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The international project on Ocean CO_2 sequestration

Baseline survey at a proposed experiment site off Norway, 19-26 July, 2002

Norwegian Institute for Water Research

Main Office
P.O. Box 173, Kjelsås
N-0411 Oslo
Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

Regional Office, Sørlandet
Televeien 3
N-4879 Grimstad
Norway
Phone (47) 37 29 50 55
Telefax (47) 37 04 45 13

Regional Office, Østlandet
Sandvikaveien 41
N-2312 Ottestad
Norway
Phone (47) 62 57 64 00
Telefax (47) 62 57 66 53

Regional Office, Vestlandet
Nordnesboder 5
N-5008 Bergen
Norway
Phone (47) 55 30 22 50
Telefax (47) 55 30 22 51

Akvaplan-NIVA A/S
N-9005 Tromsø
Norway
Phone (47) 77 68 52 80
Telefax (47) 77 68 05 09

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Abstract

A survey of a proposed experiment area off the west coast of Norway was conducted in July 2002 for the planned International CO_2 Sequestration Experiment. The survey consisted of echo sounder transects, ROV dives, CTD profiles, carbon chemistry analysis, ^{13}C /bacterial production rates, sediment grab samples, scavenger trap deployments, long line fishing, fish trap deployments, trawling, zooplankton net hauls, and ADCP current measurements. Based on the survey results, a recommendation for an exact location for the upcoming field experiment has been made. Necessary background and baseline data for the design of the field experiment and sampling scheme were collected.

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Project manager

Research manager

Research director

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Baseline survey at proposed experiment site off Norway, 19-26 July, 2002

International Project on Ocean CO_2 Sequestration

Preface

The survey described in this report was performed as part of the International Project on Ocean CO_2 Sequestration. The main objective of the survey was to identify a suitable site for an experimental release of liquid CO_2 at about 800 m depth in an area northwest of Kristiansund, Norway (Storegga continental shelf break). Furthermore, baseline data on benthic and pelagic biology, sediment and water chemistry, hydrography and current dynamics was to be gathered.

We are indebted to the crew of R/V Håkon Mosby (Institute of Marine Research, Bergen) and the pilots of the ROV Aglantha (University of Bergen) for their efforts at accomplishing a very wide range of tasks in a limited amount of time.

The project has been supported by Massachusetts Institute of Technology (MIT), Natural Resources Canada (NRC), Naval Research Laboratory (NRL), Norwegian institute for Water Research (NIVA), Norwegian Research Council (NFR), Pacific International Center for High Technology Research (PICHTR), Research Institute of Innovative Technology for the Earth (RITE) and US Department of Energy (US DoE).

Bergen, Dec. 20, 2002

Arild Sundfjord

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Summary

From July 19 to 26, 2002, a background hydrographic survey of the proposed experiment area for the planned International CO_2 Sequestration Experiment, near Storneset off the west coast of Norway, was conducted. The survey was performed from the R/V Håkon Mosby with participants from Norwegian Institute for Water Research (Norway), Massachusetts Institute of Technology (USA), University of Hawaii (USA), Hawaii Pacific University(USA), University of Bergen (Norway), Institute of Ocean Sciences (Canada), Naval Research Laboratory (USA), Institute of Marine Research (Norway), and Hareide Fiskericonsult (Norway). The survey had two primary goals:

1. To identify an exact location for the upcoming field experiment.
2. To collect background and baseline data for the design of the field experiment and sampling scheme.

This report summarizes the activities conducted to meet these survey goals.

The survey consisted of many related activities, including echo sounder transects, ROV dives, CTD profiles, carbon chemistry analysis, ^{13}C /bacterial production rates, sediment grab samples, scavenger trap deployments, long line fishing, fish trap deployments, trawling, zooplankton net hauls, and ADCP current measurements.

Based on these data, three potential sites with the desired characteristics were identified. The southernmost site, referred to as region 1, is our recommended location. This site is characterized by the following:

1. *Topography*: Area of ~500 x 500 m, with very mild slope (< 5 %) in the southeast to northwest direction. Some ridge-like features were captured by the echo-sounder and confirmed by ROV observation. In the flat regions there are randomly dispersed depressions averaging about 30 cm deep and 50-100 cm in diameter.
2. *Sediments*: Soft sediments of biogenic origin condusive to coring. Box cores revealed soupy brown surface (upper 3-4 cm), firmer but still fine-grained gray clay deeper down, with streaks of black inbetween.
3. *Benthic biology*: Deployed scavenger traps were successful in collecting large numbers of brightly colored amphipodes in a matter of a few hours, which indicates that the use of traps to collect and observe organisms will be successful. The bottom biology was typical of what would be expected at these depths and temperatures.
4. *Currents*: Tides are primarily controlled by tides. Typical current velocities between 2 and 15 cm/s (average ~7 cm/s) were found in the deepest 100 m.
5. *Hydrography*: CTD profiles and selected water samples show small temporal and spatial variability. Plume detection should therefore be feasible. The stratification is very weak in the deeper part of the water column (buoyancy frequency of $N = 0.0008\ s^{-1}$).
6. *Water chemistry*: Background samples necessary to characterize the site and design the methods for the upcoming experiment were successfully collected.
7. *Water column biology*: Various zooplankton and nekton species were caught using towed nets and trawl, at depths down to ~700 m. The catches were small, reflecting the relative scarcity of pelagic life in the cold water found at intermediate depths in this area.

1. Introduction

This report is based on observations and measurements made during an eight-day cruise with the R/V Håkon Mosby of Bergen in the Norwegian Sea in July 2002. The cruise was part of the preparations for a planned experimental ocean release of CO_2, to be performed by the International Ocean CO_2 Sequestration Project group.

The report consists of brief descriptions of the area (Ch. 2) and the survey program (Ch. 3), and separate chapters on the various survey, sampling and analysis activities, each including descriptions of method and preliminary results (Ch. 4-8). More results are given in Appendices A-E.

Cruise participants, their respective main survey tasks, and primary report contributions:

Arild Sundfjord, NIVA, Norway; Chief Scientist, current measurements, 1-3, 5 + editing
Scott Socolofsky, MIT, USA; bathymetry survey; 4.1, 4.2 + editing
Craig Smith, UH, USA; benthic biology; 4.3, 8.2.1, 8.3
Eric Vetter, HPU, USA; benthic biology; 4.3, 8.2.1, 8.3
Reidun Gangstø, GFI, UIB, Norway; hydrography; 6
Melissa Chierici and Agneta Fransson, IOS, Canada; carbon chemistry; 7.1
Rick Coffin and Keri Beeson, NRL, USA, C-14/bacterial production rates; 7.2
Magnus Johannessen, IMR, Norway, pelagic biology: trawl, plankton nets + grab; 8.1
Nils Roar Hareide, Hareide Fiskericonsult, Norway; bottom nekton; long-lines+traps; 8.2.2-3

2. General description of the area

Storneset is located around 60 Nm northwest of Kristiansund in western Norway (see map on report cover). The area is part of the shelf break between the shallow (typically less than 300 m depth) continental shelf and the deep Norwegian Sea (more than 3000 m depth). The survey area (**Figure 1**) is characterized by a relatively gentle slope of typically less than 5% with bathymetric undulations (local ridges, mounds) with height up to 10-20 meters. The bottom mostly consists of soft sediments of biological origin with scattered rocks transported to the site during the last ice age.

Three water masses dominate the area. From the surface and down to 50-100 m there is typically some influence by freshwater input and rapid heating during summer. Surface salinities around 32 and temperatures up to 15°C were measured during this survey. Below this layer, water with temperature typically between 6 and 9°C and salinity of 35.2 is found. This intermediate layer reaches down to approximately 400 m depth. A pronounced thermocline between 350 and 600 m marks the transition to the colder deep water, with temperatures of < 0.5 °C and salinity of about 34.8-34.9.

The northbound Norwegian Current dominates the flow field in the upper layer down to about 400 m depth. The general northward water transport is modified by tides, wind and air pressure variations in the area. The current velocities in the deeper water mass are usually significantly lower, primarily being forced by tidal energy.

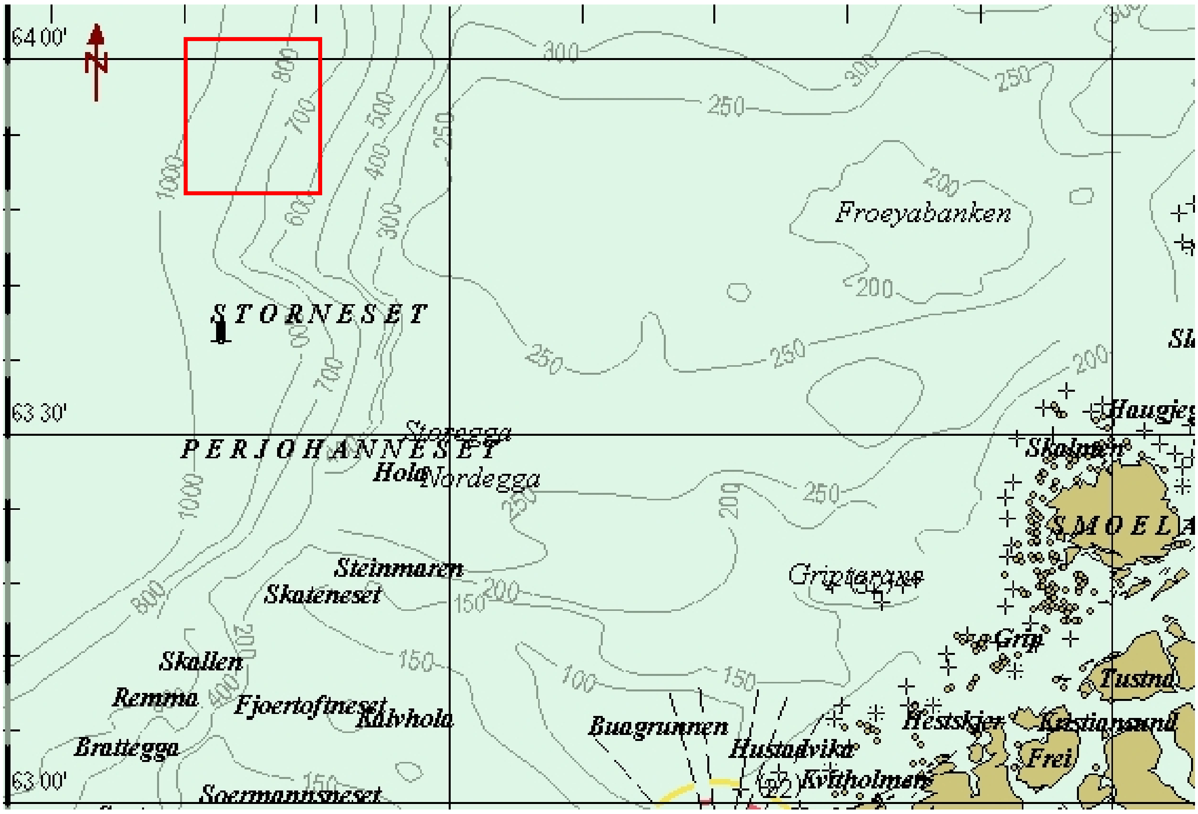


Figure 1. Map of area NW of Kristiansund, with the pre-survey site at Storneset indicated by box.

3. Survey and sampling program

During the survey, a measurement program of biogeochemical parameters was undertaken: bathymetry, sediment composition, hydrography and water column chemistry, currents, and pelagic and benthic communities including bacteria. See **Figure 2** for survey and sampling locations. The following list provides an overview of the different tasks and measurements performed (number of hours/times in parenthesis where relevant):

- Echo sounder transects (~20 hrs)
- ROV dives (4, dive time ~10 hrs)
- CTD profiles incl. pH (11)
- Carbon chemistry analysis
- C13/Bacterial production rates
- Sediment grab samples (8)
- Scavenger trap deployments (3)
- Long line fishing (1)
- Fish traps deployments (2)
- Trawling (2)
- Zooplankton hauls (3)
- ADCP current measurements (4 days)

The cruise participants boarded and loaded equipment on the R/V Håkon Mosby (www.gfi.uib.no) in Bergen beginning around 1300 hrs, July 19. Shortly after midnight the final test of the ROV Aglantha was done and the vessel was ready to steam for the investigation site. Storneset was reached around 0230 on the morning of the 21st. Time spent on site was four full days (approximately 100 hrs), with R/V Håkon Mosby leaving for Bergen at 0700 July 25. (A more detailed cruise schedule showing all the activities performed during the survey can be found in Appendix E.)

Weather conditions were good during all of the time spent on the survey site with 3-hour average wind speeds of typically 3-6 m/s and significant wave height estimated to be < 1,5 m. Winds of gale force were encountered along the coast both while transiting to and from the site.

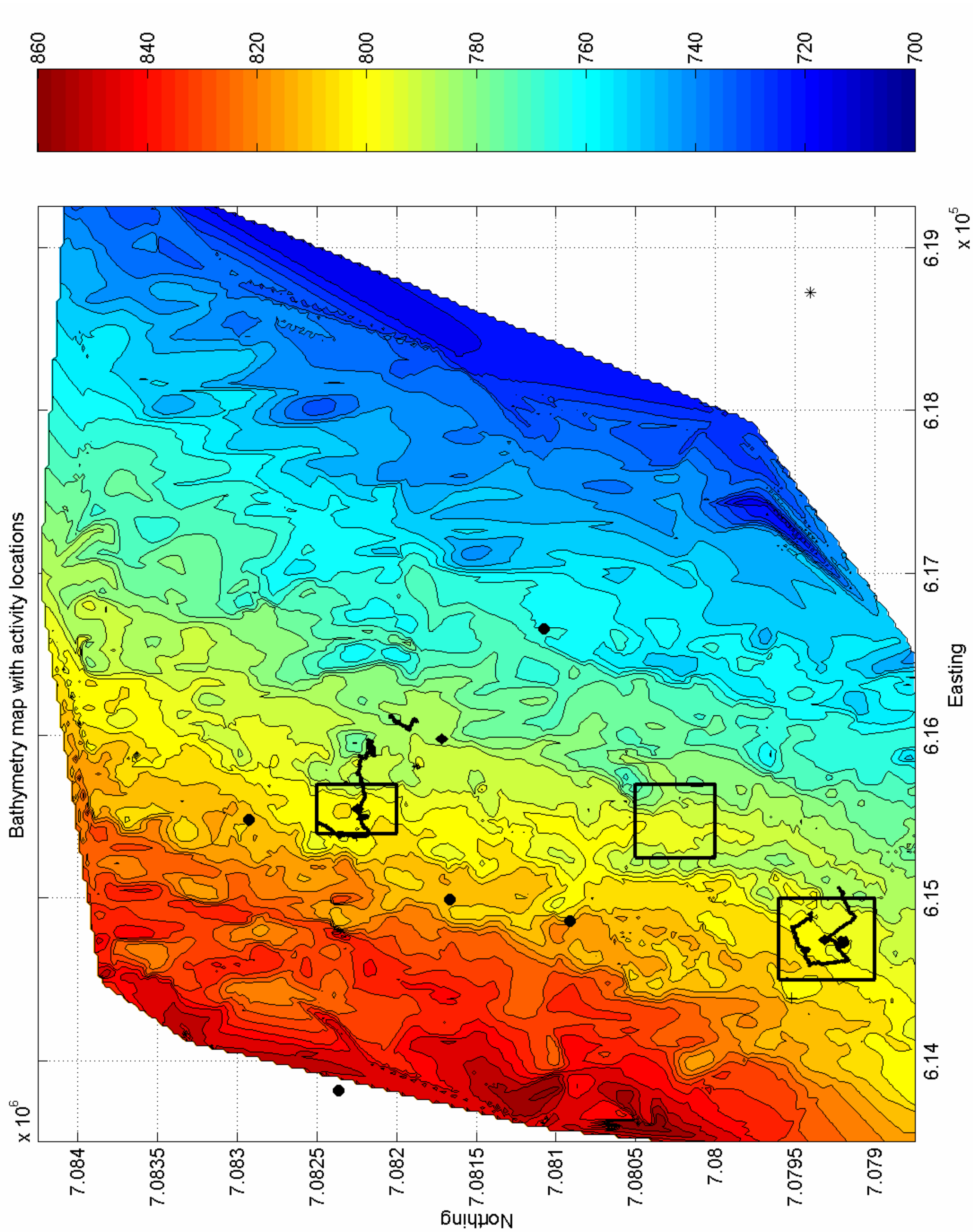


Figure 2. Bathymetry map, generated from echo sounding transects, showing the locations of survey/sampling activities. Boxes are the three identified regions (1, 2, 3 from south to north), dots are CTD casts, diamonds are sediment samples, the small plus sign (+) west of the northern part of region 1 is the ADCP mooring, and the dark transect lines are the ROV survey paths. Coordinates are UTM, the color scale on top shows depths in meters, contour lines are of 5 m intervals.

