Project POSEIDON: Cruise report from M/S H.U. Sverdrup II during transit from Kristiansund to Tromsø September 2008

– a cooperative survey between the Geological Survey of Norway and the Norwegian Defence Research Establishment

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English summary

The report describes the activities during a four-day transit and survey in September 2008 from Kristiansund to Tromsø. Since FFI's research vessel M/S H.U. Sverdrup II was in transit from the Bergen area to the Barents Sea, it was requested to make use of the transit to acquire data, primarily multibeam backscatter data, whilst underway in areas off the coast of Northern Norway.

The areas of interest had earlier been surveyed using a variety of different survey platforms, multibeam systems and data acquisition settings. This has led to backscatter data coverage of variable quality, with backscatter values that are difficult to standardize on a regional basis. This survey provides the first backscatter data coverage acquired using a single multibeam system from a single survey platform over this area. This single line of data will contribute to a dataset that can form a regional baseline for multibeam backscatter data, which will ultimately aid sediment classification off the Norwegian coast.

The survey was a cooperative project between Norges geologiske undersøkelse/Geological Survey of Norway (NGU) and FFI. The background for the cooperation is twofold. Information about the bottom conditions as sediment types, roughness and hardness are of importance in prediction of sonar performance in military operations at sea, and the area surveyed in September 2008 is through the outer part of the Navy's exercise area in Northern Norway. The data acquired will aid FFI in making backscatter maps from the exercise area. NGU is a partner in the seabed mapping programme MAREANO initiated by the Norwegian Government in 2005, where the task is to map seabed conditions and biodiversity in areas in the Barents Sea and off Lofoten. NGU is responsible for making geological maps of the seabed and the data acquired in September 2008 will help level data from earlier surveys, aiding sediment classification and the interpretation of seabed processes.

Besides multibeam echosounder data, single beam echosounder and parametric sonar data were also acquired. In addition, four grab samples were taken to provide physical sediment samples from the sea floor which could assist in interpretation of the acoustic data.

NGU planned the survey line based on earlier processed multibeam backscatter data. For this survey it was essential to use consistent acquisition settings on the multibeam echosounder. Usually the setting is dependent on the water depth which can lead to difficulties in interpretation and standardization between surveys.

This report summarises the work undertaken on board M/S H.U. Sverdrup II, shows some preliminary results and suggests further work. Processing of the single beam echosounder data shows correlation between hardness, roughness and the grab samples obtained. Processing of the multibeam backscatter data shows resemblance with earlier processed data.

Sammendrag

Denne rapporten beskriver aktivitetene under et fire-dagers tokt fra Kristiansund til Tromsø i september 2008. I forbindelse med transitt av FFIs forskningsfartøy M/S H.U. Sverdrup II fra Bergensområdet til Barentshavet, var det ønskelig å samle inn primært tilbakespredningsdata fra flerstråleekkoloddet underveis langs kysten av Nord-Norge. Områdene av interesse er tidligere blitt kartlagt med forskjellig målefartøyer, flerstrålelodd og settinger på datainnsamlingen. Dette har resultert i et dekningsområde for tilbakespredningsdata av varierende kvalitet, med tilbakespredningsverdier som vanskelig lar seg standardisere i en regional modell. Toktet har fremskaffet det første tilbakespredningsdatasettet i dette området med ett enkelt flerstrålelodd fra ett enkelt fartøy. Linjen som er oppmålt vil inngå i et datasett som vil danne en regional modell for tilbakespredningsdata fra flerstrålelodd, og på sikt bidra til sedimentklassifisering av havbunnen langs Norges kyst.

Toktet var et samarbeidsprosjekt mellom Norges geologiske undersøkelse (NGU) og FFI. Bakgrunnen for samarbeidet er tosidig. Informasjon om bunnforholdene som sedimenttype, ruhet og hardhet, er av betydning ved prediksjoner av sonarytelse i militære operasjoner til sjøs, og området kartlagt i september 2008 ligger i den ytre delen av Forsvarets øvingsområde i Nord-Norge. Dataene som ble samlet inn vil hjelpe FFI i å lage tilbakespredningskart fra øvelsesområdet. NGU er partner i havbunnskartleggingsprogrammet MAREANO initiert av norske myndigheter i 2005, der formålet er å kartlegge bunnforhold og biologisk mangfold i Barentshavet og havområdene utenfor Lofoten. NGU er ansvarlig for å lage geologiske kart av havbunnen og dataene samlet inn i september 2008 vil supplere data fra tidligere tokt, til hjelp i sedimentklassifikasjon og tolkning av havbunnsprosesser.

I tillegg til flerstråledata, ble data fra enkeltstrålelodd og parametrisk sonar logget. Dessuten ble det tatt fire grabbprøver for å samle inn fysiske sedimentprøver av havbunnen til hjelp i tolkningen av de akustiske dataene.

NGU planla linjen som ble oppmålt basert på tidligere prosesserte tilbakespredningsdata fra flerstrålelodd. Det var svært viktig å benytte samme datainnsamlingssetting på flerstråleloddet under hele toktet. Vanligvis varierer settingen med vanndybden, noe som medfører problemer i tolkningen og standardiseringen av data fra forskjellige oppmålinger.

Denne rapporten sammenfatter aktivitetene ombord i M/S H.U. Sverdrup II, viser noen foreløpige resultater og foreslår videre arbeid. Prosessering av dataene fra enkeltstråleekkoloddet viser at hardhet og ruhet samsvarer med grabbprøvene som ble tatt. Prosessering av tilbakespredningsdata fra flerstråleekkoloddet viser likhet med tidligere prosesserte data.

