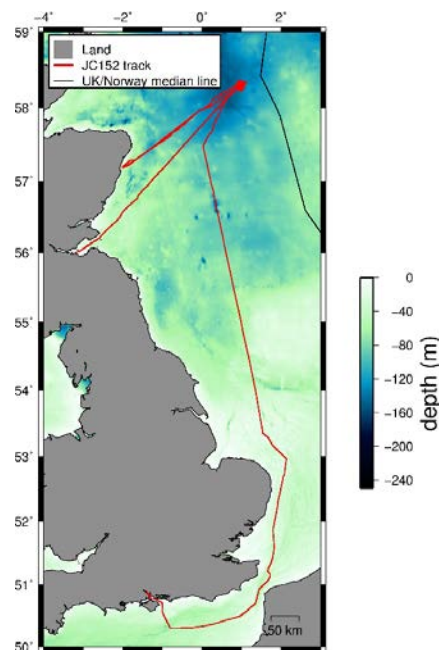


Cruise Report - RRS James Cook JC152

**CHIMNEY – Characterisation of major
overburden pathways above sub-seafloor CO₂
storage reservoirs in the North Sea.**

Scanner and Challenger Pockmark Complexes



25th August 2017 to 12th September 2017

Southampton to Leith

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1. Executive Summary

Cruise JC152 collected the major data sets for the CHIMNEY (**C**haracterisation of **m**ajor overburden leakage pathways above sub-seafloor CO₂ storage reservoirs in the North Sea) NERC highlight topics research programme. The cruise investigated the Scanner and Challenger pock marks in the northern North Sea, which were previously known to be the locations of vigorous Methane venting. The cruise objectives were to collect data that could be used to constrain the geometry and internal structures of fluid flow, “Chimney” structures, with the eventual aim of determining the current permeability of the sub-surface. The cruise successfully completed two anisotropy experiments over the Scanner and Challenger pock marks by shooting various seismic sources into a grid of 25 and 7 ocean bottom seismometers respectively. Five different seismic sources (Bolt airguns, GI guns, Squid surface sparker, Duraspark surface sparker, and Deep Tow Sparker) were recorded by the ocean bottom seismometers, and an acoustic recorder deployed c. 25 m above the seabed. Multichannel seismic reflection profiles were collected with GI guns and both surface sparker sources, and single channel seismic reflection profiles were collected with the Deep Tow Sparker source. Single and multibeam echo sounder data were collected along all seismic profiles.

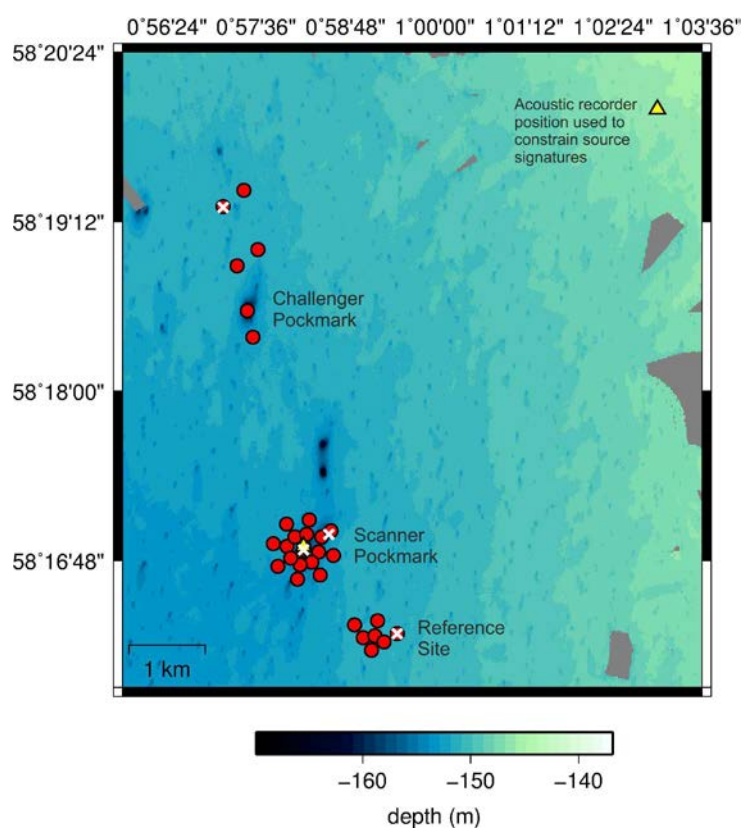


Figure 1. Location of all instruments deployed during JC152. The red circles show the position of the 25 ocean bottom seismometers (OBS) deployed at the Scanner pock mark and a reference site during the first part of the cruise, and the position of a further 7 OBS deployed around and north of the Challenger pock mark after a port call to Aberdeen. The white crosses show the position of sound velocity profiles taken in the water column, while the yellow triangles show the position of acoustic recorders deployed to the north east of the study area during the first part of the cruise (to record source signatures), and within the Scanner pockmark toward the end of JC152.

2. Scientific Background

Cruise JC152 forms part of NERC NE/NO16130/1 highlight topic grant CHIMNEY (**C**haracterisation of **m**ajor overburden leakage pathways above sub-seafloor CO₂ storage reservoirs in the North Sea). CHIMNEY focusses on determining the distribution and permeability of fluid pathways related to gas escape structures in the North Sea. Understanding these pathways is important for the development of Carbon Capture and Storage sites, as the location and potential intensity of any possible CO₂ leakage at the seafloor are critically dependent on the distribution and permeability of fluid pathways in the sediment overburden overlying any putative storage reservoir.

Evaluation of seismic reflection data, as part of a recently completed EU project (ECO2), has revealed structures cross-cutting the overburden within the North Sea and Norwegian Sea (Karstens and Berndt, 2015). These seismically-imaged pipes and chimneys are considered to be possible pathways for fluid flow. Natural fluids from deeper strata have migrated through these structures at some point in geological time. If CO₂ leaking from sub-seafloor storage reservoirs reaches the base of these structures, and if their permeability is sufficiently high, they could act as CO₂ leakage pathways towards the seafloor and overlying water column. To provide a reliable prediction of potential seafloor seep sites, the hydraulic continuity, and especially the permeability of these pathways, needs to be better constrained and quantified.

CHIMNEY will test the hypothesis that many chimney and pipe structures imaged on seismic reflection profiles in the North Sea are the consequence of: (1) a fracture network that has been reactivated by pore fluid pressure which facilitates the migration of fluids upwards; and (2) shallow sub-seafloor lateral migration of fluids along stratigraphic interfaces and near-surface fractures. We will address the critical questions: what is their in-situ permeability now; and could a CO₂ fluid use these structures as a conduit for leakage?

We chose to target the Scanner pockmark complex as: (1) existing 3D seismic data demonstrated that there are circular anomalies at depth beneath the pockmark that are unlikely to be seismic artefacts; and (2) there is vigorous and sustained methane venting from the Scanner pockmark.

2.1 CHIMNEY Programme and Scanner Pockmark

CHIMNEY combines a marine geophysical fieldwork programme, and associated rock physics experiments, geochemical characterization and modelling, to constrain chimney physical properties including permeability, potential flow rates and CO₂-fluid-rock reactions. CHIMNEY is divided into four work packages. WP1 is the marine geophysical experiment and centrally involves a unique broad-band seismic anisotropy experiment over the Scanner pockmark complex in order to understand its structure and origin, derive fracture geometry and topology and ascertain if fractures are open or closed. The second work package (WP2) will constrain chimney and surrounding rock permeability by rock physics experiments on synthetic samples. The chemical composition of sediments and their pore waters collected from core samples from the Scanner pockmark (WP3) will be used to assess hydraulic connectivity, water-rock reactions that affect permeability and the longevity of fluid flow, and to constrain reactive transport modelling. We will input the parameters derived from WPs 1-3 into the TOUGH 2 fluid flow simulator to compute (WP4) and investigate different scenarios relevant to North Sea carbon capture and storage. To minimize costs and

optimize scientific opportunities, the CHIMNEY programme was designed to piggy-back an experiment that was conducted during Horizon 2020 project STEMM-CCS.

The Scanner pockmark complex is located in UK License Block 15/25 (Figure 2), around 190 km east of Scotland within the Witch Ground Basin close to a number of oil and gas condensate fields. The closest field to Scanner is the decommissioned Blenheim Oil Field, which is a heavily faulted Palaeocene sandstone play on the flank of the Fladen Ground Spur (Figure 2). Within the Blenheim field, structure maps of the Late Palaeocene Top Mey Sandstone (Dickinson et al. 2001) show a dominant NW-SE normal fault set.

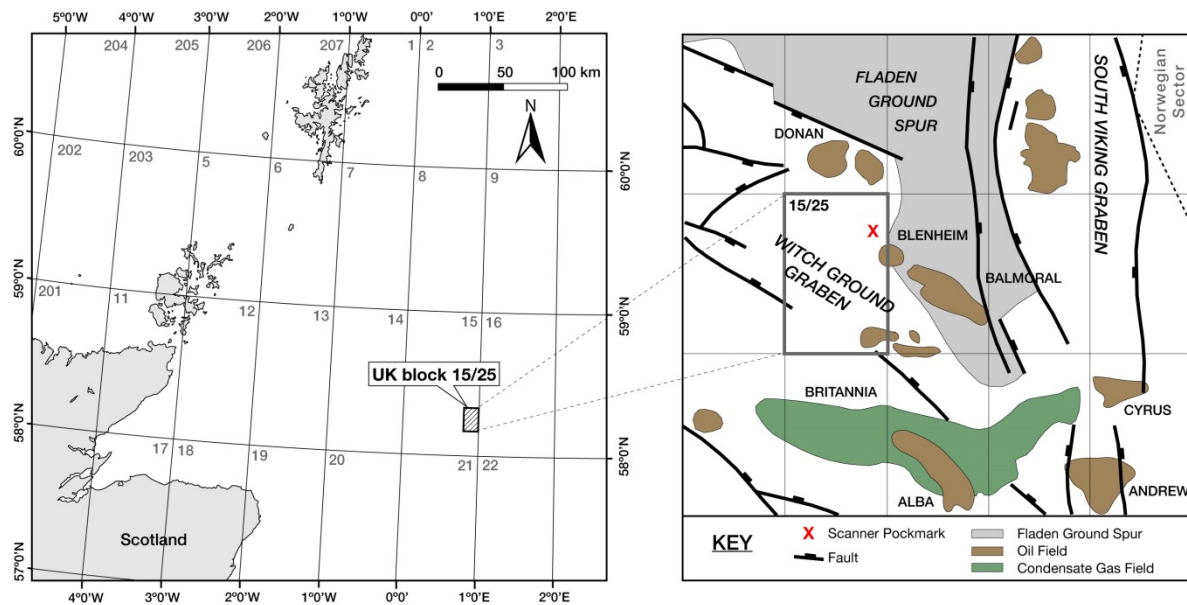


Figure 2. Position of the Scanner Pockmark within the UK Sector of the North Sea. The Scanner pockmark complex is within the Witch Ground Graben.

The Witch Ground Basin was the locus of rapid fine-grained sediment deposition between 15 and 13 ka after the end of the last glacial period. The soft muds of this formation are affected by large numbers of pockmarks (Gafeira and Long, 2015). Following the stabilisation of sea level after the last glaciation, the Witch Ground has been little affected by erosion or sedimentation, and hence pockmarks at the current seabed show the effects of gas escape over at least the last 6000 years. Although most pock marks are small, less than 2 – 3 m, several studies have identified the presence of large pockmarks within Block 15/25 with very active methane venting (Hovland and Sommerville, 1985; Dando et al., 1991; Judd et al., 1994).

The Scanner pockmark is a Special Area of Conservation (JNCC website, 2018) and has been approved as a Site of Community Importance (SCI) by the European Commission under European Habitats Directive 118. This SCI covers 3.4 km² and two pairs of pockmarks (the Scanner and Scotia pockmark complexes). In addition further north there are further large pockmarks, the Challenger and Alkor pockmarks. The pockmarks were the focus of a recent desk study (Gaferia and Long, 2015) by the British Geological Survey for the Joint Nature Conservation Committee, which utilised a JNCC 2012 multibeam bathymetry and sidescan datasets. We are grateful to the JNCC for making available the 2012 data for JC152 planning purposes.

Within the pockmarks samples of methane-derived authigenic carbonate (MDAC) have been recovered (summarised in Judd and Hovland, 2009). These MDAC deposits are formed by the anaerobic oxidation of escaping methane, cementing sediment grains just beneath the sea-bed, which with the process of continued gas movement across the seabed, become a hard ground. Dando et al. 1991 report that these habitats support specialised fauna which can exploit the methane gas, as well as species of fish which are concentrated within these seabed depressions.

There have been some previous seismic reflection investigations of these pock marks and an analogue example collected in 1983 is shown in Figure 3. However the sources of the gas and relationship to the pockmarks was not well constrained prior to JC152.

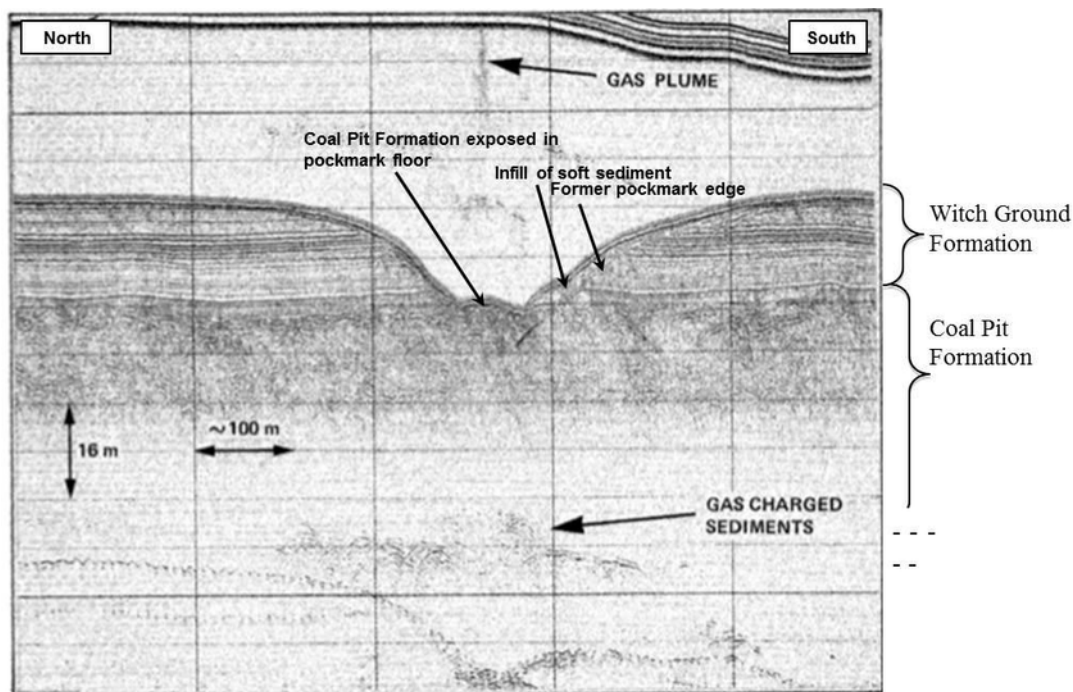


Figure 3. Deep tow sparker line collected across the western Scanner pockmark in 1983 (after Hovland and Sommerville (1985) and Gafeira and Long (2015). Methane gas in the water column and within the sub-surface are clearly imaged.

2.2 Geophysical Field Programme

The central aim of JC152 was to measure frequency-dependent anisotropic properties of the Scanner pockmark. This was completed by using ocean bottom seismometers (OBS) to measure the converted shear waves which are known to be essential for characterizing fracture systems. A key component of the technique will be to use five different seismic systems with different source frequencies, in the range 15 Hz to 6 kHz (bolt airguns, GI guns, surface-towed Squid2000 sparker, surface-towed Duraspark sparker and a Deep-Tow Sparker (DTS) source). This approach will provide a unique opportunity to study the frequency-dependence of anisotropy over a much wider frequency range than has been used in previous studies. We deployed 25 OBS centred on the Scanner pockmark and at a reference site that is not affected by the presence of gas. These instruments recorded, with a sampling rate of 4 kHz, every shot from our range of seismic sources, using a hydrophone and three orthogonal geophones. Due to excellent weather we deployed an additional 7 OBS around the Challenger Pockmark.

In order that we could fully resolve the geometry of sub-surface fluid flow features we collected normal-incidence seismic reflection profiles using GI guns, two surface-towed sparker sources, and the DTS. The NMEP does not include a multichannel streamer suitable for high-resolution work. We had two multichannel streamers available to us, a 60-channel Southampton streamer, and a 120 channel GeoEel streamer which we hired in from TTS Ltd. Unfortunately significant problems were experienced in operating the GeoEel streamer.

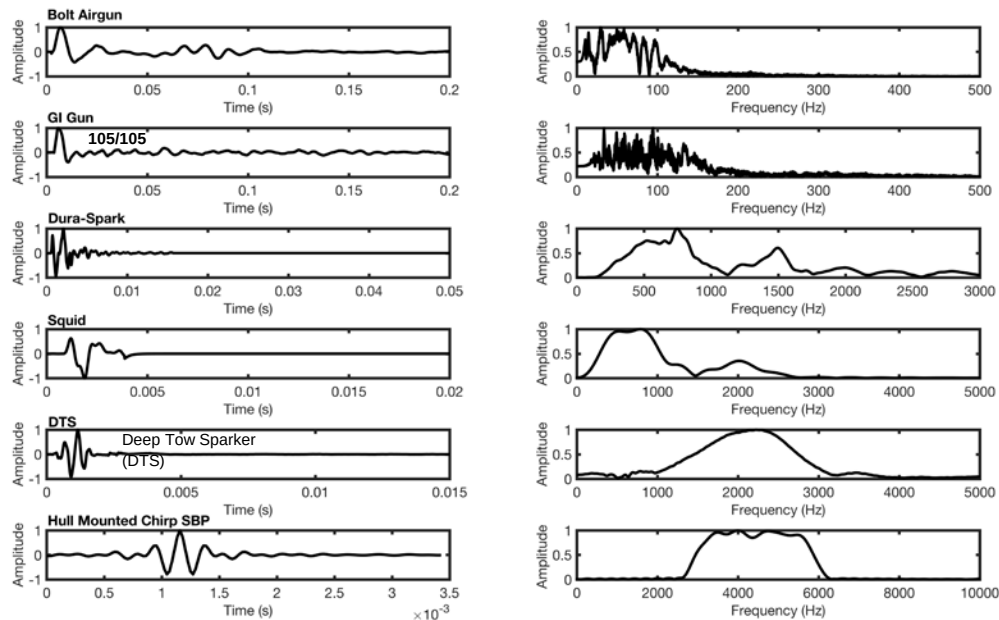


Figure 4. Far-field source signatures of six seismic sources used during JC152. Signatures as measured on a Song meter acoustic recorder deployed c. 30 m above the seabed in 140 m water depth: 1. Bolt Airgun array with frequency spectrum between 5 – 150 Hz, 2. GI Gun array (105/105) with frequency spectrum between 30-200 Hz, 3. Dura-Spark surface sparker with frequency spectrum between 200-1100 Hz, 4. Squid surface sparker with a frequency spectrum from 10 - 1500 Hz, 5. Deep Tow Sparker (DTS) with frequency spectrum between 1000 – 3000 Hz. 6. Hull mounted Chirp sub-bottom profiler, here auto-correlated zero phase Klauder wavelet, frequency spectrum is between 2.5 kHz- 6.2 kHz. Figure courtesy: Ed Jones (2018).

2.3 JC152 Cruise Objectives

The aims of the JC152 were as follows:

1. Deploy 25 Ocean Bottom Seismometers around Scanner pockmark and shoot five different sources on an asterisk and grid of lines into the OBS network. The sources were Bolt airgun array, GI gun array, Squid surface sparker, Duraspark surface sparker and Deep Tow Sparker (DTS). These data would be analysed for S-wave anisotropy, and the broad frequency range would allow determination of fracture properties and permeability.
2. Collect multichannel seismic reflection profiles using GI, Squid and Duraspark sparkers and single channel seismic profiles with the DTS system. These data would allow the geometry of fluid escape structures within the sedimentary overburden to be constrained.

3. Collect along-track sub-bottom profiler, EK60 and EM710 bathymetry. These data would be analysed to understand the seabed relief and distribution of gas within near-surface sediments and the water column.
4. Collect passive acoustic data using a Songmeter system to (a) record seismic source signatures and (b) the sounds associated with methane bubbles escaping from the seabed.

Due to excellent weather and little equipment down-time we were also able to:

5. Deploy 7 Ocean Bottom Seismometers around Challenger pockmark and shot GI gun array and surface Squid sparker into them.
6. Collect a pseudo-3D grid of GI gun and Squid sparker profiles over both the Scanner and Challenger pockmarks, and a tunnel valley complex north of the pockmarks.

3. Personnel

3.1 Ship's Officers and Crew

John Leask (Captain)
 Stewart MacKay (First Officer)
 Malcolm Graves (2nd Officer)
 Sean Hoxby (3rd Officer)
 Robert Doyle (Chief Engineer)
 Lawrence Porrelli (2nd Engineer)
 Noel Doherty (3rd Engineer)
 Edin Silajdzic (3rd Engineer)
 Christopher Howard (ETO)
 Paula McDougall (Purser)
 Martin Harrison (Chief PO, Scientific)
 Thomas Gregory (Chief PO, Deck)

Emlyn Williams (Engine Room PO)
 Stephen Day (Seaman)
 Ronald MacDonald (Seaman)
 Kevin Riley (Seaman)
 Jason Reynolds (Seamen)
 Darren Caines (Head Chef)
 Christopher Keighley (Chef)
 Peter Robinson (Steward)
 Kevin Mason (Assistant Steward)
 Charley Jess (Cadet)
 Thomas Quinn (Cadet)
 Paul McLaughlin (Cadet)

3.2 Science Party

Jonathan Bull (PSO, Southampton)
 Tim Henstock (Southampton)
 Gaye Bayrakci (Southampton)
 Mark Chapman (Edinburgh)
 Hector Moreno (NOC)
 Bhargav Boddupalli (PhD, Southampton)
 Phil Cilli (PhD student, Edinburgh)
 Dan Ellis (Undergraduate, Southampton)
 Zhaoyo Jin (PhD student, Edinburgh)
 Vanessa Monteleone (PhD, Southampton)
 Ben Ollington (Undergraduate, Southampton)
 Ben Owen (Undergraduate, Southampton)
 Giuseppe Provenzano (PhD, Southampton)

Anna Bird (OBIC)
 Andrew Clegg (OBIC)
 Ben Pitcairn (OBIC)
 Martin Weeks (OBIC)
 Joshua Hancock (Eel Gun Technician)
 Iain Miller (Eel Gun Technician)
 Matt Poxon (Applied Acoustics Ltd)
 Andrew Leadbetter (NMF)
 Mark Maltby (Sea systems)
 Ian Murdoch (NMF)
 Thomas Roberts (NMF)
 Matthew Smith (NMF)
 Matt Poxon (Applied Acoustics Ltd)

3.3 Vessel Specification

An overview of the particulars of the vessel are given below.

