JR19002 Cruise Report

ICEBERGS – RACETRAX – AEROBICS – FaNFARE – SWINC – MicroANT – ECCOMAP – MMA

Report Authors

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13th January – 4th February 2020 Rothera - Stanley (FI)

Front cover caption: Sheldon Cove, January 2020 (photo: Mike Meredith)

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Acknowledgements

JR19002 would not have been successful without all the help on board! Thank you to the officers, engineers and crew of RRS *James Clark Ross*. The science party offer a special thank-you to the AMEs (Seth, Gareth and the two Toms), technicians, and crew for keeping the operations running, notably the CTD, multibeam and multicorer, all of which required significant attention during the cruise. We would also like to thanks the officers, engineers and crew for enabling us to get up close to the ice edge in some difficult conditions, and for enabling the small boat work. All projects on board would also like to offer special thanks to Lab Manager Aisling Smith who was absolutely amazing at getting all the projects up and running, as well as deftly coordinating an impossible amount of cargo paperwork.

The RACETRAX team offer special thanks to Tobias, Carmen, Marina, Chris, Mike, Seth and Tom for deploying the endless CTDs to get our water from where we wanted it! Many thanks to the army of water-carriers, those who helped with fiber preparation, Tom for engineering some missing equipment for us, and Kate for supporting the need for small boat work and facilitating the logistics. We are very grateful to the ICEBERGS project for the opportunity to sample this remote, understudied and important region! This work is supported by NERC Independent Research Fellowship NE/P017630/1 (Amber Annett), INSPIRE Doctoral Training Programme (Rhiannon Jones), CASS-177 (FAnFARE; Oliver Flanagan), and CASS-179 (AEROBICS; Mehul Vora).

Tristyn Garza acknowledges that her project was funded by the University of West Florida Hal Marcus College of Science and Engineering Dean’s Office, the University of West Florida Department of Biology and the University of West Florida Alumni Association.

1 Objectives

JR19002 on the RRS *James Clark Ross* integrated science from four funded programs, three CASS programs and several bolt-on collaboration projects. It included scientists from 14 institutes across the UK, US, Chile, Italy, Japan, Norway and Falkland Islands. The work on board started in Sheldon Cove, Rothera, following base resupply and the laying of a mooring for the RaTS project (Mark Barham, BAS). The main components of the expedition were the final legs of the ICEBERGS and RACETRAX programs reoccupying the west Antarctic Peninsula fjord sites in Sheldon Cove (Rothera, Adelaide Island), Börgen Bay (Anvers Island) and Marian Cove (King George Island) sampled in 2017 and 2018. For the first time, small boat work was undertaken as part of ICEBERGS and RACETRAX in all three fjords. ICEBERGS is a 3 year NERC-CONICYT funded grant to University of Concepción (Chile), University of Exeter, Bangor University and BAS. The project aims to better understand through quantitative sampling the effects of glacial retreat on marine biological systems. The diverse team includes marine geologists and geophysicists, marine geochemists, biochemists, marine ecologists, oceanographers, evolutionary biologists and hydrographers. The DEEP IMPACT project (Dr Dave Barnes) seeks to quantify iceberg scouring frequency below diving depths and a bathymetric survey for this project was undertaken in Sheldon Cove at the start of the cruise. In the early stages of preparation, the RACETRAX project, written to integrate into ICEBERGS, was awarded to Dr Amber Annett (University of Southampton), further diversifying the scope of ICEBERGS. The RACETRAX project aims to identify and characterise the nutrient mineral availability and origins in each of the fjord systems. Two CASS projects were linked to the RACETRAX project on JR19002: AEROBICS, an investigation of Antarctic eukaryotic adaptations and response to oxygen in benthic interstitial communities (Dr Mehul Vora), and FAnFARE, a project to generate the first direct measurements of sedimentary Fe flux along the west Antarctic Peninsula using the $^{224}Ra/^{228}Th$ disequilibrium method (Oliver Flanagan). An additional CASS project (Dr Carmen Falagan-Rodriguez) linked to ICEBERGS investigated the response of the microbiology of Antarctic fjords to freshwater flux and likely microbiological responses to increases in freshwater associated with ongoing deglaciation.

Several small self-funded projects completed the diverse science conducted on board. A continuation of the microplastics project (from filtered water and sediment cores) was undertaken by Tristyn Garza on behalf of Dr Alexis Janosik (University of West Florida). Julian Blumenroeder (University of Hull) sampled meiofauna from recovered multicores to investigate the physiological impact of internal microplastics within key species. Professor Mark Furze continued the micropalaeontological sampling undertaken in 2017 and 2018 on behalf of Dr Anna Pieńkowski (University Centre on Svalbard). Tobias Ehmen (University of Exeter) undertook an investigation of the seismic oceanography of the fjord systems, following calibration of the EK80 multibeam at Börgen Bay, linked to the research on turbulence by his PhD supervisor Katy Sheen who sailed in 2017 and 2018. Felipe Salas de Freitas (University of Bristol) investigated the oxygen profiles of recovered multicores on behalf of the ICEBERGS team.

The cruise ended with continuation of the marine bathymetric survey and benthic sampling along the Burdwood Bank initiated in 2018 as part of a Darwin Plus funded project involving the South Atlantic Environment Research institute (SAERI) and British Antarctic Survey (BAS). The aim was to gather data to help inform management decisions regarding Falkland Island Government marine spatial planning. The two expert marine geophysical scientists on board as part of the ICEBERGS program were key in maximising the data quality collected over the limited time of the survey.

In summary, apart from some sampling limitations in Börgen Bay as a result of two major ice front collapses during our visit there, and despite extremely poor IT connectivity throughout, the cruise achieved all the predetermined scientific objectives and exceeded expectations for most collectors. This is largely down to the excellent cooperation between the ship’s crew and the scientists on board.

RRS *James Clark Ross* in Börgen Bay, January 2020 (Photo: Mark Furze)

2 List of Personnel

James Scourse	U.Exeter	Principal Science Officer and PI ICEBERGS
Amber Annett	University of Southampton	PI RACETRAX
Stella Alexandroff	University of Exeter	Sclerochronologist
David Barnes	BAS	Marine Biologist
Julian Blumenroeder	University of Hull	Microplastics
Chris Bull	BAS	Oceanographer
Paul Butler	University of Exeter	Sclerochronologist
Marina Costa	SAERI	Cetacean Biologist
Ander De Leccea	SAERI	Marine Biologist
Tobias Ehmen	University of Exeter	Oceanographer
Carmen Falagan Rodriguez	University of Exeter	Microbiologist
Oliver Flanagan	University of Southampton	RACETRAX: Biogeochemist
Gareth Flint	BAS	Marine Engineer
Alice Frémand	BAS	Geophysics Data Manager
Mark Furze	UNIS, Svalbard, Norway	Polar Geomorphologist
Tristyn Garza	University of West Florida, USA	Microplastics
Tom Gillum-Webb	BAS	Mechanical Engineer
Fabian Guzman	University Concepción, Chile	Marine Biologist
Alice Guzzi	University of Genoa	Marine Biologist
Rhiannon Jones	University of Southampton	RACETRAX: Biogeochemist
Mike Meredith	BAS	Oceanographer
Thomas Moore	Sky News Team	Journalist
Carlos Munoz Ramirez	University Concepción, Chile	Molecular Biologist
Livia Oldland	BAS	Communication manager
Tom Owen	BAS	Electronic Engineer
Davis Rees	Sky News Team	Cameraman
Kate Retallick	University of Bangor	Hydrographic Surveyor
Alejandro Roman Gonzalez	University of Exeter	Sclerochronologist
Felipe Salles de Freitas	University of Bristol	Biogeochemist
Chester Sands	BAS	Marine Biologist
Kotaro Shirai	University of Tokyo, Japan	Sclerochronologist
Aisling Smith	BAS	Lab Manager
Seth Thomas	BAS	Mechanical Engineer
Tamara Trofimova	NORCE, Norway	Sclerochronologist
Sean Vincent	BAS	IT
Mehul Vora	Rutgers University, USA	Genomics

3 Timetable of events

The following tables gives a day-to-day narrative of JR19002 cruise events. Time given in UTC.

Date	Narrative
30 December 2019	Science party arrives on board of JCR
31 December 2019	6:15 UTC Departure from Punta Arenas to Rothera. Good weather and sea conditions. First set up of the multibeam.
1 January 2020	Transit: Good weather condition. Getting stronger towards the night.
2 January 2020	Transit: Start running EM122 at 12:24 UTC. Swell height 3-4 meters.
3 January 2020	Transit: Multibeam bathymetry running. Swell height 2-3 meters. Sea state: 5 in the morning to 2 in the evening.
4 January 2020	Transit: 14:30 CTD deployment. The LADCP master probe was not working. Fixed for next deployment. 16:00 UTC: multibeam Patch Test. 18:13 UTC: Arrive at Rothera.
5 January 2020	Rothera: cargo, exchange passengers, labelling exercise
6 January 2020	Rothera: finishing labelling, moving boxes…
7 January 2020	Rothera: refuelling. Lab induction. Bubble room set up.
8 January 2020	Rothera: New labelling exercise
9 January 2020	Rothera: Visit of the research station in groups
10 January 2020	Rothera: Labelling exercise
11 January 2020	Rothera: AM: Science meeting. Strong wind
12 January 2020	Rothera: 11:55 to 15:06 UTC: Mooring deployment.
13 January 2020	Sheldon Cove: CTD and N70 deployments from 03:12 UTC
14 January 2020	Sheldon Cove: CTD and N70. Multibeam
15 January 2020	Sheldon Cove: SUCS, Multicorer and in the night Hamon Grab
16 January 2020	Sheldon Cove: Hamon grab, Aggassiz Trawl, SUCS, small boat and multibeam
17 January 2020	Sheldon Cove: SUCS, Multibeam and Multicorer.
18 January 2020	Sheldon Cove: Multibeam. Pourquoi Pas Island: Camera. Departure to Börgen Bay. Launch of Argo float at 23:55 UTC.
19 January 2020	15:54 UTC: Arrive at Börgen Bay. CTD, N70
20 January 2020	Börgen Bay: Small boat, Van veen Grab, CTD, N70
21 January 2020	Börgen Bay: CTD, N70, Hamon Grab, AGT, SUCS and calibration of EK80 The ice front collapsed at 09:30 UTC. It enabled the ship to go too close to shore.
22 January 2020	Börgen Bay: Multibeam, CTD, SUCS, Multicorer
23 January 2020	Börgen Bay: Multibeam, SUCS¸ Multicorer. 20:40 UTC: Departure for Marian Cove
24 January 2020	Transit to Marian Cove. Arrival: 16:00 UTC. CTD, N70
25 January 2020	Marian Cove: CTD, N70, multibeam, small boat.
26 January 2020	Marian Cove: Hamon Grab, AGT, SUCS, multicorer
27 January 2020	Marian Cove: Multibeam, SUCS, Multicorer
28 January 2020	Marian Cove: Visit of King Sejong station. 17:20 UTC, Departure from Marion Cove
29 January 2020	AM: Visit of Deception Island. PM: Transit to Burdwood Bank
30 January 2020	Transit to Burdwood Bank.
31 January 2020	AM: Transit to Burdwood Bank. 15:00 UTC Arrive to Burdwood Bank. Bad weather. Start science at 17:30 UTC. CTD, N70, SUCS
1 February 2020	Burdwood Bank: multibeam not working. CTD, SUCS, AGT
2 February 2020	Burdwood Bank: TOPAS, AGT, N70 net, CTD
3 February 2020	Burdwood Bank: TOPAS, multibeam, SUCS, N70.
4 February 2020	Transit from Burdwood Bank to the Falklands.

VISITS	PASSAGE + LOGISTICS	BATHYMETRY SURVEY	SCIENCE DEPLOYMENT

2020	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	30	31	1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	30	31	1	2
February	3	4	5	6			

4 Working area

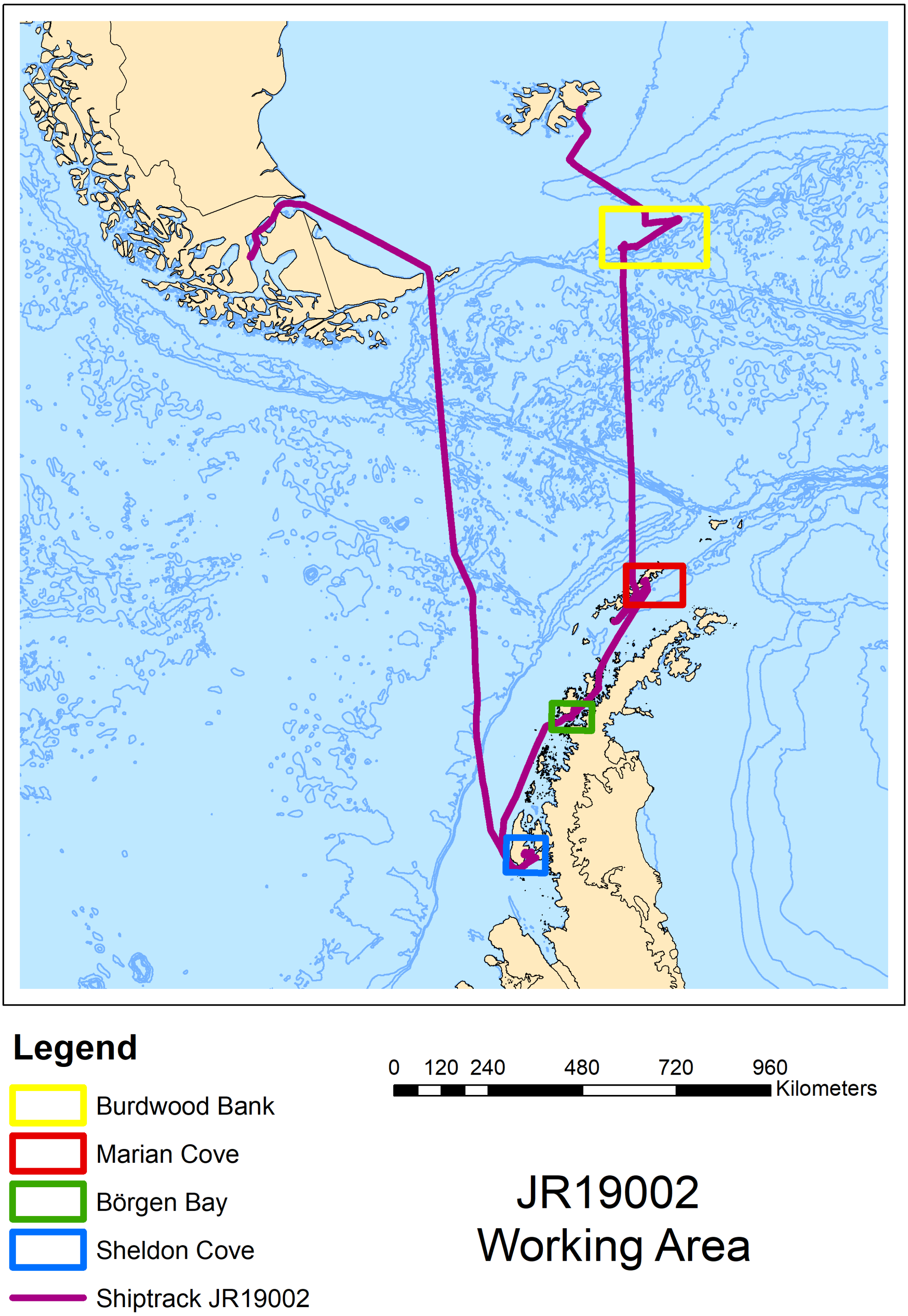

Figure 4-1 JR19002 working area

5 Introduction

5.1 IMPACTS OF DEGLACIATION ON BENTHIC MARINE ECOSYSTEMS IN ANTARCTICA ("ICEBERGS")

Professor James Scourse, PI, University of Exeter, UK

5.1.1 INTRODUCTION

Surface waters around the West Antarctic Peninsula (WAP) are experiencing rapid warming (e.g. Meredith and King 2005, Vaughan et al. 2013) resulting in retreating glaciers, collapse of ice shelves and lengthening of the sea-ice melting season (e.g. Cook et al. 2005, Stammerjohn et al. 2012). Increased iceberg scouring (Barnes and Souster 2011) and sediment discharge (Sahade et al. 2015) are the dominant physical disturbances impacting the shallow benthos of West Antarctica. However, sea ice losses over West Antarctica's continental shelves have also lead to longer phytoplankton blooms, resulting in growth increases by benthos and thus increased (blue) carbon capture and storage on the seabed – the largest negative feedback on climate change (Barnes et al. 2016, 2020). Given the lack of scientific knowledge of the Antarctic coastal ecosystems it is difficult to predict present and future responses of these ecosystems to regional warming. There is an urgency to, first, evaluate the real changes in environmental variables due to this disturbance, and second, estimate the magnitude and direction of ecosystem responses at different biological levels and spatial scales to regional warming. In addition, it is important to develop new tools to detect disturbance. These new data will allow quantification of the impact of regional warming in Antarctica and inform conservation and management strategies. **In this context, ICEBERGS aims to investigate the impacts of physical disturbance arising from climate-warming induced deglaciation on benthic communities around the West Antarctic Peninsula. We adopt a multidisciplinary approach across nested scales from individual to ecosystem level, and from an ecological to evolutionary scale, evaluating genetic, physiological, population, community and ecosystem impacts of this deglacial perturbation. In addition, we use sclerochronology to develop biological proxies for reconstructing multidecadal environmental changes in Antarctica.**

The overall aim of the ICEBERGS project is guided by the **general hypothesis** that *ice loss and deglaciation in the Antarctic Peninsula due to regional warming will have significant impacts on glacier dynamics, local coastal oceanographic conditions and the benthic coastal marine biota. These effects are observed from the individual to ecosystem level.* At the **assemblage level,** we test the hypothesis that *the combined disturbance effects of glacier retreat, loss of winter sea ice and disintegration of ice shelves generate assemblage-wide effects on the diversity and dominance patterns of benthic assemblages modulated by the differential resistance of species, leading to major shifts in community structure according to perturbation strength (magnitude of glacier retreat).* At the **individual level,** we test the hypothesis that ***i**ce loss and deglaciation affect the coastal environmental conditions in terms of temperature, salinity, turbidity and primary productivity affecting individual performance and reproductive investment. These effects are recorded temporally in the shell increments of marine invertebrate species*. At the **evolutionary level,** we test the hypothesis that *ice loss and deglaciation perturbations affect genetic diversity and population connectivity of marine benthic species, especially in species with low dispersal potential (brooding species).*

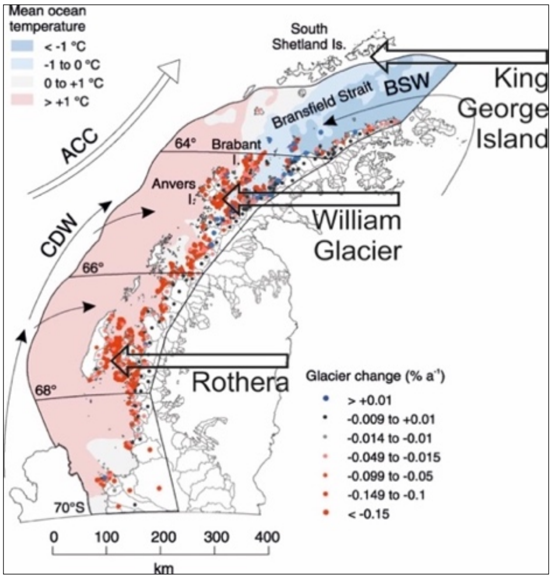

Figure 5-1 Field sites for sample collection (base map from Cook et al., 2016)

The **general objective** of ICEBERGS is *to assess the effects of ice loss and deglaciation on coastal marine habitats from the individual to the ecosystem level*. **Specific objectives are:**

1. Monitoring glacier retreat over time and scour intensity on the adjacent seabed.
2. Determine the benthic assemblage structure from localities with different perturbation levels.
3. Evaluate nutritional and reproductive conditions of adults.
4. Analyse growth rates from bivalve/ gastropod shells and bryozoan populations with different perturbation levels.
5. Develop reconstructions of physical disturbance due to iceberg discharge from growth patterns present in the carbonate structure of the shells of marine molluscs.
6. Estimate the effect of marine glacier discharge and iceberg scouring on the genetic diversity and connectivity of marine invertebrate populations and the role of dispersal potential.

In order to achieve these objectives ICEBERGS has deployed from RRS *James Clark Ross,* physical oceanographic (CTD), marine geophysics (multi-beam swath bathymetry, TOPAS sub-bottom profiling) and habitat mapping (shallow underwater camera system) instrumentation, alongside water column (plankton net) and bottom sampling (Agassiz trawl, Hamon grab, multi-corer) gear for determining and sampling seabed sediments, community structure and benthic biodiversity at three actively deglaciating fjord sites along the west Antarctic Peninsula during three field seasons starting in 2017 (Figure 5-1). These sites, Marian Cove (Maxwell Bay, King George Island, South Shetland Islands), William Glacier (Börgen Bay, Anvers Island) and Sheldon Glacier (Sheldon Cove, Ryder Bay, Adelaide Island adjacent to the BAS base at Rothera) have been selected on the basis of the availability of pre-existing bathymetric (multibeam swath bathymetry) and glacier retreat data from satellite observations (e.g. Cook et al., 2016).

During the 2019 research cruise six satellite projects took advantage of the ICEBERGS opportunity and, independently funded, these have allowed additional specialist personnel (and additional equipment) to participate in the cruise in turn conferring significant additional capability and data for the core ICEBERGS project. These are 1**: Characterisation of the impacts of microplastic ingestion by Southern Ocean filter-feeders (Alexis Janosik, West Florida University, USA; represented on JR19002 by Tristyn Garza)**, 2**. The physiological impact of internal microplastics within key meiofaunal species (Julian Blumenroeder, University of Hull)**, 3. **An investigation of the seismic oceanography of the fjord systems (Tobias Ehmen, University of Exeter), following calibration of the EK80 multibeam at Börgen Bay, linked to the research on turbulence by his PhD supervisor Katy Sheen who sailed in 2017 and 2018,** 4. **An investigation of the oxygen profiles of recovered multicores (Felipe Sales de Freitas, University of Bristol)**, 5. **A CASS project (Carmen Falagan-Rodriguez, University of Exeter) investigated the response of the microbiology of Antarctic fjords to freshwater flux and likely microbiological responses to increases in freshwater associated with ongoing deglaciation,** and 6. **Biological and biogeochemical proxy calibration of deglaciating environments in Antarctica (Anna Pieńkowski, University Studies on Svalbard [UNIS], Norway, represented on JR19002 by Mark Furze).** Projects 1, 3 and 6 are continuations of satellite projects initiated alongside ICEBERGS in 2017 and 2018.

Barnes and Souster 2011 *Nature Climate Change* 1, 365-368
Barnes et al. 2016 *Global Change Biology* 22, 1110-1120
Barnes et al. 2020 *Global Change Biology* 26, 2750–2755
Cook et al. 2005 *Science* 22 541-544
Cook et al. 2016 *Science 353* 283-286
Meredith and King 2005 *Geophysical Research Letters* 32 L19604
Sahade et al. 2015 *Science Advances* 1, doi: 10.1126/sciadv.1500050
Stammerjohn et al. 2012 *Geophysical Research Letters* 39 L06501
Vaughan et al. 2013 *Climate Change 2013: The Physical Science Basis. IPCC* 317-382

5.1.2 BOTTOM WATERS AND SURFACE SEDIMENTS OXYGEN CONCENTRATIONS

Dr Felipe Sales de Freitas, University of Bristol, UK

Oxygen plays a crucial role on biogeochemical processes as a powerful terminal electron acceptor for heterotrophic organic matter degradation and for the re-oxidation of reduced species (e.g., NH_4^+, Mn^{2+}, Fe^{2+}, H_2S) produced during organic matter respiration (e.g. Arndt et al. 2013; Hülse et al. 2017). Oxygen concentrations at the sediment-water interface and its penetration depth in the uppermost sediment layers have a strong impact on organic matter burial (e.g. Hoefs et al. 2002; Sinninghe Damsté et al. 2002) and nutrient cycling. Further, oxygen penetration depth in the sediment strongly influences the depth distributions of microbial communities, especially of those having exclusive aerobic respiration which are usually restricted to the uppermost, well-ventilated sediment layers. Oxygen penetrates into sediments mainly through molecular diffusion from bottom waters. Additionally, the activity of benthic animals can significantly impact oxygen penetration and depth zonation through bioturbation and bioirrigation (e.g. Aller 1994; Aller and Aller 1998). Bioturbation results from sediment mixing by infaunal organisms and can be described as a diffusive process. Bioirrigation is considered a non-local process and results from animals building burrows and tubes which are used to exchange water between sediments and bottom waters. Bioirrigation usually produces oxygenated micro-environments surrounding tubes and burrows, which are distinct from adjacent sediments (e.g. Burdige 2006).

Direct oxygen measurements at the sediment-water interface in Antarctic environments are scarce, especially within retreating glacial fjords. That limits our ability in fully understand biogeochemical and microbial zonation in those regions, as well as benthic animals' distributions and abundances. To fill this gap, we measured bottom waters and surface sediments oxygen concentrations along the three studied glacial fjords investigated by ICEBERGS: Sheldon Cove (SC), Börgen Bay (BB) and Marian Cove (MC). Our aims were to determine oxygen concentrations and depth penetrations and to produce supporting information for biogeochemical, microbial, and faunal studies carried out in parallel.

Aller 1994 *Chemical Geology* 114, 331-345
Aller and Aller 1998 *Journal of Marine Research* 56 905-936
Arndt et al. 2013 *Earth Science Reviews* 123, 53-68
Burdige 2006 *Geochemistry of marine sediments*, Princeton University Press
Hoefs et al. 2002 *Geochimica et Cosmochimica Acta* 66, 2719-2735
Hülse et al. 2017 *Earth Science Reviews* 171, 349-382
Sinninghe Damsté et al. 2002 *Geochimica et Cosmochimica Acta* 66, 2737-2754

5.1.3 CORE INCUBATIONS

Dr Felipe Sales de Freitas, University of Bristol, UK

Nutrient benthic fluxes are key mechanisms returning to the water column macronutrients released during organic matter heterotrophic degradation and dissolution of biogenic silica produced by diatoms. Such fluxes can be determined via nutrient porewater depth profiles, which integrate longer-term processes associated with organic matter respiration and nutrient cycling. However, short-term processes (e.g. seasonal blooms) can be underrepresented in such approaches. Directly assessing benthic fluxes through field experiments are an alternative to investigate nutrients release and uptake. Thus, we developed sediment core incubations aiming to (i) quantify macronutrients concentration evolution over a short time period due to organic matter respiration; and (ii) determine silicon isotopic composition ($\delta^{30}Si$) associated with diatoms shell sinking and dissolution. The information gained from core incubation will be complemented with nutrient concentrations and $\delta^{30}Si$ from water column and sediment porewaters for a comprehensive picture of nutrient cycling withing the three investigated glacial fjords.

5.1.4 ECCOMAP: ECHOES OF CRYOSPHERE TRANSFORMATION ALONG THE WESTERN ANTARCTIC PENINSULA

Tobias Ehmen, University of Exeter, UK

The discharge of glacial meltwater in Antarctica is a critical factor in ocean ventilation and stratification, sea ice production, global sea level rise, marine ecosystems, ocean biogeochemistry, and the ocean carbon sink (Edwards et al. 2019, Rye et al. 2014, Stammerjohn et al. 2012, Shepherd et al. 2012, Barnes et al. 2014, Purkey and Johnson 2012, Arrigo et al. 2015, Paolo et al. 2015, Constable et al. 2014, Golledge et al. 2019, Bintanja et al. 2013). Marine warming is seen to be responsible for increasing melting rates and therefore the retreat of glaciers, collapse of ice-shelves and lengthening of the sea-ice melting season (Paolo et al. 2015, Constable et al. 2014, Golledge et al. 2019, Bintanja et al. 2013). ECCOMAP (Echoes of Cryosphere Transformation along the Western Antarctic Peninsula) was conducted in an area that is highly affected by this, the Western Antarctic Peninsula (see Figure 5-1; Cook et al. 2016, Khazendar et al. 2016, Kimura et al. 2016, Meredith et al. 2017).

There is still much uncertainty regarding how underlying physical processes modulate the flux of oceanic heat to the Antarctic cryosphere, and how and where glacial meltwater is discharged, transported and modified (Edwards et al. 2019, Golledge et al. 2019). Therefore, there is an urgency to further investigate the drivers, impacts and feedbacks of deglaciation due to climate change.

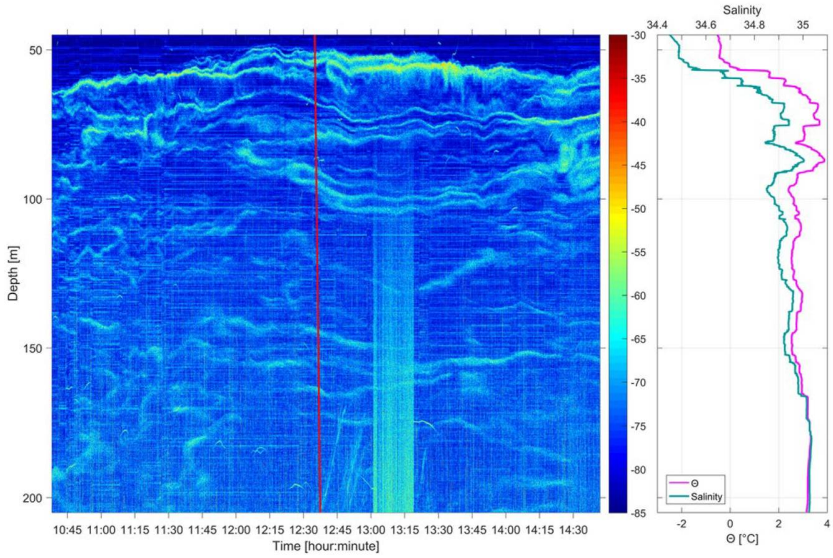

Figure 5-2 2D transect of EK80 data collected in the Arctic Ocean by Stranne et al. (2017). Note the reflectors matching changes in temperature and salinity, as indicated by the CTD data on the right panel (position of CTD on the 2D transect is the red line). From Stranne et al. (2017).

Uncertainties arise in part due to the difficulty of observing our oceans at sufficiently fine space and time scales (Gorman et al. 2018). Progress in understanding micro-scale to sub-mesoscale dynamics are mostly limited to numerical modelling studies and new observation methods are needed if the future of the Antarctic cryosphere and implications of warming oceans and melting glaciers are to be understood, modelled and predicted more thoroughly. Recent studies show that new observational approaches using acoustic reflection techniques can enable temperature and salinity gradients within the water column to be imaged at unprecedented horizontal resolutions with large spatial coverage (Holbrook et al. 2003, Stranne et al. 2017). Hull-mounted wideband echo sounders, including the model used on the *RRS James Clark Ross*, a Simrad EK80 split-beam scientific echo sounder, can image thermohaline gradients, as shown in a study in the Arctic Ocean, where closely spaced reflectors of thermohaline staircases with changes in temperature as low as ~0.05 °C and changes in salinity of ~0.015, and associated shear instabilities and turbulence, were imaged successfully (Figure 5-2; Stranne et al. 2017).

Arrigo et al. 2015 *Journal of Geophysical Research. Oceans* doi:10.1002/2015jc010888
Barnes et al. 2014 *Current Biology* doi:10.1016/j.cub.2014.04.040
Bintanja et al 2013 *Nature Geoscience* doi:10.1038/ngeo1767
Constable et al. 2014 *Global Change Biology* doi:10.1111/gcb.12623
Cook et al. 2016 *Science* doi:10.1126/science.aae0017
Edwards et al. 2019 *Nature* doi:10.1038/s41586-019-0901-4
Golledge et al. 2019 *Nature* doi:10.1038/s41586-019-0889-9
Gorman et al 2018 *Journal of Geophysical Research. Oceans* doi:10.1002/2017jc013459
Holbrook et al. 2003 *Science* doi:10.1126/science.1085116
Khazendar et al. 2016 *Nature Communications.* doi:10.1038/ncomms13243
Kimura et al. 2016 *Journal of Physical Oceanography* doi:10.1002/2016jc012149
Meredith et al. 2017 *Deep Sea Research II* doi:10.1016/j.dsr2.2017.02.002
Paolo et al. 2015 *Science* doi:10.1126/science.aaa0940
Purkey and Johnson 2012 *Journal of Climatology* doi:10.1175/jcli-d-11-00612.1
Rye et al. 2014 *Nature Geoscience* doi:10.1038/ngeo2230
Shepherd et al. 2012 *Science* doi:10.1126/science.1228102
Stammerjohn et al. 2012 *Geophysical Research Letters* doi:10.1029/2012gl050874
Stranne et al. 2017 *Scientific Reports* doi:10.1038/s41598-017-15486-3

5.1.5 MicroAnt: BENTHIC MICROBIAL COMMUNITIES IN THE ANTARCTIC PENINSULA: ASSESSING THE IMPACT OF GLACIAL RETREAT ON THE SEAFLOOR CARBON CYCLE (CASS-165)

Dr Carmen Falagan-Rodriguez, University of Exeter, UK

Aside from a few studies on bacterial community samples collected from the seabed, there is a gap in our understanding of prokaryotes inhabiting marine sediments in Antarctica compared with the Arctic. This gap is especially large regarding benthic habitats, which remain largely unstudied. The first aim of this project is to assess the effect of glacier meltwater input upon benthic microbial ecosystems in the coastal fjords from the West Antarctic Peninsula. The data and samples collected will provide insights into the benthic microbial diversity and the interactions and responses of benthic microorganisms with the input of glacial fresh water and microorganisms from coastal fjord systems with receding marine terminating glaciers. The second aim of this project is to determine the role of benthic microbial communities in the carbon cycle in Antarctic marine sediments, looking into carbon remineralization processes and possible effects of ocean warming upon the microbial role in biogeochemical cycles in the Antarctic coastal waters.

5.2 RACETRAX PROJECT

Dr Amber Annett, University of Southampton, UK

5.2.1 INTRODUCTION

In addition to providing food for the benthic organisms (by opening up new open water for primary production), glacial retreat can also provide macro- and micro-nutrients to coastal areas via melt water. These dissolved nutrients have the potential to be dispersed over long distances. The RaCE:TraX project (Radium in Changing Environments: Tracing Fluxes) complements the ICEBERGS project by characterizing the dissolved and particulate components of glacial melt water and the temporal/spatial scales over which these components are decoupled. The lateral distribution of glacial sediment, fine grained glacial flour and dissolved compounds is not known around the study sites.

Naturally occurring radioisotopes of radium (Ra) are especially useful tracers of coastal inputs, produced from particle reactive thorium (Th). Th decays, producing highly soluble Ra, thus distributions of Ra therefore show a strong source from glacial/subglacial melt water, due to elevated Th from entrained sediment. The so-called "Ra quartet" of four isotopes decay at different rates, and can be used to investigate a range of time scales from days/weeks (loss of particles from the water column) to months/years (advection and dispersal of glacially-derived nutrients). Pairs of Ra isotopes can be used to account for adsorption/desorption due to salinity changes, as well as to discriminate between different sediment sources (for example glacial versus marine sediment, both of which likely provide significant Ra flux in the coastal Antarctic). Large volume seawater samples for Ra are combined with oxygen isotopes and trace metal samples to quantify delivery of glacial sediment to the surrounding area and spatial and temporal scales of sediment loss from the water column to the seafloor.

A complementary component of this work (funded via CASS 177: FAnFARE) investigates chemical distributions in pore waters from sediments at the three ICEBERG locations, to quantify and account for benthic fluxes in coastal budgets. Sediment cores from the multicorer collected during JR18003 confirmed the feasibility of using a Ra/Th disequilibrium approach to quantify trace metal and nutrient fluxes in Antarctic sediments. This novel technique leverages the solubility of the daughter isotope Ra and the high particle affinity of Th, where the deficit of Ra in sediments relative to the expected activity determined from Th content reflects solute loss from diffusion, bioirrigation and porewater exchange over a time period of 1-2 weeks. Ratios of e.g. nutrients to Ra in porewaters, can be used to determine nutrient flux from sediments from this method.

5.2.2 SEDIMENT-WATER TRACE METAL INCUBATION EXPERIMENTS (SWINC)

Rhiannon Jones, University of Southampton, UK

The impact of sediment mixing and resuspension in fjords and bays is poorly quantified yet recognised as vital in terms of the circulation of iron and other trace metals between the sediment and the bottom water. Sediment supply from glacial erosion and subsequent resuspension into the water column in the Western Antarctic Peninsula is recognised as a source of iron to the iron-limited surface waters of the Southern Ocean. Iron concentrations in sediments tend to be high, and can create a concentration gradient between sediment, sediment pore-water and the sediment-water interface. Investigation into the effects of sediment supply upon the speciation of Fe in seawater will help elucidate the processes behind sediment supply of bioavailable Fe to the water column. At three sites proximal to the ice edge at Sheldon Cove (SCE), Börgen Bay (BBE water, BBD sediment coretop) and Marian Cove (MCE), a sediment-water incubation experiment was carried out to investigate such processes in which sediment core-top material is added to bottom water collected proximal to the sediment core, and the change in trace metal concentration is determined over a 48-hr time-series compared with a non-altered control carbuoy. To our knowledge this is the first time a SWINC experiment has been undertaken at these sites and the results will be highly interesting and useful for future experiments.

Iron and other trace metal concentrations will be analysed from SWINC samples back at the University of Southampton by Rhiannon Jones, as part of a DTP INSPIRE PhD project funded by NERC.

5.2.3 CASS-177: FAnFARE: FIRST ANTARCTIC SEDIMENTARY Fe ASSESSMENT FROM RADIUM EQUILIBRIUM

Dr Amber Annett and Oliver Flanagan, University of Southampton, UK

In vast regions of the Southern Ocean, primary production is limited by scarce supply of the essential micronutrient iron (Fe), and the western Antarctic Peninsula (WAP) has been identified as a key source region of Fe. As a result, changes in the Fe inventory of the WAP shelf have huge potential to impact productivity and carbon drawdown in the future. In the low-dust environment of the Southern Ocean, the main sources of Fe are shelf sediments and glacial inputs. Along the WAP over 87% of glaciers are retreating, with rates of deglaciation increasing, driven from below by increased heat flux onto the shelf, as well as by atmospheric warming. Thus, the delivery of glacial Fe to surface waters is expected to increase. Drivers of sedimentary Fe input are less well constrained, but high organic export fuelling bacterial remineralisation and resuspension of Fe-rich shallow sediments are believed to play a major role in sustaining the high Fe inventory of deep shelf waters, and models suggest primary productivity responds non-linearly to changes in this inventory. However, Fe flux from WAP shelf sediment has never been directly measured, so the relative importance of these two Fe sources is currently unknown.

To further complicate matters, deglaciation also affects sediments via transport of Fe-rich lithogenic particles. Fine particulate material can scavenge Fe, efficiently shuttling Fe to the sediment. However, increased delivery of particulates can increase mass accumulation rate, change sediment porosity and composition, and result in such high turbidity that benthic organisms are negatively affected. Consequent changes in composition, bioturbation and bioirrigation of the sediment has the potential to affect remineralisation rates, as well as speciation and bioavailability of Fe. With so many interconnected consequences of deglaciation, we are currently unable to predict the direction, let alone the magnitude of a resulting change in Fe inventory.

FAnFARE will address this gap by generating the first direct measurements of sedimentary Fe flux along the WAP, using the $^{224}Ra/^{228}Th$ disequilibrium method. Quantifying sedimentary fluxes is a significant challenge: the sediment-water interface is subject to myriad processes (e.g. molecular diffusion, pore water exchange, bioturbation, irrigation, tidal pumping, breaking of internal waves and resuspension) that act across a range of spatial and temporal scales. Traditional approaches to measure sediment fluxes are in-situ flux chambers, ex-situ sediment incubations, and diffusive porewater gradients; these focus on small-scale processes and as a result neglect or exclude larger-scale or heterogeneous mechanisms such as bioturbation and tidal pumping. For oxygen fluxes from parallel sediment samples, the traditional methods generally give a range of values, reflecting the different time scales and physical processes captured by each method. Especially for particle-reactive or organically-bound elements like Fe, whose solubility is further affected by redox state, it has recently become apparent that a more holistic view of sediment fluxes is needed to properly understand the oceanic Fe cycle.

The $^{224}Ra/^{228}Th$ disequilibrium method leverages the deficit of soluble ^{224}Ra with respect to its rate of production by parent isotope ^{228}Th in surface sediments. This deficit is then combined with ratios of Ra:Fe in porewater profiles in order to quantify the sedimentary flux of Fe, although the approach can be equally applied to any other solute of interest. Because this technique reflects the time scale of ^{224}Ra decay (5 × 3.6 d half-life: ~20 d), the disequilibrium method offers a distinct advantage over traditional methods in that it captures heterogeneous or intermittent processes such as bioturbation and resuspension, integrating over a time period sufficient to include tidal cycles.

This project aims to quantify $^{224}Ra/^{228}Th$ disequilibrium at two locations in each fjord, which must be done immediately following core collection due to the short half-life of ^{224}Ra. This will be the first application of $^{224}Ra/^{228}Th$ disequilibrium in the Southern Ocean.

5.2.4 AEROBICS: ANTARCTIC EUKARYOTIC ADAPTATIONS AND RESPONSE TO OXYGEN IN BENTHIC INTERSTITIAL COMMUNITIES

Dr Amber Annett, PI, University of Southampton, UK; Dr David Barnes, Co-I, British Antarctic Survey; Dr Mehul Vora, PP, Rutgers University, USA; Dr Nadescha Zwerschke, PP, British Antarctic Survey; Professor Christopher Rongo, PP, Rutgers University, USA.

***Motivation*:** Rapid glacial retreat creates new areas of open water and seafloor, considered a “blue carbon” process for sequestration of atmospheric carbon (C) on the seabed (Barnes 2017). However, rapid deglaciation and warming of shelf waters can also impact the rate and depth of sediment overturning both directly (e.g. via iceberg scour) or by changing the activity of large bioturbating animals due to turbidity from glacial discharge (Sahade et al. 2015), or heat stress (Peck et al. 2004). Oxygen (O_2) gradients within sediment can be very steep, with O_2 penetration depth frequently 0.3-4 cm along the WAP (Hartnett et al. 2008). Although larger organisms can move across these gradients to avoid O_2 stress, many interstitial microfauna are vulnerable to fluctuations that may accompany disturbance or bioturbation. The ability of these organisms to cope with large changes in O_2 availability is therefore important to cycling of organic material through the upper sediment column, impacting fluxes of macro- and micro-nutrients driven by microbial remineralisation. Understanding the response and tolerance of the microbenthos to hypoxic stress is thus crucial to predicting the consequences of continuing climate change for C cycling in WAP shelf sediments.

Observations from the 2018 ICEBERGS expedition (JR18003) show that abundance of bioturbators closest to the glacial terminus is limited to the top layer of sediment and increases in depth with distance from the glacier (Zwerschke 2018). As such, Antarctica's emerging fjords present a unique opportunity to study the effects of deglacially-driven changes in bioturbation and gene adaptations in eukaryotic meiofauna along a gradient of O_2. A sudden drop in the availability of O_2 leads to a depletion of required ATP which can lead to permanent damage or even death of the organism. The hypoxia inducible factor-1 (HIF1) is a conserved, O_2-dependent transcription factor governing the genetic response of an organism to changes in O_2 concentration (Epstein et al. 2001). Under normal O_2 (normoxia), HIF1 hydroxylation on a conserved proline residue by prolyhydroxylase domain (PHD) containing enzymes leads to HIF1 degradation. Thus, turnover of HIF1 is very high. When O_2 levels are low, PHD enzymes can no longer hydroxylate HIF, allowing it to turn on gene transcription programs that promotes organismal survival. However, how HIF1 and PHD enzymes are adapted within organisms that experience rapid and steep fluctuations in O_2 has not been studied. By increasing sedimentation rates in areas closest to the glacial terminus, glacial retreat negatively affects abundance of macrofaunal benthic bioturbators, increasing the potential for hypoxia within sediment and changing the exposure of interstitial organisms to anoxic conditions. By describing the variations within these genes and adaptations of HIF1 and PHD in these microfauna, we will have a better understanding of their sensitivity to changes in bioturbation with continued warming.

HIF1 and PHD proteins are structurally well conserved across phyla (Rytkönen et al. 2011); HIF1 and PHD sequences from early diverging cartilaginous fish (elasmobranchs) identified divergent sequences in the oxygen-dependent degradation domain and PAS domains, indicating adaptation to O_2 changes in water that are different from land vertebrates. Over and above understanding the sensitivity of WAP shelf microfauna to oxygen stresses with ongoing climate change, characterising the changes in these genes in Antarctica presents a unique advantage: this isolated region may have evolved changes that are distinct from other marine settings (as well as terrestrial organisms). Over time, loss of benthic diversity might impact nutrient availability for microbial respiration, leading to changes in the rate of bacterially-mediated C remineralisation, with implications for the potential storage capacity of marine sediments in this rapidly-warming region.

Aim: We will characterise the evolutionary function changes within the HIF and PHD genes in organisms that experience wide fluctuations in O_2 levels. By combining this investigation with ecosystem functioning of the interstitial faunal community, we will elucidate how these adaptations may influence C sequestration and nutrient cycling with increasing disturbance from rapid deglaciation.

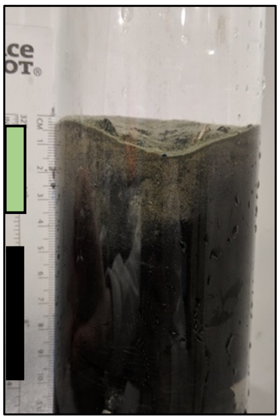

Figure 5-3 . Sediment core from Marian Cove, collected on ICEBERGS-2, showing sandy sediments and excellent preservation of the sediment-water interface. Higher-O2 sediment can be seen before a transition to anoxic sediment, denoted by green and black bars, respectively. Fine-scale heterogeneity is apparent, indicating the extent of variability in O2 levels that organisms can be exposed to in this environment.

Approach and Methods: Samples for genetic analysis of interstitial microfauna will be collected across the oxic-anoxic transition in sediment cores during the ICEBERGS-3 expedition. Cores retrieved during previous ICEBERGS cruises (Figure 5-3) have well-preserved interfaces and visible zonation from green, oxygenated sediment to black, sulfidic O_2-poor conditions. These gradients occur at 2-5cm depth in the sediment, indicating that they are ideal candidates for investigating hypoxic response where bioturbation or iceberg scour can transport target organisms across extreme O_2 gradients on very short time scales. Sampling will be done at one proximal site and one distal location in each fjord to cover a range of turbidity, iceberg scour, sediment composition and benthic community structure. Ecosystem function analysis will be provided by Project Partner Dr Zwerschke. The study fjords of the ICEBERGS project (Figure 5-1) are ideally situated along the Peninsula to characterize differences between the northern and southern regions, providing a temperature component to consider additional influence from ocean warming. Planned Oktopus deployments for the

RaCE:TraX project will provide cores for oxygen content measurements and coupled sediment collection, without any requirement for additional deployments or ship time.

Metagenomic DNA extraction, library preparation and sequencing: DNA extraction from sediments at various depths along the core collected will be performed using the MoBio PowerSoil DNA extraction kit using published protocols (Nascimento et al. 2018). Samples will be frozen for return to the UK/US for analyses. Eukaryotic diversity at each depth of the sediment will be examined by amplification of the 18s rRNA fragments using standard PCR primers. In order to obtain maximum sequence coverage, the above metagenomic library will undergo next-generation sequencing. We expect to find HIF- and PHD-like sequences which we will characterise in our structure-function studies.

Structure-function studies: Sequences obtained from 18s rRNA sequencing will be first matched against the National Center for Biotechnology Information DNA sequence database to assess the biodiversity biodiversity of the core with depth. Matches to putative HIF and PHD genes will be assessed using published guidelines (Rytkönen et al. 2011) and the following analyses will be conducted: phyologenetic tree construction, modeling rates of molecular evolution, computing rates of selection pressures and calculating functional divergence.

Overall, the proposed work will inform us of the set of adaptations within a conserved genetic program of O_2 response within the Antarctic microbenthos. These insights, in combination with the extensive context of the benthic impacts of deglaciation provided by the ICEBERGS project, will permit the first evaluation of adaptive strategies at a metagenomic scale of microeukaryotes to changing sediment mixing regimes, and how this may affect benthic cycling of nutrients and carbon in the future ocean.

Barnes 2017 Global Change Biology **23**, 5083–5091
Epstein et al. 2001 Cell **107**, 43–54
Hartnett et al. 2008 Deep Sea Research II **55**, 2415–2424
Peck et al. 2004 Functional Ecology **18**, 625–630
Nascimento et al. 2018 Scientific Reports **8**, 1–12.
Rytkönen et al. 2011 Molecular Biology and Evolution 28, 1913–1926
Sahade et al. 2015 Science Advances 1 e1500050
Zwerschke 2018, unpublished data from ICEBERGS-2.

6 Small boat operations

Dr Amber Annett, University of Southampton, UK; Kate Retallick, Bangor University, UK

Figure 6-1 Humbers operating in Sheldon Cove

6.1 INTRODUCTION

Two Humber RIB were deployed for 8 hours in each fjord to conduct surface water sampling (RACETRAX) and sediment collection (ICEBERGS). Boats were coordinated by a pre-planned schedule which was monitored by a watchkeeper (located on the bridge to improve situational awareness and liaise with the ship's crew.) A single line of communication was established by the ship's bridge team using VHF to both boats on the same frequency. This enabled boats to remain together and liaise directly with each other to coordinate their activity. Concurrent activity by the ship was limited owing to the extent of the ice cover at Sheldon Cove and Börgen Bay which required the ship to remain close to the boats for safety cover. Boats were recovered for an hour during lunchtime to limit cold weather exposure.

6.2 ICEBERGS SMALL BOAT WORK

Sediments were obtained from stations in addition to the standard ICEBERGS stations to extend the sampling spatially across each fjord (Figure 6-2, Figure 6-3, Figure 6-4). A mini Van Veen grab was hand winched using a custom pulley system created by AME staff to depths up to 200m. This configuration had a high success rate from the boat and sediments could be obtained in around 15 minutes at each location.

Water sampling took less time than sediment collection which enabled Sky TV to send a crew during the afternoon's work at Sheldon Cove and Marian Cove. At Börgen Bay, the wind picked up to 25 kn in the afternoon and deployments were conducted from the ship using first the midships winch position then capstan and crane mounted block on the aft deck. Ship deployments were problematic owing to the light weight of the Van Veen grab and extended time to position the ship at each site. This resulted in only 2 of 6 deployments being successful. A full record of sediments obtained is contained within the Van Veen log and shown in Table 6-1.

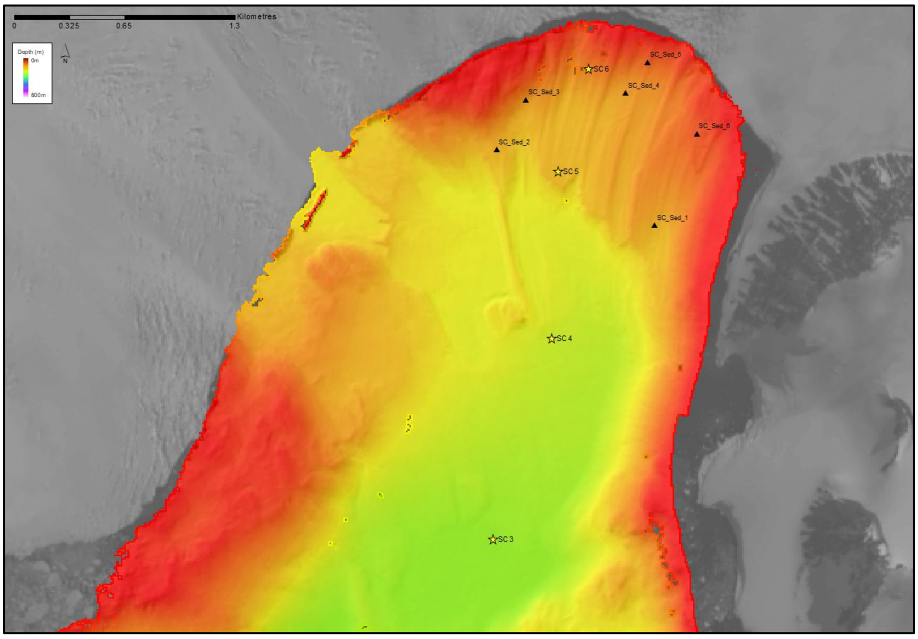

Figure 6-2 Van Veen grab locations – Sheldon Cove

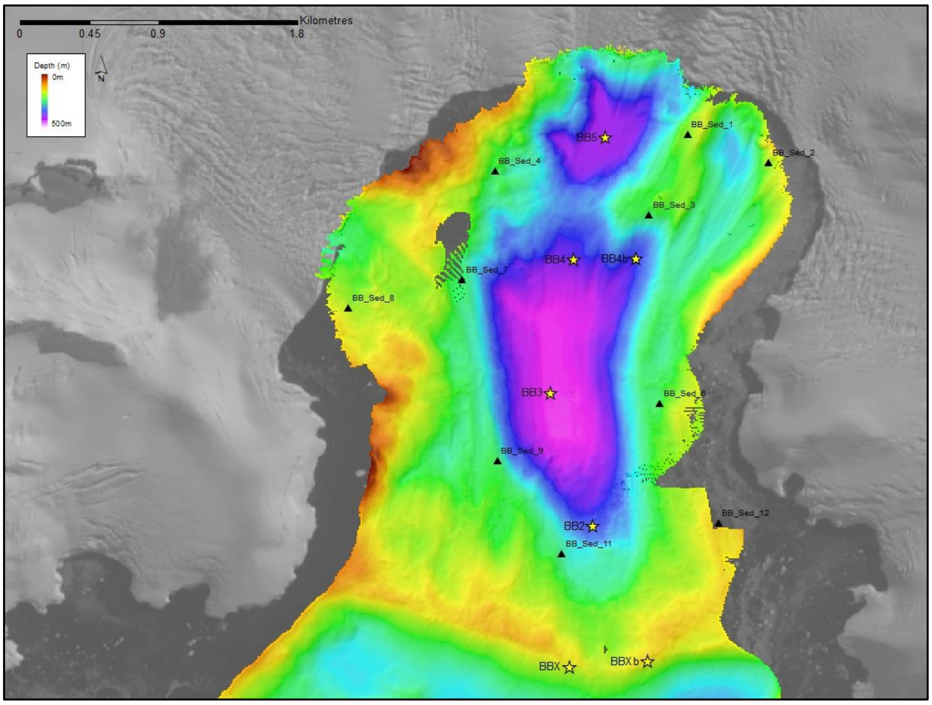

Figure 6-3 Van Veen grab locations – Börgen Bay

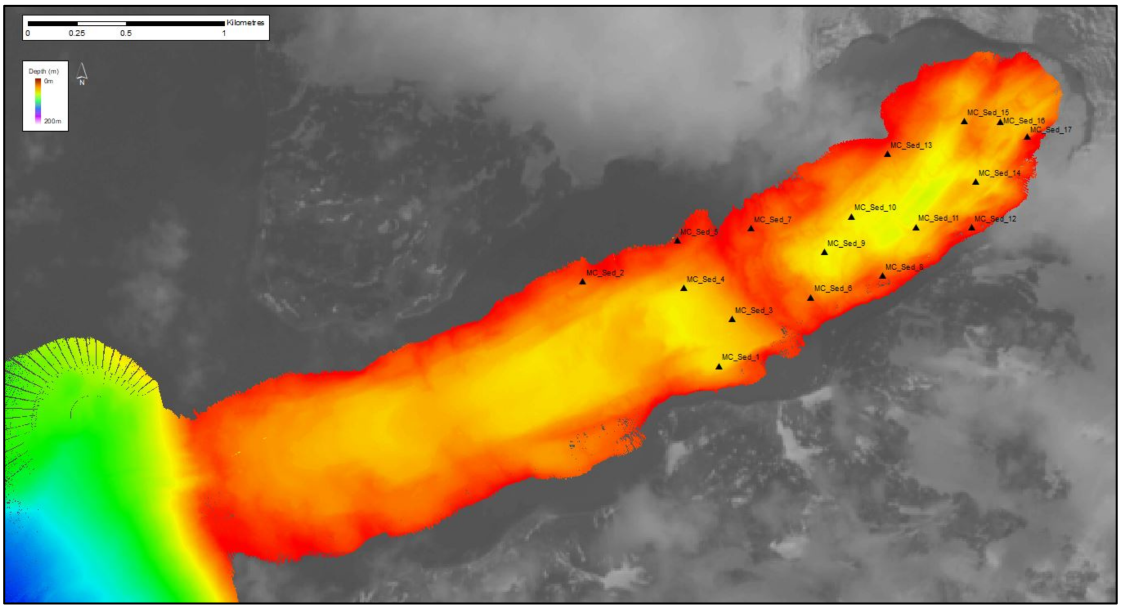

Figure 6-4 Van Veen grab locations – Marian Cove

Table 6-1 Van Veen grab log

Time	Latitude Boat	Longitude Boat	Depth Boat	Station	Action	Comment
25/01/20 17:40	62 12.20 S	058 43.57 W	50	MC_Sed_17	Successful Grab	Also Water Salinity Sample 2.17 New position - planned position too close to ice front. Position and depth approximate (to ~100m).
25/01/20 17:22	62 12.626 S	058 44.865 W	75	MC_Sed_6	Successful Grab	Also Water Salinity Sample 2.18
25/01/20 17:15	62 12.432 S	058 45.208 W	54	MC_Sed_7	Successful Grab	Also Water Salinity Sample 2.19
25/01/20 17:05	62 12.460 S	058 45.641 W	47	MC_Sed_5	Successful Grab	Also Water Salinity Sample 2.20
25/01/20 16:45	62 12.679 S	058 45.331 W	103	MC_Sed_3	Successful Grab	Also Water Salinity Sample 2.22
25/01/20 16:20	62 12.807 S	058 45.417 W	111	MC_Sed_1	Successful Grab	Also Water Salinity Sample 2.23.
25/01/20 15:55	62 12.590 S	058 45.610 W	112	MC_Sed_4	Successful Grab	Also Water Salinity Sample 2.21
25/01/20 14:30	62 12.565 S	058 46.204 W	55	MC_Sed_2	Successful Grab	
25/01/20 13:45	62 12.572 S	058 44.443 W	71	MC_Sed_8	Successful Grab	
25/01/20 13:35	62 12.502 S	058 44.779 W	121	MC_Sed_9	Successful Grab	
25/01/20 13:25	62 12.407 S	058 44.612 W	120	MC_Sed_10	Successful Grab	
25/01/20 13:05	62 12.440 S	058 44.237 W	43	MC_Sed_11	Successful Grab	
25/01/20 12:55	62 12.446 S	058 43.909 W	56	MC_Sed_12	Successful Grab	
25/01/20 12:35	62 12.320 S	058 43.877 W	110	MC_Sed_14	Successful Grab	New position owing to ice obstruction.
25/01/20 12:20	62 12.157 S	058 43.725 W	99	MC_Sed_16	Successful Grab	
25/01/20 12:05	62 12.154 S	058 43.936 W	94	MC_Sed_15	Successful Grab	
25/01/20 01:45	62 12.238 S	058 44.393 W	72	MC_Sed_13	Successful Grab	
20/01/20 20:07	64 43.141 S	063 26.587 W	184	BB_Sed_6	Successful Grab	Van Veen deployed from ship by hand stbd quarter, capstan recovered.
20/01/20 19:12	64 43.335 S	063 27.917 W	184	BB_Sed_9	Unsuccessful Grab	Deployed from Ship - hand deployed using capstan to recover. Grab did not release.
20/01/20 18:44	64 43.335 S	063 27.917 W	184	BB_Sed_9	Unsuccessful Grab	Deployed Van Veen from Ship.
20/01/20 18:32	64 43.335 S	063 27.917 W	182	BB_Sed_9	Unsuccessful Grab	Van Veen Deployed from ship. Same issue, not enough weight/tension.

20/01/20 18:00	64 43.663 S	063 27.400 W	195	BB_Sed_11	Successful Grab	Van Veen deployed from Ship. A couple of shackles were added to the grab to increase the weight.
20/01/20 17:32	64 43.661 S	063 27.346 W	195	BB_Sed_11	Unsuccessful Grab	Van Veen deployed from Ship. Not enough weight on the grab? Tension too light in wire?
20/01/20 17:07	64 43.561 S	063 26.113 W	125	BB_Sed_12	Successful Grab	Small Sample. Van Veen deployed from ship.
20/01/20 14:30	64 43.524 S	063 29.040 W	90	BB_Sed_10	Successful Grab	
20/01/20 14:15	64 42.702 S	063 28.198 W	170	BB_Sed_7	Successful Grab	Nil
20/01/20 13:52	64 42.798 S	063 29.130 W	164	BB_Sed_8	Successful Grab	Nil
20/01/20 13:36	64 42.321 S	063 27.924 W	178	BB_Sed_4	Successful Grab	Radar Position 64 42.33S 063 27.93W. Unable to attain planned position owing to ice.
20/01/20 13:15	64 42.321 S	063 27.924 W	178	BB_Sed_4	Unsuccessful Grab	Radar Position 64 42.33S 063 27.93W. Unable to attain planned position owing to ice.
20/01/20 12:55	64 42.480 S	063 26.664 W	143	BB_Sed_3	Successful Grab	Nil
20/01/20 12:35	64 42.300 S	063 25.684 W	191	BB_Sed_2	Successful Grab	Nil
20/01/20 12:15	64 42.198 S	063 26.346 W	195	BB_Sed_1	Successful Grab	Nil
16/01/20 17:30	67 31.113 S	068 15.83 W	191	SC_Sed_2	Successful Grab	Position confirmed as within 10m of planned position (monitored using handheld GPS but waypoint not marked). 1 x sample retained as SC_Sed_2. Incorrect date on label as 15/1/20. New label to be inserted.
16/01/20 17:07	67 30.953 S	068 15.592 W	143	SC_Sed_3	Successful Grab	Position from handheld GPS. 1 x sample labelled S03. Sample dated incorrectly as 15/1/20. Corrected label to be inserted.
16/01/20 17:07	67 30.953 S	068 15.592 W	143	SC_Sed_3	Successful Grab	Position from handheld GPS. 1 x sample labelled S03. Sample dated incorrectly as 15/1/20. Corrected label to be inserted.
16/01/20 16:45	67 31.346 S	068 14.514 W	195	SC_Sed_1	Successful Grab	Position by handheld GPS. 1 x sample labelled S01. Sample dated incorrectly as 15/1/20. Corrected label to be inserted.
16/01/20 16:30	67 31.055 S	068 14.175 W	134	SC_Sed_6	Successful Grab	Position by handheld GPS. 1 x sample labelled SC Sed 06 retained. Date label incorrect as 15/1/20. New label to be inserted.
16/01/20 16:00	same as ship	same as ship	n/a	n/a	Boats deployed	Nil
16/01/20 15:00	same as ship	same as ship	n/a	n/a	Boats embarked for lunch break	Nil
16/01/20 14:46	67 31.346 S	068 14.514 W	195	SC_Sed_1	Unsuccessful grab	Position by handheld GPS. Nil sample obtained.
16/01/20 14:25	67 31.055 S	068 14.175 W	134	SC_Sed_6	Unsuccessful Grab	Position by handheld GPS. Nil sample obtained.
16/01/20 14:15	67 31.055 S	068 14.175 W	134	SC_Sed_6	Unsuccessful grab	Position by handheld GPS. Nil sample obtained.
16/01/20 13:40	67 30.928 S	068 14.766 W	178	SC_Sed_4	Successful Grab	Position by handheld GPS. 1 x sample labelled S04. Sample dated incorrectly as 15/1/20. Corrected label to be inserted.
16/01/20 13:25	67 30.830 S	068 14.59 W	141m	SC_Sed_5	Successful Grab	Position by Ship's radar. 1 x sample labelled S05. Sample dated incorrectly as 15/1/20. Corrected label to be inserted.

6.3 RACETRAX SMALL BOAT WORK

Small boat work was undertaken to sample for the RaceTraX project for surface water trace metals and complementary data such as radium, nutrients, salinity and oxygen isotopes. The sampling log for RaceTraX is given in section 7.3. Due to the easy contamination of trace metal sampling directly off the ship, small boat work was highly useful in enabling the clean sampling of surface seawater for trace metal analysis. Clean Nalgene bottles were triple-bagged and brought onto the Humber RIB along with a bucket and 6 x 22 L containers for seawater collection for radium. Samples for trace metals, radium and nutrients were taken at the main ICEBERGS/RaCETraX stations, whilst salinity and $\delta^{18}O$ samples were taken both at the main stations and at various points between stations to achieve a greater sampling frequency across the transect. 500 ml, 1 L and 4 L Nalgenes were submerged just beneath the surface and rinsed three times with seawater before filling for later processing in the clean-room environment back on the ship. A Garmin GPS was used to record the exact latitude/longitude of each sample taken throughout.

Small boat work was favoured over towfish sampling as typically the towfish is less consistent in depth, which depends on current and ship speed during deployment. Furthermore, the tubing between towfish and sample is easily contaminable in a ship environment, a problem which small boat work sampling avoids. Small boat work also allowed the RaceTraX team to sample a high volume of surface salinity and $\delta^{18}O$ samples that may not have been possible with the towfish which would only have been deployed on station.

7 Equipment used and science areas

7.1 GEOPHYSICS

Kate Retallick, Bangor University, UK; Alice Frémand, British Antarctic Survey

7.1.1 MULTIBEAM MAPPING

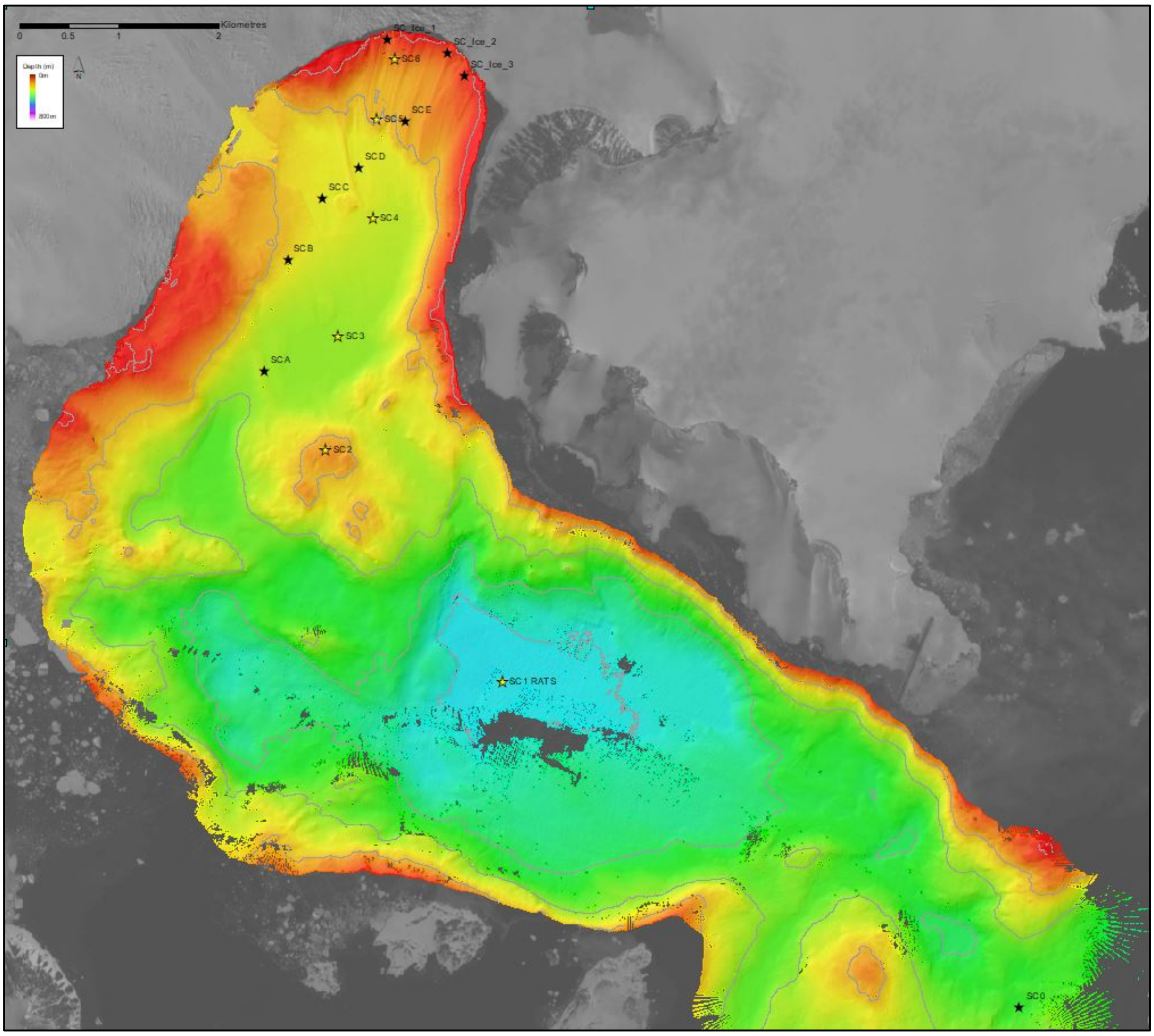

Figure 7-1 Sheldon Cove Multibeam Bathymetry (contours at 100m intervals)

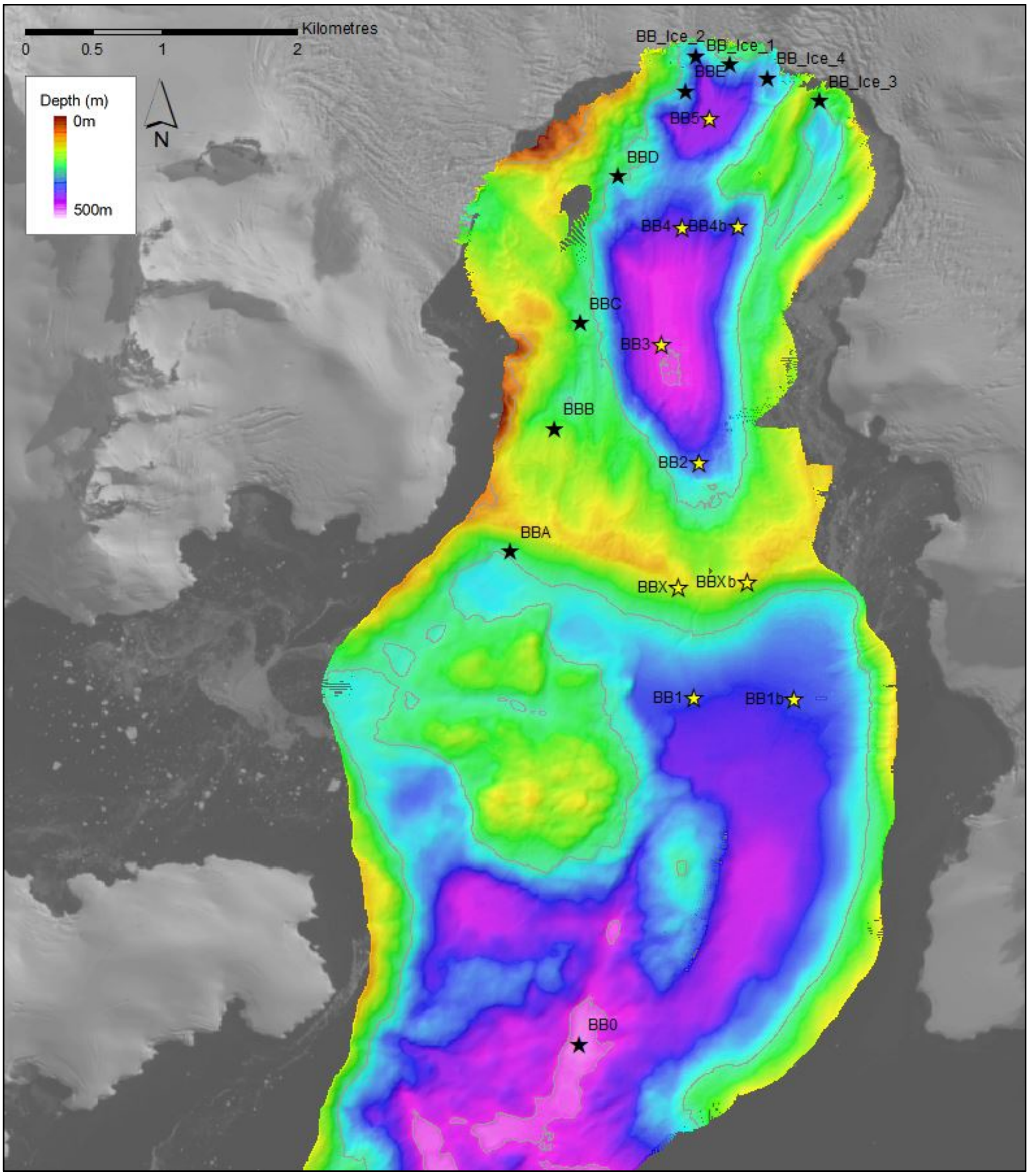

Figure 7-2 Börgen Bay Multibeam Bathymetry (contours at 100m intervals)

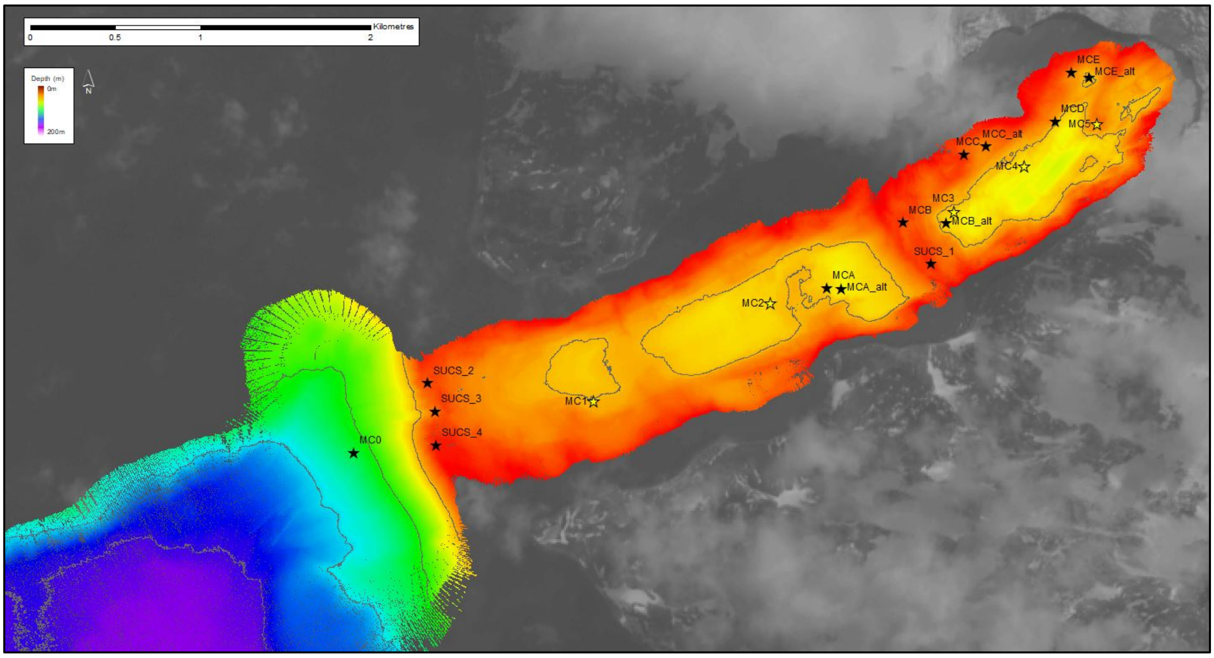

Figure 7-3 Marian Cove Multibeam Bathymetry (contours at 100m intervals)

7.1.2 DATA ACQUISITION AND PROCESSING

Bathymetric data was collected using a hull-mounted 1° x 1° EM122 Multibeam Echo Sounder (MBES) (see Appendix A.1.i for further details). The EM122 equipment was operated using Kongsberg Seafloor Information System (SIS) and Helmsman software. A detailed report on the collection and processing of the data with an evaluation of data quality and surveying methods is presented in Appendix A.1.i and A.1.v. Data were organised into nine separate surveys, summarised in Table 7-1. Changes to acquisition parameters are summarised in the EM122 event log, available on request from the UK Polar Data Centre (polardatacentre@bas.ac.uk).

