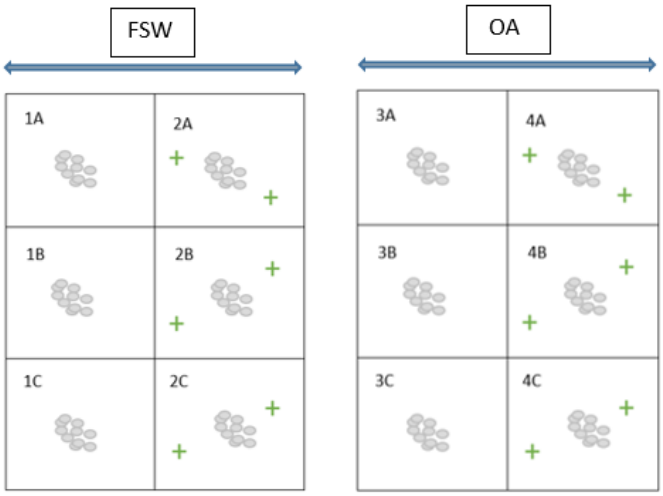

Figure 20 Schematic diagram of krill egg incubation experiment (1A-C control of 0.22µm filtered seawater, 2A-C 0.16µm aminated NP, 3A-C OA (filtered seawater adjusted to PH 7.7), 4A-C OA (filtered seawater adjusted to PH 7.7) and 0.16µm aminated NP

Eggs were monitored and photographed every 12 hours to document embryonic development using a light microscope whilst every 24 hours fluorescent microscopy images were taken to aid with preliminary NP aggregation/uptake observations. A subsample of ten eggs (total per treatment) were taken every 24 hours and immediately preserved in 4% formalin. After four days of incubation, a percentage of eggs further developed into nauplii, which were subsequently removed after reaching the calyptopis stage to prevent damaging the remaining eggs. Nauplii were observed separately in small glass jars of 0.22µm filtered seawater until the experiment end point**.** Incubations were terminated after 6 days to preserve samples as egg degradation was observed during examination. All eggs and nauplii were preserved in 4% formalin. At the end of the experiment, a subsample (250ml) of both the 0.22µm filtered seawater and OA solution (with the addition of magnesium chloride) were preserved in mercuric chloride for carbonate chemistry analysis in Cambridge.

6.1.1.2 Krill egg incubation (0.050 um NP plastic)

In a further experiment, eggs from three krill were incubated with 0.050µm NP. Three multiwells for each female contained eggs incubated in only 0.22µm filtered seawater as a control (plus magnesium chloride) whilst the NP treatment was also carried out in triplicate for each female.

As per the previous incubation (see 6.1.1.1), eggs were monitored and photographed every 12 hours to document embryonic development using a light microscope whilst every 24 hours fluorescent microscopy images were taken to aid with preliminary NP aggregation/uptake observations. On this occasion, to improve the percentage of eggs reaching their full development potential, no subsampling was carried out. Incubations were terminated after 6 days and all eggs were preserved in 4% formalin.

6.1.2. NP Maternal stress incubation experiment

A separate experiment was carried out to assess the impact of NP on the embryonic development of krill eggs in cases where gravid females are exposed to this anthropogenic stressor (Figure 21). Twelve gravid females (collected via a targeted trawl using the RMT net) were transferred into 1 litre glass kilner jars within the cold room. Each jar contained an inner plastic mesh to protect the negatively buoyant eggs after sinking from cannibalistic consumption. Each jar was also individually aerated.

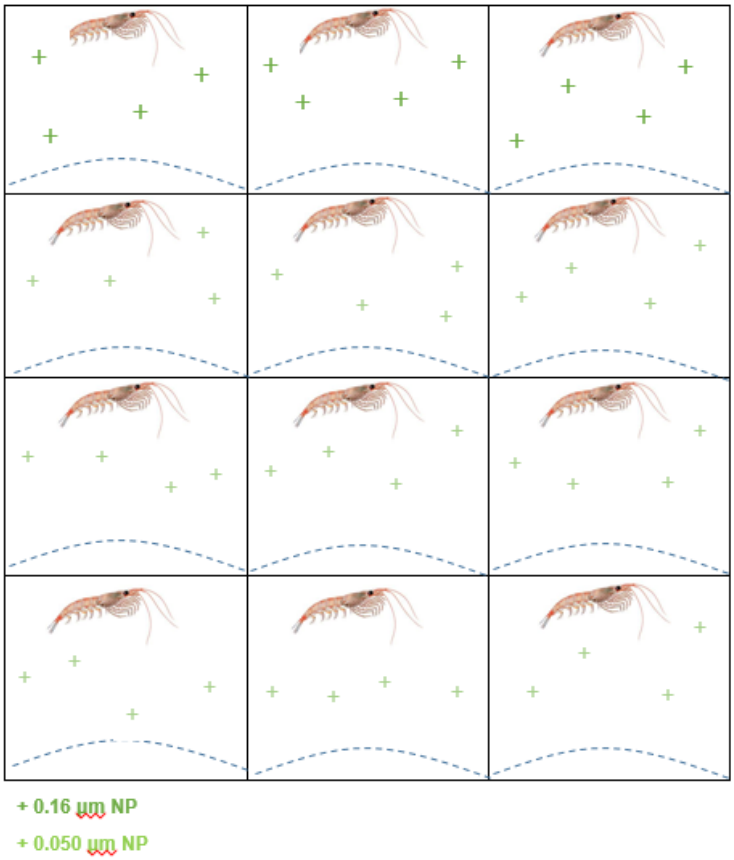

Figure 21 Schematic diagram of the NP maternal stress incubation with three females incubated with 0.16µm NP and nine females incubated with 0.050µm. All incubations contained 0.22µm filtered seawater and NP concentrations of 2.5µg /ml

Three of the females were incubated with the larger 0.16µm NP, the remaining nine were incubated with 0.050µm NP. Jars were filled to their 1l capacity with 0.22µm filtered seawater. For consistency, plastic concentrations mirrored that from the previous egg incubation experiments (2.5µg/ml).

Females were monitored every six hours for egg production. When eggs were present, as per previous experiments, a subsample was taken to check the suitability for a further egg incubation experiment i.e. successful fertilisation, lack of malformations and normality in terms of shape under the light microscope. The intention for healthy, normally formed eggs was to replicate the previous krill egg incubation experiment (see 6.1.1.) however, none of the eggs met the criteria.

Subsequently, on each occasion of eggs being produced, all eggs were removed from the incubation jars using soft-tip pipettes and preserved in 4% formalin in 15ml plastic vials. Prior to preservation, images of eggs were obtained with both the light and fluorescent microscope.

During the experiment, any specimens that died were removed and frozen at -80°C. Early in the experiment, females were preserved at -80°C after egg production for analysis back in Cambridge. As the experiment progressed however, with eggs produced not usable for incubation experiments, the protocol was altered and after removal of the eggs from the kilner jar, the incubation of the females continued in case any future eggs met the criteria for incubation. At the experiment endpoint, one final krill remained, which had not produced eggs, again the female was frozen at -80◦C for later analysis.

6.1.3. Pteropod NP egg ribbon incubation experiment

In an experiment to begin to determine the impact of NP on *L.helicina* eggs, two ribbons (obtained from pteropods captured during event 88) per well were incubated with 0.050µm NP. Three multiwells contained only 0.22µm filtered seawater as a control (plus magnesium chloride) whilst the NP treatment was also carried out in triplicate. As per the krill egg incubation protocol (see 6.1.1) the egg incubation was carried out in multiwells containing 6 x 10ml wells. The total liquid volume in each well was 8ml and plastic concentrations mirrored that from the previous egg incubation experiments (2.5µg/ml). All treatments contained magnesium chloride to act as an antibacterial agent and prevent egg degradation.

Egg ribbons were monitored and photographed every 12 hours whilst every 24 hours fluorescent microscopy images were taken to aid with preliminary NP aggregation/uptake observations. Fluorescent microscopy images showed NP particles began to aggregate and accumulate around the egg ribbons however, further analysis at Cambridge is required to determine whether NP particulates have permeated the ribbons or accumulated on the outer surface. On day three of the experiment, one ribbon from each well was removed and preserved in 2ml eppendorfs of 4% formalin. At the experiment endpoint (day 6), the remaining ribbons were preserved with the same method for later analysis.

6.2. Microplastics as a contaminant in the Southern Ocean – Exploring potential synergistic effects of microplastics on key zooplankton species *Kirstie Jones-Williams*

6.2.1. Introduction

Plastic production has exponentially increased since the 1950's, however the very virtues which have led to the successes and wide spread use of plastics, are also its curse. Namely its durability and thus its long lasting nature in the natural environment. Compounded by poor waste management, the quantities of plastic entering the world's oceans has increased, with estimations ranging for 4.6 to 12 million metric tons annually. With plastic being found in the most remote regions of our oceans, far from original source, the risk of this pollutant to marine ecosystems remains to be fully comprehended. In the Southern Ocean where marine fauna are acutely adapted to their cooler habitat, with lower metabolism and a niche set of biogeochemical thresholds), their tolerance to new environmental stressors can be significantly reduced.

Microplastics, defined as those fragments less than 5mm have either entered the marine environment already small (paint fragments, nurdles, microbeads from cosmetics) or those which have formed through the chemical degradation and physical fragmentation of larger plastics. At this size, plastics become bioavailable to marine zooplankton, which in regions where keystone species such as *Euphausia superba* (herein, Antarctic Krill), are found in some of the highest densities**,** the

risk of this new pollutant is yet to be fully explored. Whilst the repository of data regarding incubation experiments investigating the uptake and depuration rate of microplastics by zooplankton under experimental conditions is growing, the interaction of this new pollutant with an already existing suite of stressors, such as warming temperatures, ocean acidification, and increasing levels of heavy metals requires further investigation.

Furthermore, to fully comprehend ecosystem wide effects, examination of behavioural changes of individuals is critical to understand impacts beyond the individual. One such species of interest is the shelled pteropod, *Limacina helicina antarctica* (herein, pteropod).This holoplanktonic marine mollusc is a major component of the Southern Ocean biogeochemical cycle, which I evidenced to drive the particulate inorganic carbon flux during peak periods in the this region through sinking of its shell upon death. The projected reduction in carbonate saturation state in the Southern Ocean, inextricably linked to ocean acidification, over the next fifty years threatens the efficacy of this vital part of the biogeochemical cycle in this region. With a swathe of studies focused on the impact of reduced pH on this organism, namely the energetic cost to repair shells in these unfavourable conditions, the survivability of this organism with additional stressor such as microplastics is yet to be explored.

The overarching aim of this fieldwork was to address these knowledge gaps in order to better comprehend the realistic threat of microplastics to key southern ocean zooplankton. The three key objectives were to:

- Sample the surface water of the South Sandwich Islands to investigate the concentration and properties of microplastics in the region.
- Investigate the interaction of microplastics on the uptake of mercury by Antarctic Krill.
- Investigate the potential synergistic effect of microplastics and ocean acidification on the pteropod, *Limacina helicina antarctica* swimming behaviour.

6.2.2. Microplastics sampling around the South Sandwich Islands

There is a paucity of data regarding microplastic concentrations in the Southern Ocean. There is an increasing interest in the possible concentrations and nature of this pollution in the Scotia Sea due to the high biomass. As part of the South Sandwich Island Transect, microplastics sampling presents an opportunity to investigate both concentrations and the nature of possible contamination in this region, currently proposed for a new marine protected area.

6.2.2.1. Sample Collection

On a previous expeditiojn (JR17002) the NEMO was constructed to perform as per usual microplastic sampling nets in southern ocean conditions by mounting a hydobios microplastics sampling net within a neuston sledge. This year, an improved model was used, with the modified neuston net (NEMO) now comprising two microplastics nets, one within the other, with separated cod ends, mounted within a neuston sledge. The inner net has a 300 micron mesh, typical of large volume microplastic sampling. Previous expeditions using the underway pump indicates that the smaller size fraction is commonly missed when using this setup and thus a smaller mesh net has been mounted outside, with a separate cod end (100 micron).

Deployment of the NEMO aboard the RRS Discovery was over the starboard aft via the 5 ton ROMICA GP winch in tandem with the starboard aft pedestal crane (Figure 22). Following a test and toolbox talk outside KEP, the flowmeter was changed and 10 successful deployments were carried out (table 1).

Assuming a 0.2m^3/revolution using the attached flowmeter, the volumes of water filtered have been compared to that calculated using ship speed and duration of trawl. These numbers show a range of (fig. 2) with calculated flow more commonly overestimating flow than vice versa, likely due to high phytoplankton densities or higher swell inhibiting laminar flow through the net.

Figure 22 Deployment of NEMO off the starboard aft using the ROMICA GP winch and aft pedestal crane

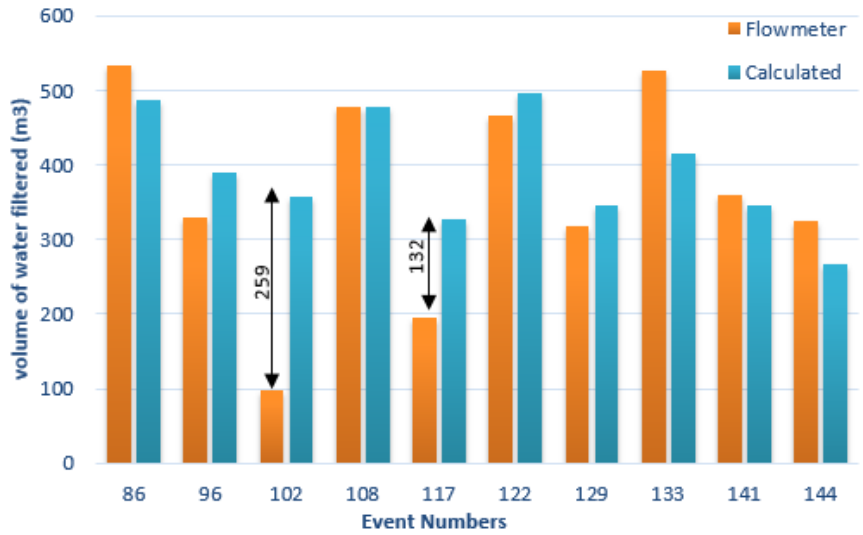

Figure 23 Calculated volumes of water versus flowmeter readings. Discrepancy at Event 102 where the flowmeter stopped working and at 117 due to high biomass content within the net prohibiting laminar flow through the net.

Calculated volume of water filtered:

$Vol = (s * t) * Q$ Where s= Ship speed (1knot =0.514m/s), t = duration of deployment (secs), Q = Volumetric flow rate (aperture area =0.28m^2)

6.2.2.2. Sample Processing

Upon recovery, the nets were washed using the non-toxic ship supplied seawater, concentrating the sample into each cod end which were then covered with foil and taken separately to the plastics laboratory. The sample was poured onto removable 300 and 100 micron mesh separately through the modular microplastics filter unit (fig.3), thus mitigating any airborne contamination.

Figure 24 Underway Microplastics filter unit for pouring the cod end through and to capture organic matter and possible plastics within the net contained in the unit

For precaution, a wetted polycarbonate filter was placed nearby the during sample processing. The mesh from the unit were then containerized in glass jars and frozen at -20 for analysis back at the University of Exeter. Any possible sources of ship-borne contamination during deployment have been taken to be added to the polymer spectral library. A blank sample was run through the nets after the final deployment, in order to capture any fragments which may be retained within nets, cod ends and the filter unit despite rinsing/acid washing between each use.

6.2.2.3. Next Steps

The samples will be taken to Exeter University where they will be analysed using fourier transform infrared spectroscopy to examine variance in concentration and polymer type across the transcect.

Time	Latitude	Longitude	Event #	Net #	Wind speed (knots)	Ship speed (knots)	Water depth(m)	Action
07/02/2019 13:05	-55.26621	-28.97988	145	11	12.47	1.20	3000.44	Recovered
07/02/2019 12:43	-55.27224	-28.96762	145	11	11.03	1.60	2999.84	Deployed
06/02/2019 23:04	-56.33435	-28.69713	141	10	3.16	1.10	3107.61	Recovered
06/02/2019 22:42	-56.32874	-28.6845	141	10	5.32	2.20	3106.42	Deployed
05/02/2019 23:29	-58.07237	-28.13402	133	9	9.98	2.10	3358.92	Recovered
05/02/2019 23:05	-58.06587	-28.11423	133	9	9.51	2.20	3366.01	Deployed
04/02/2019 21:49	-57.94683	-25.50643	129	8	2.99	2.50	3484.88	Recovered
04/02/2019 21:24	-57.93809	-25.48389	129	8	2.66	0.20	3507.52	Deployed

03/02/2019 23:42	-56.09783	-26.60677	122	7	1.86	1.80	2738.86	Recovered
03/02/2019 23:17	-56.11461	-26.60004	122	7	1.86	2.50	2776.55	Deployed
03/02/2019 03:10	-54.44686	-27.1778	117	6	8.99	2.30	4552.28	Recovered
03/02/2019 02:49	-54.43771	-27.16971	117	6	9.31	1.20	5375.24	Deployed
01/02/2019 23:33	-55.2314	-25.17477	108	5	10.31	2.40	5493.51	Recovered
01/02/2019 23:10	-55.22212	-25.15863	108	5	10.74	2.60	5492.09	Deployed
01/02/2019 00:17	-57.26682	-24.35179	102	4	9.95	1.90	6915.83	Recovered
31/01/2019 23:54	-57.26706	-24.33239	102	4	8.64	1.80	6805.44	Deployed
30/01/2019 23:52	-59.13607	-25.2962	96	3	3.50	2.40	2939.26	Recovered
30/01/2019 23:30	-59.15131	-25.29782	96	3	3.36	1.80	2951.84	Deployed
28/01/2019 17:58	-59.21098	-26.26375	86	2	6.66	2.20	1811.49	Recovered
28/01/2019 17:33	-59.21306	-26.23691	86	2	5.86	2.30	1949.32	Deployed
18/01/2019 12:04	-54.27276	-36.44427	62	1	10.18	2.30	260.66	Recovered
18/01/2019 11:43	-54.28464	-36.44775	62	1	10.01	2.20	193.52	Deployed

Table 31 NEMO deployments around the South Sandwich Islands Transect

6.2.3. Investigating the interaction of microplastics on the uptake of mercury by *Euphausia superba*

Mercury contamination is recognised as a global issue, with long range transport with the most significant portion in our oceans being attributed to atmospheric deposition. The pathways of mercury associated with the polar region's ice-influenced waters and the subsequent speciation of mercury varying depending on both abiotic and biotic factors are complex. Once taken up by zooplankton, the toxicity of mercury increases up the food chain due to its biomagnifying properties. Antarctic Krill, providing a link between primary producers and higher predators thus present a key pathway for mercury contamination. A recent study published this year highlighted this fact (Seco et al 2009), identifying sub-adult Antarctic Krill as having equal or higher concentrations of mercury as other euphausids globally. Mercury can form complexes with other particulates such as clays. For this fieldwork, it was hypothesised that mercury concentration within subadult Antarctic Krill would be lower when exposed to plastics, assuming the plastic is ingested and subsequently egested.As well as examining mercury levels, the biomarker, Lipid Peroxidase (LPO) is commonly used to assess stress in *Euphausia superba,* and samples were collected to provide the option of analysing this at a later date. Two scenarios were simulated; winter and summer wherein the former exposed the organisms without food and the latter, with the option of algae versus plastics.

6.2.3.1. Scenario 1: Winter Incubation

Sample Collection: Antarctic krill were collected using the RMT8+1 (Event 14 and 15, Net 2) on 07/01/19 and were acclimated for 72 hours in 0.2µm aerated filtered seawater (taken from CTD chl max at the same station), removing faecal pellets and any moutls as they appeared (12 hour checks). After 24 hours, 20 krill were frozen at -80˚C as a primary control to examine the natural variability of LPO levels.

Experimental Methods: During the acclimation period, incubation jars (3L glass kilner) were prepared to make up treatments as per the experimental setup (fig 4). 2700ml of 0.2µm filtered seawater was added, with fluorescently labelled polyethylene and polystyrene concentrations made

up to 100 particles/ml. Ecotoxicity experiments on Antarctic Krill and microplastics have recently identified this order of magnitude as high enough to identify sub-lethal effects, yet low enough to be comparable to realistic concentrations observed in the marine environment. Assuming the control jars had background mercury level of waters north of the polar front (<0.015mg/L), the additional mercury added, in the form of mercuric chloride (HgCl2) should have forced concentrations to those found more poleward (0.015mg/L). Each jar was individually aerated, and kept in darkness, except during 12 hour checks where a headtorch lit each jar for approximately five minutes. The experiment was carried out in a temperature cold laboratory aboard the RRS Discovery with jar temperatures having fluctuated between 4.8 and 5.1˚C.