4. Bottom Survey

4.1 Echo-sounder bathymetry survey

The purpose of the bottom bathymetry survey was to identify exact sites suitable for the upcoming International CO_2 Sequestration Experiment. Site selection criteria used were as follows:

1. *As flat a region as possible*. The main purpose of this criterion is to prevent the CO_2-enriched seawater from flowing downhill in a density current. The secondary purpose of this criterion is to provide a large landing zone for the deployment of the CO_2 injection unit.
2. *As homogeneous surroundings as possible*. Regions surrounded by large topographic features should be avoided to minimize variation and turbulence associated with topographic steering of the current field.
3. *Avoid the region near the underwater landslide ("Storeggaraset") to the South*. This also avoids complicated currents associated with the landslide area.
4. *Prefer regions in water less than 800 m to regions in water deeper than 800 m*. Because the density profile becomes very weakly stratified near 800 m, the project should avoid going too deep, where the plume would not be as effectively affected by stratification as it rises.
5. *Suitable sediments for the biology portion of the project*. This includes the ability to collect sediment cores and the abundance of suitable benthic life.

A hull-mounted Simrad EK500 echo sounder was used for the survey. This is an 8° split-beam instrument operating at 38 kHz. Available data from the bathymetry survey are logging files and maps based on these, and the original paper print-outs of transects. The bathymetric maps were produced using a cubic spline method in Matlab© (see sample plot in **Figure 2**).

Echo Sounder Survey 1
It was decided to start with a rather large area (see **Figure 3**), based on existing maps and distance from steep topography to the south (see **Figure 1**, near the name "Storegga"). After arriving on site at about 0230 on July 21, an initial bottom survey was conducted in the northern part of the region defined in the experiment release permit application[1]. The survey path with labeled turning points is shown in **Figure 3**. The long line from points 1 to 7 was chosen to survey near 795 m depth, and transects from odd to even points between points 7 and 17 were chosen to cover the maximum slope.

The topography from points 1 to 5 is generally smoother than from points 5 to 7. During this initial survey, flat regions were identified on the contouring line near point 4 and along the transect lines near point 13. Since we wanted to avoid the southernmost region and the initial survey results were promising, the survey was interrupted at point 17 and additional contour paths along 805 m depth and 790 m depth were made between points 4 and 5.

Echo Sounder Survey 2
The second night of surveying focused on the full region between points 13 and 17. A series of East-West transects with about 500 m spacing were made. After contouring the data from the first two surveys, it was decided to make the second ROV dive near point 13. This dive revealed very steep slopes to the west and large topographic features to the east with a fairly flat region about 250-300 m wide in the east-west direction. This information suggested that point 13 was not an optimal site.

Echo Sounder Survey 3
The third night of surveying focused on the sub-regions near points 17 and 13. East-west transects were made in these regions with spacing of about 125 m. After contouring the data, it was decided to make the third ROV dive near point 17. The ROV dive showed that the region was mostly flat with

[1] Application to SFT (Norwegian Pollution Control Authority) for permission to carry out an experimental release of CO_2 (Carbon dioxide) in deep waters in the Norwegian Sea. NIVA 2002.

some fine-scale ridge-like topography in the western half of the survey region. This fine-scale topography was also seen in the computer processed contour map which provided ground-truthing to the contoured bathymetry data.

Echo Sounder Survey 4
The fourth night of surveying collected north-south transects with about 100 m spacing through the area near points 13 and 17. These transects increased the resolution of the contoured data in these regions, but did not reveal any significant new features.

Echo Sounder Survey 5
A final set of cross- and along-slope transects where taken through the southernmost region during the early evening of July 24. Based on all the bathymetry data and the ROV dives, three potential regions were identified. These regions along with all survey paths and the point labels are shown in **Figure 4**.

4.2 ROV video survey

A total of 4 dives were carried out with the ROV Aglantha (University of Bergen). The ROV is equipped with color and b/w analog video cameras and one color digital video camera, sonar, CTD, manipulator arms and a positioning system. Based on observations from the ROV dives, the bottom can be characterized as smooth with soft sediments of biological origin. The large-scale topography recorded by the echo sounder was also found by the ROV. Fine-scale depressions up to half a meter in depth and several meters wide were also identified by the ROV. These depressions were the most mild in region 1, as described in the previous section. Available data from the four ROV dives: video footage of dives (including time, depth, salinity, temperature), log files with position data of mother ship + ROV, sonar data files, and CTD data. A brief summary of each dive follows.

Dive 1
About 1 hr bottom time within a region between points 13 and 14 which was identified as smooth based on the first night's echo transects (see **Figure 2**, short survey path east of Region 3). Only a short distance was covered due to problems with cable drag, associated thruster sediment stirring, and ROV ground-fault failure after 1 hr bottom time. The cable fault proved to be caused by the umbilical cable being dragged across sharp rock or coral features behind the ROV.

Dive 2
2.5 hrs bottom time within Region 3 (northernmost potential site), starting east of area. After initial adjustments, the ROV moved westwards and encountered a ridge-like feature running N-S, approximately 5 m high and rather steep. It then turned northwards for ~100 m, NE for ~100 m until communication again was disrupted and the ROV retrieved.

Dive 3
Survey of Region 1, the southernmost potential site, for about 2 hrs. General: large flat areas (often sloping slightly towards W or NW), with irregularly distributed depressions of diameter typically 30-50 cm, depth 10-20 cm (largest possibly over 1 m diameter, 30-40 cm deep). These depressions were milder than those identified on the previous dives. Some very few rocks, or possibly sponges, were observed, their maximum height being 25-30 cm.

Dive 4
2.5 hrs of bottom time in region 1. One scavenger trap was left on the bottom and the surrounding area surveyed. The trap was not recovered due to large amounts of sediments being suspended by ROV thrusters and cable, causing poor visibility.

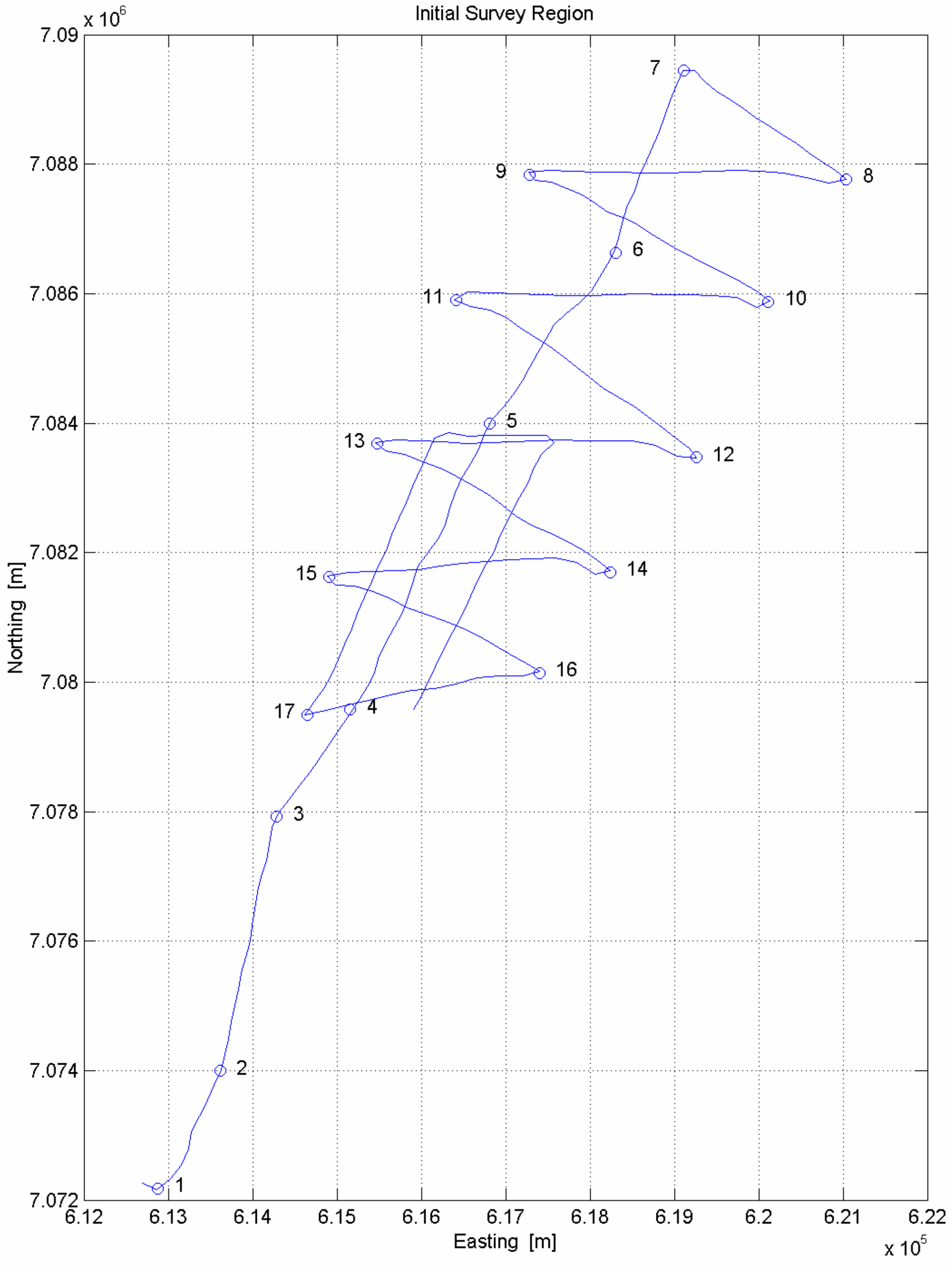


Figure 3. Initial echo-sounding survey path (Survey 1) through area with vessel turning point labels.

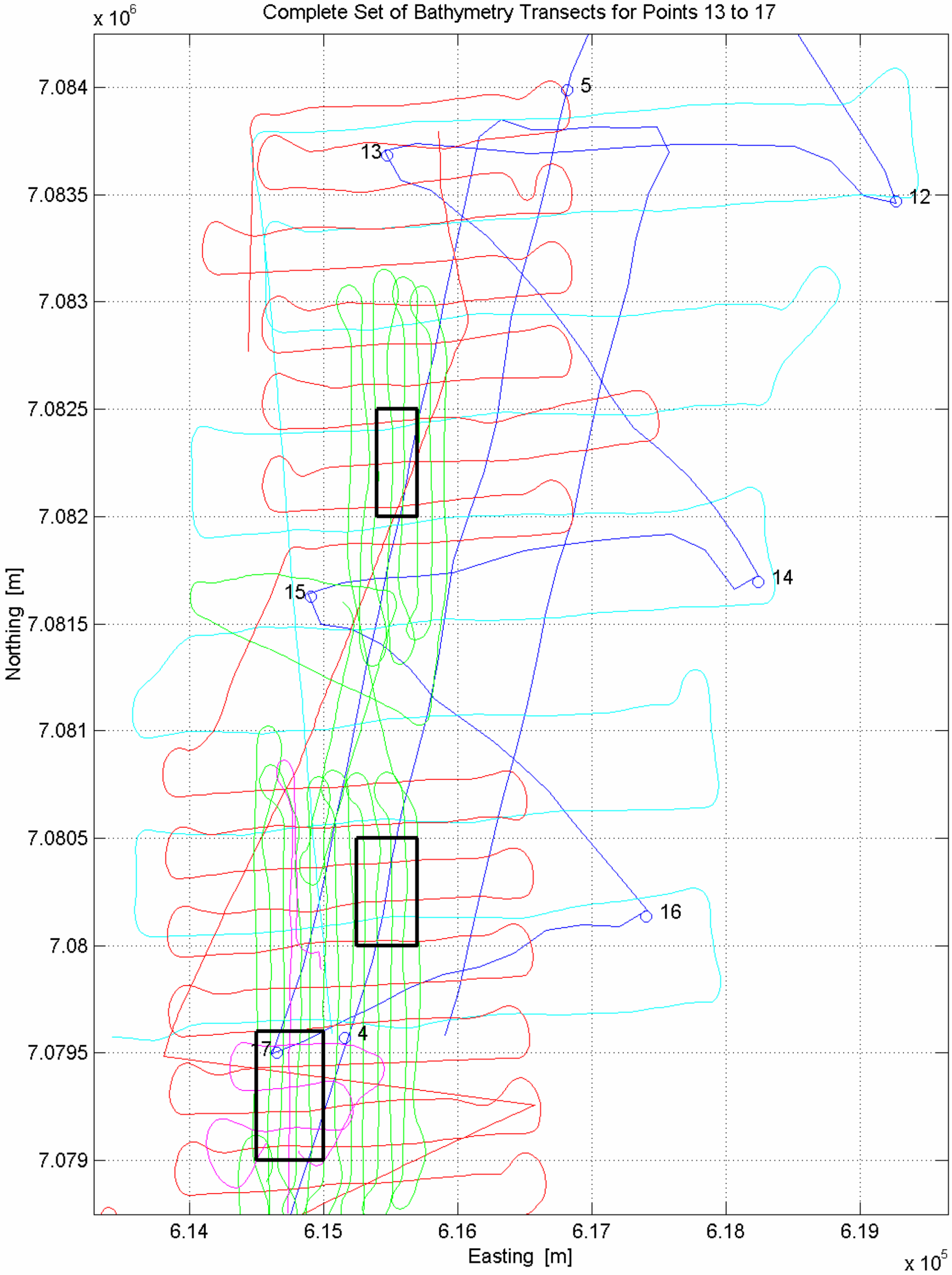


Figure 4. Survey paths for Surveys 2-5, including turning point labels from Survey 1 and rectangular regions identifying, from south to north, the regions 1, 2, and 3.

