British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Report of Survey: BGS 2012-9 South West Approaches to Tiree Multibeam and Surface Tow Boomer Survey

Marine Geoscience Programme

Internal Report CR/12/099

BRITISH GEOLOGICAL SURVEY

MARINE GEOSCIENCE PROGRAMME

INTERNAL REPORT CR/12/099

Report of Survey: BGS 2012-9 South West Approaches to Tiree Multibeam and Surface Tow Boomer Survey

R. Cooper; D. G. Wallis; K. Crombie; S. Ritson; G. Horner

Contributor/editor

A Stevenson

Keywords

Multibeam, Surface Tow Boomer, Marine Scotland.

Front cover

NLV Polestar.

Bibliographical reference

R. COOPER; D. G. WALLIS; K. CROMBIE; S. RITSON; G. HORNER. 2012. Report of Survey: BGS 2012-9. South West Approaches to Tiree. Multibeam and Surface Tow Boomer Survey. *British Geological Survey Internal Report*, CR/12/099. 52pp.

Keyworth, Nottingham British Geological Survey 2012

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham, Edinburgh and London; see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

Keyworth, Nottingham NG12 5GG

☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.geologyshop.com

Murchison House, West Mains Road, Edinburgh EH9 3LA

☎ 0131-667 1000 Fax 0131-668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE

☎ 020-7589 4090 Fax 020-7584 8270
☎ 020-7942 5344/45 email: bgslondon@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU

☎ 01392-445271 Fax 01392-445371

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF

☎ 028-9038 8462 Fax 028-9038 8461

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB

☎ 01491-838800 Fax 01491-692345

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE

☎ 029–2052 1962 Fax 029–2052 1963

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Foreword

Marine Scotland, the British Geological Survey and the Northern Lighthouse Board have entered into a collaborative Memorandum of Understanding (MoU). These MoUs provide the basis for the collaborative survey of Scotland's seas in order to further our understanding of Scotland's marine environment, increase the efficiency of use of public resources, enhance the safety of those at sea and contribute too new policy priorities such as marine protected areas, wider conservation measures, marine planning and renewables.

This report details a marine survey undertaken by the British Geological Survey (BGS) on behalf of Marine Scotland, utilising the Northern Lighthouse Board Vessel the *NLV Polestar* from the 23rd of July to 6th of August 2012. The report details the operational aspects of the survey to the South West of Tiree using Surface Tow Boomer (STB) and Multibeam Echosounder (MBES) equipment. There is no geological interpretation of the data. The BGS staff involved were: Rhys Cooper; Kirstin Crombie; Simon Ritson; David Wallis and contract Hydrographer Gillian Horner.

Acknowledgements

In addition to the BGS staff acknowledged in the Foreword, the Captain, officers and crew of the *NLV Polestar* contributed to the production of this report by providing the survey platform and much useful help and advice during the progress of the survey.

Contents

1 Introduction

The purpose of the survey was to investigate the seabed directly southwest of Tiree, for the suitability of offshore installations. The total potential survey area was approximately 360km^2; however, a priority area of interest, 232 km^2, was identified (see Figure 1). Water depths within the survey area range from 20 to 50 m. The maximum distance offshore is approximately 20 km.

The initial survey specification was for full coverage by Multibeam Echosounder (MBES) with 50% overlap and Surface-Tow Boomer (STB) seismic lines to be run at 500 metre intervals.

The survey commenced on the 23rd July and was completed on the 6th August 2012. The *NLV Polestar* was used to acquire all MBES and STB data.

The focus of the survey was to complete the priority area; however, due to poor weather that limited survey time, this was not possible. Data collection in the priority area was maximized whenever possible. It was not possible to obtain 100% multibeam coverage of the priority area therefore a corridor approach was adopted towards the end of survey to ensure maximum STB and MBES coverage.

During bad weather two potential cable routes were surveyed as contingency areas as both were sheltered from the predominant swell (see Figure 2 and Appendix 6).

Survey operations were undertaken in all areas where navigational safety allowed. This proved difficult in certain areas of the priority area due to the presence of underwater obstructions and rock outcrops.

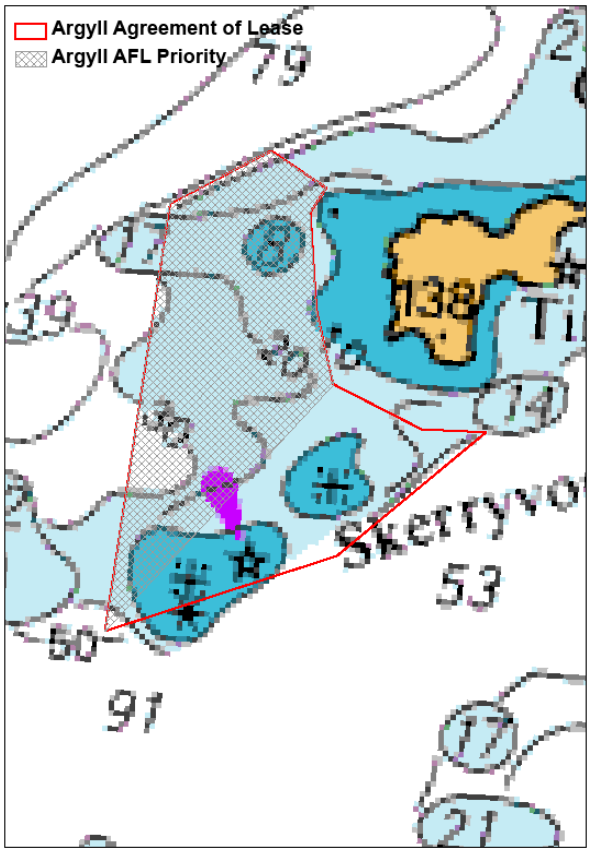


Figure 1: Regional Overview of Survey Area

2 Summary

2.1 SURVEY DATA

Bathymetric data was collected using a Kongsberg EM3002D dual head, multibeam system. Data was acquired using a Kongsberg SIS operating system, logging raw .ALL files. This data was processed offline using CARIS HIPS and SIPS 7.1 SP2.

Backscatter mosaics were created using Fledermaus GeoCoder FMGT.

The position of the vessel was obtained from an Applanix POS MV 320 with DGPS corrections from a Fugro SeaSTAR receiver.

A Valeport TideMaster tide gauge was installed on Tiree and all depths were reduced to Chart Datum. UKHO's VORF model was used to define the relationship between the ETRF 89 ellipsoid height measured at the tide gauge and Chart Datum.

Sound velocity profiles were undertaken at a maximum interval of twelve hours or as required. The Northern Lighthouse Boards own sound velocity profile (SVP) probe was used. The EM3002D has a SV sensor mounted at the heads providing a real-time indication of sound velocity at the transducer face.

Seismic data was collected using an Applied Acoustics Surface Tow Boomer (STB) and BGS Hydrophone summing amplifier and pre-filter. CODA DA2000 was used as the acquisition system and CODA GeoSurvey for processing.

Appendix 9 details all required final digital data deliverables.

Figure 2: Final multibeam coverage in priority and cable route weather contingency areas

2.2 MOBILISATION

The mobilisation was carried out at the Northern Lighthouse Board (NLB) pier at Oban on the west coast of Scotland. The mobilisation commenced at 1100 hours on Sunday 22nd July. Two BGS personnel arrived with the equipment while the remainder of the BGS team travelled by train from Edinburgh.

The Kongsberg EM3002D dual-head multibeam echosounder is hull mounted and required no additional installation by BGS. Full installation details and a vessel dimensional survey can be obtained from the Northern Lighthouse Board.

With minimal time for the survey and an unsettled weather forecast, a patch test was not performed in the survey area. A previous calibration, performed by BGS surveyors in March 2012 on a survey near Shetland, was deemed acceptable. Due to the sonar heads being hull mounted, it was safe to assume that no movement had occurred since the last patch test and the water depths are very similar for both survey areas. Full patch test details can be found in Appendix 8.

The multibeam processing PC (CARIS HIPS and SIPS 7.1 SP 2) was installed on the ship's bridge. This allowed the continual offline assessment of data quality as the survey progressed.

The Surface Tow Boomer was installed by BGS personal on Sunday 22nd July, following which sea trials were carried out. The trials allowed the inexperienced crew to become acquainted with launch and recovery operations in relatively calm conditions. The weather and sea state at the survey area on Monday 23rd July delayed departure and allowed further equipment testing. Real-time data on the sea state was obtained from a waverider buoy located near the survey area.

2.3 SURVEY OPERATIONS

The *NLV Polestar* departed Oban at 0630 on Tuesday 24th July arriving on site at around 1300 hours. Offshore operations were carried out on a 24-hour basis, operating 12-hour shifts, with two crew members and one surveyor on the bridge at all times. The seismic operator was situated on the lower deck.

A line plan was generated using the survey acquisition software to try to ensure 25-50% swath overlap and maintain data quality. The line plan was designed to minimise the influence of swell and follow the predominant seafloor trend, trying to maintain consistent swath widths whenever possible. In an area of rapidly changing seafloor topography this proved difficult and, combined with a crew relatively inexperienced at running surveys, inevitably led to gaps. These gaps were backfilled within the time constraints of the survey.

Sound velocity profiles (SVPs) were taken at least once every 12-hour shift or whenever the real-time SV sensor at the transducer heads indicated values were out of range. The SVPs were relatively stable throughout the survey area.

Tide-gauge data was logged using a Valeport TideMaster installed at the port of Tiree. This was collected at the end of a subsequent survey at Stanton Banks and downloaded to the CARIS processing PC. All depths are referenced to Chart Datum.

The Surface Tow Boomer and hydrophone were deployed on survey lines at approximately 500m intervals. The STB and hydrophone were recovered when not in use as they hampered the manoeuvrability of vessel.

The daily log in Appendix 1 provides further details on the day-to-day survey operations and all actions taken to avoid weather downtime. A time utilisation diagram is in Appendix 6.

2.4 DE-MOBILISATION

The *NLV Polestar* arrived back at Oban on 1100 on August 6th. BGS staff unloaded all relevant equipment and returned to Edinburgh by 1800.

The tide gauge was left installed at Tiree for a following survey on Stanton Banks. Gauge and data were recovered on the 1st September.

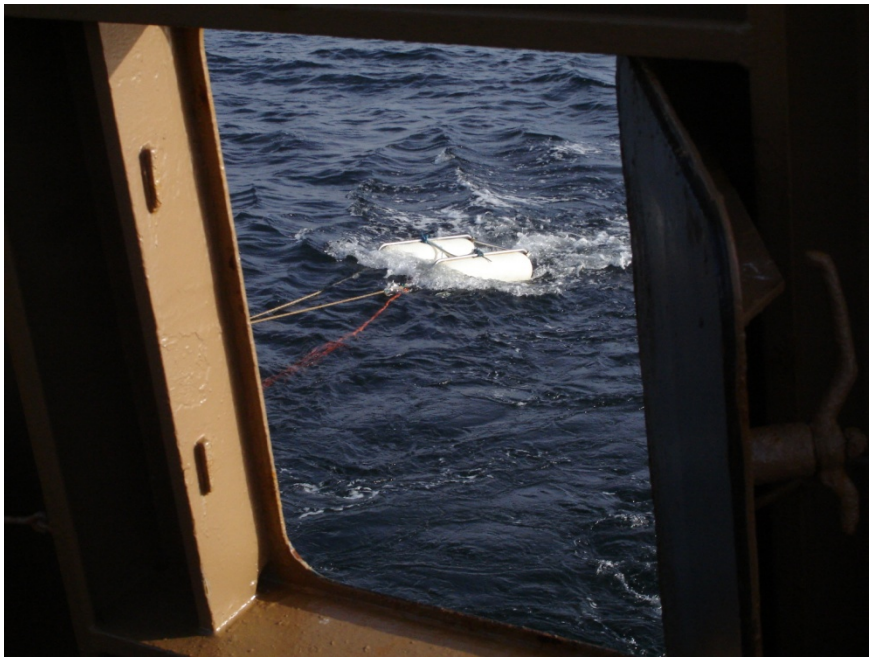


Figure 3: Surface Tow Boomer deployed from the stern of the NLV Polestar

3 Multibeam Survey Equipment

3.1 EQUIPMENT LIST

Kongsberg EM3002D Dual-Head Multibeam Echosounder

Applanix POS MV 320

Fugro SeaSTAR

Valeport TideMaster

Valeport Sound Velocity Probe

3.2 NAVIGATION/VESSEL POSITION

3.2.1 POS MV

Navigation was provided by an Applanix POS MV 320 with DGPS corrections from a Fugro SeaSTAR receiver.

