RRS James Clark Ross

JRtri006 Cruise Report

EM122 multibeam echo sounder acceptance trials

NE Atlantic

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EM122 multibeam echo sounder acceptance trials

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British Antarctic Survey Cruise Report

Portsmouth – Falmouth – Porcupine Basin – Rockall Trough – Glasgow

Report of RRS James Clark Ross cruise JRtri006, June-July 2011

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Contents:

Front and back page images: JRtri006 Scientific Party. Photos taken by Richard Turner

Summary

RRS James Clark Ross trials cruise JRtri006 took place from 27th June 2011 to 3rd July 2011. The EM122 multibeam acceptance trials began in Portsmouth and following a brief boat transfer at Falmouth proceeded to the Porcupine Basin and then north to the Hebrides Terrace seamount, west of Scotland. Following calibration tests, the cruise ended at Glasgow. A cruise track is shown in Figure 1. Weather and sea state was generally calm during the first few days with a strengthening southerly wind and increased swell towards the latter part of the cruise. All essential calibrations and trials were undertaken as well as many of the secondary objectives.

Objectives

The main objective of the cruise was to accept the installation of the Kongsberg EM122 multibeam upgrade. This upgrade replaced an EM120 which was installed during refit in 2000. As well as the commissioning report from the Kongsberg installation engineer (see Appendix A), the trials consisted of roll, pitch and heading calibrations plus tests to look at noise levels, data quality and integration with other acoustic instruments through the Simrad Synchronisation Unit (SSU). The Seatex Seapath (GPS and motion reference sensor) was also upgraded during refit to a 320+ model (replacing the Seapath 200). As the Seapath 320+ provides both position and motion data to the EM122, there is a brief discussion in this report about user configurations within the Seapath software.

A secondary focus was user training on the Kongsberg Seafloor Information System (SIS) acquisition software. This Microsoft Windows 7 based software replaced the Kongsberg Merlin acquisition software running on Sun Solaris. While the new software has much of the same functionality as Merlin, it has several new features that will be highly useful for survey work. An outcome of the cruise was to update the 'How to' document for scientific users who want to use the EM122 for opportunistic surveys (see Appendix B).

Several routines involving data transfer to and from the EM122 acquisition machine had to be changed after the upgrade including importing sound velocity profiles from XBTs and CTDs, raw data backup onto the SAN and outputting EM122 centre beam depth to the Shipboard Computer System (SCS).

Depth, backscatter and water column data logged by the EM122 were inspected in a variety of different post-processing packages to assess quality and to compare to archival EM120 data collected during cruise JR130 (multibeam training cruise, 2005).

Narrative

26th June 2011, Sunday, Jday 177
The scientific party arrived at Portsmouth at 1400.

27th June 2011, Monday, Jday 178
Setup tasks whilst the ship was still in dock. The Kongsberg engineer gave training on the Seatex Seapath 320 followed by user training on the principles of multibeam data collection and the SIS acquisition software for five of the scientific party. A problem with the SSU not correctly receiving EM122 signals was identified.

28th June 2011, Tuesday, Jday 179
Following an emergency muster drill the ship departed Portsmouth at 1100, heading into the Channel for engine and dynamic positioning trials. The SSU problem was solved (see Appendix A) and SIS user training continued for the first group. There was an overnight passage to Falmouth.

29th June 2011, Wednesday, Jday 180
Engine testing continued whilst the ship stooged close to Falmouth. Contractors and ETS support (Richard Bridgeman) were transferred to Falmouth by small boat at 1400. The ship proceeded towards a waypoint within the Porcupine Basin in order to test the EM122 in a range of depths and to test ping modes with respect to backscatter data quality. EM122 and SIS user training began for the second group from the scientific party.

30th June 2011, Thursday, Jday 181
Individual three hour watches were assigned for users to play with the SIS software. Ping mode testing was carried out as the ship travelled across the continental shelf into deeper water in order to determine effects on backscatter data. This was followed by noise tests at a variety of different speeds. Similar noise tests were also carried out with other acoustic instruments turned on while maintaining a constant speed. A brief trial synchronising multiple acoustic instruments was undertaken to compare with findings from the acoustic setup trials cruise in June 2008.

1st July 2011, Friday, Jday 182
EM122 watches continued through the day as the ship sailed north towards the roll calibration site in the Rockall Trough. Weather was mainly overcast with sea state worsening from 4/5 to 6/7 throughout the day. Roll calibration started at 2000 and continued for several hours. Line directions were 035/215 degrees in order to minimise poor data collection due to sea state and crabbing.

2nd July 2011, Saturday, Jday 183
The ship transited from the roll calibration site to the Hebrides Terrace seamount for the pitch and heading calibrations. These were completed on the south west slopes of the seamount but there was insufficient time to repeat lines collected on JR130 on the northern slopes. A three line survey was completed to the south of the seamount in order to compare overlapping swaths. This was completed with a cross track though the middle. Finally a second roll calibration was performed before trials ended at 1400. On the passage to Glasgow, EM122 data was recorded up to the continental shelf at around 1700.

3rd July 2011, Sunday, Jday 184
The ship continued passage to Glasgow, docking at 1400.

4th July 2011, Monday, Jday 185
The scientific party depart the ship at 0800.

Personnel

Officers and crew for JRtri006

BURGAN, Michael JS	Master
O'DONNELL, Wendy A	Chief Officer
CONSTABLE, John E	2nd Officer
WYLES, Spencer Riches	3rd Officer
GLOISTEIN, Michael EP	ETO Comms
BROWN, George W	Deck Cadet
DELPH, Georgina M	Deck Cadet
ANDERSON, Duncan E	Ch Engineer
ELLIOTT, Thomas R W	2nd Engineer
STEVENSON, James S	3rd Engineer
COUPER, Robert JJ	4th Engineer
WALE, Gareth M	Deck Eng
MCMANMON, John P	ETO Engineer
TURNER, Richard J	Purser
PECK, David J	Bosun
BOWEN, Albert Martin	Bosun's Mate
CHAPPELL, Kelvin E	SG1
RAPER, Ian	SG1
DALE, George A	SG1
TRIGGS, David William	SG1
DUNNE, John G	SG1
ASHWORTH, Matthew G	MG1
HANSEN, Philip C	MG1
HUNTLEY, Ashley Alan	Chief Cook
LEE, Jamie Edward	2nd Cook
JONES, Lee J	Sr Steward
GREENWOOD, Nicholas R	Steward
RAWORTH, Graham	Steward
HENRY, Glyndor N	Steward

Scientific party

TATE, Alexander J	BAS Geological Data Manager (PSO)
FIELDING, Sophie	BAS Biological Acoustician
GRAHAM, Alastair	BAS Marine Geologist
NEWTON, Gwen B	BAS Geophysical Data Manager
BRIDGEMAN, Richard	BAS (Antarctic and Marine Engineering)
COLLINS, Luke	BAS (IT Support)
EDMONSTON, Johnnie GR	BAS (IT Support)
LENS, Peter C D	BAS (IT Support)
ROBST, Jeremy P	BAS (IT Support)
HOGAN, Kelly	Scott Polar Research Institute, University of Cambridge
BACHELOR, Christine L	Scott Polar Research Institute, University of Cambridge
WALLACE Craig R	Kongsberg Maritime

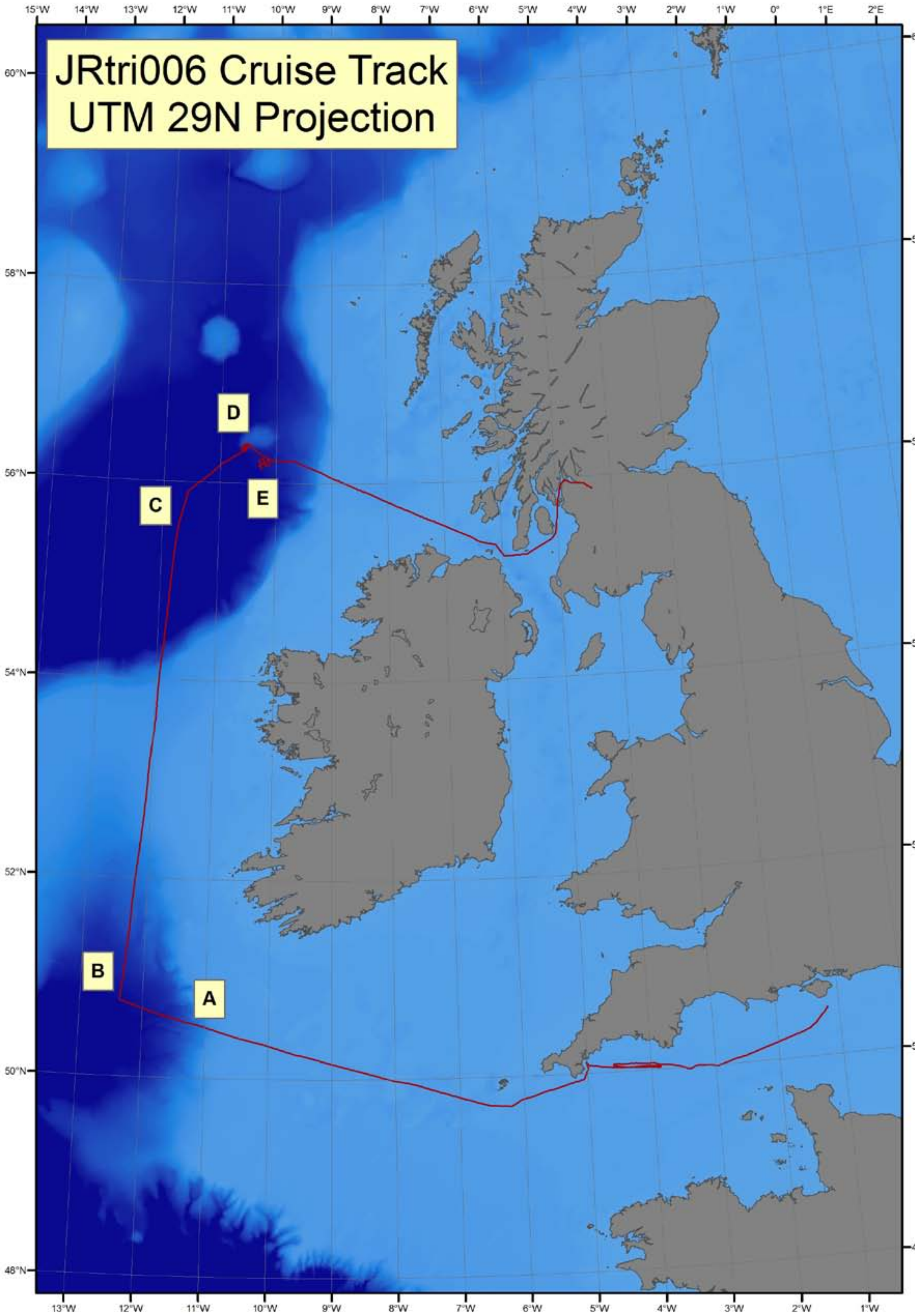


Figure 1 shows the JRtri006 cruise track. A = Ping mode tests. B = Noise tests in Porcupine Basin, C = Roll Calibration, Rockall Trough. D = Pitch and heading calibrations, Hebrides Terrace seamount. E = 3x1 overlap test with second roll calibration.

Equipment Reports

EM122 multibeam echo-sounder calibration report (Alastair Graham)

1. Introduction

A main aim of the trials cruise was to calibrate the EM122 system and its external sensors to ensure reliability and accuracy in depth measurements. Calibration should improve data quality by correcting for offsets in measurement of the pitch, heading and roll of the ship, as well as latency between sensors.

Before the cruise, the sensors (transducer and receiver arrays, and inertial sensor) on JCR were surveyed with respect to the vessel's reference plane, and installation angles established. The procedure for calibrating the EM122 involves running a series of trial lines of specific configuration, normally with overlapping swaths, from which additional biases in installation angles or time synchronisation can be established. Biases can stem from misalignments in the transducers or MRU, or from time synchronisation differences between the different sensors. Any offsets can be measured and applied to the attitude sensor (the MRU) via the SIS software.

The first calibration of the new EM122 system was performed on cruise JRtri006. This report provides:

1. A basic step-by-step guide for calibration of the multibeam system.
2. Description and results of the JRtri006 calibration surveys.
3. Recommendations for future operation.

2. Brief step-by-step procedure for EM122 calibration

Use the SIS software Operator manual as a full guide to performing an EM122 calibration. See p. 158 and onwards for details.

1. Choose a suitable location for your calibration survey. Ideally, this should be partly steep although not too steep to compromise data quality, and include areas of flat, featureless topography.
2. Take an XBT or CTD to obtain a decent sound-velocity profile in the working area.
3. Apply the SVP to your survey.

4. <u>Roll calibration:</u> roll is often the largest offset so correct for this first.

   a. preferably in >2000 metres but can be shallower; preferably flat sea-floor
   b. run two reciprocal lines with 200% overlap, at least two times the length of the swath width (normally 8-10 km) at constant vessel speed (4-6 knots).
   c. establish offsets of lines in the SIS *Calibration* window taking several corridors **across** (at 90 degrees to) the survey lines (see user guide for details); roll error will appear as depth differences increasing across-track away from the centre (Fig. 2).
   d. Input the corrections to the *Installation Parameters* window of the SIS software. For all calibration corrections, the first two sets of offsets shown in this window were provided by the surveyors during installation and **should not be changed.** The "*Attitude 1"* row relates to the MRU 5+ angles in the SIS software and offsets should be inserted here only.

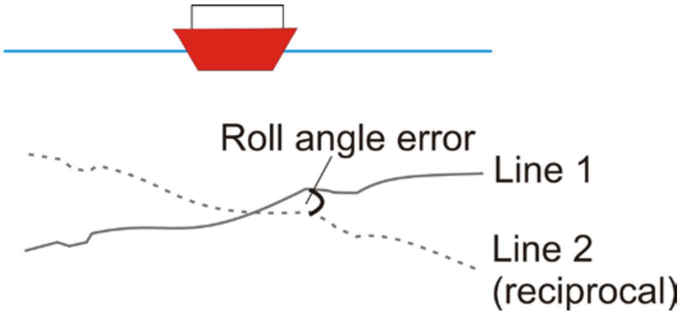


Figure 2. Cartoon showing across-track example of roll error between two lines.

5. Pitch calibration:
   a. 2000-6000 m, preferably up and down a slope or across a feature
   b. run two reciprocal lines with 200% overlap, at least two times the length of the swath width, directly up and down the slope in opposite directions.
   c. establish offsets of lines in the SIS *Calibration* window taking a corridor **along-track** (parallel) to the survey lines; as long as there are no time delay or positioning errors, pitch error will appear, on a constant gradient slope, as a depth offset between the lines increasing with depth (Fig. 3).
   d. Input the corrections to the *Installation Parameters* window of the SIS software.

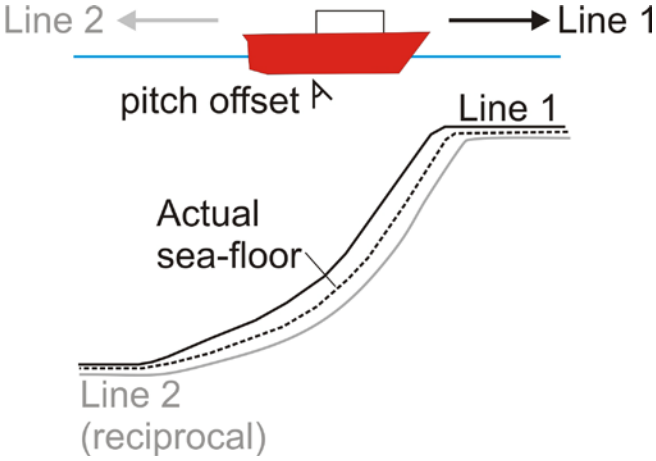


Figure 3. Cartoon showing example of expected Pitch error between two lines.

6. Heading calibration:
   a. Find a recognisable feature such as a peak or depression
   b. Survey two lines in the same direction, at opposite sides of the feature so that the feature lies in the outer beams of both swath tracks (Fig. 4).
   c. compare the offset between the two lines in the *Calibration* window, taking a corridor **along-track through the feature**: a heading error will show the feature on one line ahead of/behind the feature on the reciprocal. Adjust offsets to bring the feature on the two tracks together.
   d. Input the corrections to the *Installation Parameters* window of the SIS software.

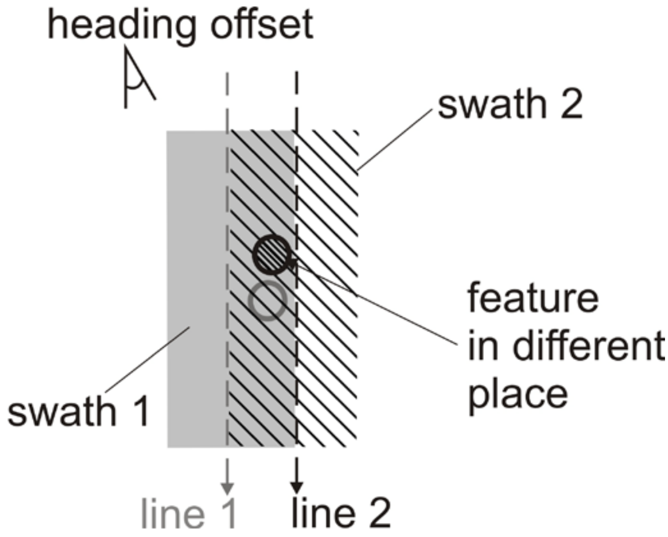


Figure 4. Example of heading error between two overlapping swath lines

7. Finally, carry out a second Roll calibration as a final check. Input offsets as an additive to the first set of corrections, if needed.

3. JRtri006 calibration narrative and results

Calibration of the EM122 was conducted south of the Hebrides Terrace Seamount on the floor of the Rockall Trough between the 1st and 2nd July 2011. A new survey JRtr006_C was started for the calibration tests. Prior to logging, T5_0007.asvp was applied from an XBT cast. The SVP was spiky and noisy in the top 800 metres, but otherwise sensible.

Line 0 (zero) was a test line.. Line 1 logged the first of the calibration tracks for measuring Roll error. Survey speed was 4 knots, and the Doppler was switched off before logging which reduced water column interference significantly. 'Horns' in the data were not as apparent as in previous data. However, 25 knot winds gave a strong swell and the edges of the data were degraded. The central part of the swath looked flat and suitable for calibration. We obtained a 7 km line heading NNE-SSW.

Line 2 logged the reciprocal, SSW-NNE. The line initially veered away from the track (~300 m), but there was good overlap in the second half of the line. Strong winds meant we were forced to crab up the line to stay on-track. Data quality was poor.

We carried out a roll calibration on the two lines (Figs 5-7). Corridors were taken at numerous intervals across the calibration tracks. A roll offset of +0.15° was measured. A cross-check with the Auto-calibration function of SIS gave a predicted offset of +0.066°. Visual inspection suggested this was probably an underestimate, because the Autocalib tool took account of poor data in the outer beams that we had largely ignored. The offset of +0.15° was applied in the Installation Parameters of the SIS software under the "Attitude 1" section.

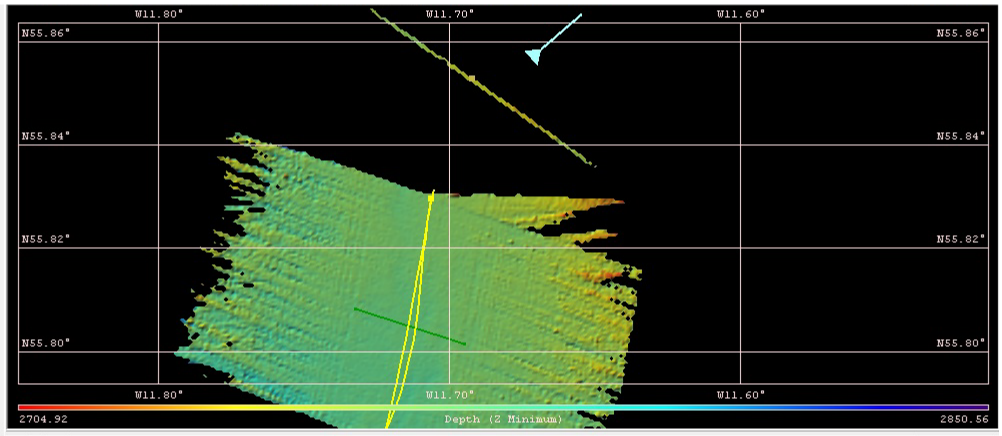


Figure 5. Roll calibration tracks

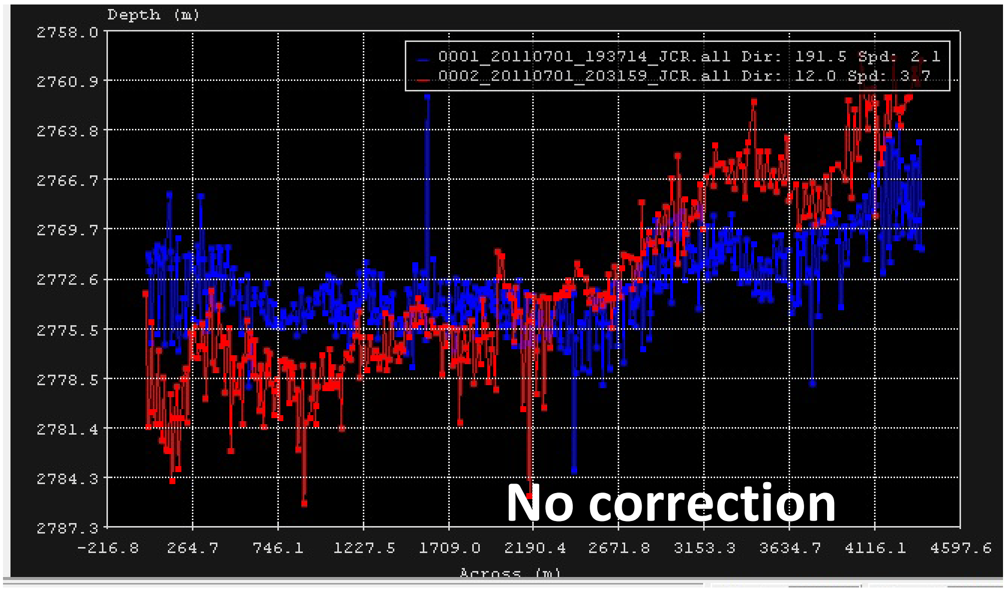


Figure 6. Across-track corridor from first roll calibration with zero correction applied.

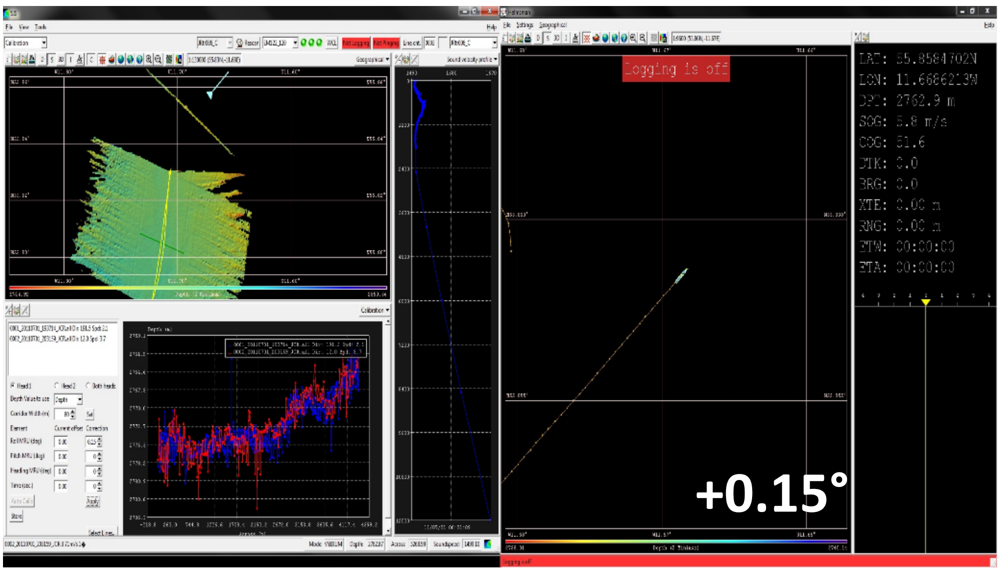


Figure 7. Across-track corridor from first roll calibration with +0.15 offset applied.

Lines 3 through 7 logged our passage overnight to the flank of the Hebrides Terrace Seamount.

Line 8 logged the first line up the seamount slope for a Pitch calibration. The line was surveyed with a NE heading at 6 knots (pilot could not hold course at 4 knots). Recognisable features were seen on the upper flank of the seamount. Data quality were good, except for in the outer beams. Line 9 logged the reciprocal for Pitch calibration.