Contents

1 Introduction

The report describes the activities during a four-day transit and survey in September 2008 from Kristiansund to Tromsø. Since FFI's research vessel M/S H.U. Sverdrup II was in transit from the Bergen area to the Barents Sea, it was requested to make use of the transit to acquire data, primarily multibeam backscatter data, whilst underway in areas off the coast of Northern Norway. The areas of interest had earlier been surveyed using a variety of different survey platforms, multibeam systems and data acquisition settings. This has led to backscatter data coverage of variable quality, with backscatter values that are difficult to standardize on a regional basis. This survey provides the first backscatter data coverage acquired using a single multibeam system from a single survey platform over this area. This single line of data will contribute to a dataset that can form a regional baseline for multibeam backscatter data, which will ultimately aid sediment classification off the Norwegian coast.

Besides multibeam echosounder data, single beam echosounder and parametric sonar data were also acquired. In addition, four grab samples were taken to provide physical sediment samples from the sea floor which could assist in interpretation of the acoustic data.

Figure 1.1 FFI's research vessel M/S H.U. Sverdrup II.

2 The survey

M/S H.U. Sverdrup II left Kristiansund at 1600 local time Sunday 21/9 2008 and arrived Tromsø at 0730 local time Thursday 25/9 2008. The transit from Kristiansund to the survey area took about 23 hours, with the first three hours at 10 knots and the remaining 20 hours at 12 knots. The survey ended at 0200 local time on Thursday 25/9 along the coast offshore Tromsø.

The survey area was from 67°N to 70°N and from 11°E to 18°E. In the beginning the survey speed was 6 knots. As the survey progressed the survey speed was increased to 8 knots in order to complete the planned baseline within the time available. The week before the survey a dual swath

option had been installed on the EM 710 multibeam system, since this doubled the ping frequency the increased speed did not result in any significant drop in data coverage.

The survey line was followed as planned, with stops for CTD profiles, grab samples and to accommodate any technical problems. The only deviation from the planned line was outside Bleiksdjupet where it was decided to avoid very deep waters (about 600 m) along the planned line and instead stick to shallower waters around the top of the canyon, thus permitting continued use of the same, shallow water data acquisition settings. At 68°22'N an additional four short lines with 100% coverage, parallel with the planned line, were surveyed to provide additional data coverage. At the end of the transit line, to make full use of some spare time, a parallel line with minimum 10 – 20% coverage was surveyed for about 1-2 hours when heading south towards Tromsø. Figure 2.1 shows the planned survey line in the integrated navigation software used onboard M/S H.U. Sverdrup II. Figure 2.2 shows the planned survey line through previously surveyed areas.

The weather and sea was heavy during the survey, but luckily it was fair wind. Hence, no stops due to the weather conditions occurred.

The multibeam data from the survey are classified as Confidential, since they are within 12 nm from the coast.

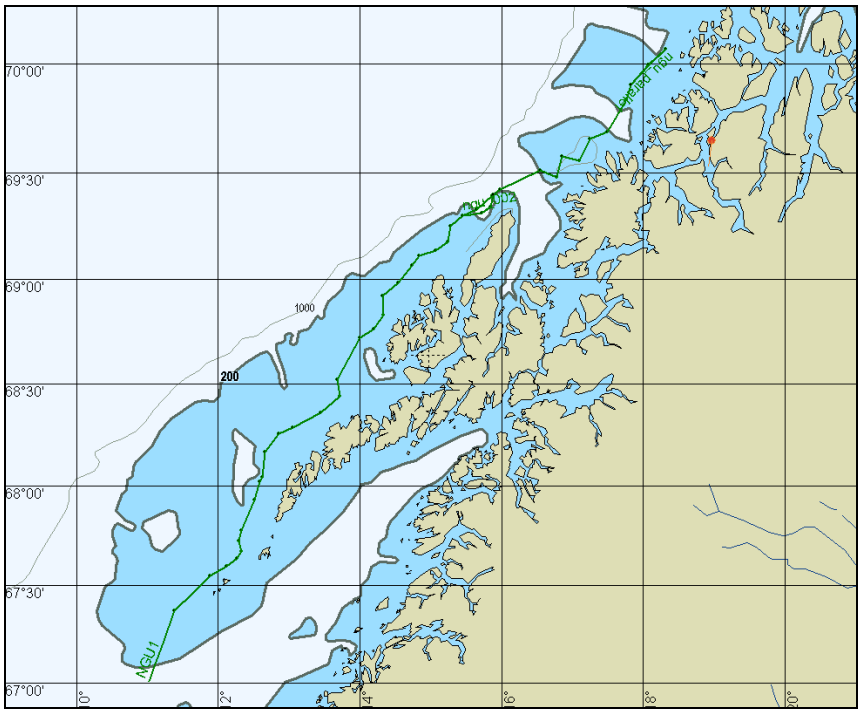

Figure 2.1 The planned survey line shown in the integrated survey software used onboard M/S H.U. Sverdrup II. Outside Bleiksdjupet off Andøya a line closer to shore was chosen in order to avoid too deep waters.