The POS MV 320 system is a GPS aided inertial navigation system that provides accurate attitude, heading, heave, position and velocity data. The unit was running with POS View V5.05 software and firmware with Trimble BD960 GNSS V4.02 firmware.

Figure 3: POS MV PCS and Inertial Measurement Unit (Applanix 2009)

PERFORMANCE SUMMARY - POS MV Accuracy

POS MV 320	DGPS	RTK	GPS Outage
Position	0.5 - 2 m[1]	0.02 - 0.10 m[1]	<2.5 m for 30 s outages, <6 m for 60 s outages
Roll & Pitch	0.020°	0.010°	0.020°
True Heading	0.020° with 2 m baseline 0.010° with 4 m baseline	-	Drift less than 1° per hour (negligible for outages <60 s)
Heave	5 cm or 5%[2]	5 cm or 5%[2]	5 cm or 5%[2]

Table 1: Accuracies of the POS MV 320 (Applanix 2009)

3.3 SEASTAR 3510R

The SeaSTAR receiver outputs a range of Fugro raw data options and calculates RTCM corrections for the user's location; it is designed for use with an external GPS receiver.

Figure 4: SeaSTAR 3510R, image courtesy of (SeaSTAR 2004)

3.4 KONGSBERG EM3002D MULTIBEAM ECHOSOUNDER

The EM3002D is a dual-headed system capable of producing up to 508 dynamically focused beams, which produce a swath width of up to 200° operable in depths of up to 150 m. The system operates in the 300 kHz frequency range, which ensures narrow beams and a small acoustic footprint, and is also robust under conditions with high particle content in the water column.

The EM3002D uses a powerful processing unit and two compact sonar heads. The processing unit applies sophisticated processing algorithms for beam forming, beam stabilisation and bottom detection.

Information from the processing unit is sent to an operator station running Windows XP, from where the surveyor can operate the system and adjust settings accordingly within the Seafloor Information System (SIS). SIS has extensive functionality such as 3D graphics and real-time data cleaning.

Position and attitude information for the EM3002D is provided via the POS MV 320. This incorporates a motion reference unit and position antennae, a combination of which positions and measures the attitude of the vessel. All of this information is tagged to the data to provide a real-world position.

Figure 5: Blister mounting of EM3002D sonar heads on the hull of the NLV Polestar

3.4.1 Cable layout

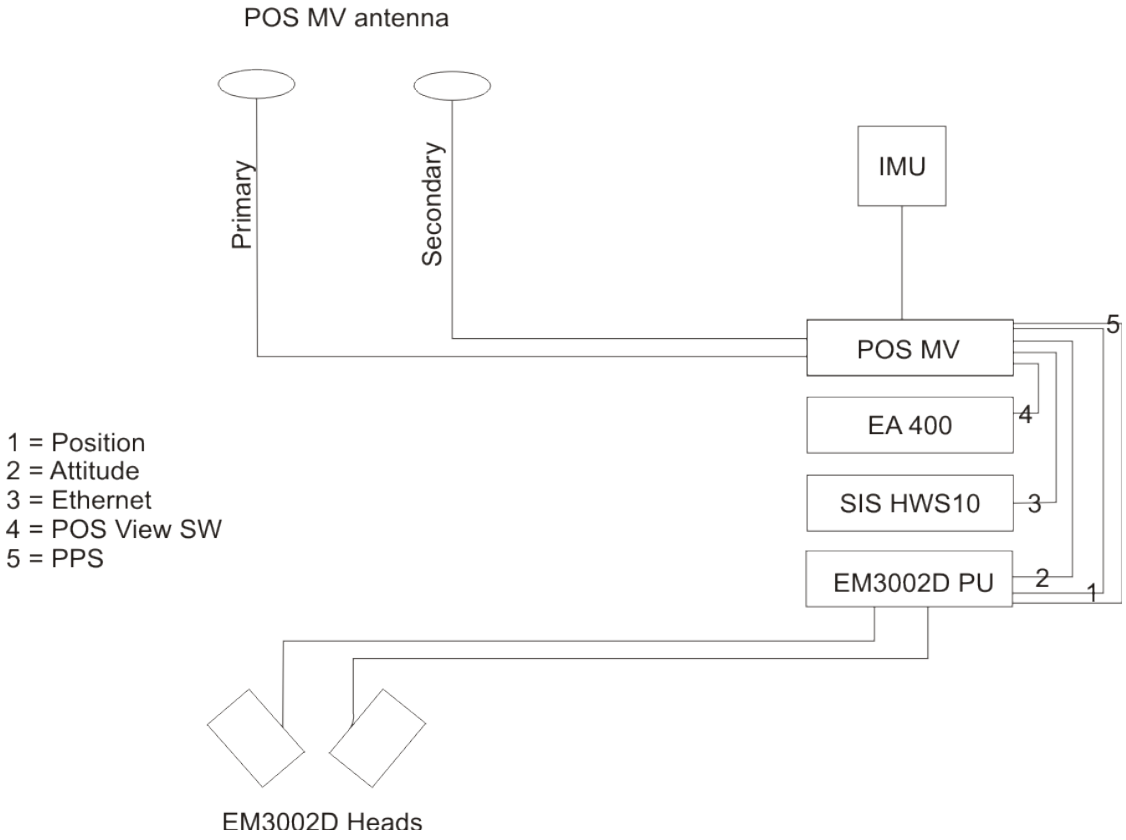


Figure 6: Schematic diagram showing the multibeam cable layout

3.5 TIDE-GAUGE INSTALLATION

Accurate tidal information is critical for multibeam survey operations. A Valeport TideMaster was installed at Tiree on the 19th July 2012 with the permission of Caledonian MacBrayne. Tide was measured in 15 second bursts and logged every ten minutes to a text file, providing a continuous record during all survey operations. All depths are referenced to Chart Datum.

The quayside at Tiree was deemed the most suitable location to install the tide gauge as it was secure, stable, and easily accessible and did not dry out at low tide. It was not possible to undertake any reconnaissance prior to installation and the time available to set-up and monitor the gauge was limited. The tide readings obtained are solid, with no visible movement of the pressure sensor.

3.5.1 Tide-gauge level

Tide-gauge height relative to Chart Datum was determined using a Leica GPS500 system, Leica GeoOffice software and the freely available RINEX data from the Ordnance Survey website. The height of the tide gauge relative to Chart Datum was calculated using ETRF ellipsoidal height and VORF (Vertical Offshore Reference Frame, provided by UKHO).

The GPS antenna was positioned on the quayside using a level tripod and tribach. Position was logged for 2 hours. The logged data was then downloaded into Leica GeoOffice to allow the application of RINEX differential corrections from the Ordnance Survey Active GPS network RINEX data server website (http://gps.ordnancesurvey.co.uk/active.asp). The logged data could then be corrected to provide an accurate position and height to approximately 1cm accuracy.

Figure 7: Leica GPS setup.

.

Date/Time	Easting	Northing	Ellipsoid Height	Position + height quality	Orthogonal Height (ODN)	Comments
07/19/2012 13:09:14	104883.6	745630.2397	60.6894	0.0064	4.0843	Logged for 2 hours.

Table 2: GPS logging summary

Ellipsoid Height entered in VORF (positive down)	Height of Quay relative to CD (from VORF)	Tide gauge below quay	Tide Gauge height relative to CD
-60.6894m	6.350341 m	6.82 m	-0.47m

Table 3: Determination of tide gauge height relative to Chart Datum

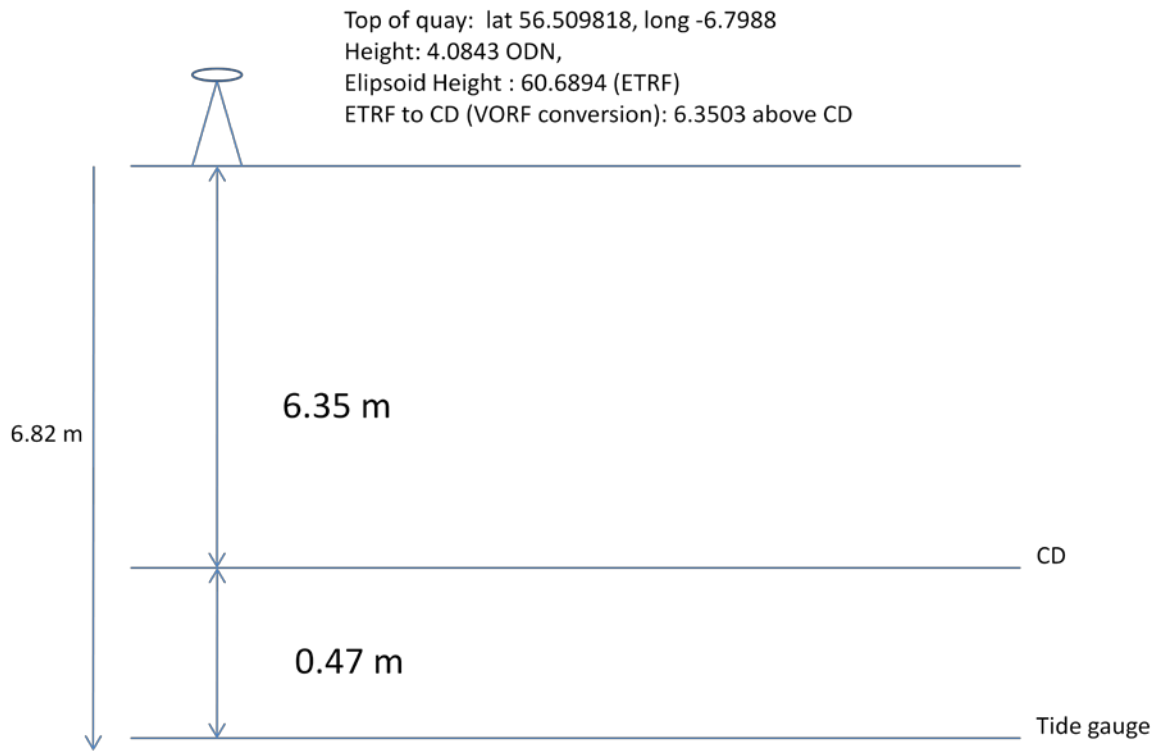


Figure 4: Height level diagram in metres for Tiree jetty. The antenna height, Chart Datum/Ellipsoid difference and top of quay to tide-gauge measurements were already known. Leica GeoOffice was used to convert ellipsoid heights to ODN heights, and VORF to determine a level below Chart Datum.

4 Geophysical Survey Equipment

4.1 EQUIPMENT LIST

Applied Acoustics AA300 boomer plate

Applied Acoustics Surface Tow Boomer catamaran

Applied Acoustics CSP2400-D high voltage (HV) power supply

SES 7 channel 10 metre hydrophone and amplifier

BGS hydrophone summing amplifier and pre-filter

CODA DA2000 digital recording system

4.2 ACOUSTIC SOURCES

The acoustic sources were an Applied Acoustics compensated surface tow boomer plate, BGS mini-spark array (4 x multi-tip candles, 15 tips per candle) mounted on a modified Applied Acoustics surface tow boomer frame. An Applied Acoustics CSP2400-D high voltage power supply was utilised in conjunction with the acoustic sources.

4.3 ACOUSTIC RECEIVERS

A BGS 10m, 7-channel hydrophone (1m spacing between channels) was utilised. Depending on weather conditions and water depth, between 2 and 7 channels were summed, amplified and filtered to produce single channel recording. A BGS hydrophone summing amplifier and pre-filter was used to remove signals above 5kHZ (anti-alias) and below 500 Hz (LF wave and swell noise).

4.4 RECORDING

A CODA DA2000 data acquisition and processing system was utilised to record the analogue data in CODA format along with DGPS from the vessel. Raw data is stored in both CODA and SEGY formats.

4.5 SURFACE TOW BOOMER NAVIGATION

The navigation for the Surface Tow Boomer was obtained as a data telegram from the GPS receivers on the bridge. This was connected to the CODA DA2000 seismic acquisition system and recorded along with the data. In addition, the same telegram was used to provide a display in the vessel workshop which was located well away from the bridge. The vessel's position was displayed on marine charts using the 'SeaPro3000 Lite' program. The data telegram was also used to synchronise the CODA DA2000 clock. No attempt was made to enter the CDP (Common Depth Point) for the data into the CODA DA2000, which was recording the raw data as received from the bridge.