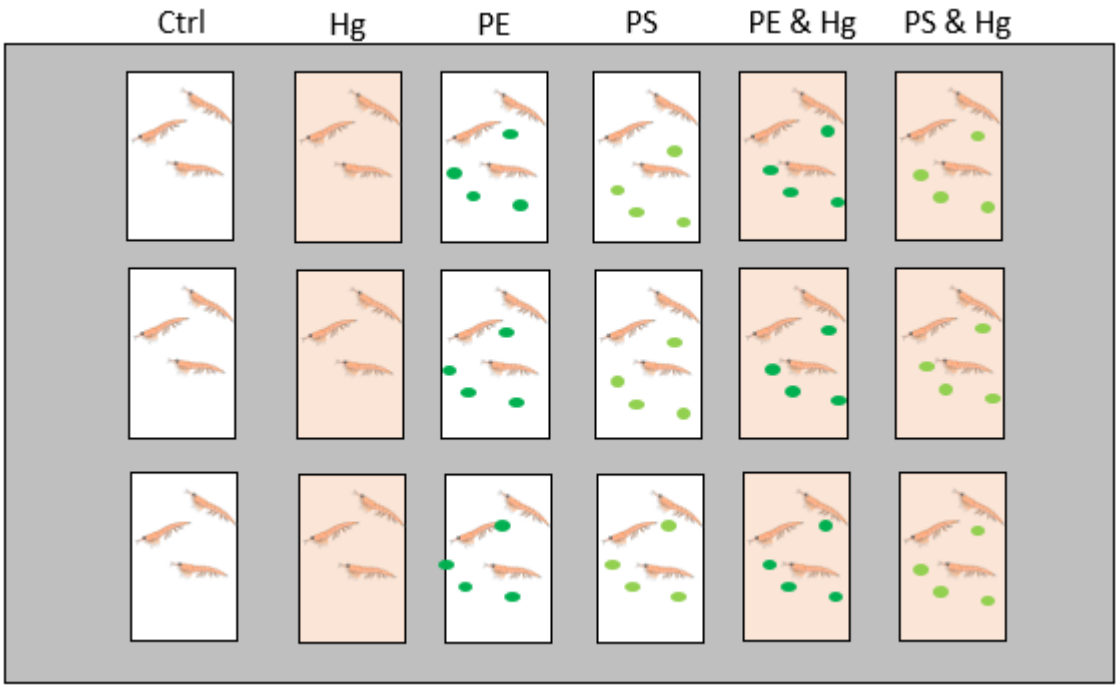

*Figure 25 Experimental setup, with each box representing an aerated 3L glass kilner jar with 3 subadult Euphausia superba. Ctrl: 0.2µm Filtered seawater, Hg Addition of 0.015mg/L HgCl2, PE (100 particles/ml of 30 µm polyethylene), PS (100 particles/ml of 30µm polystyrene), PE * Hg (Combination of the same concentrations aforementioned), PS & Hg ((Combination of the same concentrations aforementioned)*

Following a 72 hour acclimation, the healthiest individuals were incubated with a stocking density of 3 krill per 2700ml. Checks were made every 12 hours, upon which any moults were collected and preserved in 4% formalin and qualitative observations on response time, swimming speed and colouration were also made. The experiment terminated after 72 hours, with all krill being frozen in -80˚C freezer, 500ml of water frozen in acid washed HDPE Nalgene bottles and remaining water filtered onto 20 micron filters to examine residual microplastics.

6.2.3.2. Scenario 2: Summer Incubation

Sample Collection: 120 Antarctic Krill were collected from the RMT8+1 (Net 1) Event 73. In addition, 100 Antarctic krill were also collected and frozen in the -80 ˚C freezer to be acid digested back in Cambridge for analysis of possible in-situ ingestion of microplastics. A starvation 72 hour acclimation period was also carried out for the summer scenario whilst preparing the incubation jars.
Experimental Methods: The predominant difference in this scenario was the addition of algae (Iso1800, Iscochrsis instant algae purchased from Reef Mariculture) and the use of just polystyrene and an additional replicate, as opposed to polyethylene. The motivation for this, was the difficulty in centrifuging the remaining polyethylene to adequately determine 100 particles/ml concentrations.

Algal concentrations were based upon those used by Dawson et al., 2018 to replicate a 50/50 algae/plastic mix. All other methods were carried out as per the winter scenario with 12 hourly checks and termination after 72 hours (Figure 26).

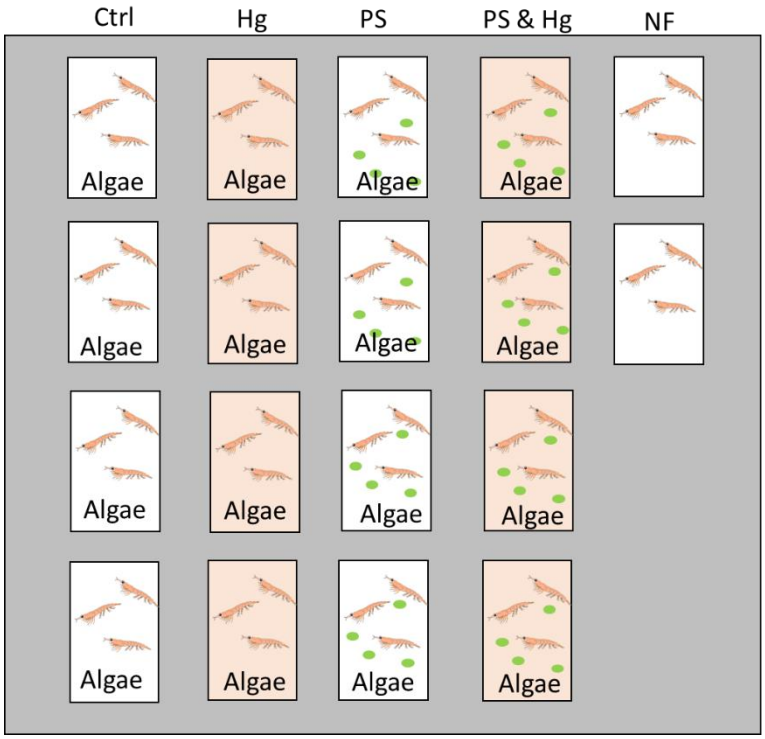

Figure 26 Experimental setup with same equipment and concentrations of Hg and PS as the winter scenario, however with all treatments including the addition of 0.034mg of instant algae and NF representing a duplicate of non-fed sub adults

Next steps: All water samples collected will be analysed for total mercury using atomic absorption spectrometry (AAS). Following liason with the appropriate laboratory managers at Cambridge, a portion of the replicate will be used to examine mercury concentration using AAS, with the remainder being used to look at LPO levels. Filters and faecal pellets will be used to determine uptake and depuration of microplastics. Comparison of organic mercury which can bioaccumulate within the krill can be made to determine possible interactions the two contaminants to further contribute to our understanding of the pathways of mercury and microplastic separately and synergistically within these keystone species.

6.2.4. Investigate the potential synergistic effect of microplastics and ocean acidification on pteropod swimming behaviour.

6.2.4.1. Sample Collection

The 200µm mesh net from the BONGO net was deployed successfully 55 times (Figure 27). Despite their ubiquitous nature in sediment traps deployed in the Scotia Sea, pteropods were elusive this year. The presence of a strong phaeocystis bloom was prohibitive and the eventual capture of *Limacina helcina antarctica* occurred in clearer waters during event 87 and 88 (Table 32 Bongo Net deployments). Once captured, all individuals (n=10) were acclimated in 0.2µm filtered seawater collected from the same station CTD water at 50m for 14 hours.

Figure 27 Retrieval of the Bongo on deck

Time	Latitude	Longitude	Event #	Water Depth (m)	Net Depth (m)	SST (˚C)	Salinity	Sampled?
07/02/2019 14:44	-55.2656	-28.9797	147	4741.74		1.6002	33.9176	No
06/02/2019 14:44	-56.8726	-28.4904	138	3402.18	100	1.7367	33.8845	200 micron formalin preserved
06/02/2019 01:31	-58.0915	-28.2324	135	3364.47	100	1.3405	33.8696	200 micron formalin preserved
04/02/2019 22:13	-57.9477	-25.5088	130	3505.15	100	1.5936	33.7641	200 micron formalin preserved
04/02/2019 00:04	-56.0971	-26.6068	123	2735.21	100	1.4879	33.8049	No
03/02/2019 16:45	-55.6947	-26.8677	127	5928.67	50	1.3925	33.8961	200 micron formalin preserved
03/02/2019 01:13	-54.4328	-27.1766	115	4036.86		3.5557	33.8259	200 micron formalin preserved
02/02/2019 01:58	-55.2886	-25.264	110	5588.25	50	3.2642	33.9175	200 micron formalin preserved
01/02/2019 02:33	-57.2568	-24.4765	104	5508.18	50	1.3627	33.834	200 micron formalin preserved
31/01/2019 04:03	-59.0317	-25.2537	99	2767.38	30	1.1753	33.607	200 micron formalin preserved
29/01/2019 00:17	-59.8224	-25.8961	92	1849.82	50	0.7719	33.6692	No
29/01/2019 00:03	-59.8228	-25.8943	91	1990.49		0.774	33.6744	No
28/01/2019 23:51	-59.8231	-25.8934	90	2198.22	50	0.7815	33.6773	No
28/01/2019 18:59	-59.2103	-26.2668	89	1805.43	30	0.7422	33.7052	No

28/01/2019 18:45	-59.2103	-26.2668	88	1805.65	50	0.7682	33.7093	200 micron formalin preserved and pteropods for incubation
28/01/2019 18:28	-59.2103	-26.2668	87	1805.24	50	0.7635	33.7104	200 micron formalin preserved and pteropod for incubation
27/01/2019 04:48	-56.4121	-27.0874	81	1842.36	50	0.742	33.8741	200 micron formalin preserved
15/01/2019 16:56	-54.2854	-36.4642	58	145.41	50	3.5079	0.0175	No
15/01/2019 16:50	-54.2854	-36.4642	57	145.05	50	3.7483	0.0174	No
13/01/2019 01:37	-52.6178	-40.2308	54	3797.73	200	5.3555	33.7538	No
11/01/2019 00:12	-53.3636	-38.1451	47	2773.32	50	4.4397	33.8099	No
10/01/2019 20:03	-53.143	-37.8276	45	3371.26	50	4.1513	33.8275	No
09/01/2019 22:13	-53.734	-37.9565	35	151.09	50	3.8976	33.7634	No
09/01/2019 05:47	-53.8467	-39.1442	30	294.95	50	4.1909	33.7559	No
06/01/2019 23:26	-53.7862	-38.5824	16	211.8	50	4.0585	33.7923	No
06/01/2019 00:00	-52.8107	-40.1618	7	3788.68	50	5.0495	33.7307	No
05/01/2019 23:48	-52.8095	-40.1617	6	3796.99	50	5.0538	33.7161	No

Table 32 Bongo Net deployments

6.2.4.2. Experimental Methods

Whilst the pteropods acclimated, the incubation waters were prepared. Total Alkalinity was calculated using Temperature and salinity measurements were taken from the CTD profile, subsurface (T=0.7˚C, S=33.609):

$TA= (683.41*SAL)-(9.139*SAL^2)-(1.37*TEMP)-(0.896*TEMP^2)-10364.16$

Using the CO2SYS macro for excel (open access), temperature, salinity and TA along with the desired pH (forced 7.7 from a standard 8.0 in this region) were input to yield a final projection of pCO2 (902.2µatm). These parameters were input into the Seacarb programme available on RStudio to alculate the necessary amounts of acid and base (HCl and NaHCO3) respectively to add to the filtered seawater to alter the carbonate chemistry of the incubation chambers.

Alike the krill incubation, polystyrene microspheres in concentrations of 100 particles/ml were used, however a smaller diameter (10µm) was used as per the previous year's expedition (see cruise report JR17002). At the end of the acclimation period, 10 out of the 12 collected pteropods, deemed healthy based on swimming and fully intact shell, were placed into optical glass chambers and filled with one of the four treatments containing microplastics, acidified conditions, ambient and acidified with microplastics (Figure 28). To prevent any accidental perturbations in the carbonate chemistry, the chambers were filled with a positive meniscus and then hermetically sealed and placed in a temperature controlled aquaria in darkness. At intervals of at least 12 hours (Table 33), chambers were taken out for 15 minutes and placed in a booth for filming the swimming behaviour of the

pteropods (Figure 29). This required agitation of the chambers through inversion and gentle vortex, without removing the lids to induce movement or reaction from the pteropods at least once every three minutes within the filming period. In addition to filming, commentary on reaction time and behaviour spent outside of the filming frame was noted down.The adult pteropods had laid 10 egg ribbons each and given the energetic cost of this, the experiment was terminated after five days, which marked two days after all eggs had been deposited (table 3).

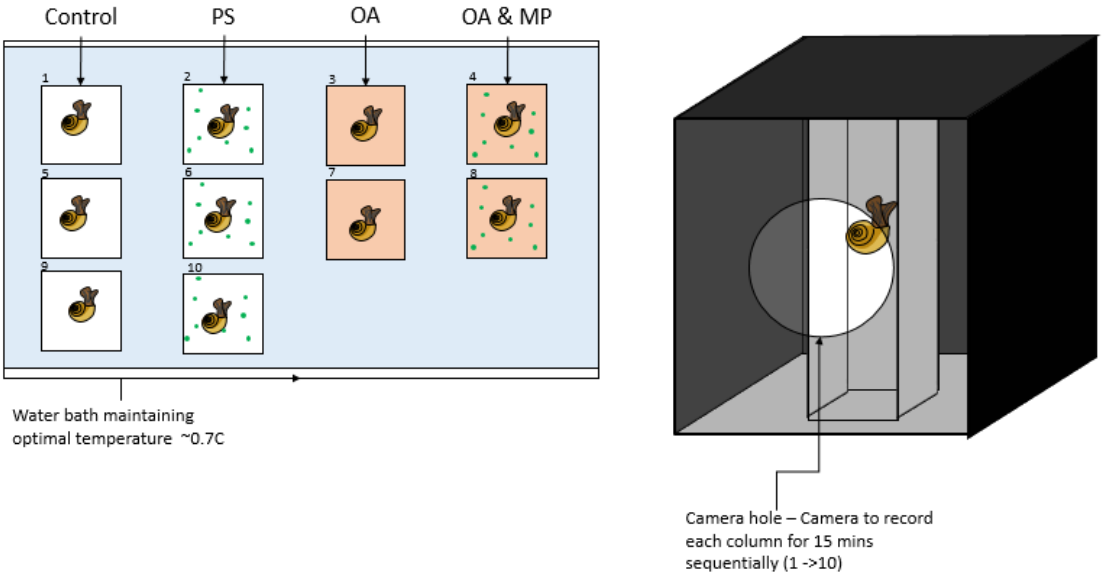

Figure 28 Set-up of incubation chambers (left) with control (ambient pH and 0.2µm filtered seawater), PS (10 µm polystyrene microspheres at 100 particles/ml) OA (ocean acidification perturbation (pH7.7)) and OA & MP (combined MP and pH7.7). Filming chamber set-up (right)

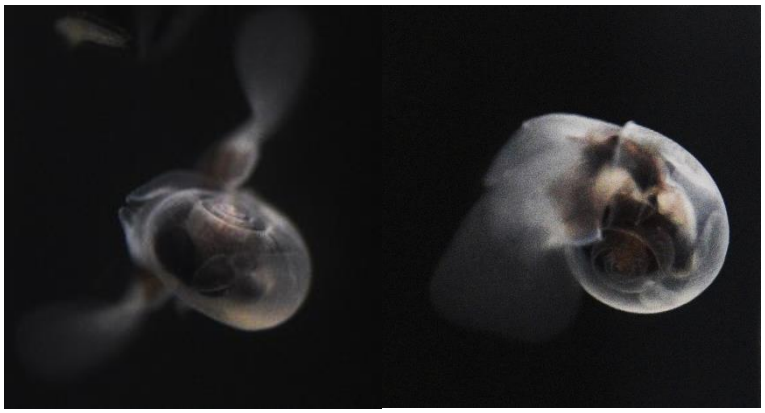

Figure 29 Viewing frame of pteropods sinking (left) and swimming (right) vertically through the incubation chamber

	Observation times (15 minute filming)			
Pteropod chamber number	1	2	3	4
CTRL2	29/01/19 15:30	30/01/19	01/02/19	03/02/19
OA2	29/01/19 15:50	30/01/19	01/02/19	03/02/19
PS2	29/01/19 16:13	30/01/19	01/02/19	03/02/19
OAPS2	29/01/19 16:29	30/01/19	01/02/19	03/02/19

CTRL1	29/01/19 16:47	30/01/19	01/02/19	03/02/19
OA1	29/01/19 17:03	30/01/19	01/02/19	03/02/19
PS1	29/01/19 17:20	30/01/19	01/02/19	03/02/19
OAPS1	29/01/19 17:34	30/01/19	01/02/19	03/02/19
PS3	29/01/19 17:50	30/01/19	01/02/19	03/02/19
CTRL3	29/01/19 18:30	30/01/19	01/02/19	03/02/19

Table 33 Timing of pteropod observation timings

Pteropod eggs had all been laid by 31/01/19 and a day, missing a day of observations to prevent exhaustion of the organisms and compromising swimming behaviour (red line). Another rest day towards the end of the incubation period on 02/02/19 (blue line) before termination on 03/02/19

6.2.4.3. Next Steps

The film will be analysed with bespoke software back in Cambridge to assess vertical migration speed, and the frequency of wingbeats during swimming. ANOVA will be used to determine the statistical significance of the variance between migrations and wing beats. In addition, the pteropods have been preserved in RNAlater for investigation of shell condition following acidified conditions and any differences in uptake or adherence of plastics by the organism can be analysed using scanning electron microscopy.

7. Cetacean survey *Mick Baines, Claire Lacey, Simon Pinder & Maren Reichelt*

7.1 Introduction

During the austral summer the Scotia Arc provides important feeding habitats for both mysticete and odontocete whale species, including humpback, blue, fin, sei, minke, southern right and sperm whales. The area was extensively exploited by the 19th and 20th century whaling industry but, following the cessation of whaling, very few sightings surveys have been conducted to estimate the density and distribution patterns of recovering whale populations and most surveys only covered parts of this area (e.g. Branch 2011; Williams et al., 2014; Viquerat & Herr 2017).

In 2000, a CCAMLR-IWC Krill Synoptic survey (known as SOWER-2000) investigated relationships between cetacean density, krill density and oceanographic conditions in this region. That collaborative project involved four research vessels and spanned the Scotia Arc and western Antarctic Peninsula (Reilly et al., 2004). The design and protocols of that survey were primarily aimed towards producing regional estimates of Antarctic krill (*Euphausia superba*) biomass, but included line transect surveys for cetaceans which allowed calculation of species abundances (Reilly et al., 2004) and distribution (Hedley et al., 2001).

The aim of the marine mammal survey component of the 2019 CCAML synoptic krill survey was to collect cetacean sightings data by replicating, as far as practically possible, the methods applied during the SOWER-2000 survey (Hedley et al., 2001; Reilly et al., 2004) in order to estimate the distribution and relative abundance of cetaceans in the study area, centred on the northern and eastern Scotia Arc.

7.2. Methods

7.2.1. Cetacean survey

A protocol for collecting cetacean sightings data was established prior to the survey. A team of four observers maintained effort between 05:30 and 20:00 when sea state was Beaufort 6 or less and visibility at least 1km. Watches were suspended whenever the vessel stopped for sampling. Two observers were on watch at any one time, with a third acting as data recorder; the observers rotated every hour, such that the same pair of observers always watched together.

The observation platform was located on the monkey island, above the bridge, with an eye height of approximately 20.8 m, although this varied slightly between observers. A three-sided chest-high shelter provided some protection from winds (Figure 30). Two angle-boards were set up at the observation platform and Fujinon 7 x 50 reticle binoculars were used to estimate ranges to sightings. Observations were carried out with the naked eye, binoculars being used only to investigate cues and estimate range from reticles.

Radial distances to sightings were calculated using the following formula:

$$\text{Distance} = (\text{Observer height} \times 1000) / (\text{mil} \times \text{reticles})$$

Where mil signifies the angle subtended by a 1 m object viewed at 1000 m. We used Fujinon 7 X 50 binoculars for which mil = 5 for each gradation mark. Note however, that reticle marks appear as alternate large and small lines and we read the distances between the larger lines as one reticle, taking the smaller lines to mark 0.5 reticle divisions, thus our 1 reticle = 10 mils. Distances corresponding to reticle values for each observer are listed in Table 34.

The data recorder was located in the bridge and communicated with the observers through a PMR radio link. Data were recorded in a MS Access database using Logger 2010 v5 software (Gillespie et al., 2010) running on a laptop with a USB GPS input. Effort records, including environmental variables, were recorded every 15 minutes or whenever a parameter changed. Position data were recorded automatically at 10 second intervals from the GPS. Sightings were reported by observers immediately, with a minimum data set of angle, reticle or estimated distance (the latter when the horizon was not visible or animals were extremely close), species and group size. Additional data included swim direction, behaviour, cue and the presence of associated seabirds. Photographs of sightings were taken whenever possible.