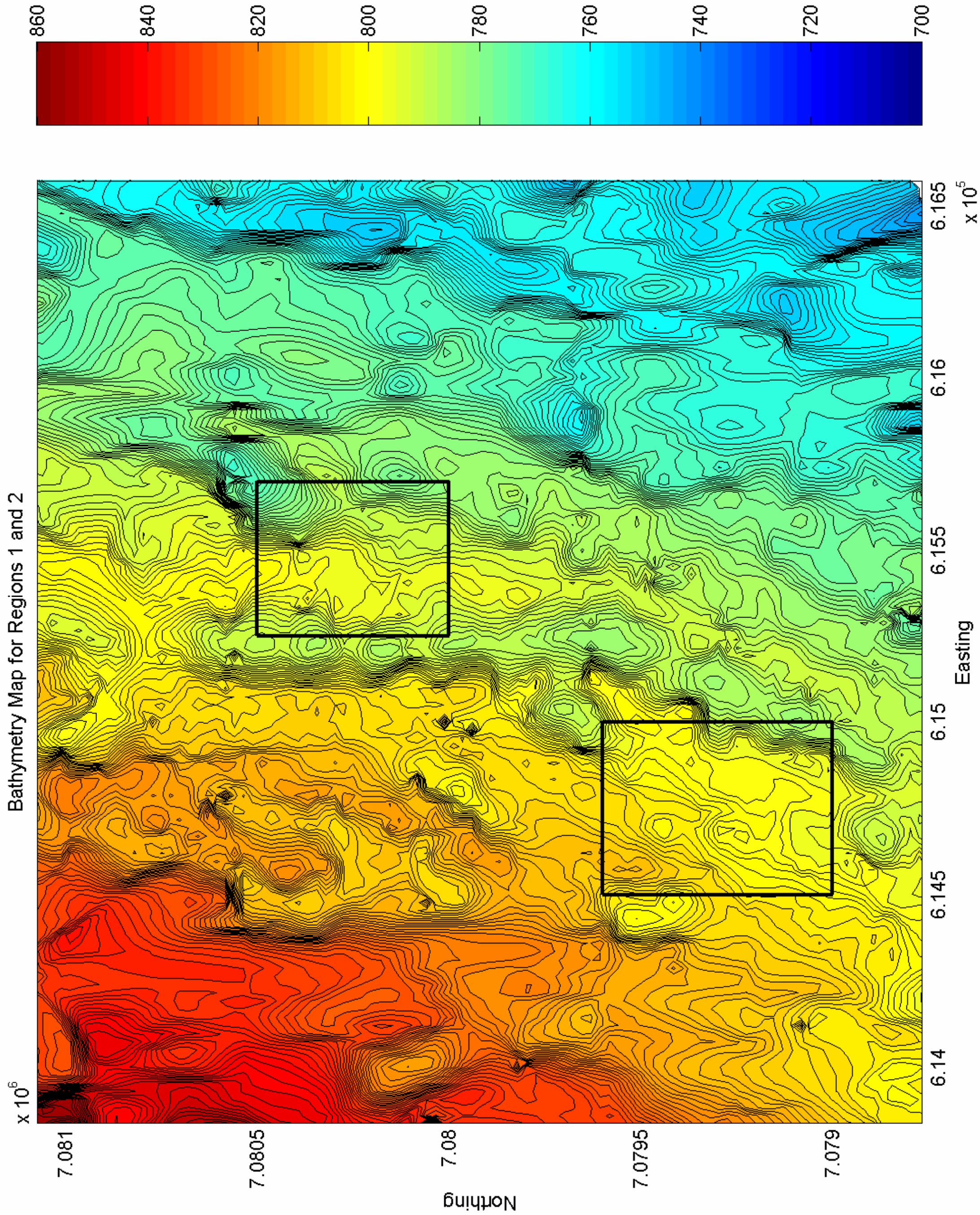


Figure 5. Bathymetric contour map near the southern regions 1 and 2. Color scale on top shows depths in meters, contour lines are one-meter equidistant, coordinates are UTM.

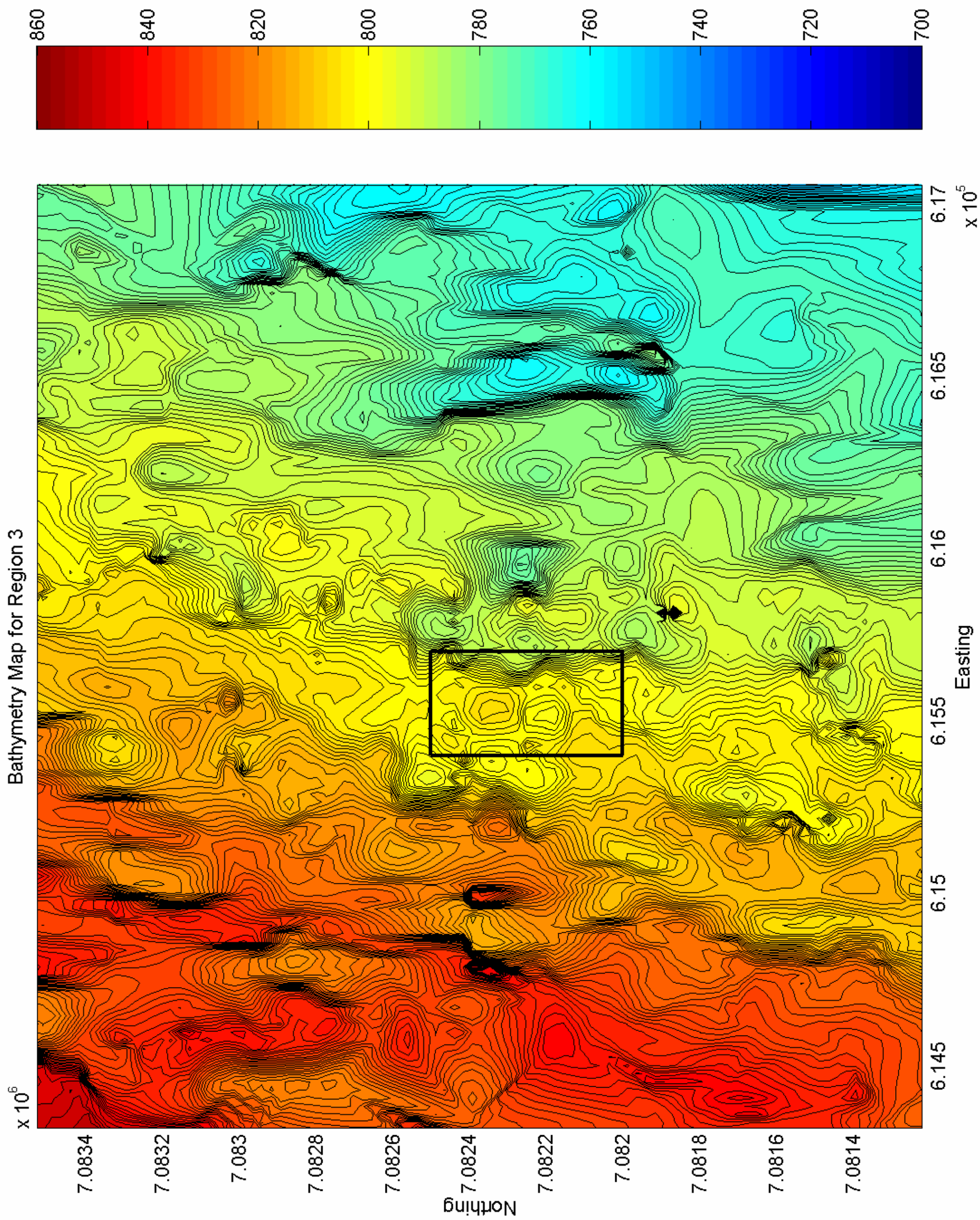


Figure 6. Bathymetric contour map near the northern region 3. Color scale on top shows depths in meters, contour lines are one-meter equidistant, coordinates are UTM.

4.3 Sediments

Sediment samples for comparison with ROV visual observations and echo-sounder data were taken at three stations. The samples were analysed for benthic biology, bacteria and physical composition. A Smøgen type box corer was used. The (interior) surface area of this corer is 29x29 cm (0.085 m^2). All samples were photographed and sensoratorily inspected once on deck. The samples from all locations were physically very similar: soupy brown surface (upper 3-4 cm), firmer but still fine-grained grey clay below this, with streaks of black inbetween. No particular smell was noted on any of the samples.

A total of eight sediment samples were taken. For a more detailed description of positions and sub-samples taken from each of these, please refer to Appendix D.

4.4 Site selection summary - identified regions

Based on the ROV dives, sediment grab samples, and the complete echo-sounder bathymetry survey, three regions were identified that may be suitable for the upcoming CO_2 experiment. The regions are numbered from south to north as regions 1, 2, and 3. **Figure 5** and **Figure 6** show the contoured bathymetry data near each of these regions.

Region 1 appears to be the most suitable. It has the largest flat region, the shallowest slopes, and the most uniform bottom (fine-scale depressions not seen in the bathymetry data, but observed by the ROV, are the weakest in region 1). The sediments are suitable for coring, and based on brief visual inspection, the benthic community composition was as can be expected for the depth and water temperature in question. The target zone is at 800 m depth; thus, it is not too deep. The region to the west (downslope) is very smooth and free of large topographic features. The region is bounded to the east by a steep wall, but such topography seems to be unavoidable.

Region 2 is similar to region 1, but with a topographic barrier on both the east and west sides. This could be useful for trapping the CO_2. Region 2 is narrower than region 1 and no ROV observations were made.

Region 3 is the narrowest region with the most varied topography. A 100 m square smooth region was observed with the ROV.

Our recommendation is to site the experiment in region 1. Detailed location coordinates and maps of the three regions and transects through regions 1 and 2 are presented in Appendix A.

5. Water currents

5.1 ADCP current measurements

Upon arrival at the survey area, an RDI 75 kHz Long Ranger ADCP was deployed for a period of almost 4 days near the western boundary of Region 1. This current meter measures 3-dimensional water motion in a number of separate vertical "cells", covering the deeper ~500 m (**Table 1**).

Table 1. Information on current measurement setup.

Bottom depth	809 m	**Logging interval**	10 minutes
Instrument depth	803 m	**Position**	63°49.96' N, 05°19.46' E
Cell thickness	5 m	**First good measurement**	July 21, 07:32 (UTC)
Number of cells	100	**Deployment duration**	94 hrs (almost 4 days)

Measured current velocity magnitudes were typically in the range of 2 to 15 cm/s deeper than ~500 m. Current direction was primarily controlled by tides, and a diurnal tidal cycle can be seen. Residual current direction (RMS) was towards south-southwest at depths below about 600 m. Above 550 m the net transport (RMS) was in a northerly direction. Current velocities increased above this depth, with average values ranging from ~ 7 cm/s at 550 m to 25 cm/s at 300 m depth. The semi-diurnal component was more pronounced at these shallower depths, in particular from about 400 m depth and up. This was primarily manifested as an increase in current speed and not so much as directional change at these depths. Statistical values for selected depths are given in **Table 2**. All values refer to recorded 10 minute measurement ensembles and not to instantaneous values.

Table 2. Statistical values for current velocity (cm/s) and direction (deg) for selected depths.

Depth [m]	790	775	750	725	700	650	600	550	500	400	300
Average velocity	7.3	7.0	7.2	7.1	6.8	6.6	6.2	7.2	7.9	16.7	25.8
Minimum velocity	0.2	0.4	0.3	0.4	0.3	0.3	0.1	0.1	0.1	3.3	3.7
Maximum velocity	18.5	18.6	21.3	16.2	18.2	16.3	16.2	18.7	25.1	32.3	40.2
RMS Velocity	2.0	2.0	2.1	1.7	1.1	1.2	0.8	1.4	3.8	14.9	24.1
RMS Direction	191.6	201.1	189.8	203.5	223.0	207.6	176.5	10.9	358.1	355.9	357.9

Plots of current velocity and direction are shown in **Figure 7** and **Figure 8** , respectively. The Range axis on the left should be seen as distance above the ADCP, meaning that range 200 m corresponds to approximately 600 m water depth. Note that the first two measurements should be discarded as the mooring was still being deployed at this time.

Sample plots of velocity and direction (**Figure 9**) and progressive vector (**Figure 10**) are shown for 775 m depth. Plots of current velocity and direction for other selected depths are given in Appendix B.

The ADCP also measures ambient pressure, which can be used to infer water depth or level. The time of high and low tides recorded by the ADCP have been compared with predictions for nearby Haltenbanken made by a numerical tide model (http://www.math.uio.no/tidepred/) at the University of Oslo. As seen in **Figure 11**, there is good agreement on the time of the passing tidal wave while absolute tidal amplitudes differ.