5 Data Processing

5.1 MULTIBEAM

The raw multibeam data was logged as .ALL files within the Kongsberg SIS acquisition software. All vessel offsets were applies in SIS and were not reapplied in CARIS HIPS processing software.

Tide values from the Valeport TideMaster tide gauge were reduced to Chart Datum using VORF and applied in CARIS.

Sound velocity profiles are applied in real-time by the Kongsberg SIS software and are not reapplied in CARIS.

All data processing was conducted in accordance with a standard CARIS Ping to Chart workflow and 'Standard Operating Procedures for Kongsberg Multibeam Systems' as outlined by the UKHO (Talbot, Read 2011). The BGS processing log attached to the CARIS folder template provides further details.

Data was filtered primarily using the 'CUBE' algorithm within CARIS to an IHO Order 1a depth uncertainty. Any necessary manual edits were performed in the subset or swath editors.

Backscatter mosaics were created in Fledermaus Geocoder FMGT.

All bathymetric final surfaces were produced with a 2m grid size. The backscatter mosaic was generated at 4m resolution.

5.2 SURFACE TOW BOOMER

Seismic data from the Surface Tow Boomer (STB) was processed using CODA GeoSurvey 5.4.0.

Raw STB data for lines 1-43 were recorded without a heading or a layback applied. To produce final SEGY files, which have the correct navigation applied, the following procedure was applied to the raw data:-

- Import raw CODA file.
- Pick the seabed.
- Apply a TVG swell filter of 40 pings along track smoothing, with a TVF of 1000-2200HZ (lines 1-4 had a TVF of 800-2200HZ). Record the file as a SEGY.
- Use Trackplot to smooth the navigation and create an artificial heading. The result of which is a cnv file with projected coordinates and a heading.
- Edit the first and last time stamp of the cnv file.
- Using the cnv file, a layback of 38m was applied to the SEGY. This was recorded to XTF format.
- The XTF was then copied to SEGY (and then finally back to coda).

From line 44-63 a heading for the ships navigation was plugged into CODA. The final files for these lines were produced by:

- Copying the raw CODA file to raw SEGY.
- Writing out the navigation from the raw CODA files.

- Applying a layback of 38m and recording the raw CODA data as processed CODA data. Although the layback has been written to this processed CODA file, it has not actually changed the X,Y coordinates. This is done by producing the SEGY file.
- Using File > copy data files to copy the in between processed CODA file to a SEGY. This produces a file with the corrected X and Y coordinates i.e. they have been adjusted to take into account the layback.
- Convert the above final SEGY to a final CODA file format.
- Navigation is then produced from this final CODA as a final QC (quality control).

Appendix 1 Daily Log

Daily Summary Log

Date:22/July/2012 JD: 204

Time	
0800	Van and Ritson depart Loanhead for Oban
0830	Van pick-up Wallis
1130	BGS team (Crombie, Cooper and Horner arriving by train) and van arrive Northern Lighthouse Board (NLB) pier at Oban
	Mobilise Surface Tow Boomer equipment
2030	Cease mobilisation for night. Mobilisation almost complete

Date:23/July/2012 JD: 205

Time	
0730	Preparing to depart Oban pier for trials
0800	Depart Oban for equipment trials in Firth of Lorn
1000	Sound Velocity Probe (SVP) deployment
1200	Hydrophone and Surface Tow Boomer (STB) in water. Turns to port and starboard to assess handling and limits to turning circle
1405	Commence recovery. Hydrophone and STB. Weather at work area too rough for operations
1415	STB and hydrophone on deck.
1515	Alongside NLB pier in Oban
	Tidy up and organise deck workshop which is used as seismic laboratory
1700	Cease operations for day

Date:24/July/2012 JD: 206

The *NLV Polestar* departed Oban at 0630 Tuesday 24th July arriving on site at around 1300 hours. After conducting a Sound Velocity Probe (SVP), the Surface Tow Boomer and hydrophone were deployed and the first survey line was commenced at 1337 hours, running both MBES and STB. This first line was run in poor weather, heading into an Atlantic swell of around 2.5 metres. Immediately on completion, a second parallel line was run in the opposite direction to see if data quality could be improved. The decision had been made to recover STB and hydrophone when they were not in use as they could seriously hamper the manoeuvrability of the vessel; the specification for seismic lines being every 500 metres.

Time	
0630	Depart Oban for work area
1300	SVP deployment at work area. 23 m water. 56° 20.254N, 6° 59.619W
1315	Commence STB and hydrophone deployment

1337	SOL 001, Fix 1. Heading 270
1512	EOL 001, Fix 46
1525	SOL 002, Fix 47. Heading 090
1654	EOL 002, Fix 91
1700	STB and hydrophone on deck. Multibeam operations only
2300	Deploy STB and hydrophone
2313	SOL 003, Fix 92. Heading 270

Date:25/July/2012 **JD: 207**

A small number of seismic lines were included in what was predominantly an MBES survey day. There was an interruption to survey between 0600 and 0900 whilst the vessel diverted to Scarinish Bay to put Rhys Cooper ashore as his involvement was only limited to the survey start-up. There were two SVP deployments. The first 3 boomer lines had been run with 90° and 270° headings; subsequent lines following diversion to Scarinish Bay were run on headings of 35° and 215° with the boomer lines being limited to the 35° heading only as this limited proximity to the shores and marine hazards of Tiree.

Time	
0029	EOL 003, Fix 129
0039	STB and hydrophone on deck. Multibeam operations
	LaCie 1TB back-up hard drive tested with Coda running in Linux operating system. Same hard works without problem with Windows XP version of Coda
0615	Finish last Multibeam line and set course for Scarinish Bay and Tiree.
0700	On Dynamic Positioning (DP) at Tiree
0710	Workboat departs with Rhys Cooper for ferry at Tiree
0800	Workboat back onboard. Depart Tiree for work area
0915	SVP deployment
1000	Commence Multibeam lines
1300	STB and hydrophone deployed
1306	SOL 004, Fix 130. Heading 035
1549	EOL 004, Fix 211
1555	STB and hydrophone on deck
1600	Recommence Multibeam lines

Date: 26/July/2012 **JD: 208**

A combination of MBES, SVP deployments and STB lines. STB lines 005 and 006 being run.

Time	
0000	Running Multibeam
0150	SVP deployment
0200	Running Multibeam
0545	Prepare to deploy STB and hydrophone
0600	STB and hydrophone in water and running. Swell filter changed to a long-Track-Averaging (ATA) 30 pings. BandPass (BP) filter set 1kHz to 2k2Hz. Good quality data.
0602	SOL 005, Fix 212 Heading 035
	First half of line was run along Multibeam swath and as a result is not straight.
0710	Back onto straight line for STB. Decision made to run MBES on lines rather than swath.
0818	EOL 005, Fix 279
0825	STB and hydrophone on deck
0830	SVP deployment
0900	Multibeam
1430	SVP deployment
1515	Multibeam
1950	STB and hydrophone deployed
1959	SOL 006, Fix 280. Heading 035
2001	Coda recording line number reset from line 005 to line 006
2205	EOL 006, Fix 342
2215	STB and hydrophone on deck
2225	Multibeam

Date: 27/July/2012 **JD: 209**

Continued as previous day but the swell was increasing and at 0900 the decision was made to abandon the main survey area and run for cover in Loch na Keal to the West of Mull. During the run in to shelter an attempt was made to run MBES along one of the potential cable routes but this was abandoned at 1700 when the vessel went for shelter behind Eorsa Island overnight.

Time	
0000	Multibeam lines
	Weather and sea state increasing. Wind force 5. Lots of white caps and chop. STB assessed as being marginal and not deployed in these conditions
0500	Backing up data and creating TIFF image files
0615	Discussion with Captain regarding weather situation: Due to weather data quality on MBES deteriorating, especially when running SW into the swell. Wind currently more than 30 kts. Swell 2 metres, building towards 3 metres. Decision made to complete current SW line and run NE back. This will take until ~0900

	when the ship will follow the cable route contingency area towards Loch na Keal.
0900	Finished MBES- heading to cable route area
0930	At western edge of cable route. Beginning MBES. Intention being to run 1 swath along cable route and asses weather and data quality
1301	MBES finished. DP on for SVP deployment
1315	MBES lines – running along cable route
1700	MBES data very poor due to weather. Decision made to shelter in Loch na Keal
1800	On DP WOW in Loch na Keal

Date: 28/July/2012 JD: 210

Waiting on weather until 0600 when the vessel set off to test whether cable route data could be collected as the swell and sea had decreased slightly overnight. The STB and hydrophone were deployed for line 007 running westwards from Mull along one of the proposed cable routes. Both STB and MBES data were collected along the full length of the cable route, terminating the line at the edge of the main survey area where the sea state and swell rendered the data poor, as well as indicating that further progress west would endanger the personnel recovering the STB. The remainder of the day was spent running MBES lines along the cable route, providing bathymetry data either side of the centre line.

Time	
0000	WOW Loch na Keal
0600	Underway for line on cable route
0700	SVP deployment.
	Beginning MBES survey with intention to do small section of infill followed by a STB/MBES line down the middle of the dogleg cable route
0805	STB and hydrophone deployed
0806	SOL 007, Fix 343. Heading 245
1002	Dogleg at Fix 401. Heading 270
1100	Swell gradually increasing as vessel heads away from sheltered waters
1330	Sea state worsening with swell filter gradually losing lock
1350	NW swell increasing; decision made to terminate line at end of cable route
1403	EOL 007, Fix 521
1410	STB and hydrophone on deck
1430	MBES along cable route back towards Loch na Keal

Date: 29/July/2012 JD: 211

Completion of the cable route survey. At 0700 the vessel headed for Tiree to drop off a crew member at Scarinish. By 1030 the vessel was again running survey lines in the main area on SW/NE lines. STB line 008 was completed and again two SVP deployments were carried out, at the beginning and end of work in the main area.

Time	

0000	MBES along cable route from work area to Loch na Keal
0720	Cable route survey completed. Heading for Tiree to drop off crew member
0815	Off Scarinish. Workboat depart with crew member
0900	Workboat back on deck. Transiting to main work area to recommence survey SW of Tiree
1015	SVP deployment
1035	MBES line away from Tiree on a SW heading
1220	STB and hydrophone deployed
1237	SOL 008, Fix 522. Heading NE with NW swell and considerable chop in sea state. Data quality very poor. Heading 035
1446	EOL 008, Fix 586. As the line progressed the data gradually improved with the last 2 kilometres being of acceptable standard.
1450	STB and hydrophone on deck
1500	MBES lines
1809	SVP deployment
1820	MBES lines

Date: 30/July/2012 **JD: 212**

MBES lines with an STB seismic line between 0200 and 0400. Some time was spent 'filling-in' data gaps in the bathymetry before the SW/NE pattern resumed at midday. One more STB seismic line was run in late afternoon with the remainder of the day being taken up with MBES bathymetry.

Time	
0000	MBES lines
0200	Deploying STB and hydrophone
0205	SOL 009, Fix 587. Heading 035
0348	EOL 009. Fix 638
0355	STB and hydrophone recovered to deck
0400	Running MBES lines
0700	Running MBES infill
1130	SVP deployment
1145	Running MBES lines
1655	STB and hydrophone deployed
1703	SOL 010, Fix 639. Heading 035
	Line recorded as 009 on Coda DA2000
1705	Line recorded as 010 on Coda DA2000
1942	EOL 010, Fix 716
1948	STB and hydrophone on deck

2000	MBES lines

Date: 31/July/2012 **JD: 213**

MBES lines, then an STB seismic line 011 between 0230 and 0430. At 0800 there was computer failure with the MBES system which took 3 hours to correct. Meanwhile at 0900 the vessel set off for Scarinish to pick up the returning crew member. The GPS position telegram received by the seismic recording equipment was checked with the two receivers on the bridge and it was confirmed which receiver was in use by the STB/CODA DA2000. The vessel departed Scarinish at 1130 and recommenced MBES at 1400, following an SVP deployment at the beginning of the survey lines. These continued into the afternoon with the weather gradually increasing from the southeast, which direction should have been relatively sheltered due to the landmass of UK, however the data became increasingly distorted and at 2000, after discussion with the Captain and Mate the decision was reached to shelter behind Mull with a view to surveying the second southerly cable route on the following day.