We carried out a Pitch calibration on the two lines. A corridor was taken along the two tracks. The two profiles showed an excellent match. No error was measured (Fig. 8).

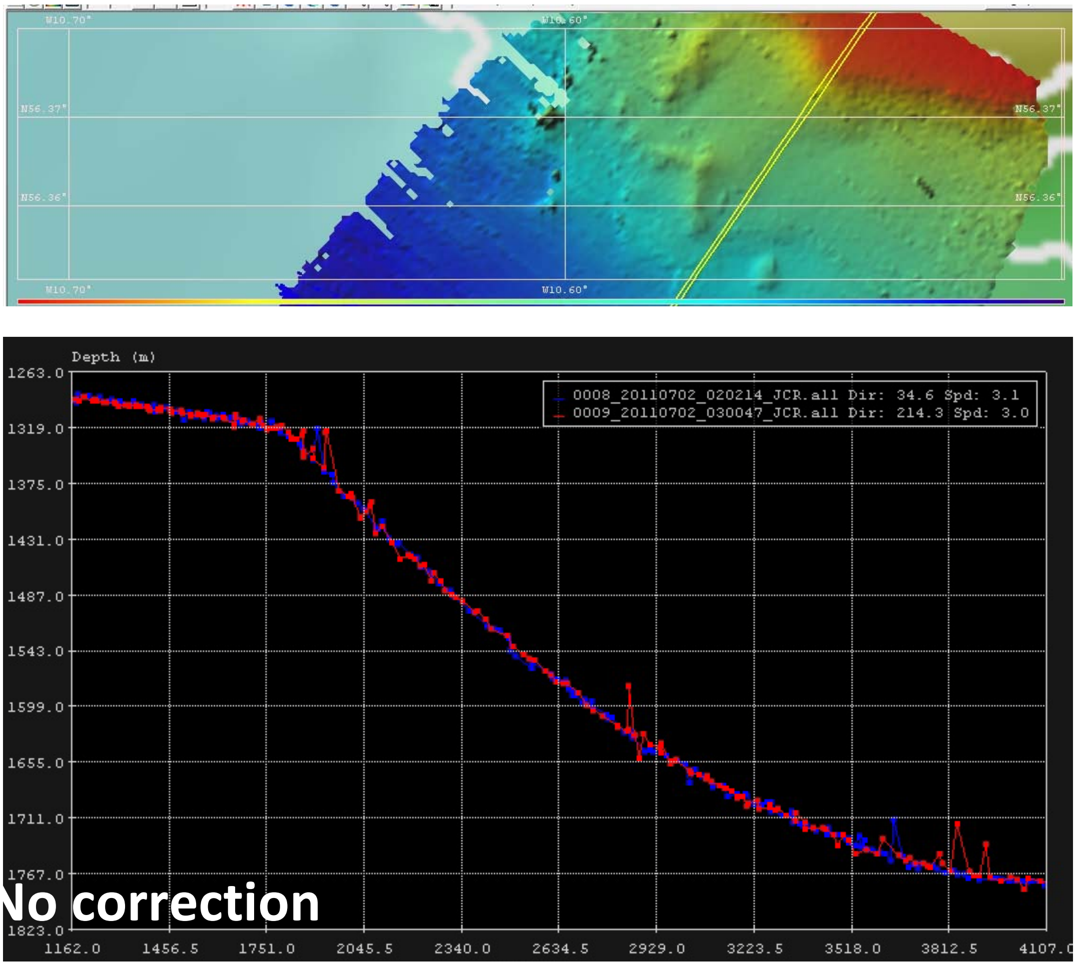


Figure 8. Along-track corridor showing calibration window with zero correction between tracks.

Two additional tracks were acquired around the Pitch calibration lines to carry out a Heading calibration. Line 10 logged a track to the west of our Pitch calibration lines, heading NE at 6 knots. Line 11 logged a parallel line to the east of the Pitch calibration lines, ensuring a 100% overlap.

We ran a Heading calibration on the two lines together with the lines acquired for Pitch calibration in the previous test. A corridor was taken along the centre track. Low signal-noise ratios in the outer beams prevented depth measurements in the outer sectors from being of any use in the calibration. Instead, we focused on the central parts of the swath where data quality was notably better. We measured a heading error of –0.6°. (Figs 9-11).

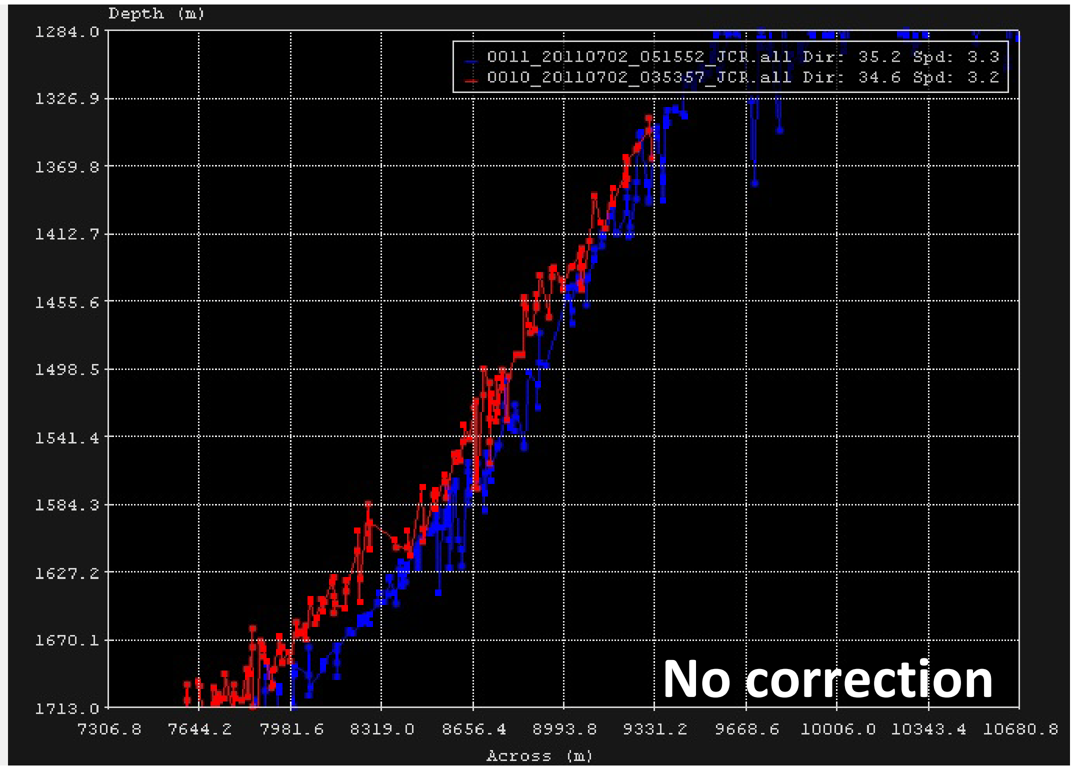


Figure 9. Along-track corridor showing Heading calibration lines, no correction.

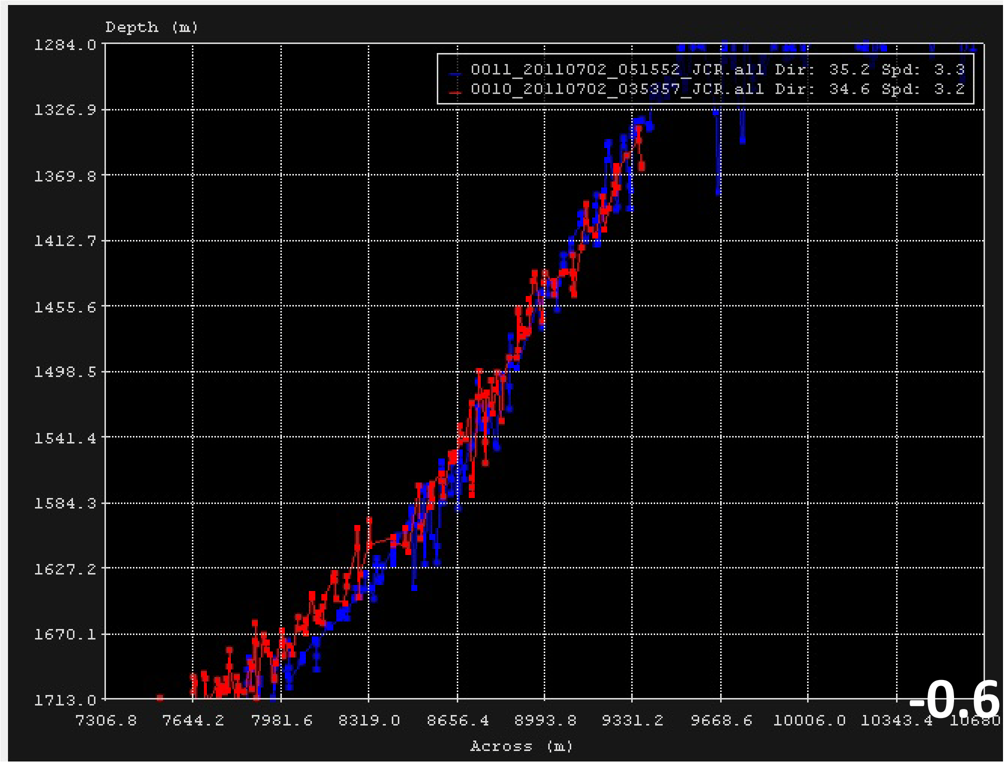


Figure 10. Along-track corridor showing Heading calibration lines with -0.6° correction.

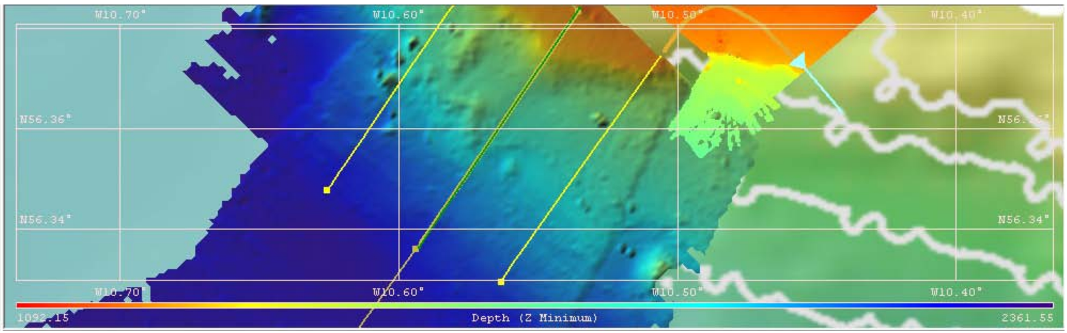


Figure 11. Tracks used for the Heading calibration.

On completion of the Heading calibration, we transited 11 nm to the SE to survey a 3 x 1-line swath grid to verify our calibration corrections. The grid survey involved collecting three parallel lines, each *c.* 7-8 km long with 100% overlap, tied together by one cross line of a similar length. A new survey was setup for the grid survey (JRtri006_D) and a new SVP (T5_0008.asvp), obtained from an XBT cast, was applied to the system prior to logging. The EM122's dual mode was also changed from a fixed setting to a dynamic setting for the survey. Strong winds on the beam during survey meant the ship had to crab along the lines, reducing the data quality.

Line 0 (zero), Line 1, and Line 2 logged the three parallel grid lines in a NNW-SSE orientation, at 6 knots. The cross line was logged to Lines 3 and 4, also at 6 knots. Engineers at Kongsberg will provide more information on data quality during post-cruise analysis of the grid.

A final roll calibration was conducted in order to verify that the roll corrections initially applied to the system were valid. Line 5 was surveyed back along the cross line of the grid survey (approximately ENE-WSW). Line 6 also collected data back across the original track of Line 0. From the latter we measured an additional Roll correction of +0.02°, bringing the total summed Roll correction for the trials to +0.17°**.**

4. Results of the EM122 calibration in summary

N.B. All corrections are additive. The Attitude sensor corrections at the start of the cruise all read at zero. The following corrections were applied to the system in SIS software, under the "Attitude 1" row of the *Installation Parameters* > *Sensor setup* > *Angular offsets*:

Calibration	***Correction***
Roll 1:	**+0.15°**
Pitch:	**0 (zero)°**
Heading:	**-0.6°**
Roll 2 (check):	**+0.02°**
Total Roll:	**+0.17°**

5. Problems and recommendations

- The outer beams on the EM122 have high noise levels (low signal-noise ratios), making calibration, using data from the outer sectors of the swath particularly difficult.
- Calibration of the sensors should be performed **at the beginning of every dedicated multibeam survey**. As a minimum, a roll check should be carried out before any cruise which involves substantial multibeam data acquisition.

- If no geophysics cruises are scheduled, calibration should still be performed at least once per year and certainly after any modifications to the sensors (e.g. during refit).

- Areas should be identified near to operational bases and ports where calibration of the EM122 can be conducted and repeated at regular intervals.

- It is better to perform a calibration than not!

6. Obtaining parameters used for an EM122 bathymetry line (from the JCR wiki: Multibeam calibration).

On the Neptune machine, use the following commands:

printDatagrams -f <surveyline>_raw.all -d #

where # is
i : installation parameters; R : runtime parameters; P : positions; D : depths

7. Lines recorded during calibration

Survey JRtr006_C
```
0000_20110701_191505_JCR.all  Test line
0001_20110701_193714_JCR.all  Roll Calibration 1
0002_20110701_203159_JCR.all  Roll Calibration 2
0003_20110701_213830_JCR.all  Transit to Hebrides Terrace Seamount
0004_20110701_223831_JCR.all  Transit to Hebrides Terrace Seamount
0005_20110701_233828_JCR.all  Transit to Hebrides Terrace Seamount
0006_20110702_003828_JCR.all  Transit to Hebrides Terrace Seamount
0007_20110702_013827_JCR.all  Transit to Hebrides Terrace Seamount
0008_20110702_020214_JCR.all  Pitch Calibration 1
0009_20110702_030047_JCR.all  Pitch Calibration 2
0010_20110702_035357_JCR.all  Heading Calibration 1
0011_20110702_051552_JCR.all  Heading Calibration 2
0012_20110702_061646_JCR.all  Transit to SE
```

Survey JRtri006_D
```
0000_20110702_074558_JCR.all  Grid survey, Line 1
0001_20110702_085955_JCR.all  Grid survey, Line 2
0002_20110702_100231_JCR.all  Grid survey, Line 3
0003_20110702_110042_JCR.all  Grid survey, Cross-line
0004_20110702_120037_JCR.all  Grid survey, Cross-line
0005_20110702_122354_JCR.all  Roll Calibration check 1
0006_20110702_123829_JCR.all  Roll Calibration check 2
0007_20110702_135009_JCR.all  Transit lines towards Clyde
0008_20110702_145008_JCR.all  Transit lines towards Clyde
0009_20110702_151355_JCR.all  Transit lines towards Clyde
0010_20110702_161352_JCR.all  Transit lines towards Clyde
```

EM122 Data Quality Testing (Christine Bachelor and Kelly Hogan)

One of the major goals of the JRtri006 Trials Acceptance cruise was to assess the quality of multibeam bathymetry data obtained from the newly upgraded EM122 system. Although the initial aims of the cruise included a comparison of EM122 data with an EM120 dataset collected during the JR133 cruise of 2005, a combination of time constraints and poor EM120 data quality precluded direct comparison of these data. Whereas the JR133 instrument calibration tests took place on the northern slope of the Hebrides Terrace Seamount, JRtri006 cruise calibration was performed on the southern slope of the seamount - a more ideal location due to its steeper slope.

Knowledge of the EM120 system from previous cruises has enabled categorisation of a number of systematic and non-systematic errors that have been observed in swath bathymetric datasets acquired on the JCR. Systematic errors included the presence of 'wobbles' in the outer beams, horn-like ridges either side of the central beams (more prevalent in shallow water depths), offsets in bathymetry between adjacent lines (non-SVP errors), and beam penetration of the seafloor. Non-systematic errors include SVP-related errors, ping dropouts, excessive noise in the outer beams, and noisy data due to poor weather conditions (beam-on). The presence/absence and magnitude of these error types in the bathymetry data collected by the EM122 system was assessed throughout JRtri006.

Systematic Errors

Wobble Errors

A distinctive 'wobble' artefact (common in EM120 datasets) was again identified from the outer beams of the JRtri006 EM122 data (Figure 12). The signal to noise ratio (SNR) is typically lower in the outer beams than in the central beams due to higher levels of interference occurring at the lower frequencies of the outer beams. This interference leads to degradation of the transmitted (and thus returned signal) in the outer sectors of the swath.

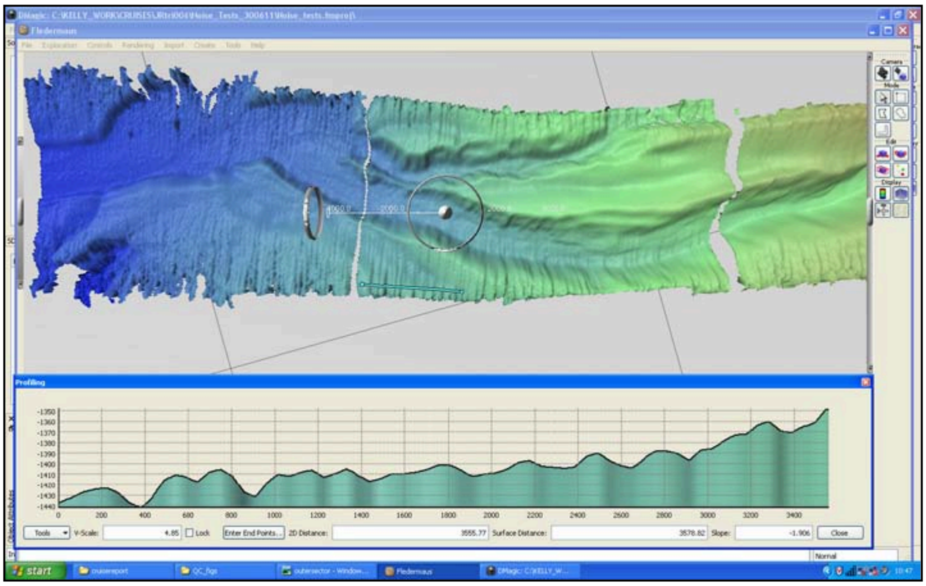


Figure 12: Example of pervasive wobble artefact in JRtri006 bathymetry data. Below is a cross-profile across the data showing the periodicity of the wobble error; profile is located on the swath data (light blue) and runs from west to east.

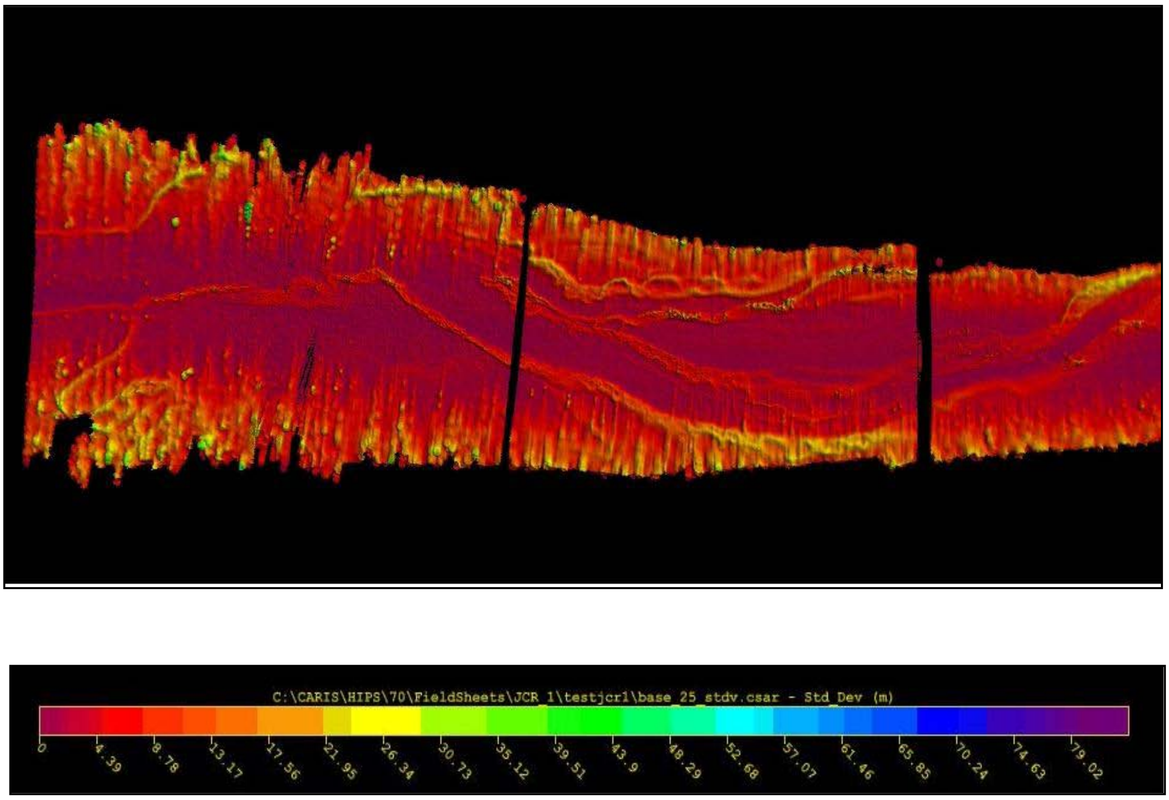


Figure 13: CARIS screengrab from a line of the JRtri006 EM122 data, showing the standard deviation of the beam errors. The lines shown are the same lines as in Fig. 12. The systematic wobble error is clearly shown in the outer beams.

Although errors due to interference are more frequently observed in the outer beams, a problem that is exacerbated by poor weather and sea conditions, the wobble effect identified on EM120 and EM122 datasets (Figs. 12 and 13) is a more systematic error. As an example, the wobbles observed on the JRtri006 lines in Figure 1 possess amplitudes of 5-10 m and a periodicity of 15-200 m (Fig. 12, cross profile). The standard deviation of the errors is shown in Fig. 13; the systematic wobble error is clearly apparent on the outer beams.

The wobble artefact may be caused by low source levels resulting from degradation of the central transmitter elements. Improved source levels may prevent the development of these outer beam errors. Analyses of the transmitter elements on the EM122 system carried out by a Kongsberg engineer prior to the start of JRtri006 revealed widespread degradation of the central transmitter elements (c. 40% elements were found to be degraded). The substandard characteristics of the central transmitter elements could be reduced by checking the hull for any damage including biological growths, silt between the titanium covers and the transducers or by replacing the transducers. Additional analyses of the JCR EM122 data with respect to transducer element problems will be carried out by Kongsberg on data collected during JRtri006.

Swath Sector Errors

Systematic errors associated with the different sectors of the EM122 swath occur in two forms: first, as a distinct line marking the boundary of the outer sector (Figure 14); and second as variable bathymetry returns between different sectors forming 'mounds' at sector boundaries (Figure 15a).