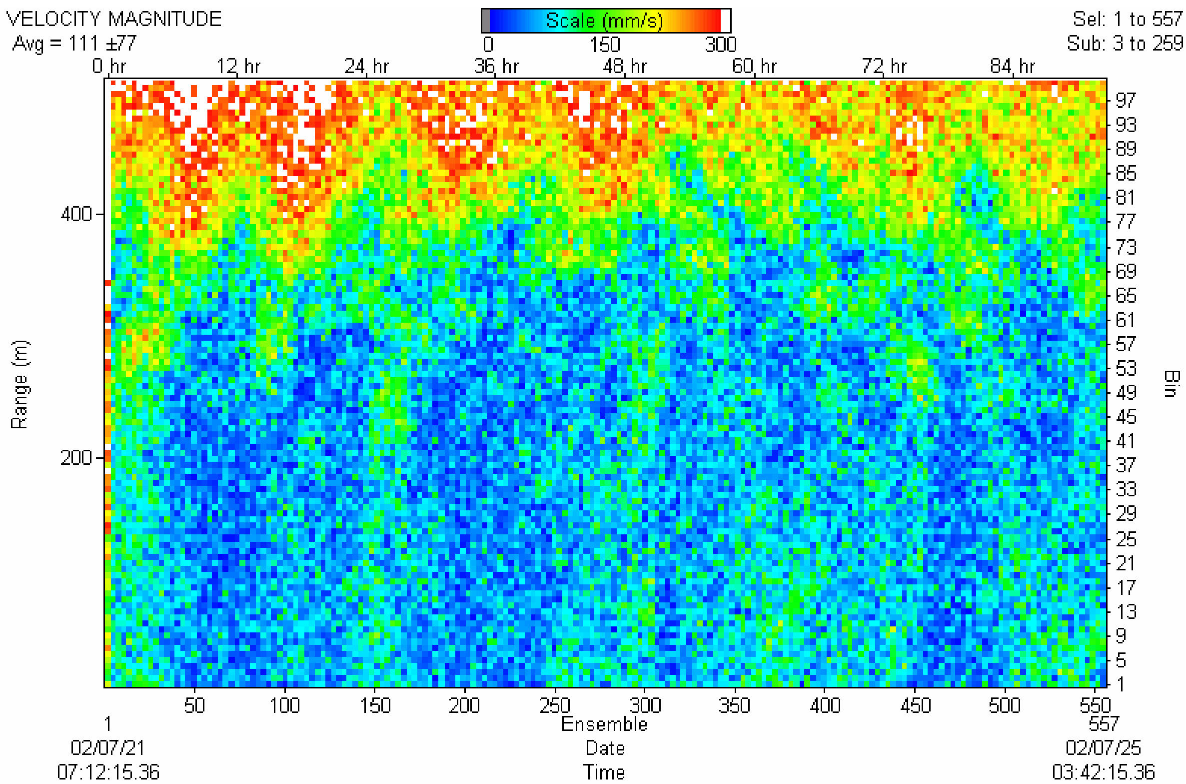


Figure 7. Velocity magnitude [mm/s] for ADCP deployment 21-25 July, 2002.

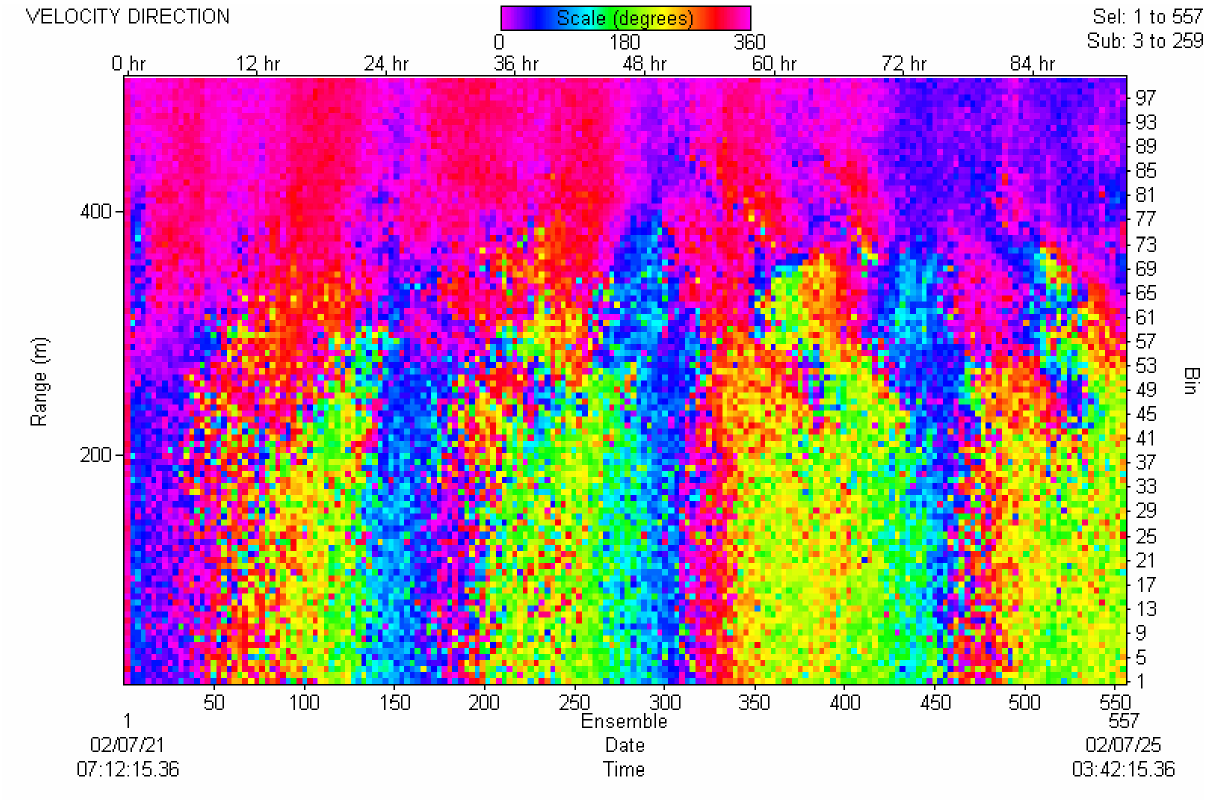


Figure 8. Current direction for ADCP deployment 21-25 July, 2002.

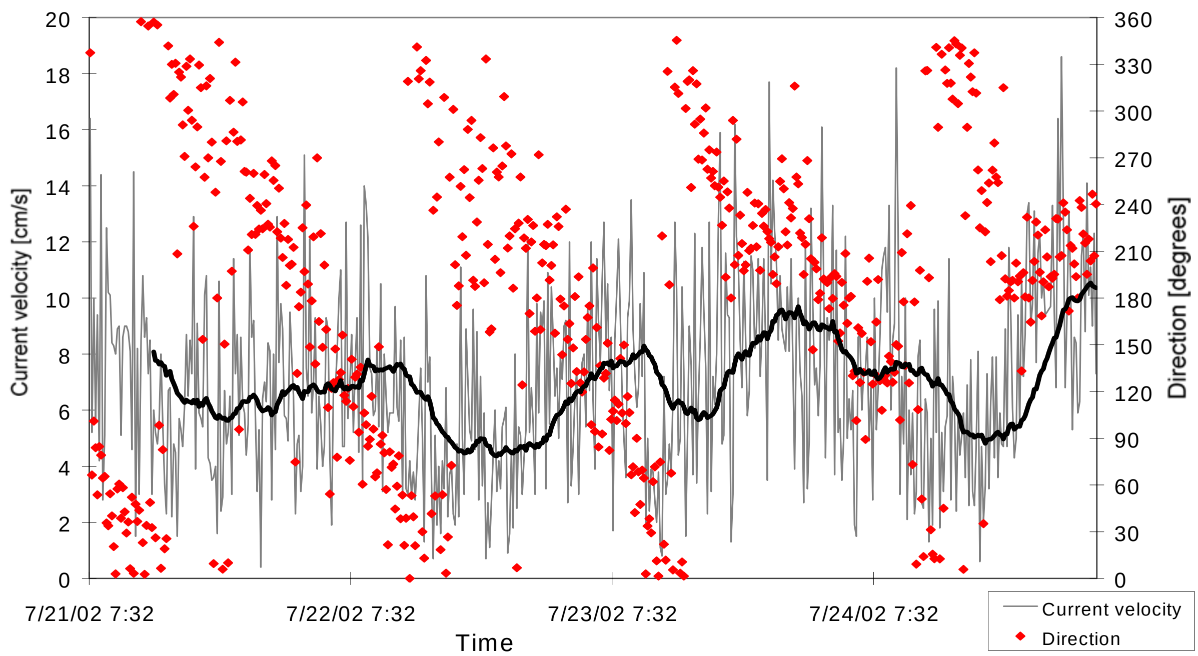


Figure 9. Current velocity (gray line) and direction (red dots) for Bin 4, 775 m depth. 6-hr moving average for velocity is shown in black.

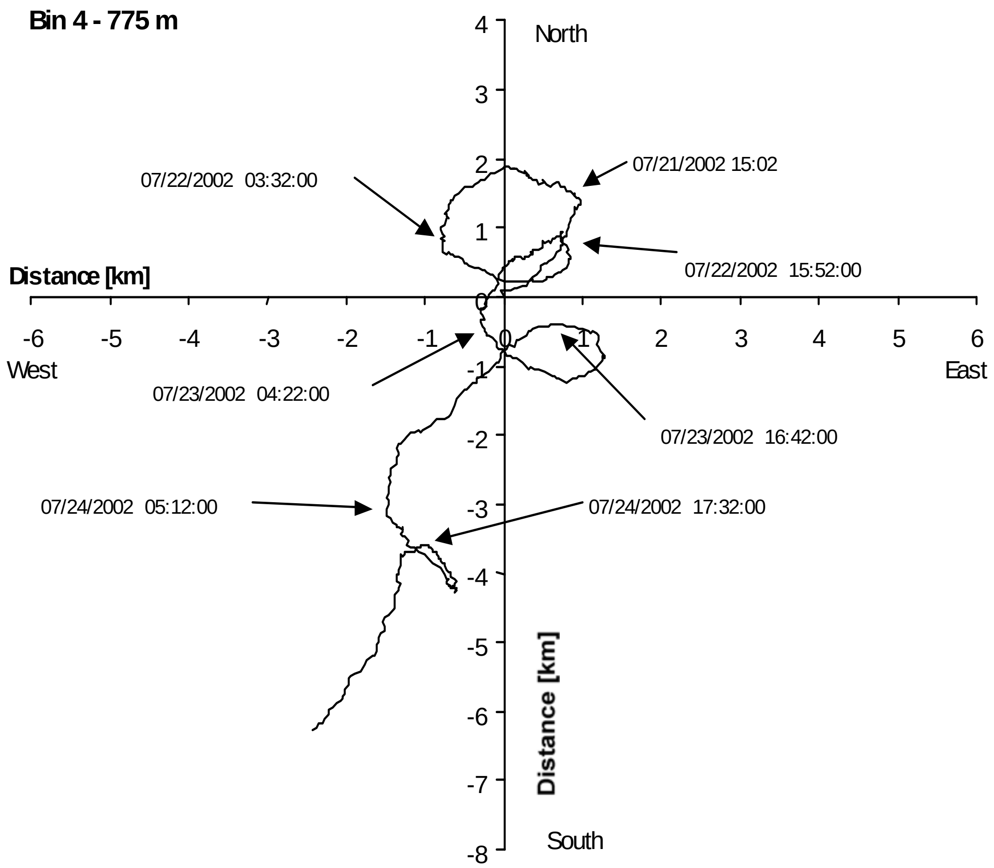


Figure 10. Progressive vector diagram for measurements at 775 m depth.

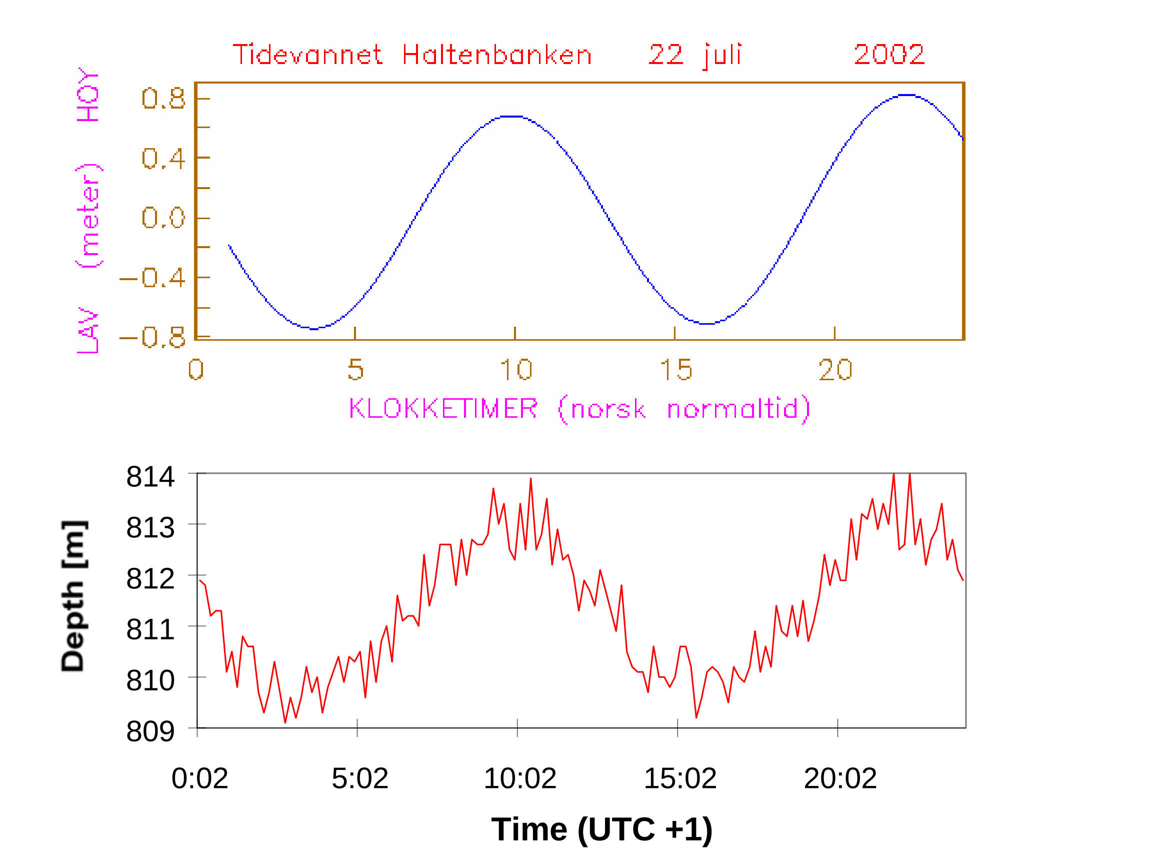


Figure 11. Model predicted tidal elevation and ADCP recorded depth variation.

6. Hydrography

6.1 Salinity, temperature and density profiles

6.1.1 Method

A Conductivity Temperature Depth (CTD) profiler was used to obtain information about the hydrography of the area of interest. The CTD system (SEA-BIRD ELECTRONICS (SBE) 911plus) consisted of a deck unit and an underwater unit. The CTD underwater unit held sensors measuring temperature, conductivity, pressure and pH. A rosette with water bottles was also attached here, from which water samples were obtained from selected depths. Data from the sensors was transmitted through a lowering cable to a computer onboard the ship. The salinity, density and depth was calculated and displayed in real time on the CTD-computer.

6.1.2 Measurements

Measurements were made at five stations. A central station (Station 1) with bottom depth 813 m was selected on the first day at the site (July 19). This was profiled for a total of seven times, with water samples being taken at various depths for analyses. To obtain some understanding of cross- and along-slope variation, another four stations were profiled, one time each. These were labeled E (shallower), W (deeper), N (north along slope) and S (south along slope) (stations are shown without labels in **Figure 2**). The distances from the central station to the north and south stations were not identical. Positions and bottom depths for the five CTD stations were as given in **Table 3**.