Time	
0000	Running MBES lines
0220	STB and hydrophone deployed
0230	SOL 011, Fix 717. Heading 035
0421	EOL 011, Fix 772
0425	STB and hydrophone on deck
0430	MBES lines
0615	SVP deployment
0630	MBES lines
0850	SIS computer lost power. Having to reboot Multibeam, POS-MV and SIS machines
0915	Heading for Scarinish Bay, Tiree for crew pick-up
1045	Sitting in Scarinish Bay on DP while crew workboat pick-up catering officer
1120	Confirmation by comparing string details with receiver display that GPS telegram received by Coda DA200 recording system is received from Simrad GN33 receiver on vessel bridge. Vessel being stationary on DP allowed easy checks of GGA string details.
1140	Steaming to work area
1330	SVP deployment
1350	Running MBES lines
1700	Wind and swell increasing from SE
1830	Deploy STB and hydrophone
1842	SOL 12, Fix 773. Heading 215
	Data very poor. Wind SE force 6
1928	EOL 012, Fix 796. Data unusable. Line aborted
1940	STB and hydrophone on deck
2000	Following discussion with the Captain and Mate, decision has been made to shelter behind Mull with a view to surveying the southern cable route in the morning. MBES also aborted

	as data now unacceptable.

Date: 01/August/2012 JD: 214

Day started with the vessel running for shelter through the Sound of Mull (the longer northerly route was chosen as it was hoped much better speed would be made on it rather than taking the direct route, punching into the weather at only 2 or 3 knots.) with a view to arriving at the start of the cable route early in the morning. Once on site, after an SVP deployment, a series of MBES and STB lines were run along the landward section of the proposed cable route.

Time	
0000	In transit to southern cable route via Sound of Mull. Weather remains too poor for MBES and STB
0400	Firth of Lorn
0450	SVP deployment
0500	Problems with SVP installed on MBES heads.
0600	Running MBES on second cable route. Plan is to run STB on following line back towards Oban
0745	Deploy STB and hydrophone
0752	SOL 013, Fix 797. Heading 051
0950	EOL 013, Fix 856
0956	STB and hydrophone on deck
1005	STB and hydrophone secure and checked over
1020	MBES
1320	STB and hydrophone deployed
1328	SOL 014, Fix 857. Data poor in sea state 5/6. Heading 230
1435	Fix 890. Increase in sea state. Data almost unusable.
1535	EOL 014, Fix 920
1540	STB and hydrophone on deck
	MBES lines
2130	SVP deployment
2200	Difficulties with importing SVP data
2230	SVP data now imported to SIS successfully

Date: 02/August/2012 JD: 215

Started with an MBES line running from the south of Mull, along the cable route, out to the work area. The vessel had a crew change arranged for 0800 – 1200 at Gott Bay just offshore Scarinish on Tiree. Following the late arrival of the incoming aircraft to Tiree, the vessel departed for the work area at 1215 and STB and MBES lines re-commenced by 1410. The last STB line of the day resulted in the boomer becoming caught on two fishing buoys but fortunately these fell away as the boomer was recovered and no damage occurred.

Time	
0000	MBES infill in section of southern cable route
0300	Begin transit along southern cable route towards Tiree. Running MBES only, there being insufficient time to run STB due to crew change requirement off Scarinish, Tiree for 0800. Intention being to have vessel on DP in Gott Bay by 0900 for off-going crew departure at 0900. Replacement crew due on at 1200 with return to survey area by 1400
0640	End of MBES. Steaming for Gott Bay
0800	Arrive Gott Bay. Settling on DP
0900	Crew change. Captain, Chief Engineer and one AB to shore on vessel standby RHIB
1100	Awaiting relief crew
1205	Relief crew arrive onboard
1215	Underway to survey area
1410	STB and hydrophone deployed
1414	SOL 015, Fix 921. Data not very good in swell from South. Heading 215
1628	EOL 015, Fix 988
1635	STB and hydrophone on deck
	MBES
2030	STB and hydrophone deployed
2038	SOL 016, Fix 989. Heading 035
2305	EOL 016, Fix 1062
2310	STB and hydrophone on deck. STB had snagged some creels and buoys but appears undamaged. Buoys fell away during recovery
	MBES lines

Date: 03/August/2012 JD: 216

Continued with MBES and STB lines in the survey area, with the weather and swell gradually reducing, resulting in a significant improvement in both datasets. At this stage the aim was to complete the Multibeam and boomer lines running on NE/SW headings before the cross lines at right angles to the STB lines were commenced in the southern section of the area already covered.

Time	
0000	Running MBES lines
0100	Deploy STB and hydrophone

0107	SOL 017, Fix 1063. Heading 035 (Note this line not recorded so no data.)
0420	EOL 017, Fix ? Failure to record data means this line must be rerun in opposite direction
0430	Restart. SOL 017, Fix 1063. Heading 215
0630	EOL 017, Fix 1120
0642	STB and hydrophone on deck. Running MBES lines
0800	SVP deployment. Running MBES lines
0950	Deploy STB and hydrophone
0959	SOL 018, Fix 1121. Heading 035
1202	EOL 018, Fix 1182. Decision taken to restrict northern latitude to 56°29' as survey time now running short.
1210	STB and hydrophone on deck
	Running MBES lines
1430	STB and hydrophone deployed.
1436	SOL 19, Fix 1183. Heading 035. little swell, excellent data.
1557	EOL 19, Fix 1223
1602	STB and hydrophone on deck
	Running MBES lines
1825	STB and hydrophone deployed.
1832	SOL 20. Fix 1224. Heading 35
1951	EOL 20, Fix 1263
1958	STB and hydrophone on deck
	Running MBES lines
2250	SVP deployment
2255	STB and hydrophone deployed.
2304	SOL 21, Fix 1264

Date: 04/August/2012 JD: 217

Completion of the seismic lines and MBES lines on the SW/NE headings and at 0200 survey of the cross lines with STB only was commenced. Some Multibeam was run initially to provide quality control on data already obtained on different headings. Initially there were fears that keeping the boomer and hydrophone in the water between lines might risk the equipment but as the officers quickly grasped the turns required between lines at a 500m spacing it became evident that there was little risk. This day continued till 2045 when the southern section had been covered and the vessel steamed north to start the cross lines in the northern section. At this stage it had been decided to limit the lines to the area already covered in order to provide complete coverage. This would leave a substantial section to the north of the area which would require surveying at a later date.

Time	

0000	Running line 21
0007	EOL 21, Fix 1295
0014	STB and hydrophone on deck
	Running MBES lines
0130	Finished MBES on main section. Beginning seismic cross-lines on 500m spacing, running NW-SE. Intention to work southwards first and then come back to the northern section of area. Where lines cross over areas not already covered by Multibeam then MBES will be run to give additional coverage.
0145	Deploying STB and hydrophone
0154	SOL 022, Fix 1296. Heading 125
0319	EOL 022, Fix 1338
0327	SOL 023, Fix 1339. Heading 305. Line name not correct at start of line on COD file
0425	EOL 023, Fix 1368
	For turns to STB pull hydrophone in to vessel, leave STB For turns to Port pull STB alongside, leave hydrophone. These instructions became unnecessary after the 3rd line as the vessel turns had become very gentle and no risk to equipment was observed.
0442	SOL 024, Fix 1369. Heading 125
0550	EOL 024, Fix 1402
0557	SOL 025, Fix 1403. Heading 305
0704	EOL 025, Fix 1436
0711	SOL 26, Fix 1437, Heading 125
0810	EOL 26, Fix 1466
0819	SOL 27, Fix 1467, Heading 305
0920	EOL 27, Fix 1497
0927	SOL 28, Fix 1498, Heading 125
1021	EOL 28, Fix 1524
1030	SOL 29, Fix 1525 Heading 305
1123	EOL 29, Fix 1549
1130	SOL 30, Fix 1550, Heading 125
1212	EOL 30, Fix 1571
	Fix 1572 lost in Coda starting problems (Finger trouble?)
1220	SOL 31, Fix 1572, Heading 305
1301	EOL 31, Fix 1591
1310	SOL 32, Fix 1592, Heading 125
1356	EOL 32, Fix 1615
1404	SOL 33, Fix 1616. Heading 305.
1441	EOL 32, Fix 1634

1450	SOL 34, Fix 1636, Heading 125
1531	EOL 34, Fix 1656
1540	SOL 35, Fix 1657. Heading 305
	Slight chop apparent in sea state. Data not so good as before. White horses visible on surface
1614	EOL 35, Fix 1673
1631	SOL 36, Fix 1675, Heading 125
1706	EOL 36, Fix 1692. Line shortened due to shallow water
1713	SOL 37, Fix 1693. Heading 305
1738	EOL 37, Fix 1705
1753	SOL 38, Fix 1706. Heading 125
1823	EOL 38, Fix 1719
1831	SOL 39, Fix 1720. Heading 305. Weather gradually deteriorating
1853	EOL 39, Fix 1730
1904	SOL 40, Fix 1732, Heading 125
1926	EOL 40, Fix 1743
1934	SOL 41, Fix 1744, Heading 305
1952	EOL 41, Fix 1752
2002	SOL 42, Fix 1753, Heading 125
2016	EOL 42, Fix 1760
2025	SOL 43, Fix 1761, Heading 305
2038	EOL 43, Fix 1767
2045	STB and hydrophone on deck. Steaming for centre of area to restart seismic lines to cover northern segment up to 56° 29’ N which is limit for this survey.
2130	SVP deployment
2155	STB and hydrophone deployed. Sea state calmer in northern section, away from Skerryvore rocks.
2159	SOL44, Fix 1768, Heading 305
2316	EOL 44, Fix 1806
2323	SOL 45, Fix 1807, Heading 125

Date: 05/August/2012 **JD: 218**

Continuing the seismic lines in the northern section with MBES being run to provide coverage of areas as yet unsurveyed previously.

Time	
0000	Running seismic line 45
0031	EOL 45, Fix 1840

	Coda DA2000 now has CMG recorded but **NO** layback entered. CMG quite unstable.
0045	SOL 46, Fix 1841, Heading 305
0157	EOL 46, Fix 1877
0213	SOL 47, Fix 1878, Heading 125
0336	EOL 47, Fix 1919
0346	SOL 48, Fix 1920, Heading 305. Nav set-up not working correctly at start of line Coda time is wrong so CODA filename is incorrect. Fault corrected before fix 1921
0410	Wind and swell beginning to pick up and affect data quality
0453	EOL 48, Fix 1953
0500	SOL 49, Fix 1954, Heading 125
0627	EOL 49, Fix 1997. Line ended early to avoid fishing traffic
0635	SOL 50, Fix 1998, Heading 305. Fix 1955 is repeated at start of line as fix numbers not set correctly until second fix. Weather has eased slightly but data not as good running into the swell
0757	EOL 50, Fix 2038
0811	SOL 51, Fix 2039, Heading 125
0926	EOL 51, Fix 2076
0939	SOL 52, Fix 2077, Heading 305
1123	EOL 52, Fix 2128
1132	SOL 53, Fix 2129, Heading 125
1248	EOL 53 Fix 2166
1259	SOL 54, Fix 2167, Heading 305
1425	EOL 54, Fix 2209
1441	SOL 55, Fix 2210, Heading 125
1555	EOL 55, Fix 2246 Shallow water
1559	SOL 56, Fix 2247, Heading 305
1701	EOL 56, Fix 2277. Weather freshening with NW wind
1709	SOL 57, Fix 2278, Heading 125
1810	EOL 57, Fix 2307
1819	SOL 58, Fix 2308, Heading 305
1900	EOL 58, Fix 2328
1908	SOL 59, Fix 2329, Heading 125
1945	EOL 59, Fix 2346
1955	SOL 60, Fix 2347, Heading 305
2033?	EOL 60, Fix 2365
2040	SOL 61, Fix 2366, Heading 125
2119	EOL 61, Fix 2384

2129	SOL 62, Fix 2385, Heading 305
2202	EOL 62, Fix 2401
2210	SOL 63, Fix 2402, Heading 125
2226	EOL 63, Fix 2410
	Now preparing to run MBES lines to use remaining time to fill gaps in MBES data in northern section of survey area.
2300	/Running MBES

Date: 06/August/2012 JD: 219

Survey vessel complets Multibeam 'infill', terminating at 0330 when the vessel set a course for Oban. The *NLV Polestar* tied up at the NLB pier at 1110 in Oban.

