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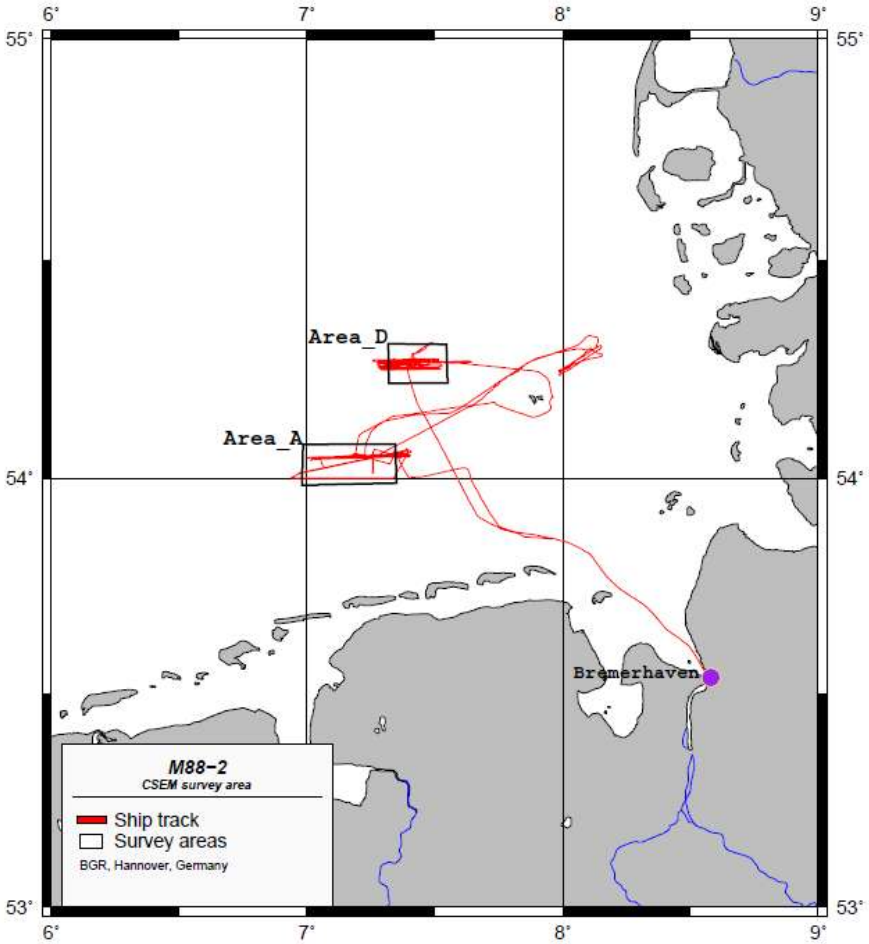
# Short Cruise Report
# METEOR M 88/2

## Bremerhaven - Bremerhaven
## September 08-22, 2012
## Chief Scientist: Katrin Schwalenberg
## Master: Thomas Wunderlich




**M88/2 GPDN-CSEM Track Chart**

## Objectives

Cruise M88/2 was dedicated to conduct controlled source electromagnetic (CSEM) measurements to study the electrical resistivity structure of possibly gas containing shallow sediments in the German North Sea sector. The experiments are part of the joint venture project "Geopotenzial Deutsche Nordsee" (GPDN), coordinated at BGR. During the 13 days cruise measurements were conducted along previously obtained seismic lines in two working areas (A and D) close to Helgoland showing strong amplitude anomalies within the first 200 m below the seafloor. Area D was also the target area for the first data acquisition with the new BGR 3-D seismic system during leg M88/1.

Two types of seabottom-towed CSEM systems were used: The “Toronto System” was developed at the University of Toronto and is presently located at GEOMAR. On the seafloor it consists of an instrument platform called “pig” hosting the CSEM transmitter followed by a 1000m long data cable connecting the 100m long transmitting dipole and four receiving units with 15m receiving dipoles at offsets of 350m, 550m, 750m, and 950m. The Toronto system has its own tow winch with 700m tow cable and storage winch to carry the 1000m long seafloor array. The system is deployed and recovered over the afterdeck using the A-Frame and a block. Once aligned on the seafloor the system is towed at a speed of 1-2 knots and stopped every 500m for a period of 5-10min to transmit a periodic square wave signal, and to take recordings of the inline electric fields at each receiver unit. The Toronto system permits online communication with all components during the survey.

The “BGR system” consists of four newly developed receiver units which are mechanically connected with rope at offsets of 150m, 250m, 450m, and 750m from the 100m long transmitting dipole. For this survey the BGR receiver array was towed behind the Toronto pig, using the BGR control unit to record the transmitted current signal. The advantage is a much higher data quality compared to the cable-based Toronto system at the expense that no communication is possible during surveying and data are only available after instrument recovery.