Figure 30 Observation platform on the monkey island

It was not always possible to identify sightings to species level, in which case they were either assigned to a broader taxonomic category or, if it was thought the sighting probably was of a certain species although diagnostic features were not seen, it was assigned to a category “like” the species.

Reticle	CL	SP	MR	MB
0.1	8364	8308	8308	8360
0.2	4182	4154	4154	4180
0.3	2788	2769	2769	2787
0.4	2091	2077	2077	2090
0.5	1673	1662	1662	1672
0.6	1394	1385	1385	1393
0.7	1195	1187	1187	1194
0.8	1046	1039	1039	1045

0.9	929	923	923	929
1	836	831	831	836
1.1	760	755	755	760
1.2	697	692	692	697
1.3	643	639	639	643
1.4	597	593	593	597
1.5	558	554	554	557
1.6	523	519	519	523
1.7	492	489	489	492
1.8	465	462	462	464
1.9	440	437	437	440
2	418	415	415	418
2.1	398	396	396	398
2.2	380	378	378	380
2.3	364	361	361	363
2.4	349	346	346	348
2.5	335	332	332	334
2.6	322	320	320	322
2.7	310	308	308	310
2.8	299	297	297	299
2.9	288	286	286	288
3	279	277	277	279
3.1	270	268	268	270
3.2	261	260	260	261
3.3	253	252	252	253
3.4	246	244	244	246
3.5	239	237	237	239
3.6	232	231	231	232
3.7	226	225	225	226
3.8	220	219	219	220
3.9	214	213	213	214
4	209	208	208	209

Table 34 Distances corresponding to reticle values for each obser

7.2.2 Bird survey

Bird surveys were intended to investigate the bird species attracted to the krill trawls and to be undertaken from the aft deck, recording the behaviour all birds, both flying and on the water, within 50m in a 180° arc around the stern of the vessel. Surveys began at the first daytime trawl on the 4th January. However, the krill netting activities were not attractive to birds due to the lack of discards produced and after four counts, all with completely blank results (i.e. no birds were recorded with the 50m arc) the surveys were stopped on the 8th January.

7.3. Results

7.3.1. Effort

A total of 198 hours of effort was carried out through 3,590 km of transect lines. The spatial distribution of effort is shown in Figure 31 The spatial distribution of observer effort (red lines)Figure 31. Viewing conditions were often challenging; high sea states, low visibility or a combination of

both, at times caused the suspension of observation effort. The proportions of effort carried out in each category of sea state, swell, visibility and glare are shown in Figure 32.

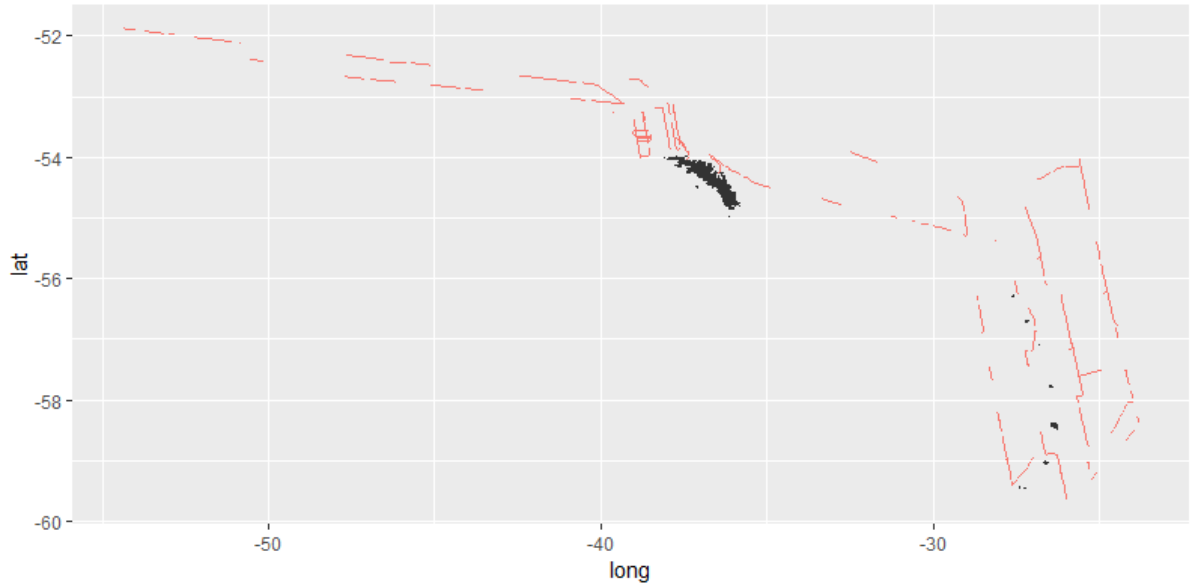

Figure 31 The spatial distribution of observer effort (red lines)

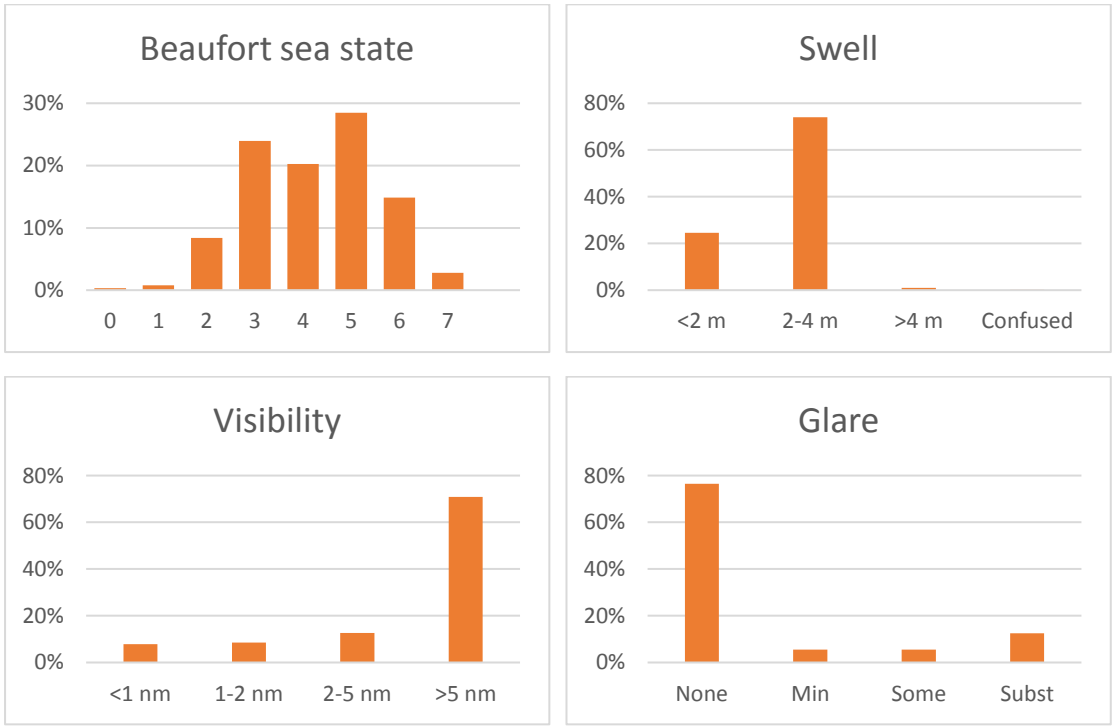

Figure 32 The percentage of effort duration in each category of sea state (upper left), swell (upper right), visibility (lower left) and glare (lower right)

7.3.2. Sightings

A total of 487 sightings were recorded while on effort (Table 35). Ten species were positively identified, not including minke whales that could have been one of two species known to occur in the region. Approximately 35% of sightings were classified as unidentified and 30% of all sightings were recorded as unidentified large baleen whales.

Humpback whales accounted for 43% of all sightings and 53% of the cumulative count of individual animals. The second most frequently identified species was fin whale, with 9% of sightings.

Long-finned pilot whales were seen on three occasions, all at times when the observers were not on effort.

Smaller and more cryptic species, such as dolphins, beaked whales and minke whales were seen rarely.

The spatial distribution of sightings is illustrated in Figure 33, Figure 35 & Figure 37 for mysticetes and Figure 34, Figure 36 & Figure 38 for odontocetes. Photographs of the species seen during the survey are provided in Figure 39 (mysticetes) and Figure 40 (odontocetes).

Species	**No. of sightings**	**Cumulative count**
Humpback whale	208	471
Like humpback whale	18	24
Southern right whale	4	5
Like southern right whale	1	1
Antarctic blue whale	7	10
Fin whale	42	62
Like fin whale	11	14
Sei whale	1	1
Undetermined minke whale	1	1
Like minke whale	1	1
Unidentified large baleen whale	146	196
Sperm whale	9	16
Like sperm whale	4	5
Unidentified large whale	17	19
Arnoux's beaked whale	1	1
Southern bottlenose whale	3	10
Killer whale	3	14
Unidentified whale	2	2
Hourglass dolphin	4	31
Unidentified dolphin	2	6
Unidentified small cetacean	2	6
Total	**487**	**896**

Table 35 Sightings recorded while on effort

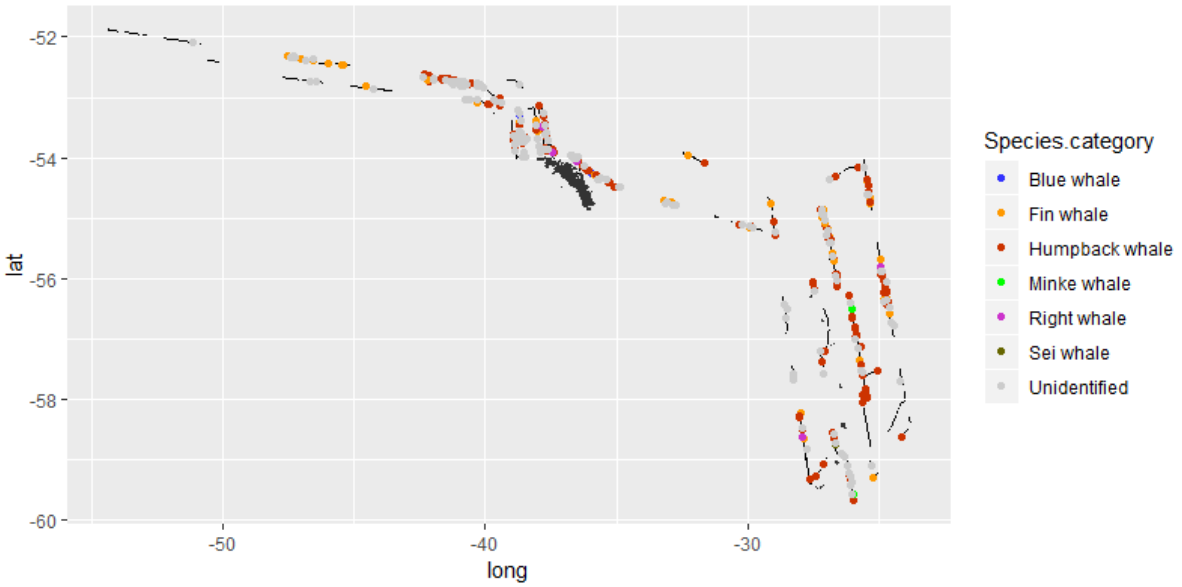

Figure 33 Plot of mysticete sighting positions. Sightings "like" a species have been combined with those positively identified in this and the following plots

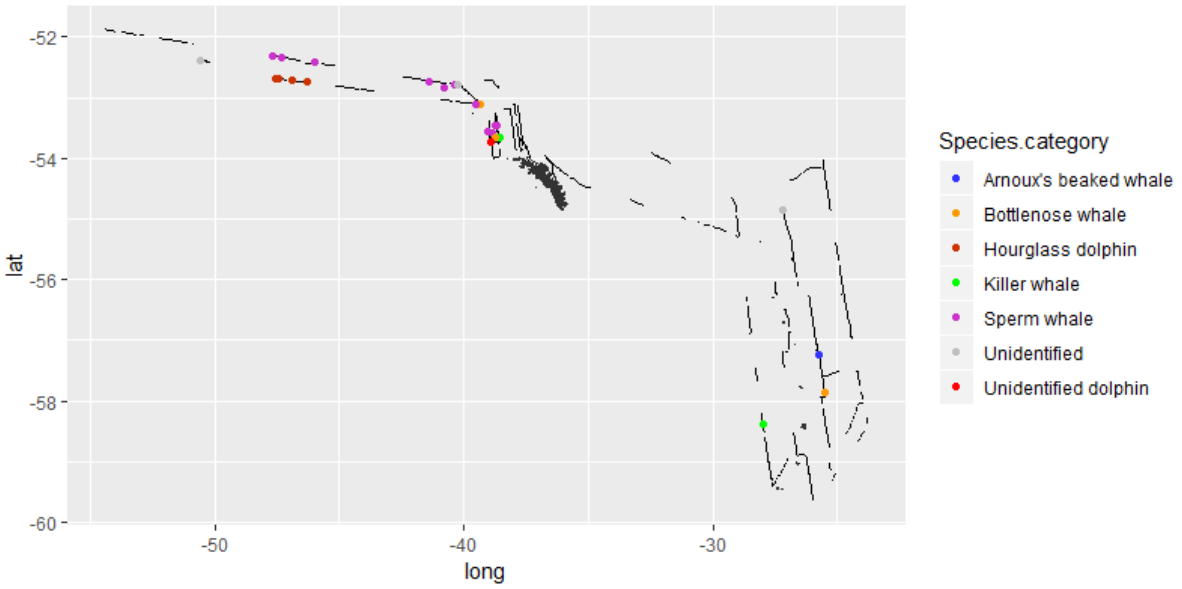

Figure 34 Plot of odontocete sighting positions

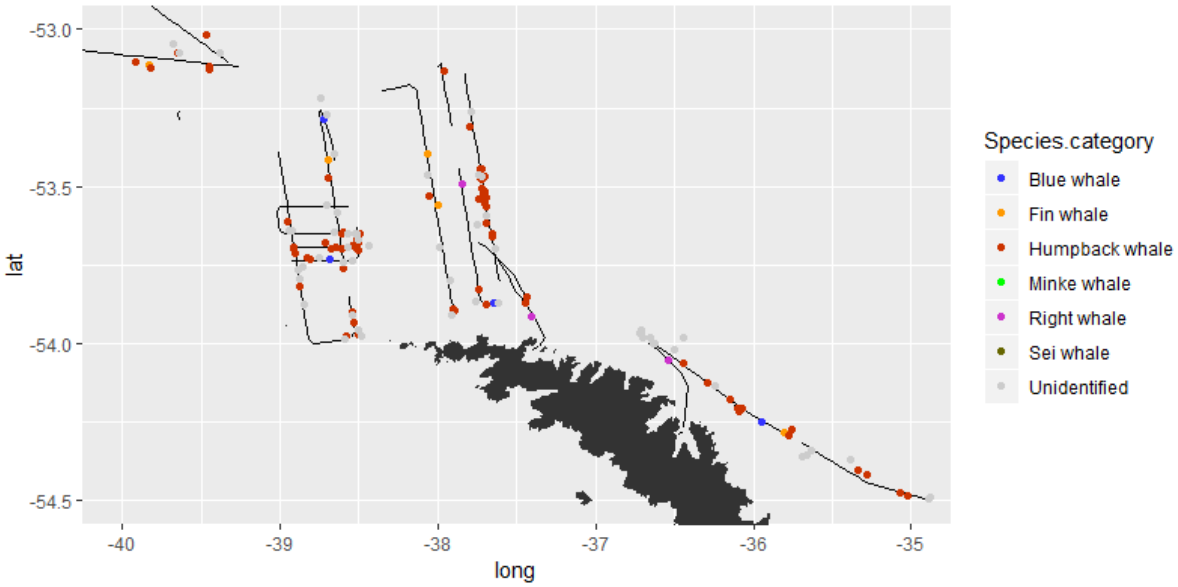

Figure 35 Plot of mysticete sighting positions in the Western Core Box area

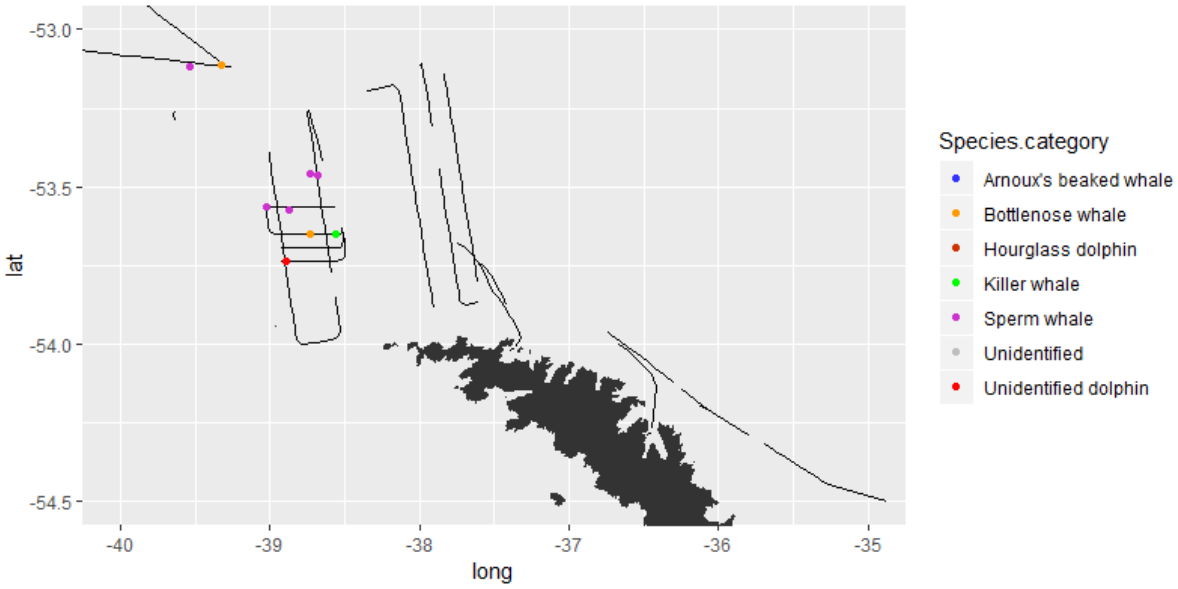

Figure 36 Plot of odontocete sighting positions in the Western Core Box area

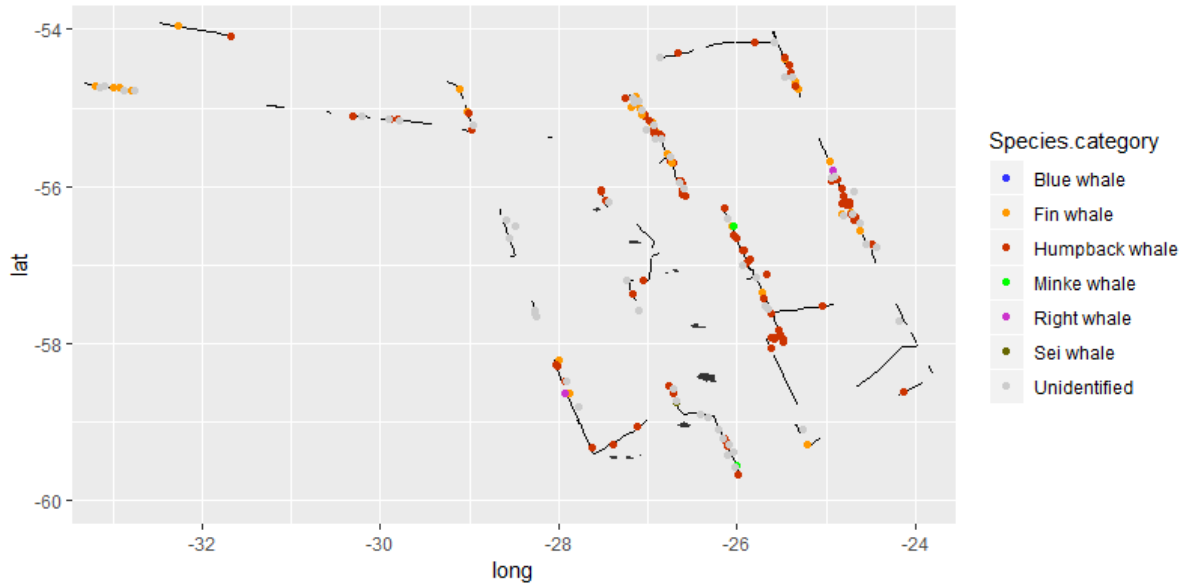

Figure 37 Plot of mysticete sighting positions in the South Sandwich Islands area.