Much of the equipment demobilisation and packing was completed before reaching Oban, leaving the unloading from the vessel until the van arrived. The van was fully loaded by 1300 and the remainder of the time was spent awaiting the data back-up of multibeam data to the RAID hard drive from BGS Data Management.

BGS staff return to Edinburgh.

Time	
0000	Running MBES lines
0330	Transit to Oban. ETA 1100
1110	Tied up in Oban at NLB pier and yard
1230	BGS hire van arrives. Horner, Crombie depart vessel for train to Edinburgh
1430	BGS team: Ritson, Wallis, Baines depart vessel in hire van
1800	BGS team return Edinburgh

Appendix 2 Personnel

BGS Party Chief	David Wallis
BGS Hydrographer	Rhys Cooper
Contract Hydrographer	Gillian Horner
Electronics Engineer	Simon Ritson
BGS Hydrographer/Geophysical Processor	Kirstin Crombie

***NLV Polestar* Officers**

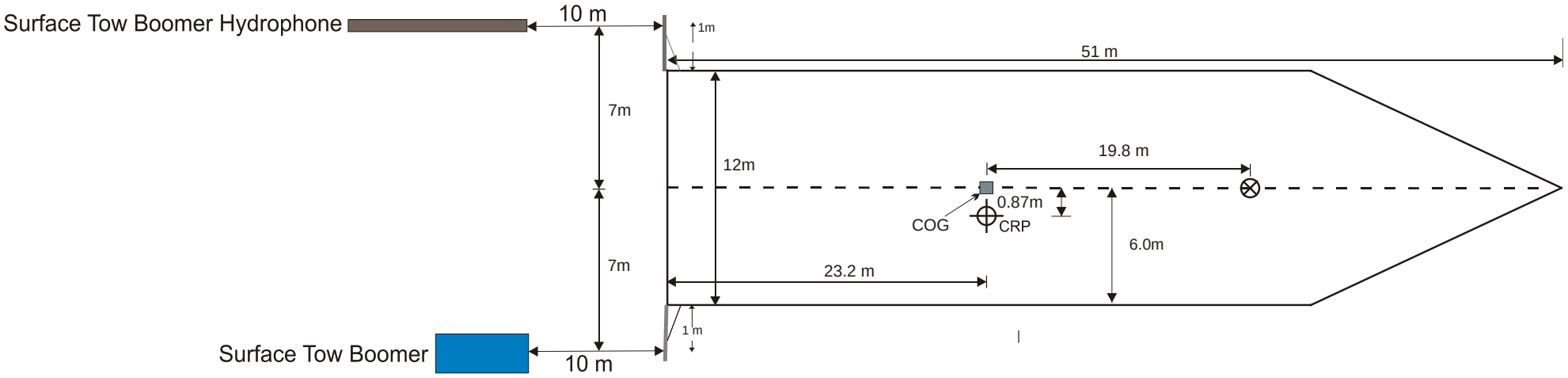
Captain	Stuart Ross / Alisdair Graham
First Mate	James Cotterill
Second Mate	Fraser Munro
Second Mate	Michael Smith
Chief Engineer	Greig Gamble / Colm O'Brien
Second Engineer	Euan MacPhail

Crew

ERT	Arthur Thomson
Bosun	Mervyn Manson
Seaman	Mark Shelton
Seaman	Alistair Gordon
Seaman	Geoffrey Bisp
Seaman	Joseph Bradley / Chris Bradley
Catering	Ian Butler
Catering	Scott Sayer
Carpenter	Gordon Kay

Appendix 3 Equipment Layback Diagrams

BGS Layback Diagram



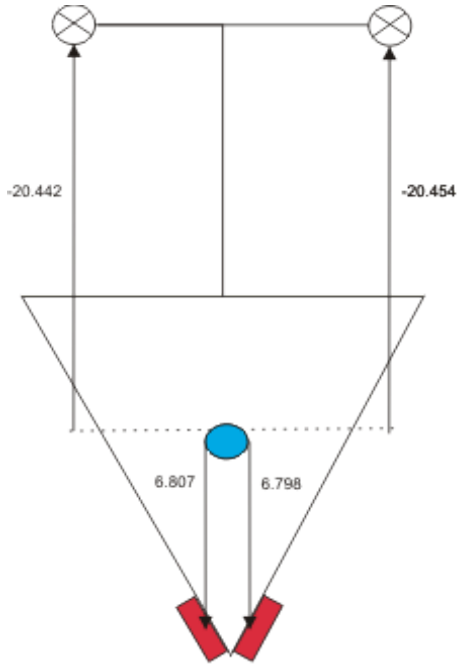
KEY

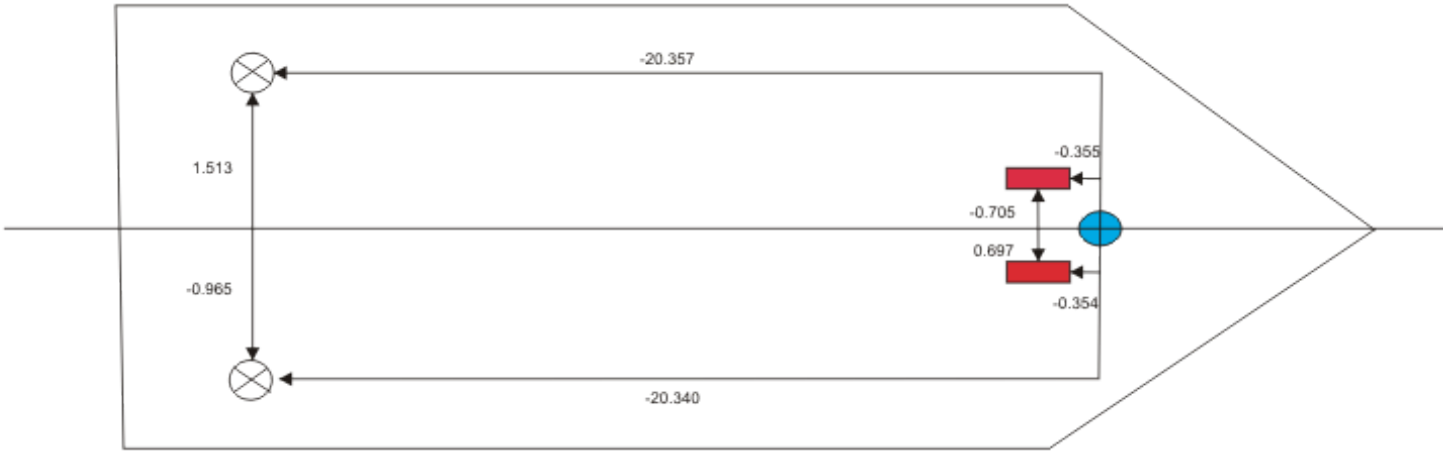
COG Mainmast

CRP GPS Common Reference Position (CRP)

⊗ Multibeam Transducer

NLV Pole Star - Survey BGS2012/09 - MS





MRU = CRP

Sonar Head

POS MV GPS antenna

Appendix 4 Geodetic Parameters

Survey Classification	IHO Order 1
Horizontal Datum	ETRS 89 (WGS84)
Vertical Datum	Chart Datum
Digital Equipment	Kongsberg EM3002 D, POS MV 320, Fugro StarFix

1 **Geodetic Reference System.**

Horizontal Datum	ETRS 89 (WGS84)
Vertical Datum	Chart Datum (VORF)
Spheroid	GRS80
Semi-major axis	6 378 137.0m
Semi-minor axis	6 356 752.3m
Inverse flattening	298.257222101

2 **Projection System.**

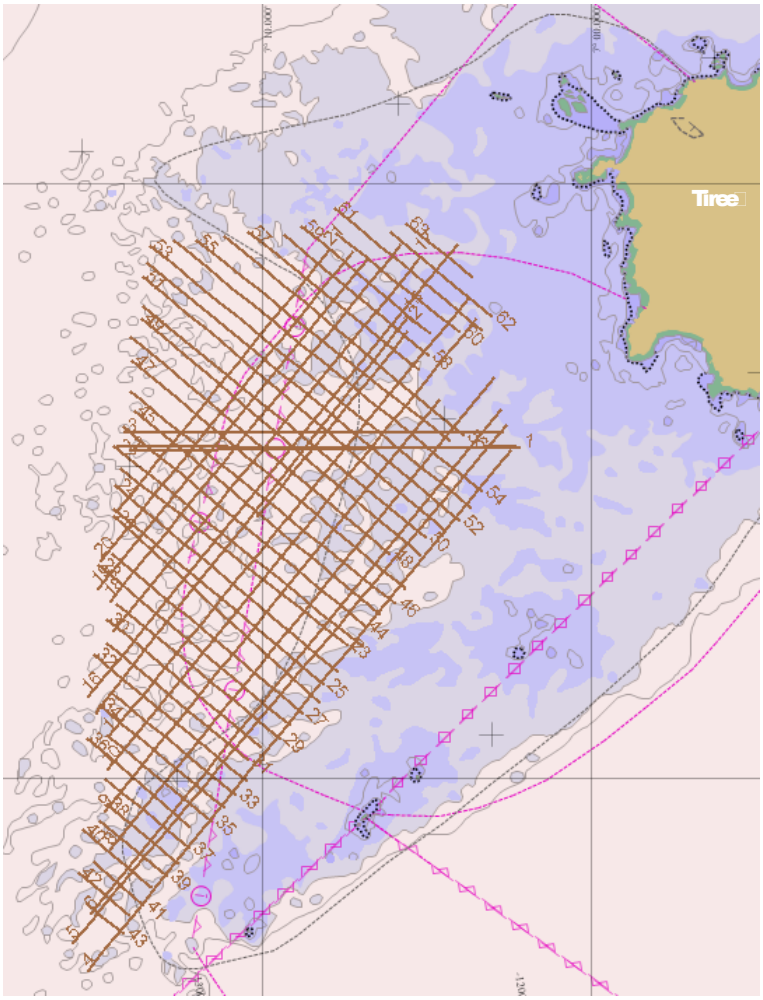
Projection	UTM Grid Zone 29 (N)
Central Meridian (CM)	6˚ W
Latitude of Origin	0˚
False Easting	500 000.00
False Northing	0.0
Scale Factor on CM	0.9996

Appendix 5 Surface Tow Boomer Line Summary Sheet

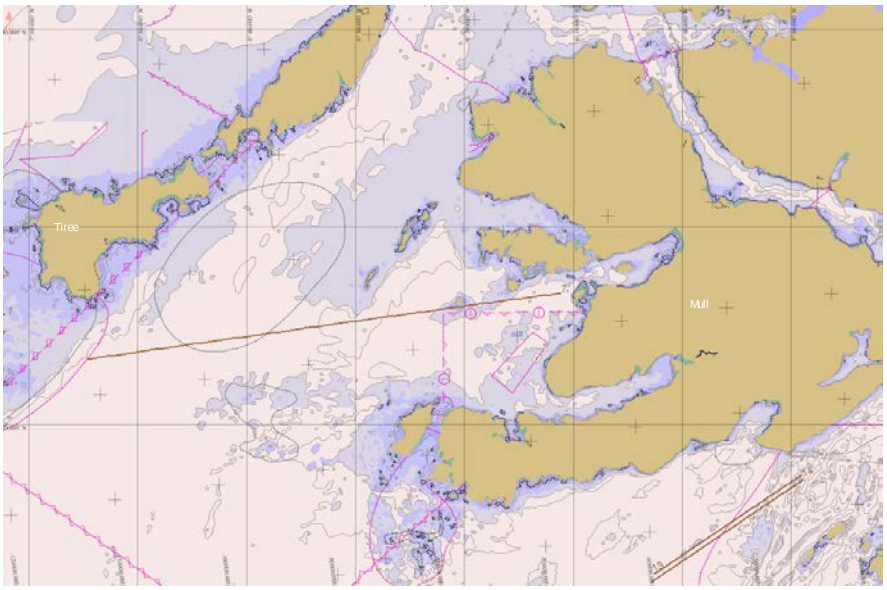
Line number	North1	East1	North2	East2
1	56.425951	-7.035478	56.426107	-7.240550
2	56.425031	-7.234205	56.426196	-7.037408
3	56.430281	-7.237284	56.430157	-7.044013
4	56.279254	-7.255369	56.425488	-7.040899
5	56.287095	-7.263058	56.432473	-7.042785
6	56.295229	-7.253957	56.437047	-7.045392
7	56.444205	-6.186194	56.388352	-6.911006
8	56.313120	-7.244308	56.445938	-7.048925
9	56.323741	-7.247238	56.439627	-7.076747
10	56.335678	-7.245623	56.462207	-7.058122
11	56.345002	-7.244909	56.467984	-7.062347
12	56.458776	-7.092873	56.406528	-7.169729
13	56.207265	-6.043426	56.290997	-5.818187
14	56.287393	-5.814065	56.200445	-6.047576
15	56.463280	-7.092176	56.351503	-7.251500
16	56.355868	-7.255492	56.483278	-7.067875
17	56.479515	-7.086422	56.374472	-7.242485
18	56.382848	-7.244385	56.483093	-7.096286
19	56.386457	-7.250337	56.479269	-7.112991
20	56.394294	-7.248784	56.481215	-7.120658
21	56.481583	-7.132485	56.408356	-7.240333
22	56.426800	-7.242934	56.370195	-7.116101
23	56.370449	-7.123777	56.420319	-7.239108
24	56.415582	-7.242122	56.363207	-7.128684
25	56.359476	-7.135371	56.409051	-7.242549
26	56.407151	-7.242731	56.354381	-7.137728
27	56.351406	-7.145916	56.396284	-7.243307
28	56.393336	-7.250581	56.348075	-7.152788
29	56.344275	-7.157599	56.382353	-7.240962
30	56.378051	-7.245927	56.341946	-7.167642
31	56.338447	-7.174162	56.371411	-7.245971
32	56.368129	-7.252975	56.332418	-7.174756
33	56.328407	-7.180152	56.357408	-7.243479
34	56.353941	-7.249613	56.324883	-7.186175
35	56.321183	-7.192455	56.345469	-7.245980
36	56.344849	-7.255986	56.319553	-7.203545
37	56.313622	-7.203683	56.333483	-7.247228
38	56.326212	-7.245940	56.309454	-7.209728
39	56.305660	-7.215270	56.321476	-7.249594
40	56.319047	-7.258266	56.302561	-7.223069
41	56.297762	-7.227108	56.309974	-7.252961
42	56.306899	-7.260103	56.294729	-7.234227
43	56.289706	-7.237330	56.298464	-7.256432