Deployment and recovery procedures are similar to the Toronto system, besides that the receiver units are not permanently connected to the array as is the case for the Toronto system and have to be assembled or disassambled before and after each deployment.

This allows for different set-ups from the pure inline configuration which was tested during the cruise. To obtain larger offsets and to measure different components of the electric field, i.e. broadside, the four BGR receiver units were connected in two pairs of two receiver units at offsets of 300m and 200m, respectively, and were aligned stationary on the seafloor. An anchor with a surface buoy was attached to the front end for instrument recovery and to avoid movements of the seafloor receiver array. The pig with the transmitter and the 100m transmitting dipole was towed behind the vessel towards and around the stationary receiver units.

During the 13 days cruise we carried out 31.5h CSEM profiling with the Toronto system, 30h with the BGR system, and 5.5h transmitting time to the stationary receiver dipoles.

After solving configuration problems with the new receiver units and the control unit, and replacing several broken cables of a new marine connector type we acquired data of highest quality with the new BGR receiver units. Regarding the Toronto system it was the first time that all components recorded clean and useful data after four previous field trials.

Previous to and between the CSEM deployments the profiles were surveyed using the shipboard multibeam and parasound systems to check seafloor conditions and to record bathymetry data in high resolution. Because of the shallow water depths each multibeam transect only covered a 160m wide seafloor section.

Altogether nine CTD casts were carried out during the cruise using the shipboard rosette water sampler and the BGR Franatech methane sensor which was either connected to the Seabird CTD sensor or to its own stand-alone data logger. The CTD casts supplied water conductivity profiles which are used as a-priori information for the CSEM data interpretation. The methane sensor was deployed to measure possible methane release from sub-seafloor gas layers, and in preparation of the upcoming BGR INDEX 2012 cruise to explore hydrothermal systems along the South Indian Ridge.

## Cruise Narrative

In the afternoon of Saturday September 8th all cruise participants boarded the METEOR at the wharf in Bremerhaven. The remaining Saturday was occupied setting up the mobile winches of the Toronto system, organizing the laboratories, and preparing ropes and cables for the controlled source electromagnetic (CSEM) experiments. METEOR left port at 8 am in the morning of September 9th for the 5h transit to our first working area A southwest of Helgoland. During the transit a security training and general alarm exercise took place with all crew and science members, followed by an informal meeting reviewing gear deployments and procedures. The afternoon and evening was filled with more preparations on deck. After arrival in working area A at 2 pm a sound velocity profile was carried out to calibrate the multibeam system. Multibeam profiling was conducted through the night along the two seismic profiles which were selected for the CSEM surveying.

On Monday morning September 10th a second sound velocity profile was performed. Now we were ready for our first CSEM deployment with the "Toronto system". Deployment started at 8 am and lasts 2.5h until the receiver array, the transmitting dipole and the pig with the transmitter were aligned on the seafloor. After a communication test with the transmitter and the receiver array we started towing along the profile in a stop & go manner. This means the array on the seafloor is kept stationary for data recording by stopping the ship for a period of 5 to 10 min. Then the vessel moves 500 m forward along the profile at a speed of 1-2 knots to the next waypoint where it is stopped again for measurements. Following this procedure about three waypoints per hour are completed. Deployment of the Toronto system was continued over night to cover the entire seismic amplitude anomaly.

On Tuesday morning September 11th at 6 am we started taking in the CSEM system which has been completed after 3h. From 10:30 – 11:30 am the water sampler with the CTD and the methane sensor was deployed on the profile. Multibeam profiling was continued from 12:00 to 2:30 pm before deploying the new BGR receiver array with the Toronto pig and transmitter. The deployment started at 3pm and was completed at 5:30 pm. Again, the array was towed in a stop & go manner along the profile, alternating data recording on site for 5-10 mins and moving the array 500 m forward. Because of wind and weather conditions the new profile was oriented in E-W direction intersecting the first profile at the middle of the amplitude anomaly at an angle of 15°.

In the morning of Wednesday September 12th we started recovering the CSEM system which was completed at 9 am. The next CTD deployment was carried out until 11 am. From 1 pm to 5 pm we performed a deployment test with a single receiver dipole array connected to an anchor and a buoy with the aim to position it stationary on the seafloor. This is a new configuration where we tried to get larger offsets between receiving and transmitting dipoles, and thus bigger penetration depths as well as broadside, i.e. 3-D information. After the single receiver array was deployed and recovered, multibeam and parasound profiling continues along a short N-S striking seismic profile.

