DY150 CRUISE REPORT

SEACHANGE - ADDMESS

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Report Authors

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10th April 2022 - 13th May 2022 Southampton - Reykjavik (Iceland)

Ship's Company

Stewart Mackay	Captain
Andrew Mahon	Chief Officer
Mike Hood	Second Officer
Rachel Astell	Third Officer
James Bills	Chief Engineer
Derek Hay	Second Engineer
Daniel Evans	Third Engineer
Jonathan Gheisari	Third Engineer
Charles Fisher	Electro-technical Officer
Graham Bullimore	Purser
Peter Lynch	Head Chef
Peter Clarke	Chef
Clementina Carrilho Mantinha	Steward
Stephen Smith	Chief Petty Officer (Scientific)
Stewart Cook	Chief Petty Officer (Deck)
Ryan Parris	Petty Officer (Deck)
Grant Fraser	Petty Officer (Scientific)
Chris Peppin	SG1A
Terry Burke	SG1A
Harry Nicholson	SG1A
Paul Quenault	Engine Room Petty Officer

Front cover caption: DY150 participants offshore Shetland

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Acknowledgements

DY150 was a very happy and successful research cruise and this would not have been possible without the positive attitude and good cheer of all on board. Huge thanks to Captain Stewart Mackay, all the officers, engineers and crew of RRS *Discovery*, to Jon Short and the other NMF engineers for a series of exceptionally successful deployments, and to Zoltan Nemeth for keeping all the ship systems operational and for existential reflections. The SEACHANGE team acknowledge the financial support of the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (grant agreement No 856488) and last-minute financial support of the UK Natural Environment Research Council to enable DY150 to happen in the face of spiralling fuel costs. Daniel Wilson would like to thank the GW4+ Doctoral Training Pprogramme (DTP) for their logistical and financial support as part of the GW4+ DTP internship scheme that allowed me to participate in the research cruise. The ADDMESS project team would also like to thank the University of Exeter, Centre for Geography and Environmental Science for financial support and Dr Andrew Matthews and Dr Eleanor Sargent, also of the University of Exeter for assistance sourcing equipment required for the ADDMESS project.

1.Objectives

James Scourse and Daniel Wilson (University of Exeter)

Cruise DY150 comprised two projects, 1. the bulk of the sampling and measurements being linked to the ERC SEACHANGE Synergy Project, and 2. an opportunistic side-project, ADDMESS. The SEACHANGE targets were to recover piston/gravity cores, megacores and dredged bivalve shell from sites in the North Sea, Northern Isles (Orkney and Shetland) and the north Icelandic shelf. The temporal focus for SEACHANGE is the Holocene in the North Sea/Northern Isles and the last 2000 years on the north Icelandic shelf. Megacore samples were required to complement the longer piston/gravity cores in order to capture the seabed boundary and surficial sediments often lost during piston/gravity coring. A bespoke Arctica dredge (designed and constructed by the University of Exeter) was used to collect samples of live and dead shell from the seabed. The target species was *Arctica islandica* in order to construct long, absolute, crossdated chronologies of marine environmental change at annual resolution (cf. Butler *et al*. 2013). Our aim was to recover significant quantities of dead shell and only limited live *Arctica* material for biochemical assay and to extend the 2006 chronology (Butler et al. 2013) to the present (2022). For eDNA analysis samples of bottom water were also collected via CTD and treated for later analysis. Prior to deployment of the coring devices and the *Arctica* dredge, seabed conditions (depth of sediment, presence/absence of seabed obstacles including bedrock outcrop, shipwreck and gas pockmarks) were assessed operationally in real time via EM710 multibeam swath bathymetry and SBP27 sub-bottom profiler. Prior to deploying geophysical equipment trained marine mammal observers performed statutory surveys (30 minutes < 200 m, 60 minutes > 200m) to confirm nil sightings. The North Sea and Northern Isles targets were the Skagerrak, the Fladen Ground, the Fetlar and St Magnus basins (Shetland) and Scapa Flow (Orkney). The objective in the Skagerrak was to deploy CTD and recover piston and megacores at the site of MD99-2286 (Gyllencreutz *et al*. 2005) to acquire fresh bottom water and samples for sedimentary eDNA analysis. In the Fladen Ground the objective was to occupy a sequence of stations from south (in the Witch Ground Basin) to north (east of Shetland) to acquire bottom water and sediment samples for eDNA analysis, and to dredge for *Arctica* for compound-specific stable isotopic analysis and in order to strengthen the absolute chronologies already established through prior work (cf. Butler *et al*., 2009; Estrella-Martinez *et al*. 2019a,b). The Shetland basins were targeted based on the published seabed sediment maps of the British Geological Survey (BGS) indicating deep bathymetric basins floored by muds close inshore; these offer the potential to link onshore evidence of environmental change (e.g. in SEACHANGE, from archaeological midden remains) with the inshore marine record. Here the objective was to acquire bottom water and sediment samples for eDNA and classical palaeoecological analyses. Scapa Flow was targeted as the only potential inshore muddy sequence close to extensive archaeological work ongoing in Orkney. Although sub-optimal in terms of acquiring a long muddy sequence, nevertheless BGS data indicated several metres of shelly, gravelly mud which we targeted with gravity and megacore. The north Icelandic shelf sites consist of two MD99 giant piston cores, MD99-2273 and MD99-2275 (Eiríksson *et al*. 2011) that have generated significant published reconstructions of the Holocene palaeoceanography of this region. We targeted these in order to acquire fresh bottom water and sediment samples for eDNA analysis constrained by the age models already established for the MD99 cores (correlation via physical properties data). The remaining sites on the north Icelandic shelf were targeted to strengthen and extend the *Arctica* sclerochronology from this region (already the longest absolute chronology for anywhere in the global ocean), to obtain *Arctica* specimens for compound-specific isotopic analysis, and to obtain fresh bottom water and sediment samples for eDNA analysis to complement the rich existing published sedimentary and sclerochronological reconstructions for this shelf.

The ADDMESS project aims to assess the depth distribution of microplastic pollution within the water column across a number of European shelf sea sampling sites. This assessment will allow the development of a better understanding of the factors that are most important in determining the abundance of microplastic pollution within the water column. This will allow better targeting of future research to understand the impact of microplastic pollution on marine life, as well as providing important data points for the validation of models that aim to track and quantify microplastics in the European shelf sea region.

2. List of personnel

James Scourse	University of Exeter	Principal Scientific Officer and PI, ERC SEACHANGE Synergy Project
Kweku Afrifa	University of York	Organic geochemist
Laura Byrne	University of Exeter	Palaeoclimatologist
Steve Corless	NMF, NOC Southampton	Mechanical engineer
Danielle Crowley	University of Exeter	Cetacean biologist
Jane Earland	University of Exeter	Micropalaeontologist
Tobias Ehmen	University of Exeter	Marine geophysicist
Tobias G Frøslev	University of Copenhagen	Molecular biologist
Charlotte Greenall	University of Exeter	Micropalaeontologist
Jen Harland	University of York	Archaeologist
Zoe Heard	University of Exeter	Cetacean biologist and marine historical ecologist
Nils Höche	Johannes Gutenberg Universität, Mainz	Sclerochronologist
Luke Holman	University of Copenhagen	Molecular biologist
Qian Huang	Johannes Gutenberg Universität, Mainz	Sclerochronologist
Emilia Langkjær	University of Copenhagen	Molecular biologist
Matt Mason	University of Exeter	Geochronologist
Ellie Nelson	University of York	Organic geochemist
Zoltan Nemeth	NMF, NOC Southampton	IT and systems
Ben Poole	NMF, NOC Southampton	Mechanical engineer
David Reynolds	University of Exeter	Sclerochronologist
Will Richardson	NMF, NOC Southampton	Mechanical engineer
Harry Robson	University of York	Archaeologist
Alejandro Roman Gonzalez	University of Exeter	Marine ecologist
Paulina Scherer	Johannes Gutenberg Universität, Mainz	Marine geologist
Jake Scolding	University of Exeter	Research Technician SEACHANGE Project
Jon Short	NMF, NOC Southampton	Instrumentation engineer
Jack Wilkin	University of Exeter	Palaeontologist and palaeoclimatologist
Dan Wilson	University of Exeter	Microplastics

3. Timetable of events

DATE	NARRATIVE
09/04/2022	Some of science party join ship following Covid-19 clearance.
10/04/2022	Remainder of science party join ship by 12.00 following Covid-19 clearance. Covid-19 quarantine starts. Covid-19 onboard testing.
11/04/2022	All participants declared clear of Covid-19 at 11.30. Mobilisation and unpacking commenced.
12/04/2022	Mobilisation and unpacking continued. Floating University initiated. Operational briefings and tour of science areas.
13/04/2022	*Arctica* dredges delivered. Mobilisation and unpacking continued. Operational briefings. Floating University continued.
14/04/2022	*Arctica* dredges and core splitter operationalised. Mobilisation and unpacking continued. Floating University continued.
15/04/2022	Mobilisation continued. Floating University continued. Safety briefing and tour. Pub quiz.
16/04/2022	Sailed Southampton at 10.30. Good weather. Transit east up English Channel. Muster test 16.00.
17/04/2022	Mobilisation continued. Transit across North Sea. PSO talk to crew about the science. 08.30 morning meetings with Master started.
18/04/2022	Mobilisation continued. Transit across North Sea.
19/04/2022	Arrived on station in **Skagerrak** (SK-A) 05.00. Very quiet conditions. SK A MMO 05.00, GP 06.00, CTD 07.30, MC 08.40, PC 10.40. Transferred to SK-B (MD99-2286 core site), GP 13.00, CTD 13.30, MC 14.45, PC 17.00. Departed SK-B 22.30.
20/04/2022	In transit towards Fladen Ground. Pub quiz in evening.
21/04/2022	Arrived on station in **Fladen Ground** (FG-T) 05.00. Good weather. MMO 05.00, GP 05.30, AD 09.00. Slow progress. Departed 13.00. Arrived station FG-J 17.00. MMO 17.00, GP 17.30, CTD 19.00, MC 19.30, PC 21.45, AD 24.00.
22/04/2022	Arrived station FG-I 05.00. Good weather. MMO 05.00, GP 05.30, CTD 07.00, MC 07.45, PC 08.45, AD 12.00. Transit to FG-G, MMO 17.00, GP 17.30, CTD 19.00, MC 20.00, PC 21.00, AD 24.00.
23/04/2022	Arrived FG-A 10.30. Fair weather (moderate swell). MMO 10.30, GP 12.00, CTD 13.00, MC 14.00, PC 15.00, AD 18.00. Poor shell recovery.
24/04/2022	Poor shell recovery. Weather fair but overcast. AD until 15.00 then transit to FG-B. MMO 16.00, GP 16.30, MC 18.30, MC 19.30, PC 20.00, AD 22.30.
25/04/2022	Good shell recovery. Continued dredging in fair but overcast conditions. Large numbers of shells collected.
26/04/2022	Arrived FG-F 05.00. Weather fair but force 6. MMO 05.00, GP 05.30, CTD 07.00, MC 07.30, GC 08.30, AD 09.00. Winch wire rubbing - remedial action took two hours from 18.00 requiring cessation of dredging.
27/04/2022	Arrived FG-M 05.00. Improvement in weather and sea state. MMO 05.00, GP 05.30, CTD 07.00, MC 08.00. MC only three tubes part-filled, very sandy. Decided not to deploy GC. AD 08.30. Transit to FG-N. MMO 15.00, GP 15.30, CTD 17.00, MC 18.00, GC 19.00, AD 20.00.
28/04/2022	Transit to FG-O 03.00. Arrived 05.00. MMO 05.00, GC 05.30, CTD 07.00, MC 08.00, no GC (too sandy) 09.00 AD. Transit to FG-P 16.00. MMO 17.00, GP 17.30, CTD 18.30, MC 19.00, GC 20.00 failed (sand), AD 21.30. Departed 04.00. Transit to Fetlar Basin (Shetland).
29/04/2022	Arrived **Fetlar Basin** (FB-A) 08.00. MMO 08.00, GP 08.30 (problems over positions, discussion with Crown Estate), CTD 11.00, MC 11.45, GC 12.45. Repositioned to FB-B. MMO 14.00, GP 14.30, MC 16.00 (failed, coarse gravel). Repositioned back to FB-A 17.00 PC, second PC 19.30. Departed 21.30. Transit to St Magnus Basin (Shetland).

30/04/2022	Arrived **St Magnus Basin** (SM-A) 08.00. MMO 08.00, GP 08.30, MC 10.00 (sand), PC 11.00. Relocated to SM- B, MC 14.00, PC 15.00. Transit to Scapa Flow, Orkney 16.30. Pub quiz 19.00.
01/05/2022	Arrived **Scapa Flow** (SF-A) 07.00. MMO 07.30, GP 08.00, MC 09.30, GC 10.00. Repositioned to SF-B, GC 10.30m MC 11.00. Transit to Kirkwall 12.00. Arrived Kirkwall 17.00. Two the science party transfer off. Transit to Iceland 20.00.
02/05/2022	In transit NE Atlantic. Switched to UTC time (one hour behind BST).
03/05/2022	In transit NE Atlantic. Safety Committee 10.30.
04/05/2022	In transit NE Atlantic.
05/05/2022	Arrived **North Icelandic Shelf** (NIS-A) 04.00. MMO 04.00, GP 05.00, MC 06.00, PC 07.00, second PC 13.00. Transit to NIS-B. MMO 14.00, GP 14.30 (adverse bottom conditions, no MC or PC), CTD 15.30, AD 16.30. Poor shell recovery, stopped dredging 24.00. Transit to NIS-C.
06/05/2022	Arrived on NIS-C 04.00. MMO 04.00, GP 04.30 (long, combining NIS-C and NIS-D), CTD 08.00, MC 09.00 (empty), redeployed MC 09.30 (live *Arctica*), GC 11.00 (empty), AD 12.00. Transit to NIS-D. CTD 18.30, MC 19.30 (empty), AD 20.00. Over 20,000 *Arctica* valves collected at NIS C and D.
07/05/2022	Transit to NIS-E, arrived 05.00. MMO 05.30, GP 06.00, CTD 08.15, MC 08.45 (empty), GC 09.00 (fell over, no sample), AD 10.30. Transit to NIS-H 16.00. Arrived 17.30 (change of sequence because of impending bad weather). 17.00 MMO, 17.30 GP, CTD 18.30, MC 20.00, PC 22.00 (delayed because of technical reasons), AD 12.00.
08/05/2022	Transit to NIS-N 04.00. MMO 05.00, GP 06.00, CTD 07.00, MC 08.00, PC 09.00. Transit to NIS-I 10.30. MMO 13.30, GP 14.30, CTD 15.30, MC 16.30, PC 17.30 (short core, 3.5 m). Transit to towards Denmark Strait; weather worsening.
09/05/2022	Transit to Islafjordur for shelter. Arrived 09.00.
10/05/2022	Sheltering in Islafjordur. Transit to Reykjavik 1200.
11/05/2022	Transit to Reykjavik. Arrived Reykjavik 15.00. Visitation from King Neptune and his wife to cover the Order of the Blue Nose 19.30.
12/05/2022	Science party start to depart.

The full Bridge Log is included as Appendix 1.

4. Working area

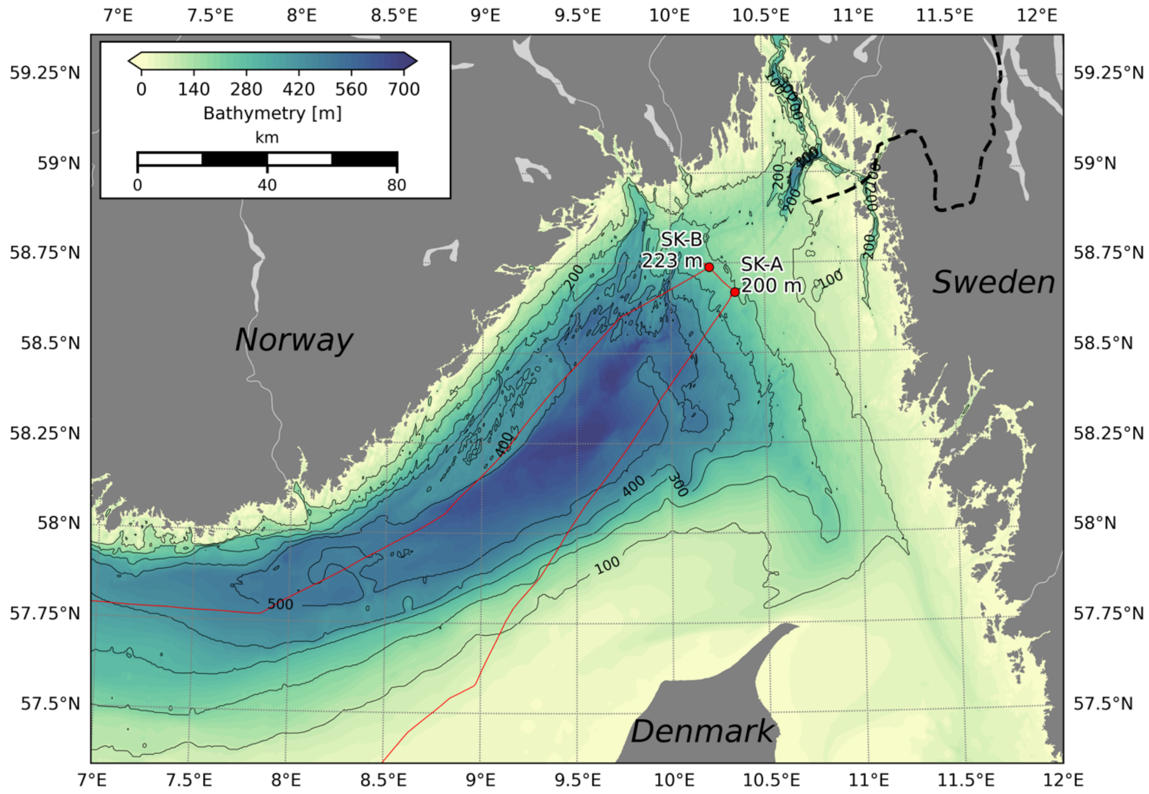


Figure 4.1. Working Area: Skagerrak

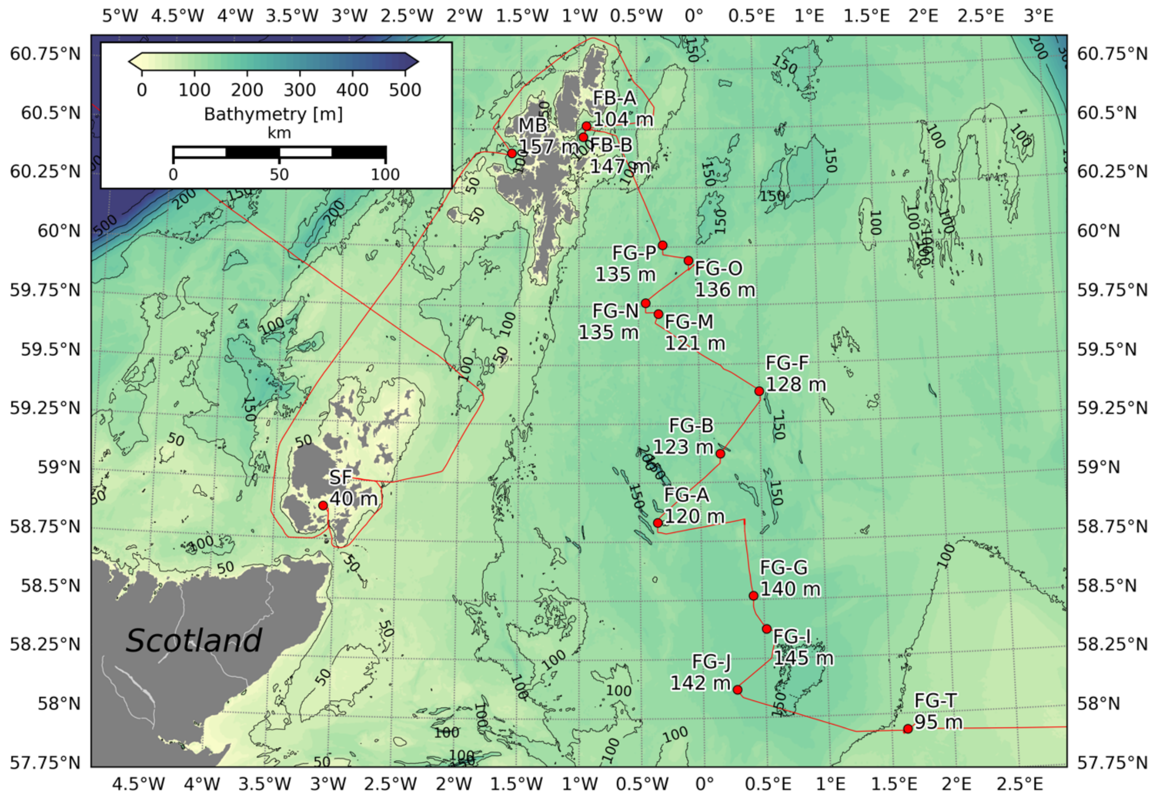


Figure 4.2. Working Area: North Sea (Fladen Ground), Shetland and Orkney.

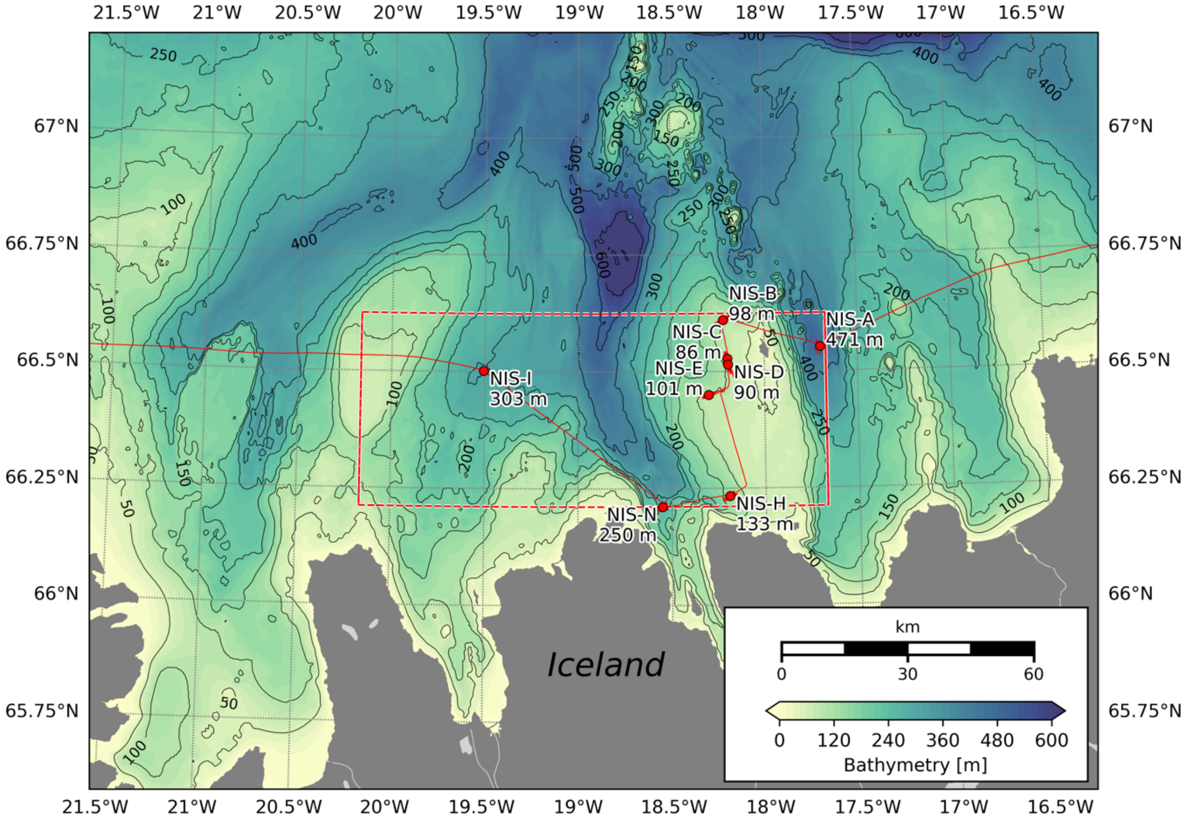


Figure 4.3. Working Area: north Icelandic shelf.

5. Introduction

5.1 SEACHANGE (seachange-erc.eu)

James Scourse (University of Exeter)

Most processes and phenomena in the sea – whether environmental, ecological or physical – take place below the surface or out of sight of land, so that the ongoing effects of human-induced (anthropogenic) impacts are not easily visible. Changes that have progressed relatively slowly out of the range of direct monitoring can seem catastrophic when their effects eventually become apparent. These changes impact the marine ecosystems and environments upon which humans have come to depend for food, energy, resources, transport, recreation and spiritual nourishment. Meanwhile, the pristine state of marine ecosystem functioning and biodiversity – that is, the system as it operated before there was any large-scale anthropogenic impact – is largely conjectural. Conservation management strategies and targets are therefore often based on highly altered ecosystems where the degree of anthropogenic change is unknown. EU criteria for "good environmental status" are generally defined on the basis of altered ecosystems assessed on the short timescales (years to several decades) of modern monitoring. These defined criteria therefore cannot capture the biodiversity, ecosystem complexity and degree of variability characteristic of marine conditions before human impacts began to intensify.

By comparison, terrestrial ecosystems are much more amenable to observation and monitoring, both in the present day and historically (Di Marco *et al*. 2017). Palaeoecological data are now well established as a means of identifying and assessing the impact of past anthropogenic disturbance on terrestrial ecosystems. With them we can assess the impacts of major cultural shifts on terrestrial ecosystems and answer questions such as 'how diverse was the system, and how did it function, before major anthropogenic impacts?' (Svenning and Faurby 2017), 'how depleted is the environment we live in now compared with that before large scale human impact?' (Ellis *et al*. 2011) and 'how long will it take for biodiversity to recover?' (Davis *et al*. 2018). The answers to these questions inform landscape and biological conservation, management and policy (Burney and Burney 2007). Similar approaches have yet to be widely adopted for the marine realm because of 1) a long-held assumption – maintained by the invisibility of most of the underwater world – that the marine environment is more resilient and has been less impacted than terrestrial ecosystems; 2) a lack, until very recently, of appropriate natural marine archives with sufficiently precise chronologies and dating control; and 3) a lack of information from marine archives that can be used to track changes in biodiversity and ecosystem function.

In order to deliver a structured and systematic approach to the reconstruction of marine ecosystem baselines and a quantification of the impact of important cultural transitions on marine ecosystems, the SEACHANGE Project was funded by the European Research Council (ERC Project 856488) as a Synergy Project with a total budget of €11.8 million starting on 1 October 2020. The Principal Investigators are James Scourse (Corresponding PI) and Callum Roberts (University of Exeter, UK), Bernd Schöne (Johannes Gutenberg Universität, Mainz, Germany) and Kristine Bohmann (University of Copenhagen, Denmark). Other Project Partners include the University of York, UK, the University of Bergen, Norway, and the University of Queensland, Brisbane, Australia.

The principal aim of SEACHANGE is to quantify the impact of anthropogenic cultural transitions on marine biodiversity and ecosystem functioning. Five key cultural transitions frame the proposed work packages (WP): the European transition to farming (Mesolithic to Neolithic, 8000 to 5000 years BP; WP1), the European pre-industrial to modern (last 2000 years; WP2), the Australian hunter-gatherer (aboriginal) to colonial (last 6,000 years; WP3), the Viking age settlement of Iceland (WP4) and the advent of intensive whaling/fishing in Antarctica (WP5). WPs 4 and 5 capture transitions from “fully pristine” to impacted, in Iceland from before the first human settlement in AD 874 to the present day, and in Antarctica the transition from pristine into the phase of intensive whaling starting in the twentieth century. ***Cruise DY150 collected key sediment and shell sample material from the North Sea and north Icelandic shelf to address WPs1, 2 and 4.***

SEACHANGE addresses two key questions over six years:

1. What was the nature of long-term changes in prehistoric marine biodiversity and ecosystem functioning in NW Europe and the degree of human impact associated with major socioeconomic changes across the Mesolithic-Neolithic boundary?

2. What has been the scale and rate of marine biodiversity loss and changes to ecosystem functioning as a result of fishing intensity and marine habitat loss during the last 2000 years (including the Industrial Transition) in the North Sea and around Iceland, eastern Australia and the west Antarctic Peninsula?

For each transition we have already assembled, or will acquire, some or all of the following samples 1) absolutely-dated or “floating” annually-resolved bivalve shell series (“sclerochronologies”), 2) marine sediment cores, 3) archaeological midden (waste) materials including mollusc shell and bone from fish, seabirds and marine mammals. To these archives we will apply a series of techniques to determine 1) chronology; proxies to reconstruct 2) the physical environment and 3) the biological environment; and 4) to undertake numerical ecosystem modelling. ***DY150 enabled the collection of marine bivalve shells and sediment cores (sample types 1 and 2).***

Dating techniques (1) are absolutely fundamental for defining, as accurately and precisely as possible, the age of all the materials analysed and include Accelerator Mass Spectrometry (AMS) radiocarbon dating of marine sediment and shell, sclerochronological crossdating and amino acid dating. Physical proxies (2) are required to define changes in the physical environment, such as climate, that may be independent of cultural changes and thus “confounding” factors. These include stable isotope analysis (O,C) of calcareous microfossils (e.g. benthic foraminifera) from marine sediment, and of bivalve shell carbonate. The biological proxies (3) provide the key information on marine biodiversity and ecosystem functioning and include bulk stable isotope analyses (BSIA), compound-specific stable isotope (CSIA) analyses (C, N), environmental DNA (eDNA) analyses of marine sediment cores and DNA metabarcoding of DNA extracted from archaeological midden materials, including mollusc shell and bone from fish, seabirds and marine mammals, in addition to conventional zooarchaeological and palaeoecological methods. We are assembling instrumental and marine historical ecological datasets to calibrate the biological and physical proxies and undertaking geochemical analyses of the organic matter in shell and bone to test for diagenetic loss and overprints. Numerical ecosystem modelling is being applied to each defined transition to test ecosystem sensitivity to specific predicted and observed impacts and hence to inform potential conservation management strategies.

The SEACHANGE proposal is novel in that it proposes to develop, and exploit, organic geochemical and molecular techniques which have demonstrated significant potential to reconstruct both biodiversity and aspects of ecosystem functioning. Further novelty is embedded in the application of these emerging techniques to recently constructed absolutely-dated sclerochronological series of marine environmental change (cf. Butler *et al*., 2013). Significant advances in stable isotope analysis and trace element chemistry can now facilitate the assessment of marine productivity and trophic structure. The techniques include the CSIA of carbon and nitrogen of individual protein amino acids in shell organic matter

(Ellis *et al*. 2014; Misarti *et al*., 2017) and organics from bone, tooth, scales and hair (collagen and keratins; Chikaraishi *et al*. 2009; Naito *et al*. 2010) as well as *in situ* analysis of barium, molybdenum and lithium-to-calcium ratios in mollusc shells as proxies for specific primary producers (Barats *et al*. 2007; Thébault *et al*. 2009; Thébault and Chauvaud 2013). We employ molecular techniques to investigate environmental (e)DNA from sediments (Bálint *et al*. 2018) and shell (Der Sarkassian *et al*. 2017) and DNA of midden bone and shell. The endogeneity of the organic geochemical and molecular signals are being tested in SEACHANGE through analysis of the intra-crystalline protein within the shells, which is able to highlight potential confounding issues such as contamination and remineralisation (Demarchi *et al*. 2016; Cappellini *et al*. 2019).

SEACHANGE comprises six work packages to address the two research questions, one on each of the five selected cultural transitions, and one on project management and data warehousing. The selection of sites/transitions investigated in SEACHANGE is based on 1) the availability of existing significant shell, sediment and midden archive collections, 2) the availability of instrumental and marine historical ecological data available for calibration, and/or 3) *a priori* evidence from terrestrial archives in the selected regions that the identified transitions are considered to have been particularly profound and/or chronologically well defined. SEACHANGE work packages are explicitly organised around the transitions since full testing of the research questions will only be possible with the synergistic application of techniques to each context. ***The work packages relevant to DY150 are WP1, WP2 and WP4. DY150 specific tasks shown in bold italic:***

WP1 – North Sea early to mid-Holocene (Research question 1): the hunter-gatherer (Mesolithic) to farming (Neolithic) transition in the North Sea. Leader: Craig (York).

Objective: To evaluate change in marine biodiversity/ecosystem functioning across the transition to agriculture by examining shell middens and ***marine sediment sequences from Denmark, and sclerochronological series from the Fladen Ground***.

In this WP we focus on the analysis of molluscs, fish and mammal bone in stratified shell middens that span the transition to farming. These provide an exceptional opportunity to resolve competing hypotheses by examining changes in the composition, trophic position and size/age structure of exploited species as well as providing shell specimens for geochemical characterisation. ***This resource will be complemented by freshly acquired, well-dated sediment cores from the highest-resolution marine Holocene sequence in NW Europe, deposited in the Skagerrak basin north of Jutland (Fig. 4.1) adjacent to the Danish middens (Hass 1996; Erbs-Hansen et al. 2012), and by CSIA of shell organic matter from freshly acquired and already assembled sclerochronological series from the Fladen Ground Estrella-Martinez et al. 2019a,b) (Fig. 4.2).*** Research into this transition poses the following questions:

- To what degree did prehistoric coastal hunter-gatherers impact on the marine environment?
- Was there a change in marine biodiversity/ecosystem functioning or the physical marine environment at this time which affected human exploitation of marine resources at the transition to farming?
- What further impact did the transition to farming have on marine biodiversity?

WP1 will also serve to establish the low impact baseline for WP2.

WP2 – North Sea late Holocene (Research question 2): analysis of the transitions of the last 2,000 years in the North Sea. Leader: Orton (York)

Objective: to evaluate changes in marine biodiversity/ecosystem functioning across (a) the medieval intensification of marine resource exploitation and terrestrial land-use around AD 1000, and (b) the industrial transition at ~ AD 1800, by examining middens in Orkney, ***sclerochronological series from the Fladen Ground, marine sediment cores from the Fladen Ground and Skagerrak***, and marine historical ecological records for the North Sea.

WP2 exploits the rich resource of middens on Orkney, containing abundant fish remains that are already in-hand. These are being supplemented by excavation of post-medieval deposits from Skaill Farm Rousay, Orkney, and ***freshly acquired sediment cores covering the last 2 ka cal BP from the Skagerrak (Erbs-Hansen et al. 2012; Asteman et al. 2018) and by CSIA of shell OM from the sclerochronological series already assembled and new material from the Fladen Ground (Estrella-Martinez et al. 2019a,b)***. Research into these transitions pose the following questions:

- Did the medieval expansion of marine fishing in the North Sea region significantly impact marine biodiversity/ecosystem functioning?
- What was the relative significance of physical (climatic) changes e.g. the Medieval Climate Anomaly into the Little Ice Age, and cultural transitions e.g. the ‘fish event horizon’, on the marine ecosystem?
- What was the relative impact of the industrial transition compared with earlier cultural transitions of the last 2,000 years in the North Sea region?

WP4 – north and east Iceland in the late Holocene (Research question 2): analysis of the transitions of the last 2,000 years around Iceland. Leader: Butler (Exeter)

Objective: to evaluate changes in marine biodiversity/ecosystem functioning around north and east Iceland resulting from the first settlement of Iceland in AD 874, the intensification in fisheries after the thirteenth century, and then the advent of industrial scale fishing over the last 100 years.

WP4 is investigating the midden remains from Möðruvellir and Oddstaðir, including *Arctica islandica* shells from these middens, ***and fresh marine sediment cores from the north and east Icelandic shelves, and will exploit, and seeks to extend, the 1,300-year A. islandica absolutely-dated sclerochronology from the north Icelandic shelf (Reynolds et al. 2016; Wanamaker et al. 2012; Butler et al. 2013)*** (Fig. 4.3), currently the longest crossdated annually-resolved series from anywhere in the world. Research into these transitions pose the following questions:

- What impact did the first settlement of Iceland have on the “pristine” ecosystem?
- How have the significant changes in the physical system over the last 1000 years - notably the transition from the Medieval Climate Anomaly into the Little Ice Age between AD 1300 and 1450, and the Little Ice Age itself - had on the marine ecosystem?
- How modified is the current marine ecosystem around Iceland as a result of the advent of industrial-scale fishing?

