UNIVERSITY OF TROMSØ UiT
FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF GEOLOGY

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UNIVERSITY OF TROMSØ cruise report

Tromsø – Longyearbyen 01-07-11 to 14-07-11

R/V Helmer Hanssen

PART I

Sub-seabed CO2 Storage: Impact on Marine Ecosystems (ECO2)
(A 7th Framework Programme EU project)

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INTRODUCTION AND OBJECTIVES

The ECO2 project sets out to assess the risks associated with the storage of CO2 below the seabed. Carbon Capture and Storage (CCS) is regarded as a key technology for the reduction of CO2 emissions from power plants and other sources at the European and international level. The EU will hence support a selected portfolio of demonstration projects to promote, at industrial scale, the implementation of CCS in Europe. Several of these projects aim to store CO2 below the seabed. However, little is known about the short-term and long-term impacts of CO2 storage on marine ecosystems even though CO2 has been stored sub-seabed in the North Sea (Sleipner) for over 13 years and for one year in the Barents Sea (Snøhvit). Against this background, the proposed ECO2 project will assess the likelihood of leakage and impact of leakage on marine ecosystems. In order to do so ECO2 will study a sub-seabed storage site in operation since 1996 (Sleipner, 90 m water depth), a recently opened site (Snøhvit, 2008, 330 m water depth), and a potential storage site located in the Polish sector of the Baltic Sea (B3 field site, 80 m water depth) covering the major geological settings to be used for the storage of CO2. Novel monitoring techniques will be applied to detect and quantify the fluxes of formation fluids, natural gas, and CO2 from storage sites and to develop appropriate and effective monitoring strategies. Field work at storage sites will be supported by modelling and laboratory experiments and complemented by process and monitoring studies at natural CO2 seeps that serve as analogues for potential CO2 leaks at storage sites.

As part of the ECO2 project, the University of Tromsø committed to conduct a cruise to the Snøhvit area in the SW Barents Sea (Figure 1). The main objective of the R/V Helmer Hanssen cruise was to acquire high-resolution baseline data in order to determine geofluid pathways and sites of gas hydrate formations and better understand fluid leakage mechanism in the subsurface. Moreover, gas hydrates and shallow gas reservoirs are sites that are potentially important for our understanding of natural methane storage and release systems. Among the data sets to be acquired is high-resolution P-Cable 3D seismic data, a potential novel technology for monitoring fluid migration in the subsurface. Furthermore, we will acquire high-resolution bathymetric data and ocean-bottom seismic (OBS) data.

Many fluid and gas anomalies exists in the SW Barents Sea, particularly at the border between the Polheim sub-platform, Loppa High and Hammerfest basin, where the Snøhvit reservoir and storage site study area is located (Figure 1). The working areas are in approx. 300 – 400 m water depths. The Snøhvit hydrocarbon field has been operated by Statoil since 2008. The reservoir lies in Jurassic sandstones at about 2 km depth. Beneath the reservoir formation, CO2 is stored in Triassic sediments of the Tubaen formation and later in the bottom part of the Jurassic Stø formation. At Snøhvit, the analysis of conventional 3D seismic data resulted in the definition of stratigraphic boundaries of the overburden structure and the identification of faults, gas chimneys and shallow gas accumulations including the potential occurrence of a gas-hydrate related bottom-simulating reflection (Figure 1). Faults both at the Jurassic and Tertiary levels have been interpreted.

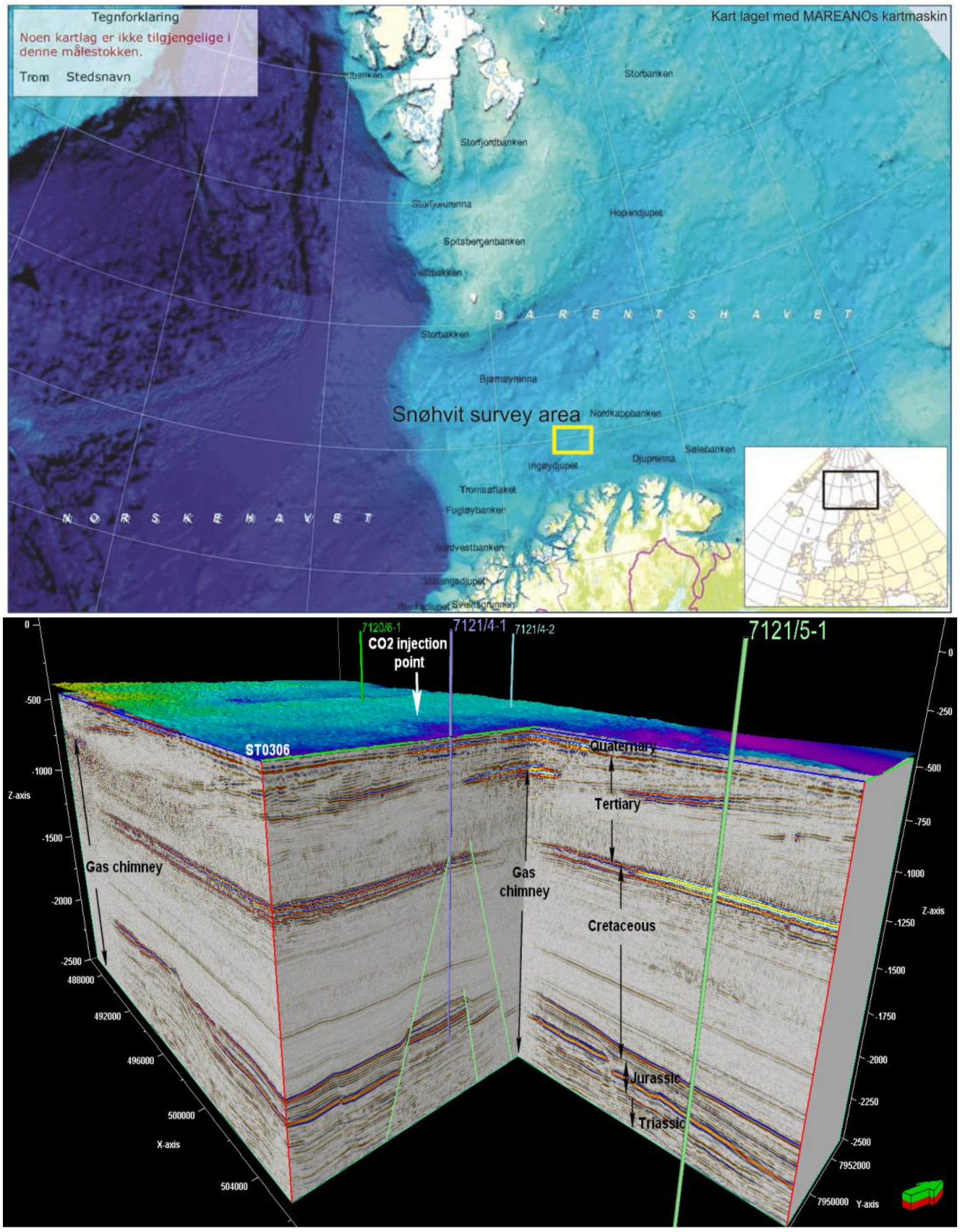


Figure 1: (top) Overview and location of the study area in the SW Barents Sea. (bottom) Perspective view of the Snøhvit study area based on conventional 3D seismic data. The Main reservoir is in the Jurassic Stø formation, whereas the CO2 is stored beneath in the Triassic Tubaen formation. The shallow subsurface shows many amplitude anomalies that can be related to the presence of shallow gas and gas hydrates.

SEISMIC METHODS

The ECO2 part of the R/V Helmer Hanssen cruise (1-14 July 2011) is aimed to acquire P-Cable high-resolution 3D seismic data over pockmark fields, gas chimneys, shallow gas accumulations, and potential gas hydrate locations at the Snøhvit CO2 storage site. We envision the acquisition of two 15- 20 km^2 large seismic cubes. Simultaneous acquisition of multi-component ocean bottom seismometer data will allow for P- and S-wave seismic modelling, analysis and integration into the 3D seismic cube. Particularly interesting sites show:

1. strong seismic amplitude anomalies in the shallow subsurface
2. cross cutting and polarity reversed seismic events possibly indicative of gas hydrates
3. large gas chimneys beneath and pockmarks at the seabed

The high-resolution P-Cable 3Dseismic system was used together with a Granzow high-pressure (210bar) compressor and one mini-GI gun (15/15 in^3). Onboard seismic processing and QC of P-Cable seismic data provided preliminary 3D cubes for quality assessment and geofluid interpretations.

During this cruise we used SIMRAD EM300 high-resolution multibeam seabed mapping see report C), P-Cable high-resolution seismic, SIMRAD EK 60 38 and 18 kHz echolot, and the Edgetech Discover penetration echolot. CTD stations are carried out to extract information about different (T, S) properties of water masses to calculate the speed of sound for calibrating the EM300.