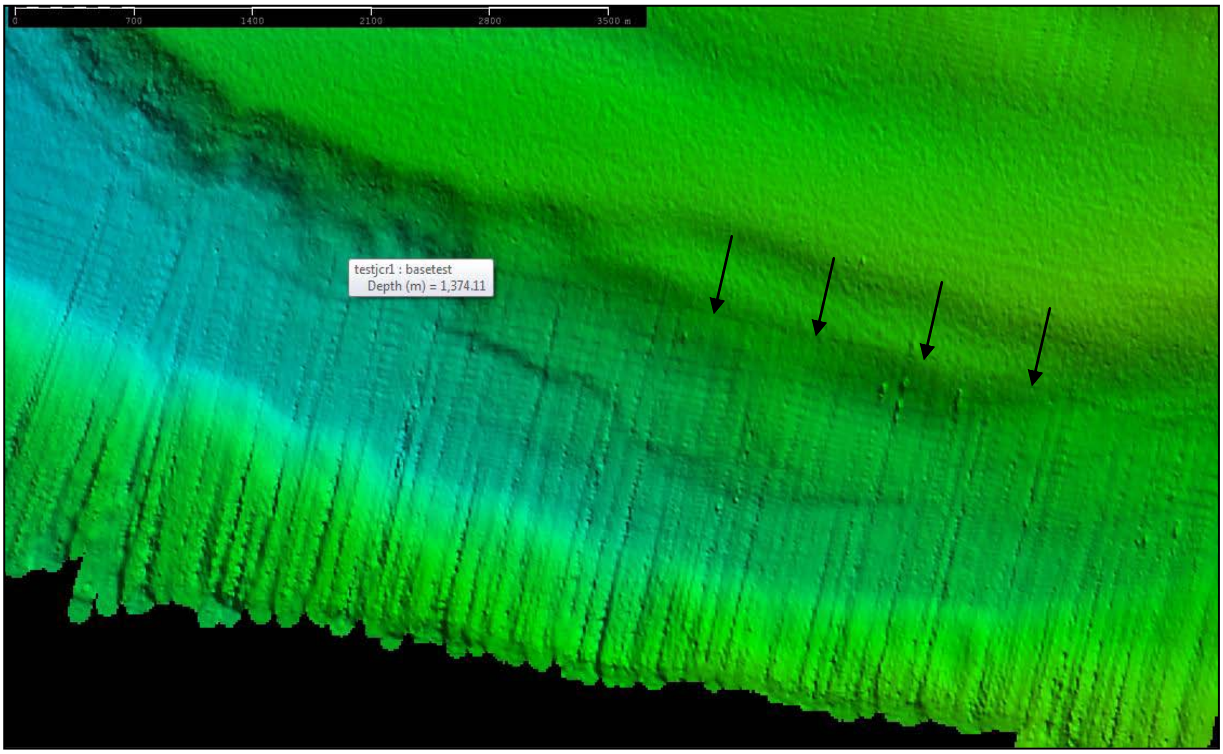


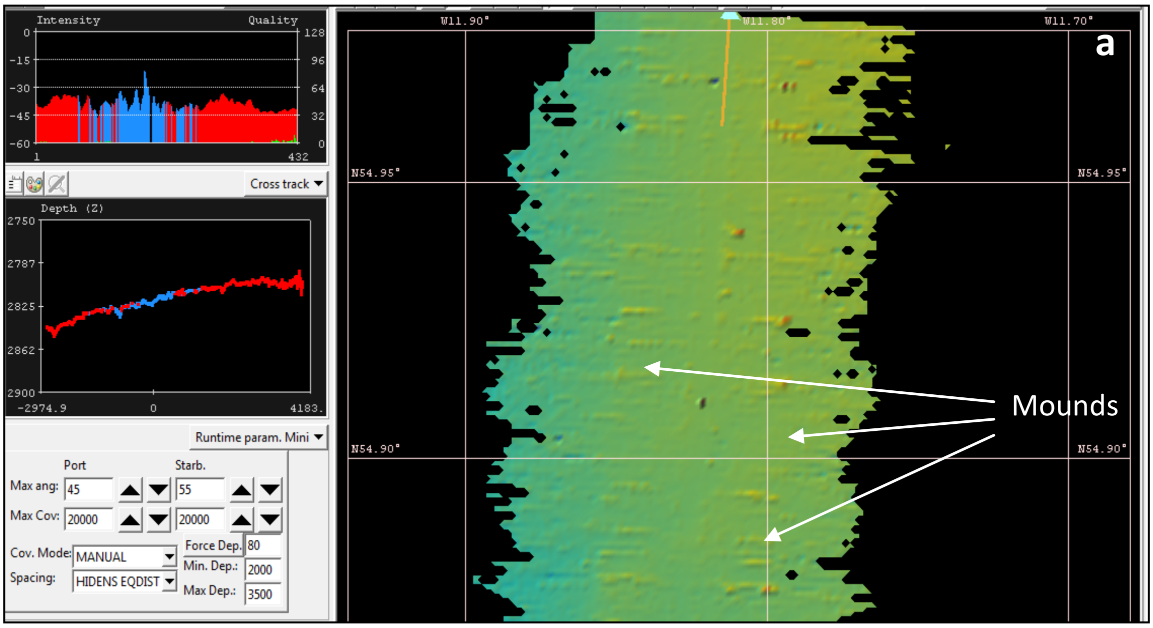
Figure 14: CARIS screengrab of a line from JRtri006 showing the outer sector line error (arrowed); outer beam wobbles are also apparent. The finer parallel along-track lines in the outer sector are gridding errors (data was gridded at a higher resolution than appropriate to show the errors).

Swath sector errors are also apparent when the individual pings of a line are viewed in MBedit (Fig. 15b). Mounds exist in groups of 2 pings and occur approximately every 4 - 12 pings. The reason for the occurrence of these mounds in groups of 2 pings is not well known but may be related to the dual ping mode used during data acquisition. This systematic error type was particularly evident in the EM122 data during lines 0024 and 0025 on 01/07/2011 during poor weather conditions. A heading of 0.003 – 0.004 degrees was recorded during data collection, with a wind from the south at 19 knots, and swell off at 45 degrees. Pitch, roll and heave values were recorded as 0.8°, 2° and 1°, respectively. Degradation of JCR swath bathymetry data quality is well known when weather conditions include wave or swell conditions that are beam-on and this is what caused the decrease in data quality on 01/07/2011.

The swath sector errors appear to be particularly pervasive in the EM122 swath data. The errors are possibly related to the transition from the central to the outer beam sectors and the corresponding change in frequency across this boundary (Kongsberg report forthcoming).

Horn Errors

Horn-shaped ridges have been observed to occur either side of the nadir in EM120 datasets from the JCR. This type of systematic error was widespread on EM120 datasets, particularly in shallow (continental shelf) water depths, but has not been identified from the JRtri006 cruise EM122 system data. The positions of the horns corresponded with the across-track transitions from amplitude to phase bottom detection. Improvements in the electronics of the EM122 as compared to the EM120, and in the beam-forming mathematics used by the EM122 mean that this error is much less likely to occur with this generation of echosounder.



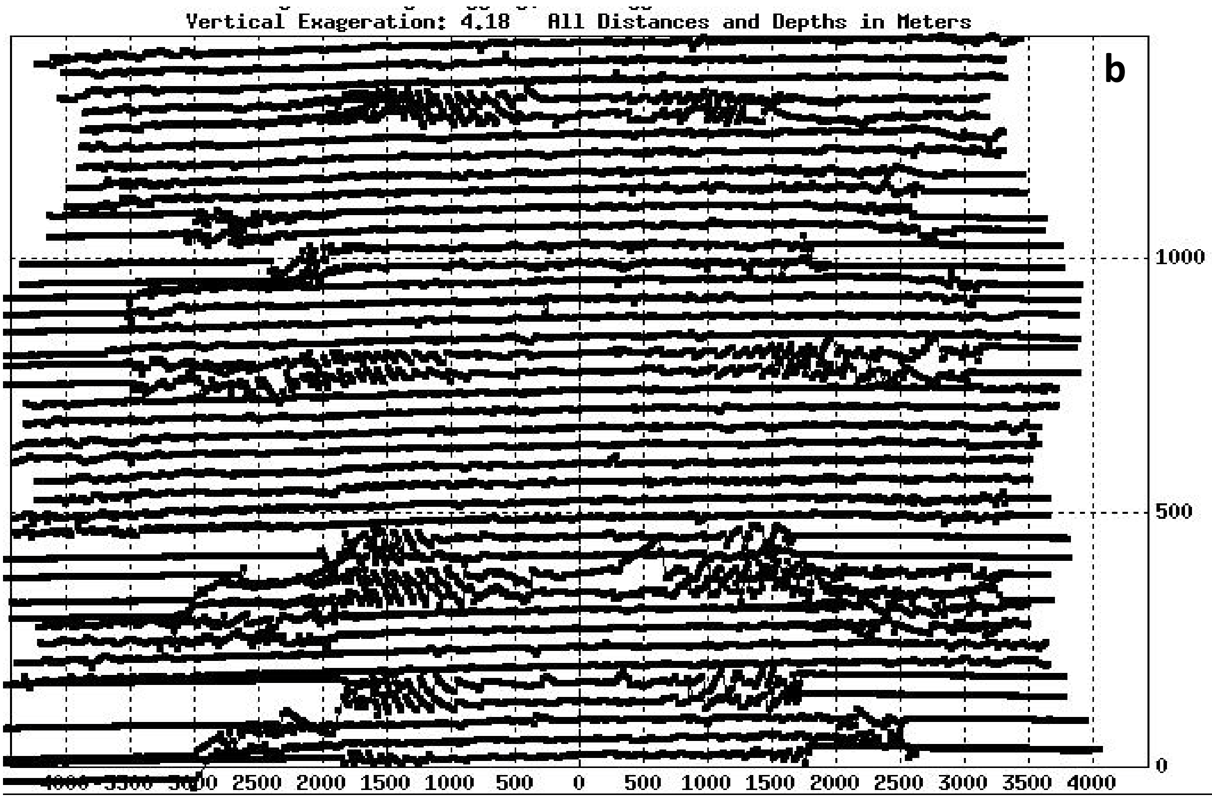


Figure 15a: Screen dump showing the presence of outer sector mounds on line 0024 (01/07/2011) acquired using the EM122 system during the JRtri006 cruise. Figure 15b: Individual pings from line 24 (VE 4.18) illustrating how the mounds occur in groups of two pings with a fairly regular periodicity.

Seafloor penetration

Central 'troughs' running along the nadir have been identified from EM120 system data (Figure 16). This artefact probably indicates those areas of the seafloor which are composed of extremely soft sediments and consequently do not provide a larger enough acoustic impedance difference with the overlying water column from which the acoustic signal can be reflected. The beams instead penetrate the seafloor and are reflected from a harder sub-bottom horizon some distance below the seafloor. The resulting depression occurs over the central section of the swath because the beam energy is most intense in this location. Seafloor penetration errors identified from Western Greenland have been observed to create central beam depressions up to 12 m deep and 300 m in width (Fig. 16, bottom).

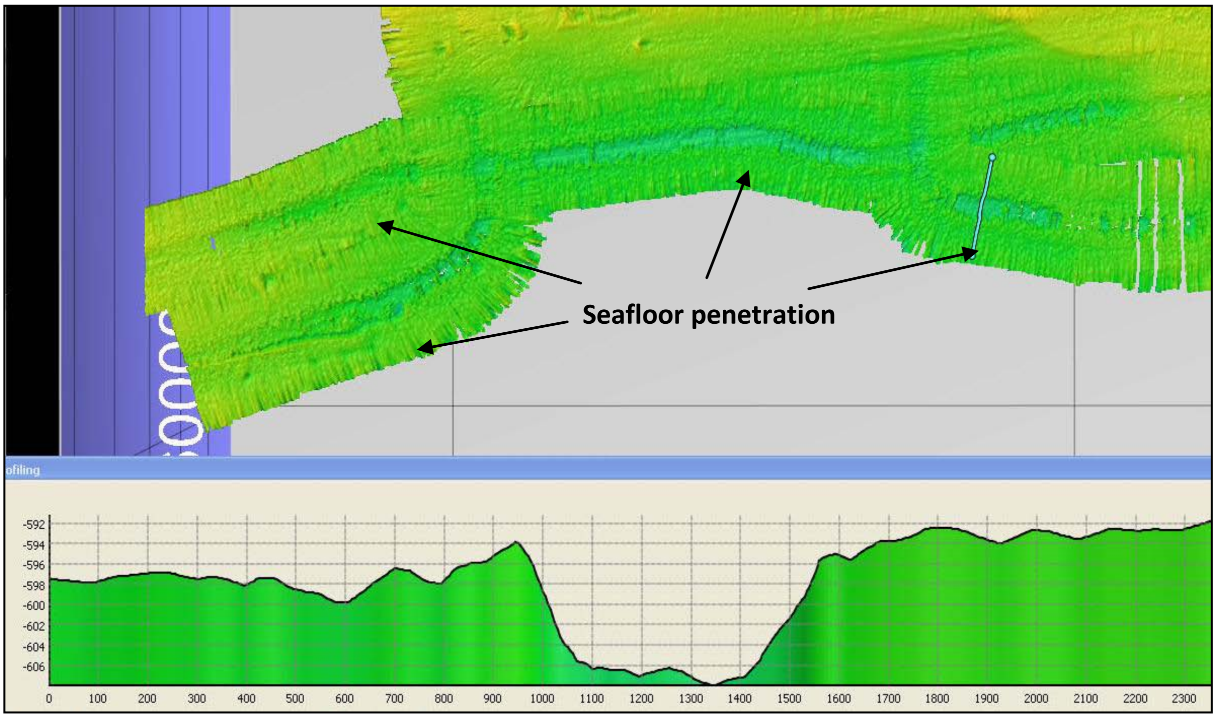


Figure 16: Screen dump illustrating central beam seafloor penetration from EM120 data collected off West Greenland. Bottom: A cross-profile across the central trough formed by seafloor penetration.

Seafloor penetration was not observed on the JRtri006 cruise. Options for avoiding this error on future cruises include reducing the maximum power of the system (*Mammal Protection* option in Runtime Parameters) so that less energy is transmitted in the outward pulse. The SIS range-gate option (in the *Filter and Gains* tab in Runtime Parameters), which determines the depths at which the seafloor can be picked, could constrain the depth at which the seafloor is detected.

Non-Systematic Errors

SVP errors

The application of inaccurate SVP profiles typically produces upward or downward 'bending' of the outer swath where errors due to the wrong sound velocity through water will result in the greatest error due to the slant-range. These artefacts are easily detected on adjacent survey lines, where the application of inappropriate SVPs results in offsets in seafloor depths between lines. Acquisition of multiple SVP profiles (from XBT or CTD) during any survey when these errors are observed on the SIS display will minimise these errors and the amount of post-processing time required in order to correct these issues.

Excessive Noise

The EM120 and EM122 systems are both vulnerable to data distortion through noise. Beams in the outer sectors are more vulnerable to noise distortions than the central beams due to higher levels of interference occurring at the outer beam frequencies. Excessive noise in the outer beams typically manifests itself as abrupt and erroneous changes in seafloor depths (Figure 17) and occurs when the returned signal is tracking noise rather than the seafloor.

The assessment of outer beam noise performed on the EM122 data from JRtri006 was purely qualitative. As with data collected with the EM120 system, 'noise' was evident in the EM122 data as poor swath returns and particularly affected beams produced by the outer sector. Noise levels, and thus the number of poor seafloor returns, increased during periods with poor weather conditions (beam-on). Given the improvements in data density with the EM122 system (i.e. total seafloor ensonification) it was hoped that the quality of noise in the outer part of the swath would improve with the upgraded EM122 system. However, poor returns from the outer sector, probably caused by degradation of transducer elements (see *Wobble Error* for explanation), meant that the proportion of poor pings owing to noise was difficult to assess. This will be easier to analyse following the replacement of transducer elements.

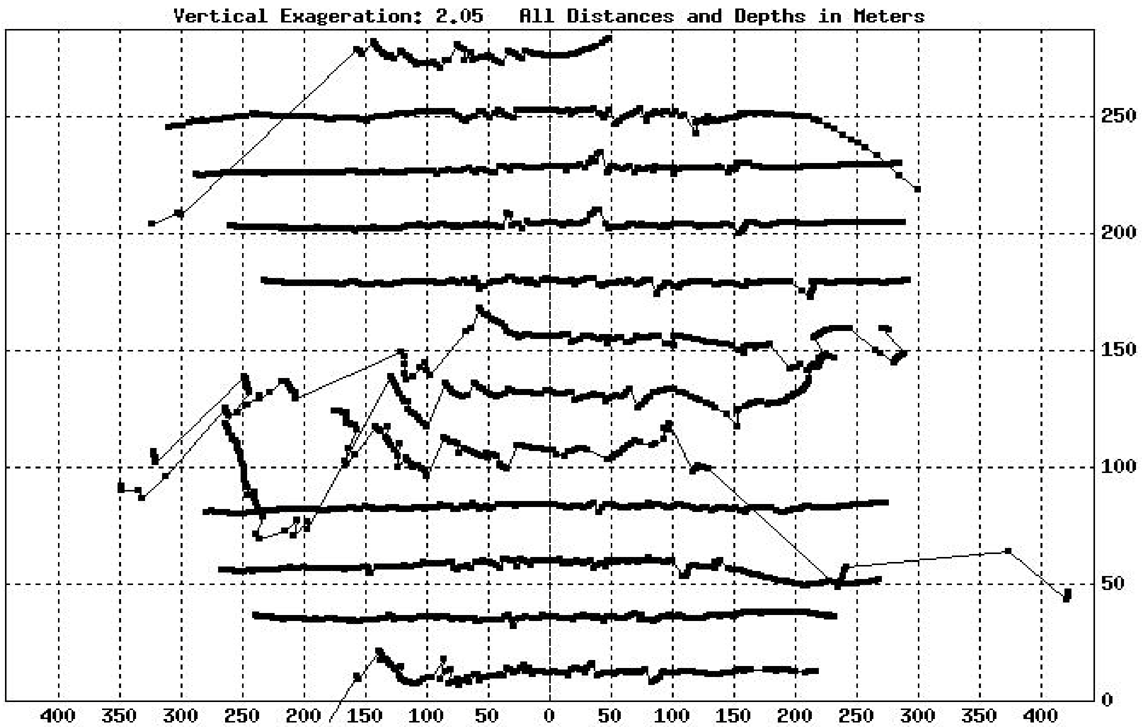


Figure 17: individual pings and beams from a section of line 24 of the JRtri006 cruise EM122 system data, showing typical outer beam distortions resulting from poor weather conditions (VE. 2.05).

Beam angles

The effect of different beam angles on data quality (particularly excessive noise in the outer beams) was not systematically tested during the JRtri006 cruise. Cruises typically log data with beam angles between 60° and 65°, reducing these values during poor weather conditions. During JRtri006 a range of beam angles were used spanning the range 50°-70° and reducing the beam angles during poor weather did result in a cleaner dataset as poor returns in the outermost beams due to random noise was reduced. However, decreasing the beam angles does not reduce the effects of systematic errors (wobble or outer sector errors), which were still evident in the JRtri006 data at all beam angles.

EM122 Noise Testing (Christine Bachelor)

An assessment of the noise generated by the JCR was performed through a series of noise tests at ship speeds of 0, 1, 2, 4, 6, 8, 10, 12 and 14 knots. In order to evaluate the influence of the different acoustic instruments, noise tests were also performed with the addition of the Doppler logger, the EK60, and the ADCP at speeds of 10 knots. Weather conditions remained calm throughout the noise tests, with wind speeds of 5-6 knots. Beam angles remained constant at 70°.

Noise and JCR Speed

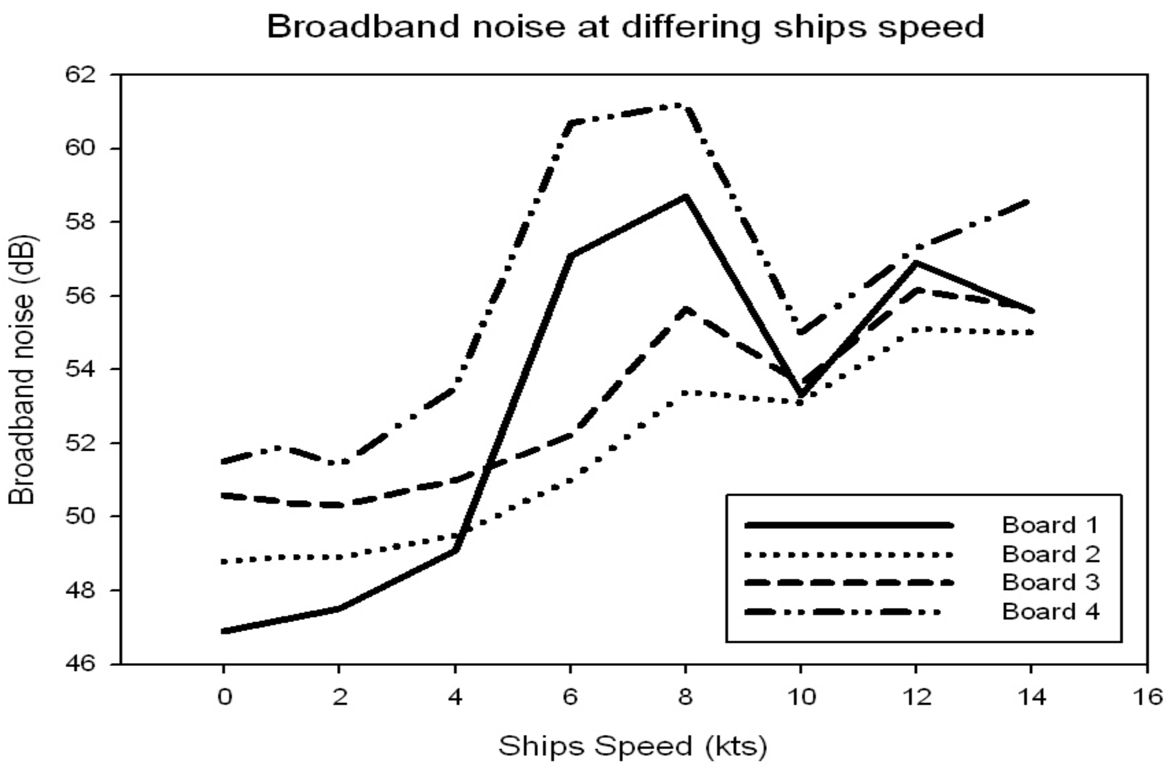
Five noise tests were performed for both broadband noise and spectral noise at each ship speed. Whereas the value for broadband noise represents the average measurement from one frequency over the modules during a given amount of time, spectral noise is the average from all the frequencies on the cards and characterises the acoustic signal being transmitted. The average (median) broadband and spectral noises at different ship speeds are depicted in Figure 18.

The results of the noise tests (Figure 18) clearly illustrate how broadband and spectral noise is greater in the outer boards, boards 1 and 4, than in the central boards. This pattern is most evident at ship speeds of 6-8 knots. The results of the noise tests (Fig. 18) also suggest that, whilst there is a general increase in broadband and spectral noise with ship speed, noise is greater at 8 knots than at 10 knots. Additional noise tests were performed at these two speeds, confirming this observation.

It is worth noting that the initial JCR trial report makes reference to clear propeller cavitation between speeds of 6.5 and 8.3 knots (Section 5.2.1, Sea Trial Report, 7^{th}-18^{th} August, 1991). At speeds greater than 8.3 knots, broadband noise produced by cavitation was significantly reduced in frequency (from 2 kHz to 200 Hz). These observations may be related to air-flow patterns over the ship's bow and could at least partially explain the results from the JRtri006 noise tests.

Noise and Acoustic Instruments

The results from the noise tests performed at 10 knots with addition of the various acoustic instruments are depicted in Fig. 19. Broadband and spectral noises were slightly greater with addition of The Doppler logger, which transmits at a frequency of 307 kHz with a bandwidth of 25% and power into the water of 15-20 W. Addition of the ADCP, which transmits at a frequency of 75 kHz, also produced a small increase in broadband and spectral noise. The EK60, which transmits at frequencies of 38 kHz, 120 kHz, and 200 kHz with power into the water of 2 kW, 500 W, and 200 W, respectively, had a minimal effect on noise.