Where possible, data were collected in a systematic manner with survey lines running parallel along depth contours to achieve consistent swath coverage and maximise insonification of slope areas. System settings were optimised for backscatter data collection. High swell combined with a degraded EM122 system (see Appendix A.1.vi for more details) on Burdwood Bank affected the quality of the resulting data making it unusable for anything other than a general indication of depths. The presence of ice, particularly in Börgen Bay, impacted our ability to conduct a systematic survey. In these instances, the ship was driven to best achieve coverage. Full details of multibeam calibration and settings can be found in Appendix A.1.i.

Table 7-1 Summary of EM122 data collected on JR19002

Survey name	Start (UTC)	End (UTC)	Description	Number of RAW files (.all)	Processed (Qimera, Fledermaus)	Comments
JR19002_a	12:23:45 02/01/2020	14:14:02 04/01/2020	Transit from Punta Arenas to Rothera	54	nil	Opportunistic passage sounding
	17:09:37 04/01/2020	19:14:44 06/01/2020				
JR19002_b _PatchTest	16:00:00 04/01/2020	17:01:56 04/01/2020	Patch test	3	3	Patch test
JR19002_b	13:22:17 13/01/2020	11:14:39 18/01/2020	Sheldon Cove	80	75	ICEBERGS / Deep Impact
JR19002_c	14:38:50 18/01/2020	11:17:39 19/01/2020	Transit from Sheldon Cove to Börgen Bay	24	nil	Opportunistic passage sounding
JR19002_d	20:01:55 19/01/2020	20:39:28 23/01/2020	Börgen Bay	55	53	ICEBERGS
JR19002_e	20:40:36 23/01/2020	15:55:10 24/01/2020	Transit from Börgen Bay to Marian Cove	6	nil	Opportunistic passage sounding
JR19002_f	18:45:10 24/01/2020	07:58:03 27/01/2020	Marian Cove	53	51	ICEBERGS
JR19002_g	17:23:35 28/01/2020	16:53:13 29/01/2020	Transit from Marian Cove to Falkland Islands	20	nil	Opportunistic passage sounding
JR19002_h	12:00:07 31/01/2020	13:51:43 03/02/2020	Burdwood Bank	37	8	SAERI MMA, large number of lines unsuitable for processing owing to noise.

Figures Figure 7-1Figure 7-2Figure 7-3 and Figure 7-4 illustrate the final bathymetry grids at each location. Initial processing of MBES bathymetry data enabled assessment of the seabed to support cruise scientific activity. Slope and hillshade products were used to assist selection of additional sampling stations during science operations at Marian Cove, Börgen Bay and Sheldon Glacier.

Sound velocity profiles (SVPs) were generated from CTD casts and applied during data acquisition. XBTs were not used to reduce cost and avoid environmental impact. Tidal observations from Prat and Rothera stations were downloaded from the IOC website[1]. USGS tidal data from Palmer Station will be made available retrospectively for Börgen Bay. For opportunistic sounding, previously collected or synthetic SVPs were applied due to time and budget constraints. Synthetic SVPs were generated using Sound Speed Manager software using the WOA09 model and following the procedure outlined in JR17004's cruise report.

Seabed texture information was generated through MBES backscatter processing in QPS FM Geocoder Toolbox (FMGT) software. Use of the FMGT Angular Range Analysis (ARA) Tool (Fonseca and Calder 2005) was avoided owing to uncertainty in the model parameters. FMGT was used to process only straight vessel tracks to reduce errors associated with turning. Initial processed uncalibrated backscatter mosaic images are shown in Figure 7-4. Seabed samples were collected by small boat Van Veen grab in addition to multicore sampling at ICEBERGS sites for particle size analysis and will be analysed in a lab to calibrate backscatter products. Further details of Van Veen sampling locations and methods are in Chapter 6 (Small

[1] http://www.ioc-sealevelmonitoring.org

boat operations).Unfortunately, coverage at Börgen Bay was incomplete owing to ice cover and a reduction in the allotted time for multibeam survey as a result of delays to the programme caused by heavy ice conditions.

Figure 7-4 Backscatter at Marian Cove (top), Borgen Bay (left) and Sheldon Cove (right)

Fonseca and Calder 2005 'Geocoder: An Efficient Backscatter Map Constructor', *U.S. Hydro 2005 Conference*, p. 9

Despite initial evidence of some change to small scale features from ICEBERGS 2017 and 2018 MBES data, the lack of corrections for horizontal position or tide prevent a full assessment at this time. Post-processed RTK observations will be used to confirm tidal models and improve accuracy of soundings to ensure small scale features can be directly compared between successive years. Ice front data were obtained at Börgen Bay and Sheldon Cove and will allow comparison with previous years. Figures Figure 7-5 to Figure 7-8 illustrate preliminary interesting seabed features and ice front observed in the multibeam data.

MBES data at Sheldon Glacier from 2018 has been authorised for release by BAS to improve navigational safety for small boat operations in vicinity of Rothera. These data will be enhanced by the 2019 data and submitted to the United Kingdom Hydrographic Office (UKHO) for charting purposes.

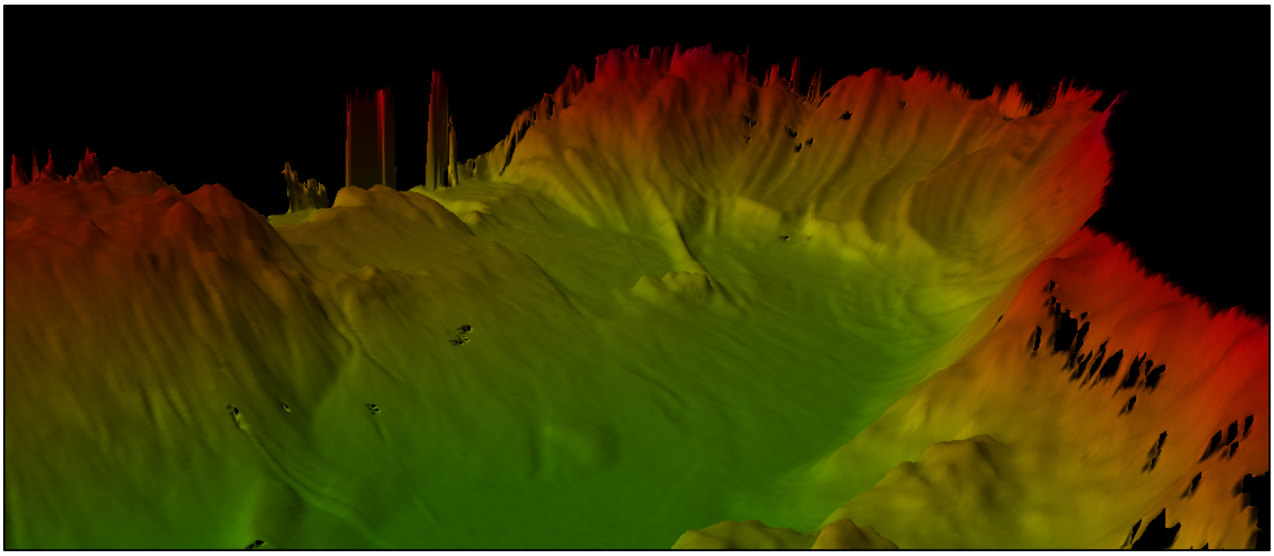

Figure 7-5 Sheldon Cove moraines and ice front

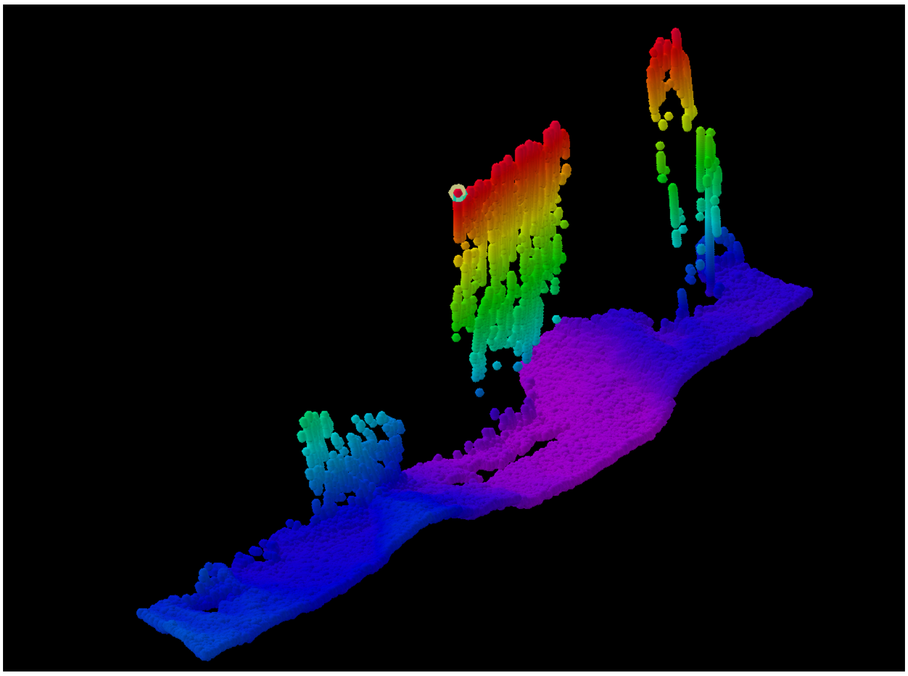

Figure 7-6 Ice front cross section at Sheldon Cove.

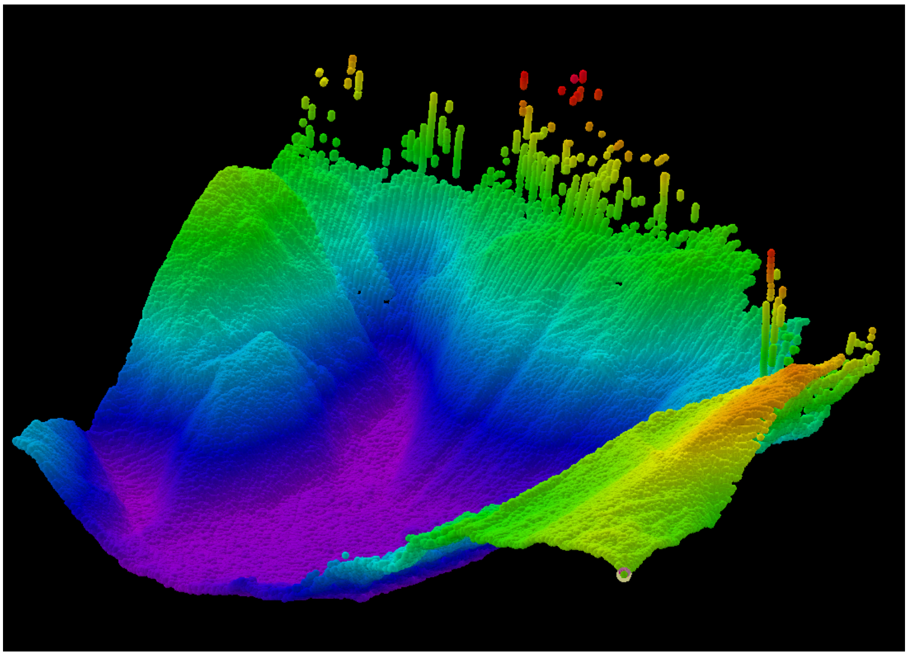

Figure 7-7 Sediment wedge and ice front at Börgen Bay

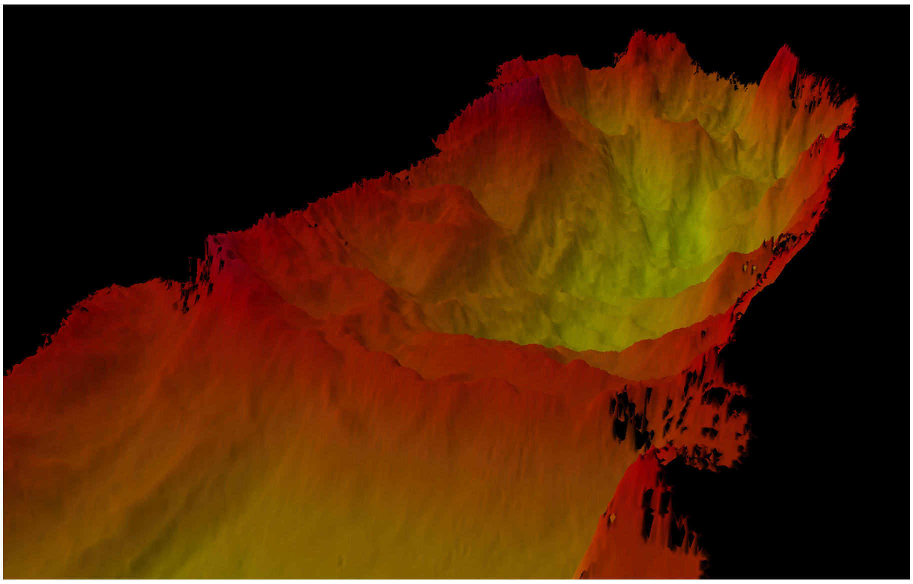

Figure 7-8 Marian Cove sill and inner bay recessional moraines

7.1.3 ADDITIONAL MULTIBEAM SOUNDING (DEEP IMPACT)

100-300m depth contours from Rothera to Sheldon Glacier were insonified where possible and are included in the project JR19002_b. Shoaler depths were not possible owing to navigational and echo sounder constraints. Data quality was impacted by EM122 overheating issues (see below). An assessment of iceberg scour will be made during post-processing by comparison with 2018 data and the results passed to BAS.

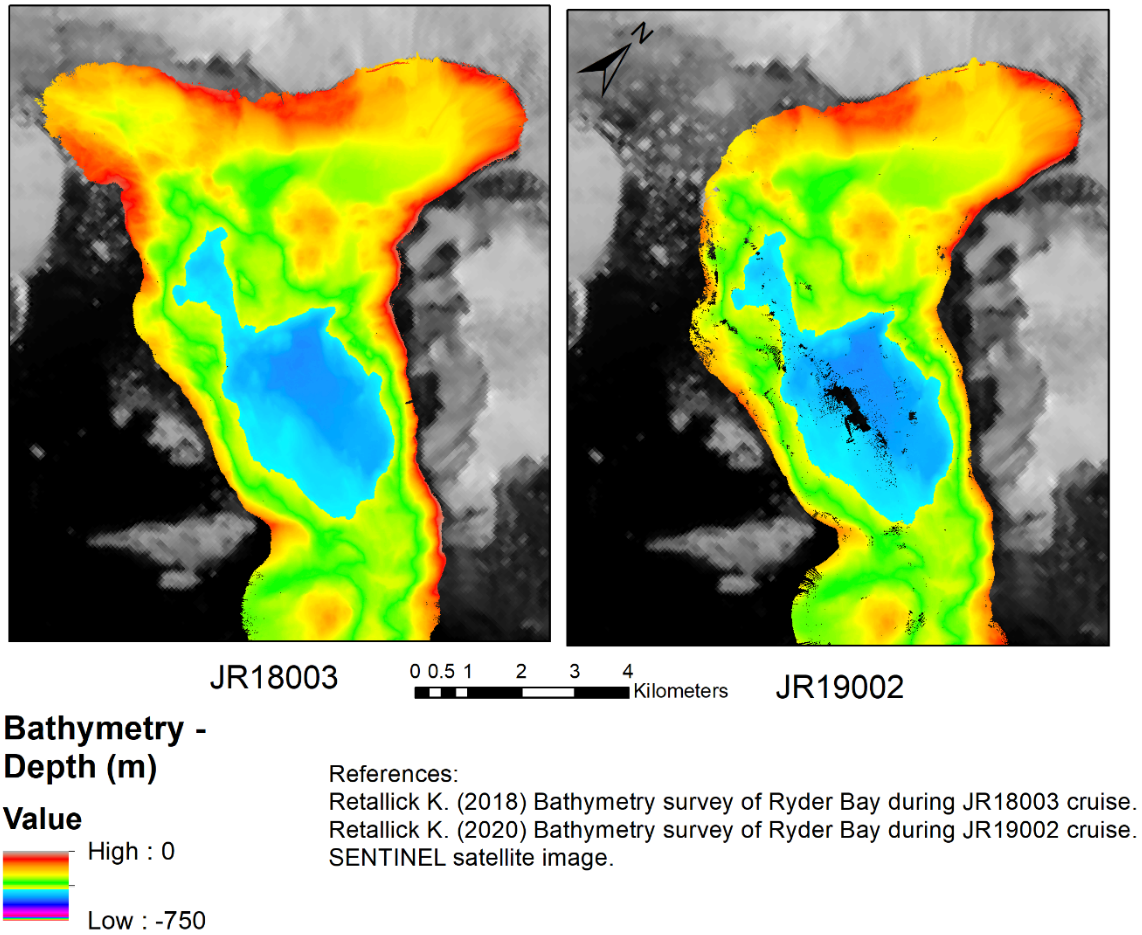

Figure 7-9 Ryder Bay survey performed during JR18003 and JR19002 cruises as part of DEEP IMPACT project

7.1.4 MBES PROBLEMS ENCOUNTERED

Following a successful patch test, excessive noise was noticed in the MBES centre beams. A BIST test was conducted and did not reveal any problems. The stave display was checked and showed significant degradation in the swath. Overheating was found to be the cause and several attempts were made to rectify the issue which was resolved for much of the cruise. The excessive noise manifested itself again, however, on arrival at Burdwood Bank where repeated attempts to cool the system had no effect. Investigation and liaison with Kongsberg continued via AME and a temporary fix was effected. System unavailability resulted in a loss of 3 days multibeam at Burdwood Bank and approximately 6 hours of DEEP IMPACT time. Full details are contained in Appendix A.1.vi and section 13.3 of this cruise report.

7.1.5 TOPAS

TOPAS was used opportunistically in support of the MMA project at Burdwood Bank. Sub-bottom profile data gives information on the seabed immediately beneath the seafloor. It was collected in using the hull-mounted Kongsberg Marine TOPAS (PS018) sub-bottom profiler. The TOPAS equipment was operated using Kongsberg TOPAS 1.7 software. The trigger was managed by K-SYNC. More information on how the instrument was operated are summarised in the user's guide 'TOPAS.docx' available on request from UK PDC.

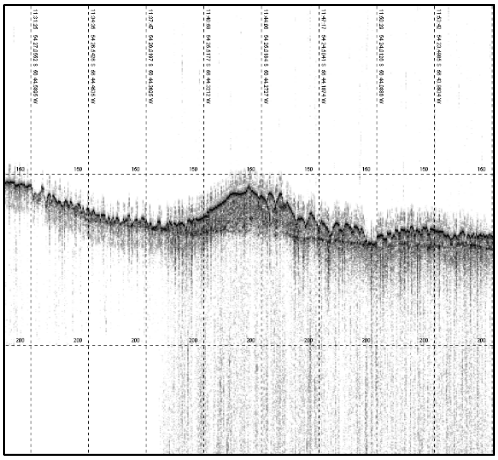

Figure 7-10 TOPAS Burdwood Bank

The list of parameters used are summarised in the Table 7-2 below. A list of the file names is provided in Table 7-3.

Table 7-2 TOPAS parameters used for Burdwood Bank survey

	Parameters	Values
TRANSMITTER	Transit mode	Normal
	Trigger Mode	External (K-sync)
	Pulse form	Chirp (LFM)
	Start frequency (kHz)	1.2
	Stop frequency (kHz)	5.0
	Chirp length (ms)	8.0
	Power level (dB)	Between -3 and 0 depending on depth
	HRP Stabilization	On
	Beam control	Auto
RECEIVER	Delay control	Manual
	Master trig delay (ms)	100 to 400 depending on depth
	Delay offset (ms)	0.0
	Sample rate (kHz)	20
	Trace length (ms)	Between 100 and 1000 depending on depth.
	Gain (dB)	6-20 depending on signal received
	HP-filter	1
DATA LOGGING	New file created every (min)	60
	Maximum file size (MB)	20
SOUND SPEED	Average sound speed selector (m/s)	1480
	Transducer Sound speed selector (m/s)	1500 at the beginning. 1480 from 11:55 on 3/02/2020

Table 7-3 Overview of the event log for TOPAS and their respective file names

Time	Latitude	Longitude	Heading	Depth EA600	Action	Name of files
03/02/2020 13:08	-54.2186	-56.7139	0.1		Stop logging	20200203111927.raw 20200203122301.raw 20200203122837.raw 20200203123147.raw 20200203123557.raw 20200203124008.raw 20200203124414.raw 20200203124822.raw 20200203130805.raw
03/02/2020 11:19	-54.4819	-56.7525	10.75	150.07	Stop and start logging as the software froze	
03/02/2020 11:13	-54.4942	-56.7562	3.7		Start logging	20200203113829.raw
03/02/2020 09:11	-54.4888	-56.7508	355.05	145.78	Stop logging	20200203085636.seg
03/02/2020 08:56	-54.4988	-56.7651	28.37	105.36	Start logging	
03/02/2020 07:54	-54.5029	-56.7633	289.25	106.28	Stop logging	20200203063340.raw 20200203073302.raw
03/02/2020 06:33	-54.3419	-56.7378	182.76	140.44	Start logging	
02/02/2020 19:25	-54.2184	-56.7141	266.39	560.45	Stop logging	20200202174452.raw 20200202181210.raw 20200202183916.raw 20200202184919.raw 20200202185335.raw 20200202185727.raw 20200202190001.raw 20200202190532.raw 20200202190725.raw 20200202191529.raw 20200202191615.raw 20200202191821.raw
02/02/2020 17:44	-54.5003	-56.7532	251.32	104.99	Start logging	
02/02/2020 12:14	-54.4987	-56.7406	206.41	106.66	Stop logging	20200202102242.raw 20200202102405.raw 20200202102842.raw 20200202104639.raw 20200202110436.raw 20200202112234.raw 20200202114033.raw 20200202115818.raw
02/02/2020 10:00	-54.4983	-56.1048	279.93		Start logging	

7.2 OCEANOGRAPHY

7.2.1 CTD OPERATIONS AND INITIAL DATA PROCESSING

Professor Mike Meredith, British Antarctic Survey; Dr Chris Bull, British Antarctic Survey; Marina Costa, SAERI, Falklands; Tobias Ehmen, University of Exeter, UK; Dr Carmen Falagan-Rodriguez, University of Exeter, UK; Thomas Owen, British Antarctic Survey; Seth Thomas, British Antarctic Survey

The CTD instrumentation and configuration are as described in the AME Electronic section of this cruise report. 63 stations were occupied during JR19002, detailed in Table 7-4, with an additional 6 CTDs conducted in the vicinity of Burdwood Bank for SAERI. CTD data were acquired with SeaSave v7.22.3. At the start of a CTD cast, the package was deployed and lowered to 10m to enable acclimatization of the sensors, and for the pumps to commence operation. After this 10m soak, the package was raised to the surface prior to commencement of the downcast. CTD casts were conducted to near-seabed, with the altimeter used to level the package at approximately 10m above bottom. For ICEBERGS casts, bottles were closed at quasi-regular intervals on the upcast, with enhanced density of sampling in the near-surface layers. Some ICEBERGS casts had multiple bottle closures in the deepest layers, to enable Radium sampling by RaCETraX. For dedicated RaCETraX casts (of which there were typically one or two at each site), multiple bottle closures were conducted at typically 3 depths, to produce the large volumes of water required. The CTD package was paused for approximately 30 seconds on the upcast for each Niskin bottle closure, to enable the SBE35 to record high-precision temperature from a near-constant vertical level in the ocean and to allow recharge of the bottle closure capacitor. In addition to the ICEBERGS and RaCETraX casts, one test CTD cast was conducted at the start of the cruise (CTD# 1), and one cast was conducted near Port Lockroy for determination of sound speed velocity as part of the calibration of the EK80 echosounder (CTD# 45).

Table 7-4 ICEBERGS CTD location and comments. Sheldon Cove: 2, 5, 8, 9, 12, 13, 14, 15, 16, 17, 20, 23. Börgen Bay: 24, 27, 28, 31, 34, 35, 36, 37, 38, 41, 44, 45, 46 and Marian Cove: 47, 49, 50, 51, 53, 55, 57, 58, 60, 61, 63.

CTD #	Date	Time	Lat	Lon	Site	Comment
2					SC0	LADCP errors (no data recovered)
5	13-01-20	8:42:37	-67.567	-68.226	SC1	
8	13-01-20	14:29:23	-67.549	-68.266	SC2	
9	13-01-20	16:35:12	-67.543	-68.281	SCA	
12	13-01-20	21:31:12	-67.533	-68.275	SCB	
13	14-01-20	0:33:26	-67.514	-68.252	SC6	
14	14-01-20	2:11:29	-67.513	-68.253	IF1	
15	14-01-20	3:41:39	-67.515	-68.241	IF2	
16	14-01-20	3:42:29	-67.516	-68.238	IF3	
17	14-01-20	7:36:58	-67.528	-68.265	SCC	
20	14-01-20	20:13:45	-67.524	-68.261	SCD	
23	15-01-20	0:51:03	-67.52	-68.249	SCE	
24	19-01-20	16:29:11	-64.764	-63.471	BB0	
27	19-01-20	21:05:06	-64.735	-63.456	BBX	
28	19-01-20	23:21:55	-64.732	-63.481	BBA	
31	20-01-20	3:35:31	-64.717	-63.471	BBC	

34	20-01-20	8:16:30	-64.703	-63.434	BB-ICE3	
35	20-01-20	9:47:52	-64.702	-63.443	BB-ICE4	
36	20-01-20	20:52:45	-64.7	-63.453	BB-ICE2	
37	20-01-20	22:19:37	-64.701	-63.448	BB-ICE1	
38	20-01-20	23:56:27	-64.707	-63.464	BBD	
41	21-01-20	4:06:10	-64.702	-63.453	BBE	
44	21-01-20	12:33:11	-64.743	-63.457	BB1	
46	22-01-20	12:26:33	-64.724	-63.475	BBB	
47					MC1	Operator error (master sent slave script, and slave sent master)
49	24-01-20	19:19:35	-62.22	-58.817	MC0	
50	24-01-20	21:30:01	-62.213	-58.769	MC2	
51	24-01-20	22:56:21	-62.212	-58.763	MCA	
53					MCB	LDEO error: not enough data to process station
55					MCC	LDEO error: not enough data to process station
57	25-01-20	6:19:04	-62.206	-58.74	MC4	
58	25-01-20	7:38:40	-62.204	-58.736	MCD	
60	25-01-20	20:30:11	-62.202	-58.728	MC-ICE1	
61					MC-ICE2	LDEO error: Cannot determine time offset between CTD and LADCP time series
63	26-01-20	0:22:03	-62.201	-58.734	MCE	

After completion of a CTD cast, a script was run to produce a sound velocity profile for the EM122, then three steps were run in SBE Data Processing: i) Data Conversion, to export the data as text (.cnv and .ros) files; ii) Align CTD, to apply a time alignment offset to data; and iii) Cell Thermal Mass, to correct the conductivity readings for the thermal mass effect. The settings used for these steps were the recommended values as provided by SeaBird. After collection, data were transferred to the Matlab environment for detailed data screening and processing (Section 7.2.5). (The exceptions to this are the CTD casts conducted at Burdwood Bank for SAERI, for which processing was conducted fully in the SBE Data Processing modules). SBE35 high precision thermometer data were collected on each CTD cast, with one reading per Niskin bottle closure. These data were downloaded using the SeaTerm program, and transferred to the Matlab environment for inclusion in the detailed data processing (Section 7.2.5). Logsheets for each CTD deployment are archived in /data/cruise/jcr/20191226/work/scientific_work_area/ logsheets completed/ctd

7.2.2 WATER SAMPLING AND ANALYSIS

Professor Mike Meredith, British Antarctic Survey; Dr Amber Annett, University of Southampton, UK; Dr Chris Bull, British Antarctic Survey; Marina Costa, SAERI, Falklands; Tobias Ehmen, University of Exeter, UK; Dr Carmen Falagan-Rodriguez, University of Exeter, UK; Thomas Owen, British Antarctic Survey; Seth Thomas, British Antarctic Survey

The physical oceanography measurements that required water sample collection were for determination of salinity and for analysis of the ratio of stable oxygen isotopes in seawater ($\delta^{18}O$). The former was used for checking/calibration of the CTD salinity data (Section 7.2.3); the latter provide additional insight into the sources of freshwater measured in the ocean (sea ice melt versus meteoric water, with the latter representing the combination of glacial discharge and precipitation; Section 7.2.4).

Large volume water samples were collected from the CTD for analysis of radium and parent isotopes, used to constrain mixing and dispersion rates of glacially- and sediment-derived macronutrients and trace metals (Section 7.3). Owing to the very low concentrations of these isotopes, multiple Niskins were fired at the same depth and water pooled to obtain ~140 L samples, hence several CTD casts were performed at each location for radium work.
Nutrient samples were collected from the CTD to investigate macronutrient cycling between fjords and between years. 60ml samples were collected from 8-10 depths at most stations (see Table 7-5) filtered in-line using a 0.2um acropak filter capsule directly attached to the Niskin. The filter capsule was rinsed with at least 3 capsule volumes of water before rinsing the sample bottle 3 times and then filling. Nutrient samples were then immediately frozen at -20. All handling was done using vinyl gloves to prevent any contamination from nitrile gloves.

Table 7-5 Nutrient samples collected from CTD on JR19002

Number	Time	Event Number	cast	Latitude	Longitude	Bottle number	Sample depth(m)	Station
1	13/01/2020 03:25	4	2	-67.5986	-68.10144	1	354.2	SC0
2	13/01/2020 03:30	4	2	-67.5986	-68.10144	8	339.8	SC0
3	13/01/2020 03:32	4	2	-67.5986	-68.10144	9	299.9	SC0
4	13/01/2020 03:35	4	2	-67.5986	-68.10144	10	200.0	SC0
5	13/01/2020 03:37	4	2	-67.5986	-68.10144	11	150.4	SC0
6	13/01/2020 03:39	4	2	-67.5986	-68.10144	12	100.3	SC0
7	13/01/2020 03:41	4	2	-67.5986	-68.10144	13	50.6	SC0
8	13/01/2020 03:45	4	2	-67.5986	-68.10144	15	30.7	SC0
9	13/01/2020 03:49	4	2	-67.5986	-68.10144	19	10.9	SC0
10	13/01/2020 08:43	8	5	-67.5669	-68.22565	8	498.3	SC1
11	13/01/2020 08:45	8	5	-67.5669	-68.22565	9	469.4	SC1
12	13/01/2020 08:55	8	5	-67.5669	-68.22565	12	200.1	SC1
13	13/01/2020 09:00	8	5	-67.5669	-68.22565	13	150.2	SC1
14	13/01/2020 09:03	8	5	-67.5669	-68.22565	14	100.3	SC1
15	13/01/2020 09:06	8	5	-67.5669	-68.22565	15	50.3	SC1
16	13/01/2020 09:12	8	5	-67.5669	-68.22565	18	20.6	SC1
17	13/01/2020 09:19	8	5	-67.5669	-68.22565	23	-0.4	SC1
18	13/01/2020 14:24	12	8	-67.5493	-68.26622	1	166.5	SC2
19	13/01/2020 14:30	12	8	-67.5493	-68.26622	3	149.9	SC2
20	13/01/2020 14:35	12	8	-67.5493	-68.26622	5	130.0	SC2
21	13/01/2020 14:39	12	8	-67.5493	-68.26622	7	100.2	SC2
22	13/01/2020 14:44	12	8	-67.5493	-68.26622	13	70.2	SC2
23	13/01/2020 14:49	12	8	-67.5493	-68.26622	17	40.2	SC2
24	13/01/2020 14:51	12	8	-67.5493	-68.26622	19	20.3	SC2
25	13/01/2020 14:56	12	8	-67.5493	-68.26622	23	1.4	SC2
26	13/01/2020 16:34	13	9	-67.5427	-68.28041	1	265.4	SCA
27	13/01/2020 16:38	13	9	-67.5427	-68.28041	3	239.7	SCA
28	13/01/2020 16:41	13	9	-67.5427	-68.28041	5	219.8	SCA

29	13/01/2020 16:44	13	9	-67.5427	-68.28041	7	180.0	SCA
30	13/01/2020 16:46	13	9	-67.5427	-68.28041	9	139.9	SCA
31	13/01/2020 16:49	13	9	-67.5427	-68.28041	11	100.0	SCA
32	13/01/2020 16:55	13	9	-67.5427	-68.28041	15	70.0	SCA
33	13/01/2020 16:57	13	9	-67.5427	-68.28041	17	35.3	SCA
34	13/01/2020 17:00	13	9	-67.5427	-68.28041	19	10.5	SCA
35	13/01/2020 17:04	13	9	-67.5427	-68.28041	23	1.0	SCA
36	14/01/2020 00:22	20	13	-67.5142	-68.25192	1	154.6	SC6
37	14/01/2020 00:25	20	13	-67.5142	-68.25192	3	130.1	SC6
38	14/01/2020 00:27	20	13	-67.5142	-68.25192	5	120.2	SC6
39	14/01/2020 00:31	20	13	-67.5142	-68.25192	10	100.3	SC6
40	14/01/2020 00:34	20	13	-67.5142	-68.25192	12	60.3	SC6
41	14/01/2020 00:43	20	13	-67.5142	-68.25192	19	10.5	SC6
42	14/01/2020 00:45	20	13	-67.5142	-68.25192	21	5.6	SC6
43	14/01/2020 00:47	20	13	-67.5142	-68.25192	23	-0.2	SC6
44	14/01/2020 02:10	21	14	-67.5134	-68.25295	1	136.8	IF-1
45	14/01/2020 02:12	21	14	-67.5134	-68.25295	3	130.1	IF-1
46	14/01/2020 02:13	21	14	-67.5134	-68.25295	5	120.1	IF-1
47	14/01/2020 02:18	21	14	-67.5134	-68.25295	9	100.1	IF-1
48	14/01/2020 02:21	21	14	-67.5134	-68.25295	12	60.1	IF-1
49	14/01/2020 02:27	21	14	-67.5134	-68.25295	17	20.5	IF-1
50	14/01/2020 02:31	21	14	-67.5134	-68.25295	22	-0.4	IF-1
51	14/01/2020 03:41	22	15	-67.5152	-68.24078	2	149.4	IF-2
52	14/01/2020 03:43	22	15	-67.5152	-68.24078	3	129.7	IF-2
53	14/01/2020 03:47	22	15	-67.5152	-68.24078	7	109.9	IF-2
54	14/01/2020 03:51	22	15	-67.5152	-68.24078	11	79.9	IF-2
55	14/01/2020 03:53	22	15	-67.5152	-68.24078	12	59.1	IF-2
56	14/01/2020 03:54	22	15	-67.5152	-68.24078	13	40.1	IF-2
57	14/01/2020 03:59	22	15	-67.5152	-68.24078	17	20.1	IF-2
58	14/01/2020 04:05	22	15	-67.5152	-68.24078	22	-0.3	IF-2
59	14/01/2020 05:19	23	16	-67.5165	-68.23757	1	130.7	IF-3
60	14/01/2020 05:23	23	16	-67.5165	-68.23757	3	109.9	IF-3
61	14/01/2020 05:25	23	16	-67.5165	-68.23757	5	89.7	IF-3
62	14/01/2020 05:28	23	16	-67.5165	-68.23757	9	59.8	IF-3
63	14/01/2020 05:30	23	16	-67.5165	-68.23757	11	50.1	IF-3
64	14/01/2020 05:34	23	16	-67.5165	-68.23757	15	30.0	IF-3
65	14/01/2020 05:36	23	16	-67.5165	-68.23757	17	20.2	IF-3
66	14/01/2020 05:41	23	16	-67.5165	-68.23757	22	-0.6	IF-3
67	14/01/2020 07:21	24	17	-67.5284	-68.26495	1	225.9	SCC
68	14/01/2020 07:28	24	17	-67.5284	-68.26495	9	214.6	SCC
69	14/01/2020 07:31	24	17	-67.5284	-68.26495	10	189.6	SCC
70	14/01/2020 07:35	24	17	-67.5284	-68.26495	11	149.7	SCC
71	14/01/2020 07:41	24	17	-67.5284	-68.26495	14	80.0	SCC
72	14/01/2020 07:44	24	17	-67.5284	-68.26495	16	58.9	SCC
73	14/01/2020 07:49	24	17	-67.5284	-68.26495	18	40.1	SCC

74	14/01/2020 07:54	24	17	-67.5284	-68.26495	20	10.3	SCC
75	14/01/2020 07:58	24	17	-67.5284	-68.26495	22	-0.2	SCC
76	15/01/2020 00:51	33	23	-67.5196	-68.24873	7	178.1	SCE
77	15/01/2020 00:52	33	23	-67.5196	-68.24873	8	159.8	SCE
78	15/01/2020 00:54	33	23	-67.5196	-68.24873	9	129.8	SCE
79	15/01/2020 00:58	33	23	-67.5196	-68.24873	13	75.0	SCE
80	15/01/2020 01:00	33	23	-67.5196	-68.24873	15	50.1	SCE
81	15/01/2020 01:04	33	23	-67.5196	-68.24873	19	20.2	SCE
82	15/01/2020 01:06	33	23	-67.5196	-68.24873	21	10.3	SCE
83	15/01/2020 01:10	33	23	-67.5196	-68.24873	23	-0.5	SCE
84	19/01/2020 16:30	78	24	-64.7645	-63.47148	8	301.1	BB0
85	19/01/2020 16:31	78	24	-64.7645	-63.47148	9	290.9	BB0
86	19/01/2020 16:34	78	24	-64.7645	-63.47148	10	251.3	BB0
87	19/01/2020 16:36	78	24	-64.7645	-63.47148	11	201.3	BB0
88	19/01/2020 16:39	78	24	-64.7645	-63.47148	12	121.5	BB0
89	19/01/2020 16:41	78	24	-64.7645	-63.47148	13	91.8	BB0
90	19/01/2020 16:43	78	24	-64.7645	-63.47148	15	61.5	BB0
91	19/01/2020 16:51	78	24	-64.7645	-63.47148	20	11.9	BB0
92	19/01/2020 16:57	78	24	-64.7645	-63.47148	24	1.5	BB0
93	19/01/2020 20:51	82	27	-64.7346	-63.45585	1	132.1	BBX
94	19/01/2020 20:55	82	27	-64.7346	-63.45585	3	115.3	BBX
95	19/01/2020 20:59	82	27	-64.7346	-63.45585	5	90.4	BBX
96	19/01/2020 21:02	82	27	-64.7346	-63.45585	7	75.5	BBX
97	19/01/2020 21:06	82	27	-64.7346	-63.45585	12	60.6	BBX
98	19/01/2020 21:14	82	27	-64.7346	-63.45585	16	40.6	BBX
99	19/01/2020 21:17	82	27	-64.7346	-63.45585	17	25.6	BBX
100	19/01/2020 21:23	82	27	-64.7346	-63.45585	19	15.8	BBX
101	19/01/2020 21:25	82	27	-64.7346	-63.45585	21	5.8	BBX
102	19/01/2020 21:28	82	27	-64.7346	-63.45585	23	-0.6	BBX
103	19/01/2020 23:20	85	28	-64.7317	-63.48139	2	173.0	BBA
104	19/01/2020 23:25	85	28	-64.7317	-63.48139	9	150.0	BBA
105	19/01/2020 23:28	85	28	-64.7317	-63.48139	11	129.8	BBA
106	19/01/2020 23:32	85	28	-64.7317	-63.48139	13	60.2	BBA
107	19/01/2020 23:35	85	28	-64.7317	-63.48139	15	40.2	BBA
108	19/01/2020 23:37	85	28	-64.7317	-63.48139	16	30.1	BBA
109	19/01/2020 23:39	85	28	-64.7317	-63.48139	18	25.3	BBA
110	19/01/2020 23:42	85	28	-64.7317	-63.48139	20	10.4	BBA
111	19/01/2020 23:44	85	28	-64.7317	-63.48139	22	5.3	BBA
112	19/01/2020 23:47	85	28	-64.7317	-63.48139	24	-0.5	BBA
113	20/01/2020 03:38	88	31	-64.7171	-63.47041	9	179.1	BBC
114	20/01/2020 03:41	88	31	-64.7171	-63.47041	11	150.2	BBC
115	20/01/2020 03:45	88	31	-64.7171	-63.47041	13	99.9	BBC
116	20/01/2020 03:49	88	31	-64.7171	-63.47041	14	59.9	BBC
117	20/01/2020 03:52	88	31	-64.7171	-63.47041	16	40.4	BBC
118	20/01/2020 03:53	88	31	-64.7171	-63.47041	17	30.5	BBC

119	20/01/2020 03:55	88	31	-64.7171	-63.47041	18	25.3	BBC
120	20/01/2020 03:57	88	31	-64.7171	-63.47041	20	10.5	BBC
121	20/01/2020 04:00	88	31	-64.7171	-63.47041	22	5.3	BBC
122	20/01/2020 04:03	88	31	-64.7171	-63.47041	24	-0.4	BBC
123	20/01/2020 08:16	92	34	-64.7029	-63.43377	1	202.1	BB-IF3
124	20/01/2020 08:19	92	34	-64.7029	-63.43377	3	179.7	BB-IF3
125	20/01/2020 08:21	92	34	-64.7029	-63.43377	5	159.9	BB-IF3
126	20/01/2020 08:27	92	34	-64.7029	-63.43377	9	99.9	BB-IF3
127	20/01/2020 08:29	92	34	-64.7029	-63.43377	11	79.9	BB-IF3
128	20/01/2020 08:34	92	34	-64.7029	-63.43377	16	40.1	BB-IF3
129	20/01/2020 08:36	92	34	-64.7029	-63.43377	17	30.2	BB-IF3
130	20/01/2020 08:40	92	34	-64.7029	-63.43377	19	10.3	BB-IF3
131	20/01/2020 08:42	92	34	-64.7029	-63.43377	21	5.3	BB-IF3
132	20/01/2020 08:45	92	34	-64.7029	-63.43377	23	-0.5	BB-IF3
133	20/01/2020 09:45	93	35	-64.7021	-63.44257	1	206.8	BB-IF4
134	20/01/2020 09:48	93	35	-64.7021	-63.44257	3	180.2	BB-IF4
135	20/01/2020 09:53	93	35	-64.7021	-63.44257	7	130.3	BB-IF4
136	20/01/2020 09:59	93	35	-64.7021	-63.44257	11	80.1	BB-IF4
137	20/01/2020 10:01	93	35	-64.7021	-63.44257	13	60.7	BB-IF4
138	20/01/2020 10:03	93	35	-64.7021	-63.44257	15	40.6	BB-IF4
139	20/01/2020 10:05	93	35	-64.7021	-63.44257	17	30.3	BB-IF4
140	20/01/2020 10:08	93	35	-64.7021	-63.44257	19	10.8	BB-IF4
141	20/01/2020 10:10	93	35	-64.7021	-63.44257	21	5.9	BB-IF4
142	20/01/2020 10:12	93	35	-64.7021	-63.44257	23	0.6	BB-IF4
143	20/01/2020 20:55	103	36	-64.7004	-63.4534	4	210.6	BB-IF2
144	20/01/2020 20:58	103	36	-64.7004	-63.4534	6	190.6	BB-IF2
145	20/01/2020 21:02	103	36	-64.7004	-63.4534	8	150.6	BB-IF2
146	20/01/2020 21:06	103	36	-64.7004	-63.4534	11	100.8	BB-IF2
147	20/01/2020 21:13	103	36	-64.7004	-63.4534	15	36.0	BB-IF2
148	20/01/2020 21:15	103	36	-64.7004	-63.4534	17	26.0	BB-IF2
149	20/01/2020 21:19	103	36	-64.7004	-63.4534	19	11.1	BB-IF2
150	20/01/2020 21:21	103	36	-64.7004	-63.4534	21	6.0	BB-IF2
151	20/01/2020 22:23	104	37	-64.7009	-63.44771	6	190.0	BB-IF1
152	20/01/2020 22:28	104	37	-64.7009	-63.44771	8	150.1	BB-IF1
153	20/01/2020 22:35	104	37	-64.7009	-63.44771	13	75.1	BB-IF1
154	20/01/2020 22:37	104	37	-64.7009	-63.44771	14	50.4	BB-IF1
155	20/01/2020 22:39	104	37	-64.7009	-63.44771	16	30.4	BB-IF1
156	20/01/2020 22:44	104	37	-64.7009	-63.44771	20	10.5	BB-IF1
157	20/01/2020 22:46	104	37	-64.7009	-63.44771	22	5.5	BB-IF1
158	20/01/2020 22:48	104	37	-64.7009	-63.44771	24	-0.3	BB-IF1
159	20/01/2020 23:42	105	38	-64.7071	-63.4644	1	182.9	BBD
160	20/01/2020 23:47	105	38	-64.7071	-63.4644	9	169.8	BBD
161	20/01/2020 23:49	105	38	-64.7071	-63.4644	10	150.0	BBD
162	20/01/2020 23:53	105	38	-64.7071	-63.4644	12	120.0	BBD
163	20/01/2020 23:56	105	38	-64.7071	-63.4644	14	100.1	BBD

164	20/01/2020 23:58	105	38	-64.7071	-63.4644	15	75.1	BBD
165	21/01/2020 00:00	105	38	-64.7071	-63.4644	16	50.2	BBD
166	21/01/2020 00:05	105	38	-64.7071	-63.4644	19	20.5	BBD
167	21/01/2020 00:09	105	38	-64.7071	-63.4644	21	10.5	BBD
168	21/01/2020 00:13	105	38	-64.7071	-63.4644	23	-0.4	BBD
169	21/01/2020 04:06	109	41	-64.7024	-63.45265	2	254.0	BBE
170	21/01/2020 04:08	109	41	-64.7024	-63.45265	3	244.0	BBE
171	21/01/2020 04:14	109	41	-64.7024	-63.45265	11	175.2	BBE
172	21/01/2020 04:17	109	41	-64.7024	-63.45265	12	109.7	BBE
173	21/01/2020 04:19	109	41	-64.7024	-63.45265	13	75.3	BBE
174	21/01/2020 04:22	109	41	-64.7024	-63.45265	15	50.3	BBE
175	21/01/2020 04:25	109	41	-64.7024	-63.45265	17	40.5	BBE
176	21/01/2020 04:30	109	41	-64.7024	-63.45265	20	10.8	BBE
177	21/01/2020 04:35	109	41	-64.7024	-63.45265	23	-0.4	BBE
178	21/01/2020 12:30	114	44	-64.7429	-63.45701	2	242.0	BB1
179	21/01/2020 12:34	114	44	-64.7429	-63.45701	4	230.4	BB1
180	21/01/2020 12:38	114	44	-64.7429	-63.45701	6	180.6	BB1
181	21/01/2020 12:46	114	44	-64.7429	-63.45701	10	100.6	BB1
182	21/01/2020 12:48	114	44	-64.7429	-63.45701	12	80.7	BB1
183	21/01/2020 12:51	114	44	-64.7429	-63.45701	14	50.8	BB1
184	21/01/2020 12:54	114	44	-64.7429	-63.45701	16	30.8	BB1
185	21/01/2020 13:00	114	44	-64.7429	-63.45701	20	11.1	BB1
186	21/01/2020 13:04	114	44	-64.7429	-63.45701	24	1.1	BB1
187	24/01/2020 16:36	150	47	-62.2175	-58.78949	1	87.2	MC1
188	24/01/2020 16:45	150	47	-62.2175	-58.78949	10	71.0	MC1
189	24/01/2020 16:48	150	47	-62.2175	-58.78949	11	50.3	MC1
190	24/01/2020 16:53	150	47	-62.2175	-58.78949	13	31.2	MC1
191	24/01/2020 16:54	150	47	-62.2175	-58.78949	14	21.3	MC1
192	24/01/2020 16:57	150	47	-62.2175	-58.78949	15	15.1	MC1
193	24/01/2020 17:04	150	47	-62.2175	-58.78949	23	5.1	MC1
194	24/01/2020 17:05	150	47	-62.2175	-58.78949	24	1.3	MC1
195	24/01/2020 19:18	153	49	-62.2199	-58.81722	1	227.8	MC0
196	24/01/2020 19:22	153	49	-62.2199	-58.81722	3	211.0	MC0
197	24/01/2020 19:25	153	49	-62.2199	-58.81722	5	180.9	MC0
198	24/01/2020 19:31	153	49	-62.2199	-58.81722	8	121.0	MC0
199	24/01/2020 19:34	153	49	-62.2199	-58.81722	11	91.1	MC0
200	24/01/2020 19:40	153	49	-62.2199	-58.81722	15	51.0	MC0
201	24/01/2020 19:45	153	49	-62.2199	-58.81722	18	31.3	MC0
202	24/01/2020 19:49	153	49	-62.2199	-58.81722	21	11.4	MC0
203	24/01/2020 19:54	153	49	-62.2199	-58.81722	23	1.2	MC0
204	24/01/2020 21:25	156	50	-62.2128	-58.7692	7	70.2	MC2
205	24/01/2020 21:30	156	50	-62.2128	-58.7692	11	49.7	MC2
206	24/01/2020 21:34	156	50	-62.2128	-58.7692	15	30.2	MC2
207	24/01/2020 21:39	156	50	-62.2128	-58.7692	19	10.1	MC2
208	24/01/2020 21:44	156	50	-62.2128	-58.7692	23	-0.3	MC2

209	24/01/2020 22:34	157	51	-62.2119	-58.76265	1	95.4	MCA
210	24/01/2020 22:45	157	51	-62.2119	-58.76265	9	85.2	MCA
211	24/01/2020 22:52	157	51	-62.2119	-58.76265	17	70.3	MCA
212	24/01/2020 22:55	157	51	-62.2119	-58.76265	18	50.4	MCA
213	24/01/2020 22:59	157	51	-62.2119	-58.76265	20	30.3	MCA
214	24/01/2020 23:00	157	51	-62.2119	-58.76265	21	20.5	MCA
215	24/01/2020 23:02	157	51	-62.2119	-58.76265	22	10.6	MCA
216	24/01/2020 23:07	157	51	-62.2119	-58.76265	24	-0.4	MCA
217	25/01/2020 01:28	161	53	-62.2086	-58.7539	8	43.6	MCB
218	25/01/2020 01:30	161	53	-62.2086	-58.7539	11	40.4	MCB
219	25/01/2020 01:34	161	53	-62.2086	-58.7539	13	30.3	MCB
220	25/01/2020 01:37	161	53	-62.2086	-58.7539	16	20.3	MCB
221	25/01/2020 01:40	161	53	-62.2086	-58.7539	18	15.4	MCB
222	25/01/2020 01:42	161	53	-62.2086	-58.7539	20	10.3	MCB
223	25/01/2020 01:46	161	53	-62.2086	-58.7539	23	-0.5	MCB
224	25/01/2020 02:38	164	55	-62.205	-58.74693	1	29.7	MCC
225	25/01/2020 02:45	164	55	-62.205	-58.74693	9	10.2	MCC
226	25/01/2020 02:51	164	55	-62.205	-58.74693	17	-0.5	MCC
227	25/01/2020 02:52	164	55	-62.205	-58.74693	19	-0.5	MCC
228	25/01/2020 02:53	164	55	-62.205	-58.74693	20	-0.5	MCC
229	25/01/2020 02:54	164	55	-62.205	-58.74693	23	-0.5	MCC
230	25/01/2020 02:55	164	55	-62.205	-58.74693	24	-0.5	MCC
231	25/01/2020 06:05	168	57	-62.2059	-58.74008	1	105.9	MC4
232	25/01/2020 06:08	168	57	-62.2059	-58.74008	3	95.0	MC4
233	25/01/2020 06:10	168	57	-62.2059	-58.74008	5	85.1	MC4
234	25/01/2020 06:12	168	57	-62.2059	-58.74008	7	75.1	MC4
235	25/01/2020 06:20	168	57	-62.2059	-58.74008	11	50.2	MC4
236	25/01/2020 06:25	168	57	-62.2059	-58.74008	16	20.4	MC4
237	25/01/2020 06:27	168	57	-62.2059	-58.74008	18	15.1	MC4
238	25/01/2020 06:33	168	57	-62.2059	-58.74008	24	-0.4	MC4
239	25/01/2020 07:24	169	58	-62.2035	-58.73634	1	86.3	MCD
240	25/01/2020 07:30	169	58	-62.2035	-58.73634	9	75.2	MCD
241	25/01/2020 07:32	169	58	-62.2035	-58.73634	10	70.4	MCD
242	25/01/2020 07:38	169	58	-62.2035	-58.73634	12	50.4	MCD
243	25/01/2020 07:44	169	58	-62.2035	-58.73634	16	20.6	MCD
244	25/01/2020 07:46	169	58	-62.2035	-58.73634	18	15.3	MCD
245	25/01/2020 07:51	169	58	-62.2035	-58.73634	22	5.5	MCD
246	25/01/2020 07:54	169	58	-62.2035	-58.73634	23	-0.5	MCD
247	25/01/2020 20:37	174	60	-62.2023	-58.72793	6	61.3	MC-Ice-1
248	25/01/2020 20:40	174	60	-62.2023	-58.72793	12	46.4	MC-Ice-1
249	25/01/2020 20:43	174	60	-62.2023	-58.72793	14	31.2	MC-Ice-1
250	25/01/2020 20:45	174	60	-62.2023	-58.72793	16	21.6	MC-Ice-1
251	25/01/2020 20:47	174	60	-62.2023	-58.72793	17	11.5	MC-Ice-1
252	25/01/2020 20:51	174	60	-62.2023	-58.72793	23	0.9	MC-Ice-1
253	25/01/2020 21:45	175	61	-62.2015	-58.72876	1	78.3	MC-Ice-2

254	25/01/2020 21:47	175	61	-62.2015	-58.72876	3	70.3	MC-Ice-2
255	25/01/2020 21:50	175	61	-62.2015	-58.72876	5	60.4	MC-Ice-2
256	25/01/2020 21:53	175	61	-62.2015	-58.72876	11	45.4	MC-Ice-2
257	25/01/2020 21:56	175	61	-62.2015	-58.72876	13	30.5	MC-Ice-2
258	25/01/2020 21:58	175	61	-62.2015	-58.72876	14	20.5	MC-Ice-2
259	25/01/2020 22:00	175	61	-62.2015	-58.72876	16	10.6	MC-Ice-2
260	25/01/2020 22:03	175	61	-62.2015	-58.72876	18	5.5	MC-Ice-2
261	25/01/2020 22:05	175	61	-62.2015	-58.72876	23	-0.3	MC-Ice-2
262	26/01/2020 00:12	178	63	-62.201	-58.73429	11	66.9	MCE
263	26/01/2020 00:18	178	63	-62.201	-58.73429	18	50.3	MCE
264	26/01/2020 00:20	178	63	-62.201	-58.73429	19	40.3	MCE
265	26/01/2020 00:23	178	63	-62.201	-58.73429	20	30.3	MCE
266	26/01/2020 00:25	178	63	-62.201	-58.73429	21	20.4	MCE
267	26/01/2020 00:27	178	63	-62.201	-58.73429	22	10.3	MCE
268	26/01/2020 00:28	178	63	-62.201	-58.73429	23	5.5	MCE
269	26/01/2020 00:28	178	63	-62.201	-58.73429	24	Surf.	MCE

At some stations (see Table 7-6), additional filtered seawater samples were collected for Rare Earth Element (REE) analysis, to provide interannual comparison of REEs as a tracer for meltwater, in collaboration with the GLARE CASS project on JR18003. After nutrient collection, a 500ml acid-cleaned bottle was rinsed and filled with filtered seawater following the same procedure as for nutrients. Samples were acidified and will be analysed by James Williams (Cardiff University).

Table 7-6 Samples collected from CTD for Rare Earth Element analysis

Number	Time	Event	Cast	Latitude	Longitude	Bottle number	Sample depth(m)	Station
1	13/01/2020 03:25	4	2	-67.59861	-68.10144	1	354.2	SC0
2	13/01/2020 03:30	4	2	-67.59861	-68.10144	8	339.8	SC0
3	13/01/2020 03:32	4	2	-67.59861	-68.10144	9	299.9	SC0
4	13/01/2020 03:35	4	2	-67.59861	-68.10144	10	200.0	SC0
5	13/01/2020 03:39	4	2	-67.59861	-68.10144	12	100.3	SC0
6	13/01/2020 03:45	4	2	-67.59861	-68.10144	15	30.7	SC0
7	13/01/2020 03:49	4	2	-67.59861	-68.10144	19	10.9	SC0
8	14/01/2020 00:22	20	13	-67.51422	-68.25192	1	154.6	SC6
9	14/01/2020 00:25	20	13	-67.51422	-68.25192	3	130.1	SC6
10	14/01/2020 00:27	20	13	-67.51422	-68.25192	5	120.2	SC6
11	14/01/2020 00:47	20	13	-67.51422	-68.25192	23	-0.2	SC6
12	21/01/2020 04:06	109	41	-64.70236	-63.45265	2	254.0	BBE
13	21/01/2020 04:08	109	41	-64.70236	-63.45265	3	244.0	BBE
14	21/01/2020 04:17	109	41	-64.70236	-63.45265	12	109.7	BBE
15	21/01/2020 04:22	109	41	-64.70236	-63.45265	15	50.3	BBE
16	21/01/2020 04:25	109	41	-64.70236	-63.45265	17	40.5	BBE
17	21/01/2020 04:30	109	41	-64.70236	-63.45265	20	10.8	BBE
18	21/01/2020 04:35	109	41	-64.70236	-63.45265	23	-0.4	BBE
19	21/01/2020 12:30	114	44	-64.7429	-63.45701	2	242.0	BB1

20	21/01/2020 12:46	114	44	-64.7429	-63.45701	10	100.6	BB1
21	21/01/2020 12:51	114	44	-64.7429	-63.45701	14	50.8	BB1
22	21/01/2020 12:54	114	44	-64.7429	-63.45701	16	30.8	BB1
23	21/01/2020 13:00	114	44	-64.7429	-63.45701	20	11.1	BB1
24	21/01/2020 13:04	114	44	-64.7429	-63.45701	24	1.1	BB1
25	24/01/2020 16:36	150	47	-62.21748	-58.78949	1	87.2	MC1
26	24/01/2020 16:45	150	47	-62.21748	-58.78949	10	71.0	MC1
27	24/01/2020 16:48	150	47	-62.21748	-58.78949	11	50.3	MC1
28	24/01/2020 16:53	150	47	-62.21748	-58.78949	13	31.2	MC1
29	24/01/2020 16:57	150	47	-62.21748	-58.78949	15	15.1	MC1
30	24/01/2020 17:05	150	47	-62.21748	-58.78949	24	1.3	MC1
31	26/01/2020 00:12	178	63	-62.201	-58.73429	11	66.9	MCE
32	26/01/2020 00:18	178	63	-62.201	-58.73429	18	50.3	MCE
33	26/01/2020 00:23	178	63	-62.201	-58.73429	20	30.3	MCE
34	26/01/2020 00:27	178	63	-62.201	-58.73429	22	10.3	MCE
35	26/01/2020 00:28	178	63	-62.201	-58.73429	23	5.5	MCE
36	26/01/2020 00:28	178	63	-62.201	-58.73429	24	Surf.	MCE

At select stations (see Table 7.7), 250ml samples of filtered seawater were also collected from the deepest Niskin. Collection procedures followed that for nutrients and REE, with the samples frozen, for analysis of dissolved organic material by Dr. Jon Hawkings at the University of South Florida.

Table 7-7 Samples collected from CTD for dissolved organic material analysis

Number	Time	Event Number	cast	Latitude	Longitude	Bottle number	Sample depth(m)	Station
1	13/01/2020 03:25	4	2	-67.59861	-68.10144	1	354.2	SC0
2	13/01/2020 14:24	12	8	-67.54933	-68.26622	1	166.5	SC2
3	13/01/2020 16:34	13	9	-67.54267	-68.28041	1	265.4	SCA
4	14/01/2020 00:22	20	13	-67.51422	-68.25192	1	154.6	SC6
5	14/01/2020 07:21	24	17	-67.52838	-68.26495	1	225.9	SCC
6	15/01/2020 00:51	33	23	-67.51964	-68.24873	7	178.1	SCE
7	19/01/2020 20:51	82	27	-64.73458	-63.45585	1	132.1	BBX
8	19/01/2020 23:20	85	28	-64.73165	-63.48139	2	173.0	BBA
9	20/01/2020 03:38	88	31	-64.71705	-63.47041	9	179.1	BBC
10	20/01/2020 23:42	105	38	-64.70714	-63.4644	1	182.9	BBD
11	21/01/2020 04:06	109	41	-64.70236	-63.45265	2	254.0	BBE
12	21/01/2020 12:30	114	44	-64.7429	-63.45701	2	242.0	BB1
13	24/01/2020 16:36	150	47	-62.21748	-58.78949	1	87.2	MC1
14	24/01/2020 19:18	153	49	-62.21989	-58.81722	1	227.8	MC0
15	24/01/2020 21:25	156	50	-62.21275	-58.7692	7	70.2	MC2
16	24/01/2020 22:34	157	51	-62.21192	-58.76265	1	95.4	MCA
17	25/01/2020 01:28	161	53	-62.20856	-58.7539	8	43.6	MCB
18	25/01/2020 02:38	164	55	-62.20498	-58.74693	1	29.7	MCC
19	25/01/2020 06:05	168	57	-62.20586	-58.74008	1	105.9	MC4
20	25/01/2020 07:24	169	58	-62.20354	-58.73634	1	86.3	MCD

21	25/01/2020 21:45	175	61	-62.2015	-58.72876	1	78.3	MC-Ice-2
22	26/01/2020 00:12	178	63	-62.201	-58.73429	11	66.9	MCE

Copies of the sampling logs are available in /data/cruise/jcr/20191226/work/scientific_work_area/ logsheets completed/niskin sampling logs

7.2.3 SALINITY

Dr Chris Bull, British Antarctic Survey; Tobias Ehmen, University of Exeter, UK; Aisling Smith, British Antarctic Survey

Samples for salinity analysis were drawn from the Niskin bottles into 200ml salinity bottles, which were rinsed three times with sample before filling. These were sealed with plastic inserts and closed with screw caps, with the bottle neck first having been dried to prevent salt crystal development. Typically, six salinity samples were drawn per ICEBERGS CTD cast, and none from RaCETraX casts. In addition, salinity samples were collected at quasi-regular intervals (approximately four times per day) from the underwater water supply; these were sealed and handled using the same methodology as for the Niskin bottle samples. Samples were also collected from the small boats deployed in each of Sheldon Cove, Börgen Bay and Marian Cove, with bottles hand-filled directly from the ocean surface and sealed following the same protocol as above.

When a salinity crate was full (24 bottles), it was moved to the Radiation Laboratory for analysis. Crates were left in this laboratory for a minimum of 24 hours to temperature acclimatise, prior to analysis on a Guildline 8400B salinometer (serial number 63360). The bath temperature of this salinometer was set to 24°C, being a couple of degrees above the approximate mean temperature of the Radiation Laboratory at 22°C; this was seen to vary significantly at the very start of the cruise, but became suitably stable by the time salinity analyses commenced. The salinometer was standardised at the start of the cruise using IAPSO P-series standard seawater (batch number P162), and the standardisation was not subsequently reset. Bottles of the same standard seawater were run at the start and end of each crate of samples, to derive the offsets needed for accurate salinity calculation.

Conductivity readings were recorded from the salinometer by hand (logsheets or computer entry), then transferred to an Excel spreadsheet from which salinity was derived. Typically, three conductivity readings were taken per sample. These values were then exported as ascii for assimilation into the Matlab data processing (Section 7.2.5). Copies of the salinometry logs are available in /data/cruise/jcr/20191226/work/scientific_work_area/ logsheets completed/salts

7.2.4 OXYGEN ISOTOPES

Professor Mike Meredith, British Antarctic Survey

Samples for $\delta^{18}O$ analysis were drawn from ICEBERGS CTD casts. Typically, eight samples were collected per cast, with vertical spacing reduced in the near-surface layers where salinity/freshwater gradients are largest. Samples were also drawn from the ship's underway water supply, at the same times as the underway salinity samples (Section 7.2.3). In addition, samples were decanted from the small boat salinity samples collected in each of Sheldon Cove, Börgen Bay and Marian Cove, with those salinity samples then re-sealed prior to analysis.

$\delta^{18}O$ samples were stored in 50ml glass vials, which had been pre-rinsed with the water to be sampled. These were sealed with rubber inserts and closed with metal crimp seals via hand crimpers. These samples will be shipped to the UK for $\delta^{18}O$ analysis at the NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth. 96 $\delta^{18}O$ samples were collected from Sheldon Cove, 96 from Börgen Bay, 88 from Marian Cove, and 51 from the pumped underway supply. In addition, 20 samples were collected using small boats in Sheldon Cove, 13 in Börgen Bay, and 24 in Marian Cove.

7.2.5 CTD PROCESSING AND CALIBRATION

Professor Mike Meredith, British Antarctic Survey

Detailed processing procedure: Detailed cleaning and processing of the CTD data were performed in Matlab using a set of scripts that have been evolved by BAS and partners over many years. The latest iteration of this code was obtained from Dr Hugh Venables immediately prior to JR19002, and adapted for the purposes of the cruise. This version had been made generic, with an initial startup file created that lists cruise-specific details such as CTD sensors fitted, variable names, etc.
The scripts run in sequence were:

ctdreadGEN – ingests the CTD data as outputted from the SBE Data Processing module, and arranges in Matlab arrays.

editctdGEN – launches a set of automated and interactive data cleaning routines, to select the start of the downcast after the 10m soak and to remove obvious sections of bad data.

*deriveGEN** – to calculate derived variables from the basic variables recorded.

*onehzctdGEN** – to subsample the data from the recorded rate of 24Hz to 1Hz, for ingestion into the LADCP data processing (see Section 7.2.6).

*splitcastGEN** – to create separate files for the downcast and upcast sections of each CTD.

*fallrateGEN** – to filter the downcast data to remove periods during which the package had stalled (or nearly stalled) in its downwards motion, due to ship rolling. This can lead to wake effects contaminating the data if not adequately addressed in the processing.

*gridctdGEN** – to average the CTD data onto a regular vertical grid (2 dbar).
(The scripts marked with an asterisk* were typically run as a batch script, *batch_ctdGEN*, unless one failed and required step-by-step investigation).

makebotGEN – create a file containing the CTD data from the timings of the Niskin bottle closures.
sb35readGEN – ingest the SBE35 high-precision thermometer data into the bottle file created above, and append the data to the temperature calibrations file.

readsalGEN# – read salinity data from the ascii files outputted from Excel into the Matlab environment.

addsalGEN# – reads bottle salinity file and adds sample data.

salcalGEN# – derives offsets between CTD and bottle salinities, for use in determining stability/performance of sensors.

mergebotGEN# – combines bottle data with SBE35 data into combined bottle file.
(The scripts marked with a hash# were typically run as a batch script, *batch_botGEN*, unless one failed and required step-by-step investigation).

For the CTD stations conducted at Burdwood Bank for SAERI, data processing was conducted entirely in the SBE Data Processing software. This is to enable any post-cruise re-processing to be conducted by SAERI using the SBE software (which is freely downloadable from the SeaBird website), without need to use Matlab. The modules used were:-

i) Data Conversion – to read the output of the CTD package and convert data to ascii.
ii) Filter – to low pass filter the pressure record prior to the Loop Edit step.
iii) Align – to apply time corrections to place the sensor measurements on the same time origin.
iv) Cell Thermal Mass – to correct the conductivity measurements for the cell thermal mass effect
v) Loop Edit – to remove artificial loops in the data caused by the ship rolling in large swell.
vi) Wild Edit – to remove data points that lie outside reasonable ranges.
vii) Derive – to derive common oceanographic variables from baseline measurements, such as potential temperature, salinity, density.
viii) Bin Average – to average the data in 2 decibar intervals in the vertical. The downcast data were selected as output at this stage.
ix) Bottle Summary – to export the CTD data from the bottle firing times.
x) SeaPlot – to produce a summary jpeg plot of the cast profiles.

Data from Burdwood Bank are stored in /legdata/ctd/JR19002_Processed; the final files are **JR19002_NNNfaclwwd2db.cnv** and **JR19002_NNN.btl** for the full profiles and data from the bottle closure depths respectively, where NNN is the CTD cast number.

Calibrations: The compiled CTD and SBE35 data were examined to investigate performance of the CTD temperature sensors. Figure 7-11 shows the offsets between SBE35 and CTD temperature (primary and secondary) for the full range of pressures on ICEBERGS; Figure 7-12 shows the same data but on an expanded scale. Whilst the scatter in the near-surface layers is inevitably large, the mean offsets are small and comfortably within the target range of the CTD temperature accuracy. Whilst there is very little deep ocean data from JR19002, such data as do exist again show CTD temperature data to be accurate to within the target range (around ±0.002°C). Accordingly, there is no justification to apply a temperature offset calibration to the JR19002 CTD data.
Figures Figure 7-13 and Figure 7-14 show the corresponding offsets between bottle conductivity measurements and the CTD conductivities (primary and secondary). There are fewer data shown in these figures compared with the temperature figures, since there were fewer bottle conductivities measured than there were SBE35 thermometer readings taken. There is considerable spread in the upper few hundred meters of these figures, as is expected given the depth of the halocline and the strong salinity gradients in the upper ocean close to Antarctica. Below this area of spread, the deeper profiles converge to an offset that is within the target range (around 0.002 to 0.003). Although there were few profiles that extended this deep, this gives confidence that no further conductivity calibration is justified.

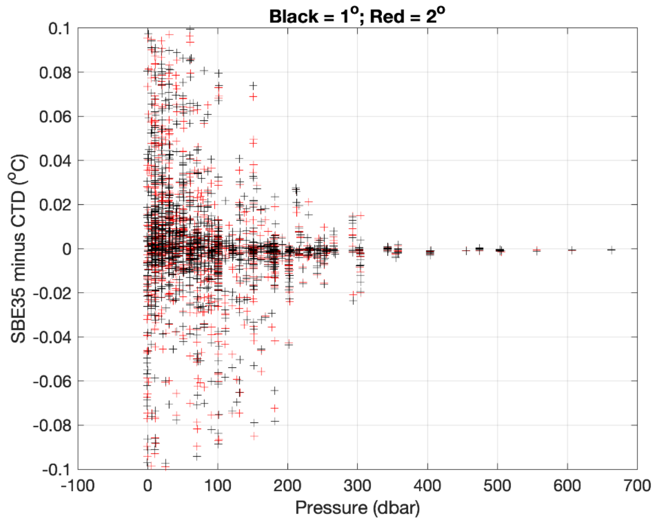

Figure 7-11 SBE35 minus CTD temperature (primary and secondary), as a function of pressure

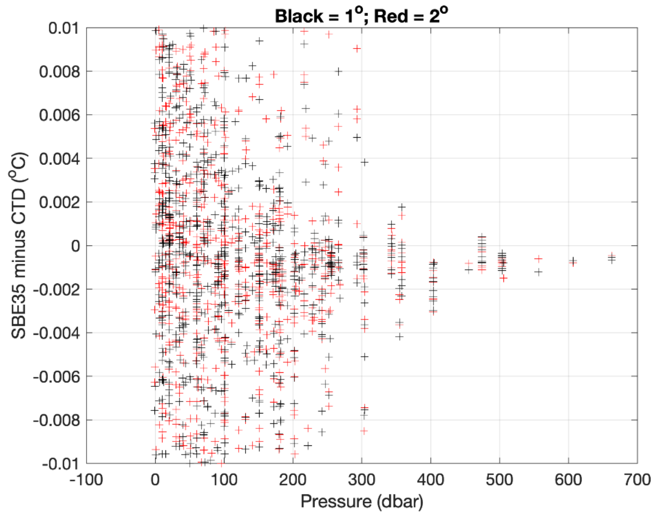

Figure 7-12 As per Figure 7-11, but on an expanded temperature offset scale

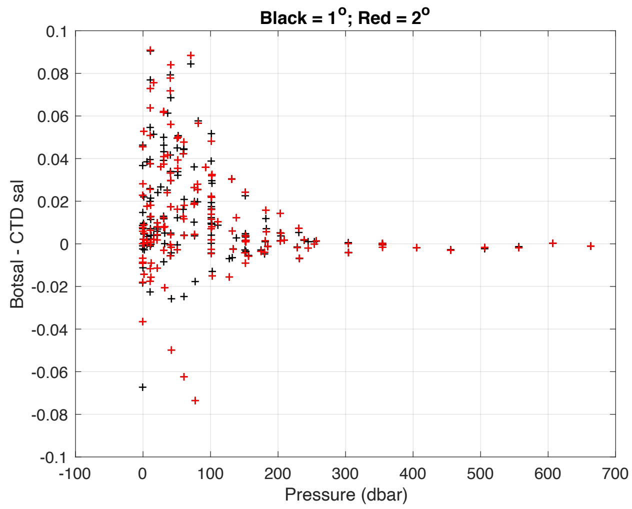

Figure 7-13 Difference between bottle and CTD conductivity, as a function of pressure. Differences for both primary and secondary CTD conductivity sensors are shown.

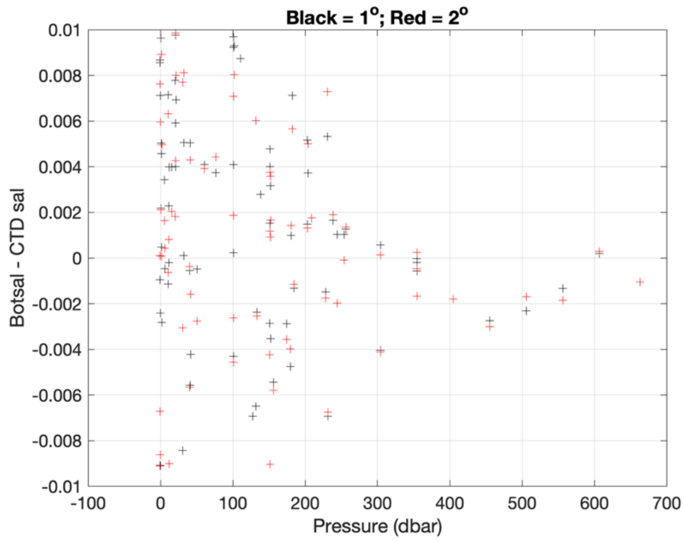

Figure 7-14 As per Figure 7-13, but on an expanded salinity offset scale

Whilst temperature and conductivity data do not require further calibration, a pressure offset in the JR19002 CTD data was observed, with pressure at the final Niskin closure (immediately and visibly below the sea surface) occasionally being recorded as negative. This was corrected for in the Matlab processing with the addition of a simple deck pressure offset (0.7 dbar), with derived variables recalculated using the corrected pressure.

Final data products are **JR19002_bot_all.mat** and **JR19002_CTD_2dbar.mat**, with the former being the compiled bottle data and CTD/SBE35 data from the bottle closure depths, and the latter being the CTD profile data processed and averaged to 2dbar vertical intervals. These files are stored in **/data/cruise/jcr/20191226/work/scientific_work_area/ctd .** The bottle data file contains blank fields for variables that will be measured from samples taken ashore, e.g. $\delta^{18}O$.

Example CTD data: Numerous features of interest were observed in the CTD data collected during JR19002, to be investigated fully as part of ICEBERGS, RaCETraX and associated projects. Figure 7-15 shows potential temperature and salinity sections across Sheldon Cove, and Figure 7-16 shows the corresponding sections of fluorescence and beam transmission. Of particular note in these sections is the plume of low-transmission water emanating from the region of the ice front at around 100-200m depth, and spreading at those levels across the cove even as the seabed deepens (Figure 7-16). This is suggestive of sediment entering the ocean from (or close to) the base of the glacier, and spreading as a neutrally-buoyant plume into the ocean interior. The characteristics and fate of this plume could have significant biogeochemical implications, to be investigated further.