The P-Cable 3D seismic system

The P-Cable 3D high-resolution seismic system consists of a seismic cable towed perpendicular (cross cable) to the vessel's steaming direction (Figure 2). An array of multi-channel streamers is used to acquire many seismic lines simultaneously, thus covering a large area with close in-line spacing in a cost efficient way. The cross cable consists of two 50-m long and one 75-m long section with a total of 14 streamers attached to it. Including lead-in cables, the cross cable has a total length of 233 m between paravanes (doors) (Figure 2). The cross-cable is spread by two paravanes that due to their deflectors attempt to move away from the ship. The paravanes itself are towed using R/V Helmer Hanssen’s large trawl winches. The spacing between the streamers is 12.5 m but due to curvature of the cross-cable, the effective spacing between the streamers may be shortened in cross line direction to about 6-12 m. Each digital streamer is 25 meters long and consists of an A/D-module and 8 channels. New Geometrics solid state streamers are used that are much less affected by sea swell and hence provide data with significantly less noise. The A/D-module converts the analogical signal from the channels to digital signals. The group spacing of channels along the streamer is of 3.125 m.

A 300-m long signal cable is run off R/V Helmer Hanssen’s net winch and connects to the starboard termination of the cross cable. It contains wiring for power and data transmission. The data is transferred via Ethernet protocol. Ethernet-to-Coax switches at the ends of the signal cable allow data transmission over long distances. The digital data is recorded using Geometrics GeoEel software.

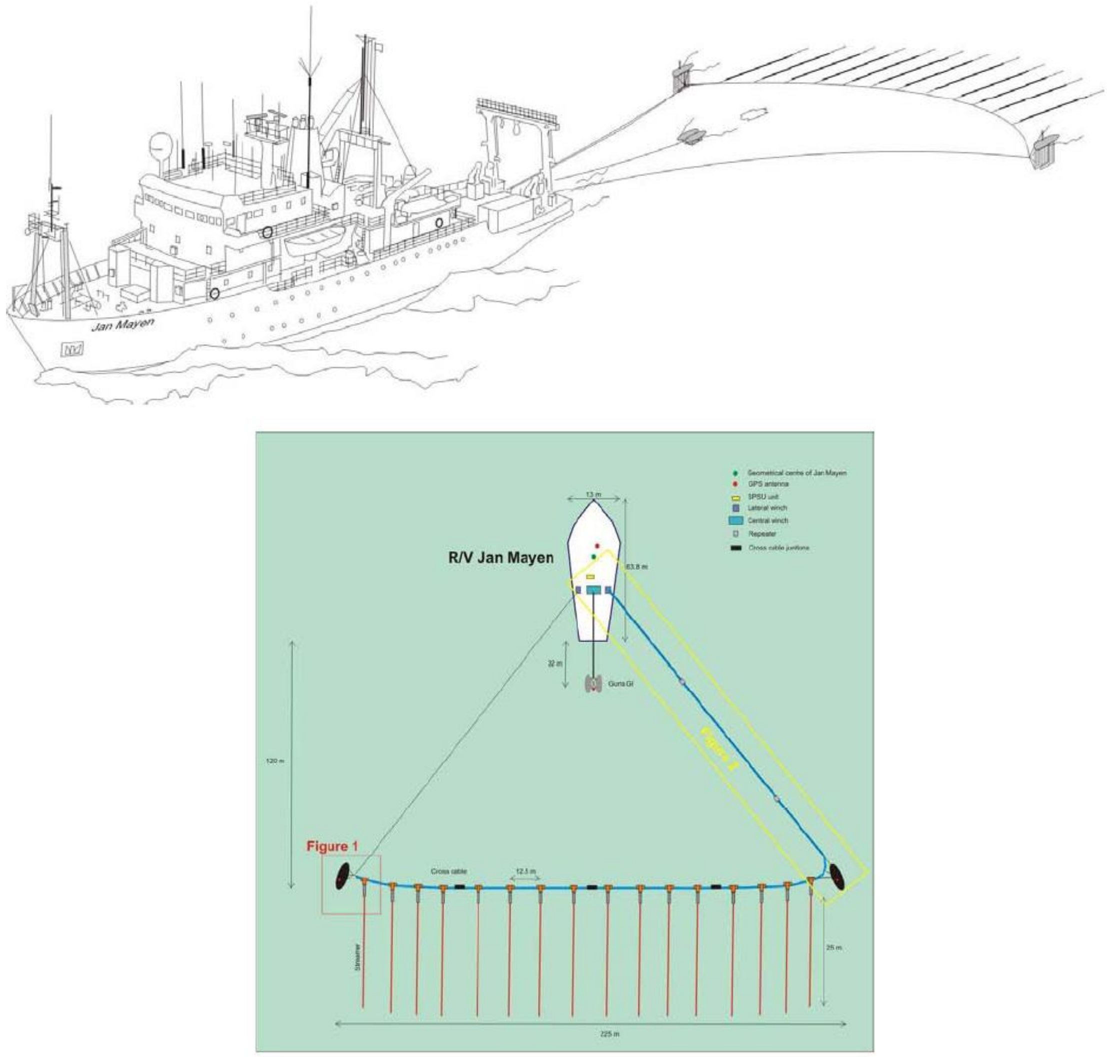


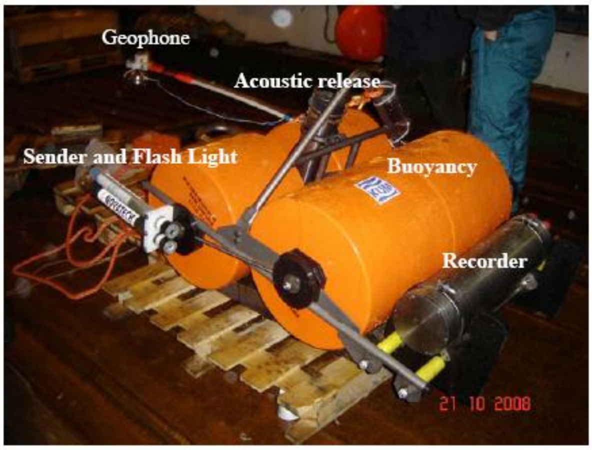
Figure 2: Schematic sketch (top) and technical drawing (bottom) of the P-Cable high-resolution 3D seismic system.

Multi-component ocean bottom seismometer (OBS)

Multi-component Ocean Bottom Seismometer (OBS) were deployed to record compressional and shear wave velocities. Four multi-component Ocean Bottom Seismometer (OBS) were deployed in approx 325 m water depth in area 1. The main purpose of the survey was to acquire P and S wave reflection data above seismic amplitude anomalies observed during the high-resolution 3D seismic survey. The aim is to model more accurately potential gas hydrate and free-gas accumulations.

The OBS systems used represent two design types that serve the same purpose (Figure 3). They are autonomous sea floor recording platforms, designed to record both, compressional and shear waves reflected and refracted through the sediments. It consists of a titanium frame with buoyancy made of syntactic foam, a KUMQUAT acoustic release system, and a digital data recorder in a separate pressure case[1]. A hydrophone and a 3-component geophone are used to record the seismic wavefield. The Tromsø OBS has a 4.5 Hz geophone attached. While the hydrophone is fixed to the frame of the OBS, the geophone is detached from it. This design insures that the geophone is mechanically decoupled from the frame, to avoid noise generated by the frame being recorded by the geophone. The whole system is rated for a water depth of up to 6000 m.

The OBS is attached to a ground weight via the acoustic release system, to make it sink to the sea floor after deployment. When the seismic experiment is completed, the OBS is released from its ground weight by sending an acoustic code and it rises to the sea surface by its buoyancy.



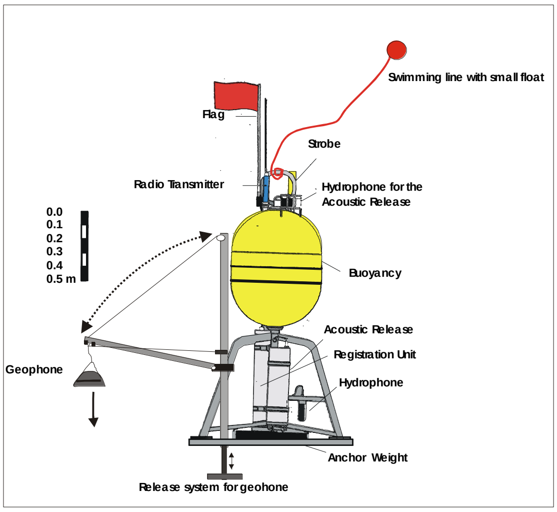


Figure 3: The old (bottom) and the new (top) Ocean Bottom Seismometer (OBS) system (UiT).

The OBS systems were prepared and programmed prior to deployment. The first channel records the hydrophone data, while channel two, three and four are connected to horizontal and vertical components of the geophone. The locations were selected based on seismic anomalies in the conventional 3D seismic data. The station list is given in the appendix and the positions of the OBS on the seafloor in area 1 is indicated in Figure 4.

CTD and water sampling

Conductivity-Temperature-Depth (CTD) is the oceanographer's standard tool for determining oceanic water masses. SeaBird's (SBE) 911plus CTD was used for oceanographic measurements. Apart from the standard temperature, conductivity and pressure (converted to depth), speed of sound, fluorescence and turbidity can also be measured. A Rosette allows for the collection of up to 12 water samples per CTD cast.