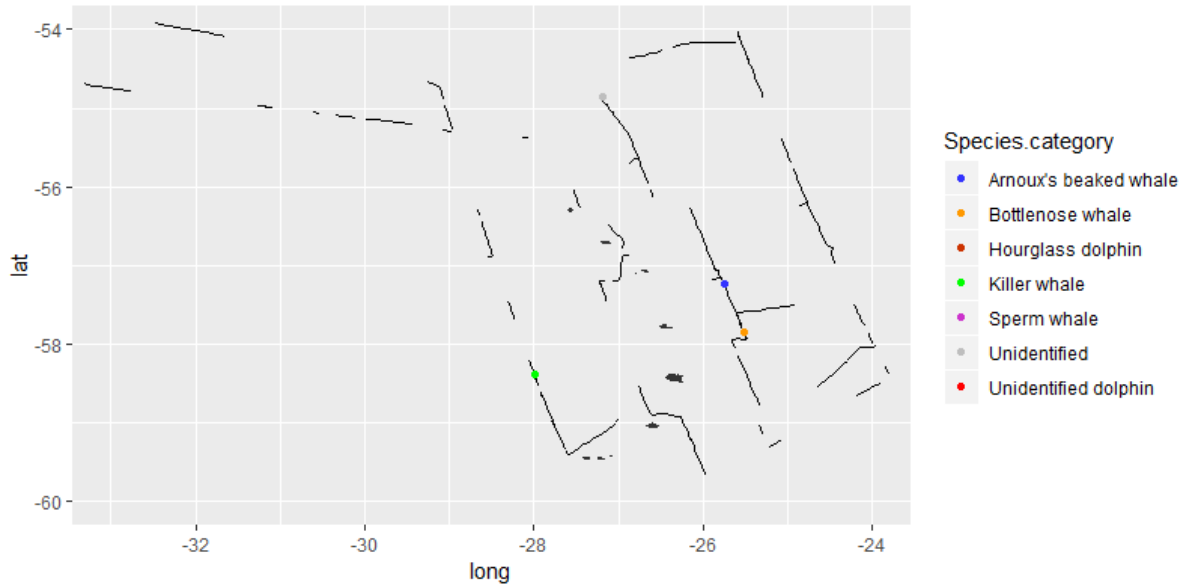

Figure 38 Plot of odontocete sighting positions in the South Sandwich Islands area

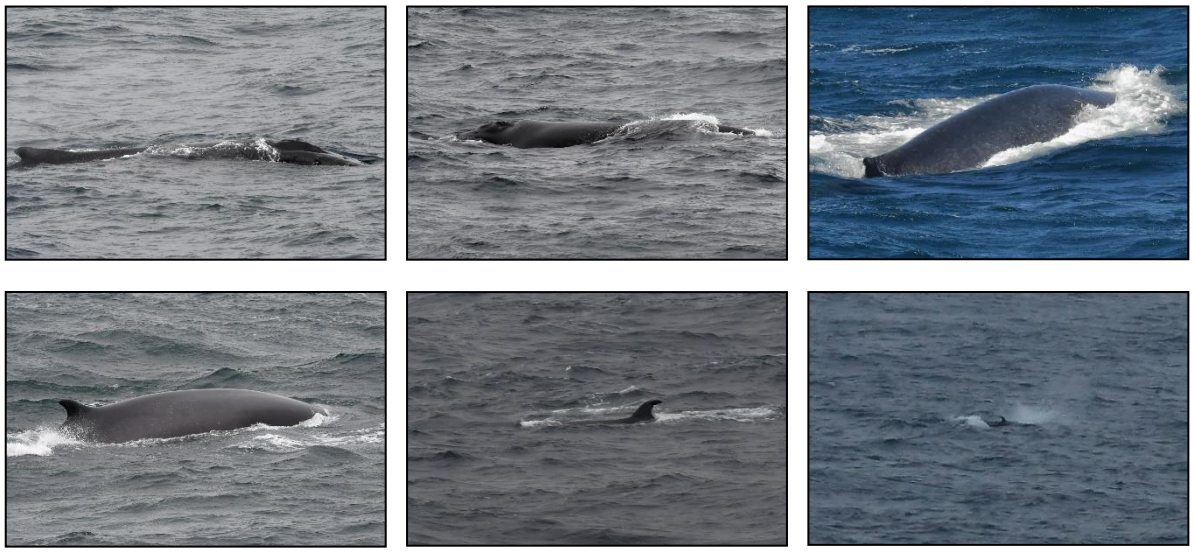

Figure 39 Baleen whales encountered during the survey were humpback whale (upper left), southern right whale (upper centre), blue whale (upper right), fin whale (lower left), sei whale (lower centre) and minke whale (lower right)

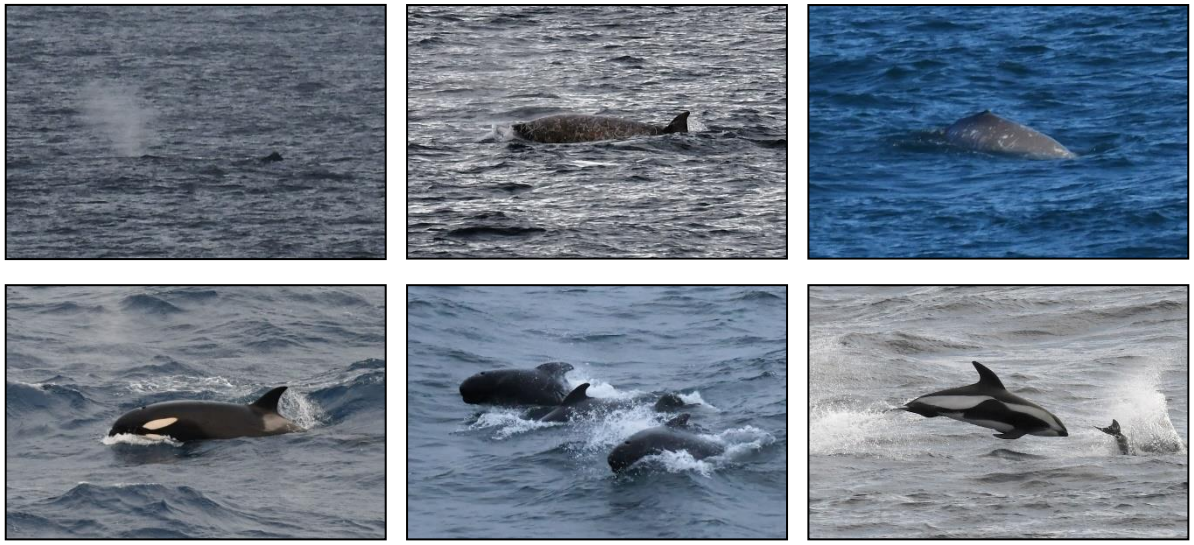

Figure 40 Toothed whales seen during the survey were sperm whale (upper left), southern bottlenose whale (upper centre), Arnoux's beaked whale (upper right), orca (lower left), long-finned pilot whale (lower centre) and hourglass dolphin (lower right)

7.4. Deliverables

Logger database

Photos of sightings

Reticle distance table

7.5. References

Branch T. A. (2011). Humpback abundance south of 60°S from three complete circumpolar sets of surveys. J. Cetacean Res. Manage. (Special Issue) 353-70.

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8. Moorings *Bjorg Apeland, Dan Ashurst, Dean Cheeseman, Andy Leadbetter, Sophie Fielding, Clara Manno, Gabi Stowasser*

8.1. Mooring at P3:

8.1.1. Reminders

Did not use the new recovery buoy rope.

Should get more stainless-steel shackles / new system for Mooring Buoys

Did not have batteries for SeaGuard Current Meters, were not redeployed

Only one sediment trap re-deployed.

Should make crib sheets for next year covering not only beacons but also renewal of shackles ropes, etc.

Water Sampler suffered severe corrosion.

8.1.2. Recovery

The recovery took place on 05/01/19 using release # 93 to release the mooring (Figure 41). The recovery took approx. 2 hours to recover with no problems to report.

8.1.2.1. Performance

Two CTD's were recovered, the data downloaded and checked. CTD 4548 does not seem to have recorded any depth, but was still redeployed.

The ADCP was missing when the main buoy surfaced. It is believed to either have imploded, or not been secured enough.

Seaguard current meters with O2 sensor (shallow and deep): The instrument was successfully recovered, and it collected data during the duration of the deployment. No sign of damage was noted. The instruments have not been re-deployed as we did not have a battery replacement.

The SAMI-PH sensor was successfully recovered and no sign of corrosion or damage were observed. Data acquisition run overall the whole year. The sensor with the new setting was redeployed as for the previous year.

The PROOCEANUS PCO2 sensor was successfully recovered and no sign of corrosion or damage were observed. Data acquisition run overall the whole year. The sensor with the new setting was redeployed as for the previous year.

This Aquamonitor was successfully recovered. The 48 plastic bags (200ml volume) collected water sample with 3 different preservative according to the analysis to achieve. Part of the bags were filled with ethanol 96%, part with formalin 4% and part with mercuric chloride 0.02%.

All the bottles were successfully recovered in both sediment traps. Bottles were packed into vermiculate boxes for storage at +4°C for analysis in Cambridge. The pH of the solution in each bottles was measured and was ranging between 8.00-8.01. This pH values confirmed that the buffer solution was working well and the samples will be suitable for further Ocean Acidification study. Only the deep sediment trap was redeployed. Bottles in the Deep sediment trap were programmed to rotate each 15-30 days as for the previous year. It is vital that the sediment traps undergo maintenance when back in Cambridge, several signs of corrosion where detected.

The phytoplankton collector (PPS) was successfully deployed for the first time this year. PPS was not deployed last year because during the deploying operation the instrument accidently fall on the deck and several filter support got broken. The PPS was set up with 48 GFF glass filters and a 2L bag unit with 4% formalin.

8.1.3. Redeployment

P3 Mooring was redeployed on 12.01.19 (Figure 42). The mooring deployment commenced at 52° 49.70'S and 40° 6.64'W with the weight dropped at 52° 47.92'S 40° 9.52'W. An attempt was made to triangulate the releases, however it was later decided that we had not triangulated from distances far enough away to confirm the location. Due to increasing weather, a further attempt to triangulate was abandoned.

8.1.3.1. Work Carried Out

Acoustic Releases: 93 + 2060

- ✓ New Batteries
- ✓ Tested
- ✓ New Linking Bar

Inmarsat Iridium Beacon: 13901110, IMEI: 3002340605535030

- ✓ New Batteries
- ✓ Tested

Argos Beacon: SN 280, ID: 60210

- ✓ New Batteries
- ✓ Tested

NOVATEC Combo Beacon: R090-020, Ch. B, 159.480 MHz

- ✓ New Batteries
- ✓ Tested

CTD on main buoy SN: 37-11807

- ✓ Download Data: P:\DY098\scientific_work_area\Moorings\P3_mooring_JR17002\ctd11807
- ✓ New Batteries
- ✓ Set up instrument for re-deployment
- ✓ Set real time clock to PC clock (p.28)
- ✓ Check instrument is ok and is set up properly by using "DS" command (p.27)
- ✓ Set up instrument for "autonomous sampling" following instructions on page 24. Started 12.00 16/01/2019
- ✓ Sample num = 0 automatically makes entire memory available for recording.
- ✓ Sample interval = 900 s

CTD 37 SMP 43742: 4548 below lower trimsin buoys

- ✓ Download Data: P:\DY098\scientific_work_area\Moorings\P3_mooring_JR17002\ctd4584
- ✓ New Batteries
- ✓ Set up instrument for re-deployment

- ✓ Set real time clock to PC clock (p.28)
- ✓ Check instrument is ok and is set up properly by using “DS” command (p.27)
- ✓ Set up instrument for “autonomous sampling” following instructions on page 24. Started 12.00 16/01/2019
- ✓ Sample num = 0 automatically makes entire memory available for recording.
- ✓ Sample interval = 900 s

ADCP

- ✓ ADCP was not on main buoy at the time of recovery and is assumed lost due to implosion or similar.

Sediment Trap Deep

- ✓ Parflux No: 13176-01
- ✓ New Batteries
- ✓ Do NOT remove both batteries at the same time.
- ✓ Always disconnect the cable on the sediment trap first, before unplugging the computer end
- ✓ Set up sediment trap with sample tubes
- ✓ Download data

Sediment traps (deep) deployment setting

- ✓ Event 1 of 22 = 01-20-19
- ✓ Event 2 of 22 = 02-01-19
- ✓ Event 3 of 22 = 02-15-19
- ✓ Event 4 of 22 = 03-01-19
- ✓ Event 5 of 22 = 04-01-19
- ✓ Event 6 of 22 = 05-01-19
- ✓ Event 7 of 22 = 06-01-19
- ✓ Event 8 of 22 = 07-01-19
- ✓ Event 9 of 22 = 08-01-19
- ✓ Event 10 of 22 = 09-01-19
- ✓ Event 11 of 22 =10-01-19
- ✓ Event 12 of 22 = 11-01-19
- ✓ Event 13 of 22 = 12-01-18
- ✓ Event 14 of 22 = 12-15-18
- ✓ Event 15 of 22 = 01-01-20
- ✓ Event 16 of 22 = 01-15-20
- ✓ Event 17 of 22 = 02-01-20
- ✓ Event 18 of 22 = 02-15-20
- ✓ Event 19 of 22 = 03-01-20
- ✓ Event 20 of 22 = 04-01-20
- ✓ Event 21 of 22 = 05-01-20
- ✓ Event 22 of 22 = 06-01-20

SAMI pH

- ✓ Setup
- ✓ Calibration
- ✓ New Battery
- ✓ New Chemicals
- ✓ Download data
- ✓ Remove D.W Bag

SAMI PH event parameters

- SAMI pH (Vb+)
- Run every 4 Hr. 0 Min.
- Cycles Between Stds=0
- #Samples Averaged=1
- #Flushes=55
- Pump On-Flush=4
- Pump Off-Flush=32
- #Reagent pumps=1
- Valve delay=8
- Pump On ind=8
- P/V Off ind=16
- #Blanks=4

PPS

- ✓ New Batteries
- ✓ Set Up Instrument
- ✓ Filters Changed
- ✓ Removed protection Cable
- ✓ Mzk Plug

_____

PPS Event Parameters

Flushing volume	=	100 [ml]
Flushing time limit	=	3 [min]
Sample volume	=	6000 [ml]
Pumping flow rate	=	100 [ml/min]
Minimum flow rate	=	50 [ml/min]
Pumping time limit	=	121 [min]
Total fixative volume	=	2116 [ml]
Fixative flush volume	=	40 [ml]

Pumping flow rate = 100 [ml/m]
Pumping time limit = 1 [min]

PROOCEANUS-PCO2 Sensor

- ✓ Testing on the bench
- ✓ Calibration
- ✓ Erase data! (Very important as there is only 2Gig storage)
- ✓ Cleaning membrane and pump
- ✓ Set up instrument
- ✓ Downloaded data file
- ✓ Charge battery clock
- ✓ Change battery units
    - Need to include foam in housing.

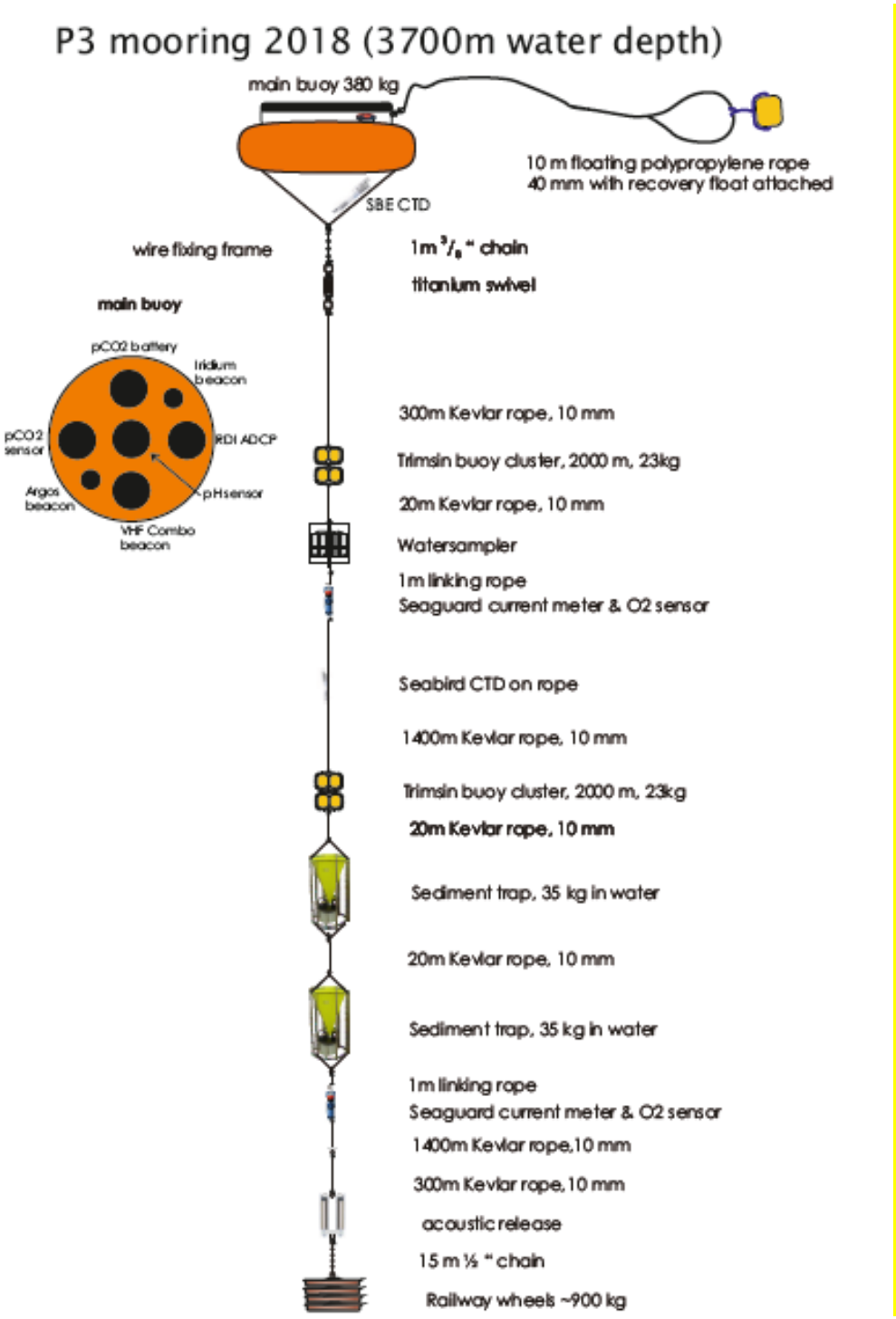

Figure 41 P3 mooring rig recovered

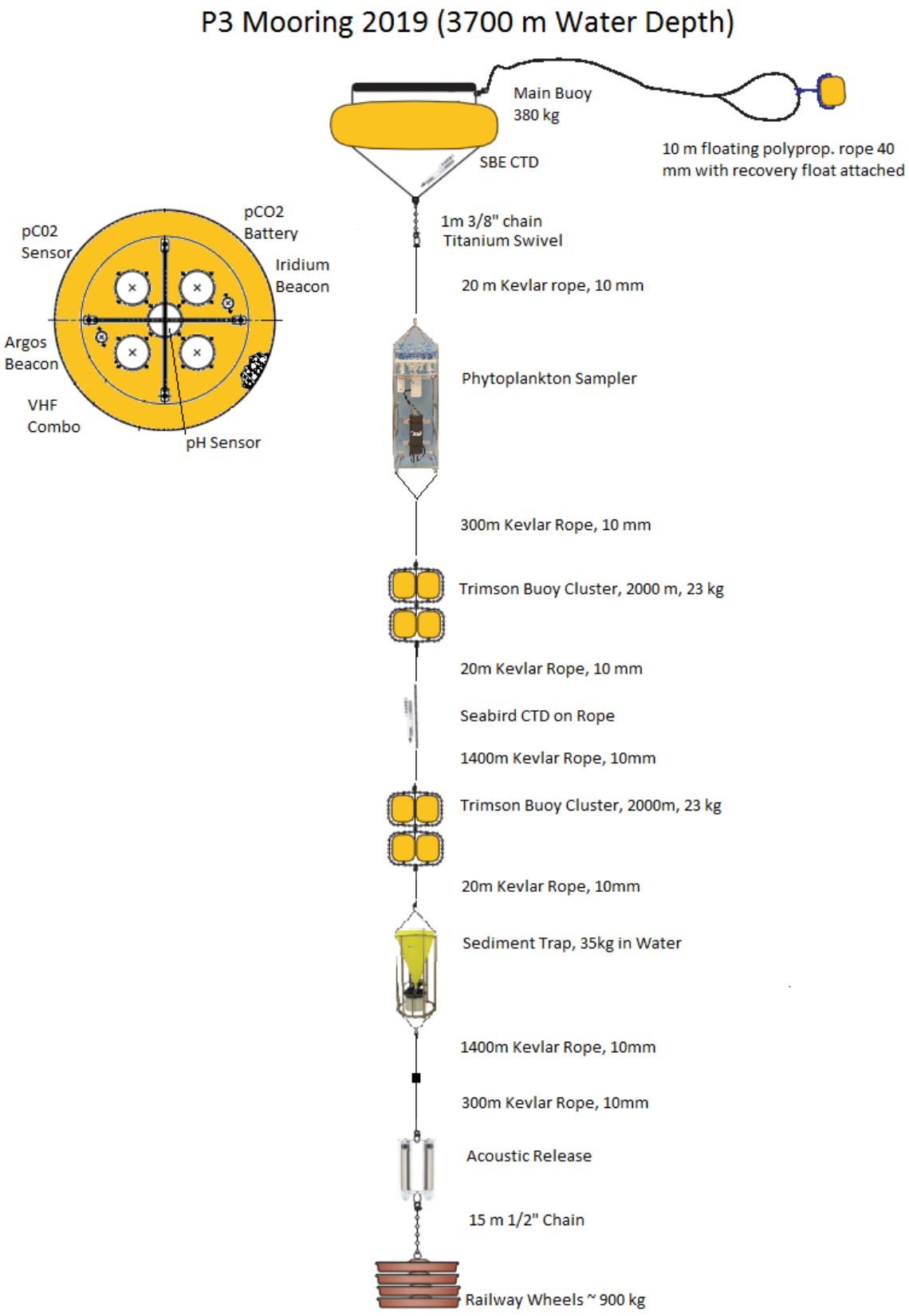

Figure 42 P3 Mooring rig deployed

8.2. WCB Mooring

8.2.1. Recovery

The mooring was released back in September by accident and was retrieved by the Pharos. The mooring buoy was handed over to BAS with the Iridium Beacon, and Argos Beacon broken. The reason for the early release seems to be corrosion of the chain that was connected to the master link on the release dropping bar.