<i>Name:</i>	RRS James Cook
<i>Type/Class:</i>	Lloyds +100 A1 Ice Class C1 + LMC, UMS, DP (AM), "Research Vessel"
<i>Nationality (Flag State):</i>	British
<i>Identification Number (IMO/Lloyds No.):</i>	9338242
<i>Owner:</i>	Natural Environment Research Council
<i>Operator:</i>	National Marine Facilities Sea Systems
<i>Overall length (metres)</i>	89.2 m
<i>Maximum draft</i>	6.32 m
<i>Displacement/Gross tonnage</i>	Net tonnage – 1620; Gross tonnage 5401
<i>Propulsion:</i>	Wartsila Diesel Electric
<i>Cruising and maximum speed:</i>	10 Knots
<i>Call sign</i>	MLRM6
<i>INMARSAT number and method and capability of communication (including emergency frequencies)</i>	773238783 – Voice 783255430 – Fax 423501712;jame x - Telex

Table 1. RRS James Cook vessel specification

4. Pre-cruise Planning

4.1 Permissions

Whilst for working in territorial waters of other nations, there is a standardised process managed by National Marine Facilities, this is not currently the case in UK waters. We therefore describe here briefly the process that was followed. For UK water one would normally expect to consult the Marine Management Organisation (MMO) regarding permissions required. However, the MMO deals only with England and Wales. Permissions for Scottish waters are administered by Marine Scotland, and the process is different and more involved than that required by the MMO. A seismic experiment such as that conducted during cruise JC152 requires two different licenses: a Marine License and an EPS license (permission to disturb European Protected Species). License applications should normally be submitted at least 14 weeks before the start of the cruise. However, we only became aware of these requirements in early July 2017, about six weeks before the start of the cruise. Forms for licensing applications can be found on Marine Scotland's website, but advice is needed regarding which licenses must be applied for – this is not obvious from the website.

A Marine License is required for any activity that will leave materials on the seabed, and therefore is required for deployments of seabed instrumentation if an anchor weight is left behind at the end of the experiment. The application process involves a short form and a fee that is determined by the "value" of the associated activity. Assessment of value involves some degree of subjectivity, but for a scientific research application, this value can be taken as the value of the consumables involved. The application specifies the number of deployments; a revised application was therefore required when further deployments were added to the original plan.

An EPS License is required for any work involving acoustic or seismic sources operating at frequencies below 100 kHz. The EPS License application is a more substantial form that requires

details of all seismic and acoustic sources, including estimates of sound levels. A full environmental impact assessment must be attached, and proposed acoustic and seismic work must also be entered in the “Noise Registry”. The license applications were completed about five weeks before the cruise and submitted together to Marine Scotland, along with “notifications” which are required for any equipment deployment of more than six months, and for sediment coring. The latter two activities were originally planned as part of the cruise but later cancelled. Following submission, Marine Scotland consult various other organisations that can specify conditions on the licenses. We were given an opportunity to respond to these conditions before the license was finalised.

4.2 Environmental Considerations

We gave careful consideration to minimise the environmental impact on marine mammals. We followed JNCC’s 2017 guidelines and used the following procedures/mitigation measures in accordance with EPS License 23/2017:

1. All marine mammal observation was conducted by observers who had completed a JNCC-approved training course. Observations were conducted from the vessel’s bridge deck, which was the highest area normally accessible at sea, and had unobstructed visibility in all directions.
2. The EM710 swath bathymetric system, SBP120 sub-bottom profiler and EK60 were switched on during the final approach to the survey area, which is all in water depths of less than 200m. The systems were started up in daylight hours and a 30-minute pre-shooting survey was conducted by qualified marine mammal observers. These systems then remained in operation throughout the survey period. During 4th-6th September, the vessel had to leave the survey area in order to pick up spare parts in Aberdeen; the above process was repeated on return to the survey area. The various sparker sources used during the survey operated at similar (or lower) source levels and similar frequencies to the sub-bottom profiler.
3. Additional pre-survey searches (30 minutes) and soft starts (30 minutes) were used for both the GI and Bolt airgun sources. Configurations of the GI gun source on the first part of the survey was two guns in harmonic mode with 105 cu. in. generator and 105 cu. in. injector volumes (2x210 cu. in.) . After the reducer inserts were picked up in Aberdeen, the guns were used as 2 x 150 cu in GI true mode (Generator 45 cu. in./Injector 105 cu. in.). The final configuration of the Bolt airgun source involved chamber sizes of 400 cu. in., 200 cu. in. and 100 cu. in., to give a total of 700 cu. in. Both sources were operated at a pressure of 2000 psi. Airgun shooting was only started during daylight hours.
4. Although not a JNCC requirement, marine mammal observation was continued during all daylight hours when airguns were being fired, in order to provide a more complete record of any sensitive species. Individual observers worked one-hour shifts to mitigate fatigue. Because of the nature of the surveys (shooting at regular time intervals into fixed seabed receivers), shooting continued throughout the active period for each source.
5. For the Bolt airgun source, the soft start involved shooting first the 100 cu. in. gun on its own for 15 minutes, then the 100 cu. in. and 200 cu. in. gun for a further 15 minutes, and then the full array of three guns.
6. For the GI gun source, the soft start involved shooting a single gun for 30 minutes and then shooting both guns.

There was only one marine mammal sighting during JC152 at 15:35 UTC on 8th September at 53° 19’ 40’’N, 00° 58’ 46’’ E.

5. Cruise Narrative (all times GMT)

Thursday 24th August 2017 – JD236

The JC152 CHIMNEY mobilisation in Southampton was managed by Jon Short and Jez Evans, and went without incident. The hired STR winch for the deep tow sparker was welded to the deck during the afternoon. The Science Party boarded RRS James Cook in the late afternoon.

Friday 25th August – Departure and Transit – JD237

The ship departed Empress Dock, Southampton into a calm sea at 10:00. The rest of the day was devoted to setting up systems on board.

Saturday 26th August – Transit – JD238

Flat calm sea. The science team were briefed in the morning by the PSO. Pressure tests on gun cabling done completed in the afternoon. A watchkeepers brief was completed at 13:00 including the approach to Marine Mammal Observation. Preparatory works continued.

Sunday 27th August – Transit, start of work – JD239

Calm. The mini-lander was rigged with programmed acoustic recorder. The surface sparker cables were run across the deck to the surface catamaran. Various seismic trigger combinations were tested. 14:00 Scientific Watches start

14:30 OBIF dip tests. En route when > 100 m water depth.

16:00 Marine Mammal Observation started before main ship's acoustic systems switched on.

17:00 Switched on bathymetry and profiler

21:06 Sound Velocity Profiles collected at OBS 1 and OBS 25 positions

21:47 Multibeam EM710 Swath patch started

Monday 28th August – JD240

Fair weather, but swell grew through the day to 2 m.

01:05 OBS deployments commence at Scanner Pockmark. OBS 1 and OBS 2 were within the western Scanner pockmark, OBS 3 in the eastern Scanner pockmark.

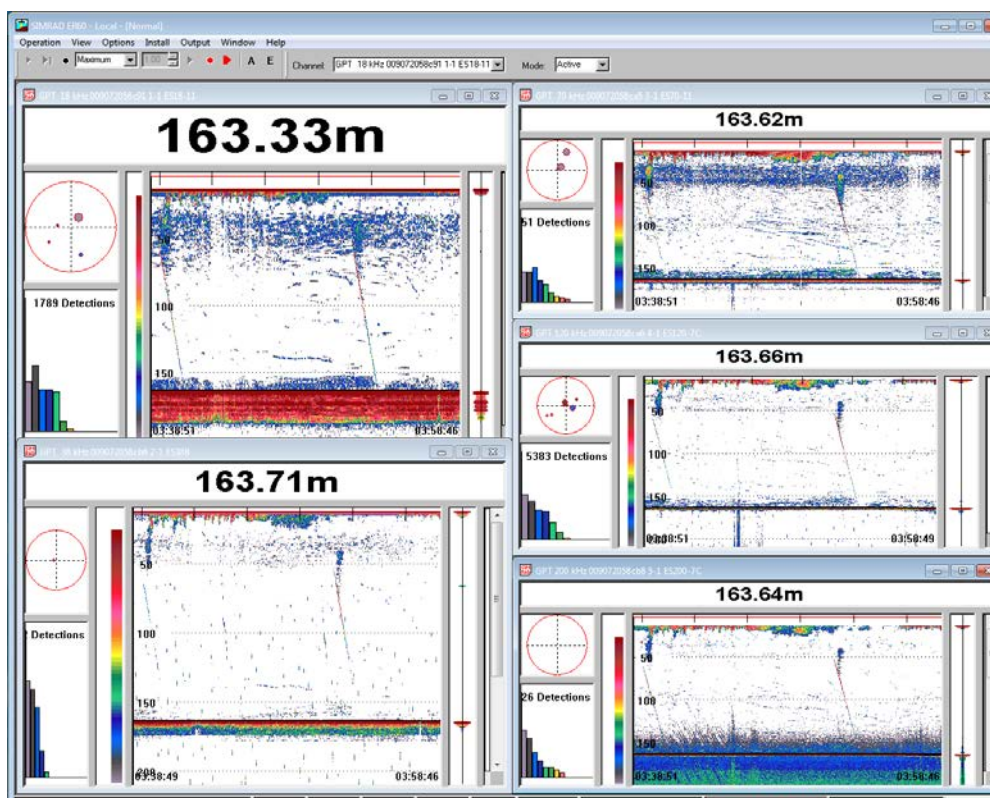


Figure 5. EK60 images which capture the deployment of OBS1 and OBS2 within the western Scanner pockmark. Vessel is stationery and the lower axis is time – note the clear linear return from the instrument as it sinks, and the release of trapped air around 60 m depth.

06:47 All OBS deployments complete. Notable gas flares seen on EK60 18 kHz at OBS3.

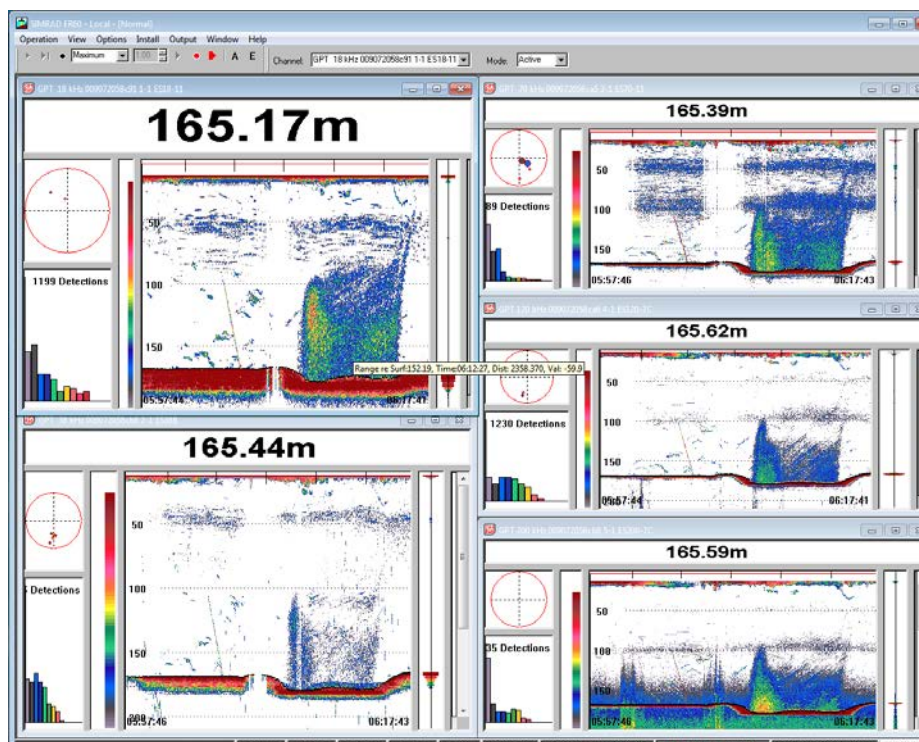


Figure 6. EK60 images of methane flares within the eastern Scanner pockmark at the location of OBS3.

Deployed acoustic recorder (Songmeter) at 1° 03.018' E, 58°20.011'N, in 143 m of water. We set gains on two channels as 0 dB (left channel) and 6 dB (right channel). 12 D-cells. Total height of deployment 25 m. 44 kHz sampling. 5 mins on, 5 mins off. Time synced to GPS clock. Recording set to start at 12.00 on 28th August. Memory capacity good until 12.00 on 6th September. See appendix for more information on configuration of the acoustic recorder.

site_id	deployed_latitude	deployed_longitude	deployed_depth (m)	datalogger_id
1	58.2812	0.9708	167.3	129
2	58.2815	0.9709	167.1	113
3	58.2827	0.9749	165.7	135
4	58.2833	0.9769	152	115
5	58.2816	0.9671	150.9	111
6	58.2809	0.9742	152	136
7	58.2797	0.9727	152.2	107
8	58.2794	0.9701	153.9	125
9	58.2802	0.9679	152.6	122
10	58.2827	0.9689	153	126
11	58.283	0.9715	156.1	110
12	58.2805	0.9774	150.5	123
13	58.2782	0.9746	151.1	131
14	58.2778	0.9695	151.7	138
15	58.2793	0.9649	151.5	124
16	58.2819	0.964	151.2	108
17	58.2842	0.9669	151	119
18	58.2847	0.972	151.8	139
19	58.2693	0.986	149.6	128
20	58.2708	0.9841	149.9	112
21	58.271	0.9868	150	109
22	58.2703	0.9889	149.2	137
23	58.2723	0.9822	150.1	117
24	58.2731	0.9874	149.5	121
25	58.2713	0.9917	149.6	130

Table 2. Summary of the 25 OBS deployments at Scanner Pockmark

First Deployment

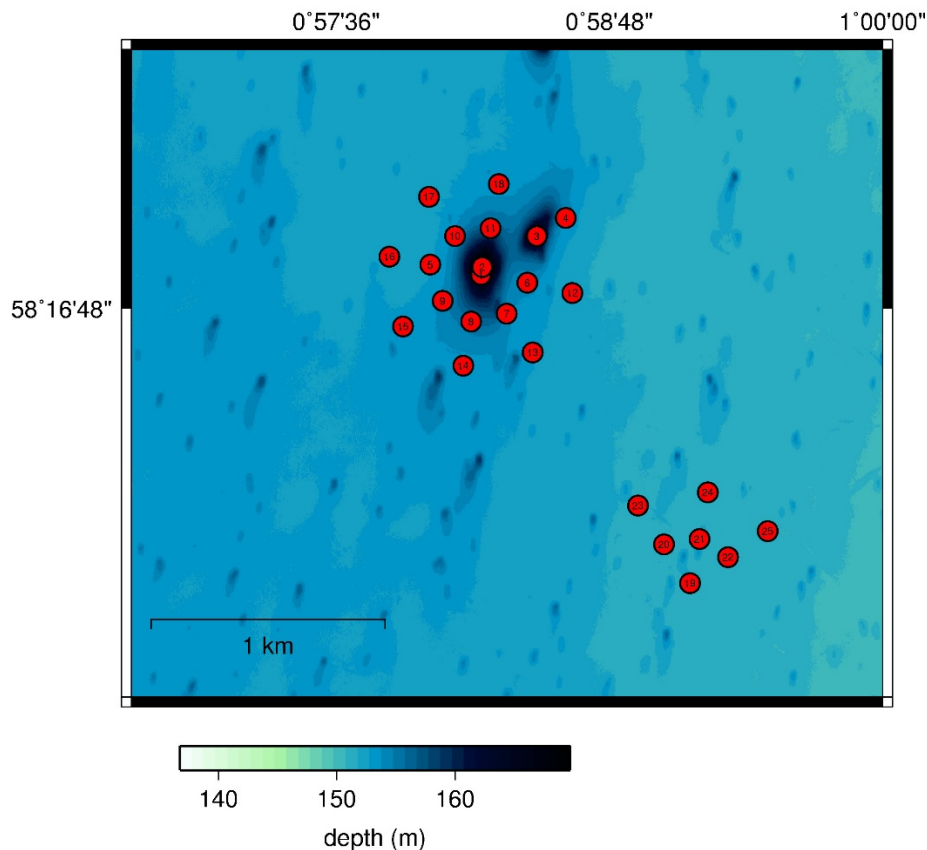


Figure 7. Map showing positions of 25 OBS deployed during Leg 1. 18 of the OBS locations surround the Scanner pockmark complex, while 7 are deployed south-east of the Scanner pockmark at a reference site not affected by fluid flow.

09:33 Deployed deep-tow sparker (DTS) and let out sufficient wire to be at 110 m water depth.

10:10 Issues with powering DTS... Does not come up to 100 V. Bring Deep-tow back onto ship for inspection. Conclusion that the winch requires a new termination.

c. 11:00 Decision to move to deploy surface Sparker with TTS streamer.

12:00 – 13:00 preparing TTS streamer, however became apparent that there was a problem with connecting to the streamer.

Weather building to 2 m swell and short period, too rough for streamer surveys. Uncomfortable.

13:00 Decision made to move to do Bolt Airgun survey without streamers. Marine Mammal observation started.

13:45 Bolt Airguns deployed with the array comprising three guns of capacity 100, 200 and 400 ci.

14:05 Soft start over 30 minutes after MMO completed for 1 hour.

14:52 Starting with Line B1. Heading south, turning to move vertically above passive acoustic recorder, then moving to Point I which will start B2. Completed Bolt Asterisk survey

Tuesday 29th August 2017 – JD241

Sea state improved over night. Calmer. Sea state improved throughout the day.

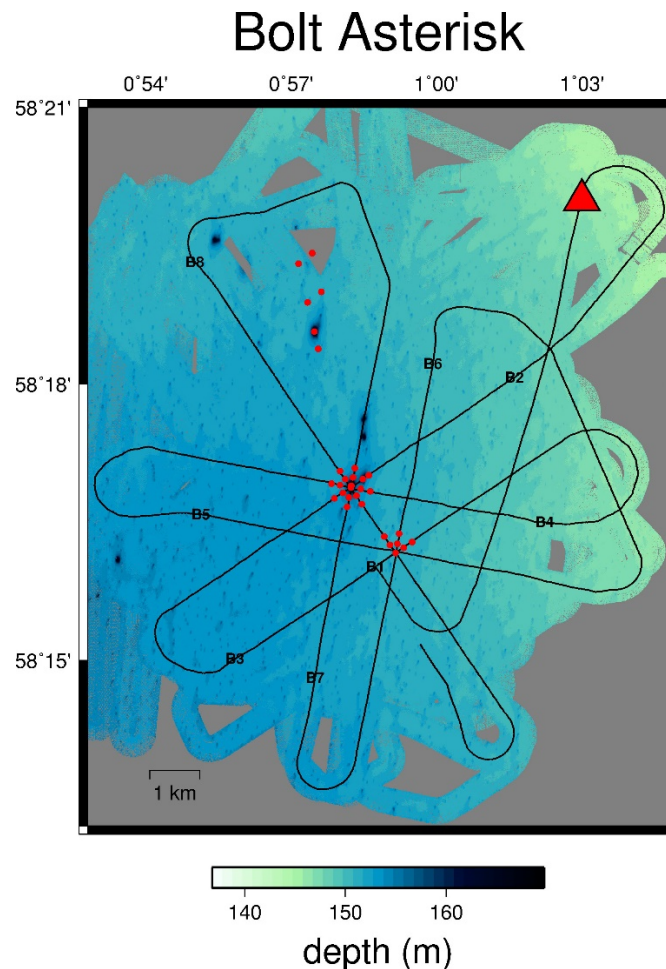


Figure 8. Map showing position of Bolt Asterisk airgun lines. These lines were collected without a surface streamer, with shots recorded on the OBS deployed during the first leg. The second leg OBS were not deployed during the bolt airgun deployments.

Bolt airguns had no misfires overnight and timing was within 0.1 ms. Started Bolt grid survey. Decision taken to suspend this survey and bring in guns, and commence streamer surveys.

08:30 End of Line B11. Bring in Bolt guns.

Deployed Squid Surface Sparker and Southampton streamer. Sparker energy 2000 J, 2 second shot interval, into 60 channel Southampton system. Data quality is good.

11:07 successfully collecting multichannel sparker data. Sparker Asterisk survey followed by Sparker grid survey.

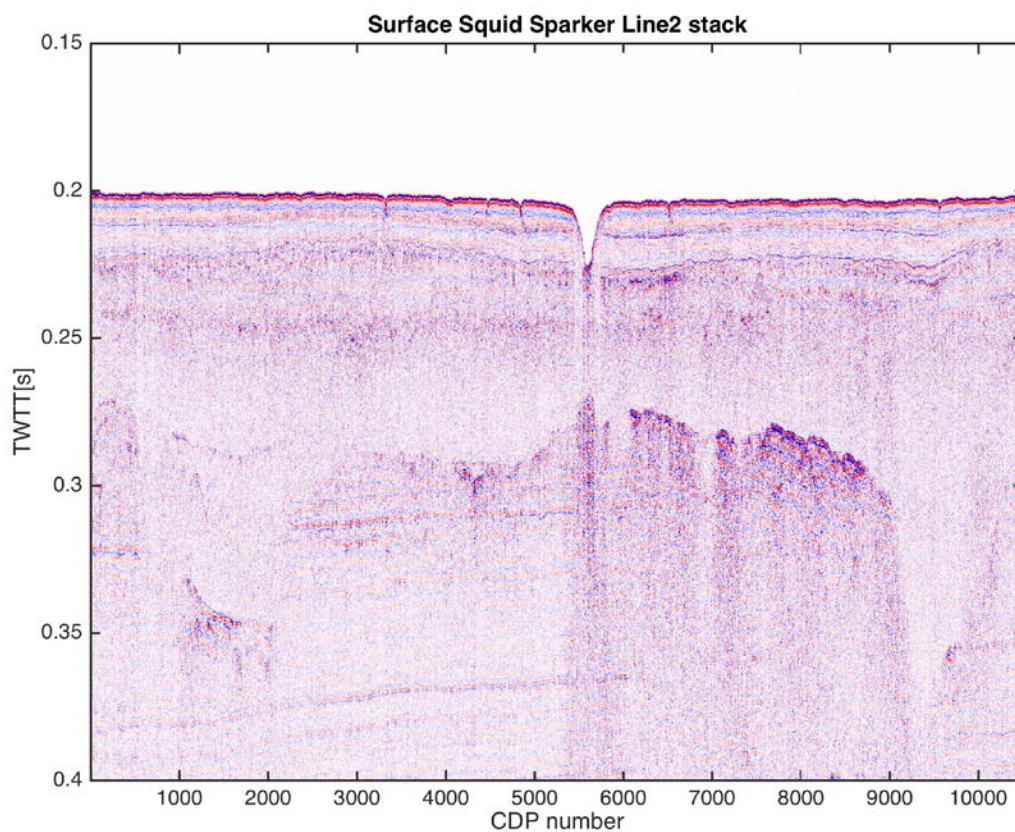


Figure 9. *Example of Squid surface sparker post-stack profile acquired by the 60-channel Southampton streamer. Position of profile is shown in Figure 10.*

30th August 2017 – JD242

Force 4. Good survey conditions. Sunny.

Successfully completed Sparker Asterisk and smaller grid part of Big Sparker Grid.