The temperature sensor is located at the base of the Rosette, thereby being the first sensor to measure the undisturbed water mass on the downcast. Furthermore, water is pumped through a conductivity tube, in which seawater conductivity is measured. Continuous pump operation is essential to prevent boundary layers forming on the tube's edges, and should data sets indicate fault malfunctions the data sets are flagged or deleted. CTD data was acquired and processed using SBE's in-house "SBE Data Processing".

PRELIMINARY RESULTS

Acquired data was processed onboard for Quality control and preliminary interpretations. This included the multibeam and 3D seismic data. OBS data processing is more demanding and will be done after the cruise.

Swath bathymetry onboard processing

Introduction

Swath bathymetry data were collected in the two survey areas during the cruise to the Snøhvit field in the SW Barents Sea (Figure 1). Mapping of the seafloor in the study areas were carried out with a hull-mounted, motion-compensated Kongsberg Simrad EM300 system. Both study areas cover an area of approximately 3 x 10 km (Figures 4 and 5). The water depth in study areas ranges from 310 to 355 m.

Processing of bathymetric data

Line statistics showed that the raw depth data had a good quality, only the outer beams had somewhat higher noise level. Kongsberg-Simrad Neptune software was used for processing of bathymetric data. The processing of bathymetric data consisted of statistical data cleaning, what was done block by block in BinStat. This function ensures an adaptive way of filtering and taking changes in the seabed terrain into account. Both areas were divided into several blocks. The basic role for blocks was putting a noise limit 2 and a STD limit 2. Noise limit 2 means that all depths with a distance from the plane larger than 2/100 * mean depth of the cell were rejected. Furthermore, STD limit is most common filtering parameter, and means that all depths with a distance from the plane larger than 2 * mean STD were rejected. In addition, raw data were also cleaned manually with the ping graphic editor to improve the accuracy on the depth data. After processing, the bathymetry data sets were exported from Neptune as a 3-column XYZ ASCII file (Easting, Northing, depth) with positive depth values based on a mean water datum. The XYZ bathymetry was gridded in the interactive visualization system Fledermaus. Aweighted-moving average gridding type was chosen with weight diameter set to 3 (Fledermaus- Reference manual 2007). The good density of measurement point allowed a grid cell size of 5 m x 5 m.

Morphological features interpretation

More or less linear and sinuous features are observed almost everywhere on the seafloor in both areas (Figures 4 and 5). They are furrows with a small rise on both sides. The furrows are several km long and up 400 m wide, but most of furrows are 1-2 km long and up to 100 m wide. They have a U-shape in a vertical profile and their shape is slightly smooth. Their depths range between 3 and 5 m. The dominant furrow orientation is ENE - WSW but the direction varies greatly. In some cases, the furrows cross-cut each other and at the end point, the furrows create a headwall. Those features were interpreted to be iceberg ploughmarks. Iceberg ploughmarks are formed when the keel of an iceberg is exceeding the water depth and erodes soft sediments. Ploughmarks indicate that the region has been influenced by glacial processes and are evidence of iceberg activity.

The seafloor in area 1 shows hundreds of small and a few large depressions (Figure 5). These depression are typical expressions of fluid escape through the seafloor and are called pockmarks. Our initial interpretation show two different pockmarks classes: hundreds of small pockmarks with diameters of up to 20 m and depth of up to 1 m, and very few large pockmarks with diameters of up 700 m and depth of up to 10 m. Hydro-acoustic surveying did not detect any indications for gas leakage from the seafloor. Further thorough interpretation of this data set and integration with the P-Cable 3D and conventional 3D seismic data will commence after the processing on the latter has been finalized.

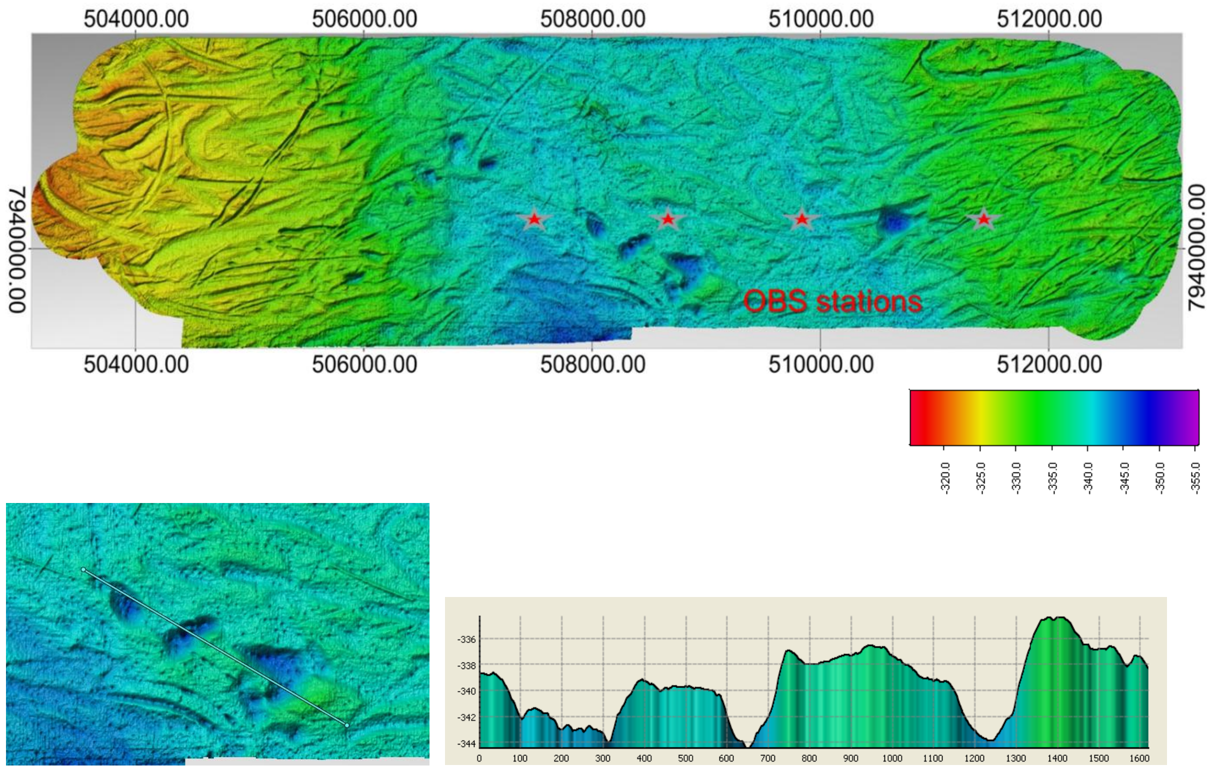


Figure 4: Seafloor map of the multibeam data acquired in area 1 with a zoomed.in section of three large pockmarks and a depth profile across them. OBS positions are indicated in the top map.

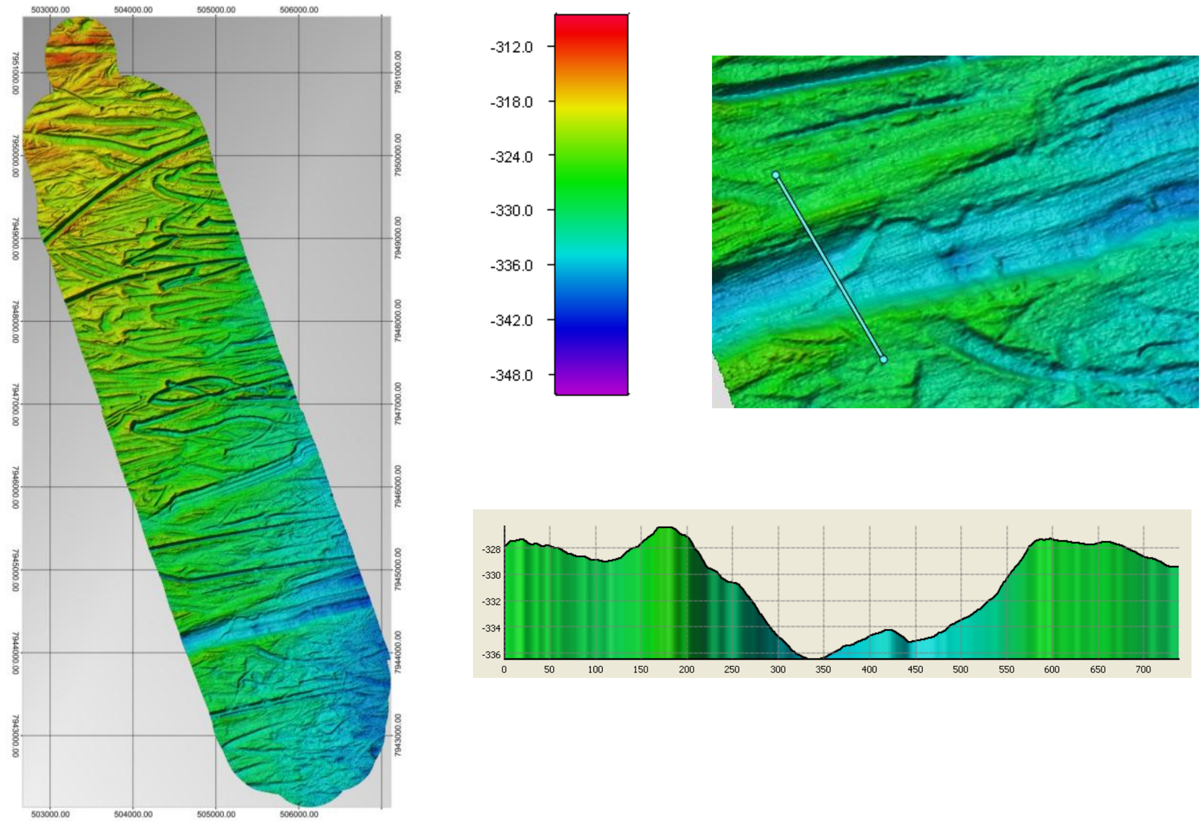


Figure 5: Seafloor map of the multibeam data acquired in area 2 with a zoomed.in section of the largest ploughmark and a depth profile across it.