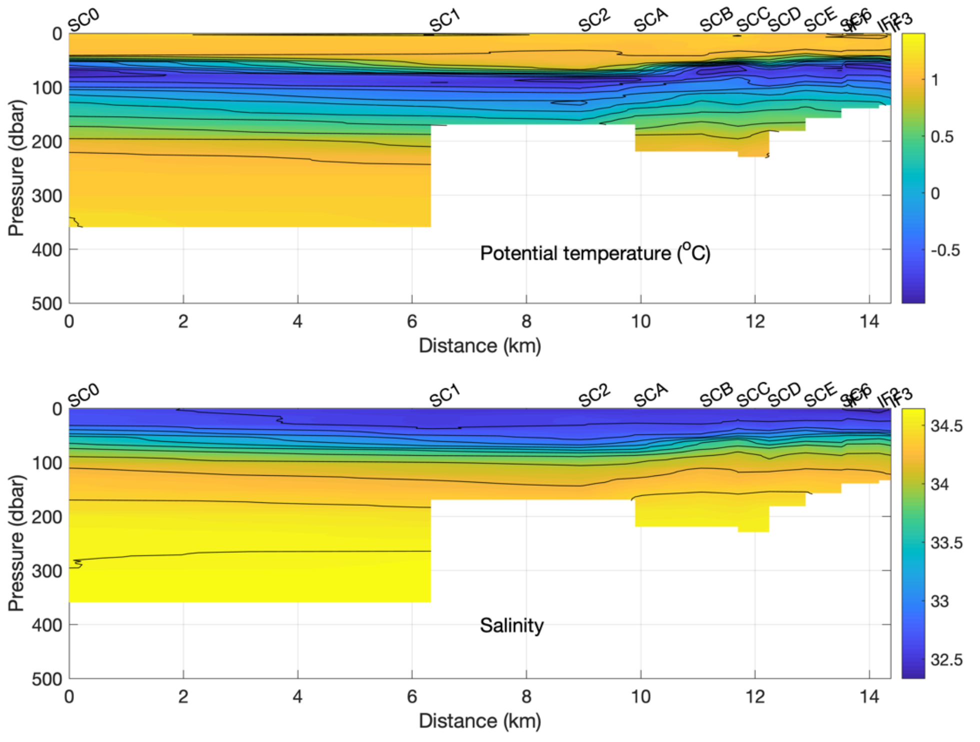

Figure 7-15 Sections of (top) potential temperature and (bottom) salinity across Sheldon Cove, with the outermost site (SC0) on the left of the panels and the sites closest to the ice front on the right

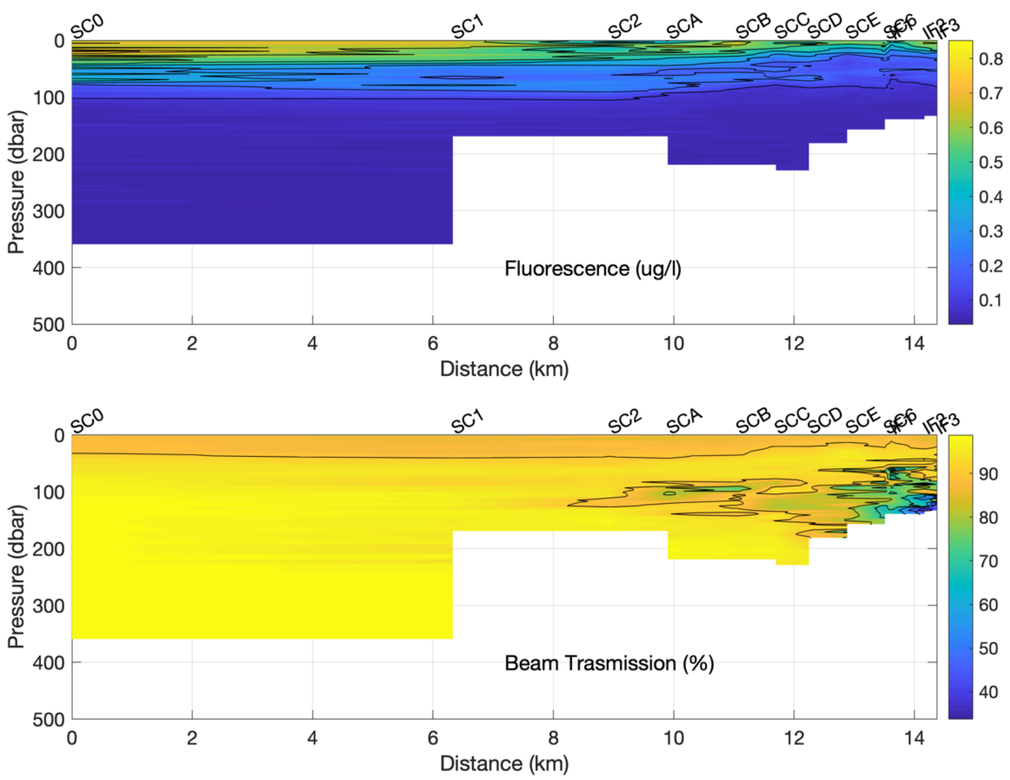

Figure 7-16 As per Figure 7-15, but for (top) fluorescence, and (bottom) beam transmission

Corresponding section plots for Börgen Bay are shown in Figures Figure 7-17 (for potential temperature and salinity) and Figure 7-18 (for fluorescence and beam transmission). Whilst the apparent plume of low-transmission water in Sheldon Cove is seemingly absent in Börgen Bay (Figure 7-18), there nonetheless appears to be some remarkable structure in the CTD profiles, most notably the differences between stations BB1/BBB and the other stations. In particular, the data at these stations show significantly deeper mixed layers (with the near-complete erosion of the temperature-minimum Winter Water layer), and much higher values of fluorescence.

Whilst the sections in Figures Figure 7-17 and Figure 7-18 portray the differences between BB1/BBB and the other Börgen Bay stations as spatial differences, it seems more likely that the real difference is temporal, since these stations were conducted after the ice shelf collapse event that occurred during the cruise there, whereas the other stations had been conducted before it. This raises the intriguing possibility that the collapse of the ice front in Börgen Bay triggered significant ocean mixing across the cove (and perhaps beyond), and that this mixing led to significant impacts on biogeochemistry and phytoplankton production. This speculation will be investigated thoroughly once sample data (e.g. nutrients) become fully available.

Vertical sections of potential temperature and salinity across Marian Cove are shown in Figure 7-19, with corresponding sections of fluorescence and beam transmission in Figure 7-20. Again, the strong mid-depth plume of low transmission water that was seen in Sheldon Cove is apparently absent here, though there is some evidence of slightly reduced beam transmission in the bottom layers immediately adjacent to the ice front. Other interesting aspects include the absence of the strong surface temperature maximum adjacent to the ice front, combined with a horizontal minimum in fluorescence here. These features will be investigated fully once all sample data become available.

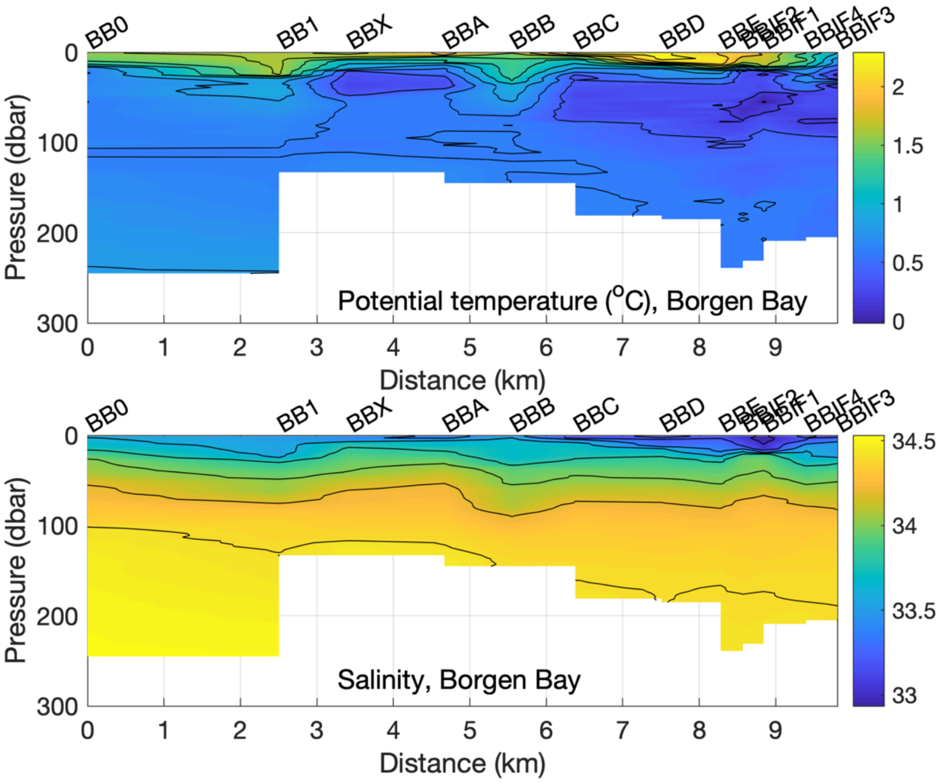

Figure 7-17 Sections of (top) potential temperature and (bottom) salinity across Borgen Bay, with the outermost site (BB0) on the left of the panels and the sites closest to the ice front on the right

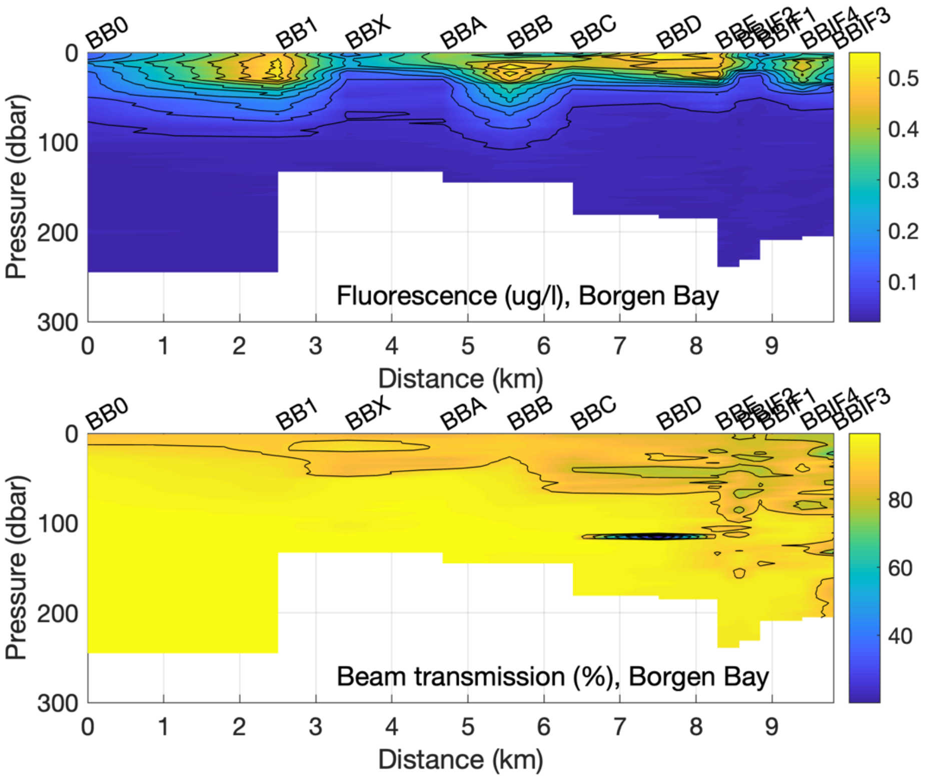

Figure 7-18 As per Figure 7-17, but for (top) fluorescence and (bottom) beam transmission

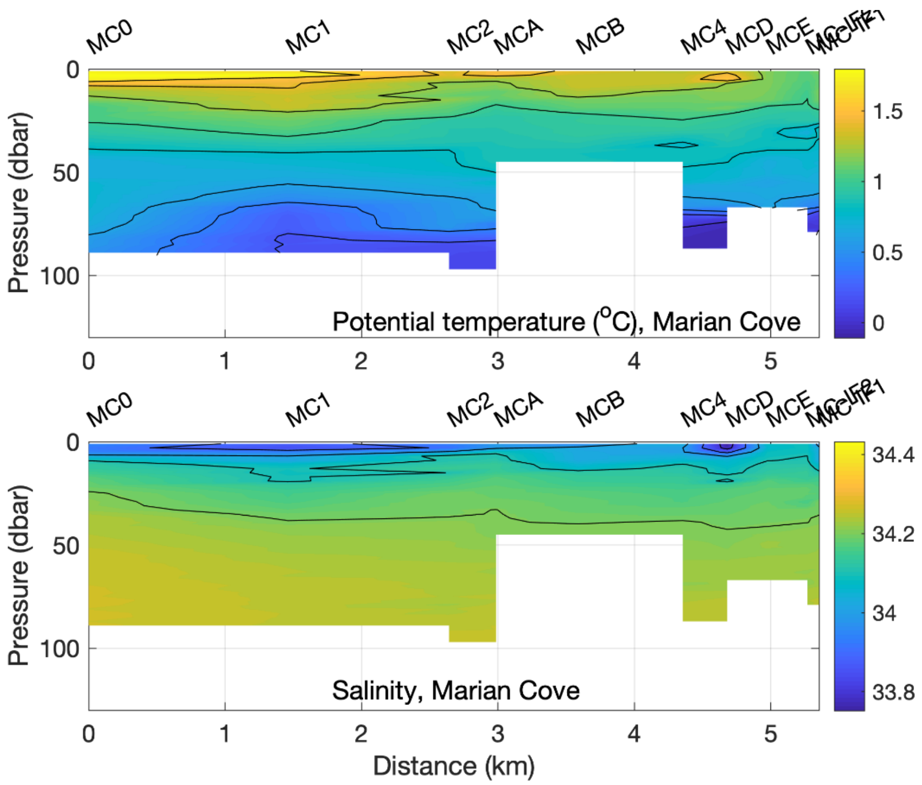

Figure 7-19 Sections of (top) potential temperature and (bottom) salinity across Börgen Bay, with the outermost site (MC0) on the left of the panels and the sites closest to the ice front on the right

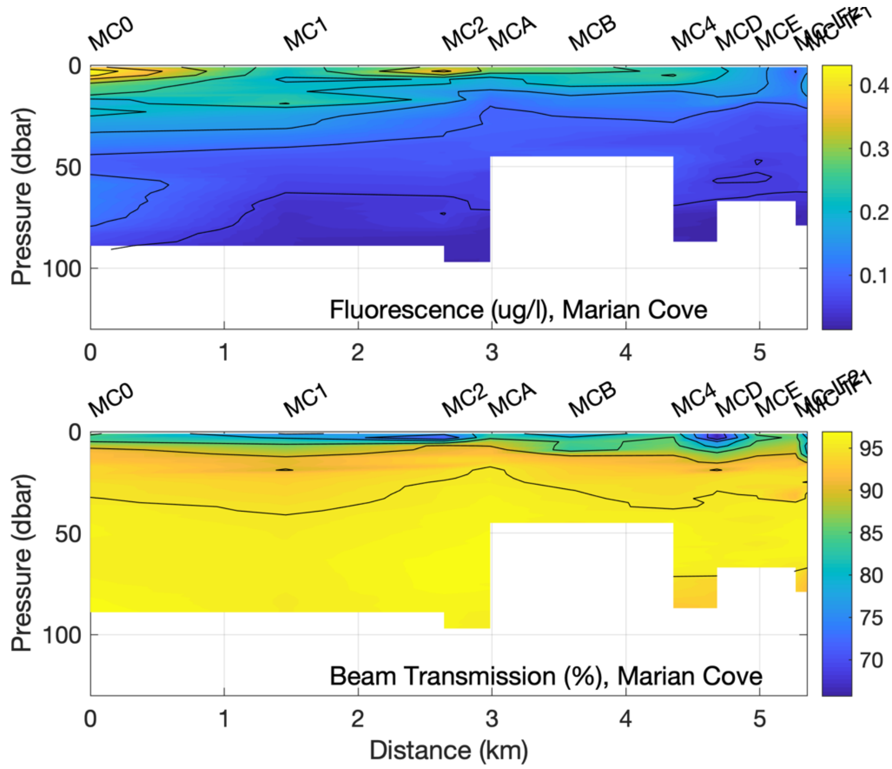

Figure 7-20 As per Figure 7-19, but for (top) fluorescence and (bottom) beam transmission

Issues: Overall, the CTD system appeared to perform reasonably well during JR19002. In Marian Cove, instances of unusual data were observed, whereby primary and secondary conductivity diverged significantly on the downcast part of the profile, before becoming well-reconciled on the upcast. The cause of this apparent hysteresis is not known; for these casts, the upcast data are preferred and are used in the processing. On Burdwood Bank, noisy data were recorded, especially during times when the ship was rolling in heavy swell. This is a well-known problem that relates to CTD package wakes; the Loop Edit and Wild Edit steps in the SBE processing helped reduce (but did not eliminate) the noise in the data that was generated.

7.2.6 LADCP

Dr Chris Bull, British Antarctic Survey

Lowered Acoustic Doppler Current Profiler (LADCP) data were collected from as many ICEBERGS CTD sites as possible (Table 7-4) in Sheldon Cove (Figure 7-21), Börgen Bay (Figure 7-22) and Marian Cove (Figure 7-23). Two 300-kHz Workhorse LADCP were used in a master/slave and downward/upward-looking configuration (respectively) on the CTD rosette. The LADCP was connected by a serial cable to the CTD computer in the UIC and data download after each station using BBTalk. The instrument was configured to sample 25 x 8 m bins, with data collected in beam coordinates and rotated to Earth coordinates during processing. Whilst only ICEBERG CTD sites have had LADCP data processed, some RaCETraX sites have LADCP data. Raw data collected is available in 20191226\ladcp on the SAN or on request from UK PDC.

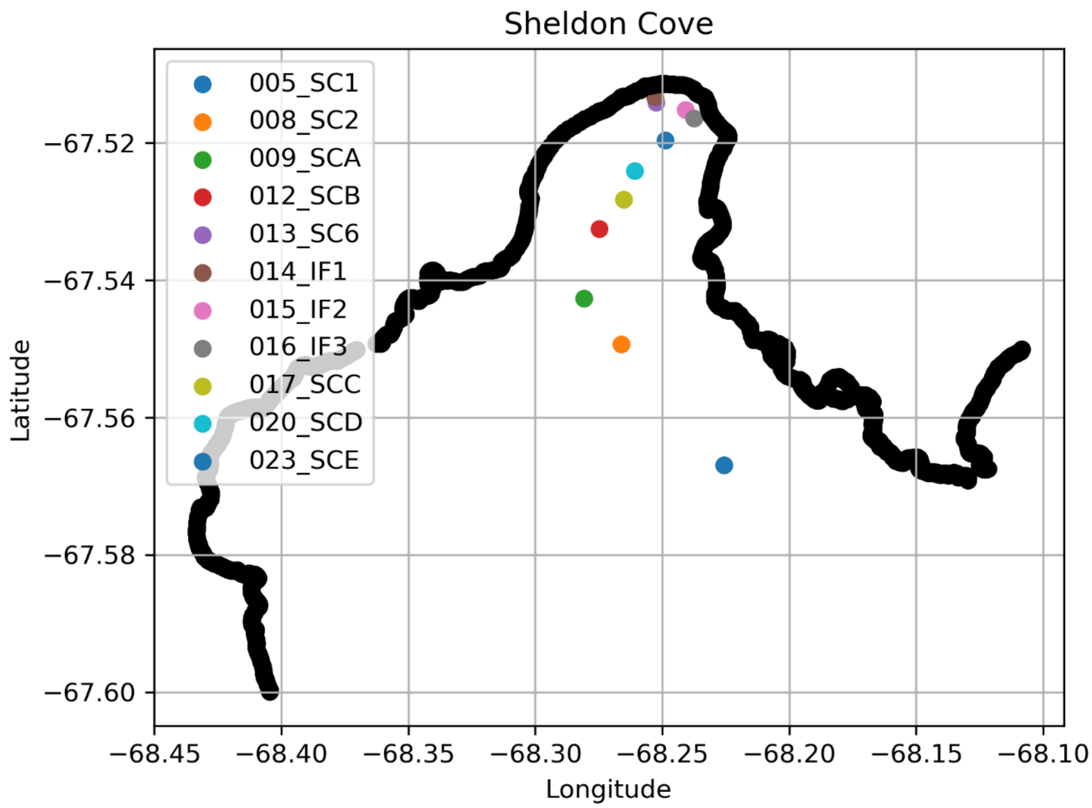

Figure 7-21 LADCP locations for Sheldon Cove

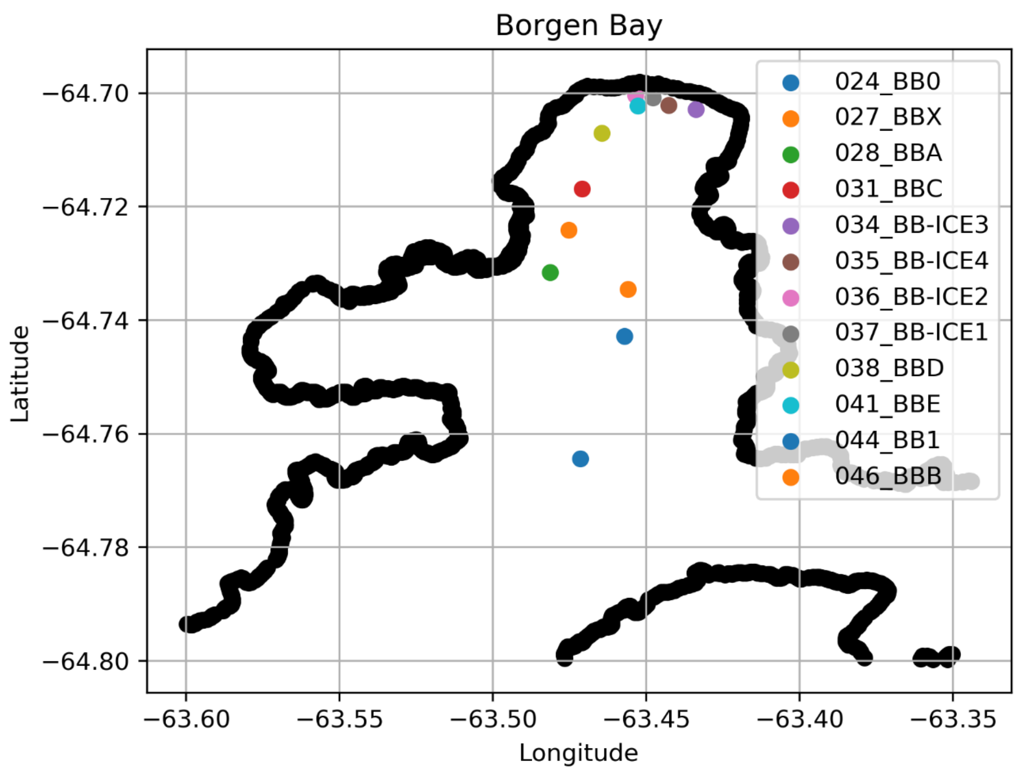

Figure 7-22 LADCP locations for Börgen Bay

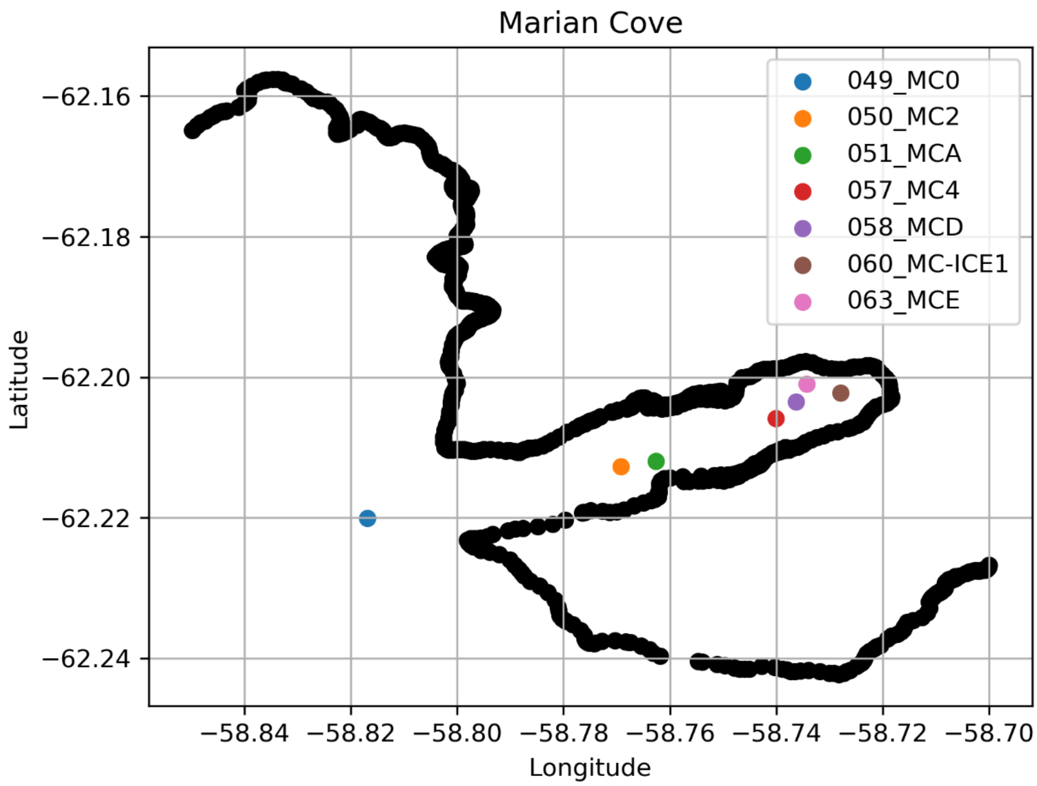

Figure 7-23 LADCP locations for Marian Cove

LDEO version IX_13 (downloaded 24/12/2019) was used to process the LADCP data. Unusable LADCP data resulted at a few stations due to operator errors (sites: 2, 10, 47) and processing issues (sites: 53, 55, 61; see Table 7-4 for details). Note here that site 10 is a RaCETraX site. CTD log files may contain relevant comments on problem casts (see: 20191226\work\scientific_work_areas\logsheets completed\ctd). Overall, the LADCP does appear to have resulted in reasonable measurements (Figure 7-24, Figure 7-25 and Figure 7-26) with median speeds in Sheldon, Borgen and Marian Cove of 0.021, 0.027, 0.032 m/s (see Figure 7-27 for histograms of current magnitude). LADCP data were processed with the LDEO IX software, incorporating ship navigation and CTD data to constrain the solution for Earth-relative velocity from the measured instrument-relative velocity. VMADCP data was not ingested into LDEO as it was not available in processed form at time of writing. As recommended by LDEO software manual ('How To Process LADCP Data With the LDEO Software (Versions IX.7 – IX.13)'), 1Hz CTD data was used (see 'CTD PROCESSING AND CALIBRATION' in section 7.2.5 and script '*onehzctdGEN*').

Processing notes:

- CTD sites: 13, 15, 16, 23, 41, 42, 50, 60, 61, 63 had to be manually cropped using WinADCP v1.14 to avoid this LDEO processing error 'Index exceeds the number of array elements (0)' (see 20191226\work\ladcp\plot_casts\inspect_prob.py for details).
- Tips on getting LDEO_IX-bce791a17f4e to work on Windows:
    - Add top directory (which contains set_cast_params.m), LDEO_IX-bce791a17f4e, geomag to matlab path.
    - Use *convert_CTD_to_ascii.m* to convert the 1Hz .mat matlab file supplied by *onehzctdGEN* to ascii. Note the column order matches what is given in set_cast_params.m.
    - Need to compile LDEO_IX-bce791a17f4e\geomag to process CTD data:

    - Download mingw a cross-compiler on linux. Modify 'LDEO_IX-bce791a17f4e\geomag\Makefile.mingw32cross' with 'CC=..' path for mingw. Compile and test.
    - Edit LDEO_IX-bce791a17f4e\loadnav.m' line 280 to point towards magdec executable just created.
- Alternatively, 64-bit windows executable available from: 20191226\work\scientific_work_areas\ladcp\LDEO_IX-bce791a17f4e\geomag\magdec.exe

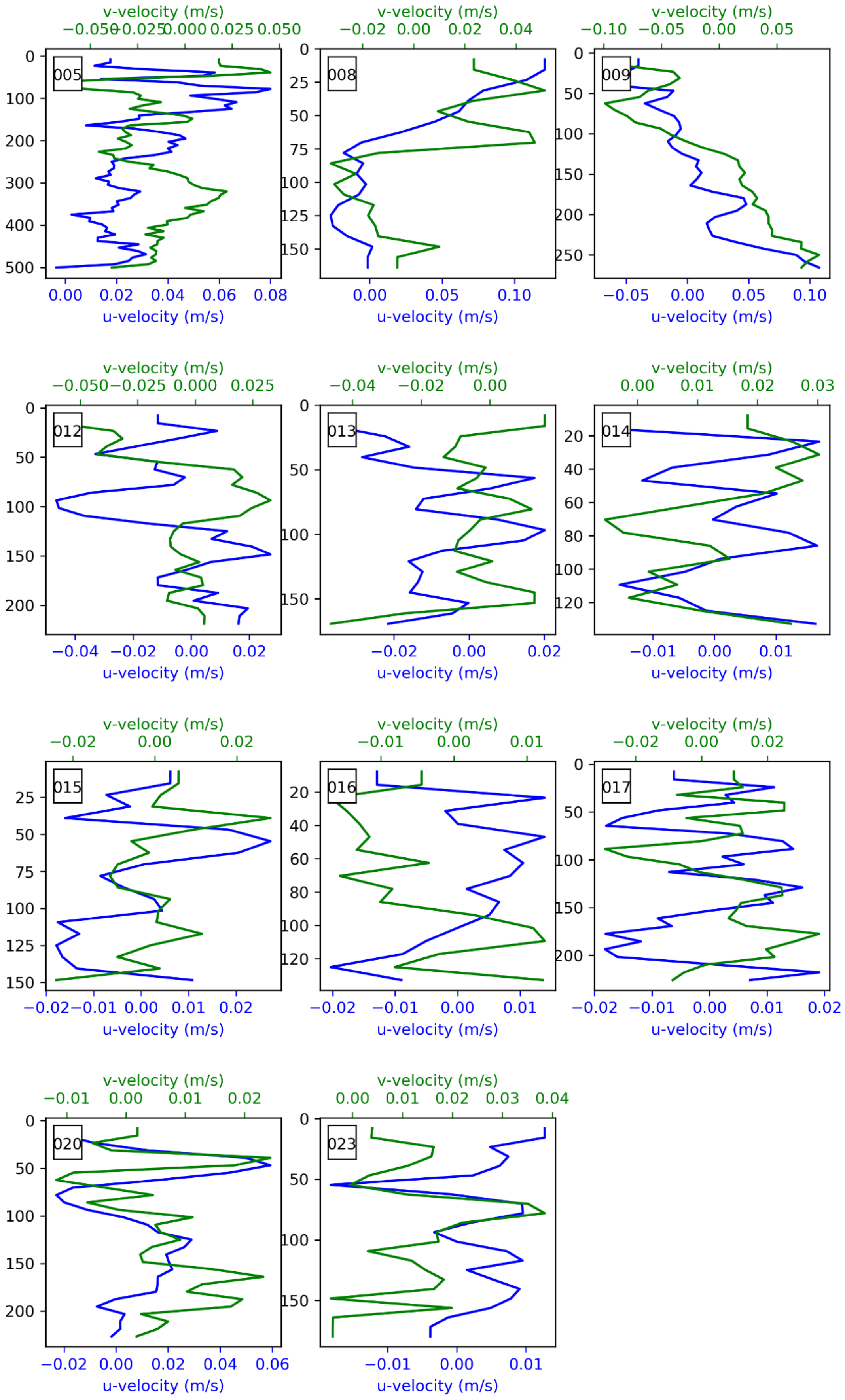

Figure 7-24 LADCP u-v velocity data for Sheldon Cove

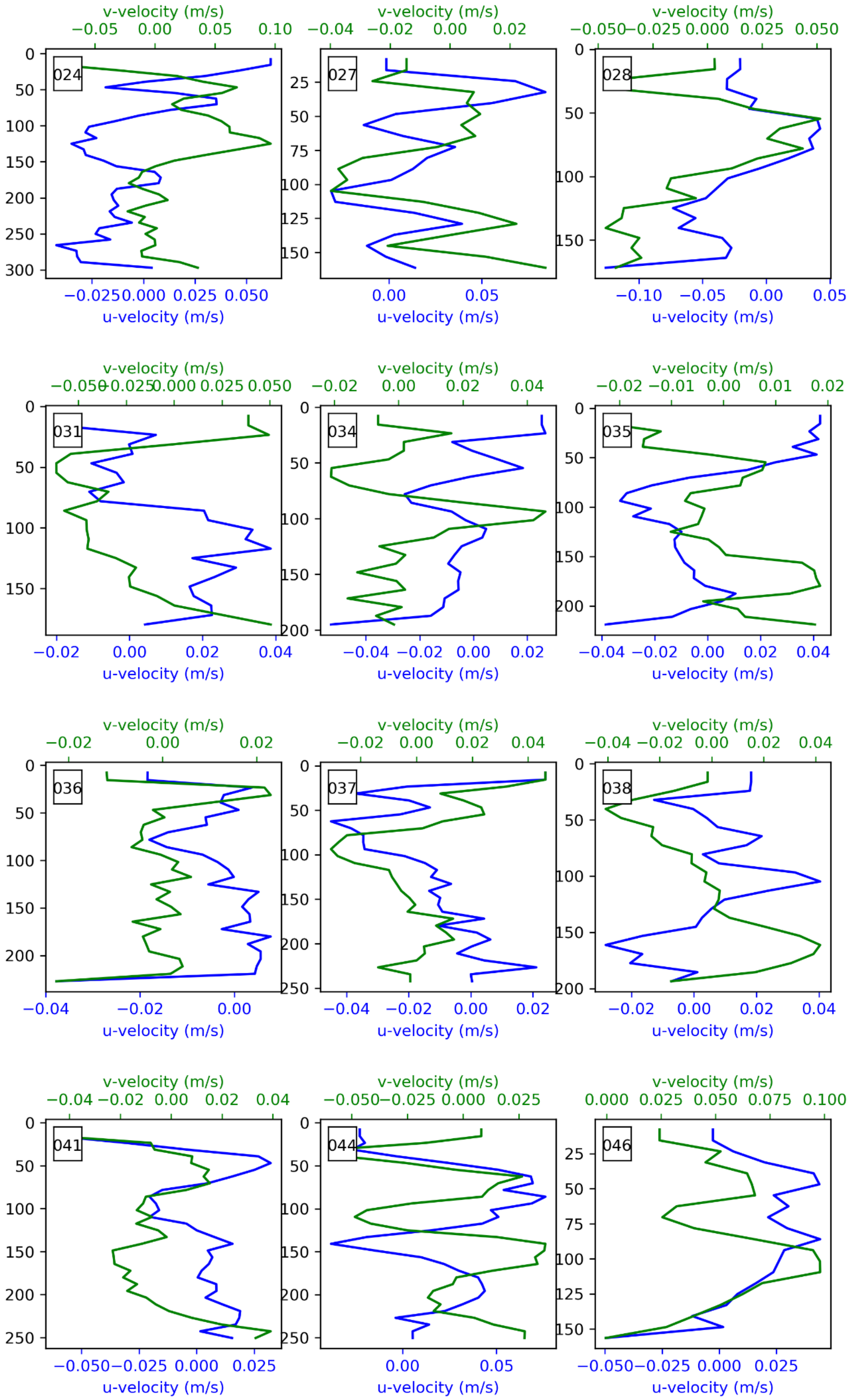

Figure 7-25 LADCP u-v velocity data for Börgen Bay

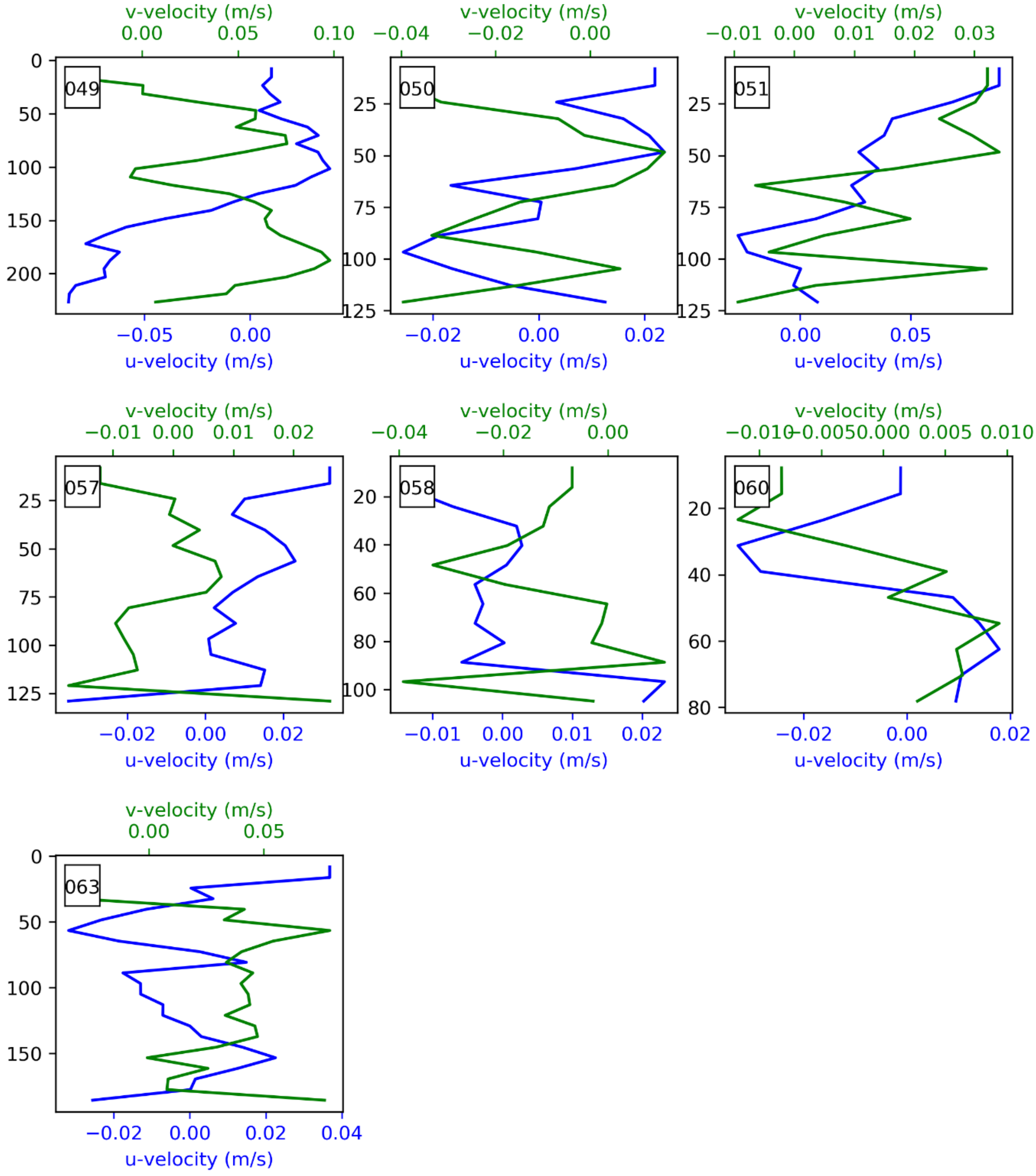

Figure 7-26 LADCP u-v velocity data for Marian Cove

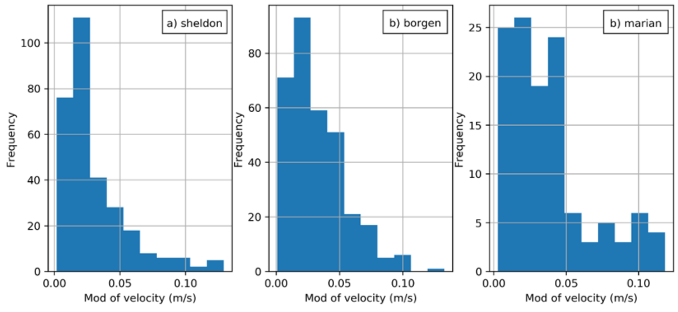

Figure 7-27 a-c) LADCP u-v velocity modulus for Sheldon Cove, Börgen Bay and Marian Cove

7.2.7 VESSEL MOUNTED ACOUSTIC DOPPLER CURRENT PROFILER (VMADCP)

Tobias Ehmen, University of Exeter, UK

Overview: Velocity and direction of ocean currents were measured using a 75 kHz Teledyne RDI Ocean Surveyor (OS75) VMADCP (Vessel Mounted Acoustic Doppler Current Profiler). Under ideal conditions (calm sea, bubble-free water, many scatterers in the water column), it should be able to sample at depths of up to 1000 m, however, in most cases about 800 m depth can be reached. It can be run in narrowband mode, allowing for deeper profiles, or broadband mode, allowing for shallower profiles, but with a higher resolution. Data is acquired by the software VmDas (version 1.42), where live data can also be displayed. Data acquisition and VMADCP control is set in VmDas by the use of control files, command files in ASCII, which control the VMADCP ping rates, modes, supporting data streams, number and lengths of bins and other options. The ADCP is fed with navigation data from the Seatex GPS system.

Setup: For the entire duration of JR19002 the VMADCP was deployed in narrowband mode, with a surface blanking distance of 8 m and pinging as fast as possible. However, two different command files were created to optimize the acquisition in different depths (see Table 7-8). For most of the cruise, through shallow waters <500 m, bottom tracking was enabled and the bin size set to 8 m, in order to increase resolution. The number of bins was set to 63, to acquire data up to 500 m. In deeper water the control was changed to water track mode, with 63 bins of 16 m length, to enable data acquisition up to 1000 m. Since deeper bins are generally more noisy and because moving though deeper water often meant fast transits during JR19002, further decreasing signal to noise ratio, a higher bin length was chosen. RDI's standard deviation is 30 cm/s for 8 m bins and 16 cm/s for 16 m bins. For the set-up of VmDas after creating the control file see the JCR ADCP Cue Card.

The VMADCP was not synchronised with other acoustic instruments via K-Sync. This decision was made after other instruments were checked for interfering VMADCP signals and it was concluded that the VMADCP can be run completely independently, as it was the case during the acoustic trials of JR218, where interference between instruments was checked more thoroughly.

Output data: VmDas is saving VMADCP files in the format 'CRUISEaaa_bbbbbb.ccc', where CRUISE is the cruise name (in this case JR19002), 'aaa' is the file sequence number and 'bbb' the file number within each sequence that increments by 1 and creates a new file after the maximum file size (set in VmDas) is reached. 'ccc' is the file extension. Files with the extension .ENR hold the raw binary data, .N1R files are navigational data in ASCII format. .STA and .LTA are both binary data files that hold the short term average and long term average of the ADCP data. .ENS binary files hold ADCP data after screening for RSSI and correlation (done by VmDas). .NMS holds navigation data in binary after screening and pre-averaging. .LOG and . VMO files are in ASCII format and hold system messages and data acquisition parameters. Finally, .ENX data is in binary format and holds both navigation data as well as bin-mapped ADCP single-ping data transformed to Earth coordinates and screened for error-velocity, vertical velocity and false targets.

Operation: The VMADCP was running around the clock during most of the cruise, especially during CTD casts, so that the VMADCP can be used in LADCP (Lowered Acoustic Doppler Profiler) data processing.

Table 7-8 Description of commands for the two control files that were in use during JR19002

Commands for control file "500 m BT"	Commands for control file "1000 m WT"	Description of command
CR1	CR1	Restore factory default settings in the ADCP
CB611	CB611	Data collection baud rate to 38400 bps, no parity, one stop bit, 8 data bits
NP1	NP1	Set for narrowband single-ping profile mode
NN63	NN63	Number of bins [63/63]
NS800	NS1600	Bin length [8 m/16 m]
NF0800	NF0800	Blanking distance [8 m/8 m]
WP000	WP000	Broadband equivalent to NP [ignored for narrowband]
WN100	WN100	Broadband equivalent to NN [ignored for narrowband]
WS800	WS800	Broadband equivalent to NS [ignored for narrowband]
WF0800	WF0800	Broadband equivalent to NF [ignored for narrowband]
WV390	WV390	Broadband ambiguity velocity (cm/s) [ignored for narrowband]
BP01	BP00	Enable/disable single-ping bottom track
BX5000	BX5000	Set maximum bottom search depth (decimetres) [500 meters/ignored if BP00]
WD111100000	WD111100000	Enable output velocity, correlation, echo intensity, percent good
TP000100	TP000100	Time between bottom and water pings [one second/ignored for WT]
TE00000100	TE00000100	Time between ensembles; ignored by VmDas
EZ1020001	EZ1020001	Set to calculate speed-of-sound, no depth sensor, external synchro heading sensor, no pitch or roll being used, no salinity sensor, use internal transducer temperature sensor
EX00000	EX00000	Output beam coordinate data (rotations are done in software)
EA6008	EA6008	Set transducer misalignment (hundredths of degrees) [60.08 degrees on JCR]
ED00063	ED00063	Set transducer depth (decimetres) [6.3m on JCR]
ES0	ES0	Set Salinity (ppt) [salinity in transducer well = 0]
CX0,0	CX0,0	Enable/disable external trigger [ADCP not run through SSU]
CK	CK	Save this setup to non-volatile memory in the ADCP

The OS75 was stopped and restarted once in a 24 hour period on average, in order to avoid single file sequences to become too large, which can cause problems in post-processing. Start and stop times of these sequences were recorded on paper on the VMADCP log sheets and it took only 1-2 minutes on average to start a new sequence, which resulted in almost no data gaps. The size of .log-files was checked regularly, because if errors occur, they are written into the .log-files and large files might indicate major issues that need to be resolved before the VMADCP can operate further, however, none of these were encountered. To check data quality or possible interference the whole VMADCP was periodically loaded into CODAS for a quick analysis (see post-processing).

Preliminary processing: In archived control files on the *RRS James Clark Ross* the misalignment angle has been set to 60.08 degrees, which remains an estimate. During post-processing a more exact misalignment angle, along with a scaling factor, can be calculated and corrected, in addition to data quality control and noise removal. The VMADCP was processed using CODAS processing. The most basic steps for preliminary processing are:

1. Set up data directories and import single ping data using *adcp_database_maker.py*
2. Heading correction was not applied, because there wasn't a second source for headings. This would be the case of .N2R files were generated by e.g. a Gyro
3. Preliminary editing of the data, but only the most obvious errors, e.g. non-flagged bins below the seabed, nothing else. Data that looks like noise pre-calibration is often biased data because of misalignment. Edit data using: *dataviewer.py –e.* Get an overview over the different types of noise in the
4. Re-run calibration using *quick_adcp*
5. Run *catxy* for estimations of ADCP-GPS offset corrections. The results were:

   ```
   **transducer-gps offset**
   ------------
   guessing ADCP (dx=starboard, dy=fwd) meters from GPS
   positions from aship.agt
   calculation done at 2020/02/03 21:12:08
   xducer_dx = -0.274280
   xducer_dy = -0.475249
   signal = 2308.808645
   ------------
   ```

   "signal "< 1000 can be seen as "weak confidence", 1000-4000 as "probably worth using" and > 4000 as a "pretty strong indication". No correction was applied in this case. A ADCP-GPS offset can lead to biased data during turns
6. Run *catwt* and *catbt* to access Watertrack and Bottomtrack calibration data. In this case Bottomtrack will be used, because most of the data was acquired in Bottomtrack mode. The Bottomtrack results were:

   ```
     **bottomtrack**
   ------------
   unedited: 10885 points
   edited:   1610 points, 2.0 min speed, 2.5 max dev
                     median   mean    std
   amplitude         1.0166   1.0166  0.0041
   phase             -0.0869  -0.0884  0.1394
   ------------
   ```

Check if there are enough data points for reasonable statistics (in this case there are more than enough). A phase correction is normally not needed if the value is less than 0.1 degrees, however, in this case a correction of -0.0869 was applied. A scale factor for the amplitude has a much higher effect on the data and should always be applied, in this case 1.0166. Rotate velocities, scale amplitude and recalculate calibration statistics by using *quick_adcp.py*

7. Check calibration data again using *catbt*:

```
**bottomtrack**
------------
unedited: 10885 points
edited:   1638 points, 2.0 min speed, 2.5 max dev
              median   mean    std
amplitude     1.0000   1.0001  0.0040
phase         0.0000   0.0023  0.1261
------------
```

   The results of the calibration can be seen in Figure 7-28.

8. Edit data much more thoroughly using: *dataviewer.py -e*
9. Repeat calibration steps and edit again, until finished

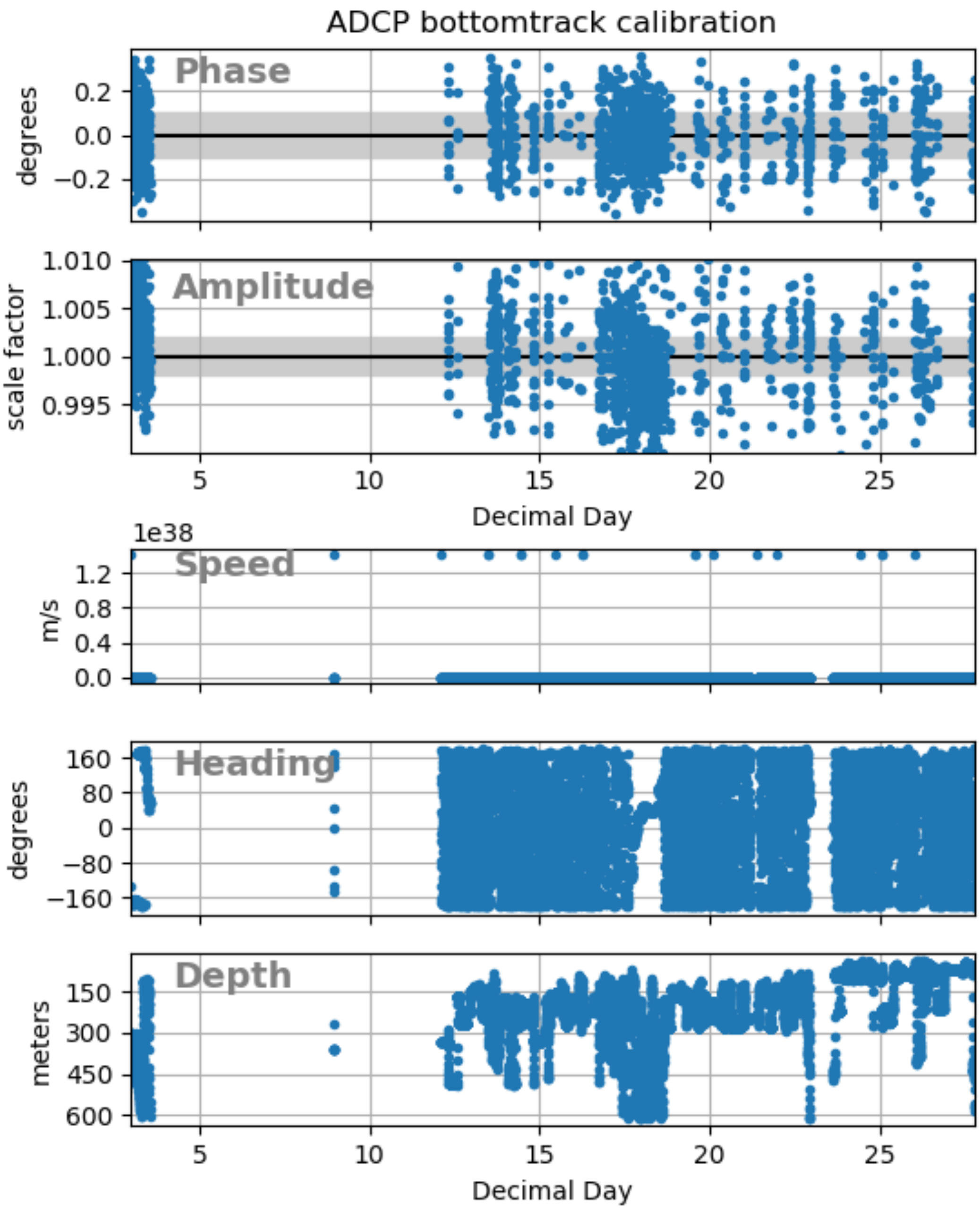

Figure 7-28 Calibration statistics of JR19002 after correction

Results: Due to the sheltered conditions in the fjords and relatively good weather during transits the data quality is high. The calibration was also very effective due to the shallow waters and the resulting high amount of Bottomtrack data points. Data of the transit between Börgen Bay and Marion Cove is shown in Figures Figure 7-29 and Figure 7-30.

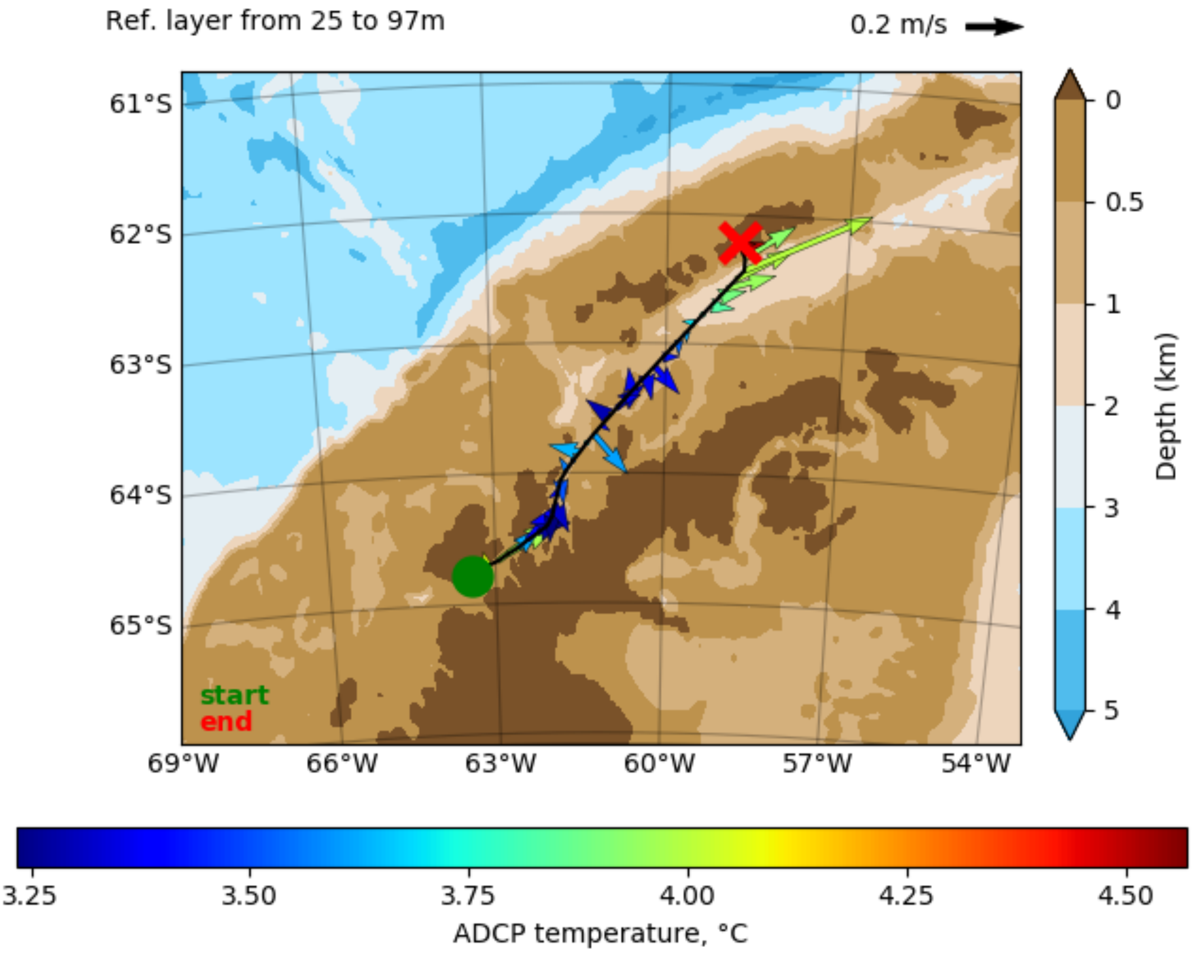

Figure 7-29 30 minute average of the layer from 25 to 97 m, including ADCP temperature and bathymetry. Note the ship track from Börgen Bay to Marian Cove.

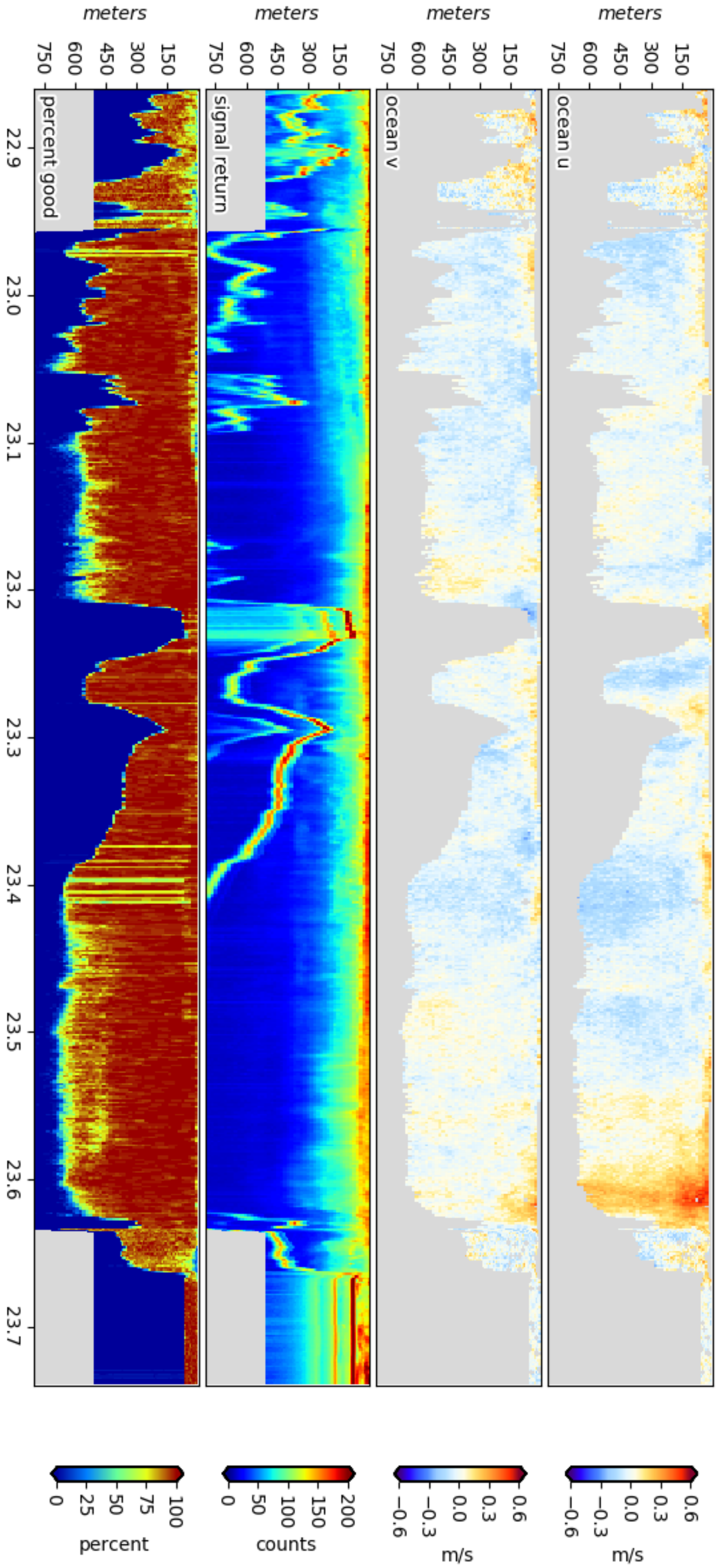

Figure 7-30 ADCP transect from Börgen Bay to Marion Cove (the same track as Figure 7-29). The panels hold u-velocities, v-velocities, amplitude and percent good.

7.2.8 EK80 WIDEBAND ECHO SOUNDER

Tobias Ehmen, University of Exeter, UK

Overview: The EK80 scientific wideband echo sounder system is mostly used to identify biological scatterers in the water column, but has further applications like sea bed analysis, or mapping the density structure of the water column. In this case the EK80 was primarily used to identify thermohaline gradients in the water column. There are currently three transducers installed: a 38 kHz, 70 kHz and 120 kHz transducer (see Table 7-9).

Table 7-9 EK80 transducers (installed on 30/08/2015)

Frequency	Model	Serial Number	Pulse modification capability
38 kHz	ES38B	SN23080	CW
70 kHz	ES70-7C	SN280	CW and FM (45 to 90 kHz)
120 kHz	ES120-7C	SN136	CW and FM (90 to 170 kHz)

Set-up: The standard pulse mode of the transducers is continuous waveform (CW), which has a narrow bandwidth centred on the main frequency. Of the three transducers, the 70 kHz and 120 kHz transducers are also capable of frequency modulation (FM) mode (indicated by the "C", for "composite", in the model name). This mode allows for a signal to stretch over a wide bandwidth of frequencies, which can be highly valuable for analysing the data in post-processing, because targets can potentially be separated. The 70 kHz transducer has a maximum bandwidth of 45 to 90 kHz and the 120 kHz transducer has a maximum bandwidth of 90 to 170 kHz. It was recommended that only one transducer should run in FM mode. To reduce reflections from biological scatterers, which is the aim in order to observe subtle thermohaline gradients, which are otherwise masked by biology, the frequency should be lowered as much as possible (Lavery et al. 2009). Therefore the 70 kHz transducer was chosen to run in FM mode. In order to decrease interference with the 75 kHz VMADCP the bandwidth was limited to 45 to 74 kHz. FM mode is divided in LFM (Linear Frequency Modulation) Up, where the pulse is a chirp signal with increasing frequency over time and LFM Down, where the signal decreases in frequency over time. During a test phase there was no apparent difference visible in the data between LFM Up and LFM Down and the former was chosen as the main mode. Transducer power was left at default values. One of the most important parameters is pulse duration, which has a high impact on signal to noise ratio if the aim is to find subtle reflections. According to Stranne et al. (2017, 2018) longer pulses have a higher signal to noise ratio, however, the range resolution is higher with shorter pulses. Furthermore, the pulse duration adds to the data lost for the upper water column, because it adds to the depth in which the transducer is mounted on the hull (6.3 m on the JCR). Data was therefore acquired starting from 7 to 13 meters depth from the surface, depending on pulse duration. After a short testing phase it was decided to keep the 70 kHz at a long pulse duration (8 ms or 4 ms in most cases) and the 38 kHz at the shortest possible pulse duration (1 ms). The 120 kHz ran with 1 ms pulse duration. During the entire cruise the ramping option was kept at Fast. Slow ramping can increase range resolution, however, it also has a negative effect on bandwidth resolution.

Operation: The EK80 was kept running at all times during stations, not just for transects between stations, therefore it was used almost around the clock. Unfortunately, due to a high workload in other scientific areas, it was not possible to keep a close eye on the EK80 data acquisition all the time. Preliminary processing was also not possible, due to the lack of suitable processing software on board and will be conducted on shore.

At the start of the cruise the synchronisation with K-Sync and the motion data stream was not set up, which was resolved on 12/01/20 with help via email and remote control from AME and BAS in Cambridge. From then on the EK80 was either run in interval mode, 3 s interval when moving or 10 s when on station, when the multibeam was not running, or in synchronised mode when the multibeam was turned on. In a few instances at the end of the cruise there were issues with the K-Sync synchronisation unit, where the multibeam did not receive enough trigger signals anymore e.g. while conducting a survey in Marion Cove during which the EK80 was shut down for 3.5 hours. Unfortunately, the EA600 echo sounder, running around the clock at a high ping rate, was not synchronised with K-Sync for the entire cruise and caused noise in the data at almost all times.

Data output*:* Data was saved in .RAW format, which holds transducer and operational information in ASCII/XML format and the samples as well as navigation and motion data in binary format. Due to the expected decrease in signal to noise ratio at higher depths and bathymetry of the sites in general, the maximum depth recorded was set to 400 m in order to save storage space. A total of 450 GB of data were acquired.

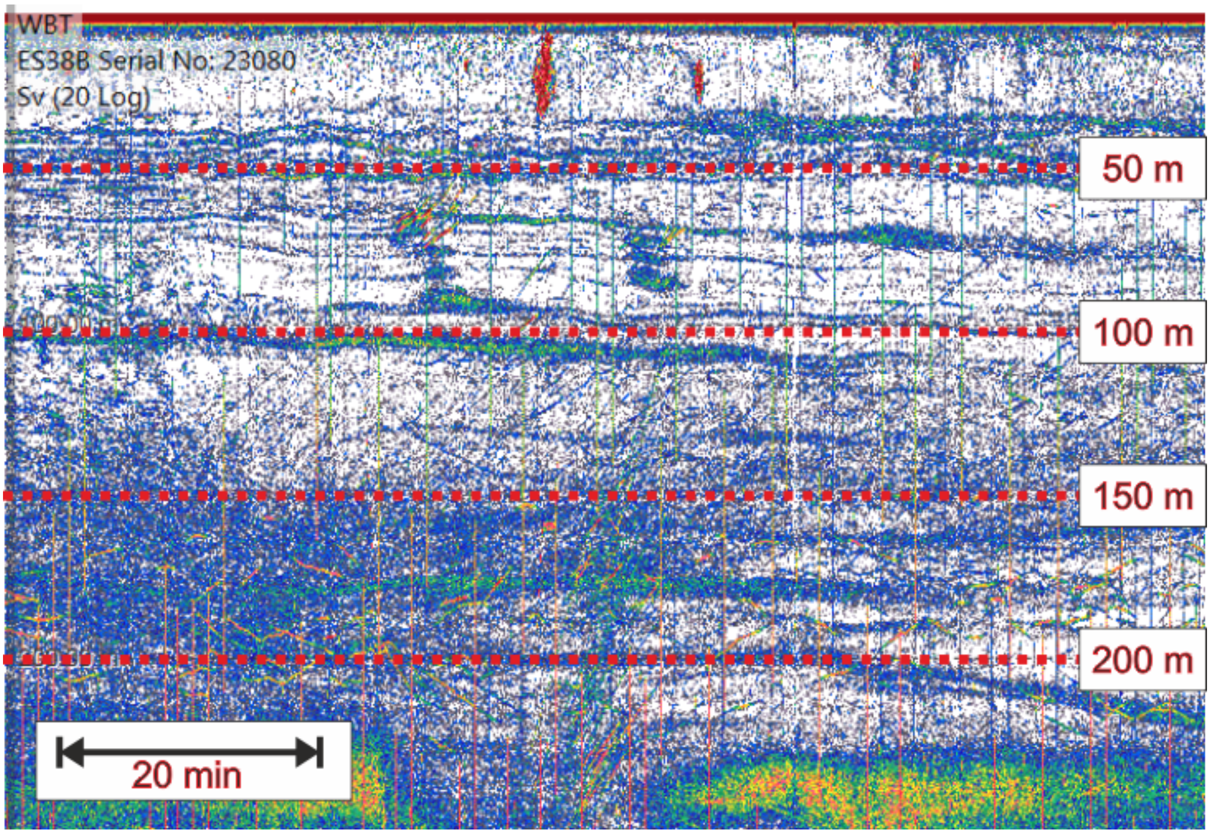

Figure 7-31 Possible thermohaline structures in the unprocessed EK80 data. Note the fine stratification aroud the 50 m line. The top of these reflectors corresponds with the base of the mixed layer in the CTD data.

Preliminary results: In general, there was always a strong decrease in signal to noise ratio for stratification in the water column as soon as the ship was moving, e.g. during multibeam surveys or in transit. Post-processing after the cruise will likely improve the signal after filtering noise, correcting for motion and applying gain. However, fine density stratification was visible at many stations (see Figure 7-31). The top of this stratification roughly matched the base of the mixed layer in the CTD data, increasing the likelihood that the origin of this stratification is related to thermohaline gradients. However, only through correlation with CTDs and synthetic echograms during post-processing on shore it will be confirmed if these are related to thermohaline structure, or rather layers of suspended sediment or biological scatterers. The data will provide an additional dataset to support the CTD and VMADCP data.

Furthermore, after the collapse of the ice front of Börgen Bay at approximately 9:00 UTC on 21/01/2020 the ship had to avoid the approaching icebergs and moved to position just off Port Lockroy, which enabled an EK80 calibration. During the calibration an increase in internal wave amplitude was observed (see Figure 7-32). After noting the time of the calving and several more during the rest of the cruise, an increase in internal wave amplitude after these events will be studied after post-processing.

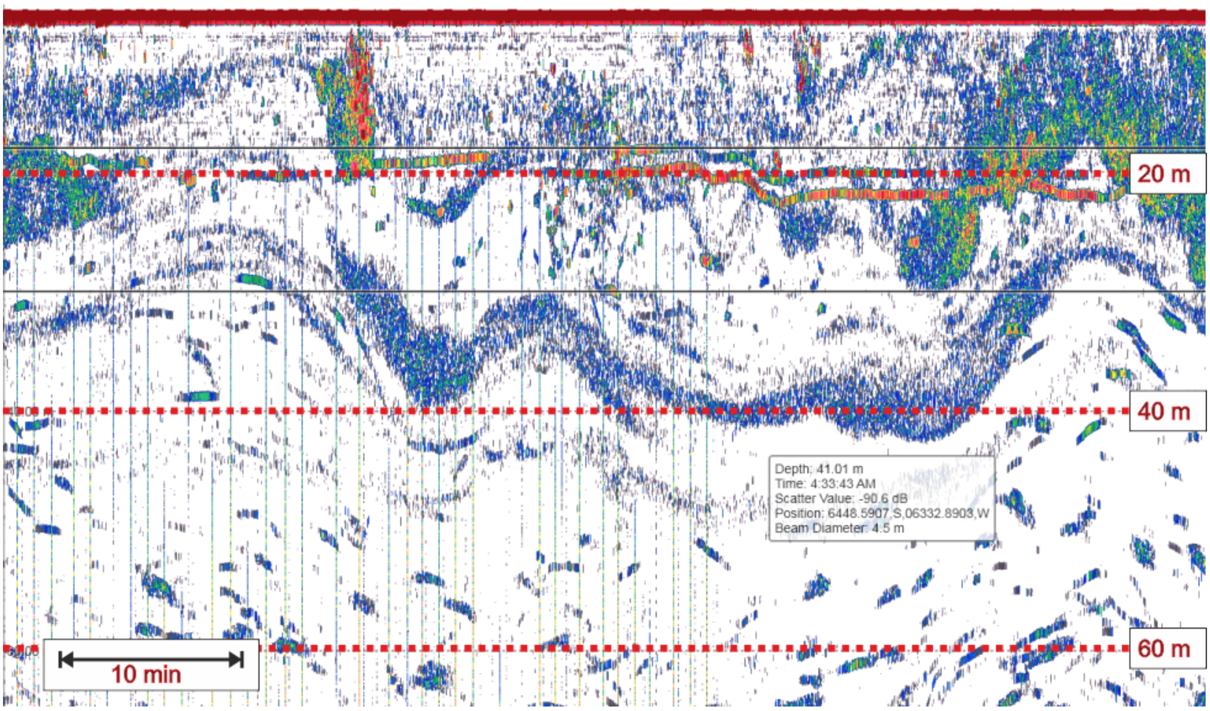

Figure 7-32 Prominent internal wave structures after the collapse of the ice front at Börgen Bay in unprocessed EK80 data during the calibration.

Calibration of the EK80: The echo sounder calibration was conducted off Port Lockroy on 22/01/2020 during the night. For calibrating the EK80 a standard calibration sphere has to be lowered underneath the transducers into each beam while the instrument is pinging. The calibration was done according to recommendations by Demer et al. 2015 and from experience and recommendations during JRtrials2019 in September 2019 in between the Orkney Islands (Scapa Flow), where the EK60 was calibrated (which uses the same transducers and a similar procedure).

Sea conditions were very calm and the ship was set to DP. The fact that thrusters were used, which can produce additional noise, had to be accepted: floating ice made anchoring or drifting a security risk for the ship.

Before starting the calibration, a 40 m CTD cast was done in order to acquire the average physical properties of the water column between transducer and the calibration depth. These properties (pressure of 18.5 dbar, temperature of 0.995 deg C and salinity of 33.811 PSU) were fed into the EK80 software as environmental variables.

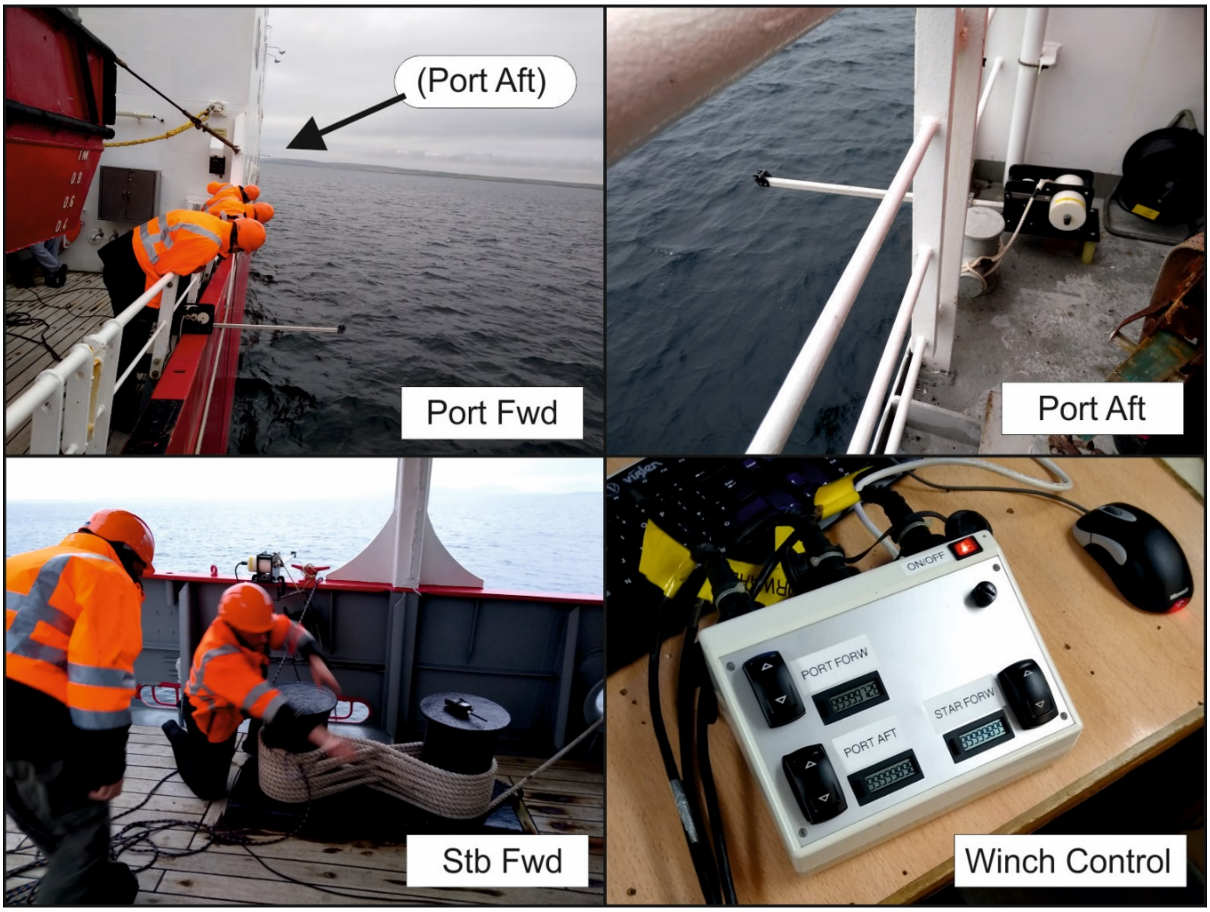

Figure 7-33 Positions of the winches on the RSS James Clark Ross and winch control instrument. Port Aft on Forecastle Deck, Port Fwd and Stb Fwd on Upper Deck. Pictures from JRtrials2019 by Tobias Ehmen, winches on JR19002 were in the same position.