The next CTD cast with the methane sensor was deployed on Thursday morning from 4 – 5:20 am. Due to a configuration error no data were recorded at the last deployment with the new BGR receivers. Therefore we repeated the measurement with the same configuration along the same profile. Deployment started at 8:20 am, and at 10:40 am the array was aligned on the seafloor ready to roll along in a stop & go manner along the profile until 6:20 pm when we were forced to stop surveying by worsening weather conditions. Instrument recovery was completed 2h later at 8:20 pm. This time all units collected data, but three out of four receiving dipoles had broken wires probably caused by bad handling of a new connector type we used to attach the electrodes to the array.

The precise weather forecasts by the Deutsche Wetterdienst (DWD) onboard permitted to adapt our deployment times flexible to the weather conditions during the cruise. On Thursday evening the METEOR steamed east of Helgoland to be lee of a low pressure system which occupied the area until Saturday morning September 15th when the METEOR returned to our first working area. We continued the multi-beam and parasound profiles on the N-S profile from 06:20 to 09:00.

One problem we experienced during the three CSEM deployments so far was the limited maximum current which we were able to transmit with the seafloor CSEM transmitter. After some considerations and tests we performed with the shipboard power supplies, the reason was found, but implied taking the 200 kg pressure vessel hosting the transmitter out of the pig, and opening the pressure vessel to change a resistor that controls the input voltage rage. This operation lasted all day. On Saturday evening the operation was successfully completed and tested in the lab, and

the transmitter was replaced in the pig on deck. To test the transmitter in the water we decided to deploy only the pig with the transmitter and the transmitter dipole. The test was positive, but during pig recovery the block disconnected from the A-frame, and caused the pig to fall back in the water which damaged the tow cable. Luckily all gear could be recovered safely on deck.
On Sunday morning September 16th, we said goodbye to three colleagues who debarked in Helgoland, and continued to our new working area D northwest of Helgoland, where seismic data also show strong amplitude anomalies possibly caused by a gas-filled layer. We spent the remaining day inspecting the damage of the block and of the tow cable with the result that a new bracket was constructed and a load test was performed before the block could be remounted on the A-frame. The PU jacket of the tow cable was sliced open in some places, but the Kevlar strength member was still in good order and the electrical lines undamaged. At the same time the broken connectors on the receiving dipoles were replaced. Multibeam and parasound profiling along the new profile was conducted from 5 pm till 7 am next morning.
On Monday September 17th more time was required to fix the damage of the tow cable. The water sampler with the CTD and the methane sensor was deployed from 8:15 am – 1 pm. 2 pm all preparations were completed and the Toronto system was deployed on the new profile in Area D. At 5:30 pm the deployment was completed and the survey started in a stop & go manner until the next morning. On Tuesday, September 18th instrument recovery started at 8 am and was completed at 11:40 am. This time the transmitter was able to operate at full power, but the transmitted current was limited to 50 A for safety reasons. Three out of four receivers recorded high quality data, one receiver dipole failed probably due to a broken cable of the new connector type.
In the evening of September 18th the BGR receiver units were deployed with the Toronto Pig and the transmitter along the same profile as the Toronto system the day before. Before deploying the complete survey we conducted a test deployment with two receivers to check the newly made connections to the receiver electrodes. The test was positive and the complete array was deployed from 8:30 pm till 10 pm, when stop & go profiling started.
At 8:15 am on Wednesday morning, September 19th, instrument recovery started and was completed at 11 am. The CTD was deployed from 11:30 am to 12:30 pm. In the afternoon preparations were completed for the stationary receiver set-up, and the first set with two receivers 300m apart was positioned 500m north and parallel to the seismic/CSEM.
On Thursday morning September 20th, while getting ready to release the second receiver pair a CTD cast was conducted between 07:45 and 09:00 am. The two receivers had an offset of at 200m and were placed 500m south and parallel to the seismic/CSEM line. At 11am the Toronto pig with the CSEM transmitter and the 100m transmitting dipole only was deployed and, and towed for 5.5h towards, 500m parallel, and away from the northern receiver pair, until all gear had to be brought back on board due to another low pressure system which started in time with 4 to 5m swell at 8 pm as accurately announced by the colleagues from the DWD.
The last CTD cast was performed on Friday morning September 21st from 8:30 – 9:30 am, before we started disassembling all equipment, packing up all gear, running back-ups and cleaning all used lab space during a rough and rainy transit back to Bremerhaven where we anchored at the Lloyd Wharf around 17:00 on Friday evening.
On Saturday morning, September 22nd, the BGR container and the Toronto system were unloaded and all remaining science staff disembarked the METEOR after a busy and eventful voyage.