P-Cable 3D seismic onboard QC and processing

This report describes the onboard QC and processing of the 3D seismic data acquired with the P-Cable system on board the R/V Helmer Hanssen. A geographical map of the working area is shown in Figures 1. During this cruise data for two different 3D cubes were acquired and processed.

Area 1: We accomplished 31 planned seismic lines. Projected spacing between lines was 60 m resulting in a block with an coverage of approximately 8 x 2 km (Figure 6). The block was acquired over an area with few large and hundreds of small pockmarks, and a clinoform system in the subsurface that shows multiple high-amplitude anomalies (Figures 7).

Area 2: Also here, we accomplished 30 planned seismic lines. Spacing between lines remained 60 m resulting in a block with an coverage of approximately 8 x 2 km (Figure 8). The block was acquired over an area that partly covers a large acoustic masking zone and BSR occurrence interpreted to be related to a gas chimneys that might connect with the reservoir and storage formations (Figure 9).

The CDP coverage for both areas is shown on Figures 10 and 11. As one can see there are some small gaps in final coverage of both areas, bur particularly in area 2. A good coverage depends on ship navigation and line tracking. In few instances the ship was off the planned line by up to 20 m, which results in the gaps. However, these gaps mostly are only one bin size wide and thus, can be easily infilled during processing. The navigation file processing and checking as well as data input, geometry assignment and further data QC and processing are reported for both areas. The QC procedures and seismic data processing were performed in the RadExPro Plus software. Brute stack cubes were generated for both areas to assess the quality of the seismic data.

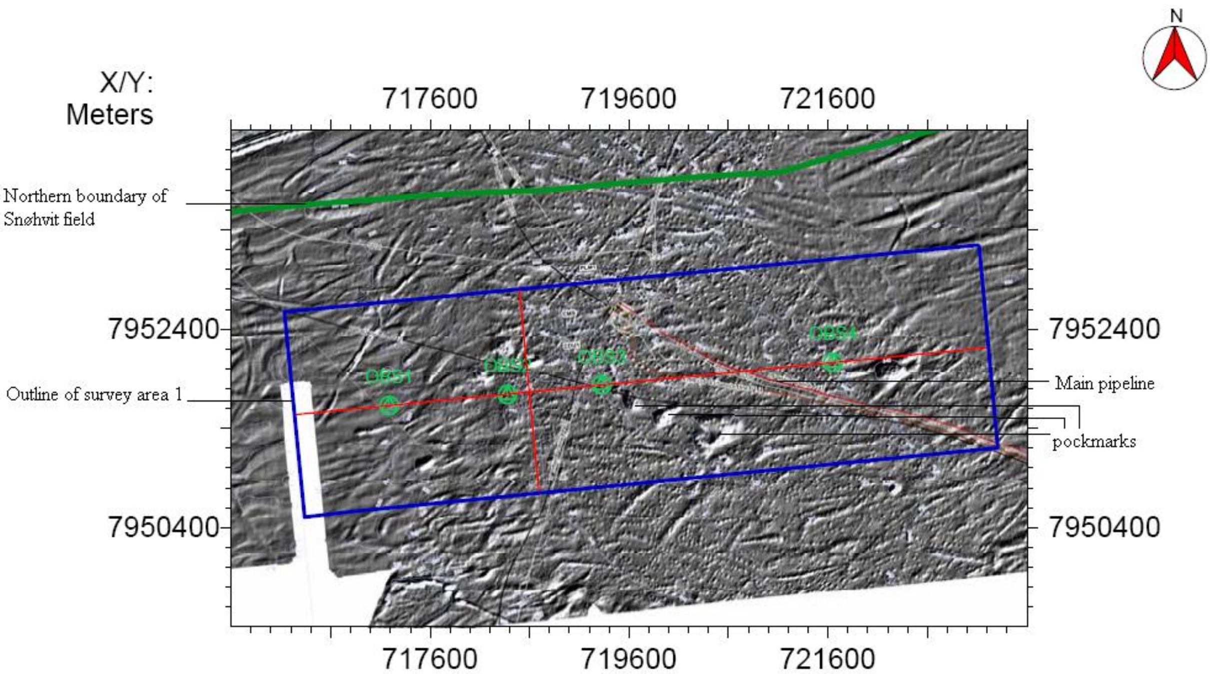


Figure 6: Seafloor map (Courtesy of Statoil) of parts of the Snøhvit area showing several hundreds of small pockmarks. The blue box indicates the location of the P-Cable 3D seismic survey 1. Green circles indicate location of OBS.

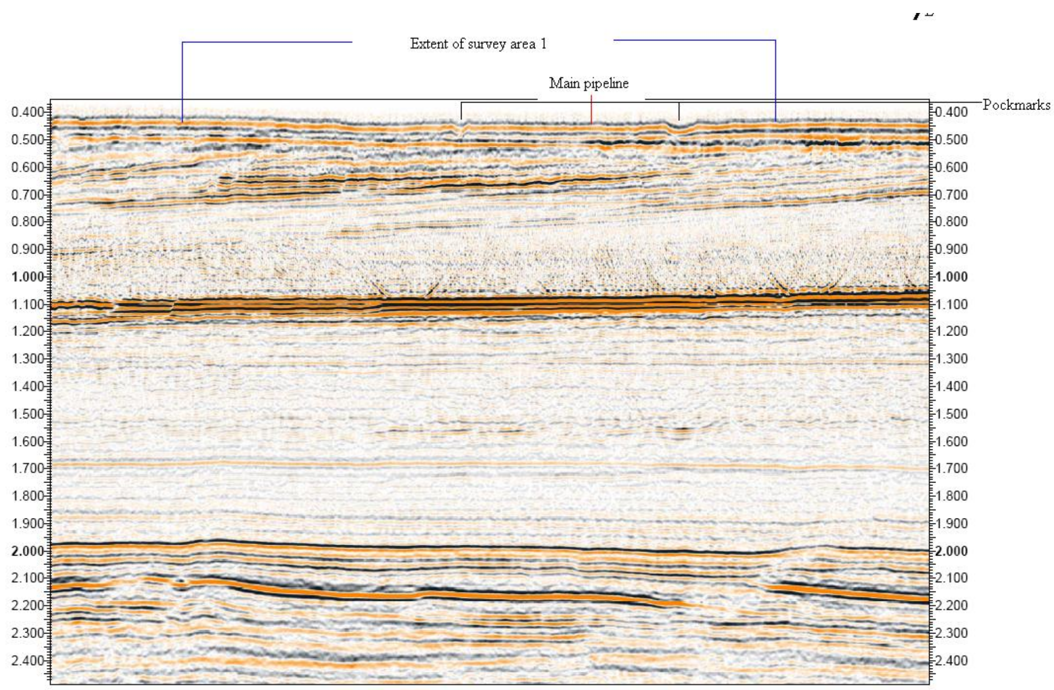


Figure 7: Subsurface structure in area 1 of Snøhvit showing a clinoform system and several high-amplitude anomalies that indicate the presence of gas in shallow sediments. The extent of survey area 1 is indicated above the seismic.