8.2.2. Performance

One CTD, and one ADCP recovered. CTD does not seem to have recorded anything. Iridium Beacon and Argos Beacon broken. SonoVault successfully recovered and re-deployed. WBAT and transducer successfully recovered and had performed for the whole duration of the deployment.

8.2.3. Redeployment

Mooring redeployed on 23/01/2019 in increasing weather () at 53° 47.88'S and 37° 56.03'W.

8.2.3.1. Work carried out

Acoustic Releases 2006, and 2062

- ✓ New Batteries
- ✓ Tested
- ✓ New Linking bar
    - The top and bottom linking bars were replaced together with new washers.

Argos Beacon SM251 ID: 35520

- ✓ Destroyed, taken back to Cambridge

Iridium Beacon SN: MOI5U5, IME: 300434060651120

- ✓ Destroyed, and taken back to Cambridge
- ✓ Replaced with 300834012098770
    - New Batteries

NOVATECH Combo Beacon

- ✓ New Batteries
- ✓ Tested

CTD 37 SMP 29579 – 2462

- ✓ Data Downloaded: No data recovered.
- ✓ New Batteries
- ✓ Set up instrument for re-deployment
    - Set real time clock to PC clock (p.28)
    - Check instrument is ok and is set up properly by using "DS" command (p.27)
    - Set up instrument for "autonomous sampling" following instructions on page 24. Started 08.00 24/01/2019
    - Samplenum = 0 automatically makes entire memory available for recording.
    - Sample interval = 900 s

ADCP WHS300-I-UG161 Serial number: 17273

- ✓ Download data: P:\DY098\scientific_work_area\Moorings\WCB_mooring_JR17002\ADCP_data17273
- ✓ New Batteries
- ✓ Set up instrument for redeployment
    - Erase Data
    - Start WinSC for set-up of instrument
    - Set up instrument:
        - Number of bins: 25(1-128)
        - Bin Size (m) : 8 (0.2 – 16)
        - Pings per ensamble: 10
        - Interval: 15 min
        - Duration: 550 days
        - Transducer depth: 200 m
        - Save deployment settings
        - Start Time: 24/01/19. 22:00:00 – Start after deployment
        - Set up ADCP real time clock to PC clock
        - Don't verify the compass
        - Run pre-deployment test to check instrument

Simrad WBT Serial Number: 240826 and 120 kHz transducer Serial Number 127

- ✓ Download data file from USB drive: P:\DY098\scientific_work_area\Moorings\WCB_mooring_JR17002\WBAT_data
- ✓ New batteries
- ✓ Set up instrument for redeployment
    - New Batteries
    - Erase USB Stick
    - Start Mission Planner
    - Send New Mission to WBT to Include
        - Start Time / End Time (to not ping in water)
        - Ping ensembles including CW/FM pings (15 each)
        - Event start interval (1 hour)
        - Range 250 m
        - Battery Usage =
        - Note firmware was not upgraded and WBAT is operating using Storage Controller FW v2.4.0-130, Storage Controller driver v0.6.92, mission controller FW v2.2.5.0, mission controller FPGA v10. These files can only be viewed in EK80 software version 1.11.

SonoVault

Was only able to retrieve data from the first SD Card. The three following cards were corrupted/unable to read, and the rest were empty.

The corrupted cards have been placed to the back of the stack of SD cards, and the SonoVault redeployed.

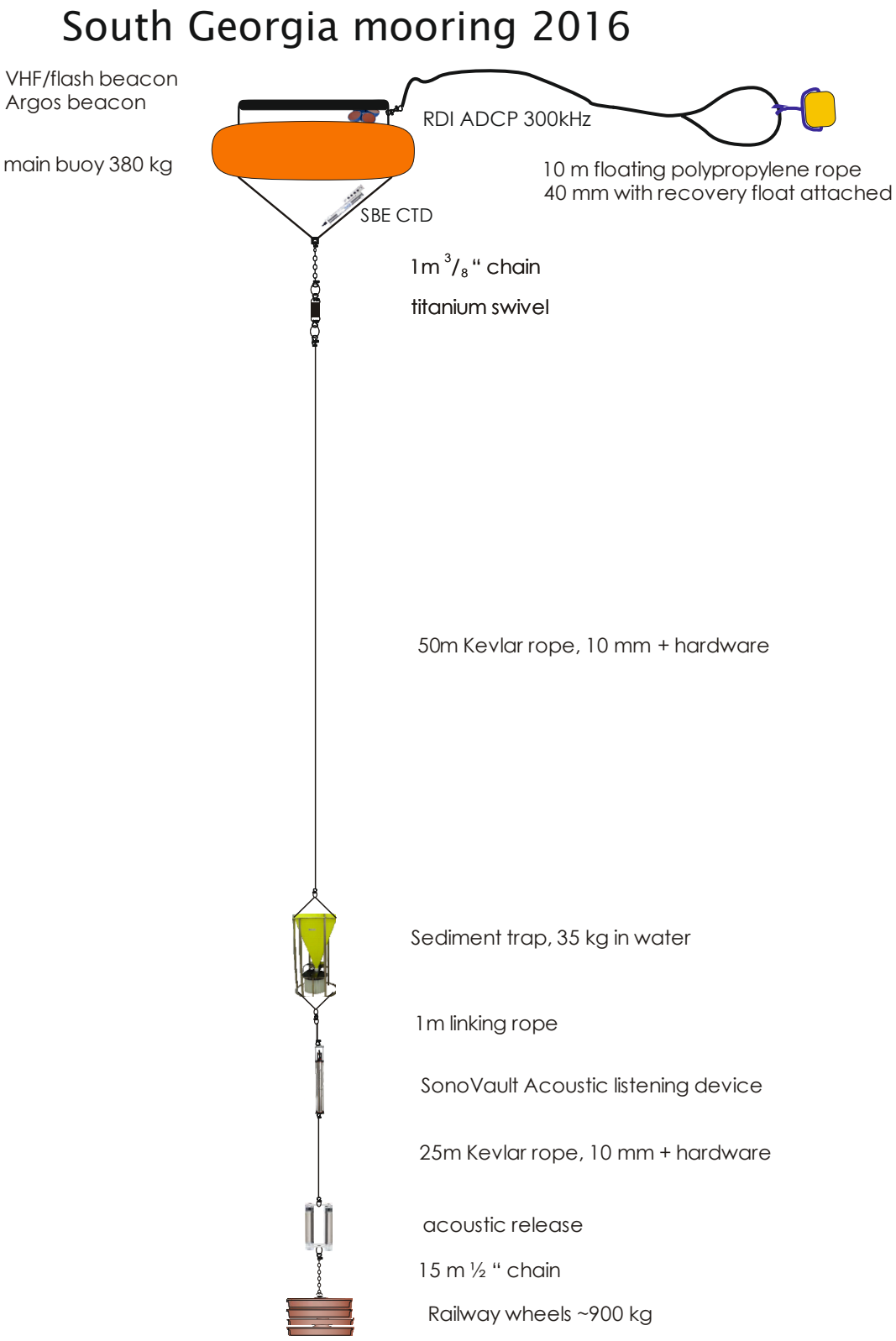

Figure 43 WCB Mooring rig recovered

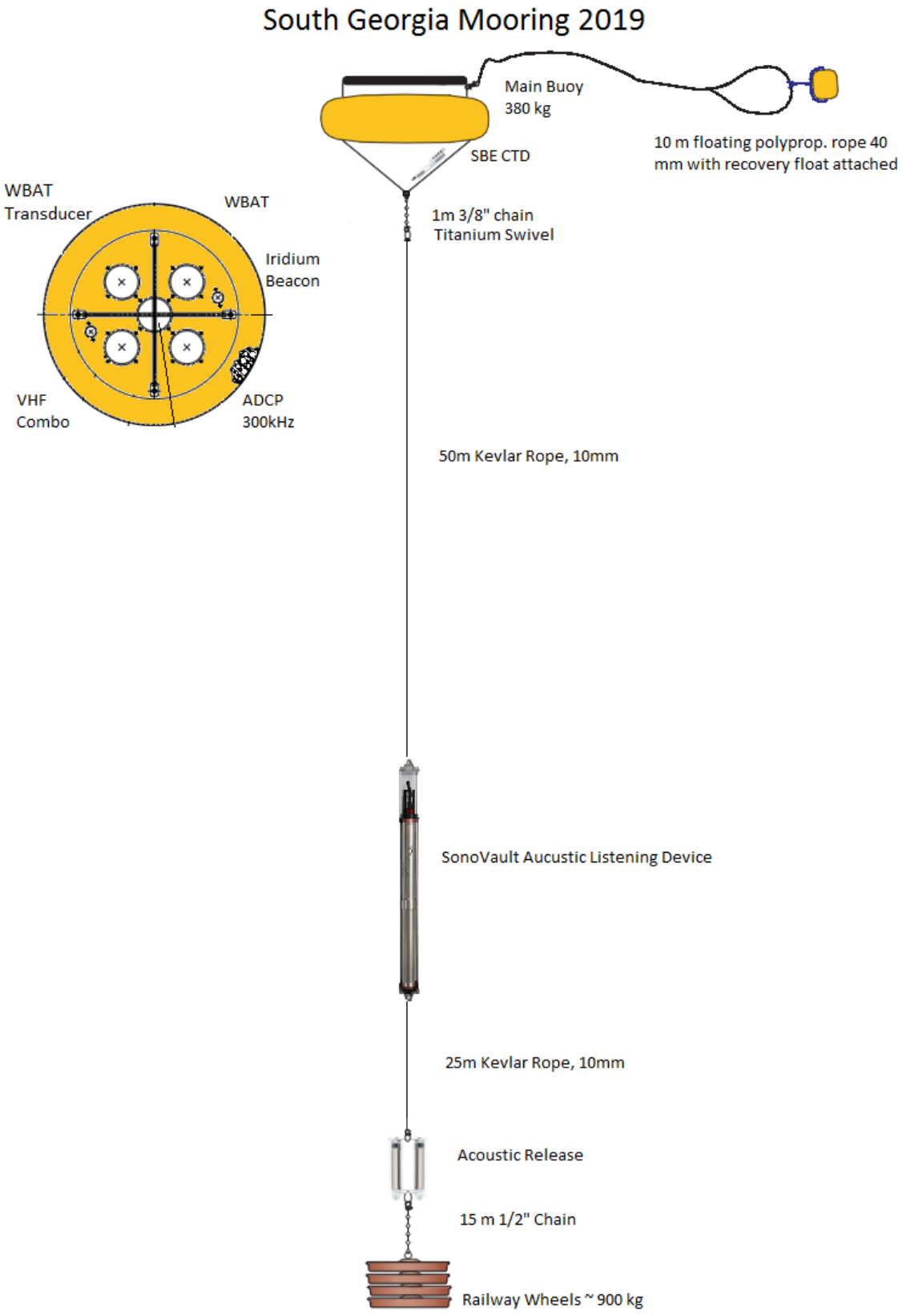

Figure 44 WCB mooring rig deployed

9. Gear Report *Dan Ashurst, Bjorg Apeland*

9.1. DWNM

Since the COMICS 1 and 2 cruises, a couple of lessons have been learned for integrating the DWNM with the Discovery's fibre optic systems. More care was taken to ensure that we had the right equipment and knowledge on board to successfully splice FO connectors together. A new FO converter box was used with a Perspex front which made it easy to assemble without causing sharp bends in the fibre cables. It also meant that the wires twisting as we moved the deep tow cable was reduced as the wires could be monitored. The FO converter wasn't swapped between nets as much as on the COMICS cruises, however the strong fibre splice and new junction box meant that damaged fibre connections did not occur.

A note about the new FO box: all the helicoils suck. Most screwed out much too easily. Spare helicoils (especially for the UNF threads) need to be brought along for further cruises using the FO converter.

Of the 3 fibres in the deep tow cable, only 1 (Red) and 3 (Black) - labelled on the junction box in the main lab - provided a successful connection. It is thought that fibre 4 (grey) has a broken link somewhere along the line, possibly at the slip ring? For deployments fibre 3 was once again used (as in COMICS 1 and 2) with fibre 1 being terminated with a connector for a back-up.

A loose connection on the deck-side FO converter caused the serial comms to cut out intermittently. This was partially fixed but a replacement board is needed and spares should be brought on further cruises. One of the two 20m fibre optic patch leads was damaged. As these are essential to reach from the fibre junction box to the PC another needs to be bought as spare.

The underwater units for both the RMT8 and the MOCNESS worked well. However a number of the 4pin-4pin FO cables and 2pin-2pin Sea cables were not working correctly. Replacements and spares need to be brought for DY100. The damage to these cables is due to the design of the RMT8 cross. **A redesign of this (and the RMT25 cross) is essential to prevent further damage to any cables.** This redesign could also give greater consideration to sensor placement and the potential for a location for the FO converter box.

A number of depth sensors that had been sent back to Sea Bird Electronics needed setting up to function correctly. Initially the sensors gave a constant reading of -11m, leading us to think that the sensors were damaged despite being refurbished. It is actually due to the factory settings being different from the setting required by the DWNM system. Setup is required (instructions for this are in the DWNM manual). All three depth sensors that were sent for refurb (0161, 0162 and 0163) have now been set up correctly. On the previous COMICS cruises when a sensor suddenly gave a reading of -11m it was automatically assumed that the sensor was broken. On future cruises it is worth trying to re-setup the sensor as an incident may have caused it to revert to factory settings.

9.2. RMT8

The RMT8 net, for the most part, worked as expected. Deployments were as follows:

- Use fibre optic deep tow cable through aft gantry
- Ship speed, 2 knots through the water, head to wind.
- Trail cod-ends over the back end of the vessel. Ensure that first cod end is trailed as far as possible before deploying second cod end to reduce chance of tangling the nets. Check to see that cod ends are trailing correctly
- Side wires hauled up so that tension just comes on to the wires

- Pick up net by moving gantry out.
- With gantry out so the nets are vertical, lower side wires together.
- Bring gantry in to switch over side wires to main towing wire
- Attach side wires to G-links on ropes attached to the aux winches. Enough slack is needed on these lines to allow the gantry to fully extend out

There is a lot more room for it to swing compared to aboard the JCR so extra care must be taken. Steady lines were fed through the towing bridles at the top spreader bar to reduce swing, however the RMT8 has a reasonable amount of weight behind it and still tends to swing if people holding the lines are not paying attention. It is essential that at least one of the steady lines manages to tie itself into a knot during deployment so that the net has to be brought in again because a net deployment without faff is not a net deployment at all.

- Maximum pay out speed, up to 0.3 ms-1 depending on winch back-tension. Haul in speed ranged from 0.1ms-1 to 0.3ms-1 depending on how the net was towing through the water.
- Stratified deployments were 200m to 100m and 100m to surface, 20 minutes per net. Target fishing was no deeper than 50m.
- Recovery was also straight forward:
- Ship speed to 1.5 knots through the water
- Pull gantry with top towing bar is just above deck level (and rest of net below)
- Shackle over to side wires
- Put gantry out so net vertical, then haul in on both side wires at same time to raise net to deck level.
- Put gantry in. Lower side wires if additional control need

The position of the weight bar on recovery also meant that a lot more of the net still in the water. To counter this, the deck winches hauled in so the weight bar was around head-height. This dragged the nets up and forward, however, care must be taken as having the weights at head-height is always a risk.

Pull nets in using either with 4 people or 1 Bjorg “Beast-Mode” Apeland hauling by hand.

Deployment and recovery of the RMT8 differed from the RMT25 because its smaller size meant that using the auxiliary winches mounted on the gantry was not possible. Instead, 2 auxiliary deck winches were used through blocks on the gantry to lift the side wires. These were operated by 2 NMF technicians. This actually worked better that using the gantry-mounted winches as they can be driven concurrently, ensuring a smoother deployment/recovery. The nets could be deployed with a minimum of 5 people: 2 BAS personnel in the square, the Boson coordinating the deployment/operating the gantry/main winch and 2 NMF technicians operating the 2 deck winches. Recovery usually had an extra 2 BAS personnel in the square to help with net-recovery.

The RMT8’s main problem was that of weight (however weight-shaming should be avoided). During deployments the net struggled to get to depth effectively, making target fishing difficult. Extra weight was added to the bottom bar however this only marginally helped. It is not fully understood why deployments from the Discovery are more problematic than from the JCR (£1 to the jar!). One thought is that the Disco’s deep tow cable is the cause. As this is the same cable as the one being installed on the SDA, serious consideration is needed for net deployments when that ship comes into service.

9.3. RMT8+1

The RMT 8 + 1 is a problematic addition to the usual RMT setup. All new line lengths were required to accommodate the extra nets. The additional 4 release lines made cocking the release mechanism an arduous task which, if not careful, resulted in a bird's nest of wires. The additional nets also seemed to put extra strain on the system. One of the short release strops parted, a number of the rings of the release wires became misshaped and the side wires of both the 8 and +1 nets were cutting into the shackles that they run through. Almost cutting entirely through some of them. This needs to be addressed.

Deployment and recovery were the same as just the RMT8 save for during recovery it was important to ensure the cod ends of the +1 were pushed behind the bars of the 8 to ensure they were accessible when on deck.

Two green rope lines were made up to assist in setting up the RMT8+1. These lines attached to the main side wires above the red G links and to the spreader bar of the +1. This raised the nets so that the bars were vertically aligned, making arranging the wires correctly much easier.

9.4. MOCNESS

The MOCNESS was used twice – never in anger.

Deployment of the MOCNESS was as follows:

- Speed through the water 2 knots
- Two long steady lines to guide the top frame until it was in the water prevented it from spinning.
- Pick up frame by hauling in deep tow wire and bringing out gantry
- Lower net into water with gantry fully out
- Veer out at 0.1m/s until tension is consistently above 0.3 tonnes. Increase to a max of 0.3m/s when possible
- Once at depth, haul in at 0.2m/s

Recovery was straight forward:

- Speed 1.5 knots through the water
- Using snap hooks, attach steady lines to the top frame
- Haul in on the main wire and bring in the gantry until the weight bar is hanging above the table.
- Lower the main wire and, using the steady lines, guide the main frame on to deck.

The personnel required for deployment and recovery was 2 BAS scientists in the square, 1 deck crew operating the main wire and the gantry, 1 winch driver for winch speed throughout deployment.

Of the two deployments one failed to fire and one was successful. For the first deployment, the old, oil filled motor was used with the new frame, weight bar and dropper bars. When this failed to work, the dropper bars were replaced with the old versions as it was believed that the new bars put too greater an angle on the release wires, thus causing the release keys to jam. The second deployment fully worked. The new dropper bars need the lugs, which the release wires feed into, changing so that the wires are all parallel with the release keys. Ideally the MOCNESS release system would have a full redesign. The stepper motor is underpowered and the keys jam too easily. A geared motor and cam system, similar to RMT nets might prove more robust.