## Acknowledgements

We like to thank Captain Wunderlich and his entire crew for the professional technical support and flexibility to comfort our science program, and for the friendly atmosphere during the cruise. We also thank our guests onboard Rainer Bergers, Jan Grobys and Hartmut Pietrek for their active and helpful participations in all operations. Ship time and financial support was provided by funds from the Geopotenzial Deutsche Nordsee Project.

## Figures

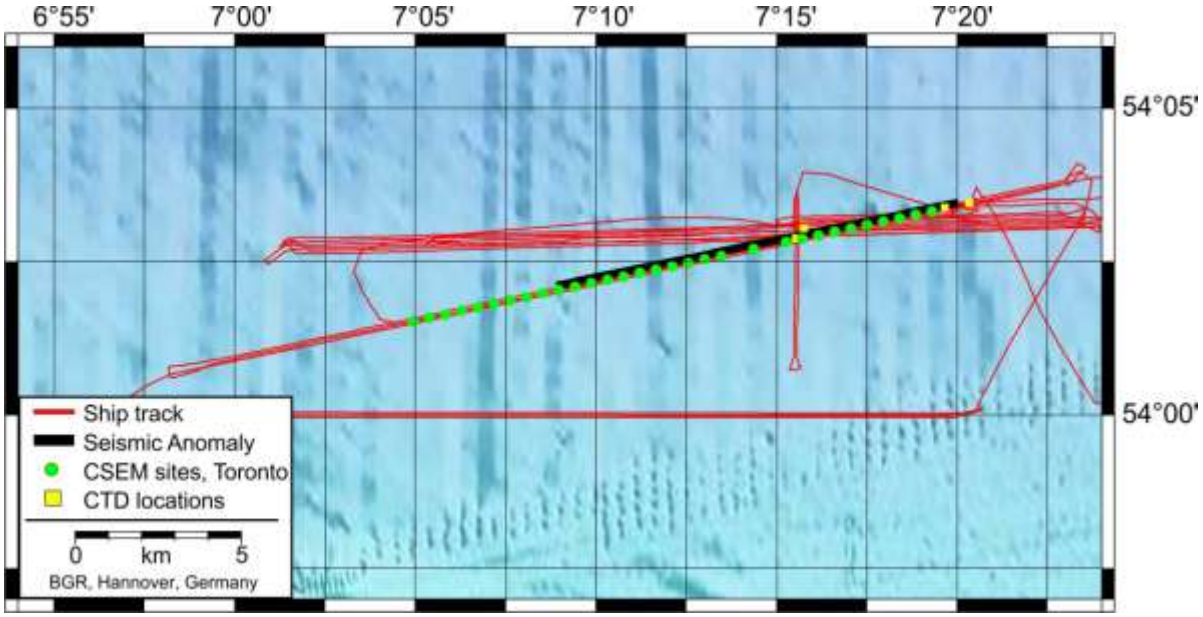



*Figure 1: Profiles and sites in working area A southwest of Helgoland*

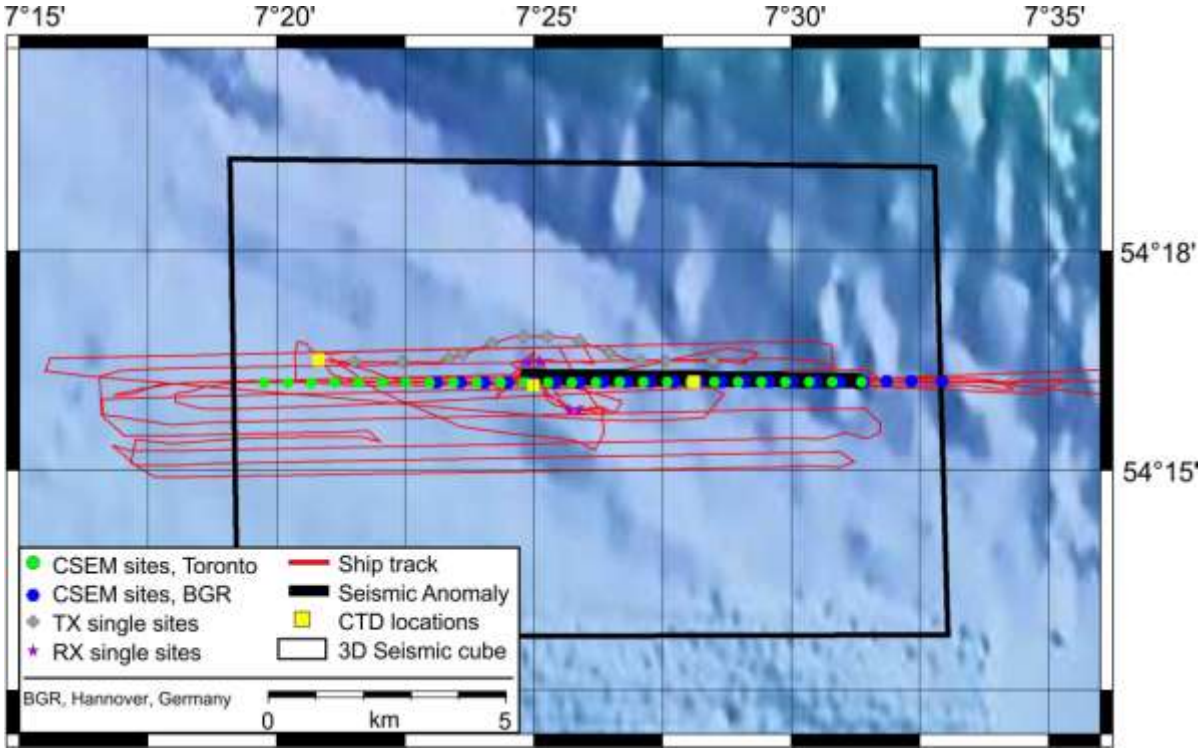



*Figure 2: Profiles and sites in working area D northwest of Helgoland*

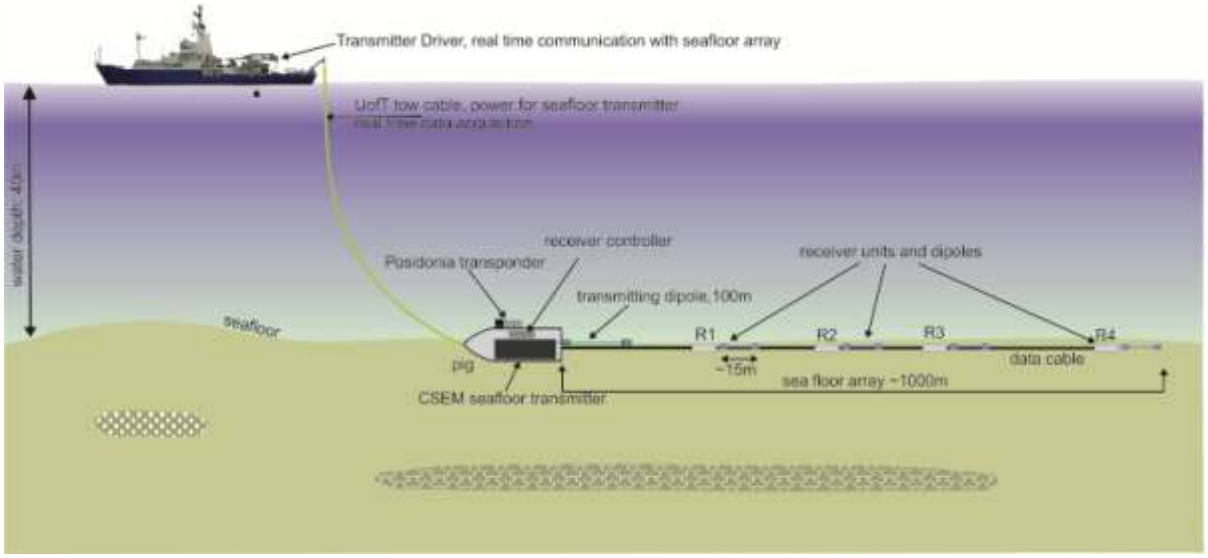



*Figure 3: Configuration of the towed CSEM system*


*Figure 4: Components of the Toronto CSEM System*

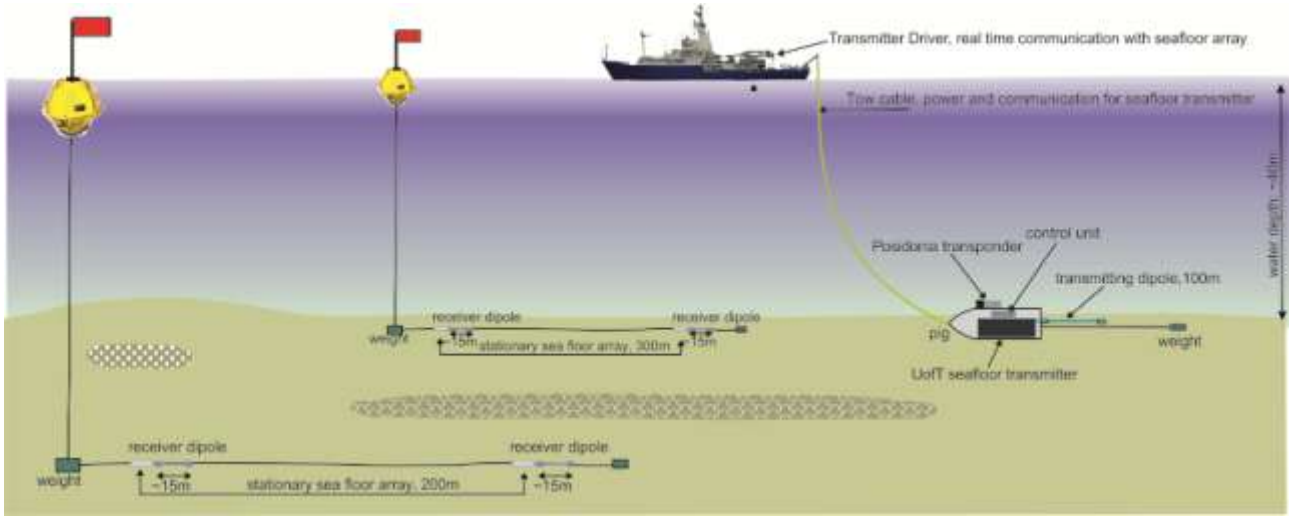



*Figure 5: Configuration of the stationary receiver pairs and towed CSEM transmitter dipole*

## Cruise Participants

| Name | | Institution |
|---|---|---|
| Dr. Katrin Schwalenberg | Chief Scientist | BGR |
| Dr. Martin Engels | CSEM | BGR |
| Joachim Deppe | CSEM | BGR |
| Hagen Schulte i.d. Bäumen | CSEM | BGR |
| Dr. Rüdiger Lutz | Bathymetry | BGR |
| Dr. Sabine Heim | CSEM | BGR |
| Anna Trampe | CSEM, Bathymetry | BGR |