The sphere is attached with thin fishing line, ensuring no additional reflections, to small winches on three points across the ship. The positions of the winches were set according to the EK60 calibration that was conducted during: the Port Aft winch was places on the port side on the Forecastle Deck behind the cabins, the Port Fwd winch on the port side on the Upper Deck in front of the bridge and the Stb Fwd winch on the opposite side of the Port Fwd winch on the Upper Deck (see Figure 7-33). To deploy the sphere two ropes were placed underneath the ship, through which the fishing lines from the Port Aft und Stb Fwd winches were pulled to and collected at the Port Fwd winch, where the sphere was attached to the three lines and dropped into the water, along with a shackle on a fishing line, which acts as a stabilising weight 6 m underneath the calibration sphere. 6 m distance between sphere and shackle is enough to ensure that both signals do not interfere. The winches can be remotely controlled, which allows the sphere to be moved underneath the ship's hull in a controlled way from the Underway Instrument Control room.

Plans of the RRS *James Clark Ross* were used to identify the positions of each transducer on the ship's hull. This included a survey of Parker Ltd from 2014. Ideal line lengths were calculated to place the sphere 25 m underneath each transducer (see

Table 7-10), however, these were only used for the 70 kHz and 120 kHz transducers, because the lines had red and black markings from previous calibrations that would place the sphere directly in the beam of the 38 kHz transducer. Adjustments were then made for the other transducers using the calculated lengths as guidance for the winch controls.

The sphere in use was a WC 38.1 mm, which works for the 38kHz, 70 kHz as well as the 120 kHz transducer. Target strengths for the physical properties of the water column up to the calibration depth were calculated using the TS package (version 1.1), a MATLAB script to calculate target strengths of different standard calibration spheres, and can be seen in Table 7-11.

	Port Aft	Port Fwd	Stb Fwd
38 kHz	43.58 m	38.52 m	38.53 m
70 kHz	45.65 m	37.42 m	37.91 m
120 kHz	45.83 m	37.64 m	37.68 m

Table 7-10 Ideal line lengths for a calibration depth of 25 m for each transducer

Transducer	Target strength WC 38.1 mm (at 18.5 dbar, 0.995 deg C and 33.811 PSU)
38 kHz	-42.09 dB
70 kHz (CW)	-40.59 dB
70 kHz (FM: 45 to 90 kHz bandwidth)	-40.84 dB
120 kHz	-39.80 dB

Table 7-11 Theoretical target strengths for the given environmental variables for each calibrated transducer and mode

After setting up the winches and the winch control, dropping the sphere and weight into the water and the lines were payed out until the markings were reached, the EK80 data acquisition was started. For this the pulse duration for each transducer was set to 1 ms and the Calibration window opened in the EK80 software. If the sphere is underneath the transducer beam and reflects the signal the single target detection of the EK80 shows the sphere position in the beam (see Figure 7-34). The winch control can then be used to move the sphere within the beam. In order to calibrate the transducer every sector of the beam has to be sufficiently sampled, from the centre to the edges, until the sectors light up green in the EK80 software (see Figure 7-34). While the sectors light up after 50-75% coverage, a higher value was attempted. Afterwards the calibration is applied and the procedure repeated for the other transducers. Results showed both gain adjustments and RMS errors within -0.2 to 0.2 dB, which are the expected values (see Figure 7-35). Much higher or lower values or odd values restricted to a single sector would indicate faulty transducers or problems with the sphere. The calibration data was saved in an ASCII file, the recorded soundings were saved in .RAW files.

Maclennan and Simmonds 2005 *Fisheries Acoustics* doi:10.1002/9780470995303
Stranne et al. 2017 *Scientific* Reports doi:10.1038/s41598-017-15486-3
Stranne et al. *2018 Ocean Science* doi:10.5194/os-14-503-2018
Demer et al. 2015 *ICES Cooperative Research Report* doi: 10.17895/ices.pub.5494
Lavery et al 2009 *ICES Journal of Marine Science* doi:10.1093/icesjms/fsp242

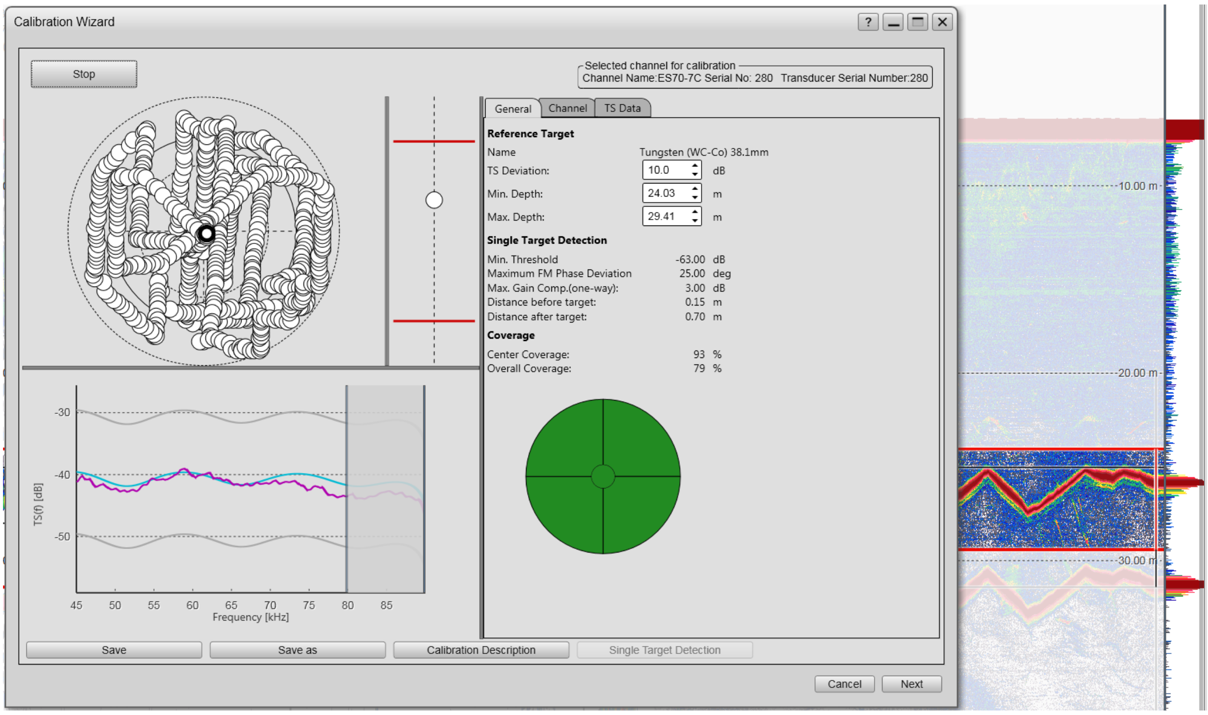

Figure 7-34 Ongoing calibration with single target detection windows. Each white circle in the upper left corner represents a sample of the sphere moved around the transducer's beam. Note the green sectors in the right panel, which indicates, that there are enough data points.

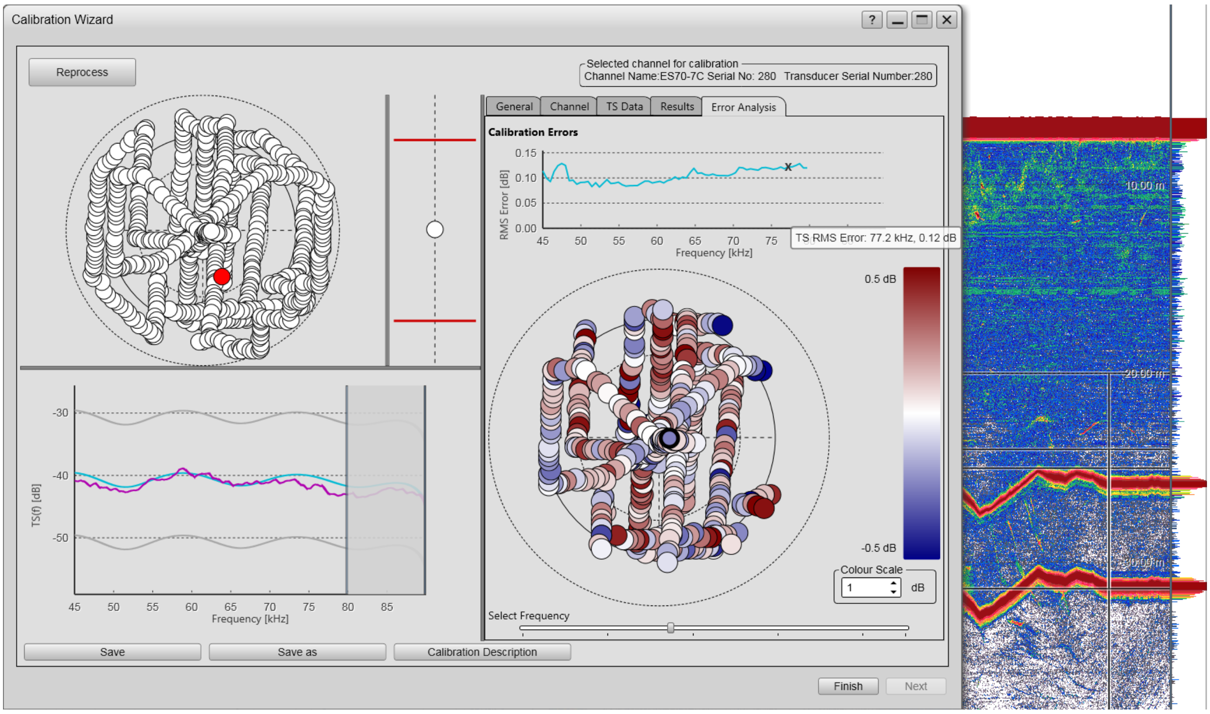

Figure 7-35 Preliminary results of calibrating the 70 kHz transducer in FM mode. The applied gain has an average of 0.1 dB over the whole bandwidth (right panel).

7.2.9 OTHER UNDERWAY DATA

Professor Mike Meredith, British Antarctic Survey; Tobias Ehmen, University of Exeter, UK

Navigation data was accessed and logged daily via the SCS (scripts *get_gyro* and *get_seatex*), with Gyro and Seatex GPS data imported into Matlab for processing (scripts *load_daily_seatex, load_daily_seahead, load_daily_seaspeed, load_daily_gyro*). A quick visual check was performed with script *plot_seatex_all,* to ensure no obviously erroneous data in the streams.

Data from the oceanlogger and meteorological instrument suite were accessed and logged daily, via SCS script *get_underway.* Data include sea surface temperature (SST), conductivity, air temperature, barometric pressure, solar radiation, humidity, surface fluorescence, surface beam transmittance, wind speed, wind direction. Scripts *loadoceanlog* and *loadanemom* was used to ingest the data into Matlab; *cleanoceanlog* was used to perform some automated data despiking and to launch an interactive editor to allow manual cleaning of the daily section of data; *truewind_derive* was used to calculate wind speed and velocity relative to the solid Earth, instead of relative to the ship as recorded. *plotoceanlog_daily* was used to display the final daily section of data and to derive 1 minute averages thereof, and *plot_oceanlog_all* was used to display data for the entirety of JR19002 to date.

Correction of Oceanlogger salinity data: The salinity values of the Oceanlogger were corrected by using the Salinometer data from the underway samples (see Figure 7-36). The correction coefficients were found using a suitable regression in an "Oceanlogger salinity-Salinometer salinity" plot. A robust linear regression was found to yield good results. For this the RANSAC regressor was chosen, because it ignores outliers (data points with residuals higher than the threshold value of the median absolute deviation of the target y) and provides a good fit for the data (see Figure 7-37). After that the coefficients were applied to the uncorrected data and new .mat files that hold the corrected Oceanlogger data were created (see Figure 7-38).

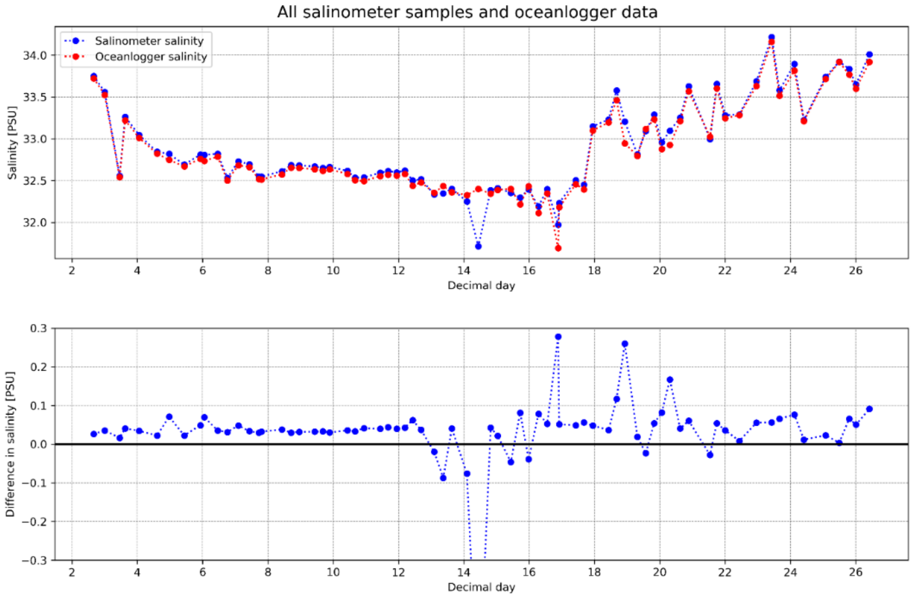

Figure 7-36 Time series of Oceanlogger salinities compared to those measured at the same time from underway samples in the Salinometer. Note the difference plot in the lower panel

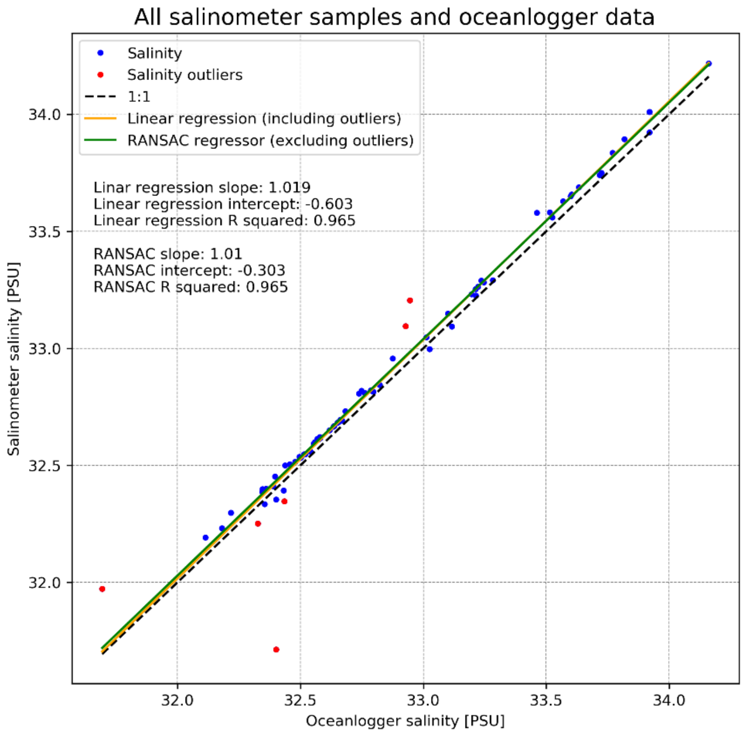

Figure 7-37 Oceanlogger data and Salinometer data from underway samples. Note the RANSAC robust linear regressor (green line), which ignores outliers (red data points). The RANSAC slope and intercept values (1.01x – 0.303) were used for the salinity correction in the Oceanlogger data. Simple linear regression was added as comparison (orange line)

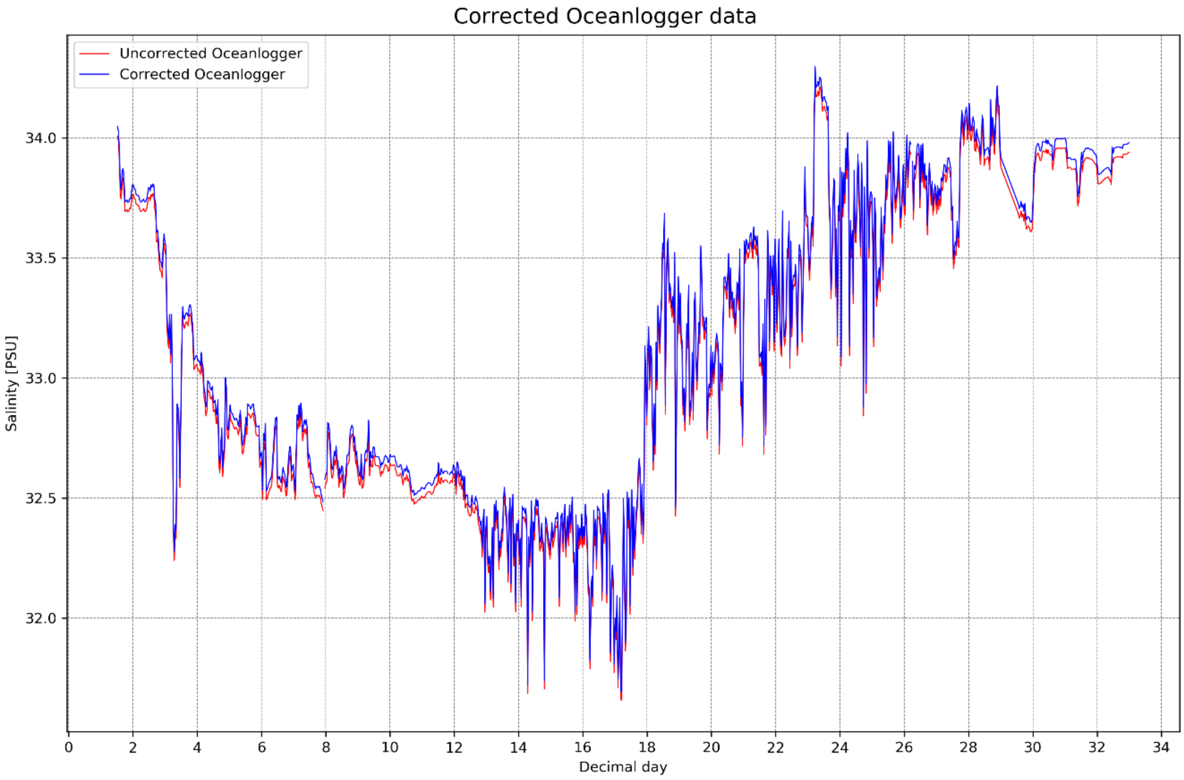

Figure 7-38 Time series plot of uncorrected (red) and corrected (blue) salinity values from the Oceanlogger

Example oceanlogger data plots are shown in Figure 7-39, which displays the surface fluorescence in Börgen Bay before and after the ice cliff collapse event on January 21st 2020. The difference is striking, and accords with the observations in the CTD sections (Figure 7-18), specifically the unusual nature of stations BB1 and BBB. The extent to which the pattern is causally related to the ice cliff collapse is not yet clear, but will be the subject of future investigation. For completeness, the corresponding oceanlogger surface temperature distribution is given in Figure 7-40. Example oceanlogger measurements covering the full period of JR19002 data logging is given in Figure 7-41, for sea surface temperature, salinity and fluorescence.

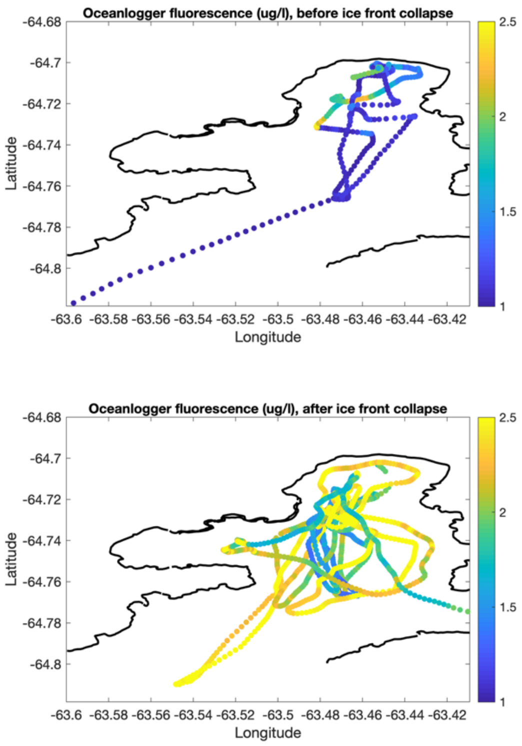

Figure 7-40 Surface distributions of fluorescence in Borgen Bay from the oceanlogger, divided into (top) the period prior to the ice front collapse, and (bottom) the period subsequent to the ice front collapse

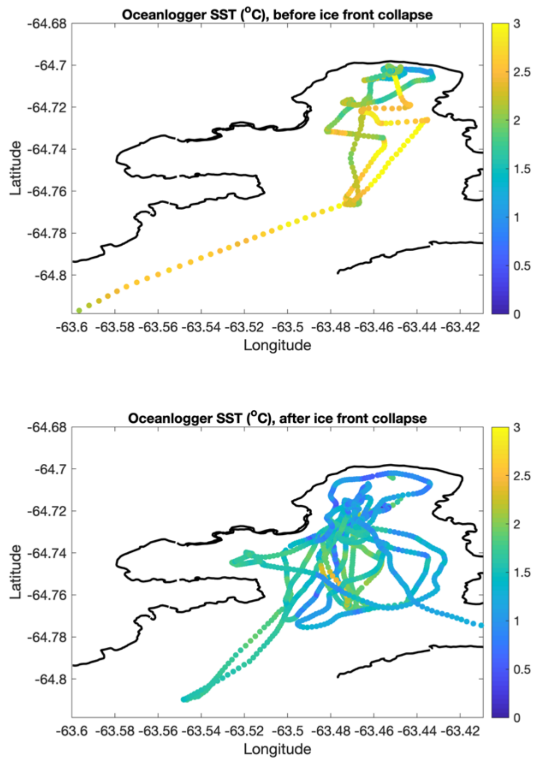

Figure 7-39 As per Figure 7-40, but for oceanlogger temperature

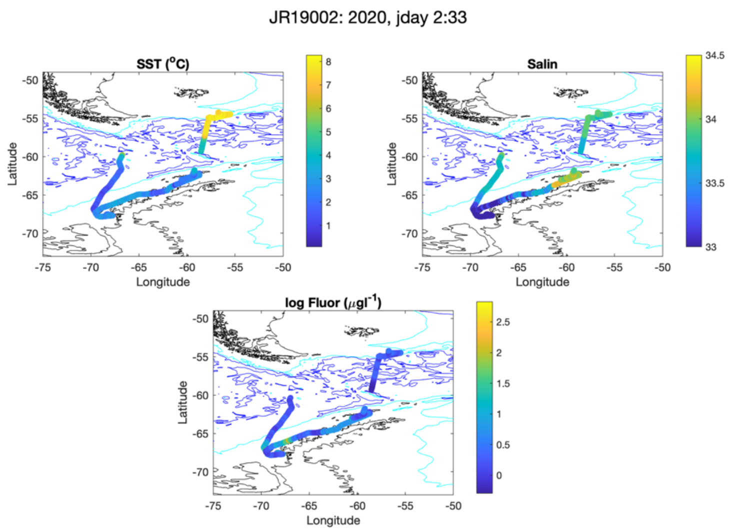

Figure 7-41 Sea surface temperature (SST), salinity and fluorescence along the ship track of JR19002, from the oceanlogger data stream

7.3 MARINE GEOCHEMISTRY (RACETRAX)

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7.3.1 RADIUM ISOTOPES IN SEAWATER

Ra sampling requires very large volumes of water, as Ra activities are typically very low away from sediment sources. Samples of ~150 L were collected from the CTD. This work was undertaken by primary sampling team Amber Annett, Rhiannon Jones, Oliver Flanagan and Mehul Vora, with great (and greatly appreciated) assistance from most of the science party. Additional surface samples were collected from the small boats, the boat work proving much simpler than last year when surface samples were collected via towfish while also providing samples from the very top of the water column (preferable to either CTD or towfish sampling). Small volumes (~10L) of coretop waters from the multicorer were also processed for Ra isotopes at sites where sediments were collected. A list of sample locations and depths is given in Table 7.12. Overall, 105 water samples were collected for Ra isotopes, from all three embayments, totalling ~15622 kg.

Samples were transferred using 20 L carboys into 160L bins for processing. Using a submersible pump, the samples were then passed through a column holding 20 g of MnO_2-coated acrylic fiber, which strongly binds Ra. The fibers were then rinsed with Milli-Q and loaded into a Ra Delayed Coincidence Counter (RaDeCC; Scientific Computer Instruments, USA) system purged with He gas, and decay of Ra was counted for 6-10 h to quantify ^{223}Ra and ^{224}Ra content. Following decay of these short-lived isotopes, the fibers will be re-analysed using the RaDeCC to determine the activity of the parent isotopes (^{227}Ac and ^{228}Th). Discrete 250mL samples were collected for 226Ra calibration, to determine extraction efficiency on the fibers.

Table 7-12 List of samples collected for Ra analysis from CTD, and small boats (in green)

	Station Name	Sample Name	Depth	CTD Cast No	dd/mm/yy	Time (CTD bottom)	Volume	Bottom Depth	Latitude (S)	Longitude (W)
1	SC0	SC0-20	20	4	13/01/2020	07:12	137.62	369	67.5986	68.10153333
2	SC0	SC0-70	70	4	13/01/2020	07:12	157.28	369	67.5986	68.10153333
3	SC0	SC0-100	100	4	13/01/2020	07:12	157.28	369	67.5986	68.10153333
4	SC0	SC0-200	200	3	13/01/2020	04:58	156.89	368	67.59861667	68.10141667
5	SC0	SC0-300	300	3	13/01/2020	04:58	137.62	368	67.59861667	68.10141667
6	SC0	SC0-340	340	3	13/01/2020	04:58	157.05	368	67.59861667	68.10141667
7	SC0	SC0-354	354	2	13/01/2020	03:23	137.09	369	67.59861667	68.10143333
8	SC1	SC1-20	20	7	13/01/2020	12:49	137.62	520	67.56695	68.2256
9	SC1	SC1-100	100	7	13/01/2020	12:49	157.28	520	67.56695	68.2256
10	SC1	SC1-150	150	7	13/01/2020	12:49	157.28	520	67.56695	68.2256
11	SC1	SC1-250	250	6	13/01/2020	10:51	157.28	520	67.56693333	68.22556667
12	SC1	SC1-400	400	6	13/01/2020	10:51	157.28	520	67.56693333	68.22556667

13	SC1	SC1-470	470	6	13/01/2020	10:51	157.28	520	67.56693333	68.22556667
14	SC1	SC1-498	498	5	13/01/2020	08:38	147.96	520	67.5669	68.22568333
15	SCA	SCA-0-SBW	0	-	16/01/2020	18:51	132	-	67.54165	68.27676667
16	SCA	SCA-10	10	11	13/01/2020	20:07	137.62	280	67.54263333	68.28116667
17	SCA	SCA-35	35	11	13/01/2020	20:07	157.28	280	67.54263333	68.28116667
18	SCA	SCA-140	140	11	13/01/2020	20:07	157.28	280	67.54263333	68.28116667
19	SCA	SCA-180	180	10	13/01/2020	18:30	157.28	276	67.54266667	68.28108333
20	SCA	SCA-240	240	10	13/01/2020	18:30	157.28	276	67.54266667	68.28108333
21	SCA	SCA-269	269	10	13/01/2020	18:30	154.62	276	67.54266667	68.28108333
22	SCC	SCC-0-SBW	0	-	16/01/2020	11:40	132	-	67.52881667	68.25715
23	SCC	SCC-0	0	19	14/01/2020	10:19	157.28	271	67.53291667	68.26113333
24	SCC	SCC-20	20	19	14/01/2020	10:19	157.28	271	67.53291667	68.26113333
25	SCC	SCC-60	60	19	14/01/2020	10:19	137.62	271	67.53291667	68.26113333
26	SCC	SCC-100	100	18	14/01/2020	09:10	157.28	270	67.53281667	68.2613
27	SCC	SCC-150	150	18	14/01/2020	09:10	137.62	270	67.53281667	68.2613
28	SCC	SCC-215	215	18	14/01/2020	09:10	156.28	270	67.53281667	68.2613
29	SCC	SCC-226	226	17	14/01/2020	07:20	139.66	244	67.528	68.26588333
30	SCE	SCE-0-SBW	0	-	16/01/2020	10:14	132	-	67.51835	68.24341667
31	SCE	SCE-0	0	22	14/01/2020	23:26	137.62	191	67.51975	68.24971667
32	SCE	SCE-20	20	22	14/01/2020	23:26	157.28	191	67.51975	68.24971667
33	SCE	SCE-60	60	22	14/01/2020	23:26	157.28	191	67.51975	68.24971667
34	SCE	SCE-90	90	21	14/01/2020	22:17	157.28	189	67.51976667	68.24896667
35	SCE	SCE-160	160	21	14/01/2020	22:17	157.28	189	67.51976667	68.24896667
36	SCE	SCE-180	180	21	14/01/2020	22:17	137.62	189	67.51976667	68.24896667
37	SC2	SC2-0-SBW	0	-	16/01/2020	19:28	132	-	67.54925	68.2697
38	SC6	SC6-0-SBW	0	-	16/01/2020	10:00	132	-	67.51451667	68.2465
Börgen Bay										
39	BB0	BB0-10	10	26	19/01/2020	19:29	157.28	316	64.76451667	63.47133333
40	BB0	BB0-90	90	26	19/01/2020	19:29	157.28	316	64.76451667	63.47133333
41	BB0	BB0-120	120	26	19/01/2020	19:29	157.28	316	64.76451667	63.47133333
42	BB0	BB0-170	170	25	19/01/2020	18:13	157.28	316	64.76445	63.47145
43	BB0	BB0-200	200	25	19/01/2020	18:13	157.28	316	64.76445	63.47145

44	BB0	BB0-290	290	25	19/01/2020	18:13	157.28	316	64.76445	63.47145
45	BB0	BB0-300	300	24	19/01/2020	16:15	157.27	315	64.76446667	63.47141667
46	BBA	BBA-0-SBW	0	-	20/01/2020	14:11	132	-	64.7315	63.46538333
47	BBA	BBA-10	10	30	20/01/2020	02:31	156.87	180	64.73168333	63.48145
48	BBA	BBA-25	25	30	20/01/2020	02:31	136.62	180	64.73168333	63.48145
49	BBA	BBA-35	35	29	20/01/2020	01:08	157.28	181	64.73163333	63.48136667
50	BBA	BBA-60	60	29	20/01/2020	01:08	157.28	181	64.73163333	63.48136667
51	BBA	BBA-150	150	29	20/01/2020	01:08	157.28	181	64.73163333	63.48136667
52	BBA	BBA-170	170	28	19/01/2020	23:15	146.91	182	64.73165	63.48136667
53	BBC	BBC-20	20	33	20/01/2020	06:38	157.28	174	64.71806667	63.473
54	BBC	BBC-50	50	33	20/01/2020	06:38	157.28	174	64.71806667	63.473
55	BBC	BBC-60	60	33	20/01/2020	06:38	157.28	174	64.71806667	63.473
56	BBC	BBC-70	70	32	20/01/2020	05:11	157.28	192	64.72308333	63.47215
57	BBC	BBC-100	100	32	20/01/2020	05:11	157.28	192	64.72308333	63.47215
58	BBC	BBC-150	150	32	20/01/2020	05:11	157.28	192	64.72308333	63.47215
59	BBC	BBC-180	180	31	20/01/2020	03:30	157.28	193	64.71701667	63.42041667
60	BBD	BBD-0-SBW	0	-	20/01/2020		132	-	64.707	63.455775
61	BBD	BBD-10	10	40	21/01/2020	02:29	157.28	200	64.70718333	63.46418333
62	BBD	BBD-40	40	40	21/01/2020	02:29	157.28	200	64.70718333	63.46418333
63	BBD	BBD-60	60	39	21/01/2020	01:20	157.28	203	64.70725	63.46443333
64	BBD	BBD-120	120	39	21/01/2020	01:20	157.28	203	64.70725	63.46443333
65	BBD	BBD-170	170	39	21/01/2020	01:20	137.62	203	64.70725	63.46443333
66	BBD	BBD-190	190	38	20/01/2020	23:39	157.28	201	64.70715	63.46441667
67	BBE	BBE-0-SBW	0	-	20/01/2020		132	-	64.70333333	63.45546667
68	BBE	BBE-10	10	42	21/01/2020	05:48	157.28	264	64.70271667	63.45261667
69	BBE	BBE-40	40	42	21/01/2020	05:48	157.28	264	64.70271667	63.45261667
70	BBE	BBE-60	60	42	21/01/2020	05:48	157.28	264	64.70271667	63.45261667
71	BBE	BBE-220	220	41	21/01/2020	04:05	171.14	254	64.70236667	63.45265
72	BBE	BBE-254	254	43	21/01/2020	07:12	157.28	283	64.70355	63.45221667
Marian Cove										
73	MC1	MC1-0-SBW	0	-			132	-	0	0
74	MC1	MC1-15	15	47	24/01/2020	16:35	137.62	99	62.2175	58.78945
75	MC1	MC1-30	30	48	24/01/2020	18:11	157.28	98	62.21753333	58.78936667
76	MC1	MC1-50	50	48	24/01/2020	18:11	157.28	98	62.21753333	58.78936667

77	MC1	MC1-70	70	48	24/01/2020	18:11	157.28	98	62.21753333	58.78936667
78	MC1	MC1-87	87	47	24/01/2020	16:35	155.16	99	62.2175	58.78945
79	MCA	MCA-0-SBW	0	-			132	-	0	0
80	MCA	MCA-10	10	52	25/01/2020	00:20	157.28	110	62.21196667	58.76253333
81	MCA	MCA-30	30	52	25/01/2020	00:20	157.28	110	62.21196667	58.76253333
82	MCA	MCA-70	70	52	25/01/2020	00:20	157.28	110	62.21196667	58.76253333
83	MCA	MCA-85	85	51	24/01/2020	22:34	157.28	109	62.21195	58.76263333
84	MCA	MCA-95	95	51	24/01/2020	22:34	131.77	109	62.21195	58.76263333
85	MCB	MCB-0	0	54	25/01/2020	02:36	157.28	60	62.20855	58.75393333
86	MCB	MCB-10	10	54	25/01/2020	02:36	157.28	60	62.20855	58.75393333
87	MCB	MCB-30	30	54	25/01/2020	02:36	157.28	60	62.20855	58.75393333
88	MCB	MCB-43	43	53	25/01/2020	01:22	157.28	59	62.20856667	58.75393333
89	MCC	MCC-0-SBW	0	-			132	-		
90	MCC	MCC-0	0	56	25/01/2020	04:46	157.28	66	62.20498333	58.74691667
91	MCC	MCC-10	10	56	25/01/2020	04:46	157.28	66	62.20498333	58.74691667
92	MCC	MCC-30	30	55	25/01/2020	03:33	137.62	65	62.20498333	58.74693333
93	MCC	MCC-40	40	55	25/01/2020	03:33	137.62	65	62.20498333	58.74693333
94	MCD	MCD-0-SBW	0	-			132			
95	MCD	MCD-20	20	59	25/01/2020	08:50	157.28	88	62.20353333	58.73633333
96	MCD	MCD-50	50	59	25/01/2020	08:50	157.28	88	62.20353333	58.73633333
97	MCD	MCD-70	70	59	25/01/2020	08:50	157.28	88	62.20353333	58.73633333
98	MCD	MCD-86	86	58	25/01/2020	07:23	137.62	94	62.20351667	58.7363
99	MCE	MCE-0-SBW	0	-			132	-		
100	MCE	MCE-10	10	62	25/01/2020	22:47	157.28	82	62.201	58.73425
101	MCE	MCE-20	20	62	25/01/2020	22:47	157.28	82	62.201	58.73425
102	MCE	MCE-30	30	62	25/01/2020	22:47	157.28	82	62.201	58.73425
103	MCE	MCE-50	50	63	26/01/2020	00:05	137.62	79	62.20098333	58.73426667
104	MCE	MCE-67	67	63	26/01/2020	00:05	122.71	79	62.20098333	58.73426667

7.3.2 RADIUM ISOTOPES IN SEDIMENT AND POREWATERS

Four or five cores from the multicorer were collected at stations A and D in each bay (except BBE which did not have suitable sediment for coring). Three to four were used for extraction of porewaters, and the remaining one for sediment processing. Porewaters were collected from depths of 0-0.5, 0.5-1, 1-1.5, 1.5-2.5, 2.5-3.5, 3.5-4.5, 6-7 and 9-10cm within the cores, using rhizon samplers (Rhizosphere) which filter the porewater at ~0.18µm, and pooled before subsampling to obtain the 30-70ml total volume at each depth interval needed for Ra analysis. 2mL of porewater were subsampled for trace metal analysis, 4mL for determination of nutrient concentrations, 5mL for silicon isotopes, and 3mL for quantification of dissolved organic carbon, all of which will be performed back in the UK. Cores were sectioned at the same depths, with half of each sample being used for porosity determinations and the other half for precipitation of Ra isotopes. Sediments were then filtered onto 142mm GF/F filters and Ra and Th content determined using the RaDeCCs. Full methodology followed Cai et al. (2012).

Table 7-13 Multicorer samples for sediment and porewater processing

Date & Time	Station	Latitude	Longitude
15/01/2020 17:15	SCA	-67.5424	-68.28134
17/01/2020 16:09	SCE	-67.5193	-68.25038
22/01/2020 22:17	BBA	-64.7333	-63.48116
27/01/2020 14:28	MCA	-62.2113	-58.76028
26/01/2020 18:53	MCE_alt	-62.2014	-58.7319

Table 7-14 Porewater samples for dissolved iron and trace metals (dFe), nutrients (Nuts), and dissolved organic carbon (DOC)

Site	SCA		SCE		BBA		MCA		MCE	
Depth	dFe	Nuts	dFe	Nuts	dFe	Nuts	dFe	Nuts	dFe	Nuts
0-0.5	2	4	2	4	2	4	2	4	2	4
0.5-1	2	4	2	4	2	4	2	4	2	4
1-1.5	2	4	2	4	2	4	2	4	2	4
1.5-2.5	2	4	2	4	2	4	2	4	2	4
2.5-3.5	2	4	2	4	2	4	2	4	2	4
3.5-4.5	2	4	2	4	2	4	2	4	2	4
6-7	2	4	2	4	2	4	2	4	2	4
9-10	2	4	2	4	2	4	2	4	2	4

Site	SCA	SCE	BBA	MCA	MCE
Depth	Vol for DOC	Vol for DOC	Vol for DOC	Vol for DOC	Vol for DOC
0-0.5	3	3	3	3	3
0.5-1	3	3	2.5	3	3
1-1.5	0	3 (pooled)	2	3	3
1.5-2.5	0		3	3	3
2.5-3.5	2.25	3	3	3	3
3.5-4.5	0	3	0	3	3
6-7	0	3	0	0	3
9-10	6	3	0	6	3

Cai et al. 2012 *Marine Chemistry* 138-139, 1-6.

7.3.3 TRACE METAL SAMPLE COLLECTION

Trace metal samples were collected via small boats, and processed back on board inside the clean space set up in the main lab. A section of the lab was isolated using plastic sheeting, with the air supply HEPA-filtered to ensure trace-metal clean conditions. Particulates were pressure filtered onto 25mm Supor PES filters (0.45um pore size), with volumes ranging from ~1-2 L, based on a 3-hour time period for filtration. A 0.2µm acropak cartridge filter and peristaltic pump were used for dissolved samples, flushed with at least 0.5L of seawater at each station. Dissolved trace metal (dTM) samples were then collected into acid-washed 125mL HDPE bottles, 60ml for nutrient analysis, 250mL for DOC, and at the proximal and distal stations in each fjord a 1L sample filtered for Fe-DOM analysis. All analyses to be done in the UK.

At 3 sites for each bay, 500 ml of surface seawater was collected for later synchrotron analysis (Rhiannon Jones). These 500 ml samples were vacuum filtered through 0.4 um polycarbonate filters and the filter kept and frozen at -20 for later analysis. Samples will be stored before analysis under a K-edge synchrotron to determine the speciation and abundance of Fe-bearing compounds found in glacial fjord surface seawater around the West Antarctic Peninsula.

All sampling and handling was performed following clean lab protocols, wearing tyvek lab coats, hair nets, and class-100 particle-free gloves.

7.3.4 SAMPLES COLLECTED (WATER, SEDIMENT, TRACE METALS)

Surface water samples for nutrients and trace metal analysis were collected during the small boat work at Sheldon Cove, Borgen Bay and Marian Cove. pFe_1 and pFe_2 refer to particulate iron for trace metal concentration and synchrotron iron speciation analysis, respectively.

Table 7-15 Nutrient and trace metal samples taken at Sheldon Cove during small boat work

Sheldon Cove	**SBW**	**Date:**	**16/01/2020**							
Time (UTC)	Lat (°)		Lon (°)		Station	Nutrients (mL)	dFe (mL)	TDFe (mL)	pFe_1 (L)	pFe_2 (mL)
12:42	67	30.965	68	14.762	SC6	60	125	60	4	500
13:00	67	30.871	68	14.79						
13:14	67	30.834	68	14.605	SCE	60	125	60	4	500
13:33	67	31.101	68	15.464						
14:40	67	31.729	68	15.429	SCC	60	125	60	4	0
14:48	67	31.745	68	15.692						
18:51	67	32.499	68	16.606	SCA	60	125	60	4	500
19:02	67	32.479	68	16.787						
19:28	67	32.955	68	16.292	SC2	60	125	60	4	0
19:37	67	32.949	68	16.288						

Table 7-16 Nutrient and trace metal samples taken at Börgen Bay during small boat work

Börgen Bay	SBW	Date:	20/01/2020							
Time (UTC)	**Lat (°)**		**Lon (°)**		**Station**	**Nutrients (mL)**	**dFe (mL)**	**TDFe (mL)**	**pFe_1 (L)**	**pFe_2 (mL)**
11:59	64	42.204	63.00	27.312	BBE	60	125	60	4	500
12:13	64	42.182	63.00	27.340						
12:43	64	42.434	63.00	27.347	BBD	60	125	60	4	0
12:52	64	42.408	63.00	27.346						
13:09	64	42.318	63.00	27.924	BBC	60	125	60	4	500
13:19	64	42.521	63.00	28.147						
14:04	64	43.879	63.00	28.020	BBA	60	125	60	4	0
14:17	64	43.901	63.00	27.826						
16:07	64	45.908	63.00	27.916	BB0	60	125	60	4	500
16:17	64	45.884	63.00	27.789						

Table 7-17 Nutrient and trace metal samples taken at Marian Cove during small boat work

Marian Cove	SBW	Date:	25/01/2020						
Time (UTC)	**Lat (dec.)**	**Lon (dec.)**	**Station**	**Nutrients (mL)**	**dFe (mL)**	**TDFe (mL)**	**pFe_1 (L)**	**pFe_2 (mL)**	
11:30	62.2036	58.7892	MCD	60	125	60	4		
12:00	62.2063	58.7423	MCE	60	125	60	4	500	
12:22	62.2031	58.7396	MCC	60	125	60	4	500	
13:30	62.2111	57.7542	MCA	60	125	60	4		
14:00	62.21	58.7592	MC1	60	125	60	4	500	

7.3.5 PRELIMINARY RESULTS: SEDIMENT-WATER TRACE METAL INCUBATION EXPERIMENT (SWINC)

Background: At three sites proximal to the ice shelf for Sheldon Cove (SCE), Borgen Bay (BBE water, BBD sediment coretop), and Marian Cove (MCE), a sediment-water incubation experiment was carried out to investigate such processes, in which sediment core-top material is added to bottom water collected proximal to the sediment core, and the change in trace metal concentration is determined over a 48-hr time-series compared with a non-altered control carbuoy. To our knowledge this is the first time a SWINC experiment has been done at these sites and the results of which will be highly interesting and useful for future experiments.

Methods: Bottom-depth water taken from CTD casts was filtered through a 0.2 um filter inline using a peristaltic pump (to filter bottom water of biological matter) into 4 x 20 L acid-clean carbuoys. These carbuoys were bagged and stored in the cold-temperature lab (4°C). Sediment cores from the same site were taken for sediment addition to 3 carbuoys. Three carbuoys had 30 ml of coretop sediment addition, and the 4th was the control (CTRL) carbuoy with no change made. The top 0.5 cm of 3 cores was mixed together and 30 ml added to carbuoys I, II, and III using an acid-clean syringe. This sediment addition marked T0. Sediment was shaken 1 hour prior to sampling. Samples were taken at pre T0, T1, T4, T12, T24, T36, T48 from the 4 carbuoys for: total dissolvable iron (TDFe), dissolved iron (<0.2 µm, dFe), and soluble iron (<0.02 µm, sFe) if able. TDFe was taken directly from the carbuoys I, II III and CTRL using acid-clean tubing and a peristaltic pump. For dFe, the same was performed but with an 0.2 um acropak filter attached. All bottles were double-bagged and stored for later acidification. At Marian Cove the soluble fraction of Fe was subsampled for. This was performed by subsequent filtering from the dFe samples taken at Marian Cove (60 ml of 125 ml). Subsampling for sFe was done under clean room conditions in a filtration hood using a soluble peristaltic pump.

Soluble Fe filtration method: The soluble fraction Fe was sampled for using a soluble pump, with attached Teflon and grey-grey tubing. Filters used were Anatop 0.02 µm. Pump lines (without filters attached) were cleaned prior to the soluble filtration using 10% HCl acid at the start of the experiment (pre T0 subsampling). Pump lines were left to soak filled with MQ in between sample timesteps. After sample filtration, between timesteps, 20 ml of 0.1% UpA acid followed by >60 ml UHP water was pumped through the soluble pump lines and attached filters to prime the lines for the next samples. Following timestep subsampling of dFe, the 125 ml dFe samples were brought into the clean room, and pumped through the lines. Using trace-metal acid-cleaned 60 ml Nalgene bottles for sFe samples, 10-20 ml was collected to rinse the bottles before discarding. The pump was then run at 7 rpm (approx. 1 ml/ min) until 60 ml had been filtered through, filling the sFe sample bottles. These samples were double-bagged and stored for later acidification.

Results: Following acidification with UpA grade Romil Hydrochloric acid to pH 1.6 (1 ml / 1 L), samples were stored for a further 6 months before analysis by flow-injection at the University of Southampton.

Sampling log:
SWINC 1 Sheldon Cove
Water collection
Station: SCE
Ship event no: 33
Date and time: 15-01-20, 22:30 local time (16-01-20, 01:30 UTC)
CTD cast: 23
Water depth: 187 m
CTD cast depth: 178 m

Sediment collection: SCE multicore deployment
Ship event no: 73
Date and time (UTC): 17/01/20 18:00
Lat: -67.5190
Lon: -068.2495
Depth: ~190 m

Sheldon Cove										
Sediment addition		**Date: 18/01/20**					**Time (UTC): 17:00**			
Timestep	**Time (UTC)**	**TDFe (60 ml)**					**dFe (125 ml)**			
		1	2	3	CTRL		1	2	3	CTRL
T0	16:20	x	x	x	x		x	x	x	x
T1	18:00	x	x	x	x		x	x	x	x
T4	21:00	x	x	x	x		x	x	x	x
T12	05:00	x	x	x	x		x	x	x	x
T24	17:00	x	x	x	x		x	x	x	x
T36	05:00	x	x	x	x		x	x	x	x
T48	17:00	x	x	x	x		x	x	x	x

SWINC 2 Börgen Bay
Water collection
Station: BBE
Ship event no: 111
Date-time: 21-01-20, 07:05 UTC
CTD CAST: 43
Water depth: 264 m
CTD cast depth: 254 m

Sediment collection
Station: BBD (due to ice conditions at BBE)
Ship event no: 149
Date-time (UTC): 23/01/20 19:00
Lat: - 64. 7071
Lon: -063.4627
Depth: ~ 200 m

Börgen Bay											
Sediment addition		**Date: 23/01/20**				**Time (UTC): 23:00**					
Timestep	**Time (UTC)**	**TDFe (60 ml)**					**dFe (125 ml)**				
		1	2	3	CTRL		1		2	3	CTRL
T0	22:05	x	x	x	x		x		x	x	x
T1	00:00	x	x	x	x		x		x	x	x
T4	03:00	x	x	x	x		x		x	x	x
T12	11:00	x	x	x	x		x		x	x	x
T24	23:00	x	x	x	x		x		x	x	x
T36	11:00	x	x	x	x		x		x	x	x
T48	23:00	x	x	x	x		x		x	x	x

SWINC 3 - Marian Cove
Water collection
Station: MCE

Ship event no: 178
CTD cast: 63
Datetime: 25-01-20 21:00 local time
Water depth: 79 m
CTD cast depth: 67 m

Sediment collection
Station: MCE
Ship event no: 197
Datetime: 26-01-20 19:00
Lat: -62.2014
Lon: -058.7319
Depth: ~ 100m

Marian Cove																	
Sediment addition		**Date:**					**Time: 08:00**										
Timestep	**Time**	**TDFe (60 ml)**					**dFe (125 ml)**					**sFe (60 ml)**					
		1	2	3	CTRL		1	2	3	CTRL		1	2	3	CTRL		
T0	07:45	x	x	x	x		x	x	x	x		x	x	x	x		
T1	09:00	x	x	x	x		x	x	x	x		x	x	x	x		
T4	12:00	x	x	x	x		x	x	x	x		x	x	x	x		
T12	20:00	x	x	x	x		x	x	x	x		x	x	x	x		
T24	08:00	x	x	x	x		x	x	x	x		x	x	x	x		
T36	20:00	x	x	x	x		x	x	x	x		x	x	x	x		
T48	08:00	x	x	x	x		x	x	x	x		x	x	x	X		

7.4 MUD

7.4.1 HAMON GRAB

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Contributors: *Ander De Lecea, Fabian Guzman, Alice Guzzi, Paul Butler, Julian Blumenroeder, Kotaro Shirai, Marke Furze, Alice Fremand, Mehul Vora, Marina Costa*

Aim: Retreating glaciers offer a unique opportunity to study the process of colonization in newly released habitats of the Antarctica sea floor. Along with this, this particular ecosystem also offers the opportunity to assess how the species are coping with perturbations derived from increased amounts of freshwater and sediments originated from glacier melting driven by climate change. In order to examine the role of these processes and their impact on the Antarctic benthic fauna, a series of samplings were conducted using a Hamon Grab equipment that collects fauna from the sediment in the sea floor. This steps are described below, and results of sampling are summarized in Table 7-18.

In previous cruises (JR17001 and JR18002), the sampling was conducted by collecting fauna from five sites along each of three different fjords (Marion Cove, Börgen Bay and Sheldon Cove), with five replicates or succesful deployments in each of the five sites. In this cruise (JR19002), only one site was sampled from each of the three fjords, a different site further away from the glacier front, with the aim to add an additional sample that could represent the original (oldest) condition previous to the colonization of the inner areas of the fjords. These new sampling sites were SC0 (at Sheldon Cove, 67° 35.922' S; 68° 6.084' W), BB0 (at Börgen Bay 64° 45.870' S; 63° 28.302' W), and MC0 (at Marian Cove, 62° 13.200' S; 58° 48.990' W). These samples will then be used to examine responses at the community, genetic, and bioenergetic levels for which specific the rationales are explained with greater detail in Chapter 8 (Chilean collaboration).

Protocol for processing Grab samples: A Hamon grab with a 20 x 40 x 40 cm bucket was used to sample the infauna present in the muddy substrate of all three glacial fjords. The Hamon grab consists of swivel spade bucket housed in a metallic frame. The grab mechanism is not spring loaded but relies on a weighted deployment catch which is released upon contact with the seabed. This changes the bucket arm position from horizontal to vertical as the grab is retrieved. Once the grab is retrieved and then placed overboard and on the ship's deck by the crew, the content is collected in a large plastic box and carried to the deck area where the sieving takes place. The following processes, sieving and sorting in the lab, were performed optimally by eight people (four for sieving and four for sorting). A minimum of seven also works, but when sorting is the most demanding part (i.e. when the amount of samples is large), at least four people are advisable for the sorting part.

Sieving on deck: We used two sieves together – a coarse sieve (which removes large stones and rocks) over a 1mm sieve which retains our sample. Important points:

1. The optimal number of people doing the sieving is approximately four.
2. Although higher water pressure makes sieving quicker- it potentially destroys delicate organisms. Do not use a very high pressure. A dispersed spray rather than a narrow jet works best.
3. Check the 10mm sieve before discarding retained stones to ensure fauna, especially worm-like organisms are not retained on the sieve; also check stones for any organisms living on them.

Once samples are clean, all material retained with the 1mm sieve was carefully put on trays and taken to the wet lab. Organisms picked directly from the mud (when they are visible and to avoid further damage with the sieving process), can also be placed on a clean tray and taken to the lab when appropriate.

Sorting in the wet lab: We sorted most samples on board. However, some samples were preserved entire when sorting did not keep pace with grabbing; these samples will be sorted in the labs at our home bases. There is a danger of different sorting accuracy onboard versus in our labs at home and different sorters may sort to different degrees of accuracy. These are the operational sorting criteria which we attempted to conform to:

- Trays with samples entering the wet lab should be immediately identified with labels to keep track of the site and grab information at all times. These trays may be photographed prior to sorting to retain a reference image of the material and community.
- Divide the material into fractions if enough people are available; this speeds up the sorting process. If material is split into different trays, add labels to all of them.
- Use a white tray for sorting to increase detectability of small animals (e.g. very small worms).
- Use a pair of fine metal tweezers if available and try avoid the very large plastic ones
- Assemble your sample at one end of the tray. Move the sediment from one side of the tray to the other and pick out all biological material.

- Always ensure you are moving material across a white background – this allows small animals like very thin polychaetes to be detected. Beware moving material through muddy opaque water.
- Ensure small animals do not dry out when picked and placed on tray prior to preserving.
- As well as live animals, also pick out dead shells (not very broken valves).
- ***Place animals in ethanol-containing vials of appropriate size. Make sure the proportion of ethanol vs animal is at least 5:1 to ensure adequate preservation for molecular analyses. Otherwise, change the ethanol at least one more time after one or two days for those vials that do not meet the 5:1 criterion.***

A dedicated person for supervising the labelling process and annotating vial codes, content (broad taxonomy, specimen quantity, vial volume and number) is highly recommended. This information greatly helps to record the samples collected, and facilitates posterior form filling (e.g. BOLs). All samples should be stored in the -20° C freezers.

Sampling Results: The broad results of this sampling are given in Table 7-18. Detailed analysis and sorting will be conducted at the author's home lab at the Universidad Catolica de la Santisima Concepcion, Chile.

Table 7-18 Results of the Hamon Grab sampling and associated storage data

Vial N°	Site_code	Taxa	Quantity	Volume (ml)	Event N°	Comments
001	SC0_G1	Polychaeta	15	20	49	
002	SC0_G1	Poriphera	32	140	49	
003	SC0_G1	Anellida	12	500	49	
004	SC0_G1	Anthozoa	1	140	49	
005	SC0_G1	Gastropoda	1	140	49	
006	SC0_G1	Sipunculida	1	500	49	
007	SC0_G1	Polychaeta	20	140	49	
008	SC0_G1	Poriphera	20	20	49	
009	SC0_G2	Soft Coral	1	20	50	
010	SC0_G2	Cidaridae	1	1000	50	Pencil Sea Urchin
011	SC0_G2	Ascidiacea	1	20	50	
012	SC0_G2	Polychaeta	20	140	50	
013	SC0_G2	Polychaeta	20	140	50	
014	SC0_G2	Poriphera	20	20	50	
015	SC0_G2	Amphipoda	1	20	50	
016	SC0_G2	Bivalvia, Scaphopoda	10	20	50	
017	SC0_G2	Ophiuroidea	3	20	50	
018	SC0_G2	Amphipoda	3	20	50	
019	SC0_G2	Holothuroidea	1	20	50	
020	SC0_G3	Sipunculida	2	140	51	
021	SC0_G3	Polychaeta	30	140	51	
022	SC0_G3	Ophiuroidea	1	20	51	
023	SC0_G3	Isopoda	1	20	51	
024	SC0_G3	Amphipoda	12	20	51	
025	SC0_G3	Bivalvia, Scaphopoda	9	20	51	
026	SC0_G3	Poriphera	1	140	51	
027	SC0_G3	Poriphera	1	140	51	
028	SC0_G3	Algae	10	20	51	
029	SC0_G4	Holothuroidea	2	500	53	
030	SC0_G4	Priapulida	1	20	53	
031	SC0_G4	Polychaeta	20	140	53	

032	SC0_G4	Amphipoda	2	20	53	
033	SC0_G4	Poriphera	2	20	53	
034	SC0_G4	Bivalvia, Scaphopoda	12	20	53	
035	SC0_G5	Eggs	1	140	54	
036	SC0_G5	Holothuroidea	1	20	54	
037	SC0_G5	Poriphera	2	20	54	
038	SC0_G5	Amphipoda	1	20	54	
039	SC0_G5	Ophiuroidea	1	20	54	
040	SC0_G5	Scaphopoda	2	20	54	
041	SC0_G5	Polychaeta	20	140	54	
042	SC0_G5	Sipunculida	1	140	54	
095	BB0_G1	Ophiuroidea	1	140	115	
096	BB0_G1	Bivalvia	1	20	115	
097	BB0_G1	Mollusca	15	20	115	Bivalvia, Scaphopoda, Gastropoda
098	BB0_G1	Polychaeta	30	140	115	
099	BB0_G1	Pychnogonida	4	140	115	
100	BB0_G1	Amphipoda	1	140	115	
101	BB0_G2	Briozoa, Anthozoa	1	1000	116	On rock
102	BB0_G2	Bivalvia	1	20	116	For Alejandro
103	BB0_G2	Amphipoda	2	20	116	
104	BB0_G2	Ophiuroidea	2	20	116	
105	BB0_G2	Polychaeta	40	140	116	
106	BB0_G2	Bivalvia, Scaphopoda	20	20	116	
107	BB0_G2	Pychnogonida	4	20	116	
108	BB0_G2	Briozoa	1	20	116	
109	BB0_G3	Pychnogonida	4	20	117	
110	BB0_G3	Amphipoda, Isopoda	2	20	117	
111	BB0_G3	Scaphopoda	7	20	117	
112	BB0_G3	Polychaeta	30	140	117	
113	BB0_G3	Briozoa	4	20	117	
114	BB0_G3	Bivalvia, Gastropoda, Foraminifera	13	20	117	
115	BB0_G4	Pychnogonida	1	20	118	
116	BB0_G4	Scaphopoda	10	20	118	
117	BB0_G4	Bivalvia, Gastropoda, Foraminifera	21	20	118	
118	BB0_G4	Polychaeta	20	140	118	
119	BB0_G4	Ophiuroidea	1	20	118	
120	BB0_G4	Amphipoda	1	20	118	
121	BB0_G4	Anthozoa	1	20	118	
122	BB0_G4	Bivalvia, Gastropoda	6	20	118	gastropod shell
123	BB0_G5	Ophiuroidea	1	20	120	
124	BB0_G5	Polychaeta	30	140	120	
125	BB0_G5	Pychnogonida	6	20	120	
126	BB0_G5	Bivalvia, Scaphopoda, Foraminifera	30	20	120	
127	BB0_G5	Amphipoda	1	20	120	
128	BB0_G5	Gastropoda	1	140	120	Limpet Shell
154	MC0_G1	Polychaeta	50	140	179	
155	MC0_G1	Polychaeta	50	140	179	
156	MC0_G1	Polychaeta	100	140	179	

157	MC0_G1	Ophiuroidea	1	140	179	
158	MC0_G1	Ophiuroidea	4	20	179	
159	MC0_G1	Briozoa	5	20	179	
160	MC0_G1	Polychaeta	50	140	179	
161	MC0_G1	Anthozoa	1	20	179	
162	MC0_G1	Bivalvia, Foraminifera	8	20	179	
163	MC0_G1	Holothuroidea	1	20	179	
164	MC0_G1	Pychnogonida	2	20	179	
165	MC0_G2	Polychaeta	50	140	180	
166	MC0_G2	Polychaeta	50	140	180	
167	MC0_G2	Polychaeta	150	140	180	
168	MC0_G2	Polychaeta	100	140	180	
169	MC0_G2	Ophiuroidea	6	140	180	
170	MC0_G2	Amphipoda	1	20	180	
171	MC0_G2	Bivalvia, Foraminifera	25	20	180	
172	MC0_G2	Briozoa	3	20	180	
173	MC0_G2	Ascidiacea	1	20	180	
174	MC0_G2	Pychnogonida	2	20	180	
175	MC0_G3	Polychaeta	100	140	181	
176	MC0_G3	Polychaeta	100	140	181	
177	MC0_G3	Ophiuroidea	3	20	181	
178	MC0_G3	Briozoa	4	20	181	
179	MC0_G3	Amphipoda	1	20	181	
180	MC0_G4	Polychaeta	100	140	182	
181	MC0_G4	Polychaeta	100	140	182	
182	MC0_G4	Polychaeta	100	140	182	
183	MC0_G4	Pychnogonida	1	20	182	
184	MC0_G4	Anthozoa	1	20	182	
185	MC0_G4	Briozoa	10	140	182	and Ascidian attached
186	MC0_G4	Poriphera	1	20	182	
187	MC0_G4	Bivalvia	3	20	182	
188	MC0_G4	Gastropoda	1	20	182	
189	MC0_G4	Holothuroidea	1	140	182	
190	MC0_G4	Ophiuroidea	3	20	182	
191	MC0_G5	Ascidiacea	1	500	183	
192	MC0_G5	Bivalvia, Foraminifera	21	20	183	
193	MC0_G5	Pychnogonida	3	20	183	
194	MC0_G5	Polychaeta	100	140	183	
195	MC0_G5	Polychaeta	100	140	183	
196	MC0_G5	Polychaeta	100	140	183	
197	MC0_G5	Bivalvia	4	20	183	
198	MC0_G5	Briozoa	30	140	183	
199	MC0_G5	Ascidiacea	2	140	183	
200	MC0_G5	Ophiuroidea	6	140	183	

7.4.2 MULTICORE: INTRODUCTION

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As in previous ICEBERGS cruises (i.e. JR17001 and JR18003) the BAS Oktopus 12-core multicorer was deployed in all studied fjords: Marian Cove, Börgen Bay and Sheldon Cove. This instrument enables high quality, undisturbed, samples of bottom water and seabed sediments. Each core sleeve is a transparent tube of 0.5 m in length and 9.4 cm inside diameter. During JR19002 successful deployments collected between 10-30 cm material.

Prior to arrival to the studied locations, sample containers (i.e. petri dishes, plastic bags and falcon tubes) were prepared and labelled (sticky labels proved useful for saving time) for all the different types of samples. Multi-corer samples were collected for the following analytical techniques: organic carbon, inorganic carbon, microbiological characterization, pigments, macrofauna and foraminifera determination, eDNA characterization, oxygen concentration in sediments, respiration in sediments, radium isotopes in pore water and metabolomics (cf. Figure 7-42). Preparation of the containers varied between techniques. Aluminium foil was used to cover the inside of the petri dishes to avoid contamination of certain samples and to provide another extra layer against spilled mud. Nitrile gloves were used in the preparation of these aluminium envelopes. In addition, an information sheet (Figure 7-42) was prepared which contained the sampling protocol (i.e. slicing guide, type of spatula needed, type of samples needed for each specific station, person in charge of specific cores) and a reference list of number of cores needed per station (Table 7-19).

MULTICORER SAMPLING

Order of cores needed per station:

1) 1x Oxygen probe (Felipe) (0,A,B,C,D,E) -> Part. size

2) 1x Incubation (Felipe) (A/0,E)

Metal spatula 3) 1 x Org. carbon (0,A,B,C,D,E)

Plastic spatula 4) 1x Inorg. carbon (0,A,B,C,D,E)

Metal spatula 5) 1x Microbiology (Carmen) (A,B,C,D,E)

6) 1x Pigments + bulk

7-12) 6x Macrofauna (Julian) (0,A,B,C,D,E)

13) 1x Forams (Mark) (A,B,C,D,E)

14-17) 3x eDNA (James) (0)

18-19) 2x (Amber) (A,E)

20-21) 2x (Mehul) (0,E)

Sampling:

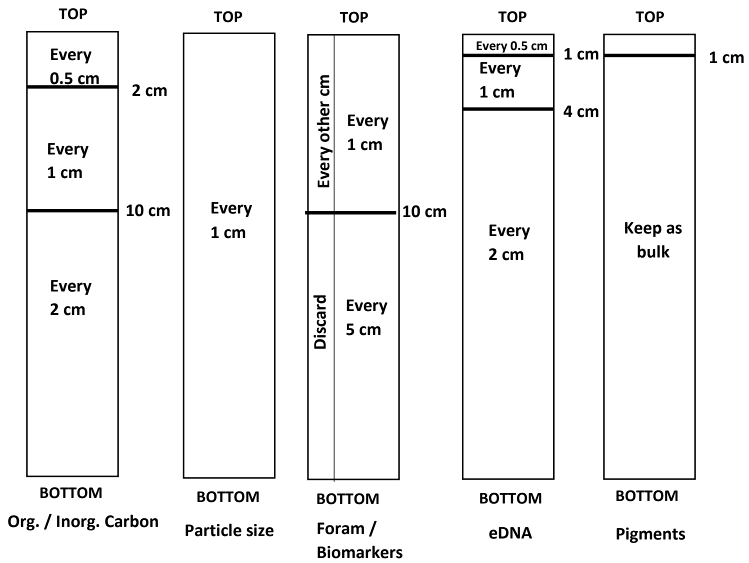

Figure 7-42 Multi-corer information sheet

Table 7-19 Number of cores needed per project on board of JR19002 according to sampling stations

Fjord position	Station	# ICEBERGS cores	# RACETRAX cores	eDNA cores
Outermost	0	11	2	3
↓	A	11	4	
	B	11		
	C	11		
	D	11		
Innermost	E	11	9	

For the macrofauna one core was sliced in 0.5, 0.5, 1 and 1 cm slices, while five cores were separated in a 0.5 cm slice for the epifauna and a 3 cm slice for the infauna. Both slices were sieved through metal sieves with a mesh size of 1 mm and rinsed with seawater to remove all mud. The benthic fauna was then picked out of the sieves and preserved in 99.8% ethanol. The rest of the core was discarded.

Six, five and six stations were sampled (Figure 7-43) at Marian Cove (i.e. MC0, MCA_ALT, MCB_ALT, MCC_ALT, MCD and MCE_ALT), Börgen Bay (i.e. BB0, BBA BBB, BBC and BBD), Sheldon Cove respectively (i.e. SC0, SCA, SCB, SCC, SCD and SCE). BBE station could not be sampled due to the presence of icebergs and ice floes resulting from the collapse of the ice front during the first night of sampling at this location. Even though three multi-corer deployments were attempted, only two usable corers could be retrieved. Core sleeves showed low penetration into the sediment and many corers showed disturbed sediment with no water inside the sleeves. The rest of the stations at Börgen Bay showed deep penetration into the sediment and higher retrieval rates than BBE.

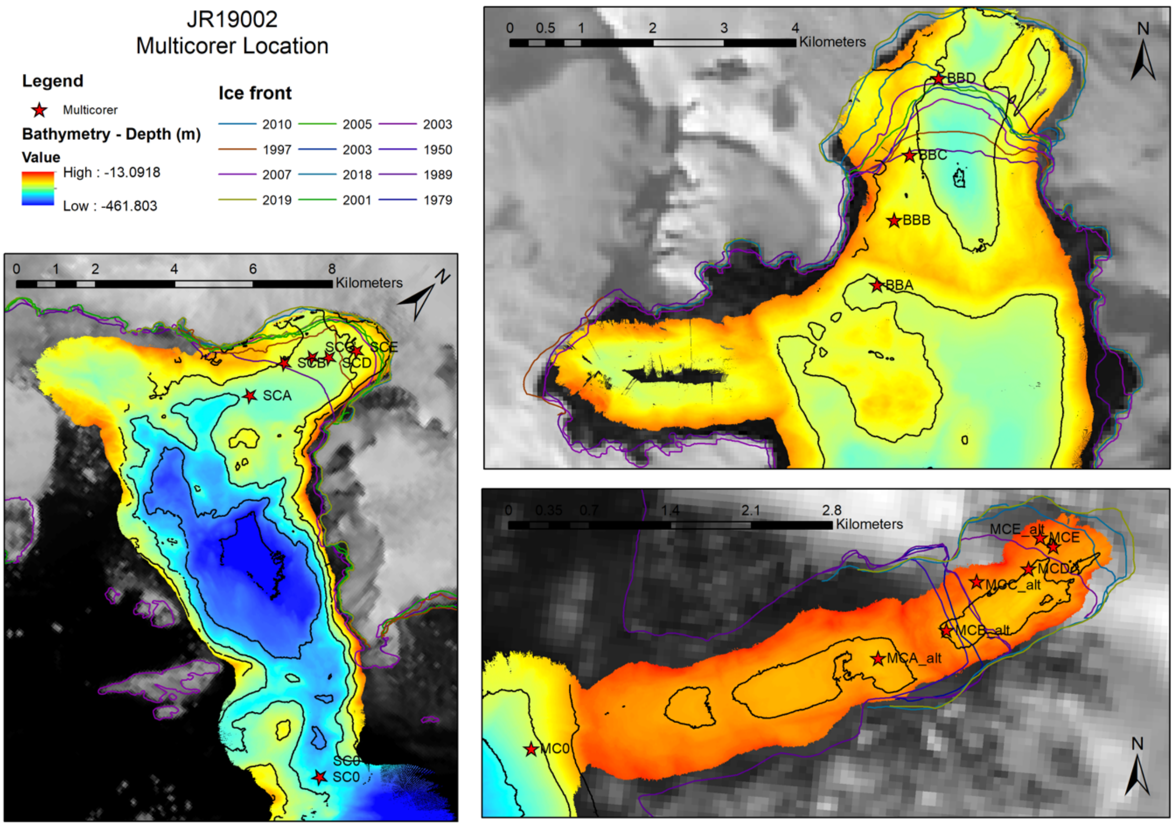

Figure 7-43 Maps showing the multi-corer sampling locations (red stars) for Sheldon Cove (left), Börgen Bay (top right) and Marian Cove (bottom right). Contour lines of the ice fronts for specific years are provided as well as a colour grading for water depth

In Marian Cove, alternative sampling stations were chosen based on TOPAS and multibeam bathymetry data. The sites were selected for low inclination and presence of thick layers of mud. At station MCE, one multi-corer was deployed but only three short cores were retrieved and the decision was made to move directly to MCE_ALT. After this station, some alternative stations were chosen in order to avoid loss of ship time. MCE_ALT station proved challenging as the sediment retrieved in the core sleeves was very liquid and ran out of the core sleeves before recovery to deck.

The success rate of the multi-corer was recorded as number of useable cores per deployment (Table 7-20). Data logging in the cruise event log of successful multi-corers (i.e. usable single sleeves) was deficient at Börgen Bay, where six out of 15 entries have this piece information missing (compared to Sheldon Cove where four out of 18 had missing information). There seems to be no relation between distance to glacier and success rate to recover usable cores. Sediment type, seafloor inclination and presence of medium to large size rocks is likely to have a greater influence in the success of a multi-corer deployment. Marian Cove showed much higher retrieval rates than Sheldon Cove or Börgen Bay (Table 7-20).

*Table 7-20 Success rate of Oktopus multi-corer per station. * Missing information in the log prevented to calculate success rates.*

Station	Success rate (%)	Station	Success rate (%)	Station	Success rate (%)
SCE	58	BBE	0	MCE_ALT	33
SCD	31	BBD	6	MCD	50
SCC	25	BBC	92	MCC_ALT	83
SCB	42	BBB	*	MCB_ALT	96
SCA	39	BBA	*	MCA_ALT	81
SC0	50	BB0	100	MC0	92
TOTAL	41	TOTAL	66	TOTAL	72

To retrieve longer cores and minimize the loss of sediment during extraction of the core from the multi-corer, we firstly inserted a thin plastic spatula between the bottom of core sleeve and lower stopper arm, then the plate was held upward to seal the core from the bottom, the lower stopper arm was then released and a rubber sealing bun was placed under the plastic plate. The plastic spatula was then removed and the rubber bun inserted into the sleeve. Usage of the thin spatula was the key point to achieve a good quality of recovery.

The availability of core extruders during multi-corer sampling proved to be the limiting factor in processing cores. A third core extruder was made in the ship's workshop on board during the transit time between Börgen Bay and Marian Cove (many thanks Rob!!!). This new extruder was made as a copy of the previously available extruders. This third extruder facilitated the processing of samples as they could be processed much more quickly than in previous stations.
For the sieving of the macrofauna samples four sieves with mesh size of 1 mm would be optimal as one person can sieve the slices of one core while another person picks and preserves the fauna from the previous core.

We recommend at least three people per extruder be available, two people to process the macrofauna cores, three people to extract the cores from the multi-corer and one data manager to record information (e.g. number of samples obtained from a single core, event numbers associated with cores). In addition, we recommend that a person is in charge of storing the collected samples (e.g. number of samples that fit in boxes, -20 C *vs* -80 C *vs* +4 C, bagging). Working shifts of nine hours are possible; however, we recommend splitting the working shifts after five hours of working as people involved in longer shifts can get very tired.

7.4.3 MULTICORE: OXYGEN PROFILES

Dr Felipe Sales de Freitas, University of Bristol, UK

A Pyro Science FireSting O2-Mini sensor was used for oxygen determination. The sensor was connected to a laptop (Windows 10) having the *Oxygen Logger* software installed. Prior to analyses, the probe was calibrated with the *one-point calibration – air saturated water* mode, using a bottle containing Milli-Q water saturated with air (vigorously shaken before calibration). The calibration was corrected by the room temperature and atmospheric pressure. After calibration, the sensor was kept in Milli-Q water.

At each sampling station, one or two intact cores (94 mm i.d.), with no disturbance in the overlying water and surface sediments, were selected for oxygen measurements. In total, 24 oxygen depth profiles were measured across the three areas (Table 7-21). Given the non-destructive nature of such assessment, the same core was used for further sampling. Shortly after retrieval, the selected core was transferred to a room at constant temperature (4 °C) and attached to a core rack for oxygen probing. The probe was attached to a mobile plastic tube, which was connected to a plastic cap sitting on top of the core (Figure 7-44). As such, an oxygen profiling at the bottom water (~ 10 cm) and surface sediment (~ 3 cmbsf) was possible. The sensor was set to *single-point measurement*. At the bottom water, five to ten consecutive points were measured at every cm in the bottom water, whereas in the sediments 10 – 20 consecutive points were determined at every 0.5 cm, from the sediment-water interface to approx. 3 cmbfs. Some of the multicorer tubes displayed many scratches which presented difficulty in correctly positioning the probe at the sediment-water interface. Additionally, the presence of dropstones in the sediment caused deterioration of the probe during the course of analyses. Following the measurements, the sensor was rinsed and placed in Milli-Q water. The data were exported into a text file and processed in an Excel spreadsheet.