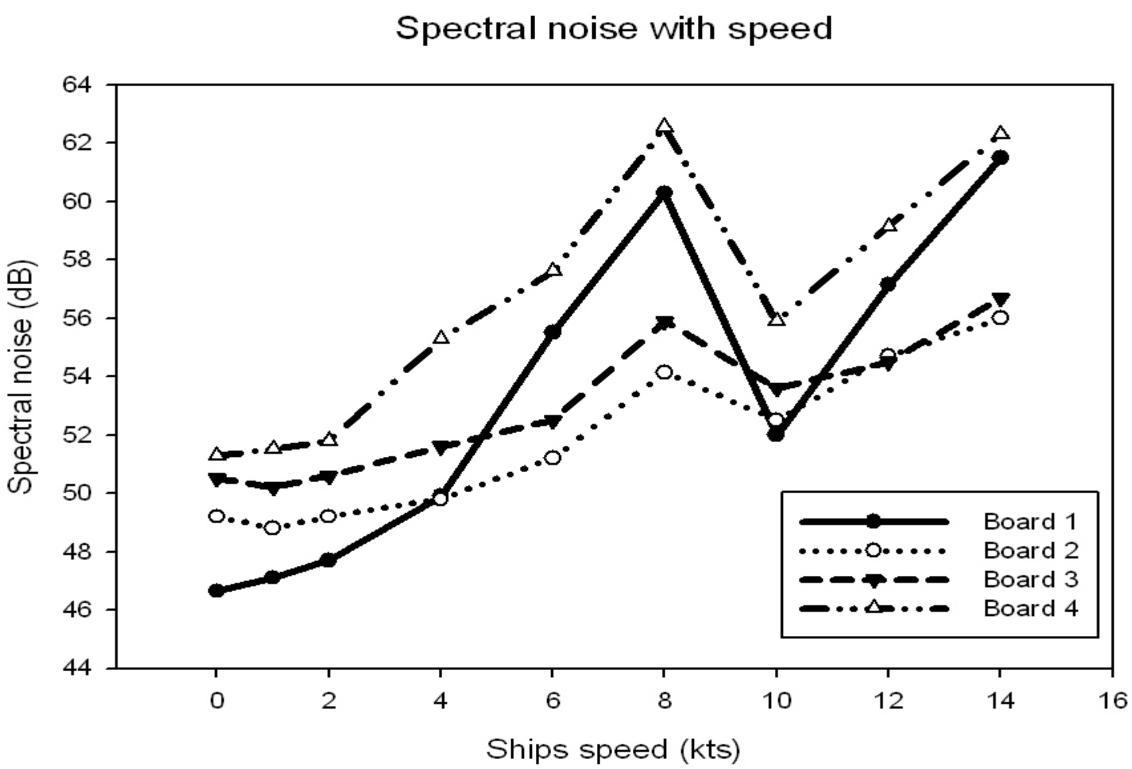
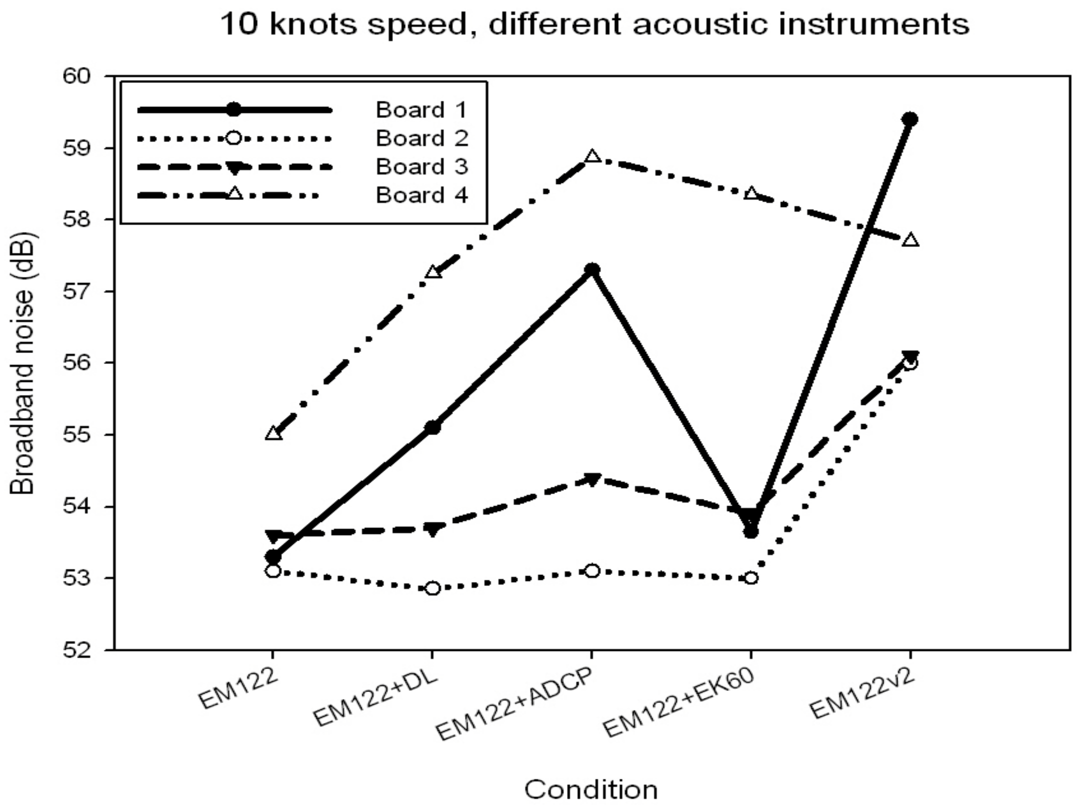


Figure 18: Variations in broadband (above) and spectral noise (below) at different ship's speed.



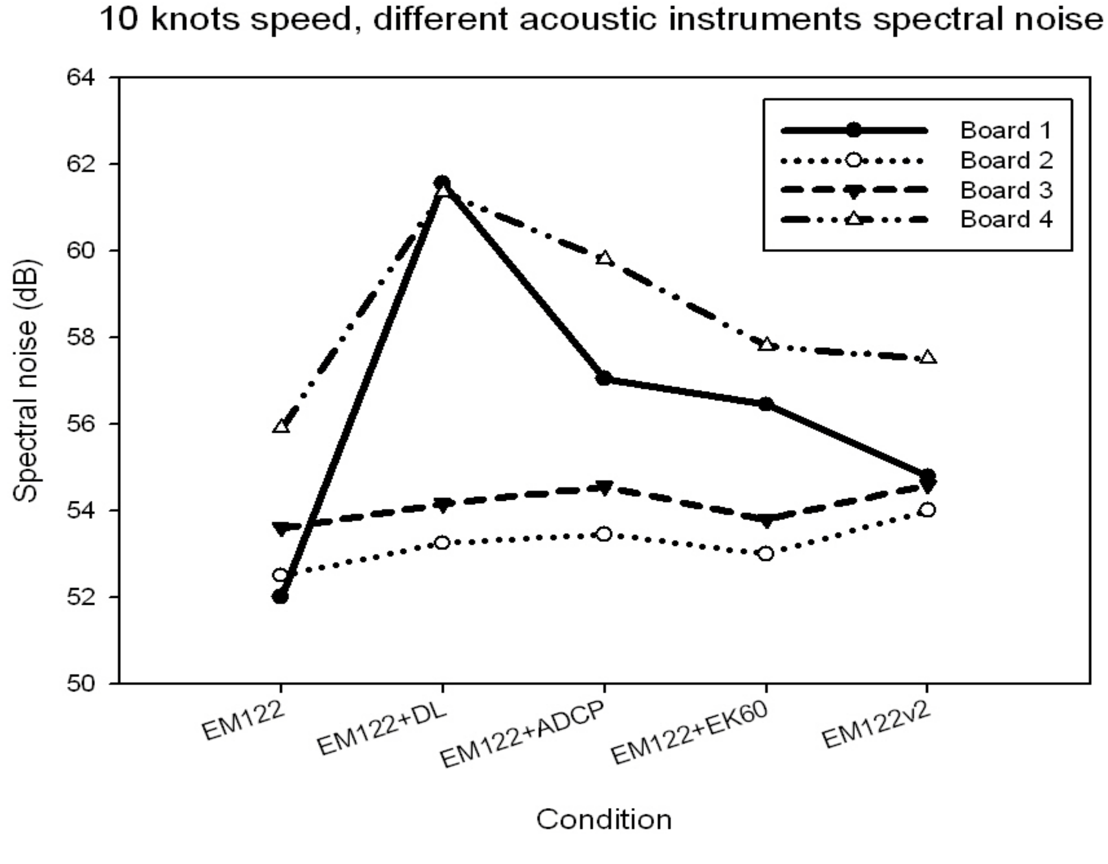


Figure 19: Variations in broadband noise and turning on different acoustic instruments (constant speed of 10 kts, upper). Variations in spectral noise with different acoustic instruments running (lower). EM122 and EM122v2 were control tests with no other acoustic instruments running other than the swath.

Recommendations

Results from the noise tests suggest that, in terms of minimising ship's noise interference with the EM122, the optimal surveying ship speed is 10 knots.

Outer sector errors are a significant problem for the EM122 system. If high quality seabed data is required a swath overlap of at least 25-30% is necessary to be able to cull poor data in the outermost parts of swath lines.

Based on the data quality it is recommended that cleaning of the transducer heads is done as soon as possible and, if possible, the transducers are replaced (Note to check the forthcoming Kongsberg analyses on transducer performance).

Tests on Backscatter data derived from the EM122 (Kelly Hogan)

The JRtri006 trials cruise provided an opportunity to test the backscatter (BS) data acquired by the newly upgraded EM122 multibeam swath bathymetry system. The reason for analysing the BS data is because of several known issues with BS data collected by the previous EM120 system and with a current EM122 system on the Swedish ice-breaker *Oden*.

1. Different ping modes and backscatter values

Known issues with EM120 backscatter

Previous observations from EM120 backscatter data collected with the JCR's EM120 have shown "steps" in backscatter values associated with changing the ping mode of the echosounder. During normal data collection the EM120 was run in automatic mode consisting of 5 preset ping modes (Very Shallow, Shallow, Medium, Deep, Very Deep). Tests on the EM120 BS during JR142 in 2006 revealed "steps" of around 4 dB in BS levels between the "Medium" and "Deep" ping modes of the EM120 system (e.g. BS values were 4 dB higher in the Deep mode; Dowdeswell, 2006). The "steps" were attributed to an increase in pulse length from 5 to 15 ms between the two modes. No appreciable "steps" were observed between the shallower ping modes which all operate with a pulse length of 5 ms.

EM122 backscatter – JRtri006

For the new EM122 echosounder there are only four preset ping modes: Shallow, Medium, Deep and Very Deep (changed on-the-fly in Runtime Parameters). When run in "Automatic" mode, the swath system determines the optimal mode based on water depth and the quality of the beam forming. The thresholds between the different modes are as follows:

- Shallow/Medium mode: 450 m
- Medium/Deep: 1000 m
- Deep/Very Deep mode: 1000-9000 m

Transmit pulse length increases with depth from 2 ms to 15 ms continuous wave (CW) pulse and up to 100 ms frequency modulated (FM) pulse. Essentially this means that the pulse length for shallow mode is 2 ms, for medium mode it is 5 ms, and for deep mode it is 15 ms. Frequencies between 10 and 13.5 kHz are used across the sectors of each ping. Note that FM functionality is not yet available on the JCR (should be upgraded in 2012) so the "FM disable" box (in Depth Settings in Runtime Parameters) was checked throughout JRtri006 and any changes in BS caused by the switch from a CW to FM pulse in deeper waters could not be assessed.

As the EM122 echosounder changes between different ping modes two things happen. First, the pulse length increases in deeper waters. Note that the pulse lengths are actually different across the sectors of the swath (not in shallow mode where it is 2ms in each sector) with increasing pulse lengths from the nadir towards the outer sectors (4 sectors for Shallow and Medium mode; 8 sectors for Deep and Very Deep modes), and that the pulse length increase occurs instantly once the swath mode has been changed. Second, the frequencies emitted by the transducers are different for the different modes. Like the pulse length the transducer frequency varies across-track e.g. outer sectors emit lower frequencies (this allows the outer beams to travel further to the seafloor, which they need to do in order to reach and return from the seafloor owing to the slant-range). However, unlike the change in pulse length, the change in frequencies is gradual and works from the outer beams inwards when switching to a deeper water mode. Therefore, any effect on backscatter values due to varying frequency should be less noticeable than effects from the changing pulse length.

EM122 BS Tests

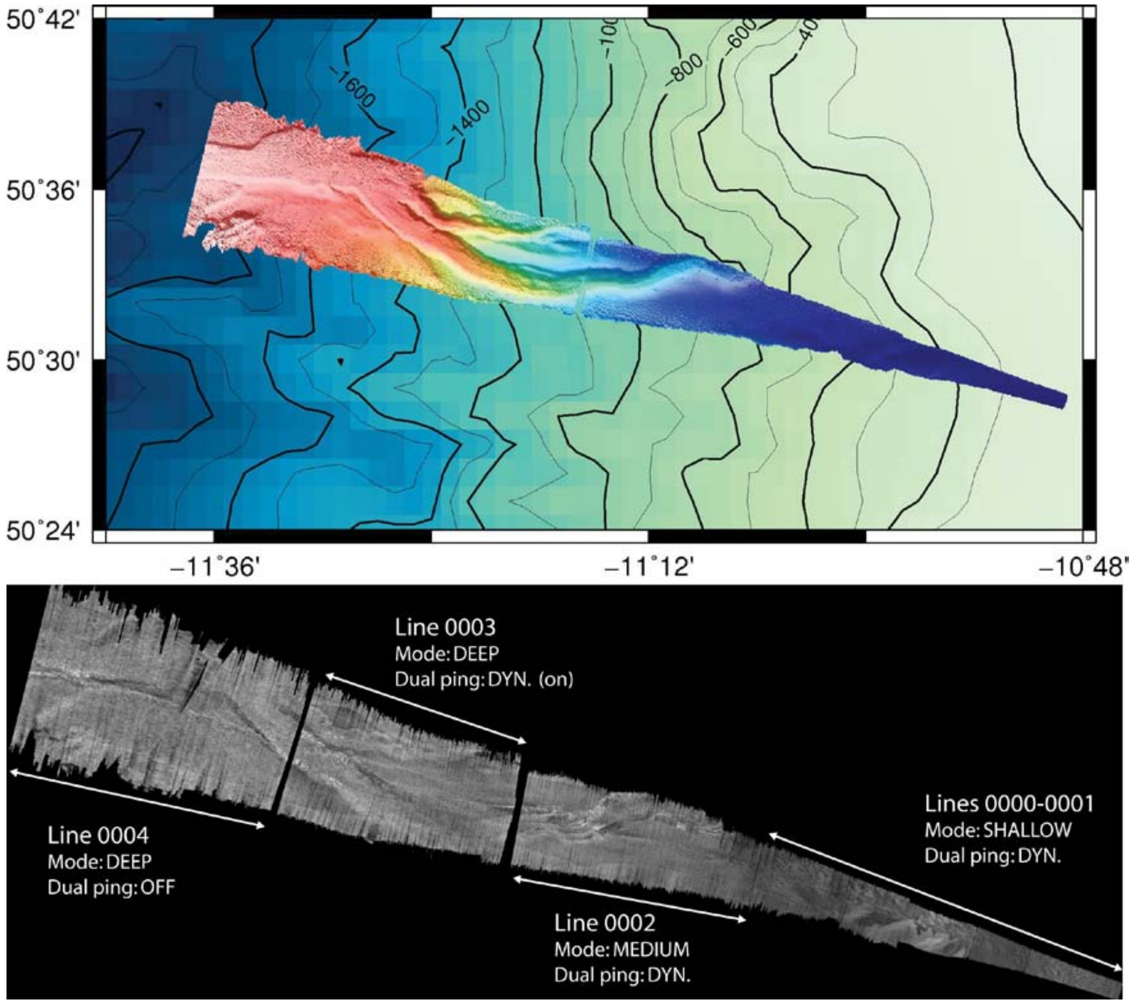


Figure 20a (upper): Bathymetry of downslope transect for testing of ping modes, and Figure 20b (lower): Backscatter data, line locations and EM122 settings used during testing.

In order to determine whether changing the ping mode affects backscatter values in the EM122 system a series of tests were run during JRtri006 on a down-slope transect. Five consecutive lines were run for 0.5-1 hour each with two lines in shallow mode, one in medium mode and two lines in deep modes (Lines 0000-0004; Fig. 20). Basic post-processing was applied to all of the lines using FMGT. Angle Varying Gain (AVG) and beam pattern corrections were applied; the Tx/Rx Power Gain (radiometric) Correction was not applied (typical for EM120/EM122 type sonars; Fledermaus Reference Manual V7, 2011). FMGT's dual swath compensation function (the ability to use only the first or second ping in dual swath systems) was not used in this test.

Three of the lines (0001, 0002 and 0003) were taken as representative of the different pinging modes for the EM122 (Fig. 20); all other settings of the EM122 remained constant during testing which was performed at a speed of approximately 8-9 kts. Average amplitude values were extracted for 5 groups of 50 pings on either side of the line increment (i.e. when ping mode was changed) in order to compare BS values in different modes and in similar seafloor terrains (Figs. 21 and 22):

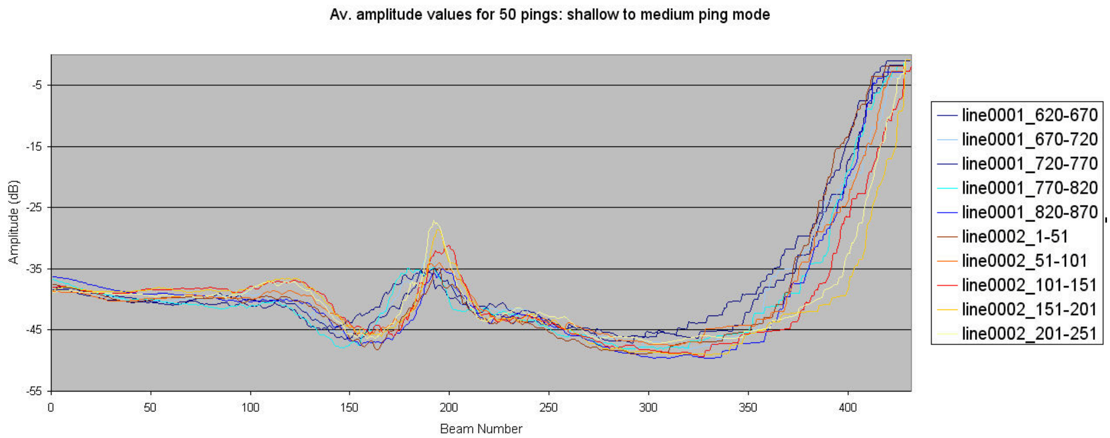


Figure 21: Average amplitude values for 5 groups of 50 pings at the end of Line 0001 and at beginning of Line 0002. Line 0001 was run in shallow mode, 0002 in medium mode.

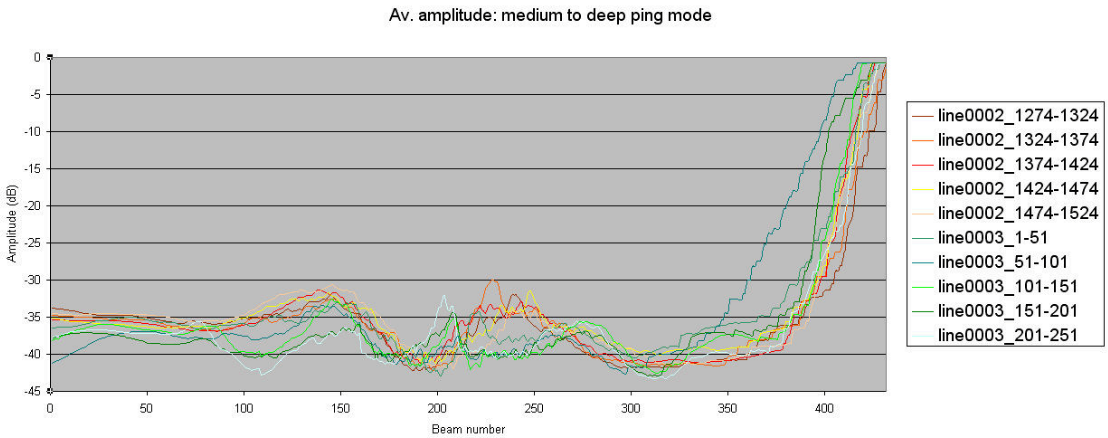


Figure 22: Average amplitude values for 5 groups of 50 pings at the end of Line 0002 and at beginning of Line 0003 over the change from medium to deep ping modes.

From Figure 21 we can see that in general, there is good agreement between backscatter data values for data acquired in shallow and medium ping modes in areas with relatively little seafloor topography e.g. beam numbers 1-100 and 220-280. This is in agreement with visual inspection of the data that revealed no significant jumps in data values (darkening or lightening between lines e.g. Fig. 20b). The rise in backscatter values to close to zero in the starboard outer beams is most likely real due to a shallowing of the seafloor in this location returning higher BS values and no return from the outermost beams.

Figure 22 shows that there does not appear to be a consistent clustering of BS data values at different levels between the medium (red hues) and deep (green hues) ping modes. BS values are 2-5 dB lower on the port side (beams 1-150) and peaks and troughs between Line 0002 and Line 0003 values seem slightly offset from one another. This probably reflects real BS variations owing to the changing morphology of the seafloor down-slope and the data gap between Lines 0002 and 0003. Again there was no evidence of data value “steps” from visual inspection of the semi-processed imagery.

Visual inspection and comparison of BS values indicates that the BS "steps" visible in EM120-derived BS data were not apparent in data collected by the new EM122 system. More gradual changes in pulse length and frequencies across different sectors of the transmitted signal have probably helped alleviate this issue.

2. Different swath modes: Single ping vs. dual ping

Noisy BS data and/or second ping gain issues are known from EM122 dual ping swath data from the Swedish icebreaker *Oden*. Therefore, we sought to test both the single and dual swath ping modes of the EM122 during JRtri006.
The Kongsberg recommended setting for Dual Ping Mode (see Runtime Parameters) is *Dynamic* (Dual ping ON), which means that the along-track angle between two pings is based on vessel speed, ping rate and depth and that the EM122 aims to maintain uniform along-track sampling of the seafloor. Note that dual pinging only initiates in >80 m water depth as it is not deemed necessary in shallow waters when you have high ping rates. In addition, dual pinging is turned off in *Very Deep* swath mode because of duty cycle limitations of the transmit transducer (see SIS Reference Manual 3.8).

The effect of dual pinging on the BS was tested by running two consecutive lines in similar water depths, the first with dual ping mode ON (Line 0003) and the second with dual ping mode OFF (Line 0004; Fig. 1b). The BS from these lines is shown in Figure 4.

The excessive noise and gain issues in EM122 dual ping BS data from the *Oden*, which appear as blocky white stripes, were not observed in the EM122 data collected on JRtri006. In general, the BS data quality was good although it is degraded in the outer beams. This is related to the degradation of the transmitted (and thus received) outer beam signal of the EM122 on the JCR (see Data Quality section of) although we note that in a real swath survey overlap with adjacent lines would result in an improved BS mosaic.

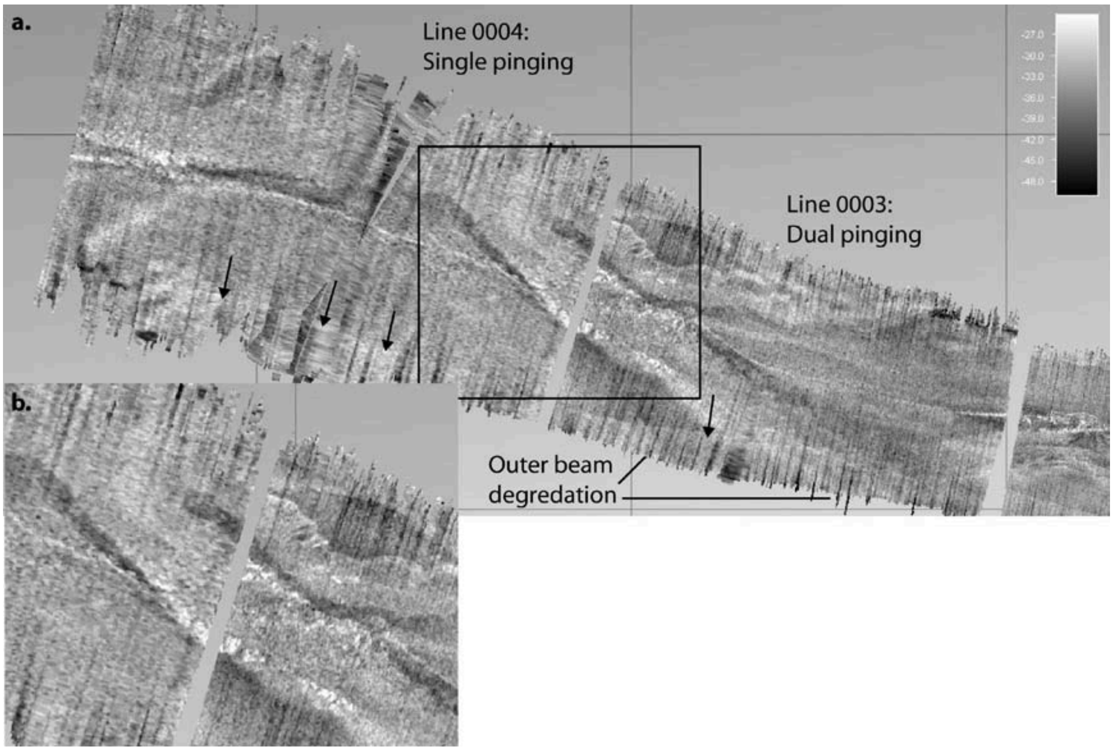


Figure 23a: Backscatter data acquired in dual ping and single ping modes with the EM122, black box shows inset location, and Figure 23b: Zoom to show the decrease in resolution between dual (RHS) and single (LHS) ping BS data. Gully edges are more "blurry" in single ping mode.

Of particular note is the decrease in resolution of the BS mosaic when in single ping mode (Fig. 23b). This is directly related to the increased data density that can be acquired with the EM122 data when compared with the old EM120 system. The last feature to note is a band of elevated BS values on the outer edges of the swath data (arrowed in Fig. 23a). Draping the BS mosaic over the gridded bathymetry data in Fledermaus showed that this band is not related to topography of the gullies on the slope and the edge of this band seems too sharp and linear to be a real (seafloor) feature. In shallower water depths this linear transition appears as a dark (low intensity) band and seems to correspond to the transition to the outer sector of the transmitted swath pulse and the curve in the band edge may represent the location of the outer sector transition in varying topography.

3. Absorption Coefficients

Application of the correct absorption coefficient is important with respect to the validity of bottom backscatter measurements. In the EM122 system a new absorption coefficient is automatically created and applied every time that a new sound velocity profile is loaded into SIS and used during data acquisition. These profiles are also based on the salinity at the transducer head, which can be input in the *Filter and Gains* tab in Runtime Parameters in SIS (default 35 psu). A user-defined absorption coefficient can be input in the *Sound Speed* tab in Runtime Parameters. Full descriptions of how to load absorption coefficient and how this is derived is given in the SIS Reference Manual (equation page 871).