9.5. Bongo

The Bongo net deployments were simple and without much issue. Initial set up of the net was much easier that previous cruises. This is purely down to the fact that all the stauff clamps were new and un-corroded. This made assembling the frame a quick task that could be done by one person. The majority of the clamps on the orange buoys are completely shot. The helicoils are all coming out of the plastic clamp mounts. These should all be replaced with a metal alternative and the buoys should not be sent on a cruise until this has been done. There are now way too many different lengths of bongo net all with different sized beads at the top. This meant finding a set of suitable nets was a palaver. These need streamlining however that is unlike to happen. As a side note, the bead system is still a bit rubbish. Setting up the nets is always a fuss resulting in two or three people wrestling the net onto the frame. A simpler system surely isn't past the realms of possibility. Swaging the top eye was done with the BAS swage press – unlike on COMICS 2 where the bongo was lost to Davey Jones's locker.

This version of the bongo didn't have any open/close mechanism and the buckets had no valves to catch the sample (the valves apparently destroy the animals, which begs the question why we bothered making them in the first place).

Deployment of the bongo was once again done from the NMF Romica winch with the ship's starboard aft-end crane. With the bongo initially propped up against a section of railing bolted to the deck, the wire from the motion compensation unit was taken up until the bongo frame was upright. This process was still as awkward as ever – trying to walk up the frame to its upright position without damaging the cod ends or having the top rings swinging around. Deployment was as follows:-

- Persons required - 1 crew member operating the crane, 1 crew member assisting in manoeuvring the net, 1 NMF winch operator, 1 person conducting set up and deployment
- Ship on DP
- With crane in line with Bongo wire, winch haul in to take up compensation unit slack. Ensure that the top end of the net is controlled by person to avoid damage
- Once slack is taken up, keep hauling with winch and guide bongo to upright position. This requires two people to help manoeuvre
- Raise bongo so legs can pass over the bulwark
- Swing crane out till net is over the side. Persons guide net as needed.
- Pay out on winch till the swivel hits water surface.
- Pay out on winch to depth. Veer rate is dependent on how much slack is in the cable. Approx. 0.1m/s for the first 100m up to a max of approx. 0.3m/s
- Once at depth wait for a minute or two to allow the net to settle.

For recovery:

- Haul in at approx. 0.3m/s
- When swivel breaches water surface slow haul rate
- Raise net so legs can pass over bulwark
- Bring crane in so net is suspended over deck
- Keep net in the air enough to be able to fit sample buckets under the cod ends. Hold the net whilst samples are taken.
- Veer out of winch till feet of net are on deck and net is standing vertically.

- If all deployments are concluded, persons pull at legs and walk net frame into stowing position as winch operator veers on the cable. Ensure person is keeping top and of net under control.

Deployments were either to 50m or 100m depth. Initially this was read off of the Romica winch's screen, but following an unfavourable interaction between the winch's PLC and sea water, the read out broke… who would have thought. The depths were measured using tape on the winch cable.

9.6. NeMo Net

The Neuston Modified (NeMo) net is a trawled surface net that was used to look for micro plastics.

Deployment was as follows:-

- Persons required – 1 crew member operating the Starboard Aft crane, 1 NMF technician operating the Romica winch, 1 person to guide net out and set towing line length, 3 people for NeMo dance party.
- Speed through the water 2 knots
- The NeMo is attached by two lines: the lifting line that goes through the crane and to the winch, and the towing line that runs from the net, up through the boom arm, through the elephant's arsehole and secured to the mooring bollard thing
- Haul in on lifting line to lift NeMo over the bulwark. Keep towing line slack.
- Slew the crane round to position the NeMo as far from the ship as possible.
- Swing out boom arm to keep net away from side of ship
- Lower NeMo into the water and pay out until tension is taken by towing line and lifting line is slack. The net should be sat on the surface just behind the aft of the ship, to starboard.
- Deployments were 20 mins

For Recovery:

- Speed 2 knots
- Haul in on lifting line. Pull in slack towing line by hand
- Slew crane around whilst bringing boom back in.
- Haul in on lifting line so that net cod ends clear the bulwark

Due to the NeMo's lack of weight, deploying the net in winds much higher than 20-22kts resulted in it flying wildly like a kite. Also, as it is designed to sit on the surface, it suffers impact forces from the waves. Because of this and its flimsy construction, sea conditions with large swell meant the net couldn't be deployed.

A new frame was made to mount the nets. This is because the nets were a different size to previous.

The flow meter's position meant that it was susceptible to having the towing and lifting lines wrapped around it. This lead to the flow meter getting bent. A position that kept the flow meter away from the towing bridles needs to be investigated.

9.7. Mammoth

The mammoth net was brought along purely for show and so that everyone could once again ask why the hell we bother lugging that depressor around with us. No deployments were attempted so no real comments can be made. For information regarding deployment aboard the Discovery, please see the cruise report for DY090.

10. OEFG gear report Andy Leadbetter, Dean Cheeseman

10.1. LEBUS 5t deck winch (x2):

Used for BAS RMT8 and RMT8+1 recovery and deployment.

2x winches used with wires over the hanging blocks in tandem to raise and lower the sidelines of the net as opposed to using the Rexroth winches on the A-frame; due to the smaller size of the RMT8/+1.

These winches worked well for the duration of the cruise without issue.

During our time anchored off of South Georgia we noticed that the return line hose on the starboard winch had perished nearly to the point of splitting; it looks like this as been caused by wrapping the hoses round the winch for transit. This appears to have split the outer rubber casing of the hose allowing the inner armoring to rust. Fortunately we had the facilities to swage a new fitting onto the end of the hose and prevent any spills.

The hose swaging unit is now set up in the hold; would recommend some shelving or a cupboard for storing dies and fittings for future cruises.

10.2. Romica 5t deck winch:

Used for BAS Motion Compensated BONGO net and Neuston net (NEMO) deployments. The winch had constant issues throughout the cruise. The display screen on the main console only worked intermittently due to weather; when cold it would not switch on and the location of the winch means that water over the side is a major issue, which also causes the screen to stop working.

Another issue caused by water due to the location is that the electric motor for the scroll carriage was completely full of water causing an earth fault and intermittent scrolling. This was emptied and cleaned out to the best of our ability on board, however after an electrical test it was found that the motor is irreparably damaged; it still runs but it wont last long.

The final fault was the PLC appears to have lost all its programmed parameters, which we have been unable to reenter on board; service engineer required due to the Siemens software and licenses. The loss of the programming means that the winch will no longer provide line out or RPM values meaning that it is just a basic dummy winch and we cannot guarantee the recovery or deployment speeds we are asked for. The only way to get the required depths is to tape mark the wire, which is realistically unfeasible on board over a couple of hundred meters. The loss of programming also means that the scroll carriage will only run at full speed on automatic which makes any deployments over 100m (the top lay of wire) unadvisable.

The winch has been left on the deck of the ship for months with no protection from the elements, which appears to be the root of most of these issues. Dean has been looking at the possibility of integrating the winch into a 10ft container that would provide protection from the elements and would allow heating or cooling to be provide to the winch as necessary to keep the PLC and electronics at a more stable temperature.

10.3. DB Winch

Used for 2x mooring deployments and 1x recovery.

Recovery and deployment of P3 mooring (3700m)

Deployment of Western Core Box mooring (70m)

There were some issues with the DB system on setup due to the variable flow control valves that have been fitted to the pressure lines on the winch. Firstly due to the flow rate supplied by the ship on the 170bar hydraulic system the winch was running extremely slow so we adjusted the valves accordingly. The main issue with the flow control valves is the heat buildup that occurs during extended use; this was causing the ships system to trip out due to high temperature. From discussions with the Chief Engineer it originally seemed that there was a faulty cooler on the ships side; this was subsequently changed and the set point for the trip switch adjusted. This improved the system however did not entirely solve the issue as the system tripped several times after changing the cooler. We measured a maximum temperature on the Staffa motor casing of 87°C. The CE is looking into getting an improved cooler system fitted for the deck distribution as we felt that the system should not be able to heat up that much with only a single winch running as there is space on the ring for over 10 winches to be running simultaneously.

Recommend looking into another way of limiting flow as the open loop nature of the system paired with these type of variable valves appears to cause extreme heating of the system in a short space of time.

10.4. LN2 generator

Not required for this cruise, stayed secured in the hanger, no issues.

10.5. Workshop

The deck workshop was relatively clean and tidy on arrival, however there was some techs equipment left behind, there is need to look at a place for storing equipment and PPE that cannot be sent home due to use during demob or no freight availability. There is a better amount of tooling than on previous cruises however there are still a few issues such as incomplete tool sets (missing allen keys, incomplete socket sets etc.)

The main issue is the lack of maintenance on the machines; the lathe, mill and pillar drill were all very rusty on the beds and slides due to the fairly open environment they are located in, all were cleaned and oiled but would recommend a proper service for all workshop machinery when the ship comes back alongside in Southampton.

We have moved the vice to a better location for holding anything of length, however it is now only mounted to the wooden top of one of the Geodore benches which is not as secure as the previous location.

However the addition of deck vices which can bolt to the matrix means that any heavy duty vice work can be done out of the workshop.

The chop saw is still unusable for cutting anything over 1m due to its location in between the mill and the pillar drill; new blades are required.

The workshop as a whole is poorly laid out and needs redesigning to make it a properly workable environment. Currently carrying out FO terminations in there is extremely difficult due to the layout and that it is a very unclean area.

10.6. Lab equipment

Fume hoods and laminar flows have been used for the duration of the cruise with no issues.

Millipore systems have had several issues, the most notable being the RO over limit alarm on the system in the GP lab, due to the membranes breaking down, needs to be returned to base for servicing. The other systems have had the usual routine parts that have required changing (Biopak,

Proguard, RO cleans etc.). However the unit in the CT lab has now started flashing up A10 lamp errors, which say, require a Millipore service engineer. Would recommend all units serviced upon ships return to Southampton.

10.7. Deep tow

The deep tow FO was required for the BAS MOCNESS, RMT8 and RMT8+1 nets. There were very few issues with this throughout the cruise; BAS have supplied a new FO junction box to replace the oil filled bottle-type one used previously. The new design; a rectangular box with a Perspex lid allows a visual inspection of the connections prior to each deployment and appears to have negated the issues of the wire leading into the JB twisting and braking. However the requirement to swap the deep tow between different equipment was fairly minimal.

10.8. Floating Sediment Trap

This is a new piece of BAS supplied equipment that required several modifications and a fairly involved deployment method.

It is essentially a floating mooring consisting of 3x sediment traps (Figure 45), separated by 50m lengths of polypropylene rope; spliced into plastic hard eyes. There is a small buoy on the surface and a 50kg steel weight at the bottom.

The traps are deployed cocked, with the lids in the open position; these are held open by lanyards and are released by a messenger suspended beneath the buoy, this sets off a chain reaction of messengers suspended beneath each trap (**Error! Reference source not found.**) to fire the other t raps.

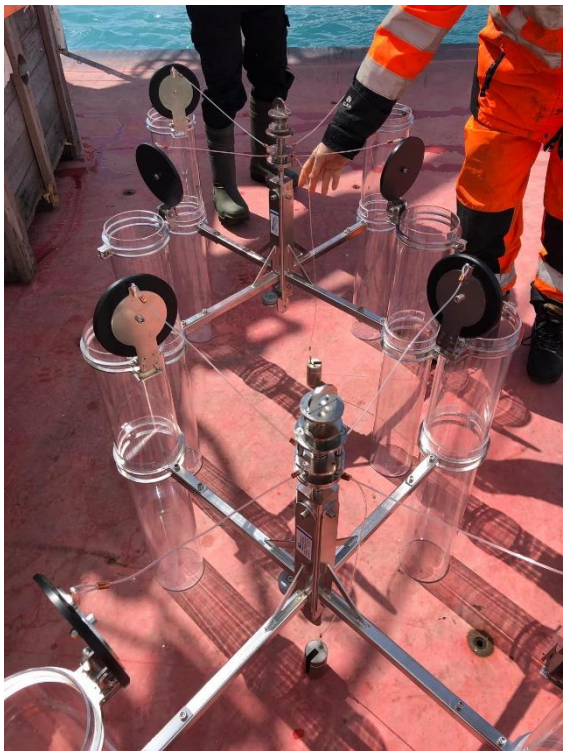

Figure 45 Floating sediment trap

The first issue we encountered was the splices being too long to allow the messenger to reach the release mechanism; these were modified with longer aluminum tubes.

We attempted an initial test deployment in Cumberland Bay over the stern using DB winch system. This proved to be problematic as the traps are fairly flimsy and could be easily damaged. Also whilst stoppered off on deck and winding a new length of rope through the system and onto the reeler, it became caught in the hanging block and parted. At this point we attempted to fire the 2 traps that were out and then recovered as it was decided that the polypropylene was not durable enough. Upon recovery neither trap had fired.

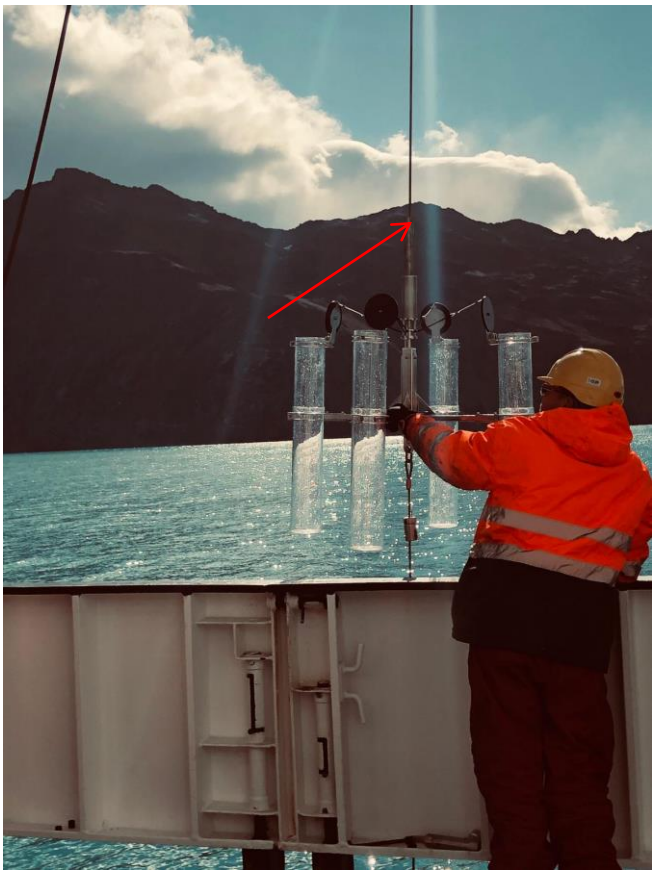

Figure 46 Floating sediment trap deployment

We decided that swapping out the rope for wire would provide reduced friction on the messenger and increase the chance of a successful deployment, however the added weight would be too much for the buoy provided so it was decided that a deployment over the P-frame leaving the wire attached to one of the Rexroth auxiliary winches would suffice.

The deployment method over the P-frame uses wire transfers between the 2 auxiliary winches; similar to piston coring. This allowed all traps to be deployed vertically and in the right orientation and prevented each trap seeing any load until it was clear of the ships side. The package is then lowered to set depth (a tape mark on the Rexroth wire) and left to hang for a set period of time, upon recovery a messenger is sent down to fire the first trap and then after allowing time for the other traps to be fired it is recovered; this is done in reverse to deployment.

On the first deployment using the P-frame and wire combination all the messengers were released, however not all of the lids were properly released. This is due to having a fairly weak spring to close them and the resistance of the water as they try and shut, combined with the messenger only opening to release mechanism for a split second. We managed to rectify this for the second deployment by shortening the lanyards using cable ties and making them tight so that upon impact

from the messenger they pulled themselves free with more force. This meant on the second deployment we had 100% success with all tubes closing as expected.

Recommended future modifications:

- More than one clamping point per tube as the current design is weak.
- Cages around each trap if it expected to be deployed as a freely floating mooring to protect the tubes on deployment and recovery.
- Larger buoy to take the extra weight of the wire.
- Swivels in between each trap; we were seeing a lot of wire torque.
- Different closing mechanism, as well as being slow to close there will be a lot of spillage if the traps are not recovered perfectly vertically (possibly a shutter type mechanism re: megacorer).
- Thinner wire than what we had available to keep weight to a minimum (we used 8.25mm).
- Heavier messengers or lower rate springs to allow the firing mechanism to remain open when the messenger hits to increase chance of successful firing.
- New lanyards, we used cable ties but this will cause a lot of wastage; suggested bungee cords.

10.8.1. Comments on floating sediment trap deployment

The floating sediment trap consist of four Perspex tubes on a stainless-steel frame. These frames can be placed in succession on a line, as to change the number of traps and depth to one's desire. There is a closing mechanism consisting of a messenger which will have to be released from the top structure (buoy or similar).

The set-up brought on the DY98 was three sediment traps with 50 m polypropylene[1] rope between the traps, and a 50 kg steel weight at the bottom.

A first test deployment was performed on 11.01 in Cumberland Bay.

The drifting sediment trap was deployed in the same manner as a mooring, using the aft mooring winch set up. However, it soon became apparent that the rope was not good enough, and the deployment was aborted when the rope snapped as it got caught on the crane block. Before the abortion of the operation there was an opportunity to check if the messengers functioned properly. And they did not. It is believed that the rope provided too much friction. It was suggested that instead of the fibre rope, steel wire rope is used.

A second test deployment was performed on 19.01 in Cumberland Bay.

4 8mm thick, 40-50m long steel wire ropes were made up, and deployment method changed from deploying them as moorings on the aft and instead deploy them on the starboard side gantry:

- Run 50m wire onto winch
- Attach bottom sediment trap, and bottom weight.
- Deploy bottom sediment trap, use second winch to stop off sediment trap wire.
- Run next length of wire onto the winch

[1] Split film, 10.1 kN breaking Load.

- Attach middle sediment trap and attach this to the stopped off bottom sediment trap wire.
- Stop of the two sediment traps with second winch and repeat as above for the third sediment trap.
- Do in reverse for recovery.

Cumberland Bay test deployment results

- ¾ tubes fired on top trap + messenger, 0/4 tubes fired on 2nd trap + messenger, 4/4 tubes fired on bottom trap.

This test deployment was successful enough that it was decided to a 24-hour deployment in Cumberland Bay:

Deployed at 17.00

- Cocking lanyards changed so they were tighter
- All tubes fired correctly

Other comments:

- Would probably be better if the traps clamped on, otherwise there is a lot of playing around with the wires.
- How strong are the eyes on the traps?
- Would be nice to have a cradle for the traps to sit in while taking tubes on and off
- Cages for the entire trap to make them less breakable.
- Deployment method before leaving Cambridge, at least a rough plan.
- Release lanyard must be taught, using bungee cord was suggested
- Reassess the size of buoy. Should perhaps be bigger.
- Figure out exactly which beacons and sensors are needed.

11. Data management *Alysa Hulbert*

11.1. Data storage

Two network drives were set up on the on-board server. Firstly a read-only drive containing files relating to the ships instruments; 'current_cruise', and secondly a scratch drive for the scientific party; 'Public'.

All data recorded by instrumentation linked to the ship's network were recorded directly to respective folders within \Ship_Fitted_Scientific_Systems in the read-only drive. Core data was logged by the TechSAS 5.11 data acquisition system as NetCDF and ASCII output data files. The format of the data files is given for each instrument in \Cruise_Documentation\Data_Description_Documents. CTD data was also saved in this drive, in \Sensors_And_Moorings\CTD\Data.

Within the 'Public' drive, work folders created by the scientists were saved in \DY098\scientific_work_area. The 'Public' drive was backed up and saved to the read-only 'current_cruise' drive every half hour. When the data are transferred to the Storage Area Network (SAN) at BAS, the pathname will be data/cruises/dy/dy098.

11.2. Site identifiers

Specific codes were given to work stations consistent with the previous Western Core Box surveys (WCB1.1, WCB1.2, WCB2.1, WCB2.2, WCB3.1, WCB3.2, WCB4.1, and WCB4.2), mooring sites (WCB and P3) and South Sandwich Islands survey (Sand1-14, SSA1-9, SSB1-17 and SSC1-9).

11.3. Event logs

Event numbers were assigned to equipment deployments sequentially by the officers on watch when completing the bridge event log. 148 separate events were recorded. In addition to the bridge event log, a number of digital logs were maintained to record deployments and sampling. Copies of these have been downloaded as .csv files and saved to the 'Public' network location as \DY098\event_logs\Downloaded Digital Event Logs. Event logs were created for the Underway Pump isotopes, Underway Pump transect, CTD, CTD bottles, RMT8, RMT8+1, XBT, Bongo, MOCNESS, NEMO and Sediment trap.