Squid2000 Asterisk

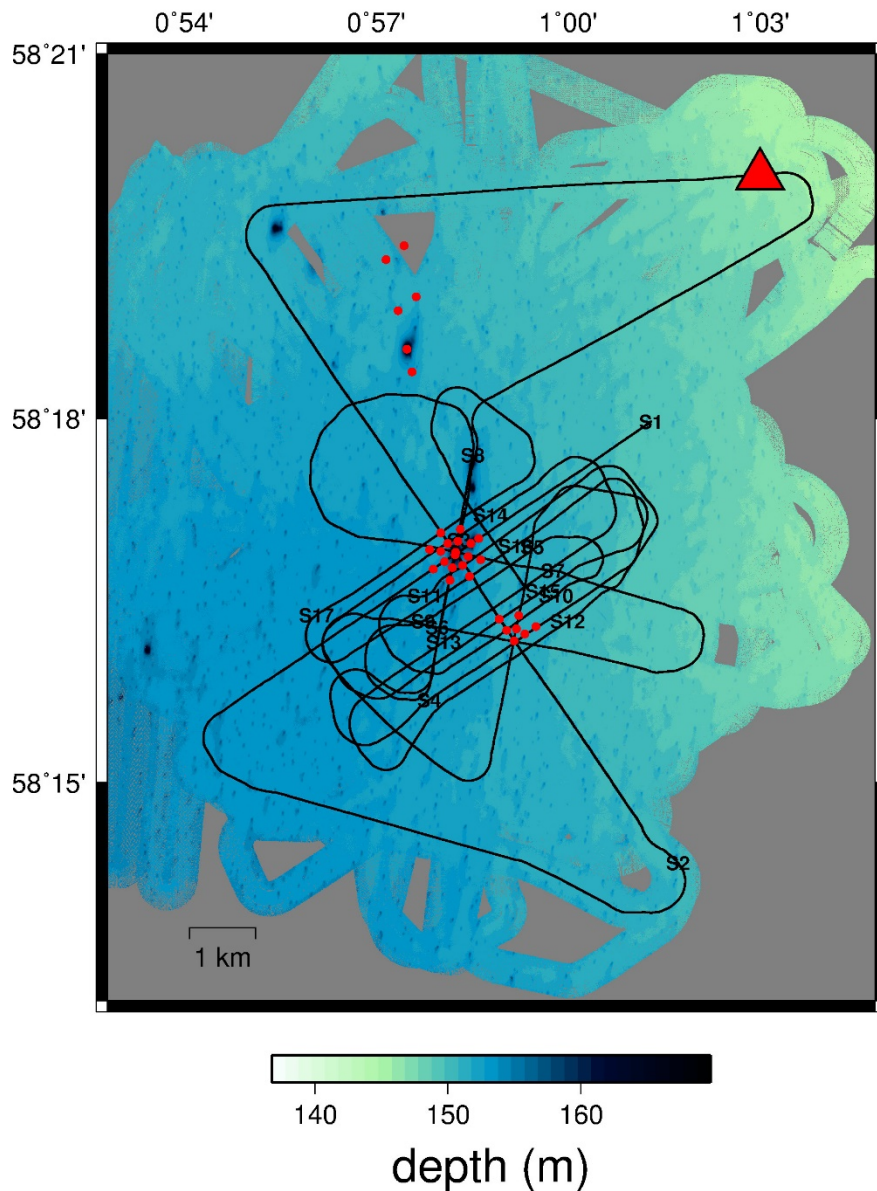


Figure 10. Map showing the position of Squid surface sparker asterisk survey. Shots recorded on the Southampton 60-channel streamer, and on the 25 OBS deployed during Leg 1.

08:15 Recovered squid sparker. Toolbox talk Duraspark. The system is very similar to Squid sparker but catamaran is substantially heavier.

09:03 Deploy DuraSpark surface sparker. 2000 J at every 2 seconds. 30 m behind stern. Recording into Southampton Streamer. (NB Squid was 33 m behind).

9:08 Soft start 500 J, 1000 J then to 2000 J.

9:15 start line on full power. All good. Clean data.

13:47 surveyed over passive acoustic recorder position

Squid sparker tips cut back.

31st August 2017 JD243

Calm overnight with continuous Duraspark profiles. Sunny today.

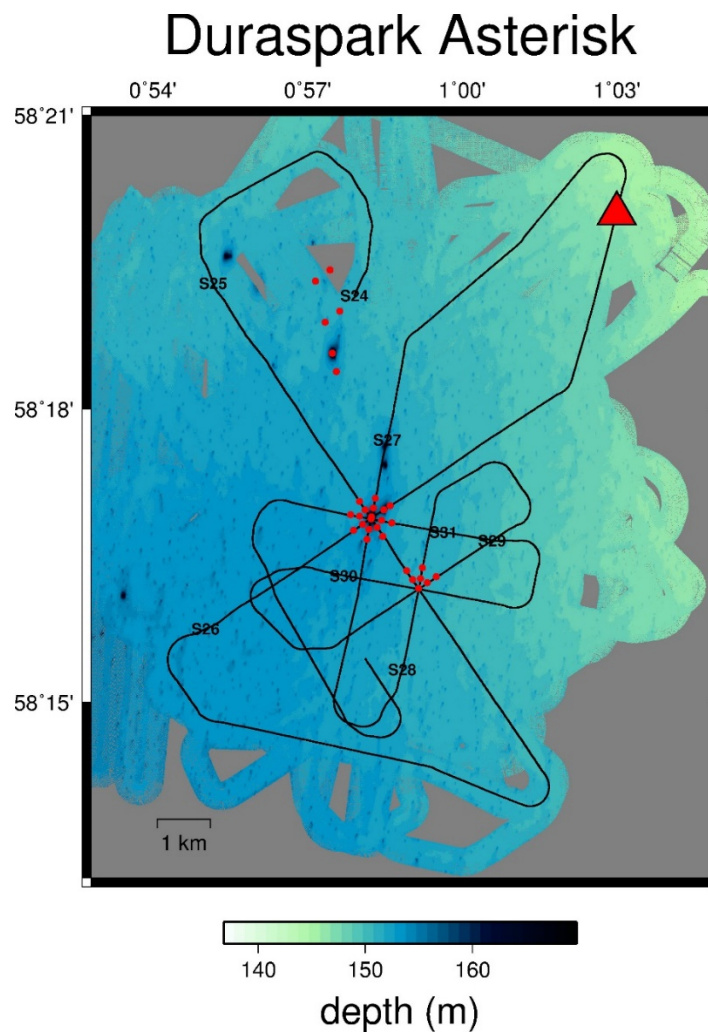


Figure 11. Map showing the position of Duraspark surface sparker asterisk survey lines. Shots were recorded on the Southampton 60-channel streamer, and on the 25 OBS deployed during Leg 1.

10:01 Over acoustic recorder position with Duraspark

10:04 End of Duraspark survey

Deploy two GI guns.

9:43 Soft start

10:14 Full power. Line G1

GI guns as 2*105/105 (not as requested 45/105). @ 2 m depth, 38 m to front of beam. Deep tow block retermination completed in the afternoon.

1st September 2017 - JD244

Very good weather. GI guns and Southampton streamer working well.

09:30 Decision taken on basis of promax analysis to put back streamer 8 – 10 m to increase far offset.

Completed GI asterisk survey now on GI grid.

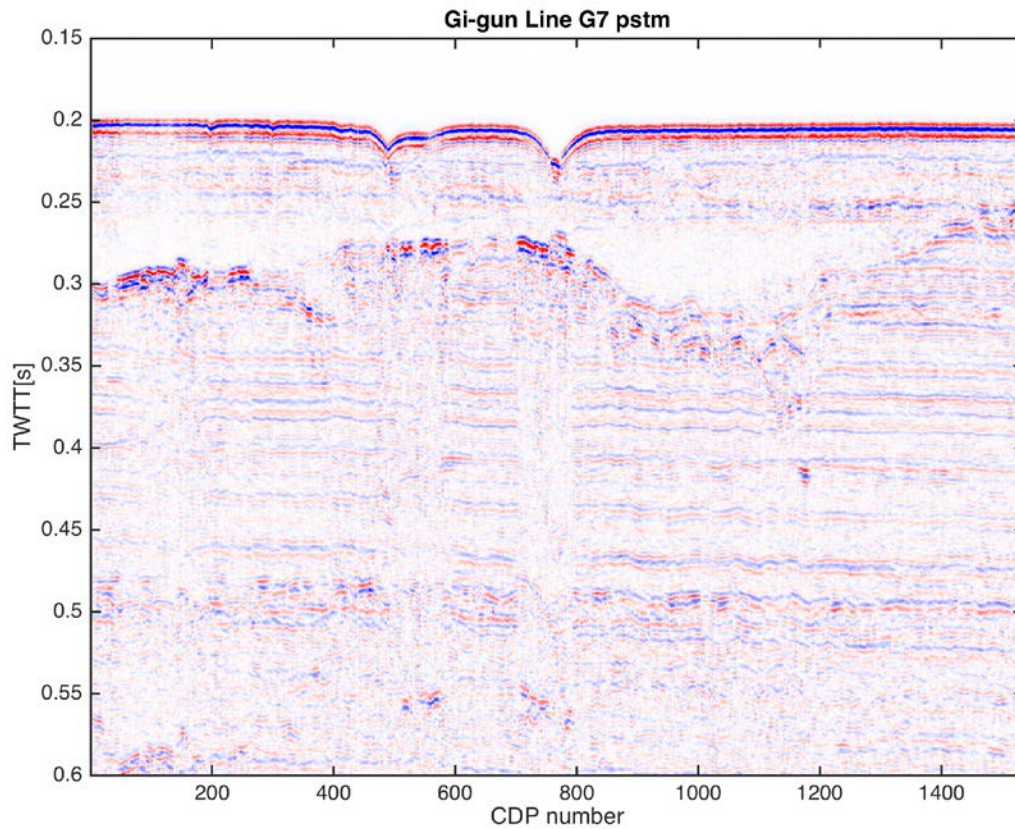


Figure 12. Example of GI-gun pre-stack time migrated profile acquired by the 60-channel Southampton streamer. Position of profile shown in Figure 13.

GI Asterisk + DASI

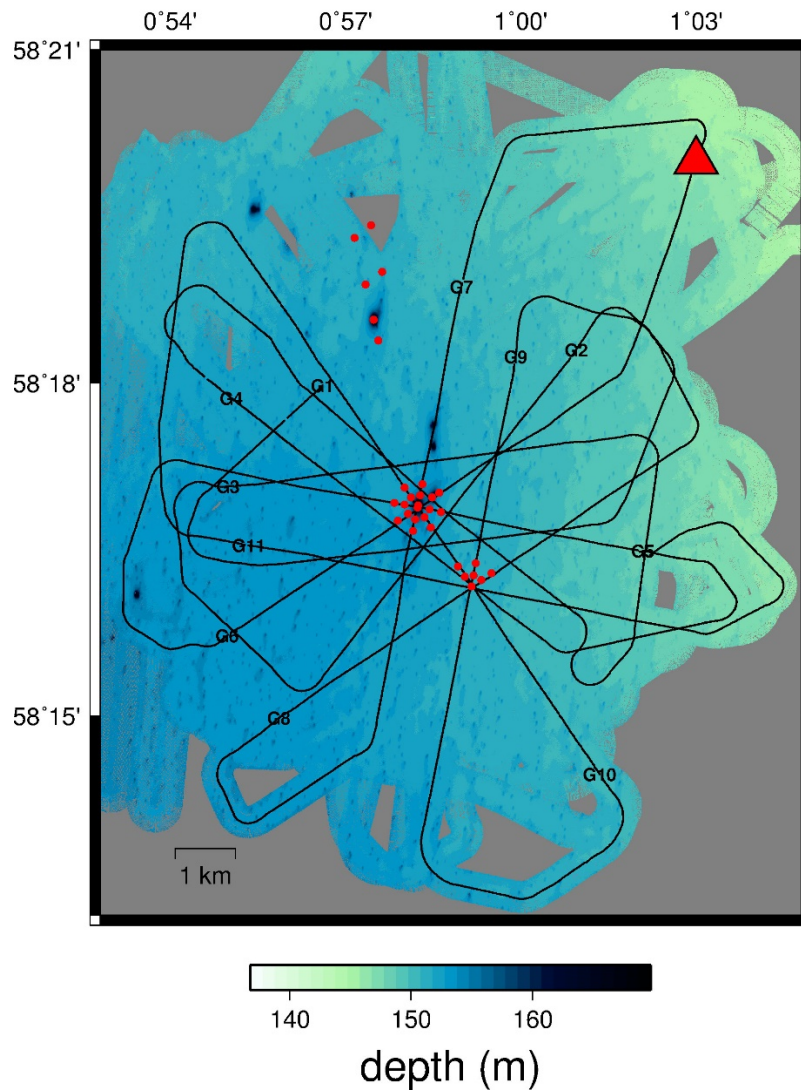


Figure 13. Map showing the position of GI guns asterisk and DASI survey lines. Shots were recorded on the Southampton 60-channel streamer, and on the 25 OBS deployed during Leg 1. Some profiles were also collected to complement lines collected during the earlier electromagnetic DASI survey on the Merian.

2nd September 2017 – JD245

Calm weather continues Completed GI grid.

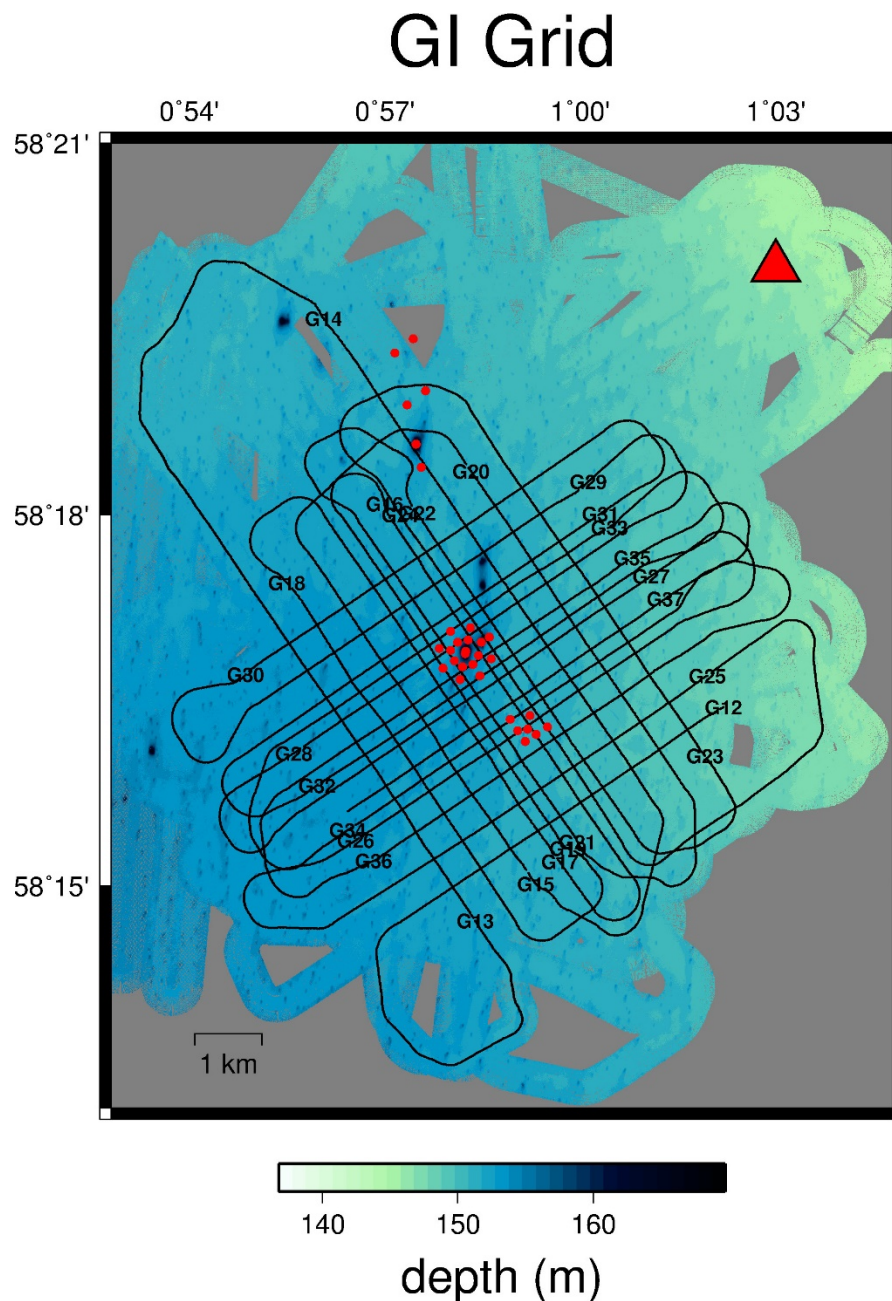


Figure 14. Map showing the position of GI guns grid survey lines. Shots were recorded on the Southampton 60-channel streamer, and on the 25 OBS deployed during Leg 1.

12:19 Recovered GI guns

12.57 Deploy deeptow with new termination. Collecting high-quality deeptow data.

Deep tow working well but in line turns the cable interfered with Southampton streamer cable. Decision made to bring in Southampton streamer. During this time a problem was found with the STR winch – the smaller power unit was not able to pull in the Deep Tow. This was fixed by switching Winch power units to the larger supplied unit.

17:30 bring in multichannel streamer.

19:00 collecting deep tow. Watchkeepers instructed how to collect DTS data with the CODA recording system. Acquiring small deeptow Asterisk survey.

DTS Asterisk

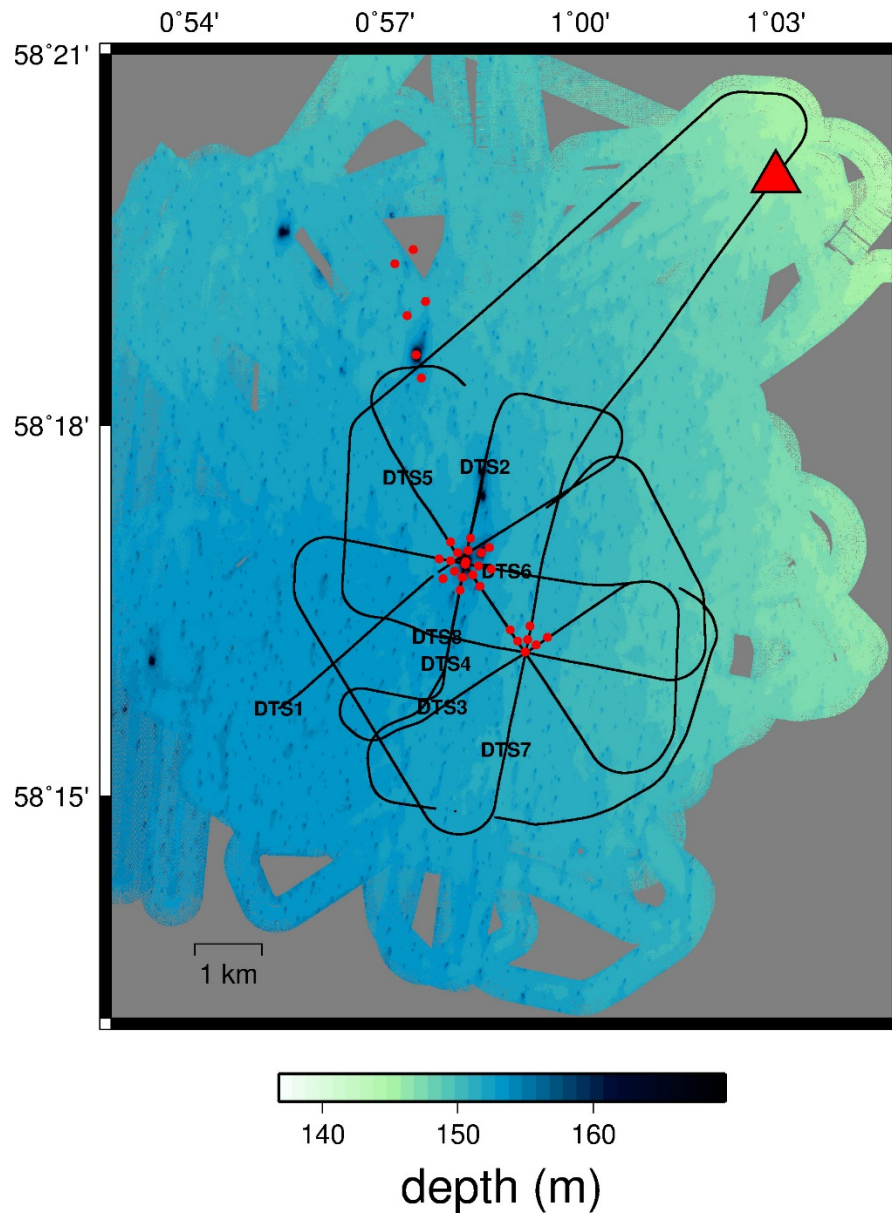


Figure 15. Map showing the position of Deep-tow sparker (DTS) asterisk survey lines. Data was recorded on a deep-tow single-channel streamer, and on the 25 OBS deployed during Leg 1. Note several DTS lines were shot multiple times due to various issues encountered with winch terminations and weather.

22:11 to 22:13: Deep tow over passive acoustic recorder.

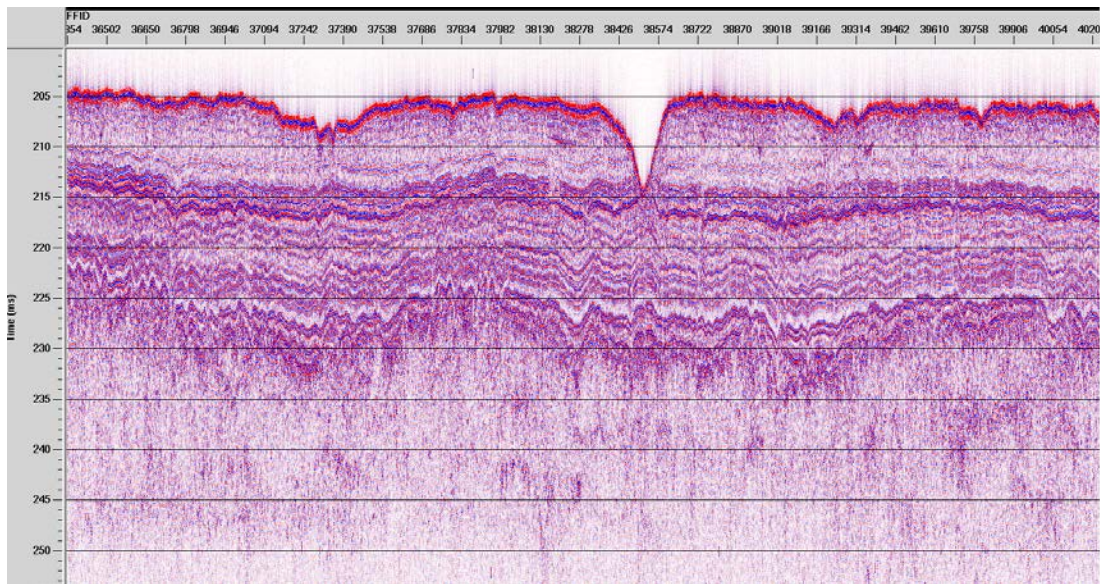


Figure 16. Example of Deep Towed Sparker single-channel line. (Figure courtesy: David Norris)

3rd September 2017 - JD246

Wind picking up noticeably. Sunny. Finished Deep tow asterisk and starting detailed sparker grid. 20 minutes line plus 1 hour line turns.