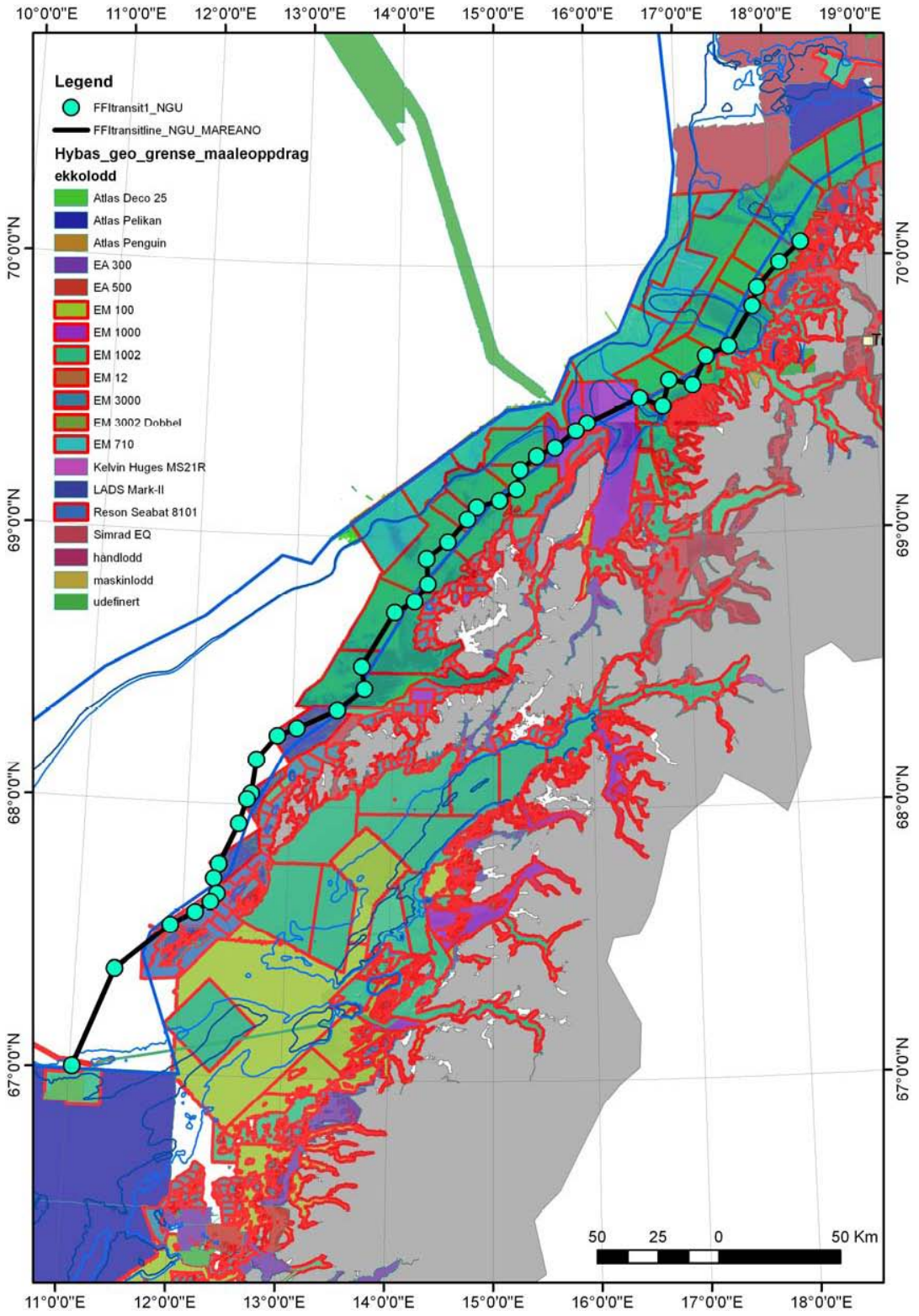

Figure 2.2 The planned survey line, showing passage through areas previously surveyed.

3 Instrumentation and data logging

3.1 Navigation system

The navigation system Skyfix.XP from Fugro Survey was used to positioning the vessel [1]. These data are sent to NaviPac and the survey instruments EM 710, EA 600 and TOPAS. The integrated survey software NaviPac from EIVA was used to plan the survey and graphically present the position of the vessel, speed, heading etc. continuously [2]. NaviPac was set up to UTM zone 33 (central meridian 15°E). All the times are in UTC which is two hours behind local time. Ship motion data (attitude, time and heading) were acquired using Seapath 200 from Kongsberg Seatex [3], and sent to EM 710, EA 600, TOPAS and NaviPac. All the data were logged in ASCII files during the entire survey by the NaviPac system.

3.2 Multibeam echosounder EM 710

Multibeam bathymetry and backscatter data were acquired using the multibeam echosounder EM 710 from Kongsberg Maritime, operating between 70 – 100 kHz with a dual swath option (doubling the ping frequency) [3]. The transmit beam width is 0.5°, while the receive beam width is 1°. Maximum number of soundings per ping is 800 (two profiles per ping).

The data acquisition software Seafloor Information System (SIS) from Kongsberg Maritime was employed for data acquisition and online visualisation. The EM 710 multibeam has several operating modes. The multibeam was run in SHALLOW mode during the whole survey, independent of the water depth. This is different from standard operation during multibeam surveys which are usually optimized for bathymetry data collection rather than for backscatter data. A standard setting was required in order to have the possibility to compare earlier backscatter data from different survey platforms, multibeam sonars and data acquisition settings to this one consistent baseline dataset. Attention to the water depth was however taken when planning the survey line.

The maximum file size was usually limited to one hour, but off the coast of Andøya the data files were of 15 minutes duration as requested by FFI.

The EM 710 water column data were also logged along the baseline.

3.3 Single beam echosounder EA 600

Single beam bathymetry data were acquired using EA 600 from Kongsberg Maritime [3]. The EA 600 has three transducers: 12 kHz, 38 kHz and 200 kHz. The EA 600 was trigged externally from EM 710. If for some reason the EA 600 was not trigged by EM 710, the parametric sonar interfered with the single beam data collection. This was easily visible in the display and was corrected immediately.

3.4 Parametric sonar TOPAS

Parametric sonar data collection was acquired using TOPAS 018 from Kongsberg Defence & Aerospace (KDA) in Stjørdal [4]. The system was set up to receive external trigging from the EM 710. The maximum pinging frequency acceptable by TOPAS is 5 Hz, and when EM 710 is pinging at higher frequencies (in very shallow waters if shallow mode) an error message occurred to indicate that the pinging frequency was too high. The data are not interrupted, the only effect is that some of the pings are not used by TOPAS.

The TOPAS system was difficult to set up so that it would not influence the EM 710 data, and different settings were tried out. The overall goal was to have as least influence on the EM 710 data as possible. This was done reducing the power level. The influence was seen as block holes at nadir. When trying a CW pulse, another reflection 10 m above the real sea floor occurred probably because of interference between the multibeam and TOPAS.

Following discussions with KDA a chirp pulse between 2 kHz and 5.5 kHz was used. The power level could be as low as -9 dB. The settings of the TOPAS used are listed in Appendix A.