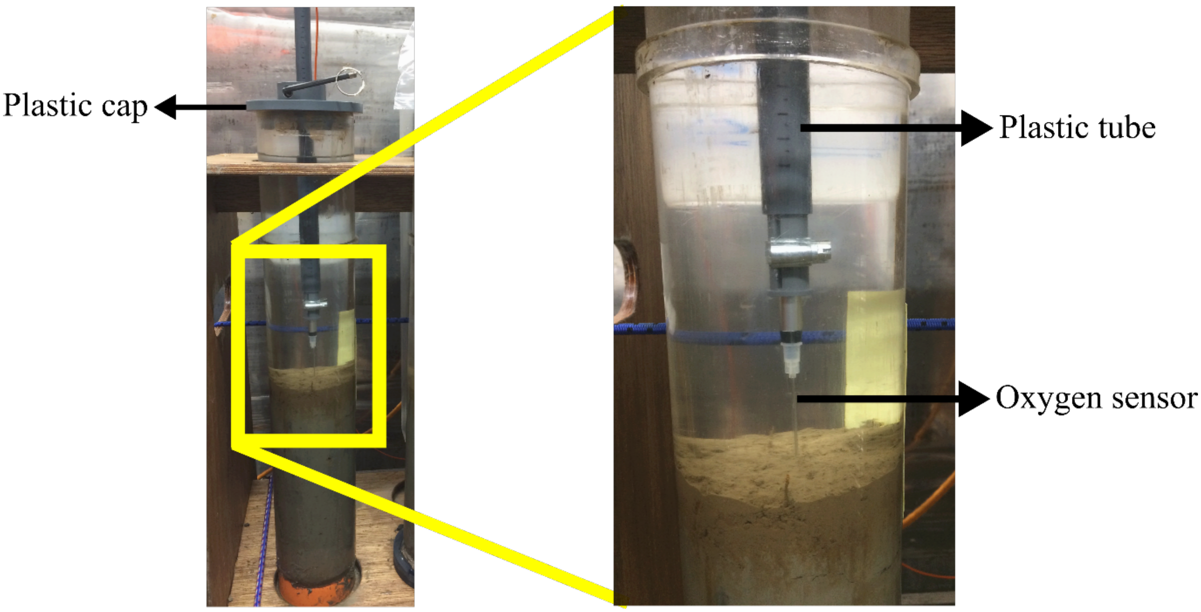

Figure 7-44 Oxygen measurements set-up. Entire core and sensor plastic support on the left-hand side and oxygen sensor at the sediment-water interface on the right-hand side. Photo: Felipe S. Freitas

Table 7-21 List of oxygen depth-profiles measured in each fjord during JR19002 cruise

Area	Station	Number of O_2 depth-profiles
Sheldon Cove	SC-0	1
	SC-A	2
	SC-B	1
	SC-C	1
	SC-D	1
	SC-E	2
Börgen Bay	BB-0	2
	BB-A	2
	BB-B	1
	BB-C	1
	BB-D	Not Sampled
	BB-E	Not Sampled
Marian Cove	MC-0	1
	MC-A	2
	MC-B	1
	MC-C	2
	MC-D	1
	MC-E	2
	Total depth-profiles	***24***

Overall, oxygen concentrations of bottom waters (10 to 1 cm) were consistent with those measured with the deepest CTD casts taken in each site. Figure 7-45 shows the oxygen depth profiles taken at the outermost station of each fjord. At Sheldon Cove, bottom water oxygen concentrations ranged between 130 and 160 µmol L^{-1}. At Börgen Bay values were between 225 and 260 µmol L^{-1}. Marian Cove bottom waters displayed the highest oxygen concentrations, ranging from 290 to 340 µmol L^{-1}.

In all sites, a marked decrease in oxygen concentrations was observed at the sediment-water interface (Figure 7-45). In most stations, a further decrease was observed from 0.5 to 1.0 cmbsf. Similar to bottom waters, Sheldon Cove sediments displayed the lowest oxygen concentrations, whereas Marian Cove exhibited the highest sediment oxygen concentrations. Some sites at Sheldon Cove displayed sub-oxic conditions (O_2 < 20 µmol L^{-1}). None of the sites exhibited any significant drop in oxygen concentrations from 1 cmbsf to 3 cmbsf (deepest measurements taken). In some cases, a minor increase in oxygen with increase in depth were recorded, which are likely caused by bioirrigation burrows and tubes.

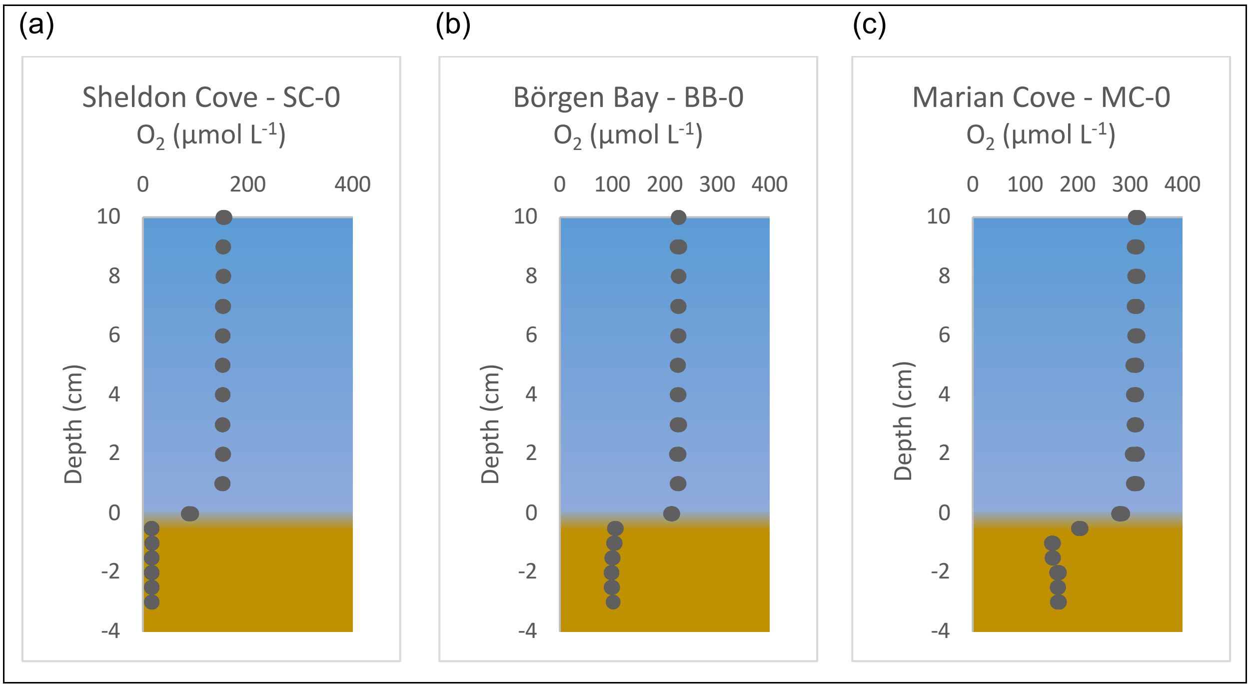

Figure 7-45 Oxygen concentration depth-profiles at (a) Sheldon Cove, (b) Börgen Bay, and (c) Marian Cove.

7.4.4 MULTICORE: CORE INCUBATIONS

Dr Felipe Sales de Freitas, University of Bristol, UK

An intact sediment core (94 mm i.d.) containing undisturbed surface sediments and overlying water from the outermost (St A) and innermost (St-E) station of each fjord was selected for core incubation experiments. Incubation experiments were done at SC-A, SC-E, BB-A, MC-A, and MC-E. Core incubation was not done at BB-E due to difficulties to access this location. Shortly after retrieval the core had the rubber bung replaced by a plastic base, and then it was transported to a room with constant temperature (4 °C), attached to a core rack and kept in the dark for the course of the incubation. A plastic cap fitted with a magnetic stirrer bar for gently homogenising the overlying water, and a plastic tube for sampling collection was fitted on the top of the core. The cap was then lowered until it reached the top of the overlying water. A magnetic motor was fitted on the top of the cap to power the stirrer bar. The water height was measure with a measuring tape to determine the water volume at the beginning of the incubation. Figure 7-46 shows the incubation set up.

At each experiment, the incubation ran for 24 hours. A bottom water sample was taken at the beginning of the incubation (T – 0h), and then at every three hours (T – 3h; T – 6h; T – 9h; T – 12h; T – 15h; T – 18h; T – 21h; and T – 24h). In total 9 water samples per experiment were taken. A 60 mL plastic syringe attached to the plastic tubing was used to withdraw samples. After taken each sample, the plastic cap was further lowered down to meet the new water level. Each sample was approx. 50 mL, which were filtered with an Acrodisc PF syringe filter (0.8/0.2 µm Supor Membrane) and split into two aliquots: 25 mL for macronutrients and 25 mL for δ^{30}Si. Nutrient samples were frozen at -20 °C for future analysis at the Plymouth Marine Institute. The δ^{30}Si samples were kept at 4 °C for future analysis at the University of Bristol

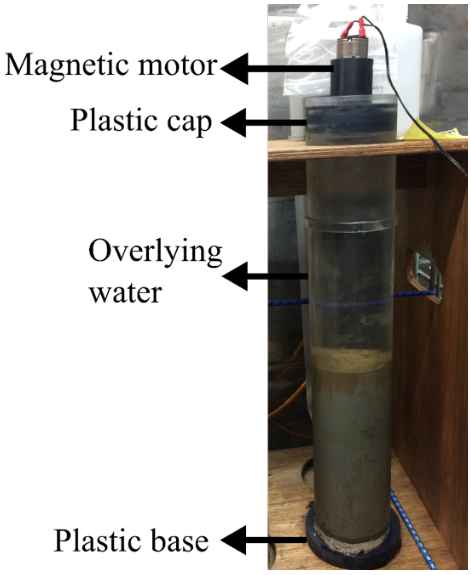

Figure 7-46 Sediment core incubation set up. Photo: Felipe S. Freitas

7.4.5 MULTICORE: FORAMINIFERA AND SEA ICE BIOMARKERS

Professor Mark Furze, UNIS, Svalbard, Norway; Dr Anna Pieńkowski, UNIS, Svalbard, Norway

Background and Rationale: The seabed, with its sediments beneath, constitutes one of the most valuable archives of environmental change available for the study of Earth's climate (Ruddiman 2014). Whereas the physical character of marine sediments records shifts from glaciated to ice-free environments (Pudsey and Evans 2001), other biological and chemical material incorporated and preserved in sediments can provide indirect ('proxy') information regarding ocean parameters (temperature, salinity, sea-ice cover), as well as ecosystem composition and biodiversity (Pieńkowski et al. 2013; Belt 2018). Determining the timing of glacial to deglacial transitions and the precise environmental context are crucial for reconstructing ice sheets (Furze et al. 2017; Streuff et al. 2017) and, consequently, constraining numerical ice sheet models that elucidate past and future ice sheet behaviour (Nowicki and Seroussi 2018). Palaeoenvironmental data derived from climate proxies (e.g., microfossils, biomarkers) are furthermore critical for identifying mechanisms driving deglaciation (Jennings et al. 2017). Although deglacial sediment sequences are potentially challenging to interpret given the rapid temporal and spatial changes (Korsun et al. 1995; Straneo et al. 2011), the major obstacle in our current understanding of the sedimentary signature of such systems is the extreme rarity of calibration/process studies from modern environments on which to base interpretations of past climate palaeoclimatic interpretations (Limoges et al. 2018).

This project seeks to overcome this knowledge gap by creating a novel and accurate framework in which to interpret glacial to deglacial marine sequences by fingerprinting the biological and biogeochemical signature of modern marine-based ice retreat recorded in seabed sediments. It constitutes an unrivalled opportunity to sample a series of actively retreating marine ice margins around Antarctica to identify the biogenic proxies in sediments most useful for reconstructing key environmental gradients in deglaciating environments. This will be achieved by identifying the biogenic proxies most useful for determining key environmental gradients in deglaciating marine environments, to successfully reconstruct 1. ocean temperature, 2. sea ice cover, and 3. distance from the ice front.

This project complements ICEBERGS, focussing on remains of microscopic planktonic or benthic organisms (primarily protists) that are preserved in the sedimentary record as microfossils or chemical fossils (biomarkers) and which are used for reconstructing past environmental conditions.

Sampling Protocol: Ideally, a core with >30cm sediment recovery and a level sediment-water interface was selected for combined foraminiferal and biomarker sampling. This was not always the case due to recovery of short core samples. A sampling strategy was developed that differed from previous ICEBERGS cruises due to the limited availability of suitable containers provided for the foram/biomarker activities during JR19002. 1cm thick sample slices were taken at every 1cm interval from 0-1cm to 9-10cm and then 1cm slices at 5cm intervals at 14-15, 19-20, 24-25, and 29-30cm. Odd-numbered samples (e.g. 0-1, 2-3cm etc) in the top 10cm were split, ~20cc for foraminiferal analysis and ~40cc for sea ice biomarkers. Even-numbered samples and those below 10cm were only sampled for biomarkers.

Foraminiferal samples were placed in plastic centrifuge tubes (when available) containing 20cc of pink Rose Bengal dye dissolved in ethanol or in larger plastic tubs (25cc Rose Bengal – ethanol), shaken, sealed with high-flexibility electrical tape, and stowed at +4°C – ultimately to be placed in UN box for hazardous transport. Biomarker samples were placed in plastic Ziplock bags and stowed at -20°C.

Results / Sample Recovery: Foraminiferal and biomarker samples were collected from stations A through to E at all three fjords investigated. Additional stations 0 (zero) were not sampled due to the limited number of containers available. While all five stations in Sheldon and Marian coves were sampled, stations BBD and BBE were not sampled due to multicorer performance issues and excessive floating ice debris. Sheldon Cove saw the recovery of 25 foraminiferal samples and 64 biomarker samples. Börgen Bay saw recovery of 15 foraminiferal and 32 biomarker samples. Marian Cove saw 25 foram and 63 biomarker samples. A total of 65 foraminiferal and 159 biomarker samples were taken. Full details of each sample are given in Tables Table 7-22 and Table 7-23.

Post Cruise Analyses: Post cruise investigation will involve the analyses of collected sediments (multicores) for a variety of proxy groups, using standard collection and preparation techniques. Traditional proxy approaches include: micropalaeontology (planktonic & benthic foraminifera, stained with Rose Bengal dye for determining living vs. dead fauna; dinoflagellate cysts = dinocysts & other NPPs = non-pollen palynomorphs), and foraminiferal stable isotopes ($\delta^{18}O$, $\delta^{13}C$). Novel proxy approaches are: stable isotopes of siliceous algae (diatom $\delta^{18}O$, $\delta^{13}C$, $\delta^{15}N$) and organic biomarkers (sea-ice algae: $IPSO_{25}$, open-water algae: sterols). Environmental datasets against which to calibrate proxy data will be derived from instrumental series and cruise data (e.g., from CTD); these data will be aided by standard sedimentary analyses for biological productivity (biogenic silica, total organic and inorganic carbon) and grain size. Underlying proxy-environment relationships will be calibrated by multivariate statistics (Šmilauer and Leps 2014) to identify proxies that successfully and faithfully quantitatively reconstruct: 1. ocean temperature, 2. sea ice, and 3. distance from ice front.

Recommendations: Sampling intervals had to be reduced due to the limited number of containers supplied. The assumption that sufficient extra containers would be available in the vessel proved to be incorrect. It is strongly recommended that when planning future sampling, a clear sampling strategy be developed prior to deployment and communicated with the individuals performing the sampling and that sufficient containers be provided ahead of joining the ship.

Belt 2018 *Organic Geochemistry* 125, 277–298
Furze et al. 2017 *Boreas* doi: 10.1111/bor.12265
Jennings et al. 2017 *Earth and Planetary Science Letters* 472, 15, 1-13
Korsun et al. 1995 *Polar Research* 14, 15-32
Limoges et al. 2018 *Journal of Geophysical Research: Biogeosciences* doi: 10.1002/2017JG002840
Nowicki and Seroussi 2018 *Oceanography* 31, 109-117
Pieńkowski et al. 2013 *Antarctic Science* 25, 565–574
Pudsey and Evans 2001 *Geology* 29, 787–790.
Ruddiman 2014 *Earth's Climate: Past and Future* (3rd Edition). MacMillan
Šmilauer and Leps 2014 *Multivariate analysis of ecological data using Canoco 5* (2nd edition). Cambridge University Press, Cambridge
Streuff et al. 2017 *Quaternary Science Reviews* 169, 206-230.
Straneo et al. 2011 *Nature Geoscience* 4, 322–327

Table 7-22 Foraminiferal samples from multicore activities, JR19002

Sample No.	Location	Site	Event No.	Date	Core depth (cm)	Water Depth (m)	Vol. ethanol rose bengal (cc)	Vol. sediment (cc)	Stow Temp (°C)	Aprox. Weight (g)
2019_SCA_F1	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	0-1	278	21	~40	+4	45
2019_SCA_F3	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	2-3	278	20	~40	+4	45
2019_SCA_F5	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	4-5	278	20	~40	+4	45
2019_SCA_F7	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	6-7	278	20	~40	+4	45
2019_SCA_F9	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	8-9	278	20	~40	+4	45
2019_SCB_F1	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	0-1	240	21	~40	+4	45
2019_SCB_F3	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	2-3	240	20	~40	+4	45
2019_SCB_F5	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	4-5	240	20	~40	+4	45
2019_SCB_F7	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	6-7	240	20	~40	+4	45
2019_SCB_F9	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	8-9	240	20	~40	+4	45
2019_SCC_F1	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	0-1	205	20	~40	+4	45
2019_SCC_F3	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	2-3	205	20	~40	+4	45
2019_SCC_F5	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	4-5	205	20	~40	+4	45
2019_SCC_F7	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	6-7	205	20	~40	+4	45
2019_SCC_F9	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	8-9	205	20	~40	+4	45
2019_SCD_F1	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	0-1	244	21	~40	+4	45
2019_SCD_F3	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	2-3	244	21	~40	+4	45
2019_SCD_F5	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	4-5	244	20	~40	+4	45
2019_SCD_F7	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	6-7	244	21	~40	+4	45
2019_SCD_F9	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	8-9	244	20	~40	+4	45
2019_SCE_F1	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	0-1	199	21	~40	+4	45
2019_SCE_F3	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	2-3	199	20	~40	+4	45
2019_SCE_F5	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	4-5	199	21	~40	+4	45
2019_SCE_F7	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	6-7	199	20	~40	+4	45
2019_SCE_F9	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	8-9	199	21	~40	+4	45
2019_BBA_F1	Börgen Bay, Anvers Is.	BBA	133	22/01/20	0-1	184	20	~40	+4	45
2019_BBA_F3	Börgen Bay, Anvers Is.	BBA	133	22/01/20	2-3	184	20	~40	+4	45
2019_BBA_F5	Börgen Bay, Anvers Is.	BBA	133	22/01/20	4-5	184	20	~40	+4	45
2019_BBA_F7	Börgen Bay, Anvers Is.	BBA	133	22/01/20	6-7	184	20	~40	+4	45
2019_BBA_F9	Börgen Bay, Anvers Is.	BBA	133	22/01/20	8-9	184	20	~40	+4	45
2019_BBB_F1	Börgen Bay, Anvers Is.	BBB	137	22/01/20	0-1	149	20	~40	+4	45
2019_BBB_F3	Börgen Bay, Anvers Is.	BBB	137	22/01/20	2-3	149	20	~40	+4	45
2019_BBB_F5	Börgen Bay, Anvers Is.	BBB	137	22/01/20	4-5	149	20	~40	+4	45
2019_BBB_F7	Börgen Bay, Anvers Is.	BBB	137	22/01/20	6-7	149	20	~40	+4	45
2019_BBB_F9	Börgen Bay, Anvers Is.	BBB	137	22/01/20	8-9	149	20	~40	+4	45
2019_BBC_F1	Börgen Bay, Anvers Is.	BBC	141	23/01/20	0-1	191	20	~40	+4	45
2019_BBC_F3	Börgen Bay, Anvers Is.	BBC	141	23/01/20	2-3	191	20	~40	+4	45
2019_BBC_F5	Börgen Bay, Anvers Is.	BBC	141	23/01/20	4-5	191	20	~40	+4	45
2019_BBC_F7	Börgen Bay, Anvers Is.	BBC	141	23/01/20	6-7	191	20	~40	+4	45
2019_BBC_F9	Börgen Bay, Anvers Is.	BBC	141	23/01/20	8-9	191	20	~40	+4	45
2019_MCA_F1	Marian Cove, King George Is.	MCAalt	211	27/01/20	0-1	119	25	~40	+4	45
2019_MCA_F3	Marian Cove, King George Is.	MCAalt	211	27/01/20	2-3	119	25	~40	+4	45
2019_MCA_F5	Marian Cove, King George Is.	MCAalt	211	27/01/20	4-5	119	25	~40	+4	45
2019_MCA_F7	Marian Cove, King George Is.	MCAalt	211	27/01/20	6-7	119	25	~40	+4	45
2019_MCA_F9	Marian Cove, King George Is.	MCAalt	211	27/01/20	8-9	119	25	~40	+4	45
2019_MCB_F1	Marian Cove, King George Is.	MCBalt	209	27/01/20	0-1	103	25	~40	+4	45
2019_MCB_F3	Marian Cove, King George Is.	MCBalt	209	27/01/20	2-3	103	25	~40	+4	45
2019_MCB_F5	Marian Cove, King George Is.	MCBalt	209	27/01/20	4-5	103	25	~40	+4	45
2019_MCB_F7	Marian Cove, King George Is.	MCBalt	209	27/01/20	6-7	103	25	~40	+4	45
2019_MCB_F9	Marian Cove, King George Is.	MCBalt	209	27/01/20	8-9	103	25	~40	+4	45
2019_MCC_F1	Marian Cove, King George Is.	MCCalt	202	26/01/20	0-1	82	25	~40	+4	45
2019_MCC_F3	Marian Cove, King George Is.	MCCalt	202	26/01/20	2-3	82	25	~40	+4	45
2019_MCC_F5	Marian Cove, King George Is.	MCCalt	202	26/01/20	4-5	82	25	~40	+4	45
2019_MCC_F7	Marian Cove, King George Is.	MCCalt	202	26/01/20	6-7	82	25	~40	+4	45
2019_MCC_F9	Marian Cove, King George Is.	MCCalt	202	26/01/20	8-9	82	25	~40	+4	45
2019_MCD_F1	Marian Cove, King George Is.	MCD	201	26/01/20	0-1	101	25	~40	+4	45
2019_MCD_F3	Marian Cove, King George Is.	MCD	201	26/01/20	2-3	101	25	~40	+4	45
2019_MCD_F5	Marian Cove, King George Is.	MCD	201	26/01/20	4-5	101	25	~40	+4	45
2019_MCD_F7	Marian Cove, King George Is.	MCD	201	26/01/20	6-7	101	25	~40	+4	45
2019_MCD_F9	Marian Cove, King George Is.	MCD	201	26/01/20	8-9	101	25	~40	+4	45
2019_MCE_F1	Marian Cove, King George Is.	MCEalt	197	26/01/20	0-1	105	25	~40	+4	45
2019_MCE_F3	Marian Cove, King George Is.	MCEalt	197	26/01/20	2-3	105	25	~40	+4	45
2019_MCE_F5	Marian Cove, King George Is.	MCEalt	197	26/01/20	4-5	105	25	~40	+4	45
2019_MCE_F7	Marian Cove, King George Is.	MCEalt	197	26/01/20	6-7	105	25	~40	+4	45
2019_MCE_F9	Marian Cove, King George Is.	MCEalt	197	26/01/20	8-9	105	25	~40	+4	45

Table 7-23 Biomarker samples from multicore activities, JR19002

Sample No.	Location	Site	Event No.	Date	Core depth (cm)	Water Depth (m)	Vol. sediment (cc)	Stowage Temp (°C)	Aprox. Weight (g)
2019_SCA_F1	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	0-1	278	~40	-20	55
2019_SCA_F2	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	1-2	278	~40	-20	55
2019_SCA_F3	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	2-3	278	~40	-20	55
2019_SCA_F4	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	3-4	278	~40	-20	55
2019_SCA_F5	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	4-5	278	~40	-20	55
2019_SCA_F6	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	5-6	278	~40	-20	55
2019_SCA_F7	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	6-7	278	~40	-20	55
2019_SCA_F8	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	7-8	278	~40	-20	55
2019_SCA_F9	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	8-9	278	~40	-20	55
2019_SCA_F10	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	9-10	278	~40	-20	55
2019_SCA_F15	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	14-15	278	~40	-20	55
2019_SCA_F20	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	19-20	278	~40	-20	55
2019_SCA_F25	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	24-25	278	~40	-20	55
2019_SCA_F30	Sheldon Cove, Adelaide Is.	SCA	46	15/01/20	29-30	278	~40	-20	55
2019_SCB_F1	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	0-1	240	~40	-20	55
2019_SCB_F2	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	1-2	240	~40	-20	55
2019_SCB_F3	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	2-3	240	~40	-20	55
2019_SCB_F4	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	3-4	240	~40	-20	55
2019_SCB_F5	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	4-5	240	~40	-20	55
2019_SCB_F6	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	5-6	240	~40	-20	55
2019_SCB_F7	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	6-7	240	~40	-20	55
2019_SCB_F8	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	7-8	240	~40	-20	55
2019_SCB_F9	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	8-9	240	~40	-20	55
2019_SCB_F10	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	9-10	240	~40	-20	55
2019_SCB_F15	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	14-15	240	~40	-20	55
2019_SCB_F20	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	19-20	240	~40	-20	55
2019_SCB_F25	Sheldon Cove, Adelaide Is.	SCB	41	15/01/20	24-25	240	~40	-20	55
2019_SCC_F1	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	0-1	205	~40	-20	55
2019_SCC_F2	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	1-2	205	~40	-20	55
2019_SCC_F3	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	2-3	205	~40	-20	55
2019_SCC_F4	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	3-4	205	~40	-20	55
2019_SCC_F5	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	4-5	205	~40	-20	55
2019_SCC_F6	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	5-6	205	~40	-20	55
2019_SCC_F7	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	6-7	205	~40	-20	55
2019_SCC_F8	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	7-8	205	~40	-20	55
2019_SCC_F9	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	8-9	205	~40	-20	55
2019_SCC_F10	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	9-10	205	~40	-20	55
2019_SCC_F15	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	14-15	205	~40	-20	55
2019_SCC_F20	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	19-20	205	~40	-20	55
2019_SCC_F25	Sheldon Cove, Adelaide Is.	SCC	64	17/01/20	24-25	205	~40	-20	55
2019_SCD_F1	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	0-1	244	~40	-20	55
2019_SCD_F2	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	1-2	244	~40	-20	55
2019_SCD_F3	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	2-3	244	~40	-20	55
2019_SCD_F4	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	3-4	244	~40	-20	55
2019_SCD_F5	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	4-5	244	~40	-20	55
2019_SCD_F7	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	6-7	244	~40	-20	55
2019_SCD_F8	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	7-8	244	~40	-20	55
2019_SCD_F9	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	8-9	244	~40	-20	55
2019_SCD_F10	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	9-10	244	~40	-20	55
2019_SCD_F15	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	14-15	244	~40	-20	55
2019_SCD_F20	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	19-20	244	~40	-20	55
2019_SCD_F25	Sheldon Cove, Adelaide Is.	SCD	66	17/01/20	24-25	244	~40	-20	55
2019_SCE_F1	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	0-1	199	~40	-20	55
2019_SCE_F2	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	1-2	199	~40	-20	55
2019_SCE_F3	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	2-3	199	~40	-20	55
2019_SCE_F4	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	3-4	199	~40	-20	55
2019_SCE_F5	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	4-5	199	~40	-20	55
2019_SCE_F6	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	5-6	199	~40	-20	55
2019_SCE_F7	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	6-7	199	~40	-20	55
2019_SCE_F8	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	7-8	199	~40	-20	55
2019_SCE_F9	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	8-9	199	~40	-20	55
2019_SCE_F10	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	9-10	199	~40	-20	55
2019_SCE_F15	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	14-15	199	~40	-20	55
2019_SCE_F20	Sheldon Cove, Adelaide Is.	SCE	70	17/01/20	19-20	199	~40	-20	55
2019_BBA_B1	Börgen Bay, Anvers Is.	BBA	133	22/01/20	0-1	184	~40	-20	55
2019_BBA_B2	Börgen Bay, Anvers Is.	BBA	133	22/01/20	1-2	184	~40	-20	55
2019_BBA_B3	Börgen Bay, Anvers Is.	BBA	133	22/01/20	2-3	184	~40	-20	55

2019_BBA_B4	Börgen Bay, Anvers Is.	BBA	133	22/01/20	3-4	184	~40	-20	55
2019_BBA_B5	Börgen Bay, Anvers Is.	BBA	133	22/01/20	4-5	184	~40	-20	55
2019_BBA_B6	Börgen Bay, Anvers Is.	BBA	133	22/01/20	5-6	184	~40	-20	55
2019_BBA_B7	Börgen Bay, Anvers Is.	BBA	133	22/01/20	6-7	184	~40	-20	55
2019_BBA_B8	Börgen Bay, Anvers Is.	BBA	133	22/01/20	7-8	184	~40	-20	55
2019_BBA_B9	Börgen Bay, Anvers Is.	BBA	133	22/01/20	8-9	184	~40	-20	55
2019_BBA_B10	Börgen Bay, Anvers Is.	BBA	133	22/01/20	9-10	184	~40	-20	55
2019_BBA_B15	Börgen Bay, Anvers Is.	BBA	133	22/01/20	14-15	184	~40	-20	55
2019_BBA_B20	Börgen Bay, Anvers Is.	BBA	133	22/01/20	19-20	184	~40	-20	55
2019_BBB_B1	Börgen Bay, Anvers Is.	BBB	137	22/01/20	0-1	149	~40	-20	55
2019_BBB_B2	Börgen Bay, Anvers Is.	BBB	137	22/01/20	1-2	149	~40	-20	55
2019_BBB_B3	Börgen Bay, Anvers Is.	BBB	137	22/01/20	2-3	149	~40	-20	55
2019_BBB_B4	Börgen Bay, Anvers Is.	BBB	137	22/01/20	3-4	149	~40	-20	55
2019_BBB_B5	Börgen Bay, Anvers Is.	BBB	137	22/01/20	4-5	149	~40	-20	55
2019_BBB_B6	Börgen Bay, Anvers Is.	BBB	137	22/01/20	5-6	149	~40	-20	55
2019_BBB_B7	Börgen Bay, Anvers Is.	BBB	137	22/01/20	6-7	149	~40	-20	55
2019_BBB_B8	Börgen Bay, Anvers Is.	BBB	137	22/01/20	7-8	149	~40	-20	55
2019_BBB_B9	Börgen Bay, Anvers Is.	BBB	137	22/01/20	8-9	149	~40	-20	55
2019_BBB_B10	Börgen Bay, Anvers Is.	BBB	137	22/01/20	9-10	149	~40	-20	55
2019_BBC_B1	Börgen Bay, Anvers Is.	BBC	141	23/01/20	0-1	191	~40	-20	55
2019_BBC_B2	Börgen Bay, Anvers Is.	BBC	141	23/01/20	1-2	191	~40	-20	55
2019_BBC_B3	Börgen Bay, Anvers Is.	BBC	141	23/01/20	2-3	191	~40	-20	55
2019_BBC_B4	Börgen Bay, Anvers Is.	BBC	141	23/01/20	3-4	191	~40	-20	55
2019_BBC_B5	Börgen Bay, Anvers Is.	BBC	141	23/01/20	4-5	191	~40	-20	55
2019_BBC_B6	Börgen Bay, Anvers Is.	BBC	141	23/01/20	5-6	191	~40	-20	55
2019_BBC_B7	Börgen Bay, Anvers Is.	BBC	141	23/01/20	6-7	191	~40	-20	55
2019_BBC_B8	Börgen Bay, Anvers Is.	BBC	141	23/01/20	7-8	191	~40	-20	55
2019_BBC_B9	Börgen Bay, Anvers Is.	BBC	141	23/01/20	8-9	191	~40	-20	55
2019_BBC_B10	Börgen Bay, Anvers Is.	BBC	141	23/01/20	9-10	191	~40	-20	55
2019_MCA_B1	Marian Cove, King George Is.	MCAalt	211	27/01/20	0-1	119	~40	-20	55
2019_MCA_B2	Marian Cove, King George Is.	MCAalt	211	27/01/20	1-2	119	~40	-20	55
2019_MCA_B3	Marian Cove, King George Is.	MCAalt	211	27/01/20	2-3	119	~40	-20	55
2019_MCA_B4	Marian Cove, King George Is.	MCAalt	211	27/01/20	3-4	119	~40	-20	55
2019_MCA_B5	Marian Cove, King George Is.	MCAalt	211	27/01/20	4-5	119	~40	-20	55
2019_MCA_B6	Marian Cove, King George Is.	MCAalt	211	27/01/20	5-6	119	~40	-20	55
2019_MCA_B7	Marian Cove, King George Is.	MCAalt	211	27/01/20	6-7	119	~40	-20	55
2019_MCA_B8	Marian Cove, King George Is.	MCAalt	211	27/01/20	7-8	119	~40	-20	55
2019_MCA_B9	Marian Cove, King George Is.	MCAalt	211	27/01/20	8-9	119	~40	-20	55
2019_MCA_B10	Marian Cove, King George Is.	MCAalt	211	27/01/20	9-10	119	~40	-20	55
2019_MCA_B15	Marian Cove, King George Is.	MCAalt	211	27/01/20	14-15	119	~40	-20	55
2019_MCA_B20	Marian Cove, King George Is.	MCAalt	211	27/01/20	19-20	119	~40	-20	55
2019_MCA_B25	Marian Cove, King George Is.	MCAalt	211	27/01/20	24-25	119	~40	-20	55
2019_MCA_B30	Marian Cove, King George Is.	MCAalt	211	27/01/20	29-30	119	~40	-20	55
2019_MCB_B1	Marian Cove, King George Is.	MCBalt	209	27/01/20	0-1	103	~40	-20	55
2019_MCB_B2	Marian Cove, King George Is.	MCBalt	209	27/01/20	1-2	103	~40	-20	55
2019_MCB_B3	Marian Cove, King George Is.	MCBalt	209	27/01/20	2-3	103	~40	-20	55
2019_MCB_B4	Marian Cove, King George Is.	MCBalt	209	27/01/20	3-4	103	~40	-20	55
2019_MCB_B5	Marian Cove, King George Is.	MCBalt	209	27/01/20	4-5	103	~40	-20	55
2019_MCB_B6	Marian Cove, King George Is.	MCBalt	209	27/01/20	5-6	103	~40	-20	55
2019_MCB_B7	Marian Cove, King George Is.	MCBalt	209	27/01/20	6-7	103	~40	-20	55
2019_MCB_B8	Marian Cove, King George Is.	MCBalt	209	27/01/20	7-8	103	~40	-20	55
2019_MCB_B9	Marian Cove, King George Is.	MCBalt	209	27/01/20	8-9	103	~40	-20	55
2019_MCB_B10	Marian Cove, King George Is.	MCBalt	209	27/01/20	9-10	103	~40	-20	55
2019_MCB_B15	Marian Cove, King George Is.	MCBalt	209	27/01/20	14-15	103	~40	-20	55
2019_MCB_B20	Marian Cove, King George Is.	MCBalt	209	27/01/20	19-20	103	~40	-20	55
2019_MCB_B25	Marian Cove, King George Is.	MCBalt	209	27/01/20	24-25	103	~40	-20	55
2019_MCC_B1	Marian Cove, King George Is.	MCCalt	202	26/01/20	0-1	82	~40	-20	55
2019_MCC_B2	Marian Cove, King George Is.	MCCalt	202	26/01/20	1-2	82	~40	-20	55
2019_MCC_B3	Marian Cove, King George Is.	MCCalt	202	26/01/20	2-3	82	~40	-20	55
2019_MCC_B4	Marian Cove, King George Is.	MCCalt	202	26/01/20	3-4	82	~40	-20	55
2019_MCC_B5	Marian Cove, King George Is.	MCCalt	202	26/01/20	4-5	82	~40	-20	55
2019_MCC_B6	Marian Cove, King George Is.	MCCalt	202	26/01/20	5-6	82	~40	-20	55
2019_MCC_B7	Marian Cove, King George Is.	MCCalt	202	26/01/20	6-7	82	~40	-20	55
2019_MCC_B8	Marian Cove, King George Is.	MCCalt	202	26/01/20	7-8	82	~40	-20	55
2019_MCC_B9	Marian Cove, King George Is.	MCCalt	202	26/01/20	8-9	82	~40	-20	55
2019_MCC_B10	Marian Cove, King George Is.	MCCalt	202	26/01/20	9-10	82	~40	-20	55
2019_MCC_B15	Marian Cove, King George Is.	MCCalt	202	26/01/20	14-15	82	~40	-20	55
2019_MCC_B20	Marian Cove, King George Is.	MCCalt	202	26/01/20	19-20	82	~40	-20	55
2019_MCD_B1	Marian Cove, King George Is.	MCD	201	26/01/20	0-1	101	~40	-20	55
2019_MCD_B2	Marian Cove, King George Is.	MCD	201	26/01/20	1-2	101	~40	-20	55
2019_MCD_B3	Marian Cove, King George Is.	MCD	201	26/01/20	2-3	101	~40	-20	55
2019_MCD_B4	Marian Cove, King George Is.	MCD	201	26/01/20	3-4	101	~40	-20	55
2019_MCD_B5	Marian Cove, King George Is.	MCD	201	26/01/20	4-5	101	~40	-20	55
2019_MCD_B6	Marian Cove, King George Is.	MCD	201	26/01/20	5-6	101	~40	-20	55

2019_MCD_B7	Marian Cove, King George Is.	MCD	201	26/01/20	6-7	101	~40	-20	55
2019_MCD_B8	Marian Cove, King George Is.	MCD	201	26/01/20	7-8	101	~40	-20	55
2019_MCD_B9	Marian Cove, King George Is.	MCD	201	26/01/20	8-9	101	~40	-20	55
2019_MCD_B10	Marian Cove, King George Is.	MCD	201	26/01/20	9-10	101	~40	-20	55
2019_MCD_B15	Marian Cove, King George Is.	MCD	201	26/01/20	14-15	101	~40	-20	55
2019_MCE_B1	Marian Cove, King George Is.	MCEalt	197	26/01/20	0-1	105	~40	-20	55
2019_MCE_B2	Marian Cove, King George Is.	MCEalt	197	26/01/20	1-2	105	~40	-20	55
2019_MCE_B3	Marian Cove, King George Is.	MCEalt	197	26/01/20	2-3	105	~40	-20	55
2019_MCE_B4	Marian Cove, King George Is.	MCEalt	197	26/01/20	3-4	105	~40	-20	55
2019_MCE_B5	Marian Cove, King George Is.	MCEalt	197	26/01/20	4-5	105	~40	-20	55
2019_MCE_B6	Marian Cove, King George Is.	MCEalt	197	26/01/20	5-6	105	~40	-20	55
2019_MCE_B7	Marian Cove, King George Is.	MCEalt	197	26/01/20	6-7	105	~40	-20	55
2019_MCE_B8	Marian Cove, King George Is.	MCEalt	197	26/01/20	7-8	105	~40	-20	55
2019_MCE_B9	Marian Cove, King George Is.	MCEalt	197	26/01/20	8-9	105	~40	-20	55
2019_MCE_B10	Marian Cove, King George Is.	MCEalt	197	26/01/20	9-10	105	~40	-20	55
2019_MCE_B15	Marian Cove, King George Is.	MCEalt	197	26/01/20	14-15	105	~40	-20	55
2019_MCE_B20	Marian Cove, King George Is.	MCEalt	197	26/01/20	19-20	105	~40	-20	55
2019_MCE_B25	Marian Cove, King George Is.	MCEalt	197	26/01/20	24-25	105	~40	-20	55

7.4.6 MULTICORE: GENETICS

Dr Amber Annett, University of Southampton, UK; Dr David Barnes, British Antarctic Survey; Dr Mehul Vora, Rutgers University, USA

This work will characterise the evolutionary adaptations and changes within the HIF and PHD genes in organisms that experience wide fluctuations in O_2 levels. By combining this investigation with ecosystem functioning of the interstitial faunal community, we will elucidate how these adaptations may influence C sequestration and nutrient cycling with increasing disturbance from rapid deglaciation. Overall, the proposed work will inform us of the set of adaptations within a conserved genetic program of O_2 response within the Antarctic microbenthos. These insights, in combination with the extensive context of the benthic impacts of deglaciation provided by the ICEBERGS project, will permit the first evaluation of adaptive strategies at a metagenomic scale of microeukaryotes to changing sediment mixing regimes, and how this may affect benthic cycling of nutrients and carbon in the future ocean.

Approach and Methods: Samples for genetic analysis of interstitial microfauna were collected across the oxic-anoxic transition in sediment cores at during the ICEBERGS-3 multicoring during JR19002. Sampling was done at one proximal site and one distal location in each fjord to cover a range of turbidity, iceberg scour, sediment composition and benthic community structure. Cores with well-preserved interfaces and visible zonation from green, oxygenated sediment to black, sulfidic O_2-poor conditions were selected and oxygen measurements were carried out by Dr. Felipe Salis de Freitas. Measurements were collected about 20 cms above the water-sediment interface down to the 3 cms within the sediment core at regular intervals. Two cores were retrieved per site. Cores were then sliced at 0.5cm, 1cm and 1.5 cm intervals. The slices from the first core were split for DNA and RNA analyses respectively while all of the slice for the 2nd core will be used for metabolomic analyses. Core slices were collected in 50 ml conical falcon tubes and flash frozen in liq. N2 for 1 min followed by long-term storage at -80C.

Further sample analysis will be performed on shore as per the following:

Metagenomic DNA extraction, library preparation and sequencing: DNA extraction from sediments at various depths along the core collected will be performed using the MoBio PowerSoil DNA extraction kit using published protocols (Nascimento et al. 2018). Samples will be frozen for return to the UK/US for analyses. Eukaryotic diversity at each depth of the sediment will be examined by amplification of the 18s rRNA fragments using standard PCR primers. In order to obtain maximum sequence coverage, the above metagenomic library will undergo next-generation sequencing. We expect to find HIF- and PHD-like sequences which we will characterise in our structure-function studies.

Structure-function studies: Sequences obtained from 18s rRNA sequencing will be first matched against the National Center for Biotechnology Information DNA sequence database to assess the biodiversity biodiversity of the core with depth. Matches to putative HIF and PHD genes will be assessed using published guidelines (Rytkönen et al. 2011) and the following analyses will be conducted: phyologenetic tree construction, modeling rates of molecular evolution, computing rates of selection pressures and calculating functional divergence.

Nascimento et al. 2018 Scientific Reports **8**, 1–12.
Rytkönen et al. 2011 Molecular Biology and Evolution 28, 1913–1926

7.5 BIOLOGY

7.5.1 SHELF UNDERWATER CAMERA SYSTEM (SUCS)

Dr Dave Barnes, British Antarctic Survey; Dr Tamara Trofimova, University of Bergen, Norway; Stella Alexandroff, University of Exeter, UK

The key priority for SUCS work was the Sheldon Cove deployments. The ICEBERGS1 cruise (JR17001) did not reach Sheldon Cove because of sea ice and ICEBERGS2 cruise (JR18003) did not have SUCS because it had been damaged on a previous voyage. Thus, JR19002 was the last ICEBERGS opportunity to gain imagery from the third fjord and retreating glacier at Sheldon. The repaired SUCS had worked well on the Arctic JR18006 voyage in July 2019, but initial set up at Sheldon Cove revealed some image quality issues, resulting in grainy image output. The reason for this was found to be that the gain settings were set to auto-gain, which created problems in low-light conditions. Thus, at subsequent stations, all images were taken under full light exposure to reduce image grain size. In addition, low-light images were taken of each frame to allow for identification of overexposed specimens. Each image captures 970 mm by 830 mm of the sea bottom. The SUCS was deployed with RMT8 weights on the UW-tripod (using short strops and cable ties) with twin 3200 lumen lights, as used on previous cruises. USBL beacon (4) was used in its purpose-built bracket and worked well apart from occasional erroneous depth readings. The USBL beacon remained turned off during transit between stations to save battery. At Sheldon Cove, USBL was not used for all stations, as sea ice conditions rendered the deployment of the USBL pole difficult.

The purpose of SUCS on ICEBERGS3 was to investigate epifaunal composition and estimate faunal densities. SUCS images can also be analysed to provide micro-topography (rugosity) and approximate particle size (e.g. by Wentworth scale). The SUCS and Agassiz, when both deployed at the same site, increase the value of the data obtained, as the specimens trawled in the latter and identified by detailed morphological inspection or using molecular methods then improve the likelihood and confidence of correct identifications of individuals seen in the SUCS images. Carbon content (drymass and ash-free drymass) can be determined for each specimen of particular size from each species from trawl samples. Substitution of these values onto the SUCS density data can allow estimation of zoobenthic carbon per unit area, and allow comparison on seabed carbon accumulation in time and space.

There were approximately 25 planned SUCS deployments, which were subject to sea ice/weather conditions and results obtained by other sampling methods. Twenty pictures were taken at each site to try to capture the range of mega and macrobiota variation and to allow for meaningful comparisons between sites. All but two (BBD and BBE at Börgen Bay) of the planned SUCS deployments were possible (Table 7-24). In addition, a number of opportunistic deployments were made adjacent to the glacier terminus at Marian Cove and on moraine sills at both Marian Cove and Börgen Bay. At MC_SUCS4 (Marian Cove), pictures were taken starting on the tip of the sill, moving downhill towards the open sea. In contrast, the transects at MC_SUCS2 and MC_SUCS3 followed an eastward direction towards the fjord. During JR19002, 599 photographic stills were taken, spanning a depth range of c. 47–523 m. In total, 30 different sites across three fjords were examined (Figure 7-47 and Figure 7-48). Several videos of lower resolution were also taken.

Table 7-24 Summary of SUCS deployments

Site	No. SUCS sites planned	No. SUCS sites undertaken
Sheldon Cove	12	12
Börgen Bay	6	7*
Marian Cove	7	11


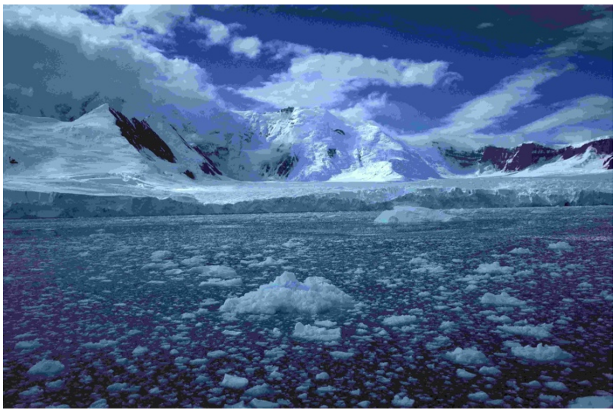

Figure 7-47 SUCS being readied for deployment (left) but sea ice at some Börgen Bay sites prevented SUCS use (right)

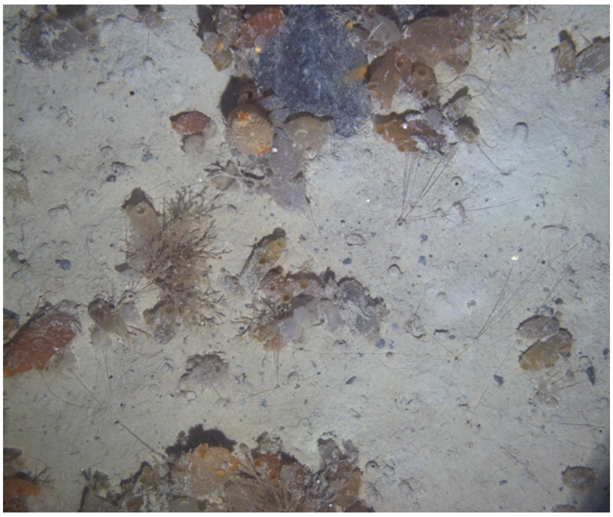
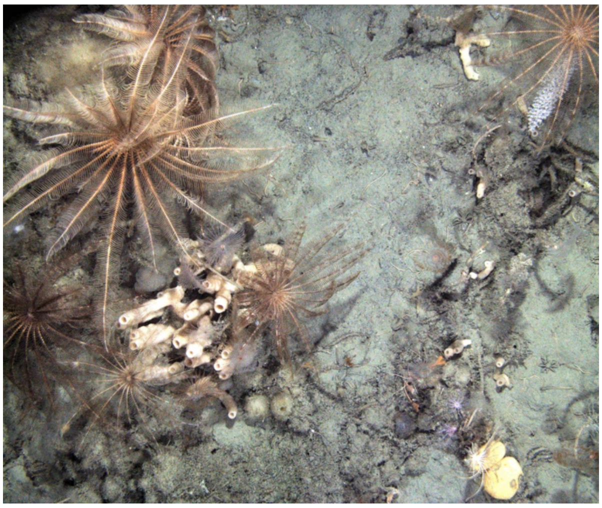

Figure 7-48 Life was sparse close to the glacier termini (left) but rich and abundant on moraine sills (right)

7.5.2 N70 PLANKTON SAMPLING

Julian Blumenroeder, University of Hull, UK

Rationale: The N70 net was deployed in four locations, Sheldon Cove, Börgen Bay, Marion Cove and Burdwood Bank. The rationale was to sample phyto- and zooplankton from the water column to identify the environmental consequences (e.g. ingestion, adhesion etc.) of microplastic on marine planktonic ecosystems.

Gear: The N70 net has a circular opening of 70 cm and a length of roughly 3m. The upper quarter of the net is cylindrical and has a wider mesh size of 445µm to allow macro-nekton to escape the net. The lower three quarters are conical and have a smaller mesh size of 195µm. The net ends in a brass bucket, in which the plankton is collected. Below the brass bucket is a weight which guarantees a vertical haul of the net.

Sampling sites: The following sites were sampled in Sheldon Cove, Börgen Bay and Marion Bay respectively: SC0, SC1, SCA, SCB, SCC, SCD, SCE and SC6, BB0, BBX, BBA, BBB, BBC, BBD and BBE and MC0, MC1, MC2, MC4, MCA, MCB, MCC, MCD and MCE. Additionally, in Burdwood Bank the sites 1, 2, 3, 4, 5 and 6 were sampled with the N70 net.

N70 catch processing and initial assessment: The N70 net was deployed down to 50m below the surface and then slowly vertically hauled with a speed of roughly 10m/min. Once back on deck, the net was hosed down from the outside with saltwater. The brass bucket was unscrewed and its contents were filtered with milliQ in the wet lab. The plankton was washed off the filter into a 150ml container using 99.8% EtOH, which was used to preserve the sample. Samples were stored in the -20˚C freezer.

The three fjords (SC, BB and MC) seemed to be dominated by phytoplankton, whereas Burdwood Bank showed more zooplankton. Some macrofauna, such as, shrimps, gastropods and salpes were also caught with the net. In several of the samples bright fibres could be seen, which might be microplastic.

7.5.3 AGASSIZ TRAWL (AGT)

Dr Chester Sands, British Antarctic Survey; Alice Guzzi, University of Siena, Italy; Dr Carlos Munoz-Ramirez, Universidad Catolica de la Santisima Concepcion, Chile*; Dr David Barnes, British Antarctic Survey; Dr Alejandro Roman Gonzales, University of Exeter, UK; Dr Paul Butler, University of Exeter, UK; Marina Costa, SAERI, Falklands; Julian Blumenroeder, University of Hull, UK; Dr Kotaro Shirai, University of Tokyo, Japan; Fabian Guzman, Universidad Catolica de la Santisima Concepcion, Chile; Tristyn Garza, University of West Florida, USA; Stella Alexandroff, University of Exeter, UK; Dr Tamara Trofimova, University of Bergen, Norway; Dr Carmen Flagan Rodriguez, University of Exeter, UK.

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For the ICEBERG series of cruises the mini Agassiz trawl (AGT) has been the primary apparatus to sample benthic assemblages. The catches are used as "type" material for museums (e.g. Antarctic Museum Genoa), for population genetic study collections (Munoz et al. submitted *Biological Letters* 2019) and to ground truth seafloor images from SUCS that provide quantitative estimates of abundance and biomass.

During ICEBERGS 3 we conducted three AGTs, one at each of the “site 0” stations that represent an assemblage outside of each of the three fjord systems.

The mini AGT has a mesh size of 1 cm and a mouth width of 1.25 m. Trawl stations were slightly offset from the deployment of the grab, SUCs and multicore and chosen by examining features shown on multibeam sonar (swath) imagery to ensure safe deployment.

The deployment protocol of the mini AGT deviated slightly from the standard AGT procedure. While the AGT was lowered, the ship had to compensate for the wire lowering speed of max of 45 m/min by steaming at 0.5 knots until the AGT reached the seabed and until the full trawling wire length was put out. The full trawling cable length used was two times the water depth (standard BAS AGT uses a cable length of 1.5 times water depth). The net was then trawled at 0.5 knots for 5 minutes (standard BAS AGT protocol is a trawling speed of 1 knot). Afterwards, with the ship speed kept to 0.1 knots, the AGT was hauled at 30 m/min in order to avoid damaging the gear. When the AGT had left the seafloor, the hauling speed was increased to 45 m/min. The reduced size of the trawl and reduced trawling speed often results in a slightly smaller (although we had very large catches at our three sites) but much higher quality catch. Importantly the trawl damages substantially less sea floor than the larger AGTs used on this and other vessels.

As the trawl was raised from the water, fire hoses were used to wash most of the mud out of the net – much more efficient that sieving on the deck. Once the net was clean it was held over the 1mm mesh sieve and the cod end released so the catch was caught in its entirety into the sieves where the remaining mud was carefully washed off.

Samples were sorted to class and where possible to morphotype. Most specimens were preserved in pre chilled 99.8% ethanol (total vial volume at least 80% ethanol) and stored in the -20°C freezer. The gastropods kept aside and statoliths were removed for aging and the two fish were frozen at -80°C for stable isotope analyses. Selected specimens were kept aside for detection of plastic ingestion.

A total number of 1377 specimens were collected representing 13 phyla and 24 classes. Ophiuroids (492), polychaets (303) and pycnogonids (172) dominated the catches, however, the catch composition, richness and abundance differed markedly between the three fjord systems. Marion Cove catch contained more than three times the number of specimens compared to Börgen Bay and Sheldon. The data summary is presented in Table 7-25.

Table 7-25 Summary of AGT samples by site

Class	Marian Cove	Borgen Bay	Sheldon Cove
	MC0	BB0	SC0
Anthozoa	5	6	17
Articulata	0	1	1
Ascidiacea	39	0	6
Asteroidea	5	4	2
Bivalvia	30	5	4
Bryozoa	27	8	10
Cephalopoda	0	1	0
Chlorophyta	0	3	0
Crinoidea	4	1	6
Demospongia	0	0	1

Echinoidea	1	0	7
Gastropoda	1	1	11
Hexactinellida	18	1	14
Holothuroidea	5	0	12
Hydrozoa	0	4	0
Malacostraca	9	57	26
Nemertea	0	0	1
Ophiuroida	435	7	50
Pisces	0	0	9
Polycheata	172	40	91
Pycnogonida	60	100	12
Rhodophyta	2	7	0
Scaphopoda	12	18	7
Sipunculida	0	1	0

7.5.4 MICROPLASTICS WITHIN ORGANISMS

Julian Blumenroeder, University of Hull, UK

The rationale of this project is to assess the environmental consequences of microplastics in remote marine food webs. Plankton, water, benthic macrofauna and sediment samples were taken to investigate the vulnerability towards impacts from microplastics based on biology (family or lower), feeding type, morpho type, functional group, habitat and place in the Antarctic marine food web. Water and sediment samples will be analysed for background levels of microplastics. Filter papers were placed on the bench in the wet lab during each of the different sampling and processing procedures to account for microplastic contamination during the handling of the samples. Samples of all plastic objects involved in the sampling and processing methods were taken to cross reference with microplastic particles and fibres found in the samples.

For microplastic analysis of plankton and benthic organisms the N70 net was deployed at each station and surface water samples taken with the Niskin bottle for background levels, as well as multicorer samples for benthic organisms and background levels in the sediment. Additionally, opportunistic samples were taken from the Agassiz trawl to obtain a bigger picture of microplastic accumulation in the food chain.

The soft tissue of the fauna will be dissolved and plastic particles found within the bio sample will be analysed using FTIR (Fourier-Transformed Infra-Red) spectroscopy.

7.5.5 MICROPLASTIC QUANTIFICATION

Tristyn Garza, University of West Florida, USA

This project seeks to quantify and characterize microplastic pollution in Antarctic fjords with minimal human influence experiencing glacial retreat over a three-year period. Locations are based near varying amounts of scientific bases and move in towards the ice front within each fjord that have only been exposed a short amount of time. Water samples were collected from the seafloor, and at the surface using a CTD rosette with stainless steel Niskin bottles. Using the mini-Agassiz Trawl, organisms that are either filter or deposit feeders were also collected and later digested with nitric acid to quantify microplastics from the organisms.

The collection sites are located in Sheldon Cove, Börgen Bay and Marian Cove, all three of which are geologically, newly exposed habitat vulnerable to many rapid changes occurring due to glacial retreat. This year, opportunistic collection took place within Burdwood Bank as a reference point for the Antarctic Circumpolar Current. In 2017 and 2018 collections took place at stations 1-5 in Marian Cove, stations 1-5 in Börgen Bay and in 2018 stations 1-6 in Sheldon Cove. This year a total of eight numbered stations were swapped for the lettered stations, including three stations in Sheldon Cove, two stations in Börgen Bay and three stations in Marian Cove (Table 7-26). As the glaciers retreat, the area exposed is quickly colonized by organisms that are tolerant to both sedimentation and freshwater input. Although microplastic pollution is not associated with glacial retreat, it is a compounding stressor in conjunction with ocean acidification, global climate change, and glacial melt, and it remains unknown if the organisms colonizing these areas are also tolerant of microplastic pollution. Multiple sites within each fjord (Table 7-26) were sampled consisting of three litres from as close to the surface as possible and three litres from the benthos, approximately ten meters above the sediment surface. All collection and filtration equipment was rinsed with milliQ water prior to collection and in between 1-litre samples. Lastly three litres of milliQ water were filtered to serve as controls prior to collection in each geographic region, Sheldon Cove, Börgen Bay, Marian Cove and Burdwood Bank for a total of 12 control filters. Microplastics samples were collected after nutrients, rare earths, oxygen isotopes and salinity samples as the microplastics had the smallest contamination potential. All six litres collected from the CTD were immediately filtered using a vacuum filtration pump through cellulose filter paper with a pore size of .45μm (Whatman)**,** in one-litre subsamples. The pore size allowed for the retention of any materials, organic and inorganic, larger than .45μm on the filter. This resulted in six filters per station, three surface and three benthic for a total of 126 filters, as station Börgen Bay 3 was not accessible due to the ice front collapse. During the filtration process, filtration equipment was covered to minimize any contamination via air flow. All filters were then dried for at least 24 hours in petri dishes, with the petri dishes being covered to allow air to escape without contamination.

Upon return to the US, filters will be hand processed for microplastic quantification using a compound microscope at 4x and 10x magnifications. Post quantification, each filter will be photographed in its entirety using a Nikon DS-Fi2 and complement software of Nikon Elements (Figure 7-49), with each filter having approximately 15 photos. These photographs will then be used to further classify microplastics by size, colour and type of plastic, either fibre, fragment, foam, or bead, using open access software of ImageJ.

Organismal collections that were completed using the mini Agassiz Trawl at Sheldon Cove, Börgen Bay, Marian Cove consist of single collections from one site, however Burdwood Bank had multiple trawls but microplastic samples were only taken from one station based on availability of specific organisms. Filter and deposit feeders were the target organisms, collecting samples that included Ophiuroideans, Pycnogonidans, Malacostracans, and Poriferans, based on the availability in the trawls. Upon return to the US the organisms will be photographed and analyzed for species type then digested with nitric acid to dissolve any tissue from the bodies while leaving synthetic materials intact. The remains will then be sterile filtered and quantified for microplastic abundance in the same fashion as the filtered water samples.

Table 7-26 Water collection sites and depths

Station	Benthic or Surface	Latitude S	Longitude W	Depth Collected (m)
SC1	Benthic	67.34.017	68.13.534	504
	Surface			0
SC2	Benthic	67.32.961	68.15.969	167
	Surface			1.4
SCA (3)	Benthic	67.32.562	67.32.562	266
	Surface			1.04
SCC (4)	Benthic	67.31.668	68.15.973	240
	Surface			0
SCE (5)	Benthic	67.31.185	67.31.185	180
	Surface			0
SC6	Benthic	67.30.852	67.30.852	157
	Surface			0
BB1	Benthic	64.44.573	63.27.423	242
	Surface			2
BBB (2)	Benthic	64.43.4521	63.28.518	142
	Surface			0
BB3	Benthic	n/a	n/a	n/a
	Surface			n/a
BBD (4)	Benthic	64.42.429	63.27.866	183
	Surface			0
BBE (5)	Benthic	64.42.429	63.27.866	254
	Surface			1
MC1	Benthic	62.13.050	58.47.368	87
	Surface			0
MC2	Benthic	62.12.764	58.46.149	100
	Surface			0
MCB (3)	Benthic	62.12.513	58.45.232	44
	Surface			0
MC4	Benthic	62.12.350	58.44.405	106
	Surface			0
MCD (5)	Benthic	62.12.211	58.44.178	86
	Surface			0
BuB1	Benthic	54.57.553	57.45.108	340
	Surface			0
BuB2	Benthic	54.57.397	57.11.781	370
	Surface			1
BuB3	Benthic	54.29.693	55.31.171	602

	Surface			2
BuB4	Benthic	54.30.454	56.01.094	334.87
	Surface			4.96
BuB5	Benthic	54.29.833	54.44.652	95.51
	Surface			4.08
BuB6	Benthic	54.13.095	56.42.840	737
	Surface			4.45

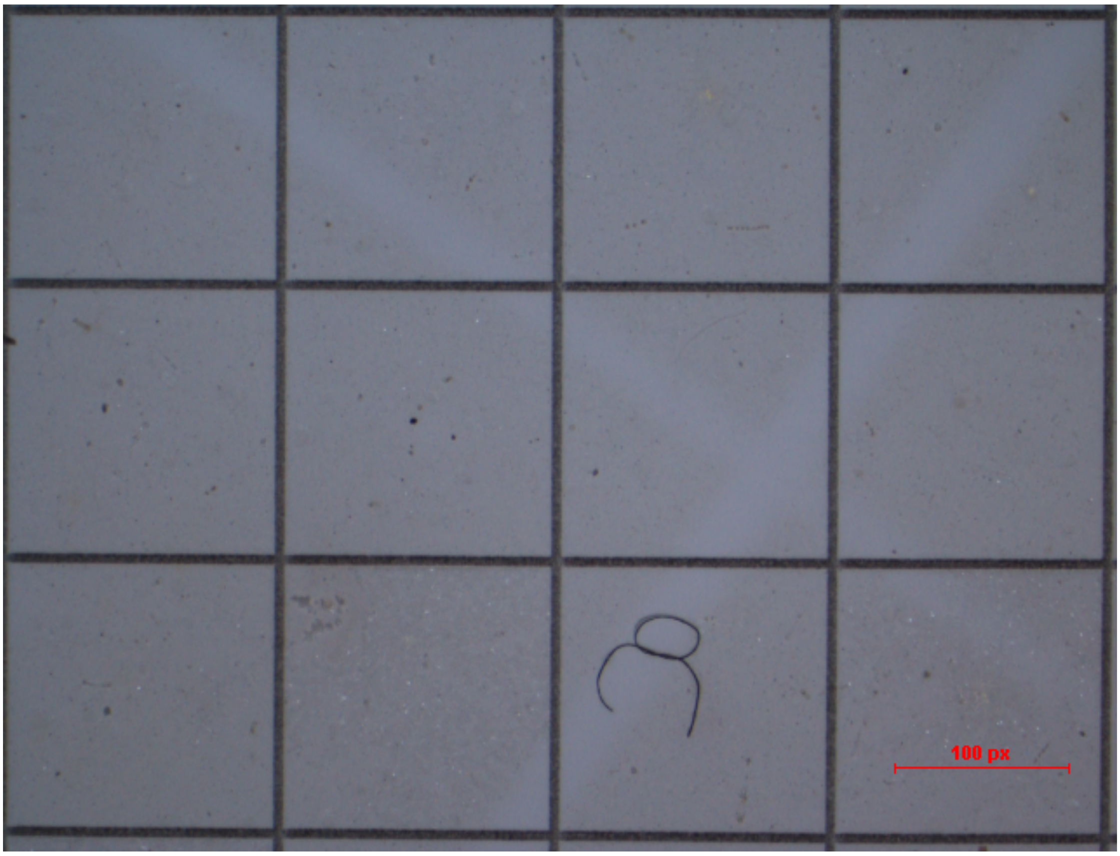

Figure 7-49 Börgen Bay benthic 2018 sample photograph using Nikon DS-Fi2

7.5.6 MICROBIOLOGY

Dr Carmen Falagan Rodriguez, University of Exeter, UK.

One core from each station (when sampling was successful) was used to sample for microbiological analyses. Sampling at Sheldon Cove was more detailed (every 2 cm) in station A and E as those are the most distant locations, with respect to each other, sampled in each fjord. Sampling at Börgen Bay and at Marian Cove was performed every 2 cm in all the sampled stations. Samples were stored in 50 mL sterile falcon tubes at -80°C for further analyses upon return to UK. The remaining sediment samples, when available, were stored in plastic bags at -20°C and will be used for mineral and chemical analysis of the sediments. The majority of the cores were loose in the top few centimetres while the sediment was more compact at depth. The sediment was less compact with presumably more water content in cores taken at sites E and D in Marian Cove. Although black sediment patches were visually identified in the core suggesting anoxic conditions at depth, clear stratification of sediments was not identified in any of the samples taken at Börgen Bay and Sheldon Cove. Core sediments collected at Marian Cove displayed larger black areas suggesting lower concentration of oxygen and degradation of organic matter, however, oxygen was not analysed at depth within the cores.

Table 7-27 Microbiology samples collected during JR19002

Sites	Site 0	Site A	Site B	Site C	Site D	Site E
Sheldon Cove	0	10	2	3	6	10
Börgen Bay	14	11	6	8	0	0
Marian Cove	15	15	11	13	10	16

7.6 SUSPENDED PARTICULATE MATTER

Aisling Smith, British Antarctic Survey; Kate Retallick, Bangor University, UK

Suspended particulate matter samples were collected at Sheldon Cove, Börgen Bay, and Marian Cove during ICEBERGS III, JR19002. Samples were collected at sites A-E at each bay.
The collection method used was taken from Suzie Jackson, Bangor University (see cruise Health and safety folder for details). The target depths for this work were surface and bottom. Although the protocol stated a maximum volume of 1000 ml was to be filtered, it was decided to increase this to 5000 ml as filters were very clear, especially at bottom depths; all volumes filtered were recorded.
After Sheldon Cove an anomaly in the beam transmittance was noticed in the data; for subsequent site locations these areas were targeted should the feature repeat. It did not repeat to the same extent so surface and bottom depths were sampled unless target beam transmittance features were identified in the downcast profile.

Sample water was collected in Milli-Q cleaned 5 L Jerrycans from the CTD rosette. A maximum of 15 L was collected at each depth. Filters used were 47 mm 0.2 um GF/F Whatman pre-ashed and weighed prior to the cruise. A vacuum filter rig was used to filter the water through the filters. Once sample filtering was completed the filters were washed with 200 ml Milli-Q water and frozen at -20 °C until further analysis at Bangor.

Table 7-28 Suspended particulate matter samples collected during JR19002

Filter		Date	Location	Site	Event number	Depth	Volume filtered	Stowage temperature
1	SPM	13/01/2020	Sheldon cove	SC-B	17	217	1000	-20
2	SPM	13/01/2020	Sheldon cove	SC-B	17	217	1000	-20
3	SPM	13/01/2020	Sheldon cove	SC-B	17	217	1000	-20
4	SPM	13/01/2020	Sheldon cove	SC-B	17	6	1000	-20
5	SPM	13/01/2020	Sheldon cove	SC-B	17	6	1000	-20
6	SPM	13/01/2020	Sheldon cove	SC-B	17	6	1000	-20
7	SPM	14/01/2020	Sheldon cove	SC-C	24	226	1000	-20
8	SPM	14/01/2020	Sheldon cove	SC-C	24	226	1000	-20

9	SPM	14/01/2020	Sheldon cove	SC-C	24	226	1000	-20
10	SPM	14/01/2020	Sheldon cove	SC-C	24	0.5	1000	-20
11	SPM	14/01/2020	Sheldon cove	SC-C	24	0.5	1000	-20
12	SPM	14/01/2020	Sheldon cove	SC-C	24	0.5	1000	-20
13	SPM	14/01/2020	Sheldon cove	SC-D	28	229	1000	-20
14	SPM	14/01/2020	Sheldon cove	SC-D	28	229	1000	-20
15	SPM	14/01/2020	Sheldon cove	SC-D	28	229	1000	-20
16	SPM	14/01/2020	Sheldon cove	SC-D	28	1	1000	-20
17	SPM	14/01/2020	Sheldon cove	SC-D	28	1	1000	-20
18	SPM	14/01/2020	Sheldon cove	SC-D	28	1	1000	-20
19	SPM	15/01/2020	Sheldon cove	SC-E	33	178	1000	-20
20	SPM	15/01/2020	Sheldon cove	SC-E	33	178	1000	-20
21	SPM	15/01/2020	Sheldon cove	SC-E	33	178	1000	-20
22	SPM	15/01/2020	Sheldon cove	SC-E	33	0.5	1000	-20
23	SPM	15/01/2020	Sheldon cove	SC-E	33	0.5	1000	-20
24	SPM	15/01/2020	Sheldon cove	SC-E	33	0.5	1000	-20
25	SPM	19/01/2020	Borgen Bay	BB-A	85	170	1000	-20
26	SPM	19/01/2020	Borgen Bay	BB-A	85	170	1000	-20
27	SPM	19/01/2020	Borgen Bay	BB-A	85	170	1000	-20
28	SPM	19/01/2020	Borgen Bay	BB-A	85	150	5000	-20
29	SPM	19/01/2020	Borgen Bay	BB-A	85	150	5000	-20
30	SPM	19/01/2020	Borgen Bay	BB-A	85	150	5000	-20
31	SPM	20/01/2020	Borgen Bay	BB-C	88	180	5000	-20
32	SPM	20/01/2020	Borgen Bay	BB-C	88	180	5000	-20
33	SPM	20/01/2020	Borgen Bay	BB-C	88	180	5000	-20
34	SPM	20/01/2020	Borgen Bay	BB-C	88	40	3000	-20
35	SPM	20/01/2020	Borgen Bay	BB-C	88	40	3000	-20
36	SPM	20/01/2020	Borgen Bay	BB-C	88	40	3000	-20
37	SPM	20/01/2020	Borgen Bay	BB-D	105	170	5000	-20
38	SPM	20/01/2020	Borgen Bay	BB-D	105	170	5000	-20
39	SPM	20/01/2020	Borgen Bay	BB-D	105	170	5000	-20
40	SPM	20/01/2020	Borgen Bay	BB-D	105	50	5000	-20
41	SPM	20/01/2020	Borgen Bay	BB-D	105	50	5000	-20
42	SPM	20/01/2020	Borgen Bay	BB-D	105	50	5000	-20
43	SPM	21/01/2020	Borgen Bay	BB-E	109	110	4000	-20
44	SPM	21/01/2020	Borgen Bay	BB-E	109	110	4000	-20
45	SPM	21/01/2020	Borgen Bay	BB-E	109	110	4000	-20
46	SPM	21/01/2020	Borgen Bay	BB-E	109	50	4000	-20
47	SPM	21/01/2020	Borgen Bay	BB-E	109	50	4000	-20
48	SPM	21/01/2020	Borgen Bay	BB-E	109	50	4000	-20
49	SPM	22/01/2020	Borgen Bay	BB-B	125	142	5000	-20
50	SPM	22/01/2020	Borgen Bay	BB-B	125	142	5000	-20

51	SPM	22/01/2020	Borgen Bay	BB-B	125	142	5000	-20
52	SPM	22/01/2020	Borgen Bay	BB-B	125	0.5	5000	-20
53	SPM	22/01/2020	Borgen Bay	BB-B	125	0.5	5000	-20
54	SPM	22/01/2020	Borgen Bay	BB-B	125	0.5	5000	-20
55	SPM	21/01/2020	Borgen Bay	BB-E	109	175	5000	-20
56	SPM	21/01/2020	Borgen Bay	BB-E	109	175	5000	-20
57	SPM	21/01/2020	Borgen Bay	BB-E	109	175	5000	-20
58	SPM	24/01/2020	Marian Cove	MC-A	157	95	4000	-20
59	SPM	24/01/2020	Marian Cove	MC-A	157	95	4000	-20
60	SPM	24/01/2020	Marian Cove	MC-A	157	95	4000	-20
61	SPM	24/01/2020	Marian Cove	MC-A	157	0.5	4000	-20
62	SPM	24/01/2020	Marian Cove	MC-A	157	0.5	4000	-20
63	SPM	24/01/2020	Marian Cove	MC-A	157	0.5	4000	-20
64	SPM	25/01/2020	Marian Cove	MC-B	161	0.5	2000	-20
65	SPM	25/01/2020	Marian Cove	MC-B	161	0.5	2000	-20
66	SPM	25/01/2020	Marian Cove	MC-B	161	0.5	2000	-20
67	SPM	25/01/2020	Marian Cove	MC-B	161	50	4000	-20
68	SPM	25/01/2020	Marian Cove	MC-B	161	50	4000	-20
69	SPM	25/01/2020	Marian Cove	MC-B	161	50	4000	-20
70	SPM	25/01/2020	Marian Cove	MC-C	165	45	4000	-20
71	SPM	25/01/2020	Marian Cove	MC-C	165	45	4000	-20
72	SPM	25/01/2020	Marian Cove	MC-C	165	45	4000	-20
73	SPM	25/01/2020	Marian Cove	MC-C	165	0.5	2000	-20
74	SPM	25/01/2020	Marian Cove	MC-C	165	0.5	2000	-20
75	SPM	25/01/2020	Marian Cove	MC-C	165	0.5	2000	-20
76	SPM	NOT USED						
77	SPM	25/01/2020	Marian Cove	MC-D	169	86	4000	-20
78	SPM	25/01/2020	Marian Cove	MC-D	169	86	4000	-20
79	SPM	25/01/2020	Marian Cove	MC-D	169	86	4000	-20
80	SPM	25/01/2020	Marian Cove	MC-D	169	86	2000	-20
81	SPM	25/01/2020	Marian Cove	MC-D	169	86	2000	-20
82	SPM	25/01/2020	Marian Cove	MC-D	169	86	2000	-20
83	SPM	25/01/2020	Marian Cove	MC-E	178	69	3600	-20
84	SPM	25/01/2020	Marian Cove	MC-E	178	69	4000	-20
85	SPM	25/01/2020	Marian Cove	MC-E	178	69	4000	-20
86	SPM	25/01/2020	Marian Cove	MC-E	178	0.5	2500	-20
87	SPM	25/01/2020	Marian Cove	MC-E	178	0.5	2500	-20
88	SPM	25/01/2020	Marian Cove	MC-E	178	0.5	2500	-20

7.7 CETACEAN OBSERVATIONS

Marina Costa, South Atlantic Environmental Research Institute (SAERI), Falklands; Dr Ander M. de Lecea, South Atlantic Environmental Research Institute (SAERI), Falklands

7.7.1 INTRODUCTION

The waters comprised between the Falkland Islands and the Western side of the Antarctic Peninsula provide critical habitats for a large number of cetacean populations, several of which have been reduced extensively in size during the twentieth century whaling activities.

Many of these Southern Ocean species still face anthropogenic impacts including direct hunting (Clapham 2016) and through indirect effects such as prey depletion and reduced sea ice due to global climate change. This is particularly true for species restricted to polar geographical regions such as *Cephalorhynchus* spp. (MacLeod 2009).

Knowledge of cetacean occurrence and distribution in this region are essential for conservation purpose. However, surveys in the Southern Ocean are particularly expensive and challenging due to far-from-ideal weather conditions, and to the vastness and remoteness of the region. Consequently, there is a lack of information on distribution and possible distribution shifting for many cetacean species.

The use of platforms of opportunity such as the *RRS James Clark Ross* (hereafter JCR) has proven essential for cetacean monitoring in the remote areas of the Southern Ocean. During the JR19002 cruise, opportunistic cetacean observations were carried out the aim to gather information about dolphins and whales occurring in the area. Pinnipeds and sea bird presence was also recorded.