Succeeded getting tow fish depth in as “water depth” on DTS18 into Coda system. DTS19 excellent line with depth information in CODA segy over pockmark.

12:30 End of detailed DTS grid

12:45 Recovered Deep tow

Squid2000 Grid

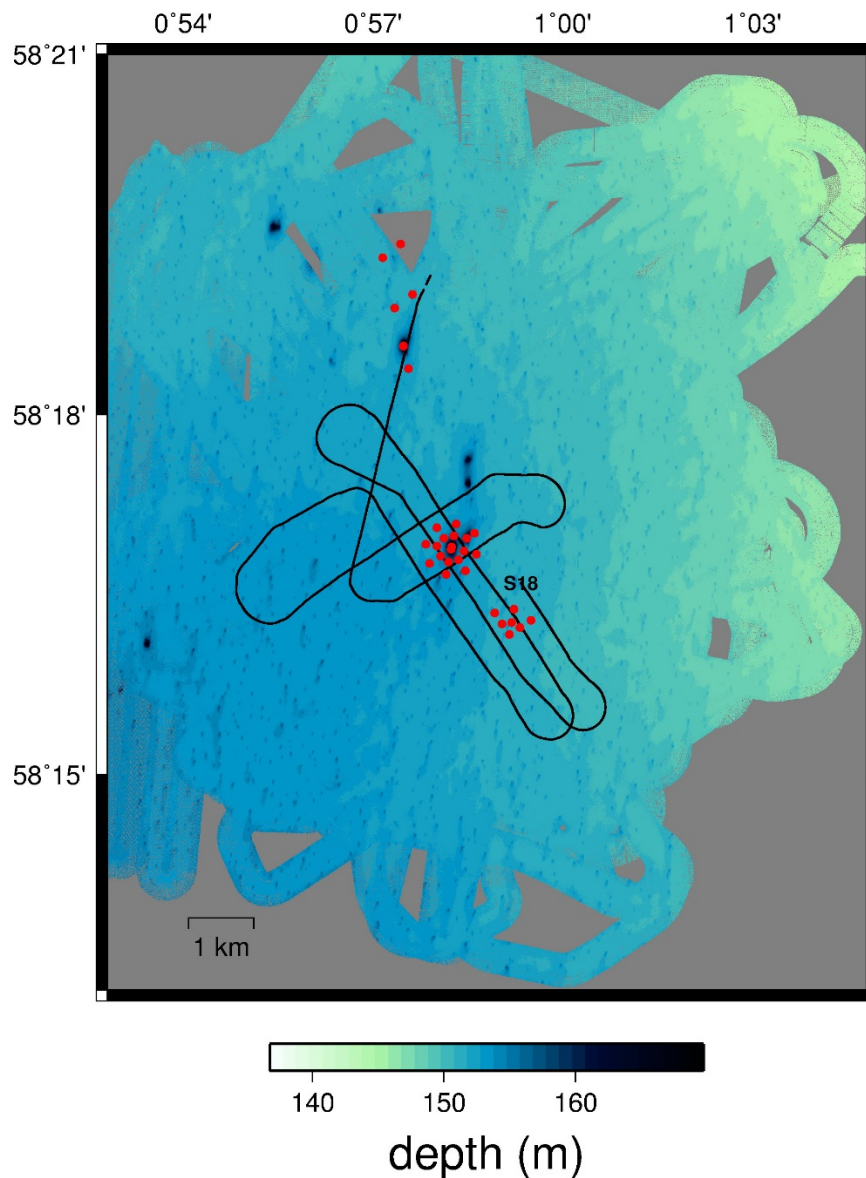


Figure 17. Map showing surface squid sparker grid profiles. These lines were collected with the Southampton streamer, with shots recorded in the Leg 1 OBS around the Scanner pockmark. Note the leg 2 OBS were not deployed during this survey.

12:55 Deployed surface squid sparker to ensure that we had successfully travelled across songmeter acoustic recorder location.

14:51 Above passive acoustic recorder with Surface sparker

15:03 Recovered surface sparker

15:30 Popped mini-lander.

15:48 Mini-lander on board

Started MMO observation

16:30 Deployed Bolt airguns. Soft Start

4th September 2017 - JD247

Gusting 25 knots, choppy seas. Bolt airgun grid continuing fine overnight.

08:45 Big shot controller PC (not big shot) has crashed. Some break in knowledge of SPs.

09:30 workaround found for controller PC issue.

13:55 Sea state had deteriorated to such a degree that Captain determined we should bring in airguns. 18 lines in Bolt grid completed out of 26. Overall good representative coverage completed.

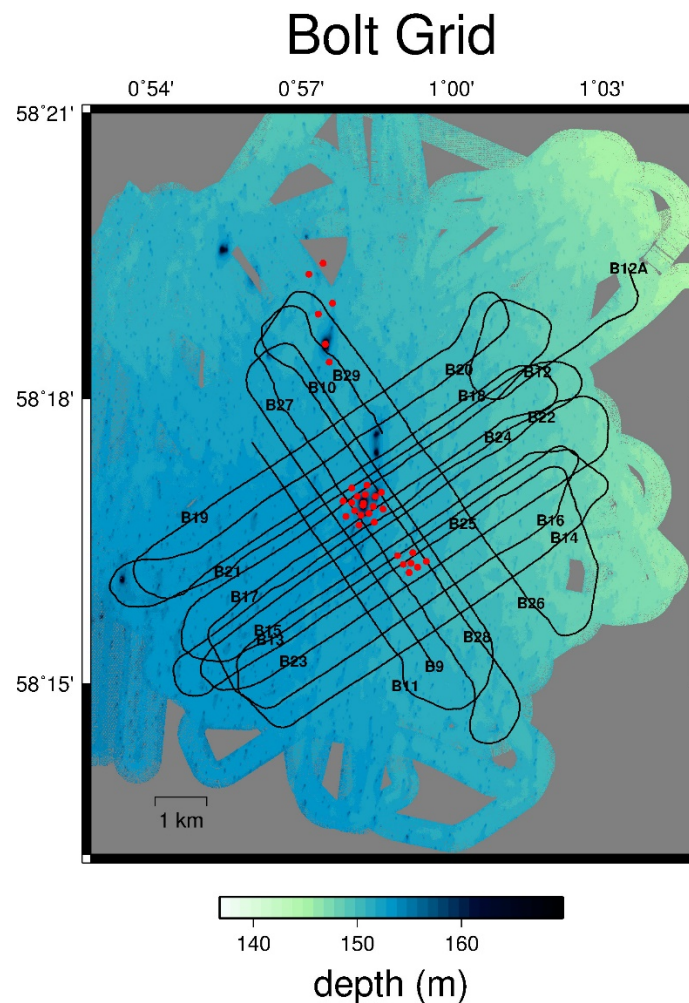


Figure 18. Map showing the location of the Bolt airgun grid. This grid was shot without a streamer into the 25 OBS around the Scanner pockmark and the reference location. Note that the northern OBS around the Challenger pockmark were only deployed after the bolt grid was completed.

Hove-to to ride out gale.

5th September 2017 – JD248

Rough weather till c. 3 am. Improving weather thereafter.

02:38 Sound Velocity Profile at OBS11 position.

03:23 First OBS recovery.

11:30 Final OBS recovery.

12:30 – 18:30 Regional bathymetry and sub-bottom profiling in improving seastate, but still rough seas.

18:30 Break off survey to go to Aberdeen for TTS streamer part.

6th September 2017

Calm, sunny day.

06:30 arrived Aberdeen. Awaiting replacement parts for TTS streamer deck unit and deck cable.

08:00 Replacement parts on board. Crew member gone ashore for medical treatment.

11:30 All onboard returning to survey area.

c. 16:00 news that a personal emergency for a crew member meant we had to return to Aberdeen to offload that person.

c. 21:00 Aberdeen again.

21:30 Leave Aberdeen for second time after offloading crew member.

7th September 2017 – JD 250

06:30 Sound Velocity Profile at OBS30 location. This is the second OBS area investigating the Challenger Pockmark, channel system and fault structure.

JC152 – Sound Velocity Profiles (SVP)

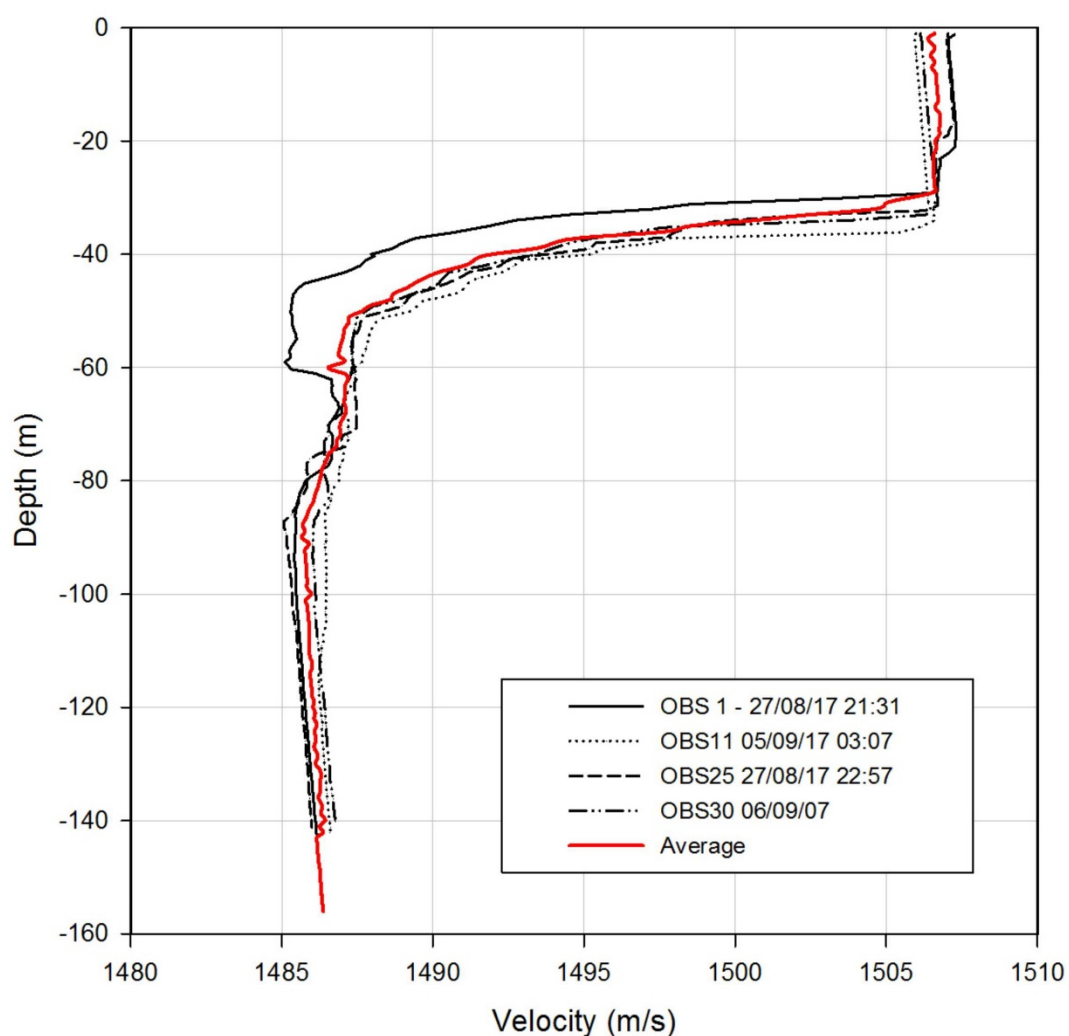


Figure 19. Graphs showing the sound velocity profiles (SVP) collected during JC152. The red line is the average depth profile.

07:00 Start deploying 7 OBS.

site_id	deployed_latitude	deployed_longitude	deployed_depth (m)	datalogger_id
26	58.3093	0.958	165.8	129
27	58.3147	0.956	149.2	138
29	58.3165	0.9607	149.7	107
30	58.3217	0.9527	150.7	126
31A	58.3236	0.9573	149.1	139
31B	58.3237	0.9575	149	113
32	58.3063	0.9597	150.2	110

Table 3. Summary of 7 OBS deployments at Challenger Pockmark

08:40 Last OBS deployed.

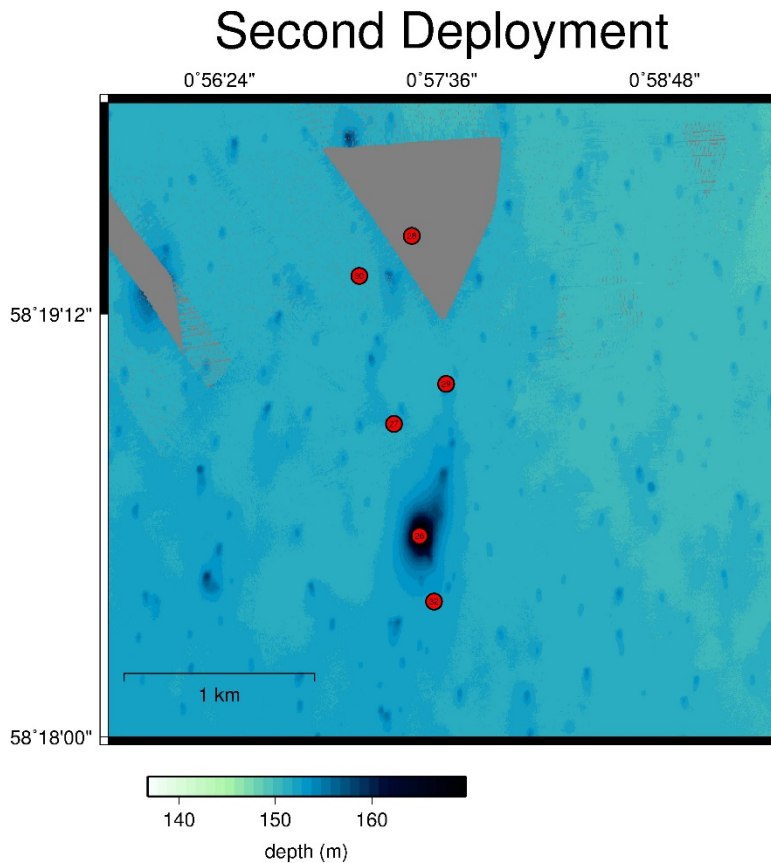


Figure 20. Map showing location of OBS 25-32 deployed during the second leg of JC152 around Challenger pockmark.

8:45 Deployed TTS streamer with tailbuoy. GeoEel set at 1 second record length and 0.125 second sampling.

09:16 Deployed Squid Surface Sparker.

09:29 Sparker on full power

10:00 Recovered front of streamer and weighted down front.

10:42 Started Sparker line 101 (I-J, Asterisk), but streamer towing very close to surface

11:35 End of line 101. Bring in streamer completely. All flotation removed.

12:30 Redeployed streamer to complete surface asterisk lines, before starting new grid lines through both Scanner and Challenger pockmarks.

13:08 Started Line S102. Streamer is now much deeper and data looks cleaner.

15:30 Collected data at 1750J squid sparker as keeps on cutting out at 2000 J. Doing asterisk lines through the main pock mark then some east-west and key north south lines

Friday 8th September – JD251

Winds dropped overnight. Slight swell, low winds.

Collected good TTS streamer data with sparker overnight. Tail buoy communications failed, have not managed to restart. Not worth bring in streamer.

05:50 sparker off.

05:55 Sparker recovered

MMO started

06:05 GI guns in. Soft start. Shooting every 6 seconds using GI reducers so volumes are $2 * 45/105$.

3 second recording on GeoEel. Watchkeepers and PSO going to cover for missing gun tech during 12 noon to midnight watch.

09:00 Deployed second "Southampton" streamer. Going to do 25 m GI grid with 4 E-W crossing strike lines.

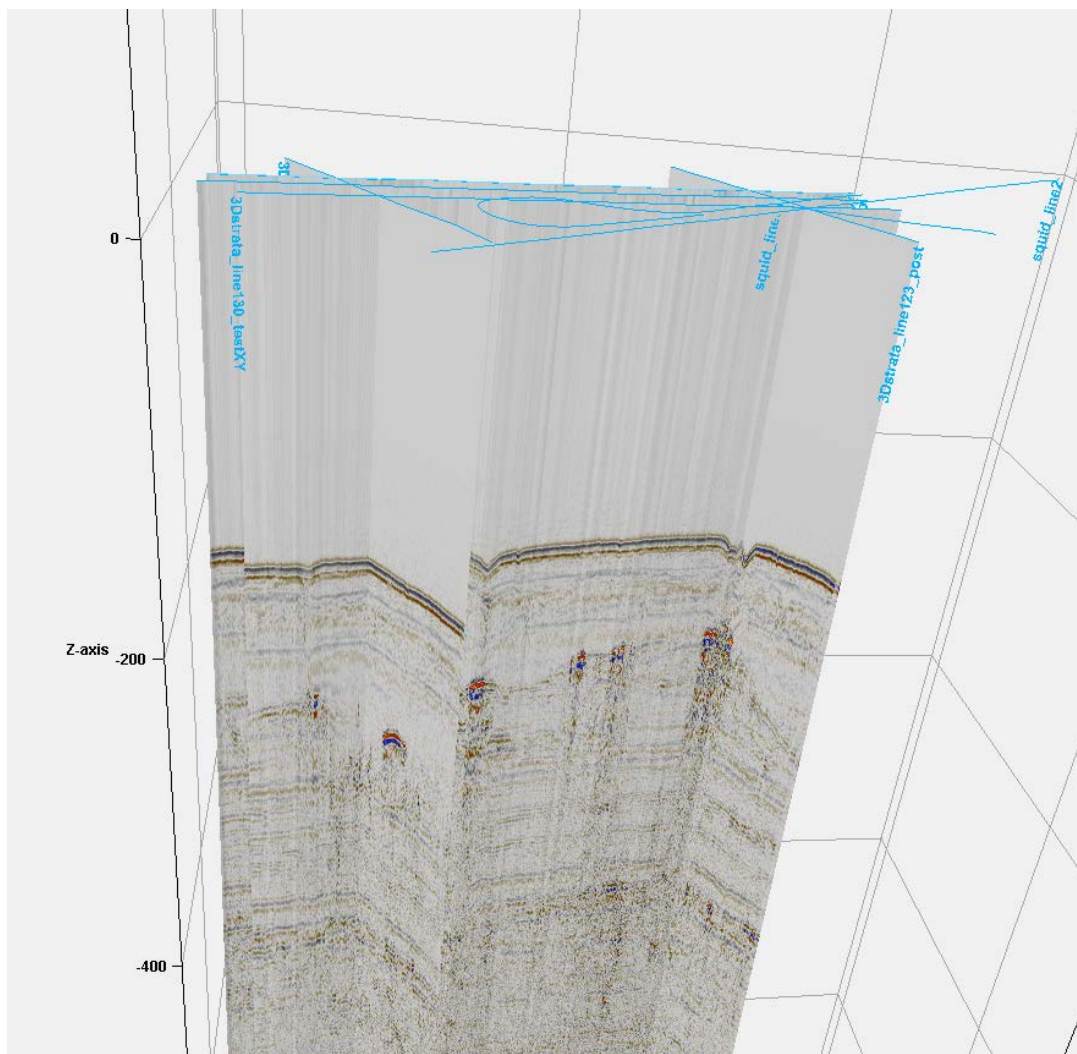


Figure 21. Intersecting post-stack GI-gun lines within the pseudo-3D volume. (Figure courtesy: H. Birinci)

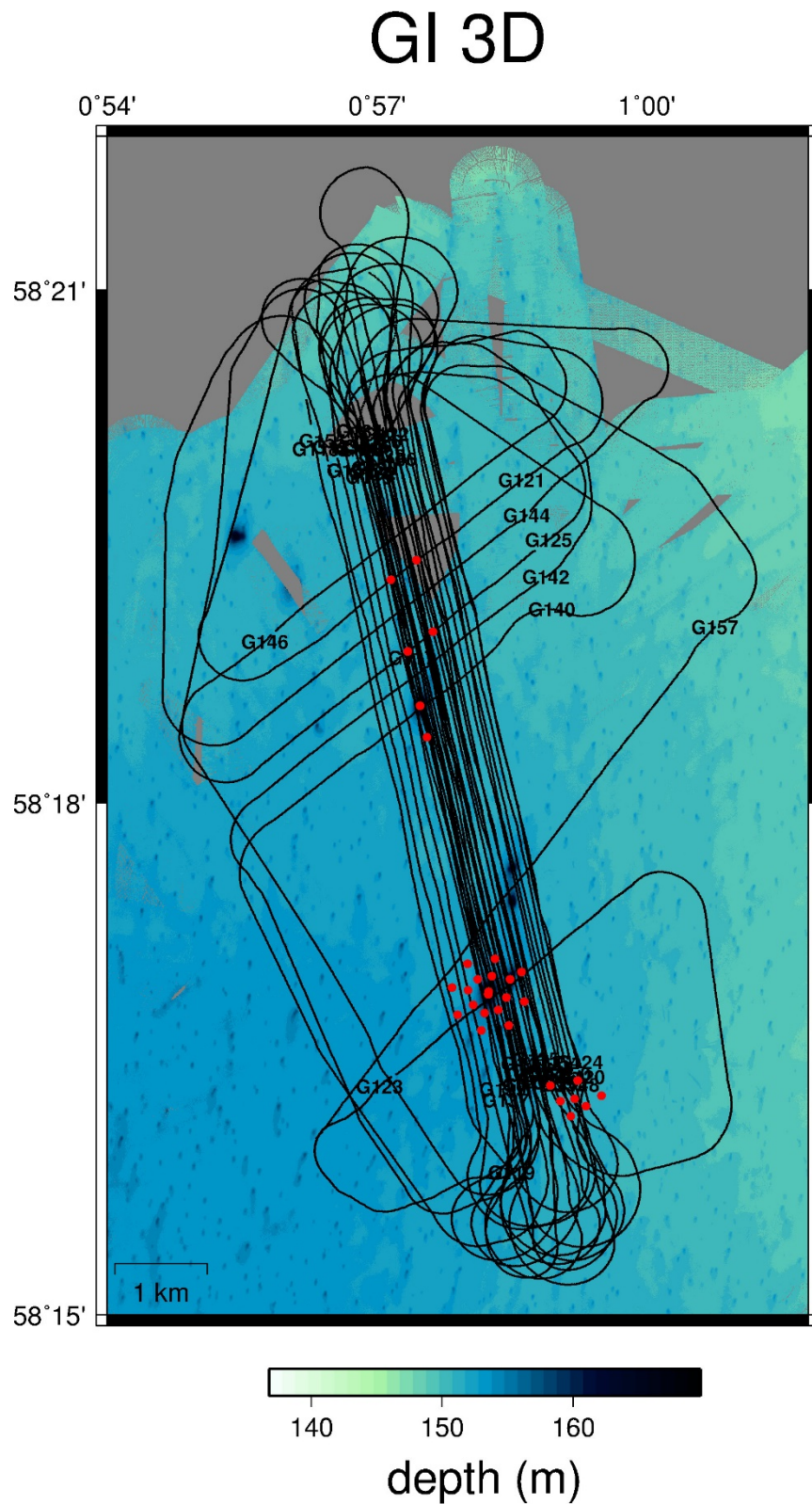


Figure 22. Map showing position of pseudo-3d grid of closely spaced GI gun profiles. These profiles were collected with two streamers, with line spacing c. 25 m. Note that only the northern OBS grid was down during the pseudo-3D grid survey. Lines were designed to cover both the Scanner and Challenger pockmark complexes, as well as northern tunnel valley, and possible position of a buried fault.