Data was collected to support the research of the following scientists:

- Dr Sophie Fielding (BAS, UK)
- Dr Clara Manno (BAS, UK)
- Dr Gabriele Stowasser (BAS, UK)
- Dr Cecilia Silverstri (ISPRA, Italy)
- Dr Saccomandi (ISPRA, Italy)
- Kirstie Jones-Williams (BAS, UK)
- Frances Perry (PML, UK)
- Emma Langan (UEA, UK)
- Louise Cornwell (PML, UK)
- Emily Rowlands (University of Exeter, UK)
- Angelika Slomska (University of Gdansk, Poland)
- Dr Jennifer Jackson (BAS, UK)

11.4. Cruise data deposit

Both the read-only and the public scratch drive were combined at the end of the cruise and copied to discs for the PSO, BAS PDC and BODC. All data are archived for storage with the BAS Polar Data Centre and BODC. For cruise participants internal to BAS, the data has been saved on the UNIX drive under data/cruise/dy/dy098. Cruise participants external to BAS or any other external party who would like copies of the data can contact the PDC at polardatacentre@bas.ac.uk.

11.5. Datasets overview

Equipment/activity	Number of deployments
Bongo	28
MOCNESS	2
RMT8	19
RMT8+1	22
NEUSTON Modified (NEMO)	11
Floating Sediment Trap	5
Conductivity-Temperature-Depth (CTD)	33
Expendable Bathythermograph (XBT)	10
Underway sea surface water sampler	91 samples taken
EK60 multi-frequency echosounder (fisheries)	Continuous recording
OS75 Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP)	Continuous recording
Other underway data from ship-fitted instrumentation	Continuous recording
P3 deep mooring	1
WCB mooring	1
Marine mammal observations	198 hours through 3,590km

Table 36 List of all sampling gear on DY098

11.6. Data sets description

Dataset	Bongo
Instruments	Bongo net, mesh sizes 100µm and 200µm.
Description	Bongo deployments were undertaken to provide pteropods (KJW) and copepods (LC) for incubation experiments (temperature, acidification and microplastic treatments). Samples were also taken from South Sandwich Island deployments using the 200µm net for later taxonomic analysis.
Metadata	Digital event log: 'Bongo'
Physical samples	The primary repository for the physical samples will be the BAS biological store. Post-cruise the samples will be examined, described and analysed. Biological samples were preserved in 4% formalin.
Long term data management	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Kirstie Jones-Williams, Louise Cornwell

Dataset	MOCNESS
Instruments	Multiple Opening and Closing Net and Environmentally Sampling System net
Description	The MOCNESS was only deployed twice, with both being test deployments.

Metadata	Paper logs and their scanned copies: \DY098\event_logs\Paper scans\MOCNESS Digital event log: 'MOCNESS'
Long term data management	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.

Dataset	RMT8
Instruments	Rectangular Midwater Trawl 8 opening and closing nets (8m), mesh size 5mm. Two nets per event.
Description	Targeted hauls for Antarctic krill *Euphasia superba*, and oblique trawls for zooplankton sampling. Biological samples will be used for taxonomic composition and stable isotope analysis (GS), *Euphasia superba* biomass estimates (SF), salp population composition (AS), temperature incubation experiments of the gravid *Euphasia superba* females (FP), nanoplastic and acidification incubation experiments with *Euphasia superba* eggs (ER), and microplastic incubation experiments with *Euphasia superba* (KJW).
Metadata	Paper logs and their scanned copies: \DY098\event_logs\Paper scans\RMT8 Digital event log: 'RMT8'
Digital data	\DY098\scientific_work_area\RMT8
Physical samples	The primary repository for physical samples will be the BAS biological store. Post-cruise the samples will be examined, described and analysed. Biological samples were sorted after the RMT8 was recovered and a record made of (rough) taxonomy, weight and number of individuals. Biological samples were frozen at -20°C, -80°C or preserved in 4% formalin.
Long term data management	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding, Gabriele Stowasser, Kirstie Jones-Williams, Frances Perry, Emily Rowlands, Angelika Slomska.

Dataset	RMT8+1
Instruments	Rectangular Midwater Trawl 8+1 (RMT8+1) opening and closing nets (8m and $1m^2$), mesh sizes 5mm and 300µm. Two nets per size each event.
Description	As above
Metadata	Paper logs and their scanned copies: \DY098\event_logs\Paper scans\RMT8+1 Digital event log: 'RMT8+1'
Digital data	As above
Physical samples	As above
Long term data management	As above
Users of the data	As above

Dataset	NEMO
Instruments	Neuston modified net, mesh sizes 300µm inside a 100µm net

Description	NEMO deployments were performed to collect microplastics.
Metadata	Digital event log: 'NEMO'
Physical samples	The primary repository for physical samples will be the BAS biological store. Samples were frozen at -20°C
Long term data management	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Clara Manno, Kirstie Jones-Williams

Dataset	Floating sediment trap
Instruments	Four Perspex tube on a stainless steel frame
Description	Samples to be analysed for Dissolved Organic Carbon (DOC), nano and microplastics when back in the UK
Metadata	Digital event log: 'Sediment trap'
Physical samples	The primary repository for physical samples will be the BAS biological store. Samples were frozen at -20°C.
Long term data management	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Clara Manno, Emily Rowlands

Dataset	CTD
Instruments	Temperature, Conductivity, Digiquartz Pressure, Dissolved O_2, Fluorimeter, Altimeter, UWIRR PAR, DWIRR PAR, Backscatter, Transmissometer, 20L water samplers, LADCP
Description	CTD deployments recorded measurements of temperature, salinity, depth, dissolved oxygen, fluorescence, PAR, and also data from a lowered ADCP. Niskin bottle seawater samples were taken for phytoplankton species diversity analysis back in Cambridge (SF). Seawater samples were also filtered on board for later analysis of chlorophyll a concentration (SF), Particulate Organic Matter (POM), Dissolved Organic Carbon (DOC), High Molecular Weight Dissolved Organic Matter (H-DOM) and phytoplankton DNA (EL).
Metadata	Paper logs and their scanned copies: CTDs: '\Sensors_And_Moorings\CTD\Documents\Logsheets\CTD Logsheets' Bottle consignees: '\DY098\event_logs\Paper scans\CTD_consignees' Chl_filtering: \DY098\event_logs\Paper scans\Chl_filtering Digital Event logs: 'CTD' and 'CTD bottles'
Digital data	'\Sensors_And_Moorings\CTD\Data'
Physical samples	The primary repository for physical samples will be the BAS biological store with the POM, DOC and H-DOM filters eventually being forwarded to ISPRA. Filters were frozen at -20°C (SF, CS and FS) or -80°C (GS and EL) and water samples stored in 1% Lugol's.
Long term data management	Raw and processed data will be stored on the SAN at BAS and also available from the BODC.

	Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding, Gabi Stowasser, Clara Manno, Cecilia Silverstri, Flavia Saccomandi, Emma Langan

Dataset	XBT
Instruments	Lockheed Martin Sippican T5 Expendable Bathythermograph
Description	XBTs were used for temperature profile measurements through the water column during the Western Corebox survey. Two probes were deployed on each of five WCB transects
Metadata	Digital Event log 'XBT'
Digital data	'\DY098\scientific_work_area\XBT\DY098'
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding

Dataset	Underway water sampling
Instruments	SLH80 Twin Screw Pump
Description	Samples were taken from the underway seawater stream for three investigations: 1) Filtering for phytoplankton for DNA sequencing (EL) (142mm cellulose acetate filters with 0.2 µm pore size), 2) Particulate Organic Matter (POM), Dissolved Organic Carbon (DOC) and High Molecular Weight Dissolved Organic Matter (H-DOM) analysis (CS and FS), and 3) the sampling of plankton along a transect (LC) (double filtration; mesh sizes 200µm and then 63µm).
Metadata	DNA log: \DY098\event_logs\Emma Isotope log: \DY098\event_logs\Cecilia&Flavia Transect log: \DY098\event_logs\Louise\L_Cornwell_DY098_underway_water_log Digital Event logs: 'UW Pump Isotopes' and 'UW Pump Transect'
Physical samples	The primary repository for physical samples will be the BAS biological store, with the POM, DOC and H-DOM filters eventually being forwarded to ISPRA. Filters were frozen at -20°C (CS and FS), or -80°C (EL and LC).
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Emma Langan, Cecilia Silverstri, Flavia Saccomandi, Louise Cornwell

Dataset	EK60 multi-frequency echosounder
Instrument	Kongsberg Maritime Simrad EK60 scientific echosounder
Description	The EK60 echosounder operated 6 frequencies (18kHz, 38kHz, 70kHz, 120kHz, 200kHz, 333kHz,) and generated data vital for

	locating swarms of Antarctic krill. Acoustic data from both the WCB transects and the SSI transects were recorded as part of the surveys. The ping rate was configured to be every 2 seconds. The EK60 was calibrated on 15-16/01/2019 in Cumberland Bay, South Georgia. There was a fault with the 18kHz transducer and it was not calibrated. Data from it should be treated with caution. The 333kHz transducer was also not calibrated.
Digital data	\Ship_Fitted_Scientific_Systems\Acoustics\EK60\dy098
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding

Dataset	Vessel mounted ADCP
Instruments	Teledyne RD Instruments Ocean Surveyor 75kHz (OS75) VM-ADCP
Description	The OS75 ADCP was employed to measure water current velocities. The ping rate was configured to be every 4 seconds.
Digital data	\Ship_Fitted_Scientific_Systems\Acoustics\OS75kHz\dy098
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding

Dataset	Other underway data from ship-fitted instrumentation
Instruments	Various. Applanix POS MV320 V5 GPS. Surfmet meteorology and surface hydrography suites. WaMoS II wave radar. CLAM system winch log. Simrad EA640 single beam echo sounder.
Description	Underway data streams logged by TechSAS software. For example, Surfmet: sea surface temperature, salinity, wind direction, wind speed. Applanix: ship speed, position. CLAM: wire out. EA640: depth.
Digital data	\Ship_Fitted_Scientific_Systems\TechSAS
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding, any cruise participant

Dataset	P3 deep mooring
Instruments	SBE CTD. RDI ADCP. Seaguard current meters with O_2 sensor. SAMI pH sensor. ProOceanus PCO_2 sensor. Aquamonitor. Sediment trap. PPS Phytoplankton collector.
Description	Recovery 05/01/2019. (Deployed by JR17002) CTD 4548 did not record any depth data. The ADCP was missing. Redeployment 12/01/2019.

	No replacement batteries for Current Meters, so were not redeployed. Only one sediment trap, the deep one, redeployed. PPS Phytoplankton collector new deployment for this year. The Aquamonitor was not redeployed.
Digital data	\DY098\scientific_work_area\Moorings\P3_mooring_JR17002
Physical samples	The primary repository for physical samples will be the BAS biological store. Samples from the Sediment trap were preserved in 4% Formalin. Samples from the Aquamonitor were preserved in either 4% Formalin, 75% ethanol or 0.02% $HgCl_2$.
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding, Gabi Stowasser, Clara Manno

Dataset	WCB mooring
Instruments	SBE CTD. ADCP. SonoVault acoustic recorder. WBAT echosounder.
Description	Recovery 09/2018. (Deployed by JR17002) The mooring released by accident and was retrieved by the Pharos. One CTD recovered, but with no data. ADCP, SonoVault, WBAT and transducer recovered. The SonoVault had only one SD card with retrievable data. Redeployment 23/01/2019. CTD, ADCP, WBAT, SonoVault
Digital data	\DY098\scientific_work_area\Moorings\WCB_mooring_JR17002
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC. Event metadata will be stored within the Marine Metadata Portal developed by the UK Polar Data Centre at BAS.
Users of the data	Sophie Fielding, Gabi Stowasser, Clara Manno

Dataset	Marine mammal observations
Instruments	Two observers on the monkey island (approx. 20.8m above sea level) using angle-boards and Fujinon 7x50 reticule binoculars to estimate range.
Description	Observers reported sightings immediately to a data recorder in the bridge, using PMR radio. Minimum of angle, reticule, species and group size reported. Photographs of sightings were taken whenever possible. Data were recorded on an MS Access database using Logger 2010 v5 software. Position data logged automatically at 10s intervals from a USB GPS input. Environmental variables recorded every 15mins or when changed.
Digital data	\DY098\scientific_work_area\Cetacean survey
Long term data management	Data will be stored on the SAN at BAS and also available from the BODC.
Users of the data	Jennifer Jackson

12. Eventlog

Time (GMT)	Event	Latitude	Longitude	Comment
04/01/2019 15:43	1	-52.4148	-46.325	RMT O/B
04/01/2019 15:49	1	-52.4177	-46.3294	RMT I/B
04/01/2019 16:08	2	-52.4252	-46.3401	RMT O/B
04/01/2019 16:15	2	-52.4272	-46.3441	RMT I/B
04/01/2019 17:19	3	-52.4282	-46.3463	CTD O/B
04/01/2019 17:45	3	-52.4282	-46.3463	CTD @1000m
04/01/2019 18:12	3	-52.4282	-46.3462	CTD I/B
05/01/2019 19:13	4	-52.7979	-40.1955	P3 Mooring recovered on deck
05/01/2019 20:00	5	-52.811	-40.1691	CTD Outboard
05/01/2019 21:09	5	-52.8145	-40.172	Max wire out 3040m
05/01/2019 22:25	5	-52.8202	-40.1764	CTD In Board
05/01/2019 23:42	6	-52.8095	-40.1617	bongo net
05/01/2019 23:45	6	-52.8097	-40.1617	at depth 50 mtrs
05/01/2019 23:48	6	-52.8102	-40.1618	recovered
05/01/2019 23:54	7	-52.8107	-40.1618	bongo net deploy
06/01/2019 00:00	7	-52.8112	-40.1618	recovered
06/01/2019 08:12	8	-53.7288	-38.9694	commence line WCB SS1
06/01/2019 08:12	8	-53.7288	-38.9694	commence line WCB SS1
06/01/2019 09:50	8	-53.7343	-38.5418	complete line WCB SS1
06/01/2019 10:38	9	-53.6492	-38.5343	commence line WCB SS2
06/01/2019 12:16	9	-53.6486	-38.9729	COMPLETE WCBSS2
06/01/2019 12:56	10	-53.5664	-38.9936	START WCBSS3
06/01/2019 14:33	10	-53.5623	-38.5469	COMPLETE WCB SS3
06/01/2019 15:33	11	-53.692	-38.5355	Commence Line WCB SS4
06/01/2019 16:54	11	-53.6918	-38.9181	Break off survey
06/01/2019 17:31	12	-53.6948	-38.8823	RMT Target O/B
06/01/2019 17:39	12	-53.6929	-38.89	RMT Target I/B
06/01/2019 17:47	13	-53.6911	-38.8976	RMT Target O/B
06/01/2019 18:18	13	-53.6831	-38.9279	RMT Target I/B
06/01/2019 20:17	14	-53.7901	-38.5846	RMT O/B
06/01/2019 21:35	14	-53.7567	-38.6261	RMT I/B
06/01/2019 22:39	15	-53.7862	-38.5824	CTD Outboard WCB 2.2S
06/01/2019 22:53	15	-53.7862	-38.5824	max wire out at 193m
06/01/2019 23:04	15	-53.7862	-38.5823	CTD I/B
06/01/2019 23:18	16	-53.7862	-38.5824	BONGO O/B
06/01/2019 23:26	16	-53.7862	-38.5824	BONGO I/B
07/01/2019 02:32	17	-53.4327	-38.6949	CTD O/B
07/01/2019 02:57	17	-53.4327	-38.6949	CTD MAX WIRE 1000mtrs
07/01/2019 03:33	17	-53.4327	-38.695	CTD I/B
07/01/2019 09:06	18	-53.3391	-39.6075	Commence Transect 1.1 (Heading South)
07/01/2019 10:16	19	-53.5245	-39.5497	XBT Deployed
07/01/2019 12:33	20	-53.8776	-39.4446	XBT Deployed
07/01/2019 13:47	18	-54.055	-39.3901	WCB 1.1 S COMPLETE
07/01/2019 15:13	21	-54.0068	-39.094	Commence WCB 1.2S

07/01/2019 21:17	21	-53.3166	-39.3053	Complete line WCB 1.2N
08/01/2019 07:38	22	-53.286	-39.0373	Commence Line WCB 2.1 N
08/01/2019 08:54	23	-53.4643	-38.9829	2.1 XBT 1 Deployed
08/01/2019 11:21	24	-53.816	-38.8744	XBT LAUNCH (FAILED)
08/01/2019 12:34	22	-53.9937	-38.8195	COMPLETE WCB 2.1 N
08/01/2019 13:45	25	-53.9618	-38.5273	START WCB 2.2 S
08/01/2019 18:31	25	-53.2574	-38.7503	End WCB 2.2
08/01/2019 19:58	26	-53.42	-38.6652	RMT O/B
08/01/2019 21:13	26	-53.4351	-38.7469	RMT I/B
09/01/2019 00:19	27	-53.8385	-39.1011	DEPLOY RMT8 NET
09/01/2019 01:08	27	-53.8369	-39.1423	MAX DEPTH 283 mtrs
09/01/2019 01:35	27	-53.8346	-39.17	RECOVER RMT8
09/01/2019 03:04	28	-53.8372	-39.1796	TARGET FISHING O/B
09/01/2019 03:45	28	-53.8083	-39.1596	Target Fishing I/B
09/01/2019 04:40	29	-53.8466	-39.1442	CTD O/B
09/01/2019 04:52	29	-53.8467	-39.1442	CTD @281m
09/01/2019 05:00	29	-53.8467	-39.1442	CTD I/B
09/01/2019 05:36	30	-53.8467	-39.1442	Bongo O/B
09/01/2019 05:47	30	-53.8467	-39.1442	Bongo I/B
09/01/2019 09:35	31	-53.931	-38.2241	commence line WCB 3.1 S
09/01/2019 10:53	32	-53.752	-38.2768	3.1 XBT Deployed
09/01/2019 13:34	33	-53.4041	-38.3907	DEPLOY XBT 3.1 XBT 2
09/01/2019 14:55	31	-53.2206	-38.4501	WCB 3.1 S COMPLETED
09/01/2019 16:13	34	-53.1847	-38.1411	Commence Line WCB 3.2N
09/01/2019 20:30	34	-53.8916	-37.907	Complete line WCB 3.2 S
09/01/2019 22:03	35	-53.734	-37.9565	Bongo O/B
09/01/2019 22:13	35	-53.734	-37.9566	Bongo I/B
09/01/2019 22:38	36	-53.7317	-37.9596	RMT O/B
09/01/2019 23:32	36	-53.7138	-37.9803	RMT I/B
09/01/2019 23:57	37	-53.7196	-37.9689	CTD O/B
10/01/2019 00:09	37	-53.7196	-37.9689	MAX DEPTH 128 MTRS
10/01/2019 00:14	37	-53.7196	-37.9689	CTD I/B
10/01/2019 05:14	38	-53.3611	-38.0806	CTD O/B
10/01/2019 05:41	38	-53.3611	-38.0806	CTD @1000m
10/01/2019 06:03	38	-53.3611	-38.0807	CTD I/B
10/01/2019 08:55	39	-53.1638	-37.9646	cOMMENCE LINE WCB 4.1 N
10/01/2019 10:10	40	-53.3369	-37.9039	4.1 XBT 1 DEPLOYED
10/01/2019 12:46	41	-53.6927	-37.7871	XBT DEPLOYED
10/01/2019 14:01	39	-53.8678	-37.7288	COMPLETE WCB 4.1N
10/01/2019 14:39	42	-53.8527	-37.5942	START LINE WCB 4.2S
10/01/2019 15:56	43	-53.6761	-37.6543	XBT Deployed
10/01/2019 18:27	44	-53.3116	-37.7773	XBT Deployed
10/01/2019 19:34	42	-53.1492	-37.8319	COMPLETE LIN WCB 4.2 N
10/01/2019 19:54	45	-53.143	-37.8276	Bongo O/B
10/01/2019 20:03	45	-53.143	-37.8276	Bongo I/B
10/01/2019 22:18	46	-53.3449	-38.0701	RMT O/B
10/01/2019 23:38	46	-53.3629	-38.1395	RMT I/B