| Dr. Katja Heeschen | CTD | BGR |
| Reza Mir (PhD) | CSEM | GEOMAR |
| Rainer Bergers | CSEM | Uni Köln |
| Dr. Jan Grobys | CSEM | RWE Dea |
| Hartmut Pietrek | CSEM, Bathymetry | BSH |
| Andreas Raeke | Meteorology | DWD |
| Rudolf Kemnitz | Meteorology | DWD |

| | |
|---|---|
| **BGR** | Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover |
| **GEOMAR** | Helmholtz-Zentrum für Ozeanforschung Kiel |
| **Uni Köln** | Universität zu Köln |
| **RWE Dea** | RWE Dea AG, Hamburg |
| **BSH** | Bundesamt für Seeschifffahrt und Hydrographie, Hamburg |
| **DWD** | Deutscher Wetterdienst, Hamburg |

**Station Lists**

**CSEM Profile Toronto System, 10.09.2012, Area A**

| Waypoint | Latitude ship | Longitude ship | Water Depth +5m | Tx Current Signal | Time UTC |
|---|---|---|---|---|---|
| 1 | 54°03.249 | 7°18.751 | 27 | 30A square, 6s | /11:06 |
| 2 | 54°03.196 | 7°18.305 | 28 | 35A square, 6s | 12:44/12:19 |
| 3 | 54°03.14 | 7°17.857 | 28 | 35A square, 6s | 13:15/13:08 |
| 4 | 54°03.084 | 7°17.409 | 28 | 35A square, 6s | 13:44 |
| 5 | 54°03.028 | 7° 16.961 | 28 | 35A square, 6s | 14:11 |
| 6 | 54°02.972 | 7°16.513 | 28 | 35A square, 6s | 14:43 |
| 7 | 54°02.916 | 7°16.066 | 28 | 35A square, 6s | 15:11 |
| 8 | 54°02.894 | 7°15.615 | 28.5 | 35A square, 6s | 15:40 |
| 9 | 54°02.804 | 7°15.169 | 28.5 | 35A square, 6s | 16:10 |