Research cruises and fieldwork: Although significant shell, midden and sediment collections assembled by the SEACHANGE investigators are available for analysis, in order to achieve the project aims new materials will be collected through two research cruises and four fieldwork campaigns. ***The research cruise #1 (DY150) will be to the North Sea and Iceland to acquire (a) sediment cores from the Skagerrak basin north of Jutland (WP1/2); (b) shell material from the Fladen Ground, northern North Sea (WP1/2) and (c) sediment cores from the north and east Icelandic shelves (WP4).*** Cruise #2 will be to the SE Queensland shelf to acquire sediment cores and shells (WP3). Scourse will be Chief

Scientist on both cruises, assisted by PP Welsh as Co-Chief for cruise #2. Fieldwork campaigns will collect new and museum-curated material from Skaill Farm, Rousay, and other middens on Orkney (led by Harland), Denmark (led by Robson), Möðruvellir, Oddstaðir and other middens in Iceland (led by PP Harrison).

5.2 ADDMESS

Daniel Wilson (University of Exeter)

Since the widespread production of plastic first began in the 1950's (GESAMP 2015), the versatility of plastic as a material has led global plastic production to increase year on year, with an estimated 380 million metric tons of plastic produced in 2015 (Geyer *et al.* 2017). As the global production of plastic has increased, so has the quantity of plastic pollution entering the world's oceans, with an estimated 1.15 – 2.41 million metric tons of plastic entering the oceans every year from rivers alone (Lebreton *et al.* 2017), with additional plastic pollution entering the oceans directly through fishing and shipping activities.
Once plastic pollution has entered the ocean it is likely to persist for centuries (Galgani *et al.* 2013), with plastics gradually breaking down into smaller pieces as a result of UV radiation, biofilm formation and physical stress, such as the motion of waves (Jahnke *et al.* 2017). Once plastics have broken down to pieces smaller than 5 mm in size, they can generally be defined as microplastics (Masura *et al*. 2015) and it is this size fraction of plastics that the ADDMESS project aims to assess the depth distribution of across the European shelf sea region covered by the DY150 cruise.

Microplastics can be considered a ubiquitous marine contaminant and have been reported on beaches (Urban-Malinga *et al.* 2020; Wilson *et al.* 2021), seafloor sediments (Blumenröder *et al.* 2017; Lorenz *et al.* 2019) and surface waters (Lorenz *et al.* 2019) in European shelf seas. However, there is currently no large-scale assessment of the abundance of microplastic pollution at different depths within the water column in the European shelf sea region. This is a knowledge gap that the ADDMESS project aims to tackle. Conductivity, temperature and depth profilers (CTD's) are fitted with Niskin Bottles that can be used to collect water samples between the sea surface and seafloor. This technique has been used in the North Atlantic (Courtene-Jones *et al.* 2017) and Arctic Central Basin (Kanhai *et al.* 2018) regions and the ADDMESS project will use a similar technique to assess the depth distribution of microplastic pollution in four European shelf sea regions (Skagerrak, Fladen Ground – North Sea, the Shetland Islands and the north Icelandic shelf).

Microplastic pollution has been reported in a large number of marine species that live in European shelf seas, from large marine mammals (Nelms *et al.* 2019) to species such as mussels destined for human consumption (Li *et al.* 2018). By assessing and reporting the depth distribution of microplastic pollution, future research that aims to understand the impacts from microplastic pollution on marine species and track exposure pathways can take into account spatial variation in microplastic pollution concentrations within European shelf seas.

Whilst current Lagrangian particle tracking models that have been developed for the European shelf sea region (Delandmeter and Van Sebille 2019; Kaandorp *et al.* 2022) focus on the surface transport of microplastics, as the field continues to develop and 3D model set ups are created for the region, the baseline assessment by the ADDMESS project of the depth distribution of microplastic pollution in the European shelf sea region is likely to be a valuable source of validation data.

6. Equipment used and science areas

6.1 Geophysics

Tobias Ehmen (University of Exeter)

6.1.1 Multibeam swath bathymetry

An EM710 multibeam echo sounder system (MBES) was used to collect bathymetry and backscatter data of the seabed. The EM710 is primarily used for shallow water and operates with a wavelet frequency of 70 kHz and beam widths of 1° x 1°. Kongsberg's Seafloor Information System (SIS) and Helmsman software was used for data acquisition.

The main purpose was to map a clear path for dredging operations and avoid obstacles that could lead to the loss of the dredging equipment. Because bathymetric maps are playing a minor scientific role in SEACHANGE, the surveys were designed to be as efficient and time-saving as possible while still retaining enough data quality to reliably identify potential obstacles. For these reasons the data was not fully processed. Instead, the data were only treated to have to a sufficient quality to identify the following:

- Obstacles like large boulders, pipelines, wrecks or lost containers
- Steep slopes or cliffs
- Unsuitable substrate like coarse gravel or boulders

This also meant that several preparations, that are normally part of a full MBES survey, were skipped. A patch test, which can be used to calibrate the MBES and correct for pitch, roll and yaw errors in the transducer position, was not done during SEACHANGE. Instead, we relied on a previous patch test that provided a sufficient correction.

After MMO operations finished (see Section 7 for details) a soft start was performed by starting to ping at -20 dB and increasing the power in increments to full power after 20 minutes. A new track file was created every time a straight line was finished or started. To reduce errors and noise in the multibeam data only straight tracks were used. A table of all surveys including the number of straight tracks is shown in Table 6.1.

Survey	Date	Soft start (UTC)	Survey start (UTC)	Survey end (UTC)	Number of profiles	Profile spacing [m]
SK-A	19/04/2022	05:01	05:22	06:11	2	N/A
SK-B	19/04/2022	11:25	11:45	12:21	2	N/A
FG-T	21/04/2022	04:35	04:55	07:31	6	180
FG-J	21/04/2022	16:32	16:50	17:47	3	270
FG-I	22/04/2022	04:31	04:54	05:51	3	280
FG-G	22/04/2022	15:59	16:19	17:16	3	270
FG-A	23/04/2022	10:02	10:20	11:19	4	230
FG-B	24/04/2022	15:40	15:54	17:11	4	240
FG-F	26/04/2022	04:30	04:52	06:27	5	240
FG-M	27/04/2022	04:31	04:47	06:03	4	230
FG-N	27/04/2022	14:23	14:44	16:01	4	260
FG-O	28/04/2022	04:31	04:48	06:01	4	260
FG-P	28/04/2022	15:33	15:53	17:09	4	260
FB-A	29/04/2022	07:31	07:51	09:49	6	200
FB-B	29/04/2022	12:46	13:06	13:24	1	N/A
MB	30/04/2022	07:31	07:52	09:21	5	300
SF	01/05/2022	07:01	07:22	08:13	2	cross

NIS-A	05/05/2022	05:01	05:25	06:05	2	cross
NIS-B	05/05/2022	16:54	17:15	18:38	4	180
NIS-C+D	06/05/2022	04:34	04:54	08:03	7	160
NIS-E	07/05/2022	05:25	05:48	07:18	4	190
NIS-H	07/05/2022	17:18	17:38	18:58	4	250
NIS-N	08/05/2022	06:01	06:25	07:03	2	cross
NIS-I	08/05/2022	13:50	14:10	14:42	2	cross

Table 6.1. Table of multibeam surveys during DY150.

Sound velocity profiles (SVPs) were mostly generated from CTD data apart from two stations, where a MIDAS sound velocity profiler was deployed. Tidal corrections were not applied during the cruise. Settings are listed in Section 9. However, for most sites, except at the beginning of the North Icelandic Shelf, a CTD was only deployed after each MBES survey. This was to ensure that the CTD location was the same as the coring position, which could have changed depending on the geophysical data available. However, this meant that there was no sound velocity profile available for the survey itself. Fortunately, SVPs from the previous sites usually provided sufficient corrections for the following sites.

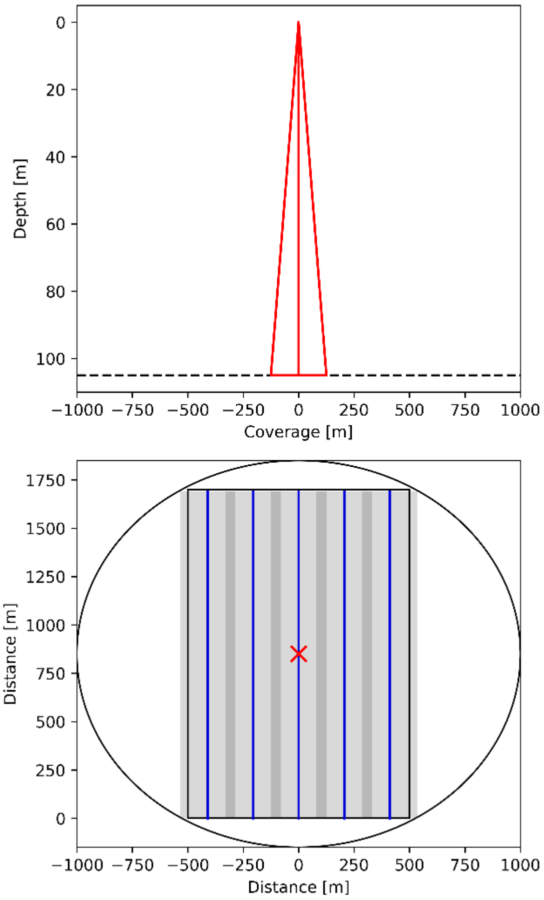


Figure 6.1. Output of Python script aiding multibeam survey design. Top panel shows the vertically exaggerated multibeam swatch and the resulting coverage. Bottom panel shows the permitted sampling area (black circle with 2 km diameter), where the inner black rectangle shows area targeted for the multibeam survey including tracks (blue lines) necessary to achieve full coverage with a 10% overlap (grey area). The red x marks the centre point, often the initially proposed core location.

The resolution of the MBES data in the across track direction strongly depends on the chosen multibeam angle, which can range from 45° on either side of the nadir to a maximum of 70°. For all surveys an angle of 50° was chosen and the resulting coverage and required space between profiles, depending on the depth of each site, calculated with a Python script. This resulted in data points every 1-2 m for most surveys. Due to a lower data quality from the outer beams, as is common in MBES systems, and also to account for navigational errors, an overlap of 10-20% was included. Bad weather and swell had an immediate impact on data quality, but this was only the case for a few stations. In these cases, the overlap was further increased, to decrease the importance of the outer beams, which are most affected by noise. An example plot for the survey planning is shown in Figure 6.1 and profile spacings for each survey are shown in Table 6.1.Acquired data were loaded into Caris HIPS and SIPS as soon as possible. Data were then thoroughly checked using the Subset Editor. Almost no editing was done at most of the sites, except for noise that introduced large errors and extremely large depth intervals. Instead, the data point clouds were only searched for potential obstacles and had to be distinguished from noise. This relied on experience with how and where noise is most likely to develop. Where the SVP was sub-optimal the data were checked only along-track and data points from different tracks were viewed as separate colours. This way, and with overlapping coverage from adjacent lines, most of the noise resulting from bad outer beams could be easily identified. Where both lines in the overlapping section showed the same behaviour, confidence was high that a real feature was present. In uncertain cases the feature was flagged as an obstacle to err on the side of caution. The importance of distinguishing between noise and real features is highlighted in Figure 6.2: two depression features look very similar on the gridded surface. However, they have very different sources. While the first one is a real pockmark (Fig. 6.2b), the second one is noise (Fig. 6.2c).

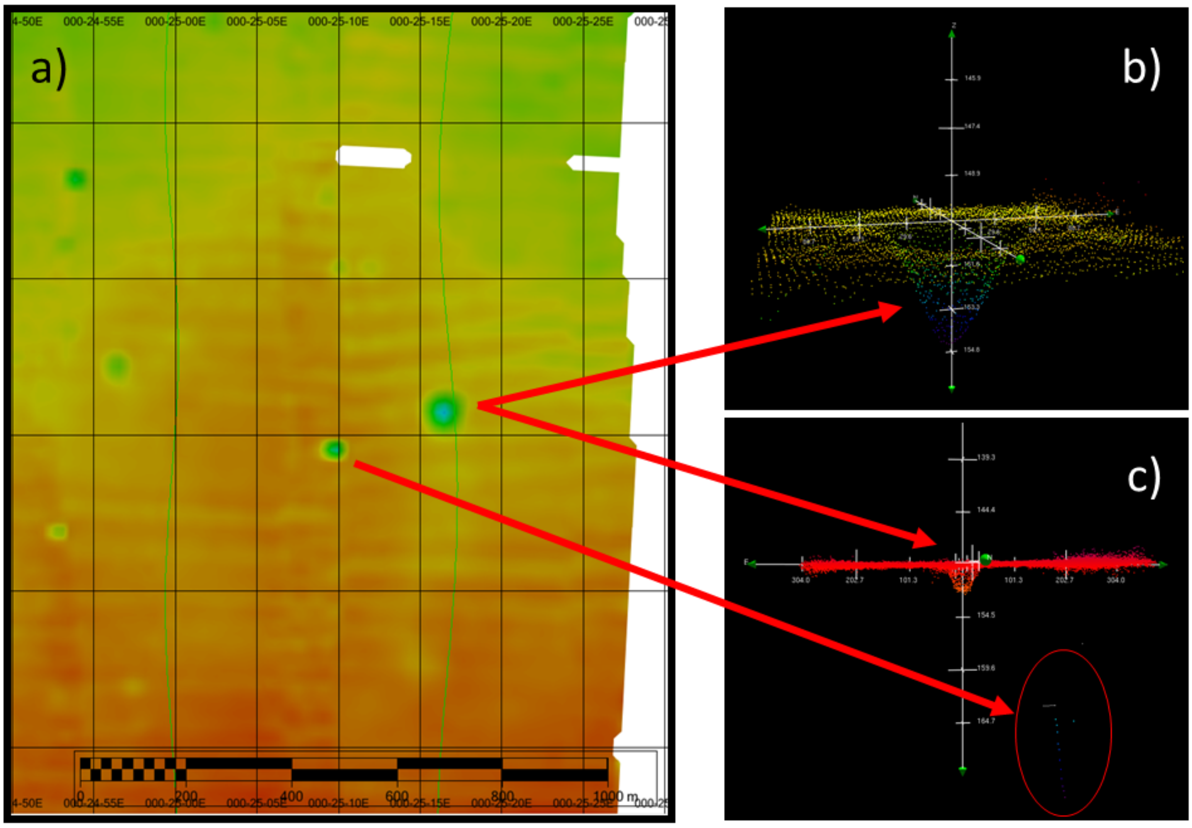


Figure 6.1. a) Caris HIPS & SIPS subset editor view of a part of station FG-F showing bathymetry along with several pockmarks. b) data point cloud of one of the pockmarks in the area. c) data point cloud covering two pockmark-like depressions. However, the first one is the pockmark from panel b), the other one consists of noise.

Afterwards, dredging locations were created using the gridded surface in Caris. Caris' measuring tool, accurately providing latitude and longitude locations, distances between points and headings, was helpful in designing dredge paths in as little time as possible. For all stations except for the North Icelandic Shelf dredging was only permitted within a circle 2 km in diameter (see Section 6.4). It was not necessary to acquire data covering the whole circle, instead only a rectangle-shaped area through the middle of the circle was chosen as a target area for MBES data acquisition. Dredging locations were not selected solely on the basis of available sea floor information but also on the wind speed and direction, which controlled the orientation of dredging transects.

Uncalibrated backscatter data were generated through Caris HIPS and SIPS using a beam pattern from each station. Differences between sediments composed of fine grain sizes were difficult to interpret, but the data were useful to identify sea floor patches with very coarse grain sizes or boulders, which were avoided for dredging. An example output for both bathymetry and backscatter for station FB-M is shown in Figure 6.3. No backscatter data are available for stations SK-B, SF and FG-T.

During all surveys the EM122 MBES, using a frequency of 12 kHz, was run simultaneously as a backup, but never required due to the high data quality of the EM710 and comparatively poor data quality of the EM122. Data quality issues from interference with other systems was low, although the OS75 VMADCP (with a frequency of 75 kHz) was turned off prior to any EM710 survey to avoid interference.

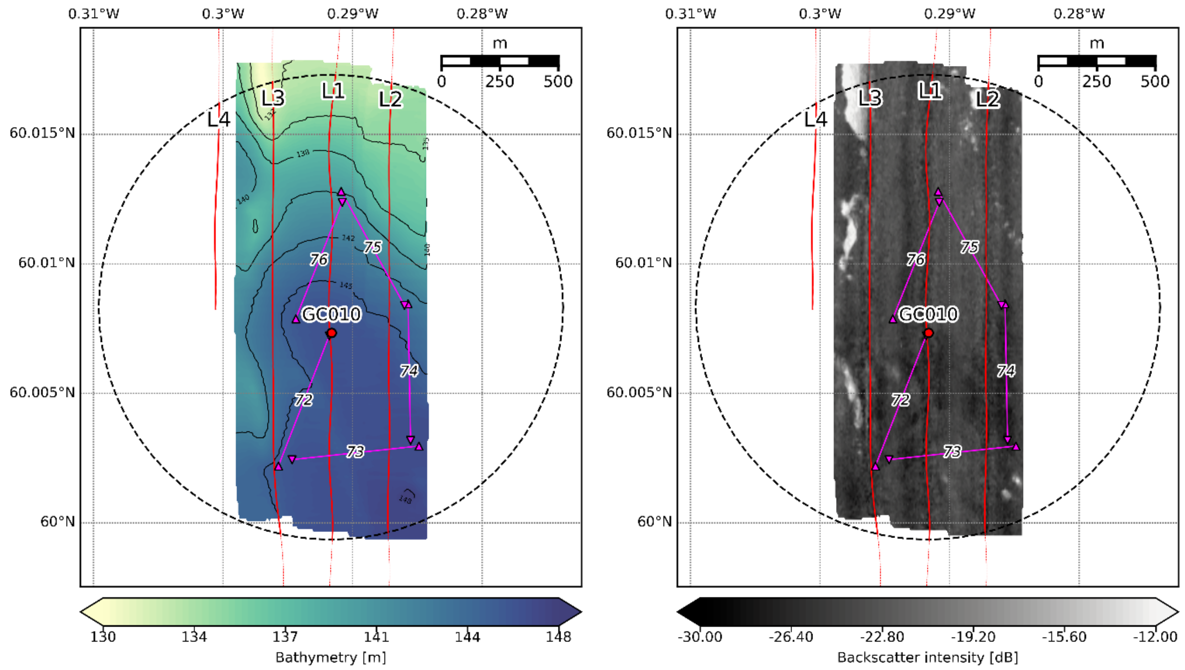


Figure 6.2. Plot output example for multibeam bathymetry (left) and backscatter data (right) at station FG-P. Plots include the permitted sampling area (dashed back circle), the coring position (red circle) with coring name, dredging locations (lines in magenta; upside down triangle marks the start point, triangle marks the end point) with dredging number and sub-bottom profiler lines (red lines) with line names. Here, dredging locations were chosen to avoid the ridge showing very high backscatter intensity.

6.1.2 Sub-bottom profiling (SBP 27)

Locating suitable locations for sediment cores and choosing between different coring techniques relied heavily on images from the sub-bottom profiler. The SBP 27 by Kongsberg used the transducer of the EM122 MBES. The operating frequencies chosen were 2.4 kHz and 9 kHz. The acquisition window below the seafloor was 200 ms, which was more than sufficient as the maximum penetration depth was 50 m (~65 ms) below the sea floor.

Reflections occur where the reflection coefficient *R* is non-zero. *R* is given by

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1} = \frac{\rho_2 v_2 - \rho_1 v_1}{\rho_2 v_2 + \rho_1 v_1}$$

with Z_1 and Z_2 being the acoustic impedance of medium 1 and 2, which is the product of the density ρ of medium 1 and 2 and the sound velocity v of medium 1 and 2. This is most prominently the case for the boundary between the water column and the seafloor but also between different geological strata. No or diffuse reflections indicate no contrast in density and sound velocity between layers or at least a contrast lower than the signal-to-noise ratio. Each reflection is convolved with the source wavelet, in this case a short chirp signal, producing the final echograms.

Data was acquired with Kongsberg's SBP 27 Operator Station software and exported in both .raw and .segy format. Whilst the SBP 27 Operator Station was used to view data in real time, a more thorough analysis was conducted during the survey and also for post-survey plots using Seismic Unix. This allows for information headers be extracted separately, instead of relying on the replay function of SBP 27 Operator Station.

Due to a wrong pitch-parameter for the MRU input an insufficient motion correction was applied for the whole cruise. If desired post-cruise an approximate motion correction may be possible by tracking and flattening the water column data, which was always acquired.

Post-survey plots were also created through Seismic Unix and Generic Mapping Tools. The data were split into separate straight profiles, similar to the straight tracks used for the MBES surveys (see Section 6.1.1). Two-way travel time was converted to depth using a constant sound velocity of 1480 m/s, a good approximation for most stations except for the shallowest one, SF. Profiles acquired with a S-N or E-W orientation were reversed for plotting to ensure all plots of the same station have the same N-S or W-E orientation. Coring locations were added as a vertical line on the plot using the available header data. Due to the varying speed of the ship sounding numbers were not converted to distance. Instead, the average speed was used to create a 100 m scale on each plot. Each plot uses an absolute amplitude range of 0.0-0.6. An example for station FG-I line 1 is shown in Figure 6.4.

Similar to running the MBES system after MMO operations finished (see Section 7 for details) a soft start was performed by starting to ping at -20 dB and increasing the power in increments to full power after 20 minutes. Ideally, the first profile crossed the initially proposed coring site to allow assessing this site in real time. In case of unsuitable geology that site could be adjusted and moved to another location.

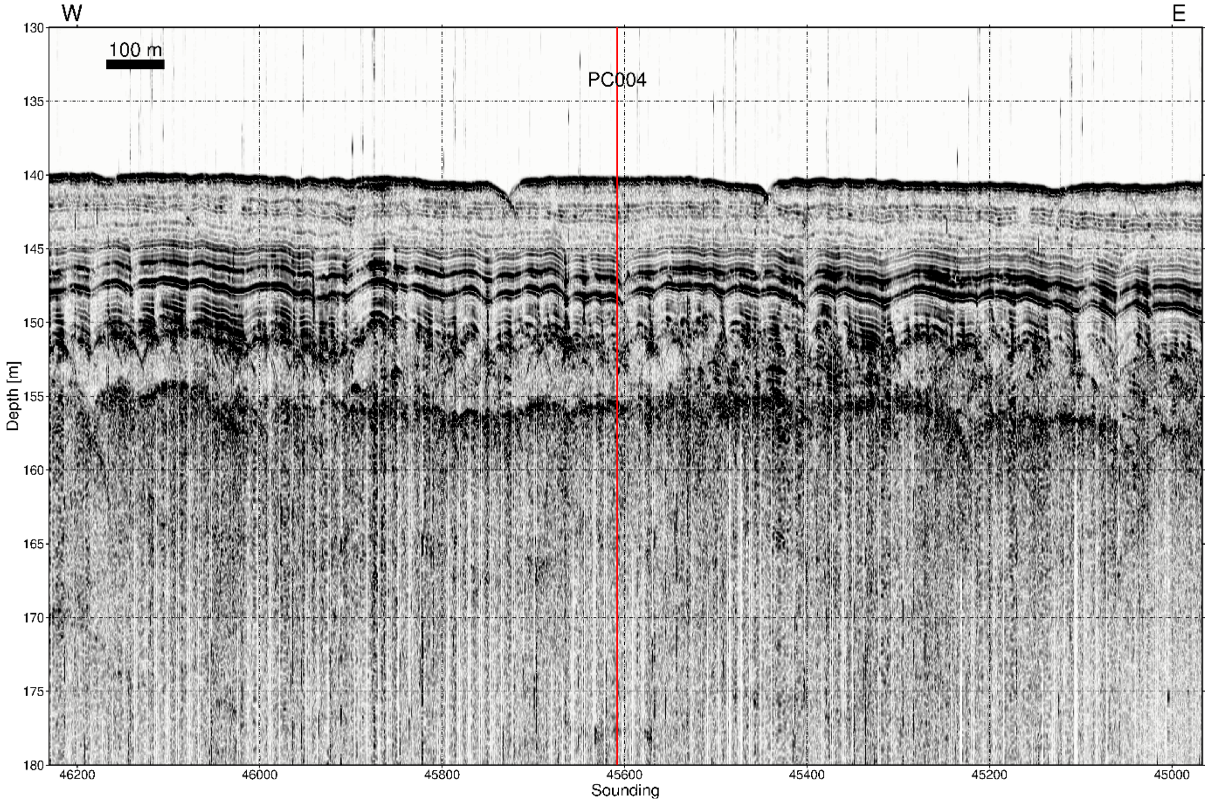


Figure 6.3. Plot of sub-bottom profiler data for station FG-I. Note the finely laminated layers from 140 to 150 m. Coring position marked as red vertical line.

The SBP 27 has the ability to use the across-track transducer to gather parallel profiles or across track slope information. While data for this feature were acquired they were not used in plot generation or to inform coring strategy.

Interference with other systems was an issue throughout the cruise. The EA640, operating on a frequency of 10 kHz, produced noise bursts throughout the whole dataset. Because this system was necessary for navigational and safety purposes, it remained on during the whole cruise. Another issue was the necessity to have the EM120 running simultaneously to supply the SBP27 with depth information. Unfortunately, since the EM120 runs on very similar frequencies (12 kHz) there was a lot of interference whenever the trigger signal for both EM120 and SBP27 was not synchronised. This effect can be seen in Figure 6.5, where the interference issue was resolved after the first third of the soundings. It can also not be ruled out that even when transmitting signals simultaneously that the data quality was affected. For the last three stations the EM120 was run in 10 second intervals, whereas the SBP27 was still running in 1 second intervals, potentially reducing the impact of the EM120 to 10%. It is likely that there are more ideal solutions – but due to time constraints further tests and contacting support was only possible in a limited way.

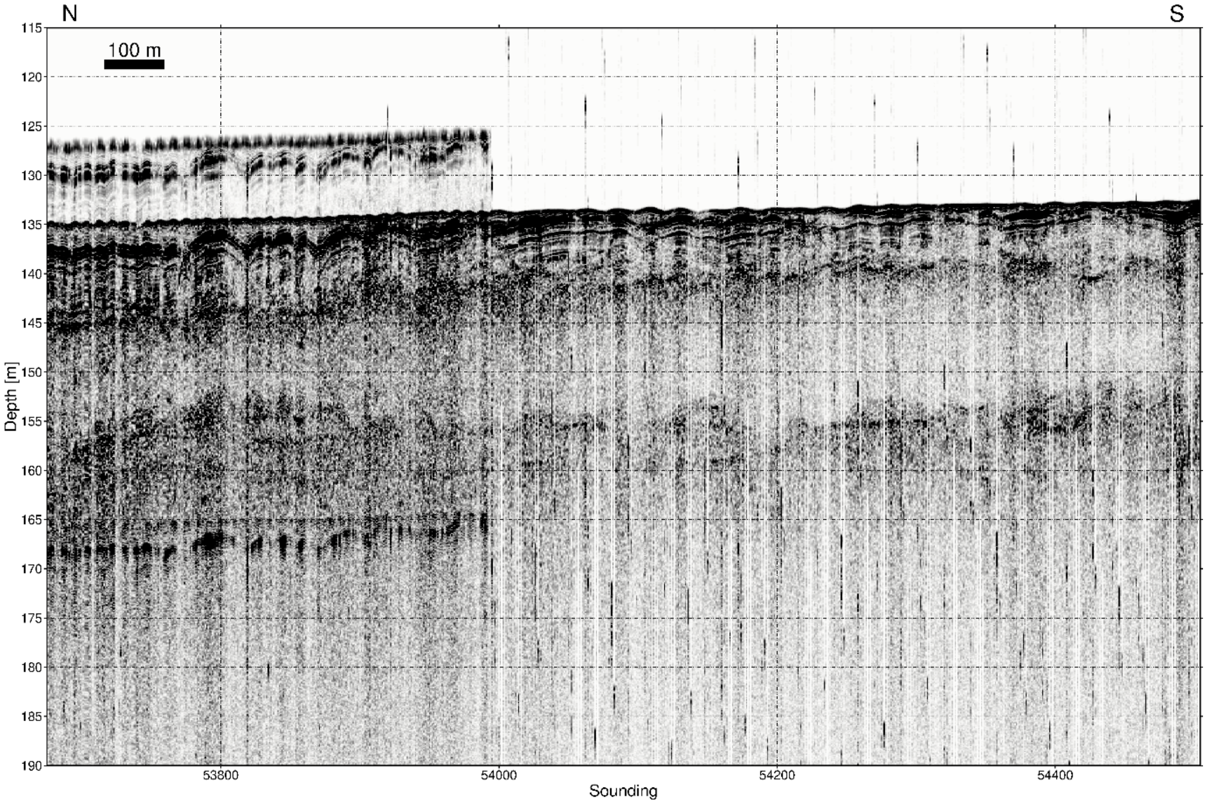


Figure 6.4. Plot of sub-bottom profiler data for station FG-G showing interference due to unsynchronised triggering of the EM122. Note that issues were resolved at sounding 54000. Smaller noise bursts throughout all plots due to interference with the EA640.

6.2 Oceanography

Tobias Ehmen and Daniel Wilson (University of Exeter)

6.2.1 CTD operations and initial data processing

In total, 23 CTD casts were deployed during the cruise, without any repeat casts (see Table 6.2). CTD data were recorded with Seabird Seasave software. CTD rosette configuration and instruments are described in the NMF report in Section 9. At the beginning of each cast the CTD was lowered to a depth of approximately 10 m for a few minutes to allow the sensors to acclimatise to the change from air to water and to allow the pumps to turn on and produce a steady flow. Afterwards, the CTD rosette was brought back close to the surface and lowered down to the seabed at a steady speed of 0.5 m/s to produce the downcast data. The altimeter was used to lower the CTD to a depth of 10 m above bottom, to account for movement of the ship particularly in bad weather. Water sampling was conducted using Niskin bottles on the upcast. Bottles were always closed at the deepest part of the cast as well as 10 m below the sea surface and two more at varying depths. Water samples were used for salinity, microplastics and eDNA. Microplastics was sampled at all bottle depths, eDNA only at the bottom and salinity samples were taken at three depths. A detailed overview of the sampling strategy of microplastics, the main factor for the chosen bottle depths, can be found in Section 6.2.2. There were multiple bottle closures at all sampling depths. This was done to account for faulty bottles but also to keep bottles in use, test them continuously and to keep the gravity centre of the CTD in the centre of the rosette. A waiting time of approximately 30 seconds before each bottle was fired was added to allow the bottle closure capacitor to recharge and the SBE35 to gather high-precision temperature data at a constant depth for later calibration. Most Niskin bottles functioned well, except two bottles which did not fire or close properly for three casts.

Station name	Date	Time (UTC)	CTD cast	Latitude [DD]	Longitude [DD]	Depth [m]	Micro-plastics	eDNA
SK-A	19/04/2022	06:28:51	001	58.66817	10.34038	200.1	Y	Y
SK-B	19/04/2022	12:34:45	002	58.73842	10.20436	227.4	Y	Y
FG-J	21/04/2022	18:16:45	003	58.11766	0.27004	147.1	Y	Y
FG-I	22/04/2022	06:15:39	004	58.37500	0.51638	150.8	Y	Y
FG-G	22/04/2022	17:44:56	005	58.51648	0.41693	144.8	Y	Y
FG-A	23/04/2022	11:50:23	006	58.83363	-0.36030	129.1	Y	Y
FG-B	24/04/2022	17:39:43	007	59.11736	0.16666	130.2	Y	Y
FG-F	26/04/2022	06:58:08	008	59.38298	0.49837	133.7	Y	Y
FG-M	27/04/2022	06:26:16	009	59.70977	-0.33885	128	Y	Y
FG-N	27/04/2022	16:31:16	010	59.76684	-0.44461	140.6	Y	Y
FG-O	28/04/2022	06:32:18	011	59.93836	-0.07413	143.6	Y	Y
FG-P	28/04/2022	17:27:48	012	60.00734	-0.29162	141.1	Y	Y
FB-A	29/04/2022	10:12:25	013	60.50541	-0.94052	117.1	Y	Y
FB-B	29/04/2022	13:56:48	014	60.46839	-0.96255	152	Y	N
MB	30/04/2022	09:49:41	015	60.39596	-1.55859	144.4	Y	Y
NIS-A	05/05/2022	06:36:39	016	66.55174	-17.70029	476.2	Y	Y
NIS-B	05/05/2022	16:31:33	017	66.60982	-18.21896	101.8	Y	Y
NIS-C	06/05/2022	08:25:15	018	66.52745	-18.19892	91.1	Y	N
NIS-D	06/05/2022	18:40:39	019	66.51576	-18.19452	94.4	Y	N

NIS-E	07/05/2022	07:28:13	020	66.46413	-18.21080	104.1	Y	N
NIS-H	07/05/2022	19:13:40	021	66.23618	-18.16988	137	Y	Y
NIS-N	08/05/2022	07:20:45	022	66.21390	-18.52771	273.8	Y	Y
NIS-I	08/05/2022	15:32:43	023	66.50076	-19.50550	309.2	Y	Y

Table 6.1. Table of CTD casts acquired during DY150 along with an indication whether or not microplastic or eDNA samples were taken at those stations.

After a successfully deployed CTD a script was run to produce a SVP for the MES systems. Initial processing of the CTD was done with SBE Data Processing (see Section 9). Detailed processing and data quality checks were not completed by the end of the cruise because of a lack of time. For producing plots (see below) CTD data was binned into 1 m bins and the downcast extracted using a Python script.

Salinity samples were collected in 200 ml glass bottles. Each bottle, cleaned prior to use, was rinsed three times with the sample itself, filled to the shoulder and closed with a plastic inset and screw cap. Samples were analysed on-board with a salinometer (see Section 9). No salinity samples were taken from the underway water supply.

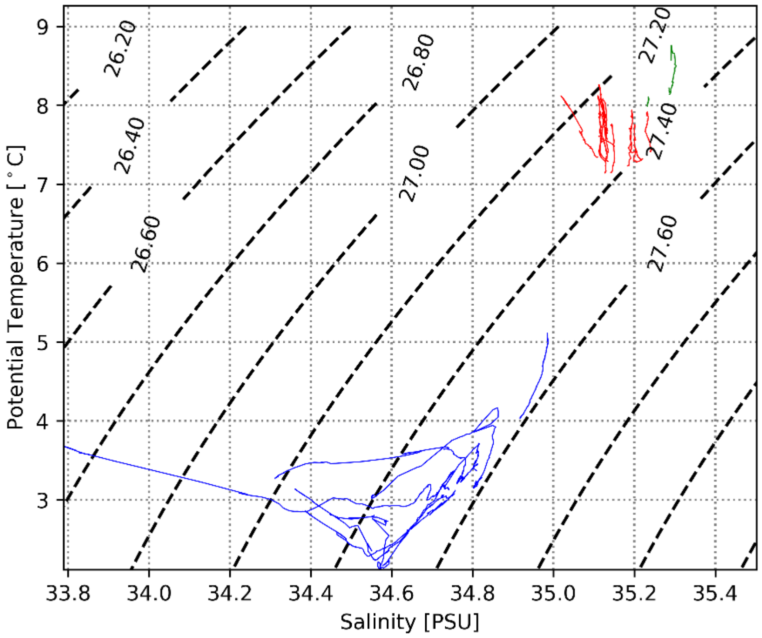


Figure 6.5. Temperature-Salinity diagram of CTD data from NIS, FG, FB and MB stations. Dashed contour lines with labels show potential density –1000 kg/m^3. NIS casts shown in blue, FG in red, FB and MB in green. SK casts were omitted in this plot due to their wide salinity range.

As expected, the different sites produced vastly different thermohaline signatures. A Temperature-Salinity diagram of all casts except SK stations (due to scaling reasons) are shown in Figure 6.6; vertical CTD profiles of SK stations are shown in Figure 6.7, FG, FB and MB stations in Figure 6.8 and both FG/FB/MB and NIS stations in Figure 6.9. While CTD casts at SK stations have an average temperature of 6.8°C, FG casts are higher with 7.4°C and FB and MB casts even higher with 7.6°C. North Icelandic Shelf casts are expectedly colder, with 2.6°C on average. Both casts at SK stations have a temperature minimum layer of 6.2°C at 15 m depth. This is also true for most NIS casts, although less prominently and at varying depths. Furthermore, SK stations, due to their proximity to the coast and the fjords, feature a low salinity layer of 31 PSU at shallow depths of up to 20 m. Some of the stations on the NIS closer to the coast (e.g. NIS-N) also show a salinity minimum. Salinity is slightly higher and more consistent at depth at FG stations.