TOPAS data were processed on-board. Both raw files and processed files were stored. The disk the TOPAS data were stored to, ran 6 minutes too fast. Hence the times the files were saved, are not correct.

3.5 CTD profiles

CTD measurements were carried out to provide sound velocity profiles to be exported to EM 710. The standard CTD probe on M/S H.U. Sverdrup II is a Falmouth Scientific model CTD-BP-702-STD as shown in Figure 3.1 [5]. The acquisition and post-processing software is called FSIPost from Falmouth Scientific Inc, USA.

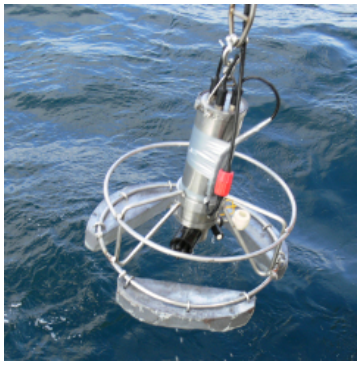

Figure 3.1 The CTD probe.

The CTD winch broke down twice. During the reparations the surveying continued. In total 16 CTD profiles were done; three 22/9, six 23/9 and seven 24/9. Table 3.1 lists position and water depth of each of the profiles. Figure 3.2 shows the position of the CTD along the survey line. The measured sound velocity profiles are plotted in Figure 3.3. This plot shows that a warmer surface

layer was present. However, the depth of this layer varied from 25 m to 110 m between the profiles in different areas. The surface temperature also varied from 1487 m/s to 1495 m/s.

Date	Time UTC (hh:mm:ss)	Profile name	Depth (m)	Velocity (m/s)	Latitude (dd mm.mm)	Longitude (ddd mm.mm)
09/22/2008	13:02:34	220908_01	252	1495.4	66 59.93 N	011 00.85 E
09/22/2008	17:52:53	220908_02	181	1494.6	67 10.61 N	011 11.15 E
09/22/2008	21:05:44	220908_03	127	1492.0	67 25.34 N	011 30.83 E
09/23/2008	03:24:30	230908_01	123	1491.9	67 47.64 N	012 21.47 E
09/23/2008	06:39:22	230908_02	156	1492.4	68 01.60 N	012 35.81 E
09/23/2008	10:34:11	230908_03	111	1491.9	68 15.80 N	012 52.93 E
09/23/2008	13:10:09	230908_04	137	1490.7	68 20.58 N	013 22.56 E
09/23/2008	17:23:53	230908_05	170	1491.3	68 22.31 N	013 30.05 E
09/23/2008	21:54:38	230908_06	141	1491.5	68 37.31 N	013 50.48 E
09/24/2008	01:37:14	240908_02	206	1490.4	68 52.95 N	014 20.84 E
09/24/2008	05:59:41	240908_03	169	1490.2	69 06.66 N	014 50.24 E
09/24/2008	09:13:21	240908_04	137	1490.5	69 18.64 N	015 38.97 E
09/24/2008	12:12:11	240908_05	327	1489.9	69 26.36 N	016 07.92 E
09/24/2008	16:39:49	240908_06	123	1490.2	69 32.93 N	017 05.57 E
09/24/2008	18:43:29	240908_07	372	1488.2	69 43.43 N	017 33.81 E
09/24/2008	20:13:04	240908_08	118	1487.5	69 51.46 N	017 47.25 E

Table 3.1 Position of CTD profiles. The velocity column gives the sound velocity at the surface.

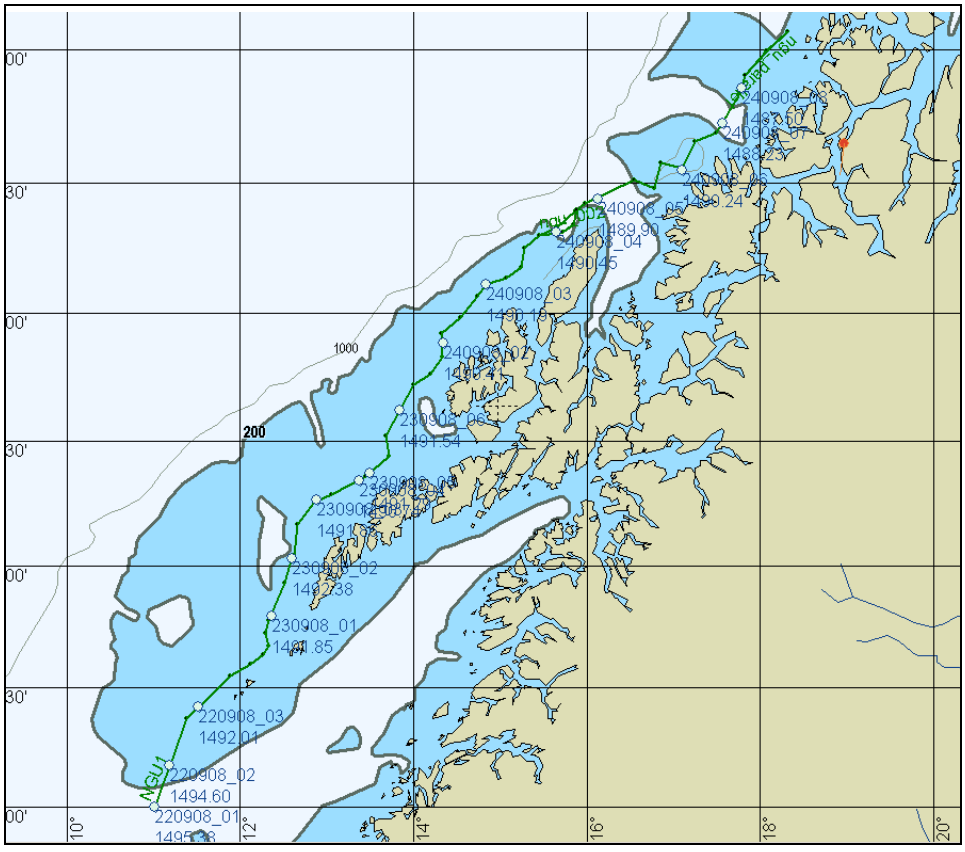

Figure 3.2 Position of the CTD profiles shown in the map (white circles along the survey line).