44	56.376197	-7.115226	56.432061	-7.237705
45	56.436675	-7.232068	56.379161	-7.107242
46	56.382169	-7.099536	56.441963	-7.234362
47	56.450559	-7.233196	56.386440	-7.094441
48	56.396084	-7.102239	56.457278	-7.233933
49	56.462534	-7.228821	56.395867	-7.086632
50	56.400631	-7.083551	56.465731	-7.227698
51	56.474325	-7.227699	56.402518	-7.073944
52	56.405497	-7.066585	56.477897	-7.225370
53	56.482753	-7.224135	56.409073	-7.061067
54	56.413638	-7.055408	56.484461	-7.212281
55	56.484277	-7.200754	56.427847	-7.071989
56	56.429325	-7.064933	56.485695	-7.186480
57	56.486831	-7.174315	56.447842	-7.087637
58	56.451704	-7.082288	56.485894	-7.156210
59	56.488383	-7.147353	56.457952	-7.082023
60	56.458416	-7.067079	56.486247	-7.129841
61	56.493446	-7.130678	56.458845	-7.055714
62	56.462896	-7.050799	56.486609	-7.102544
63	56.489057	-7.094554	56.473926	-7.060354

SURFACE TOW BOOMER LINES TO SW OF TIREE

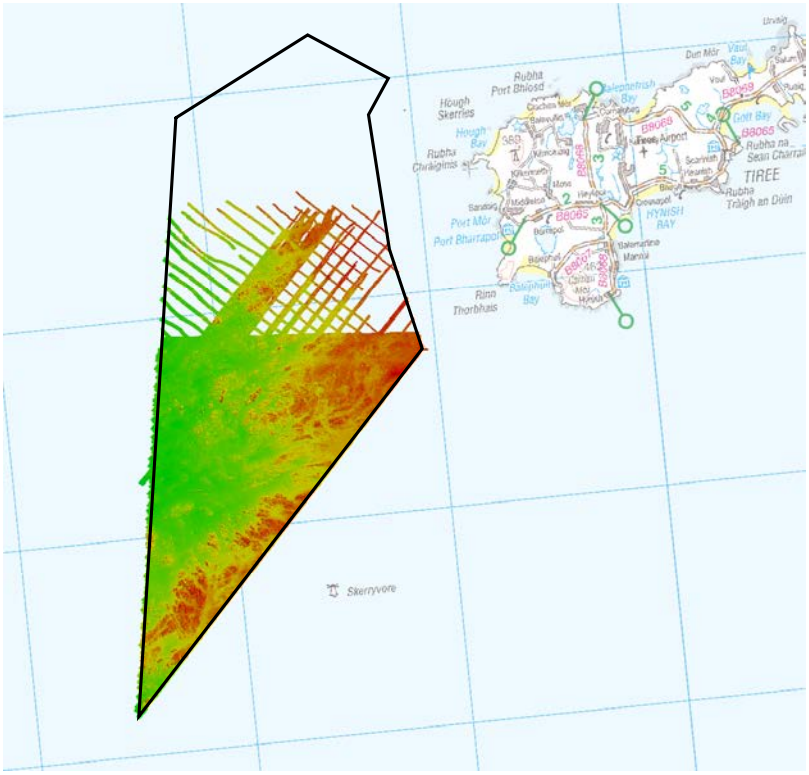


CABLE ROUTE STB LINES



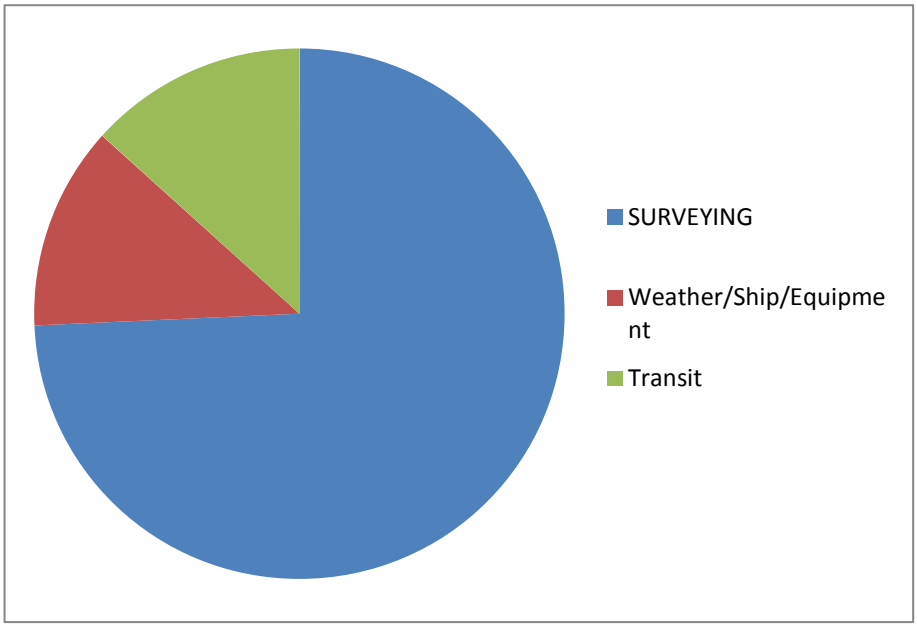
Appendix 6 Swath images

MULTIBEAM COVERAGE IN PRIORITY AREA



MULTIBEAM COVERAGE IN PRIORITY AREA & CABLE ROUTES

Appendix 7 Time Utilisation Diagram



CALENDAR DAY		HOURS LOST		
	SURVEYING	Weather/Ship/Equipment	Transit	TOTAL
23/07/2012	6	18		24
24/07/2012	12		12	24
25/07/2012	21		3	24
26/07/2012	24			24
27/07/2012	15	7	2	24
28/07/2012	18	6		24
29/07/2012	21		3	24
30/07/2012	24			24
31/07/2012	14	6	4	24
01/08/2012	17	3	4	24
02/08/2012	16		8	24
03/08/2012	24			24
04/08/2012	24			24
05/08/2012	4		7	11
TOTAL	240	40	43	323

Appendix 8 MBES Patch Test

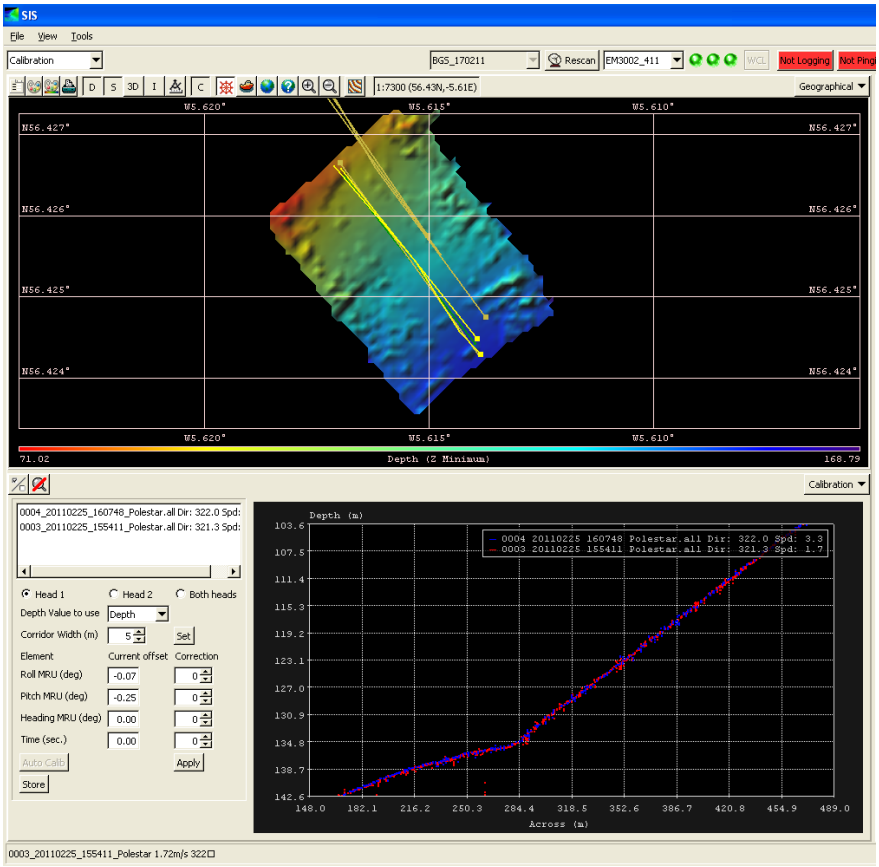
Patch test for *NLV Polestar*.

Due to time limitations a patch test was not performed at the start of this survey. Weather conditions were extremely marginal in survey area.

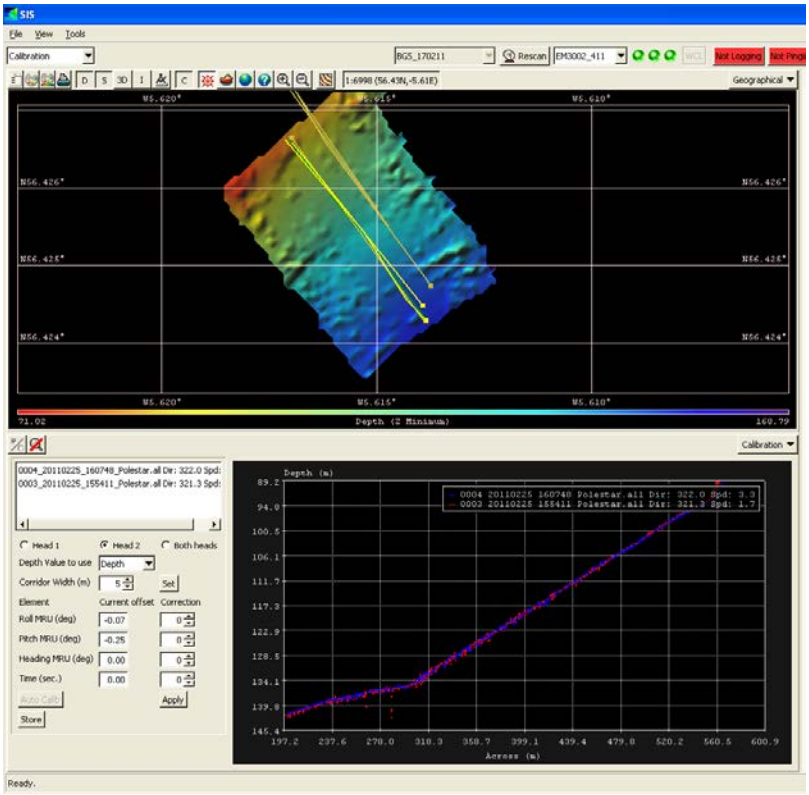
A patch test was carried out on board the *NLV Polestar* on 15 March 2012 by BGS surveyor Nick Smart.