Fluorescence is highest at the upper 50-70 m for NIS casts with up to 4 µg/l, second highest is FG with up to 2 µg/l, lowest values have the FB and MB casts with 0.8 µg/l and SK casts with up to 1 µg/l but limited to the position of the temperature minimum. Beam transmission is lowest for NIS and FG casts with minima of 82% and 84%, respectively. Values at the FB and MB stations are consistently >95% and SK stations reach 90% at the temperature minimum zone at 15 m, decrease to >99% between 25 and 50 m and increase again with greater depths to 92% at the bottom.

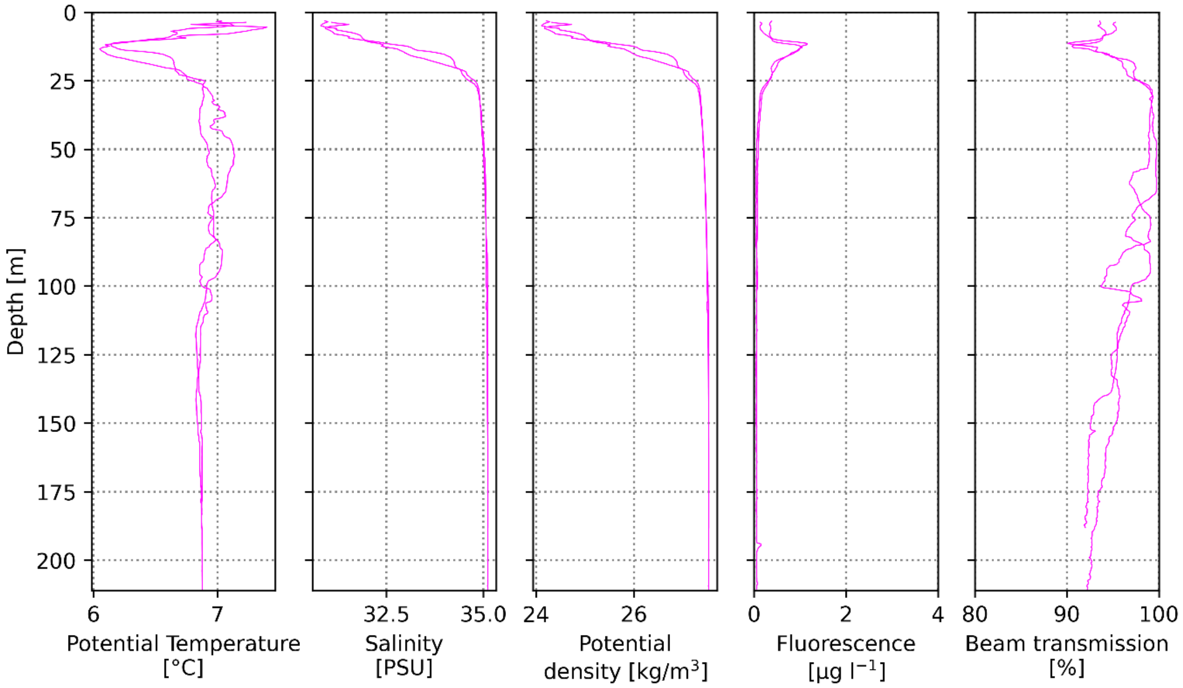


Figure 6.6. Vertical profiles of Potential Temperature, Salinity, Potential density, Fluorescence and Beam transmission for stations SK-A and SK-B. Note the temperature minimum zone at 15 m depth.

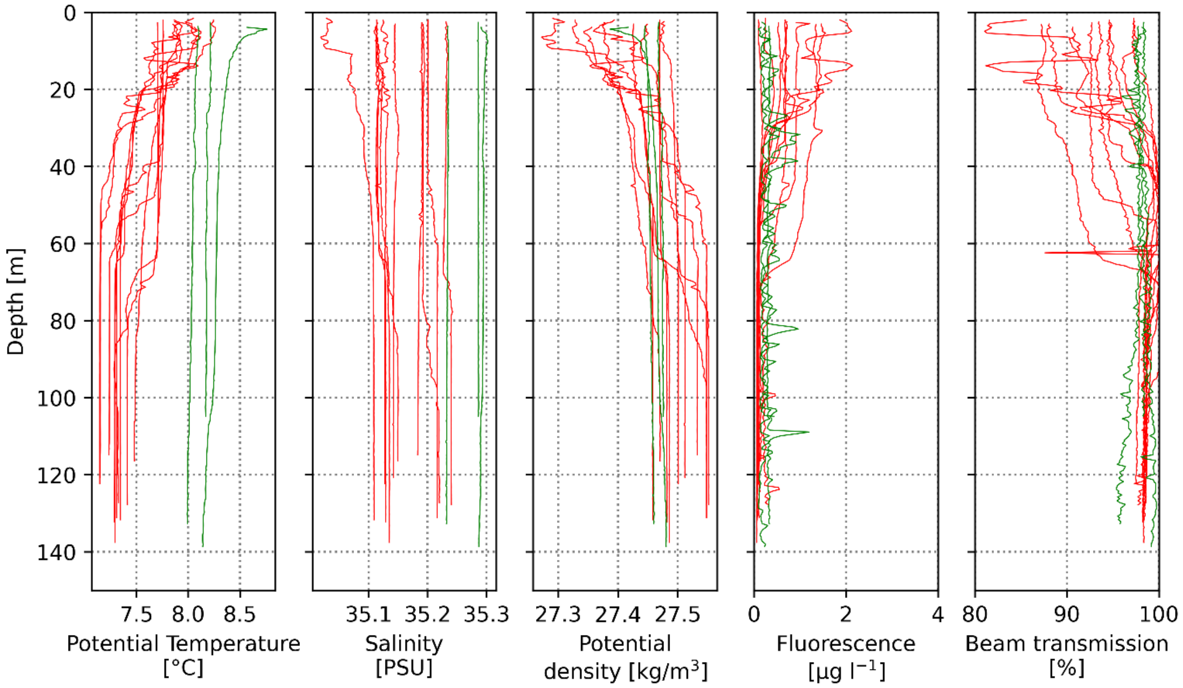


Figure 6.7. Vertical profiles of Potential Temperature, Salinity, Potential density, Fluorescence and Beam transmission for all FG stations (red lines) as well as FB-A, FB-B and MB (green lines).

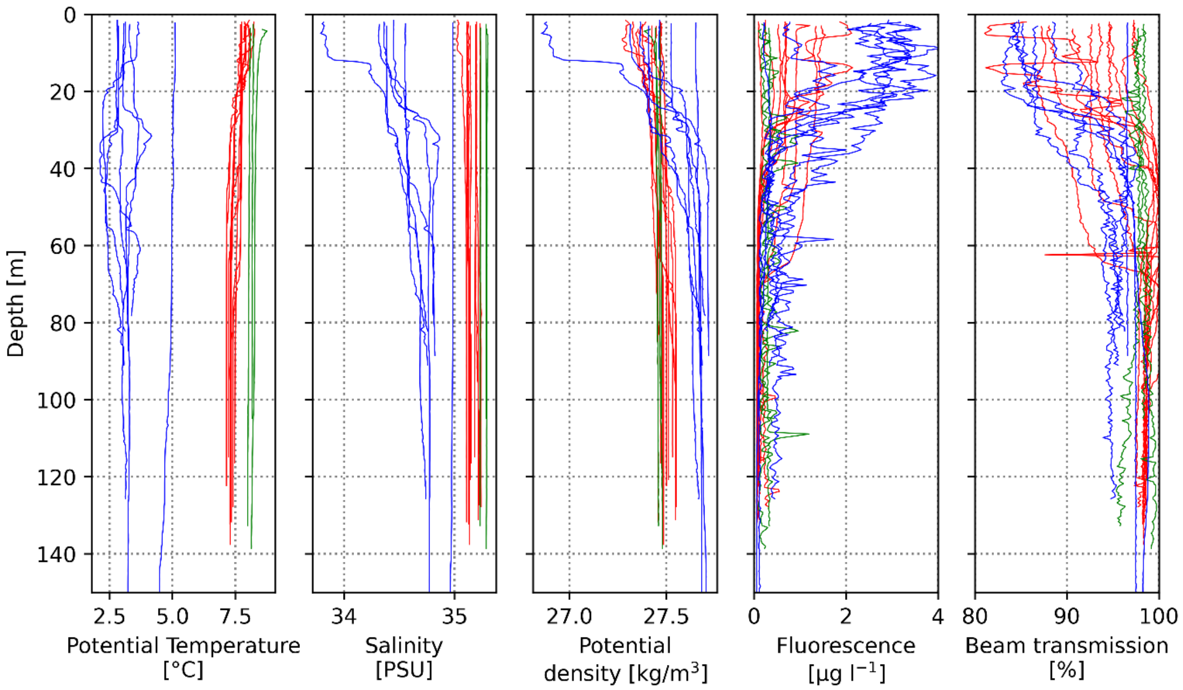


Figure 6.9. Vertical profiles of Potential Temperature, Salinity, Potential density, Fluorescence and Beam transmission comparing all NIS stations (blue lines) with all FG stations (red lines) as well as FB-A, FB-B and MB (green lines). Note the differences particularly in temperature and fluorescence.

6.2.2 Water sampling and analysis

6.2.2.1 Microplastics

Daniel Wilson (University of Exeter)

At each location (see Table 6.2) where microplastics were sampled, the depth of the pycnocline was recorded, as determined by the temperature, salinity and density profiles recorded on the downcast of the conductivity, temperature and depth profiler (CTD). The depth of the seabed was also noted. Then on the upcast of the CTD, Niskin bottles were used to take four samples at the following depths: 10 m above the seafloor, 50% of the depth between the below pycnocline and seafloor sample (or in the Fladen Ground within the same water mass as identified at the 50% depth at the first Fladen Ground site), 1o m below the pycnocline and finally 10 m below the sea surface.

Once the CTD was on deck, seawater samples were transferred from the CTD Niskin Bottles to glass Duran jars and taken into the onboard laboratory. In the laboratory, 5 litres, split equally across 2 filters, from each sample depth were vacuum filtered across 90 mm Whatman GF/C 1.2 μm glass microfiber filters. Filter papers were folded and sealed into a foil package before being placed in a labelled sample bag and transferred to a -20°C freezer for transit.

These filters will then be analysed back on land, to determine the depth distribution of microplastic pollution across the European shelf sea areas that were sampled. To reduce the likelihood of contamination of the samples, a number of measures were taken. Firstly, the use of plastic was limited where at all possible, with glassware or porcelain used for the filtration and storage of samples. The lab work was conducted in a specified area of the lab, with all nearby air vents covered to reduce airborne contamination of samples. Additionally, 100% cotton lab coats and nitrile gloves were used when working with samples. All benchtops were cleaned with 70% ethanol before lab work began and glassware cleaned with MilliQ water between samples. To account for contamination that occurred despite these control measures, a series of air contamination, full filtering protocol blanks and MilliQ water blanks were carried out during the cruise.

6.2.2.2 eDNA analysis

Luke Holman (University of Copenhagen)

CTD casts sampled for water eDNA followed the deployment described in the microplastics section. For each deployment three 700ml samples were taken from a single Niskin bottle deployed at 10m above the seabed using sterile disposable plastic bags. These samples were stored at 4°C until processed within one hour of collection. Water eDNA processing was conducted in a separate lab to sediment eDNA work and new disposables gloves were used for each Niskin processed.

A total of 500ml of seawater was filtered using a 60ml sterile syringe into a 0.22μm pore PES Sterivex inline filter (Merck cat:SVGPL10RC). This process was repeated three times per deployment for a total of three replicates per Niskin sampled. Filters were flushed with air until visible seawater was removed and 1ml of Qiagen ATL Buffer was added to the filter inlet for preservation. After processing samples were stored at -20°C. An unused control filter and a Niskin control filter (500ml of ultrapure water sampled from a Niskin rinsed and then filled entirely with ultrapure water) were processed and stored identically to experimental samples.

6.3 Sediments

6.3.1 Megacore

Alejandro Roman Gonzalez (University of Exeter), Luke Holman, Emilia Langkjær, Tobias Guldberg Frøslev (University of Copenhagen), Kweku Afrifa (University of York), Paulina Scherer, Nils Höche (Mainz University), Jake Scolding (University of Exeter), Jen Harland (University of York), Danielle Crowley and Zoë Heard (University of Exeter).

This section contains all the information related to megacorer sampling. Information regarding the sampling stations (e.g. GPS location, water depth) and the collected samples (e.g. core length, sampling strategy) is summarised in Table 6.3.

Prior to departure, the megacorer team and other members of the science party prepared petri dishes (90 mm in diameter) in advance, lining them with aluminium foil to enclose all cruise samples. Additionally, one core sleeve was cut to produce spacer measurement rings of 0.5, 1.0 and 2.0 cm; several spacers were made of each size.

Megacorer sampling equipment can collect undisturbed sediment samples from the seabed with a typical depth of between 50 and 60 cm. An OSIL (Ocean Scientific Instruments ltd.; Fig. 6.10) megacorer was used during DY150, equipped with up to eight cores (core dimensions: 60 cm L, 95 mm in diameter). As suggested by NMF personnel, eight core sleeves were fitted to the main frame to assure the maximum success rate and the collection of longest possible cores per deployment. This particular model of megacorer has a sliding plate at the base of the cores to catch and seal the samples within the sleeves after collection. This catch mechanism was particularly effective in capturing and retaining the sediment samples, especially compared to other mechanisms available such as swinging lateral arms, employed in similar sampling environments (see cruise reports JR17001, JR18003 and JR19002).

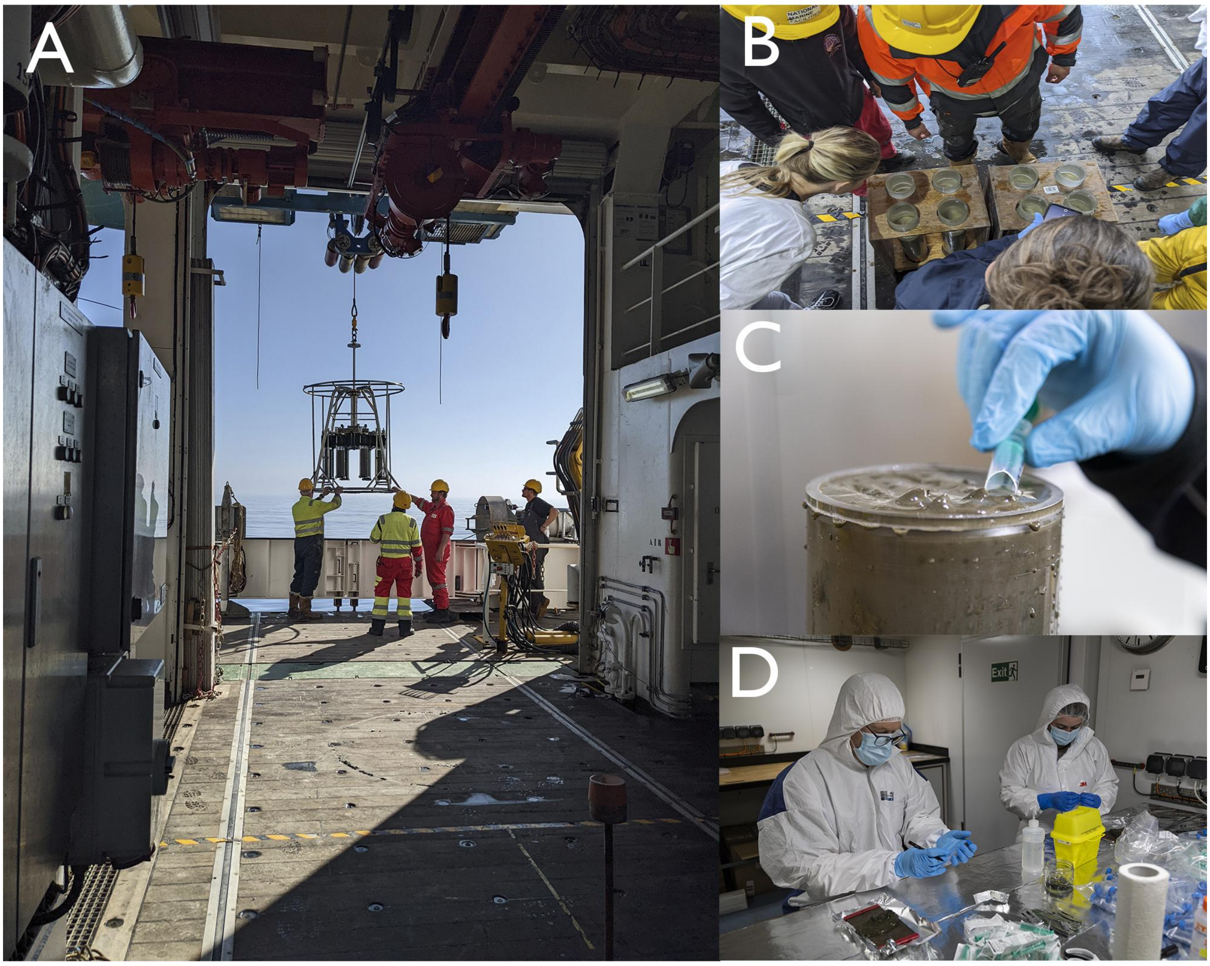


Figure 6.10. Photographic multipanel showing A) deployment of the megacorer, B) Assessment of the individual cores in the core rack, C) collection of eDNA samples from the top of the core using a cut-off syringe and D) collection of eDNA samples from core sections in the eDNA lab.

The megacorer was deployed from the side winch of RRS *Discovery*. Once the equipment was recovered, the core sleeves were removed from the main frame and sealed at bottom using rubber bungs and the cores were stacked in wooden racks. The cores were then assessed by at least two members of the megacorer team (Fig. 6.10B); only three cores per station were selected for processing. Core selection was based on several characteristics: i) undisturbed sediment (if the sediment within a core was clearly disturbed, it was discarded) ii) length of the core (longer cores preferred over shorter ones) iii) presence of live fauna; epifauna and infauna were often found within the cores. For epifauna it is easier to assess presence as they tend to remain on top of the sediment. For infauna, tubes / proboscis may be retracted or buried during the sediment sample collection and it may take a few minutes for the animal to acclimatise and clear any sediment covering holes or biogenic structures. It is therefore recommended to leave the sediment cores in the storage rack for a few minutes (usually less than 10 min) to detect any infauna present in the core. Any cores containing living fauna (especially large specimens of infauna) were discarded whenever possible (sometimes an animal may be buried too deep into the sediment and showed no signs of presence before sliding the core). Any unexpected presence of living animals in the core was recorded in the megacorer data log.

Sediment core extruding and slicing was carried out by one or two members of the team. Removing the bottom rubber bung from the core and inserting the core onto the extruder is the most delicate part of this operation; this can be done either by inserting a metal spatula between the bung and the bottom of the core, aligning it with the extruder and then removing the spatula or alternatively just sliding the core sleeve quickly onto the extruder. The rest of the megacorer team assisted from inside the wet lab, preparing sample trays, labels, sterilizing slicing spatulas and sample containers (i.e. petri dishes lined with aluminium foil). Differences in the sampling strategy for eDNA and non-DNA samples is shown in Figure 6.11.

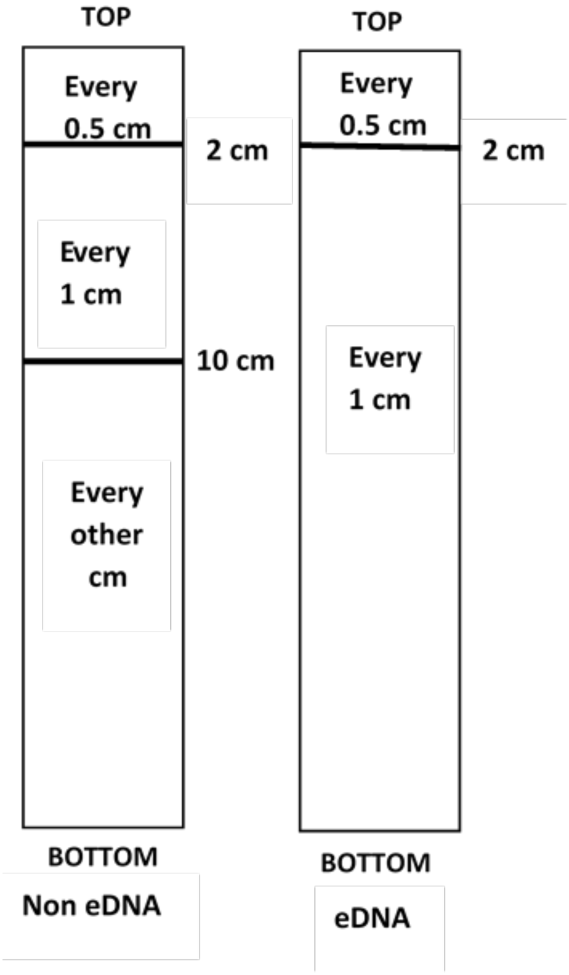


Figure 6.11. Sampling strategy for eDNA and non-eDNA cores.

Slicing progress through the core was recorded with tick marks on a laminated piece of paper containing sediment sample depths. This was done when the sediment sample was handed over from the slicing team to the wet lab team. Slicing was carried out using a couple of metal spatulas that were used to cut the sediment (Fig. 6.12). On some occasions a spacer was used on top of the core to measure desired thickness (e.g. 0.5 cm, 1 cm) and the spatulas were inserted between the core sleeve and the spacer. On other occasions the spacer was used to measure the desired distance at the bottom, between the core sleeve and the resting plate of the extruder. This second method saves time and effort as the spacer does not need to be sterilized as often. For cores destined for eDNA subsampling, a new set of sterilized spatulas was used per sample (core slice). Spatulas were sterilized by rinsing them thoroughly in water and with a brush until devoid of visible sediment, then dipped into a bleach solution (5% solution of household bleach, which is a standard chemical approach for sterilizing by destroying DNA), some minutes of waiting, and then wiped with paper cloth containing ethanol (ethanol to speed up evaporation). For “non-eDNA” cores the spatulas were cleaned thoroughly with water between samples. It is worth pointing out that the metal spatulas used were not made from stainless steel. Thus, the spatulas became progressively rusty during the length of the cruise, due to continued exposure to water and bleach which is corrosive. It is recommended that stainless steel spatulas are used in similar processes in the future.

Figure 6.12. Photograph of the core being sectioned using steel spatulas and a 0.5 cm spacer ring.

For eDNA sub sampling, each core slice (on two spatulas, but see below) was placed on a piece of tin foil in a tray and carried to the eDNA lab. Each tray typically contained two pieces of tin foil (and thus room for two core slices). Each piece of foil was equipped with two identical labels with the sample number. In the DNA lab one label was transferred to the eDNA subsample tube, and thereby indicating the sample on the tin foil (now with one label) as being subsampled and ready for further processing (packing down in petri dishes in the wet lab). One or more persons had the role of bringing core slices to and from the eDNA lab.

For the eDNA cores, the cleaning of spatulas quickly became the bottleneck for sample processing. We used approximately 90 spatulas in rotation, but even with that number, clean spatulas quickly became limited as they backed up in the eDNA lab (spatulas loaded with sediment slices for subsampling) and cleaning proceeded slowly. Whenever possible we tried to slide sediment slices onto only one spatula or even onto the tin foil without spatulas underneath. The aim was to work with entire slices with as few cracks as possible.

For non-eDNA cores the samples were placed directly into their labelled designated petri dish containers. These petri dishes containing the samples were then packed, sealed in stacks within heavy duty plastic tubing, boxed and frozen at – 20°C.

As eDNA-based techniques can be extremely sensitive it is critical to clean surfaces and reused equipment between samples. Bleach solution (5% solution of 4-5% active chlorine household unscented bleach with no thickening agent) was used to decontaminate surfaces and equipment. To avoid any possible contamination of samples with bleach solution, 70% ethanol was used to clean surfaces and reused equipment. Subsequent reference to bleach solution or ethanol refers to the concentrations above unless otherwise noted.

Subsampling of eDNA sediment slices proceeded in a designated temperature-controlled laboratory (the Controlled Temperature Laboratory) separate from extruding with the exception of the top core slice which was subsampled on the extruder using a cut-off syringe (Fig. 6.10C); this Laboratory had restricted access for the duration of the cruise (Fig. 6.10D). The room was set to 18.0°C and 38% humidity and was equipped with a freezer set to -20°C for intermediate storage of processed sub samples. All scientists conducting subsampling donned protective clothing to minimize cross-contamination and contamination of samples. This clothing consisted of a full body, disposable plastic suit, a pair of disposable nitrile gloves, protective sleeves, and a second set of disposable plastic gloves. Blue overshoes, hair net and facemask were worn. Outer gloves and sleeves were regularly sterilised by wiping first with bleach solution followed by ethanol.

The worktable was covered with aluminium foil and was changed approximately every three days. During processing and between cores the workspace was cleaned with bleach and ethanol.

The extruded and sliced core material was transported by the extruding sub-team to the designated clean room for processing. Material to be processed (subsampled for eDNA) was kept on a separate surface to samples being processed and post-subsampled material. The top 1-2 mm of sediment was removed from the surface of the extruded slice, avoiding any areas with clear cracking, fissures, or suspected folds from the extruding process, using a new sterile scalpel blade for each sample. A 5 ml sterile syringe (with the end cut in advance using scissors cleaned with bleach solution) was used as a spatula to subsample material from the area of the extruded core slice cleared in the previous step, carefully avoiding material from the bottom 1-2 mm of the extruded slice. Large infauna, visible biological tissue or material around burrows were not subsampled. Sediment was deposited in a sterile 15 ml centrifuge tube and stored at -20°C. One of the two pre-printed labels was transferred to the tube (from the tin foil) and the tube cap was labelled with a short version of the sample number as well. All tubes with subsamples from one core were stored together in a zip lock bag labelled with the core id.

Any shell material present in the sample cores was preserved independently in labelled bags recoding the location, core depth where the shell was found and core number.

Figure 6.13. Photograph of the megacoring team.

Skagerrak and Fladen Ground stations showed good penetration of the megacorer into the sediment in contrast to Shetland and Orkney stations from which only short cores were recovered. In addition, the sediment from Shetland and Orkney show low consistency below 10 cm depth, unconsolidated broken shell material; pebbles and sand were common at these locations. Maps displaying the sampling locations are available in Figures 4.1-3.

The megacorer team would like to acknowledge the support received from other members of the science party, who offered their help and company during sampling!

The megacores subsampled are listed in Table 6.3.

Table 6.3. Multicorer sampling summary including station number, location, water depth, number of cores sampled and sampling strategy (i.e. eDNA and non-eDNA cores), deployment success rate and core length. Information not available is indicated with NA.

Location	Station	Latitude	Longitude	Water depth (m)	Sampling	Success rate (%)	Core length (cm)
Skagerrak	SK_A	58 40.08972N	10 20.42274E	200	1x non-eDNA	100	56
	SK_B	58 44.30514N	10 12.26118E	227	3x eDNA	100	41/37/38
Fladen Ground	FG_J	58 7.05888N	0 16.20210E	146.6	1x eDNA 2x non-eDNA	NA	34.5/33.5/33
	FG_I	58 22.49796N	0 30.98700E	150.6	1x eDNA 2x non-eDNA	88	38/38/35
	FG_G	58 30.98880N	0 25.01592E	145	1x eDNA 2x non-eDNA	75	NA
	FG_A	58 50.018104N	0 21.61764W	129	3 x eDNA	100	39/36/36
	FG_B	59 7.04136N	0 10.00032E	129	1x eDNA 2x non-eDNA	100	28.5/36/36
	FG_F	59 22.97340N	0 29.89638E	133	1x eDNA 2x non-eDNA	100	31/27/27
	FG_M	NA	NA	133	Not sampled // cores too small	NA	NA
	FG_N	59 46.01166	0 26.67690W	140.8	1x eDNA 2x non-eDNA	100	37/33.5/37
	FG_O	59 56.30166	0 4.44720W	144	1x eDNA 2x non-eDNA	63	16/15/13
	FG_P	60 0.44076	0 17.49678	144	3 x eDNA	100	33/35/33
Shetland Is.	FB_A	60 30.32400N	0 56.43090W	117	3 x eDNA	100	35/35/NA
	FB_B	60 28.10352N	0 57.75270W	151.8	Not sampled // poor core quality	NA	NA
	MB_A	60 23.75784N	1 33.51480W	147.3	3 x eDNA	100	NA
	MB_B	60 23.58516N	1 33.62256W	147	Not sampled // poor core quality	NA	NA
Orkney Is.	SF_A	58 53.51328N	3 6.1740W	148	3 x eDNA	100	NA
	SF_B	58 53.80147N	3 5.41541W	41.8	3 x eDNA	100	NA
Iceland	NIS_A	66 33.10182N	17 42.01278W	NA	3 x eDNA	100	58/53/51
	NIS_C	66 31.64664N	18 11.93334W	NA	Not sampled	0	NA
	NIS_D	66 30.94554N	18 11.67078W	NA	Not sampled	0	NA
	NIS_E	66 27.84906N	18 12.64704W	NA	Not sampled	0	NA
	NIS_H	66 14.17128N	18 10.1916W	139	3 x eDNA	100	34/33/29
	NIS_N	66 12.8337N	18 31.66254W	274	3 x eDNA	100	38/41/41
	NIS_I	66 30.0456N	19 30.33228W	319	3 x eDNA	88	50/50/51

6.3.2 Piston and gravity coring

James Scourse, Laura Byrne, Jane Earland, Tobias Ehmen, Charlotte Greenall and Jack Wilkin (University of Exeter)

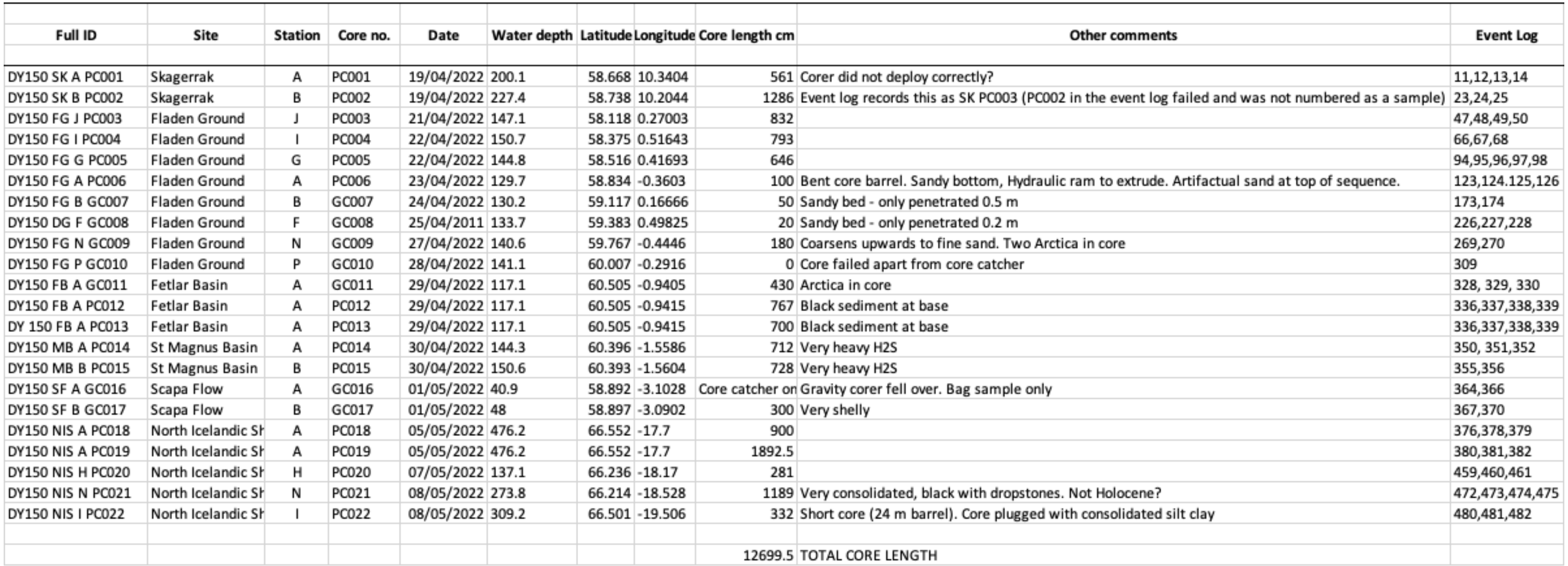
The National Marine Equipment Pool (NMF) NIOZ piston corer was used to recover high quality long cores from muddy basins. The length of core barrel used was based on real time assessment of bottom conditions and sub-bottom profiles based on the geophysical data. The criteria used to determine length of core barrel to be deployed included thickness of mud sequence and predicted pull-out weight. The maximum core barrel length was 24 m. At some sites (e.g. NIS-A) a preliminary short piston core (e.g. 12 m) was deployed in order to assess pull-out weight prior to a longer core barrel being deployed. Where prior data or real time geophysical assessment indicated thin sequences of sediment or coarse sediment (clasts, shell, sand), the equipment was deployed without a piston in gravity core mode (e.g. SF-B).

Table 6.4 summarises details of the cores recovered during DY150.

Some piston cores were taken in muddy depositional basins where long giant piston cores had been recovered previously in order to retrieve fresh material for sedimentary eDNA with the aim of generating age models by correlation with physical property data from the earlier cores. These sites in the Skagerrak (PC002; site of MD99-2286; Gyllencreutz *et al*. 2005) and on the north Icelandic shelf (PC019; site of MD99-2275; Eiríksson *et al*. 2011) resulted in the recovery of the longest piston cores of the cruise. However, piston core PC022 was recovered from the site of MD99-2273 but did not recover a long sequence, with the base plugged by consolidated silt-clay.

Identifying the Holocene sedimentary sequence from the geophysical data at the reported location of MD99-2273 proved difficult. The Fladen Ground cores were taken in order to provide a sedimentary eDNA context for the long sclerochronologies from the region (Butler *et al*. 2009; Estrella-Martínez *et al*. 2019b; see Section 6.4.1); in general, recovery was better in the southern part of the basin (in the Witch Ground; PC003, PC004, PC005) characterised by muds and deteriorated as bottom sediments coarsened northwards where the corer was deployed in gravity mode. The Fetlar Basin cores (GC011, PC012, PC013) were recovered from the flank rather than the base of the bathymetric basin since geophysical data indicated little or no Holocene accumulation with Pleistocene glacigenic (tectonised) sequences at seabed. The St Magnus Basin cores (PC014, PC015) exuded H_2S on recovery indicating high organic loading and strong reducing conditions. A short but very shelly core was recovered from Scapa Flow (GC017). Piston core PC021 was recovered from the mouth of Eyjafjörður; here the sediments consisted of very dense, black (basaltic-derived?), silts and fine sands with dropstones suggesting that this might not be a Holocene but rather a Pleistocene glacigenic sequence.

All cores were split onboard using a Geotek core splitter, logged and photographed (Fig. 6.14).