Table 3. Positions and depths for CTD stations.

Station ID	Position, North	Position, East	Bottom depth
CTD 1	63°50.61'	05°20.31'	813 m
CTD E	63°50.25'	05°22.30'	760 m
CTD N	63°51.10'	05°21.30'	810 m
CTD S	63°50.00'	05°20.50'	810 m
CTD W	63°51.00'	05°18.90'	860 m

The distribution of temperature, salinity and density (σ_θ) with pressure based on the data obtained at the different CTD-stations show similar features for all stations. Full-depth curves from all the CTD profiles taken at all stations are shown in **Figure 12**, and more detailed plots of the 700-800 m depth interval for station 1 are shown in **Figure 13** (1 db is approximately equal to 1 m).

The temperature near the surface varied around 14-15°C, with rapidly decreasing values down to about 50 meters depth. From there the gradient was weak until about 330 meters, and again stronger down to around 550 meters depth. The values show little variation from around 600 meters depth and downwards, reaching a near-bottom minimum of -0.86°C. Salinity values increased rapidly with depth in the surface layer until approximately 50 meters depth, then increased more slowly leading to a maximum at around 100 meters depth. From here the values decrease somewhat, showing 34.8-34.9 from around 500 meters depth and down to the bottom. The density curves showed a strong gradient from the surface and down to about 50 meters depth. From there it increased more gradually, with a secondary strong gradient between 400 and 550 meters depth. The density was almost constant from 550 meters depth to the bottom, where σ_θ-values were around 28.07 kg/m^3.

The buoyancy frequency, given by $N = ((g/\rho)(d\rho/dz))^{0.5}$, is an indicator of the vertical stability at a given depth interval. Reflecting the small density gradient at the experiment target depth around 800 m, this is found to have a value of around of 0.0008 s^{-1}.

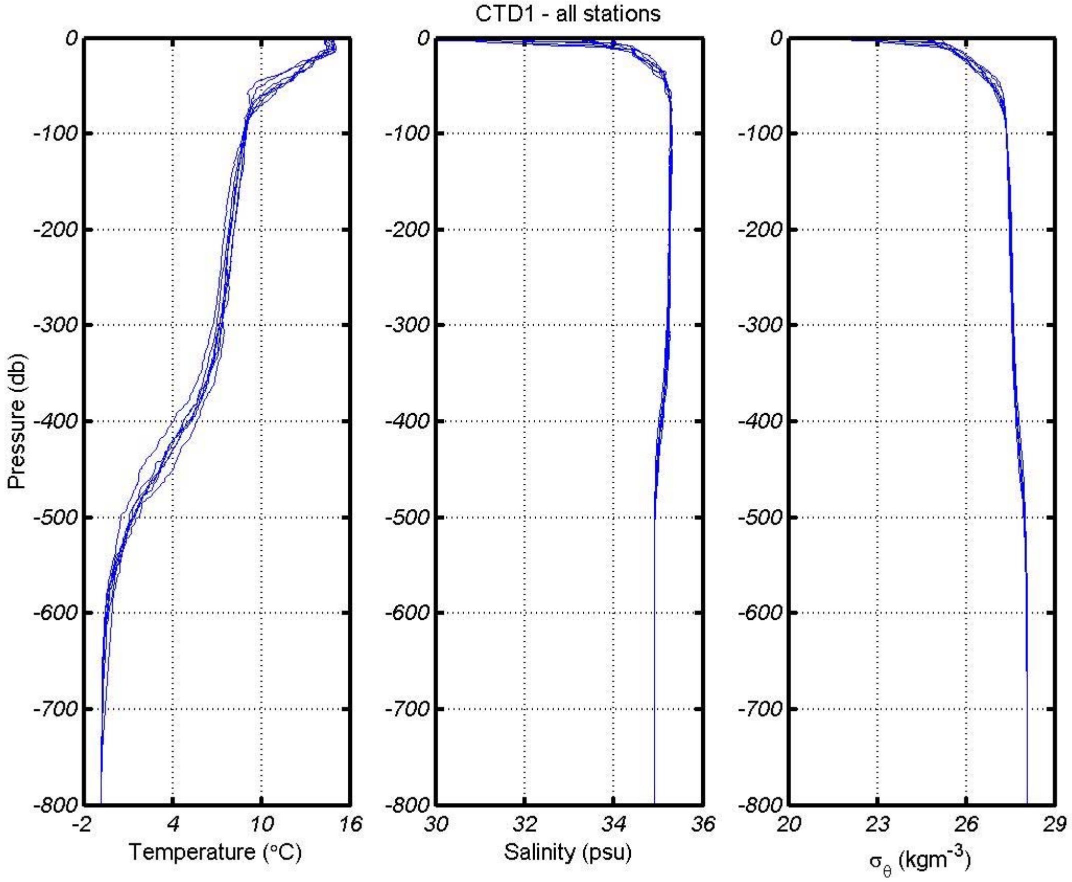


Figure 12. Temperature, salinity and density vs. pressure for all CTD stations, 21-24 July, 2002.

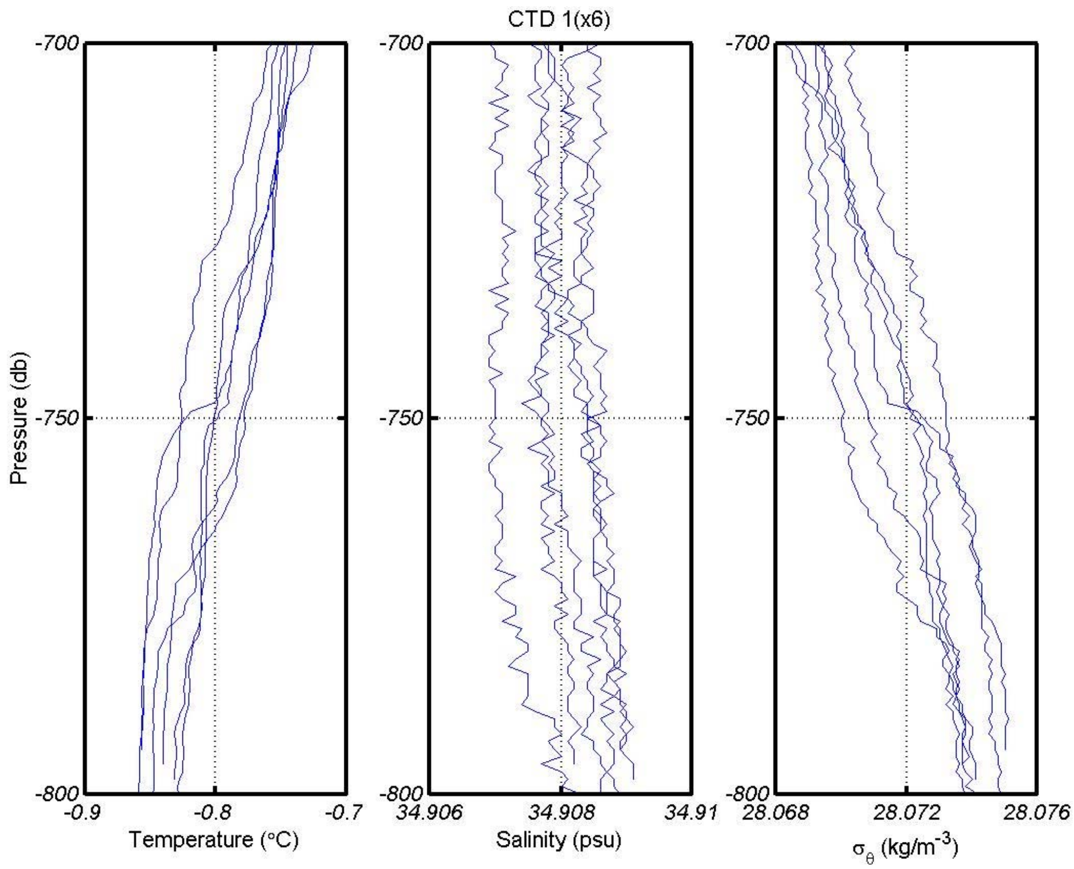


Figure 13. Temperature, salinity and density vs. pressure in the 700-800 db interval for 6 profiles taken at Station 1, 21-24 July 2002.

Separate plots from all CTD casts are shown in Appendix C. In the morning of day three (July 22) some of the CTD measurements from Station 1 and partly also Station W were erroneous. After adjustments of an erratic winch drum, the CTD appeared to yield correct data. The bad data have been filtered out in the plots from the affected stations.

6.2 Water samples

The following lists the CTD stations with the depths at which water samples were taken:
CTD1 #1: 800, 750, 700, 650, 600, 400, 200, near-surface
CTDE: triplicate samples at 750 m
CTD1 #2: same as above
CTDW: same as above
CTDN: same as above
CTD1 #3: same as above
CTDS: same as above
CTD1 #4: 800, 750, 700, 650, 600, 400, 200, near-surface
CTD1 #5: triplicate samples at 800, 750 and 700 m)
CTD1 #6: 800, 750, 700, 650, 600, 400, 200, near-surface (6 samples for salinity calibration)
CTD1 #7: 800, 750, 700, 650, 600, 400, 200, near-surface (including 4 oxygen samples)

6.3 pH measurements

Two different pH-sensors were mounted on the CTD system. The RV Håkon Mosby is equipped with one sensor supplied with their standard SeaBird CTD. Uncalibrated measurements from Station 1 from this sensor are presented in **Figure 14** without further comments.

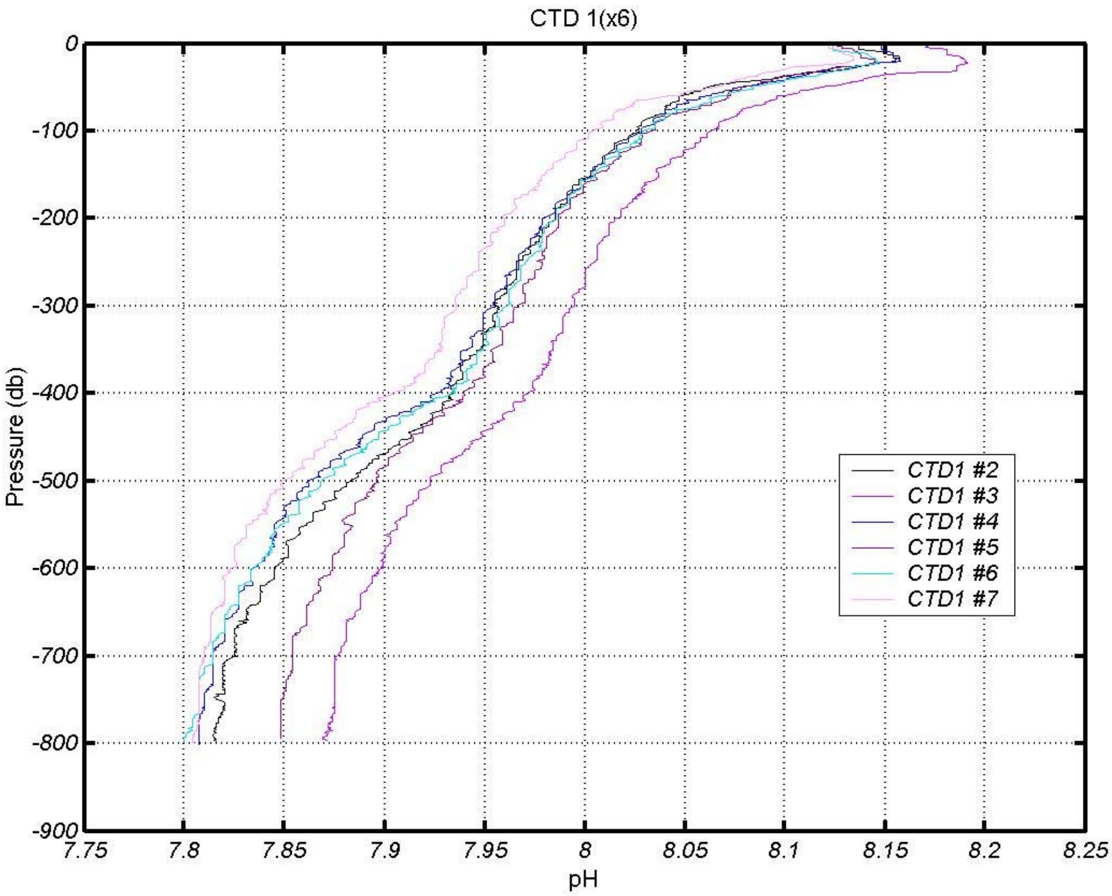


Figure 14. pH vs. depth for 6 profiles at Station 1, 21-24 July, 2002.

7. Water Chemistry

7.1 Carbon dioxide system

7.1.1 Introduction

The oceanic carbon dioxide system was studied by analysing total dissolved inorganic carbon (DIC) and total alkalinity (A_T) at CTD station 1 and on two transects (N to S and E to W with the main site in the center at each transect). The bottom depth was 810 meters at the main site.

Total dissolved inorganic carbon is defined as the sum of the species in the oceanic carbon dioxide system as follows;

DIC= $[HCO_3^-]+[CO_3^{2-}]+[CO_2^*]$, where $[CO_2^*]$ is the sum of H_2CO_3 and $CO_2(aq)$

Total alkalinity is the sum of the bases with an equilibrium constant > 4.5 and is thus a measure of the buffering capacity of the seawater.

From 10 CTD casts, totally 70 water samples were collected in 250 ml glass bottles for DIC and 250 ml Nalgene bottles for A_T from Niskin bottles attached to the rosette. The water column was studied at 8 depths, focused on 750 meters and 800 meters. From the A_T and DIC and a CO_2 calculation program (computer program by Lewis and Wallace) pH and the fugacity of CO_2 (fCO_2) were calculated at both *in situ* temperature and 25°C.

7.1.2 Analytical methods

DIC was determined using gas extraction of an acidified sample followed by colorimetric titration and photometric detection (Johnson et al 1993[2]). The determination of A_T was performed using a potentiometric titration with hydrochloric acid (0.05M). The equivalence point was evaluated from a Gran evaluation (Haraldsson et al., 1997[3]).

Samples were measured at a constant temperature of 25°C and analyses were performed between half an hour to five hours after sampling. The analytical precision for both A_T and DIC was estimated from two to three analyses on individual samples and the mean standard deviation was ±1 μmol kg^{-1}. The variability between replicates on samples from different Niskin bottles (same depth) was for A_T ±1 μmol kg^{-1} and for DIC ±2 μmol kg^{-1}. This variability includes difference in Niskin bottles, spatial distribution of the water and analytical precision.

The values were corrected for the difference between the measured and the certified value from a Certified Reference Material (CRM) obtained from A. Dickson at Scripps Institution of Oceanography, USA. The correction was 3.7% for DIC and 0.3% for A_T. CRM was analysed after each station for A_T, and daily or after a change cell solution for DIC. Two repetitive analyses were performed on each of five CRM bottles, and the measured concentration for AT and DIC showed little variation throughout the cruise. From this the mean standard deviation was calculated to ± 1 μmol kg^{-1} for both A_T and DIC.