Saturday 9th September – JD252

Calm sea conditions, very slight swell. Continued GI guns with both streamers overnight and throughout day.

10th September 2017 – JD253

Continued with GI guns with both streamers. Calm sea conditions. However weather deteriorated in the evening. Have completed centre of 3D grid with 25 m spacing, 50 m to east of centre, and c. 100 m to west. Completing one line to complement DASI survey where seismic data from Merian was not complete.

15:30 Bring in both streamers and then GI guns.

16:00-16:45. Choosing deployment position of passive acoustic recorder on the Mini-lander (second deployment) with Songmeter 1 m above its base. We had chosen a line based on multibeam bathymetry water column data (looked through all data in Caris). Ship went along c. 50 m line and we chose co-ordinates where the flare was most intense. These co-ordinates were then used by the Bridge to dynamically position the stern of the vessel over the position. 16:41 Lander deployed @ 58° 16.901'N; 0° 58.237' E

17:15 Preparing to recover OBS.

17:52 First OBS recovered.

19:50 Last OBS recovered.

19:30 Deployed Deep-Tow. Going to do some regional profiles

21:30 Seastate building considerably: 2 – 3 m swell. During a turn ships speed varied a lot and during this turn the power to the Deep Tow was lost. We thought that it was likely that the termination had failed again, and we brought the deep-tow in. During the recovery of the Deep Tow there were major problems with the winch, with spooling of the winch broken.

Monday - 11th September 2017 – Recovered mini-lander, transit - JD254

2-m swell and uncomfortable overnight.

06:00 Ship more than 5 km away from acoustic recorder (on the mini-lander).

06:20 All acoustic systems turned off for 10 minutes and ship still.

c. 07:15 Recover minilander

08:00 Depart survey area for Leith. Packing up commenced on Main Deck

Tuesday 12th September 2017 – JD255

7:45 Arrived Leith. Demobilisation mostly completed on 12th September, including sending back the hired in winch to Great Yarmouth.

6. Data Acquisition and Equipment Performance

6.1 Overall seismic data acquisition geometry during JC152

JC-152 - Acquisition Geometry

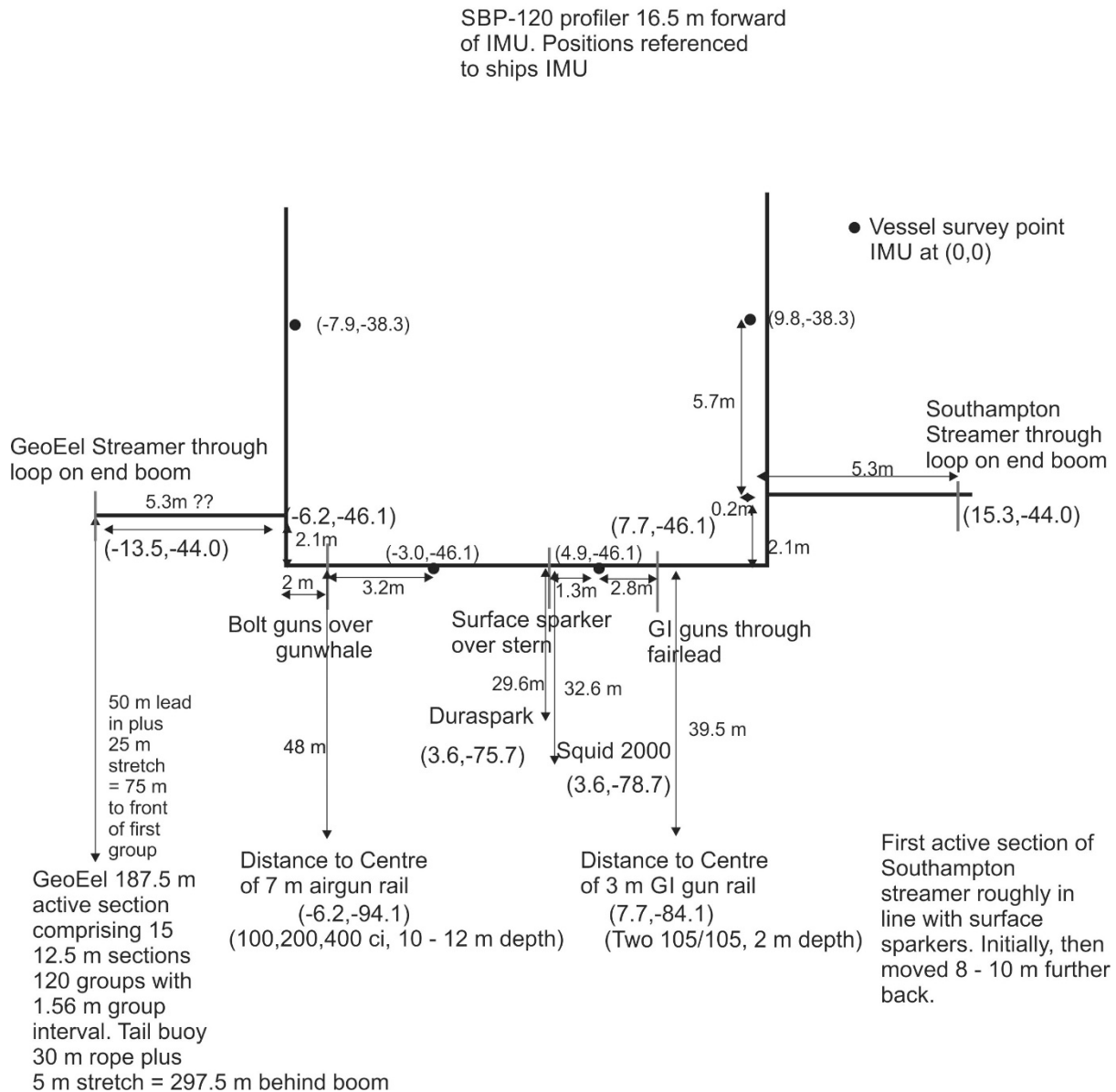


Figure 23. Overall acquisition geometry for seismic sources and multichannel streamers during JC152.

Key Acquisition Parameters Seismic Sources and Recording Systems					
				Tow position	
Seismic Sources		Firing Interval	Depth	behind stern	
Bolt Airguns	700 ci (100, 200 and 400 ci guns)	10 seconds	10 - 12 m	48 m	
GI guns					
Main Survey	420 ci (2x105/105)	8 seconds	2 m	38 m	
3D Grid	300 ci (2x45/105))	6 seconds	2 m	38 m	
Surface Sparker					
Squid	2000 or 1750J	2 seconds	Surface	33 m	
Duraspark	2000 J	2 seconds	Surface	30 m	
Deep Tow Sparker					
DTS	300J	1 second	100 - 130 m	Variable	
Source Recording Parameters					
Bolt Airguns	Only recorded on OBS				
GI Guns	Strataview: 0.5m s sample interval, 3 second record length				
	Geoeel: 0.25ms sample interval, 3 second record length				
Surface Sparker	Strataview 0.125 ms Sample interval, 0.5 second record length				
	Geoeel:0.125 ms Sample interval, 1 second record length				
Deep Tow Sparker	Strataview: 0.125 ms sample interval, 0.225 record length, 0.1 s delay				
	Coda:0.052 ms samle interval 0.2 second window length				
Seismic acquisition system and streamer details					
Strataview: 60 channels recording, 1-m group interval; 36 or 44 m from tow point to front of first group					
GeoEel : 120 channels, 1.56 m group interval; 75 m from tow point to front of first group,					

Table 4. Key acquisition parameters seismic sources and recording systems

6.2 Summary of Ocean Bottom Seismometer Deployments

OBIC deployed 32 LJ1 Ocean Bottom Seismometers spread over two deployments. The OBS were configured with metal anchor weights, a 3-axis gimballed geophone pack consisting of Sercel L28 geophones, and a Hi-Tech HTI-90-U hydrophone. The data was recording using an LJ1-type datalogger, configured to record at 4000 samples per second, and using geophone gains of x64 and a hydrophone gain of x2. The first 25 instruments were deployed for approximately 8 days and recorded approximately 50 GB of raw data each. The raw data was processed to SEG-Y, using a trace length of 8 s for the Bolt/GI shooting, limited by the total number of samples available in a SEG-Y record. The sparker data was processed using 3 s traces for the Duraspark and Squid Sparker (50% overlap), and 2 s traces for the Deep Tow Sparker (100% overlap). When processed to SEG-Y, this

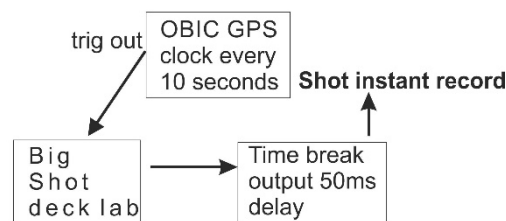
yielded 43 GB of SEG-Y data consisting of a total of 810,692 traces over the four channels. All instruments recorded without errors.

The instruments were deployed using a Seacatch TR-5 drop mechanism, rigged from the starboard parallelogram. During the first leg, 25 OBS were deployed between 01:28 and 06:50 on 28/08/17 around or close to Scanner pockmark. The recovery took an average of 8 minutes to rise from seabed to surface, and were brought on board by grappling the stray line attached to the instrument and winching it onboard. The overall pace of recovery was one instrument every 20 minutes, and took place between 03:24 and 11:21 on 05/09/17. During the second leg 7 OBS were deployed around and north of Challenger pockmark between 06:53 and 08:38 on 07/09/2017 and these instruments were recovered between 18:30 and 19:49 on 10/09/2017.

6.3 Seismic Air gun report

During JC152 two different types of airgun sources were used: Bolt Airguns and GI guns. The Bolt airguns were not used in conjunction with a streamer during JC152, these shots were recorded in the OBS deployed during Leg 1. The GI guns, as well as being recorded by the OBS, were recorded on two different multichannel streamers. There were no gun breakdowns with either type of source during the survey.

Bolt Airguns



GI guns

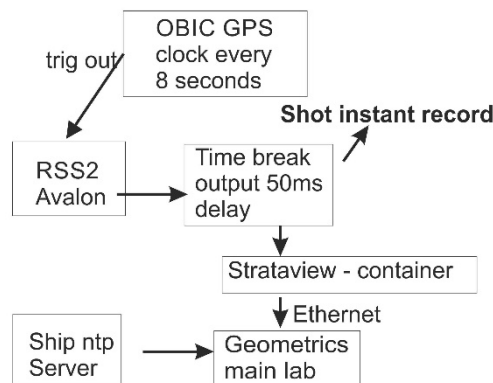


Figure 24. Triggering configuration for airguns used during JC152. The Big Shot and Avalon systems responded passively to the OBIC clock and the output time from these units was the time that should have driven the gun firing time.

Bolt Airgun

During JC152 an array of 3 x Bolt airguns was used comprising: (gun 1) 400 cu. in. furthest aft, (gun 2) 100 cu.in. in the middle of the array and (gun 3) 200 cu.in. forward and were operated at a nominal pressure of 2000 psi. These were towed on a steel beam gun frame at 48 m behind the vessel (to

centre) and at a tow depth of 10 m. A large buoy was shackled onto the aft of the frame to keep them at the desired depth. The guns were fixed with 1m of chain that secured to the frame. On this system, 2 depth sensors were installed on the frame at gun 1 and gun 3. This was to ensure that keep the guns were at a good depth at all times. For most part of the survey they stayed constant at the appropriate target depth of 10 m. Over the duration of the survey, depending on weather, current direction and vessel speed, the depth sensors gave readings between 9 m - 12 m. The guns were fired at a rate once every 10 seconds.

The gun controller used for the Bolt airgun operations was Bigshot (manufactured by Real Time Systems, RTS). The Bigshot system was set up in the Deck Lab and connected to the PC hydrophone recording system in the Main Lab by Ethernet cable using the ships switch ports. The system comprises two components: the controller module and power supply unit. The connections we used for our operations to the controller module consist of 2 BNC trigger cables, one sending a TTL 5v pulse, from the GPS master clock, the other from the CTB output to the GPS clock that was logging shot instants. To communicate between the controller unit and the PSU is a serial cable, each PSU can handle up to 4 airguns. Into the PSU are the cables coming from gun umbilical, via a junction box. Sensors, solenoids, hydrophones and depth sensors connect into here.

During survey, a total of 4 logs were recorded each line: a seg-y file, dat file and 2 log files. Each log provides different information and statistical analysis of the gun along with data recorded from the near field hydrophone.

During the first Bolt survey it became clear that no signal was being recorded for the near field phone due to incorrect wiring in a junction box. This was rectified for the second set of Bolt Airgun firing. The Bolt Airguns worked reliably during the cruise, although the source signature is mediocre. The PC for the Bigshot completely failed and died in the later stages of the survey. A work around was found using the Bigshot DOS operating system by connecting a monitor and keyboard directly into the controller module. No data files and logs could be recorded and taken off at this point. Due to this hardware failure, some log files were irretrievable.

GI guns

The majority of the airgun shooting used two Sercel GI guns. For the first part of the survey, prior to the port call in Aberdeen, the guns were set up as 2 x 210 cu.in. GI harmonic mode, Generator 105 cu.in./Injector 105 cu.in. fired at a nominal pressure of 2000 psi, with 8 second firing interval. The guns were towed on a 3 m steel beam gun frame, with 39.5 m from the stern of the vessel to the centre of the beam at a tow depth of 2 m. Gun separation on the beam was 2.1 m. The frame was held at depth by a large A5 buoy with a 1 m strop onto the aft of the frame. From the frame to the guns there was a 1 m length of chain attached to source.

After the reducer inserts were picked up in Aberdeen, the guns were used as 2 x 150 cu.in GI harmonic true mode Generator 45 cu.in./Injector 105 cu.in. at a pressure of 2000 psi, with 6 second firing interval. When shooting the 3D site, the SPI was reduced to 6 s. Modelling of source signatures before the cruise had suggested that a broader frequency spectrum could be produced using the 45/105 cu.in. combination.

For the GI guns, the recording system used was RSS2 (manufactured by Avalon Sciences). Gun signatures are shown on the acquisition screen (see Fig 25), as well as the peak voltage for each gun and the timing error in ms. Throughout the survey the near field bottle hydrophone (AGH-7100T) displayed a stable and impressively temporally short overall gun array source signature. A GPS timestamp was run from the RSS2 system and synced with the GPS clock. The RSS2 sent triggers to both the guns and also a timebreak (TB) pulse which went from our trigger junction box to the streamer recording systems. The gun timing had a 50 ms aim point delay for the correct firing of the GI guns, with the Injector having a +57 ms delay.

A total of 3 files for each line were saved, a seg-y file of the near field hydrophone, a .txt file which displayed the statistics of the line, misfires, timing errors etc. and an Excel spreadsheet which summarised the number of shots along each line, GPS start times, and corresponding record number for the multichannel seismic acquisition systems (Strataview and/or GeoEel).

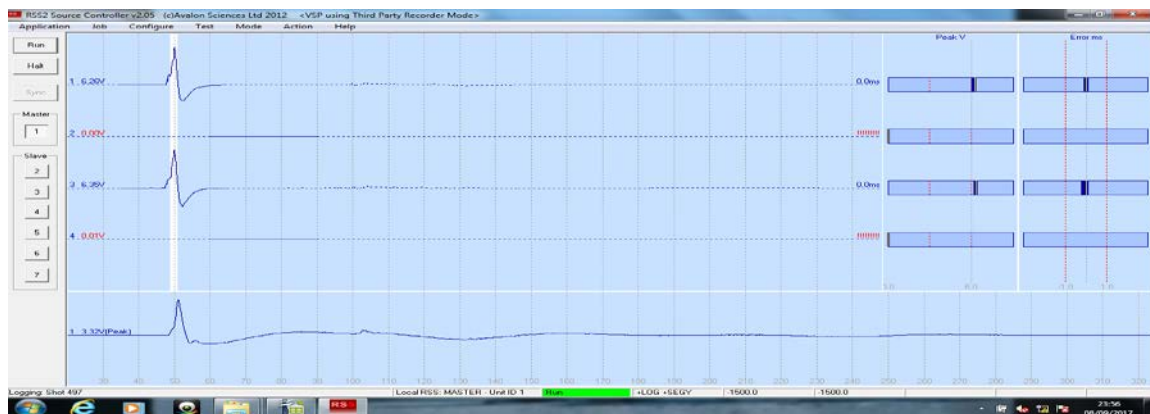


Figure 25. Source signature of each GI gun (above) and far field hydrophone (below). Image as shown on board the RSS2 unit.

6.4 High Frequency seismic systems – Sparkers

A central component of JC152 was the use of three different high frequency sparker seismic sources. manufactured by Applied Acoustics Ltd: Deeptow DTS-500, Duraspark 400 and the Squid 2000 system. The DeepTow and Duraspark systems were supplied by Applied Acoustics Ltd, together with a technical staff member, Matt Poxon. The Squid 2000 system is owned by the University of Southampton. JC152 was part of a collaboration between the University of Southampton and Applied Acoustics Ltd. All three systems worked well during the cruise, and the only issues were with the winch system used to deploy the Deep Tow sparker.

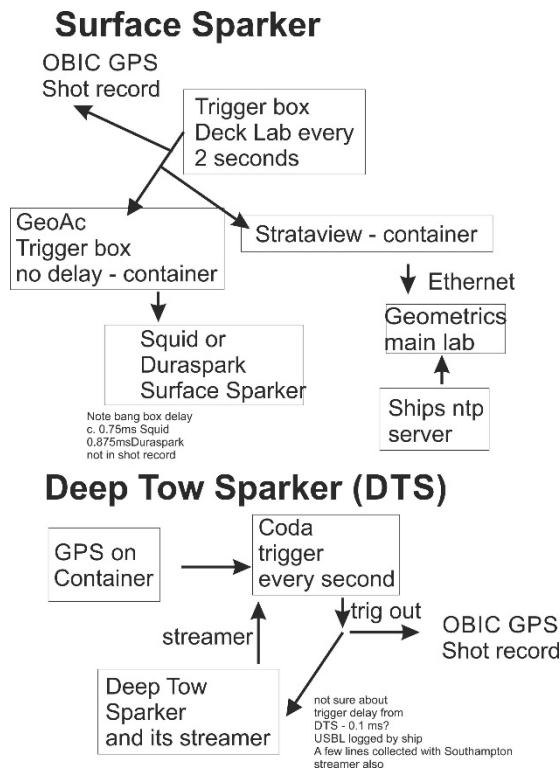


Figure 26. Summary of triggering configuration for sparker seismic sources used during JC152.

Squid 2000 Surface Sparker system

Squid 2000 catamaran was used in conjunction with the Applied Acoustics supplied CSP-D 2400 energy source which produced up to 2000 J per shot with a maximum load of 6000 A being placed on the CSP unit. Triggering for this system was provided by a free running clock provided by TTS, this was then sent via BNC at 5 volts on rising pulse to a Geo-acoustics junction box to “boost” the voltage before being sent for the CSP-D for triggering. The trigger was then timestamped via a GPS string input. This occurred on a 2 second interval. Earthing of the unit was done via cable to an external point on the port aft crane pedestal, a sea-earth was also deployed. Connection between the energy source and the Squid 2000 system was achieved via the university HV2000 cable and a HV junction box supplied by Applied Acoustics. During JC152 the system operated in the range of 1750 to 2000 J. From our past experience there is a delay of ~0.7-0.8 ms between the shot trigger and the sparker discharge.

Duraspark 400 Surface Sparker system

The Duraspark 400 system consisted a catamaran and a CSP-NV 2400 energy source. Unlike the Squid 2000 system, the Duraspark uses specially coated tips covered in plastic and the negative discharge of the CSP-NV unit to create the spark at the tips on the catamaran, increasing the endurance of the sparker tips. Its operating output of 10,000 A is greater than the Squid system. For the JC152 cruise the maximum shot output was 2000 J. Triggering was identical as for the Squid 2000, via a boosted rising time pulse every second sourced from an OBIC free running clock every 2 seconds. Earthing also remained unchanged. The connection between the towed Duraspark array was provided by a HVC 3500HV cable with connected to the CSP-NV via a HVJ-3004 junction box.

DTS-2000 Deep Tow Sparker system and associated winch system

The DTS-2000 system comprises a DTS-2000-7300 Towfish and CSP DTS 500 energy source. Unlike traditional CSP systems, where energy is transferred from a surface energy source via tow wire and emitted via a source towed behind a vessel, the CSP sends a DC voltage via a connected winch to the DTS towfish, where power modulation converts this to a useable form to power a small sparker array outputting a maximum of 300 J. Reflected signals are detected on a small towed hydrophone array towed behind the towfish. This then sends the data via BNC connection to a display unit (in this case the University of Southampton CODA system). Depth and layback was provided by the installation of an Applied Acoustics 1015 directional beacon and the vessel USBL system. Depth data was then brought in later to the CODA trace headers directly from the inbuilt depth sensor. The triggering in this instance was also provided by the CODA, and timestamped via GPS every 2 seconds. The earthing of the unit was the same as for the surface sparker sources (vessel and Sea-Earth) with the addition of the DTS tow fish being earthed to the tow wire.

For JC152 we hired in a winch with 11 mm cable from STR Ltd. The system supplied was deficient in a number of regards. First of all, the general condition of the wire was poor, it looked worn and well-used. Secondly, although the mechanical termination is sound, the overall design is not suitable as it fails offshore. The potting of the electrical connection within the mechanical termination effectively forces a full re-termination whenever there are issues. For future surveys a better design would be to bring the electrical connection further through the termination and allow a smaller amount of central core to be cut. Thirdly, and most importantly, the supplied termination failed on the first dive, and on inspection looked like it had not been carefully done. Finally, all the controllers provided for the winch had their control wiring the wrong way round, meaning that pay out ended up heaving in and vice versa.

During mobilisation for JC152 the smaller control box was fitted, rather than the larger one. We had to hastily attach the larger control unit, as the smaller one was not powerful enough to drive the winch when we needed to haul in.

6.4 Multichannel hydrophone streamers

During JC152 two different multichannel streamers were used, both specifically designed for high-frequency use in relatively shallow water. These were a 60-channel analogue streamer owned by University of Southampton ("Strataview"), and a 120-channel digital streamer rented from TTS ("Geoeel").