Full ID	Site	Station	Core no.	Date	Water depth	Latitude	Longitude	Core length cm	Other comments	Event Log
DY150 SK A PC001	Skagerrak	A	PC001	19/04/2022	200.1	58.668	10.3404	561	Corer did not deploy correctly?	11,12,13,14
DY150 SK B PC002	Skagerrak	B	PC002	19/04/2022	227.4	58.738	10.2044	1286	Event log records this as SK PC003 (PC002 in the event log failed and was not numbered as a sample)	23,24,25
DY150 FG J PC003	Fladen Ground	J	PC003	21/04/2022	147.1	58.118	0.27003	832		47,48,49,50
DY150 FG I PC004	Fladen Ground	I	PC004	22/04/2022	150.7	58.375	0.51643	793		66,67,68
DY150 FG G PC005	Fladen Ground	G	PC005	22/04/2022	144.8	58.516	0.41693	646		94,95,96,97,98
DY150 FG A PC006	Fladen Ground	A	PC006	23/04/2022	129.7	58.834	-0.3603	100	Bent core barrel. Sandy bottom, Hydraulic ram to extrude. Artifactual sand at top of sequence.	123,124.125,126
DY150 FG B GC007	Fladen Ground	B	GC007	24/04/2022	130.2	59.117	0.16666	50	Sandy bed - only penetrated 0.5 m	173,174
DY150 DG F GC008	Fladen Ground	F	GC008	25/04/2011	133.7	59.383	0.49825	20	Sandy bed - only penetrated 0.2 m	226,227,228
DY150 FG N GC009	Fladen Ground	N	GC009	27/04/2022	140.6	59.767	-0.4446	180	Coarsens upwards to fine sand. Two Arctica in core	269,270
DY150 FG P GC010	Fladen Ground	P	GC010	28/04/2022	141.1	60.007	-0.2916	0	Core failed apart from core catcher	309
DY150 FB A GC011	Fetlar Basin	A	GC011	29/04/2022	117.1	60.505	-0.9405	430	Arctica in core	328, 329, 330
DY150 FB A PC012	Fetlar Basin	A	PC012	29/04/2022	117.1	60.505	-0.9415	767	Black sediment at base	336,337,338,339
DY 150 FB A PC013	Fetlar Basin	A	PC013	29/04/2022	117.1	60.505	-0.9415	700	Black sediment at base	336,337,338,339
DY150 MB A PC014	St Magnus Basin	A	PC014	30/04/2022	144.3	60.396	-1.5586	712	Very heavy H2S	350, 351,352
DY150 MB B PC015	St Magnus Basin	B	PC015	30/04/2022	150.6	60.393	-1.5604	728	Very heavy H2S	355,356
DY150 SF A GC016	Scapa Flow	A	GC016	01/05/2022	40.9	58.892	-3.1028	Core catcher on	Gravity corer fell over. Bag sample only	364,366
DY150 SF B GC017	Scapa Flow	B	GC017	01/05/2022	48	58.897	-3.0902	300	Very shelly	367,370
DY150 NIS A PC018	North Icelandic Sh	A	PC018	05/05/2022	476.2	66.552	-17.7	900		376,378,379
DY150 NIS A PC019	North Icelandic Sh	A	PC019	05/05/2022	476.2	66.552	-17.7	1892.5		380,381,382
DY150 NIS H PC020	North Icelandic Sh	H	PC020	07/05/2022	137.1	66.236	-18.17	281		459,460,461
DY150 NIS N PC021	North Icelandic Sh	N	PC021	08/05/2022	273.8	66.214	-18.528	1189	Very consolidated, black with dropstones. Not Holocene?	472,473,474,475
DY150 NIS I PC022	North Icelandic Sh	I	PC022	08/05/2022	309.2	66.501	-19.506	332	Short core (24 m barrel). Core plugged with consolidated silt clay	480,481,482
								12699.5	TOTAL CORE LENGTH	

Table 6.4. Gravity and piston cores recovered during DY150

Figure 6.14. A break in core logging in the General Purpose (Chemistry) Laboratory.

6.4 Biology

Dave Reynolds (University of Exeter), Qiang Huang (Mainz University), Matt Mason (University of Exeter) Ellie Nelson and Harry K Robson (University of York).

6.4.1 *Arctica* dredge introduction and rationale

Arctica islandica is a relatively common infaunal bivalve mollusc found across Atlantic continental shelf seas of Europe and North America (Dahlgren et al. 2000). The species inhabits sandy mud to muddy sand substrates at water depths from ca.4-400m and can reach sizes of up to 12 cm in length (Hayward and Ryland 2017). The DY150 cruise targetted *A. islandica* from two geographic regions, the Fladen Ground (North Sea), and the vicinity of Grimsey Island (north Icelandic shelf). These locations are oceanographically and scientifically important due to the interplay between basin scale North Atlantic Ocean dynamics and regional hydrography. *Arctica islandica* have previously been found commonly across both regions.

Previous sclerochronological studies have examined the biology, population structures, and growth history of *A. islandica* populations across the North Sea and on the North Icelandic Shelf (Witbaard 1996; Witbaard *et al*. 1997a; Witbaard *et al*. 1997b; Witbaard and Bergman

2003; Witbaard *et al*. 2003; Schöne and Fiebig 2009; Schöne *et al*. 2011; Scourse *et al*. 2012; Butler *et al*. 2013; Schöne 2013; Reynolds *et al*. 2017). The DY150 sampling locations were therefore specifically selected to provide supplementary shell material to facilitate an extension to these previous studies and to add additional complementary study locations.

Arctica islandica collected from the Fladen Ground formed part of some pioneering sclerochronological studies. These publications focused on developing techniques to construct some of the first crossdated *A. islandica* growth increment width chronologies (Scourse *et al*., 2006, Butler *et al*., 2009). Subsequently, additional *A. islandica* chronologies have also been constructed providing insights into modern ecosystem dynamics over past centuries and over past large scale oceanographic events (e.g. the 8.2ka event) (Estrella-Martínez *et al*. 2019a, 2019b). Sampling locations in the Fladen Ground were therefore selected to provide additional live-collected *A. islandica* to extend the existing sclerochronologies up to the present day. Additionally, dead-collected *A. islandica* were also obtained from these locations to facilitate the extension of the records back through time and to bolster the replication within the chronologies. In addition to the sampling localities that are proximal to existing sclerochronological records, sampling localities were identified that could provide sufficient *A. islandica* to construct new sclerochronologies (e.g. sites T, M, N, O, and P). These localities were selected based on their proximity to large marine infrastructure projects (e.g. oil and gas facilities; station FG-T) as well as the proximity to oceanographic inflows into the North Sea (M, N, O, and P).

Due to the abundance of *A. islandica,* and the climatically important hydrography of the region, the North Icelandic Shelf has been a primary focus of many previous sclerochronological and paleoceanographic studies (Schöne *et al*. 2005; Sicre *et al*. 2008, 2011; Wanamaker *et al*. 2008, 2012; Butler *et al*. 2013; Reynolds *et al*. 2016, 2017). The DY150 sampling locations were therefore selected to complement the existing marine sediment core records and sclerochronological records on the North Icelandic Shelf.

Sampling methodology at locations within the Fladen Ground and on the North Icelandic Shelf followed the same protocols. Given that water depths exceeded 40m at all locations it was not possible to deploy scientific divers to collect the samples. Therefore, all of the *A. islandica* were collected using a specially designed mechanical *Arctica* dredge. Prior to deployment of the dredge the entire sampling locality (*ca*. 1km x 2km grid) was surveyed using multi-beam sonar and a sub-bottom profiler (see Section 6.1.1). The backscatter intensity profile and multi-beam data were then used to define obstacle-free trajectories along which the dredge could be deployed. The dredge was deployed by lowering it over the stern of the vessel to the sea floor whilst the ship was stationary. Once the dredge was stationary on the seabed the vessel steamed forwards a predefined distance (100-500m) whilst laying out cable such that the dredge would remain stationary whilst the ship moved. Once the ship was stationary, at the end of the transect, the winch was used to tow the dredge across the seabed. The dredge was towed at a speed of 0.3 ± 0.1 ms^{-1}. During the dredging process, the tension on the wire was monitored and the tow speed adjusted to minimise the chance of damaging the dredge on any undetected obstacles on the seabed.

Anecdotally, the variability in the wire strain also provided a very approximate guide to the potential success of the deployment. Whilst the data were not recorded, and so no quantitative analyses have been performed, tows with a high degree of variability in the wire strain appear to coincide with deployments that returned larger numbers of shells.

Originally, the dredge was planned to be repeatedly deployed along 100m transects until sufficient numbers of shells were collected at each location. However, no samples were initially obtained so the deployments were increased to 250-500m. The precise distances were dictated by the sea floor structures and the proximity of the deployment to the consented sampling area. At station NIS-B, the initial trawl was set to 100m and, as previously, returned no samples. Subsequently, the dredge was deployed for 250-300m and returned large volumes of shells. It is likely therefore that a longer transect is required to ensure that the dredge is in contact with the seabed for a sufficient amount of time to collect samples.

6.4.2 *Arctica* dredge samples

Full *Arctica* dredge data are presented in Appendix 2 and Figures 6.15 and 6.16 show *Arctica* samples being processed in the Deck Laboratory.

Figures 6.15 and 6.16. *Arctica* shells being processed in the Deck Laboratory.

Table 6.5. Summary of the *Arctica islandica* collection made at sites across A) the Fladen Ground (North Sea) and B) The North Icelandic Shelf. The *Live shells* column refers to the total number of live *Arctica islandica* that were collected by the dredge. The *Kept Live* column details the number of the live *Arctica islandica* that were then retained.

A) Fladen Ground

Station	lat	long	Live	Live kept	Articulated	Single valves	Umbone	Total	No. of tows	Tow mean
T	57.922	1.6308	0	0	0	11	24	35	2	17.5
J	58.119	0.2719	0	0	0	2	0	2	2	1.0
I	58.375	0.5167	0	0	1	30	1	32	4	8.0
G	58.517	0.4167	0	0	8	66	16	90	4	22.5
A	58.831	-0.356	0	0	7	39	11	57	17	3.4
B	59.121	0.1667	373	98	84	629	447	1631	21	77.7
F	59.383	0.5	102	16	21	231	74	444	8	55.5
M	59.717	-0.333	2	2	1	18	7	30	3	10.0
N	59.763	-0.44	0	0	0	0	0	0	5	0.0
O	59.942	-0.075	0	0	1	4	2	7	5	1.4
P	60.008	-0.292	0	0	0	1	0	1	5	0.2

B) Iceland

Station	lat	long	Live	Live kept	Articulated	Single valves	Umbone	Total	No. of tows	Tow mean
B	66.61	-18.22	0	0	0	0	0	0	3	0.0
C	66.527	-18.2	667	114	66	6021	1823	8577	7	1225.3
D	66.516	-18.19	887	201	135	7635	2315	10972	6	1828.7
E	66.464	-18.21	0	0	13	310	209	532	4	133.0
H	66.236	-18.17	0	0	0	0	0	0	2	0.0

C) Totals

Region	Live	Live kept	Articulated	Single valves	Umbone	Total	No. of tows	Tow mean
Fladen Ground	477	116	123	1031	582	2329	76	30.6
Iceland	1554	315	214	13966	4347	20081	22	912.8

Locations where *A. islandica* were numerous were dominated by sandy to sandy mud substrate. Figures 6.17 and 6.18 indicate the total numbers of *A. islandica* collected per site within the Fladen Ground and north Icelandic shelf.

Bycatch was surprisingly minimal across all the North Icelandic and Fladen Ground stations. The dredge either solely caught *A. islandica* or returned empty (albeit, occasionally full of mud or rocks). Other shells returned within the dredge included the Red Whelk (*Neptunea antiqua*).

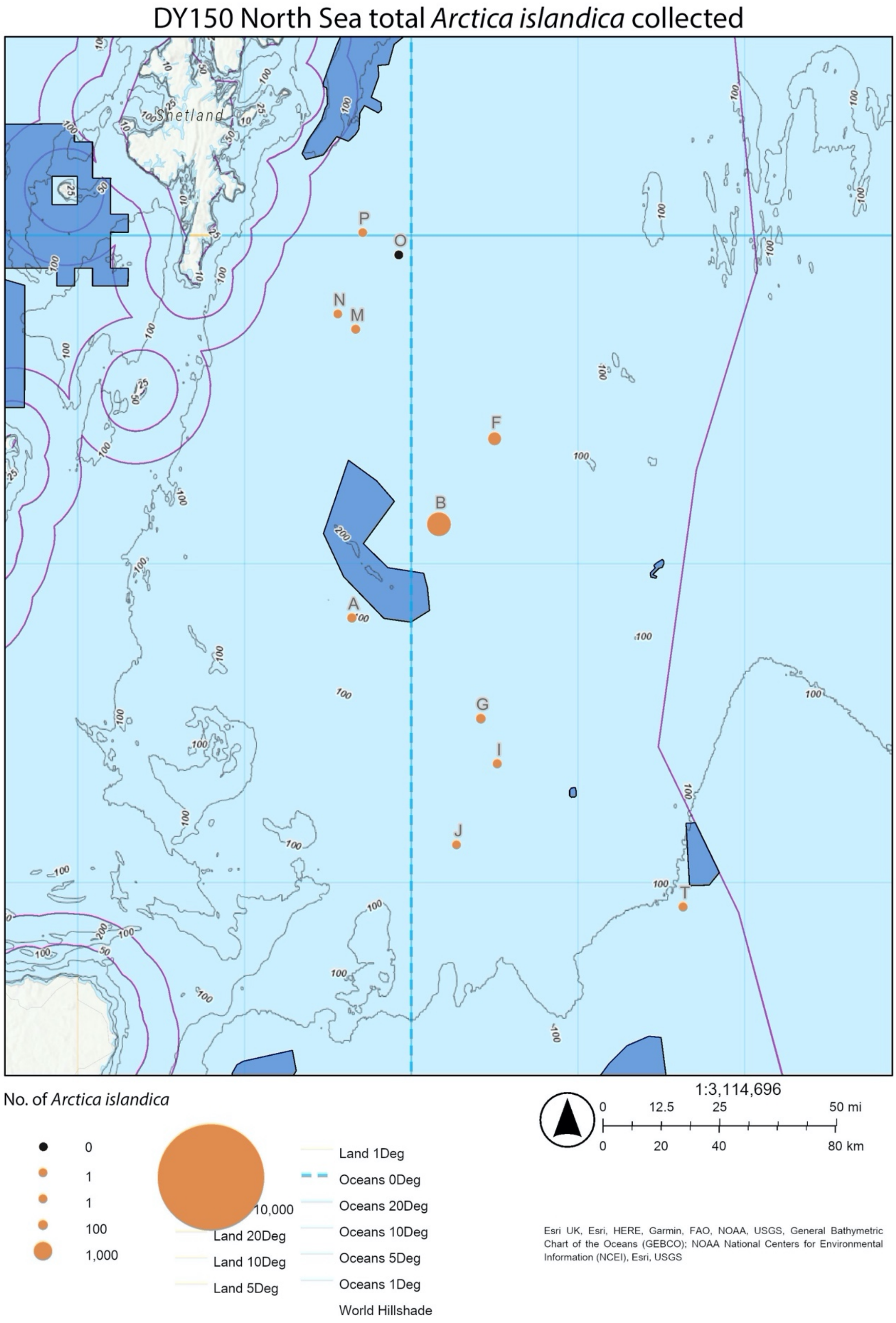
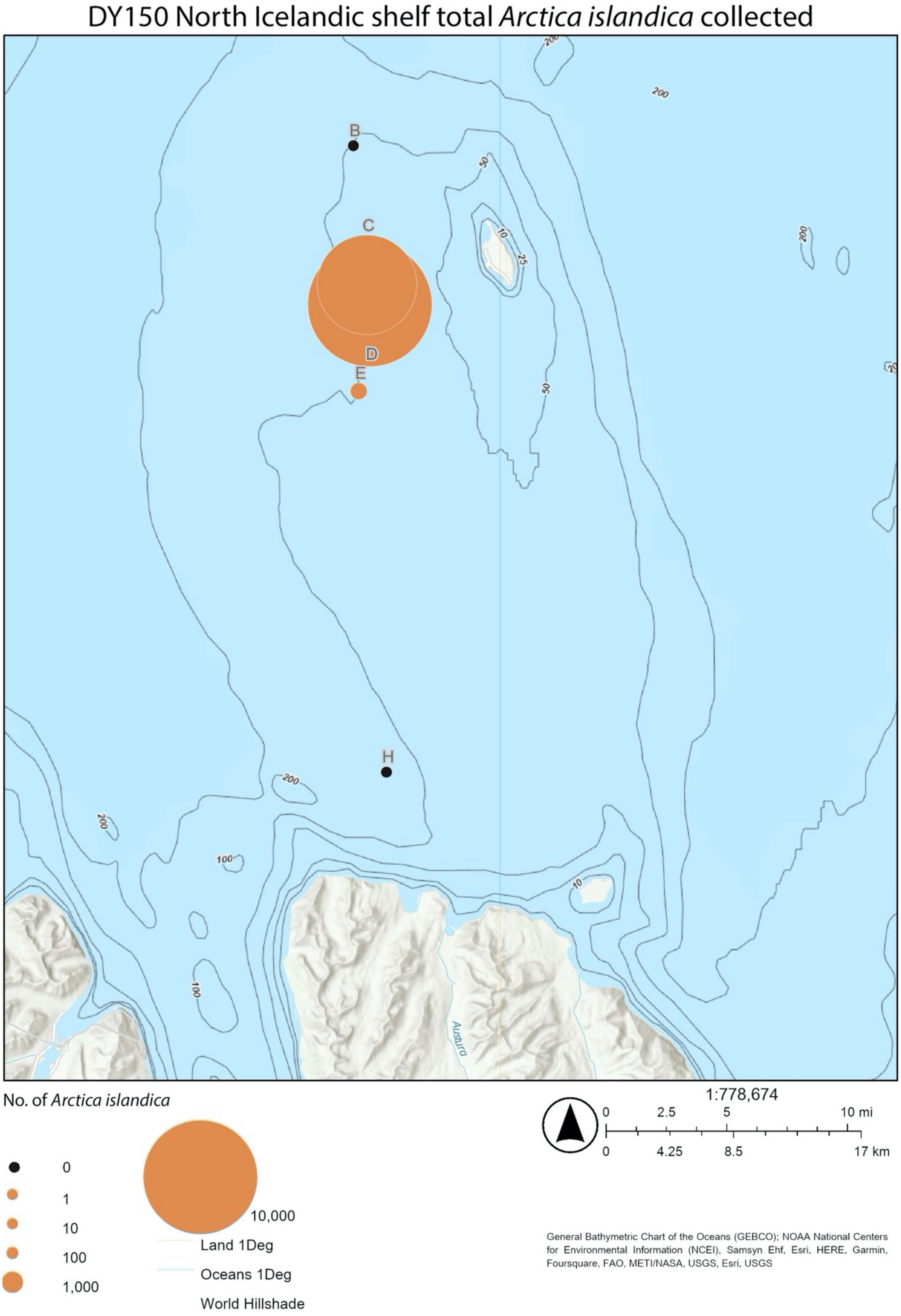


Figure 6.17. DY150 *Arctica* totals per site in the Fladen Ground.



General Bathymetric Chart of the Oceans (GEBCO); NOAA National Centers for Environmental Information (NCEI), Samsyn Ehf, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Esri, USGS

Figure 6.18. DY150 *Arctica* totals per site in the north Icelandic shelf

7. Cetacean observations

Danielle Crowley, Zoe Heard (University of Exeter) and Harry K Robson (University of York)

7.1 Introduction

The North Sea and North Atlantic Ocean once hosted large and diverse populations of marine mammal species. These populations have been exposed to a number of cumulative stressors. These include targeted hunting, such as the culling of seals for fur from the 17th century and the onset of industrial whaling activities in the 19th and 20th centuries (Roman and Palumbi 2003). Furthermore, overfishing and subsequent prey depletion, climate change, and ship-strike have also had an impact (Bearzi *et al.* 2008; Bechdel *et al*. 2009). More recently, the diversification of marine spatial usage and intensification of activity e.g., for oil exploration, renewable energy plants and busy shipping lanes, present new threats to cetacean species. The constant stream of ships travelling between ports introduces large amounts of noise to their habitat and impacts their communication - essential for successful feeding, breeding, navigation and social relationships (Melcón *et al.* 2012). We have a relatively poor understanding of the long-term impacts of these cumulative stressors on marine mammal population health (Cato *et al.* 2013).

Research vessels such as the RRS *Discovery* facilitate important marine wildlife surveys in remote offshore locations which can be used to gather information about cetacean, pinniped and seabird occurrence and diversity.

7.2 Working area

The survey area during this expedition ranged between 57.75°N and 67.5°N and included the temperate waters of the North Sea and North Atlantic Ocean, and cold-temperate waters off north Iceland and Grimsey (just breaching the Arctic Circle; Figs. 4.1-3). The survey area was divided into four zones and included the Skagerrak, the Fladen Ground, Shetland/Scapa Flow and the north Icelandic shelf.

Survey sites in the Skagerrak and some on the north Icelandic shelf were deep (>200m) and required a longer marine mammal pre-watch of one hour to allow for the deeper diving species to reach the surface to breathe and be observed. The Fladen Ground and sites in Orkney and Shetland were shallower (<200m) and thus required a shorter pre-watch of thirty minutes.

7.3 Data collection

Cetacean observations were made from the outermost upper deck known as the “Monkey Island”, at approximately 19m above sea level. Weather conditions allowed observation here throughout the majority of the cruise. When weather conditions were unsuitable, i.e., heavy rain or strong winds, observations were carried out in the main bridge approximately 17m above sea level. Marine mammal observations were carried out during the last half an hour/hour (depending on the depth of the water) of navigation before arriving at a survey site. During this time, the observer scanned the ocean directly ahead of the track-line and periodically scanned the surrounding 360°. Marine mammal surveys continued for the duration of the geophysical survey. Navigation data and environmental conditions were hand recorded on JNCC forms at the beginning of the survey and every time there was a change in weather or source activity (e.g. soft start to full power). The variables recorded included:

- Date & Time (the ship's time was used; this became one hour earlier in Iceland)
- Observer/s name/s
- Observation platform
- Water depth (m)
- Type/frequency/intensity of noise source
- Coordinates of vessel
- Wind direction
- Sea state (Beaufort scale)
- Swell height
- Visibility
- Sun glare
- Precipitation

Presence and number of marine mammals were also recorded after a sighting. The following data were recorded:

- Timing of encounter (start and end time)
- Cue (e.g. fin/blow/splash)
- Position of vessel
- Water depth
- Species/species group
- Description
- Bearing to animal
- Range of animal
- Total number
- Number of adults/juveniles/calves
- Picture taken?
- Behaviour
- Direction of travel
- Source activity (i.e. not firing/soft start/full power)
- Time of entry into and exit of exclusion zone
- Distance between animal and ship
- Action taken/disruption to activity

Equipment used to confirm sightings included waterproof 7 x 50 magnification reticle binoculars and 8 x 42 binoculars. A rangefinder stick was also used to determine distance of the animal to the ship. The ship's compass was used for measuring the bearing of the animal and its swimming direction. Where possible, a photo was taken on a digital camera to confirm the sighting and help determine species ID. This was particularly useful when a photo captured the unique shape/characteristics of the dorsal fin, blow, or tail fluke which can help to determine the species.

NB: marine mammal sightings occurring outside of official watches were not recorded on official JNCC forms but have been noted in the results section.

7.4 Results

From the 19th April to the 8th May 2022, dedicated marine mammal observations were carried out for 58 hours and 29 minutes. Approximately 9% of watches occurred with moderate or poor visibility (<5km) and would likely have impacted our ability to spot animals, in particular small or timid cetaceans.

Marine mammals were spotted on 23 occasions (Table 7.1). Ten (43%) of these sightings were made during active MMO searches: 80% were made in the north Icelandic shelf region, 10% occurred in the North Atlantic Ocean or Faroese waters (*en route* to Iceland) and 10% in Shetland. We also had 13 incidental sightings (i.e. sightings made while watching for leisure). No sightings occurred during the pre-watches so there were no delays to the rest of the operations. However, one humpback whale sighted during the acoustic survey breached and then travelled away from the ship very quickly, which may have been a response to the acoustics. All other animals sighted during operations appeared to behave normally.

Nine species were identified, including harbour porpoise (*Phocoena phocoena*), Risso's dolphin (*Gramous griseus*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), long finned pilot whale (*Globicephala melas*), sperm whale (*Physeter microcephalus*), common minke whale (*Balaenoptera acutorostrata*), humpback whale (*Megaptera novaeangliae*), white-beaked dolphin (*Lagenorhynchus albirostris*) and fin whale (*Balaenoptera physalus*). In addition, two further sightings of unidentified large baleen whales were made; these were most likely fin whales, however the blows rather than the animal themselves were observed making species level identification impossible. Moreover, one additional sighting of an unidentified marine mammal was made incidentally in Ísafjörður, Iceland and was likely a dolphin species due to the evidenced jumping and splashing.

No pinniped species were sighted during surveys but 35 seabird species were noted. Photos were taken of the marine mammals where possible. There is potential for these to be used for photo identification of individuals and relevant project details will be circulated to interested cruise participants.

Table 7.1. Account of marine mammal sightings.

SPECIES	LOCATION	ON DUTY/INCIDENTAL	DATE	TIME	COMMENT
Harbour porpoise	Denmark	Incidental	18/04/22	16:26	Multiple sightings.
Harbour porpoise	Denmark	Incidental	18/04/22	17:21	Three individuals.
Harbour porpoise	Norway	Incidental	20/04/22	16:27	One individual.
Minke whale	Norway	Incidental	20/04/22	16:32	One individual.
Risso's dolphin	Shetland	On duty	29/04/22	09:14	Three to five individuals.
Minke whale	North Atlantic	On duty	02/05/22	12:15	
Long-finned pilot whale	Faroese waters	Incidental	02/05/22	15:13	Twelve individuals (family pod).
Atlantic white-sided dolphin	Faroese waters	Incidental	02/05/22	15:13	Four individuals. Seen in association with the pilot whales.
Humpback whale	Faroese waters	Incidental	02/05/22	16:13	One individual.
Sperm whale	Faroese waters	Incidental	02/05/22	17:17	One individual.
Fin whale	North Icelandic shelf	On duty	05/05/22	05:51	One individual.
Unidentified baleen whale	North Icelandic shelf	On duty	05/05/22	11:58	At least one individual.
Humpback whale	North Icelandic shelf	On duty	06/05/22	05:58	
Sperm whale	North Icelandic shelf	On duty	07/05/22	17:54	Multiple sightings.
Humpback whale	North Icelandic shelf	On duty	08/05/22	06:48	One individual.
Sperm whale	North Icelandic shelf	On duty	08/05/22	06:58	One individual.
Unidentified baleen whale	North Icelandic shelf	On duty	08/05/22	07:13	One individual.

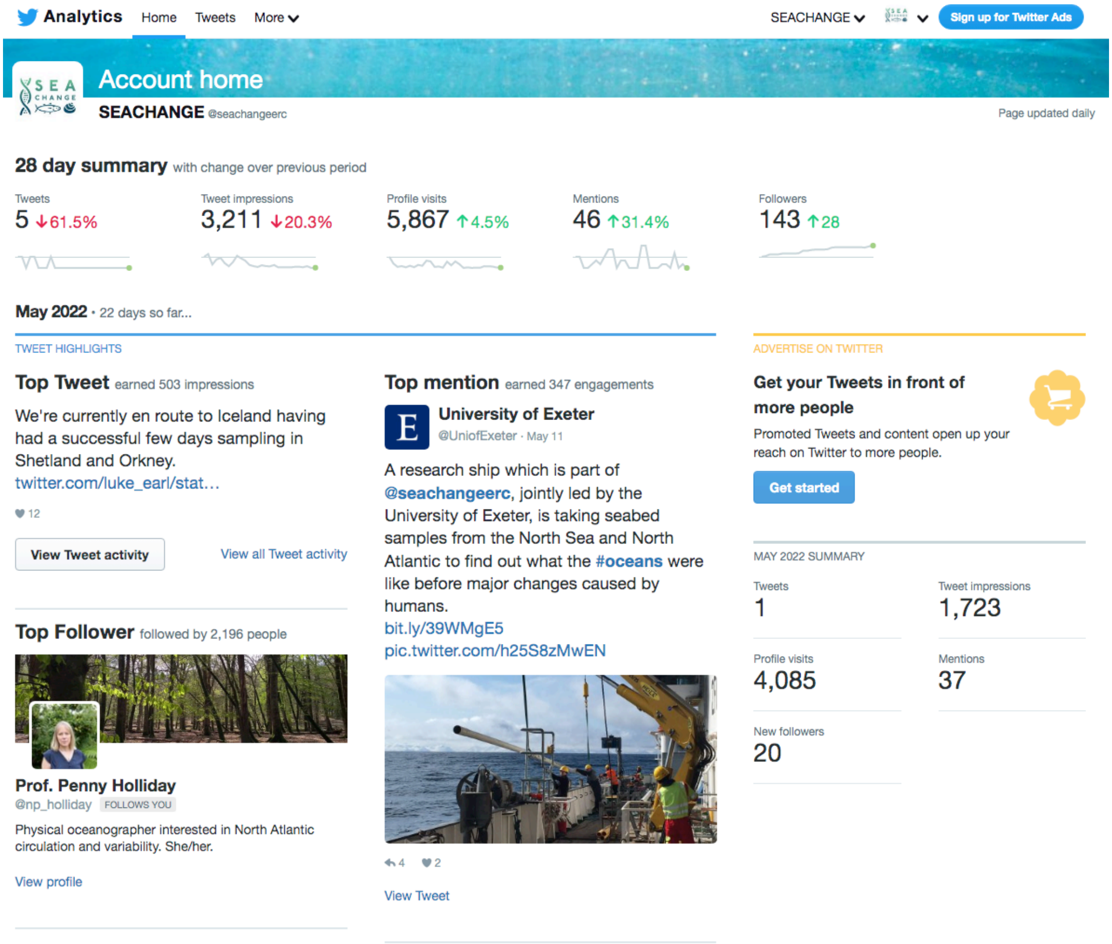
Sperm whale	North Icelandic shelf	On duty	08/05/22	07:19	Two individuals, one likely to be animal recorded earlier
Humpback whale	North Icelandic shelf	Incidental	08/05/22	ca. 12:00-15:15	Three humpback whales sighted separately.
Unidentified marine mammal	NW Iceland fjord (Ísafjörður)	Incidental	09/05/22	09:26	Splashes and jumping observed.
Humpback whale	NW Iceland fjord (Ísafjörður)	Incidental	09/05/22	ca. 09:00-17:00	Multiple sightings throughout the day in the same area. Breaching and lob tailing behaviour observed. At least seven individuals.
Minke whale	Reykjavik	Incidental	11/05/22	09:17	One individual.
White-beaked dolphin	Reykjavik	Incidental	11/05/22	10:18	Six to eight individuals.

8. Outreach activities

Harry K Robson (University of York)

8.1 Twitter

Twitter was successfully utilised during the cruise. In total, 54 Tweets or Retweets were made during the period from 10/04/22 to the 20/05/22. Profile visits exceeded >5,800 during the majority of the cruise period (i.e. 28 day summary; Fig. 8.1), whilst the account obtained >140 new followers.



SEACHANGE @seachangeerc

Page updated daily

28 day summary with change over previous period

Tweets	Tweet impressions	Profile visits	Mentions	Followers
5 ↓61.5%	3,211 ↓20.3%	5,867 ↑4.5%	46 ↑31.4%	143 ↑28

May 2022 · 22 days so far...

TWEET HIGHLIGHTS

Top Tweet earned 503 impressions

We're currently en route to Iceland having had a successful few days sampling in Shetland and Orkney. twitter.com/luke_earl/stat…

♥ 12

Top Follower followed by 2,196 people

Prof. Penny Holliday
@np_holliday FOLLOWS YOU

Physical oceanographer interested in North Atlantic circulation and variability. She/her.

Top mention earned 347 engagements

University of Exeter
@UniofExeter · May 11

A research ship which is part of **@seachangeerc**, jointly led by the University of Exeter, is taking seabed samples from the North Sea and North Atlantic to find out what the **#oceans** were like before major changes caused by humans.
bit.ly/39WMgE5
pic.twitter.com/h25S8zMwEN

4 ♥ 2

ADVERTISE ON TWITTER

Get your Tweets in front of more people

Promoted Tweets and content open up your reach on Twitter to more people.

MAY 2022 SUMMARY

Tweets	Tweet impressions
1	1,723

Profile visits	Mentions
4,085	37

New followers
20

Figure 8.1. Screen-grab showing the analytics of the SEACHANGE Twitter account for 28-days 25/04/22 to 23/05/22.

8.2 Instagram

Instagram was also successfully employed. A total of 19 posts were made during the cruise or shortly thereafter, i.e. during the period from 10/04/22 to the 20/05/22. Overall, the account obtained 65 new followers.

8.3 Other Comments

It was intended that daily posts on both the Twitter and Instagram accounts would be posted, but this was not always feasible, largely due to the restricted bandwidth on RRS *Discovery*, particularly when the ship was outside UK Territorial Waters. Despite this, a Blog Post was written by one of the Science Party, which was successfully uploaded to the SEACHANGE website (https://seachange-erc.eu/news/6/37/North-West-European-Research-Cruise-Week-One).

9. NMF scientific ship systems cruise report

Zoltan Nemeth (National Marine Facilities, NOC, Southampton)

9.1 Instrumentation systems used on DY150

9.1.1 Position, attitude and time

System	**Navigation (Position, attitude, time)**		
Statement of Capability	`/Ship_Systems/Documentation/GPS_and_Attitude`		
Data product(s)	NetCDF: `/Ship_Systems/Data/TechSAS/NetCDF/` Pseudo-NMEA: `/Ship_Systems/Data/TechSAS/NMEA/` Raw NMEA: `/Ship_Systems/Data/RVDAS/RAM/` NCC: `/Ship_Systems/Data/RVDAS/NCC`		
Data description	`/Ship_Systems/Documentation/TechSAS` `/Ship_Systems/Documentation/RVDAS`		
Other documentation	`/Ship_Systems/Documentation/GPS_and_Attitude`		
Component	*Purpose*	*Outputs*	*Headline Specifications*
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m. With L2 correction from CNAV3050 within 0.15 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m. With L2 correction from Fugro within 0.15m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	Correction to primary GPS	Positional accuracy within 0.15 m.
Fugro Seastar / MarineStar	Correction service for primary and secondary GPS and dynamic positioning.	Correction to secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	Time accuracy within microseconds

9.1.2 Ocean and atmosphere monitoring systems

9.1.2.1 SURFMET

System	**SURFMET (Surface water and atmospheric monitoring)**	
Statement of Capability	`/Ship_Systems/Documentation/Surfmet`	
Data product(s)	NetCDF: `/Ship_Systems/Data/TechSAS/NetCDF/` Pseudo-NMEA: `/Ship_Systems/Data/TechSAS/NMEA/` Raw NMEA: `/Ship_Systems/Data/RVDAS/NMEA/` NCC: `/Ship_Systems/Data/RVDAS/NCC`	
Data description	`/Ship_Systems/Documentation/TechSAS` `/Ship_Systems/Documentation/RVDAS`	
Underway events and other documentation	`/Ship_Systems/Documentation/Surfmet`	
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	*Purpose*	*Outputs*
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet	Serial to Interface Box
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space	Analogue to NUDAM
Thermosalinograph (SBE45)	Measure temperature, salinity, conductivity and sound velocity at sampling board	Serial to Interface Box
Interface Box (SBE 90402)	Signals management	Serial to Moxa
Debubbler	Reduces bubbles through instruments.	No recorded output
Transmissometer (CST)	Measure of transmittance	Analogue to NUDAM
Fluorometer (WS3S-134)	Measure of fluorescence	Analogue to NUDAM
Flowmeter (Litremeter)	Measure of flow	Analogue to NUDAM
Air temperature and humidity probe (HMPxxx)	Temperature and humidity at met platform	Analogue to NUDAM
Ambient light sensors (PAR, TIR)	Ambient light and energy at met platform	Analogue to NUDAM
Barometer (PTB210)	Atmospheric pressure at met platform	Analogue to NUDAM
Anemometer (Windsonic)	Wind speed and direction at met platform	Analogue to NUDAM

NUDAM	A/D converter	Serial NMEA to Moxa
Moxa	Serial to UDP converter	UDP NMEA to Surfmet VM
Surfmet Virtual Machine	Data management	UDP NMEA to TechSAS, RVDAS

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

9.1.2.2 Surface water sampling board maintenance

All underway events are recorded in the undervay.pdf in:

/Ship_Systems/Documentation/Surfmet

The system was cleaned prior to the cruise on 2022-04-15.

TSG Data Acquisition valid from: 2022-04-17 13:45:00 (52° 41.96N, 004° 02.66E)

TSG Data Acquisition paused (Kirkwall) 2022-05-01 08:45 (58° 53.63N, 003° 07.73W)

TSG Data Acquisition restarted 2022-05-02 08:00 (60° 07.33N, 003° 56.37W)

TSG Data Acquisition terminated: 2022-05-09 08:00 (66°16.81N, 023°29.56W)

9.1.2.3 Wave radar

System	**WAMOS Wave Radar**		
Statement of Capability	*/Ship_Systems/Documentation/Wamos*		
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Raw NMEA: */Ship_Systems/Data/RVDAS/RAM/* NCC: */Ship_Systems/Data/RVDAS/NCC*		
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*		
Other documentation	*/Ship_Systems/Documentation/Wamos*		
Component	*Purpose*	*Outputs*	*Headline Specifications*
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.	
RS Aqua REX Waveradar	Non-contact wave height measurement	Data to RVDAS	
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.	