We recommend that in the future similar opportunities continue to be encouraged and efforts coordinated allowing trained people to join ships travelling to these remote and still poorly understood areas to record cetacean occurrence.

7.7.2 STUDY AREA

The waters surveyed during this expedition range between the latitude of -51°S to -67°S and include both cold-temperate and Antarctic habitats that are separated by the Polar Front (PF). This is the most important feature of a system of fronts and currents created by the Antarctic Circumpolar Current (ACC) circulating around Antarctica from west to east. These waters are among the most productive areas in the Southern hemisphere in particular south of the PF where high densities of Antarctic krill (*Euphasia superba*) constitutes the key stone species in Antarctic food-webs (Atkinson et al. 2008, Arkhipkin et al. 2013). For commodity the study area has been divided in three zones: the western coast of the Antarctic Peninsula (hereafter WAP), the Drake Passage (hereafter DP), and the Burdwood Bank (hereafter BB) (Figure 7-50).

The **WAP** is the northernmost part of the Antarctica continent and it has one of the highest biomass, supporting large standing stocks of krill and top predators, including cetaceans (Perrin et al. 2009). The industrial whaling that operated for more than 60 years from the early years of the twentieth century removed about 71 million tons of whale biomass from the whole Antarctic severely depleting most populations of large baleen whales (Perrin et al. 2009). In the past 40 years the protection provided by several international treaties (such as the Antarctic Treaty, and the Convention for the Conservation of Antarctic

Marine Living Resources – CCAMLR) allowed the recovery of some populations in particular humpback and southern right whales (Zerbini et al. 2019). Currently, the WAP is one of the world's regions most affected by climate change (Friedl et al. 2018) experiencing 0.6°C increase in temperature per decade at depth between 300-1000m (Turner et al. 2014).

The **DP** is a very dynamic oceanographic region dominated by the Antarctic Circumpolar Current (ACC) consisting in a system of fronts that other than the PF includes, the Subantarctic Front (SAF), the Southern Antarctic Circumpolar Current Front (SACCF) and the Southern Antarctic Circumpolar Current Boundary (SACCB) (Orsi et al. 1995). The PF marks the boundary between cold southern polar waters and temperate northern waters acting as a barrier for marine mammal distributions.

The **BB** is a submerged plateau located about 200 km south of the Falkland Islands. The area comprises about 34,000 km^2, delineated by the 200m isobaths of which about 11,400 km^2 (34%) are included in the Falkland Islands waters (Figure 7-50). Depths on the plateau range between 50 and 200m and increases abruptly reaching to depths of than 4000m on the northeast, east and south sides. Due to the persistent westerly winds and strong currents influenced by the Antarctic Circumpolar Current, the region is an extremely dynamic environment. The plateau also causes the divergence of the Falkland Current heading north towards the Falkland Islands, which creates strong upwelling in the region. Despite the strong currents and winds, the plateau waters are fairly homogeneous vertically, without a thermocline being recorded, with seasonal small variation in temperatures (ranging from 4 to 9°C), and with a mean salinity of 34 ppm. The BB is characterized by great diversity of marine organisms, particularly benthic invertebrates, seabirds and pinnipeds (Baylis et al. 2019, Gordillo et al. 2019)

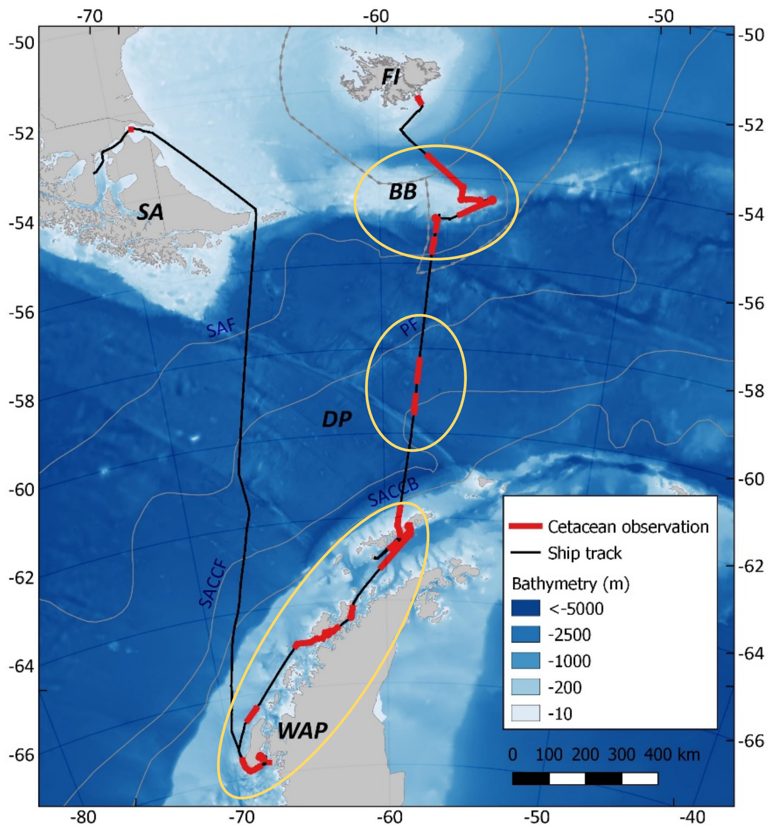

Figure 7-50 The study area surveyed on board of the James Clarke Ross from the 31st of December 2019 to the 4th of February 2020. The map shows the ship track (black line) and the legs during which observation was carried out (red line). The yellow circles indicate the three zones of the study area: BB - Burdwood Bank; DP - Drake Passage, and; WAP - Western Antarctic Peninsula. Also shown are the inner and outer Falkland Islands conservation zones (grey dotted line) and the main fronts. FI: Falkland Islands; SA: South America; SAF: Subantarctic Front; PF: Polar Front; SACCF: Southern Antarctic Circumpolar Current Front, and; SACCB.

7.7.3 DATA COLLECTION

Opportunistic cetacean observations were carried out from the outermost upper deck known as *Monkey Island* located at about 17m above the sea level. When weather conditions were unsuitable for observation outside (i.e. winds stronger than seven Beaufort and or severe rain), observers moved inside in the main bridge, located at about 15m above the sea level (Figure 7-51). Observations were typically carried out during navigation (hereafter called *navigation mode*) at cruising speed of about 18 km/h (10 knots) and when the ship was stationary or moving below 6 km/h (3 knots) (hereafter called *stationary mode*).

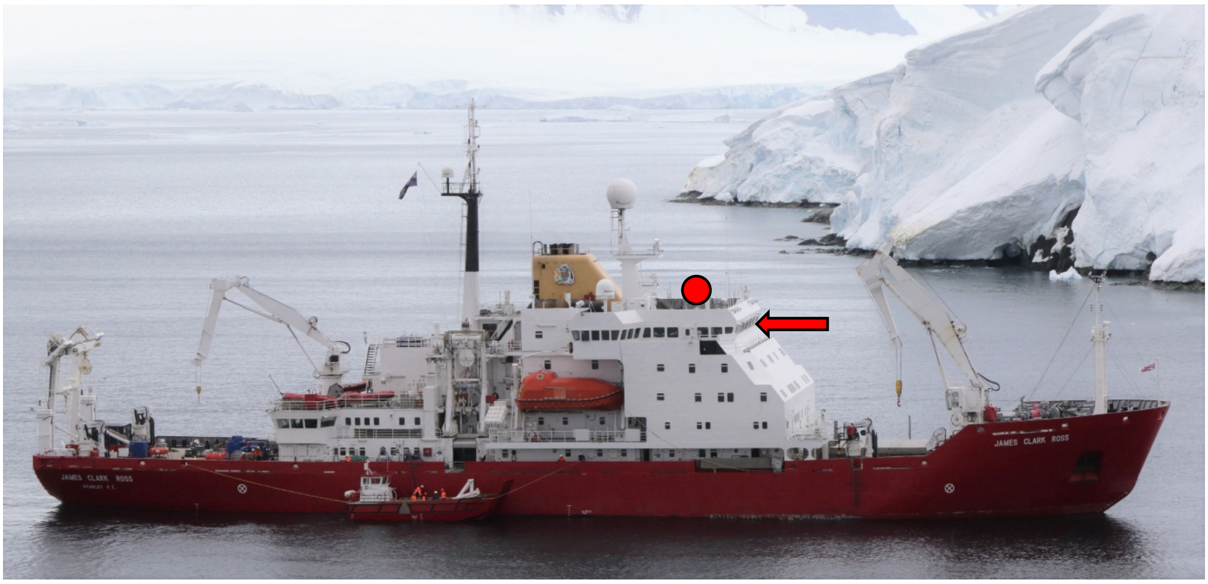

Figure 7-51 The RRS James Clarke Ross. The red dot shows the Monkey island where cetacean observation was carried out in good sea condition; the red arrow shows the windows of the bridge where observation was carried out with bad sea conditions.

During navigation, observer/s searched with naked eyes a sector of 180 degrees directly ahead of the track-line with 70% of the effort concentrated in the central 90 degrees. When the ship was stationary, the observation sector was extended to 360 degrees. Navigation data and environmental conditions were tape-recorded at the beginning and at the end of each survey block and every time there was a change. The variables recorded included:

- Date
- Time (Falkland Islands time)
- Observer/s name/s
- Observation platform (*Monkey island* or *bridge*)
- Ship cruise (*navigation mode* or *stationary mode*)
- Effort (*Positive*: when observer was searching for cetaceans; or *Negative*: when observation was interrupted)
- Sea state as Beaufort scale
- Swell high (in centimetres)
- Cloud and ice cover (in %)
- Glare, rain, snow and fog (as categories: *none, mild, moderate* and *severe*)
- Glare sector (as sector degrees affecting the area)
- Visibility and Sightability (as categories: *poor, moderate, good*, and *excellent*)

Presence and number of birds and pinnipeds within 200m from the ship was also recorded. To avoid double counting, number and species of birds constantly following the ship were recorded apart.

When cetaceans were sighted, the following data were recorded:

- Estimate of animal/group distance from the ship
- Bearing respect to the ship heading
- Cue (e.g. fin, blow, splash, etc.)
- Species and species certainty (as categories: *likely, possibly, certain*)
- Spotter name
- Group size (as minimum counted, maximum number estimated and best estimate based on min and max data)
- Number of young (if any), and age class (as categories: *newborn*, *calf*, *juvenile*)
- Swimming direction for baleen whales (as cardinal direction)
- Animal reaction to the ship
- Animal behaviour at sighting (e.g. travelling, feeding, resting, undetermined)
- Pictures taken and picture number
- Picture use (e.g. for species identification or individual identification)

A waterproof 7x50 binocular was used to confirm species identification, group size and whale swimming direction. The ship compass was used for measuring the bearing and report swimming direction. Distances were estimated without a tool and therefore they must be considered strongly biased. When whales were spotted swimming perpendicular to the ship heading trackline, distances at sighting were verified using the interval time from when the animal was spotted turne 7D Mark II, equipped with a lens EF 70-200mm f/2.8 L IS II USM and a CANON EF Extender 2x extension tube.

Cetacean observation was carried out from the 6th of January when the Marine Managed Area Team joined the expedition in Punta Arenas. One sighting was recorded on the 31st of December 2019 by a researcher during the navigation from Punta Arenas to Rothera base.

7.7.3.1 Data handling

Geographical position and oceanographic data (such as bathymetry, air temperature, air humidity, atmospheric pressure, surface water temperature, salinity, and chlorophyll) recorded by the vessel instruments (see chapters above for instrument specifications). Alice Fremand from BAS produced a script using the software Python 3.7 (see Appendix A.2.ii Script python) to associate geographical position and oceanographic data to the recorded data using the date-time stamp from the GPS.

When data were available, animal position at sighting was calculated using the ship position and bearing and distance estimated using the following formulas:

$$lat2 = \arcsin(\sin(lat1)*\cos(d/R) + \cos(lat1)*\sin(d/R)*\cos(\theta))$$

$$lon2 = lon1 + \mathrm{arc\,tan2}(\sin(\theta)*\sin(d/R)*\cos(lat1), \cos(d/R)-\sin(lat1)*\sin(lat2))$$

Where lat1 and lon1 was the ship position, d the estimated distance of animal, R the radius of the earth, and θ the animal bearing in radians. The vessel position was used as a proxy for animal position when distance and bearing were not available.

7.7.4 RESULTS

From the 6th of January to the 4th of February 2020, cetacean observations were carried out for 74 hours and 48 minutes. Effort included 20 hours and 4 minutes (27%) of observations in *stationary mode* and 54 hours and 43 minutes (73%) of observation in *navigation mode*. A total of 1,013 km were covered during *navigation mode* of which 67% were done with sightability conditions *poor* and 33% with any of the three sightability conditions of excellent (3%), good (10%) or moderate (21%). Sightability affected the three regions differently with poor sightability affecting 49% of the effort made in 49% of effort with poor sightability made in the **WAP**, 100% of the effort made in the **DP**, and 84% of the effort made in the **BB**. Poor sightability is likely to have affected the probability to spot animals, in particular small delphinids.

Cetaceans were spotted in 130 occasions including one sighting of one individual of sei whale made during navigation in the Strait of Magellan on the 31st of December 2019. 72% of the sightings were made during active searching for cetaceans (effort=*positive*). Eight species were identified including humpback whale (83 sightings), minke whale (7 sightings), fin whale (3 sightings), sei whale (2 sightings), killer and pilot whales (5 sightings each), and hourglass and Peale's dolphins (1 sighting each). Furthermore 14 sightings of unknown baleen whales, and 7 of unknown cetaceans were made. Hourglass dolphins where spotted in a mixed-species group with pilot whales. Average group sizes were 1.7 (SD=1.0) for humpback whales, 1.3 (SD=0.5) for minke whales, 2.3 (SD=0.6) for fin whales, 3.2 (2.3) for killer whales, and 6.8 (SD=3.3) for pilot whales (Table 7-29).

Of the 129 sightings made in the study area, 113 sightings (88%) were made in the **WAP**. Cetacean community was dominated by baleen whales species (95%) in particular by humpback whales (75% of the sightings). Killer whale was the only toothed whale observed in the region. Nine sightings (7%) were made in the **DP**. Species were identified only in two sightings (one of fin and minke whales) corresponding to 22% of the sightings made in the area against the 78% of the sightings with certain species identification made in the **WAP**. This was mainly due to the poor sightability affecting navigation in the DP (100% of navigation with poor sightability) respect to the WAP (49% of navigation with poor sightability). Seven sightings (5%) were made in the **BB** including three species of delphinids (pilot whales, hourglass dolphin, and Peale's dolphin). Contrarily to the 2018 cruise, baleen whales were not observed in the area.

Table 7-29 Number of sightings made for each species/group in each region of the study area and in total. Group size and standard deviation estimated for the total number of sightings. Legend: WAP=West Antarctic peninsula; DP=Drake Passage; BB=Burdwood Bank.

Species	WAP	DP	BB	Other areas	Total	Group size	Std Dev
Humpback whale	85				85	1.7	1.0
Minke whale	6	1			7	1.3	0.5
Fin whale	2	1			3	2.3	0.6
Sei whale	1			1*	2	-	-
Killer whale	5				5	3.2	2.3
Pilot whale			5		5	6.8	3.3
Hourglass dolphin			1		1	-	-
Peale's dolphin			1		1	-	-
Unknown baleen whale	8	6			14	1.4	0.6
Unknown cetacean	6	1			7	1.1	0.4
Total	**113**	**9**	**7**	**1**	**130**		

* This value was not considered for the group size.

Table 7-30 summarizes for the three regions the number of kilometres to be navigated and the time before a sighting is made.

Table 7-30 Kilometres, hour of observations, number of sightings, number of kilometres to navigate and time before one sighting is made for the three regions within the study area. Legend: WAP=West Antarctic peninsula; DP=Drake Passage; BB=Burdwood Bank.

Region	Effort (km)	Effort (hh:mm)	No of sighting	Distance before a sighting (km)	Time before a sighting (hh:mm)
WAP	511	31:12	83	6	00:23
DP	127	06:40	5	25	01:33
BB	347	31:42	6	58	05:22
Total	**985**	**69:34**	**94**		

Sighting distribution is showed in Figure 7-52 and in Figure 7-53 for the three regions.

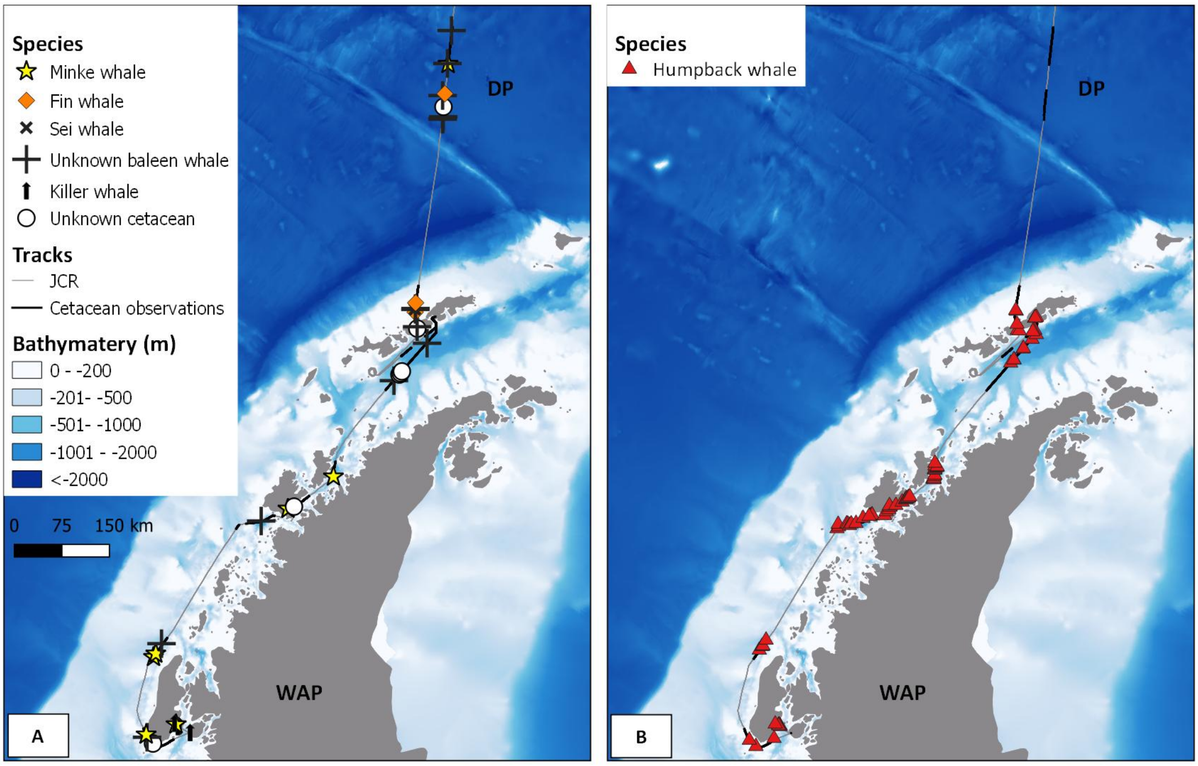

Figure 7-52 Sighting distribution in the Western Antarctic Peninsula (WAP) and in the Drake Passage (DP) regions. Humpback whale sightings are shown in B.

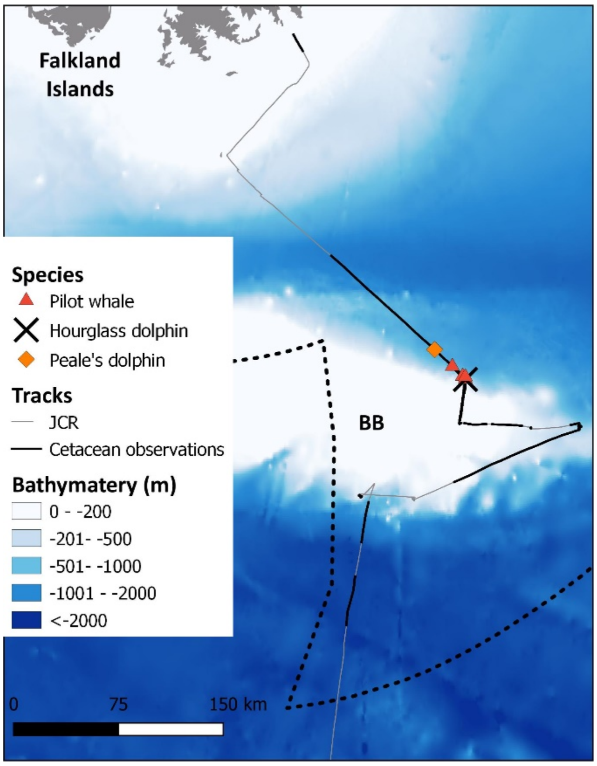

Figure 7-53 Sighting distribution in the Burdwood Bank (BB). The dotted line represents the limit of the Falkland Islands Outer Conservation Zone.

7.7.4.1 Photo-Identification

Pictures of humpback whales dorsal fin possibly useful for individual photo-identification were taken during 13 sightings (Figure 7-54). Pictures of the tails were taken for five individuals although the angle was not always perpendicular (Figure 7-55).

Figure 7-54 Humpback dorsal fin.

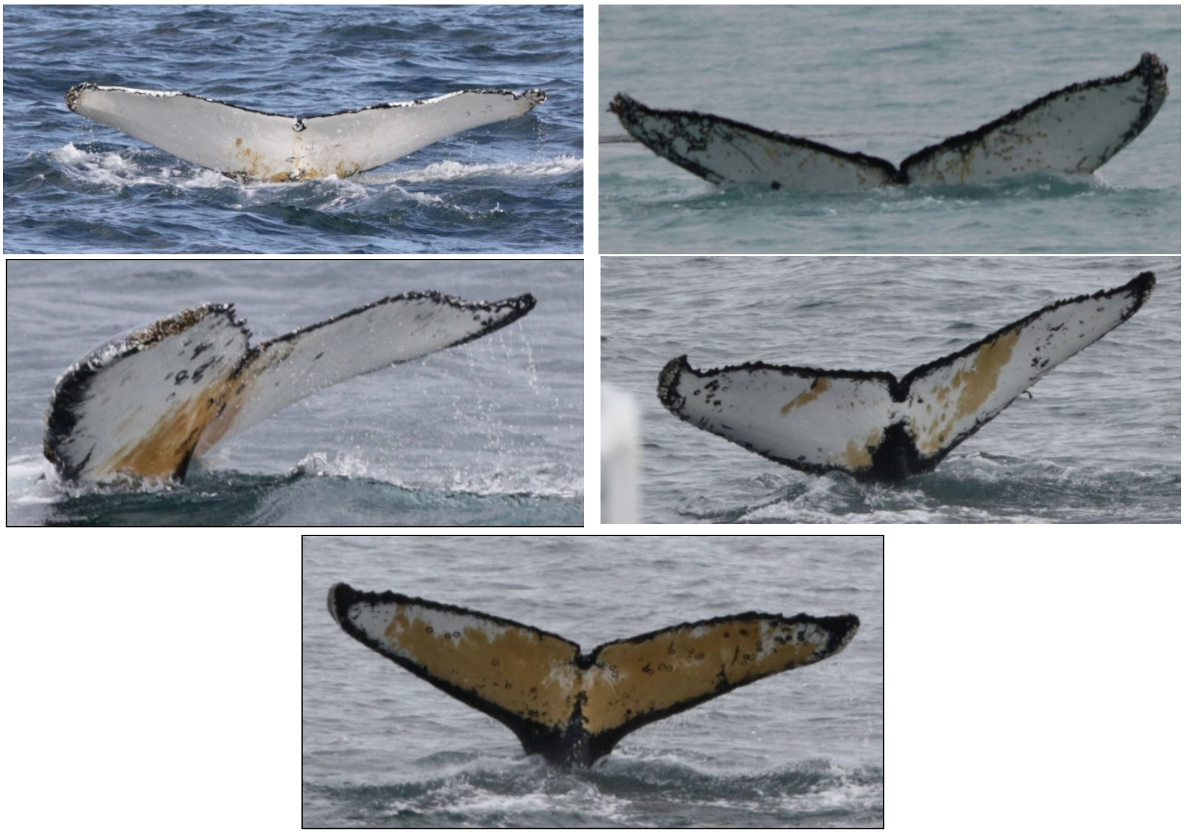

Figure 7-55 Humpback whale tail, used for photo-identification.

In the BB, at least 5 new born pilot whales were observed in 4 out of the 5 sightings, suggesting the presence of a reproduction peak for the population in the Falklands waters in the period January-February. This is new information and it will be particularly important for the management of the pilot whales population in the Falkland Islands waters. Newborns were identified by presence of foetal crest on the body sides, small body-size (less than half of an adult), and a particular way of swimming including a close-association with an adult all the time and surfacing with half of the body (Figure 7-56). During navigation, Pilot whales did not appear to be attracted by the research vessel contrary to the Peale's dolphins.

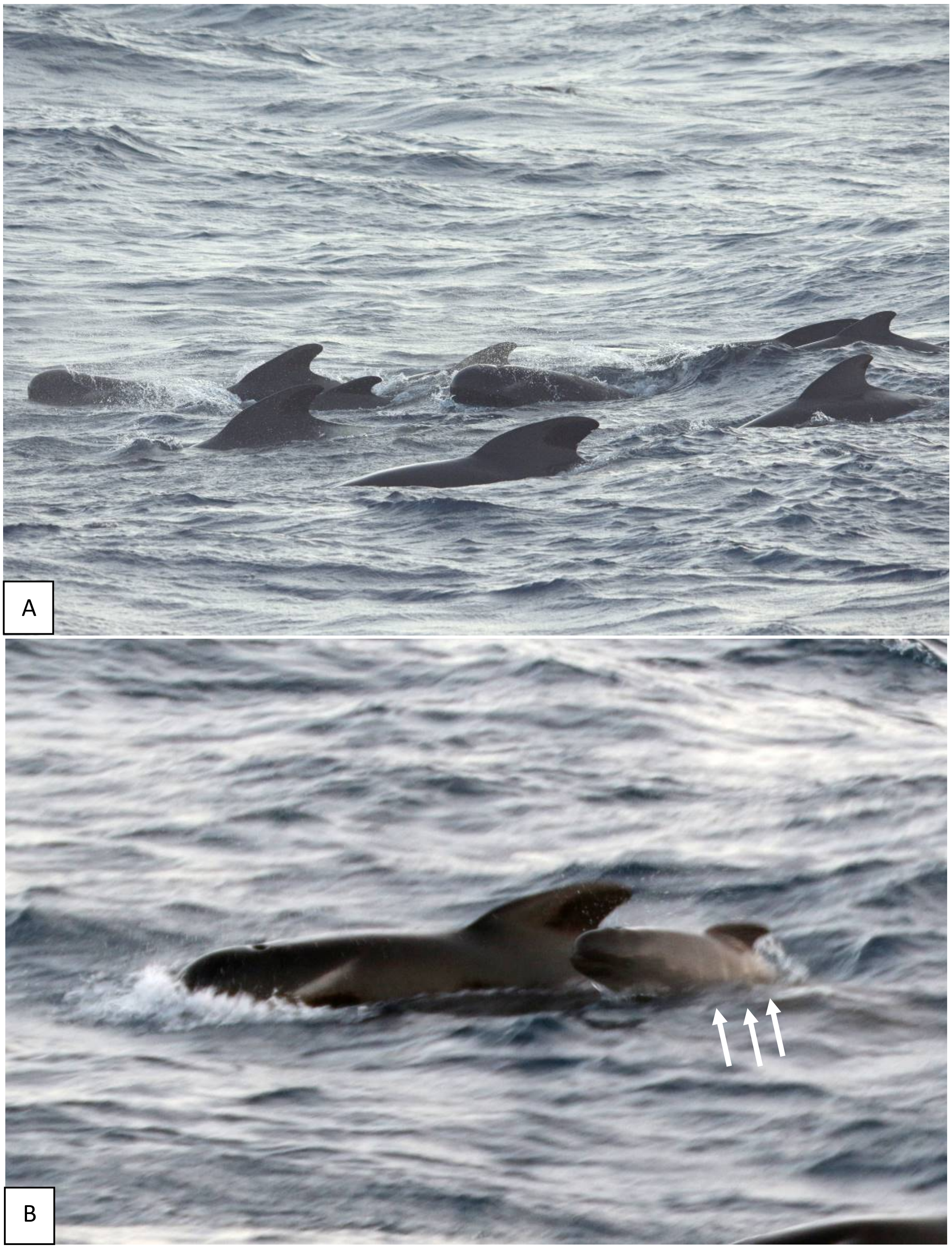

Figure 7-56 A group of long-finned pilot whales observed on the Burdwood Bank plateau on the 2nd of February 2020. B. Female adult with newborn of long-finned pilot whale. The newborn is identifiable by presence of foetal crest on the body sides (white arrows), small body-size (less than half of an adult), and a particular way of swimming including a close-association with an adult all the time and surfacing with half of the body.

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Baylis, A. M. M., et al. 2019 Sci Rep 9(1): 8517.
Clapham, P. 2016 Oceanography 29(3).
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Orsi, A. H., et al. 1995 Deep Sea Research I 42(5): 641-673.
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8 Burdwood Bank benthic and oceanographic survey

Marina Costa, South Atlantic Environmental Research Institute (SAERI), Falklands; Dr Ander M. de Lecea, South Atlantic Environmental Research Institute (SAERI), Falklands

8.1 INTRODUCTION

The "Fine scaling the design of Falkland Islands Marine Management Areas" project is part of a long-term process of marine spatial planning that began in 2014 with the aim to develop holistic marine management across all sectors and maritime spaces in the Falkland Islands. The Burdwood Bank was proposed as a potential Marine Management Area (MMA) in 2017 when the Falkland Islands Government (FIG) contracted SAERI to undertake an Assessment of Fishing Closure Areas as Sites (AFCAS) to advance marine management in the Falkland Islands. The Burdwood Bank is a submerged plateau of the northern sector of the Scotia Ridge located about 200 km south of the Falkland Islands (Figure 8-1). The Bank is known for its benthic invertebrate diversity, which includes several endemic species that are often used as indicators for Vulnerable Marine Ecosystems (VMEs) such as bryozoans, sponges, corals and tunicates (Jones and Lockhart 2011). Furthermore, the Bank is a key foraging area for marine megafauna such as pinnipeds, marine birds, and cetaceans (Schejter et al. 2016, Schejter et al. 2017, Fraysse et al. 2018, Baylis et al. 2019, Gordillo et al. 2019, Schejter and Bremec 2019, Schejter et al. 2020).

Despite its ecological importance, the eastern part of the Burdwood Bank is still poorly described and understood. In particular, the role of the Bank as a refuge for shallow water invertebrates and how this contributes to climate associated range shifts of invertebrates is poorly studied. In fact, the Bank represents the southernmost limit of the continental shelf and could become an important refuge for temperate species at their limit, providing strong justification for special management status, if data can be gathered to support this.

In order to gather more information about the biology and oceanography of Burdwood Bank, data were collected on board of the *RRS James Clark Ross* (hereafter JCR) in cooperation with the British Antarctic Survey (BAS) during JR19002 in January 2020. Specifically, we collected CTD data to quantify trends in temperature and salinity and water samples to quantify microplastics. A N70 Plankton net was deployed at stations to assess the zooplankton community and an Agassiz trawl to sample the benthic community. We collected multibeam data to produce high-resolution bathymetry and a bottom profile for the Bank.

Baylis et al. 2019 Scientific Reports **9**, 8517
Fraysse et al. 2018 Polar Biology **41**, 2423-2433
Gordillo et al. 2019 Marine Biodiversity **49**, 1667-1681
Jones and Lockhart 2011 Marine Policy **35**, 732-736
Schejter and Bremec 2019 Scientia Marina **83**, 1-15
Schejter et al. 2020 Aquatic Conservation: Marine and Freshwater Ecosystems
Schejter et al. 2017 Pan-American Journal of Aquatic Sciences **12**, 248-253
Schejter et al. 2016 Polar Biology **39**, 2373-2386

8.2 STUDY AREA

Burdwood Bank comprises about 34,000km^2, delineated by the 200m isobaths of which about 11,400 km^2 (34%) are included in the Falkland Islands waters (Figure 8-1). Depths on the plateau range between 50 and 200m and decrease abruptly reaching from 2000 to more than 4000m on the northeast, east and south sides. Due to the persistent westerly winds and strong currents influenced by the Antarctic Circumpolar Current, the region is an extremely dynamic environment. Despite this the water column above the plateau appears to be fairly homogeneous vertically without a thermocline being recorded, with seasonal small variation in temperatures (ranging from 4 to 9°C), and with a mean salinity of 34 ppm.

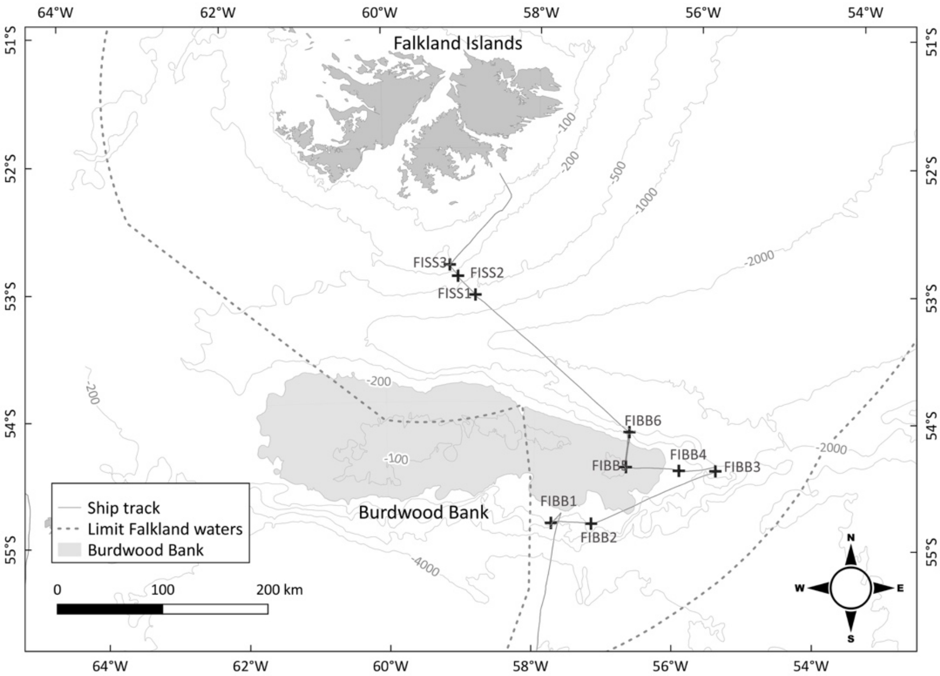


Figure 8-1 Map of Burdwood Bank showing the six stations on top of the bank (FIBB1-FIBB6) and the six stations south of Beauchene Island (not visible in the map). The grey line shows the ship track from the 31st of January to the 4th of February 2020. The dotted lines show the limit of the Falkland Islands waters.

8.3 DATA COLLECTION

Samples and data were collected while on board of the *RRV James Clark Ross* at six stations on Burdwood Bank and at three stations south-east of Beauchene Island, between the 31st January and the 4th of February 2020. The southernmost stations of Burdwood Bank (FIBB1 and FIBB2) were sampled on a previous survey in December 2018. The other four stations were selected to obtain data for the eastern (FIBB3-4) and northern (FIBB5) region of the Bank, and on top of the Bank (FIBB6). Data collection included CTD, water collection, N70 Plankton sampling, mini Agassiz trawl (AGT), and Shelf Underwater Camera System (SUCS). A summary of data collected at each station can be found in Table 8-1. At the first two stations of Burdwood Bank the AGT was carried out on the cruise conducted on December 2018 (JR18003) and was not repeated. Multibeam and TOPAS were also collected during navigation although technical issues prevented collection of good quality data for the majority of the navigation time.

Table 8-1 Summary of location and typology of data collected at the Burdwood Bank (FIBB stations) and southern of Beauchene Island (stations FISS) from the 31st of January to the 4th of February 2020. 1 AGT repeated twice at this station. SUCS: Self Underwater Camera System.

Stations	CTD	Water Collection	N70 Plankton Net	AGT	SUCS
FIBB1	V	V	V		V
FIBB2	V	V	V		V
FIBB3	V	V	V	V[1]	V
FIBB4	V	V		V	
FIBB5	V	V	V	V	V
FIBB6	V	V		V	V
FISS1					V
FISS2					V
FISS3					V

8.4 RESULTS

8.4.1 CTD DATA AND WATER BOTTLE SAMPLES

CTD deployments, with water sampling for microplastics at surface and at the bottom were performed at the six stations on Burdwood Bank. The sites are represented by CTD casts 64-69 on the logsheets and summarised in Table 8-2. Bottle depths where water samples were collected for microplastics are summarized in Table 8-3. Data processing was conducted by Dr. Mike Meredith (BAS) in the SBE Data Processing software (www.seabird.com/software). Due to the ship rolling in heavy swell, noisy data were recorded. The Loop Edit and Wild Edit steps in the SBE processing helped reduce (but did not eliminate) the noise in the data. The profiles of temperature, salinity, and fluorescence respect to the depth for the six stations sampled at the Burdwood Bank are presented in Figure 8-2.

Table 8-2 Summary of CTD stations at the Burdwood Bank. UTC time.

Time	Station	Bridge Number	Cast CTD number	Lat	Lon	Depth EA600_m	SST
31/01/2020 17:53	FIBB1	216	64	-54.95924	-57.75181	389.64	7.2994
01/02/2020 02:09	FIBB2	221	65	-54.95662	-57.19635	384.45	7.6952
01/02/2020 13:51	FIBB3	226	66	-54.49488	-55.51948	607.49	7.5195
02/02/2020 01:37	FIBB4	233	67	-54.50751	-56.01827	N/A*	7.5846
02/02/2020 12:34	FIBB5	235	68	-54.49727	-56.74416	106.12	7.783
02/02/2020 19:41	FIBB6	239	69	-54.21827	-56.71400	767.23	7.4128

*This table represents the official ship's log, however, the CTD was deployed to a depth of about 340m (see Figure 8-2)

To assess microplastic presence, each filter/litre collection will be examined under the microscope to count and classify plastic by type (e.g. fibre, fragment, foam, beads). Plastic samples will be then measured using ImageJ software and, depending on funding, tested with a micro-Fourier transform infrared spectroscopy (Micro-FTIR) to determine the composition. The water samples will also be used for environmental-DNA analysis. Analyses will be carried out by Tristyn Garza, University of West Florida.

8.4.2 N70 PLANKTON NET

Table 8-3 Bottle depths and temperatures for which microplastics were sampled. UTC time.

Time	Cast CTD number	Bottle No	Depth	Temperature
02/02/2020 20:19	69	4	4.45	7.28
02/02/2020 20:18	69	3	3.96	7.28
02/02/2020 20:04	69	2	737.26	3.88
02/02/2020 20:04	69	1	737.39	3.88
02/02/2020 13:28	68	4	3.91	7.47
02/02/2020 13:27	68	3	4.08	7.47
02/02/2020 13:23	68	2	95.62	5.43
02/02/2020 13:22	68	1	95.5	5.44
02/02/2020 01:54	67	4	4.96	7.44
02/02/2020 01:53	67	3	4.54	7.44
02/02/2020 01:46	67	2	334.87	4.75
02/02/2020 01:45	67	1	335.4	4.75
01/02/2020 14:23	66	4	1.99	7.27
01/02/2020 14:22	66	3	1.9	7.27
01/02/2020 14:08	66	2	601.73	3.96
01/02/2020 14:08	66	1	601.84	3.94
01/02/2020 02:32	65	4	1.06	7.39
01/02/2020 02:31	65	3	1.26	7.39
01/02/2020 02:23	65	2	370.33	4.34
01/02/2020 02:22	65	1	370.05	4.34
31/01/2020 18:09	64	4	2.92	7
31/01/2020 18:08	64	3	3.04	7
31/01/2020 18:00	64	2	370.8	4.28
31/01/2020 17:59	64	1	370.66	4.28

8.4.3 MINI AGASSIZ TRAWL (AGT)

The miniAGT was successfully deployed in four stations on Burdwood Bank (Table 8-5). Trawling in station FIBB3 resulted in a large quantity of material and needed to be sub-sampled (Figure 8-4) whereas station FIBB5 yielded very little material (relative to other stations), despite a second 10-minute trawling attempt.

*Table 8-4 N70 plankton net hauls in Burdwood Bank. Time refers to date and time of deployment. UTC time. Abbreviations: SST = sea surface temperature; SSS = sea surface salinity. * Depth corresponding to time of retirement as datum was not available at time of deployment.*

Station	Time	Bridge event number	Latitude	Longitude	EA600 depth (m)	SST	SSS
FIBB5	02/02/2020 17:18	238	-54.5003	-56.753	104.99	7.58	33.92
FIBB3	01/02/2020 14:36	227	-54.4949	-55.5195	383.91*	7.36	33.91
FIBB2	01/02/2020 02:49	222	-54.9566	-57.1964	384	7.54	33.88
FIBB1	31/01/2020 18:24	217	-54.9593	-57.7518	388.25	7.25	34.00

Table 8-5 Mini Agassiz Trawl start and end time (UTM) and location, and depth on the bottom for each station. Trawling was carried out twice at station FIBB5 because the first deployment resulted in little material collected. UTC time.

Bridge event No	Station	Date	Time Start	Time End	Delta	Latitude Start	Longitude Start	Latitude End	Longitude End	EA600 depth (m) Start
231	FIBB3	01/02/2020	21:46	21:54	00:08	-54.471	-55.526	-54.470	-55.525	758.6
234	FIBB4	02/02/2020	07:00	07:00	00:00	-54.504	-56.017	-54.504	-56.017	352.7
236	FIBB5a	02/02/2020	15:31	15:36	00:04	-54.498	-56.745	-54.498	-56.746	120.0
237	FIBB5b	02/02/2020	16:10	16:20	00:10	-54.499	-56.749	-54.500	-56.752	120.0
240	FIBB6	02/02/2020	22:23	22:28	00:05	-54.217	-56.729	-54.217	-56.730	707.5

A total of 1854 specimens belonging to 13 phyla and 56 taxa were collected on Burdwood Bank; for six specimens, taxa were not identified. The other 53 samples included more than one species of the identified taxa; these were kept in such a way in order to understand community structures around hard skeletal specimens such as corals. Specimens were preserved in 286 containers and 12 plastic bags. The number of specimens per each trawling station is reported in Table 8-6. Examples of specimens collected in Burdwood Bank with the AGT are shown Figure 8-5. The number of taxa is expected to increase following analyses.

Phylum composition for each station can be seen in Figure 8-6. Although one sample per station cannot fully characterize the benthic assemblage of the area, these data represent a valuable source of information and a baseline for future research. In station FIBB5 two trawling events were carried out, although sample size was small. The graphs corresponding to stations FIBB3 and FIBB4 show similar species composition with echinoderms, cnidarian, and bryozoans being the three most abundant taxa. Molluscs and crustaceans appear to also be an important component of the fauna in the deeper stations. These stations were located on the slope in the easternmost part of the Bank at about 35km of distance although at different depths, -757m and -353m respectively. Station FIBB5 is located in shallow water (-120m), on top of the Bank. Taxa composition in this station differs when compared to the previous two as sponges were the third most abundant group while cnidarians (the third most abundant group in the deeper stations) where almost absent. In addition, bryozoans were twice as abundant passing from 11-14% to 28%. Station FIBB6 (-708m), also located on the slope but

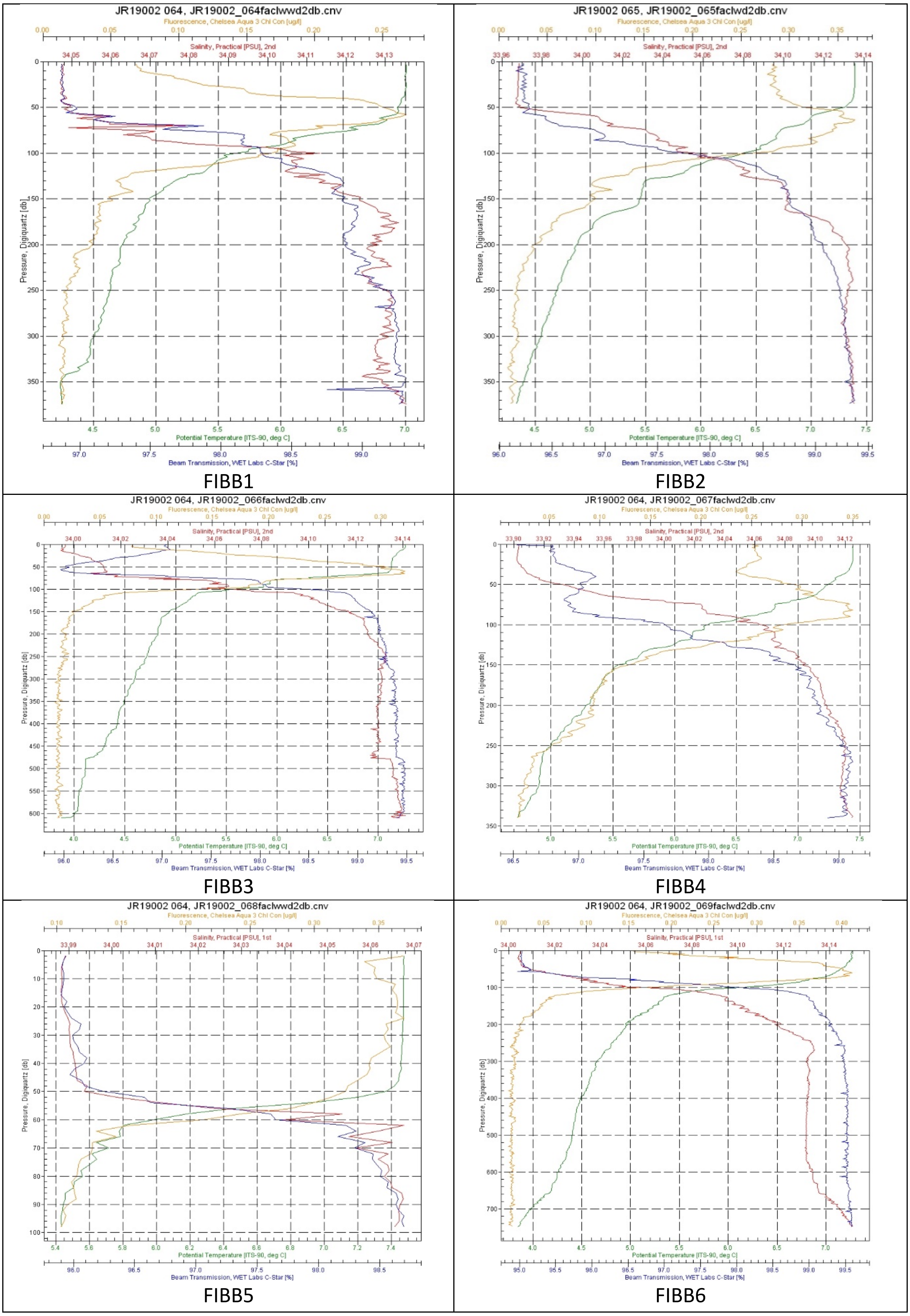


Figure 8-2 Profiles of temperature (green line), salinity (red line), and fluorescence (yellow line) respect to the depth (expressed as pressure) for the six stations sampled at Burdwood Bank. The blue line represents the beam transmission.

in the northern sector of Burdwood Bank shows a very different composition when compared to the other stations, with cnidarians being the most abundant group, followed by echinoderms and sponges. Number of phyla in this station also decreases from 10 to 7.

Figure 8-3 Plankton net ready for deployment

Figure 8-4 A. Material collected in station FIBB3; B. Example of the material collected; C. Some of the specimens sorted.

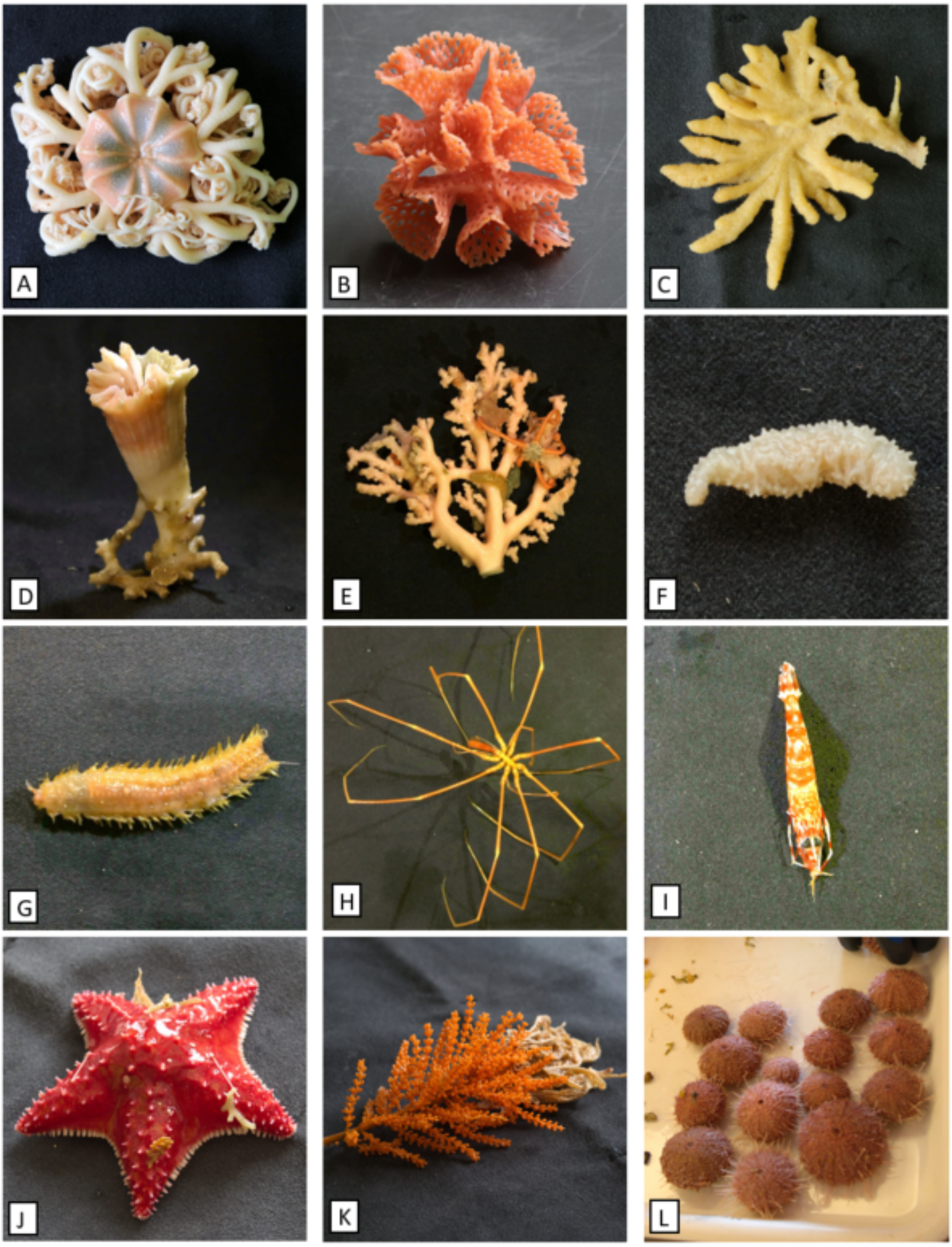


Figure 8-5 Examples of specimen collected on Burdwood Bank using AGT. A: ophiuroid genus Gorgonocephalus, B: bryozoan genus Reteporella, C: sponge genus unknown, D: cup coral order Scleractinia, E: lace coral family Stylasteridae with ophiuroid and polychaete, genera unknown, F: holothurian genus unknown, G: polychaete genus unknown, H: sea spider order Pantopoda, I: shrimp genus Camphylonotus (possibly C. semistriatus), J: starfish Gabraster anarctica, K: gorgonian with crinoid, genera unknown, L: sea urchins Sterechinus agassizii.

Table 8-6 Number of specimens collected at each trawling station using the AGT per taxa

Phylum/Taxa	FIBB3	FIBB4	FIBB5a	FIBB5b	FIBB6	Grand Total
Anellida						
Polychaeta	19	30	2	9	26	86
Brachiopoda						
Brachiopoda	6	15		1		22
Bryozoa						**185**
Bryozoa	65	58	24	38		185
Chaetognatha				**1**		**1**
Chaetognatha				1		1
Chordata					**6**	**6**
Thaliacea					6	6
Cnidaria						
Actinaria	2					2
Gorgonaria	2	4				6
Hydrozoa	10	7	1			18
Isididae		2				2
Octocorallia	21	1		1	10	33
Scleractinia	103	53	1		170	327
Sub Total	**138**	**67**	**2**	**1**	**180**	**388**
Crustacea						
Amphipoda		3		2		5
Crustacea	4	7		2		13
Decapoda			1	3		4
Isopoda	46	3	1			50
Mysidacea		1				1
Pantopoda	3	1		3	5	12
Sub Total	**53**	**15**	**2**	**10**	**5**	**85**
Echinodermata						
Ascidiacea	1	1				2
Asteroidea	53	13		11		77
Crinoidea	7	2	5	9		23
Echinoidea	17	7	21			45
Holothuroidea	6		2	19		27
Ophiuroidea	104	145	2	7	93	351
Sub Total	**188**	**168**	**30**	**46**	**93**	**525**
Hemichordate						
Hemichordate	9	5	1	1		16
Mollusca						
Bivalvia	10			7		17
Gastropoda	57	20	1	1		79
Mollusca				1	16	17
Sub Total	**67**	**20**	**1**	**9**	**16**	**113**
Nematoda						
Nematoda	1					1
Porifera						
Porifera	44	37	35	8	71	195

Sipunculida						
Sipunculida		1				1
Grand Total	**590**	**416**	**97**	**124**	**397**	**1624**

The class composition of echinoderms varies among stations (Figure 8-7). Ophiuroidea appear to dominate the community in the deepest stations while in the shallower station almost all groups are present in similar percentages. A similar trend occurs when considering the cnidarian composition per station, where the *Scleractinia* group appears to be the most important in the three deepest stations while in the shallower station class percentages are more similar, although cnidarian presence is very low compared to the other stations.

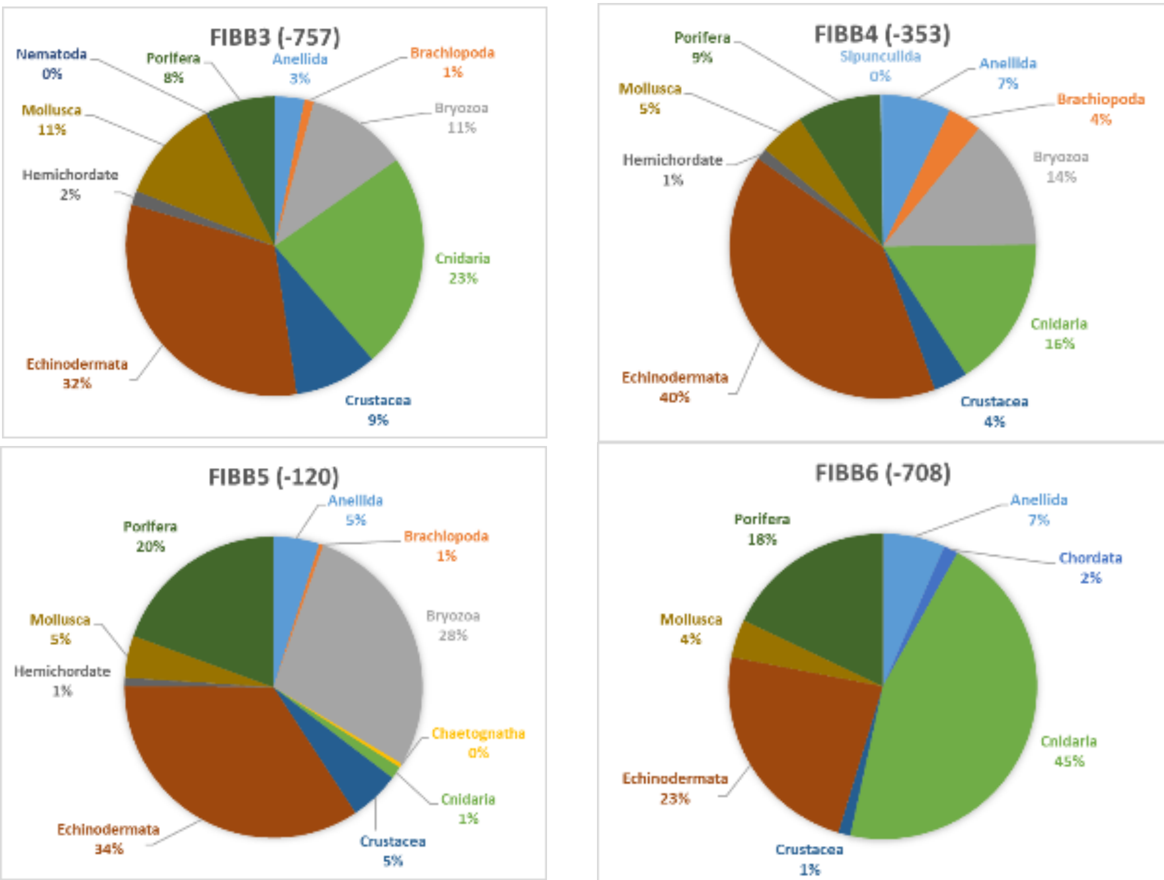
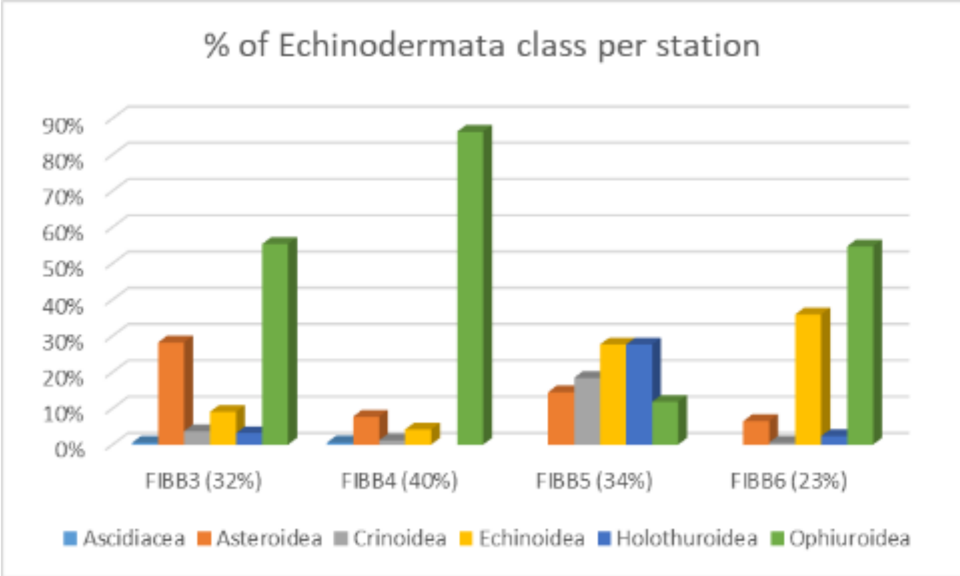


Figure 8-6 Percentages of specimen per phylum at each station. Trawling depth is reported in the parenthesis. In station FIBB5 two trawlings were carried out.



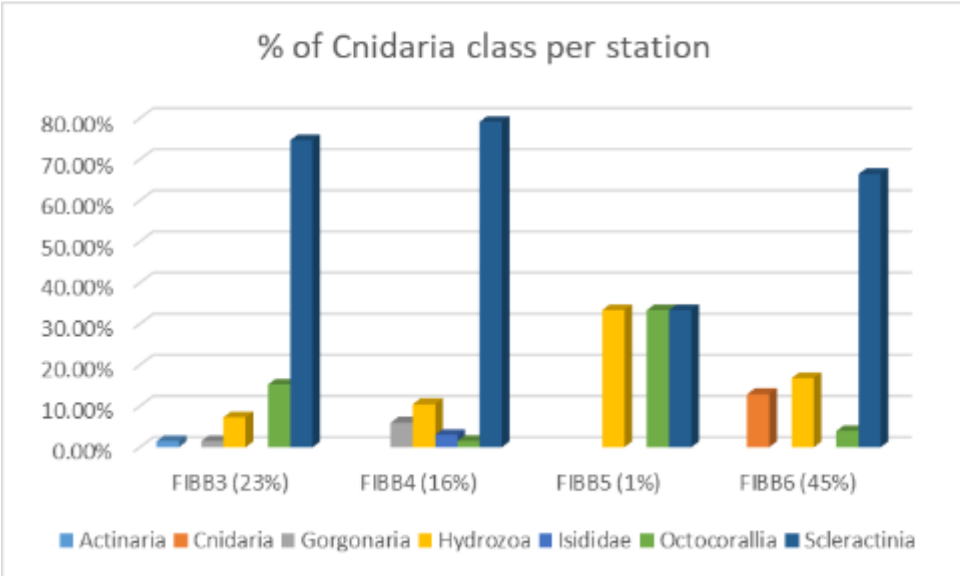


Figure 8-7 Percentage of Echinodermata and Cnidaria class per station. The % phylum occurrence is shown in parentheses.

8.4.4 SUCS

The Shelf Underwater Camera System (SUCS) was used at all five stations with the exception of station FIBB4 where weather conditions hampered the camera deployment. For the five stations in Burdwood Bank, three replicates with 20 pictures each were carried out (Figure 8-8); only one replicate of 20 pictures was possible in each of the three stations south of Beauchene Island (Figure 8-9), making the total number of underwater pictures taken 360.

Preliminary image analyses show higher biodiversity at the shallow station (FIBB5) on top of Burdwood Bank when compared to the other stations. The images have been analysed using the free software Photoquad to identify specimens at the lowest taxonomic level. Data will be used to better understand the biodiversity of the area as well as to identify the biological component of ocean carbon that is relevant in terms of uptake of atmospheric carbon dioxide and burial.

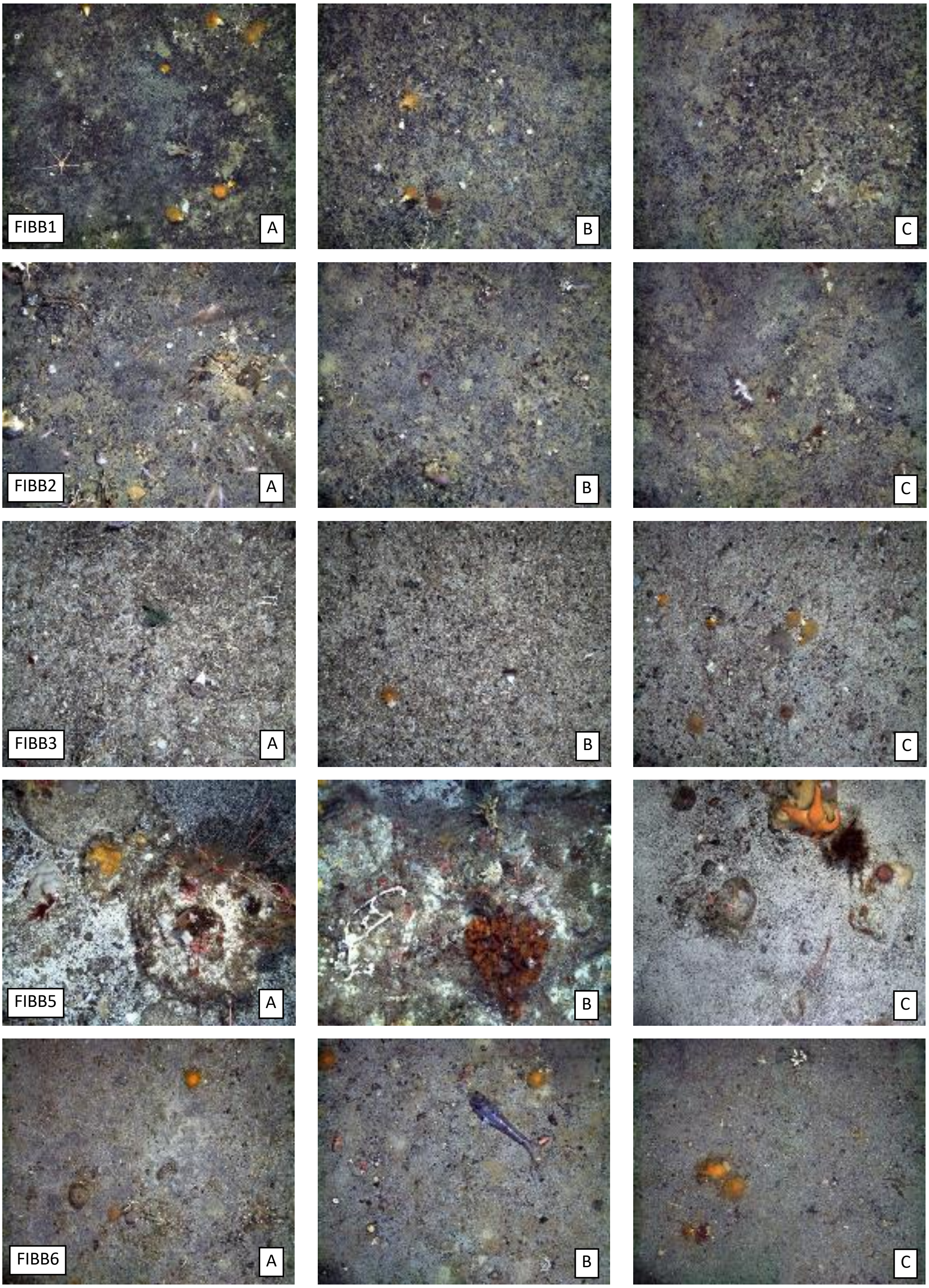


Figure 8-8 Examples of digital images taken in each stations at Burdwood Bank. Letters refers to the replicates in each station. The average depths per station are: FIBB1 -360m south, FIBB2 -412 south, FIBB3 -671 far east, FIBB5 -125 middle Burdwood Bank, FIBB6 -711m north.

Figure 8-9 Examples of images taken at each station south of Beauchene Island. The average depths per station and distance from Beauchene Island are the following: FISS1 -575m southernmost, FISS2 -396m, FISS3 -158m nearest.

8.4.5 MULTIBEAM AND TOPAS

The multibeam echo sounder returns information about the depth and shape of the seafloor whereas the topographic parametric sonar (TOPAS) system provides information about the density of the material *below* the water-seafloor boundary. The aim of the research was to obtain high-resolution bathymetry and sub-bottom profiler data from Burdwood Bank where data are poor or missing (Figure 8-10). Due to a problem with the instruments, data collected from the 31st of January to the 3rd of February had too much noise to be useful. The issue was resolved on the last day of data collection allowing for only eight lines of good data recorded on the northern part of Burdwood Bank and one during the transfer to Beauchene Island (Figure 8-11).

The multibeam tracks were essential to better understand the geological evolution of Burdwood Bank. In particular, a feature corresponding to a paleo cliff was identified on top on the Bank, suggesting that the region might have been above sea level in the past (Figure 8-12-Figure 8-14).

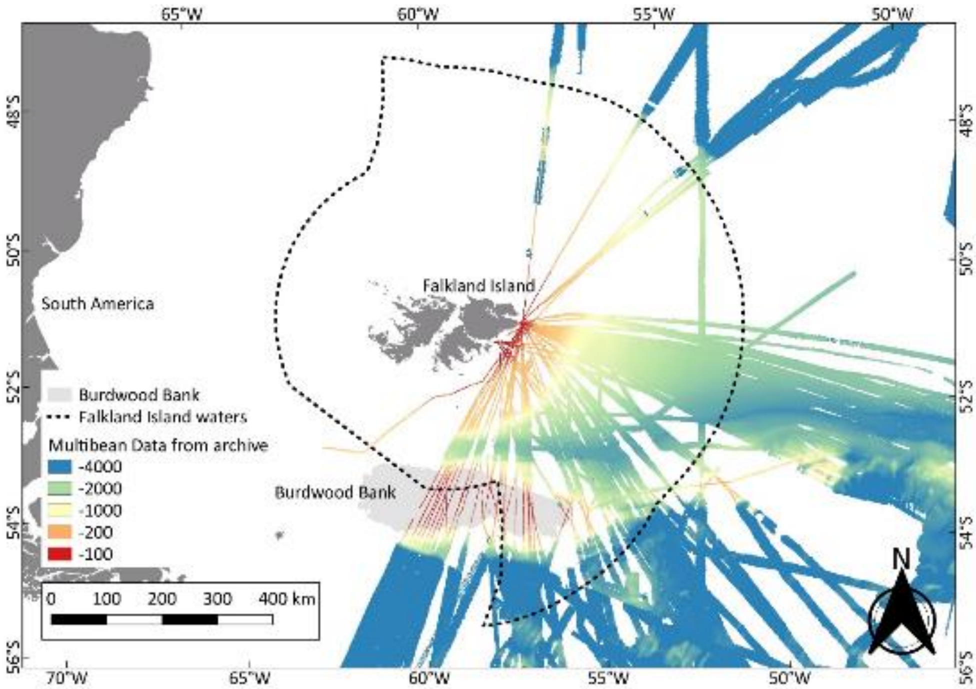


Figure 8-10 Multibeam data available from the British Antarctic Survey archive. The dotted black line shows Falkland Islands waters.

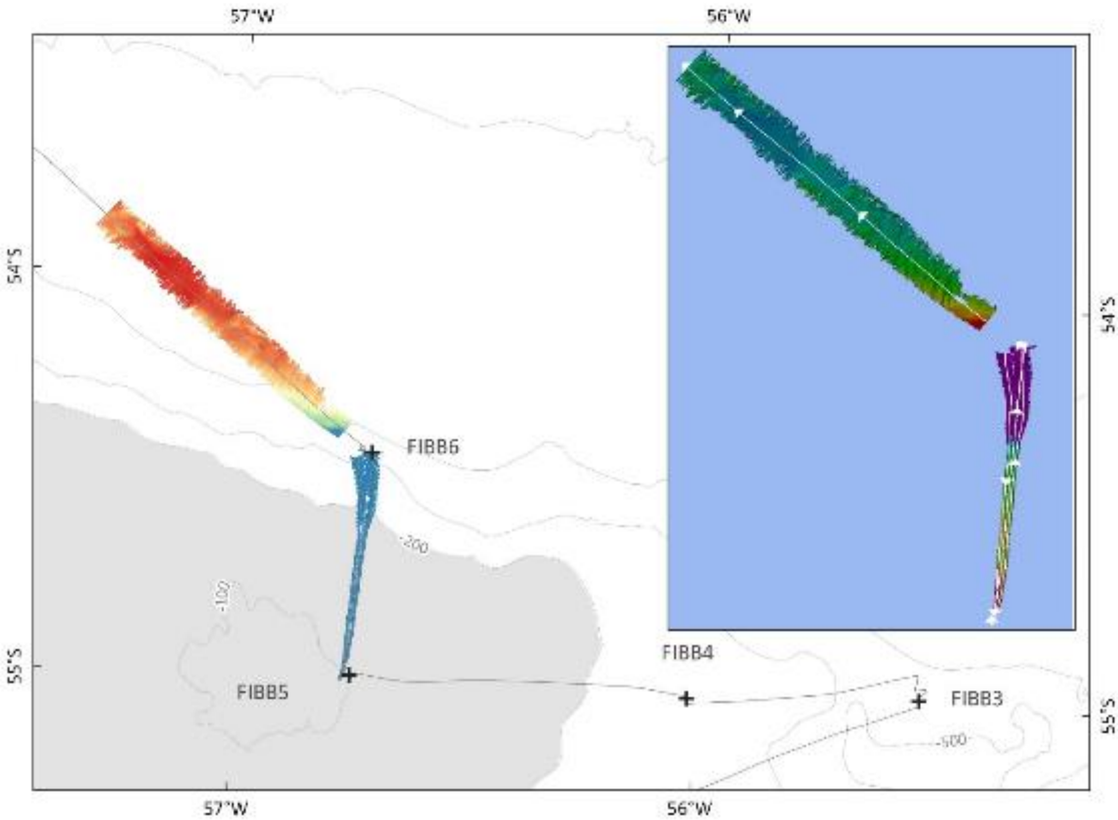


Figure 8-11 Multibeam tracks recorded during the JR19002 expedition between the stations FIBB5 and FIBB6 and during the transfer to Beauchene Island stations. The small window shows the navigation direction.

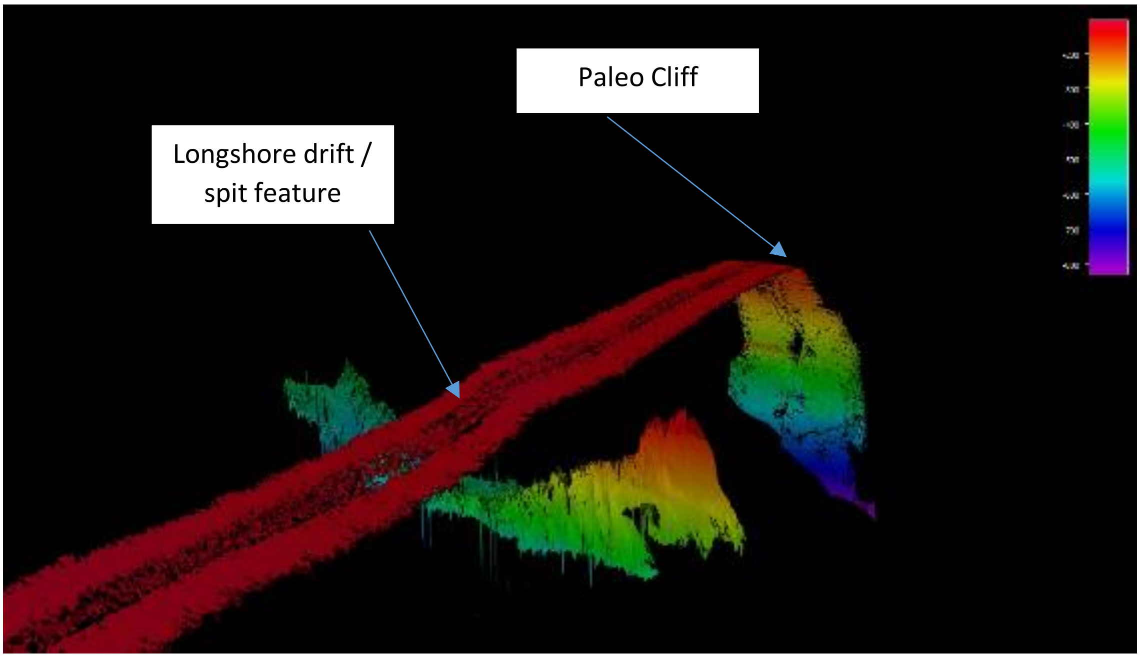


Figure 8-12 3D representation of Burdwood Bank covered during the JR19002 expedition, showing the presence of a palaeo cliff and a longshore drift feature (spit or transgressed bar). The feature suggests that the top part of Burdwood Bank was emergent in the past.