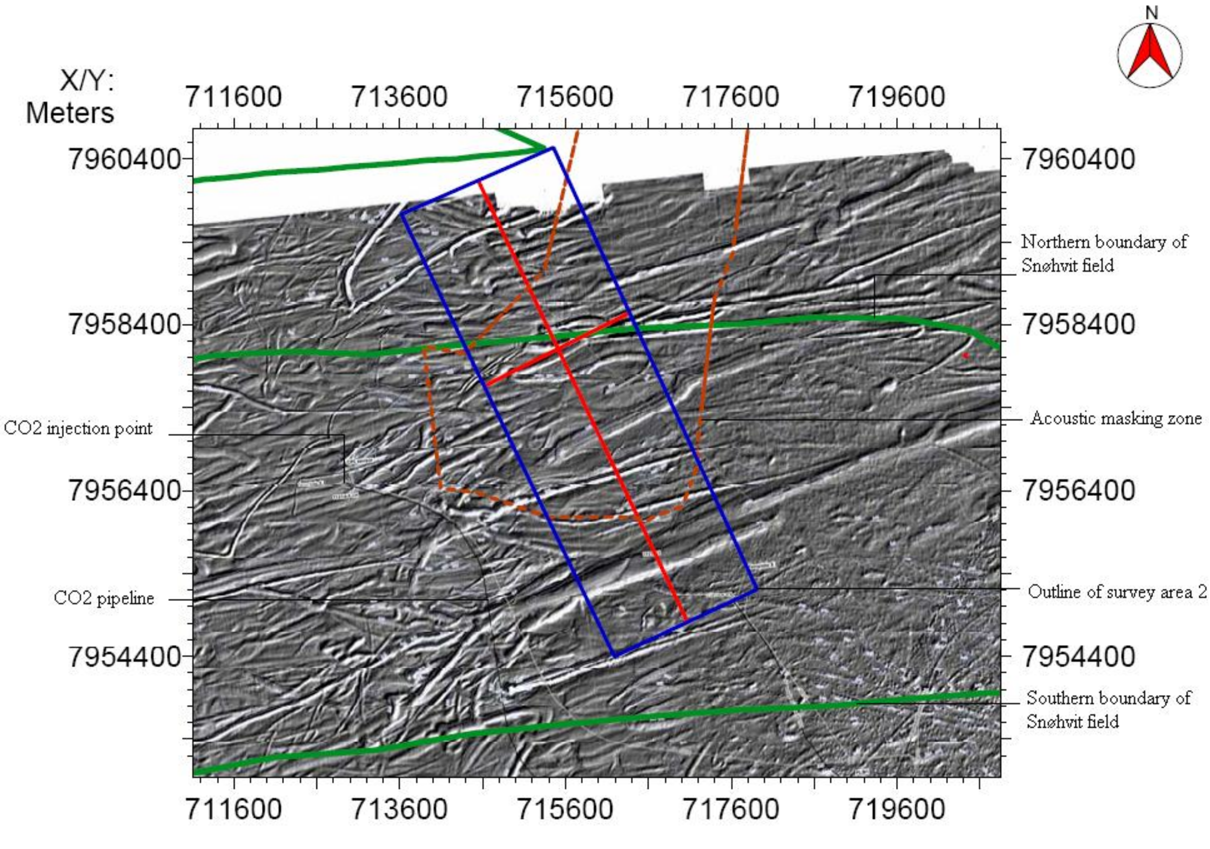


Figure 8: Seafloor map (Courtesy of Statoil) of parts of the Snøhvit area showing several ploughmarks and pockmarks in the SE corner. The blue box indicates the location of the P-Cable 3D seismic survey 2. The red thin line indicates the location of a large gas chimney in the subsurface that was a major target for this survey

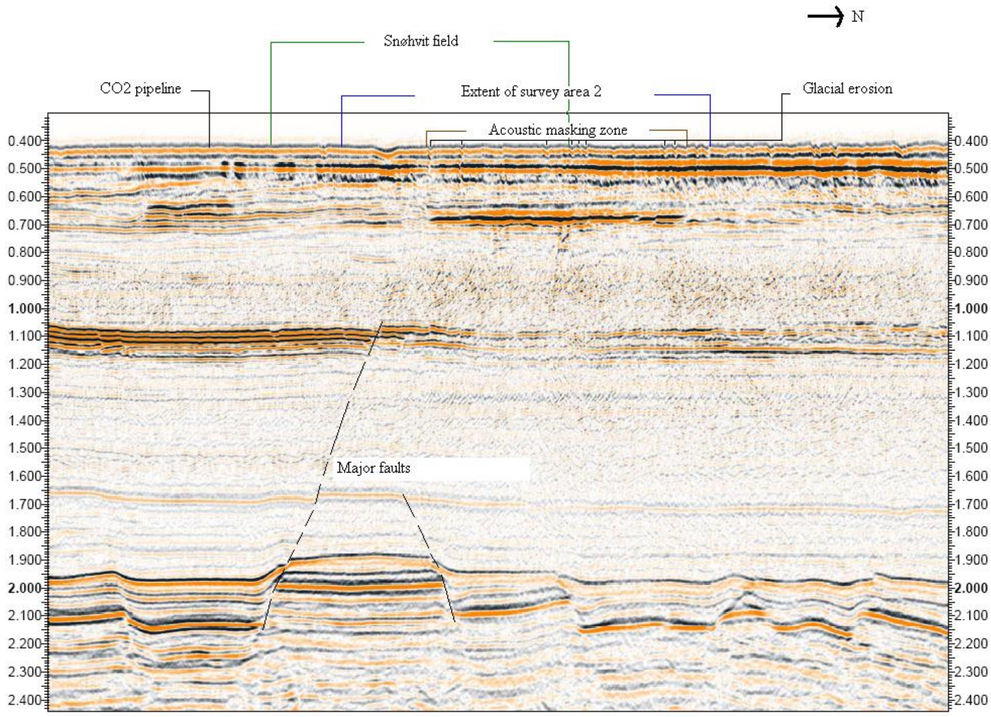


Figure 9: Subsurface structure in area 2 of Snøhvit showing an acoustic masking zone and several high-amplitude anomalies that indicate the presence of vertical flow of gas and gas in shallow sediments. The extent of survey area 1 is indicated above the seismic.

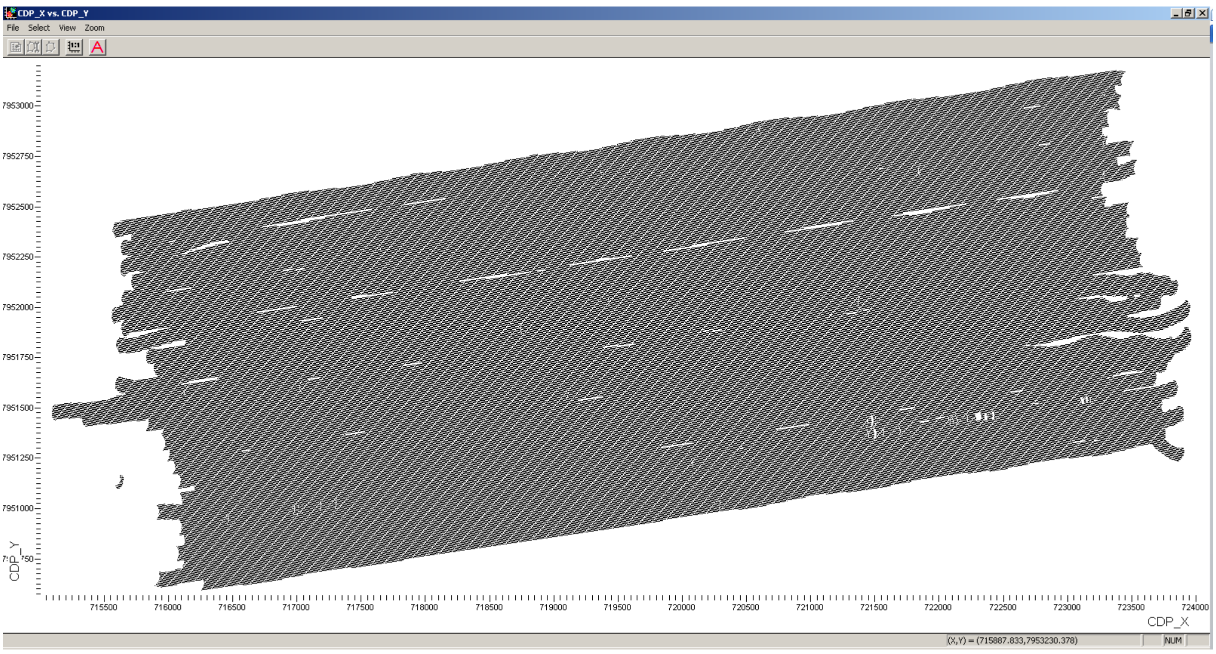


Figure 10: Coverage map of survey area 1.

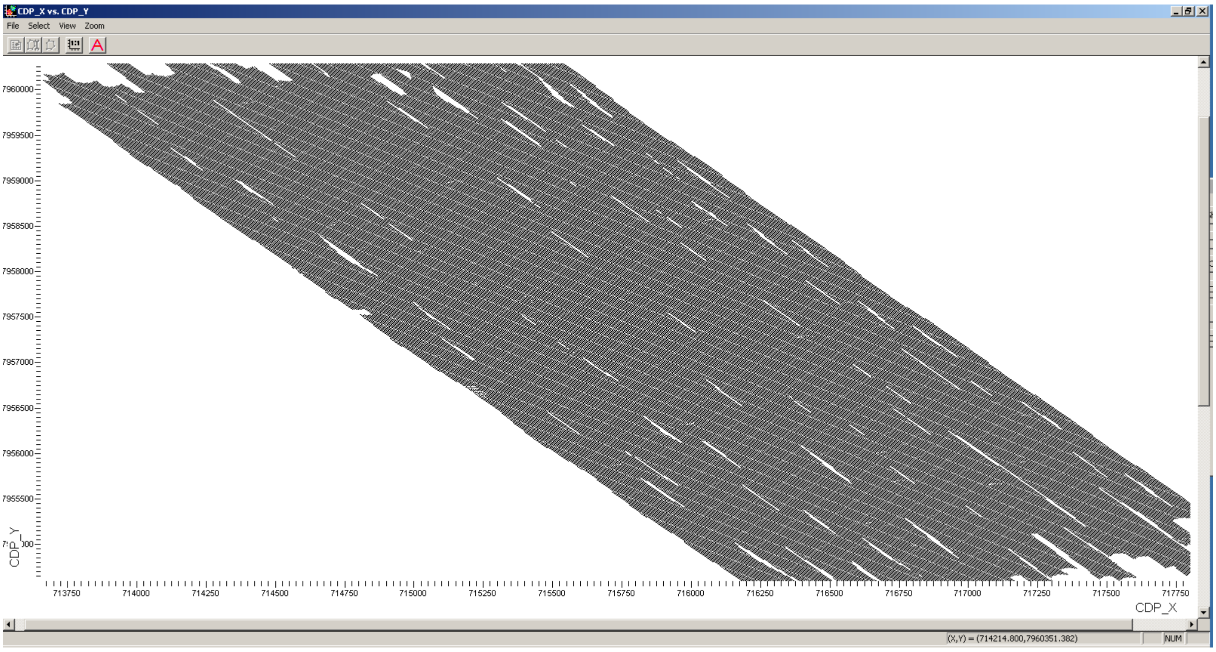


Figure 11: Coverage map of survey area 2.