The wave radar magnetron requires annual replacement. Following replacement, WAMOS needs to collect wave data within 5 km of another wave height sensor over the full range of sea-states in order to derive wave height calibration coefficients for the new magnetron. This reference dataset can be derived by examining the ship's track for wave buoys and downloading their data. The sensor was out calibration during the cruise. Only collecting data in a short period for calibration and test purpose.

9.1.3 Hydroacoustic systems

System	**Acoustics**
Statement of Capability	`/Ship_Systems/Documentation/Acoustics`
Data product(s)	Raw: `/Ship_Systems/Data/Acoustics` NetCDF (EA640, EM122cb): `/Ship_Systems/Data/TechSAS`, `/Ship_Systems/Data/RVDAS` NMEA (EA640, EM122cb): `/Ship_Systems/Data/RVDAS`
Data description	`/Ship_Systems/Documentation/Acoustics`
Other documentation	`/Ship_Systems/Documentation/Acoustics`

Component	*Purpose*	*Outputs*	*Operation*
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	NMEA over serial, raw files	Continuous Triggered by K-Sync
Kongsberg EK-80 Fish radar	Split beam scientific echo sounder	Raw, XYZ, NetCDF	Discrete
Kongsberg SIS (EM122)	Multibeam Deep Water sounder	Kongsberg .all	Discrete
2.5–6.5 kHz Sub-bottom Profiler (Kongsberg SBP-27)	Multi-frequency echogram to provide along-track sub-bottom imagery.	BMP, raw, SEGY files, optional water column data.	Discrete
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Value over serial to Acoustics System.	Continuous
Sound velocity profilers (Valeport Midas, Lockheed XBT)	Direct measurement of sound velocity in water column.	ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.	Discrete (See deployment event log, below)
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running

9.1.3.1 ADCPs

Path of ADCP data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/ADCP`

Attribute	*Value*
Acquisition software	UHDAS
Frequencies used	75 kHz (3 beams), 150 kHz
Running mode	Free-running untriggered by K-Sync
Configuration details	os150: Narrow band 40 bins, length 8m, 4m blanking, os75: narrow band, 60 bins, length 16m, 8m blanking Bottom tracking with was run from leaving Southampton from 2022-04-16 09:32 to 2022-05-02 13:06 then, used narrowband with water tracking mode from 2022-02-05 13:07 to 2022-05-05 17:09. After over shallow water continue on bottom tracking mode from 2022-05-05 17:11 to 2022-05-08 13:56. Survey name: DY150. During SBP27 surveys the ADCP recording on OS75 paused!

9.1.3.2 EM-122 Configuration and Surveys

Path of Multibeam data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/EM-122`

From 2020-September-30 patch test

Item	*X (m, + Forward)*	*Y (m, + Starboard)*	*Z (m, + Down)*
Tx transducer	39.910	0.885	7.426
Rx transducer	35.219	-0.005	7.438
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to Waterline)			1.44 / 1.64

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	0.07	0.15	0.05
Rx transducer	0.05	0.37	359.98
Att 1 (Applanix)	-0.10	0.00	-0.85
Att 2 (Seapath)	0.00	0.00	0.00

Draught: Southampton: 2022-04-16 16:06 6.4m then Kirkwall: 2022-05-01 17:57 6.2m

Survey information – note any particular transducer settings (e.g. beam spacing) in comments, Applanix PosMV used for providing position and attitude data.

Survey Site Name	***SIS Survey Name***	***Datetime Start***	***Total time of Logging***	***Vessel survey speed (kts)***	***SVP(s) Used (Filename)***	***Comments***
Skagerrak	dy150-SK	2022-04-19 05:05	02:09:39 h:m:s	2-6	Default 20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150-FG_T	2022-04-21 04:34	02:57:22	6	20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150_FG_J	2022-04-21 16:33	01:14:11	6	20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150-FG-I	2022-04-22 04:31	01:19:20	6	20220421_21900_salinity_03500.asvp	SVP from CTD003
Fladen Ground	Dy150-FG-G	2022-04-22 16:00	01:15:48	6	20220421_21900_salinity_03500.asvp	SVP from CTD003
Fladen Ground	Dy150-FG-A	2022-04-23 10:01	02:21:20	6	20220421_21900_salinity_03500.asvp	SVP from CTD003 first 7 lines are obsolote
Fladen Ground	Dy150-FG_B	2022-04-24 15:38	01:33:16	6	20220423_122300_salinity_03500.asvp	SVP from CTD006
Fladen Ground	Dy150-FG_F	2022-04-26 04:26	01:57:17	6	20220425_090300_salinity_03500.asvp	SVP from CTD007
Fladen Ground	Dy150-FG_M	2022-04-27 04:31	01:32:36	6	20220425_090300_salinity_03500.asvp	SVP from CTD007
Fladen Ground	Dy150-FG_N	2022-04-27 14:22	01:39:16	6	20220427_133300_salinity_03500.asvp	SVP from CTD009
Fladen Ground	Dy150-FG_O	2022-04-28 0430	01:30:53	6	20220427_133300_salinity_03500.asvp	SVP from CTD009
Fladen Ground	Dy150-FG_P	2022-04-28 1534	01:33:48	6	20220428_074700_salinity_03500.asvp	SVP from CTD011
Fellar Basin	Dy150-FB	2022-04-29 07:32	02:14:58	4-6	20220428_074700_salinity_03500.asvp	SVP from CTD011
Fellar Basin	Dy150-FB_B	2022-04-29 12:44	00:36:32	4-6	20220429_112000_salinity_03500.asvp	SVP from CTD013

St Magnus Bay	Dy150-StM	2022-04-30 07:32	01:43:20	3-7	20220430_050600_salinity_03500.asvp	SVP from CTD014
Scapa Flow	Dy150-SF	2022-05-01 07:01	01:01:16	0-6	20220430_050600_salinity_03500.asvp	SVP from CTD014
North Sea	Dy150-em122-test	2022-05-02 11:53	01:11:31	9-11	20220430_050600_salinity_03500.asvp	SVP from CTD014
Near Grimsey Iceland	Dy150-NIS_A	2022-05-05 05:06	00:47:15	6	20220430_050600_salinity_03500.asvp	SVP from CTD014
Near Grimsey Iceland	Dy150-NIS_B	2022-05-05 16:54	01:34:04	6	20220505_073500_salinity_03500.asvp	SVP from MIDAS 22356 on CTD016
Near Grimsey Iceland	Dy150-NIS_C	2022-05-06 04:44	03:28:58	6	20220505_0170400_salinity_03500.asvp	SVP from CTD017 Site C+D combined
Near Grimsey Iceland	Dy150-NIS_E	2022-05-07 05:07	01:47:54	6	20220505_0170400_salinity_03500.asvp	SVP from CTD017
Near Grimsey Iceland	Dy150-NIS_H	2022-05-07 17:26	01:32:02	6	20220507_164000_salinity_03500.asvp	SVP from CTD020
Near Grimsey Iceland	Dy150-NIS_N	2022-05-08 06:03	00:58:12	6	20220507_1640000_salinity_03500.asvp	SVP from CTD020
Skagasfjardjarjup	Dy150-NIS_I	2022-05-08	00:40:36	6	20220508_084100_salinity_03500.asvp	SVP from CTD022

Data processed daily with CARIS HIPS&SHIPS version 11 and with MB-System version 5.5.

Path of processed data on the cruise datastore

`/Ship_Systems/Data/Acoustics/EM-122/Caris_processed`

`/Ship_Systems/Data/Acoustics/MB-System_processed_multibeam_data`

9.1.3.3 EM-710 Configuration and Surveys

Path of Multibeam data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/EM-710`

Item	*X (m, + Forward)*	*Y (m, + Starboard)*	*Z (m, + Down)*
Tx transducer	37.570	-1.994	7.425
Rx transducer	36.819	-2.051	7.427

Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to W/L)			1.43 / 1.63

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	-0.07	0.33	0.22
Rx transducer	0.01	0.12	359.7
Att 1 (Applanix)	-0.14	-0.40	-1.00
Att 2 (Seapath)	0.00	0.00	0.00

Draught: Southampton: 2022-04-16 16:06 6.4m then Kirkwall: 2022-05-01 17:57 6.2m

Survey information – note any particular transducer settings (e.g. beam spacing) in comments, Applanix PosMV used for providing position and attitude data.

Survey Site Name	***SIS Survey Name***	***Datetime Start***	***Total time of Logging***	***Vessel survey speed (kts)***	***SVP(s) Used (Filename)***	***Comments***
North Sea	DY150	2022-04-13 10:19	01:29:35 h:m:s	6-11	Default	Default SVP profile and Sensor
Skagerrak	dy150-SK em710	2022-04-19 05:05	02:12:12 h:m:s	2-6	Default 20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150-FG_T	2022-04-21 04:34	02:55:57 h:m:s	6	20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150_FG_J	2022-04-21 16:31	01:15:32	6	20220419_072900_salinity_03500.asvp	SVP from Midas s/n 22356
Fladen Ground	Dy150-FG-I	2022-04-22 04:31	01:19:21	6	20220421_21900_salinity_03500.asvp	SVP from CTD003
Fladen Ground	Dy150-FG-G	2022-04-22 16:00	01:16:36	6	20220421_21900_salinity_03500.asvp	SVP from CTD003
Fladen Ground	Dy150-FG-A	2022-04-23 10:01	02:22:37	6	20220421_21900_salinity_03500.asvp	SVP from CTD003
Fladen Ground	Dy150-FG_B	2022-04-24 15:38	01:33:34	6	20220423_122300_salinity_03500.asvp	SVP from CTD006
Fladen Ground	Dy150-FG_F	2022-04-26 04:26	01:56:46	6	20220425_090300_salinity_03500.asvp	SVP from CTD007

Fladen Ground	Dy150-FG_M	2022-04-27 04:27	01:32:01	6	20220425_090300_salinity_03500.asvp	SVP from CTD007
Fladen Ground	Dy150-FG_N	2022-04-27 14:26	01:35:09	6	20220427_133300_salinity_03500.asvp	SVP from CTD009
Fladen Ground	Dy150-FG_O	2022-04-28 0440	01:21:19	6	20220427_133300_salinity_03500.asvp	SVP from CTD009
Fladen Ground	Dy150-FG_P	2022-04-28 1533	01:34:22	6	20220428_074700_salinity_03500.asvp	SVP from CTD011
Fellar Basin	Dy150-FB	2022-04-29 07:32	02:14:59	4-6	20220428_074700_salinity_03500.asvp	SVP from CTD011
Fellar Basin	Dy150-FB_B	2022-04-29 12:54	00:29:39	4-6	20220429_112000_salinity_03500.asvp	SVP from CTD013
St Magnus Bay	Dy150-StM	2022-04-30 07:33	01:47:08	3-7	20220430_050600_salinity_03500.asvp	SVP from CTD014
Scapa Flow	Dy150-SF	2022-05-01 07:01	01:06:05	0-6	20220430_050600_salinity_03500.asvp	SVP from CTD014
North Sea	Dy150-em710-test	2022-05-02 11:53	01:11:17	9-11	20220430_050600_salinity_03500.asvp	SVP from CTD014
Near Grimsey Iceland	Dy150-NIS_A	2022-05-05 05:09	00:55:31	6	20220505_073500_salinity_03500.asvp	SVP from MIDAS 22356 on CTD016
Near Grimsey Iceland	Dy150-NIS_B	2022-05-05 17:05	01:33:53	6	20220505_073500_salinity_03500.asvp	SVP from MIDAS 22356 on CTD016
Near Grimsey Iceland	Dy150-NIS_C	2022-05-06 04:33	03:29:14	6	20220505_0170400_salinity_03500.asvp	SVP from CTD017 Site C+D combined
Near Grimsey Iceland	Dy150-NIS_E	2022-05-07 05:07	01:49:44	6	20220505_0170400_salinity_03500.asvp	SVP from CTD017
Near Grimsey Iceland	Dy150-NIS_H	2022-05-07 17:26	01:31:08	6	20220507_164000_salinity_03500.asvp	SVP from CTD020
Near Grimsey Iceland	Dy150-NIS_N	2022-05-08 06:03	00:58:24	6	20220507_1640000_salinity_03500.asvp	SVP from CTD020
Skagasfjardjarjup	Dy150-NIS_I	2022-05-08	00:51:29	6	20220508_084100_salinity_03500.asvp	SVP from CTD022

Data processed daily with CARIS HIPS&SHIPS version 11 and with MB-System version 5.5.

> *Path of processed data on the cruise datastore*
>
> `/Ship_Systems/Data/Acoustics/EM-710/Caris_processed`
>
> `/Ship_Systems/Data/Acoustics/MB-System_processed_multibeam_data`

9.1.3.4 USBL Configuration and deployments

> *Path of USBL calibration information on the cruise datastore:*
> `/Ship_Systems/Data/Acoustics/USBL`

Attribute	*Value*
Number of deployments	?
Datetime of last CASIUS	15 August 2019 12:41:24
Starboard Head 1DRMS	See in the included Casius report
Port Head 1DRMS	See in the included Casius report

Deployment information:

Deployment name	*Head used*	*Beacon(s) used*	*Date*	*Remarks*
Simulation	Stbd	2406	2022-04-18	
SK_A PC	Stbd	3003	2022-04-19 09:45-10:10	PC - On Piston Core bracket
SK_B MC	Stbd	2707	2022-04-19 13:45-14:03	MC - On Megacorer wire 30m above MC
FG_J PC	Stbd	3003	2022-04-21 20:50-21:02	
FG_I PC	Stbd	3003	2022-04-22 08:25-08:35	
NIS_A PC	Stbd	3003	2022-05-05 08:50-09:18	
NIS_A PC	stbd	3003	2022-05-05 13:24-13:37	

9.1.4 Other systems

9.1.4.1 Cable Logging and Monitoring

Winch activity is monitored and logged using the CLAM system.

9.1.4.2 VSAT and FBB Satellite Internet

Satellite communications were provided with both the VSAT and Fleet Broadband systems. While underway, the ship operated with bandwidth controls to prioritise business use.

VSAT Usage:

DATE	Total Inbound (MB)	Total Outbound (MB)	Max IN	Max OUT
2022-04-15	4112	1101	1.97	0.66
2022-04-16	18336	4793	3.35	0.99
2022-04-17	35159	12202	6.02	1.89
2022-04-18	39385	10837	5.89	1.83
2022-04-19	36920	11459	5.92	1.86
2022-04-20	45692	10121	7.11	1.88
2022-04-21	46237	11286	6.85	1.81
2022-04-22	46338	8448	7.21	1.85
2022-04-23	43472	9811	6.98	1.93
2022-04-24	45967	9074	7.09	1.97
2022-04-25	48699	12611	7.21	2.03
2022-04-26	41468	15632	6.61	1.95
2022-04-27	42387	12203	7.03	1.94
2022-04-28	43256	9129	7.15	1.89
2022-04-29	45246	8427	6.84	1.84
2022-04-30	41081	8811	7.08	1.69
2022-05-01	42929	9787	6.57	1.85
2022-05-02	45918	8323	7.29	1.86
2022-05-03	47517	10019	7.19	1.91
2022-05-04	38396	11614	7.63	1.86
2022-05-05	21548	6585	6.84	1.76
2022-05-06	26234	8060	6.43	1.84
2022-05-07	32465	12008	6.39	1.93
2022-05-08	29306	11050	5.38	1.81
2022-05-09	26397	9094	6.09	1.86
2022-05-10	17040	5082	6.19	1.95

9.2 Notes for systems used

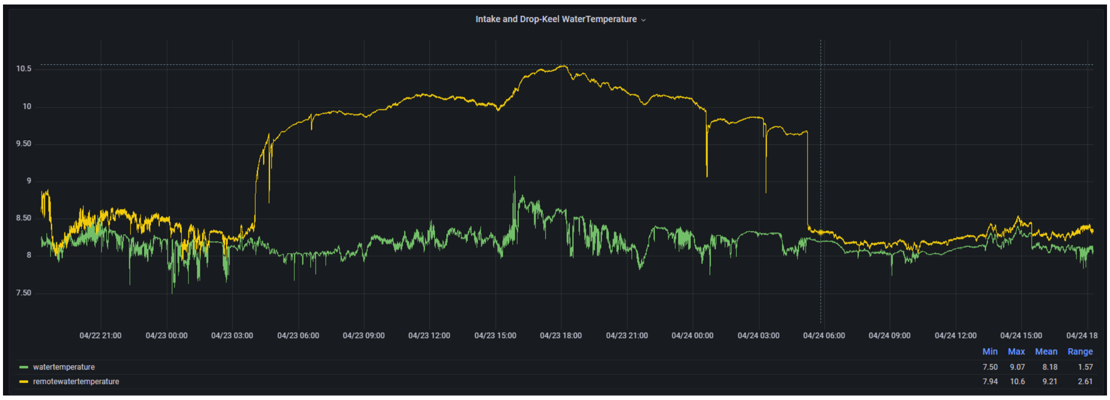
9.2.1 Significant acquisition events

Primary TechSAS logger DY150 mission started on 2022-04-15 11:33
Secondary TechSAS logger DY150 mission started on 2022-04-16 11:53
RVDAS primary RAM Acquisition started on 2022-04-12 10:55
RVDAS secondary RAM Acquisition started on 2022-04-16 07:15
Level-C acquisition started on 2022-04-15 17:34
RVDAS – NCC: TRUEWIND calculation valid from 2022-04-15 10:47 to 2022-05-11 13:00
RVDAS RAM Acquisition terminated on 2022-05-11 13:00
TechSAS logger DY150 mission terminated on 2022-05-11 13:00

9.2.2 Data gaps

Acoustic sensor routinely switched off/on during trilateration or mooring release or deployment tests, these events recorded with the eventlogger, data available in Documentation/Eventlogs folder.

Sensor	From:	To:	Length:	Issue:	Reason:



SBE38 intake remotewatertemperature oddity between 2022-04-23 03:50 and 2022-04-24 05:16

9.3 Pre-cruise tasks

- Underway System Atmospheric Monitoring Sensors inspected on 2022-04-15
- Underway System Water Monitoring Systems cleaned on 2022-04-15
- The Inlet Water Temperature Sensor SBE38 replaced prior the cruise.
- SMB, AFP and NFS access set to Public/DY150 and Current_Cruise folders on NAS.
- Operational checks done with the required Systems on 2022-04-15

9.4 Daily and weekly tasks

9.4.1 Daily tasks

Multibeam systems BIST TEST daily and before every survey
Underway Water Sampling test daily, Data range checking every odd day.
NAS and Cruise Disk checks daily
Cybersecurity checks daily.
Data Acquisiton checks three times a day.

9.4.2 Weekly tasks

Cybersecurity report on every Tuesday.

9.5 End of cruise checks

Data disks checked make sure not missing or corrupted data files on it. Systems default states are reinstated where it was a special setting.

10. NMF Sensors and moorings

Jon Short (National Marine Facilities, NOC, Southampton)

10.1 CTD

Total number of casts: 23

Deepest cast: 455m (016)

Stainless Steel CTD

CDT Wire 2 was used for all casts. The mechanical and electrical termination was renewed at the beginning of the cruise using the “skotchkote”, self-almagamating tape and insulation tape method. Resistance and insulation of the cable were checked periodically throughout the cruise. The torque setting on the fasteners of the mechanical termination was checked throughout and no slippage was noted.

CTD Wire 2 before cast 001 readings:
Resistance 82 Ohms Insulation >858 MOhms @500 VDC
CTD Wire 2 readings after cast 022:
Resistance 75.9 Ohms Insulation >550 MOhms @500 VDC

The CTD frame was set-up as for DY149 with primary conductivity and temperature sensors on the 9plus and secondary conductivity and temperature sensors on the vane. Other sensors on the frame were dissolved oxygen, altimeter, fluorometer, transmissometer and backscatter (BBRTD). Full sensor information can be found on the Sensor Information Sheet in Appendix 3. All sensors functioned well without any problems. No sensors were swapped out during the cruise.

OTE 20L Water Samplers were used on the SS frame and performed well throughout the cruise with only one bottle not firing (Bottle 5 Cast 021. Bottle 24 did not seal on the last two casts (21 & 22). This is a suspected O-ring issue and will be repaired during DY151.

A recently calibrated Valeport MIDAS SVP (sound velocity probe) was carried on the CTD for SSS. The data from this were compared to a CTD calculated sound velocity profile. The probe was attached to outside of frame with steel cable and jubilee clips on CTD casts 001, 002 and 016.

10.2 SBE data processing

Basic post-processing of the CTD cast data was carried out following guidelines established with BODC (ref. Moncoiffe 7th July 2010). Additionally, CTD2MET processing was carried out for each cast as well as processing to obtain sound velocity profiles for the acoustic systems. The data were processed using SBE Data Processing, V7.26.7. The following modules were used to process the data:

- Data Conversion
- Bottle Summary
- Align CTD
- CellTM
- Derive
- Bin Average

- Strip

A configuration report can be found in Appendix 4 (stainless steel).

10.3 Autosal

A Guildline Autosal 8400B salinometer, S/N: 71185, was used for salinity measurements. The salinometer was sited in the Salinometer lab. Bath temperature was set at 21°C, the ambient temperature being approximately 18.5-19.0°C. The salinometer was standardised before the first set of samples and checked with an additional standard analysed prior to setting the RS. Once standardised the Autosal was not adjusted for the duration of sampling. A standard was analysed after each crate of samples to monitor and record drift. Standards were recorded in the spreadsheet as ‘0’ and had a standard salinity value of 34.994 from batch P165. Standard deviation was set to 0.0002.

A program written in Labview called “Autosal” was used to record data for salinity values. Salinity samples were taken and analysed from most casts and the results tabulated in spreadsheets SALFORM_SS.xlsx.

11. Ocean Engineering Technical Report

Steve Corliss (National Marine Facilities, NOC, Southampton)

11.1 *Arctica* dredge

Two newly fabricated identical *Arctica* dredges with spare sets of teeth were supplied by the University of Exeter. Only one of the dredges was deployed.

98 dredges were completed with varying results in the attempt to collect *Arctica* shells (see Appendix 2). In the early stages in the North Sea the dredges results returned mostly muddy sediment and few shells. As the sites progressed this turned into sandy sediment returning empty dredges and / or few shells, to the extremes of returning with just rocks. Once in Icelandic waters the dredges returned with just shells, mostly from the last four locations, but resulting in over 22,000 shells being collected for further scientific investigation and dating.

11.2 Megacorer

The megacorer was supplied by National Marine Equipment Pool (NMEP). Twenty-two megacore sampling operations took place, resulting in 80 successful sample tubes.

80% of the sampling was successful returning 8/8 sampling tubes with a core sample of 57cm from the Fladen Ground.

The 20% unsuccessful were due to sandy or rocky sediment or where 1-2 slides failed to close due to thick sediment resulting in a loss at surface. Some slides were manually closed during recovery to prevent additional loss of samples. The science team were aiming for 3/8 successful sample tubes and were happy with the success rate achieved throughout the cruise.

The extruder made by Ben Poole (National Marine Facilities, NOC) proved a great success allowing controlled sampling of sections ranging from 1-5 cm and allowing the sampling to be conducted by 1-2 scientists allowing the rest of the science team to analyse and catalogue the data.

10.3 Gravity and piston coring

The piston corer was supplied by NMEP. Twenty-four piston/gravity cores were undertaken (Table 6.4). Six gravity cores were undertaken using the piston core set up with no trigger using 6m barrel lengths due to hard / sandy seabed conditions identified through geophysical survey and prior megacore sampling producing small sandy core sample or no sample at all. Eighteen piston cores were undertaken.

The first core at Skagerrak sunk produced a 5.61m sample from a 12m barrel length; the barrel sank to the bomb so a decision was made to reduce the rebound. The second attempt was in a water depth of 228m and the hydrostatic release failed. This was removed and the third core produced a 12.8m sample from an 18m barrel.

Cores 4-6 were successful producing on average 10m samples from 12m barrel lengths. Core 7 failed to penetrate the seabed and resulted in the recovery of 1 bent barrel from the 12m barrel length. Core 8 was a gravity core following this in the same location and penetrated just 0.5m. Core 9 did not take place due to the seabed conditions. Cores 10-12 were gravity cores with varying results of no penetration to 4.15m samples. Cores 13-16 were of 12m barrel lengths producing samples around 7m in length. Cores 17-18 were gravity cores with 0.2-0.35m samples due to adverse seabed conditions. Core 19 was a 12m barrel producing a sample of 10m in length. Core 20 was a 24m barrel length in North Iceland with nearly 19m of sample length recovered. Core 21 was a gravity core due to solid seabed producing no sample as it was suspected the barrel fell over as it could not penetrate. Core 22 was 12m barrel length, followed by a Core 23 of 18m barrel length producing sediment recovery around 12m. Core 24 was 24m barrel length recovering a 3m sample. Reasons are unknown for the small sample recovered but science feedback points to a possible layer at 4m that the cutter was unable to penetrate in conjunction with thick sticky mud as the pull-out tension was over 6T. The hydrostatic release was used on this core as the water depth was over 300m and the release was successful.

The general success of sampling was due to seabed and sediment conditions identified through geophysical survey, megacore sampling and direction from the Principal Scientist.

Further notes to add:

It was found that assembling both the 12 m and 24 m barrel lengths on the RRS *Discovery* is made difficult due to the positions of the ship’s hydraulic manifolds.

The wire diameter on the 1T North Sea Winch fitted to the davit needs to be increased to either 14mm or greater to assist with scrolling and lay of the wire on the drum.

The bridle at the end of the trellis was damaged due to its position when using a 24m barrel length on the final core (24) and will need to be looked at by the group following DY150 for better placement to allow barrel lengths of 24m to be deployed and recovered more easily.

12. IT

Zoltan Nemeth (National Marine Facilities, NOC, Southampton)

12.1 Overview

Table 12.1 provides a summary of the information technology provision on RRS *Discovery* under standard operating conditions.

<table>
<tr><td>Satellite internet links</td><td>1 x C-Band VSat (Primary, 3 Mbps)
1 x BGAN Fleet Broadband (Backup, 0.256 Mbps)</td></tr>
<tr><td>Upload speed</td><td>1.5 Mbps (~183 KB/sec)</td></tr>
<tr><td>Download speed</td><td>1.5 Mbps (~183 KB/sec)</td></tr>
<tr><td>Download burst speed</td><td>Upto 10 Mbps (~1.2 MB/sec)</td></tr>
<tr><td>Max upload/download time</td><td><table>
<tr><td><i>1 photo (~5MB)</i></td><td>~ 30 seconds</td></tr>
<tr><td><i>1 photo per person onboard (~250 MB)</i></td><td>~ 20 minutes</td></tr>
<tr><td><i>10 min video @ 240P</i></td><td>~ 2 minutes 30 seconds</td></tr>
<tr><td><i>10 min video @ 1080P HD</i></td><td>~ 25 minutes</td></tr>
<tr><td><i>1 gigabyte</i></td><td>~ 1 hour 30 minutes</td></tr>
</table></td></tr>
<tr><td>Video conferencing / livestreaming support</td><td>Can support 1 video call (e.g. Skype) or livestream (e.g. YouTube) session at any one time consuming up to 1.2 Mbps of each upload and download bandwidth.</td></tr>
<tr><td>Telephone lines</td><td>4 x UK phone lines over satellite, shared to all cabins and workspaces. Free to receive calls from off-ship, phonecard required to make non-business calls off-ship.</td></tr>
<tr><td>Access management</td><td>Optimised for business use; some usage management in place to regulate personal use.</td></tr>
<tr><td>Wi-Fi access</td><td><table>
<tr><td><i>Working Areas</i></td><td>Available, managed access</td></tr>
<tr><td><i>Bar / Lounge</i></td><td>Available, open access</td></tr>
<tr><td><i>Accommodation</i></td><td>Not available</td></tr>
</table></td></tr>
<tr><td>Wired access</td><td><table>
<tr><td><i>Working Areas</i></td><td>Available, managed access</td></tr>
<tr><td><i>Bar / Lounge</i></td><td>Available, managed access</td></tr>
<tr><td><i>Accommodation</i></td><td>Available, managed access</td></tr>
</table></td></tr>
<tr><td>Open internet access</td><td>Available to key business users (Master, Chief Engineer, Chief Mate, Purser, Chief Scientist and Senior Technician).
Available on 10 public machines throughout the ship.
Available on the Wi-Fi in the Bar and Lounge areas.
Negotiable depending on performance and requirements.</td></tr>
<tr><td>Intranet</td><td>Digital notice board for Master, Purser and Chief Scientist, news feed (BBC, Guardian, Metro), weather service, live data feeds.</td></tr>
<tr><td>File storage and sharing</td><td>1 x Public shared folder, 1 x Read-only cruise data archive. Up to 48TB storage (6TB primary + 7 x 6TB backup).</td></tr>
</table>

Table 12.1. IT provision on RRS *Discovery* under standard operating conditions.

10.2 Internet link over satellite

It is prohibitively expensive and technically challenging to provide an internet link at sea via satellite to a speed and reliability equivalent to that ordinarily found in most workplaces. The internet provision on our ships is reasonable compared to other ships, but compared to a normal workplace it is around 50 times slower: the speed of 1.5Mbps shared between 50 people onboard, is the recommended speed that would be allocated *per employee* in a land-based workplace!

In order to provide a usable service on this limited bandwidth, a mix of access- and use-management techniques are employed onboard. Business traffic is prioritised through the configuration of the ship's routers and different levels of usage restriction are in operation to enable key users to use the internet with minimum disruption.

Recognising however, that connectivity for personal use is of immense value to most people, WhatsApp and email are enabled to all devices and unrestricted Wi-Fi access is provided in the ships' recreational areas. The balance of restrictions is negotiable with the Master and ship's Science Systems Technician in order to adapt the provision to different use requirements, events or performance issues. As our satellite link is shared with other ships in the satellite's footprint, users can enjoy higher download (not upload) speeds during periods when traffic from other ships is reduced.

Personal devices for most of the science party (excepting the Chief Scientist) may be subject to usage restrictions, unless used in the Bar or Lounge. This may restrict access to a 'whitelist' of institutional, cruise-specific or business websites and the ship's intranet or slow down access to non-whitelist websites. Bandwidth-intensive applications such as video streaming, gaming, file sharing (like Dropbox, OneDrive), some cloud services and VPN connections are blocked or severely restricted for all users. Websites in categories deemed to be in breach of the NERC IT Policy are blocked.

10.3 IT infrastructure

Most scientists, technicians and crew will use their own devices. But in case they are required, there are ten open-access computers around the ship available for general use. In addition, there is one high-performance computer loaded with the CARIS multibeam-processing software for hydrographic use.

The ship is fitted with VMware high-performance virtual machine host servers. If there is a particular computing environment you would like onboard, it is possible to supply us with the virtual machine image or deployment template and your computing environment, with which we can set up your environment.

The ship is fitted with primary and backup network allocated storage (NAS) units offering up to 40TB primary data storage or 6TB primary storage with 7 days' backup. The cruise scientific data is aggregated into a central store which is made available across the ship as a read-only folder share. The data store also exposes a public read/write share that can be used a general file store and sharing area for all the embarked scientists.
The data is further copied to external USB storage volumes to hand over to the Chief Scientist at the conclusion of the cruise. Generally, 2TB external data storage is sufficient for most cruises.

10.4 Onboard support

IT support is one of the roles played by the ship's Science System Technician, drawn from the NMF Ship Scientific Systems team at the National Oceanography Centre. This Technician supports the full suite of ship-fitted scientific systems, from the underway and meteorological sampling, gravity, magnetics, multibeam and other echosounders through to the data acquisition systems and IT infrastructure, and are the first point of contact concerning your IT requirements and getting your devices working on the ship.

13. RRS *Discovery* laboratories

James Scourse (University of Exeter)

13.1 Laboratory set up

Four laboratories were used on DY150:

1. Main Laboratory: Deployment/operational control of geophysical equipment and CTD
2. Deck Laboratory: Sorting of shell samples and processing of megacore subsamples. Samples then placed in adjacent chill room or freezers in hold.
3. General Purpose (GP) (Chemistry) Laboratory: Piston and gravity core description; water filtration and processing for eDNA and microplastics (ADDMESS)
4. Controlled Temperature (CT) Laboratory: Processing of megacore samples for eDNA analysis

In addition, the stern deck was used for initial sorting of *Arctica* dredge samples, and the hangar area was used for gravity and piston core splitting via the Geotek core splitter prior to being taken into the GP Laboratory for description, and for megacore extrusion and subsampling.

13.2 Scientific sample collection and consignment

Biological and megacore samples were placed either in the chill room or the hold freezers, and core sections in a reefer on the stern deck, and returned to NOC following DY151. From there the chilled and frozen material was returned to the University of Exeter (Penryn Campus). The core sections were delivered directly into the adjacent BOSCORF facility for scanning and subsampling, and from there also returned to storage at the University of Exeter (Penryn Campus).

14. Data management

James Scourse (University of Exeter)

14.1 Data storage

All data during DY150 were compiled on a Sharepoint site on the ship drive. These data were downloaded to a hard drive given to the PSO on the conclusion of the cruise by the Science System Technician. These data will also be accessible via NMF. Subsequent to the cruise the hard drive data were copied to a reserve hard drive, held at the University of Exeter (Penryn Campus) by the PSO, and also uploaded onto the SEACHANGE Project internal Sharepoint site. This source was used to compile this cruise report and many of the datasets and their metadata are included in other sections of this report.

Ultimately these data, and the data deriving from post-cruise analysis, will be uploaded to open access data repositories, including the British Oceanographic Data Centre for sites within UK waters. The use of open access repositories is mandatory for data deriving from the ERC SEACHANGE Project; responsibility for ensuring compliance lies with Paul Butler, SEACHANGE Science Manager (University of Exeter, Penryn Campus).

14.2 Site identifiers

The following guidance on sample labelling was distributed at the start of DY150 and used for labelling all samples deriving from the cruise. This should enable to site location and context of any sample collected on DY150 to be established post-cruise:

SEACHANGE Sample Labelling

It is crucially important that we employ a standardised and consistent system for the labelling of samples from the cruise, so please adopt the following in all labelling:

ALL SAMPLES/DATA: prefixed DY150

Use the following codes for the different sites:

SK: Skagerrak
FG: Fladen Ground
SH: Shetland, then FB: Fetlar Basin and MB: St Magnus Basin
SF: Scapa Flow
NIS: North Icelandic Shelf

Stations within FG and NIS will be prefixed A, B, C….

PISTON/GRAVITY CORES

PC: Piston core
GC: Gravity core

Numbered sequentially for the whole cruise (not within sites) whether PC or GC e.g. PC001, GC002, PC003 etc.

So, a piston core from the St Magnus Basin might be labelled something like:

DY150 SH MB PC009

And a gravity core from the Fladen Ground station H might be labelled something like:

DY150 FG H GC005

ARCTICA DREDGE

All samples prefixed AD (Arctica dredge) with trawls numbered sequentially for the whole cruise (not within sites), and then bagged as Live (L: to be frozen), Articulated (A) or Dead (D).

So, bag of dead shells from NIS station F might be labelled something like:

DY150 NIS F AD034 D

MEGACORER

All samples prefixed MC, then station number (if more than a single station), the megacore deployment, then tube number prefixed #, then by core depth.

So, a megacore sample from the Fladen Ground station B might be labelled something like:

DY150 FG B MC01 #3 0.5-1 cm

14.3 Digital and paper logs

All data were either logged directly onto the Sharepoint site on the ship drive (see Section 14.1) or initially onto a dedicated SEACHANGE Project laptop within the working labs. The latter was mostly used for logging sample data in real time for the megacore and Arctica dredge sampling, and transferred onto the Sharepoint site later. No paper logs were used.

14.4 Datasets and their use

The data included in this cruise report are open access and not covered by an embargo or restriction. Enquiries of the use of these data should be directed to Paul Butler, SEACHANGE Project Science Manager at the University of Exeter (p.butler@exeter.ac.uk). Post-cruise datasets will be uploaded during the course of the Project onto the SEACHANGE Project Sharepoint site and will be embargoed until such time as the data are published or the data are uploaded onto a public repository (see Section 14.1).