4. Recommendations

- For highest resolution BS data dual swath mode should be left on DYNAMIC whilst surveying.
- For BS surveys plan for good overlap of adjacent swaths to reduce outer beam errors in the final mosaic.
- Users should be aware that sector differences in the transmitted frequencies of the swath system might affect BS data.
- Because BS data quality is directly related to bathymetry data quality optimal bathymetry survey speeds for the JCR will likely produce the best BS mosaics as well.
- For accurate absorption coefficients the correct salinity should be entered in Runtime Parameters.

5. References

Dowdeswell, J.A., 2006. RRS James Clark Ross Cruise Report – JR142: North and East Svalbard: Past Ice-Sheet and Slide Activity.

Fledermaus Reference Manual Version 7, 2011. www.ivs3d.com.

Seafloor Information System SIS Reference Manual, Release 3.8, 2010. SIS on-line help manual.

Water column data (Sophie Fielding)

Water column data was not examined during the cruise because no software capable of looking at it existed on the JCR. However two sets of example files were collected, representative of the two water column logging modes of SIS.

1) Water column data were logged to a separate file (from the .all) with ending .WCD. Data were recorded during the first roll calibration JRtri006_C 19:37 – 20:56 01/07/2011. This file collected 88 MB of WCD files and 50 MB of .all files in approximately 90 minutes.

2) Water column data were logged to the .all file in JRtri006_C 21:38 – 23:40 01/07/2011. Two .all files were saved each of 126 MB of data (256 in total)

Seafloor Information System – Useful Information (Gwen Newton)

Kongsberg authored user and technical EM122 manuals are on board and they give a detailed description of the Seafloor Information System. In addition, Appendix C of this report provides a user guide to acquiring swath bathymetry on the James Clark Ross. Listed below are a few pieces of additional information that may not be found in the Kongsberg manuals.

The Grid in Geographical View

Whilst pinging and logging SIS automatically creates a grid of the data which can be viewed in the Geographical window.

If multibeam is being monitored throughout the cruise and different surveys will be set up for shelf and deep water sections then the GridEngine parameters (under Runtime Parameters > Advanced Options) should be chosen with the following in mind. A typical choice for the number of cells in the processing grid is 128x128. The across track swath width can be estimated from the depth and the maximum angle of the beams using trigonometry. Finally, the Cell Size in m should be estimated as approx. swath width / number of cells in processing grid.

Note: If the grid cell size is too small for the current conditions then black (apparently missing data) areas will appear in the grid in the Geographical Window. This does not necessarily mean that the multibeam isn't working. However, it will make it harder to assess the quality of the data coming in. It is not possible to change the GridEngine Parameters of a survey once it has been started which is why it is so important that these are correct before starting the survey. If this problem occurs the Waterfall and Across track views should be used to assess the data instead.

If you press the 'I' button (Inspection Mode) in the Geographical window then the grid will be displayed in the highest resolution no matter how far you are zoomed in our out. This uses a lot of memory and only a certain extent of the grid will be available to view in this mode, a white rectangle will define the extent. This mode should only be used for quick checks of the data. If it is left on there is a chance it will crash the grid.

Setting a Suitable Depth Range

Check that the Min. and Max. Depth range (Runtime Parameters > Sounder Main) is suitable for the area that you are going to be covering. The values should be half the water depth above and below the current depth i.e. in 1000m of water they should be set to 500m and 1500m. This helps the multibeam locate the bottom. If the bottom depths fall outside the min and max values set in the Runtime Parameters the Depth will be flagged red in the Numerical Display and you will notice that the centre beams drop out first. This can easily be fixed by updating the values in the Runtime Parameters or the Runtime Parameters Mini window.

Additional Useful Points

FM Mode: The EM122 has the capability to operate in FM mode which allows it to see further out to the side in deep water. On the JCR this function is not yet available and hence has been disabled in the system. In the future when the function become available it will be very important to ensure that the roll calibration and SVP are accurate.

Water Column Logging: If you would like to log water column data in a certain area you need to open the Show/Hide window for the Water Column and check the box to turn logging on. In the main toolbar the WCL button will turn green. In Installation Parameters > Output the current settings force the water column data to be logged to a separate file. These files are very large and hence water column logging should only be turned on when necessary. Remember to uncheck the box when you no longer need the data.

Message Log: The Message Log window can be opened at any time and will give you a list of all recent messages / warnings. If you encounter problems with the multibeam then this is a good place to get an idea of what the issue might be.

Planning Module: This can be used to define lines that you would like to survey. Before you start you need to make sure the 'P' button at the top of the window is checked. Once you are happy with the lines they can be transferred to the Helmsman Display so that they can be seen on the bridge.

Background Grids: It is possible to import your own background grids to be displayed in the Geographical window. This can be done by going to File > Import/Export.

True Heave Logging: It is possible to log the true heave of the vessel to a file which can then be used in post processing software. The true heave is taken from the SEAPATH system and is not calculated instantaneously. Hence if you would like to log true heave then you need to wait about an hour after starting the survey before turning it on. The logging is switched on via Runtime Parameters > GPS and Delayed Heave then tick the box 'Start Seapath Real Heave logging'.

Bugs: If you chose to open the Runtime Parameters in a tear off window then it is likely that the system will crash (apparent when you can no longer use the drop down menus). If this happens you will have to shut down and restart SIS. Hence it is recommended that Runtime Parameters is never opened in a tear off window.

Returning to a Previous Survey: If you would like to go back to a previous survey and start logging to it again, there are two options. You can use a New Survey window and in the Basic Parameters tab you can choose your survey from the Existing Survey drop down and then press the 'Continue on existing survey' button. The survey will then appear in the far right box of the main toolbar and the correct line number will be displayed in the Line cnt. box. Alternatively you can choose the survey directly from the drop down box on the far right of the main toolbar. However, the line count will be incorrect until you turn pinging on.

Sound Velocity import (Alex Tate)

The SIS software provides a large range of import options for sound velocity profiles collected by XBTs, CTDs and hull mounted sensors. These are well documented in the SIS user manual and this report will only describe the preferred method of importing Sippican XBT and Seabird CTD sound velocities as collected on the majority of JCR scientific cruises.

Sippican XBTs

Sippican T-5 (deep) and T-7 (shallow) XBTs can be deployed whilst the vessel is moving, preferably at 6 knots to ensure a full depth profile. Launch instructions are located near the XBT acquisition machine and a successful deployment results in an .EDF and .RDF file being written to the current cruise XBT folder on the network (e.g. /data/cruise/jcr/20110627/xbt/T5_00002.EDF).

A cron job (run under user ID, jcrdata) running every minute on the minute, searches for newly acquired xbt data and when found converts the .EDF file into an .asvp that can be read directly into SIS. The following steps are required to load the .asvp into the current EM122 survey file.

1) From the SIS Tools menu select Tools menu and select Custom>SVP Editor

2) Use File>Open and navigate to the U drive (named as em122)> asvp directory >cruise/<leg id> and select the latest XBT profile gathered. This is a samba link to /data/asvp/by-leg/<leg id> on the network.

3) When loaded the profile can be edited to remove bad points, especially those points at the bottom of the profile where the XBT has hit the seabed before finishing recording. The profile screen can be zoomed by changing values in the from/to depth and sound speed boxes and hitting redraw. Multiple rows can be selected by using shift-click on the spreadsheet view before hitting delete row to remove them.

4) When the profile is clean it needs to be extended to 12,000m using Tools>Extend Profile in order to satisfy SIS requirement. Using Tools>Check profile automatic will identify any problems points that have been missed.

5) Use Tools>Thin Profile to reduce the number of points within the profile. Accept the 0.1 thinning ratio and the software will automatically reduce the number of points by 90 percent, leaving the most in areas of fastest sound velocity change within the profile. Note the EM122 can handle profiles with up to 1000 points in. A new file will be created in the current directory called <original_name>_thinned.asvp. This file will be automatically transferred to the EM122 machine under D:\sisdata\common\svp_abscoeff\<leg id>. The transfer is based on a chron job running every minute so there will be a brief delay before being able to select the profile. Close the SVP editor.

6) In SIS Runtime parameters choose the Sound Speed tab and select the correct thinned profile from D:\sisdata\common\svp_abscoeff\<leg id>. Click 'Use sound speed profile' to apply the profile to the current survey line even while still logging. Note that auxiliary absorption coefficient files will be automatically created as the sound speed is applied and that the survey line count does not increment automatically.

Seabird CTDs

Following the processing steps on the CTD computer, a batch file is run generating an .asvp file that is written to the /data/asvp directory. This can be selected in the same way as XBT data following the steps already mentioned.

XBT/CTD sound velocity profiles for archival cruises will be added later in 2011 and can be selected in exactly the same way.

EM122 Post-processing software (Alex Tate)

MB System v5.2.1880

MB System successfully read and processed EM122 data. As with EM120 data, the function mbcopy is used to transfer raw files into an extended format that holds additional flag values. A perl script written by Jeremy Robst streamlines this task as well as producing auxiliary files. To run the script type,

```
setup gsd
mbcopy_em122
```

Further details regarding processing with MB System can be found in a number of previous JCR cruise reports (see http://www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/jr206.pdf for example).

IVS 3D Fledermaus

We were unable to secure a trial copy of IVS 3D Fledermaus for the cruise but a copy belonging to the Scott Polar Research Institute was available. Fledermaus successfully read and processed EM122 data (both raw.all and MB System .fbt files) but we did not have the FMMidwater module so no water column data could be viewed or processed.

Kongsberg Neptune

We were unable to get Neptune to read any of the new EM122 data files but this is unsurprising given that we have not had a Neptune upgrade in several years and that this software is no longer being developed. The primary use of Neptune in recent seasons has been to quickly visualise the current survey data. Now that this functionality is available within the SIS acquisition software, Neptune is effectively redundant. It is left on the JCR in case users bring archival swath data, processed within Neptune, and want to view/edit these data.

Integration of EM122 with SSU and other instruments (Sophie Fielding)

Over the course of the trials cruise the integration of the EM122, EA600, EK60 and ADCP through the SSU were examined and compared with the results from JR218 (JR218 Acoustic trials report). Each instrument was turned on individually and pinged under its own trigger control to ensure that it was operating. Each instrument was then turned on to trigger from the SSU and pinged. The EA600, ADCP and EK60 worked as desired. The EM122 did not trigger correctly through the SSU, Tx pulse and fixed time settings work okay, but the SSU did not appear to be receiving a release signal ready for the next trigger. The Kongsberg Engineer had to rewire the wiring between the EM122 and SSU due to broken wires. After this the EM122 worked correctly with the SSU, allowing it to be used in calculated mode.
One further trial was undertaken to examine whether the new EM122 could withstand being triggered by the SSU before it was ready. This was unsuccessful and the SSU should be used as described in the JR218 report. It should be noted that THE EM122 AND EA600 NEED TO BE RUN THROUGH THE SSU TO PREVENT INTERFERENCE IN THE EM122 DATA. Below is a quick guide to SSU settings for each type of cruise.

SSU Settings

Opportunistic SSU mode and settings

Setup	Group	Time usage			
		EA600 (passive)	EM122	EK60	ADCP
Swath only	EM&EA&EK&AD	Tx pulse	Calculated	Off	Off
Swath + ADCP	EM&EA&EK&AD	Tx pulse	Calculated	Off	Free running*
Swath + EK60	EM&EA&EK&AD	Tx pulse	Calculated	Free running	Off

* Free running – means not controlled by the SSU (on internal trigger)

Opportunistic instrument settings

Instrument	Comments
EA600	Needs to be in passive mode, external trigger, max ping rate
EM122	External trigger, auto settings, may need to manually find depth at points
EK60	Internal trigger, 2 second ping rate, interference removed in processing
ADCP	Water depth <500m load command file JCR_BT_opp.txt Water depth >500m load command file JCR_WC_opp.txt

Biology cruise SSU mode and settings

Setup	Group	Time usage

		EA600	EM122	EK60	ADCP
EK60+EA600	EM&EA&EK&AD	Tx pulse (active)	Off	Calculated	Off
EK60+EA600+ADCP	EM&EA&EK&AD	Tx pulse (active)	Off	Calculated	Tx pulse
EK60+EA600+ADCP+EM122 Water < 500	EM&EA&EK&AD	Tx pulse (passive)	Tx pulse	Calculated	Tx pulse
EK60+EA600+ADCP+EM122 Water >500	Shallow	Tx pulse (passive)	Fixed time (500ms)	Calculated	Tx pulse
EK60+EA600+ADCP+EM122 Water >2500	Medium	Tx pulse (passive)	Fixed time (500ms)	Calculated	Tx pulse
EK60+EA600+ADCP+EM122 Water >5000	Deep	Tx pulse (passive)	Fixed time (500ms)	Calculated	Tx pulse

Biology cruise instrument settings

Instrument	Comments
EA600	Need to be active, external trigger when EM122 off, otherwise passive, max ping rate
EM122	Active mode, 60° beam fan on either side, auto settings, may need to manually find depth at points. Requires updating Sv profile if needed
EK60	Water depths <500m use a 3 second ping rate, for depths >500m use 2 seconds* External trigger
ADCP	Water depth <250m load command file JCR_BT250.txt Water depth <500m load command file JCR_BT500.txt Water depth >500m load command file JCR_WC800.txt

Geophysics SSU mode and settings

Setup	Group	Time usage			
		EA600 (passive)	EM122	EK60	ADCP
Swath only	EM&EA&EK&AD	Tx pulse	Calculated	Off	Off

Swath + ADCP	EM&EA&EK&AD	Tx pulse	Calculated	Off	Free running*
Swath + EK60	EM&EA&EK&AD	Tx pulse	Calculated	Free running	Off

* Free running – means not controlled by the SSU (on internal trigger)

Geophysics instrument settings

Instrument	Comments
EA600	Needs to be in passive mode, external trigger, maximum ping rate
EM122	External trigger, controller changing settings
EK60	Internal trigger, 2 second ping rate, interference removed in processing
ADCP	Water depth <250m load command file JCR_BT250.txt Water depth <500m load command file JCR_BT500.txt Water depth >500m load command file JCR_WC800.txt

Physics cruise SSU mode and settings

Setup	Group	Time usage			
		EA600	EM122	EK60	ADCP
ADCP+EA600	EM&EA&EK&AD	Tx pulse (active)	Off	Off	Calculated
ADCP+EK60+EA600	EM&EA&EK&AD	Tx pulse (active)	Off	Tx pulse	Calculated
ADCP+swath	EM&EA&EK&AD	Tx pulse (passive)	Calculated	Off	Free running
ADCP+EA600+EK60+EM122 Water < 500	EM&EA&EK&AD	Tx pulse (passive)	Tx pulse	Tx pulse	Calculated
ADCP+EA600+EK60+EM122 Water >500	Shallow	Tx pulse (passive)	Fixed time (500ms)	Tx pulse	Calculated
ADCP+EA600+EK60+EM122 Water >2500	Medium	Tx pulse (passive)	Fixed time (500ms)	Tx pulse	Calculated
ADCP+EA600+EK60+EM122 Water >5000	Deep	Tx pulse (passive)	Fixed time (500ms)	Tx pulse	Calculated

Physics cruise instrument settings

Instrument	Comments
EA600	Need to be active, external trigger when EM122 off, otherwise passive, max ping rate
EM122	Active mode, 60° beam fan on either side, auto settings, may need to manually find depth at points. Requires updating Sv profile if needed
EK60	External trigger, assumes 2 second ping rate
ADCP	Water depth <250m load command file JCR_BT250.txt* Water depth <500m load command file JCR_BT500.txt* Water depth >500m load command file JCR_WC800.txt*

SSU integration diary

Monday 27th June 2011
EK60 fired up – initially no contact with GPTs. J noted netgear not turned on at GPT area. Once on EK60 communicated with GPTs. All EK parameters working ok and IT sorted GPS string into the ER60 software.
EM122 not working with SSU correctly. Not able to control through the SSU. Craig and Richard found cabling not wired correctly.

Tuesday 28th June 2011
ADCP fired up all working within parameters expected by novice user.
SSU integrated EK60, ADCP and EA600 according to previous protocols.
SSU now able to trigger EM122 when in either fixed time or tx pulse mode but not working with EM122 when put in calculated mode. Appears not to see released signal.

Wednesday 29th June 2011
SSU now integrated with all instruments correctly. Can run EM&EA&EK&AD mode trigger all at rate of EK60 (2 sec ping rate) all working together. Need to test whether EM122 no longer falls over if you try and trigger at the wrong time, because if not we can just use the EM&EA&EK&AD mode in the future controlling trigger rate by the EK60 and the EM122 not firing when not ready.

Thursday 30th June 2011
Examined whether EM122 failed when triggered when not quite ready. Put group EM&EA&EK&AD on SSU in ~1800 m of water. Ping rate 2 seconds controlled by EK60. EM122 failed to trigger and cope with repetitive triggering when not ready. The new dual pulse mode may make it more acceptable to have a slower EM122 ping rate interfaced with the other instruments.

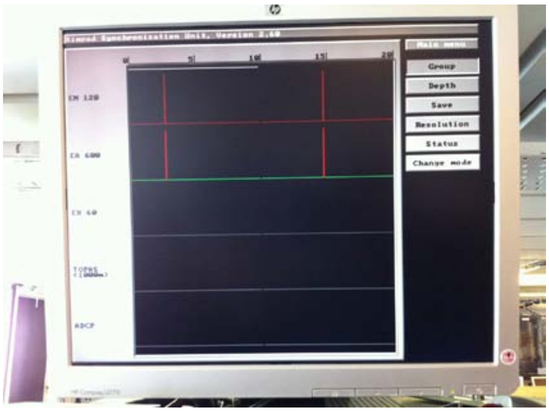
Operating the swath and EA600 through the SSU (Sophie Fielding)

The EM122 and EA600 must be run through the Simrad Synchronisation Unit (SSU) to prevent interference and noise in both (as they both work at the same frequency). Many of these stages can be completed through a chat with your friendly IT support.

The SSU is located in the acoustic electronics cabinet, at the top. It is turned on using the black switch, after which the green power light lights up. The SSU monitor, situated on top of the cabinet, is shared with the Seapath GPS system and can be chosen by pressing the PC2 button on the KVM switch next to the monitor. The SSU is controlled either using the arrows on the attached (grey) keyboard or using the arrowed control handset. On start up the SSU boots to a mode selection menu, choose either “default” or allow to boot up into the auto selected mode.

At the first screen select the second configuration (Photo 1) by using the arrow keys to navigate down and the right arrow key to select the option. This configuration is listed as EM&EA EK TO. Once up and running ensure both the EM122 and the EA600 are in external trigger mode, and the EA600 is set to passive (EA600 note 1). Select GROUP (using the right arrow key), select EM EA (using the right arrow key), select EM120 (using the right arrow key), select TRIGGER (using the right arrow key) and select ON. Check that the EM mode is set to calculated (select GROUP, EM EA, EM120, TIME USAGE, CALCULATED). Then set up the EA600 following GROUP, EM EA, EA600, TRIGGER, ON and GROUP, EM EA, EA600, TIME USAGE, TX PULSE. Start pinging on the EM122, the systems may take a minute to start pinging correctly. Eventually the SSU screen should look like photo 2 (in deep water – there will be more pings in shallow water).

Photo 1 – select the group EM&EA EK TO at start up menu, Photo 2 – the SSU screen when the EM122 and EA600 are synchronised in deep water



Note 1 - setting EA600 to passive
Phone the bridge and ask the OOW to set the EA600 in passive mode on external trigger. Alternatively, inform the bridge of your intentions (and get them to press scroll lock if the light is lit up on the EA600 keyboard), and apply the following
File -> Operation -> tick/untick Extern trig and set ping rate to maximum
Right click on ’12 kHz’ -> mode set to passive when synching with EM122 and back to active when the EM122 is off.

Seatex Seapath 320+ (Alistair Graham)

1. Introduction and Equipment Purpose

The Seapath 320+ is a positioning, attitude and heading sensor, combining inertial measurements with satellite signals to achieve high precision information on the ship's position and vessel motion. On JCR, the specific function of the Seapath is to measure heading, position, roll, pitch, heave and timing. The Seapath provides positional and inertial data for the EM122 multibeam echo-sounder.

The Seapath is a GNSS system meaning it needs free sight to the sky to function correctly. For positioning at least 4 satellites are required for the Seapath to operate, and the accuracy of the position calculation varies with the number of visible satellites and their locations. The Seapath 320+ uses a combination of GPS and GLONASS GNS systems, meaning better geospatial coverage, particularly in operating environments with obstructions or otherwise poor satellite connection. Positional accuracy may be enhanced further using differential GPS/GLONASS corrections, which take account for small errors in satellite orbit by correcting from a reference station with known co-ordinates. The Seapath can also use the free-of-charge SBAS system to provide additional accuracy to the GPS system.

The new Seapath was installed prior to cruise JRtri006, and trialled as part of the Kongsberg EM122 multibeam echo-sounder acceptance trials. For a detailed user guide and further information refer to the Seapath 320+ Product Manual.

2. Components

The main components of the Seapath 320+ are:

- The MRU 5+ inertial sensor
- Two GNSS antenna.
- The two-module Seapath product in the UIC room, comprising separate Processing and HMI (Human-Machine Interface) units, connected via Ethernet. The units are rack-mounted in the black cabinet directly behind the EM122 and TOPAS workstations. The terminal for the Seapath HMI is on top of the black computer cabinet.

3. Usage

Power on/off switches for the units are located on their front panels, under flick lids.

The HMI will be used for system configuration and visualisation of data related to JCR's GPS inputs, attitude and heading. The operator software is intuitive and easy to use, running on a Windows XP platform. The system has three user modes: *Operation* (the default user mode), *Configuration* and *Engineering.* The main features are accessible in all three modes, but substantive changes to the system can only be made in Engineering mode. A password is required to access the advanced user modes. Most users will only require the features offered in the *Operation* mode (see p. 27 of the manual for info on system modes).

4. Useful features and points-of-interest

The software is described in detail in the user manual, and user instructions are not repeated here. However, some features that will be immediately useful are:

Changing data views on the HMI

The main display is divided into 4 view windows: the top bar, main display (view 1), view 2 and view 3. Combinations of shortcuts F2, F3, shift+F2, and shift+F3, cycle and switch between the different views. See page 26 of the manual.

Assessing data quality and status

Seapath has a real-time quality control feature for monitoring data quality. The left part of the top bar on the NavEngine display has a number of status indicators for Pos/Vel, Heading, Heave, Roll/Pitch, and system status. If these are green, then status is normal. For all indicators except the system status, alarms are triggered if quality degrades or thresholds are passed, resulting in the indicator turning yellow. This indicates reduced performance. Red alarms indicate the data are invalid. See p. 41 of manual for info on Alarms.

N.B. The thresholds for alarms are set low on the JCR. 'Yellow' alarms are not uncommon and do not usually signify that data quality is compromised. It is likely that when South, such alarms will be a regular occurrence requiring no further action. Nevertheless, the operator should still take note of alarms and verify that data quality remains adequate. Red alarms will still require action.

The 'Integrity' view is a useful quick visualisation of the system accuracy.

Looking at available satellite coverage (Sky View)

The Sky view shows which satellites the system is tracking and which are being used in the position calculation. The large numbers to the top left and right show these information for GPS and GLONASS respectively. Hovering over the circular satellite markers provides further details on individual satellites. See p. 29 of manual.

Looking at real-time motion and heading data (Motion Data view)

Shows real-time values for the inertial measurements, including speed and heading, and rate of turn.

Planning for satellite drop-outs (Satellite Prediction)

A tool to display satellite numbers and geometry for a defined position and period of time. Useful for planning, to see likely future positional accuracy and to predict satellite drop-outs. Drag the time indicator bar to see the constellation change, or insert a manual time and position and click update. Shadow sectors can also be manually inserted, to account for shadowing by nearby obstacles. See p. 44 of manual.

Changing display modes (e.g. at night-time)

Found in the View menu, or by toggling F7 (for 4 different day settings) or F8 (for night view). Allows user to change display colours in varying light conditions.

5. Performance report

No problems were reported with the Seapath during cruise JRtri006. In UK waters, we enabled the SBAS corrections, which improved our positional accuracy. It was noted by several of the science party that the Seapath 320+ was a significant improvement over the old system, in terms of information relay and user-friendliness.

6. Recommendations

- GNSS heading should be properly calibrated in next dry dock.
- Configuration files should be saved and stored routinely after each JCR cruise.
- Thresholds for 'yellow' warnings could be reduced to avoid repeated alarms.

ICT Cruise Report (Jeremy Robst)

The onboard ICT wiki has been updated with procedures and notes relating to the multibeam upgrade. Modifications have been made to the processes for backing up the EM122 data from the operator workstation to the central fileserver (JRLB) and for generating sound velocity profiles from XBTs and CTDs. (Note no CTDs where performed during the trials cruise, so whilst the SVP import should work this has not been tested).