Data Input

Seismic data were loaded from seg-d files and saved as RadExPro datasets within the RadExPro project database. In both areas, the lines were loaded separately directly after acquisition to be sure to correct for geometry input . Afterwards, the lines were loaded by blocks to one dataset.

Geometry Input

The geometry characteristics of the P-Cable system in this survey are described below. The P-Cable system was configured with 14 streamers that have 12.5 meters distance between streamers. Distance from Paravanes to the first and last streamers was 32.5 m and 26.25 m. Geometry was loaded with Geometry Input Module using the parameters listed before. Navigation files were prepared. Alpha trimmed averaging of raw navigation was involved in geometry input routine prior to geometry assignment. The geometry for every part was assigned in a similar way. There were no problems with navigation assignments and the geometry was used for all shots.

Geometry Check

After geometry input the assigned geometry was checked for consistence. Observed direct wave arrival time was compared with one calculated from the assigned geometry. To calculate this time, the velocity was assumed to be equal to 1.5 m/ms. Quality control was performed by visualizing every 10th common shot point gather. Figures 12 and 13 show some examples of such QC plots. On some shots the difference between calculated direct wave arrival time and observed one was about 3 ms, but on most shots the calculated time fitted the observed one well. Such difference can be caused by strong currents in the area and bad ship positioning.

Partial cubes, brute stacks and QC coverage

As data acquisition continued, partial brute stacks were calculated over the available subset of seismic lines to assess gaps in the coverage and seismic data quality. Coverage control is very important during data acquisition. Coverage of the data was controlled using QC plots generated in the

RadExPro. Locations of CDP points were displayed in the 3D CDP Binning tool. At the end of each area coverage plots were made for all lines (figures), and a brute stack cube for each area was generated. The seismic data quality is generally very good. However, several additional processing steps need to be run in the post-processing before the final version of the data is ready. These include, tide and residual statics corrections, amplitude corrections, filtering and migration.

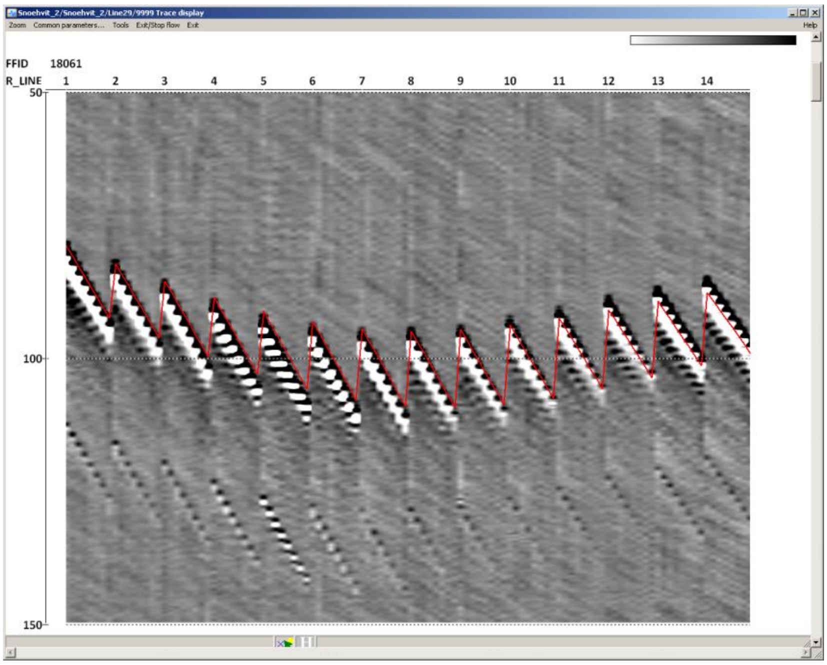


Figure 12: Geometry check plot with direct wave arrival and predicted theoretical arrival time (red line).

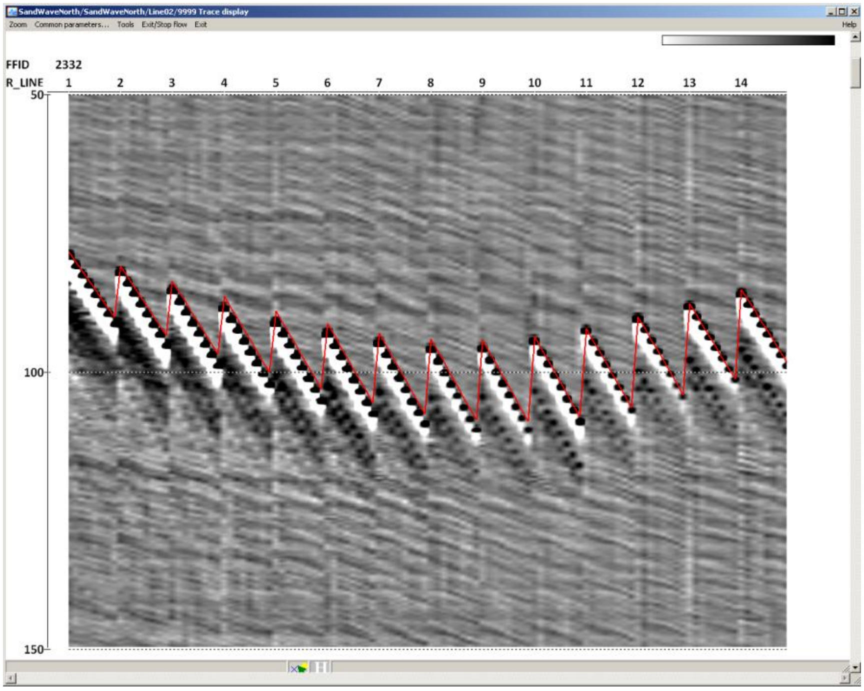


Figure 13: Geometry check plot with direct wave arrival and predicted theoretical arrival time (red line).

NARRATIVE OF THE CRUISE

Times in this report are given in local time (local time -2 hrs = UTC), 3D seismic data are logged in UTC time and ship logs are given in UTC time. The weather for most of the cruise provides a calm sea (Bft <3), fog and grey skies. Air temperatures were between 5 °C and 12 °C. During the cruise, five systems HighRes 3D reflection seismic, SIMRAD EM300 swath bathymetry, CHIRP subbottom profiler, EK 60 38 and 18 kHz fishfinder, and GPS Navigation are working parallel. In addition, OBS systems were deployed once in the Snøhvit area. We started to prepare the cruise in Tromsø on July 1 with loading and assembling all seismic equipment.

Friday, 01.07.
The scientific crew arrived during the morning hours. We started to load all equipment onboard the ship. After the compressor container was lifted onboard we began assembling the seismic equipment. The signal cable was spooled on one of Jan Mayens large winches. The new cross cable was spooled on University of Tromsø's versatile winch. Electronics and computers for seismic data acquisition is set up in the laboratory. Loading and assembling lasted until 1 hour after midnight.

Saturday, 02.07.
01:00 Departure from Tromsø heading north to the Snøhvit area.
09:00: During the transit to the working area, the OBS systems are prepared.
13:30 Arrival at the Snøhvit area. The cross cable has been modified to provide better balance. However, the cross cable has not been operated after these modification and therefore, further balancing is required.
15:00: The first deployment of the cross cable is without streamers and floatation are only connected at the tri-point connections. The depth readings show that the cable is dipping between 1 – 3 m beneath the sea surface. The desired cable depth is 1 m and hence we connect three more floatation along the cross cable.
18:00: Another deployment test showed that the depth is now stable between 0,9 – 1,3 m, which we deem acceptable given weather conditions and hydrodynamic nature of the cross able.
19:30 We acquire a CTD cast in 314 m water depth.
22:00 The OBS seismographs are being synchronized and a last check is run.
23:00 OBS release systems are set up and mounted on the OBS frame.

Sunday, 03.07.
00:30 All OBS systems are ready for deployment.
01:10 OBS 1 deployed.
01:30 OBS 2 deployed
01:45 OBS 3 deployed
02:05 OBS 4 deployed
02:30 The P-cable system is prepared for deployment with streamers. 16 drop-lead-digitizer-streamer assemblies are set up for a quick and efficient deployment operation.
03:00 We start to deploy the P-cable.
04:15 The system is in the water but there is leakage along the cable. Test showed that it is most likely related to streamer 10.
05:00 The system is back on deck and we replace streamer assembly no. 10 with a spare one.
05:30 Another deployment operation starts.