15. Floating University

James Scourse (University of Exeter)

We used the opportunity provided by the requirement to quarantine alongside in Southampton for six days prior to sailing to organise and run a Floating University. All participants were given the opportunity to give a seminar on a topic of their choice. In practice most of the topics chosen were relevant to the SEACHANGE Project (see schedule below, Table 15.1). These seminars were held in the mornings in the Conference Room onboard – which proved to be an excellent venue – leaving the afternoons free to continue with unpacking and mobilisation (Fig. 15.1). The Floating University had multiple benefits: 1. It prevented the science party from becoming bored during the quarantine period, 2. It added some structure to the days which otherwise would have been unstructured, 3. It provided excellent opportunities for the science party to get to know each other – especially those who had not met before - and to find out what their expertise was, 4. It provided opportunities for the officers, crew and technical support staff to get to know the science party and what the science aims of the cruise were. The feedback from all on board about the Floating University was unanimously positive. It undoubtedly helped to ensure that DY150 was a very productive and happy research cruise.

Table 15.1. The DY150 Floating University schedule

DY150 DISCOVERY FLOATING UNIVERSITY

Seminar Room RRS *Discovery*

Tuesday 12 April

09.00 – 09.45 James: The ERC SEACHANGE Synergy Project

09.45 – 10.30 James: DY150 – where are we going, why, and what are we going to do when we get there

10.30 – 10.45 Coffee break

10.45 – 11.30 James, Dave, Alejandro, Tobias E: DY150 operational introduction

11.30 – 12.15 Tour of lab space, equipment and working area

Wednesday 13 April

09.00 – 09.45 James: The evolution of the NW European shelf seas since the Last Glacial Maximum

09.45 – 10.00 Matt: Dating multicores

10.00 – 10.15 Jack: Palaeoceanographic and climatic change around South Georgia since the late deglacial using marine micropalaeontology and geochemistry

10.15 – 10.30 Coffee break

10.30 – 11.15 Dave: Sclerochronology – the basics

11.15 – 11.45 Dave: Sclerochronology - Local to regional scale reconstructions using sclerochronology (not the basics)

11.45 – 12.00 Jane: Investigating growth rates of *Arctica islandica* in different time periods, and the application of growth rates as a shell dating method

12.00 – 12.15 Nils: Bivalve shell microstructures and their connection to the environment

Thursday 14 April

09.00 – 09.45 Jen: Fishing from the Vikings to the herring industry: middens, trade, and historical records

09.45 – 10.30 Harry: Something on middens

10.30 – 10.45 Coffee break

10.45 – 11.30 Alejandro: Antarctic marine ecosystems in relation to industrial whaling and sealing

11.30 – 11.45 Daniel: Plastics in the ocean – modelling and observations

11.45 – 12.15 Danielle: Potential Whale and Seabird Sightings of DY150

Friday 15 April

09.00 – 09.45 Luke: Introduction to eDNA for modern and ancient biodiversity inference

09.45 – 10.30 Tobias: General overview of eDNA, biodiversity assessment (contemporary not ancient) and some of the issues with eDNA stability and persistence

10.30 – 10.45 Coffee break

10.45 – 11.15 Emilia: A library of sequences – the importance of having good DNA reference data

11.15 – 12.00 Kweku and Qian: Compound Specific Isotope Analysis (CSIA) of lipid biomarkers and amino acids

12.00 – 12.15 Charlotte: Using sedimentary aDNA to interpret changes in phytoplankton communities

Figure 15.1. The DY150 Floating University in the Conference Room, RRS *Discovery*.

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APPENDIX 1. DY150 Bridge Log

time	entry#	event	category	comment	Latitude (degree_north)	Longitude (degree_east)	Heading (degree)	Ground Speed (knot)	Relative Wind Direction (degree)	Relative Wind Speed (m/s)
2022-04-15T11:34:35.000Z	0			log started	50.891661	-1.394654	308.2000122	0	208	1.419999957
2022-04-19T04:00:00.000Z	1	SK	Surv	MMO watch started	58.556187	10.188776	32.09999847	7.900000095	7	4.130000114
2022-04-19T05:00:00.000Z	2	SK	Surv	MMO watch complete SBP/EM122 survey started	58.649455	10.314147	29.29999924	6.099999905	47	3.920000076
2022-04-19T05:50:00.000Z	3	SK	Surv	SBP/EM122 survey complete	58.660393	10.329144	214.8000031	5.5	334	3.400000095
2022-04-19T06:20:00.000Z	4	SK A	Stat	On station	58.668168	10.340385	54.09999847	0.100000001	125	0.899999976
2022-04-19T06:28:51.000Z	5	SK A CTD001	Stat	CTD O/B	58.668168	10.34038	54.20000076	0	119	1.5
2022-04-19T06:49:00.000Z	6	SK A CTD001	Stat	max wire out 187m	58.668168	10.34038	54.5	0	234	1.100000024
2022-04-19T07:06:29.000Z	7	SK A CTD001	Stat	CTD Recovered	58.668171	10.340388	54.59999847	0.100000001	31	2.75
2022-04-19T07:43:02.000Z	8	SK A MC001	Stat	Megacore Deployed	58.668162	10.340387	53.70000076	0.100000001	291	3.130000114
2022-04-19T07:54:19.000Z	9	SK A MC001	Stat	Megacore on the seafloor @ 201m	58.668162	10.340382	53.40000153	0.100000001	295	3.069999933
2022-04-19T08:03:53.000Z	10	SK A MC001	Stat	Megarcore Recovered	58.668165	10.340379	52.90000153	0.100000001	288	3.440000057
2022-04-19T09:44:19.000Z	11	SK A PC001	Stat	PC in the water	58.66816	10.340368	54.20000076	0	333	3.529999971
2022-04-19T09:51:41.000Z	12	SK A PC001	Stat	Piston core deployed	58.668158	10.340383	54.20000076	0	318	3.140000105
2022-04-19T09:58:30.000Z	13	SK A PC001	Stat	Piston core on the sea floor	58.668158	10.34039	53.59999847	0	321	2.819999933
2022-04-19T10:44:34.000Z	14	SK A PC001	Stat	Piston core recovered	58.668164	10.340388	53.5	0.100000001	355	2.50999999
2022-04-19T12:34:45.000Z	15	SK B CTD002	Stat	CTD O/B	58.738421	10.204357	105.9000015	0.100000001	47	1.059999943
2022-04-19T12:56:33.000Z	16	SK B CTD002	Stat	CTD I/B	58.738424	10.204368	106.8000031	0	86	1.529999971

2022-04-19T13:40:29.000Z	17	SK B MC002	Stat	MULTI CORER O/B	58.738417	10.204357	104.3000031	0.100000001	107	1.850000024
2022-04-19T13:55:50.000Z	18	SK B MC002	Stat	CORER ON SEABED	58.738421	10.204345	104.5999985	0	106	1.50999999
2022-04-19T14:07:48.000Z	19	SK B MC002	Stat	CORER I/B	58.738422	10.20435	105	0.100000001	98	1.440000057
2022-04-19T15:46:05.000Z	20	SK B PC002	Stat	PISTON CORE O/B	58.738485	10.204419	121.3000031	0	163	3.019999981
2022-04-19T17:04:17.000Z	21	SK B PC002	Stat	PISTON CORE RECOVERED TO TRESTLE	58.738479	10.204416	120.8000031	0	137	1.230000019
2022-04-19T18:39:32.000Z	22	SK B PC003	Stat	PISTON CORE O/B	58.73849	10.204405	121.8000031	0	172	3.349999905
2022-04-19T19:33:56.000Z	23	SK B PC003	Stat	Piston core deployed	58.738485	10.204415	121.5999985	0.100000001	187	1.74000001
2022-04-19T19:39:47.000Z	24	SK B PC003	Stat	PC ON THE SEABED	58.738485	10.204414	121.3000031	0	23	2.519999981
2022-04-19T20:23:04.000Z	25	SK B PC003	Stat	PISTON CORE RECOVERED TO TRESTLE	58.738479	10.204409	120.3000031	0.100000001	226	2.680000067
2022-04-21T04:01:02.000Z	26	FG	Stat	COMMENCE MMO	57.953808	1.687326	229.8000031	0	205	5.070000172
2022-04-21T04:35:35.000Z	27	FG	Surv	UNDERWAY, COMMENCE COLD START	57.953171	1.686102	228.6999969	2.400000095	225	2.660000086
2022-04-21T04:57:01.000Z	28	FG	Surv	COMMENCE SURVEY	57.932407	1.639501	232.8000031	5.699999809	213	2.690000057
2022-04-21T09:01:21.000Z	29	FG T AD001	Stat	VESSEL ON STATION	57.928937	1.629072	308.7999878	0.100000001	128	6.880000114
2022-04-21T09:04:33.000Z	30	FG T AD001	Stat	DREDGE IN THE WATER	57.928947	1.629089	304	0	133	6.559999943
2022-04-21T09:10:28.000Z	31	FG T AD001	Tow	COENCED DREDGING	57.929037	1.628847	304.3999939	0.400000006	133	5.869999886
2022-04-21T09:28:09.000Z	32	FG T AD001	Stat	COMENCED HAULING	57.930264	1.625695	305.2000122	0.100000001	134	6.119999886
2022-04-21T09:52:24.000Z	33	FG T AD001	Stat	DREDGE OF THE SEABED	57.93026	1.625694	305.3999939	0.100000001	143	9.079999924
2022-04-21T09:56:40.000Z	34	FG T AD001	Stat	DREDGE RECOVERED TO DECK	57.93026	1.62569	305.8999939	0	139	8.989999771
2022-04-21T10:16:53.000Z	35	FG T AD002	Stat	VESSEL ON STATION	57.929765	1.614819	230.3000031	0.100000001	217	9.520000458
2022-04-21T10:19:24.000Z	36	FG T AD002	Stat	DREDGE IN THE WATER	57.929751	1.614819	230.8999939	0	219	9.090000153

2022-04-21T11:02:56.000Z	37	FG T AD002	Stat	DREDGE OFF THE SEABED	57.926615	1.607409	231.8000031	0	23	8.56000042
2022-04-21T12:12:12.000Z	38	FG T AD002	Stat	DREDGE I/B	57.926618	1.607402	231.1000061	0.100000001	23	8.029999733
2022-04-21T16:04:57.000Z	39	FG J	Surv	COMENCE MMO	58.064007	0.441032	291.3999939	10.10000038	27	2.180000067
2022-04-21T18:14:11.000Z	40	FG J CTD003	Stat	ON STATION	58.117637	0.270056	29.10000038	0.300000012	9	6.389999866
2022-04-21T18:16:45.000Z	41	FG J CTD003	Stat	CTD O/B	58.117658	0.270038	35.90000153	0.100000001	357	6.010000229
2022-04-21T18:26:59.000Z	42	FG J CTD003	Stat	MAX WIRE @ 130m	58.117656	0.270039	36.20000076	0	355	6.929999828
2022-04-21T18:38:55.000Z	43	FG J CTD003	Stat	CTD I/B	58.117655	0.270037	35.79999924	0.200000003	2	7.179999828
2022-04-21T18:59:22.000Z	44	FG J MC003	Stat	MEGA CORE O/B	58.117653	0.27004	35.70000076	0.100000001	354	6.849999905
2022-04-21T19:09:27.000Z	45	FG J MC003	Stat	MAX WIRE OUT 158M	58.117653	0.270047	35.09999847	0	349	7.159999847
2022-04-21T19:22:42.000Z	46	FG J MC003	Stat	RECOVERED TO DECK	58.117654	0.270048	35	0	353	6.769999981
2022-04-21T20:44:37.000Z	47	FG J PC003	Stat	PISTON CORE IN THE WATER	58.117649	0.270043	35.59999847	0	356	5.889999866
2022-04-21T21:01:16.000Z	48	FG J PC003	Stat	PISTON CORE DEPLOYED	58.117646	0.270042	35.20000076	0.100000001	354	5.760000229
2022-04-21T21:04:19.000Z	49	FG J PC003	Stat	ON THE SEAFLOOR	58.117648	0.270041	35.5	0.200000003	356	5.96999979
2022-04-21T22:00:59.000Z	50	FG J PC003	Stat	RECOVERED TO TRESTLE	58.117649	0.270028	35	0.100000001	348	6.929999828
2022-04-21T22:35:32.000Z	51	FG J AD003	Stat	ON STATION	58.126221	0.261371	171.5	0.400000006	21	6.110000134
2022-04-21T23:21:02.000Z	52	FG J AD003	Stat	DREDGE O/B	58.125247	0.261619	172	0	216	5.929999828
2022-04-21T23:28:00.000Z	53	FFG J AD003	Stat	DREDGE ON SEABED	58.12522	0.261622	171.3999939	0.600000024	216	6.349999905
2022-04-22T00:18:19.000Z	54	FG J AD003	Stat	DREDGE I/B	58.123471	0.26209	169.6999969	0.100000001	215	4.789999962
2022-04-22T00:25:11.000Z	55	FG J AD004	Stat	DREDGE O/B	58.123475	0.262091	170.3000031	0.100000001	215	5.440000057
2022-04-22T00:33:00.000Z	56	FG J AD004	Stat	DREDGE ON SEABED	58.123471	0.262088	170	0.300000012	218	4.880000114

2022-04-22T01:08:49.000Z	57	FG J AD004	Stat	DREDGE I/B	58.121699	0.262656	170	0.100000001	22	6.5
2022-04-22T04:00:37.000Z	58	FG I	Surv	COMMENCE MMO	58.365797	0.574732	281.7000122	2.599999905	116	4.940000057
2022-04-22T04:55:35.000Z	59	FG I	Surv	COMMENCE SURVEY	58.372555	0.532116	288	6	89	5.46999979
2022-04-22T06:10:34.000Z	60	FG I CTD 004	Stat	ON STATION	58.375022	0.516354	55.20000076	0.100000001	343	4.809999943
2022-04-22T06:15:39.000Z	61	FG I CTD004	Stat	CTD O/B	58.374995	0.516384	47.70000076	0.100000001	35	5.070000172
2022-04-22T06:22:55.000Z	62	FG I CTD 004	Stat	MAX WIRE OUT 136m	58.37499	0.516384	45.40000153	0.100000001	348	4.960000038
2022-04-22T06:41:02.000Z	63	FG I CTD 004	Stat	CTD I/B	58.374976	0.51641	37.70000076	0.100000001	3	4.940000057
2022-04-22T07:11:43.000Z	64	FG I MC004	Stat	MEGACORE IN THE WATER	58.374964	0.516451	35.40000153	0.300000012	2	5.329999924
2022-04-22T07:26:12.000Z	65	GF I MC 004	Stat	RECOVERED TO DECK	58.374964	0.516448	35.09999847	0.200000003	16	5.289999962
2022-04-22T07:52:25.000Z	66	FG I PC 005	Stat	COMMENCED DEPLOYMENT	58.374961	0.516443	35.29999924	0.100000001	16	5.670000076
2022-04-22T08:14:47.000Z	67	FG I PC 005	Stat	PC IN THE WATER	58.374966	0.516433	34.70000076	0.200000003	14	5.53000021
2022-04-22T09:04:38.000Z	68	FG I PC 005	Stat	RECOVERED TO TRESTLE	58.374961	0.516441	35.90000153	0.100000001	45	5.820000172
2022-04-22T10:23:18.000Z	69	FG I AD 005	Stat	DREDGE IN THE WATER	58.370091	0.528089	1.5	0.100000001	93	6.679999828
2022-04-22T10:47:35.000Z	70	FG I AD 005	Stat	COMMENCED HAULING	58.372295	0.528186	0.100000001	0.100000001	91	5.5
2022-04-22T11:04:21.000Z	71	FG I AD 005	Stat	RECOVERED TO DECK	58.372288	0.528173	0.600000024	0.200000003	95	5.920000076
2022-04-22T11:17:40.000Z	72	FG I AD006	Stat	DREDGE O/B	58.372295	0.528169	1.299999952	0.100000001	87	6.099999905
2022-04-22T11:25:52.000Z	73	FG I AD006	Stat	DREDGE ON SEABED	58.372296	0.528176	0.699999988	0.200000003	88	5.150000095
2022-04-22T12:03:00.000Z	74	FG I AD006	Stat	DREDGE I/B	58.374534	0.528251	0.400000006	0.100000001	8	5.539999962
2022-04-22T12:27:57.000Z	75	FG I AD007	Stat	DREDGE O/B	58.374539	0.527682	288.1000061	0.400000006	148	4.420000076
2022-04-22T12:38:15.000Z	76	FG I AD007	Stat	DREDGE ON SEABED	58.374557	0.527558	287	0.600000024	155	4.150000095

2022-04-22T13:06:58.000Z	77	FG I AD007	Stat	DREDGE CLEAR OF SEABED	58.375249	0.523624	287.2000122	0.100000001	147	4.699999809
2022-04-22T13:13:49.000Z	78	FG I AD007	Stat	DREDGE I/B	58.375246	0.523616	288	0.5	144	4.369999886
2022-04-22T13:30:50.000Z	79	FG I AD008	Stat	DREDGE O/B	58.375238	0.523611	287.6000061	0	14	4.710000038
2022-04-22T13:42:46.000Z	80	FG I AD008	Stat	DREDGE ON SEABED	58.375281	0.523371	287.5	0.5	124	4.070000172
2022-04-22T14:22:53.000Z	81	FG I AD008	Stat	DREDGE I/B	58.375931	0.51954	288.5	0.100000001	125	4.510000229
2022-04-22T15:30:57.000Z	82	FG G	Pass	COMMENCE MMO	58.453632	0.423526	346.5	3.200000048	66	4.539999962
2022-04-22T16:04:24.000Z	83	FG G	Surv	COMMENCE SOFT START	58.483743	0.415679	4	5.300000191	22	6.929999828
2022-04-22T16:20:04.000Z	84	FG G	Surv	COMMENCE SURVEY	58.507736	0.4166	5.300000191	5.400000095	24	6.800000191
2022-04-22T17:18:22.000Z	85	FG G	Surv	COMPLETE SURVEY	58.527036	0.411968	5.300000191	5.900000095	35	4.71999979
2022-04-22T17:38:47.000Z	86	FG G CTD 005	Stat	ON STATION	58.516477	0.416946	12.5	0.100000001	26	4.340000153
2022-04-22T17:44:56.000Z	87	FG G CTD 005	Stat	CTD O/B	58.516477	0.416925	12.69999981	0.300000012	19	4.539999962
2022-04-22T17:54:08.000Z	88	FG G CTD005	Stat	MAX WIRE @ 130m	58.51648	0.416925	13	0.200000003	12	3.190000057
2022-04-22T18:03:11.000Z	89	FG G CTD 005	Stat	CTD I/B	58.516484	0.416939	12.39999962	0.100000001	17	4.420000076
2022-04-22T18:21:14.000Z	90	FG G MC005	Stat	MEGA CORE O/B	58.516483	0.416929	12.39999962	0.100000001	33	3.190000057
2022-04-22T18:29:54.000Z	91	FG G MC 005	Stat	MEGA CORE ON SEA BED	58.516479	0.416928	12.30000019	0.600000024	14	3.839999914
2022-04-22T18:32:57.000Z	92	FG G MC 005	Stat	COMMENCE HAULING FROM SEA BED	58.516479	0.416929	12.19999981	0.300000012	19	3.460000038
2022-04-22T18:38:44.000Z	93	FG G MC 005	Stat	MEGA CORE I/B	58.516479	0.416921	12.69999981	0.300000012	18	4.139999866
2022-04-22T19:26:15.000Z	94	FG G PC 006	Stat	COMMENCED DEPLOYING PISTON CORE	58.516484	0.416925	13	0.100000001	2	4.639999866
2022-04-22T20:00:10.000Z	95	FG G PC 006	Stat	PISTON CORE IN THE WATER	58.516488	0.416936	12.39999962	0.200000003	1	5.670000076
2022-04-22T20:03:47.000Z	96	FG G PC 006	Stat	PISTON CORE DEPLOYED	58.516489	0.416933	12.39999962	0.200000003	11	6.340000153

2022-04-22T20:07:05.000Z	97	FG G PC 006	Stat	PISTON CORE ON THE SEABED	58.516475	0.416931	13.10000038	0.200000003	16	6.650000095
2022-04-22T20:57:53.000Z	98	FG G PC 006	Stat	PISTON CORE RECOVERED TO DECK	58.516478	0.416926	12.5	0.200000003	27	6.079999924
2022-04-22T21:13:39.000Z	99	FG G AD 009	Stat	VESSEL ON STATION	58.510964	0.411199	2.700000048	0.400000006	32	6.809999943
2022-04-22T21:50:55.000Z	100	FG G AD 009	Stat	DREDGE IN THE WATER	58.510973	0.411093	2	0.100000001	26	7.170000076
2022-04-22T22:16:03.000Z	101	FG G AD 009	Stat	COMMENCED HAULING	58.513194	0.411468	2.599999905	0.400000006	25	7.25
2022-04-22T22:32:40.000Z	102	FG G AD 009	Stat	DREDGE RECOVERED TO DECK	58.513216	0.411488	1.899999976	0.699999988	32	8.359999657
2022-04-22T23:13:45.000Z	103	FG G AD010	Stat	DREDGE O/B	58.513211	0.41147	4.5	0.300000012	25	7.360000134
2022-04-22T23:21:42.000Z	104	FG G AD 010	Stat	DREDGE ON SEABED	58.513211	0.411457	4.800000191	0.400000006	25	7.849999905
2022-04-22T23:54:21.000Z	105	FG G AD010	Stat	DREDGE OFF SEABED	58.515448	0.411859	4.300000191	0.100000001	39	4.929999828
2022-04-23T00:02:55.000Z	106	FG G AD010	Stat	DREDGE I/B	58.515448	0.411845	5.400000095	0.100000001	45	5.909999847
2022-04-23T00:46:27.000Z	107	FG G AD011	Stat	DREDGE O/B	58.516462	0.412634	95.19999695	0.300000012	277	7.25
2022-04-23T00:54:41.000Z	108	FG G AD011	Stat	DREDGE ON SEABED	58.516462	0.412646	96.09999847	0.800000012	291	5.539999962
2022-04-23T01:27:05.000Z	109	FG G AD011	Stat	DREDGE OFF SEABED	58.516281	0.41692	96.69999695	0.200000003	278	8.149999619
2022-04-23T01:35:41.000Z	110	FG G AD011	Stat	DREDGE I/B	58.516282	0.416923	96.90000153	0.200000003	294	5.369999886
2022-04-23T01:46:54.000Z	111	FG G AD012	Stat	DREDGE O/B	58.516282	0.416922	96.5	0.300000012	283	7.230000019
2022-04-23T01:53:42.000Z	112	FG G AD012	Stat	DREDGE ON SEABED	58.516279	0.416916	96.5	0.800000012	287	5.860000134
2022-04-23T02:33:48.000Z	113	FG G AD012	Stat	DREDGE I/B	58.515815	0.421459	19.79999924	0.300000012	4	7.829999924
2022-04-23T05:49:48.000Z	114	FG A	Stat	COMMENCE MMO	58.790656	0.355489	11.30000019	0.100000001	4	5.659999847
2022-04-23T06:22:37.000Z	115	FG A	Surv	COMMENCE SOFT START	58.790746	0.355917	5.199999809	1.299999952	42	5.099999905
2022-04-23T06:43:46.000Z	116	FG A	Surv	COMMENCE SURVEY	58.820633	0.355839	3	6	27	6.809999943

2022-04-23T11:50:23.000Z	117	FG A CTD006	Stat	CTD O/B	58.833633	-0.360299	16.39999962	0.200000003	67	2.670000076
2022-04-23T12:16:08.000Z	118	FG A CTD006	Stat	CTD I/B	58.833632	-0.360313	16.29999924	0.300000012	82	3.400000095
2022-04-23T12:34:59.000Z	119	FG A MC006	Stat	MULTI CORER O/B	58.833624	-0.360296	15	0.300000012	77	4.369999886
2022-04-23T12:41:54.000Z	120	FG A MC006	Stat	CORER ON SEABED	58.833638	-0.360295	16.20000076	0.100000001	96	2.289999962
2022-04-23T12:44:40.000Z	121	FG A MC006	Stat	CORER PULLOUT	58.833636	-0.36029	15.5	0.100000001	92	2.839999914
2022-04-23T12:51:23.000Z	122	FG A MC006	Stat	CORER I/B	58.833643	-0.3603	15.30000019	0.100000001	92	2.779999971
2022-04-23T14:07:43.000Z	123	FG A PC006	Stat	PISTON CORER O/B	58.833632	-0.360322	16.39999962	0.300000012	83	2.289999962
2022-04-23T14:21:40.000Z	124	FG A PC006	Stat	COMMENCED VEERING	58.833633	-0.36032	16.29999924	0.100000001	95	2.980000019
2022-04-23T14:24:53.000Z	125	FG A PC006	Stat	COMMENCED HAULING	58.833635	-0.360306	15.60000038	0.300000012	91	3.690000057
2022-04-23T15:08:56.000Z	126	FG A PC006	Stat	PISTON CORE RECOVERED	58.833636	-0.360295	15.39999962	0.400000006	75	5.789999962
2022-04-23T16:11:22.000Z	127	FG A AD013	Stat	ON STATION FOR DREDGE	58.838394	-0.356407	255.3999939	0.200000003	212	4.829999924
2022-04-23T16:19:10.000Z	128	FG A AD013	Stat	DREDGE O/B	58.838408	-0.356401	254.5	0.400000006	215	4.929999828
2022-04-23T16:27:27.000Z	129	FG A AD013	Stat	DREDGE ON SEA BED	58.838407	-0.356405	254.5	0.300000012	199	2.74000001
2022-04-23T17:06:59.000Z	130	FG A AD013	Stat	DREDGE ON I/B	58.837858	-0.360597	254.3000031	0.300000012	207	3.269999981
2022-04-23T17:10:44.000Z	131	FG A AD014	Stat	DREDGE O/B	58.837842	-0.360619	255.3000031	1.100000024	215	3.720000029
2022-04-23T17:52:06.000Z	132	FG A AD014	Stat	DREDGE I/B	58.837259	-0.364772	253.8999939	0.300000012	204	3.180000067
2022-04-23T18:23:37.000Z	133	FG A AD015	Stat	DREDGE O/B	58.836931	-0.364375	125.6999969	0.200000003	31	3.150000095
2022-04-23T19:09:32.000Z	134	FG A AD 015	Stat	RECOVERED TO DECK	58.835657	-0.360836	124.1999969	0.300000012	309	2.319999933
2022-04-23T19:17:42.000Z	135	FG A AD016	Stat	DREDGE O/B	58.835667	-0.360826	124.0999985	0.400000006	297	3.00999999
2022-04-23T20:16:02.000Z	136	FG A AD 017	Stat	DREDGE O/B	58.834071	-0.356767	272.2999878	1	147	3.079999924

2022-04-23T21:27:36.000Z	137	FG A AD 017	Stat	DREDGE I/B	58.834145	-0.365418	272.3999939	0.200000003	12	3.039999962
2022-04-23T21:44:17.000Z	138	FG A AD 018	Stat	DREDGE O/B	58.833922	-0.367664	183.8000031	0.300000012	204	3.980000019
2022-04-23T22:50:55.000Z	139	FG A AD 018	Stat	DREDGE I/B	58.829996	-0.368203	183.6999969	0.100000001	212	7.239999771
2022-04-23T23:12:37.000Z	140	FG A AD019	Stat	DREDGE O/B	58.830285	-0.36771	80	0.400000006	301	6.300000191
2022-04-24T00:26:53.000Z	141	FG A AD019	Stat	DREDGE I/B	58.831004	-0.35917	80	0.200000003	30	4.920000076
2022-04-24T00:37:10.000Z	142	FG A AD020	Stat	DREDGE O/B	58.830998	-0.359189	83.30000305	0.200000003	29	7.699999809
2022-04-24T01:23:41.000Z	143	FG A AD020	Stat	DREDGE I/B	58.831304	-0.355042	81.69999695	0.200000003	291	6.75
2022-04-24T01:50:42.000Z	144	FFG A AD021	Stat	DREDGE O/B	58.831181	-0.356028	252.6000061	0.100000001	138	7.96999979
2022-04-24T03:04:47.000Z	145	FG A AD021	Stat	DREDGE I/B	58.829846	-0.364293	253.8000031	0.200000003	135	8.819999695
2022-04-24T03:14:16.000Z	146	FG A AD022	Stat	DREDGE O/B	58.829842	-0.364293	254	0.200000003	128	8.890000343
2022-04-24T03:48:14.000Z	147	FG A AD022	Stat	DREDGE I/B	58.829354	-0.367328	252.6000061	0.300000012	14	10.22000027
2022-04-24T04:02:39.000Z	148	FG A AD023	Stat	DREDGE O/B	58.829143	-0.366804	185.3000031	0.300000012	214	8.840000153
2022-04-24T05:06:36.000Z	149	FG A AD023	Stat	DREDGE I/B	58.82522	-0.367749	187.1999969	0.300000012	232	1.960000038
2022-04-24T05:26:30.000Z	150	FG A AD024	Stat	DREDGE O/B	58.825696	-0.367003	66.59999847	0.300000012	294	7.650000095
2022-04-24T06:17:53.000Z	151	FG A AD024	Stat	DREDGE I/B	58.826836	-0.36136	67.69999695	0.100000001	314	7.670000076
2022-04-24T06:26:57.000Z	152	FG A AD025	Stat	DREDGE O/B	58.826835	-0.361366	69.19999695	0.300000012	322	9.380000114
2022-04-24T07:22:50.000Z	153	FG A AD 025	Stat	DREDGE I/B	58.828034	-0.355795	68.90000153	0.200000003	315	6.329999924
2022-04-24T07:40:02.000Z	154	FG A AD 026	Stat	DREDGE O/B	58.827581	-0.356401	179.5	0.300000012	215	4.5
2022-04-24T08:40:36.000Z	155	FG A AD 026	Stat	DREDGE I/B	58.823354	-0.356281	180.1000061	0.100000001	209	7.539999962
2022-04-24T08:55:36.000Z	156	FG A AD 027	Stat	DREDGE O/B	58.823707	-0.356627	281.5	0.100000001	115	8.079999924

2022-04-24T10:09:44.000Z	157	FG A AD 027	Stat	DREDGE I/B	58.824791	-0.365988	282.3999939	0.100000001	124	5.889999866
2022-04-24T10:18:41.000Z	158	FG A AD 028	Stat	DREDGE O/B	58.82489	-0.365188	21.60000038	0.100000001	9	5.789999962
2022-04-24T11:25:03.000Z	159	FG A AD028	Stat	DREDGE I/B	58.829524	-0.361962	19.10000038	0.100000001	29	3.5
2022-04-24T11:43:09.000Z	160	FG A AD029	Stat	DREDGE O/B	58.82953	-0.36196	19.20000076	0.300000012	14	4.519999981
2022-04-24T12:48:19.000Z	161	FG A AD029	Stat	DREDGE I/B	58.833757	-0.359032	20.10000038	0.200000003	8	4.789999962
2022-04-24T15:11:29.000Z	162	FG B	Pass	COMMENCE MMO	59.041918	0.079758	47.90000153	7.699999809	NaN	5.670000076
2022-04-24T15:38:32.000Z	163	FG B	Surv	COMMENCE SOFT START	59.078377	0.15946	49	6.599999905	343	6.550000191
2022-04-24T15:58:45.000Z	164	FG B	Surv	COMMENCE SURVEY	59.111106	0.166807	0.699999988	6.300000191	25	6.420000076
2022-04-24T17:35:18.000Z	165	FG B CTD007	Stat	ON STATION	59.117352	0.16667	7.800000191	0.100000001	9	3.049999952
2022-04-24T17:39:43.000Z	166	FG B CTD007	Stat	CTD O/B	59.11736	0.166656	8.399999619	0.100000001	NaN	3.670000076
2022-04-24T17:54:36.000Z	167	FG B CTD 007	Stat	MAX WIRE OUT @115m	59.117361	0.166665	8.300000191	0	5	2.74000001
2022-04-24T18:07:38.000Z	168	FG B CTD007	Stat	CTD I/B	59.117348	0.166663	7.699999809	0.100000001	332	3.269999981
2022-04-24T18:35:40.000Z	169	FG B MC007	Stat	MEGA CORE O/B	59.117365	0.166665	7.400000095	0.100000001	17	3.450000048
2022-04-24T18:43:53.000Z	170	FG B MC007	Stat	MEGA CORE ON SEA BED	59.11736	0.16667	7.300000191	0.100000001	357	1.269999981
2022-04-24T18:45:58.000Z	171	FG B MC007	Stat	COMMENCE HAULING FROM SEA BED	59.117361	0.166663	8.199999809	0.200000003	36	1.529999971
2022-04-24T18:52:12.000Z	172	FG B MC007	Stat	MEGA CORE I/B	59.117353	0.166663	7.400000095	0.200000003	46	1.25999999
2022-04-24T19:56:57.000Z	173	FG B GC 001	Stat	COMMENCED DEPLOYMENT OF GRAVITY CORE	59.117359	0.166659	7.400000095	0.300000012	356	1.799999952
2022-04-24T20:48:29.000Z	174	FG B GC 001	Stat	GRAVITY CORE RECOVERED	59.117362	0.166663	7.599999905	0.100000001	13	2.50999999
2022-04-24T21:22:48.000Z	175	FG B AD 030	Stat	DREDGE O/B	59.117811	0.166714	359.7000122	0.100000001	347	1.470000029
2022-04-24T22:01:21.000Z	176	FG B AD 030	Stat	DREDGE I/B	59.120057	0.166662	0.400000006	0.100000001	21	3.319999933

2022-04-24T22:15:23.000Z	177	FG B AD 031	Stat	DREDGE O/B	59.120055	0.166666	0	0.100000001	22	5.429999828
2022-04-24T23:16:39.000Z	178	FG B AD031	Stat	DREDGE I/B	59.123977	0.166611	0.100000001	0.200000003	23	3.529999971
2022-04-24T23:31:04.000Z	179	FG B AD032	Stat	DREDGE O/B	59.123884	0.167013	37.09999847	0.100000001	316	5.239999771
2022-04-25T00:41:55.000Z	180	FG B AD032	Stat	DREDGE I/B	59.127959	0.173208	38.29999924	0.300000012	9	2.109999895
2022-04-25T00:58:23.000Z	181	FG B AD033	Stat	DREDGE O/B	59.127644	0.172155	261.7999878	0.400000006	313	0.829999983
2022-04-25T01:47:55.000Z	182	FG B AD033	Stat	DREDGE I/B	59.127251	0.166091	262.5	0	134	1.600000024
2022-04-25T01:56:33.000Z	183	FG B AD034	Stat	DREDGE O/B	59.127254	0.16609	262.3999939	0.300000012	14	1.460000038
2022-04-25T02:51:22.000Z	184	FG B AD034	Stat	DREDGE I/B	59.126817	0.15989	262.7000122	0.100000001	14	0.74000001
2022-04-25T03:06:29.000Z	185	FG B AD035	Stat	DREDGE O/B	59.126597	0.160522	184.6999969	0.100000001	295	0.930000007
2022-04-25T04:15:43.000Z	186	FG B AD035	Stat	DREDGE I/B	59.121932	0.159879	184.6000061	0.100000001	236	0.419999987
2022-04-25T04:32:29.000Z	187	FG B AD036	Stat	DREDGE O/B	59.122214	0.160603	100.1999969	0.300000012	307	1.210000038
2022-04-25T05:23:53.000Z	188	FG B AD036	Stat	DREDGE I/B	59.121744	0.166643	98.59999847	0.400000006	223	1.24000001
2022-04-25T05:32:53.000Z	189	FG B AD037	Stat	DREDGE O/B	59.121738	0.166637	98.30000305	0.300000012	238	0.889999986
2022-04-25T06:35:00.000Z	190	FG B AD037	Stat	DREDGE I/B	59.121196	0.173338	267.7000122	0.400000006	78	3.589999914
2022-04-25T06:56:02.000Z	191	FG B 038	Stat	DREDGE O/B	59.12129	0.171171	265.3999939	0.100000001	118	3.349999905
2022-04-25T07:49:25.000Z	192	FG B AD 038	Stat	DREDGE I/B	59.121065	0.164335	267	0.100000001	124	4.019999981
2022-04-25T07:57:28.000Z	193	FG B AD 039	Stat	DREDGE O/B	59.12106	0.164351	267.1000061	0.200000003	118	4.480000019
2022-04-25T08:42:42.000Z	195	FG B AD 039	Stat	DREDGE I/B	59.12093	0.15929	267.7999878	0.100000001	117	7.010000229
2022-04-25T09:14:16.000Z	194	FG B AD 040	Stat	DREDGE O/B	59.120797	0.160497	122.8000031	0.300000012	251	8.760000229
2022-04-25T10:10:32.000Z	196	FG B AD 040	Stat	DREDGE I/B	59.118994	0.165916	121.6999969	0.300000012	258	7.849999905