| 10 | 54°02.749 | 7°14.721 | 28.7 | 35A square, 6s | 16:39 |
| 11 | 54°02.636 | 7°13.824 | 28.7 | 35A square, 6s | 17:19 |
| 12 | 54°02.53 | 7°12.926 | 28.5 | 35A square, 6s | 17:58 |
| 13 | 54°02.462 | 7°12.465 | 28 | 35A square, 6s | 18:33 |
| 14 | 54°02.412 | 7°12.014 | 27.8 | 35A square, 6s | 19:01 |
| 15 | 54°02.356 | 7°11.566 | 27.6 | 35A square, 6s | 19:31 |
| 16 | 54°02.301 | 7°11.118 | 27.7 | 35A square, 6s | 20:04 |
| 17 | 54°02.245 | 7°10.67 | 27 | 25A square, 6s | 21:02 |
| 18 | 54°02.189 | 7°10.223 | 26.8 | 25A square, 6s | 21:33 |
| 19 | 54°02.135 | 7°09.776 | 26.9 | 25A square, 6s | 22:09 |
| 20 | 54°02.074 | 7°09.327 | 26.5 | 25A square, 6s | 22:36 |
| 21 | 54°02.023 | 7°08.878 | 26.4 | 25A square, 6s | 23:03 |
| 22 | 54°01.966 | 7°08.428 | 26.3 | 25A square, 6s | 23:30 |
| 23 | 54°01.91 | 7°07.98 | 26.3 | 25A square, 6s | 23:59 |
| 24 | 54°01.855 | 7°07.533 | 26.3 | 25A square, 6s | 00:25 |
| 25 | 54°01.798 | 7°07.087 | 26.4 | 25A square, 6s | 00:55 |
| 26 | 54°01.743 | 7°06.64 | 26.4 | 25A square, 6s | 01:22 |
| 27 | 54°01.687 | 7°06.192 | 26.5 | 25A square, 6s | 01:49 |
| 28 | 54°01.653 | 7°05.742 | 26.7 | 25A square, 6s | 02:16 |
| 29 | 54°01.576 | 7°05.294 | 26.7 | 25A square, 6s | 02:44 |
| 30 | 54°01.521 | 7°04.846 | 26.7 | 25A square, 6s | 03:11 |
| 31 | 54°01.464 | 7°04.399 | 26.8 | 25A square, 6s | 03:40 |