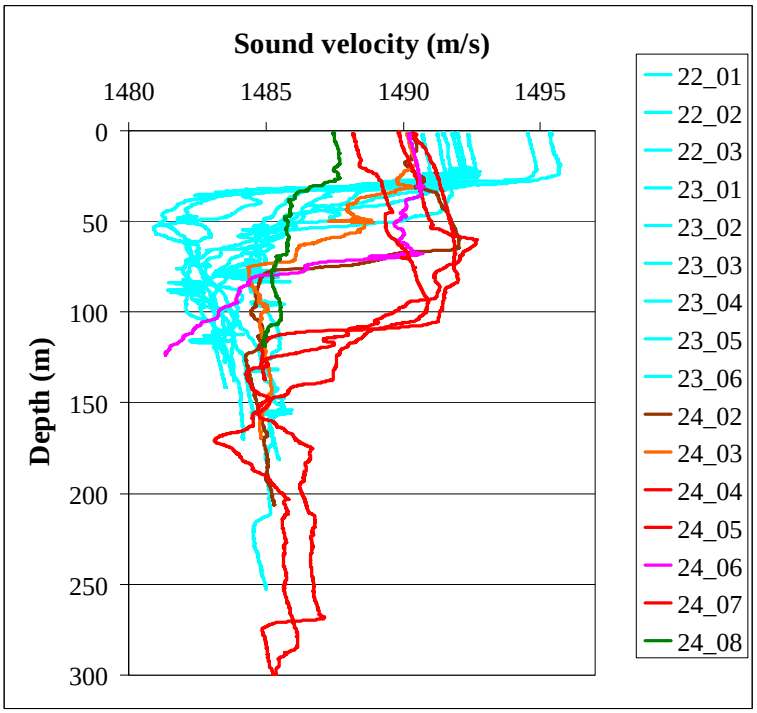

Figure 3.3 Plot of the sound velocity profiles.

3.6 Grab samples

Grab samples were obtained using the grab shown in Figure 3.4. A transponder was fastened to the wire and the acoustic underwater positioning and navigation system HiPAP from Kongsberg Maritime was used to position the grab relative to the vessel during the drop [3]. The grab was retrieved when the transponder showed the sea floor was reached.

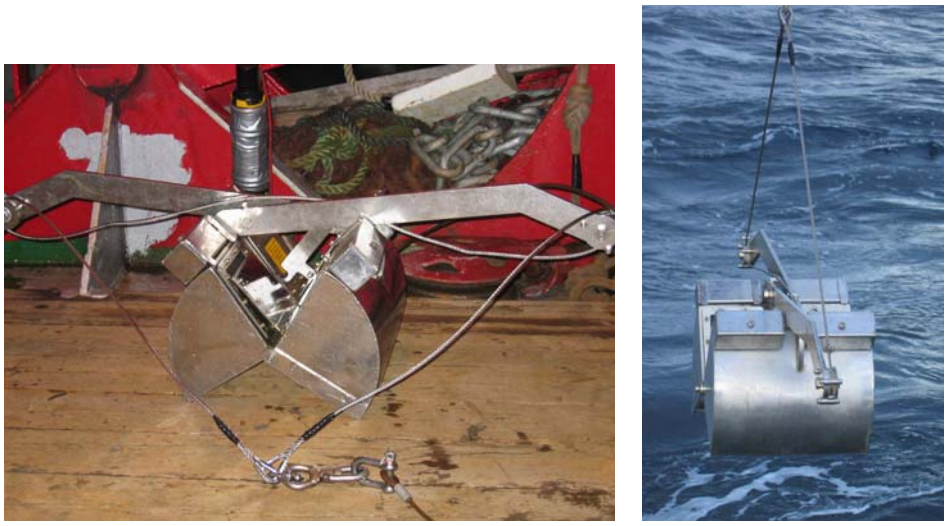

Figure 3.4 The grab used to collect grab samples from the sea floor. A transponder was fastened to the wire in order to know when the sea floor was reached.

Four grab samples were successfully obtained. In addition, one grab attempt collected a single stone. It was difficult to deploy the grab effectively due to strong currents and deep waters and many of the trials failed. Table 3.2 lists the position of the vessel and water depth as the grab hits the sea floor. The position of the grab is not stored. Due to strong currents, the grab could be about 50 m from the vessel. Figures 3.5 – 3.6 show photos of the four grab samples. A short description of the sediment samples are given in Table 3.2. Listing the samples from fine to coarse by inspection onboard, the sequence is: # 1, # 4, # 2 and # 3.

Figure 3.5 Grab samples # 1 and # 2.

Figure 3.6 Grab samples # 3 and # 4.

Grab #	Date	Time UTC	Latitude (dd mm.mm)	Longitude (dd mm.mm)	Depth (m)	Description
1	22/09/2008	17:26:55	67 11.202 N	11 11.623 E	191	Grey – sandy mud
2	23/09/2008	06:24:59	68 01.461 N	12 35.392 E	178	Brown – sand with stones
3	23/09/2008	10:21:30	68 15.687 N	12 52.466 E	117	Black – gravel
4	24/09/2008	16:20:05	69 33.253 N	17 06.123 E	129	Brown – sand with sea urchin? & worm
	23/09/2008	~17:00	68 22.30 N	13 30.51 E		One stone of a few cm

Table 3.2 The obtained grab samples in the survey in September 2008. Listing the samples from fine to coarse by inspection onboard, the sequence is: # 1, # 4, # 2 and # 3.