06:30 The P-Cable system is in the water and working properly. We are running some pre-survey test and configuration checks.
07:14 3D seismic line 1 starts.
12:02 Shortly before lunch we have completed line 4. Everything is working fine. The weather is cloudy with light winds and waves of 0.5 m.
23:59 As the days ends we have almost finished line 14.

Monday, 04.07.
00:26 Line 15 starts.
02:00 A Statoil operated vessel is in the area and is doing inspections of seafloor installations. Good communication assures that both survey vessels do not interfere with each other.
10:30 Shut down Geoeel (at shot 16861 on line 23) due to problems with triggers and leakage on SPSU. Guns are being brought in for problems with the towing point. The cross cable was also brought in for inspection of the signal cable attachment point. Modifications to the gun array are required. We also identify a leaking streamer and replace it.
11:00 While maintenance work is going on, we decide to recover the OBS.
12:05 OBS 1 recovered.
12:55 OBS 2 recovered.
14:10 OBS 3 recovered-
15:15 OBS 4 recovered.
17:00 Maintenance work has finished and we start to deploy again.
18:22 We start again on line 23.
23:59 Acquiring line 27 as the day ends.

Tuesday, 05.07.
07:30 The last line of the first 3D seismic cube has just finished. The P-Cable system will stay in the water as we slowly steam to the nearby area 2.
08:09 Line 1 in area 2 starts. Unchanged weather conditions provide relatively good conditions for acquisition of 3D seismic data.
23:59 We are on line 14 as the day comes to an end

Wednesday, 06.07.
20:00 The last line (no 30) has just finished and we are recovering the P-Cable system.
22:00: Work at Snøhvit is concluded and we are heading towards working area 2 on the upper continental slope of the SW-Barents Sea.

Thursday, 14.07.
09:00: Arrival in Longyearbyen. End of cruise.

ACKNOWLEDGEMENT

We thank the captain and his crew of R/V Helmer Hanssen of the University of Tromsø for their excellent support during the 3D and multicomponent seismic survey. We are grateful to the ECO2 project, a Collaborative Project funded under the European Commission's Framework Seven Programme Topic OCEAN.2010.3 Sub-seabed carbon storage and the marine environment, project number 265847 for providing financial support to carry out this cruise to the SW Barents Sea.

APPENDIX

CTD stations

Date	Time	StationNr	Latitude	Longitude	Depth [m]
02.07.2011	19:41:58	294	71 38.71932 N	020 52.74085 E	313,94

OBS Stations

OBS station	Date / Time	Deployment sites Longitude	Latitude
1	02.07.2011 /	21 09.798’E	71 33.968’N
2	02.07.2011 /	21 11.856’E	71 33.961’N
3	02.07.2011 /	21 13.546’E	71 33.953’N
4	02.07.2011 /	21 17.460’E	71 33.939’N

3D seismic line log

Expedition: P-Cable Juli 2011 Survey: Snøhvit area 1. – Sheet #: 1 -

Times are UTC

3D line number:	Date: Start - end	Time (UTC): Start - end	Shot point number First - last	Shot point number when crossing planned start and end of line	Comments (sailing direction, ship speed, depth sensor, wind speed, air temperature downtime, etc.)
1	03.07.11	05.14 – 06.19	710 -1481	784 - 1432	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 93 deg., Wind: 4.5m/s 302 deg., Temp: 7.3 deg C
2	03.07.11	06.30 - 07.31 syst. 06.36 – 07.26 line	1482 - 2179	1525 - 2129	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 274 deg., Wind: 7.5 m/s 317 deg., Temp: 7.3 deg C
3	03.07.11	07.45 – 08.54 syst. 07.53 –08.50 line	2180 - 3000	2274 - 2949	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 90 deg., Wind: 6.0 m/s 290 deg., Temp: 7.7 deg C
4	03.07.11	09.06– 10.06 syst. 09.09 – 10.02 line	3001 - 3723	3035 - 3677	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.4 kn, Heading: 275 deg., Wind: 6.0 m/s 319 deg., Temp: 7.6 deg C
5	03.07.11	10.18 – 11.17 syst. 10.21 – 11.13 line	3724 - 4430	3765 - 4392	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.4 kn, Heading: 95 deg., Wind: 2.5 m/s 321 deg., Temp: 8.1 deg C
6	03.07.11	11.27 – 12.34 syst. 11.31 – 12.30 line	4431 - 5228	4469 - 5183	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.7 kn, Heading: 270 deg., Wind: 5.0 m/s 314 deg., Temp: 7.7 deg C
7	03.07.11	12.50 – 13.48 syst 12.51 – 13.45 line	5229 - 5931	5243 - 5893	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 89 deg., Wind: 2.2 m/s 292 deg., Temp: 8.1 deg C

8	03.07.11	14.02 – 15.02 syst 14.05 – 14.58 line	5932 - 6649	5963 - 6608	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.8 kn, Heading: 269 deg., Wind: 6.0 m/s 310 deg., Temp: 7.8 deg C
9	03.07.11	15.17 – 16.14 syst 15.18 – 16.11 line	6650 - 7340	6667 - 7303	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.6 kn, Heading: 90 deg., Wind: 3.8 m/s 260 deg., Temp: 7.5 deg C
10	03.07.11	16.23 – 17.21 syst 16.27 – 17.18 line	7341 - 8040	7392 - 8003	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 268 deg., Wind: 6.2 m/s 321 deg., Temp: 7.5 deg C
11	03.07.11	17.36 – 18. 32 syst 17.36– 18.30 line	8041 - 8702	8041 - 8676	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 90 deg., Wind: 6.0 m/s 320 deg., Temp: 7.5 deg C
12	03.07.11	18.41 – 19.40 syst 18.45 – 19.38 line	8703 - 9410	8739 - 9377	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 270 deg., Wind: 4.8 m/s 324 deg., Temp: 7.6 deg C
13	03.07.11	19.56 – 20.57 syst 19.59 – 20.55 line	9411 - 10141	9451 - 10114	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 87 deg., Wind: 2.0 m/s 287 deg., Temp: 7.8 deg C
14	03.07.11	21.08 – 22.09 syst 21.11 – 22.06 line	10142 - 10865	10181 - 10840	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.5 kn, Heading: 271 deg., Wind: 4.2 m/s 334 deg., Temp: 7.6 deg C
15	03.07.11	22.26 – 23.28 syst 22.29 – 23.24 line	10868 - 11607	10904 - 11558	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 89 deg., Wind: 2.5 m/s 334 deg., Temp: 7.6 deg C
16	03.07.11 - 04.07.11	23.38 – 00.43 syst 23.43 – 00.39 line	11608 - 12380	11662 -12341	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 268 deg., Wind: 3.2 m/s 325 deg., Temp: 7.6 deg C

17	04.07.11	00.55 – 01.51 syst 00.59 – 01.49 line	12381 - 13051	12421 - 13023	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.8 kn, Heading: 91 deg., Wind: 1.9 m/s 322 deg., Temp: 7.1 deg C
18	04.07.11	02.06 – 03.08 syst 02.08 – 03.03 line	13052 - 13797	13083 - 13743	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.9 kn, Heading: 263 deg., Wind: 3.2 m/s 299 deg., Temp: 7.3 deg C
19	04.07.11	03.22 – 04.21 syst 03.25 – 04.17 line	13798 - 14507	13833 - 14463	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.5 kn, Heading: 86 deg., Wind: 2.3 m/s 311 deg., Temp: 7.6 deg C
20	04.07.11	04.38 – 05.36 syst 04.40 – 05.34 line	14508 - 15233	14531 - 15208	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 270 deg., Wind: 3.2 m/s 288 deg., Temp: 7.3 deg C. Gather window show some noise at end of line (channel 57) between shot 15095 and 15205 no noise in noise window.
21	04.07.11	05.55 – 06.50 syst 05.57 – 06.48 line	15234 - 15906	15259 - 15876	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.5 kn, Heading: 95 deg., Wind: 3.4 m/s 346 deg., Temp: 7.8 deg C.
22	04.07.11	07.07 – 08.05 syst 07.10 – 08.03 line	15907 -16632	15942 - 16600	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.4 kn, Heading: 271 deg., Wind: 5.1 m/s 345 deg., Temp: 7.5 deg C.
23	04.07.11	08.25 – syst 08.28 – line	16633 -	16663 -	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 90 deg., Wind: 5.8 m/s 353 deg., Temp: 7.4 deg C. Shut down geoeel (at shot 16861) due to problems with triggers and leakage on SPSU.
24	04.07.11	10.00 – 10.15 syst 10.05 – line	17156 - 17337	17229 -	Guns are being brought in for problems with the towing point. The cross cable was also brought in for inspection of the signal cable attachment point.
23a	04.07.11	16.22 – 17.18 syst 16.24 – 17.16 line	17338 - 18009	17363 - 17998	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 89 deg., Wind: 6.0 m/s 340 deg., Temp: 7.0 deg C. Reshot of line 23