The Strataview streamer consists of 60 groups, each with 7 hydrophone elements equally spaced over 1 m. There is a 10 m head stretch section, and a 50 m lead-in/deck cable. The analogue signals are digitised and time-stamped on a Geometrics Strataview R60 which was positioned in a container on the rear of the deck. The data are logged on a PC in the main lab running Geometrics CNT1 Marine Controller software in SEG-D format connected to the R60 over a dedicated 100baseT Ethernet link; for each line there is also a single-channel monitor SEG-Y file, and an ASCII logfile that records the shot times for each FFID and system status. The PC used the NMF NTP server to keep synchronised to UTC, and the time on the R60 was automatically synchronised at the start of each

line, but then drifts freely. Data security during acquisition was maintained by mirrored internal disks within the PC, and files were copied over to the Southampton NAS at regular intervals. A BNC cable to the container provided the shot trigger. Recording parameters varied according to the sources in use: For the surface sparker sources 0.125 ms sample interval and 0.5 s record length, for the DTS 0.125 ms sample interval and 0.225 s record length, for the GI guns 0.25 ms sample interval and 3 s record length.

The Geoeel streamer consists of 120 groups, at 1.56 m spacing. There is a 25 m stretch section, 100 m tow lead, and additional 50 m deck lead. This is a digital streamer, with digitising cans every 8 channels in the water, a 60 V power supply runs down the streamer with Ethernet used to transmit data back to the deck unit/power supply in the deck lab. Each channel has 4 hydrophones; for the first 6 sections (48 channels) the hydrophones are spaced at 10 cm, and for the remainder of the streamer at 20 cm, around the middle of the section. Data were logged on a PC in the main lab running Geometrics CNT2 Marine Controller Software; as with the Strataview this records a SEG-Y single-trace file and an ASCII logfile along with the SEG-D shot records. A self-contained active tailbuoy was attached to the streamer, with a GPS and a radio modem that transmitted a GGA position stream to the main lab. The GGA string received most closely to the shot time is recorded in the logfile, containing both the tailbuoy position and the UTC time. Unfortunately during the deployment the tailbuoy battery compartment leaked, and so the positions are only available for lines 100-107. Subsequently we reconfigured the CNT2 software to listen to the UDP strings transmitted on the NMF network once per second, and the ZDA string received most closely to the shot time is recorded in the logfile. The Geoeel recorded Squid2000 lines at 0.125 ms sample interval and 1 s record length, and GI gun lines at 0.25 ms sample interval and 3 s record length.

6.5 NMF Scientific Ship Systems

Position and Attitude

GPS and attitude measurement systems were provided by the **Applanix POSMV** system (the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room). The position fixes attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM710 systems. The vessel's secondary GPS system is the **Kongsberg Seapath 300+** system. This was the position and attitude source that was used by the EM710 due to its superior real-time heave data. Position fixes and attitude data were logged to the Techsas system. The **CNav 3050** GPS system is the vessel's differential correction service. It provides the Applanix POSMV and Seapath330+ system with RTCM DGPS corrections (greater than 1 m accuracy). The position fixes data are logged to the Techsas system.

Throughout JC152 the heading accuracy of the **Applanix POSMV** system was degraded to ~ 0.8 of a degree while underway due to the failure of the systems secondary antenna. The accuracy decreased further while on station.

Meteorology and sea surface monitoring

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and alongside.

Kongsberg EA600 12 kHz single-beam

The EA600 single-beam echo-sounder was run throughout the cruise triggered via K-sync with the exception of times during which it was disabled whilst communication was undertaken with OBS releases. It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing. Kongsberg Raw files and History BMP files are logged and depths were logged to Techsas and Level-C. The transducer locations were altered each time the drop keel was moved.

Kongsberg EM710 Shallow multi-beam echo sounder

The EM710 multibeam echo-sounder was run mounted on the port drop keel, which was lowered to 2.270 m below the hull for the duration of operation in the work area, this is for lines 53 – 482 & 509 - 699 all other lines are with the drop keel flush with the hull. The position and attitude data was supplied from the Seapath 300+ due to its superior real-time heave. Note that the receive transducer is installed backwards.

The following figures show the system installation configuration.

Location offset (m)			
	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1/MCAST1:	0.00	0.00	0.00
Pos, COM3/MCAST2:	0.00	0.00	0.00
Pos, COM4/UDP2/MCAST3:	0.00	0.00	0.00
TX Transducer:	5.415	-0.015	6.965
RX Transducer:	4.988	0.013	6.965
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			0.368
Depth Sensor:	0.00	0.00	0.00

Figure 27 – EM710 transducer locations drop keel flush

Location offset (m)			
	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1/MCAST1:	0.00	0.00	0.00
Pos, COM3/MCAST2:	0.00	0.00	0.00
Pos, COM4/UDP2/MCAST3:	0.00	0.00	0.00
TX Transducer:	5.415	-0.015	9.235
RX Transducer:	4.988	0.013	9.235
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			0.368
Depth Sensor:	0.00	0.00	0.00

Figure 28 – EM710 transducer locations drop keel lowered

Settings | Locations | **Angular Offsets** | ROV. Specific

TX Transducer Orient.

Port
Starb.

RX Transducer Orient.

Forw.
Aft

Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	-0.418	0.228	0.000
RX Transducer:	0.130	-0.000	0.000
Attitude 1, COM2/UDP5:	-0.45	0.68	-0.38
Attitude 2, COM3/UDP6:	0	0	0
Stand-alone Heading:			0.00

Figure 29 – EM710 transducer offsets

Post processing of the EM710 was undertaken with CARIS HIPS & SIPS 10.3. A file structure was created for the cruise and two projects created, JC152_patch_test and JC152. The initial lines in the work area 53, 55, 57, 59, 61, 63 were used in project JC152_patch_test to establish the attitude Angular Offsets for the attitude system, Attitude 2. It was decided by the science party not to enter these into the EM710 system but to have them in the CARIS vessel file so they are only applied in post processing. Lines 53 – 482 & 509 - 699 were then imported daily by the technician into the project JC152, predicted tide from POLPRED software was applied and initial cleaning was undertaken by removing some of the outer beams and removing major spikes. The scientific party then undertook additional cleaning.

In addition to the standard depth and backscatter data we recorded the water column amplitudes for later identification of bubble plumes.

Kongsberg SBP120 Sub Bottom Profiler

The SBP120 Sub Bottom Profiler was run throughout JC152. There are breaks in the data due to the acoustic instrumentation being isolated for OBS deployment and recovery operations. Uncorrelated data was recorded in Kongsberg raw format and processed data in Seg-Y format.

The SBP120 runtime parameters used are shown in figure 5, the echogram display settings are shown in figure 6, and the legend settings for the display are shown in figure 7. The only processing

options enabled were in the following order below. These were the suggested settings from the Kongsberg training notes. The SBP120 software is included with the data for replay and reprocessing.

Gain correction

Transmission loss: 0.7 dB/km

Filters

Filter type: Matched

Corner frequencies: Auto

Replica shaping: enabled

Attribute processing

Attributes: Inst. amplitude

Gain

Filter coefficient 0.5

Installation parameters

Install state: Data sent 1
Install OK: true

System

EM receiver type: EM 120
No of Tx channels: 64
No of Rx channels: 64
Sampling rate [Hz]: 20480
Water level Z-pos [m]: 0.0

Transmitter array

X-position [m]: 19.18
Y-position [m]: 0.08
Z-position [m]: 6.98
Alongship angle [deg]: 0.229
Across angle [deg]: -0.139
Asimuth angle [deg]: -0.062

Receiver array

X-position [m]: 14.092
Y-position [m]: 0.954
Z-position [m]: 6.926
Alongship angle [deg]: 0.034
Across angle [deg]: -0.063
Asimuth angle [deg]: 0.133

GPS

X-position [m]: 0.00
Y-position [m]: 0.00

MRU

X-position [m]: 0.0
Y-position [m]: 0.0
Z-position [m]: 0.0
Pitch offset [deg]: -0.235
Roll offset [deg]: -0.063

Figure 30 - Sub Bottom Profiler Installation Parameters

Runtime parameters

Run state: Data sent 36932

Transmit mode: Normal

Synchronisation: External trigger
Acquisition delay [ms]: 150
Acquisition window [ms]: 150
☒ Reduce EM<->SBP crosstalk

Pulse form: Linear chirp up
Sweep low frequency [Hz]: 2500
Sweep high frequency [Hz]: 6500
☐ Minimize pulse shape
Pulse shape [%]: 20
Pulse length [ms]: 40.0
Source power [dB]: -10
Power ramping rate [dB/min]: 0.0

Beam width Tx: Normal
Beam width Rx: Normal
Number of beams: 3
Beam spacing [deg]: 3.0

☐ Calculate delay from depth
Depth from transducer [m]: 149.8
Delay hysteresis [%]: 5.0
Bottom screen position [%]: 25.0

Automatic slope correction: Off
Slope along [deg]: 0.0
Slope across [deg]: 0.0
Slope quality: 0.0
Bottom incidence range [ms]: 195
Normal incidence range [ms]: 195
Transducer sound speed: 1534.8
Average sound speed: 1534.8
Bottom sound speed: 1534.8

Figure 31 - Sub Bottom Profiler Runtime Parameters.

Echogram 1

Trace width [pixel]: 2

☒ Adjust to current window
☐ Adjust to current trace length
Min. range [ms]: 150
Max. range [ms]: 340
☒ Grid enabled
Grid depth unit: ms
Ping tick spacing: 29.0
Depth tick spacing: 10.0
☒ Show selected beam only
Selected beam number: 0
☐ Bottom lock
☐ 3D enabled

Figure 32 - Sub Bottom Profiler Echogram display settings.

Colors

View mode: Normal
Polarity: +
Scale: Linear
Color map: INVGRAY
Background:
Foreground:
Upper threshold: 100
Lower threshold: 0
Maximum value: 1.0
Minimum value: 0.0
Scale gain: 100.0
Scale unit: %

Figure 33 - Sub Bottom Profiler Legend display settings.

SIMRAD EK60 Scientific Echosounder

The Simrad EK60 Scientific Echosounder is a fish finder with several frequencies. The setup was as follows:

Frequency kHz	Power W	Pulse Length µs	Record Range m
18	2000	2048	0 - 200
38	2000	1024	0 - 200
70	300	512	0 - 200
120	250	256	0 - 200
200	150	256	0 - 200

During operation it was noted that there were linear shifts in the data with the initial pulse, which should have been seen at 6.9 m ranging from 0 m to 15 m. Investigations into the triggering and synchronisation systems found no errors. A sample of the shifts is shown in figure 8 below. Data was saved in the raw format, which can be replayed in the software provided.

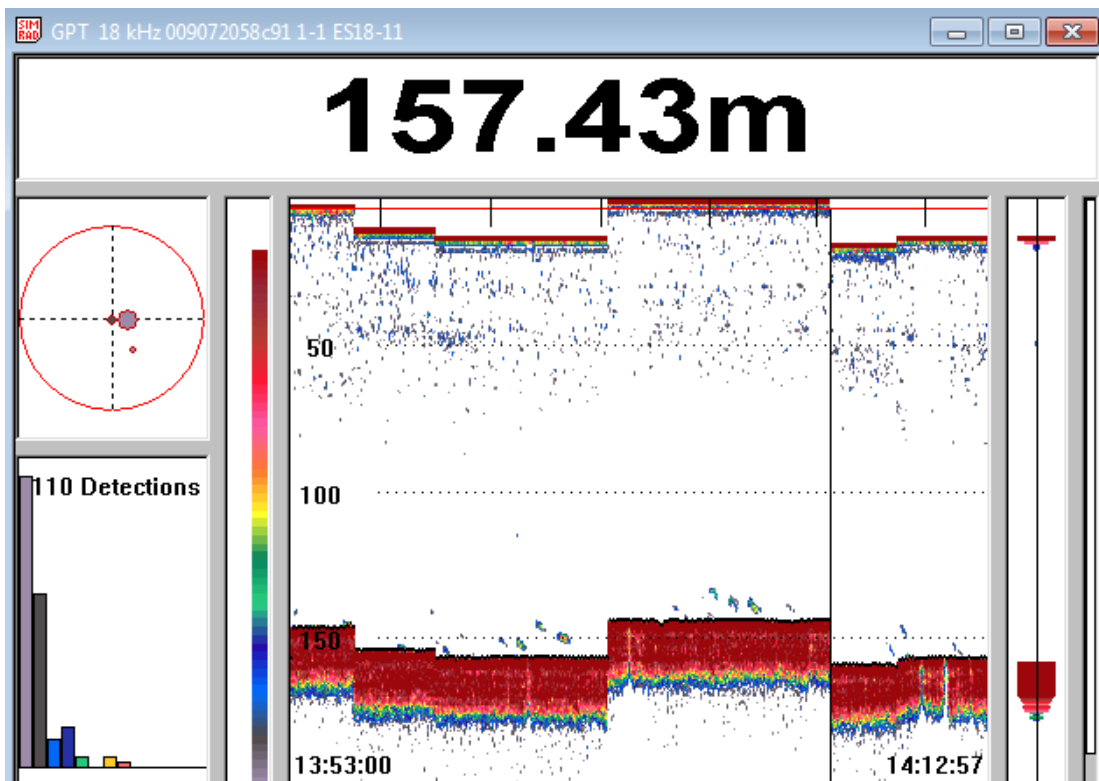


Figure 34 - EK60 datum shift

Sonardyne Ranger 2 USBL

The Sonardyne Ranger 2 USBL system was used to determine the position of the deep tow sparker system. The Applied Acoustics beacon setting were input into the Ranger 2 system with the beacon given the ID "DTS WsA1". During the first test deployment one of NMF's Sonardyne WMS beacons was also attached to the cable but wasn't required as tracking was reliable using the Applied acoustics beacon. Data was acquired by Techsas but there are gaps in the data for the period 14:31:29 – 23:31:20 on 2nd September due to the module in Techsas repeatedly crashing and requiring resetting by the watch keepers. Due to the losses in Techsas of the USBL data, files from the Ranger 2 system are available.

Sound Velocity Profiles

Four sound velocity profiles were collected during JC152 using a MIDAS Valeport SVP (SN:22355).

Time	Profile	Location
27/08/17 21:31	JC152_OBS1_sorted_extended_thinned.asvp	N 58° 16.878' E 000° 58.236'
27/08/17 22:57	JC152_OBS25_sorted_extended_thinned.asv p	N 58° 16.284' E 000° 59.496'
05/09/17 03:07	JC152_OBS11_sorted_extended_thinned.asv p	N 58° 16.986' E 000° 58.578'
06/09/07	JC152_OBS30_sorted_extended_thinned.asv p	N 58° 19.30' E 000° 57.156'

Table 5. Positions of Sound Velocity Profiles collected during JC152.

7. Recommendations

Overall JC152 was a very successful cruise with the science enabled by the excellent platform, *RRS James Cook*, and well-motivated and skilled ships company and scientific party. However the following are recommendations for improvement.

1. For all airgun systems used from the *RRS James Cook* it is important that air pressure can be logged to check system performance and ensure efficient operation.
2. The main portable scientific equipment from NMEP comprised an array of GI guns and an array of Bolt airguns. The GI guns worked well, but no depth sensors were fitted to the array, so no depth information is available; analysis of the seismic data suggests they were deeper than the 2 m requested. The Bolt guns were also deeper than the depth requested and the beam was not horizontal, so the resulting waveform bears little resemblance to the waveform designed for the experiment. The near-field hydrophones were not fitted for the first deployment. The automatically logging pressure recorders for the guns were not mobilised and therefore we have no information about gun pressures. Overall it is clear that the NERC Bolt airgun source (more than 20 years old) is no longer fit for purpose. The containerised compressors are unable to deliver a sufficiently stable air supply to operate them according to their specification; the array cannot be towed at a controlled depth. There needs to be a rethink as to how to deploy a better-tuned (ie. more guns, low frequency source).
3. Calibrated depth sensors are required for the GI guns as well as the Bolt airguns. GI guns should never be mobilised without their volume reducers.
4. Proper logging and timestamping of shot instants by NMF for their sources (Bolt and GI) with a serial string provided to recording systems is needed.
5. NMF should advise PI's on requirements and timescales for permissions processes for UK waters as they do for other coastal states. Please read Section 4.1 for our experience of the permissions process.
6. The hired in winch from STR Ltd did not perform well and was problematic for the PSO to negotiate and get installed. Much better that NMF have the requisite winches.

8. Acknowledgements

The professionalism and hard work of the entire ship's company helped to make JC152 highly successful. We thank the captain John Leask for his positive approach to ensuring that the science got completed. We are grateful to the catering staff for excellent food throughout, and the pursar Paula MacDougall for ensuring that JC152 ran smoothly.

We received valuable advice about the licensing process from Dr Barbara Berx of Marine Scotland. We thank Lylian Burke of Marine Scotland for dealing very rapidly with our application, such that the licenses arrived in time despite our very late application. We are grateful to Professor Tim Minshall (University of Southampton) for logistical support prior to, and for advice during JC152.

We thank Applied Acoustics Ltd for their support of JC152, in particular for the provision of three different sparker seismic systems, and expert technical support during the voyage.



Figure 35. James Cook 152 shipboard scientific party.

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10. Appendices

Appendix A - JC152_OBS_Deployments_Leg1

						ID									
							raw	split-track	receiver-gathers						
site_id	Lat	Long	depth(m)	deployed_time	recovered_time	logger	data_start_time	data_end_time	data_size	data_size	data_size	datalogger_sync_time	datalogger_timetag	datalogger_drift_rate	
1	58.2812	0.9708	167.3	2017:240:06:49	2017:248:03:24	129	2017:239:05:59:59.0000	2017:248:03:33:43.0000	52.53	49.21	45.48	2017:237:15:41:00	2017:248:03:34:59.9976765	-2.56E-09	
10	58.2827	0.9689	153	2017:240:05:51	2017:248:05:43	126	2017:239:05:59:59.0000	2017:248:05:50:16.0000	53.1	49.73	45.48	2017:237:16:03:00	2017:248:05:50:00.0720836	7.89E-08	
11	58.283	0.9715	156.1	2017:240:06:01	2017:248:05:25	110	2017:239:05:59:59.0000	2017:248:05:31:20.0000	52.99	49.66	45.48	2017:237:11:37:00	2017:248:05:31:59.9688721	-3.35E-08	
12	58.2805	0.9774	150.5	2017:240:04:39	2017:248:07:50	123	2017:239:05:59:59.0000	2017:248:07:54:37.0000	53.61	50.21	45.48	2017:237:13:50:00	2017:248:07:55:59.9390881	-6.56E-08	
13	58.2782	0.9746	151.1	2017:240:04:53	2017:248:07:27	131	2017:239:05:59:59.0000	2017:248:07:32:11.0000	53.51	50.12	45.48	2017:237:13:32:00	2017:248:07:33:00.0736085	7.92E-08	
14	58.2778	0.9695	151.7	2017:240:05:08	2017:248:07:09	138	2017:239:05:59:59.0000	2017:248:07:17:21.0000	53.45	50.06	45.48	2017:237:15:58:00	2017:248:07:18:00.0054857	0.000000006	
15	58.2793	0.9649	151.5	2017:240:03:22	2017:248:09:14	124	2017:239:05:59:59.0000	2017:248:09:18:43.0000	53.91	50.53	45.48	2017:237:14:23:00	2017:248:09:20:00.1528799	0.000000164	
16	58.2819	0.964	151.2	2017:240:03:38	2017:248:08:59	108	2017:239:05:59:59.0000	2017:248:09:06:49.0000	53.86	50.48	45.48	2017:237:14:05:00	2017:248:09:07:59.9888686	-1.19E-08	
17	58.2842	0.9669	151	2017:240:03:50	2017:248:08:43	119	2017:239:05:59:59.0000	2017:248:08:56:28.0000	53.86	50.44	45.48	2017:237:12:36:00	2017:248:08:55:59.9080663	-9.81E-08	
18	58.2847	0.972	151.8	2017:240:04:09	2017:248:08:24	139	2017:239:05:59:59.0000	2017:248:08:33:19.0000	53.76	50.35	45.48	2017:237:15:44:00	2017:248:08:32:59.9788571	-2.29E-08	
19	58.2693	0.986	149.6	2017:240:01:28	2017:248:11:21	128	2017:239:05:59:59.0000	2017:248:11:25:42.0000	54.43	51.02	45.48	2017:237:14:44:00	2017:248:11:26:59.9791272	-2.22E-08	
2	58.2815	0.9709	167.1	2017:240:06:45	2017:248:03:47	113	2017:239:05:59:59.0000	2017:248:03:52:01.0000	52.58	49.28	45.48	2017:237:14:33:00	2017:248:03:52:59.9907350	-1.02E-08	
20	58.2708	0.9841	149.9	2017:240:02:43	2017:248:09:54	112	2017:239:05:59:59.0000	2017:248:10:01:46.0000	54.12	50.7	45.48	2017:237:16:34:00	2017:248:10:03:00.0472437	0.000000051	
21	58.271	0.9868	150	2017:240:02:31	2017:248:10:12	109	2017:239:05:59:59.0000	2017:248:10:18:21.0000	54.22	50.76	45.48	2017:237:13:21:00	2017:248:10:17:59.9809948	-2.02E-08	
22	58.2703	0.9889	149.2	2017:240:01:45	2017:248:10:56	137	2017:239:05:59:59.0000	2017:248:11:01:50.0000	54.32	50.93	45.48	2017:237:14:45:00	2017:248:11:02:59.9437744	-0.00000006	
23	58.2723	0.9822	150.1	2017:240:02:56	2017:248:09:38	117	2017:239:05:59:59.0000	2017:248:09:43:42.0000	54.02	50.63	45.48	2017:237:14:19:00	2017:248:09:45:00.0349309	3.74E-08	
24	58.2731	0.9874	149.5	2017:240:02:16	2017:248:10:29	121	2017:239:05:59:59.0000	2017:248:10:36:06.0000	54.22	50.83	45.48	2017:237:16:20:00	2017:248:10:36:59.9026708	-1.05E-07	
25	58.2713	0.9917	149.6	2017:240:01:57	2017:248:10:43	130	2017:239:05:59:59.0000	2017:248:10:51:14.0000	54.38	50.88	45.48	2017:237:14:33:00	2017:248:10:51:00.0030481	3.25E-09	
3	58.2827	0.9749	165.7	2017:240:06:13	2017:248:05:06	135	2017:239:05:59:59.0000	2017:248:05:13:24.0000	52.94	49.59	45.48	2017:237:16:13:00	2017:248:05:12:59.9384678	-6.76E-08	
4	58.2833	0.9769	152	2017:240:04:27	2017:248:08:06	115	2017:239:05:59:59.0000	2017:248:08:11:14.0000	53.66	50.27	45.48	2017:237:14:05:00	2017:248:08:11:59.9836751	-1.76E-08	
5	58.2816	0.9671	150.9	2017:240:05:41	2017:248:06:11	111	2017:239:05:59:59.0000	2017:248:06:18:22.0000	53.25	49.83	45.48	2017:237:15:52:00	2017:248:06:17:59.9609084	-4.27E-08	
6	58.2809	0.9742	152	2017:240:06:24	2017:248:04:39	136	2017:239:05:59:59.0000	2017:248:04:44:51.0000	52.79	49.48	45.48	2017:237:16:26:00	2017:248:04:45:59.9614662	-4.24E-08	
7	58.2797	0.9727	152.2	2017:240:06:34	2017:248:04:10	107	2017:239:05:59:59.0000	2017:248:04:14:34.0000	52.69	49.36	45.48	2017:237:12:22:00	2017:248:04:15:59.9893433	-1.16E-08	
8	58.2794	0.9701	153.9	2017:240:05:18	2017:248:06:48	125	2017:239:05:59:59.0000	2017:248:06:56:49.0000	53.4	49.98	45.48	2017:237:16:09:00	2017:248:06:56:00.0003648	3.98E-10	
9	58.2802	0.9679	152.6	2017:240:05:30	2017:248:06:29	122	2017:239:05:59:59.0000	2017:248:06:36:36.0000	53.3	49.9	45.48	2017:237:12:03:00	2017:248:06:36:00.0162014	1.74E-08	

channel_mapping for all OBS
Ch0 = Horizontal Geophone 1, Ch1 = Horizontal Geophone 2, Ch2 = Vertical Geophone, Ch3 = Hydrophone/DPG
Data Logger Type for all OBS - LJ1
Sample Rate for all OBS - 4000