**CSEM Profile Toronto System, 17.09.2012, Area D**

| Waypoint | Latitude ship | Longitude ship | Water Depth +5m | Tx Current Signal | Time UTC |
|---|---|---|---|---|---|
| 1 | 54°16.006 | 7°30.811 | 35.1 | 30A square, 6s | 16:00 |
| 2 | 54°16.007 | 7°30.249 | 35.2 | 50A square, 6s | 16:32 |
| 3 | 54°16.007 | 7°29.788 | 35.3 | 50A square, 6s | 17:00 |
| 4 | 54°16.007 | 7°29.326 | 35 | 50A square, 6s | 17:28 |
| 5 | 54°16.009 | 7°28.862 | 34.8 | 50A square, 6s | 17:59 |
| 6 | 54°16.009 | 7°28.404 | 35 | 50A square, 6s | 18:27 |
| 7 | 54°16.008 | 7°27.945 | 35 | 50A square, 6s | 18:56 |
| 8 | 54°16.008 | 7°27.485 | 35.3 | 50A square, 6s | 19:26 |
| 9 | 54°16.009 | 7°27.024 | 36 | 50A square, 6s | 19:57 |
| 10 | 54°16.007 | 7°26.567 | 36.2 | 50A square, 6s | 20:27 |
| 11 | 54°16.006 | 7°26.103 | 36.6 | 50A square, 6s | 20:56 |
| 12 | 54°16.007 | 7°25.644 | 35.8 | 50A square, 6s | 21:29 |
| 13 | 54°16.004 | 7°25.182 | 36 | 50A square, 6s | 22:02 |

| | | | | | |
|---|---|---|---|---|---|
| 14 | 54°16.006 | 7°24.720 | 36.3 | 50A square, 6s | 22:37 |
| 15 | 54°15.986 | 7°24.261 | 36.7 | 50A square, 6s | 23:24 |
| 16 | 54°15.993 | 7°23.802 | 36.6 | 50A square, 6s | 00:05 |
| 17 | 54°15.995 | 7°23.339 | 36.3 | 50A square, 6s | 00:38 |
| 18 | 54°15.999 | 7°22.880 | 36.1 | 50A square, 6s | 01:09 |
| 19 | 54°15.999 | 7°22.417 | 35.7 | 50A square, 6s | 02:00 |
| 20 | 54°16.003 | 7°21.954 | 35.6 | 50A square, 6s | 02:39 |
| 21 | 54°16.004 | 7°21.494 | 34.7 | 50A square, 6s | 03:18 |
| 22 | 54°16.004 | 7°21.034 | 34.7 | 50A square, 6s | 03:48 |
| 23 | 54°16.003 | 7°20.573 | 34.9 | 50A square, 6s | 04:20 |
| 24 | 54°16.004 | 7°20.114 | 35.6 | 50A square, 6s | 04:48 |
| 25 | 54°16.002 | 7°19.652 | 33.7 | 60A square, 6s | 05:20 |
| 26 | 54°16.004 | 7°19.193 | 34.2 | 60A square, 6s | 05:47 |