24a	04.07.11	17.36 – 18.32 syst 17.38 – 18.29 line	18010 - 18687	18035 - 18651	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 273 deg., Wind: 4.5 m/s 351 deg., Temp: 6.7 deg C. Reshot of line 24
25	04.07.11	18.53 – 19.54 syst 18.56 – 19.51 line	18688 - 19415	18721 - 19381	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 86 deg., Wind: 4.2 m/s 357 deg., Temp: 7.0 deg C.
26	04.07.11	20.13 – 21.15 syst 20.16 -21.12 line	19416 - 20154	19446 - 20118	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.1 kn, Heading: 267 deg., Wind: 5.0 m/s 333deg., Temp: 6.9 deg C. Went far offline. Wrong endpoint was chosen in Nav.
26 B	04.07.11 05.07.11	23.03 – 00.03 syst 23.05 – 00.07 line	20910 - 21671	20934 -21631	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 273 deg., Wind: 2.7 m/s 291 deg., Temp: 5.8 deg C
27	04.07.11	21.38 – 22.41 syst 21.41 – 22.37 line	20155 - 20909	20189 - 20864	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.1 kn, Heading: 91 deg., Wind: 4.3 m/s 290 deg., Temp: 6.2 deg C.
29	05.07.11	00.29 – 01.28 syst 00.31 – 01.25 line	21672 - 22384	21697 - 22348	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.1 kn, Heading: 89 deg., Wind: 1.3 m/s 301 deg., Temp: 5.8 deg C.
28	05.07.11	01.49 – 02.50syst 01.52 – 02.46 line	22385 - 23122	22422 - 23069	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.5 kn, Heading: 272 deg., Wind: 3.2 m/s 303 deg., Temp: 5.8 deg C. GeoEel file 29!!
31	05.07.11	03.11 – 04.11syst 03.14 -04.07 line	23123 - 23835	23161 - 13795	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0kn, Heading: 90 deg., Wind: 3.1 m/s 271 deg., Temp: 5.9 deg C

30	05.07.11	04.32 – 05.31syst 04.35 – 05.29 line	23836 - 24535	23867 - 24519	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.1kn, Heading: 270 deg., Wind: 4.2 m/s 272 deg., Temp: 5.8 deg C
End Area 1					

Start Area 2					
3D line number:	**Date:** **Start - end**	**Time (UTC):** **Start - end**	**Shot point number** **First - last**	**Shot point number when crossing planned start and end of line**	**Comments (sailing direction, ship speed, depth sensor, wind speed, air temperature downtime, etc.)**
1	05.07.11	06.09 – 7.03 syst 06.10 – 7.00 line	41 - 688	57 - 655	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.8 kn, Heading: 342 deg., Wind: 7.6 m/s 265 deg., Temp: 6.2 deg C
2	05.07.11	07.38 – 08.33 syst 07.41 – 08.31 line	689 - 1340	717 - 1313	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 160 deg., Wind: 3.4 m/s 268 deg., Temp: 6.6 deg C
3	05.07.11	08.55 – 09.50 syst 08.58 – 09.47 line	1341 - 2006	1376 - 1970	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.9 kn, Heading: 342 deg., Wind: 4.5 m/s 242 deg., Temp: 7.9 deg C
4	05.07.11	10.36 – 11.28 syst 10.39 – 11.25 line	2007 -2633	2031 - 2590	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 165 deg., Wind: 3.7 m/s 307 deg., Temp: 6.6 deg C (gun moved 20-25M further back)
5	05.07.11	11.46 – 12.39 syst 11.48 – 12.36 line	2634 - 3268	2652 - 3229	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 165 deg., Wind: 3.7 m/s 307 deg., Temp: 6.6 deg C
6	05.07.11	12.59- 13.49 syst 13.01-13.36 line	3269-3857	3270-3840	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 158 deg., Wind: 5.9 m/s 301 deg., Temp: 7.2 deg C
7	05.07.11	13.57 – 14.51 syst 13.58 – 14.50 line	3858-4420	3867 - 4404	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 333 deg., Wind: 7.3m/s 303 deg., Temp: 7.5 deg C

8	05.07.11	15.10 - 16.00syst 15.12 - 15.58 line	4421-5010	4446-4988	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 168 deg., Wind: 7.3m/s 308 deg., Temp: 7.4 deg C
9	05.07.11	16.12 – 17.05 syst 16.14 – 17.01 line	5011-5647	5037-5605	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 349 deg., Wind: 7.4m/s 303 deg., Temp: 7.7deg C
10	05.07.11	17.17– 18.10 syst 17.21 – 18.06 line	5648-6280	5690-6233	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.8 kn, Heading: 168 deg., Wind: 6.3m/s 315 deg., Temp: 7.0deg C (Missed few shots before file no. 5722)
11	05.07.11	18.22 – 19.16 syst 18.25 – 19.12 line	6281 - 6932	6317 -6878	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 335 deg., Wind: 7.4m/s 322 deg., Temp: 7.0deg C
12	05.07.11	19.28 – 20.22 syst 19.31 – 20.19 line	6968 - 7579	6933 - 7538	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 166 deg., Wind: 6.5m/s 317 deg., Temp: 6.7 deg C
13	05.07.11	20.37 – 21.30 syst 20.37 – 21.27 line	7580 - 8203	7580 - 8167	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 340 deg., Wind: 7.4m/s 299 deg., Temp: 6.3 deg C (System started right when ship started line)
14	05.07.11	21.45 – 22.38 syst 21. 47– 22.34 line	8204 - 8825	8211 - 8781	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 165 deg., Wind: 7.5m/s 301 deg., Temp: 6.5 deg C (off course until line 8290)
15	05.07.11	22.49 – 23.44 syst 22.51 – 23.41 line	8826 - 9482	8850 - 9442	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 346 deg., Wind: 5.9m/s 315 deg., Temp: 5.9 deg C
16	05.07.11 06.07.11	23.59 – 00.48 syst 00.01 – 00.46 line	9483 - 10069	9514 - 10050	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 155 deg., Wind: 5.2m/s 320 deg., Temp: 6.9 deg C

17	06.07.11	01.02 – 02.00 syst 01.04 – 01.55line	10070 - 10768	10095 - 10703	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.7 kn, Heading: 339 deg., Wind: 6.8m/s 306 deg., Temp: 6.9 deg C
18	06.07.11	02.14 – 03.05 syst 02.16 – 03.03 line	10769 - 11375	10787 - 11353	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 158 deg., Wind: 4.99m/s 308 deg., Temp: 6.0 deg C
19	06.07.11	03.21 – 04.12 syst 03.23 – 04.10 line	11376 - 11982	11396 - 11961	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.3 kn, Heading: 346 deg., Wind: 7.9m/s 297 deg., Temp: 6.1 deg C
20	06.07.11	04.29 – 05.19 syst 04.30 – 05.16 line	11983 - 12579	11988 - 12541	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 167 deg., Wind: 6.4m/s 303 deg., Temp: 6.3 deg C
21	06.07.11	05.36 – 06.25 syst 05.36 – 06.23 line	12580 - 13172	12588 -13141	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.6 kn, Heading: 340 deg., Wind: 8.0m/s 285 deg., Temp: 6.2 deg C
22	06.07.11	06.47 – 07.42 syst 06.52 – 07.38 line	13173 - 13829	13228 - 13779	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 167 deg., Wind: 6.0m/s 293 deg., Temp: 6.1 deg C
23	06.07.11	08.00 – 09.00 syst 08.03– 08.56 line	13830 - 14546	13863 - 14502	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.6 kn, Heading: 333 deg., Wind: 9.8m/s 290 deg., Temp: 6.2 deg C
24	06.07.11	09.25 – 10.19 syst 09.28– 10.15 line	14547 - 15180	14580 - 15142	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 159 deg., Wind: 6.8m/s 287 deg., Temp: 6.3 deg C
25	06.07.11	10.36 – 11.36 syst 10.40 – 11.31 line	15181 - 15899	15231 - 15844	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.8 kn, Heading: 340 deg., Wind: 8.8m/s 281 deg., Temp: 6.6 deg C
26	06.07.11	12.01 – 12.51 syst 12.04 – 12.49 line	15900 - 16501	15935-16483	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 155 deg., Wind: 8.8m/s 287 deg., Temp: 6.4 deg C (30 meters off planned line during

					some shots around file.no 15998)
27	06.07.11	13.09 – 14.02syst 13.12 – 13.59 line	16502 - 17144	16537 - 17104	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.0 kn, Heading: 340 deg., Wind: 7.8m/s 279 deg., Temp: 6.3 deg
28	06.07.11	14.25 –15.18 syst 14.28 – 15.16 line	17145- 17774	17182 - 17759	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.3 kn, Heading: 161 deg., Wind: 7.2m/s 285 deg., Temp: 7.1 deg
29	06.07.11	15.39 – 16.33 syst 15.40 – 16.31 line	17775 - 18418	17794 - 18394	14 streamers, 2 x 30 cu in mini G guns. Speed: 4.2 kn, Heading: 347 deg., Wind: 9 m/s 272 deg., Temp: 6.8 deg
30	06.07.11	16.58 – 17.49 syst 16.59 – 17.48 line	18419 – 19035	18430 - 19020	14 streamers, 2 x 30 cu in mini G guns. Speed: 3.8 kn, Heading: 156 deg., Wind: 8.1 m/s 287 deg., Temp: 6.2 deg. Last line
End Area 2					