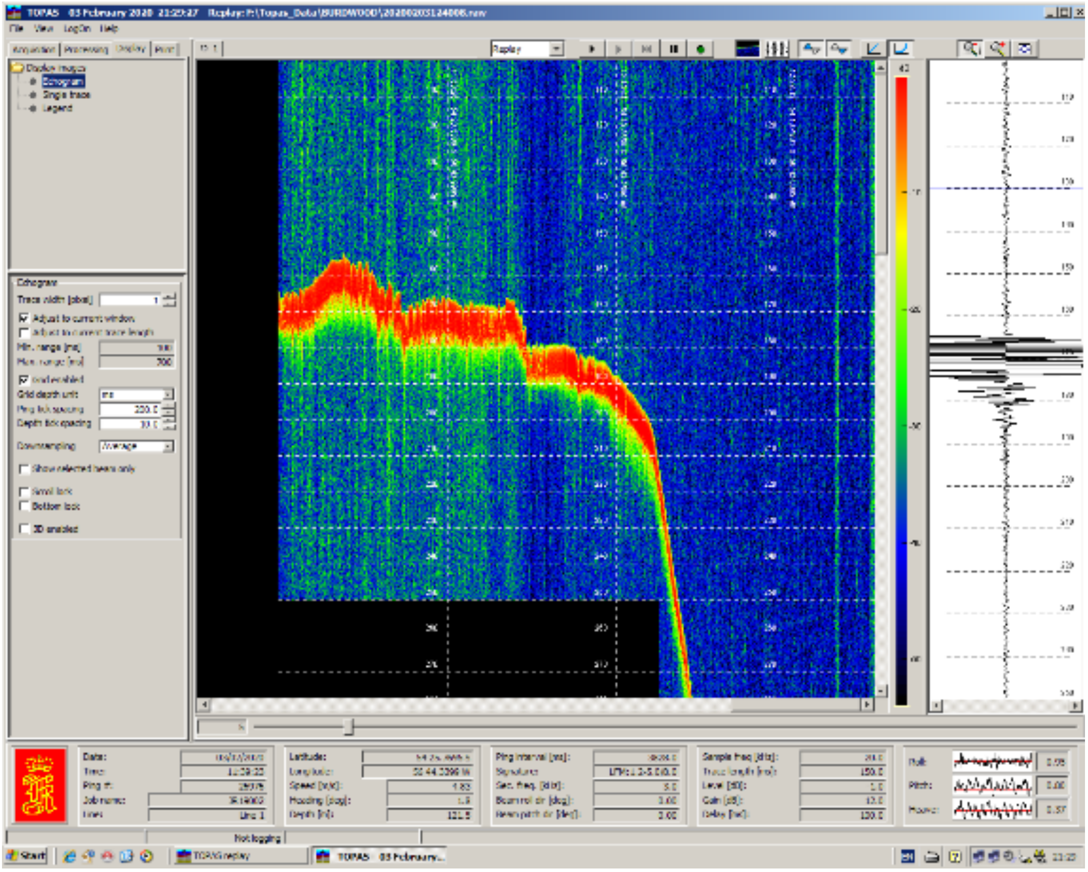


Figure 8-13 Detail of the profile of the paleo cliff identified in the multibeam data on top of Burdwood Bank

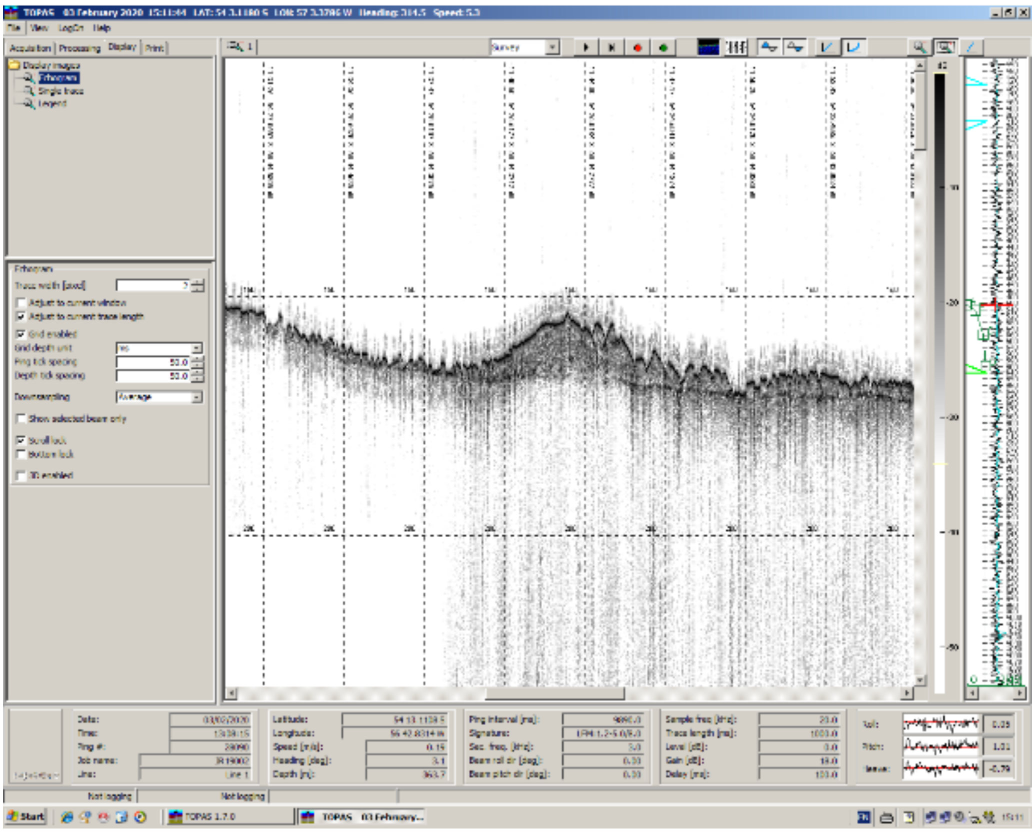


Figure 8-14 TOPAS profiles identifying a longshore drift feature on top of Burdwood Bank

9 DEEP IMPACT

Dr Dave Barnes, British Antarctic Survey

DEEP IMPACT is a 3-year BAS core funded project, currently in its second (middle) year. The purpose of the project is to assess iceberg scour disturbance below SCUBA depths around Ryder Bay as a deeper extension of Rothera Time Series (RaTS), Iceberg Impact Survey (IbIS) programme. IbIS has been monitored annually in South Cove, adjacent to Rothera Research Station since 2003. Deep Impact fieldwork is undertaken by repeat multibeam Swath mapping of the seabed from 100-400 m depth contours. If/when new icebergs scours are found they will be investigated using the SUCS benthic imaging apparatus by photographing benthic life in and around the identified scour. The final part of the work was daily sea ice observations, at Sheldon Cove by an automatic sea ice camera set up on Badger Buttress and PourquoiPas Island set up opposite Moraider Glacier.

The first year DEEP IMPACT fieldwork was carried out was the Austral summer of 2018/2019 on science cruise JR18003, with the multibeam run by Kate Retallick (Bangor University) and Floyd Howard (BAS). On JR19002 the multibeam team was Kate Retallick (Bangor University) and Alice Fremand (BAS). The multibeam component of DEEP IMPACT work took place on 17th January 2020 (Figure 9-1); no SUCS was undertaken and the sea ice camera at PourquoiPas Island was visited on 18th January 2020 (Figure 9-2). The snow clearing wiper on the original camera installed had broken so had been removed in 2018/19 so the plan was to replace the whole camera system with one from BAS, Cambridge. However, on arrival at the camera placement a new power fault was discovered in the new system so the old and new camera boxes were cannibalised to make one functioning unit, which was tested to be okay. The memory card of the old camera was found to have recorded a year's worth of sea ice observations as planned.

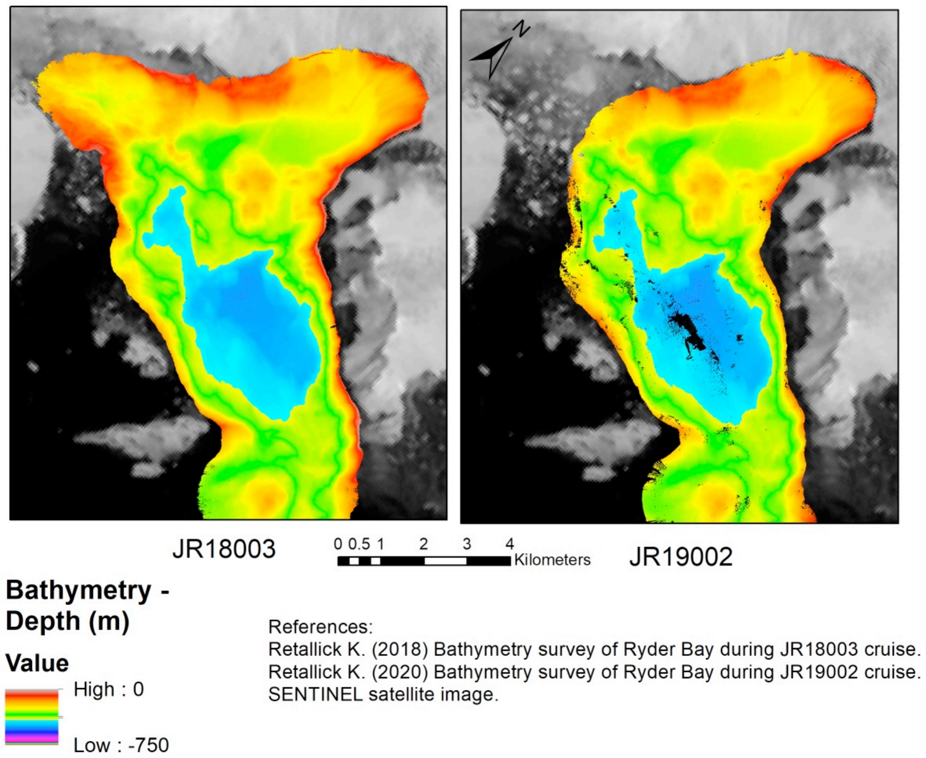


Figure 9-1 DEEP IMPACT multibeam imagery

Figure 9-2 Sea ice camera being serviced at Pourquoi Pas Island (left) and in position at Badger Buttress (right).

10 ROTHERA MOORING DEPLOYMENT

10.1 BACKGROUND

For over 20 years, the Rothera time series has acquired weekly measurements of physical and biological water column properties to assess the changing temperature and ecosystem changes of the West Antarctic. While highly valuable in their own right, it has been increasingly realised that several important processes happen at shorter timescales than are easily sampled with the existing measurements alone. With this in mind, funding was acquired to deploy a year-long mooring close to the existing Rothera time series site.

The mooring includes CTDs, current meters and ADCPs to measure velocity and water column turbulence, and a sediment trap capable of collecting 21 x 250ml of organic material. It has recently been demonstrated from underwater glider deployments near Rothera that turbulence levels are significantly enhanced over the topographic sill that separates Ryder Bay from Laubeuf Fjord, yet the controlling processes on this interaction and its effect on water property transformations remain poorly known. This package of work will significantly enhance the existing CTD and glider capabilities and better quantify the high-frequency variability that occurs in the ocean close to Rothera.

10.2 DEPLOYMENT OPERATIONS

Deployment of the mooring was conducted from the aft deck of the JCR utilising the A-frame and mooring winch. After discussion with the bridge it was decided to deploy the mooring in an anchor last configuration. This method saw the mooring deployed in reverse order with the top (shallowest) element being deployed first and streamed out behind the vessel as it progressed towards the deployment location. Inline mooring elements were connected into the mooring line by securing the outboard section of the mooring to a hard point on deck, disconnecting the mooring line and connecting the inline mooring element into the mooring. Clamp on elements were fitted by simply clamping them onto the mooring line.

Deployment progressed smoothly without any incidents. The mooring was released just beyond the planned mooring position to allow for some lay-back when the mooring dropped through the water. Attempts were made to triangulate the final position using an acoustic deck unit. However, communicating with the releases was intermittent to the point where positions were not deemed to be reliable. A GPS fix from the bridge at the time of anchor release was used as the deployment position. Given the water depth of 400m it is not anticipated the mooring will have fallen too far from the original drop location.

Table 10-1 Deployment location

Mooring	Deployment date (UTC)	Recovery date (UTC)	Latitude (DD MM.m)	Longitude (DDD MM.m)	Latitude (DD.d)	Longitude (DD.d)	Depth (m)	JR19002
Rothera Mooring	12-Jan-2020 13:17		67°S 34.850'	068°W 09.340'	-67.5808	-068.1556	400	1
target:	-	-	67°S 34.850'	068°W 09.340'	-67.5808	-068.1556	400	

Bridge calculated position – no deck unit triangulation

10.3 MOORING INSTRUMENTATION AND SETUP

The Rothera mooring is constructed of 12mm Gleistein Tasmania braid-on-braid polyester and 8mm 12-strand single-braid polyurethane-coasted polyester (Maffioli Evolution Splice) in addition to 12mm 3-strand polypropylene for a recovery line. Floatation comprises two strings of Vitrovex glass spheres mounted on 3m Kevlar topes using Vitrovex's Eddygrip swivel system. A Trelleborg elliptical float was used to mount the 75kHz ADCP and provide additional buoyancy within the mooring. At the top of the mooring, five 9 inch Neptunplast trawl floats were used to float the recovery line.

The 75kHz RDI Long Ranger ADCP was mounted within the Trelleborg buoy in an upward facing configuration with the intention of sampling the entire water column. To aid recovery and notify any unplanned surfacing, a Novatech iBCN-7 Iridium beacon, Xeos XMA-11 Argos beacon and a Novatech RF-700C1 VHF and flasher combo beacon were also fitted to the Trelleborg floatation. A McLane MK78H sediment trap was installed approximately 25m above the releases and was configured to sample over the 1-year deployment duration with concentrated sampling around the expected flux events. The 600kHz RDI Workhorse Sentinel ADCP was mounted within a Deepwater Buoyancy inline frame (ILF-001-HF), also in an upward looking configuration. This ADCP was fitting with a lithium battery pack and a high-resolution water profiling firmware upgrade with a view to capturing turbulence events. The two SBE37-SMP microcat CTDs were clamped to the mooring line with a section of 8mm inner diameter plastic hose to act as strain relief. At the bottom of the mooring two IXSEA Oceano 2500S (AR861) acoustic releases were coupled together in an either/or release configuration meaning only one release needs to be fired in order to release the mooring from the anchor. The anchor itself was a 750kg clump of 48mm stud link chain.

Instrument configurations can be found in the tables below.

On the 4th January 2020, both microcat CTDs were attached to the JCR CTD rosette and sent down for a calibration cast. Stable parts of the profile, in terms of temperature and conductivity, were identified from the downcast. Two stops that provided a reasonable difference in temperature and conductivity were selected, i.e. a "warm" calibration point and a "cold" calibration point. The CTD was held at these two stops for at least 2-minutes.

Table 10-2: SBE37-SMP MIcrocat instrument configurations

	SBE37-SMP Microcat
Sampling interval	300 s
Data format	Converted Engineering
Pump minimum conductivity frequency	3000
Battery	12 SAFT LS14500

Table 10-3: 600kHz Workhorse Sentinel configuration

Ensemble interval	1 second	TE00:00:01.00
Time per burst	1 hour	TB01:00:00.00
Ensemble per burst	300	TC300
Pings per ensemble	2	WP2
Profiling Mode	11	WM11
Number of cells	26	WN26
Depth cell size	10 cm	WS10
Processing bandwidth	Wide	WB0
Blanking distance	88cm	WF88
Mode 5 Ambiguity velocity	20 cm/s	WZ20

Table 10-4: 75kHz Long Ranger configuration

Ensemble interval	30 minutes	TE00:30:00.00
Time between pings	Pings spread evenly over ensemble	TP02:43.63
Ensemble per burst	300	TC300
Ping per ensemble	11	WP11
Number of cells	27	WN27
Depth cell size	16 m	WS1600
Processing bandwidth	Wide	WB0
Blanking distance	7.04 m	WF704
Ambiguity velocity	1.75 m/s	WV175

Table 10-5: McLane MK78H bottle schedule

Event Number	Event Start Time (mm/dd/yy hh:mm:ss)
Event 1 of 21	01/14/20 00:00:01
Event 2 of 21	01/26/20 00:00:01
Event 3 of 21	02/10/20 00:00:01
Event 4 of 21	02/25/20 00:00:01
Event 5 of 21	03/11/20 00:00:01
Event 6 of 21	04/03/20 00:00:01
Event 7 of 21	04/18/20 00:00:01
Event 8 of 21	05/20/20 00:00:01
Event 9 of 21	06/21/20 00:00:01
Event 10 of 21	08/21/20 00:00:01
Event 11 of 21	10/01/20 00:00:01
Event 12 of 21	10/16/20 00:00:01
Event 13 of 21	11/01/20 00:00:01
Event 14 of 21	11/16/20 00:00:01
Event 15 of 21	11/26/20 00:00:01
Event 16 of 21	12/06/20 00:00:01
Event 17 of 21	12/16/20 00:00:01
Event 18 of 21	12/26/20 00:00:01
Event 19 of 21	01/10/21 00:00:01
Event 20 of 21	01/25/21 00:00:01
Event 21 of 21	02/09/21 00:00:01

10.4 MOORING SCHEMATIC

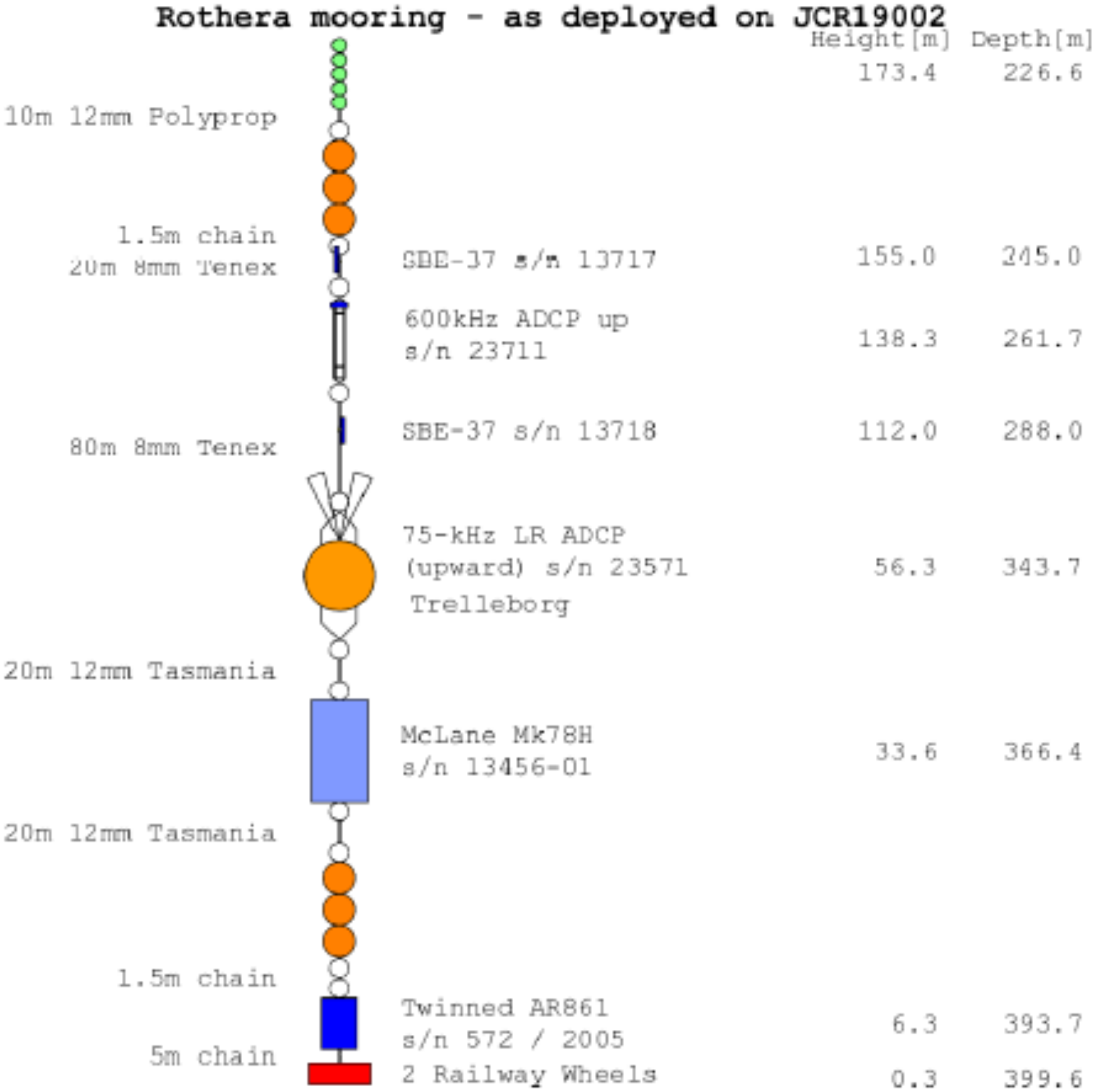


Figure 10-1 Mooring schematic

11 Chilean collaboration

Dr Carlos Munoz-Ramirez, Universidad Catolica de la Santisima Concepcion, Chile*; Fabian Guzman, Universidad Catolica de la Santisima Concepcion, Chile

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ICEBERGS is a UK-Chilean collaboration program, supported by a NERC-CONICYT grant, with Dr. Antonio Brante from Universidad Catolica de la Santisíma Concepción (UCSC) as the PI in the Chilean group. The Chilean team includes (as associated researchers) Dr. Patricio Camus (UCSC), Dr. Florence Tellier (UCSC), Dr. Angel Urzua and Dr. Carlos Munoz (UCSC). The project adopts a multidisciplinary approach to evaluate the role of climate change on Antarctic benthic ecosystems. The Chilean collaborators contribute to this project with their experience in ecological, genetic and bioenergetic analyses that contribute to the understanding of relevant processes at the individual and population levels within the main frame of the project. In addition to Dr. Carlos Munoz (UCSC), MSc student Fabian Guzman joined this year's cruise to collaborate with the sampling process and will perform part of the bioenergetic analyses at the UCSC.

11.1 BIOENERGETICS

As glaciers retreat due to the increase in temperatures, meltwater discharge from glaciers is causing physical changes in the sea that may impact on benthic fauna as environmental stressors. At the individual level, stressors affect physiological processes and bioenergetic components that may be translated as a deficiency in individual performance directly impacting population dynamics and community structure. Hence, these changes in environmental conditions in Antarctic waters may influence fitness traits of individuals such as growth, survival and reproductive output. In this situation, it is expected that organisms inhabiting localities impacted by ice loss and deglaciation may show a decrease in bioenergetic constituents, nutritional condition and reproductive output. In this project we will evaluate the effects of these perturbations on the bioenergetic, nutritional quality and reproductive output of Antarctic marine invertebrate organisms. We will examine such physiological parameters in the context of temporal disturbance revealed through sclerochronological analyses of mollusc shells as well as multiple environmental variables provided by CTD data. At the time of writing this cruise report, a manuscript has been submitted for publication.

11.2 GENETICS

Extreme perturbation events, such as ice loss and deglaciation, not only produce important effects at individual and ecological levels but also at the genetic level, with implications for the long-term sustainability of local benthic ecosystems. Decrease in species abundances as a result of perturbations may produce a genetic bottleneck increasing genetic drift and negatively impacting genetic diversity. In addition, both theory and experiments indicate that allelic richness is more sensitive to the effects of short, severe bottlenecks than is haplotype diversity. These genetic changes would affect viability of populations at two temporal scales: (1) over the short term it is expected that a reduction in genetic diversity will lead to an increase in the susceptibility of populations to pathogens and parasites, and fastening the fixation of deleterious alleles. (2) Over the long term, the diminished population would reduce their capacity to respond to changing selection pressures if genetic reduction is associated with adaptive genes and so the absence of genetic variation may increase the risk of extinction. Increasing local fecundity may not be an effective strategy to compensate for abundance reduction because glacier perturbations strongly affect mortality of benthic species locally. In contrast, abundance and genetic population diversity may be maintained by immigration (dispersal), the “rescue effect”. In this situation, genetic diversity would be maintained or would be less impacted through genotype immigration from neighbouring populations. The significance of the rescue effect depends on the extent of the perturbation effect and the dispersal potential of the species. We predict a reduction of genetic diversity in localities impacted by ice loss and deglaciation with higher effects in species with low dispersal potential than those with high dispersal potential. In addition, disturbed localities will show less population connectivity (higher population genetic distance) and higher inbreeding levels than less impacted localities.

Another aspect that is being investigated is the potential role of oceanic currents on species migration. In the shallow waters of the Western Antarctic Peninsula, it seems that coastal currents such as the Antarctic Peninsula Coastal Current (APCC) and the Antarctic Coastal Current may play a dominant role in the dispersal of species with a larval stage. However, the Antarctic Circumpolar Current (ACC), which is predominant in the open ocean around Antarctica, may also contribute in this respect. We will therefore use genetic information in order to provide indirect evidence about the potential role of the different oceanic currents on species dispersal. At the time of writing this cruise’s report, a manuscript about the latter topic has been submitted to the Royal Society Open Science journal for consideration for publication.

Sampling for all these objectives was performed using the Hamon Grab, whose experimental design and protocols are explained in detail in section 7.4.

12 Outreach activities

Alice Guzzi, University of Sienna, Italy; Dr Alejandro Román González, University of Exeter, UK; Livia Oldman, British Antarctic Survey

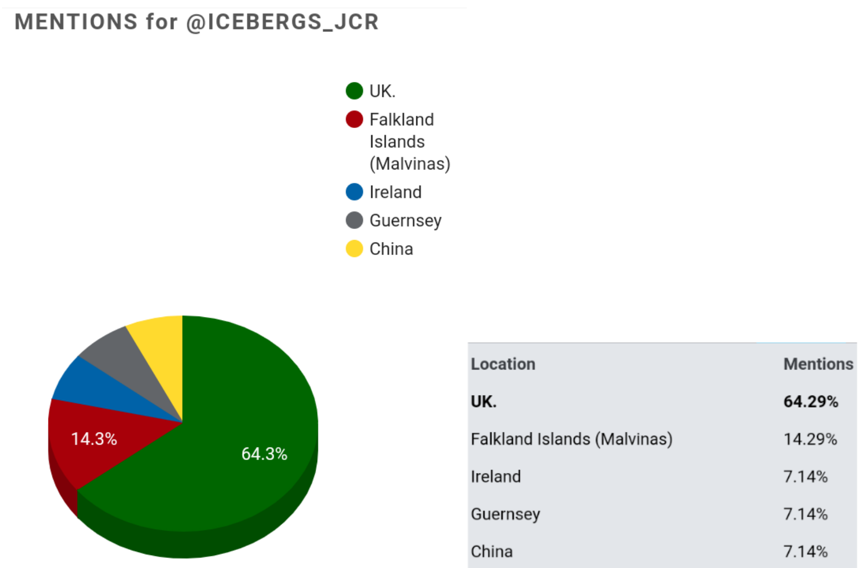
The activities carried out during the expedition were promoted through two main social media as the main platforms to communicate with the public: Twitter and Instagram. The creation of a hashtag dedicated to the cruise (#ICEBERGS3) allowed easy access to all the contents and to simplify the sharing on different social media platforms. One of the main problems faced during the cruise regarding the sharing of online content was the absence of internet connection at some sampling sites; in these cases the publication of materials has been postponed. The participation of the Sky News team was an extraordinary contribution to share the activity carried out on board with all interested.

12.1 TWITTER

During ICEBERGS3 Twitter was the main social media used. Thanks to the collaboration of the participants we were able to start updating the profile before the beginning of the expedition with the team presentation posts. The profile, ICEBERGS_JCR, active since September 2017, has reached 892 subscribers. The sharing of material related to the cruise from the team members on their own private social media pages enabled the frequency of tweets to remain high. This year the ICEBERGS_JCR had a high profile on this social media; many of these contributions came from UK (64.29%), Falkland Island (14.29%) followed by Ireland, Guernsey and China (7.14%). Unfortunately, the unstable internet connection did not allow us to publish material frequently. Most of our follower results were from the UK (57.54%), followed by USA (14.96%), Australia (2.88%), Canada (2.3%); for details see Table 12-1 and Figure 12-1.

Table 12-1 Twitter data

MONTH	N of Tweets	Tweet impressions	Profile visits	Mentions
JAN 2020	18	66.8K	981	144
FEB 2020	2	20.2K	120	9



Location	Mentions
UK.	**64.29%**
Falkland Islands (Malvinas)	14.29%
Ireland	7.14%
Guernsey	7.14%
China	7.14%

Location	Followers
UK.	**57.54%**
USA	14.96%
Australia	2.88%
Canada	2.3%
Ireland	1.96%
France	1.84%
Norway	1.61%
Falkland Islands (Malvinas)	1.38%
Italy	1.27%
Chile	1.27%
Spain	1.04%
Germany	1.04%
Brazil	0.92%
Finland	0.92%
Argentina	0.92%
Netherlands	0.92%
Sweden	0.92%
South Africa	0.69%
New Zealand	0.69%
Switzerland	0.69%
India	0.46%
Seychelles	0.35%
Denmark	0.35%
Greenland	0.35%
Peru	0.35%
Romania	0.12%
Portugal	0.12%
Costa Rica	0.12%
Guernsey	0.12%
Bermuda	0.12%
Pakistan	0.12%
Kuwait	0.12%
Cameroon	0.12%
Slovakia	0.12%
Greece	0.12%
Bermuda	0.12%
Pakistan	0.12%
Kuwait	0.12%
Cameroon	0.12%
Slovakia	0.12%
Greece	0.12%
Colombia	0.12%
Nepal	0.12%
Kenya	0.12%
Uruguay	0.12%
Mongolia	0.12%
Malaysia	0.12%
Czechia	0.12%
Ukraine	0.12%
Egypt	0.12%
Turkey	0.12%
Austria	0.12%

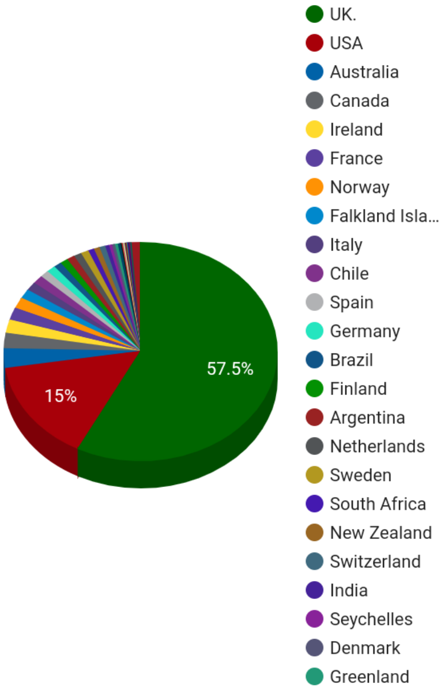


Figure 12-1 Twitter data

12.2 INSTAGRAM

The sharing of material through this social network has expanded public profile and involved different age groups. The Instagram profile, active since October 2018, has reached 204 followers, with an average of 40 likes for each shared photo.

12.3 SKY NEWS MEDIA VISIT

British Antarctic Survey runs an annual media visits programme which facilitates up to two media visits to Antarctica per year. Over the past 20 years, BAS has taken many of the major news and TV broadcasters, along with children's TV, print journalists, news agencies and several documentary makers. This media visit provided an opportunity for BAS and NERC to continue to raise awareness of UK Antarctic research and understanding the impacts of climate change in the region.

Sky News successfully applied to BAS in May 2019 to join the ICEBERGS3 cruise. They have an annual TV Reach of just under 22 million in the UK every quarter. Sky News has shown a commitment to environmental reporting and through their Ocean Rescue campaign, they are credited with transforming public, political and business attitudes to plastic.

The media team of three consisted of Thomas Moore, Science Correspondent, David Rees, Cameraman and Livia Oldland, Communications Manager from BAS. In the run up to the cruise, a joint reporting plan was created, along with several preparatory meetings in Cambridge and London.

Sky News produced a range of packages suitable for today's online news environment, including live broadcasts, news segments, podcasts, mobile/social media videos and online rich media content. A documentary of around 30 minutes will be published shortly after the cruise.
Sky News also produced a daily blog throughout the 30+ day cruise, with interviews with crew members, scientists and research station staff. It included a mixture of content from history on Antarctica, ship life and the latest research on polar science.

BAS cross-promoted the Sky News coverage and online content on their own internal and external channels, including social media channels (Twitter: 40k followers, Facebook: 31k followers) and internal Digital Workspace,

Table 12-2 Media Reports from ICEBERGS3 Cruise

Date	Type	Title	Subject	Link
30.12.2019	Live broadcast	N/A	Start of ICEBERGS3 cruise	N/A
30.12.2019	Online article	Climate crisis: Scientists brave the cold to study the hell that Antarctica could unleash	Climate change, sea level rise, deglaciation,	Link
06.01.2020	Live broadcast from Rothera			
09.01.2020	Live broadcast from Rothera			
10.01.2020	News package	Climate change in Antarctica	Thwaites, climate change, elephant seals, marine mammals	

Mid January	Online article	On the edge: Why Antarctica's melting ice sheet will affect the UK	Sea level rise, climate change, ice sheet collapse	Link
22.01.2020	News package	Antarctica Sea Plastic	Microplastics	
22.01.2020	Mobile/social media video	Camping on the ice	Surviving in the field	
	Mobile/social media video	Life at Rothera		
27.01.2020	News package	The geopolitics of Antarctica	Antarctic Treaty, geopolitics	
27.01.2020	Live broadcast	N/A	200th anniversary of the discovery of Antarctica	N/A
27.01.2020	Online article	The future of Antarctica	Antarctic Treaty, geopolitics	
27.01.2020	Online article	National flags, military presence and pregnant women - the battle for Antarctic dominance	200th anniversary of the discovery of Antarctica, Antarctic Treaty, geopolitics	Link
27.01.2020	Online article	Antarctica: A timeline of human discovery	History of exploration and science in Antarctica	Link
28.01.2020	As live	N/A	Climate change in Antarctica	
03.01.2020	Podcast	1. Ice Bound - en route to Antarctica	Navigating in the Southern Ocean, running the galley aboard the JCR,	
13.01.2020	Podcast	2. On the edge - Antarctica's melting ice shelves	Rothera, climate change, sea level rise, Thwaites, ice diving, elephant seals	
28.01.2020	Podcast	3. Antarctica - Beneath the Surface	ICEBERGS3 cruise, deglaciation, carbon sequestration, carbon storage, microplastics,	
	News article	'Big worry' as scientists find plastic 'pouring' into Antarctica	Microplastics	Link
15.01.2020	YouTube Video	A New Climate: Antarctica under Threat		Link
04.02.2020	News package	Deglaciation in Antarctica	Calving off Williams Glacier in Börgen	

13 AME Scientific Ship Systems Cruise Report

Seth Thomas (Ship Science Engineer), British Antarctic Survey; Leigh Wirtz (BAS Instrument Contact), British Antarctic Survey; Mike Rose (Head of Antarctic and Marine Engineering), British Antarctic Survey.

AME onboard JR19002: Seth Thomas, Thomas Owen

13.1 INSTRUMENTATION: SYSTEMS USED ON CRUISE

Instrument	#SN if Used	Make and Model	Comments
Lab Instruments			
AutoSal	63360	Osil	Worked well
AutoSal	68959	Osil	Ran hot, see below.
Scintillation counter	SGTC20150612	PERKINELMER TRI-CARB 2910TR	Not used on cruise
XBT	NO		
UWIA	Yes		
Acoustic			
ADCP	Yes		
EM122	Yes		
TOPAS	Yes		
EK60/80	Yes		
K-Sync	Yes		
SSU	No		
USBL	Yes		
10kHz IOS Pinger	No		
Benthos 12kHz Pinger	No		
Benthos 14kHz Pinger	No		
Mors 10kHz Transponder	No		
EA600	Yes		Bridge Equipment but logged
Oceanlogger			
Barometer1	V145002	VAISALA PTB210B1A2B	Inside the UIC
Barometer2	V145003	VAISALA PTB210B1A2B	Inside the UIC
Air humidity & temp1	61019333	Rotronic Hygroclip 2	On Foremast
Air humidity & temp2	61019251	Rotronic Hygroclip 2	On Foremast
TIR1 sensor (pyranometer)	172882	Kipp & Zonen Sp Lite2	On Foremast
TIR2 sensor (pyranometer)	172883	Kipp & Zonen Sp Lite2	On Foremast
PAR1 sensor	160959	Kipp & Zonen PQS-1	On Foremast
PAR2 sensor	160960	Kipp & Zonen PQS-1	On Foremast
Thermosalinograph	4524698-0018	SBE45	PrepLab
Transmissometer	1399DR	CST	PrepLab
Fluorometer	1498	WSCHL-1498	PrepLab

Flow meter	05/811950	LitreMeter F112-P-HC-AP-OR-PP	PrepLab
Seawater temp 1	0601	SBE38	Sea Inlet
Seawater temp 2	0599	SBE38	Sea Inlet

Instrument	#SN if Used	Make and Model	Comments
CTD			
Deck unit 1	0458	SBE11plus	
Underwater Comms/ Depth	0480	SBE9plus	
Temp1	5766	SBE3plus	
Temp2	2366	SBE3plus	
Cond1	2255	SBE 4C	
Cond2	2289	SBE 4C	
Pump1	1813	SBE5T	
Pump2	4709	SBE5T	
Standards Thermometer	0047	SBE35	
Transmissometer	CST-1505DR	C-Star	
Oxygen sensor	2291	SBE43	Plumbed on T2&C2 line.
PAR sensor	70688	QCP2350	
Fluorometer	088216	CTG Aqua Tracker MkIII	
Altimeter	10127.27001	Tritech S10127 232	
CTD swivel linkage	196115	Focal Technologies Group	
LADCP Master Down	14443	TeleDyne WHM300	
LADCP Slave Up	14897	TeleDyne WHM300	
Pylon	0636	SBE32	
Other ship's systems (non-AME)			
Anemometer	Yes		Bridge Equipment, logged
Ships Gyro	Yes		Bridge Equipment, logged
System(s) brought by science team (non-AME)			
EXTRA NOTEWORTHY Sensors	No		

13.2 NOTES FOR LAB INSTRUMENTS USED

13.2.1 AUTOSAL

AutoSal #68959 was observed to have a significantly higher bath temperature than the other unit (63360) while both had the same target temperature. The front panel was also much warmer to the touch. This was found to be due to the small window illumination lamp that allows the user to view the conductivity cell.

Voltage and bulb comparisons between the two units showed no discrepancies and the only difference between the two was the material used to mount the bulb holder. It is surmised that the wood used on 68959 conducts heat much more readily than the plastic block on 63360. It is recommended that the wood be replaced with nylon or some such when back in Cambridge. This was not done during the cruise so as to keep the temperature stable in the lab.

63360 has a biological build up that did not shift by use of a long ethanol rinse. It is advised that this unit gets a deep clean before being used again.

13.2.2 UNDERWAY ISOTOPE ANALYSER (UWIA)

The UWIA had a new pump installed and a fresh cylinder of Dry-Rite fitted on the 22nd January 2020. After failing to see the humidity drop to a sufficient level, it was decided to brim-fill the Dry-Rite cylinder (with enough space to fit the felt filter just below the outlet. The system was switched to underway seawater on 23 January, but on 24 January it was noticed that the tube was empty of water so the pump speed was increased. It has been running since then, but will be switched off and cleaned when the ship comes alongside at the Falklands.

13.3 NOTES FOR ACOUSTIC SYSTEMS USED: EM122 SWATH

[See also Appendix A.1.vi]

At the start of the cruise it was noted that the swath output was very broken and reasonable mapping of the seafloor was not possible. The 'stave display' showing the return quality of the array of 432 beams showed a great number to be not getting qualifiable returns.

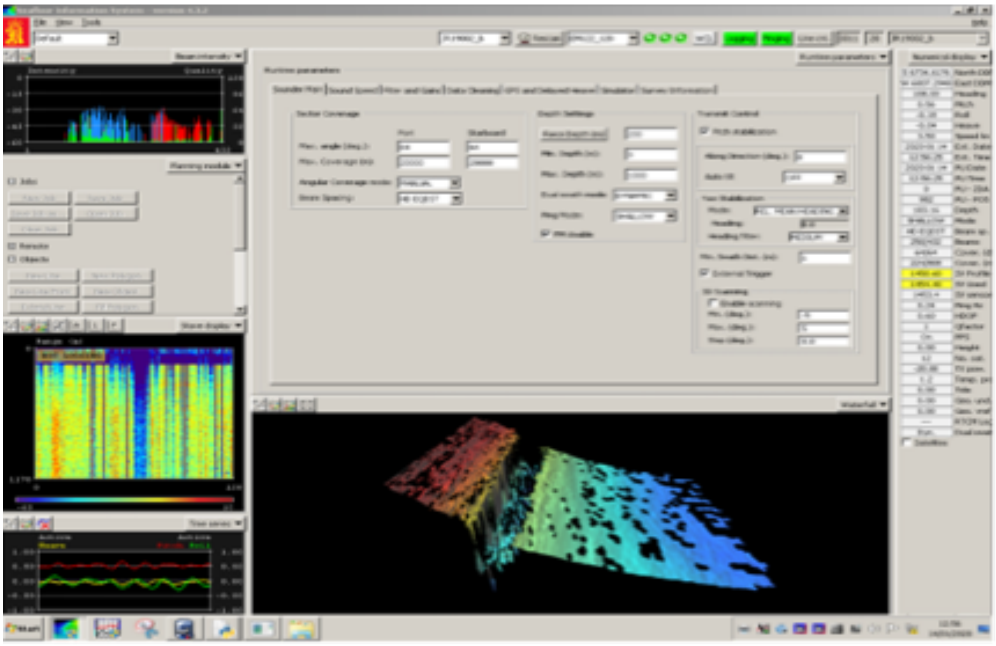


Figure 13-1 Screenshot of EM122 output

Stave display is the second window from the bottom on the left hand side (Figure 13-1). In normal 'good quality' operation this display has only two thin stripes missing (as there are two faulty transducers in the hardware installation). After being turned off overnight to allow the system to cool down, it was noticed when reactivated that all expected staves were operating satisfactorily. This was observed to degrade to the previous level over a period of about eight hours. A check of the cooling fans in the pre-amp cabinet showed that two of the fans were completely non-functional, and the third was very stiff and hardly spinning at all. The mesh intake filter was found to be very dirty. The fans were replaced and the filter cleaned. Following this the system behaved beautifully for many days.

Following a system shut down in between survey areas, when re-activated the stave display was disappointingly striped again. The pre-amp cabinet was found to be suspiciously cool, while the transceiver cabinet was very hot. An email from Kongsberg support suggested that the striping could be due to old potentiometers on the +/-12V supply in the pre-amp cabinet, and that moving and resetting them may help.

"We have seen that the 12v power supply sometimes trip, so only +12v is working, this would cause something similar. On the powersupply there is 2 adjustment potmeter. Iadjust + and -. These should be set to approx. 90 %, sometimes it helps just turning it to min-max and back to 90%. There is also a V adjust, this should not be touched."
(From Kongsberg email)

On inspection of said power supply, it was found that there were two potentiometers labelled "V.adj" and two labelled "O.C.P." (none marked as "I.adj") All of these potentiometers showed severe signs of age and thermal damage with the plastic housings all fragmented all falling off. This has resulted in the wiper being in contact with both output pins of the potentiometer creating a 0 ohm short (which results in no output power as this controls the max output current). A temporary repair has been carried out involving small pieces of cable tie and tape glued under the wipers. This repair is not expected to last long. The PCB looks like it has been run very hot for a lot of time. It is my opinion that this PSU module should be replaced, and doing so should result in a reliable Swath system once more (Kongsberg Simrad +/-12V Power Supply part# 290-213103).

More replacement fans for the pre-amp box will need to be acquired as there are none left in stock (RS part# 5440706).

It is also recommended that the pre-amp cabinet be turned off when the system is not in use, especially during cargo operations when the doors to the main hold are open and there is much opportunity for dust to get into the system. (The transceiver cabinet power is controlled remotely from the acoustic cabinet in the UIC, whereas the pre-amp power must be manually turned off in the cabinet near the ships bond store).

13.4 NOTES ON THE CTD

Basic Stats			
Number Of Casts	69	Number of Successful Casts	69
Max Depth	767	Min Depth	74
Cable Removed (m)	0	Number of Re-terminations (elect.)	0

Both LADCP units (#14897 and #14443) showed intermittent comms faults that seemed to be related to the units (as they required power cycling or a lengthy time to self restart, to bring back), and not the cables as is usual. They have not been away for service for a good few years (I think) so it would be good to get these looked over if funds allow. They used to get serviced every year as they would invariably fail every year. It is unknown to me if they have been serviced since Teledyne sorted out their potting compound and the units became halfway reliable. Also the star cable has been repaired many times and a new one would be beneficial.

Information about CTD physical configuration:

Name	Purpose	Distance from Base of Frame to Sensor (m)
Altimeter	Distance to sea bed (max 100m)	0.05
LADCP Master	Downward Facing LADCP	0.09
Temp1/Temp2	Temperature at 24Hz	0.3
Fluorimeter	Measures Florescence	0.185
9+	Communications and Pressure measurement	0.39
C1/C2	Conductivity Cells	0.345
Dissolved Oxygen	Oxygen in the Water	0.405
Bottles Bottom End Cap	Water collection (24)	0.56
Bottles Top End Cap	Water collection (24)	1.66
Transmissometer	Measure of light transmitted through water	0.275
SBE35 Top	Accurate Temperature sensor	1.38 (1.355)
SBE35 Bottom	Accurate Temperature sensor	0.72
Par	Radiation Sensor	1.605

13.5 NOTE ON DECK SYSTEMS: SUCS WINCH

The spooling system for the SUCS winch showed intermittent faults which manifested in the total loss of power on the 24V control system for the winch. This fault was traced and shown to be the result of a power short in the scroller rotary encoder. With this encoder removed, the spooling system now works by use of the manual spooling controls, although the automatic spooling is unavailable.

A replacement encoder is required. Type 760N/1/HV from www.encoders-uk.com

13.6 NOTE ON OCEANLOGGER

The oceanlogger performed well however the primary humidity sensor gave a zero reading throughout the cruise (the secondary is working fine). This will have to be investigated when alongside in Harwich (if needed, the complete sensor array on the foremast could be replaced with a 2nd rig built in Cambridge. If JCR is not to do any science next season then this will not be necessary.
The transmissometer appeared at one point to be giving a flatline zero reading, but this was found to be due to a blob of biological debris stuck to the lens of the receiver. Both optical instruments (transmissometer and fluorometer) were removed and cleaned and full system functionality restored.

13.7 ADDITIONAL WORK COMPLETED ON CRUISE: POURQUOI PAS SEA ICE CAMERA

The sea ice camera that was presented to me for pre-deployment testing was not sufficiently assembled for deployment. It was found to have an internal enclosure that was not assembled (no screws), with a loose (and flat) battery rattling around inside it with the linux board. This enclosure was also not secured to the outer pelicase. Testing of the system was not carried out due to lack of documentation as to the power requirements and connection pinout. After efforts were made to secure all the loose components within the case and replace the battery, the system was deployed without an electronics engineer present so no further comment can be made by myself.

13.8 PRIORITY NEEDS AND NOTICES

Replacement power supply and cooling fans needed for the EM122 pre-amp cabinet (it has new fans, but there are no more spares in stock.)

A replacement rotary encoder is required for the SUCS winch.

13.9 PRE-CRUISE TASKS

Task	Status
Download AME_Eng/Platform_Specific/JCR	Y
Check cruise planning meeting notes	N
Number of hours hand over with previous ships AME Engineer	0H

13.10 DAILY AND WEEKLY TASKS

Task	Frequency	Status
Sanity check the Oceanlogger data	Daily	Y
Check the Following Fans: Oceanlogger Acoustic Rack Seapath EM122 (Tween) Topas (Tween)	Monthly	Y
Mega test CTD cable	Weekly	N

13.11 END OF CRUISE CHECKS

Task	Status
XBT left in cage, in a suitable state	Y
The salinity bottles have been cleaned, if used	Y
CTD left in suitable state - Ducts cleaned with Triton and deionised water, blanking plugs installed and system washed with water	Y
CTD Slip Ring have been cleaned	N
Office is tidy, with manuals and files returned and items stowed for sea	Y
Clean the following fans: Oceanlogger Acoustic Rack Seapath EM122 (Tween) Topas (Tween)	Y
Scintillation Counter test Procedure	Y

14 AME mechanical technical report

Gareth Flint, British Antarctic Survey

14.1 MULTICORER

56 deployments, 29 successful (8 or more useable cores), 9 total failures

After the first couple of deployments, some minor adjustment was needed to some release wires (not releasing) and lids (not closing). An experimental release was tried where the metal spring wire was replaced with Niskin bottle wire and a retaining p-clip. This proved consistently reliable, easier to arm and safer, due to the removal of the eye-poking wires (safety glasses were worn whilst working with the corer). Half of the assemblies were modified in this way – there weren't enough p-clips to modify them all.

The multicorer proved temperamental for the remainder of the cruise and only worked well in favourable conditions, coping very badly with sediment which was too soft or too hard, and uneven terrain. On one deployment, the corer seemed to have tipped over on the sea floor, bending some of the legs. The 'mud shoes' were fitted when working in very soft sediment but were still unable to prevent the unit from sinking far enough to malfunction on some sites. Perhaps the most significant problem was insufficient spring force to close the bottom lids. This resulted in the loss of many cores at the surface. Spacers were fitted to some assemblies to preload the springs, but only slight improvement was apparent. Much stronger springs would be needed to resolve the problem.
The lower arms can also swing past vertical during closing, which can also cause misalignment of the lower lids and loss of samples. It may be that stronger springs eliminate this problem. A conical self-aligning lower lid was tried and worked well on deck, but the spring force was still the limiting factor.

14.2 MINI AGT

4 deployments, all successful.

No setup required as a pre-assembled AGT was brought on the cruise. An unassembled spare was also brought but was not needed. The inner net was damaged at Marion Cove. Temporary repairs were carried out, but the net will need replacing/repairing.

14.3 HAMON GRAB

17 deployments, 15 successful.

The Hamon grab is prone to twist its strop during deployments, which resulted in poor endurance of steel wire ropes on ICEBERGS 2. On this cruise, the grab was fitted with a Dyneema strop[2]and Nylon sheaves. On fitment, it was noticed that some of the spliced area – of greater diameter than the rope itself – ran on the top sheave. This was undesirable, but not unacceptable. A 30 cm longer strop would be needed to overcome this.

[2] 3810 mm x 8 mm DynaOne®HS GeoBend

The two failed deployments were due to the strop getting hung-up on the grab. There is little that can be done to prevent this without significant modification. On several deployments the strop was hung-up, but the grab still worked. This caused localised wear to the strop, but it still lasted the duration of the cruise and was an improvement on the SWR configuration.

14.4 N70 PLANKTON NET

24 deployments, 23 successful.

The N70 was set up without the closing rope. The jubilee clip holding the net to the cod end came loose once, otherwise fine.

14.5 SUCS

31 deployments, all successful.

A new larger-diameter deck sheave was used and worked well. Due to its weight, it was set up differently to the previous sheave.

The SUCS winch had an intermittent fault with the outboard proximity sensor which prevented the scrolling mechanism from working. The fault was usually cleared by resetting but this wasn't the case when it reappeared at Burdwood Bank. The motor was removed, and the scrolling lead screw turned by hand drill to enable deployments to continue until fault investigation could be carried out. The cause of the failures was found to be the encoder, which was shorted and pulling too much current through the 24V circuit. We didn't have a spare on board but were able to refit the motor and spool the cable on in manual mode for the remainder of the cruise.

The camera itself had some problems with glitching. All fibre optic connections were cleaned, and some minor alterations were made to the routing of cables which led to significant improvement.
On one deployment, only 17 photos were taken as there appeared to be another glitch with the camera. On investigation, it was found that the network drive allocated to SUCS was full and the photos were only being partially saved.

Some increased image noise was apparent, possibly the auto-gain or exposure settings on the camera but this was not resolved as we were reluctant to tamper with the settings mid-cruise.

14.6 POURQUOI PAS CAMERA

A replacement camera and case was taken to Pourquoi Pas as the current one had no lens wiping mechanism. The replacement generated an error light when plugged, so the wiping mechanism was taken off the new unit and fitted to the old one.

A functional test of the wiper and camera itself was carried out.

14.7 VAN VEEN GRAB

42 deployments, 34 successful.

The Van Veen grab was primarily deployed from one of the ship's RIBs. An A-frame and base-board were fabricated, from which a small sheave was hung to allow hand-hauling of the grab on a 12 mm Dyneema rope.

The grab was also deployed from the ship, initially using the bongo wire, although this proved ineffective as the grab was so light that the slack couldn't be felt in the wire when it reached the seabed. The grab was then set up in a similar way to the boats, with a small sheave from the starboard Effer. The same rope was also used, and the grab lowered by hand but retrieved using the small mooring winch. Although this made deployments less physically demanding, it was no quicker and the final set of grabs were successfully carried out from the RIB.

15 IT

Sean Vincent, British Antarctic Survey

2019/12/26

1. Newleg run, ACQ started

2019/12/30

1. "P:\Shared\JCR Officers" folder missing - found in "P:\Shared\Lab Manager", moved back into P:\Shared bit still not visible, re-applied P_JCROfficers_RW AD group Modify permission.
2. Re-started jrw-labview-V2 to restore navmet display
3. Radio Officer (RO) connected Plexus to network with replacement USB - Ethernet adaptor but it is still not working RO emailed Omniaccess.

2020/01/02

1. WeTransfer drive mapped to Sky Laptop, and WeTransfer file transfer confirmed to be working correctly.

2020/01/03

1. Completed build of jrw-dc-s2 on ESX1, connected to domain, promoted to DC and replication tested.

2020/01/04

1. Transferred DHCP to jrw-dc-s2

2020/01/05

1. Wireless connected laptops not getting IP address - reconfigured WIFI controller DHCP setting to new DHCP server.

2020/01/06

1. Issue with running out of DHCP leases - Many devices have two leases, as the WIFI leases are not being released after being connected to ethernet. Lease reduced to 2 hrs (From 24 hrs) to free them up more quickly, will shorten it further if required.

2020/01/13

1. Sent email to OmniAccess to chase up progress on plexus USB-Ethernet adaptor issue.
2. Jeremy Robst VNC'd into EK80 from Cambridge and added Serial Port 3 as the Sync port.
3. Jeremy also modified the Event Log script to include CTD cast number.

2020/01/14

1. SUCS camera connected to data network and bridge monitor.

2020/01/15

1. DHCP transferred back to jrw-dc-s1 as the CISCO phones where not getting leases, suspect issue is with RSX1 network port and switch not being configured to connect to VLAN 3.
2. Plexus Controller - tested USB-ethernet adaptor on windows PC to confirm it is working. Ran old Plexus PC in recovery mode to confirm that the USB-Ethernet adaptor was being mounted, however doing the same with the new Plexus PC showed that the that the adaptor is not being mounted. Emailed OminiAccess to inquirer about progress and also pass on the results of our investigation. NOTE: using a different USB - ethernet adaptor on the old Plexus PC gave an error, which confirms that their recommended Kingston adaptor should be used.

2020/01/17

1. Plexus now working correctly - tagged JCR computers and set them as VIP.

2020/01/18

1. Replaced lab PCO2 monitor (No picture).

2020/01/19

1. Created Excel workbook for Lab Manager to import/Export BOLS for easier editing.

2020/01/21

1. BBC web site is not contactable, ETO Comms has raised ticket with ServiceDesk. They had the same problem on the Shackleton in the past, which was caused by BBC being blocked by a web filter.

2020/01/22

1. Re-started Print serve as users were having trouble printing from Mac. Issue resolved.

2020/01/25

1. Internet and telephone connectivity very is very poor, despite having a good lock on the satellite and ample bandwidth. Tracert is showing latency of over 1000 ms over a number of hops mainly through JANET. An Email sent to OmniAccess and cc'd Sara Jacobs, requesting they investigate.

> "Although the ship appears to have very good connectivity and bandwidth, we are having a number of issues.
> We are having great difficulty in getting phone connections with both our Voice and SIP phones, the quality is poor and connections are being dropped. The SIP phones are frequently dropping off the network.
> We are unable to connect to a number of web sites including the BBC and Twitter and are having great difficulty connecting to web mail in particular Google Mail.
> We suspect the problems are due to latency causing connections to timing out.
> Whilst it is accepted there are a large number of devices on-board, it is very unusual to be having issues with the telephone connectivity unless band-width is very low"

2020/01/26

1. Reply to email regarding latency from Sara Jacobs, saying that Halley are having similar problems and confirming that latency should be 600 - 700 ms.

2020/01/28

1. Internet and telephones were unusable, despite being in open water, having good satellite signal, and Plexus showing we had plenty of bandwidth. Tried blocking all non-JCR PCs but made no difference.
2. Replied to Email from BAS network team reference access to BBC website, explained that internet connectivity is very poor despite strong satellite signal and good bandwidth, and that it is suspected that latency is the cause of the issue.

2020/01/29

1. Internet is working again but very slow, still cannot connect to BBC. Seems to be better between 1:30 and 6:00 am

2020/01/30

1. SCS data acquisition stopped. Restarted data acquisition and carried out JRLB reboot recovery/Samba restart procedure. Data streams are all green.

2020/01/31

1. Users could not print, re-started print server.

2020/02/02

1. EM122 not syncing data to SAMBA. Have confirmed data is being logged to SCS PC where the operators are accessing the data, will restart SCS when science has finished.

2020/02/03

1. Internet link has been getting steadily worse throughout the day; no emails are being sent.
2. ETO COMM's contacted OmniAccess. Omniaccess have changed noise floor. Initially bandwidth was very good, however after about 60 minutes it has fallen away to zero!

2020/02/04

1. Omniaccess have changed the configuration for the whole of BAS. Internet is now working well, and BBC is now working.

16 RRS James Clark Ross Laboratories

Aisling Smith, Laboratory Manager, British Antarctic Survey.

16.1 LABORATORY SET UP

The laboratories of the RRS James Clark Ross were mobilised for ICEBERGS III during cargo relief at Rothera from the 7th January 2020. All lab spaces were in use for the cruise, with the focus of activities being the Wet lab and the CTD annex.

Laboratory handover took place on the 7th January with the PSO and Laboratory Manager, James Scourse and Aisling Smith. Some requests were made to better facilitate mobilisation, these were completed and mobilisation commenced.

Whilst at Rothera a fill of liquid nitrogen was arranged for transport to the JCR to support the CASS Project of Mehul Vora. NOCS supplied a 25 L dewar, that was transported by tender on the 11th January, an additional 4 L dewar was supplied on the 12th. These were fitted with a continuous oxygen monitor alarm system and stowed for poor weather.

Laboratory inductions for all scientific and technical staff were completed on the 7th of January and final process documentation was requested from all parties. The Cruise Health and Safety folder was compiled and signed by all involved listed processes. The cruise medical brief with the Doctor was held on the 8th January and emergency SDS folder and cruise overview was discussed.

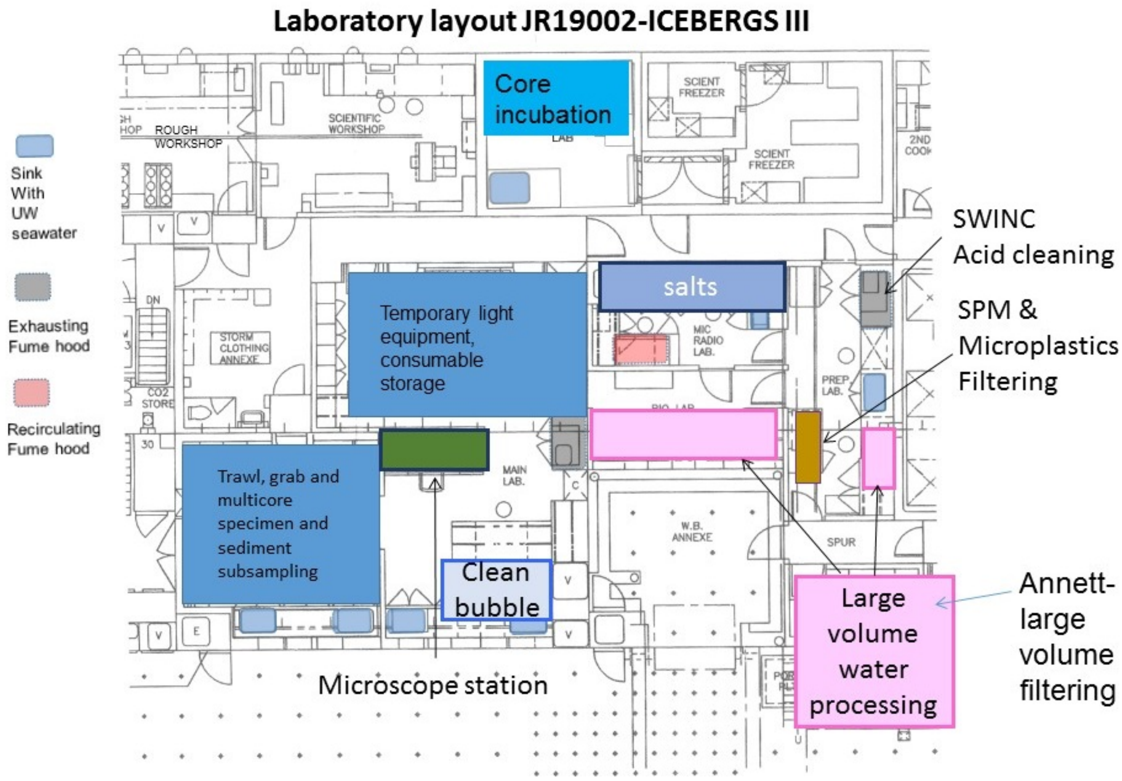


Figure 16-1 Laboratory layout-ICEBERGS III

Table 16-1 Laboratory use and function during ICEBERGS III cruise

Laboratory space	Primary use	Research leads
Wet lab	Multicore and grab processing, N70 net preservation, AGT sample processing and preservation.	James Scourse, Dave Barnes, Chester Sands, Amber Annett, Mark Furze
Main lab	Clean bubble (SWINC experiments), radium bulk water filtering, preparation of manganese dioxide fibre filters, flash freezing of sediment using LN2, acid cleaning, and microscope bench.	Amber Annett, Dave Barnes, Mehul Vora
Bio Lab	Radium bulk water filtering, storage of samples bottles.	Amber Annett
Rad Lab	Salinometer lab, storage of O18 bottles and samples.	Mike Meredith
Prep Lab	Metal free acid cleaning, Filtering station for microplastics and suspended particulate matter (SPM), Radium bulk water filtering, general staging area for CTD annex sampling.	Amber Annett, Tristyn Garza, Kate Retallick
Chem Lab	Radium bulk water filtering, storage area for radium work.	Amber Annett
CTD annex	Used by all involved in sampling from the CTD.	Mike Meredith and others
Science hold	Storage of cruise equipment, supplies and spares	PSO, James Scourse
NMF Container	Radium detectors, pore-water processing. Helium plumbed into lab.	Amber Annett
CT Lab (Cool spec. room)	Sediment core oxygen/nutrient experiments, processing CTD water samples for nutrients analysis, DNA/RNA core sampling, SWINC experiment bulk water filtering and storage, specimen storage.	Felipe Salles de Freitas, Mehul Vora, Amber Annett, Kate Retallick
-20 Freezer	Storage of sediment samples, biological samples and bulk ethanol.	Dave Barnes, Chester Sands, Mark Furze, James Scourse, Julian, Felipe, Amber Annett, Carlos Ramirez
-80 Freezers	Scientific freezers No. 1 and No. 2 used for initial freezing, samples were then moved to Scientific freezer No. 3 and No. 4 for transit north.	James Scourse, Mehul Vora, Chester Sands, Julian Blumenroeder and others.

16.2 OPPORTUNISTIC DATA COLLECTION

Opportunistic scientific equipment were logging during passage and during survey days in each fjord as permissions allowed. Key equipment included PML operated Auto-Flux system located in the mail room on the Forecastle, BAS operated atmospheric pCO2 Picarro located in the UIC and PML operated underway pCO2 located in the Prep Lab. During this cruise the PML instruments were maintained by the Laboratory Manager.

16.3 SCIENTIFIC SAMPLE COLLECTION AND CONSIGNMENT

A number of sample types were collected during this cruise, primarily marine sediment, water for chemical analysis, benthic invertebrates, benthic vertebrates, rock samples for biological analysis, plankton and filters containing suspended marine matter for various methodologies.

These samples were packaged in accordance to the BAS guidelines on sample consignment and IMDG regulations as applicable. There were two primary collection permits issued for this cruise, for marine sediments, 02/2017 BAS-S6-2019/01 and marine benthos permit BAS-S7-2019/08. SAERI acquired an independent permit, Research Permit 48/2018, from the Falkland Islands Government for the collection of specimens from the Burdwood bank. SAERI samples were removed from the RRS James Clark Ross at Mare Harbour, as per the licence arrangements. Collection permits were accompanied by the cruise PEA and cruise hazard register.

For import into the UK, samples were consigned to return to the UK under BAS's import licences to Cambridge as the named site address. Several of the cruise participants opted to make their own arrangements to hand carry samples to their home institutes and assistance was provided to secure transport where necessary. One set of biological samples contained CITES material that was consigned with request for additional licencing as is required under CITES, to be organised by BAS.

Table 16-2 Summary of samples collected during ICEBERGS III, additional sample information available on request.

Case number	Researcher	Sample type	Stowage	Preservative	Import detail
JS/C/20/2501	Kate Retallick	Marine Sediment	4 °C	None	BAS
JS/C/20/2606	Kate Retallick	Marine Sediment	-20 °C	None	BAS
JS/C/20/2607	Kate Retallick	Marine Sediment	-20 °C	None	BAS
JS/C/20/2608	Kate Retallick	Marine Sediment	-20 °C	None	BAS
JS/C/20/2609	Kate Retallick	SPM Filters	-20 °C	None	BAS
JS/20/KR01	Kate Retallick	Marine Sediment	Ambient	None	Hand carry
JS/C/20/3615	Chester Sands	Benthic inverts	-20 °C	Ethanol	BAS
JS/C/20/3616	Chester Sands	Cup coral (CITES)	-20 °C	Ethanol	BAS
JS/C/20/3557	Mike Meredith	δ^{18} samples	4 °C	None	BAS
JS/C/20/3558	Mike Meredith	δ^{18} samples	4 °C	None	BAS
JS/C/20/2503	Felipe Salles de Freitas	Samples for nutrient analysis	4 °C	None	BAS
JS/C/20/2504	Felipe Salles de Freitas	Samples for nutrient analysis	4 °C	None	BAS
JS/C/20/2505	Felipe Salles de Freitas	Samples for	4 °C	None	BAS

		nutrient analysis			
JS/C/20/2610	Felipe Salles de Freitas	Samples for nutrient analysis	-20 ºC	None	BAS
JS/20/FREITAS_1	Felipe Salles de Freitas	Porewater for nutrient analysis	Ambient	None	Hand carry
JS/20/MUNOZ_1	Carlos Munoz	Benthic inverts	-20 ºC	Ethanol	Hand carry
JS/C/20/2605	James Scourse/ C. Falagan	Sediment core samples	-20 ºC	None	BAS
JS/C/20/2612	James Scourse/ C. Falagan	Sediment core samples	-20 ºC	None	BAS
JS/C/20/2611	James Scourse/ A. Gonzalez	Sediment core samples	-20 ºC	None	BAS
JS/C/20/2618	James Scourse/ A. Gonzalez	Sediment core/ benthic inverts	-20 ºC	Ethanol	BAS
JS/C/20/2719	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2720	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2723	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2724	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2729	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2730	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2731	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2732	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/C/20/2733	James Scourse/ A. Gonzalez	Sediment core samples	-80 ºC	None	BAS
JS/20/ALICE_1	Alice Guzzi	Invert tissue sample	Ambient	None	Hand carry

JS/C/20/2613	Julian Blumenroeder	Benthic biological specimens	-20 °C	Ethanol	BAS
JS/C/20/2614	Julian Blumenroeder	Benthic biological specimens	-20 °C	Ethanol	BAS
JS/C/20/2615	Julian Blumenroeder	Benthic biological specimens	-20 °C	Ethanol	BAS
JS/20/Julian_1	Julian Blumenroeder	Marine plastic	Ambient	none	Hand carry
JS/C/20/2506	Amber Annett	Preserved water samples	4 °C	HCl 0.01%	BAS
JS/C/20/2507	Amber Annett	Preserved water samples, sediment	4 °C	HCl 0.01%	BAS
JS/C/20/2508	Amber Annett	Preserved water samples	4 °C	HCl 0.01%	BAS
JS/C/20/2616	Amber Annett	Preserved water samples	-20 °C	HCl 0.01%	BAS
JS/C/20/2617	Amber Annett	Preserved water samples	-20 °C	HCl 0.01%	BAS
JS/C/20/2619	Amber Annett	Preserved water samples	-20 °C	HCl 0.01%	BAS
JS/C/20/2725	Mehul Vora	Sediment samples	-80 °C	None	BAS
JS/C/20/2726	Mehul Vora	Sediment samples	-80 °C	None	BAS
JS/C/20/2727	Mehul Vora	Sediment samples	-80 °C	None	BAS
JS/C/20/2728	Mehul Vora	Sediment samples	-80 °C	None	BAS
JS/20/ANNETT_1	Amber Annett	Porewater samples	Ambient	None	Hand carry
JS/20/ANNETT_2	Amber Annett	Radium samples	Ambient	None	NMF container
JS/20/SAERI_1	Ander De Leca	Biological samples, Burdwood bank	-20 °C	Ethanol	Hand carry
JS/20/SAERI_2	Ander De Leca	Biological samples, Burdwood bank	-20 °C	Ethanol	Hand carry
JS/C/20/2502	Mark Furze	Benthic invert samples	4 °C	Ethanol/Rose bengal	BAS
JS/C/20/2604	Mark Furze	Sediment samples	-20 °C	None	BAS

JS/C/20/2509	Trystan Garza	Preserved water samples	4 °C	Ethanol	BAS

16.4 SHIP'S FIXED EQUIPMENT IN USE

During ICEBERGS III a number of pieces of ship's fixed equipment were in use, including three -80 °C freezers, a walk in 4 °C cool room, two LEV fumehoods, two Milli-Q dispensing points, multi-lab uncontaminated seawater supplies, Guildline Salinometer. See AME report for configuration and performance of salinometer.

16.5 CRUISE HEALTH AND SAFETY MEETING

The ship's Health and Safety meeting was help prior to arrival at Mare Harbour, Falkland Islands, in early February. Aisling Smith attended in the role of both Laboratory Manager and Science Representative, at the request of the PSO. AINME's from the previous 6 weeks were discussed and a number of them closed. Other AINME's required further consultation and were deferred to the correct department for comment. Details of AINME's raised are held with the BAS Health and Safety Advisor.

16.6 END OF CRUISE HANDOVER

On arrival to Mare Harbour, Falkland Islands, cruise de-mob and lab cleaning was undertaken by the science party. The Labs were handed back to the ship on the 4th of February, following laboratory handover with the Chief Officer, PSO, and Laboratory Manager. The vessel was due to continue to Punta Arenas and a subset of the science party were to remain on board to continue analysis. Labs were then handed over to Amber Annett, NOCS, for the remainder of the passage until the 13th of February ahead of departure of all remaining cruise members on the 14th of February.

Should you require further information on laboratory set up or biological samples collected please contact Aisling Smith, Laboratory Manager, on aismith@bas.ac.uk

17 Data Management

Alice Frémand, UK Polar Data Centre, British Antarctic Survey

17.1 DATA STORAGE

All data recorded by instrumentation linked to the ship's network were recorded directly to respective folders within the directory /data/cruise/jcr/20191226/. Additional folders were created within the directory /data/cruise/jcr/20191226/work/ to allow the cruise scientists to back-up their work. When all data will be archived as read-only on the Storage Area Network (SAN) at BAS, the pathname to the files will remain the same, i.e. **/data/cruise/jcr/20191226/**. The data are under embargo for the minimum period of two years with the exception of the underway scs data streams.

17.2 SITE IDENTIFIERS

Specific codes were given to workstations consistent with the previous ICEBERGS cruise (JR17001 and JR18003). Additional saplings were collected on each site closer to the ice front using small boats.

The three main sites consisted of:

- Sheldon Cove with the respective SCXX sites
- Börgen Bay with the respective BBXX sites
- Marian Cove with the respective MCXX sites
- Burdwood Bank with the respective FIBBXX sites

17.3 DIGITAL AND PAPER LOGS

Digital and paper logs were created to provide an overview of equipment deployments and record details of sampling. All deployments were assigned consecutive event numbers by the officers on watch and documented in the digital bridge event log. In addition to the bridge event log a number of digital science logs were maintained to view deployment-relevant underway data in the context of sampling details. Copies of these have been downloaded as csv files into the file path /data/cruise/jcr/20191226/work/data_management/Digital_logs. A guide named on how to use the digital logging system currently installed on the RRS James Clark Ross is available on the ship intranet (http://www.jcr.nerc-bas.ac.uk/docs/logsheets_guide.pdf). The following 13 digital science logs were created: Van Veen, miniAGT, Argo float, VMADCP (digital log not used), SUCS, N70 Plankton net, Hamon Grab, Multicorer, CTD Bottles, CTD, EK80, Weather, TOPAS and EM122.

Paper sampling logs were maintained for CTD, niskin bottles, small boat work and underway bottles. The latter have been scanned at the end of the survey and available in the Storage Area Network archive directory /data/cruise/jcr/20191226/work/scientific_work_area/logsheets completed.

17.4 DATA COLLECTION

Equipment (*activity*)	Number of deployments	Digital data stored at UK PDC	Digital log available	Data users
Agassiz Trawl	8		X	David Barnes, Marina Costa, Ander de Lecea, Carlos Munos Ramirez, Alejandro Roman Gonzales, Chester Sands, Fabian Guzman, Alice Guzzi
Argo Float	1		X	Mike Meredith
Conductivity-Temperature-Depth (CTD)	69	X	X	Mike Meredith, Tobias Ehmen, Christopher Bull
CTD Bottle samples	68		X	Amber Annett (Ra), Rhiannon Jones, Oliver Flanagan, Felipe Sales de Freites (Nutrients), Tristyn Garza (microplastics), Julian Blumenroeder (microplastics), Kate Retallick (SPM), Mike Meredith, Tobias Ehmen
EM122 multi-beam echosounder	vessel-mounted	X	X	Kate Retallick
EK80 echosounder	vessel-mounted	X	X	Tobias Ehmen
EA600 single-beam echosounder	vessel-mounted	X		Mike Meredith
Hamon Grab	16 (1 unsuccessful)		X	Carlos Munos Ramirez, Fabian Guzman, Alice Guzzi, Chester Sands, David Barnes, Ander de Leccea, Marina Costa
Lowered Acoustic Doppler Current Profiler (LADCP)	63 (1 test and 3 unsuccessful)	X		Christopher Bull
Mooring	1			Mark Barham
Multicorer	56 (8 unsuccessful)		X	James Scourse, Amber Annett (pore water), Oliver Flanagan (pore water), Alejandro Roman Gonzalez, Carmen Falagan Rodriguez, Felipe Sales de Freites, Tristyn Garza, Julian Blumenroeder, Mehul Vora, Mark Furze
N70 Plankton Net	27		X	Julian Blumenroeder
SUCS	43		X	David Barnes, Ander de Lecea, Marina Costa, Alejandro Roman Gonzalez
TOPAS	vessel-mounted	X	X	Mark Furze, Ander de Lecea, Kate Retallick
Underway Water sample	Vessel-mounted			Mike Meredith, Tobias Ehmen
Underway data – oceanlogger	Vessel-mounted	X		Mike Meredith, Tobias Ehmen

Van Veen	42 (34 successful)		X	Kate Retallick
VMADCP	vessel-mounted	X		Tobias Ehmen
Water samples from small boat	39 stations		X	Amber Annett (Ra), Rihannon Jones, Oliver Flanagan

Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre. Digital logs are available on request at UK PDC.

Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report. Contact cruise lab manager or BAS collections manager for the lab report.