[2] Johnson, KM; Wills, KD; Butler, DB; Johnson, WK; Wong, CS, 1993. Coulometric total carbon dioxide analysis for marine studies: maximizing the performance of an automated gas extraction system and coulometric detector. Marine Chemistry, 44 (1993) 167-187

[3] Haraldsson, C; Anderson, LG; Hasselloev, M; Hulth, S; Olsson, K, 1997. Rapid, high-precision potentiometric titration of alkalinity in ocean and sediment pore waters Deep-Sea Research (Part I, Oceanographic Research Papers) Vol. 44, no. 12, pp. 2031-2044. Dec 1997.

7.1.3 Results

Figure 15 shows the variation of DIC and A_T concentrations in the water column for three of the casts at CTD station 1 (253, 260 and 262). During the two transects (along-slope and cross-slope), the water at 750 and 800 meter depths was further investigated. From all 750 meter samples the average DIC and A_T concentrations were calculated to 2159 ± 2 µmol/kg (CV=0.1%, n=25) and 2299 ± 2 µmol/kg (CV=0.09%, n=28), respectively. This shows that the natural variability is larger than the precision of the analytical methods.

The calculated pH *in situ* at 750 m was 8.078 ± 0.002 and $f CO_2$ was 316 ± 2 µatm. In these values there are additional uncertainties from the error in the equilibrium constants used in the CO_2 calculation program, hence they should be treated with caution.

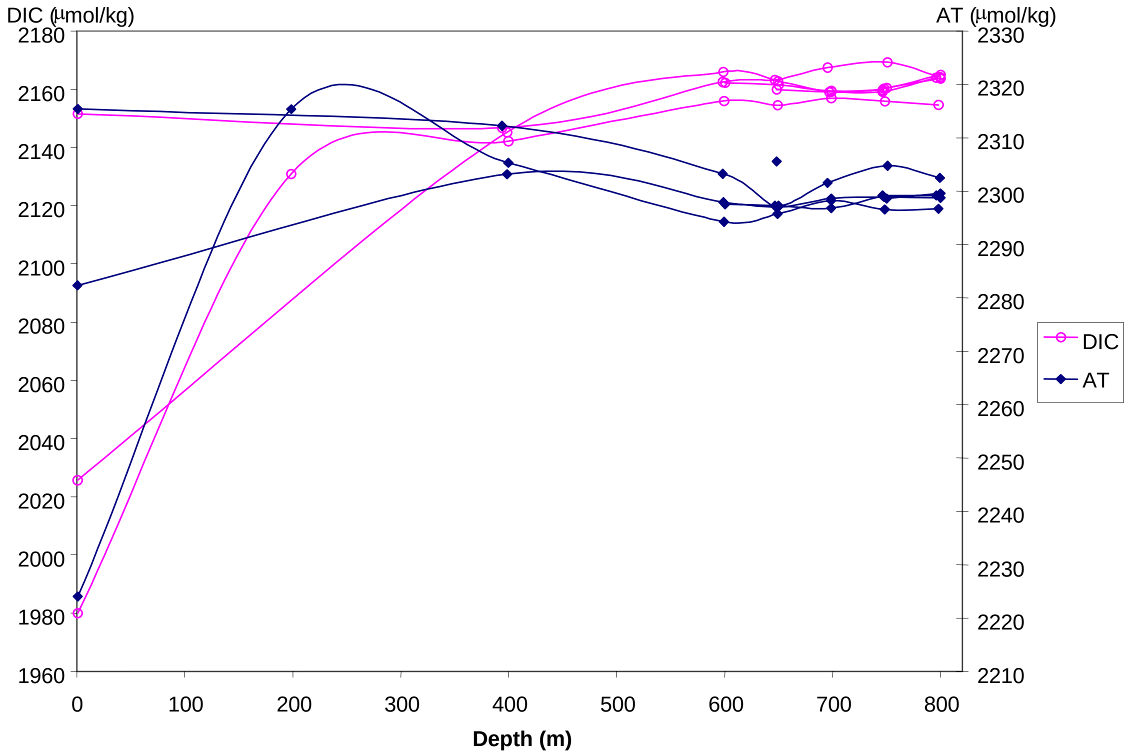


Figure 15. DIC and A_T vs depth from three casts at CTD station 1.

7.2 Carbon isotopes and bacterial production rates

7.2.1 Introduction

NRL participated in the Storneset baseline survey, 19-26 July, 2002, to develop a baseline data set that will assist in the following topics that are associated with CO_2 release experiment:

1. Prediction for the influence of pH changes on bacterioplankton growth and influence on biogeochemical cycles in the water column. This work addresses the direct effect on bacterial production and the indirect effect on the food chain resulting from changes in key elemental cycles.
2. Establish a baseline for stable carbon isotope ratios of the DIC pool to determine if carbon isotope analysis can be employed to trace the CO_2 release.
3. Do a preliminary survey of bacterial production in the sediment to determine if the amount of nutrient remineralization could be inhibited through carbon sequestration on the ocean floor.

7.2.2 Sampling Strategy

Sediment sampling was conducted with sediment taken by a shipborne Smøgen sampler. These samples were taken to measure the bacterial production in the sediment and the sediment carbon content. The sediment grabs were obtained from two locations. Because of the ROV down time no push cores were obtained. Push cores were taken from the sediment grabs as a test of the corers for the following experiment. Water samples were taken with the CTD/rosette.

7.2.3 Micro biology

Samples were taken for bacterial production in 6 sediment grabs. Heterotrophic bacterial production in surface sediments was measured through analysis of ^{3}H-leucine incorporation (Smith and Azam, 1992[4]).

Sediment bacterial production will be related to the sediment carbon content. This analysis will be conducted with a Carlos-Erba 1100 CNS instrument (Parsons et al. 1984)[5].

7.2.4 Water Chemistry

Water samples were taken in vertical and horizontal profiles to set a baseline for microbial heterotrophic production, chemosynthetic bacterial production, stable carbon and stable carbon isotope analysis of DIC. Parameters that are related to these topics include DOC and DIC concentrations and bacterial biomass.

The water column samples were taken through 10 CTD/rosette casts through the research cruise. The following locations and depths were surveyed by NRL (see **Table 3** for positions of stations):

CTD cast #	Site	Depths (m)
1	CTD1	800, 750, 700, 650, 600, 400, 200, S
2	CTDE	3 bottles 750
3	CTD1	3 bottles 750
4	CTDW	3 bottles 750
5	CTDN	3 bottles 750
6	CTD1	3 bottles 750
7	CTDS	3 bottles 750
8	CTD1	800, 750, 700, 650, 600, 400, 200, S
9	CTD1	3@800, 3@750, 3@700
10	CTD1	800, 750, 700, 650, 600, 400, 200, S

The following methods will be used for the parameters.

Water column bacterial production will be measured according to Smith and Azam (1992)[4].

The ^{14}C-assimilation was measured using a modified version of the Steeman-Nielsen method (1952)[6]. Water samples were dispensed into four 15-ml screw-capped tubes. All tubes were covered with aluminum foil, with one of the tubes receiving 1ml of formalin (2.5% final concentration) as a killed control. Ten microliters of the stock ^{14}C-bicarbonate solution was added to each tube with a micropipette (10µCi per 15ml sample). The tubes were kept at in situ temperatures (4°C) in the dark for 24hrs. Upon completion of the incubation, 1ml of formalin was added to the three experimental tubes. The entire contents of each tube were then filtered through Whatman (GF/F) glass fiber filters

[4] Smith, DC and F Azam. 1992. A simple, economical method for measuring bacterial protein synthesis rates in seawater using 3H-leucine. Mar. Microb. Food Webs 6(2): 107-114

[5] Parsons, T. R., Y. Maita, and C. M. Lalli. 1984. A manual of chemical and biological methods of seawater analysis. Pergamon Press, New York

[6] Steeman-Nielsen, E , 1952. The use of radioactive carbon (^{14}C) for measuring organic production in the sea. *J. Cons. Int. Explor. Mer.* **18**:117.

mounted in filter holders. The filters were then placed in scintillation vials for drying. Once dry, 5ml scintillation cocktail was added and the radioactivity counted in a scintillation counter.

Stable carbon isotope analysis of the DIC is measured with the following approach:

Stable carbon isotope ratios are measured on a Finnigan Delta Plus Isotope Ratio Mass Spectrometer with a sample injection through a Varian GC. Samples are prepared by placing the seawater in a argon gas evacuated serum bottle, sealing the water sample and adding HCl to transfer the DIC to carbon dioxide in the bottle head space. The carbon dioxide is removed with a gas tight syringe and injected into the mass spectrometer. $\delta^{13}C$ analysis is applied to trace the variation in sources, where the values are calculated as:

$$\delta^{n}C = \left[\frac{R_s}{R_{std}} - 1\right] \times 1000 \ (‰)$$

where δ^n is the stable carbon isotope ratio, R is the $^{13}C/^{12}C$ for stable carbon, s is the sample and std is the standard. For $\delta^{13}C$ analysis the standard is PeeDee Belmenite.

8. Biology

8.1 Pelagic

8.1.1 Zooplankton – MOCNESS

The MOCNESS tool used for collection of zooplankton is a towed construction with 8 nets that can be opened and closed on command from the research vessel. The nets are made from nylon, with openings of 180 µ. Individual nets were open at the following intervals: 700-650, 650-600, 600-500, 500-400, 400-300, 300-200, 200-100, 100-0 m. Vessel velocity while towing was 0.9 knots, and it was attempted to keep the gear at an optimal angle of 45°.

The first net haul (July 21) started at position 63°53’ N, 05°22’ E. It was assumed that the current direction in the deeper water masses would be about the same as that given by the vessel-mounted ADCP, and the towing was done against the surface current direction. During the sampling from 700-300 m the MOCNESS angle was around 10-25°. A possible explanation for this significant deviation from the desired angle of 45° is strong current sideways or from behind while towing. During the deployment of the MOCNESS on July 21 several hundred meters of signal cable was released by a renegade winch while the wire winch ran as normal. The flow meter ceased to function and the filtered volume was therefore not automatically calculated.

MOCNESS hauls 22 and 24 July both failed. In the first of these it was not possible to open and close the individual nets in a controlled manner, probably due to strong current and possibly too great wire weight. In the latter, the computer control program failed.

Results from the first net haul (Some biological terms are given also in Norwegian):

<u>Krill</u>
Meganyctiphanes norvegica caught at depth intervals 696-641, 399-199 and 101-0 m
Thysangessa longicudata 598-399, 399-199, 101-0 m
Thysangessa inermis 101-0 m

<u>Copepode</u>
Eucheta, Calanus finmarchicus and small copepods caught in the entire interval from 696-0 m

Arrow worms – Chaetognatha was caught at all depths, particularly in the deep water masses.

Naked Sea Butterfly– Limacina helicina was caught from 100-0 m

Amhipode – Parathemisto was caught in the intervals from 641-199 m.

The total biomass of zooplankton was dominated by Calanus finmarchicus.

8.1.2 Nekton – trawl

A Harstad-type pelagic trawl was used in the pre-survey. This has an opening of 16 x 16 m, and should be towed at 3 knots. The trawl was towed for 20 minutes at each of the following depths: 700, 650 and 600 m. From 600 m to surface the trawl was hauled directly onto the deck. Bottom depth during trawling was about 800 m. Trawling was done twice during the cruise, July 22 starting at 63°52.3' N, 05°22.9' E towards south, and July 24 from 63°51' N, 05°21.9' E towards south.

Results
The catch consisted of krill, shrimp, "vassild" (norw.) (*Argentinidae*), "kolmule" (*Micromesistus poutassou*), "laksesild" (*Maurolicus muelleri*), "nordlig ringbuk" (*Careproctus reinhardti*), "tangbrosme" (*Rhinonemus cimbrius*), arrow worms (*Chaetognatha*) and *Periphylla periphylla*.

Total catches for the two trawls were 9.5 kg (of which 5 kg were *Periphylla*) on July 22 and 10.4 kg (of which 5 kg were *Periphylla* plus one 1-kg individual pollack, probably caught while the trawl was retrieved) on July 24.

8.2 Near bottom biology

8.2.1 Scavenger traps

A single scavenger trap was deployed with the fish traps by long line for about 17 hours on 22 July, two traps were deployed by themselves on long line for 4 hours and 20 minutes on the 23rd, and a single trap was taken down by the ROV on the 24th.

Two of the three traps deployed by long line captured hundreds of small white amphipodes and dozens of large red amphipodes. At least 4 species were represented. The third captured only one amphipode and came up covered with mud. It is likely that the opening of that trap was blocked by mud while on the sea floor. The capture of significant numbers of large conspicuously colored amphipodes in only a few hours was a very desirable result as this shows that it is feasible to capture sufficient numbers of animals in a short period of time and that these animals will contrast sharply with the background.

The trap deployed by ROV was released about a meter above the bottom after which the ROV settled to the bottom while turning away from the trap. Sediment disturbed by the ROV and its cable obscured the trap and after over two hours of searching, the trap was abandoned. It is possible that the ROV buried the trap in the sediment while searching.

Several important lessons were learned here:

1. Great care and planning must be used to mitigate the problem of sediment clouds during the experiment.
2. Strong sonar reflectors must be placed in the vicinity of any small objects that must be found by the ROV.
3. Do not confine bait to the teaboy (the fine mesh may have prevented the development of an odor plume).
4. It's adviceable to construct a platform to keep the traps just over the mud while they are deployed to collect scavengers.
5. 2-3 additional traps should be constructed. The current design worked well though somehow the traps need to be made more sonar reflective.

8.2.2 Long lines

One set of long lines was deployed by a nearby fishing vessel on July 21 at 63°50.6' N, 05°20.3' E, at depths 823-810 m. The line was a 7 mm polyester line. Spacing between hook lines was 1.4 m, and the 600 hooks were of type Mustad EZ #12. 50% squid and 50% mackerel was used for bait.

The total catch was 48.7 kg, consisting of Arctic Skate (*Raja hyperborea*) (14 individuals of total weight 38.9 kg), Greenland Halibut (*Reinhardtius hippoglossoides*) (4 pcs @ 8.6 kg) and Starry Skate (*Raja radiata*) (1 @ 1.2 kg).

8.2.3 Fish traps

Two-floor fish traps with two entrances were used. Mackerel was used for bait. Six traps with 15 m spacing inbetween were used for each deployment, anchored with a 40 kg grapnel.

The traps were deployed twice; on 22 July (63°48.3' N, 05°18.3' E, depth 802 m, 17 hrs) and 23 July (63°49.0' N, 05°25.2' E, depth 714 m, 22 hrs).