The MBSystem processing software was upgraded (to version 5.2.1880) on JRUJ and on JRLD. The associated GMT package was upgrade to version 4.5.6. An 'mb' user was created for mb processing by scientists without a personal unix account.

Separately to the EM122 upgrade, the SCS was also upgraded to v4.5.1.1603 and the trials cruise was used to test out this new version.

Recommendations

EM122 Operator Workstation

1. **Mirror the system disk.** The operator workstation contains 2 (1TB) disks, one used for the OS and raw survey data, and one used for the automatically generated grid files. The OS & raw data disk at least should be mirrored to another disk so that the system will continue to work in the event of a disk failure.
2. **Bare-metal image the system.** For disaster recovery, a bare-metal image needs to be made on a regular basis (once per year) and kept in the computer office.

UIC AME/EM122 Cabinets

1. **Network patch panel and switch.** Temporary cat5 cables have been run for the network & KVMs, however a proper patch panel and possibly a switch needs to be installed.

Plotter

1. **Turn 90 degrees.** The new position of the plotter means it has turned 90 degrees relative to the old position. This might make it vulnerable to the ship roll; if this happens then it should be remounted.

Unix/Linux Workstations

1. **General purpose Linux workstation.** The Solaris workstations (JRUH/JRUJ) are now quite old and struggle to handle the volumes of data being generated, and it is also a struggle to compile software on them. There is a virtual general purpose linux machine (JRLD), however it may prove more useful to replace the Solaris workstations with a physical linux workstation.

SCS/Instruments

1. **Ashtech GPS replacement.** The Ashtech GPS provided wildly inaccurate headings during the trials cruise, and for several years has needed rebooting every few days. Either a replacement GPS needs to be installed or the Ashtech needs to be removed – the Seatex Seapath system is a very good 3D GPS so the Ashtech is probably no longer needed.
2. **Truewind**. The derived truewind sensor doesn't appear to work in the new SCS version so an alternate means of providing true wind needs to be investigated.

Recommendations

Individual sections have their own recommendations in context but they are repeated here for completeness.

EM122 calibration

- Calibration of the sensors should be performed **at the beginning of every dedicated multibeam survey**. As a minimum, a roll check should be carried out before any cruise which involves substantial multibeam data acquisition.
- If no geophysics cruises are scheduled, calibration should still be performed at least once per year and certainly after any modifications to the sensors (e.g. during refit).
- Areas should be identified near to operational bases and ports where calibration of the EM122 can be conducted and repeated at regular intervals.

EM122 data quality

- Results from the noise tests suggest that, in terms of minimising ship's noise interference with the EM122, the optimal surveying ship speed is 10 knots.
- Outer sector errors are a significant problem for the EM122 system. If high quality of seabed data is required a swath overlap of at least 25-30% is necessary to be able to cull poor data in the outermost parts of swath lines.
- Based on the data quality it is recommended that cleaning of the transducer heads is done as soon as possible and, if possible, the transducers are replaced.

EM122 backscatter data

- For highest resolution BS data dual swath mode should be left on DYNAMIC whilst surveying.
- For BS surveys plan for good overlap of adjacent swaths to reduce outer beam errors in the final mosaic.
- Users should be aware that sector differences in the transmitted frequencies of the swath system might affect BS data.
- Because BS data quality is directly related to bathymetry data quality optimal bathymetry survey speeds for the JCR will likely produce the best BS mosaics as well.
- For accurate absorption coefficients the correct salinity should be entered in Runtime Parameters.

EM122 sound velocity import

- Add archival xbt/ctd data into the new directories used to import sound velocity information into SIS.
- Investigate bringing sound velocity data collected by the Oceanlogger (via the SCS) into SIS using a free COM port. This would give a visual indication when the sound velocity at the hull deviates significantly from the sound velocity profile being used.
- Investigate costs of installing a Kongsberg sound velocity probe positioned near the EM122 transducer.

Seatex Seapath 320+

- GNSS heading should be properly calibrated in next dry dock.
- Configuration files should be saved and stored routinely after each JCR cruise.
- Thresholds for 'yellow' warnings could be reduced to avoid repeated alarms.

EM122 Operator Workstation

- Mirror the system disk. The operator workstation contains 2 (1TB) disks, one used for the OS and raw survey data, and one used for the automatically generated grid files. The OS & raw data disk at least should be mirrored to another disk so that the system will continue to work in the event of a disk failure.
- Bare-metal image the system. For disaster recovery, a bare-metal image needs to be made on a regular basis (once per year) and kept in the computer office.

Conclusions

The cruise was successful in that the majority of the objectives were completed and the EM122 upgrade was accepted from a technical and scientific viewpoint. A range of different users now have first-hand knowledge of the EM122 and the SIS acquisition software and hopefully this report will help those not present to use the upgraded system in its first few seasons.

As stated in the acceptance testimonial (see Appendix B), there is significant concern about poor data seen in the EM122 outer beams. Impedance measurements on the EM122 Tx (and to a lesser extent Rx) elements suggest significant degradation rates especially in the middle sectors, reducing the signal strength and impeding beam formation.

Consequently the main conclusion and recommendation of this report is that the Tx transducer array should be replaced as soon as possible.

Kongsberg will perform further analysis using data acquired on this cruise and any future technical report will be appended to this document.

Acknowledgements

We are grateful to Captain Burgan and the officers and crew of the RRS James Clark Ross for their help in carrying out this EM122 acceptance cruise.

We acknowledge the significant effort put in by Craig Wallace, the Kongsberg installation engineer aboard the trails cruise. His time and patience explaining both the EM122 system and the newly installed SIS acquisition software to the cruise participants was much appreciated.

Appendix A – Kongsberg Technical Report (Craig Wallace)

Seapath

The Seapath 320+ has been installed in the same rack as the HWS machine for the EM and Topaz and is replacing and older Seapath200. The old unit was already removed prior to arrival so it is not clear which systems all received feeds from the unit however the .par configuration file was removed and cabling matched to the outputs. I believe all systems which had an input previously have been catered for but cannot be 100% sure.

As the unit replaces and older system it was necessary to determine a vessel dimensional control. The new MRU5+ has been located immediately beside the old MRU5 which has been left in place and may be utilised at a later date. From the old configuration file the previous vessel measure point was the old MRU so to ensure that all systems expecting data at this reference have no lever errors this location remains the Navigation point for the new Seapath.

Parker Survey were employed to perform a survey for the vessel taking into account all the Seapath unit locations. This was provided in reference to frame 76.

It should be noted that with the vessel not being in dry-dock a measurement for the Em122 transducers was not possible and these levers have been taken from the original Dim Con report in 2000. Unfortunately the vessels chosen reference has changed over the years and whilst we believe the transducers measurements to be accurate we cannot be 100% sure until a full survey is performed at the next dry docking.

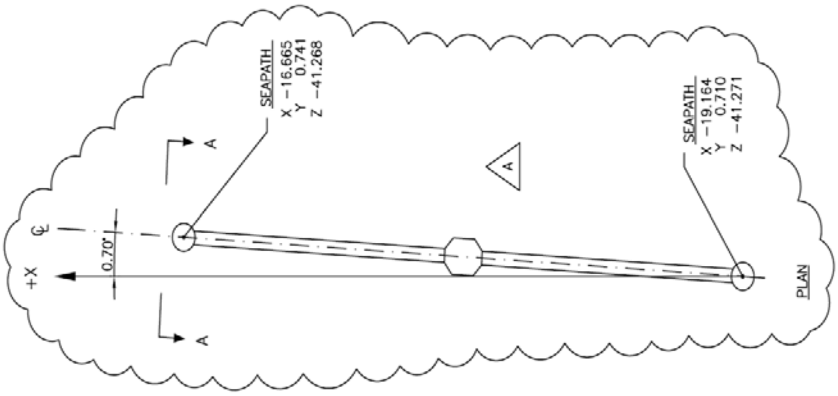
The table below shows the results from the Surveyors which are referenced to frame 76 at the keel whilst the second table shows the measurements transposed to the stern point.

	X +ve For	Y +ve Star	Z +ve down	Yaw +ve clock	Pitch +ve Fore up	Roll +ve Port up
MRU5+	-1.165	-0.191	-7.105	2.74	-0.02	-0.03
MRU5	-1.212	0.006	-7.558	1.33	0.01	-0.72
320 Aft Ant	-19.164	0.71	-41.271	0.7		
320 ForW Ant	-16.665	0.741	-41.268			
Stern/origin	-56.4	0	0			
Frame 76	0	0	0			

	X +ve For	Y +ve Star	Z +ve down	Yaw +ve clock	Pitch +ve Fore up	Roll +ve Port up

MRU5+	55.235	-0.191	7.105	2.74	-0.02	-0.03
MRU5	55.188	0.006	7.558	1.33	0.01	-0.72
320 Aft Ant	37.236	0.71	-41.271	0.7		
320 Forw Ant	39.735	0.741	-41.268			
Stern/origin	0	0	0			
Frame 76	56.4	0	0			

Using the above values from the stern the Seapath was configured to output data valid to the MRU5. Note that Antennae one is the Aft and therefore the heading offset of 0.7 degrees is clockwise. The diagram below from the survey report shows the error,

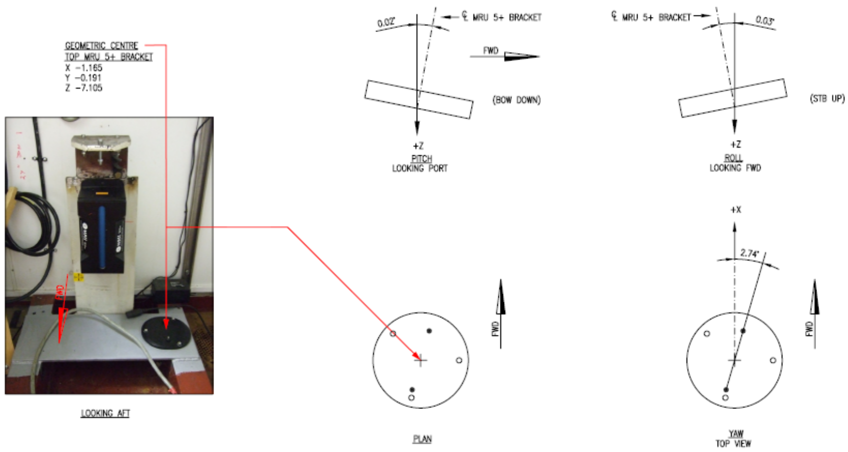


With the Seapath running it was necessary to apply this offset however it should be noted that the error in the Seapath is a C-O error so the applied value is what is needed to correct the system hence a value of -0.7 has been applied to the unit.

A baseline calibration was performed to find any error in the baseline length and height however since the vessel was floating at quayside a proper surveyed in calibration could not be performed. Again this is something that should be performed at the next dry dock visit. After the cal the baseline error of 2.502 in length and 0.017 for height has been applied.

The mounting angles for the new MRU5+ were installed into the software as shown in the picture across.

It should be noted that any other systems receiving a Roll/Pitch signal will require a recalibration to take account.



To my knowledge the only systems this will be necessary for will be the Topaz unit and the Sonardyne USBL system.

The outputs from the Seapath have been configured as follows,

Telegrams Out	Type	Settings	Details
1	Serial	Com 9, 19200, 232	Position and Time to EM122
2	Serial	Com 9, 19200, 232	EM3000 Attitude to EM122
3	Ethernet	UDP Lan3, 3001	FM correction to EM122
4	Serial	Com11, 4800 232	Feed to AIS (via 422 adapter) and SCS
5	Serial	Com 1, 19200, 232	EM3000 output to USBL (via 422 adapter)
6	Serial	Com12, 19200, 422	Position, Time etc to USBL
7	Serial	Com13, 19200, 232	EM3000 to Topaz
8	Serial	Com2, 19200, 232	GPS feed to Topaz

The vessel has several outputs which are daisy chained where it would be much better to use serial splitters and it is recommended that this implemented in the future.

With the system setup as above both GPS and Glonass satellites were detected without issue with good SNR on both constellations. Unfortunately the vessel does not use diff corrections meaning that the position error is usually greater than 2.5 metres and will leave the system in a reduced mode, this does not affect nay output strings merely gives a yellow indicator on the screen. On top of this the integrity value will always be quite high, again putting the system into a cautious mode. The new Seapath error limits are obviously quite tight and not suited to operation without DGPS however it will not affect any data outputs so can generally be disregarded.

EM122

Upon arrival original EM120 TRU had been removed and new 122 unit had been mounted. Due to mounting restrictions the new transceiver location differs from the original and cable paths had to be altered for termination.

All Tx module connections were removed from the Tx junction boxes and all locations noted. The system has been installed sequentially with the lowest serial numbers towards the fore of the vessel. Similarly the Rx has been installed with the modules increasing in serial number from Port to Starboard.

The impedance of each element was tested and plots produced across the operational frequency of the transducers. These plots were subsequently sent to Norway for simulation. It should be noted that a high number of elements located around the centre of the TX array showed significant signs of degradation which indicates that the system would struggle to achieve a wide swath and would struggle to reach the greater extent of the expected depths for any particular mode. The Rx channels showed fairly good results with only a few questionable elements. The graphs of these measurements has been included at the end of this document.

A full report indicating the extent of damaged elements will be issued by Kongsberg but until then the FM mode of the system has been disabled in the TRU, not just in the runtime menu. It should be noted that this will need to be edited upon installation of new transducers.

With the elements tested all cabling was terminated in the Tx junction boxes/Rx pre amp and inside the transceiver cabinet.

As shown the system retains the original Tx junction boxes and pre-amplifier, due to the greater Bandwidth used by the EM122 all amplifier/filter cards within the transceiver have been replaced with the newer versions.

Old Cards	Replacements
78254	676886
78252	676894
78253	673013
Blank	676013
76949	673009
76948	676885
76950	673010
76951	676891

The following tables give the various transducer connections within the system.

Tx Module	TX No	T No	Rio No
931	1	T1	R1 J3
952	2		
953	3	T2	R1 J4
956	4		
958	5	T3	R2 J3
963	6		
964	7	T4	R2 J4
965	8		
966	9	T5	R3 J3
968	10		
969	11	T6	R3 J4
970	12		
972	13	T7	R4 J3
973	14		
974	15	T8	R4 J4
975	16		
976	17	T9	R5 J3
977	18		
978	19	T10	R5 J4
979	20		
980	21	T11	R6 J3
981	22		
982	23	T12	R6 J4
983	24		

Tx Module	TX No	T No	Rio No
984	25	T13	R7 J3
985	26		
986	27	T14	R7 J4
992	28		
994	29	T15	R8 J3
995	30		
996	31	T16	R8 J4
997	32		
998	33	T17	R9 J3
999	34		
1005	35	T18	R9 J4
1006	36		
1016	37	T19	R10 J3
1017	38		
1023	39	T20	R10 J4
1024	40		
1025	41	T21	R11 J3
1026	42		
1028	43	T22	R11 J4
1029	44		
1030	45	T23	R12 J3
1032	46		
1033	47	T24	R12 J4
1035	48		

Rx Module	Rx No	R No	Rear IO
121	1	R1	R1 J3
124	2		
125	3	R1	R1 J4
126	4		
127	5	R2	R2 J3
128	6		
129	7	R2	R2 J4
130	8		

Rx Module	Rx No	R No	Rear IO
131	9	R3	R3 J3
132	10		
133	11	R3	R3 J4
134	12		
135	13	R4	R4 J3
136	14		
137	15	R4	R4 J4
138	16		

The inputs to the system were then terminated. Although the terminations are still D_Sub connectors unfortunately there was not enough length and all cables had to be extended using Cat 5 network cable. This has been secured to help prevent vibration however it should be noted that the cable is single stranded and could prove brittle after several years in a soldered connector.

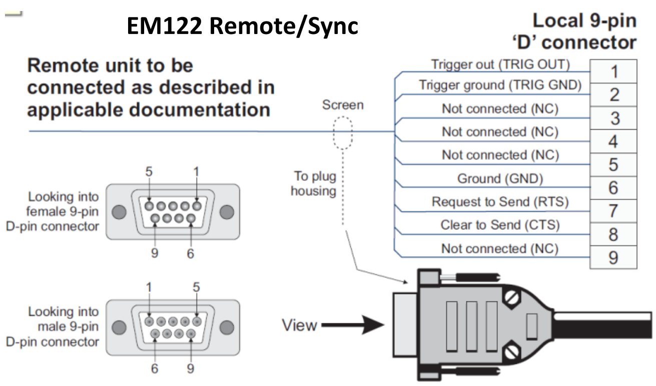
The system was configured with GPS input on com 1 which contained ZDA and VTG in the string at 19200 whilst the Com 2 receives attitude in EM3000 format at 100Hz 19220 Baud.

A PPS signal direct from the Seapath has also been implemented.

The primary Ethernet port is connected to the topside HWS via crossed network cable for SIS and the secondary port connects to the Seapath to receive the Seapath binary format 11 telegram for FM corrections.

The final input was for the remote on/off and synchronisation signals from the SSU.

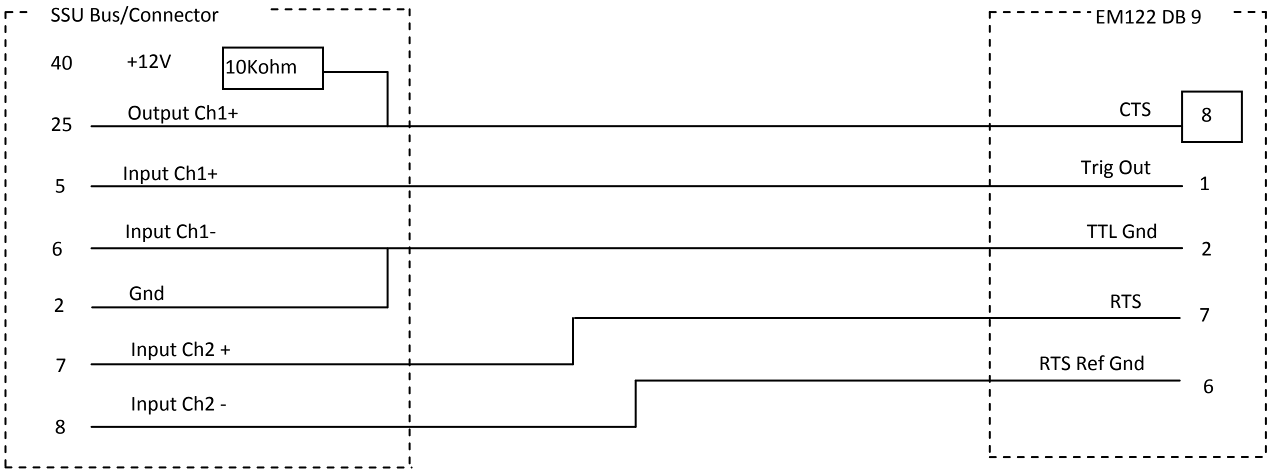
These are both fed in on a 9 pin D SUB and it should be noted that the pin outs have changed from the EM120 system. These are as follows.



Note that the remote On/Off using pins 3,4 and 5 remains unchanged and has been tested as operational.

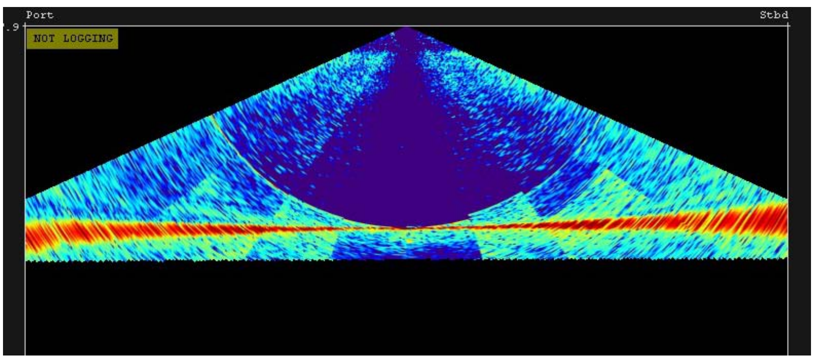
The EM 120 used pin 8 as ground for the 232 signals whilst RTS and CTS were pins 6 and 7 respectively so these have been re-soldered within the connector to match the EM122.

It should also be noted that connection to the SSU previously used a common reference ground for both the TTL signals and the 232 signals. This did not work correctly with the EM122 and a separate ground path had to be used. Note the current interface to the SSU has been rewired and tested. The new wiring interconnect is shown below,

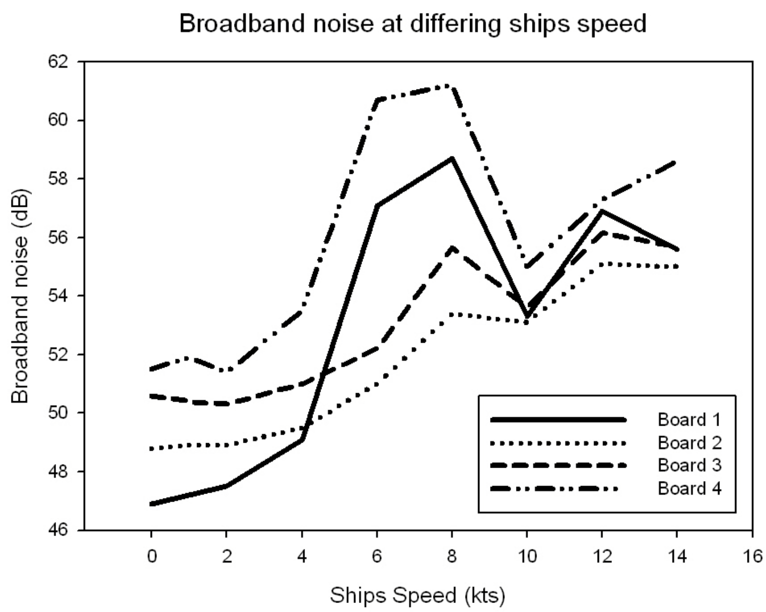


With the system installed and all inputs verified the vessel sailed to perform sea trials.

Initially due to the shallow waters the system showed large amounts of interference in the outer sectors, initially this was attributed to the water depth however as the depth increased the noise became quite prominent in the outer sectors.



This picture shows the noise which causes large errors in the outer beams. It should be noted that in shallow water the energy in the central 5 degrees gives a large spike of noise. To try reduce this various settings were changed such as the Tx angle and various filters but without any effect.



To try and better understand the problem various noise tests were done at variable speeds. The vessel has a single fixed pitch prop and is driven through electric drives. The graph below shows the noise at increasing speeds all done in 2000m of water. It clearly shows a general increase in noise through the speed range as expected with a small sweet spot at 10 knots. The dramatic increase of noise in Boards 1 and 2 which represent the outer edges of the Rx array suggests that the vessel suffers from considerable flow noise, i.e.; vortices which cross the face of the transducers until we reach higher speeds whereby they clear the edges of the array.

The data subsequently collected confirms that the issue lies in the outer sectors with quite large artefacts in the outer sectors. Initially theses errors appear to be a roll/heading error however the central region of the swath is very stable giving good data with no oscillations.

Various tests were done such as logging data at various speeds with fixed beam angles which showed that the system struggled to keep a full swath as the speed increased. This again indicates a noise issue however the values shown although high are not enough to cause the issues observed and it is more likely cause by a very low SNR.

Again at this stage we are essentially guessing but it is believed that reduced performance of the transducers is causing a drop in the transmission pulse and quite possibly due to the failed central elements giving larger side lobe interference which is causing the tracking issues in the outer sectors. All the data will be post processed to try and find the cause of the interference, once the current element values have been simulated in Norway we will hopefully see that the results tie in with the real data.

Despite this the vessel performed a full calibration followed by 3 by 1 patch test. Unfortunately the weather had increased considerably so the lines had to be run at a greater speed which in turn increased the noise. Roll and pitch cals gave good results as were able to rely on the central beams however the heading calibration was very due to the noise in the outer sectors. Despite this however no attitude artefacts were found in the data and good results were obtained.

The final system settings are as below.

System serial numbers

EM122 TRU	**sn 120**	
HWS 14	**343246**	**sn1011**

Current software versions

SIS	**3.8.3 build 89**
CPU	**1.2.3**
DDS	**3.5.2**
BSP	**2.2.3**
RX	**1.11**
TX`	**1.11**

COM PORTS AND LOCATION OFFSETS

It should be noticed that the output from the Seapath has been referenced to the MRU5 not the MRU5+. Note that X is +'ve forward, Y is +'ve starboard and Z is +'ve downward.

				X	y	z
COM 1	**SEAPATH 320**	**GPS,ZDA**	**19200,8,n,1**	**0**	**0**	**0**
COM 2	**EM3000 Attitude**		**19200,8,n,1**	**0**	**0**	**0**
Tx Sonar Array				**6.369**	**1.3861**	**7.5486**
Rx Sonar Array				**11.3618**	**-0.0056**	**7.4783**
Waterline						**0.755**
1 PPS	**SEAPATH 320+**					

ANGULAR OFFSETS

	ROLL	PITCH	HEADING
TX	**0.05**	**0.02**	**0.01**
RX	**0.04**	**0.11**	**0.01**
SEAPATH MRU	**0.17**	**0.0**	**-0.6**

EXTERNAL SENSORS

None configured however a null modem has been linked between this HWS14 com 3 and the Topaz HWS12.