Appendix A - JC152 OBS Deployments Leg 2

						ID									
site_id	Lat	Long	Depth (m)	deployed_time	recovered_time	logger	data_start_time	data_end_time	raw	split_tracks	receiver	gathers			
									data_size	data_size	data_size	datalogger_sync_time	datalogger_tag	datalogger_drift_rate	
26	58.3093	0.958	165.8	2017:250:08:19	2017:253:10:32	129	2017:249:23:59:59.000000	2017:253:19:38:23.000000	22.53	21.11	27.61	2017:249:14:00:00	2017:253:19:38:59.9996240	-0.000000001	
27	58.3147	0.956	149.2	2017:250:07:42	2017:253:19:11	138	2017:249:23:59:59.000000	2017:253:19:18:18.000000	22.53	21.03	27.61	2017:249:14:38:00	2017:253:19:18:00.0023420	6.46E-09	
29	58.3165	0.9607	149.7	2017:250:07:57	2017:253:18:52	107	2017:249:23:59:59.000000	2017:253:18:56:51.000000	22.43	20.95	27.61	2017:249:13:17:00	2017:253:18:57:59.9954844	-1.23E-08	
30	58.3217	0.9527	150.7	2017:250:06:53	2017:253:18:30	126	2017:249:23:59:59.000000	2017:253:18:36:18.000000	22.32	20.87	27.61	2017:249:14:22:00	2017:253:18:36:00.0312145	8.65E-08	
31A	58.3236	0.9573	149.1	2017:250:07:09	2017:253:18:12	139	2017:249:23:59:59.000000	2017:253:18:19:31.000000	22.27	20.81	27.61	2017:249:14:33:00	2017:253:18:18:59.9910911	-2.48E-08	
31B	58.3237	0.9575	149	2017:250:07:23	2017:253:17:51	113	2017:249:23:59:59.000000	2017:253:17:56:58.000000	22.12	20.72	27.61	2017:249:14:04:00	2017:253:18:02:59.9955934	-1.22E-08	
32	58.3063	0.9597	150.2	2017:250:08:38	2017:253:19:49	110	2017:249:23:59:59.000000	2017:253:19:54:27.000000	22.63	21.18	27.61	2017:249:14:18:00	2017:253:19:54:59.9864674	-0.000000037	

channel_mapping for all OBS
Ch0 = Horizontal Geophone 1, Ch1 = Horizontal Geophone 2, Ch2 = Vertical Geophone, Ch3 = Hydrophone/DPG
Data logger type - LJ1
Data sample rate - 4000

Appendix B Song Meter SM2M Passive Acoustic Recorder Summary

During JC152, two deployments were made of a passive acoustic recorder (Song Meter SM2M) using a mini-lander and associated mooring buoys. In the first deployment the acoustic recorder was placed c. 28 m above the seabed on a mooring rope above the mini-lander with the aim of recording far-field seismic source signatures from all the different seismic systems used. In the second deployment the acoustic recorder was mounted directly on the mini-lander c. 1 m above the seabed within the western Scanner pockmark in a methane bubble flare. The aim in the second deployment was to record and determine the methane gas flux.

Parameters - Deployment (1)

Location: 1° 03.018' E, 58°20.011'N, in 143 m of water. Northwest of the Scanner Pockmark, uniform seabed.

Program: To record every other 5 minutes from GMT 12:00 on 28/8/17 (such that data will be collected from 12:00 to 12:05, 12:10 to 12:15, 12:20 to 12:25...) until collection of device at GMT 15:50 on 3/9/17.

Sample Rate: 44,100 Hz (44.1 kHz). C channels: 2 (Left & Right).

Digital Gain: ± 0 dB (Left Channel), + 6 dB (Right Channel). Filtering: No filters applied.

File Format: WAV. Filename Prefix: CD152DEP1

Song Meter Configuration Utility 3.2.4

The image displays five screenshots of the Song Meter Configuration Utility 3.2.4 software interface, showing different configuration tabs:

- General Tab:** Shows the model (SM2M), schedule (Advanced), and start time (08/28/2017 12:00:00). It includes a list of events: 01 AT TIME 12:00:00, 02 RECORD 00:05:00, 03 PAUSE 00:05:00, and 04 GOTO LINE 02:00X. There are buttons for 'Delete', 'New Line', 'Command', 'Go to line', 'Loops', and 'Insert'.
- Audio Tab:** Shows sample rate (44100), channels (Stereo), and file format (WAV). It includes microphone gain settings for Left (+0.0) and Right (+6.0) channels, and an 'Override' checkbox.
- Location Tab:** Shows the prefix (CD152DEP1), solar mode (Sunrise/set), and an 'Override' checkbox. It also shows time zone (+00 :00) and latitude/longitude (0.00 N, 0.00 W).
- Sensors Tab:** Shows internal and external sensor configurations. Internal sensor type is Linear, zero is 400.00, unit is 19.50, and digits are 1. External sensor type is Linear, zero is 0.00, unit is 1000.00, and digits are 3.
- Capacity Tab:** Shows flash card capacities (64GB, None, None, None) and power consumption settings (Power Source: Internal, Battery Type: Alkaline, mAh capacity: 96000, %/mo discharge: 1).

Parameters - Deployment (2) in Scanner Pockmark

10th September 2018_16:41 Lander deployed @ 58° 16.901'N; 0° 58.237' E in Scanner pockmark

Program: To record every other 5 minutes

Sample Rate: 44,100 Hz (44.1 kHz).

Channels: 2 (Left & Right). Digital Gain: 6 dB (Left Channel), 36 dB (Right Channel).

Filtering: None applied File Format: WAV.

Filename Prefix: CD152DEP2

Appendix C JC152 Survey lines start and end times and coordinates shot

Type	Type	SOL						EOL						GeoEel/Strataview file		start	end	Source	Coda Log File
Source	Survey	JD	Start	Lat	Long	Shot	Shot	JD	End	Lat	Long	Shot	Shot	Area	Line				
1	1	240	14:52	58 15.913	0 58.828	1		240	17:09	58 18.443	1 2.469	880		Bolt_Asterisk	B1	No streamer	test		Bolt lander shot555
1	1	240	17:18	58 18.443	1 2.469	882		240	18:37	58 15.018	0 55.92	1355		Bolt_Asterisk	B2	No streamer	I	J	Bolt 700ci 10s
1	1	240	18:38	58 15.018	0 55.92	1356		240	20:20	58 16.506	1 2.885	1970		Bolt_Asterisk	B3	No streamer	R	Q	Bolt 700ci 10s
1	1	240	20:20	58 16.506	1 2.885	1971		240	21:55	58 16.564	0 55.321	2538		Bolt_Asterisk	B4	No streamer	K	L	Bolt 700ci 10s
1	1	240	21:55	58 16.564	0 55.321	2539		241	00:15	58 18.129	0 59.889	3372		Bolt_Asterisk	B5	No streamer	T	S	Bolt 700ci 10s
1	1	241	00:14	58 18.129	0 59.889	3373		241	01:47	58 19.895	0 57.523	3928		Bolt_Asterisk	B6	No streamer	V	U	Bolt 700ci 10s
1	1	241	01:47	58 19.895	0 57.523	3929		241	03:44	58 19.236	0 55.157	4633		Bolt_Asterisk	B7	No streamer	O	P	Bolt 700ci 10s
1	1	241	03:44	58 19.236	0 55.157	4634		241	05:36	58 15.247	0 59.566	5302		Bolt_Asterisk	B8	No streamer	N	M	Bolt 700ci 10s
1	2	241	05:36	58 15.247	0 59.566	5303		241	06:44	58 18.024	0 57.534	5709		Bolt_Grid	B9	No streamer	AY	AZ	Bolt 700ci 10s
1	2	241	06:44	58 18.024	0 57.534	5710		241	07:50	58 15.07	0 59.033	6106		Bolt_Grid	B10	No streamer	BJ	BI	Bolt 700ci 10s
1	2	241	07:50	58 15.07	0 59.033	6107		241	08:31	58 17.542	0 55.995	6363		Bolt_Grid	B11	No streamer	BX	DU	Bolt 700ci 10s
2	3	241	11:07	58 17.909	1 1.149	989		241	13:03	58 14.382	1 1.575	3656		Sparker_Asterisk	S1	1	I	J	Squid 2000J 2s
2	3	241	13:03	58 14.382	1 1.575	3657		241	16:25	58 16.889	0 58.242	9429		Sparker_Asterisk	S2	2	M	N	Squid lander Shot 7654
2	3	241	16:25	58 16.889	0 58.242	9430		241	17:08	58 15.746	0 58.006	10740		Sparker_Asterisk	S3	3	BY	BZ	Squid 2000J 2s
2	3	241	17:08	58 15.746	0 58.006	10741		241	18:01	58 16.855	0 59.405	12292		Sparker_Asterisk	S4	4	CB	CA	Squid 2000J 2s
2	3	241	18:01	58 16.855	0 59.405	12293		241	19:04	58 16.269	0 58.115	14169		Sparker_Asterisk	S5	5	CF	CE	Squid 2000J 2s
2	3	241	19:04	58 16.269	0 58.115	14170		241	19:56	58 16.752	0 59.55	15721		Sparker_Asterisk	S6	6	CD	CC	Squid 2000J 2s
2	3	241	19:56	58 16.752	0 59.55	15722		241	20:55	58 17.65	0 58.487	17476		Sparker_Asterisk	S7	7	BX	BW	Squid 2000J 2s
2	3	241	20:55	58 17.65	0 58.487	17477		241	21:39	58 16.386	0 57.338	18804		Sparker_Asterisk	S8	8	BZ	BY	Squid 2000J 2s
2	3	241	21:39	58 16.386	0 57.338	18805		241	22:12	58 16.501	0 59.705	19766		Sparker_Asterisk	S9	9	CR	CQ	Squid 2000J 2s
2	3	241	22:12	58 16.501	0 59.705	19767		241	22:48	58 16.603	0 57.937	20841		Sparker_Asterisk	S10	10	CW	CX	Squid 2000J 2s
2	3	241	22:48	58 16.603	0 57.937	20842		241	23:36	58 16.26	0 59.802	22266		Sparker_Asterisk	S11	11	CN	CM	Squid 2000J 2s
2	3	241	23:36	58 16.26	0 59.802	22267		242	00:21	58 16.206	0 58.177	23605		Sparker_Asterisk	S12	12	CY	CZ	Squid 2000J 2s
2	3	242	00:21	58 16.206	0 58.177	23606		242	01:05	58 17.169	0 58.683	24902		Sparker_Asterisk	S13	13	CT	CS	Squid 2000J 2s
2	3	242	01:05	58 17.169	0 58.683	24903		242	01:58	58 16.631	0 59.753	26520		Sparker_Asterisk	S14	14	CK	CL	Squid 2000J 2s
2	3	242	01:58	58 16.631	0 59.753	26521		242	02:33	58 16.911	0 59.056	27526		Sparker_Asterisk	S15	15	CV	CU	Squid 2000J 2s
2	3	242	02:33	58 16.911	0 59.056	27527		242	03:03	58 16.44	0 56.231	28456		Sparker_Asterisk	S16	16	CO	CP	Squid 2000J 2s
2	3	242	03:03	58 16.44	0 56.231	28457		242	04:10	58 16.521	0 59.442	30433		Sparker_Asterisk	S17	17	CJ	CL	Squid 2000J 2s
2	4	242	04:10	58 16.521	0 59.442	30434		242	04:57	58 16.925	0 57.923	31816		Sparker_Grid	S18	18	DL	DK	Squid 2000J 2s
2	4	242	04:57	58 16.925	0 57.923	31817		242	05:53	58 16.179	0 59.424	33504		Sparker_Grid	S19	19	DE	DF	Squid 2000J 2s
2	4	242	05:53	58 16.179	0 59.424	33505		242	06:18	58 15.807	0 58.888	34220		Sparker_Grid	S20	20	DH	DG	Squid 2000J 2s
2	4	242	06:18	58 15.807	0 58.888	34221		242	07:24	58 16.913	0 57.225	35046		Sparker_Grid	S21	21	DA	DB	Squid 2000J 2s
2	4	242	07:24	58 16.913	0 57.225	35047		242	07:57	58 17.012	0 59.027	37168		Sparker_Grid	S22	22	CH	CG	Squid 2000J 2s
2	4	242	07:57	58 17.012	0 59.027	37169		242	09:12	59 19.285	0 58.013	37538		Sparker_Grid	S23	23	CM	CN	Squid 2000J 2s
3	3	242	09:12	59 19.285	0 58.013	37539		242	10:07	58 19.18	0 55.287	39311		Sparker_Asterisk	S24	24	testline		Duraspark 2000J 2 s
3	3	242	10:07	58 19.18	0 55.287	39312		242	12:28	58 18.799	0 55.028	43504		Sparker_Asterisk	S25	25	N	M	Duraspark 2000J 2 s
3	3	242	12:28	58 18.799	0 55.028	43505		242	14:44	58 17.572	0 58.992	47504		Sparker_Asterisk	S26	26	J	I	Duraspark lander - 45839-45944
3	3	242	14:44	58 17.572	0 58.992	47585		242	15:34	58 15.439	0 58.886	49066		Sparker_Asterisk	S27	27	BZ	BY	Duraspark 2000J 2 s
3	3	242	15:34	58 15.439	0 58.886	49067		242	16:24	58 16.545	1 0.238	50584		Sparker_Asterisk	S28	28	CE	CF	Duraspark 2000J 2 s
3	3	242	16:24	58 16.545	1 0.238	50585		242	17:18	58 16.288	0 57.859	52147		Sparker_Asterisk	S29	29	CA	CB	Duraspark 2000J 2 s
3	3	242	17:18	58 16.288	0 57.859	52148		242	18:06	58 16.753	0 59.473	53588		Sparker_Asterisk	S30	30	CD	CC	Duraspark 2000J 2 s
3	3	242	18:06	58 16.753	0 59.473	53588		242	19:21	58 15.477	0 58.061	55828		Sparker_Asterisk	S31	31	BW	BX	Duraspark 2000J 2 s
3	4	242	19:21	58 15.477	0 58.061	55829		242	20:41	58 19.342	0 55.555	58231		Sparker_Grid	S32	32	DO	DP	Duraspark 2000J 2 s
3	4	242	20:41	58 19.342	0 55.555	58232		242	21:58	58 16.447	1 0.783	60527		Sparker_Grid	S33	33	DN	?	Duraspark 2000J 2 s
3	4	242	21:58	58 16.447	1 0.783	60528		242	23:23	58 19.038	0 54.978	63007		Sparker_Grid	S34	34 AND 35	DQ	DR	Duraspark 2000J 2 s
3	4	242	23:23	58 19.038	0 54.978	63008		243	00:43	58 16.34	0 59.475	65447		Sparker_Grid	S35	36	DM	DC	Duraspark 2000J 2 s
3	5	243	00:43	58 16.34	0 59.475	65448		243	01:36	58 17.456	0 57.163	67000		Sparker_OBS	S36	37	?		Duraspark 2000J 2 s
3	5	243	01:36	58 17.456	0 57.163	67001		243	02:29	58 16.198	0 59.31	68572		Sparker_OBS	S37	38	JA	JB	Duraspark 2000J 2 s

Type	Type	SOL						EOL						GeoEel/Strataview file									
Source	Survey	JD	Start	Lat	Long	Shot	Shot	JD	End	Lat	Long	Shot	Shot	Area	Line		start	end	Source	Coda Log File			
3	5	243	02:29	58 16.198	0 59.31	68573		243	03:25	58 17.361	0 57.452	70242		Sparker_OBS	S38	39	IV	IU	Duraspark 2000J 2 s				
3	5	243	03:25	58 17.361	0 57.452	70243		243	04:20	58 16.284	0 59.093	71906		Sparker_OBS	S39	40	IY	IZ	Duraspark 2000J 2 s				
3	5	243	04:20	58 16.284	0 59.093	71907		243	05:18	58 17.292	0 57.881	73591		Sparker_OBS	S40	41	JF	JE	Duraspark 2000J 2 s				
3	5	243	05:18	58 17.292	0 57.881	73592		243	06:09	58 16.061	0 58.524	75128		Sparker_OBS	S41	42	IW	IX	Duraspark 2000J 2 s				
3	5	243	06:09	58 16.061	0 58.524	75129		243	07:19	58 16.881	1 0.011	77178		Sparker_OBS	S42	43	JH	JG	Duraspark	(DS)			
3	5	243	07:19	58 16.881	1 0.011	77179		243	09:16	58 20.195	1 2.461	80302		Sparker_OBS	S43	44	JL	JK	DS lander 80217 - 80254				
4	6	243	10:14	58 17.904	0 56.437	171		243	12:08	58 17.961	1 0.452	1009		GI_DASI	G1	45	F	E	2*GI 105/105 8sec				
4	6	243	12:08	58 17.961	1 0.452	1010		243	13:35	58 17.076	0 55.279	1659		GI_DASI	G2	46	A	B	2*GI 105/105 8sec				
4	6	243	13:35	58 17.076	0 55.279	1660		243	16:24	58 17.79	0 55.207	2888		GI_DASI	G3	47	H	G	2*GI 105/105 8sec				
4	6	243	16:24	58 17.79	0 55.207	2889		243	17:54	58 16.505	1 1.841	3591		GI_DASI	G4	48	C	D	2*GI 105/105 8sec				
4	7	243	17:54	58 16.505	1 1.841	3592		243	19:24	58 15.779	0 55.088	4264		GI_Asterisk	G5	49	L	L	2*GI 105/105 8sec				
4	7	243	19:24	58 15.779	0 55.088	4265		243	21:48	58 18.805	0 58.955	5331		GI_Asterisk	G6	50	G	L	GI lander 4979-4989				
4	7	243	21:48	58 18.805	0 58.955	5332		243	23:27	58 15.05	0 56.065	6080		GI_Asterisk	G7	51	P	O	2*GI 105/105 8sec				
4	7	243	23:27	58 15.05	0 56.065	6081		244	01:02	58 18.095	0 59.875	6790		GI_Asterisk	G8	52	R	Q	2*GI 105/105 8sec				
4	7	244	01:02	58 18.095	0 59.875	6791		244	02:39	58 19.934	1 1.242	7509		GI_Asterisk	G9	53	V	U	2*GI 105/105 8sec				
4	7	244	02:39	58 19.934	1 1.242	7510		244	04:45	58 16.529	0 55.561	8451		GI_Asterisk	G10	54	M	N	2*GI 105/105 8sec				
4	7	244	04:45	58 16.529	0 55.561	8452		244	06:14	58 16.396	1 2.018	9115		GI_Asterisk	G11	55	T	S	2*GI 105/105 8sec				
4	8	244	06:14	58 16.396	1 2.018	9116		244	07:37	58 14.767	0 58.314	9735		GI_Grid	G12	56	AW	AX	2*GI 105/105 8sec				
4	8	244	07:37	58 14.767	0 58.314	9735		244	09:26	58 19.501	0 56.209	10552		GI_Grid	G13	57	BO	BP	2*GI 105/105 8sec				
4	8	244	09:26	58 19.501	0 56.209	10552		244	10:55	58 15.084	0 59.213	11216		GI_Grid	G14	58	BR	BQ	2*GI 105/105 8sec				
4	8	244	10:55	58 15.084	0 59.213	11217		244	11:52	58 17.962	0 57.14	11640		GI_Grid	G15	59	BK	BU	2*GI 105/105 8sec				
4	8	244	11:52	58 17.962	0 57.14	11641		244	12:54	58 15.235	0 59.618	12096		GI_Grid	G16	60	BF	BE	2*GI 105/105 8sec				
4	8	244	12:54	58 15.235	0 59.618	12097		244	13:52	58 17.412	0 55.561	12525		GI_Grid	G17	61	AY	AZ	2*GI 105/105 8sec				
4	8	244	13:52	58 17.412	0 55.561	12526		244	14:55	58 15.356	0 59.675	12987		GI_Grid	G18	62	BN	BM	2*GI 105/105 8sec				
4	8	244	14:55	58 15.356	0 59.675	12988		244	15:58	58 18.3	0 58.411	13454		GI_Grid	G19	63	BA	DS	2*GI 105/105 8sec				
4	8	244	15:58	58 18.3	0 58.411	13455		244	17:01	58 15.437	0 59.831	13930		GI_Grid	G20	64	BT	BS	2*GI 105/105 8sec				
4	8	244	17:01	58 15.437	0 59.831	13931		244	18:13	58 17.961	0 57.586	14368		GI_Grid	G21	65	BC	BD	2*GI 105/105 8sec				
4	8	244	18:13	58 17.961	0 57.586	14369		244	19:14	58 16.087	1 1.845	14921		GI_Grid	G22	66	BJ	BL	2*GI 105/105 8sec				
4	8	244	19:14	58 16.087	1 1.845	14922		244	20:29	58 17.86	0 57.413	15485		GI_Grid	G23	67	DU	DX	2*GI 105/105 8sec				
4	8	244	20:29	58 17.86	0 57.413	15486		244	22:07	58 16.673	1 1.856	16218		GI_Grid	G24	68	DT	BG	2*GI 105/105 8sec				
4	8	244	22:08	58 16.673	1 1.856	16219		244	23:21	58 15.426	0 56.712	16767		GI_Grid	G25	69	AU	AV	2*GI 105/105 8sec				
4	8	244	23:21	58 15.426	0 56.712	16768		245	00:29	58 17.425	1 0.869	17271		GI_Grid	G26	70	AI	AK	2*GI 105/105 8sec				
4	8	245	00:29	58 17.425	1 0.869	17272		245	01:36	58 16.181	0 55.909	17774		GI_Grid	G27	71	AE	AF	2*GI 105/105 8sec				
4	8	245	01:36	58 16.181	0 55.909	17775		245	02:39	58 18.149	0 59.837	18246		GI_Grid	G28	72	Z	Y	2*GI 105/105 8sec				
4	8	245	02:39	58 18.149	0 59.837	18247		245	03:48	58 16.763	0 54.974	18753		GI_Grid	G29	73	AQ	AR	2*GI 105/105 8sec				
4	8	245	03:48	58 16.763	0 54.974	18754		245	04:51	58 17.952	1 0.153	19224		GI_Grid	G30	74	AT	AS	2*GI 105/105 8sec				
4	8	245	04:51	58 17.952	1 0.153	19225		245	05:53	58 15.864	0 56.098	19686		GI_Grid	G31	75	AO	AP	2*GI 105/105 8sec				
4	8	245	05:53	58 15.864	0 56.098	19687		245	07:02	58 17.84	1 0.247	20201		GI_Grid	G32	76	AD	AC	2*GI 105/105 8sec				
4	8	245	07:02	58 17.84	1 0.247	20202		245	08:08	58 15.526	0 56.639	20637		GI_Grid	G33	77	W	X	2*GI 105/105 8sec				
4	8	245	08:08	58 15.526	0 56.639	20638		245	09:22	58 17.688	1 0.618	21246		GI_Grid	G34	78	AJ	AI	2*GI 105/105 8sec				
4	8	245	09:22	58 17.688	1 0.618	21247		245	10:30	58 15.267	0 57.001	21755		GI_Grid	G35	79	AA	AB	2*GI 105/105 8sec				
4	8	245	10:30	58 15.267	0 57.001	21756		245	11:40	58 17.235	1 1.079	22281		GI_Grid	G36	80	AN	AM	2*GI 105/105 8sec				
4	8	245	11:40	58 17.235	1 1.079	22282		245	12:19	58 15.588	0 56.424	22567		GI_Grid	G37	81	AG	AH	2*GI 105/105 8sec	Coda Log File	Fish min. dep. (m)	Fish max. dep. (m)	
5	9	245	13:01	58 17.738	0 55.46	1227		245	14:20	58 17.627	0 58.317	3217		DTS-asterisk	DTS1	jc152--dts	test		Deeptow300J 1s	20917.13473	107	117	
5	9	245	14:20	58 17.627	0 58.317	3218		245	15:19	58 15.739	0 57.984	6743		DTS-asterisk	DTS2	jc152--dts	BZ	BY	DTS 300J 1s 200ms	20917.14204	106	117	
5	9	245	15:19	58 15.739	0 57.984	6744		245	17:22	58 16.1	0 57.947	8151		DTS-asterisk	DTS3	No lng stream.	CB	CA	DTS 300J 1s	20917.15192	115	98	
5	9	245	17:22	58 16.1	0 57.947	72		245	18:20	58 17.526	0 57.414	1473		DTS-asterisk	DTS4	No lng stream.	BY	BZ	DTS 300J 1s	20917.17572	105	108	
5	9	245	18:20	58 17.526	0 57.414	1483		245	19:43	58 16.728	0 59.903	6456		DTS-asterisk	DTS5	No lng stream.	JL	JM	DTS 300J 1s	20917.18205	106	120	
5	9	245	19:43	58 16.728	0 59.903	6465		245	20:55	58 15.389	0 58.868	10746		DTS-asterisk	DTS6	No lng stream.	BW	BX	DTS 300J 1s	20917.19435	113	120	
5	9	245	20:55	58 15.389	0 58.868	10754		245	23:57	58 16.317	0 57.654	21689											