3.7 Weather data

Weather data were not logged during the survey, but a daily report was sent to FFI as listed in Table 3.3. Wind speed and direction were displayed continuously in the lab. The wind direction was mostly from south west/west and hence giving fair wind. The wind speed was up to 20 m/s during the survey.

Date and time (UTC)	Wind direction	Wind speed (m/s)	Sea state	Temperature (°C)	Pressure (bar)	Heaven
22/09/08 08:50	240°	9	4	10	1032	Partly cloudy
23/09/08 08:40	210°	10	5	8	1027	Cloudy
24/09/08 08:50	330°	6	3	5	1032	Partly cloudy

Table 3.3 Weather data during the three survey days.

4 Manning

M/S H.U. Sverdrup II was manned with six persons during the transit survey from 21/9 – 25/9 2008.

Personnel from Forsvarets Forskningsinstitutt/Norwegian Defence Research Establishment:

Ellen Johanne Eidem (party chief)
Gisle J. Bjørneseth
Martin J. Ohldieck

Personnel from NAVOCEANO (Naval Oceanographic Office, USA):

Dave Sanders
Jack Vice

Personnel from Norges geologiske undersøkelse/Geological Survey of Norway

Margaret Dolan

Bjørneseth and Sanders were responsible for the data logging in each 12 hour shift. Dolan was supervising the survey. Ohldieck assisted during the day shift whenever necessary.

Dolan and Eidem embarked in Kristiansund, while the remaining four were already onboard. Dolan, Ohldieck and Eidem disembarked in Tromsø, while the remaining three continued.

5 Preliminary results and further work

5.1 Multibeam echosounder data

Multibeam backscatter data will be processed by NGU. Initial processing shows the data to be of good quality, except in a few areas due to sea conditions. Some examples of the data are shown in Figures 5.1 – 5.3.

The backscatter values from these multibeam data will be compared with those obtained in previous surveys and used to help level the data from existing surveys for presentation of the regional dataset. This is required for regional mapping such as that underway in the MAREANO programme [6].

In order to calibrate the backscatter values from this new baseline dataset in terms of sediment properties the sediment samples obtained during the cruise will be sent for grain size analysis.

It will be helpful if future transits by FFI/NGU and others can extend the supporting dataset, with additional sediment samples, video observations etc. Any further opportunities for M/S H.U. Sverdrup II to build on this initial backscatter data coverage with further EM 710 data would also be a welcome contribution to this regional baseline dataset, which will ultimately aid sediment classification off the entire Norwegian coast.

Multibeam bathymetry data were not the primary focus of this survey, however it is possible that these data could be useful, particularly at NGU for the examination of mobile bedforms, e.g. sandwaves, which could have shifted since the earlier multibeam surveys were undertaken.

EM 710 water column data are of interest particularly in relation to fish distribution and/or gas seepage from the seabed. These data were acquired and have been archived. They should be examined further once NGU/FFI obtain software which enable processing and visualisation of such data. Since EM 710 is a relatively new multibeam and water column data processing is an emerging science, at present there is a lack of commercially available software for this work.

5.2 TOPAS data

TOPAS data will be further processed and interpreted at NGU and compared with backscatter results for the interpretation of sediment distribution.

5.3 Single beam echosounder data

The single beam data were processed by FFI using the classification software SeaBec from Kongsberg Maritime [3]. Plots of hardness and roughness are shown in Figure 5.4. Special sections are shown in Figures 5.5 – 5.7. The computed values are relative, and the scales are

restricted to enhance different areas. Only data from the survey are used to make the model in SeaBec. The model used is 10 m reference depth, start depth -0.5 m and stop depth +2 m. Data from 38 kHz and 200 kHz are used to estimate the hardness and roughness.

According to the SeaBec processing an area of soft bottom (blue) is observed in the south. Further north areas of hard bottom (red) are observed. Andfjorden is the area with least roughness (blue), see Figure 5.5.

Studying the area were the grab samples were taken, we see some correlation between the hardness and the physical sample of the sea floor, see Table 5.1. The finest, muddy sediment sample (# 1) has low hardness and low – medium roughness (relative values), while the coarse, gravel sediment sample (# 3) has high hardness and medium – high roughness. The low hardness of the sea floor in the area where grab sample # 4 was obtained, is shown in Figure 5.7

Grab	**Inspection of sample onboard**	**Hardness**	**Roughness**
# 1	Fine	Low	Low - medium
# 4	⇓	Low	Medium
# 2	⇓	Low - medium	Medium
# 3	Coarse	High	Medium – high
Stone		Low - medium	Medium

Table 5.1 Hardness and roughness in the area were the grab samples were obtained, according to the classification software SeaBec processing the single beam echosounder data. Comparison with the results of the inspection of the grab samples onboard, show correlation between the SeaBec processing and the physical samples.