17.5 DATASETS AND THEIR USE

Dataset	**Trawl physical samples**
Instruments	**Mini Agassiz Trawl** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1252/)
Description	Biological samples were sorted after trawls and a record was made of (rough) taxonomy, number of individuals, weight and sample preservation technique all linked to a storage vial ID.
Digital data	Burdwood Bank: /data/cruise/jcr/20191226/work/scientific_work_areas/AGT-SAERI AGT log: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/miniAGT.csv
Physical samples	Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report.
Long-term preservation	Refer to lab report.
Data users	David Barnes, Marina Costa, Ander de Lecea, Carlos Munos Ramirez, Alejandro Roman Gonzalez, Chester Sands, Fabian Guzman, Alice Guzzi

Dataset	**CTD data**		
Instruments	**Sensors on the CTD frame** (http://vocab.nerc.ac.uk/collection/L05/current/130/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0058/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0416/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0417/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0318/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0036/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0059/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL01254/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0424/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0160/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0749/ http://vocab.nerc.ac.uk/collection/L22/current/TOOL0931/)		
Description	Conductivity, Temperature and Depth measurements at SC, BB, MC and Burdwood bank.		
Metadata	Paper Logs	Scans of the paper logs are in the directory /data/cruise/jcr/20191226/work/scientific_work_area/ logsheets completed/ctd	
	Digital Log	Digital logs are available in the following directory: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/CTD.csv	
Digital data	Raw	.bl, .hdr, .hex, .000 (LADCP) /data/cruise/jcr/20191226/ctd	
	Processed	asc, .cnv, .ros,	/data/cruise/jcr/20191226/ctd/JR19002_ Processed
Long-term preservation	Raw and processed data will be stored on the SAN at BAS and processed data also available from the BODC. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.		
Data users	Any cruise participant, Met Office		

Dataset	**CTD bottle samples**	
Instrument	**Niskin bottle** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0412/)	
Description	Sea water from Niskin bottles was collected at SC, BB, MC and Burdwood bank stations. For details see the report chapter on CTD operation and Burdwood Bank	
Metadata	Paper Logs	Scans of the paper logs are in the directory /data/cruise/jcr/20191226/work/scientific_work_area/ logsheets completed/ctd
	Digital Logs	Digital logs are available in the following directory: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/CTD_Bottles.csv
Digital data	/data/cruise/jcr/20191226/ctd	
Physical samples	Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report.	
Long-term preservation	Raw data will be stored on the SAN at BAS.	
Data users	Amber Annett (Ra), Rhiannon Jones, Oliver Flanagan, Felipe Sales de Freitas (Nutrients), Tristyn Garza (microplastics), Julian Blumenroeder (microplastics), Kate Retallick (SPM), Mike Meredith, Christopher Bull, Tobias Ehmen	

Dataset	**EA600 data**
Instruments	**Kongsberg EA600 single-beam echosounder** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0319/)
Description	Kongsberg EA600 single-beam echosounder for measurement of depth below transducer and used to estimate water depth
Digital data	/data/cruise/jcr/20191226/ea600
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Any cruise participant

Dataset	**EK80 data**
Instruments	**Simrad EK80 echosounder** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1205/)
Description	Simrad EK60 echosounder was primarily used to identify thermohaline gradients in the water column.
Digital data	/data/cruise/jcr/20191226/ek60
Calibration	/data/cruise/jcr/20191226/work/scientific_work_areas/EK80
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Tobias Ehmen

Dataset	**EM122 data**
Instruments	**Kongsberg EM122 multi-beam echosounder** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0492/)
Description	Kongsberg EM122 multi-beam echosounder used to map SC, BB, MC and briefly on Burdwood Bank. More information in Geophysics section
Digital data	/data/cruise/jcr/20191226/em122
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Kate Retallick

Dataset	**Hamon grab physical samples**
Instruments	**Hamon Grab** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0960/)
Description	Biological samples were sorted after grab to be sorted and analysed after the research cruise.
Digital data	Protocol for grab is available in: /data/cruise/jcr/20191226/work/scientific_work_areas/HamonGrab Hamon grab log: /data/cruise/jcr/20191226/work/data_management/Digital_Logs/Hamon_Grab.csv
Physical samples	Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report.
Long-term preservation	Refer to lab report.
Data users	Carlos Munos Ramirez, Fabian Guzman, Alice Guzzi, Chester Sands, David Barnes, Ander de Lecea, Marina Costa

Dataset	**Lowered Acoustic Doppler Current Profiler (LADCP)**
Instruments	**Lowered Acoustic Doppler Current Profiler (LADCP)**
Description	Lowered Acoustic Doppler Current Profiler (LADCP) data were collected in SC, BB and MC.
Digital data	Raw data: /data/cruise/jcr/20191226/ladcp Processing: /data/cruise/jcr/20191226/work/scientific_work_areas/ladcp/processing
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Christopher Bull

Dataset	**Multicore physical samples**
Instruments	**Oktopus 12-core multi-corer** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1191/)
Description	
Digital data	Multicorer log: /data/cruise/jcr/20191226/work/data_management/Digital_Logs/Multicorer.csv
Physical samples	Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report.
Long-term preservation	Refer to lab report
Data users	James Scourse, Amber Annett (pore water), Oliver Flanagan (pore water), Alejandro Roman Gonzalez, Carmen Falagan Rodriguez, Felipe Sales de Freitas, Tristyn Garza, Julian Blumenroeder, Mehul Vora, Mark Furze

Dataset	**N70**
Instruments	**N70 net** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0996/)
Description	Biological samples collected with a N70 net.
Digital data	N70 log: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/N70_Plankton_Net.csv
Physical samples	The majority of the samples will be returned to the biological store at BAS and remain fresh frozen at -20 degrees for any future analyses. A small subset of organisms we preserved in 96% ethanol, and frozen at -80 degrees for microplastic analysis at the University of West Florida.
Long-term preservation	Refer to lab report.
Data users	Julian Blumenroeder

Dataset	**PML met system data**
Instruments	**Plymouth Marine Laboratory meteorological sensing system** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0085/ http://vocab.nerc.ac.uk/collection/L05/current/101/ http://vocab.nerc.ac.uk/collection/L05/current/385/)
Description	PML meteorological system consisting of Licor 7500 water vapour flux sensor, Metek sonic anemometer, LPMS motion sensor, Systron Donner motion sensor
Digital data	/data/cruise/jcr/2019114/autoflux
Long-term preservation	Raw data will be stored on the SAN at BAS and also transferred to the PML on regular bases.
Data users	Ming-Xi Yang, Plymouth Marine Laboratory

Dataset	**SUCS photos and video**
Instruments	**Shallow Underwater Camera System**
Description	The SUCS frame holds an underwater Prosilica video camera that can be operated in a number of modes. On JR19002, the camera was 167 mainly used to capture still photos when the SUCS frame was at rest on the seabed
Digital data	SUCS log: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/SUCS.csv Photos and video: /data/cruise/jcr/20191226/work/scientific_work_areas/SUCS/ICEBERGS
Long-term preservation	Metadata will be stored on the SAN at BAS and managed by the Polar Data Centre.
Data users	David Barnes, Ander de Lecea, Marina Costa, Alejandro Roman Gonzalez

Dataset	**TOPAS**
Instruments	**Kongsberg Parametric Sub-bottom Profiler 18** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0859/)
Description	
Digital data	TOPAS data: /data/cruise/jcr/20191226/topas TOPAS log: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/TOPAS.csv
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Mark Furze, Ander de Lecea, Kate Retallick

Dataset	**Underway data**
Instruments	**Underway navigation, meteorology, oceanlogger**, **netmonitor, dopplerlog, gyro** (see AME report for details)
Description	Various underway data streams, such as navigation, surface oceanographic, meteorological, net winch data, logged by the NOAA Scientific Computer System software
Digital data	/data/cruise/jcr/20191226/scs
Long-term preservation	Raw will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Any cruise participant

Dataset	**Van Veen Grab – physical samples**
Instruments	**Van Veen grab** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0653/)
Description	
Digital data	Van Veen Grab log: /data/cruise/jcr/20191226/work/data_management/ Digital_Logs/Van_Veen.csv
Physical samples	Physical samples will be analysed at Bangor University. More information on the protocols, methodologies and sample preservation available in the lab report.
Long-term preservation	The primary repository for physical samples will be the institution mentioned above.
Data users	Kate Retallick

Dataset	**VMADCP data**
Instruments	**Vessel Mounted Ocean Surveyor Acoustic Doppler Current Profiler** (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0351/)
Description	A vessel-mounted acoustic 75kHz Ocean Surveyor for measurement of water current velocity using the Doppler effect on sound waves scattered back from particles within the water column.
Digital data	/data/cruise/jcr/20191226/adcp
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Data users	Tobias Ehmen

A. Appendices

Kate Retallick, Bangor University, UK

A.1 Geophysics

A.1.i. EM122 SYSTEM SETUP AND CALIBRATION

Installation and runtime parameters can be found in the document 'EM122 Settings 2 Dec.rtf' within the 'scientific work areas / EM122' folder and are available on request from the UK Polar Data Centre (polardatacentre@bas.ac.uk).

Initial set-up of EM122 followed the process outlined in the document 'Using EM122 Multibeam on an Opportunistic Basis v3.3' provided on the JCR. A Basic Installation Self-Test (BIST) was conducted in SIS on system start up and no errors were identified. The system appeared in good health with the exception of the stave display which (as discovered during ICEBERGS 2) showed staves 60 and 97 as having reduced signal level (Figure A1-1). This did not impact data quality but unfortunately further degradation became evident as the survey progressed and required rectification.

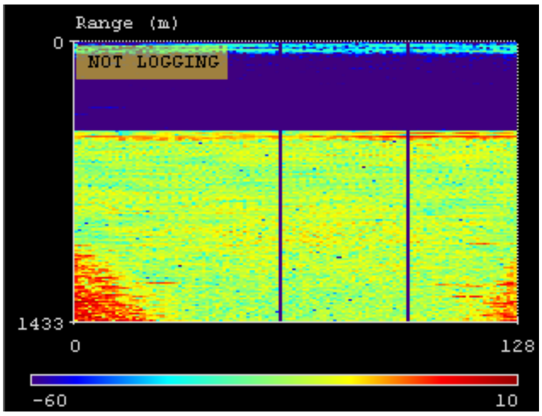


Figure A1.1. SIS Stave display showing 2 receive staves with reduced signal level (vertical blue lines)

A patch test was conducted prior to start of the scientific work using a rock feature on the seabed located in 500m of water in Marguerite Bay (67°39.19'S 067°57.93'W). Lines were run at 8 kn and 4 kn to check for latency, pitch, roll and heading errors. No changes were made. Results are shown in *Figures A1.2 – A1.6.*

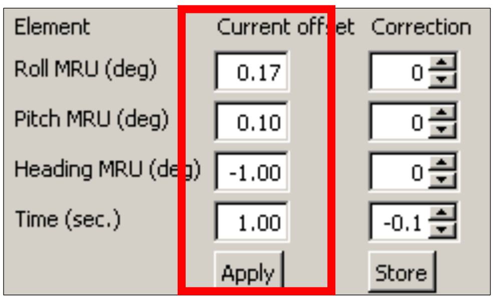


Figure A1.2. SIS Calibration display showing initial settings

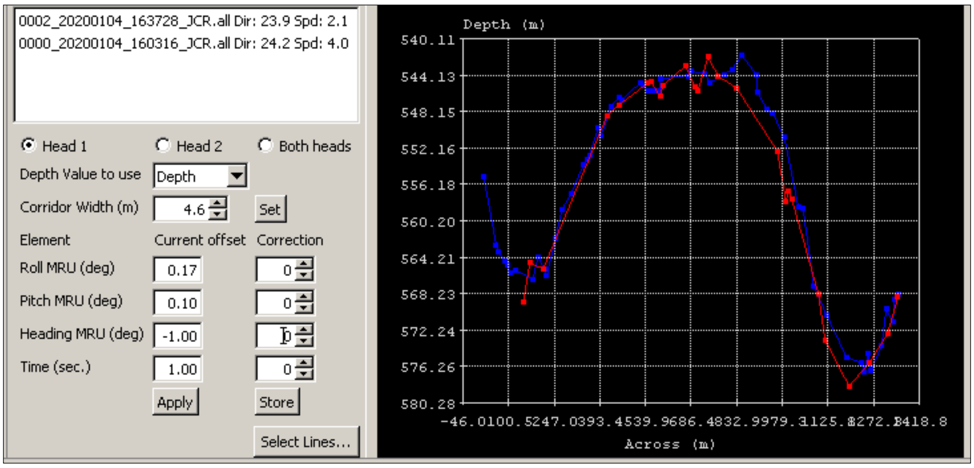


Figure A1.3 SIS Calibration display showing Latency check. No correction applied.

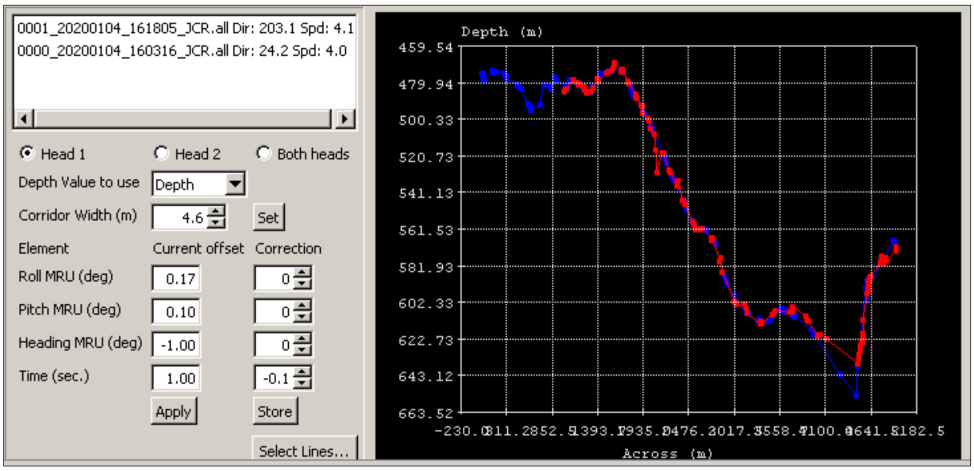


Figure A1.4 SIS Calibration display showing Roll check. No correction applied.

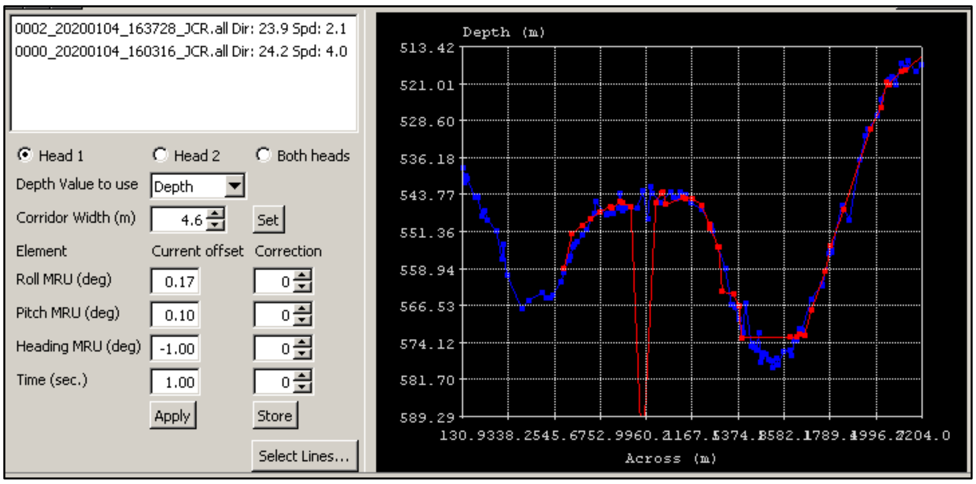


Figure A1.5 SIS Calibration display showing Pitch check. No correction applied.

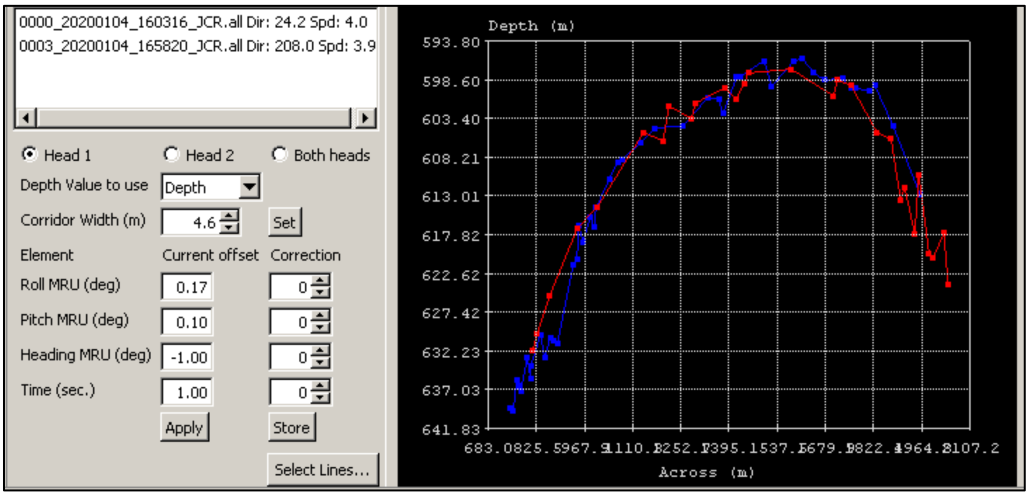
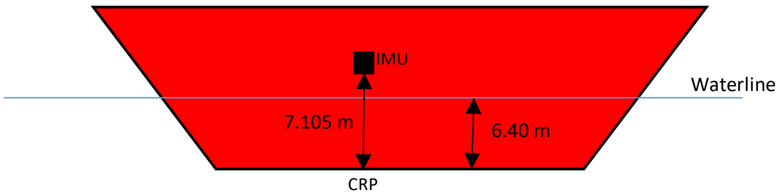


Figure A1.6 SIS Calibration display showing Heading check. No correction applied.

A value for the MRU to waterline offset was calculated from vessel's midships draft marks and input in SIS installation parameters (see Fig. A1.7 and Table A1.1*)*. All other values for offsets were checked against the vessel's latest reference frame survey[3]. Calibration certificates for all systems are also on board and in the JR18003 Legwork folder. JCR's last Dimension control survey in Harwich, UK, 15-17 September 2018, included gyro and MRU calibration, DGNSS verification, vessel reference frame survey and static validation. A visit by Kongsberg (2 October 2019) included a system check and update of SIS software. The report of the visit entitled: 'KM_SR_20190210_James_Clark_Ross_Acouistics_DWK.pdf' can be found within the 'scientific work areas / EM122' folder and is available on request from the UK Polar Data Centre (polardatacentre@bas.ac.uk).



MRU to Common Reference Point (CRP) (keel @ midships): 7.105m
MRU to waterline measurement calculated as: 7.105m - 6.40m = 0.705m (downwards)

Figure A1.7 MRU to waterline calculation on departure from Punta Arenas

Table A1.1 MRU to waterline corrections

Date	Occurrence	Draft Fwd / Midships / Aft (m)	Correction Applied
01/01/20	Sailing from Punta Arenas	5.80 / 6.40 / 6.80	0.705m (downwards)
10/01/20	Depart Rothera after cargo offload	5.45 / 5.95 / 6.45	1.145m (downwards)
16/01/20	Sheldon Cove Small boat work	5.55 / 5.90 / no reading	1.205m (downwards)

[3] Oceanfix International RRS James Clark Ross, Gyro & MRU Calibration, DGNSS Verification and Offset Survey Report, 15-17 September 2018

The settings in table A1.2 were applied during multibeam data collection at Sheldon Cove, Börgen Bay and Marian Cove to prioritise good backscatter results as advised by QPS.

Table A1.2. SIS settings optimised for backscatter collection

Option	Setting
Angular Coverage	Manual
Beam spacing	HD EQDIST
Yaw Stabilization	Rel. Mean Heading
Pitch Stabilization	On
Filters	Off
Sector Tracking	Off
Ping Mode*	Shallow
Absorption Coefficient	Salinity

** Although a BSCorr.txt file was available on the SIS terminal, the swath mode was set locked manually to prevent sudden changes.*

A.1.ii. POSITION DATA

Seapath 320 GNSS NMEA data were logged to the JCRs computer system (SCS) and input to SIS during data collection. The position output is the standard GNSS service with no differential corrections outside of the standard Northern Hemisphere EGNOS[4] and WAAS[5] service areas. Standard GNSS position was logged during all MBES operations and raw Seapath data were logged to enable position to be refined using Real Time Kinematic (RTK) during post processing if required[6].
The post processing method requires Seapath raw data to be exported as Telegram outputs (R24,R25, R26 Seapath Proprietary formats, RTCM v3 messages and IMU Raw data). RTCM data may then be converted using the Kongsberg 'rinexconverter 2.00.00' tool and post processed using the RTKLib 'RTKPost' tool (Kinematic setting). IGS observation data (*.18o file for each IGS station) and navigation files (brbc *.18n) obtained from the NASA Space Based Geodesy website: CDDIS[7]. RTK processed data will be converted for use in Qimera processing software to refine the vessel's horizontal accuracy and check the tidal model through comparison with observed tide at the nearest station.

A.1.iii. TIDES

The small tidal range in all areas enabled rapid initial MBES processing without application of tidal corrections to support cruise scientific activity. Tide files will be generated using the stations listed in Table A3.1 and checked using post processed RTK GNSS heights.

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[4] https://www.gsa.europa.eu/egnos/services
[5] https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/
[6] JCR AME Wiki webpage
[7] https://cddis.nasa.gov/Data_and_Derived_Products/GNSS/broadcast_ephemeris_data.html

Table A3.1 Tide stations used

Tide station	IOC Code	Position	Download link
Rothera	Rothe	67° 34′·002 S 68° 07′·998 W	http://www.ioc-sealevelmonitoring.org/station.php?code=rothe
Palmer	Palm (USAP)	64° 46′·760 S 64° 03′·333 W	ftp://amrc.ssec.wisc.edu/pub/palmer/tidegauge/
Prat	Prat3	62° 28′·756 S 59° 39′·774 W	http://www.ioc-sealevelmonitoring.org/station.php?code=prat3

Seapath raw data were logged with the ship at DP adjacent to Rothera wharf to obtain values for a GPS tide validation against the Rothera Tide Gauge. Periods suitable for use were confined to those outside of stores transfer and fuelling activity to avoid draught changes. Rothera tides were downloaded from the IOC website at 1 minute intervals and compared with the RTK processed Seapath positions. Rothera IGS station was intermittently offline and no alternate station was within suitable range. It was not possible to access the gauge at Rothera to conduct a tide comparison owing to significant construction work at the station. A photograph of the tide gauge and correspondence with the station staff indicates there has been no change since ICEBERGS 2. Despite the intermittent IGS corrections, the resultant post processed GPS curve (Fig. A3.1) provides confidence that the Rothera tide gauge is operating as expected. The position solution generated in 'RTKLib Post' software is shown in Figure A3.2.

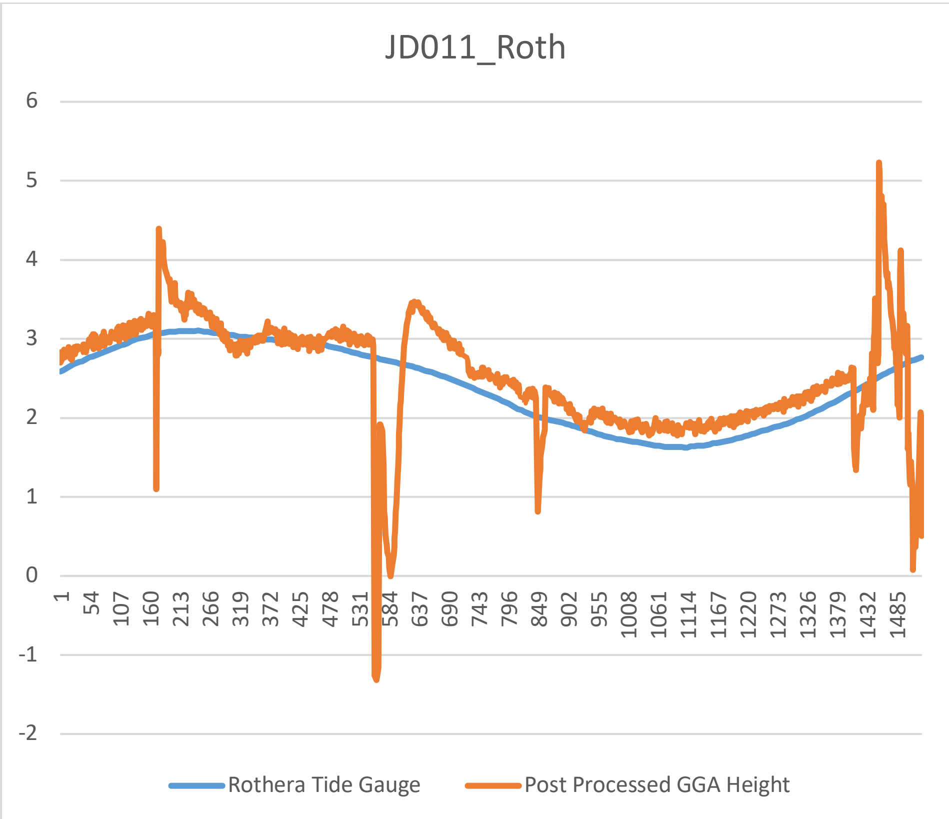

Figure A3.1 24 hour tidal comparison for 11 January 2020 at Rothera

Figure A3.2 RTK Post screen capture showing the positional errors generated by intermittent IGS data availability at the Rothera station

A visit to King Sejong Station (South Korea) confirmed presence of a radar and pressure tide gauge at the station. The station leader stated that the gauge was being installed by a commercial company to create a new hydrographic chart of the area and has only been active this year. Email details were passed to the station along with our gridded bathymetry product for Marian Cove and the station leader confirmed he would be in touch to discuss potential use of the gauge for our work.

A.1.iv. SOUND VELOCITY

CTD casts performed routinely as part of the scientific cruise plan were used to obtain SVPs and were preferred to XBT generated SVPs for cost and environmental reasons. During passage synthetic SVPs were applied due to time and budget constraints. These SVPs were generated using HydrOffice Sound Speed Manager software following the procedure outlined in JR17004's cruise report.

The 'sound speed at the transducer' value in SIS runtime parameters was set to 'sensor' and updated at 5 second intervals with sound velocity values taken from the vessel's uncontaminated seawater. This was achieved by running the python script from the documents folder on the SIS terminal in Windows Powershell using the command: "python .\JCR_c_keel.py" following the procedure outlined in JR17004's cruise report. The sound velocity was monitored during data collection for differences greater than 3 ms^{-1} between the SV profile and SV in use. A list of sound velocity (*.asvp) files is shown in Table A4.1.

Table A4.1 Sound Velocity Profiles used during JR19002

Filename	Date and Time (UTC)	Project
JR18003_013_thinned.asvp	02/01/2020 1236	JR_19002_a
20181227-2142_WOA.asvp	03/01/2020 1202	JR_19002_a
JR19002_000_thinned.asvp	04/01/2020 1545	JR_19002_b
JR19002_007_thinned.asvp	13/01/2020 1318	JR_19002_b
JR19002_011_thinned.asvp	13/01/2020 2035	JR_19002_b
JR19002_012_thinned.asvp	13/01/2020 2226	JR_19002_b
JR19002_009_thinned.asvp	14/01/2020 1226	JR_19002_b
JR19002_003_thinned.asvp	17/01/2020 1856	JR_19002_b
JR19002_002_thinned.asvp	17/01/2020 1853	JR_19002_b
JR19002_004_thinned.asvp	17/01/2020 1925	JR_19002_b
JR19002_002_thinned.asvp	17/01/2020 2049	JR_19002_b
JR19002_???_thinned.asvp	17/01/2020 2126	JR_19002_b
JR19002_002_thinned.asvp	17/01/2020 2232	JR_19002_b
JR19002_003_thinned.asvp	18/01/2020 0316	JR_19002_b
JR19002_000_thinned.asvp	18/01/2020 0431	JR_19002_b
JR19002_024_thinned.asvp	19/01/2020 1710	JR_19002_c
JR19002_025_thinned.asvp	19/01/2020 1920	JR_19002_d
JR19002_047_thinned.asvp	24/01/2020 1725	JR_19002_f
JR19002_048_thinned.asvp	24/01/2020 2027	JR_19002_f
JR19002_049_thinned.asvp	24/01/2020 2026	JR_19002_f
JR19002_050_thinned.asvp	25/01/2020 0509	JR_19002_f
JR19002_051_thinned.asvp	25/01/2020 0508	JR_19002_f
JR19002_052_thinned.asvp	25/01/2020 0508	JR_19002_f
JR19002_053_thinned.asvp	25/01/2020 0507	JR_19002_f
JR19002_054_thinned.asvp	25/01/2020 0506	JR_19002_f
JR19002_055_thinned.asvp	25/01/2020 0506	JR_19002_f

A.1.v. MBES PROCESSING

Raw Kongsberg (.all) files were imported into QPS Qimera and an initial rough edit performed to remove gross error. Standard filters and further and manual editing was used to remove systematic noise and random errors. Tide and GNSS solutions were not applied during the cruise owing to IGS data delays, internet unavailability and time constraints. Data will be processed after the cruise with a more thorough edit and application of tidal corrections.

An initial appraisal of each area was conducted to look for significant changes from the 2018 ICEBERGS cruise. No significant changes were found in bathymetry but ice front position and profile changes were noted.

QPS FMGT software was used to perform an initial assessment of MBES backscatter data using raw and Qimera exported .GSF files. Seabed sample particle-size analysis will enable calibration of backscatter and elicit better assessment of seabed sediment characterisation.

Outputs for each survey area are shown in Table A5.1. QPS iView4D Free Software can be used to view QPS files. For details of the 44 x sound velocity .asvp files, see the CTD section of this report.

Table A5.1 Survey Data Outputs for JR18003 – Processed Projects

Survey	Area	Projection	QPS Project	Products	Comments
JR19002_b	Sheldon Cove / Deep Impact	WGS 84 UTM Zone 19S	Sheldon 2019	81 x .all files (Raw) QPS Dynamic Surfaces: - Sheldon_Cove_2020_10m BAG files: - Sheldon_2020.bag ASCII files: - JR19002_b_Accepted_Soundings_WGS84.xyz - JR19002_b_Rejected_Soundings_WGS84.xyz - JR19002_b_All_Soundings_WGS81.xyz Images: Sheldon_2020_10m.tif	10m filtered grid produced. Edited with Strong Spline filter and manually checked to ensure features preserved. No Tide / SV / or GNSS post processing conducted during cruise.
JR19002_d	Börgen Bay	WGS 84 UTM Zone 20S	Börgen Bay 2019-20	56 x .all files (Raw) QPS Dynamic Surfaces: - Borgen_Bay_2020_10m BAG files: - Borgen_Bay_2020.bag ASCII files: - JR19002_d_Accepted_Soundings_WGS84.xyz - JR19002_d_Rejected_Soundings_WGS84.xyz - JR19002_d_All_Soundings_WGS84.xyz Images: Borgen_Bay_2020_10m.tif	10m filtered grid produced. Edited with Strong Spline filter and manually checked to ensure features preserved. No Tide / SV / or GNSS post processing conducted during cruise.
JR19002_f	Marian Cove	WGS 84 UTM Zone 21S	Marian Cove 2019	54 x .all files (Raw) QPS Dynamic Surfaces: - Marian Cove_2020_5m BAG files: - Marian_Cove_2020.bag ASCII files: - JR19002_f_Accepted_Soundings_WGS84.xyz - JR19002_f_Rejected_Soundings_WGS84.xyz - JR19002_f_All_Soundings_WGS84.xyz Images: Marian Cove_2020_5m.tif	5m filtered grid produced. Edited with Medium Spline filter and manually checked to ensure features preserved. No Tide / SV / or GNSS post processing conducted during cruise.
JR18003_h	Burdwood Bank	WGS84 World Mercator	Burdwood Bank	37 x .all files (Raw) BAG file: - Burdwood_Bank_2020.bag ASCII file: - Burdwood_Bank_Accepted Soundings_WGS84.xyz - Burdwood_Bank_Rejected_Soundings_WGS84.xyz - Burdwood_Bank_All_Soundings_WGS84.xyz Gridded ASCII file: - Burdwood_Bank_2020_10m.xyz Images: Burdwood Bank_2020_10m.tif	No Tide / SV / or GNSS post processing conducted. Only 8 lines processed owing to equipment defects and excessive noise from weather.

Opportunistic sounding was conducted between survey sites was not processed onboard. WGS84 World Mercator projection was used. These will be rendered in raw data format to BAS.

A.1.vi. EQUIPMENT ISSUES

Following the patch test, significant noise was noted in the SIS 'Waterfall' display with many beams missing across the swath. The Stave display was checked (Figure A6.1) and there were several staves with missing or degraded data. This had a significant impact on the first DEEP IMPACT work with unusable data generated for several hours making the results unsuitable for assessment of scour features on the seabed. At one point, 53 of the 128 staves were showing as 'missing' data with 207 beams received (from a total of 432).

A BIST test was conducted and no issues were found. A full system restart was conducted and it was noticed that the transceiver cabinet compartment was very warm with the EM122 pre-amp unit being particularly hot to touch. Both transceiver and pre-amp were switched off for several hours and allowed to cool. During this period, the system was checked by the AME electrical engineer who identified the pre-amp unit cooling fans had worn bearings. All three fans were replaced with new fans and on start-up, the pre-amp unit ran at a much cooler temperature. The stave noise was no longer present and data quality returned to normal. Throughout survey operations, the noise returned periodically at lower levels and addition of a desk fan to the space and cooling of the compartment by leaving doors ajar to adjacent compartments helped to prevent significant degradation. The system generally behaved for around 4 days at a time before the noise returned and where possible, the system was shut down to promote further cooling. Unfortunately, when the system was turn on again in Burdwood Bank after 36 hours of cooling the noise remained excessive and stave display degraded. This had a significant impact on the multibeam work at Burdwood Bank where multibeam data were sufficient only to provide a general indication of depth.
Advice was sought from Kongsberg but the online request for assistance form could not be completed owing to poor internet bandwidth and emails to the support addresses were not returned. Alex Tate (BAS SDA Data Manager) liaised with Kongsberg on behalf of the ship and a reply was received several days later from a support engineer highlighting a possible 12V power supply issue. Investigation by the AME engineer could not confirm or rectify the defect based on the information given. The issue was temporarily rectified by cooling of the system and no further support from Kongsberg was sought. The problem re-occurred at Burdwood Bank on 31 January and support from AME (with assistance from Kongsberg if required) was requested. The AME engineer subsequently identified the problem as potentially linked to the pre-amp unit's power supply since that unit was much cooler than the transceiver cabinet, which now appeared to be excessively warm. This correlated with the noise associated with overheating and general loss of power observed in the display stave. A temporary fix was made on 2 February which enabled multibeam operation at Burdwood Bank to commence. System downtime resulted in unavailability for 3 days at Burdwood Bank and ~ 6 hours during DEEP IMPACT survey work.

It is recommended that the issue be robustly investigated with, Kongsberg assistance, when communications permit to identify the cause and fully rectify the defect with a permanent repair. Further details may be found contained within the AME section of the cruise report.

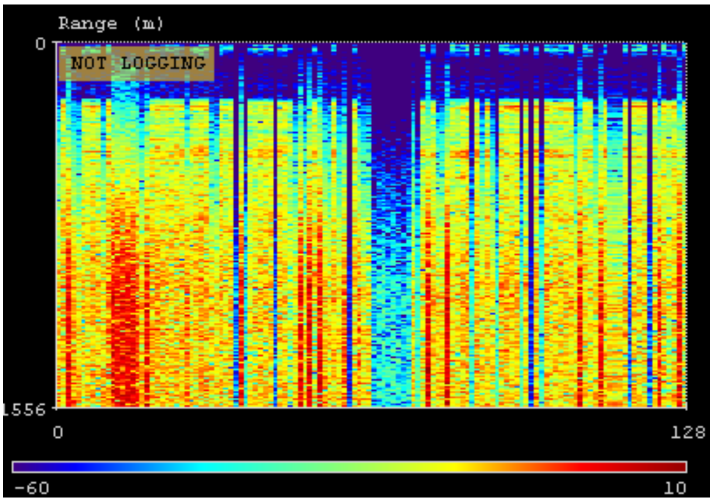

Figure A6.1. SIS Stave display showing many missing or degraded staves across the swath (see also figure A5.1.1 for usual display)

A.1.vii. CONFLICTS WITH OTHER SYSTEMS

JCR's Kongsberg K-SYNC system was used to avoid interference with other underwater acoustic systems by deconflicting transmissions. Despite this, interference was stilled noted between EM122 and the EA600. EA600 was switched to passive mode whenever sounding with MBES to avoid this. No interference was observed with the EK80 or ADCP which were used extensively throughout the cruise although the use of EK80 did reduce the ping rate of EM122 when operated through K-SYNC. For this reason, and owing to the shallow depths in Marian Cove, the EK80 was switched to standby for part of the Marian Cove work.

Use of the TOPAS at Burdwood Bank produced significant noise in EM122 which disappeared when K-SYNC was used to deconflict active transmission periods.

A.1.viii. SOFTWARE AND VERSIONS

Seapath 320-5+ Product version 1.10.00 Processing SW version 4.15.02
GNSS Antenna 1 Type Novatel OEMV Firmware L1G DES10319106V1GV-1.03-TT 3.907 3.010 2015/May/27 16:29:46
GNSS Antenna 2 Type Novatel OEMV GNSS 2 Firmware L1G DES10160010V1GV-1.02-TT 3.907 3.010 2015/May/27 16:29:46

Kongsberg Seafloor Information System (SIS) Version 4.3.2 Build 31
Qimera 64 bit edition Version 1.7.6 Build 1638
FM Geocoder Toolbox 64 bit edition Version 7.8.9 Build 283
Kongsberg RINEXCONVERTER Version 2.00.00

A.1.ix. SUPPORTING PHOTOGRAPHS

Eleven panoramic photographs were taken to show detail the ice front at each location. Images were combined in Microsoft Image Composite Editor using a cylindrical projection. Details are shown in table A9.1 below. Examples of panoramas at Börgen Bay are shown in Figures A9.1 and A9.2.

Table A9.1 Supporting Photos

Ship Position		Date / Time	Location	File Number	Panorama File Name	Comments
Latitude	Longitude					
67°32'.632S	068° 16'.100W	16/01/20 1856 UTC	Sheldon Cove	D72_2522-D72_2535	D72_2522_stitch.tiff	Ice Front panorama
67°31'.604S	068° 16'.042W	17/01/20 0940 UTC	Sheldon Cove	D72_2598-D72_2612	D72_2598_stitch.tiff	Ice Front panorama (left)
67°31'.604S	068° 16'.042W	17/01/20 0941 UTC	Sheldon Cove	D72_2612-D72_2628	D72_2612_stitch.tiff	Ice Front panorama (right)
67°31'.604S	068° 16'.042W	17/01/20 0942 UTC	Sheldon Cove	D72_2630-D72_2653	D72_2630_stitch.tiff	Ice Front panorama
64°42'.042S	063° 27'.186W	20/01/20 1059 UTC	Börgen Bay	D72_2901-2907	D72_2901_stitch.jpg	Ice Front panorama (right of bow)
64°42'.042S	063° 27'.186W	20/01/20 1110 UTC	Börgen Bay	D72_2921-2928	D72_2921_stitch.jpg	Ice Front panorama (left of bow)
64°42'.042S	063° 27'.186W	20/01/20 1123 UTC	Börgen Bay	D72_2929-2950	D72_2929_stitch.tiff	Ice Front panorama
64°45'.703S	063° 28'.371W	21/01/20 1930 UTC	Börgen Bay	D72_3424-D72_3446	D72_3424_stitch.tiff	Ice Front panorama
64°44'.412S	063° 31'.037W	23/01/20 1418 UTC	Börgen Bay	D72_2481-D72_3501	D72_3481_stitch.tiff	Ice Front panorama
62°12'.212S	058° 44'.179W	25/01/20 0720 UTC	Marian Cove	D72_3943-D72_3961	D72_3943_stitch.tiff	Ice Front panorama
62°12'.212S	058° 44'.179W	25/01/20 0720 UTC	Marian Cove	D72_3972-D72_3999	D72_3972_stitch.tiff	Ice Front panorama

Figure A9.1. Börgen Bay Panorama (D72_2921_stitch.jpg)

Figure A9.2. Börgen Bay Panorama (D72_2901_stitch.jpg)

A.2 Cetacean observations

A.2.i. Cetacean sightings

Area, date, time, position Sightings made from the 31st of January to the 4th of February 2020 in the Western Antarctic Peninsula (WAP), Drake Passage (DP), and Burwood Bank (BB). Legend: Nav=navigation mode; Sta=stationary mode; Unk=unknown; bal=baleen; pict=pictures.

Area	Date	Time	Ship Mode	Latitude	Longitude	Species	Group Size	Pict. No
WAP	31/12/2019	14:44:00	Nav	-52.357	-69.237	Sei whale	1	2
WAP	08/01/2020	23:12:00	Sta	-67.588	-68.103	Humpback whale	6	9
WAP	09/01/2020	23:32:00	Sta	-67.585	-68.129	Killer whale	7	29
WAP	10/01/2020	12:00:00	Sta	-67.571	-68.136	Humpback whale	1	
WAP	10/01/2020	16:47:00	Sta	-67.571	-68.135	Humpback whale	1	1
WAP	10/01/2020	19:22:42	Sta	-67.571	-68.135	Humpback whale	1	21
WAP	10/01/2020	22:09:27	Sta	-67.571	-68.135	Humpback whale	1	
WAP	10/01/2020	22:21:00	Sta	-67.571	-68.135	Humpback whale	1	
WAP	11/01/2020	01:20:00	Sta	-67.595	-68.100	Humpback whale	1	
WAP	11/01/2020	01:37:05	Sta	-67.583	-68.100	Humpback whale	1	58
WAP	11/01/2020	02:00:00	Sta	-67.595	-68.100	Killer whale	3	41
WAP	11/01/2020	19:20:00	Sta	-67.573	-68.138	Humpback whale	2	
WAP	11/01/2020	20:25:00	Sta	-67.573	-68.137	Humpback whale	1	34
WAP	12/01/2020	10:15:00	Sta	-67.580	-68.155	Humpback whale	3	237
WAP	14/01/2020	13:50:00	Sta	-67.602	-68.149	Killer whale	2	
WAP	16/01/2020	19:35:00	Sta	-67.549	-68.264	Humpback whale	2	130
WAP	17/01/2020	18:05:00	Sta	-67.568	-68.208	Minke whale	1	6
WAP	17/01/2020	22:52:00	Sta	-67.550	-68.255	Killer whale	3	15
WAP	18/01/2020	12:30:00	Nav	-67.710	-67.741	Killer whale	1	
WAP	18/01/2020	15:49:57	Nav	-67.745	-68.393	Humpback whale	2	40
WAP	18/01/2020	17:13:30	Nav	-67.813	-69.103	Humpback whale	1	3
WAP	18/01/2020	17:24:56	Nav	-67.777	-69.163	Unk. cetacean	1	
WAP	18/01/2020	17:51:00	Nav	-67.710	-69.301	Humpback whale	1	12
WAP	18/01/2020	18:03:56	Nav	-67.675	-69.335	Unk. bal. whale	1	
WAP	18/01/2020	18:12:18	Nav	-67.638	-69.350	Minke whale	2	36
WAP	19/01/2020	00:50:00	Nav	-66.589	-68.609	Minke whale	1	
WAP	19/01/2020	01:08:01	Nav	-66.549	-68.512	Minke whale	2	5

WAP	19/01/2020	01:30:24	Nav	-66.496	-68.397	Humpback whale	1	5
WAP	19/01/2020	01:46:39	Nav	-66.452	-68.291	Humpback whale	2	41
WAP	19/01/2020	01:51:57	Nav	-66.451	-68.266	Humpback whale	1	
WAP	19/01/2020	01:53:35	Nav	-66.444	-68.251	Humpback whale	1	6
WAP	19/01/2020	01:58:10	Nav	-66.424	-68.257	Unk. bal. whale	1	
WAP	19/01/2020	02:18:47	Nav	-66.373	-68.110	Humpback whale	3	38
WAP	19/01/2020	11:38:12	Nav	-64.972	-65.239	Humpback whale	2	75
WAP	19/01/2020	11:50:16	Nav	-64.948	-65.180	Humpback whale	1	21
WAP	19/01/2020	11:58:55	Nav	-64.914	-65.186	Humpback whale	2	
WAP	19/01/2020	12:26:46	Nav	-64.917	-64.904	Humpback whale	4	81
WAP	19/01/2020	12:31:46	Nav	-64.927	-64.866	Humpback whale	2	17
WAP	19/01/2020	12:35:18	Nav	-64.945	-64.821	Humpback whale	1	
WAP	19/01/2020	12:44:00	Nav	-64.926	-64.761	Humpback whale	1	10
WAP	19/01/2020	13:03:30	Nav	-64.926	-64.603	Humpback whale	2	7
WAP	19/01/2020	13:31:00	Nav	-64.911	-64.399	Unk. Bal. whale	1	
WAP	19/01/2020	13:34:00	Nav	-64.864	-64.358	Humpback whale	5	21
WAP	19/01/2020	14:01:00	Nav	-64.846	-64.152	Humpback whale	2	3
WAP	19/01/2020	14:06:38	Nav	-64.846	-64.114	Humpback whale	1	
WAP	19/01/2020	14:06:45	Nav	-64.840	-64.105	Humpback whale	1	
WAP	19/01/2020	14:13:00	Nav	-64.830	-64.059	Humpback whale	4	129
WAP	19/01/2020	14:13:20	Nav	-64.832	-64.053	Humpback whale	2	0
WAP	19/01/2020	14:15:00	Nav	-64.845	-64.156	Humpback whale	1	
WAP	19/01/2020	15:11:34	Nav	-64.853	-63.649	Humpback whale	1	
WAP	19/01/2020	15:26:37	Nav	-64.802	-63.590	Humpback whale	1	
WAP	19/01/2020	15:45:50	Nav	-64.776	-63.499	Humpback whale	1	
WAP	19/01/2020	15:46:00	Nav	-64.775	-63.498	Minke whale	1	
WAP	19/01/2020	20:20:00	Sta	-64.738	-63.455	Humpback whale	1	5
WAP	21/01/2020	13:00:00	Sta	-64.743	-63.457	Humpback whale	2	68
WAP	23/01/2020	19:36:00	Sta	-64.722	-63.469	Humpback whale	1	2
WAP	23/01/2020	21:11:28	Nav	-64.751	-63.295	Unk. cetacean	1	
WAP	23/01/2020	21:18:57	Nav	-64.726	-63.262	Humpback whale	1	36

WAP	23/01/2020	21:55:45	Nav	-64.686	-63.050	Humpback whale	3	
WAP	23/01/2020	22:15:19	Nav	-64.658	-62.939	Humpback whale	1	
WAP	23/01/2020	22:17:02	Nav	-64.650	-62.917	Humpback whale	2	
WAP	23/01/2020	22:21:25	Nav	-64.641	-62.891	Humpback whale	4	77
WAP	23/01/2020	22:32:58	Nav	-64.626	-62.828	Humpback whale	2	
WAP	23/01/2020	22:34:11	Nav	-64.635	-62.843	Humpback whale	5	
WAP	23/01/2020	22:37:21	Nav	-64.620	-62.793	Humpback whale	3	28
WAP	24/01/2020	00:45:33	Nav	-64.396	-62.019	Humpback whale	1	16
WAP	24/01/2020	00:45:50	Nav	-64.395	-62.016	Humpback whale	1	
WAP	24/01/2020	00:49:36	Nav	-64.381	-61.991	Humpback whale	1	
WAP	24/01/2020	00:52:12	Nav	-64.405	-61.980	Humpback whale	2	
WAP	24/01/2020	00:52:38	Nav	-64.392	-61.982	Humpback whale	2	
WAP	24/01/2020	00:53:48	Nav	-64.372	-61.967	Minke whale	1	
WAP	24/01/2020	00:58:08	Nav	-64.361	-61.974	Humpback whale	1	108
WAP	24/01/2020	01:03:16	Nav	-64.342	-61.951	Humpback whale	2	167
WAP	24/01/2020	01:04:53	Nav	-64.341	-61.952	Humpback whale	3	0
WAP	24/01/2020	01:20:13	Nav	-64.265	-61.957	Humpback whale	2	
WAP	24/01/2020	01:24:10	Nav	-64.273	-61.941	Humpback whale	1	25
WAP	24/01/2020	01:27:00	Nav	-64.260	-61.937	Humpback whale	1	
WAP	24/01/2020	01:31:09	Nav	-64.244	-61.924	Humpback whale	2	
WAP	24/01/2020	01:34:17	Nav	-64.214	-61.930	Humpback whale	2	
WAP	24/01/2020	01:38:24	Nav	-64.236	-61.868	Humpback whale	1	
WAP	24/01/2020	01:39:42	Nav	-64.227	-61.861	Humpback whale	1	
WAP	24/01/2020	01:47:17	Nav	-64.177	-61.927	Humpback whale	1	
WAP	24/01/2020	09:53:18	Nav	-63.079	-59.983	Unk. bal. whale	1	
WAP	24/01/2020	10:31:22	Nav	-62.996	-59.815	Unk. cetacean	2	
WAP	24/01/2020	10:39:11	Nav	-62.978	-59.775	Unk. cetacean	1	
WAP	24/01/2020	10:50:07	Nav	-62.953	-59.739	Unk. cetacean	1	6
WAP	24/01/2020	11:44:00	Nav	-62.831	-59.499	Humpback whale	2	
WAP	24/01/2020	12:02:00	Nav	-62.788	-59.394	Humpback whale	1	
WAP	24/01/2020	12:04:00	Nav	-62.786	-59.404	Humpback whale	3	26

WAP	24/01/2020	13:07:06	Nav	-62.639	-59.133	Humpback whale	2	
WAP	24/01/2020	13:11:48	Nav	-62.630	-59.112	Humpback whale	1	
WAP	24/01/2020	13:39:13	Nav	-62.569	-58.977	Unk. bal. whale	1	
WAP	24/01/2020	14:04:53	Nav	-62.505	-58.857	Humpback whale	2	
WAP	24/01/2020	14:30:35	Nav	-62.442	-58.730	Humpback whale	1	
WAP	24/01/2020	16:37:00	Sta	-62.217	-58.789	Humpback whale	2	117
WAP	24/01/2020	22:07:00	Sta	-62.212	-58.764	Humpback whale	1	133
WAP	25/01/2020	02:52:00	Sta	-62.209	-58.754	Humpback whale	1	3
WAP	25/01/2020	10:18:00	Sta	-62.204	-58.731	Humpback whale	2	16
WAP	25/01/2020	15:09:00	Sta	-62.212	-58.768	Humpback whale	2	1
WAP	28/01/2020	19:11:45	Nav	-62.379	-58.779	Humpback whale	1	
WAP	28/01/2020	19:16:55	Nav	-62.386	-58.820	Humpback whale	1	
WAP	28/01/2020	19:22:39	Nav	-62.400	-58.837	Humpback whale	2	
WAP	29/01/2020	20:37:12	Nav	-62.382	-59.292	Humpback whale	1	
WAP	29/01/2020	20:39:35	Nav	-62.389	-59.234	Humpback whale	2	
WAP	29/01/2020	20:47:51	Nav	-62.368	-59.267	Unk. cetacean	1	
WAP	29/01/2020	20:54:35	Nav	-62.343	-59.272	Unk. bal. whale	1	
WAP	29/01/2020	21:10:42	Nav	-62.299	-59.303	Humpback whale	1	
WAP	29/01/2020	22:02:30	Nav	-62.143	-59.327	Fin whale	3	6
WAP	29/01/2020	22:09:32	Nav	-62.120	-59.321	Humpback whale	1	21
WAP	29/01/2020	22:14:23	Nav	-62.106	-59.319	Unk. bal. whale	2	
WAP	29/01/2020	22:15:12	Nav	-62.110	-59.337	Humpback whale	1	
WAP	29/01/2020	22:17:27	Nav	-62.103	-59.334	Sei whale	1	16
WAP	29/01/2020	22:20:12	Nav	-62.093	-59.316	Unk. bal. whale	1	
WAP	29/01/2020	22:43:14	Nav	-62.016	-59.312	Fin whale	2	38
DP	30/01/2020	11:45 AM	Nav	-59.516	-58.566	Unk. bal. whale	2	
DP	30/01/2020	11:45 AM	Nav	-59.511	-58.566	Unk. bal. whale	2	
DP	30/01/2020	11:55 AM	Nav	-59.483	-58.549	Unk. bal. whale	1	
DP	30/01/2020	12:43:50	Nav	-59.349	-58.545	Unk. cetacean	1	
DP	30/01/2020	13:32:54	Nav	-59.196	-58.571	Unk. bal. whale	3	14
DP	30/01/2020	13:41:10	Nav	-59.171	-58.511	Fin whale	2	27
DP	30/01/2020	16:01:00	Nav	-58.770	-58.434	Minke whale	1	8
DP	30/01/2020	16:02:17	Nav	-58.763	-58.451	Unk. bal. whale	1	

DP	30/01/2020	18:42:40	Nav	-58.319	-58.354	Unk. bal. whale	1	
BB	02/02/2020	19:11:00	Nav	-54.233	-56.713	Pilot whale	12	435
BB	02/02/2020	19:12:00	Nav	-54.234	-56.712	Hourglass dolphin	2	4
BB	02/02/2020	23:06:00	Sta	-54.218	-56.740	Pilot whale	5	55
BB	02/02/2020	23:28:17	Sta	-54.215	-56.743	Pilot whale	7	42
BB	03/02/2020	13:25:58	Sta	-54.219	-56.714	Pilot whale	3	
BB	03/02/2020	14:11:56	Nav	-54.159	-56.851	Pilot whale	7	44
BB	03/02/2020	15:06:00	Nav	-54.062	-57.037	Peale's dolphin	2	

A.2.ii. Script python

```
"""
Created on Wed May 22 13:38:14 2019

Remember to use Python 3 instruction

@author: Alice FREMAND & Marina Costa
"""
import datetime
import csv
import os ## to change directory, import/export files, etc.####
ID = 'JR18004'
                      ##################################################
                      ##############READ DATA###########################
                      ##################################################

gps = open("seatex-gga.ACO", "r")
gps_data = []
for line in gps:
    if line.startswith('20'): #this line has been added to avoid to have empty lines
        gps_data.append(line.split(','))


bathy = open("ea600.ACO", "r")
bathy_data = []
for line in bathy:
    if line.startswith('20'): #this line has been added to avoid to have empty lines
        bathy_data.append(line.split(','))

em122 = open("em122.ACO", "r")
em122_data = []
for line in em122:
    if line.startswith('20'): #this line has been added to avoid to have empty lines
        em122_data.append(line.split(','))

oceanlogger = open("C:/Anaconda/JR18004_data/oceanlogger.ACO", "r")
oceanlogger_data = []
for line in oceanlogger:
    if line.startswith('20'): #this line has been added to avoid to have empty lines
        oceanlogger_data.append(line.split(','))

ceta_data = []
with open('Ceta.csv') as f:
    f_csv = csv.reader(f)
    headers = next(f_csv)
    for row in f_csv:
#for line in ceta:
        ceta_data.append(row)

track_Ceta= open("trackCeta_JR18004.csv" , "w+")
```

```
                            #################################################
                            #############CONVERT DATE#######################
                            #################################################
date_gps = []
DateTime_gps = []
for i in range(0, len(gps_data)):
    T0= datetime.datetime(int(gps_data[i][0]), 1, 1)
    T1 = T0 + datetime.timedelta(days=float(gps_data[i][1])+ 0.000005-1)
    DateTime_gps.append(T1)
    date_gps.append(T1.strftime('%Y-%m-%d %H:%M:%S'))

date_bathy = []
DateTime_bathy = []
for i in range(0, len(bathy_data)):
    T0= datetime.datetime(int(bathy_data[i][0]), 1, 1)
    T1 = T0 + datetime.timedelta(days=float(bathy_data[i][1])+ 0.000005-1)
    DateTime_bathy.append(T1)
    date_bathy.append(T1.strftime('%Y-%m-%d %H:%M:%S'))

date_em122 = []
DateTime_em122 = []
for i in range(0, len(em122_data)):
    T0= datetime.datetime(int(em122_data[i][0]), 1, 1)
    T1 = T0 + datetime.timedelta(days=float(em122_data[i][1])+ 0.000005-1)
    DateTime_em122.append(T1)
    date_em122.append(T1.strftime('%Y-%m-%d %H:%M:%S'))

date_oceanlogger = []
DateTime_oceanlogger = []
for i in range(0, len(oceanlogger_data)):
    T0= datetime.datetime(int(oceanlogger_data[i][0]), 1, 1)
    T1 = T0 + datetime.timedelta(days=float(oceanlogger_data[i][1])+ 0.000005-1)
    DateTime_oceanlogger.append(T1)
    date_oceanlogger.append(T1.strftime('%Y-%m-%d %H:%M:%S'))

date_ceta = []
DateTime_ceta = []
for i in range(0, len(ceta_data)):
    Date = ceta_data[i][3]
    Time = ceta_data[i][7]
    datetime_i = Time + " " + Date
    T1=  datetime.datetime.strptime(datetime_i, '%H:%M:%S %d/%m/%Y')
    T1_UTC = T1 + datetime.timedelta(hours=3)
    DateTime_ceta.append(T1_UTC)
    date_ceta.append(T1_UTC.strftime('%Y-%m-%d %H:%M:%S'))

                            #################################################
                            #############PROCESSING#########################
                            #################################################
track_Ceta.write('Datetime, JulianDay, lat, lon, EM122, EA600, AirTemp, Hummidity, AirTemp2, Humidity2, Barometer1, Barometer2, TSGtemperature, TSGconductivity, Salinity, SoundVelocity, Flowrate, SeaTemp2, SeaTemp1, Chlorophyl, IDpro, SE_value, ActiveObs, Date, DateGis, DateUTC, TimeUTC, LocalTime, LocalTimeFKEnd, endSight, FalseLeg, DeltaTime, LapUTC, Platform, HeightM, Observer, Cetacean, BackAfterSigh, Effort, ShipMode, Beau, Swellcm, CloudCove, Rain, Fog, FogNote, Snow, IceCoverage, Glare, GlareDegree, Visbility, VisbilityNote, Sightability, BirdsAroundBird, BirdsOccasional, BirdsNote, OtherAnimals, SightingNumber, BearingShipCompass, DistanceM, Taxa, Species, SpeciesQuality, Spotter, Cue, Min, Max, Best, WhaleSwimDirection, ReactionAtSight, BehaviorAtSight, Pictures, Pics_no, UsefulForIdentification, UsefulForPhotoID, Note,\n')
v=0
w=0
x=0
y=0
z=0
temp_effort = 'neg'
data_dict={}
tempDateTimeGPS = DateTime_gps[x]
while x<len(gps_data)-1:
    while z<len(bathy_data)-1:
        while y<len(em122_data)-1:
            while w<len(oceanlogger_data)-1:
                while v<len(ceta_data):
#for x in range(0, len(gps_data)-1):
```

```
#    for z in range(0, len(bathy_data)-1):
#        for y in range(0, len(em122_data)-1):
#            for w in range(len(oceanlogger_data)-1):
#                for v in range(0, len(ceta_data)-1):
                    if   v<len(ceta_data)+1   and   abs(DateTime_gps[x]   -   DateTime_ceta[v])<
datetime.timedelta(seconds=5):
                        #print('Ok, x=%s, y=%s, z=%s, v=%s, w=%s' %(x, y, z, v,w))
                        #print('%s, %s, %s' %( date_gps[x], date_em122[y], date_bathy[z]))
                        data_dict["Datetime"] = date_gps[x]
                        tempDateTimeGPS = DateTime_gps[x]
                        data_dict["lat"]= gps_data[x][5]
                        data_dict["lon"]=gps_data[x][6]
                        data_dict['JulianDay'] = gps_data[x][2]
                        if          abs(DateTime_gps[x]          -          DateTime_em122[y])<
datetime.timedelta(seconds=25):
                            if float(em122_data[y][4])==0.00:
                                data_dict['EM122'] = ""
                                #y=y+1
                            else:
                                data_dict['EM122'] = em122_data[y][4].strip()
                                #y=y+1
                        else:
                            data_dict['EM122'] = ""
                        if          abs(DateTime_gps[x]          -          DateTime_bathy[z])<
datetime.timedelta(seconds=25):
                            if bathy_data[z] == ['\n'] or float(bathy_data[z][5])==0.00:
                                #z=z+1
                                data_dict["EA600"] = ""
                            else:
                                data_dict["EA600"] = bathy_data[z][5]
                                #z=z+1
                        else:
                            data_dict["EA600"] = ""
                        if date_gps[x][-2] == date_oceanlogger[w][-2]:
                            data_dict['AirTemp'] = oceanlogger_data[w][5]
                            data_dict['Hummidity'] = oceanlogger_data[w][6]
                            data_dict['AirTemp2'] = oceanlogger_data[w][9]
                            data_dict['Humidity2'] = oceanlogger_data[w][10]
                            data_dict['Barometer1'] = oceanlogger_data[w][13]
                            data_dict['Barometer2'] = oceanlogger_data[w][14]
                            data_dict['TSGtemperature'] = oceanlogger_data[w][15]
                            data_dict['TSGconductivity'] = oceanlogger_data[w][16]
                            data_dict['Salinity'] = oceanlogger_data[w][17]
                            data_dict['SoundVelocity'] = oceanlogger_data[w][18]
                            data_dict['Flowrate'] = oceanlogger_data[w][21]
                            data_dict['SeaTemp2'] = oceanlogger_data[w][22]
                            data_dict['SeaTemp1'] = oceanlogger_data[w][24].strip()
                            data_dict['Chlorophyl'] = oceanlogger_data[w][19]
                            #w=w+1
                        else:
                            data_dict['AirTemp'] = ""
                            data_dict['Hummidity'] = ""
                            data_dict['AirTemp2'] = ""
                            data_dict['Humidity2'] = ""
                            data_dict['Barometer1'] = ""
                            data_dict['Barometer2'] = ""
                            data_dict['TSGtemperature'] = ""
                            data_dict['TSGconductivity'] = ""
                            data_dict['Salinity'] = ""
                            data_dict['SoundVelocity'] = ""
                            data_dict['Flowrate'] = ""
                            data_dict['SeaTemp2'] = ""
                            data_dict['SeaTemp1'] = ""
                            data_dict['Chlorophyl'] = ""
                        if ceta_data[v][1] == 'S':
                            temp_effort = 'Pos'
                        if ceta_data[v][1] == 'E':
                            temp_effort = 'Neg'
                        data_dict['IDpro'] = ceta_data[v][0]
                        data_dict['SE_value'] = ceta_data[v][1]
                        data_dict['ActiveObs'] = ceta_data[v][2]
                        data_dict['Date'] = ceta_data[v][3]
```

```
                        data_dict['DateGis'] = ceta_data[v][4]
                        data_dict['DateUTC'] = ceta_data[v][5]
                        data_dict['TimeUTC'] = ceta_data[v][6]
                        data_dict['LocalTime'] = ceta_data[v][7]
                        data_dict['LocalTimeFKEnd'] = ceta_data[v][8]
                        data_dict['endSight'] = ceta_data[v][9]
                        data_dict['FalseLeg'] = ceta_data[v][10]
                        data_dict['DeltaTime'] = ceta_data[v][11]
                        data_dict['LapUTC'] = ceta_data[v][12]
                        data_dict['Platform'] = ceta_data[v][13]
                        data_dict['HeightM'] = ceta_data[v][14]
                        data_dict['Observer'] = ceta_data[v][15]
                        data_dict['Cetacean'] = ceta_data[v][16]
                        data_dict['BackAfterSigh'] = ceta_data[v][17]
                        data_dict['Effort'] = ceta_data[v][18]
                        data_dict['ShipMode'] = ceta_data[v][19]
                        data_dict['Beau'] = ceta_data[v][20]
                        data_dict['Swellcm'] = ceta_data[v][21]
                        data_dict['CloudCove'] = ceta_data[v][22]
                        data_dict['Rain'] = ceta_data[v][23]
                        data_dict['Fog'] = ceta_data[v][24]
                        data_dict['FogNote'] = ceta_data[v][25]
                        data_dict['Snow'] = ceta_data[v][26]
                        data_dict['IceCoverage'] = ceta_data[v][27]
                        data_dict['Glare'] = ceta_data[v][28]
                        data_dict['GlareDegree'] = ceta_data[v][29]
                        data_dict['Visbility'] = ceta_data[v][30]
                        data_dict['VisbilityNote'] = ceta_data[v][31]
                        data_dict['Sightability'] = ceta_data[v][32]
                        data_dict['BirdsAroundBird'] = ceta_data[v][33]
                        data_dict['BirdsOccasional'] = ceta_data[v][34]
                        data_dict['BirdsNote'] = ceta_data[v][35]
                        data_dict['OtherAnimals'] = ceta_data[v][36]
                        data_dict['SightingNumber'] = ceta_data[v][37]
                        data_dict['BearingShipCompass'] = ceta_data[v][38]
                        data_dict['DistanceM'] = ceta_data[v][39]
                        data_dict['Taxa'] = ceta_data[v][40]
                        data_dict['Species'] = ceta_data[v][41]
                        data_dict['SpeciesQuality'] = ceta_data[v][42]
                        data_dict['Spotter'] = ceta_data[v][43]
                        data_dict['Cue'] = ceta_data[v][44]
                        data_dict['Min'] = ceta_data[v][45]
                        data_dict['Max'] = ceta_data[v][46]
                        data_dict['Best'] = ceta_data[v][47]
                        data_dict['WhaleSwimDirection'] = ceta_data[v][48]
                        data_dict['ReactionAtSight'] = ceta_data[v][49]
                        data_dict['BehaviorAtSight'] = ceta_data[v][50]
                        data_dict['Pictures'] = ceta_data[v][51]
                        data_dict['Pics_no'] = ceta_data[v][52]
                        data_dict['UsefulForIdentification'] = ceta_data[v][53]
                        data_dict['UsefulForPhotoID'] = ceta_data[v][54]
                        data_dict['Note'] = ceta_data[v][55]
                        v=v+1
                        track_Ceta.write('%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s' %(data_dict["Datetime"],
data_dict["JulianDay"], data_dict["lat"],data_dict["lon"], data_dict["EM122"],
data_dict["EA600"], data_dict["AirTemp"], data_dict["Hummidity"],data_dict["AirTemp2"],
data_dict["Humidity2"], data_dict["Barometer1"],
data_dict["Barometer2"],data_dict["TSGtemperature"], data_dict["TSGconductivity"],
data_dict["Salinity"], data_dict["SoundVelocity"], data_dict["Flowrate"], data_dict["SeaTemp2"],
data_dict["SeaTemp1"], data_dict["Chlorophyl"],
data_dict["IDpro"], data_dict["SE_value"], data_dict["ActiveObs"], data_dict["Date"],
data_dict["DateGis"], data_dict["DateUTC"], data_dict["TimeUTC"], data_dict["LocalTime"],
data_dict["LocalTimeFKEnd"], data_dict["endSight"], data_dict["FalseLeg"],
data_dict["DeltaTime"], data_dict["LapUTC"], data_dict["Platform"], data_dict["HeightM"],
data_dict["Observer"], data_dict["Cetacean"], data_dict["BackAfterSigh"], data_dict["Effort"],
data_dict["ShipMode"], data_dict["Beau"], data_dict["Swellcm"], data_dict["CloudCove"],
data_dict["Rain"], data_dict["Fog"], data_dict["FogNote"], data_dict["Snow"],
data_dict["IceCoverage"], data_dict["Glare"], data_dict["GlareDegree"], data_dict["Visbility"],
data_dict["VisbilityNote"], data_dict["Sightability"], data_dict["BirdsAroundBird"],
```

```
data_dict["BirdsOccasional"],         data_dict["BirdsNote"],         data_dict["OtherAnimals"],
data_dict["SightingNumber"],       data_dict["BearingShipCompass"],       data_dict["DistanceM"],
data_dict["Taxa"],   data_dict["Species"],   data_dict["SpeciesQuality"],   data_dict["Spotter"],
data_dict["Cue"],          data_dict["Min"],          data_dict["Max"],          data_dict["Best"],
data_dict["WhaleSwimDirection"],    data_dict["ReactionAtSight"],    data_dict["BehaviorAtSight"],
data_dict["Pictures"],        data_dict["Pics_no"],        data_dict["UsefulForIdentification"],
data_dict["UsefulForPhotoID"], data_dict["Note"]))
                        track_Ceta.write('\n')

                    elif date_gps[x] == date_oceanlogger[w] and DateTime_gps[x] >= tempDateTimeGPS
+ datetime.timedelta( seconds=29):
                        data_dict["Datetime"] = date_gps[x]
                        tempDateTimeGPS = DateTime_gps[x]
                        data_dict["lat"]= gps_data[x][5]
                        data_dict["lon"]=gps_data[x][6]
                        data_dict['JulianDay'] = gps_data[x][2]

                        data_dict["IDpro"] = ''
                        data_dict["SE_value"] = ''
                        data_dict["ActiveObs"] = ''
                        data_dict["Date"] = ''
                        data_dict["DateGis"] = ''
                        data_dict["DateUTC"] = ''
                        data_dict["TimeUTC"] = ''
                        data_dict["LocalTime"] = ''
                        data_dict["LocalTimeFKEnd"] = ''
                        data_dict["endSight"] = ''
                        data_dict["FalseLeg"] = ''
                        data_dict["DeltaTime"] = ''
                        data_dict["LapUTC"] = ''
                        data_dict["Platform"] = ''
                        data_dict["HeightM"] = ''
                        data_dict["Observer"] = ''
                        data_dict["Cetacean"] = ''
                        data_dict["BackAfterSigh"] = ''
                        data_dict["Effort"] = ''
                        data_dict["ShipMode"] = ''
                        data_dict["Beau"] = ''
                        data_dict["Swellcm"] = ''
                        data_dict["CloudCove"] = ''
                        data_dict["Rain"] = ''
                        data_dict["Fog"] = ''
                        data_dict["FogNote"] = ''
                        data_dict["Snow"] = ''
                        data_dict["IceCoverage"] = ''
                        data_dict["Glare"] = ''
                        data_dict["GlareDegree"] = ''
                        data_dict["Visbility"] = ''
                        data_dict["VisbilityNote"] = ''
                        data_dict["Sightability"] = ''
                        data_dict["BirdsAroundBird"] = ''
                        data_dict["BirdsOccasional"] = ''
                        data_dict["BirdsNote"] = ''
                        data_dict["OtherAnimals"] = ''
                        data_dict["SightingNumber"] = ''
                        data_dict["BearingShipCompass"] = ''
                        data_dict["DistanceM"] = ''
                        data_dict["Taxa"] = ''
                        data_dict["Species"] = ''
                        data_dict["SpeciesQuality"] = ''
                        data_dict["Spotter"] = ''
                        data_dict["Cue"] = ''
                        data_dict["Min"] = ''
                        data_dict["Max"] = ''
                        data_dict["Best"] = ''
                        data_dict["WhaleSwimDirection"] = ''
                        data_dict["ReactionAtSight"] = ''
                        data_dict["BehaviorAtSight"] = ''
                        data_dict["Pictures"] = ''
                        data_dict["Pics_no"] = ''
                        data_dict["UsefulForIdentification"] = ''
                        data_dict["UsefulForPhotoID"] = ''
```

```
                        data_dict["Note"] = ''
                        tempDatetime = DateTime_gps[x]
                        data_dict["lat"] = gps_data[x][5]
                        data_dict["lon"] = gps_data[x][6]
                        data_dict["JulianDay"] = gps_data[x][2]

                        if          abs(DateTime_gps[x]          -          DateTime_em122[y])<
datetime.timedelta(seconds=25):
                            if float(em122_data[y][4])==0.00:
                                data_dict['EM122'] = ""
                                #y=y+1
                            else:
                                data_dict['EM122'] = em122_data[y][4].strip()
                                #y=y+1
                        else:
                            data_dict['EM122'] = ""
                        if          abs(DateTime_gps[x]          -          DateTime_bathy[z])<
datetime.timedelta(seconds=25):
                            if bathy_data[z] == ['\n'] or float(bathy_data[z][5])==0.00:
                                #z=z+1
                                data_dict["EA600"] = ""
                            else:
                                data_dict["EA600"] = bathy_data[z][5]
                                #z=z+1
                        else:
                            data_dict["EA600"] = ""
                        data_dict['AirTemp'] = oceanlogger_data[w][5]
                        data_dict['Hummidity'] = oceanlogger_data[w][6]
                        data_dict['AirTemp2'] = oceanlogger_data[w][9]
                        data_dict['Humidity2'] = oceanlogger_data[w][10]
                        data_dict['Barometer1'] = oceanlogger_data[w][13]
                        data_dict['Barometer2'] = oceanlogger_data[w][14]
                        data_dict['TSGtemperature'] = oceanlogger_data[w][15]
                        data_dict['TSGconductivity'] = oceanlogger_data[w][16]
                        data_dict['Salinity'] = oceanlogger_data[w][17]
                        data_dict['SoundVelocity'] = oceanlogger_data[w][18]
                        data_dict['Flowrate'] = oceanlogger_data[w][21]
                        data_dict['SeaTemp2'] = oceanlogger_data[w][22]
                        data_dict['SeaTemp1'] = oceanlogger_data[w][24].strip()
                        data_dict['Chlorophyl'] = oceanlogger_data[w][19]
                            #w=w+1


                        track_Ceta.write('%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s,
%s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s,  %s'  %(data_dict["Datetime"],
data_dict["JulianDay"],          data_dict["lat"],data_dict["lon"],          data_dict["EM122"],
data_dict["EA600"],     data_dict["AirTemp"],     data_dict["Hummidity"],data_dict["AirTemp2"],
data_dict["Humidity2"],                                                 data_dict["Barometer1"],
data_dict["Barometer2"],data_dict["TSGtemperature"],                data_dict["TSGconductivity"],
data_dict["Salinity"], data_dict["SoundVelocity"], data_dict["Flowrate"], data_dict["SeaTemp2"],
data_dict["SeaTemp1"],                                                  data_dict["Chlorophyl"],
data_dict["IDpro"],     data_dict["SE_value"],     data_dict["ActiveObs"],     data_dict["Date"],
data_dict["DateGis"],    data_dict["DateUTC"],    data_dict["TimeUTC"],    data_dict["LocalTime"],
data_dict["LocalTimeFKEnd"],            data_dict["endSight"],            data_dict["FalseLeg"],
data_dict["DeltaTime"],    data_dict["LapUTC"],    data_dict["Platform"],    data_dict["HeightM"],
data_dict["Observer"],  data_dict["Cetacean"],  data_dict["BackAfterSigh"],  data_dict["Effort"],
data_dict["ShipMode"],     data_dict["Beau"],     data_dict["Swellcm"],     data_dict["CloudCove"],
data_dict["Rain"],        data_dict["Fog"],        data_dict["FogNote"],        data_dict["Snow"],
data_dict["IceCoverage"],  data_dict["Glare"],  data_dict["GlareDegree"],  data_dict["Visbility"],
data_dict["VisbilityNote"],       data_dict["Sightability"],       data_dict["BirdsAroundBird"],
data_dict["BirdsOccasional"],          data_dict["BirdsNote"],          data_dict["OtherAnimals"],
data_dict["SightingNumber"],       data_dict["BearingShipCompass"],       data_dict["DistanceM"],
data_dict["Taxa"],   data_dict["Species"],   data_dict["SpeciesQuality"],   data_dict["Spotter"],
data_dict["Cue"],          data_dict["Min"],          data_dict["Max"],          data_dict["Best"],
data_dict["WhaleSwimDirection"],   data_dict["ReactionAtSight"],   data_dict["BehaviorAtSight"],
data_dict["Pictures"],        data_dict["Pics_no"],        data_dict["UsefulForIdentification"],
data_dict["UsefulForPhotoID"], data_dict["Note"]))
                        track_Ceta.write('\n')
                        #print('Ok, x=%s, y=%s, z=%s, v=%s, w=%s' %(x, y, z, v,w))
#                   else:
```

```
#                         x=x+1
                    while z<len(bathy_data) -1 and  date_bathy[z]<date_gps[x]:
                        z=z+1
                    while y<len(em122_data)-1 and date_em122[y]< date_gps[x] :
                        y=y+1
                    while w<len(oceanlogger_data)-1 and date_oceanlogger[w]< date_gps[x]:
                        w=w+1
                    while v<len(ceta_data)-1 and date_ceta[v]< date_gps[x]:
                        print('skip data number: %s' %data_dict['IDpro'])
                        print('GPS time :%s, Ceta time (UTC)%s' %( date_gps[x], date_ceta[v]))
                        v=v+1
                    x=x+1
                    if x == len(gps_data)-2:
                        break
                break
            break
        break
    break


print("It's finished")

gps.close()
bathy.close()
em122.close()

oceanlogger.close()
track_Ceta.close()
```