**CSEM Profile BGR System, 18.09.2012, Area D**

| Waypoint | Latitude ship | Longitude ship | Water Depth +5m | Tx Current Signal | Time UTC |
|---|---|---|---|---|---|
| 1 | 54°16.00 | 7°30.811 | 35.1 | 50A square, 6s | 20:17 |
| 2 | 54°16.02 | 7°31.91 | 36.3 | 50A square, 6s | 20:46 |
| 3 | 54°16.01 | 7°31.44 | 36.4 | 50A square, 6s | 21:15 |
| 4 | 54°16.01 | 7°30.98 | 35.2 | 50A square, 6s | 21:44 |
| 5 | 54°16.01 | 7°30.52 | 35.4 | 50A square, 6s | 22:15 |
| 6 | 54°16.01 | 7°30.06 | 35.8 | 50A square, 6s | 22:44 |
| 7 | 54°16.01 | 7°29.60 | 37.6 | 50A square, 6s | 23:12 |
| 8 | 54°16.01 | 7°29.14 | 38.1 | 50A square, 6s | 23:41 |
| 9 | 54°16.01 | 7°28.68 | 37 | 50A square, 6s | 00:11 |
| 10 | 54°16.01 | 7°28.22 | 37.2 | 50A square, 6s | 00:40 |
| 11 | 54°16.01 | 7°27.77 | 36.7 | 50A square, 6s | 01:07 |
| 12 | 54°16.01 | 7°27.30 | 37.5 | 50A square, 6s | 01:35 |
| 13 | 54°16.01 | 7°26.84 | 36.2 | 40A square, 6s | 02:03 |
| 14 | 54°16.01 | 7°26.38 | 37.2 | 30A square, 6s | 02:30 |
| 15 | 54°16.01 | 7°25.92 | 37.4 | 30A square, 6s | 02:57 |
| 16 | 54°16.01 | 7°25.46 | 35.2 | 30A square, 6s | 03:25 |
| 17 | 54°16.01 | 7°25.00 | 35.9 | 30A square, 6s | 03:51 |
| 18 | 54°16.01 | 7°24.54 | 34.6 | 30A square, 6s | 04:17 |
| 19 | 54°16.01 | 7°24.08 | 36.7 | 30A square, 6s | 04:43 |
| 20 | 54°16.01 | 7°23.62 | 35.1 | 30A square, 6s | 05:09 |
| 21 | 54°16.01 | 7°23.16 | 35.6 | 30A square, 6s | 05:36 |
| 22 | 54°16.01 | 7°22.69 | 34.8 | 30A square, 6s | 06:06 |

**CTD / Water Sampler / METS Deployments**

| CTD Station | Date | Time | Latitude | Longitude | Mode of METS | # water samples | Bottle number |
|---|---|---|---|---|---|---|---|
| Area A | | | | | | | |
| 01 | 11.09.12 | 08:53 | 54°02.88 | 7°15.53 | online | 11 | 37-47 |
| 02 | 12.09.12 | 08:27 | 54°03.45 | 7°20.33 | online | 10 | 49-58 |
| 03 | 13.09.12 | 02:30 | 54°03.38 | 7°19.65 | offline | 0 | |
| 04 | 15.09.12 | 11:44 | 54°03.05 | 7°15.75 | offline | 6 | 7-12 |
| Area D | | | | | | | |
| 05 | 17.09.12 | 06:21 | 54°16.01 | 7°28.11 | offline | 0 | |
| 06 | 17.09.12 | 10:06 | 54°16.01 | 7°28.11 | online | 4 | 13-16 |
| 07 | 19.09.12 | 09:34 | 54°16.26 | 7°20.82 | online | 0 | |
| 08 | 20.09.12 | 05:59 | 54°15.97 | 7°24.99 | online | 0 | |

**Multibeam / Parasound Profiles**

| Date | Time Begin | Time End | Latitude | Longitude | Water Depth | distance |
|---|---|---|---|---|---|---|
| Area A | | | | | | |
| 09.09.12 | 18:18 | | 54°03.78 | 7°23.04 | 29.5 | |
| 10.09.12 | | 04:00 | 53°59.96 | 7°20.07 | 25.7 | 89.5nm |
| 11.09.12 | 09:56 | | 54°02.92 | 7°14.64 | 28.4 | |
| 11.09.12 | | 12:37 | 54°03.05 | 7°23.08 | 27.3 | 20.4nm |
| 12.09.12 | 15:42 | | 54°03.63 | 7°15.56 | 28.2 | |
| 13.09.12 | | 01:50 | 54°03.28 | 7°19.19 | 26.9 | 74.5 nm |
| 15.09.12 | 04:13 | | 54°03.09 | 7°15.33 | 27 | |
| 15.09.12 | | 06:53 | 54°03.33 | 7°10.89 | 29.5 | 7nm |
| Area D | | | | | | |
| 16.09.12 | 22:31 | | 54°16.01 | 7°33.60 | 35.3 | |
| 17.09.12 | | 05:04 | 54°16.29 | 7°16.60 | 33.6 | 104nm |