When setting up the Topaz it will be necessary to output the depth telegram in external sensors.

Network

TRU Connection – 157.237.2.30

Vessel connection – 10.104.254.224

All system settings have been copied from the vessel and will be attached to the KM service desk for future reference.

Appendix B - EM122 Acceptance testimonial text (Alex Tate)

The EM122 acceptance test formed the main part of the RRS James Clark Ross trials cruise JRtri006. Full details of the trials undertaken and preliminary results can be found in the JRtri006 cruise report. In summary the EM122 installation has been accepted while noting that there are significant issues with poor data in the outer beams. Data collected during the acceptance tests have been passed to Kongsberg for further analysis. Impedance measurements on the EM122 Tx and Rx elements suggest significant degradation rates especially in the middle sectors, reducing the signal strength and impeding beam formation. However, it is accepted that the EM122 is performing as well as it can given the degraded state of the transducers (installed during 2005).

Calibrations were performed successfully and motion correction is being applied correctly. Noise tests were performed satisfactorily but there was limited scope to perform noise tests in a variety of sea states given the short duration of the trial cruise.

This testimonial acknowledges the significant effort put in by Craig Wallace, the Kongsberg installation engineer aboard the trails cruise. His time and patience explaining both the EM122 system and the newly installed SIS acquisition software to the cruise participants was much appreciated.

Appendix C - Using the EM122 Multibeam on an Opportunistic Basis (Gwen Newton and Alex Tate)

This guide will continue to be updated in the future as we gain more experience with the EM122. It will be available as a stand-alone document on the ship and is included here for the sake of completeness.

Background Information

The multibeam swath on the JCR is now operated through a windows based program called Seafloor Information System (SIS). The system is capable of operating several instruments simultaneously. However, on the JCR we only have one system the EM122 and its serial number is 120, hence in SIS it appears as EM122_120. The full reference manual for SIS is available at:
http://www.jcr.nerc-bas.ac.uk/docs/computing/em122/EM_reference_manual.pdf

Event Log

If you are using the EM122 then you should have a dedicated event log for it (see ITS for how to set up and event log). As a minimum please record when you start and stop logging, when you change to a new survey and when you update the SVP.

Turning the System On

Open the glass door of the multibeam computer housing. Lift the flap over the EM122 button and press it. The button should light up red. Turn on the HWS 14 (Hydrographic Work Station) machine (sits below the button for the EM122 and the ON button is behind a door on the right). Turn on both of the EM122 monitors. Wait for five minutes for the EM122 to boot up. From the start menu select SIS (Seafloor Information System) and the SIS user interface should open. Alternatively click on the quick link, a square icon of bathymetry.

Note: An Unknown Publisher pop up will appear when you start SIS. Always choose 'Yes' and the system will open.

The SIS interface has a menu bar along the top and seven frames (each containing one of 13 possible windows). A useful set up for carrying out an opportunistic multibeam survey on the JCR has been saved. This can be opened by choosing JCR_opportunistic from the drop down list in the top left hand corner of the menu bar.

Preliminary Checks

The following preliminary checks should always be carried out prior to starting the survey:
On the main toolbar the dropdown box (which will currently read Not Started) to the right of the 'Rescan' button should be changed so that EM122_120 is selected. After 20 -30 seconds the name EM122_120 should turn from red to black. To the right of this the three status lamps should turn green.

Note: The option for EM122_120 should appear in the 'Not Started' list about 5 mins after the system is turned on. If it has not appeared then press the rescan button and wait at least 10 mins. If the option still does not appear then there may be a network issue – contact ITS.

From the main toolbar select View > Tear Off > Installation Parameters. The installation parameters should open in a new window. Click on the tab labelled BIST (Built-In Self Tests). Press the 'Clear All' button to clear the results of any previous tests. Run each test in order by clicking the buttons one by one (do not press the 'Run all BIST's' button as the software may cause a test to start before the preceding one has finished, which could result in a false failed test). Wait for one test to finish before starting the next one. Some tests may take a while to run but it is worth taking the time to do this prior to starting the multibeam. There are currently some failed channels in the transceiver unit on the JCR. These will show up as failed during test 7, the TX Channels test, but do not hamper the operation of the swath. All the other tests should be successful and the buttons should turn green. If one fails the results will be displayed in the 'PU BIST result' field and you should consult the manual or contact ITS. When all BIST's have finished running save the results of the tests by pressing the 'Save' button. The results should be saved in D:/sisdata/common/bist and called after the survey name and the date e.g. jr105_a_01012011. The Installation Parameters window can then be closed. Take care not to accidently alter anything in the other tabs of this window.

Note: The noise test (Test 8) is set so that it will fail if the background noise is above 80dB. If this occurs then the first check to make is that the EA600 (the single beam echosounder) is running in passive mode. If this has been verified then try doing the test again. Ideally a value of 40-50dB is best but the multibeam can function with noise up to about 80 dB.

Finally, start the multibeam pinging by pressing the red 'Not Pinging' button on the main toolbar. The button should turn green and you should see data appearing in the Geographical, the Water Column, the Beam Intensity and the Cross track windows.

Starting a new survey

To start a new survey, change the Cross Track window to a New Survey window using the drop down menu in the top right corner of the Cross Track window. In the Basic Parameters tab choose the Default template by selecting it from the drop down menu. Add a survey name in the box. A typical name for a survey should start with the JCR cruise ID and then involve sequential letters, i.e. jr153_a, jr153_b etc. The locations of these should be described in the cruise report. Survey names based on physical locations are only meaningful at the time and can become confusing when the data is used in later years. If you are not doing a dedicated multibeam cruise and will not be splitting the cruise into individual surveys then the cruise ID is enough.

If you feel it will be helpful then you can also add a comment in at this time.

The SIS system creates grids of the data as it is collected which can be seen in the Geographical window. The parameters for the gridding are set up when you define a new survey. Hence, these parameters must be valid for all depths that you will encounter in the survey.

If multibeam is being recorded on an opportunistic basis and only one survey will be used during the whole cruise then the grid options should be set as follows:

In the new survey window choose Advanced Options > GridEngine Parameters. The depth variable should always be set as 'Z'. Set the 'Number of Cells in Processing Grid' to: 128x128. Set the 'Cell Size in m' to 120.

Note: In the JCR_opportunistic layout the grid in the Geographical view is completely transparent. Instead you will see the real time depths. This has been set up because a coarse grid is required to allow for the range of depths which will be encountered. Hence visual display of the grid is not useful for assessing data quality.

When you are happy with the naming and gridding of the survey go back to the Basic Parameters tab and click 'Save new survey'. This will make your survey the current survey and the name will appear in both the second left and the far right boxes on the main toolbar. The box to the right of the 'Line cnt.' button should read 0000 if you are starting a new survey. If the line counter is not correct then you can click in the box and change it manually. The next box to the right should read 60 (the time in minutes before the line is incremented to the next number). Finally, change the New Survey window back to a Cross Track window using the drop down menu in the top right of the window.

Note: You should not have to change any of the storage options or Advanced Options (other than the GridEngine Parameters) as these will be defined for you in the default.

Checking the SVP

Before commencing logging it is necessary to check that the sound velocity profile (SVP) is representative of the local water conditions. This is best done by looking at the Cross Track window and checking whether the sea bottom profile looks like either a smile or a frown. If so then the SVP is probably wrong. Refer to the section below called 'Updating the SVP' to find out how to upload a new SVP.

Checking Runtime Parameters

The final task prior to logging is to check that the Runtime Parameters are valid. Change the Cross Track window to a Runtime Parameters window using the drop down menu in the top right corner of the Cross Track window.

If running an opportunistic survey set the following:

Navigate to the Sounder Main tab. Set the Max Angle to 55° port and 55° starboard and the Max Width to 20000m port and 20000m starboard. Set Angular Coverage mode to MANUAL and Beam Spacing to HIDENS EQDIST (High Density Equidistant). Set the Min. Depth to 10m and the Max. Depth to 10000m. Set Dual swath mode to DYNAMIC and Ping Mode to AUTO and make sure the FM disable box is checked. Tick the box for Pitch stabilisation, set Auto tilt to OFF and the Along Direction (deg) to 0. Set Yaw Stabilisation Mode to OFF, Heading Filter to MEDIUM and tick the External Trigger box.

Select the Filter and Gains tab. Set Spike Filter Strength to MEDIUM, Range Gate to NORMAL, Phase Ramp to NORMAL and Penetration Filter Strength to OFF. Tick boxes for Slope and Sector Tracking but not for Aeration and Interference. Set the Angle from nadir to 6°. Set the Absorption Coefficient Source to Salinity and Salinity to 35 ppt (the default). Turn the Mammal protection TX power level to Max and the Soft startup ramp time to 0 mins.

You do not need to change anything in any of the other Runtime Parameters tabs.

To Start Logging

Once you are happy with the New Survey setup and the Runtime Parameters you can start logging by clicking the red 'Not Logging' button on the main toolbar. The button should turn green and say 'Logging'.

To Stop Logging and Pinging

To stop logging press the green 'Logging' button on the main toolbar. To stop logging and pinging simultaneously press the green 'Pinging' button.

To Turn Off the EM122

Close down SIS and turn off the monitors. Open the glass door of the multibeam computer housing and turn off the HWS 14 machine and the EM122 (button behind flap – red light should go off when the system is off).

Passing Through Economic Zones

Unless permission has been gained from the relevant authorities the EM122 must not be running in economic zones. You need to stop logging and stop pinging.

Watchkeeping

There are several things which should be checked regularly whilst the multibeam is logging. On a supported cruise these should be checked at least hourly and if the multibeam is being used opportunistically they should be checked twice a day.

Line Incrementation: The line counter should increment automatically every hour so that the raw data files do not become too large. If this does not happen automatically then it can be done by pressing the 'Line cnt.' button.

Note: The box to the right of the 'Line cnt.' button shows the line you are logging to if logging is on and the line you will start logging to if logging is off. If you stop logging for any reason and would like to start logging again to the same line then keep a note of the line number before you stop and then enter the number manually into the box before you start again.

Depth Range: Check that the current depth is not getting too close to either the min or max depth values set in the Runtime Parameters. If it is then you can change these parameters without stopping the logging by using either the Runtime Parameters > Sounder Main tab or the Runtime Parameters Mini window. If the multibeam is having trouble finding the bottom then you can force the depth by using a value from the EA600. In the Runtime Parameters > Sounder Main tab or the Runtime Parameters Mini window enter a value in the Force Depth box which is just shallower than the actual depth (i.e. if the EA600 reads 1025m then put a depth of 1020m in) then press the 'Force Depth' button and the multibeam should find the bottom again.

Disk Space: Check the remaining disk space on drive D (the raw data drive).

Updating the SVP

The preferred method of importing Sippican XBT and Seabird CTD sound velocities as collected on the majority of JCR scientific cruises is described below.

Sippican XBTs

Sippican T-5 (deep) and T-7 (shallow) XBTs can be deployed whilst the vessel is moving, preferably at 6 knots to ensure a full depth profile. Launch instructions are located near the XBT acquisition machine. The results of the XBT are transferred over the network and a couple of minutes after successful deployment they can be imported into SIS.

From the main toolbar select Tools > Custom > SVP Editor. Use File > Open and navigate to the U drive (named as em122) > asvp directory >cruise/<survey id> and select the latest XBT profile gathered. When loaded the profile can be edited to remove bad points, especially those points at the bottom of the profile where the XBT has hit the seabed before finishing recording. The profile screen can be zoomed by changing values in the from/to depth and sound speed boxes and hitting redraw. Multiple rows can be selected by using shift-click on the spreadsheet view before hitting delete row to remove them. When the profile is clean it needs to be extended to 12,000m using Tools > Extend Profile in order to satisfy SIS requirement. Using Tools > Check profile automatic will identify any problems points that have been missed. Use Tools > Thin Profile to reduce the number of points within the profile. Accept the 0.1 thinning ratio and the software will automatically reduce the number of points by 90 percent, leaving the most in areas of fastest sound velocity change within the profile. Note the EM122 can handle profiles with up to 1000 points in. A new file will be created in the current directory called <original_name>_thinned.asvp. This file will be automatically transferred to the EM122 machine under D:\sisdata\common\svp_abscoeff\<leg id>. The transfer is based on a cron job running every minute so there will be a brief delay before being able to select the profile. Close the SVP editor.

Change the Cross Track window to a Runtime Parameters window and choose the Sound Speed tab. Select the correct thinned profile from D:\sisdata\common\svp_abscoeff\<leg id>. Click 'Use sound speed profile' to apply the profile to the current survey line even while still logging.

Seabird CTDs

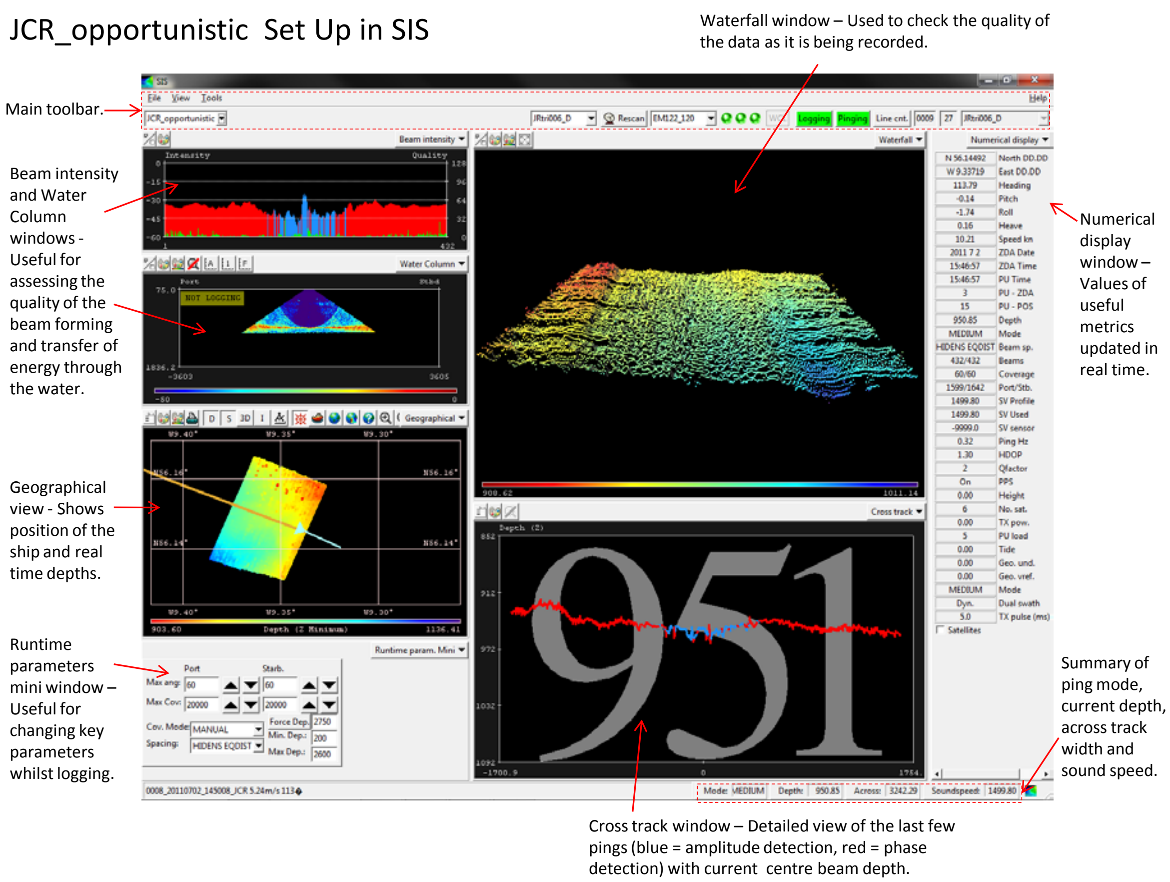
Following the processing steps on the CTD computer a batch file is run generating an .asvp file that is written to the /data/asvp directory. This can be selected in the same way as XBT data following the steps already mentioned.

XBT/CTD sound velocity profiles for archival cruises will be added later in 2011 and can be selected in exactly the same way.

What if the Data Looks Suspect?

Some reasons for occasional glitches in the data include:

- The multibeam losing the bottom. This can be fixed by forcing the depth. In the Runtime Parameters > Sounder Main tab or the Runtime Parameters Mini window enter a value in the Force Depth box which is just shallower than the actual depth (i.e. if the EA600 reads 1025m then put a depth of 1020m in) then press the 'Force Depth' button and the multibeam should find the bottom again.
- The SVP is incorrect for the current conditions. If you notice a smile or a frown in the Across track view then it is time to change the SVP.
- The data being collected become patchy (seen in the Waterfall, Cross track and Geographical windows). There are two main things to check. First the bottom depth may have gone outside the min and max values in the Runtime Parameters as discussed above. This often results in the centre beams dropping out first. The second reason could be that the ping mode is wrong. The mode should usually be set to Auto and hence the system should change from deep to shallow etc as necessary. If however it does not change for some reason then it can be done manually. To check which mode the system is in look at the grey bar along the very bottom of the SIS screen. The mode should be displayed as either: SHALLOW (up to 450m), MEDIUM (450-1000m), DEEP (1000-9000m) or VERY DEEP (over 9000m). If this mode does not relate to the depth you are currently surveying then go to Runtime Parameters > Sounder Main and change the drop down menu for Ping Mode to the correct setting. Do not forget to change the setting back to AUTO after the multibeam has gone back to functioning normally.



Appendix D – Event logs (EM122 and XBT)

EM122 log

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
30/06/2011 08:04	50.40106	-10.41839	33.56	15.3	285.99	JRtri006_xbt1_thinned.asvp created and applied. Not logging.
30/06/2011 09:25	50.47513	-10.81691	217.59	14.3	285.65	Start logging to JRtri006_a survey. Testing swath modes over variety of water depths (down slope).
30/06/2011 09:59	50.49748	-10.92656	430	11.2	287.27	Started survey with -20dB mammal protection setting. Changed to MAX at 09:59GMT. This will effect backscatter.
30/06/2011 10:13	50.50676	-10.97428	477.3	10	286.35	beams to 70/70
30/06/2011 11:02	50.53522	-11.13725	730	14.4	284.32	JRtri006_xbt3_thinned.asvp loaded onto swath. Logging to line 2, survey JRtri006_a
30/06/2011 11:38	50.55113	-11.25749	605	13.8	282.07	incremented to new line 003 - Deep mode. Check depth from EM122 centreline.
30/06/2011 11:44	50.55377	-11.27801	1048.02	12.5	281.52	beams changed to 68/68
30/06/2011 12:26	50.57694	-11.41585	1629.33	15.6	286.83	Incremented to line 0004: turned off dual ping (still in deep mode).
30/06/2011 13:34	50.61643	-11.63594	1977.53	14	284.4	XBT4 Sv profile uploaded IN LINE 5 FILE
30/06/2011 13:38	50.61883	-11.65101		13.3	284.78	Trying to switch EM122 from single to dual beam mode. Software won't allow any changes to parameters. SIS restarted but cause of software glitch not identified.
30/06/2011 13:42	50.62096	-11.66417	1870.09	11.4	285.23	Restarted SIS. Pinging and logging to line 0006, survey JRtri006_a. Ping mode deep, dynamic for dual ping and 70/70 beams
30/06/2011 14:32	50.65655	-11.86736		6.9	320.92	Starting Noise tests. Tests performed at 0, 1,2,4,6,8,10,12,14 knots
30/06/2011 14:32	50.64936	-11.83524	2043.96	9.4	289.22	test1: killed engines and sounders, prop disengaged

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
30/06/2011 14:59	50.65655	-11.86736	0	6.9	320.92	test2: 1 knot with prop
30/06/2011 16:16	50.70531	-12.07707		18	288.31	Finished noise tests at different speeds
30/06/2011 16:33	50.72266	-12.15809		16	285.39	Noise tests with doppler on at 10 knots
30/06/2011 16:39	50.728	-12.18649		14.7	285.44	Doppler logger off
30/06/2011 16:43	50.73089	-12.20186		15.7	284.96	Noise test with ADCP on at 10 knots
30/06/2011 16:48	50.73496	-12.22353		16	285.37	ADCP off
30/06/2011 16:55	50.74095	-12.25552		17.6	285.16	Noise tests with EK60 on at 10 knots
30/06/2011 17:02	50.74631	-12.28485		15.6	285.73	EK60 off. Speed then at 8 knots to repeat noise tests with only prop on
30/06/2011 17:13	50.75377	-12.32509		13.6	284.89	Noise test finished
30/06/2011 18:15	50.87137	-12.35161	2066.86	8.6	6.67	New survey started, Noise_Tests_300611. Slowing to 4 kts to ping and log at 4, 6, 8, 10 kts (15 minutes at each speed).
30/06/2011 18:20	50.87908	-12.35029	2067	6.8	4.48	Started logging to Noise_Tests_300611 (4 kts).
30/06/2011 18:34	50.89324	-12.34726	2053	7.7	7.6	Stopped logging. Increasing speed to 6kts.
30/06/2011 18:40	50.90164	-12.34549	2044	8.3	6.46	Started logging (6 kts).
30/06/2011 18:54	50.92466	-12.34089	2022	7.6	6.15	Stopped logging. Increasing speed to 8 kts.
30/06/2011 18:58	50.93293	-12.33941	2016	9.2	6.14	Started logging (8 kts).
30/06/2011 19:13	50.9661	-12.33382	1983	7.9	5.54	Stopped logging. Increasing speed to 10 kts.

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
30/06/2011 19:19	50.98249	-12.33099	1966	7.2	5.84	Started logging (10 kts).
30/06/2011 19:30	51.01785	-12.32505	1913	8.8	6.11	Stopped logging. Increasing to 12 kts.
30/06/2011 19:38	51.03553	-12.32173	1892	8.5	6.08	Started logging (12 kts).
30/06/2011 19:47	51.06567	-12.31666	1855	7.6	4.24	Stopped logging.
30/06/2011 19:48	51.06871	-12.31622	1846.95	8.8	4.05	Started logging; line 0005. Beams to 60/60.
30/06/2011 20:04	51.12057	-12.30877	1798	8.9	4.52	Stopped logging. Doppler logger on bridge turned on.
30/06/2011 20:07	51.13056	-12.30723	1777	7.9	4.03	New survey started: JRtri006_b. SSU synchronisation testing. Not logging, not pinging.
30/06/2011 20:10	51.14172	-12.30547	1778	7.3	3.72	EM122 pinging, external trigger.
30/06/2011 20:25	51.18986	-12.29833			3.92	SSU synchronisation end - EM122 does not interface with SSU in same way as EA600 (where it ignores triggers if not ready)
30/06/2011 20:26	51.19375	-12.29775		9.4	3.75	Start logging to JR_tri006_b. min max beams 65 and 65, min max swath width 20000. Depth range 50 to 2400
30/06/2011 20:33	51.21553	-12.29446	1718.07	8.2	3.74	SSU crashing. EM122 stopped/started pinging. Eventually logging to line 1.
01/07/2011 06:00	53.18232	-12.04223		3.8	5.39	Overnight data collection OK until shallow depths. Ping mode inadvertently left on 'Deep' so very poor data from around 0400. Mode set to Auto and system happy once more.
01/07/2011 08:56	53.82727	-11.96017	338.15	3.8	2.88	SIS menu crashing
01/07/2011 12:37	54.55385	-11.86947		3.1	4.14	Switched to autologin as operator, and rebooted machine to check this & U: drive mapping works
01/07/2011 12:49	54.59721	-11.86303		3.7	4.28	Stopped pinging to view TOPAS output options

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
01/07/2011 13:53	54.80663	-11.83519		7.9	3.8	stopped pinging to take photographs of SSU setup
01/07/2011 13:56	54.81962	-11.8336		8.6	4.24	Stopped pinging to re-interface with SSU
01/07/2011 13:57	54.8208	-11.83347			4.15	Start pinging again logging to line 24
01/07/2011 19:37	54.47949	-11.88129	2865.96	24.1	198.44	T5_00007.asvp entered into system and roll calibration line 1 started logging to survey JRtr006_C. Water column data also logged to separate file.
01/07/2011 20:18	55.78257	-11.7232		29.4	201.7	Stopped logging to Line 0001 of the roll bias calibration JRtri006_C.
01/07/2011 20:31	55.78284	-11.72349	2764.75	17.6	21.05	Start of roll calibration line 2. Logging to line 2, survey JRtr006_C
01/07/2011 20:56	55.83146	-11.70519		12	0.66	End roll calibration line 2. Stopped logging
01/07/2011 21:34	55.90175	-11.57596	2725	21	48.55	Finished roll calibration exercise, applied correction of +0.15.
01/07/2011 21:38	55.9087	-11.56114	2703.22	22.8	48.81	Water column data now being saved in raw.all file. Started pinging, started logging. Line 0003 in JRtr006_C survey.
01/07/2011 23:40	56.12366	-11.10434	2546.18	20.7	46.06	Water column logging stopped. Changed setting to store water column date in separate file for future collection. Logging to line 5.
02/07/2011 02:02	56.3363	-10.59358		18.6	42.22	Start pitch calibration line 1 heading northeast upslope. Logging to line 0008, survey JRtr006_C. Speed 6 knots over ground. Beams at 60/60 degrees
02/07/2011 02:36	56.38342	-10.5351	1242.54	22.7	41.95	End pitch calibration line 1 at top of seamount slope. Stopped logging on line 0008, survey JRtr006_C.
02/07/2011 03:01	56.38335	-10.536		25.7	209.98	Start pitch calibration line 2 heading downslope. Logging to line 0009, survey JRtr006_C. Speed 6 knots.
02/07/2011 03:35	56.33739	-10.59254	2217	22.7	207.37	Stopped logging, end of line 0009. Turning to parallel line.
02/07/2011 03:40	56.33083	-10.60178		24.1	254.72	Pitch calibration completed, no correction (0.0).