There were no fish caught in the traps deployed at 800 m depth. In the 714 m deployment the total catch of 7.3 kg consisted of 3.5 kg/2 pcs Roughhead Grenadier (*Macrourus berglax*), 2.3 kg/1 pc Greenland halibut (*Reinhardtius hippoglossoides*) and 1.5 kg/4 pcs arctic rockling (*Onogadus argentatus*).

8.3 Benthos – sediment samples

Description and overview of the samples taken are given in Chapter 4.3 and Appendix D. Analysis was not completed at time of printing.

Appendix A. Bathymetry Maps and Transects

This Appendix presents detailed bathymetry maps of the three major regions surveyed and transects through regions 1 and 2. The bathymetry maps are interpolated contour plots with 1 m intervals, and the transects are actual measured depth data. Bathymetry measurements were recorded every 2 s with an average ship speed of 8 knots. The contour plots are based on resampled data at every 8 s; the transects are based on the full dataset.

The following table contains the position data for the southwest corner, midpoint, and northeast corner of each of the regions defined in the surveys. The coordinates on the left are the Easting and Northing in UTM (region 31) coordinates in meters and the coordinates on the right are the latitude and longitude in degrees and minutes.

Region 1			
614500	7079000	63° 49.18'	05° 19.58'
614750	7079300	63° 49.33'	05° 19.99'
615000	7079600	63° 49.49'	05° 20.22'
Region 2			
615250	7080000	63° 49.70'	05° 20.54'
615475	7080250	63° 49.83'	05° 20.82'
615700	7080500	63° 49.96'	05° 21.11'
Region 3			
615400	7082000	63° 50.77'	05° 20.81'
615550	7082250	63° 50.91'	05° 21.01'
615700	7082500	63° 51.04'	05° 21.20'

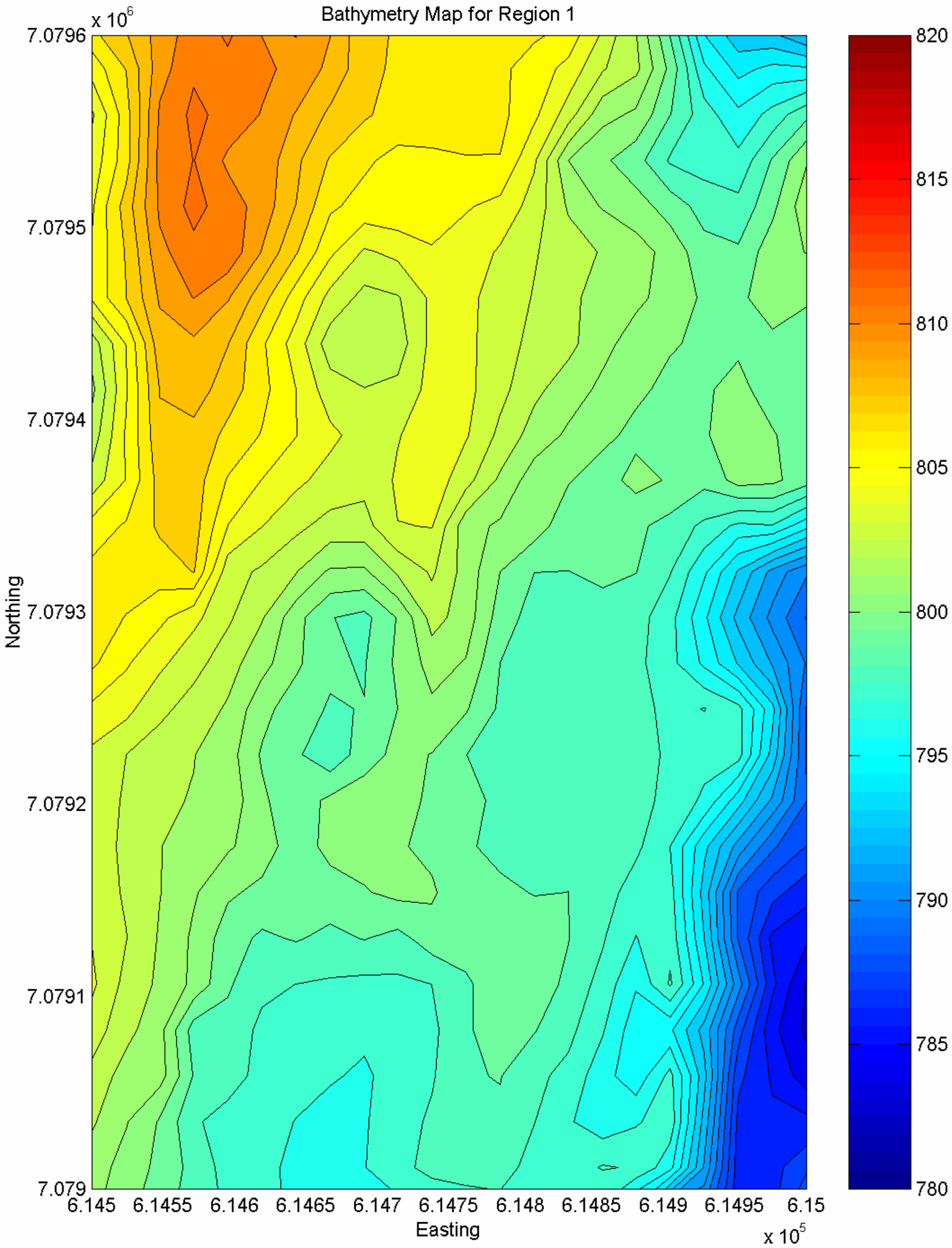


Figure A1: Bathymetry map for Region 1 based on all the transects collected.

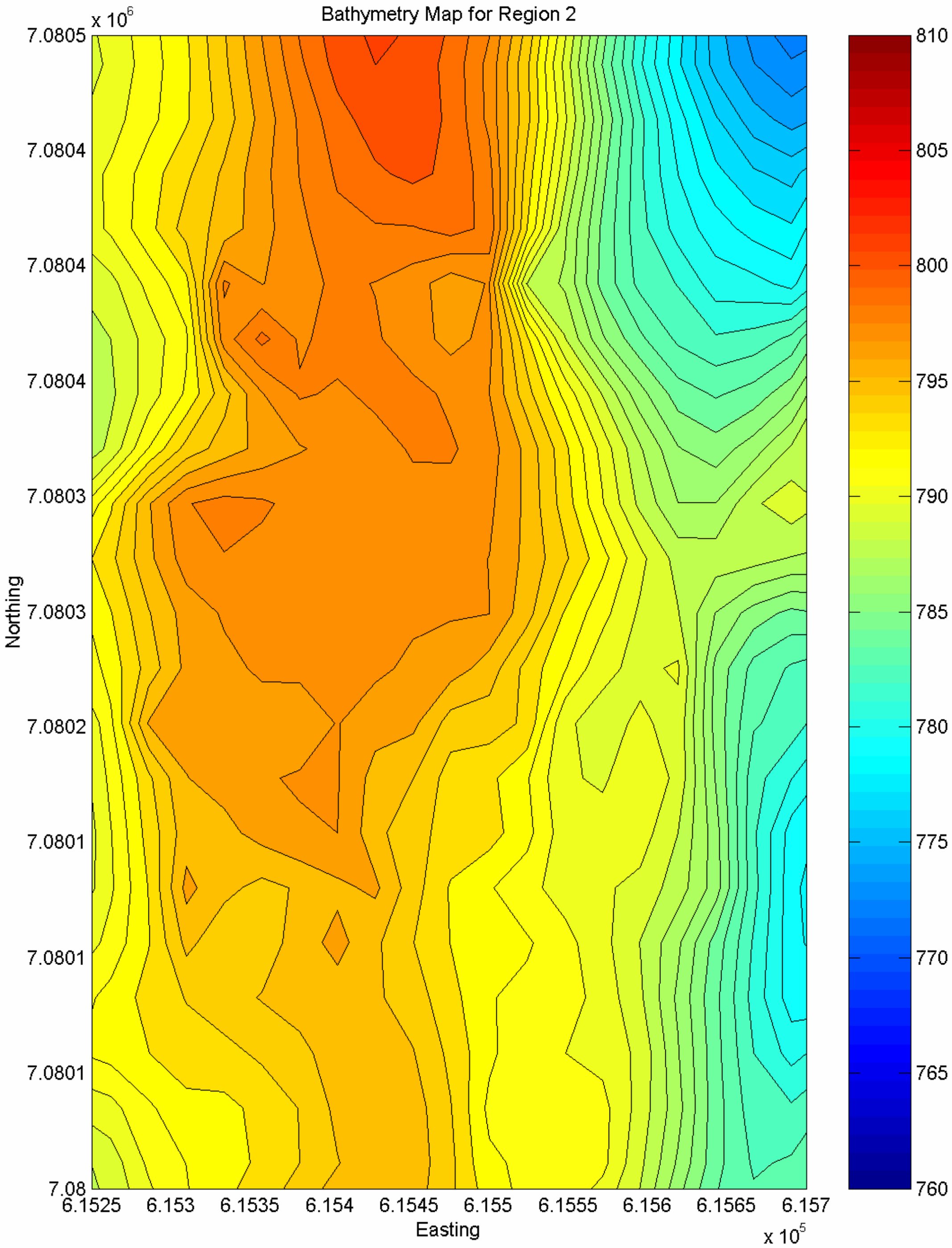


Figure A2: Bathymetry map for Region 2 based on all the transects collected.

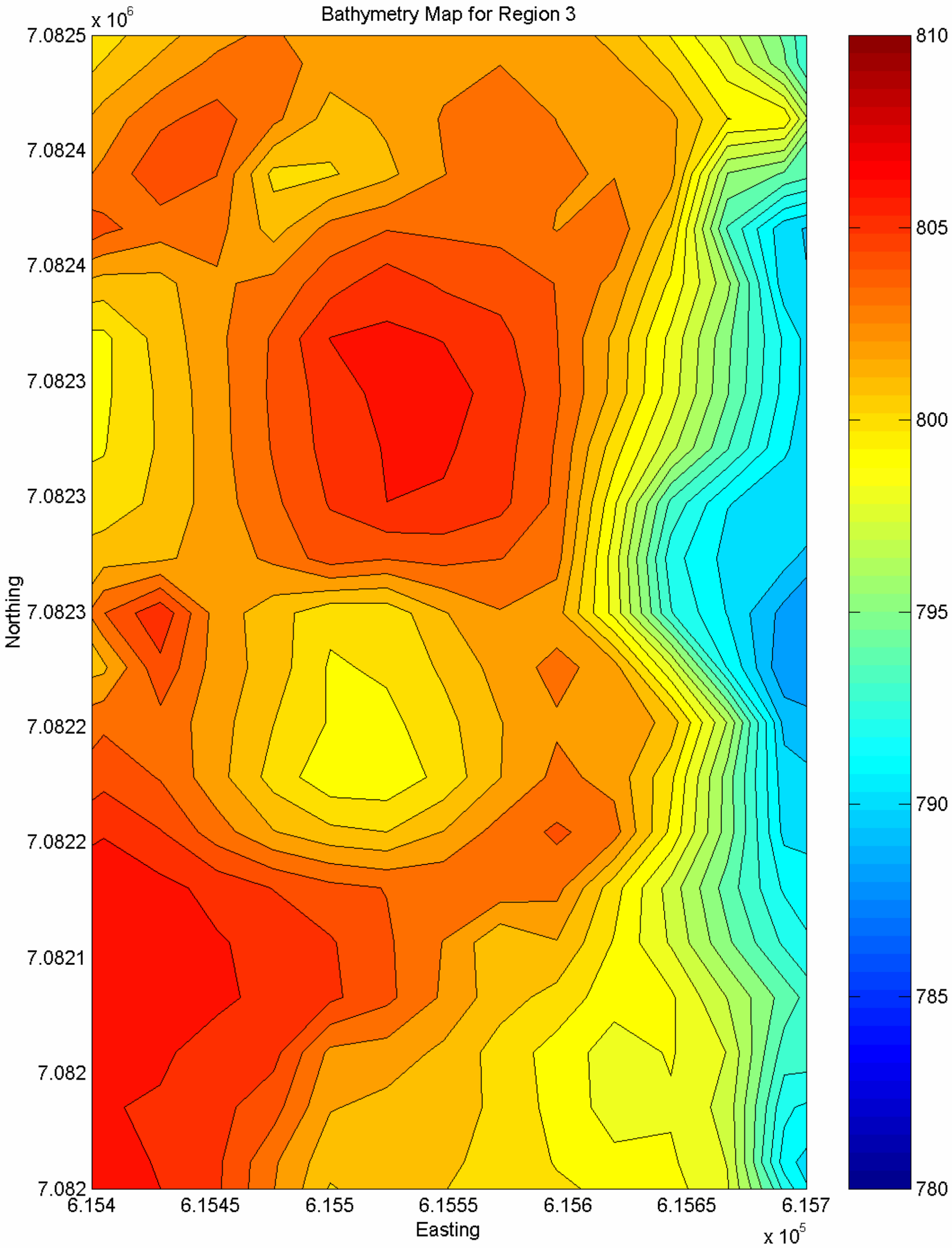


Figure A3: Bathymetry map for Region 3 based on all the transects collected.