Type	Type	SOL						EOL						GeoEel/Strataview file									
Source	Survey	JD	Start	Lat	Long	Shot	Shot	JD	End	Lat	Long	Shot	Shot	Area	Line		start	end	Source	Coda Log File			
5	9	245	23:57	58 16.317	0 57.654	21690		246	01:07	58 17.325	0 59.425	25868		DTS-asterisk	DTS8	No lng stream.	CC	CD	DTS 300J 1s	20917.23567	102	121	
5	10	246	01:07	58 17.325	0 59.425	25869		246	02:26	58 16.639	0 57.695	30588		DTS-grid	DTS9	No lng stream.	JO	JN	DTS 300J 1s	30917.01071	111	113	
5	10	246	02:26	58 16.639	0 57.695	30589		246	03:15	58 17.132	0 57.452	33662		DTS-grid	DTS10	No lng stream.	KP	KQ	DTS 300J 1s	30917.02255	119	116	
5	10	246	03:15	58 17.132	0 57.452	33663		246	04:01	58 16.496	0 59.496	36353		DTS-grid	DTS11	No lng stream.	JX	JZ	DTS 300J 1s	30917.03171	116	114	
5	10	246	04:01	58 16.496	0 59.496	36354		246	05:06	58 17.295	0 57.598	40233		DTS-grid	DTS12	No lng stream.	KS	KR	DTS 300J 1s	30917.04016	112	114	
5	10	246	05:06	58 17.295	0 57.598	40234		246	05:58	58 16.59	0 57.891	43373		DTS-grid	DTS13	No lng stream.	KE	KF	DTS 300J 1s	30917.05064	109	113	
5	10	246	05:58	58 16.59	0 57.891	43374		246	06:56	58 17.249	0 57.541	46835		DTS-grid	DTS14	No lng stream.	KN	KO	DTS 300J 1s	30917.05586	125	114	
5	10	246	06:56	58 17.249	0 57.541	46836		246	07:46	58 16.688	0 59.52	49852		DTS-grid	DTS15	No lng stream.	KC	KD	DTS 300J 1s	30917.06564	114	113	
5	10	246	07:46	58 16.688	0 59.52	49853		246	08:41	58 17.335	0 57.658	53123		DTS-grid	DTS16	No lng stream.	KW	KB	DTS 300J 1s	30917.07466	110	114	
5	10	246	08:41	58 17.335	0 57.658	53124		246	09:26	58 16.637	0 59.413	55839		DTS-grid	DTS17	No lng stream.	KG	KH	DTS 300J 1s	30917.08413	113	115	
5	10	246	09:26	58 16.637	0 59.413	55840		246	10:19	58 17.166	0 57.997	59115		DTS-grid	DTS18	No lng stream.	KU	KT	DTS 300J 1s	30917.0926-30917.0950			
5	10	246	10:19	58 17.166	0 57.997	59116		246	11:08	58 16.552	0 59.012	61943		DTS-grid	DTS19	No lng stream.	KI	KJ	DTS 300J 1s	30917.10212	In header		
5	10	246	11:08	58 16.552	0 59.012	61944		246	12:29	58 17.4	0 57.823	65893		DTS-grid	DTS20	No lng stream.	KM'	KM	DTS 300J 1s	30917.11083	In header		
5	10	246	12:29	58 17.4	0 57.823	65894		246	12:29	58 16.462	0 59.022	66880		DTS-grid	DTS21	No lng stream.	KK	KL	DTS 300J 1s	30917.12142	In header		
2	3	246	13:29	58 15.426	1 0.015			246	14:53	58 20.043	1 3.043			Sparker_Asterisk	S44	No lng stream.	JM	JL	Squid 2000J 2s	lander@14:53			
1	2	246	16:22						16:45	58 18.022	1 1.119	6353		Bolt_Grid	B12A	No lng stream.	test		Bolt, 700ci, 10s				
1	2	246	16:46	58 18.022	1 1.119	6354		246	18:42	58 15.522	0 56.611	7025		Bolt_Grid	B12	No lng stream.	Y	Z	Bolt, 700ci, 10s				
1	2	246	18:42	58 15.522	0 56.611	7026		246	19:50	58 16.488	1 2.081	7431		Bolt_Grid	B13	No lng stream.	AJ	AI	Bolt, 700ci, 10s				
1	2	246	19:50	58 16.448	1 2.081	7432		246	20:57	58 15.611	0 56.49	7830		Bolt_Grid	B14	No lng stream.	AW	AX	Bolt, 700ci, 10s				
1	2	246	20:57	58 15.611	0 56.49	7831		246	22:00	58 16.657	1 1.85			Bolt_Grid	B15	No lng stream.	AH	AG	Bolt, 700ci, 10s				
1	2	246	22:00	58 16.657	1 1.85			246	23:10	58 15.939	0 55.976			Bolt_Grid	B16	No lng stream.	AU	AV	Bolt, 700ci, 10s				
1	2	246	23:10	58 15.939	0 55.976			247	00:21	58 17.982	1 0.266			Bolt_Grid	B17	No lng stream.	AB	AA	Bolt, 700ci, 10s				
1	2	247	00:21:00	58 17.982	1 0.266			247	01:30	58 16.794	0 55.049			Bolt_Grid	B18	No lng stream.	AO	AP	Bolt, 700ci, 10s				
1	2	247	01:30	58 16.794	0 55.049			247	02:36	58 18.21	0 59.947			Bolt_Grid	B19	No lng stream.	AT	AS	Bolt, 700ci, 10s				
1	2	247	02:36	58 18.21	0 59.947			247	03:36	58 16.244	0 55.743			Bolt_Grid	B20	No lng stream.	AQ	AR	Bolt, 700ci, 10s				
1	2	247	03:56	58 16.244	0 55.743			247	05:00	58 17.466	1 0.948			Bolt_Grid	B21	No lng stream.	X	W	Bolt, 700ci, 10s				
1	2	247	05:00	58 17.466	1 0.948	10761		247	06:16	58 15.288	0 55.021	11176		Bolt_Grid	B22	No lng stream.	AE	AF	Bolt, 700ci, 10s				
1	2	247	06:16	58 15.288	0 55.021	11177		247	07:28	58 17.526	1 0.791	11609		Bolt_Grid	B23	No lng stream.	AN	AM	Bolt, 700ci, 10s				
1	2	247	07:28	58 17.526	0 0.791	11610		247	09:12	58 16.709	1 0.369			Bolt_Grid	B24	No lng stream.	AC	AD	Bolt, 700ci, 10s				
1	2	247	09:12	58 16.709	1 0.369			247	09:59	58 15.985	1 1.417	12469		Bolt_Grid	B25	No lng stream.	AL	AK	Bolt, 700ci, 10s				
1	2	247	09:59	58 15.985	1 1.417	12470		247	11:17	58 17.802	0 56.787	12946		Bolt_Grid	B26	No lng stream.	BS	BT	Bolt, 700ci, 10s				
1	2	247	11:17	58 17.802	0 56.787	12947		247	12:34	58 15.57	1 0.414	13412		Bolt_Grid	B27	No lng stream.	BD	BC	Bolt, 700ci, 10s				
1	2	247	12:34	58 15.57	1 0.414	13413		247	13:49	58 18.218	0 57.919	13848		Bolt_Grid	B28	No lng stream.	BG	DT	Bolt, 700ci, 10s				
1	2	247	13:49	58 18.218	0 57.919	13849		247	13:58	58 17.815	0 58.408	13912		Bolt_Grid	B29	No lng stream.	DW	NaN	Bolt, 700ci, 10s				
Transit to Aberdeen to pick up spare parts.																							
2	3	250	09:22	58 19.14	1 1.343			250	10:42	58 10.015	1 1.445	1696		Sparker_Asterisk	test				Squid 1750J 2s	GeoEel Streamer			
2	3	250	10:42	58 10.015	1 1.445	1697		250	13:07	58 16.22	0 57.98	4618		Sparker_Asterisk	S101	GE-101	I	J	Squid 1750J 2s	GeoEel Streamer			
2	3	250	13:07	58 16.22	0 57.98	4619		250	14:18	58 17.034	0 56.782			Sparker_Asterisk	S103	GE-103	BY	BZ	Squid 1750J 2s	GeoEel Streamer			
2	3	250	14:18	58 17.034	0 56.782			250	15:54	58 14.78	1 0.938			Sparker_Asterisk	S104	GE-104	BX	BW	Squid 1750J 2s	GeoEel Streamer			
2	3	250	15:54	58 14.78	1 0.938			250	18:00	58 18.123	0 56.488	13359		Sparker_Asterisk	S105	GE-105	M	N	Squid 1750J 2s	GeoEel Streamer			
2	11	250	18:00	58 18.123	0 56.488	13360		250	18:59	58 19.88	0 58.514	15097		3D_Sparker	S106	GE-106	PC	PD	Squid 1750J 2s	GeoEel Streamer			
2	11	250	18:59	58 19.88	0 58.514	15098		250	19:52	58 18.45	0 56.29	16688		3D_Sparker	S107	GE-107	OZ	OY	Squid 1750J 2s	GeoEel Streamer			
2	11	250	19:52	58 18.45	0 56.29	16688				58				3D_Sparker	S108	GE-108			Squid 1750J 2s	GeoEel Streamer			
2	11		?	58						58				3D_Sparker	S109	GE-109			Squid 1750J 2s	GeoEel Streamer			
2	11	250	20:51	58 19.88	0 56.93	18364		250	22:14	58 16.439	0 57.105	2860?		3D_Sparker	S110	GE-110	MM	MN	Squid 1750J 2s	GeoEel Streamer			
2	11	250	22:14	58 16.439	0 57.105	2860?		250	23:32	58 16.526	0 58.657	23155		3D_Sparker	S111	GE-111	PE	PF	Squid 1750J 2s	GeoEel Streamer			
2	11	250	23:32	58 16.526	0 58.657	23156		251	01:15	58 19.914	0 56.861	26216		3D_Sparker	S112	GE-112	NJ	NI	Squid 1750J 2s	GeoEel Streamer			
2	11	251	01:15	58 19.914	0 56.861	26217		251	02:34	58 16.41	0 58.702	28580		3D_Sparker	S113	GE 113	MI	MJ	Squid 1750J 2s	GeoEel Streamer			
2	11	251	02:34	58 16.41	0 58.702	28581		251	04:08	58 19.856	0 56.387	31387		3D_Sparker	S114	GE_114	NF	NE	Squid 1750J 2s	GeoEel Streamer			
2	11	251	04:08	58 19.856	0 56.387	31388		251	05:37	58 16.362	0 58.986	34111		3D_Sparker	S115	GE_115	KY	KZ	Squid 1750J 2s	GeoEel Streamer			

Type	Type	SOL						EOL						GeoEel/Strataview file									
Source	Survey	JD	Start	Lat	Long	Shot	Shot	JD	End	Lat	Long	Shot	Shot	Area	Line		start	end	Source		Coda Log File		
2	11	251	05:37	58 16.362	0 58.986	34111		251	05:51	58 17.37	0 58.022	34464		3D_Sparker	S116	GE_116	MM	MN	Squid 1750J 2s		GeoEel Streamer		
4	11	251	06:15	58 18.985	0 57.311	1		251	07:09	58 13.33	0 56.351	290		3D-GI	G117	GE_117	test		2*GI 45/105 6sec		GeoEel Streamer		
4	11	251	07:09	58 13.33	0 56.351	291		251	08:17	58 16.72	0 58.67	951		3D-GI	G118	GE_118	KY	KZ	2*GI 45/105 6sec		GeoEel Streamer		
4	11	251	08:17	58 16.72	0 58.67	952		251	08:37	58 16.57	0 59.16	1144		3D-GI	G119	GE_119	turning		2*GI 45/105 6sec		GeoEel Streamer		
4	11	251	08:37	58 16.57	0 59.16	1145		251	10:02	58 19.784	0 58.354	1978		3D-GI	G120	GE_120	OT	OS	2*GI 45/105 6sec		GeoEel Streamer		
#	#	#	#			#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#		
GI 3D SURVEY																							
						SOL tts	SOL					EOL tts	EOL			tts file		Strata file					
4	11	251	10:02	58 19.784	0 58.354	1979	10308	251	11:24	58 19.8	0 57.25	2809	11137	3D-GI	G121	G121	121	OZ	OY	2*GI 45/105 6sec		Both Streamers	
4	11	251	11:24	58 19.8	0 57.25	2810	11138	251	12:50	58 16.37	0 57.039	3667	11985	3D-GI	G122	G122	122	NI	NJ	2*GI 45/105 6sec		Both Streamers	
4	11	251	12:50	58 16.37	0 57.039	3668	11986	251	14:09	58 16.522	0 59.193	4994	13349	3D-GI	G123	G123	123	PE	PF	2*GI 45/105 6sec		Both Streamers	
4	11	251	14:09	58 16.522	0 59.193	4995	13350	251	15:39	58 19.4	0 58.576	5303	13661	3D-GI	G124	G124	124	OV	OU	2*GI 45/105 6sec		Both Streamers	
4	11	251	15:39	58 19.4	0 58.576	5304	13662	251	17:13	58 19.952	0 57.106	6233	14592	3D-GI	G125	G125	125	PB	PA	2*GI 45/105 6sec		Both Streamers	
4	11	251	17:13	58 19.952	0 57.106	6234	14593	251	18:52	58 16.425	0 58.658	7209	15567	3D-GI	G126	G126	126	NA	NB	2*GI 45/105 6sec		Both Streamers	
4	11	251	18:52	58 16.425	0 58.658	7210	15568	251	20:11	58 19.99	0 56.851	7939	16350	3D-GI	G127	G127	127	NH	NG	2*GI 45/105 6sec		Both Streamers	
4	11	251	20:11	58 19.99	0 56.851	7939	16350	251	21:37	58 16.444	0 58.85	8792	17202	3D-GI	G128	G128	128-129	MK	ML	2*GI 45/105 6sec		Both Streamers	
4	11	251	21:37	58 16.444	0 58.85	8793	17203	251	23:08	58 19.861	0 57.008	9681	18091	3D-GI	G129	G129	130	NQ	NR	2*GI 45/105 6sec		Both Streamers	
4	11	251	23:08	58 19.861	0 57.008	9682	18092	252	00:34	58 16.62	0 58.835	10533	18950	3D-GI	G130	G130	131	MS	MT	2*GI 45/105 6sec		Both Streamers	
4	11	252	00:34	58 16.62	0 58.835	10534	18951	252	02:16	58 19.86	0 56.987	11544	19949	3D-GI	G131	G131	132	NZ	NY	2*GI 45/105 6sec		Both Streamers	
4	11	252	02:16	58 19.86	0 56.987	11545	19950	252	03:43	58 16.49	0 58.285	12438	20884	3D-GI	G132	G132	133	MR	MQ	2*GI 45/105 6sec		Both Streamers	
4	11	252	03:43	58 16.49	0 58.285	12439	20885	252	05:14	58 19.872	0 59.984	13347	21754	3D-GI	G133	G133	134	NP	NO	2*GI 45/105 6sec		Both Streamers	
4	11	252	05:14	58 19.872	0 59.984	13348	21755	252	06:51	58 16.592	0 58.71	14270	22693	3D-GI	G134	G134	135	MO	MP	2*GI 45/105 6sec		Both Streamers	
4	11	252	06:51	58 16.592	0 58.71	14271	22694	252	08:24	58 19.87	0 57.26	15208	23618	3D-GI	G135	G135	136	NN	NM	2*GI 45/105 6sec		Both Streamers	
4	11	252	08:24	58 19.87	0 57.26	15209	23619	252	09:53	58 16.345	0 58.381	16098	24510	3D-GI	G136	G136	137	NK	NL	2*GI 45/105 6sec		Both Streamers	
4	11	252	09:53	58 16.345	0 58.381	16099	24511	252	11:20	58 19.94	0 57.104	16951	25363	3D-GI	G137	G137	138	MH	MG	2*GI 45/105 6sec		Both Streamers	
4	11	252	11:20	58 19.94	0 57.104	16952	25364	252	12:50	58 16.45	0 58.31	17853	26261	3D-GI	G138	G138	139	NE	NF	2*GI 45/105 6sec		Both Streamers	
4	11	252	12:50	58 16.45	0 58.31	17854	26262	252	14:28	58 19.105	0 58.689	19193	27605	3D-GI	G139	G139	140	MF	ME	2*GI 45/105 6sec		Both Streamers	
4	11	252	14:28	58 19.105	0 58.689	19194	27606	252	15:51	58 16.533	0 58.593	19688	28046	3D-GI	G140	G140	141	PD	PC	2*GI 45/105 6sec		Both Streamers	
4	11	252	15:51	58 16.533	0 58.593	19689	28047	252	17:16	58 19.325	0 58.84	20494	28904	3D-GI	G141	G141	142	ND	NC	2*GI 45/105 6sec		Both Streamers	
4	11	252	17:16	58 19.325	0 58.84	20495	28905	252	18:39	58 16.398	0 58.622	21299	29729	3D-GI	G142	G142	143	PL	PK	2*GI 45/105 6sec		Both Streamers	
4	11	252	18:39	58 16.398	0 58.622	21300	29730	252	20:15	58 19.688	0 58.648	22250	30673	3D-GI	G143	G143	144	MZ	MY	2*GI 45/105 6sec		Both Streamers	
4	11	252	20:15	58 19.688	0 58.648	22251	30674	252	21:38	58 20.041	0 56.326	23077	31502	3D-GI	G144	G144	145	PH	PG	2*GI 45/105 6sec		Both Streamers	
4	11	252	21:38	58 20.041	0 56.326	23078	31503	252	23:42	58 14.035	0 55.924	24318	32745	3D-GI	G145	G145	146	MW	MX	2*GI 45/105 6sec		Both Streamers	
4	11	252	23:42	58 14.035	0 55.924	24319	32746	253	00:39	58 19.94	0 57.04	24878	33289	3D-GI	G146	G146	147	PI	PJ	2*GI 45/105 6sec		Both Streamers	
4	11	253	00:39	58 19.94	0 57.04	24879	33290	253	02:04	58 16.39	0 59.16	25727	34140	3D-GI	G147	G147	148	MU	MV	2*GI 45/105 6sec		Both Streamers	
4	11	253	02:04	58 16.39	0 59.16	25728	34141	253	03:29	58 20.034	0 58.88	26559	34958	3D-GI	G148	G148	149	OP	OO	2*GI 45/105 6sec		Both Streamers	
4	11	253	03:29	58 20.034	0 58.88	26560	34959	253	04:48	58 16.471	0 59.083	27350	35766	3D-GI	G149	G149	150	MM	MN	2*GI 45/105 6sec		Both Streamers	
4	11	253	04:48	58 16.471	0 59.083	27351	35767	253	06:07	58 19.864	0 56.754	28122	36352	3D-GI	G150	G150	151	OL	OK	2*GI 45/105 6sec		Both Streamers	
4	11	253	06:07	58 19.864	0 56.754	28123	36353	253	07:34	58 16.431	0 59.03	28997	37416	3D-GI	G151	G151	152	LX	LW	2*GI 45/105 6sec		Both Streamers	
4	11	253	07:34	58 16.431	0 59.03	28998	37417	253	08:55	58 19.996	0 56.574	29808	38222	3D-GI	G152	G152	153	OH	OG	2*GI 45/105 6sec		Both Streamers	
4	11	253	08:55	58 19.996	0 56.574	29809	38223	253	10:22	58 16.328	0 58.015	30656	39069	3D-GI	G153	G153	154	LO	LP	2*GI 45/105 6sec		Both Streamers	
4	11	253	10:22	58 16.328	0 58.015	30657	39070	253	11:35	58 20.024	0 56.46	31397	39823	3D-GI	G154	G154	155	OD	OC	2*GI 45/105 6sec		Both Streamers	
4	11	253	11:35	58 20.024	0 56.46	31398	39824	253	12:57	58 16.48	0 58.84	32191	40617	3D-GI	G155	G155	156	LH	LG	2*GI 45/105 6sec		Both Streamers	
4	11	253	12:57	58 16.48	0 58.84	32192	40618	253	14:34	58 18.935	1 0.602	33159	41582	3D-GI	G156	G156	157	NV	NU	2*GI 45/105 6sec		Both Streamers	
4	11	253	14:34	58 18.935	1 0.602	33160	41583	253	15:22	58 15.906	0 56.149	33630	42056	3D-GI	G157	G157	158	PN	PM	2*GI 45/105 6sec		Both Streamers	
Deployed Minilander and retrieved OBS.																							
5	10	253	20:09	58 18.293	0 57.96			253	21:01	58 15.063	0 57.985			Initial_line			heading to PM-PN		DTS 300J 1s		100917.200902		
Deep Tow sparker connector failed. End of seismic survey																							
Collected minilander																							
Departed survey area for Leith																							