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
02/07/2011 03:53	56.34776	-10.62569	2267	18.2	40.21	Started logging. Heading calibration test; logging to line 0010, survey JRtr006_C. Speed 6 kts.
02/07/2011 04:29	56.39735	-10.56401	1261	17.7	42.53	End of line, stopped logging. Transit to next parallel line.
02/07/2011 05:16	56.33015	-10.56245	2166	19.4	37.44	Started logging third line for pitch calibration test; line 0011. Speed 6 kts.
02/07/2011 05:47	56.18921	-10.11357	1977.9	27.3	160.63	Stopped logging line for heading calibration. Transit to grid survey site. Heading correction applied -0.6.
02/07/2011 07:09	56.25855	-10.16306	0	25.7	123.26	Set Up New Survey "JRtri006_D" to be used for the Grid survey.
02/07/2011 07:20	56.25068	-10.13457	1989.44	24.4	124.61	New XBT profile T5_008 input
02/07/2011 07:33	56.25758	-10.15934	0	20.3	279.46	EM122 dual mode changed from fixed to dynamic
02/07/2011 07:45	56.25962	-10.16578	2006.52	27.1	137.81	Start first grid line -EM122 line 000
02/07/2011 08:28	56.18921	-10.11357	1977.9	27.3	160.63	End of first grid line
02/07/2011 08:59	56.17648	-10.19387	2235.82	13	338.85	Second Grid Line, Swath line 0001, started logging.
02/07/2011 09:37	56.24191	-10.23871		16.1	334.07	End logging of second grid line, (0001)
02/07/2011 10:02	56.22539	-10.30999		29	160.32	Start Logging grid line 3, (0002)
02/07/2011 10:39	56.15989	-10.26356	2070.63	28.1	161.98	Stopped logging. End of grid line 3. Line no. 002 (survey JRtri006_D)
02/07/2011 11:01	56.18221	-10.29702	2083.23	21.8	45.36	Start of gridline 4 logged to line_0003 in the swath survey
02/07/2011 12:07	56.2341	-10.11042	1977.72	25.2	73.08	Stopped logging end of grid line 4
02/07/2011 12:23	56.23377	-10.11219	1981.41	24.3	232.28	Start of gridline 5 - roll calibration Swath line 0005

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Wind Speed	Heading - Seatex	Comment
02/07/2011 12:34	56.22704	-10.13722	1993	23.1	235.99	Stopped logging - too much crabbing on the ship for good swath - re-running gridline 1 heading north for roll cal
02/07/2011 12:38	56.23043	-10.14481	1997.94	13.7	340.73	Start logging gridline 6 for roll cal repeat of gridline 1 - swath line 006
02/07/2011 12:48	56.2471	-10.1559	1998.39	11.1	334.91	End of roll cal and end of logging
02/07/2011 12:54	56.25828	-10.1594	3121.17	25.4	110	Adding 0.02 to roll calibration
02/07/2011 13:50	56.22424	-9.89633	3121.17	27	90.76	Commence logging swath to line 0007, survey JRtri006_D
02/07/2011 13:52	56.22458	-9.88195		22.7	91.93	Waterline value added to installation parameters. Given as 0.755m. Calculated from ship draught values and new survey values linking frame 76 and Seatex MRU.
02/07/2011 16:25	56.10018	-9.15678	1043.67	19.5	118.21	Stop logging as at continental shelf. Last line logged was 0010, survey JRtri006_D
03/07/2011 14:00	55.87113	-4.35358	0	4.9	173.48	Arrive at Glasgow

XBT log

Date/Time	Latitude - Seatex	Longitude - Seatex	Depth - EA600	Comment
30/06/2011 07:46	50.38921	-10.3413	142.86	JRtri006_xbt1; T5 probe launched successfully.
30/06/2011 10:39	50.52301	-11.06	567.91	JRtri006_xbt2 launched but no data received in UIC. Failed XBT.
30/06/2011 10:43	50.52583	-11.0759	613.92	JRtri006_xbt3; T5 probe launched successfully
30/06/2011 13:09	50.60563	-11.5665	1914	Slowing to 6kts to launch XBT in full range of water depth.
30/06/2011 13:15	50.60787	-11.5811	1925.92	XBT T5_0004 deployed
30/06/2011 13:24	50.61144	-11.6042	1950.76	Increasing speed to 8 knots again
01/07/2011 12:15	54.47949	-11.8813	2865.96	JRtri006_xbt5.asvp applied to survey
02/07/2011 07:11	56.25758	-10.1593	2012	XBT T5_008 deployed prior to calibration grid

Appendix E – Kongsberg transducer report (received September 2011)

EM 120 transducers on James Clark Ross

Report made by KM: September 2011

RX array

1 degree RX array, 128 hydrophones, module serial numbers: 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, and 138

The impedance of the RX transducer staves has been measured on board the ship. We use these measurements to simulate the beam pattern of the receiver array. Looking at the conductance G of each hydrophone (presented in Figure 1) we note a worrying trend: There are eight hydrophones per module and many of the edge elements 1, 8, 9, 16, 17, 24, 25,…..120, 121, and 128 can be seen to have an increased G. Based on (limited) empirical knowledge about the relationship between EM 120 hydrophone conductivity G and receive sensitivity, we apply reduced sensitivity to all elements whose G is above 0.5 mS. Also, for every element we assume the phase of an incident sound wave is affected by the phase of the impedance. The resulting element shading is illustrated in Figure 2.

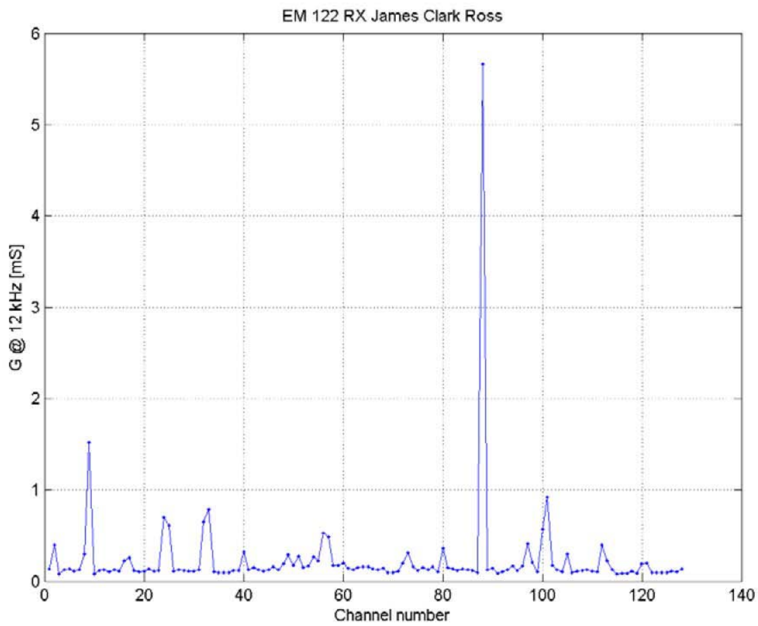


Figure 1: Conductance G for all 128 EM 120 hydrophones measured at 12 kHz.

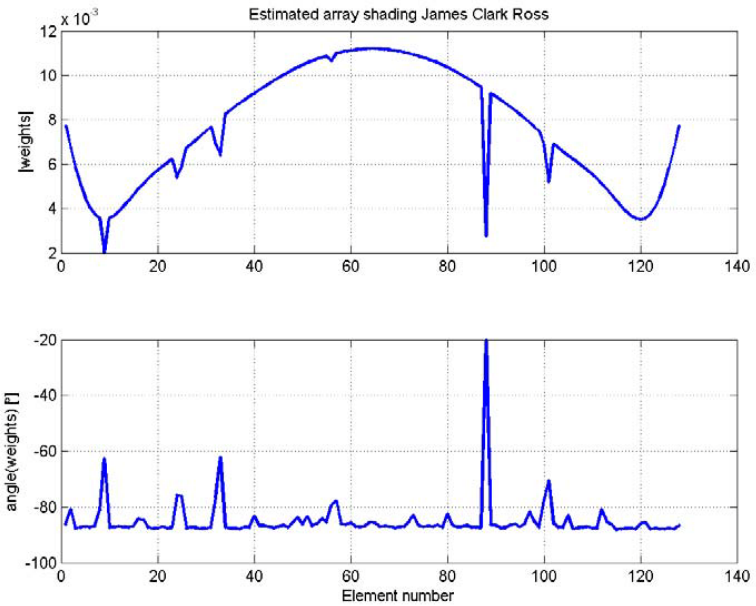


Figure 2: Array shading. Top: Magnitude of estimated element weights (desired weighting scaled to account for reduced element sensitivity and distorted element phase). Bottom: Phase of estimated element weights.

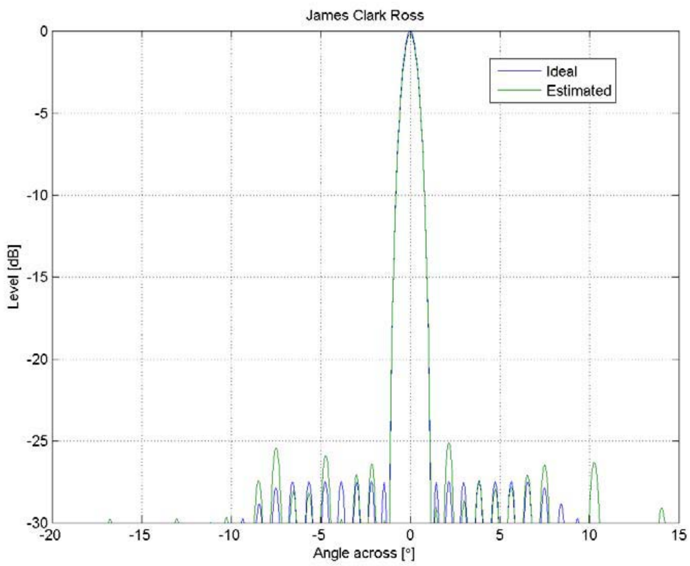


Figure 3: The ideal across beam pattern (blue) and the estimated beam pattern (green) for the EM 120 Rx array installed on James Clark Ross. The most noticeable difference is an increase in maximum side lobe level of about 2.5 dB. The main lobe is reduced by < 0.2 dB.

The simulated beampattern (across) is shown in Figure 3 along with the ideal beam pattern. It is found that the sensitivity in the main lobe is reduced by less than 0.2 dB and the side lobe levels are increased by less than 2.5 dB compared to the ideal case.

The reduction of the main lobe is very small and in practice it is not likely to give a noticeable degradation of the data quality. The increased side lobe levels *may* in special situations under good survey conditions cause a minor decrease of data quality. In general we find a side lobe suppression of 25 dB to be within acceptable limits and judged only from these criteria (main lobe / side lobes) there is no need to correct this array.

However, see the discussion below.

1 deg. Transmitter array

The 864 TX transducer elements have been measured by an impedance analyzer. Module serial numbers are 931, 952, 953, 956, 958, 963, 964, 965, 966, 968, 969, 970, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 992, 994, 995, 996, 997, 998, 999, 1005, 1006, 1016, 1017, 1023, 1024, 1025, 1026, 1028, 1029, 1030, 1032, 1033, and 1035.

It is found that 137 elements are out of specifications. These elements transmit a reduced amount of power and cause a significant reduction of the system source level. This reduction is frequency dependent (maximum reduction at the lowest frequencies, minimum reduction around 12 kHz). Also, the peak side lobe level increases.

To assess the effect of the bad TX elements we simulate the transmit beam patterns. Since the EM 120 has sectorized transmission with different signal frequencies and in general also different array shading in the various sectors we calculate the beam patterns for all sectors to determine the damaged elements impact on the beam pattern. Also, the use of frequencies and array shading varies with depth so we do these calculations for operating modes deep and very deep.
In mode “deep” we find that the reduction in source level varies from 1.3 dB up to 1.8 dB. The combined effect of source level reduction and increased side lobe level is that the main lobe to side lobe margin (side lobe suppression – SLS) is reduced by 2.2 to 6.5 dB. A sample beam pattern from deep mode is shown in Figure 4.

In mode “very deep” we find that the reduction in source level varies from 1.3 dB up to 1.4 dB. The SLS is reduced by 4.5 to 6 dB. A sample beam pattern from very deep mode is shown in Figure 5.

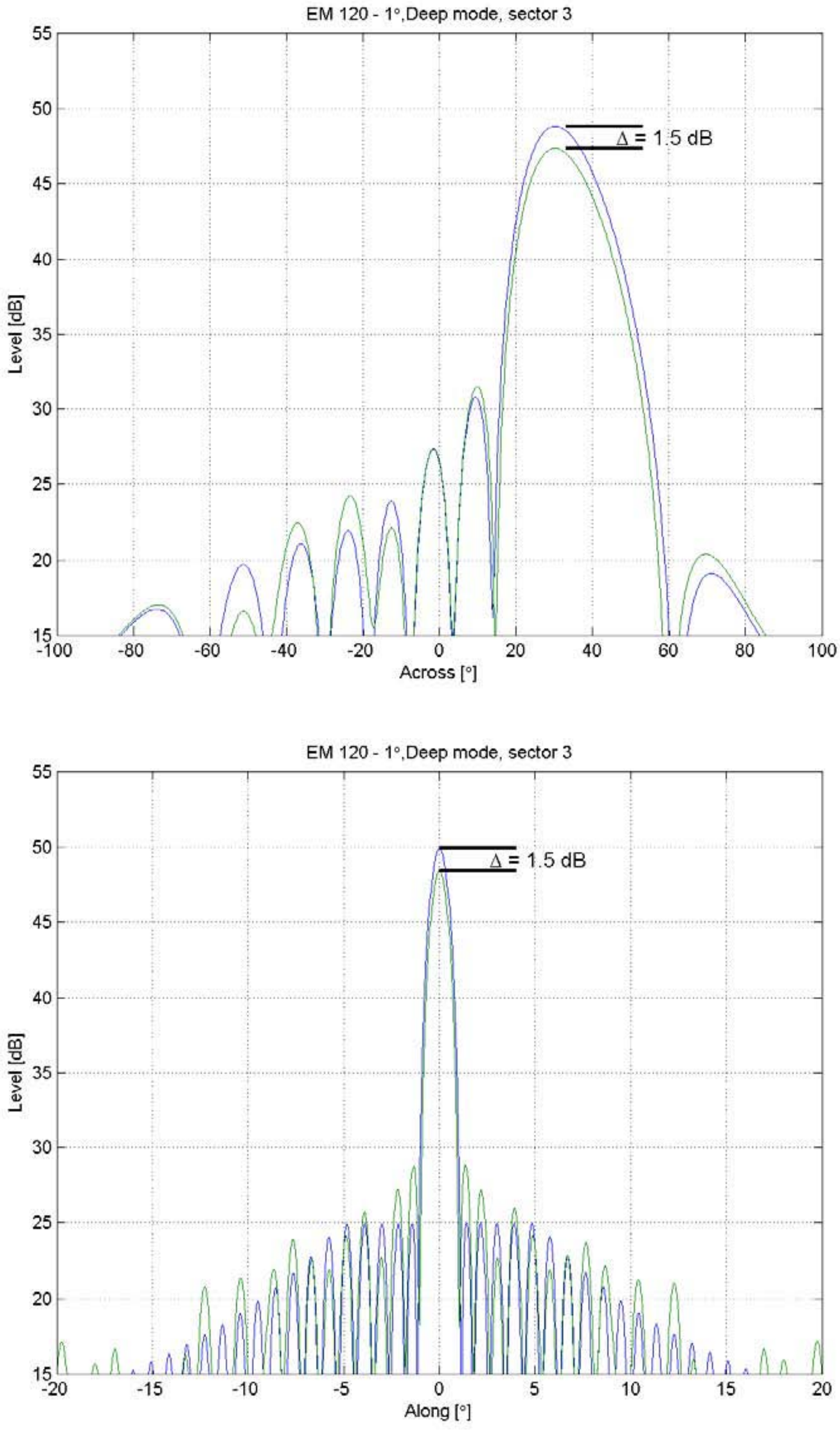


Figure 4: Beam pattern across (top) and along (bottom) for sector 3 of the EM 120 in deep mode. The blue curves show the ideal beampatterns. The green curves show the estimated beam patterns of the degraded TX array. The obvious disagreement in peak level is caused by the beam pattern "along" being calculated without roll: The rolled sector (top) is somewhat attenuated due to the directivity of the transmit elements.

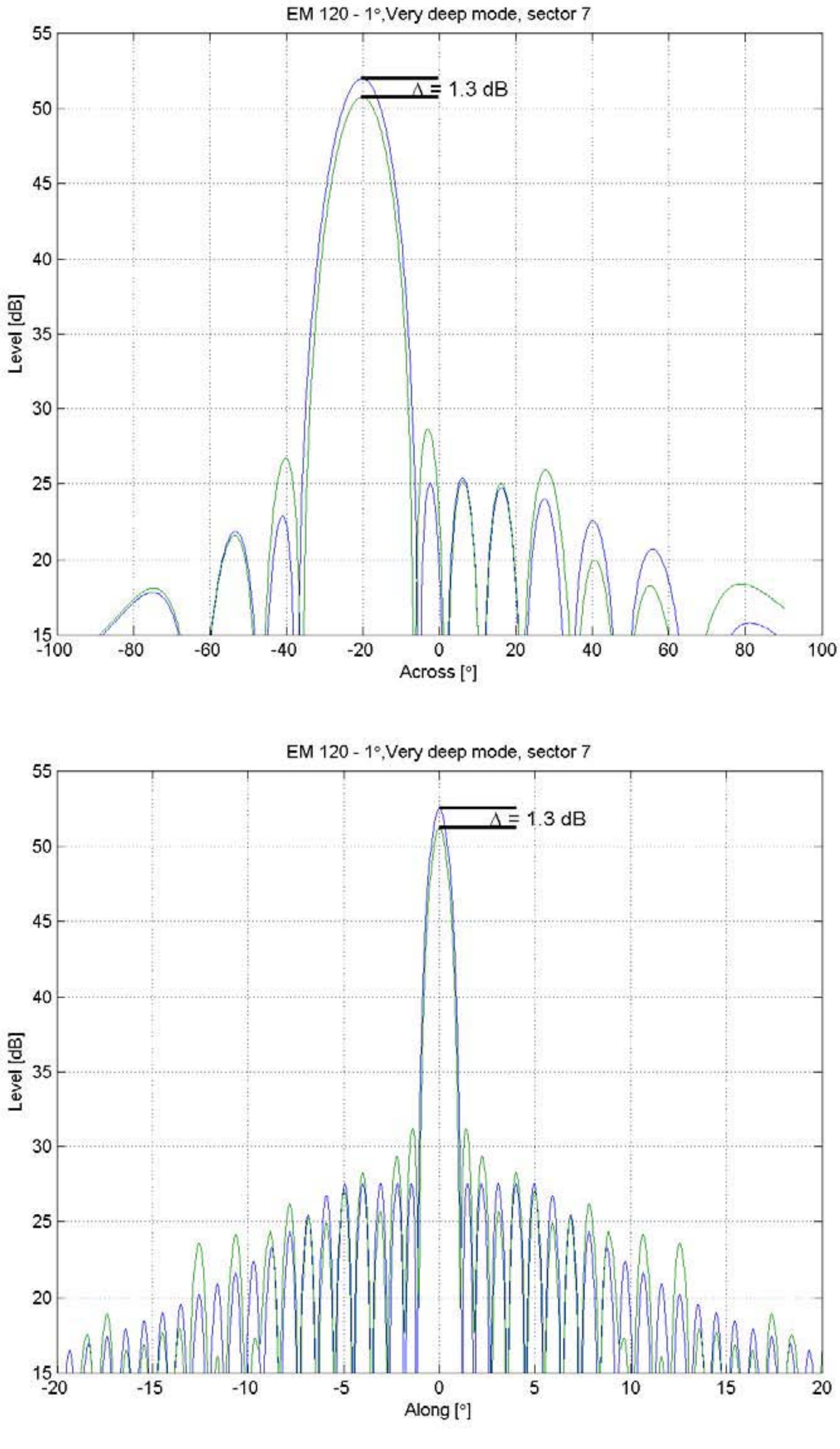


Figure 5: Beam pattern across (top) and along (bottom) for sector 7 of the EM 120 in very deep mode. The blue curves show the ideal beampatterns. The green curves show the estimated beam patterns of the degraded TX array.

Discussion

The total performance of the system may under otherwise excellent conditions be somewhat reduced by the errors observed on the receiver array. The most alarming regarding the RX array is that we see a tendency to increased conductance at the RX modules edge elements. This may indicate that the Rx array is under deterioration. We have little experience with how this kind of damage develops over time. We recommend monitoring this array closely. A complete set of impedance measurements should be carried out every 6 to 12 months. Also operators should look for any sign of staves with reduced sensitivity, e.g. BIST noise test.

The transmitter is affected by the large extent of damaged transducers. On the transmit side we are not so troubled by increased side lobes: For most practical situations it is the reduction of the source level that limits the performance of the system. We found that the source level reduction is less than 2 dB for all frequencies/sectors in both "deep" and "very deep" mode. To get an idea of the performance of this degraded system we include in Figure 6 an illustration showing the estimated performance of an ideal 1° x 1° EM 122 system together with the performance of an identical system with source level reduced by 2 dB. We see there is no loss of coverage in shallow water (< ~2500 m water depth). With increasing depth the loss of performance is evident. As an example: With a **sandy bottom** at **water depth 6000 m** the coverage is reduced from 26/6 times the water depth to 25/6 times the water depth when the **source level is reduced by 2 dB** –a **reduction of coverage around 4 %**. In addition to this reduced coverage it may be possible to find examples of reduced data quality due to the degraded RX array.

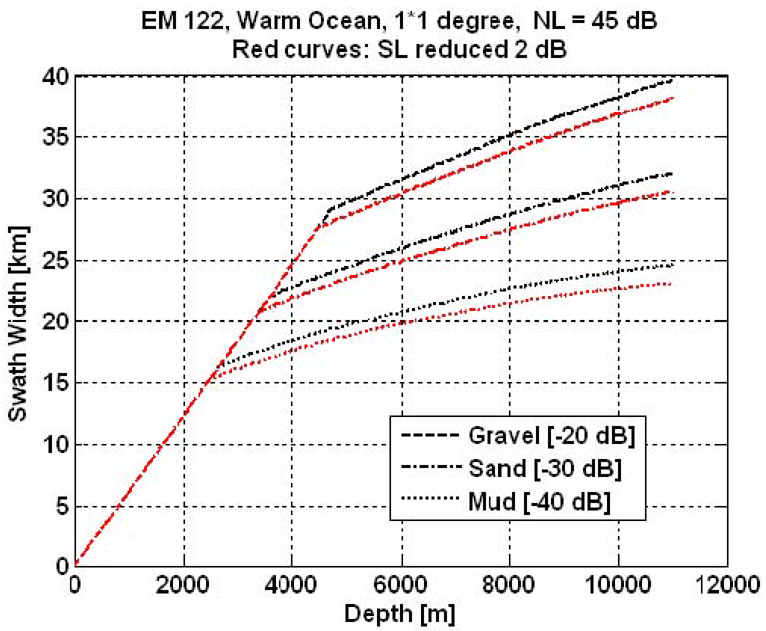


Figure 6: Estimated coverage with three kinds of seabed for an ideal system and a system with 2 dB reduced source level.

JRtri006 Scientific Party (from left): Jeremy Robst, Christine Bachelor, Luke Collins, Kelly Hogan, Gwen Newton, Sophie Fielding, Johnnie Edmonston, Alex Tate, Alastair Graham, Craig Wallace.

Photo taken by Richard Turner.