2022-04-25T10:19:29.000Z	197	FG B AD 041	Stat	DREDGE O/B	59.118992	0.165923	121.4000015	0.400000006	27	9.260000229
2022-04-25T11:11:57.000Z	198	FG B AD041	Stat	DREDGE I/B	59.117196	0.171343	123.5	0.400000006	259	7.679999828
2022-04-25T11:32:06.000Z	199	FG B AD042	Stat	DREDGE O/B	59.117398	0.170229	274.7999878	0.200000003	135	7.510000229
2022-04-25T12:56:40.000Z	200	FG B AD042	Stat	DREDGE I/B	59.118037	0.159265	275.1000061	0.200000003	11	9.239999771
2022-04-25T13:14:52.000Z	201	FG B AD043	Stat	DREDGE O/B	59.117806	0.160343	131.6000061	0.200000003	251	9.220000267
2022-04-25T14:24:39.000Z	202	FG B AD043	Stat	DREDGE I/B	59.114886	0.166957	131.1000061	0.200000003	254	8.640000343
2022-04-25T14:39:24.000Z	203	FG B AD044	Stat	DREDGE O/B	59.114883	0.16697	131.1000061	0.300000012	251	7.889999866
2022-04-25T15:21:57.000Z	204	FG B AD044	Stat	DREDGE I/B	59.113452	0.170108	133.6000061	0.600000024	245	7.03000021
2022-04-25T16:21:28.000Z	205	FG B AD045	Stat	DREDGE O/B	59.113998	0.169413	342	0.200000003	45	10.10999966
2022-04-25T17:30:00.000Z	206	FG B AD045	Stat	DREDGE I/B	59.118239	0.166514	342.8999939	0.300000012	41	9.529999733
2022-04-25T17:51:45.000Z	207	FG B AD046	Stat	DREDGE O/B	59.118236	0.166527	340.2999878	0.200000003	48	10.26000023
2022-04-25T18:59:37.000Z	208	FG B AD046	Stat	DREDGE I/B	59.122472	0.163611	342.6000061	0.200000003	43	9.210000038
2022-04-25T19:16:13.000Z	209	FG B AD 047	Stat	DREDGE O/B	59.122455	0.163601	340.7999878	0.300000012	38	10.98999977
2022-04-25T20:39:07.000Z	210	FG B AD 047	Stat	DREDGE I/B	59.127211	0.160264	339.2999878	0.200000003	3	7.070000172
2022-04-25T21:02:36.000Z	211	FG B AD 048	Stat	DREDGE O/B	59.126682	0.160965	135.3000031	0.600000024	225	9.989999771
2022-04-25T22:20:53.000Z	212	FG B AD 048	Stat	DREDGE I/B	59.123545	0.167244	126.9000015	0.5	239	11.02000046
2022-04-25T23:06:02.000Z	213	FG B AD 049	Stat	DREDGE O/B	59.11397	0.169542	7.699999809	0.100000001	351	8.420000076
2022-04-26T00:12:51.000Z	214	FG B AD049	Stat	DREDGE I/B	59.1175	0.170679	9.399999619	0.100000001	344	14.02999973
2022-04-26T00:22:39.000Z	215	FG B AD050	Stat	DREDGE O/B	59.117501	0.170694	8.899999619	0	353	12.09000015
2022-04-26T01:26:46.000Z	216	FG B AD050	Stat	DREDGE I/B	59.121023	0.171761	10.10000038	0.5	335	11.02999973

2022-04-26T03:59:41.000Z	217	FG F	Pass	COMENCE MMO	59.307399	0.452349	35.70000076	4.5	342	17.23999977
2022-04-26T04:50:39.000Z	218	FG B	Surv	COMENCE SURVEY	59.372875	0.508018	0.300000012	5.800000191	15	13.61999989
2022-04-26T06:56:13.000Z	219	FG F CTD 008	Stat	ON STN	59.382979	0.498357	14.39999962	0.200000003	353	12.38000011
2022-04-26T06:58:08.000Z	220	FG F CTD008	Stat	CTD O/B	59.382982	0.498368	13.19999981	0	359	11.90999985
2022-04-26T07:08:41.000Z	221	FG F CTD 008	Stat	MAX WIRE 120M	59.382956	0.49836	13	0.100000001	357	12.27000046
2022-04-26T07:27:02.000Z	222	FG F CTD 008	Stat	CTD RECOVERED	59.382984	0.498399	12.19999981	0.100000001	4	12.59000015
2022-04-26T07:50:02.000Z	223	FG F MC 008	Stat	MEGACORE DEPLOYED	59.38299	0.498309	24	0.300000012	346	13.11999989
2022-04-26T07:55:45.000Z	224	FG F MC 008	Stat	MAX WIRE 137M	59.382951	0.498277	25.70000076	0.600000024	348	13.71000004
2022-04-26T08:02:29.000Z	225	FG F MC 008	Stat	MEGACORE RECOVERED	59.38289	0.498273	18.89999962	0.100000001	356	13.01000023
2022-04-26T08:26:33.000Z	226	FG F GC 002	Stat	COMMENCED GRAVITY CORE DEPLOYMENT	59.38293	0.498278	22.60000038	0.200000003	356	14.17000008
2022-04-26T08:38:22.000Z	227	FG F GC 002	Stat	GRAVITY CORE DEPLOYED	59.38287	0.498251	20.89999962	0.300000012	357	10.42000008
2022-04-26T08:58:22.000Z	228	FG F GC 002	Stat	RECOVERED TO TRESTLE	59.382545	0.498053	17.29999924	0.200000003	355	11.42000008
2022-04-26T09:47:40.000Z	229	FG F AD 051	Stat	DREDGE O/B	59.385759	0.507974	20.70000076	0.200000003	358	12.30000019
2022-04-26T11:12:56.000Z	230	FG F AD051	Stat	DREDGE I/B	59.390791	0.508282	20.29999924	0.300000012	344	12.32999992
2022-04-26T12:27:24.000Z	231	FG F AD052	Stat	DREDGE O/B	59.380568	0.498263	26.79999924	0.400000006	348	13.76000023
2022-04-26T13:43:19.000Z	232	FG F AD052	Stat	DREDGE I/B	59.384584	0.502218	25.79999924	0.100000001	343	11.47000027
2022-04-26T13:52:29.000Z	233	FG F AD053	Stat	DREDGE O/B	59.384571	0.502197	24	0.800000012	353	11.28999996
2022-04-26T15:08:45.000Z	234	FG F AD053	Stat	DREDGE I/B	59.388595	0.506174	26.39999962	0.300000012	35	11.27000046
2022-04-26T15:18:55.000Z	235	FG F AD054	Stat	DREDGE O/B	59.388585	0.506152	28.79999924	0.400000006	346	11.80000019
2022-04-26T16:08:00.000Z	236	FG F AD054	Stat	DREDGE I/B	59.390814	0.508515	25.89999962	0.100000001	4	11.78999996

2022-04-26T16:30:24.000Z	238	FG F	DTShip	MODIFICATION TO WIRE LEAD	59.384055	0.500235	223.1000061	2.799999952	149	9.920000076
2022-04-26T16:40:47.000Z	237	FG F AD55	Stat	ON STATION	59.382922	0.498617	25.29999924	0.400000006	348	12.64999962
2022-04-26T18:19:01.000Z	239	FG F	DTShip	MODIFICATION TO WIRE LEAD COMPLETED	59.38292	0.4984	21.20000076	0.699999988	356	13.64000034
2022-04-26T18:24:55.000Z	240	FG F AD055	Stat	DREDGE O/B	59.382926	0.498409	20	0.200000003	359	11.39999962
2022-04-26T19:35:40.000Z	241	FG F AD 055	Stat	DREDGE I/B	59.386947	0.501474	21.39999962	0.200000003	351	11.28999996
2022-04-26T19:48:31.000Z	242	FG F AD 056	Stat	DREDGE O/B	59.386941	0.501463	21.79999924	0.300000012	346	11.92000008
2022-04-26T20:57:00.000Z	243	FG F AD 056	Stat	DREDGEI/B	59.390976	0.504354	20.10000038	0.5	1	10.80000019
2022-04-26T21:30:40.000Z	244	FG F AD 057	Stat	DREDGE O/B	59.386853	0.497729	18.89999962	0.100000001	353	10.77000046
2022-04-26T22:48:01.000Z	245	FG F AD 057	Stat	DREDGE I/B	59.391692	0.501448	18.39999962	0.100000001	347	7.929999828
2022-04-26T23:29:04.000Z	246	FG F AD058	Stat	DREDGE O/B	59.378002	0.499493	22.39999962	0.400000006	356	10.06000042
2022-04-27T00:19:26.000Z	247	FG F AD058	Stat	DREDGE I/B	59.38053	0.501502	23.10000038	0.100000001	348	7.420000076
2022-04-27T04:00:14.000Z	248	FG M	Pass	COMMENCE MMO	59.647047	-0.267571	301.7000122	7	39	8.699999809
2022-04-27T04:31:18.000Z	249	FG M	Surv	COMMENCE SOFT START	59.681091	-0.358497	19	6.699999809	358	7.309999943
2022-04-27T04:49:52.000Z	250	FG M	Surv	COMMENCE SURVEY	59.711125	-0.337156	13.19999981	5	343	8.569999695
2022-04-27T06:24:12.000Z	251	FG M CTD009	Stat	ON STATION	59.709774	-0.338849	34.70000076	0.200000003	311	4.730000019
2022-04-27T06:26:16.000Z	252	FG M CTD009	Stat	CTD O/B	59.709767	-0.338851	32.40000153	0.200000003	307	3.640000105
2022-04-27T06:33:15.000Z	253	FG M CTD009	Stat	MAX WIRE @ 113m	59.709769	-0.338855	32.59999847	0.100000001	307	4.420000076
2022-04-27T06:50:33.000Z	254	FG M CTD009	Stat	CTD I/B	59.709769	-0.338861	32.79999924	0.300000012	325	3.480000019
2022-04-27T07:11:13.000Z	255	FG M MC 009	Stat	MEGACORE O/B	59.709756	-0.338783	27.10000038	0.300000012	344	6.360000134
2022-04-27T07:16:29.000Z	256	FG M MC 009	Stat	MAX WIRE 133M	59.709753	-0.338783	25.39999962	0.100000001	34	6.420000076

2022-04-27T07:24:14.000Z	257	FG M MC 009	Stat	MEGACORE I/B	59.70975	-0.338791	26.39999962	0.100000001	338	7.480000019
2022-04-27T08:11:53.000Z	258	FG M AD 059	Stat	DREDGE O/B	59.717032	-0.342037	19.39999962	0.200000003	316	4.570000172
2022-04-27T09:31:50.000Z	259	FG M AD 059	Stat	DREDGE I/B	59.721763	-0.338624	19.5	0.100000001	291	4.25
2022-04-27T09:54:36.000Z	260	FG M AD 060	Stat	DREDGE O/B	59.721281	-0.332187	197.1000061	0.200000003	144	3.50999999
2022-04-27T11:07:00.000Z	261	FG M AD060	Stat	DREDGE I/B	59.716681	-0.335235	199.6999969	0	103	2.359999895
2022-04-27T11:38:30.000Z	262	FG M AD061	Stat	DREDGE O/B	59.716559	-0.327717	1.600000024	0.200000003	359	3.799999952
2022-04-27T13:05:01.000Z	263	FG M AD061	Stat	DREDGE I/B	59.721763	-0.327408	1.899999976	0.200000003	246	2.549999952
2022-04-27T16:25:58.000Z	264	FG N CTD010	Stat	ON STN	59.766812	-0.444549	13	0.100000001	238	5.440000057
2022-04-27T16:31:16.000Z	265	FG N CTD010	Stat	CTD O/B	59.766842	-0.444605	12.80000019	0.400000006	238	6.679999828
2022-04-27T16:56:49.000Z	266	FG N CTD010	Stat	CTD I/B	59.766846	-0.44461	12.5	0.200000003	243	7.670000076
2022-04-27T17:14:06.000Z	267	FG N MC010	Stat	MEGA CORE O/B	59.766862	-0.444615	12.30000019	0.100000001	233	6.849999905
2022-04-27T17:30:00.000Z	268	FG N MC010	Stat	MEGA CORE I/B	59.76686	-0.444618	12.19999981	0.600000024	242	8.079999924
2022-04-27T17:53:57.000Z	269	FG N GC003	Stat	GRAVITY CORE O/B	59.766863	-0.444617	12.10000038	0.200000003	269	8.180000305
2022-04-27T18:08:14.000Z	270	FG N GC003	Stat	GRAVITY CORE I/B	59.766862	-0.444626	12.80000019	0.200000003	261	8.100000381
2022-04-27T18:46:21.000Z	271	FG N AD062	Stat	DREDGE O/B	59.767108	-0.443825	84.40000153	0.200000003	21	5.25
2022-04-27T20:05:41.000Z	273	FG N AD 062	Stat	DREDGE I/B	59.767772	-0.434739	127.0999985	1.299999952	152	6.289999962
2022-04-27T20:14:38.000Z	272	FG N AD 063	Stat	DREDGE O/B	59.767278	-0.435301	179.1000061	0.200000003	11	6.139999866
2022-04-27T21:25:13.000Z	274	FG N AD 063	Stat	DREDGE I/B	59.762749	-0.435492	180.1000061	0.100000001	113	5.690000057
2022-04-27T21:28:30.000Z	275	FG N AD 064	Stat	DREDGE O/B	59.762749	-0.435488	180.3999939	0.200000003	106	6.090000153
2022-04-27T22:42:59.000Z	276	FG N AD 064	Stat	DREDGE I/B	59.757557	-0.43594	180.1999969	0.100000001	99	6.119999886

2022-04-27T22:55:25.000Z	277	FG N AD 065	Stat	DREDGE O/B	59.757694	-0.436515	247	0.200000003	16	6.570000172
2022-04-28T00:17:04.000Z	278	FG N AD065	Stat	DREDGE I/B	59.755491	-0.446898	247.3000031	0	35	4.989999771
2022-04-28T00:32:36.000Z	279	FG N AD066	Stat	DREDGE O/B	59.755927	-0.446378	351.2999878	0.100000001	24	6.349999905
2022-04-28T01:48:37.000Z	280	FG N AD066	Stat	DREDGE I/B	59.760993	-0.447887	351.2000122	0.100000001	245	5.880000114
2022-04-28T03:59:46.000Z	281	FG O	Pass	COMMENCE MMO	59.921045	-0.028158	58.70000076	7.5	21	2.880000114
2022-04-28T04:30:52.000Z	282	FG O	Surv	COMMENCE SOFT START	59.905321	-0.07493	352.7000122	5.699999809	276	6.139999866
2022-04-28T04:49:42.000Z	283	FG O	Surv	COMMENCE SURVEY	59.933949	-0.074916	352.7999878	5.5	277	8.170000076
2022-04-28T06:28:28.000Z	284	FG O CTD011	Stat	ON STATION	59.938368	-0.074141	238.6000061	0.5	1	7.130000114
2022-04-28T06:32:18.000Z	285	FG O CTD011	Stat	CTD O/B	59.938362	-0.074128	241.1000061	0.400000006	1	6.800000191
2022-04-28T06:40:51.000Z	286	FG O CTD011	Stat	MAX WIRE @ 129m	59.938361	-0.074126	241.6999969	0.200000003	4	6.340000153
2022-04-28T07:02:19.000Z	287	FG O CTD011	Stat	CTD I/B	59.938359	-0.074122	240.6999969	0.300000012	1	6.659999847
2022-04-28T07:19:38.000Z	288	FG O MC 011	Stat	MEGACORE DEPLOYED	59.938359	-0.074128	241.6999969	0	358	7.550000191
2022-04-28T07:29:13.000Z	289	FG O MC 011	Stat	MEGACORE RECOERED	59.938356	-0.074122	241.8000031	0.300000012	351	7.440000057
2022-04-28T08:14:10.000Z	290	FG O AD 067	Stat	DREDGE O/B	59.937628	-0.07493	166.1000061	0.100000001	78	7.650000095
2022-04-28T09:25:20.000Z	291	FG O AD 067	Stat	DREDGE I/B	59.933189	-0.072647	164.6999969	0.100000001	96	6.78000021
2022-04-28T09:36:49.000Z	292	FG O AD 068	Stat	DREDGE O/B	59.933368	-0.07259	358.3999939	0.100000001	251	5.78000021
2022-04-28T10:37:02.000Z	293	FG 0 AD 068	Stat	DREDGE I/B	59.937074	-0.073004	358.1000061	0.200000003	259	6.429999828
2022-04-28T10:44:29.000Z	294	FG 0 AD 069	Stat	DREDGE O/B	59.937075	-0.073004	357.8999939	0.100000001	258	5.699999809
2022-04-28T11:42:20.000Z	295	FG O AD069	Stat	DREDGE I/B	59.940773	-0.07341	358.2999878	0.200000003	247	5.650000095
2022-04-28T11:53:42.000Z	296	FG O AD070	Stat	DREDGE O/B	59.94052	-0.073933	287.5	0.300000012	318	5.179999828

2022-04-28T13:02:47.000Z	297	FG O AD070	Stat	DREDGE I/B	59.941972	-0.082372	288.2000122	0.100000001	326	4.059999943
2022-04-28T13:23:50.000Z	298	FG O AD071	Stat	DREDGE O/B	59.942608	-0.068138	358.7999878	0.100000001	253	3.869999886
2022-04-28T14:33:20.000Z	299	FG O AD071	Stat	DREDGE I/B	59.947201	-0.068305	359.2999878	0.200000003	238	5.679999828
2022-04-28T15:04:37.000Z	300	FG P	Pass	COMMENCE MMO	59.954771	-0.13957	276.7999878	9.399999619	343	9.720000267
2022-04-28T15:33:18.000Z	301	FG P	Surv	COMMENCE SOFT START	59.966397	-0.274578	274.8999939	7.199999809	342	6.789999962
2022-04-28T15:53:37.000Z	302	FG P	Surv	COMMENCE SURVEY	59.995453	-0.2917	357	5.800000191	327	2.809999943
2022-04-28T17:23:00.000Z	303	FG P CTD012	Stat	ON STATION	60.007337	-0.291633	2.200000048	0.100000001	22	4.630000114
2022-04-28T17:27:48.000Z	304	FG P CTD012	Stat	CTD O/B	60.007338	-0.291615	1.899999976	0.100000001	225	5.139999866
2022-04-28T17:40:50.000Z	305	FG P CTD 012	Stat	MAX WIRE @ 126m	60.007341	-0.291624	1.899999976	0.200000003	225	5.809999943
2022-04-28T17:56:25.000Z	306	FG P CTD012	Stat	CTD I/B	60.007342	-0.291625	1.700000048	0.100000001	201	3.99000001
2022-04-28T18:11:07.000Z	307	FG P MC012	Stat	MEGA CORE O/B	60.007348	-0.291618	1.600000024	0.300000012	209	3.529999971
2022-04-28T18:25:23.000Z	308	FG P MC012	Stat	MEGA CORE I/B	60.007348	-0.291612	2.5	0.400000006	22	4.019999981
2022-04-28T19:01:17.000Z	309	FG P GC004	Stat	GRAVITY CORE O/B	60.007341	-0.291621	1.600000024	0.100000001	235	4.28000021
2022-04-28T19:55:05.000Z	310	FG P AD 072	Stat	DREDGED O/B	60.007226	-0.291804	198.5	0.100000001	47	4.039999962
2022-04-28T21:18:56.000Z	311	FG P AD 072	Stat	DREDGE I/B	60.002196	-0.295724	88.59999847	0.100000001	141	2.970000029
2022-04-28T21:24:38.000Z	312	FG P AD 073	Stat	DREDGE O/B	60.002444	-0.294675	85	0.100000001	138	2.769999981
2022-04-28T22:34:49.000Z	313	FG P AD 073	Stat	DREDGE I/B	60.00297	-0.284877	84.5	0.100000001	107	2.039999962
2022-04-28T22:45:13.000Z	314	FG P AD 074	Stat	DREDGE O/B	60.003184	-0.285526	357.2999878	0.100000001	148	1.320000052
2022-04-29T00:03:20.000Z	315	FG P AD074	Stat	DREDGE I/B	60.008465	-0.285716	358.6000061	0.100000001	54	2.309999943
2022-04-29T00:13:47.000Z	316	FG P AD075	Stat	DREDGE O/B	60.008402	-0.286	330.6000061	0.100000001	73	3.00999999

2022-04-29T01:28:04.000Z	317	FG P AD075	Stat	DREDGE I/B	60.012805	-0.290882	330.7999878	0.200000003	71	6.739999771
2022-04-29T01:43:01.000Z	318	FG P AD076	Stat	DREDGE O/B	60.012369	-0.290803	200.6999969	0.100000001	215	5.380000114
2022-04-29T02:55:22.000Z	319	FG P AD076	Stat	DREDGE I/B	60.007878	-0.294392	201.5	0.100000001	194	4.019999981
2022-04-29T03:12:06.000Z	320	FG P	Stat	OFF STATION	60.00572	-0.297332	240	4.300000191	138	5.710000038
2022-04-29T10:09:14.000Z	321	FETLAR BASIN	Stat	ON STATION	60.505409	-0.940522	252.5	0	167	4
2022-04-29T10:12:25.000Z	322	FB CTD 013	Stat	CTD DEPLOYED	60.505405	-0.940515	253.5	0.100000001	147	2.519999981
2022-04-29T10:18:02.000Z	323	FB CTD 013	Stat	MAX WIRE OUT 103M	60.505401	-0.940517	253.6000061	0.100000001	182	2.690000057
2022-04-29T10:34:12.000Z	324	FB CTD013	Stat	CTD I/B	60.505397	-0.940517	253.1000061	0.100000001	187	1.50999999
2022-04-29T10:57:55.000Z	325	FB MC 013	Stat	MEGACORE DEPLOYED	60.505401	-0.940516	254	0.100000001	178	2.819999933
2022-04-29T11:06:34.000Z	326	FB MC 013	Stat	MAX WIRE 123M	60.505397	-0.940518	254.8999939	0	17	3.220000029
2022-04-29T11:14:01.000Z	327	SH FB MC013	Stat	MEGACORER I/B	60.5054	-0.940517	254.8000031	0	164	3.059999943
2022-04-29T11:48:54.000Z	328	SH FB GC005	Stat	GRAVITY CORER O/B	60.5054	-0.940515	255.3000031	0	153	1.659999967
2022-04-29T11:55:50.000Z	330	SH FB GC005	Stat	CORER I/B	60.505402	-0.940514	255	0.100000001	216	2.24000001
2022-04-29T12:02:56.000Z	329	SH FB GC005	Stat	GRAVITY CORER IN CRADLE	60.505401	-0.940517	255.1999969	0.100000001	192	1.220000029
2022-04-29T13:56:48.000Z	331	SH FB CTD014	Stat	CTD O/B	60.468389	-0.962549	260.7000122	0	24	2.130000114
2022-04-29T14:17:51.000Z	332	SH FB CTD014	Stat	CTD I/B	60.468397	-0.96254	259.2999878	0	253	2.230000019
2022-04-29T14:28:56.000Z	333	SH FB MC014	Stat	MEGACORER O/B	60.468397	-0.962545	258.7999878	0	248	2.109999895
2022-04-29T14:44:47.000Z	334	SH FB MC014	Stat	MEGACORER I/B	60.468394	-0.962546	259.1000061	0	272	3.230000019
2022-04-29T15:32:22.000Z	335	SH FB PC007	Stat	ON STATION	60.50478	-0.941139	255.3999939	0.100000001	267	2.970000029
2022-04-29T15:57:32.000Z	336	SH FB PC007	Stat	PISTON CORE O/B	60.504782	-0.941149	253.6999969	0.100000001	248	2.809999943

2022-04-29T17:06:29.000Z	337	SH FB PC007	Stat	PISTON CORE I/B	60.504773	-0.941156	255	0.100000001	269	2.890000105
2022-04-29T19:34:09.000Z	338	SH FB PC 008	Stat	PISTON CORE DEPLOYED	60.504937	-0.941549	179.8000031	0.100000001	353	3.730000019
2022-04-29T20:13:08.000Z	339	SH FB PC 008	Stat	PISTON CORE RECOERED TO TRESTLE	60.504932	-0.941554	179.8999939	0.100000001	2	4.539999962
2022-04-30T06:57:55.000Z	340	SH MB	Pass	COMMENCE MMO	60.493512	-1.716913	144.5	8.399999619	28	9.840000153
2022-04-30T07:30:51.000Z	342	SH MB	Surv	COMMENCED 'SOFT START'	60.434168	-1.628361	147.6999969	6.199999809	29	9.279999733
2022-04-30T07:50:50.000Z	343	SH MB	Surv	COMMENCED SURVEY	60.406656	-1.588631	150.8000031	5.800000191	22	8.699999809
2022-04-30T09:45:38.000Z	341	SH MB	Stat	ON STATION	60.395963	-1.558575	175.1000061	0.100000001	2	6.730000019
2022-04-30T09:49:41.000Z	344	SH MB CTD 015	Stat	CTD DEPLOYED	60.395964	-1.558588	173.5	0	8	5.889999866
2022-04-30T09:55:27.000Z	345	SH MB CTD 015	Stat	MAX WIRE 130M	60.395959	-1.558588	173.1000061	0	NaN	5.360000134
2022-04-30T10:12:42.000Z	346	SH MB CTD 015	Stat	CTD RECOVERED	60.395964	-1.558578	173.3999939	0.100000001	11	6.71999979
2022-04-30T10:31:26.000Z	347	SH MB MC 015	Stat	MEGACORE DEPLOYED	NaN	NaN	NaN	NaN	NaN	NaN
2022-04-30T10:39:11.000Z	348	SH MB MC 015	Stat	MAX WIRE 153M	60.395967	-1.558593	172.6000061	0.100000001	15	6.349999905
2022-04-30T10:46:29.000Z	349	SH MB MC 015	Stat	MEGACORE RECOVERED	60.395967	-1.558588	173.6000061	0.200000003	1	6.429999828
2022-04-30T11:55:59.000Z	350	SH MB PC009	Stat	PISTON CORER O/B	60.395966	-1.558588	173.3999939	0	11	6.71999979
2022-04-30T12:13:34.000Z	351	SH MB PC009	Stat	BOMB I/B	60.395965	-1.558583	173.1000061	0.100000001	4	5.670000076
2022-04-30T12:32:52.000Z	352	SH MB PC009	Stat	CORE I/B	60.395959	-1.558566	175.1000061	0.100000001	17	6.230000019
2022-04-30T13:17:11.000Z	353	SH MB MC016	Stat	MEGA CORER O/B	60.393083	-1.560379	169.6999969	0.100000001	9	5.809999943
2022-04-30T13:32:45.000Z	354	SH MB MC016	Stat	MEGACORE I/B	60.393084	-1.56038	170.3000031	0	1	6.699999809
2022-04-30T14:36:45.000Z	355	SH MB PC010	Stat	PISTON CORER O/B	60.393087	-1.560361	170.1000061	0.100000001	11	6.929999828
2022-04-30T15:16:30.000Z	356	SH MB PC010	Stat	PISTON CORE I/B	60.393085	-1.560367	169.6000061	0	343	7.739999771

2022-04-30T15:38:57.000Z	357	SH MB	Stat	OFF STATION PROCEEDING TO SCAPA FLOW	60.389456	-1.561781	250.3000031	5.400000095	286	6.570000172
2022-05-01T07:10:48.000Z	361	SF	Stat	ALL STOPPED, COMMENCED SOFT START	58.888836	-3.098054	147.3000031	0	349	9
2022-05-01T07:35:45.000Z	362	SF	Surv	COMMENCED SURVEY	58.887056	-3.094206	148.5	0.100000001	349	10.31999969
2022-05-01T08:12:28.000Z	363	SF	Surv	SURVEY COMPLETE	58.88609	-3.107725	228.5	5.699999809	293	7.769999981
2022-05-01T08:32:39.000Z	359	SF	Stat	ON STATION	58.891886	-3.102838	147.8000031	0	359	9.090000153
2022-05-01T08:35:25.000Z	358	SF MC 0017	Stat	MEGACORE DEPLOYED	58.891886	-3.102832	148.3000031	0	358	8.420000076
2022-05-01T08:43:06.000Z	360	SF MC 017	Stat	MEGACORE RECOVERED	58.891885	-3.102835	148.3999939	0.100000001	355	7.579999924
2022-05-01T08:59:37.000Z	364	SF GC 006	Stat	COMMENCED GC DEPLOYMENT	58.891887	-3.102842	148.1999969	0	359	7.179999828
2022-05-01T09:08:05.000Z	365	SF GC 006	Stat	GRAVITY CORE DEPLOYED	58.891886	-3.102842	148.3000031	0	4	6.71999979
2022-05-01T09:20:20.000Z	366	SF GC 006	Stat	RECOVERED TO TRESTLE	58.891886	-3.102838	147.8999939	0	9	7.090000153
2022-05-01T09:48:08.000Z	367	SF GC 007	Stat	COMMENCED DEPLOYING GRAVITY CORE	58.896701	-3.090237	154.6000061	0.100000001	356	7.449999809
2022-05-01T10:08:08.000Z	370	SF GC 007	Stat	RECOVERED	58.896688	-3.090254	152.3000031	0	349	6.559999943
2022-05-01T10:24:04.000Z	368	SH MC 018	Stat	MEGACORE DEPLOYED	58.896693	-3.090259	152.3999939	0.100000001	356	6.769999981
2022-05-01T10:32:00.000Z	369	SF GC 018	Stat	MEGACORE RECOVERED	58.896699	-3.090262	152.3000031	0.100000001	346	6.289999962
2022-05-05T06:28:07.000Z	371	NIS A CTD016	Stat	ON STATION	66.551739	-17.700299	57.70000076	0.300000012	342	4.260000229
2022-05-05T06:36:39.000Z	372	NIS A CTD 016	Stat	CTD O/B	66.55174	-17.700293	56.59999847	0.200000003	349	5.300000191
2022-05-05T06:52:00.000Z	373	NIS A CTD016	Stat	MAX WIRE @ 450m	66.551712	-17.700243	47.59999847	0.100000001	356	4.690000057
2022-05-05T07:15:49.000Z	374	NIS A CTD016	Stat	CTD I/B	66.551701	-17.70022	44.09999847	0.5	1	5.239999771
2022-05-05T07:39:14.000Z	375	NIS A MC018	Stat	MEGA CORE 0/B	66.551697	-17.700213	44.29999924	0.300000012	327	3.720000029
2022-05-05T08:14:34.000Z	377	NIS A MC 018	Stat	MEGACORE I/B	66.551721	-17.700271	53	0.300000012	30	2.25999999

2022-05-05T08:30:19.000Z	376	NIS A PC 011	Stat	COMMENCED PISTON CORE DEPLOYMENT	66.551725	-17.700249	52.79999924	0.5	309	3.019999981
2022-05-05T09:01:00.000Z	378	NIS A PC 011	Stat	PISTON CORE DEPLOYED	66.551726	-17.700265	53	0.200000003	318	1.710000038
2022-05-05T10:00:23.000Z	379	NIS A PC 011	Stat	PISTON CORE RECOVERED TO TRESTLE	66.551719	-17.700271	52.29999924	0.100000001	351	3.190000057
2022-05-05T12:56:55.000Z	380	NIS A PC012	Stat	TRESTLE LOWERED	66.551717	-17.700282	52.90000153	0.100000001	12	1.340000033
2022-05-05T13:24:52.000Z	381	NIS A PC012	Stat	PISTON CORE DEPLOYED	66.551721	-17.700281	53.59999847	0.400000006	84	1.090000033
2022-05-05T14:35:08.000Z	382	NIS A PC012	Stat	CORE I/B	66.551765	-17.700333	52.79999924	0.400000006	67	3.289999962
2022-05-05T16:26:20.000Z	383	NIS B CTD017	Stat	ON STATION	66.609813	-18.218983	67.5	0.200000003	8	6.590000153
2022-05-05T16:31:33.000Z	384	NIS B CTD017	Stat	CTD O/B	66.609821	-18.21896	66.90000153	0.200000003	9	7.130000114
2022-05-05T16:37:28.000Z	385	NIS B CTD017	Stat	MAX WIRE @ 87m	66.609824	-18.218952	67.59999847	0.300000012	2	7.690000057
2022-05-05T16:53:07.000Z	386	NIS B CTD017	Stat	CTD I/B	66.609826	-18.218956	66.5	0.5	358	10.13000011
2022-05-05T19:24:57.000Z	387	NIS B AD 077	Stat	DREDGE O/B	66.605959	-18.24178	51.5	0.400000006	15	11.93999958
2022-05-05T20:14:48.000Z	389	NIS B AD 077	Stat	DREDGE I/B	66.607393	-18.237415	50.79999924	0.200000003	13	11.01000023
2022-05-05T20:28:22.000Z	388	NIS B AD 078	Stat	DREDGE O/B	66.607385	-18.237444	49.90000153	0.400000006	21	13.28999996
2022-05-05T22:39:59.000Z	390	NIS B AD 078	Stat	DREDGE I/B	66.612359	-18.223028	49.5	0.100000001	349	13.32999992
2022-05-05T23:08:51.000Z	391	NIS B AD 079	Stat	DREDGE O/B	66.6065	-18.24277	50	0.200000003	34	13.14000034
2022-05-05T23:57:34.000Z	392	NIS B AD 079	Stat	DREDGE I/B	66.607964	-18.238424	47.20000076	0.300000012	331	16.02000046
2022-05-06T08:03:47.000Z	394	NIS C / NIS D	Surv	SURVEY COMPLETE	66.519449	-18.206242	336.5	6.300000191	323	12.35999966
2022-05-06T08:25:15.000Z	393	NIS C CTD 018	Stat	CTD DEPLOYED	66.527448	-18.198916	302.7999878	0.699999988	336	12.80000019
2022-05-06T08:32:07.000Z	395	NIS C CTD 018	Stat	MAX WIRE 75M	66.527417	-18.198917	307.1000061	0.699999988	341	11.35000038
2022-05-06T08:50:45.000Z	396	NIS C CTD	Stat	CTD RECOVERED	66.527442	-18.198892	305.2999878	0.200000003	334	10.47999954

2022-05-06T09:11:30.000Z	397	NIS C MC 019	Stat	MEGACORE DEPLOYED	66.527444	-18.198889	305.1000061	0.300000012	337	9.010000229
2022-05-06T09:27:37.000Z	399	NIS C C 019	Stat	MEGACORE RECOVERED	66.52744	-18.198899	305	0.200000003	336	10.22999954
2022-05-06T09:36:47.000Z	398	NIS C MC 020	Stat	MEGACORE DEPLOYED	66.527359	-18.19864	305	0.200000003	35	11.17000008
2022-05-06T09:47:41.000Z	400	NIS C MC 020	Stat	MEGACORE RECOVERED	66.52736	-18.198614	304.1000061	0.600000024	344	10.17000008
2022-05-06T10:32:45.000Z	401	NIS C GC 008	Stat	GRAVITY CORE DEPLOYED	66.527162	-18.197924	304.3999939	0.200000003	326	9.18999958
2022-05-06T10:49:47.000Z	402	NIS C GC 008	Stat	GRAVITY CORE RECOVERED TO TRESTLE	66.527155	-18.197926	305.7999878	0.100000001	337	9.529999733
2022-05-06T11:19:40.000Z	403	NIS C AD 080	Stat	DREDGE O/B	66.527169	-18.197932	305	0.200000003	323	9.399999619
2022-05-06T11:40:42.000Z	404	NIS C AD 080	Stat	DREDGE I/B	66.5277	-18.19976	304	0.100000001	33	9.390000343
2022-05-06T11:41:10.000Z	405	NIS C AD 081	Stat	DREDGE O/B	66.527695	-18.199757	303.6000061	0.400000006	333	9.460000038
2022-05-06T12:24:40.000Z	406	NIS C AD081	Stat	DREDGE I/B	66.529012	-18.204296	305.2999878	0.200000003	326	9.68999958
2022-05-06T12:34:14.000Z	407	NIS C AD082	Stat	DREDGE O/B	66.529	-18.204318	304.2999878	0.100000001	331	9.340000153
2022-05-06T13:25:37.000Z	408	NIS C AD082	Stat	DREDGE I/B	66.530581	-18.209801	304.5	0.5	323	9.880000114
2022-05-06T13:32:22.000Z	409	NIS C AD083	Stat	DREDGE O/B	66.530592	-18.209748	306.2000122	0.200000003	311	8.75
2022-05-06T14:36:21.000Z	410	NIS C AD083	Stat	DREDGE I/B	66.532745	-18.217295	306.3999939	0.5	302	7.550000191
2022-05-06T15:08:08.000Z	411	NIS C AD084	Stat	DREDGE O/B	66.524515	-18.195577	302.8999939	0.100000001	313	10.05000019
2022-05-06T16:18:24.000Z	412	NIS C AD084	Stat	DREDGE I/B	66.526997	-18.204921	303.8999939	0.100000001	305	5.840000153
2022-05-06T16:22:56.000Z	413	NIS C AD085	Stat	DREDGE O/B	66.527002	-18.204912	303.5	0.100000001	305	6
2022-05-06T17:08:58.000Z	414	NIS C AD085	Stat	DREDGE I/B	66.52825	-18.209599	304.2999878	0.100000001	311	7.980000019
2022-05-06T17:14:43.000Z	415	NIS C AD086	Stat	DREDGE O/B	66.528254	-18.209591	303.2999878	0	304	6.329999924
2022-05-06T17:59:22.000Z	416	NIS C AD086	Stat	DREDGE I/B	66.529515	-18.214243	303.6000061	0.300000012	30	6.480000019