10/01/2019 23:46	47	-53.3641	-38.1453	Bongo O/B
11/01/2019 00:12	47	-53.3636	-38.1451	Bongo I/B
11/01/2019 04:47	48	-53.6536	-37.876	RMT Target O/B
11/01/2019 05:21	48	-53.6521	-37.9089	RMT Target I/B
11/01/2019 15:24	49	-54.0209	-37.4112	CTD O/B
11/01/2019 15:37	49	-54.0209	-37.4112	CTD @112m
11/01/2019 15:49	49	-54.0209	-37.4112	CTD I/B
11/01/2019 17:26	50	-54.0208	-37.4112	WBAT O/B
11/01/2019 18:41	50	-54.0208	-37.4112	WBAT I/B
11/01/2019 18:43	51	-54.0208	-37.4112	Sediment Trap O/B
11/01/2019 18:48	51	-54.0208	-37.4112	Sediment Trap I/B
12/01/2019 13:42	52	-52.8	-40.1585	CTD O/B
12/01/2019 14:56	52	-52.8006	-40.1581	CTD MAX WIRE 3750
12/01/2019 16:22	52	-52.8014	-40.1578	CTD I/B
12/01/2019 19:42	53	-52.8284	-40.1107	COMMENCE P3 DEPLOYMENT
12/01/2019 22:01	53	-52.7987	-40.1587	P3 mooring deployed
13/01/2019 01:12	54	-52.6163	-40.2277	BONGO O/B
13/01/2019 01:37	54	-52.6178	-40.2308	BONGO I/B
13/01/2019 01:56	55	-52.6159	-40.2319	RMT 8 O/B
13/01/2019 03:26	55	-52.5686	-40.252	RMT 8 I/B
13/01/2019 05:50		-52.8177	-39.9332	Commence Line P3W1-P3W2
13/01/2019 08:18		-52.4799	-39.9338	complete line P3 W1 - P3 W2
13/01/2019 10:00		-52.4759	-40.2171	Commence line P3W3-P3W4
13/01/2019 10:00		-52.4759	-40.2171	Commence line P3W3-P3W4
13/01/2019 12:02		-52.8146	-40.2183	COMPLETE LINE P3W3 >P3W4
13/01/2019 14:11		-52.8172	-40.5	START LINE P3W5 >P3W6
13/01/2019 14:12		-52.8155	-40.4999	STOP LINE P3W5 > P3W6 DUE TO HIGH WINDS/ SWELL
15/01/2019 16:32	56	-54.2854	-36.4642	CTD O/B
15/01/2019 16:39	57	-54.2854	-36.4642	Bongo O/B
15/01/2019 16:40	56	-54.2854	-36.4642	CTD @ 128m
15/01/2019 16:50	57	-54.2854	-36.4642	Bongo I/B
15/01/2019 16:53	58	-54.2854	-36.4642	Bongo O/B
15/01/2019 16:56	56	-54.2854	-36.4642	CTD I/B
15/01/2019 17:07	58	-54.2854	-36.4642	Bongo I/B
15/01/2019 17:33	59	-54.2874	-36.4502	Mocness O/B
15/01/2019 18:26	59	-54.2569	-36.4416	Mocness I/B
15/01/2019 19:05		-54.2857	-36.4569	Commence Acoustic Calibration
16/01/2019 03:35		-54.2863	-36.4653	Complete Acoustic Calibration
16/01/2019 17:28	60	-54.2849	-36.4493	Mocness O/B
16/01/2019 17:30	60	-54.2836	-36.4488	Mocness I/B
16/01/2019 17:48	61	-54.2856	-36.4462	Mocness O/B
16/01/2019 18:20	61	-54.2693	-36.4452	Mocness I/B
18/01/2019 11:43	62	-54.2846	-36.4478	NEMO O/B
18/01/2019 12:04	62	-54.271	-36.4437	NEMO I/B
19/01/2019 09:56	63	-54.2512	-36.4413	SEDIMENT TRAP O/B
19/01/2019 10:36	63	-54.255	-36.4418	TRAP ABORTED BACK INBOARD

19/01/2019 16:30	64	-54.2596	-36.4387	Sediment Trap O/B
19/01/2019 16:36	64	-54.2596	-36.4387	Sediment Trap I/B
19/01/2019 17:03	65	-54.2596	-36.4387	Sediment Trap O/B
19/01/2019 17:41	65	-54.2596	-36.4387	Sediment Trap I/B
19/01/2019 18:36	66	-54.2657	-36.444	Sediment Trap O/B
20/01/2019 19:05	66	-54.2658	-36.4438	Sediment Trap I/B
20/01/2019 20:10	67	-54.266	-36.4437	CTD O/B
20/01/2019 20:23	67	-54.266	-36.4437	MAX DEPTH 247 mtrs
20/01/2019 20:33	67	-54.266	-36.4437	CTD I/B
21/01/2019 12:48	68	-54.2763	-36.4465	RMT8 +1 O/B
21/01/2019 13:26	68	-54.2511	-36.4411	RMT8+1 I/B
22/01/2019 18:53	69	-54.287	-36.4671	WBAT O/B
22/01/2019 21:45	69	-54.2871	-36.4665	WBAT I/B
23/01/2019 23:41	70	-53.798	-37.934	WCB MOORING DEPLOY
24/01/2019 12:51	71	-54.1249	-36.2903	CTD O/B
24/01/2019 13:02	71	-54.1249	-36.2903	CTD MAX WIRE OUT
24/01/2019 13:19	71	-54.1248	-36.2903	CTD I/B
24/01/2019 15:15	72	-54.2072	-36.0638	Target Fishing O/B
24/01/2019 16:12	72	-54.1999	-36.1386	Target Fishing I/B
24/01/2019 17:00	73	-54.2328	-36.1272	Target Fishing O/B
24/01/2019 17:40	73	-54.1999	-36.1386	Target Fishing I/B
24/01/2019 23:58	74	-54.5313	-34.615	RMT 8 O/B
25/01/2019 00:40	74	-54.5287	-34.5849	RMT 8 I/B
26/01/2019 02:39	75	-55.2768	-28.8348	CTD O/B
26/01/2019 03:13	75	-55.278	-28.8325	CTD @1500m
26/01/2019 03:58	75	-55.2796	-28.8291	CTD I/B
26/01/2019 11:00		-55.4217	-27.7387	START LINE SAND 14
26/01/2019 13:16	76	-55.663	-27.6626	CTD O/B
26/01/2019 13:43	76	-55.6631	-27.6626	CTD MAX WIRE OUT 1217
26/01/2019 14:22	76	-55.6631	-27.6626	CTD I/B
26/01/2019 14:46	77	-55.6619	-27.667	RMT8 +1 O/B
26/01/2019 14:48	77	-55.6614	-27.669	RMT8+1 I/B
26/01/2019 15:31	78	-55.6525	-27.7065	RMT8 +1 O/B
26/01/2019 16:51	78	-55.631	-27.7563	RMT8+1 I/B
26/01/2019 17:35		-55.6525	-27.6612	Resume Transect
26/01/2019 21:56		-56.2773	-27.4512	End line 12
26/01/2019 22:32		-56.3092	-27.284	STAERT LINE SAND 10
27/01/2019 00:51	79	-56.4152	-27.0174	RMT8 +1 O/B
27/01/2019 02:18	79	-56.4121	-27.0871	RMT8+1 I/B
27/01/2019 02:43	80	-56.4121	-27.0875	CTD O/B
27/01/2019 03:19	80	-56.4121	-27.0875	CTD @1500m
27/01/2019 04:07	80	-56.4121	-27.0875	CTD I/B
27/01/2019 04:20	81	-56.4121	-27.0875	Bongo O/B
27/01/2019 04:48	81	-56.4121	-27.0874	Bongo I/B
27/01/2019 06:20		-56.4233	-27.1767	Resume Transect line Sand 10
27/01/2019 12:36		-57.1808	-26.988	FINISH LINE SAND SAND 10
27/01/2019 13:11	82	-57.1873	-27.0606	CTD O/B

27/01/2019 13:48	82	-57.1873	-27.0606	CTD MAX WIRE OUT 1500
27/01/2019 14:28	82	-57.1874	-27.0606	CTD I/B
27/01/2019 15:01	83	-57.1881	-27.0679	RMT8 +1 O/B
27/01/2019 16:35	83	-57.2178	-27.1456	RMT8+1 I/B
27/01/2019 17:38		-57.1992	-27.2322	Commence Transect Sand 8
28/01/2019 04:19		-58.0787	-26.9146	Complete Transect
28/01/2019 04:48		-58.1266	-26.9128	Commence Transect Sand 5
28/01/2019 14:02	84	-59.2113	-26.1497	CTD O/B
28/01/2019 14:36		-59.2113	-26.1498	Clump Weight O/B
28/01/2019 14:43	84	-59.2113	-26.1497	CTD @1500m
28/01/2019 15:15		-59.2113	-26.1497	Clump Weight I/B
28/01/2019 15:24	84	-59.2113	-26.1497	CTD I/B
28/01/2019 15:45	85	-59.2116	-26.1537	RMT8 +1 O/B
28/01/2019 17:15	85	-59.2146	-26.2247	RMT8+1 I/B
28/01/2019 17:33	86	-59.2131	-26.2369	NEMO O/B
28/01/2019 17:58	86	-59.211	-26.2637	NEMO I/B
28/01/2019 17:58	86	-59.211	-26.2637	NEMO I/B
28/01/2019 17:58	86	-59.211	-26.2637	NEMO I/B
28/01/2019 18:19	87	-59.21	-26.2667	Bongo O/B
28/01/2019 18:28	87	-59.21	-26.2667	Bongo I/B
28/01/2019 18:31	88	-59.21	-26.2667	Bongo O/B
28/01/2019 18:45	88	-59.21	-26.2667	Bongo I/B
28/01/2019 18:49	89	-59.21	-26.2667	Bongo O/B
28/01/2019 18:59	89	-59.21	-26.2667	Bongo I/B
28/01/2019 19:41		-59.204	-26.1473	Rejoin Survey line Course 168(T)
28/01/2019 23:25		-59.8128	-25.9017	finish line sand1
28/01/2019 23:44	90	-59.8233	-25.8925	Bongo O/B
28/01/2019 23:51	90	-59.8231	-25.8934	BONGO I/B
29/01/2019 00:04	91	-59.8228	-25.8943	Bongo O/B
29/01/2019 00:04	91	-59.8228	-25.8943	RECOVER SHIP LOST GPS POSN FAILED DEPLOY
29/01/2019 00:07	92	-59.8229	-25.8942	Bongo O/B
29/01/2019 00:17	92	-59.8224	-25.8961	BONGO I/B
29/01/2019 15:02		-58.392	-23.8015	Commence Transect SSA9
29/01/2019 23:32	93	-57.4694	-24.2214	RMT8 O/B
30/01/2019 00:09	93	-57.4612	-24.2127	RMT8 I/B DEPTH SENSOR PROBLEM
30/01/2019 01:19	94	-57.4493	-24.2085	CTD O/B
30/01/2019 02:17	94	-57.4494	-24.2084	CTD @3000m
30/01/2019 03:43	94	-57.4494	-24.2085	CTD I/B
30/01/2019 10:00		-57.6085	-25.6122	START LINE SSB7
30/01/2019 12:00		-57.9338	-25.4807	FINISH LINE SSB7
30/01/2019 12:52		-57.9515	-25.6662	START LINE SSB6
30/01/2019 18:14		-58.883	-25.305	END LINE SSB4
30/01/2019 18:49		-58.8417	-25.4217	START LINE SSB3
30/01/2019 22:00	95	-59.2128	-25.2907	RMT8 O/B
30/01/2019 22:59	95	-59.1723	-25.2942	RMT8 I/B
30/01/2019 23:30	96	-59.1513	-25.2978	NEMO O/B

30/01/2019 23:52	96	-59.1361	-25.2962	NEMO I/B
31/01/2019 00:11	97	-59.1216	-25.2944	RMT8 O/B
31/01/2019 01:32	97	-59.0644	-25.289	RMT8 I/B
31/01/2019 02:30	98	-59.0316	-25.2536	CTD O/B
31/01/2019 03:05	98	-59.0317	-25.2537	CTD @1500m
31/01/2019 03:47	98	-59.0317	-25.2537	CTD I/B
31/01/2019 03:53	99	-59.0317	-25.2537	Bongo O/B
31/01/2019 04:03	99	-59.0317	-25.2537	Bongo I/B
31/01/2019 13:39	100	-58.0221	-23.9604	CTD O/B
31/01/2019 14:13	100	-58.0221	-23.9604	CTD @1500m
31/01/2019 14:53	100	-58.0221	-23.9604	CTD I/B
31/01/2019 15:21	101	-58.0213	-23.9666	RMT8 +1 Stratified O/B
31/01/2019 17:11	101	-58.0146	-24.0864	RMT8 +1 Stratified I/B
31/01/2019 19:09		-57.9933	-23.985	commence line SSA8
31/01/2019 23:54	102	-57.2671	-24.3324	NEMO O/B
01/02/2019 00:17	102	-57.2668	-24.3518	NEMO I/B
01/02/2019 00:34	103	-57.2659	-24.3709	RMT8 O/B
01/02/2019 01:58	103	-57.2575	-24.4646	RMT8 I/B
01/02/2019 02:20	104	-57.2568	-24.4765	Bongo O/B
01/02/2019 02:33	104	-57.2568	-24.4765	Bongo I/B
01/02/2019 02:50	105	-57.2568	-24.4765	CTD O/B
01/02/2019 03:06	105	-57.2568	-24.4765	CTD @400m
01/02/2019 03:27	105	-57.2568	-24.4765	CTD I/B
01/02/2019 13:14	106	-56.1901	-24.7764	CTD O/B
01/02/2019 13:45	106	-56.1901	-24.7764	CTD MAX WIRE OUT 1500
01/02/2019 14:22	106	-56.1901	-24.7765	CTD I/B
01/02/2019 14:43	107	-56.2119	-24.8321	RMT Stratified O/B
01/02/2019 16:15	107	-56.2271	-24.863	RMT Stratified I/B
01/02/2019 23:10	108	-55.2221	-25.1586	NEMO O/B
01/02/2019 23:33	108	-55.2314	-25.1748	NEMO I/B
01/02/2019 23:53	109	-55.2407	-25.1902	RMT8 O/B
02/02/2019 01:32	109	-55.2846	-25.2611	RMT8 I/B
02/02/2019 01:46	110	-55.2873	-25.2659	BONGO O/B
02/02/2019 01:58	110	-55.2886	-25.2639	BONGO I/B
02/02/2019 02:22	111	-55.289	-25.2634	CTD O/B
02/02/2019 02:49	111	-55.2889	-25.2634	CTD @1500m
02/02/2019 03:28	111	-55.2889	-25.2634	CTD I/B
02/02/2019 13:28	112	-54.1309	-25.5646	CTD O/B
02/02/2019 13:58	112	-54.1309	-25.5646	CTD MAX WIRE OUT 1500
02/02/2019 14:41	112	-54.1309	-25.5646	CTD I/B
02/02/2019 15:01	113	-54.1334	-25.5673	RMT Stratified O/B
02/02/2019 16:17	113	-54.1618	-25.6009	RMT Stratified I/B
02/02/2019 23:23	114	-54.3964	-27.1175	RMT8 O/B
03/02/2019 00:50	114	-54.4299	-27.176	RMT8 I/B
03/02/2019 01:00	115	-54.4313	-27.1784	BONGO O/B
03/02/2019 01:13	115	-54.4328	-27.1766	BONGO I/B
03/02/2019 01:31	116	-54.433	-27.1763	CTD O/B

03/02/2019 02:02	116	-54.4347	-27.1733	CTD MAX WIRE OUT 1500
03/02/2019 02:41	116	-54.4371	-27.1691	CTD I/B
03/02/2019 02:49	117	-54.4377	-27.1697	NEMO O/B
03/02/2019 03:10	117	-54.4499	-27.179	NEMO I/B
03/02/2019 04:46		-54.4983	-27.3094	Commence Transect SSB16
03/02/2019 13:07	118	-55.6467	-26.7682	CTD O/B
03/02/2019 13:35	118	-55.6467	-26.7682	CTD MAX WIRE OUT 1500
03/02/2019 14:13	118	-55.6467	-26.7682	CTD I/B
03/02/2019 14:35	119	-55.652	-26.7784	RMT Stratified O/B
03/02/2019 16:09	119	-55.6929	-26.8654	RMT Stratified I/B
03/02/2019 16:34	127	-55.6943	-26.8686	Bongo O/B
03/02/2019 16:45	127	-55.6947	-26.8677	Bongo I/B
03/02/2019 21:09	120	-56.1106	-26.6015	RMT O/B
03/02/2019 22:05	120	-56.145	-26.59	RMT8 I/B
03/02/2019 22:35	121	-56.1468	-26.5889	RMT 8 O/B
03/02/2019 23:00	121	-56.1277	-26.5954	RMT8 I/B
03/02/2019 23:17	122	-56.1146	-26.6	NEMO O/B
03/02/2019 23:42	122	-56.0978	-26.6068	NEMO I/B
03/02/2019 23:53	123	-56.0971	-26.6068	BONGO O/B
04/02/2019 00:04	123	-56.0971	-26.6068	BONGO I/B
04/02/2019 00:22	124	-56.0974	-26.6126	RMT8 O/B
04/02/2019 02:13	124	-56.1092	-26.7395	RMT8 I/B
04/02/2019 02:28	125	-56.109	-26.7409	CTD O/B
04/02/2019 02:57	125	-56.1088	-26.7409	CTD @1500m
04/02/2019 03:31	125	-56.1088	-26.7409	CTD I/B
04/02/2019 13:10	126	-57.1594	-25.7965	CTD O/B
04/02/2019 13:40	126	-57.1594	-25.7965	CTD MAX WIRE OUT 1500
04/02/2019 14:19	126	-57.5227	-25.6442	CTD I/B
04/02/2019 14:39	128	-57.1605	-25.8033	RMT Stratified O/B
04/02/2019 15:55	128	-57.174	-25.8909	RMT Stratified I/B
04/02/2019 21:24	129	-57.9383	-25.4867	NEMO O/B
04/02/2019 21:50	129	-57.9472	-25.5075	NEMO I/B
04/02/2019 21:58	130	-57.9477	-25.5088	BONGO O/B
04/02/2019 22:13	130	-57.9477	-25.5088	BONGO I/B
05/02/2019 10:46		-59.3946	-27.6096	START TRANSECT THULE 1
05/02/2019 13:09	131	-59.016	-27.7611	CTD O/B
05/02/2019 13:45	131	-59.016	-27.7611	CTD MAX WIRE OUT 1500
05/02/2019 14:25	131	-59.016	-27.7611	CTD I/B
05/02/2019 14:42	132	-58.9769	-27.7939	RMT Stratified O/B
05/02/2019 16:10	132	-58.9778	-27.7937	RMT Stratified I/B
05/02/2019 23:05	133	-58.0659	-28.1142	NEMO O/B
05/02/2019 23:29	133	-58.0724	-28.134	NEMO I/B
05/02/2019 23:46	134	-58.077	-28.1524	RMT8 O/B
06/02/2019 00:56	134	-58.0905	-28.2281	RMT8 I/B
06/02/2019 01:11	135	-58.0915	-28.2324	BONGO O/B
06/02/2019 01:30	136	-58.0915	-28.2324	CTD O/B
06/02/2019 01:31	135	-58.0915	-28.2324	BONGO IB

06/02/2019 02:01	136	-58.0915	-28.2324	CTD @1500m
06/02/2019 02:41	136	-58.0915	-28.2325	CTD I/B
06/02/2019 13:11	137	-56.8718	-28.4921	CTD O/B
06/02/2019 13:40	137	-56.872	-28.4921	CTD MAX WIRE OUT 1500
06/02/2019 14:16	137	-56.872	-28.4921	CTD I/B
06/02/2019 14:28	138	-56.872	-28.492	Bongo O/B
06/02/2019 14:44	138	-56.8726	-28.4904	Bongo I/B
06/02/2019 14:55	139	-56.8733	-28.4927	RMT Stratified O/B
06/02/2019 16:11	139	-56.8905	-28.5241	RMT Stratified I/B
06/02/2019 21:19	140	-56.3001	-28.6312	RMT O/B
06/02/2019 22:27	140	-56.3244	-28.6758	RMT I/B
06/02/2019 22:42	141	-56.3287	-28.6845	NEMO O/B
06/02/2019 23:04	141	-56.3344	-28.6971	NEMO I/B
06/02/2019 23:19	142	-56.3391	-28.7085	RMT8 OB
07/02/2019 00:39	142	-56.3608	-28.7683	RMT8 I/B
07/02/2019 01:13	143	-56.3641	-28.7758	BONGO I/B
07/02/2019 01:19	144	-56.364	-28.7758	CTD O/B
07/02/2019 01:51	144	-56.364	-28.7758	CTD MAX WIRE OUT 1500
07/02/2019 02:31	144	-56.3639	-28.7758	CTD I/B
07/02/2019 12:43	145	-55.2722	-28.9676	NEMO O/B
07/02/2019 13:05	145	-55.2662	-28.9799	NEMO I/B
07/02/2019 13:11	146	-55.2657	-28.9797	CTD O/B
07/02/2019 13:42	146	-55.2657	-28.9797	CTD MAX WIRE OUT 1500
07/02/2019 14:22	146	-55.2718	-29.0319	CTD I/B
07/02/2019 14:24	147	-55.2719	-29.0323	Bongo O/B
07/02/2019 14:44	147	-55.2656	-28.9797	Bongo I/B
07/02/2019 15:00	148	-55.2721	-29.0335	RMT Stratified O/B
07/02/2019 16:44	148	-55.2803	-29.0823	RMT Stratified I/B

Table 37 DY098 eventlog

Appendix 1 NMF Ship systems cruise report *Andrew Moore & Nick Harker*