The results are given below.

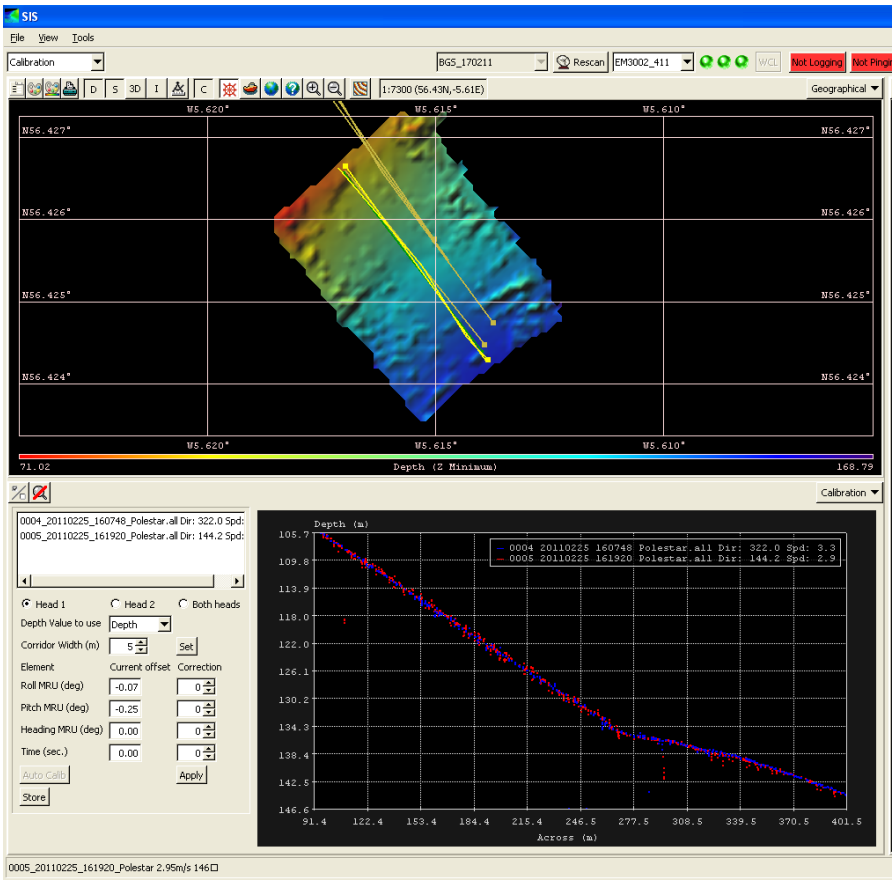
Latency – Head 1



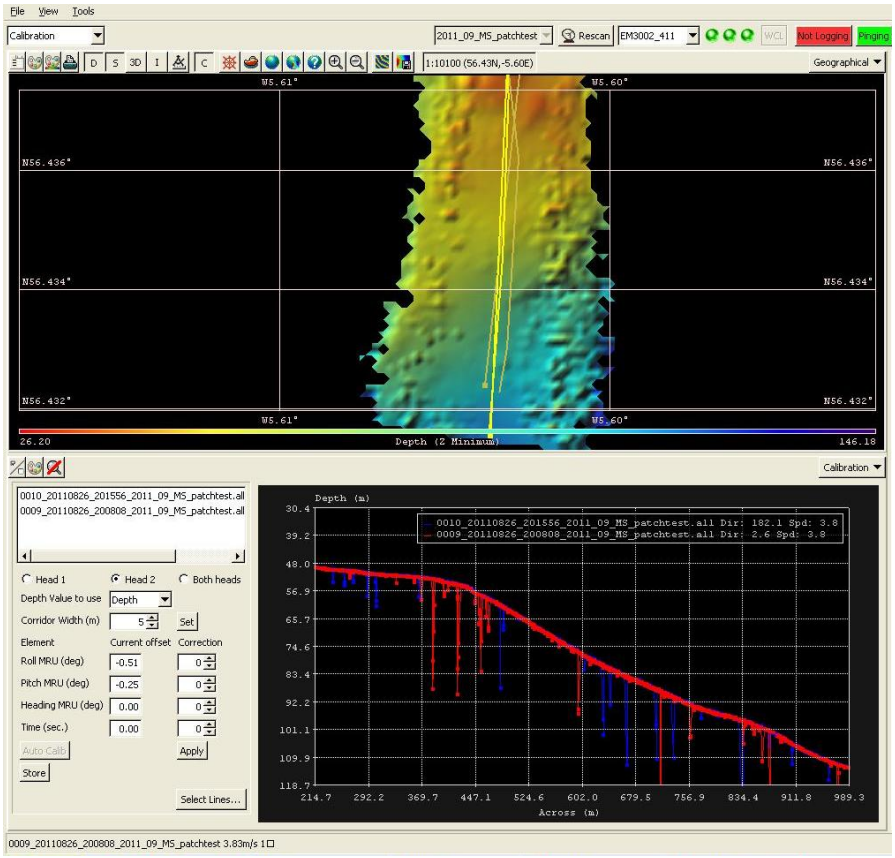
Latency – Head 2



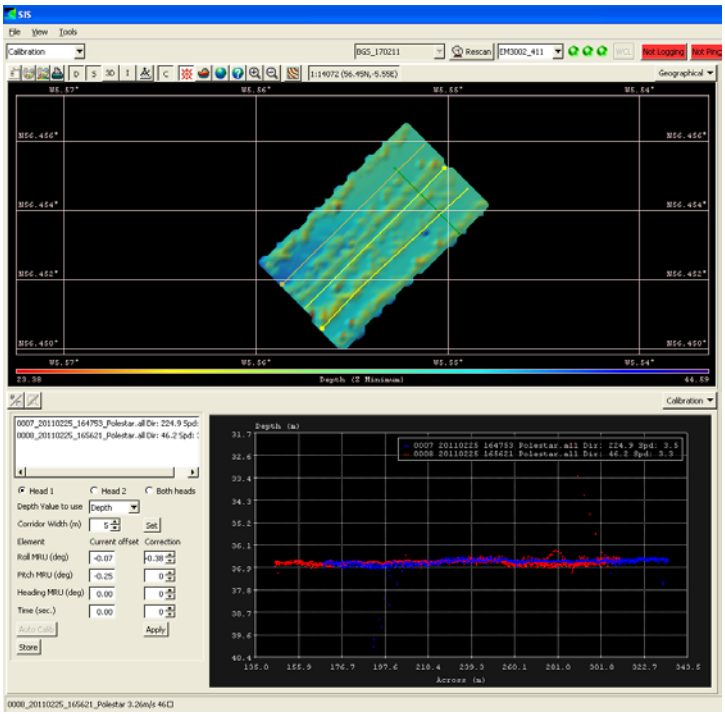
Pitch – Head 1



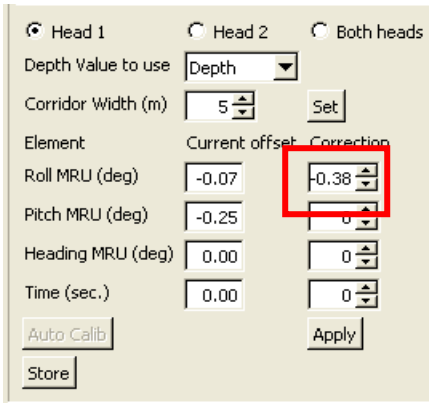
Pitch – Head 2



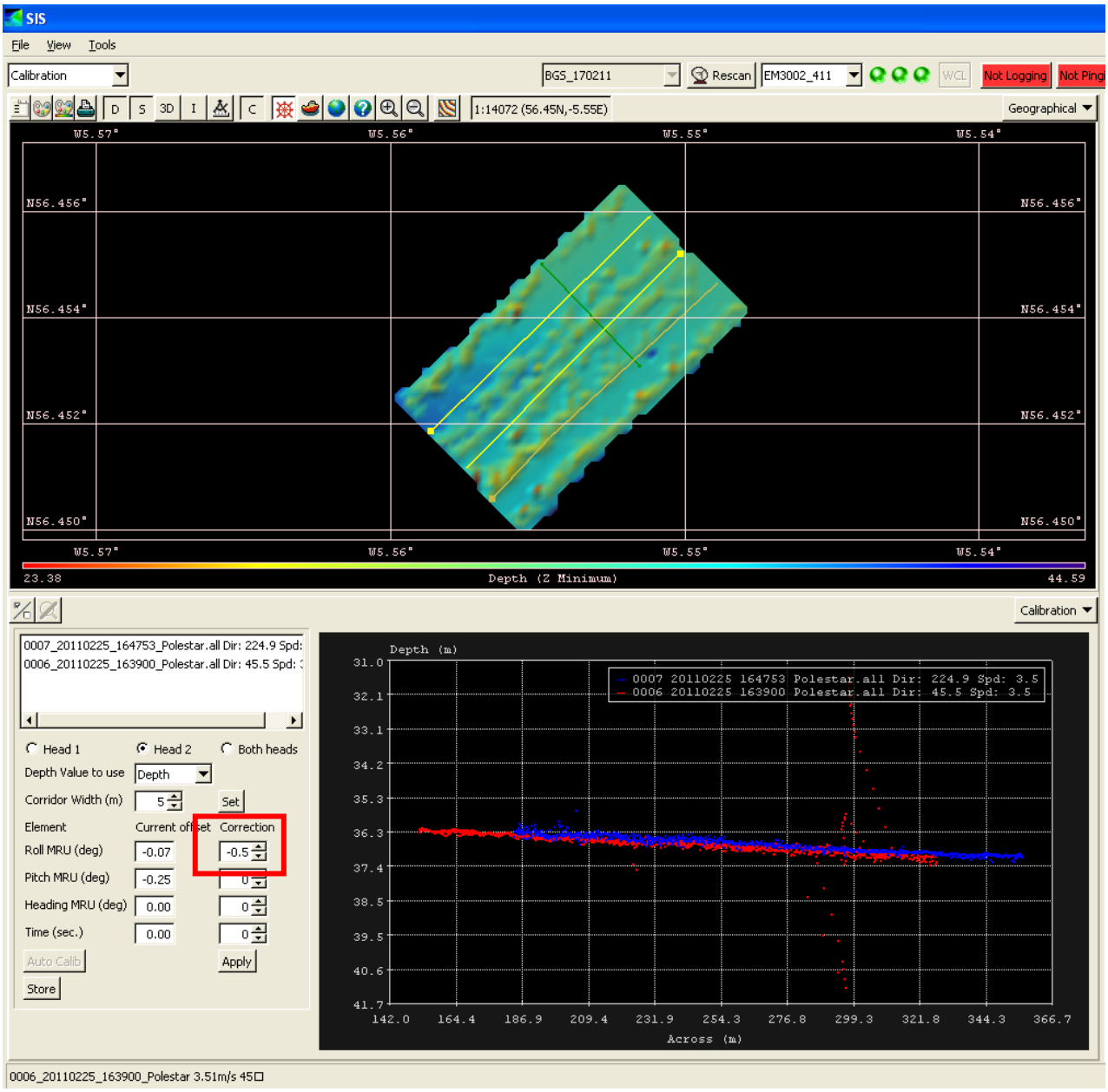
Roll - Head 1



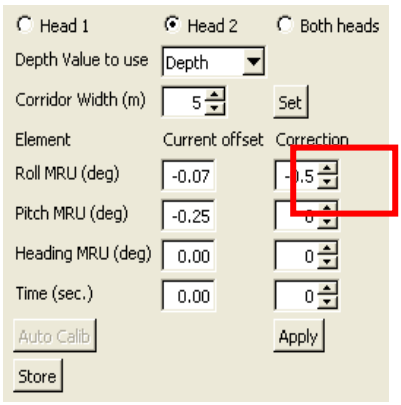
Head 1 correction needed:



Roll - Head 2



Head 2 correction needed:



Roll correction application:

Head 1 = -0.38

Head 2 = -0.5

Common Error (CE) = (-0.38+-0.5)/2 = -0.44

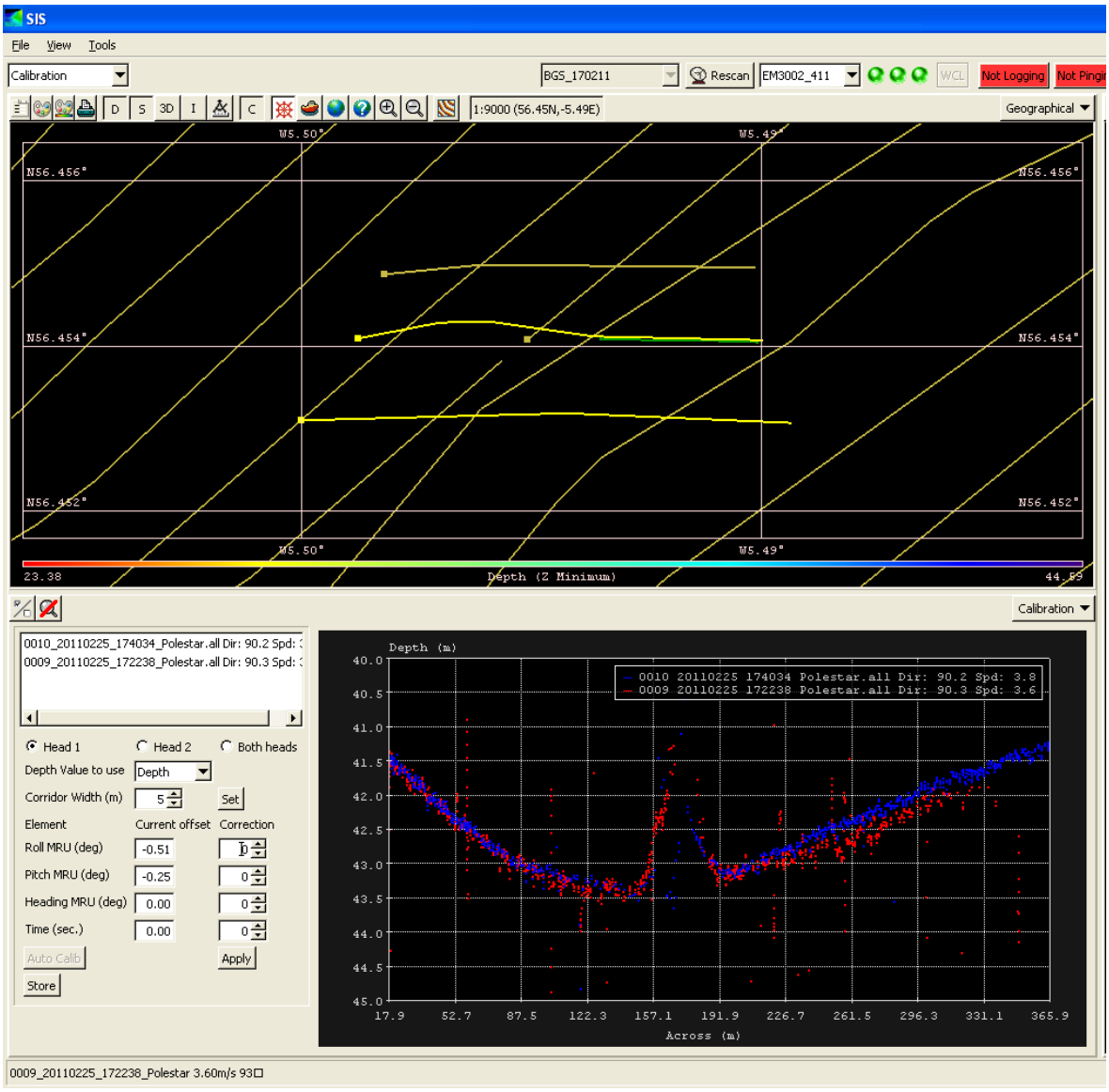
Head 1 correction = +0.06

Head 2 correction = -0.06

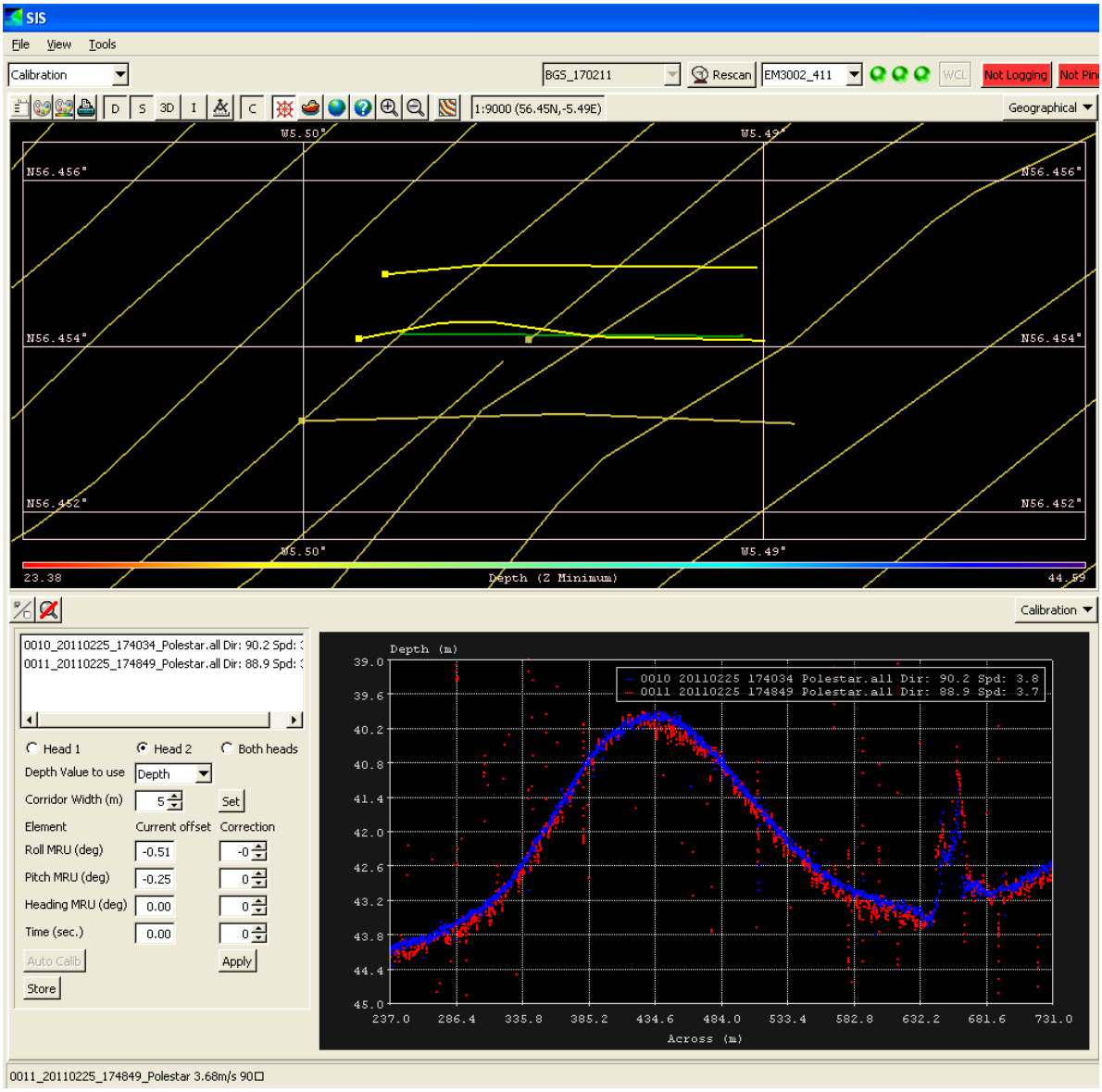
Head 1 installation = 39.345

Head 2 installation = -38.515

Heading – Head 1



Heading – Head 2



There were no corrections required for latency, pitch or heading.

Appendix 9 Data Delivery Folder Structure

Boomer

Raw Coda - ..\2012_9_MS\Geophysical\CODA\RawCoda

Final Processed Coda - ..\2012_9_MS\Geophysical\CODA\ProcessedCoda

Raw SEGYs - ..\2012_9_MS\Geophysical\SurfaceTowBoomer\RawData

Final SEGYs - ..\2012_9_MS\Geophysical\SurfaceTowBoomer\ProcessedData\OffsetsApplied

Final tiffs of processed coda files - ..\2012_9_MS\Geophysical\SurfaceTowBoomer\ProcessedImages

Boomer Navigation

Raw Navigation - ..\2012_9_MS\Navigation\RawData

Processed Navigation - ..\2012_9_MS\Navigation\ProcessedData

Track Chart pdf and shape file - ..\2012_9_MS\Navigation\TrackChart

Multibeam

Caris Project - ..\2012_9_MS\Multibeam\SoftwareFiles\Tiree

Raw .all files - ..\2012_9_MS\Multibeam\SoftwareFiles\Tiree\PreProcess

GSF's - ..\2012_9_MS\Multibeam\ProcessedData\GSFs

Bathymetry Products

ArcGrids:

..\2012_9_MS\Multibeam\BathymetryProducts\PriorityArea\ArcGrids

..\2012_9_MS\Multibeam\BathymetryProducts\CableNorth\ArcGrids

..\2012_9_MS\Multibeam\BathymetryProducts\CableSouth\ArcGrids

iff images of bathymetry Fledermaus SDs:

..\2012_9_MS\Multibeam\BathymetryProducts\PriorityArea\Images

..\2012_9_MS\Multibeam\BathymetryProducts\CableNorth\Images

..\2012_9_MS\Multibeam\BathymetryProducts\CableSouth\Images

Flerdermaus SDs:

..\2012_9_MS\Multibeam\BathymetryProducts\PriorityArea\SD

..\2012_9_MS\Multibeam\BathymetryProducts\CableNorth\SD

..\2012_9_MS\Multibeam\BathymetryProducts\CableSouth\SD

XYZs:

..\2012_9_MS\Multibeam\BathymetryProducts\PriorityArea\XYZ

..\2012_9_MS\Multibeam\BathymetryProducts\CableNorth\XYZ

..\2012_9_MS\Multibeam\BathymetryProducts\CableSouth\XYZ

Backscatter Products

Ascii and tiffs:

..\2012_9_MS\Multibeam\BackscatterProducts\CableNorth

..\2012_9_MS\Multibeam\BackscatterProducts\CableSouth

..\2012_9_MS\Multibeam\BackscatterProducts\PriorityArea

XYZ of Priority Area:

..\2012_9_MS\Multibeam\BackscatterProducts\PriorityArea

Appendix 10 Initial Risk Assessment

5.2.1.1 NAME OF SHIP POLE STAR **Record no. 027**

Work Area being assessed **Deck Third Party Personnel**

Task Id number	Work process/action undertaken in area	Hazards associated with activity	Controls already in place	Significant risks identified	Further assessment Required (Y/N)
1	All areas of the ship	Recognition of Shipboard Hazards by Third Party Personnel	Familiarisation Tour and under the supervision of Ships Staff	None	No
2	All areas of the ship	Third Party Equipment Failure	Must meet NLB Standards	None	No
3	All areas of the ship	Position and securing of Third Party Equipment	To be approved by Ship's Staff	None	No
4	All areas of the ship	Personnel Injury	Appropriate PPE gear to be worn. Ship Task specific Risk Assessments to be Followed	None	No

Declaration:

Where no significant risk has been listed, we as assessors have judged that the only risks identified were of an inconsequential nature and therefore do not require a

more detailed assessment.

Signed _____S.S.Tyler_____

References

APPLANIX. [2009]. http://www.applanix.com/products/marine/pos-mv.html [online]. Last update 2009 [cited 14 March 2011].

APPLANIX. [2009]. http://www.applanix.com/media/downloads/products/specs/posmv_specifications.pdf [online]. Last update 2009 [cited 14 March 2011].

TALBOT, A.; READ, R [2011], CARIS HIPS AND SIPS V 7: STANDARD OPERATING PROCEDURES FOR KONGSBERG MARITIME MBES DATA. UNITED KINGDOM HYDROGRAPHIC OFFICE

FUGRO SEASTAR. [20045]. http://www.seastar.co.uk/Support/Seastar%203510_nov04.pdf [online]. Last update Nov 2004 [cited 14 March 2011].