2022-05-06T18:35:41.000Z	417	NIS D CTDO18	Stat	ON STATION	66.515753	-18.19452	250.3000031	0.200000003	336	8.31000042
2022-05-06T18:40:39.000Z	418	NIS D CTD018	Stat	CTD O/B	66.515757	-18.194519	249.3000031	0.100000001	331	9.100000381
2022-05-06T18:50:50.000Z	419	NIS D CTD018	Stat	MAX WIRE @ 79m	66.515757	-18.194523	249.3000031	0.100000001	323	7.46999979
2022-05-06T19:04:42.000Z	420	NIS D CTD018	Stat	CTD I/B	66.515758	-18.194512	248.1999969	0.100000001	337	7.079999924
2022-05-06T19:22:31.000Z	421	NIS D MC021	Stat	MEGA CORE O/B	66.515759	-18.194513	248.5	0.100000001	358	7.159999847
2022-05-06T19:35:43.000Z	422	NIS D MC021	Stat	MEGA CORE I/B	66.515758	-18.194507	248.5	0.100000001	19	6.099999905
2022-05-06T20:07:35.000Z	423	NIS D AD 087	Stat	DREDGE O/B	66.514764	-18.187152	245	0.200000003	1	6.900000095
2022-05-06T21:04:14.000Z	429	NIS D AD 087	Stat	DREDGE I/B	66.51349	-18.19435	246.1000061	0.100000001	2	12.51000023
2022-05-06T21:12:57.000Z	424	NIS D AD 088	Stat	DREDGE O/B	66.513494	-18.194322	245.8999939	0.200000003	359	11.57999992
2022-05-06T22:06:41.000Z	425	NIS D AD 088	Stat	DREDGE I/B	66.512192	-18.201751	245.1999969	0.100000001	354	15.15999985
2022-05-06T22:23:37.000Z	426	NIS D AD 089	Stat	DREDGE O/B	66.512522	-18.18567	243.5	0.100000001	355	15.27000046
2022-05-06T23:26:51.000Z	427	NIS D AD 089	Stat	DREDGE I/B	66.510911	-18.19359	242.6999969	0.100000001	354	17.64999962
2022-05-06T23:34:13.000Z	428	NIS D AD 090	Stat	DREDGE O/B	66.510911	-18.193574	242.8999939	0.200000003	355	15.72999954
2022-05-07T00:39:04.000Z	430	NIS D AD090	Stat	DREDGE I/B	66.509269	-18.201589	243.1999969	0.100000001	5	13.35999966
2022-05-07T01:03:23.000Z	431	NIS D AD091	Stat	DREDGE O/B	66.509559	-18.183348	240	0.100000001	9	13.47999954
2022-05-07T02:07:19.000Z	432	NIS D AD091	Stat	DREDGE I/B	66.507734	-18.191066	238.8000031	0	355	16.87000084
2022-05-07T02:18:36.000Z	433	NIS D AD092	Stat	DREDGE O/B	66.507723	-18.191049	239.6000061	0.200000003	349	14.47000027
2022-05-07T03:21:58.000Z	434	NIS D AD092	Stat	DREDGE I/B	66.505875	-18.198739	242.3000031	0.100000001	356	12.09000015
2022-05-07T07:26:25.000Z	435	NIS E CTD020	Stat	ON STATION	66.464149	-18.210801	245.3000031	0.100000001	353	15.68999958
2022-05-07T07:28:13.000Z	436	NIS E CTD020	Stat	CTD O/B	66.464134	-18.2108	245.5	0.200000003	346	15.78999996

2022-05-07T07:38:11.000Z	437	NIS E CTD020	Stat	MAX WIRE @ 90m	66.464144	-18.210712	243.8999939	0.300000012	348	12.36999989
2022-05-07T07:49:54.000Z	438	NIS E CTD020	Stat	CTD I/B	66.46415	-18.210804	244.1000061	0.100000001	348	14.92000008
2022-05-07T08:06:30.000Z	439	NIS E MC 022	Stat	MEGACORE DEPLOYED	66.464151	-18.210784	243.6000061	0.200000003	352	13.39999962
2022-05-07T08:17:01.000Z	440	NIS E C 022	Stat	MEGACORE RECOVERED	66.464152	-18.210782	243.1999969	0.100000001	347	14.11999989
2022-05-07T08:36:07.000Z	441	NIS E GC 009	Stat	COMMENCED DEPLOYING GRAVITY CORE	66.464157	-18.210783	244.1999969	0.200000003	353	13.97000027
2022-05-07T08:41:27.000Z	442	NIS E GC 009	Stat	GRAVITY CORE DEPLOYED	66.464145	-18.21075	244.3000031	0.300000012	346	14.60999966
2022-05-07T08:51:56.000Z	443	GRAVITY CORE RECOVERED TO TRESTLE	Stat	NIS E GC 009	66.464154	-18.210779	244.5	0.200000003	345	13.35000038
2022-05-07T08:55:16.000Z	444	NIS E GC 009	Stat	GRAVITY CORE ON DECK	66.464147	-18.210766	244.8999939	0.100000001	34	15.27999973
2022-05-07T10:19:00.000Z	445	NIS E AD 099	Stat	DREDGE O/B	66.463991	-18.210608	241.8000031	0.100000001	356	13.14000034
2022-05-07T11:26:19.000Z	446	NIS E AD 099	Stat	DREDGE I/B	66.462218	-18.219915	240.1999969	0	35	9.739999771
2022-05-07T11:32:35.000Z	447	NIS E AD 100	Stat	DREDGE O/B	66.462219	-18.219933	240.3999939	0.100000001	348	8.75
2022-05-07T12:41:21.000Z	448	NIS E AD100	Stat	DREDGE I/B	66.460411	-18.229228	240.5	0.100000001	2	8.069999695
2022-05-07T13:05:57.000Z	449	NIS E AD101	Stat	DREDGE O/B	66.463285	-18.211324	245.6999969	0.200000003	357	8.159999847
2022-05-07T14:07:19.000Z	450	NIS E AD101	Stat	DREDGE I/B	66.461778	-18.219416	244.6000061	0.100000001	339	5.389999866
2022-05-07T14:17:16.000Z	451	NIS E AD102	Stat	DREDGE O/B	66.461772	-18.219423	244.8999939	0.100000001	341	5.710000038
2022-05-07T15:24:12.000Z	452	NIS E AD102	Stat	DREDGE I/B	66.460127	-18.228659	245.5	0.100000001	33	4.46999979
2022-05-07T19:11:19.000Z	453	NIS H CTD021	Stat	ON STATION	66.236223	-18.169784	141.6000061	0.300000012	345	6.829999924
2022-05-07T19:13:40.000Z	454	NIS H CTD021	Stat	CTD O/B	66.236183	-18.169878	130.6000061	0.200000003	359	6.590000153
2022-05-07T19:25:31.000Z	455	NIS H CTD021	Stat	MAX WIRE 124m	66.236193	-18.169862	131.8999939	0	353	7.380000114

2022-05-07T19:42:40.000Z	456	NIS H CTD021	Stat	CTD I/B	66.236186	-18.169864	133.3000031	0.200000003	354	7.380000114
2022-05-07T19:55:49.000Z	457	NIS H MC022	Stat	MEGA CORE O/B	66.236188	-18.16986	132.5	0.100000001	NaN	7.920000076
2022-05-07T20:05:00.000Z	458	NIS H MC O22	Stat	MEGACORE I/B	66.236191	-18.169853	131.6999969	0.100000001	355	7.650000095
2022-05-07T21:49:51.000Z	459	NIS H PC 012	Stat	COMMENCED DEPLOYING PISGON CORE	66.236189	-18.169874	131.1999969	0.100000001	1	4.619999886
2022-05-07T22:18:39.000Z	460	NIS H PC 012	Stat	PISTON CORE DEPLOYED	66.236195	-18.169859	133	0	1	4.619999886
2022-05-07T23:17:38.000Z	461	NIS H PC 012	Stat	PISTON CORE RECOVERED TO DECK	66.236193	-18.169857	131.5	0	32	3.369999886
2022-05-08T00:37:41.000Z	462	NIS H AD103	Stat	DREDGE O/B	66.236202	-18.169841	136.6999969	0	34	4.789999962
2022-05-08T01:36:46.000Z	463	NIS H AD103	Stat	DREDGE I/B	66.233814	-18.164546	137.1000061	0.100000001	38	4.920000076
2022-05-08T01:57:31.000Z	464	NIS H AD104	Stat	DREDGE O/B	66.235685	-18.158152	311.2999878	0.200000003	221	5.159999847
2022-05-08T03:09:40.000Z	465	NIS H AD104	Stat	DREDGE I/B	66.238471	-18.166006	311	0.100000001	216	8.270000458
2022-05-08T07:19:18.000Z	466	NIS N CTD023	Stat	ON STATION	66.213898	-18.527711	163.5	0.100000001	27	3.710000038
2022-05-08T07:20:45.000Z	467	NIS N CTD023	Stat	CTD O/B	66.213901	-18.527705	164.1000061	0	27	4.019999981
2022-05-08T07:33:13.000Z	468	NIS N CTD023	Stat	MAX WIRE @ 253m	66.213896	-18.527702	163.8999939	0.100000001	356	5.239999771
2022-05-08T07:54:12.000Z	469	NIS N CTD023	Stat	CTD I/B	66.213897	-18.527701	164.1000061	0.200000003	359	6.840000153
2022-05-08T08:07:49.000Z	470	NIS N MC 023	Stat	MEGACORE DEPLOYED	66.213895	-18.527709	163.8000031	0.200000003	344	5.090000153
2022-05-08T08:30:43.000Z	471	NIS N MC 023	Stat	MEGACORE RECOVERED	66.213895	-18.527702	163.5	0	353	5.190000057
2022-05-08T09:12:07.000Z	472	NIS N PC 013	Stat	COMMENCED PISTON CORE DEPLOYMENT	66.213899	-18.527702	163.8999939	0.100000001	349	5.320000172
2022-05-08T09:43:14.000Z	473	NIS N PC 013	Stat	PISTON CORE DEPLOYED	66.213897	-18.527709	164.3999939	0.200000003	327	4.840000153
2022-05-08T10:29:40.000Z	474	NIS N PC 013	Stat	PISTON CORE RECOVERED	66.213897	-18.527697	163.8999939	0.200000003	333	5.860000134
2022-05-08T10:44:50.000Z	475	NIS N PC 013	Stat	RECOVERED TO DECK	66.213897	-18.527708	163.8000031	0.100000001	327	5.329999924

2022-05-08T15:32:43.000Z	476	NIS I CTD024	Stat	CTD O/B	66.500762	-19.505502	80.30000305	0	347	11.14000034
2022-05-08T16:10:23.000Z	477	NIS I CTD24	Stat	CTD I/B	66.50076	-19.505546	80.19999695	0	348	10.90999985
2022-05-08T16:24:36.000Z	478	NIS I MC25	Stat	MEGA CORE O/B	66.50076	-19.505538	79.59999847	0	355	13.38000011
2022-05-08T16:48:16.000Z	479	NIS I MC25	Stat	MEGA CORE I/B	66.500758	-19.50554	79.59999847	0.100000001	352	13.43000031
2022-05-08T17:57:54.000Z	480	NIS I PC014	Stat	PC O/B	66.500763	-19.50553	79.59999847	0.200000003	346	12.71000004
2022-05-08T18:58:00.000Z	481	NIS I PC014	Stat	PISTON CORE RECOVERED	66.500766	-19.50553	79.90000153	0.100000001	346	13.06999969
2022-05-08T19:11:38.000Z	482	NIS I PC024	Stat	PISTON CORE RECOVERED TO DECK	66.500759	-19.505537	80.09999847	0.100000001	349	14.64999962

Appendix 2. Arctica dredge full data

Full ID	Date	Time in	Lat in	Lon in	Depth (m)	Time out	Lat out	Lon out	Depth	Sediment type	Total live Arctica	Live Arctica kept	Articulated dead shells	Dead single valves	Umbone only
		(UTC)	deg. Dec minutes	deg. Dec minutes	(m)	(utc)	deg. Dec minutes	deg. Dec minutes	(m)						
DY150FGTAD001	21/04/2022	09:05:32	57.55.73646	1.37.74504	96.8	09:54	57.55.81572	1 37.54194	97.7	soft mud	0	0	0	5	4
DY150FGTAD002	21/04/2022	10:18:45	57.55.78512	1.36.88926	97.1	12:12:49	57.55.5972	1.36.44436	97.5	softy mud	0	0	0	6	20
DY150FGJAD003	21/04/2022	23:19	58.7.57128	0.15.68052	146.6	00:08:55	58.7.50844	0.15.72606	147	v soft mud	0	0	0	0	0
DY150FGJAD004	22/04/2022	00:25:11	58.7.40826	0.15.72510	146.7	01:04:00	58.7.30200	0.15.75906	147	soft mud	0	0	0	2	0
DY150FGIAD005	22/04/2022	10:23	58.22.20540	0.31.68648	151.7	10:59	58.22.33788	0.31.69074	151.2	v soft mud	0	0	0	14	0
DY150FGIAD006	22/04/2022	11:17:40	58.22.33776	0.31.69038	151.3	11:10	58.22.47180	0.31.69482	150.9	v soft mud	0	0	0	0	0
DY150FGIAD007	22/04/2022	12:13:03	58.22.47990	0.31.71780	155.3	13:10:01	58.22.51470	0.31.41732	150.8	v soft mud	0	0	0	7	0
DY150FGIAD008	22/04/2022	13:32:05	58.22.51386	0.31.41624	151	14:21:21	58.22.55592	0.31.17282	156	v soft mud	0	0	1	9	1
DY150FGGAD009	22/04/2022	21:50:56	58.30.65862	0.24.66570	144	22:29:54	58.30.79296	0.24.68976	144	v soft mud	0	0	3	22	5
DY150FGGAD010	22/04/2022	11.15	58.30.79215	0.25.6876	144.8	12:00:00	58.30.92688	0.24.71118	144.4	v soft mud	0	0	1	22	4
DY150FGGAD011	23/04/2022	00:47	58.30.98808	0.24.75828	144.4	01:33	58.30.97716	0.25.01544	145	v soft mud	0	0	2	4	4
DY150FGGAD012	23/04/2022	1.46	58.30.97716	0.25.01548	144.3	02:30	58.30.95106	0.25.28466	144.4	v soft mud	0	0	2	18	3
DY150FGAAD013	23/04/2022	16:18:55	58.50.30490	0.21.38418	238	17:03:24	58.50.27148	0.21.63570	137	sandy	0	0	0	0	0
DY150FGAAD014	23/04/2022	17:08:40	58.50.30490	0.21.38418	130	17:48:49	58.50.23512	0.21.88584	130	soft mud	0	0	0	1	0
DY150FGAAD015	23/04/2022	18:24:22	58.50.21592	0.21.86298	130	19:06:24	58.50.13972	0.21.64980	130	soft mud	0	0	0	0	1
DY150FGAAD016	23/04/2022	19:20:40	58.50.13942	0.21.64986	130	20:00:12	58.50.06232	0.21.43668	129	soft mud	0	0	0	1	0
DY150FGAAD017	23/04/2022	20:15:26	58.50.04528	0.21.40482	129	21:21:41	58.50.04948	0.21.92490	130	soft mud	0	0	0	2	0
DY150FGAAD018	23/04/2022	21:48:38	58.50.03616	0.22.05984	130	22:48:12	58.49.79994	0.22.09230	125	soft mud	0	0	2	3	1
DY150FGAAD019	23/04/2022	11:14.0	58.49.81638	0.22.06295	124.3	12:20	58.49.86018	0.21.55014	126	soft mud	0	0	0	0	1
DY150FGAAD020	24/04/2022	12:40	58.49.86000	0.21.56020	127	01:20	58.49.87758	0.21.30188	126.6	soft mud	0	0	0	1	0
DY150FGAAD021	24/04/2022	01:50	58.49.87115	0.21.36180	126	03:04	58.49.79100	0.21.85812	126	soft mud	0	0	1	11	2
DY150FGAAD022	24/04/2022	03:17	58.49.79088	0.21.82880	126.3	03:44	58.49.76172	0.22.03932	126.8	empty	0	0	0	0	0
DY150FGAAD023	24/04/2022	04:04	58.49.54876	0.22.00830	127	05:01	58.49.51350	0.22.06542	128.8	soft mud	0	0	0	5	4
DY150FGAAD024	24/04/2022	05:29	58.49.54170	0.22.02120	132.7	06:12	50.49.61024	0.21.68179	132.11	soft mud	0	0	0	3	1
DY150FGAAD025	24/04/2022	06:28	58.49.61016	0.21.68124	128.2	07:13	58.49.68258	0.21.34644	127.5	soft mud	0	0	0	4	0
DY150FGAAD026	24/04/2022	07:40	58.49.65486	0.21.38430	127.5	08:33	58.49.40112	0.21.37812	125.8	soft mud	0	0	0	5	0
DY150FGAAD027	24/04/2022	08:58	58.49.42290	0.21.39l744	126.1	10:01	58.49.48740	0.21.96090	127.7	soft mud	0	0	2	2	0
DY150FGAAD028	24/04/2022	10:17	58.49.49328	0.21.91140	127.5	11:24:16	58.49.77186	0.21.71742	126	soft mud	0	0	2	1	1
DY150FGAAD029	24/04/2022	11:43	58.49.77180	0.21.71760	126	12:45:07	58.50.02542	0.21.54264	129	soft mud	0	0	0	0	0
DY150FGBAD030	24/04/2022	21:22	59.07.06872	0.10.00302	134	21:59:42	59.07.20336	0.09.99996	128	soft mud	10	10	0	15	14
DY150FGBAD031	24/04/2022	22:26:31	59.07.23312	0.09.99990	128	23:11:07	59.7.43886	0.9.99570	128	no sediment	13	9	9	33	16
DY150FGBAD032	25/04/2022	11:34	59.7.43368	0.10.01546	130	12:39	59.07.67772	0.10.39206	127.6	no sediment	2	1	3	16	11
DY150FGBAD033	25/04/2022	12:56	59.2.65888	0.10.32900	127.8	01:44	59,07.63458	0.09.96510	124.2	no sediment	5	5	1	16	13
DY150FGBAD034	25/04/2022	02:00	59.07.63470	0.09.96516	124.3	02:45	59.07.89842	0.09.59190	126.7	no sediment	2	1	1	14	5
DY150FGBAD035	25/04/2022	03:00	59.07.59570	0.096312	126.6	04:10	59.7.31604	0.9.59202	129	soft mud	36	19	13	39	49
DY150FGBAD036	25/04/2022	04:32	59.07.33314	0.09.63612	128.4	05:18	59.07.30494	0.9.99822	127.3	soft mud	16	7	0	16	20
DY150FGBAD037	25/04/2022	05:32	59.07.3043	0.09.9982	127.7	06:16	59.7.2749	0.10.35018	127.8	soft mud	9	7	3	27	27

DY150FGBAD038	25/04/2022	06:31	59.7.28670	0.10.37428	132.3	06:56	59.7.26906	0.10.02312	128.1	soft mud	16	3	6	19	25
DY150FGBAD039	25/04/2022	07:56	59.7.26372	0.9.86100	126.7	08:33	59.7.25626	0.9.55680	129.4	soft mud	12	1	6	18	16
DY150FGBAD040	25/04/2022	09:13	59.7.24794	0.9.62976	129.1	10:01	59.7.13988	0.9.95466	129.6	soft mud	19	3	4	29	45
DY150FGBAD041	25/04/2022	10:21	59.07.13974	0.09.95550	129.4	11:10:59	59.07.03152	0.10.28106	130	soft mud	30	5	4	40	11
DY150FGBAD042	25/04/2022	11:31	59.07.04412	0.10.21398	130	12:54:46	59.07.08036	0.09.55392	129	soft mud	44	6	7	74	38
DY150FGBAD043	25/04/2022	13:14	59.07.06854	0.09.62124	133	14:23:00	59.06.89298	0.10.01772	130	soft mud	34	6	3	49	53
DY150FGBAD044	25/04/2022	14:40:46	59.06.89328	0.10.01826	130	15:22:05	59.6.80700	0.10.20594	131	soft mud	10	0	0	11	12
DY150FGBAD045	25/04/2022	16:17:50	59.06.83988	0.10.16370	131	17:31:38	59.07.09392	0.09.99186	130	soft mud	22	2	4	41	16
DY150FGBAD046	25/04/2022	17:49:32	59.07.09446	0.09.99120	130	18:59:05	59.07.34808	0.9.81654	132	no sediment	24	1	2	49	20
DY150FGBAD047	25/04/2022	19:16:20	59.7.34730	0.9.81606	131	20:35:43	59.7.63248	0.9.61518	134	no sediment	8	3	4	40	
DY150FGBAD048	25/04/2022	21:04:12	59.7.60092	0.9.65790	131	22:21:16	59.07.41258	0.10.03452	127	no sediment	1	1	0	7	6
DY150FGBAD049	25/04/2022	23:05	59.6.683808	0.10.17204	131	00:07	59.07.04964	0.10.23948	129.5	soft mud	25	3	7	32	34
DY150FGBAD050	26/04/2022	00:25	59.07.04934	0.10.24110	129.6	01:23	59.10.26114	0.10.30680	127	soft sediment	35	5	7	44	16
DY150FGFAD051	26/04/2022	09:47:40	59.23.14554	0.30.47844	129	11:10:30	59.23.44776	0.30.49680	134	soft mud	3	3	3	39	9
DY150FGFAD052	26/04/2022	12:29:11	59.22.83402	0.29.89502	132	13:43:19	59.23075	0.30.13308	132	no sediment	17	8	1	22	5
DY150FGFAD053	26/04/2022	13:52:29	59.23.07426	0.30.13182	130	15:08:45	59.23.31570	0.30.37044	133	no sediment	18	0	1	8	4
DY150FGFAD054	26/04/2022	15:18:55	59.23.31510	0.30.36912	133	16:06:32	59.23.44866	0.30.50970	133	no sediment	5	0	0	14	1
DY150FGFAD055	26/04/2022	18:26:10	59.22.97622	0.29.90490	133	19:34:13	59.23.21622	0.30.08894	133	no sediment	3	0	3	5	0
DY150FGFAD056	26/04/2022	19:50:42	59.23.21598	0.30.08844	133	20:54:19	59.23.45880	0.30.26214	134	soft mud*	8	0	1	41	11
DY150FGFAD057	26/04/2022	21:31:29	59.23.21034	0.29.86488	137	22:46:28	59.23.50200	0.30.08706	133	soft mud	5	0	1	60	19
DY150FGFAD058	26/04/2022	11:30	59.22.68060	0.29.97042	130.7	00:19	59.22.83108	0.30.88540	131.8	gravel/mud	43	5	11	42	25
DY150FGMAD059	27/04/2022	08:12:00	59.43.02192	0.20.52204	128	09:20	59.43.30596	0.20.32198	131	sandy	1	1	0	5	3
DY150FGMAD060	27/04/2022	09:56	59.43.27692	0.19.93000	126	11:04	59.43.00092	0.20.11500	125.5		1	1	0	6	2
DY150FGMAD061	27/04/2022	11:38:30	59.42.99354	0.19.66302	121.2	13:16:36	59.43.30566	0.19.64466	124	gravel/boulder	0	0	1	7	2
DY150FGNAD062	27/04/2022	18:46:22	59.46.02648	0.26.62950	141	19:56:56	59.46.05870	0.26.07780	141	no sediment	0	0	0	0	0
DY150FGNAD063	27/04/2022	20:14:38	59.46.03668	0.26.11806	140	21:23:06	59.45.76505	0.26.12970	140	no sediment	0	0	0	0	0
DY150FGNAD064	27/04/2022	21:31:17	59.45.76506	0.26.12976	140	22.42.19	59.45.45348	0.26.15634	139	no sediment	0	0	0	0	0
DY150FGNAD065	27/04/2022	22:55	59 45.46164	0 26.19090	139	12:15	59.45.32984	0.26.81418	138.4	no sediment	0	0	0	0	0
DY150FGNAD066	28/04/2022	12:33	59.45.35962	0.26.7934	138.3	01:43	59.45.65970	0.26.87322	140.7	no sediment	0	0	0	0	0
DY150FGOAD067	28/04/2022	08:13	59.96.25762	0.04.49560	144.6	09:19:44	59.55.99146	0.04.35912	144	no sediment	0	0	1	0	0
DY150FGOAD068	28/04/2022	09:38	59.56.00225	0.04.35510	144.5	10:38:38	59.56.22498	0.04.38006	144.6	no sediment	0	0	0	2	0
DY150FGOAD069	28/04/2022	10:44:43	59.56.22456	0.04.38036	145	11:40:38	59.56.44620	0.04.40448	144	no sediment	0	0	0	0	0
DY150FGOAD070	28/04/2022	11:53:49	59.56.43132	0.04.43628	142	13:04	59.56.51028	0.04.98642	142	no sediment	0	0	0	1	0
DY150FGOAD071	28/04/2022	13:23:46	59.56.55618	0.04.08852	142	14:38:33	59.56.83164	0.04.09602	138	mud	0	0	0	1	2
DY150FGPAD072	28/04/2022	19:56:30	60.00.43362	0.17.50806	142	21:12:25	60.00.14400	0.17.70852	142	no sediment	0	0	0	0	0
DY150FGPAD073	28/04/2022	21:24:38	60.00.14664	0.17.68050	142	22:36:23	60.0.17478	0.17.09094	151	no sediment	0	0	0	0	0
DY150FGPAD074	28/04/2022	22:45:13	60.0.19104	0.17.13156	140	00:03	60.0.501802	0.17.14235	138.9	no sediment	0	0	0	0	0
DY150FGPAD075	29/04/2022	00:15	60.0.50424	0.17.16076	139.2	01:28	60.0.76866	0.17.45286	134.2	no sediment	0	0	0	0	0
DY150FGPAD076	29/04/2022	01:44	60.0.74262	0.17.44800	135	02:52	60.0.47256	0.17.66400	140	no sediment	0	0	0	1	0
DY150NISBAD077	05/05/2022	19:26:45	66.36.35772	18.14.50464	107	20:15:52	66.36.44304	18.14.24664	105	boulders; most ~10-20cm diameter	0	0	0	0	0
DY150NISBAD078	05/05/2022	20:27:05	66.36.44346	18.14.24502	105	21:08	66.61236	-18.223		boulders; most ~10-20cm diameter	0	0	0	0	0

DY150NISBAD079	05/05/2022	21:17	66.6065	-18.2428		23:57:34	66.60796	-18.2384		boulders; most ~10-20cm diameter	0	0	0	0	0
DY150NISCAD080	06/05/2022	11:20	66.31.62996	18.11.8k774	91.1	11:36	66.31.66172	18.11.98476	91.7	empty	0	0	0	0	0
DY150NISCAD081	06/05/2022	11:43	66.31.66172	18.11.98476	91.7	12:25:14	66.31.74036	18.12.25860	93.2	no sediment	135	15	18	1081	491
DY150NISCAD082	06/05/2022	12:35:16	66.31.74012	18.12.25812	94	13:19	66.31.8346	18.12.58626	94.4	no sediment	123	11	24	575	177
DY150NISCAD083	06/05/2022	13:32:42	66.31.83570	18.12.58442	94	14:33:48	66.31.96482	18.13.03716	96	some black sand within shells	72	14	1	654	171
DY150NISCAD084	06/05/2022	15:07:47	66.31.47090	18.11.73456	92	16:22:14	66.31.6200	18.12.29484	95	some black sand within shells	167	34	4	1384	497
DY150NISCAD085	06/05/2022	16:22:56	66.31.62012	18.12.29472	92	17:09:21	66.31.69506	18.12.57516	96	some black sand within shells	96	20	12	1230	278
DY150NISCAD086	06/05/2022	17:18:10	66.31.69512	18.12.57630	95	17:59	66.31771	18.12855	95	some black sand within shells	74	20	7	1097	209
DY150NISDAD087	06/05/2022	20:05:12	66.30.88548	18.11.22882	91	21:04:53	66.30.80946	18.11.66058	95	some black sand within shells	101	25	6	1347	419
DY150NISDAD088	06/05/2022	21:14:57	66.30.80946	18.11.65980	95	22:04:21	66.30.73158	18.12.10458	99	some black sand within shells	175	40	17	1831	459
DY150NISDAD089	06/05/2022	22:25:41	66.30.75132	18.11.13936	91	23:24:10	66.30.65472	18.11.61516	97	some black sand within shells	189	40	27	1710	590
DY150NISDAD090	06/05/2022	23:35:29	66.30.65472	18.11.61492	97	12:34	66.30.55955	18.12.09486	99.5	some black sand within shells	230	55	28	350	120
DY150NISDAD091	07/05/2022	01:03	66.30.57394	18.10.99962	91.4	02:04	66.30.46374	18.11.192	95.8	some black sand within shells	91	16	31	854	221
DY150NISDAD092	07/05/2022	02:18	66.30.46350	18.11.46288	95.9	03:19	66.30.35268	18.11.92686	98.8	some black sand within shells	101	25	26	1543	506
DY150NISEAD093	07/05/2022	10:19	66.22.83952	18.12.63774	104	11:15	66.27.73248	18.13.19134	107.2	some black sand within shells	0	0	2	23	25
DY150NISEAD094	07/05/2022	11:32	66.27.73320	18.13.19610	107.3	12:35:14	66.27.62430	18.13.75212	107	no sediment	0	0	5	48	28
DY150NISEAD095	07/05/2022	13:06:13	66.27.79698	18.12.67938	105	14:07	66.27.70662	18.13.16508	109	FINER SAND WITHIN SHELLS	0	0	6	168	126
DY150NISEAD096	07/05/2022	14:18:26	66.27.70662	18.13.16550	108	15:22:07	66.27.60786	18.13.72062	107	FINER SAND WITHIN SHELLS	0	0	0	71	30
DY150NISHAD097	08/05/2022	12.41	66.14.17200	18.10.16988	137	01:45	68.14.02988	18.9.87440	133	very soft mud	0	0	0	0	0
DY150NISHAD098	08/05/2022	01:56	66.14.14168	18.9.48912	135	03:06	68.14.30892	18.9.97892	12236	very soft mud	0	0	0	0	0

Appendix 3. Sensor information sheet (stainless steel frame)

SHIP: RRS DISCOVERY	CRUISE: DY150

FORWARDING INSTRUCTIONS / ADDITIONAL INFORMATION:
Main Stainless Steel 24-way CTD frame on DY150

Checked By: Jon Short	DATE: 17/4/22

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Primary CTD deck unit	SBE 11plus	11P-24680-0588	n/a	All casts
CTD Underwater Unit	SBE 9plus	09P-24680-0637	n/a	All stainless casts
Titanium EM CTD Swivel	Machinery Development Services/V2_2	1267-2	n/a	All casts
Stainless steel 24-way frame	NOCS	SBE CTD6	n/a	All stainless casts
Primary Temperature Sensor	SBE 3P	03P-4593	F0	All stainless casts
Primary Conductivity Sensor	SBE 4C	04C-2571	F1	All stainless casts
Digiquartz Pressure sensor	Paroscientific	79501	F2	All stainless casts
Secondary Temperature Sensor	SBE 3P	03P-4712	F3	All stainless casts
Secondary Conductivity Sensor	SBE 4C	04C-3272	F4	All stainless casts
Primary Pump	SBE 5T	05T-3085	n/a	All stainless casts
Secondary Pump	SBE 5T	05T-3607	n/a	All stainless casts
24-way Carousel	SBE 32	32-31240-0423	n/a	All stainless casts
Primary Dissolved Oxygen Sensor	SBE 43	43-3836	V0	All stainless casts
Free	NA	NA	V1	NA
Fluorometer	CTG Aquatracka MKIII	088244	V2	All stainless casts
Altimeter	Teledyne Benthos PSA-916T	59494	V3	All stainless casts
PAR Upward-looking DWIRR	CTG 2pi PAR	PAR02	V4	Not required
PAR Upward-looking UWIRR	CTG 2pi PAR	PAR04	V5	Not required
Transmissometer	WETLabs CStar	CST-1719TR	V6	All stainless casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-1055	V7	All stainless casts
20L Water Samplers	OTE	Set D	n/a	All stainless casts

Appendix 4. CTD data processing configuration report

```
Date: 14/04/22

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY150\Data\Seasave
Setup Files\DY150_SS_0637_nmea_PAR.xmlcon

Configuration report for SBE 911plus/917plus CTD
-----------------------------------------------

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

1) Frequency 0, Temperature

  Serial number : 03P-4593
  Calibrated on : 12-May-2021
  G          : 4.35399637e-003
  H          : 6.44584672e-004
  I          : 2.17867036e-005
  J          : 1.76162691e-006
  F0         : 1000.000
  Slope      : 1.00000000
  Offset     : 0.0000

2) Frequency 1, Conductivity

  Serial number : 04C-2571
  Calibrated on : 22-Apr-2021
  G          : -9.94000277e+000
  H          : 1.54257691e+000
  I          : -2.28658601e-004
  J          : 1.28188621e-004
  CTcor      : 3.2500e-006
  CPcor      : -9.57000000e-008
  Slope      : 1.00000000
  Offset     : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

  Serial number : 79501
  Calibrated on : 24-Jan-2020
```

C1 : -6.052595e+004
C2 : -1.619787e+000
C3 : 1.743190e-002
D1 : 2.819600e-002
D2 : 0.000000e+000
T1 : 3.011561e+001
T2 : -5.788717e-004
T3 : 3.417040e-006
T4 : 4.126500e-009
T5 : 0.000000e+000
Slope : 0.99977900
Offset : -1.24262
AD590M : 1.293660e-002
AD590B : -9.522570e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4712
Calibrated on : 07-May-2021
G : 4.40432474e-003
H : 6.33750828e-004
I : 1.93980572e-005
J : 1.21554176e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-3272
Calibrated on : 13-Apr-2021
G : -9.77399824e+000
H : 1.27209077e+000
I : 1.87324341e-004
J : 4.72878715e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 43-3836
Calibrated on : 30-Mar-2021
Equation : Sea-Bird
Soc : 4.18500e-001
Offset : -5.04000e-001
A : -4.90320e-003
B : 2.06780e-004
C : -2.90040e-006
E : 3.60000e-002

Tau20 : 1.09000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Fluorometer, Chelsea Aqua 3

Serial number : 088244
Calibrated on : 07 August 2020
VB : 0.176199
V1 : 2.032520
Vacetone : 0.245650
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Altimeter

Serial number : PSA-916T 59494
Calibrated on :
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor

Serial number : 02
Calibrated on : 27-Jun-2019
M : 0.45712800
B : 1.08610800
Calibration constant : 100000000000.00000000
Conversion units : Watts/m^2
Multiplier : 0.99890000
Offset : 0.00000000

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2

Serial number : 04
Calibrated on : 03-Sep-2020
M : 0.51512300
B : 1.00565600
Calibration constant : 100000000000.00000000
Conversion units : Watts/m^2
Multiplier : 0.99830000
Offset : 0.00000000

12) A/D voltage 6, Transmissometer, WET Labs C-Star

Serial number : CST-1719TR
Calibrated on : 15th March 2022
M : 21.1708
B : -0.0783
Path length : 0.250

13) A/D voltage 7, OBS, WET Labs, ECO-BB

Serial number : 1055
Calibrated on : 15/07/2019
ScaleFactor : 0.003639
Dark output : 0.043000

Scan length : 45