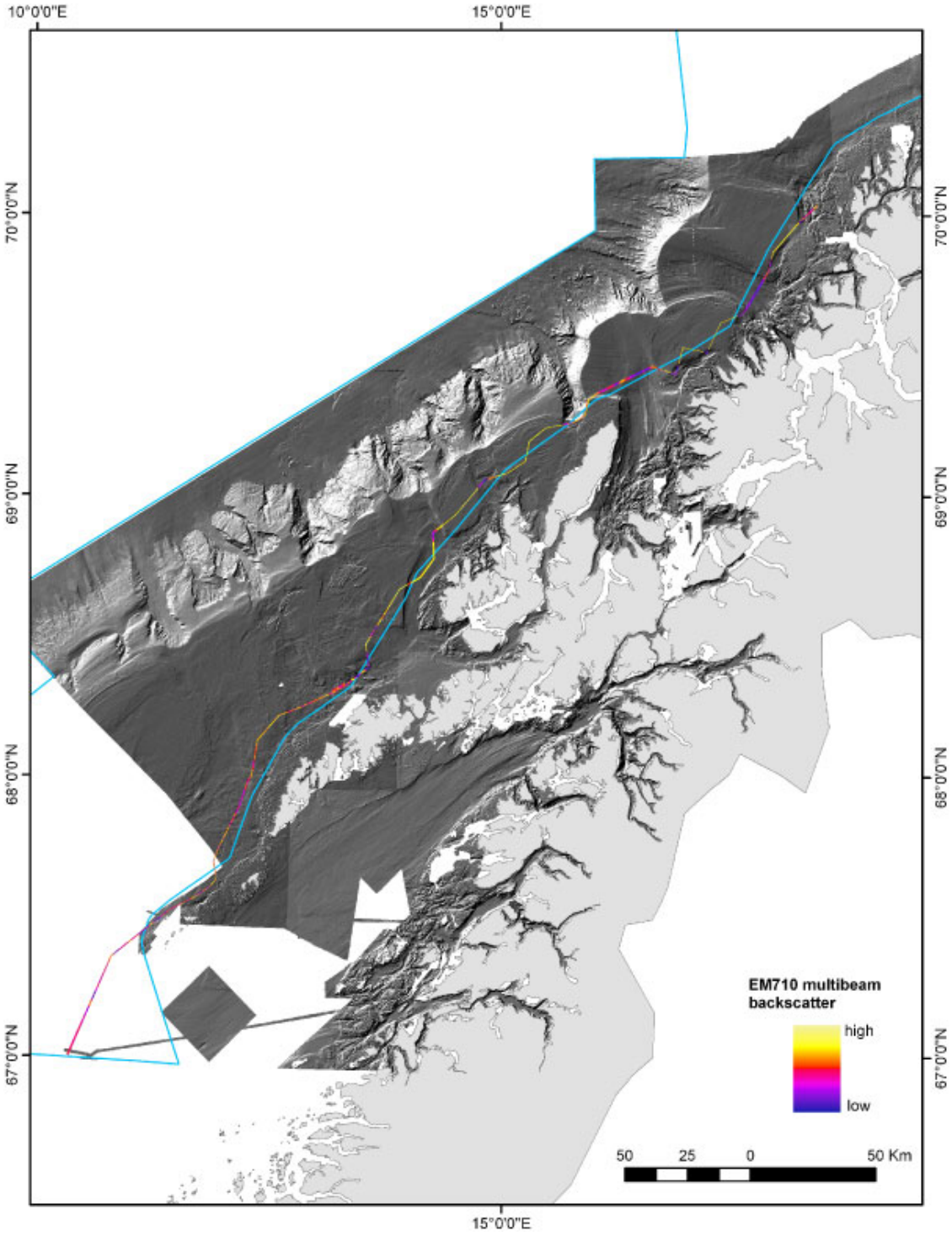

Figure 5.1 Overview map showing EM 710 multibeam backscatter data acquired along the entire survey line. The MAREANO-programme boundary is shown in blue for reference and existing multibeam bathymetry data are shown as shaded relief.

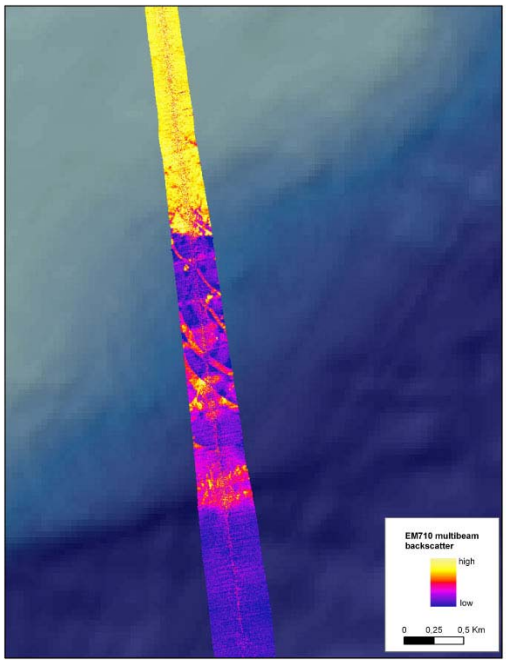

Figure 5.2 Example of EM 710 multibeam backscatter data acquired during transit between a deep through with soft sediments onto a shallow bank with harder, more compact sediments. Backscatter data are gridded at 5 m resolution. Colour shaded bathymetry shown in the background at 50 m resolution – dark blue indicates deeper water.

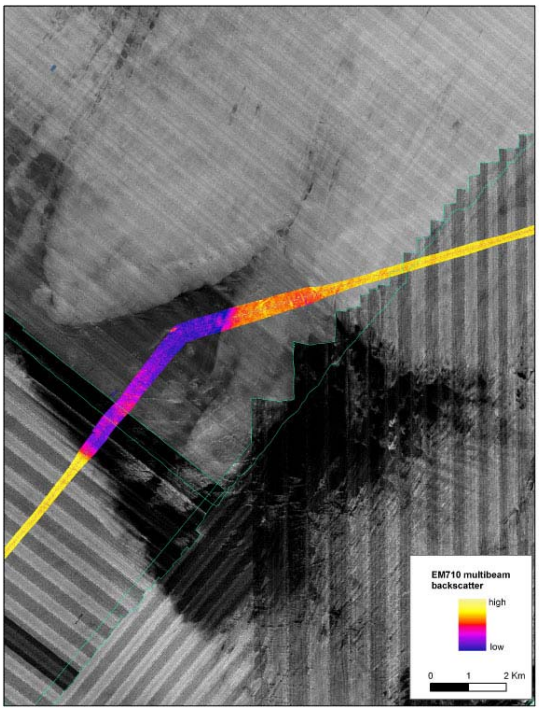

Figure 5.3 Example of EM 710 multibeam backscatter data crossing the boundary between data from 3 different previously acquired surveys. Data from the single-swath baseline survey will assist in levelling values between these previous surveys.

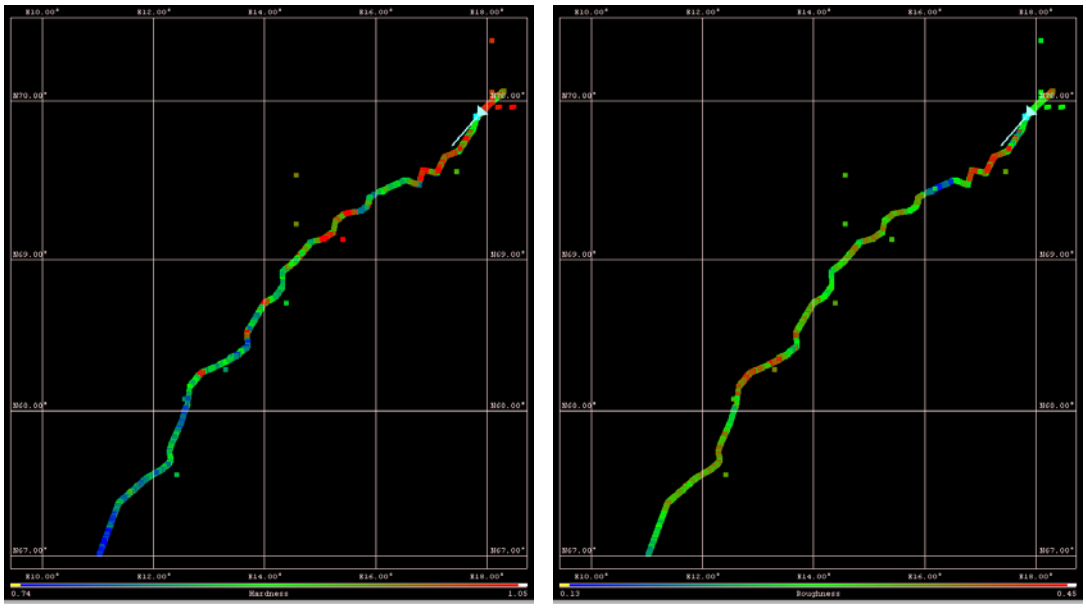

Figure 5.4 Estimation of the hardness (left) and roughness (right) according to the classification software SeaBec from Kongsberg Maritime processing the single beam echosounder data (low values are blue, high values are red).

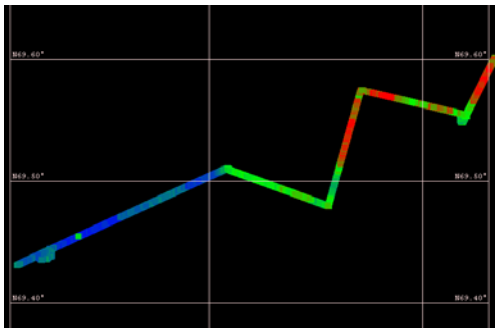

Figure 5.5 Section of Figure 5.4 showing low roughness across Andfjorden (blue), and high roughness further north (red).

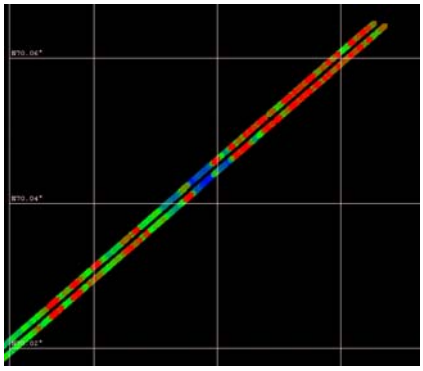

Figure 5.6 Section of Figure 5.4 showing areas with high (red) and low (blue) roughness at the end of the survey line.

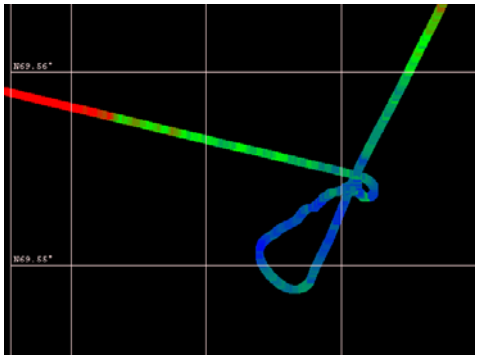

Figure 5.7 Section of Figure 5.4 showing low hardness (blue) where the grab sample # 4 was obtained.

References

[1] www.fugro.no
[2] www.eiva.dk
[3] www.km.kongsberg.com
[4] www.kongsberg.com
[5] www.falmouth.com
[6] www.mareano.no

Appendix A TOPAS settings

ACQUISITION SETTINGS

Transmitter
Transmit mode: Normal
Trigger mode: External
Pulse Form: Chirp
Start frequency (kHz): 2.0
Stop frequency (kHz): 5.5
Chirp Length (ms): 15.0
Power Level (dB): -3dB to -9dB
HRP: checked
Beam Control: Auto
Tx Sound Speed (m/s): 1480 – 1485 m/s

Receiver 1
Delay Control: Manual
Master Trip Delay: to be set according to water depth
Delay Offset: 10.0
Sample Rate (kHz): 24.0
Trace Length (ms): 250.0
Gain (dB): to be set
HP-filter (kHz): 1.0

PROCESSING

Filters
Enabled: checked
Filter Type: Matched
Corner Frequencies: Manual
Low Stop (Hz): 1900
High Pass (Hz): 2100
Low Pass (Hz): 5400
High Stop (Hz): 5600
Replica Shaping: checked

Time Varying Filter
Enabled: not checked

Mute
Enabled: not checked

Reverberation
Enabled: not checked

Stacking
Enabled: not checked

Automatic Gain Control
Enabled: not checked

Time Variable Gain
Enabled: checked
TVG: tracking
Offset (ms): 0.0

Section:	length	slope
A-B:	7.1	1.25
B-C:	14.7	0.67
C-D:	27.0	0.05

Attribute Processing
Enabled: checked
attributes: inst. amplitude

Gain
Enabled: checked
Auto Gain: not checked
Gain (dB): to be set