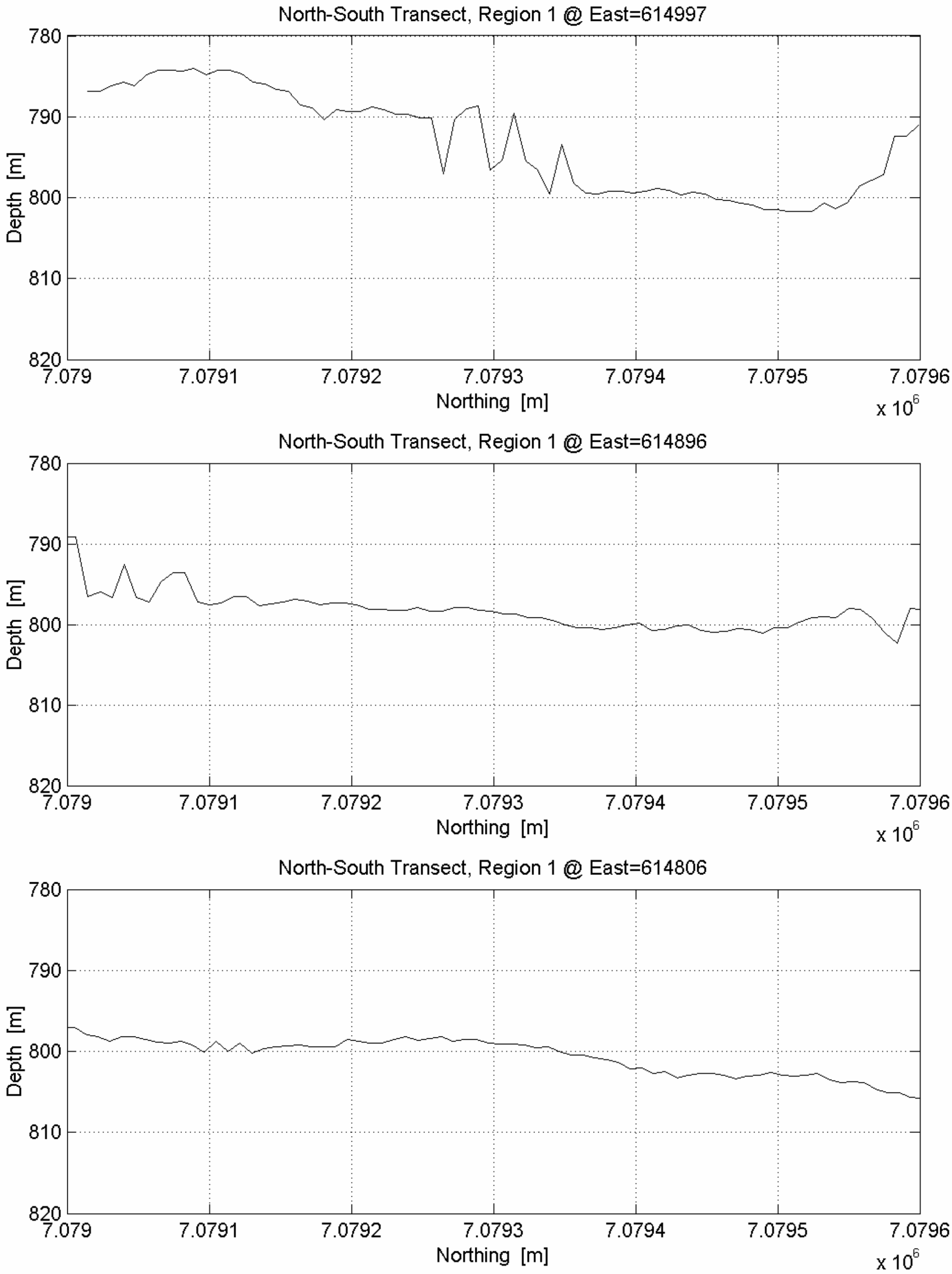


Figure A4: North-South transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

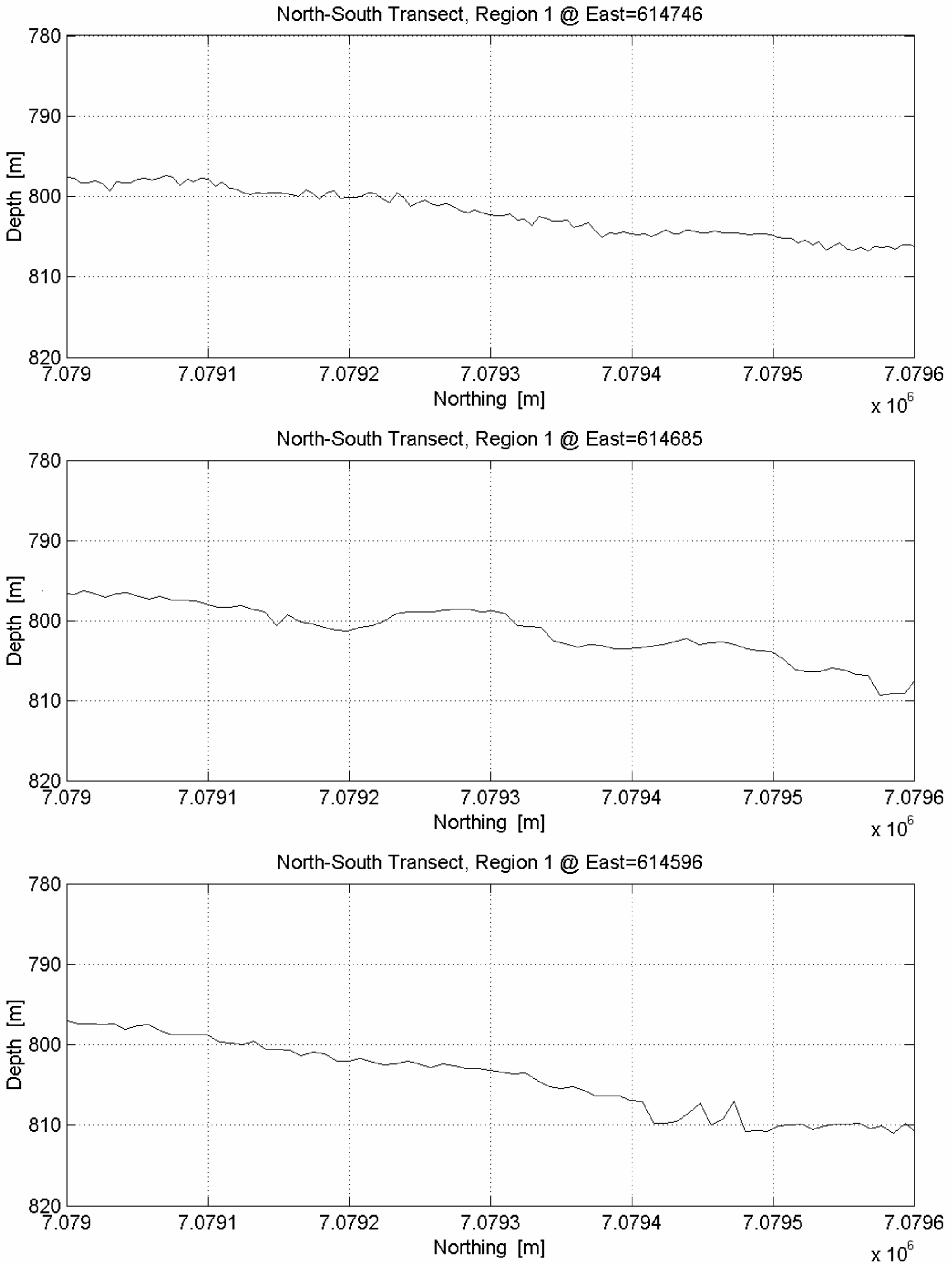


Figure A5: North-South transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

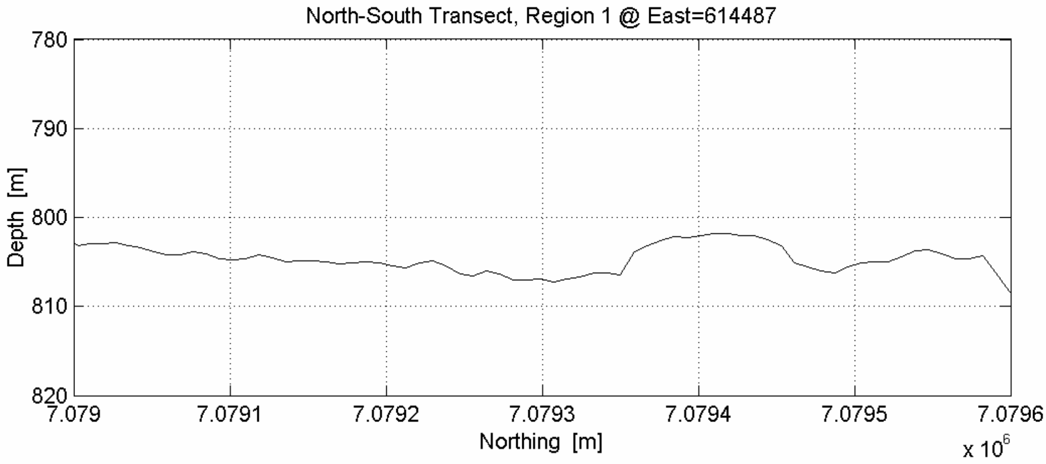


Figure A6: North-South transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

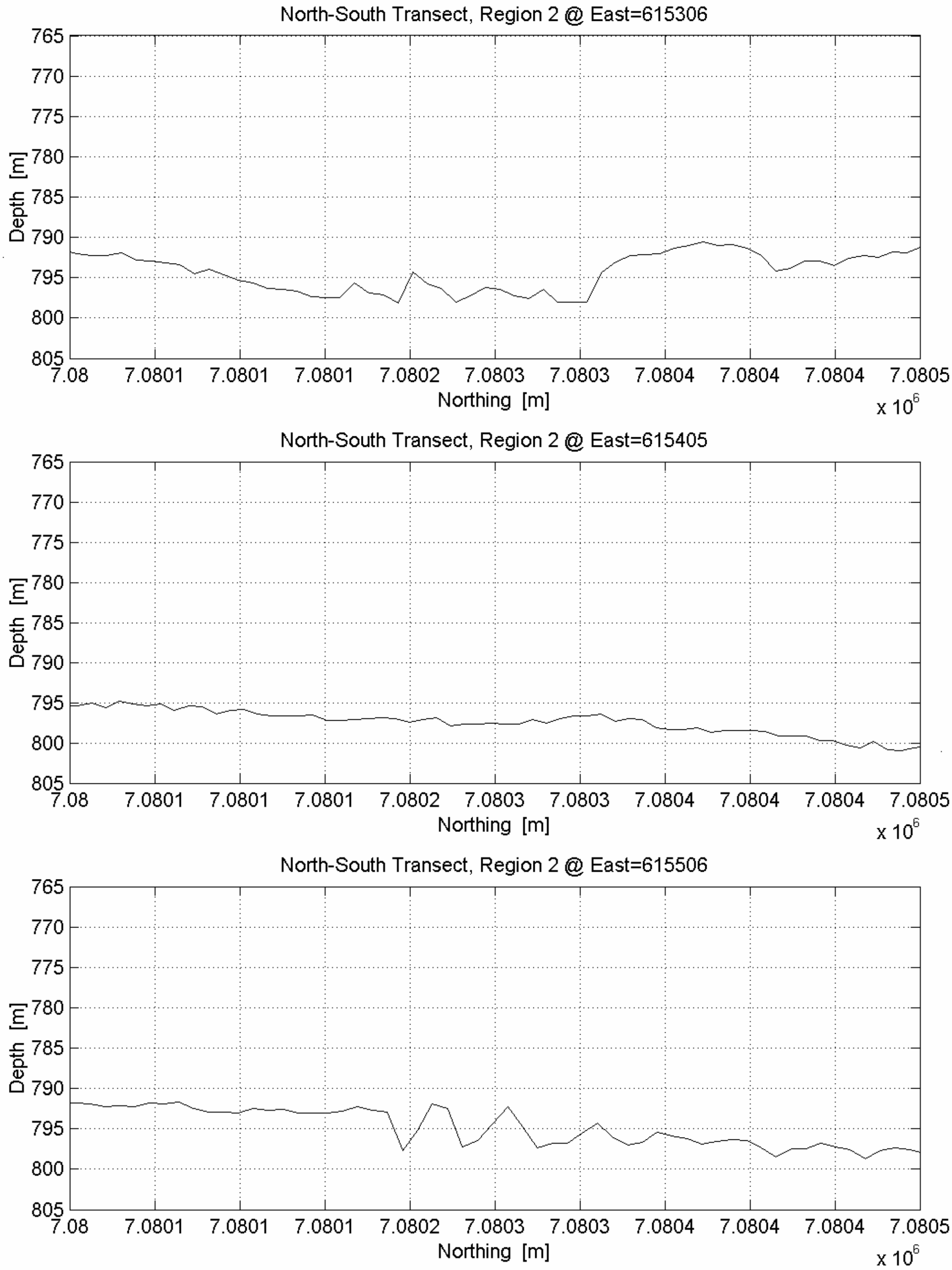


Figure A7: North-South transects through Region 2 showing the non-interpolated depth data collected from individual surveys.

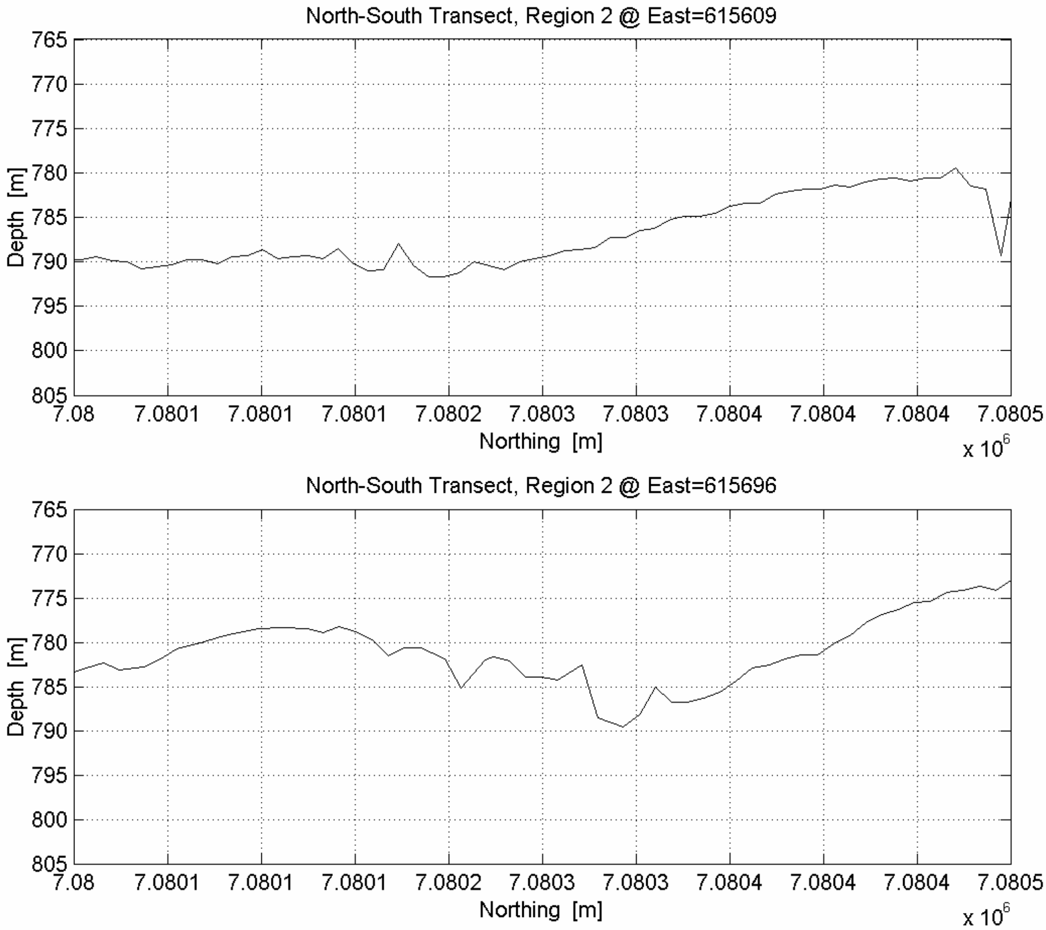


Figure A8: North-South transects through Region 2 showing the non-interpolated depth data collected from individual surveys.

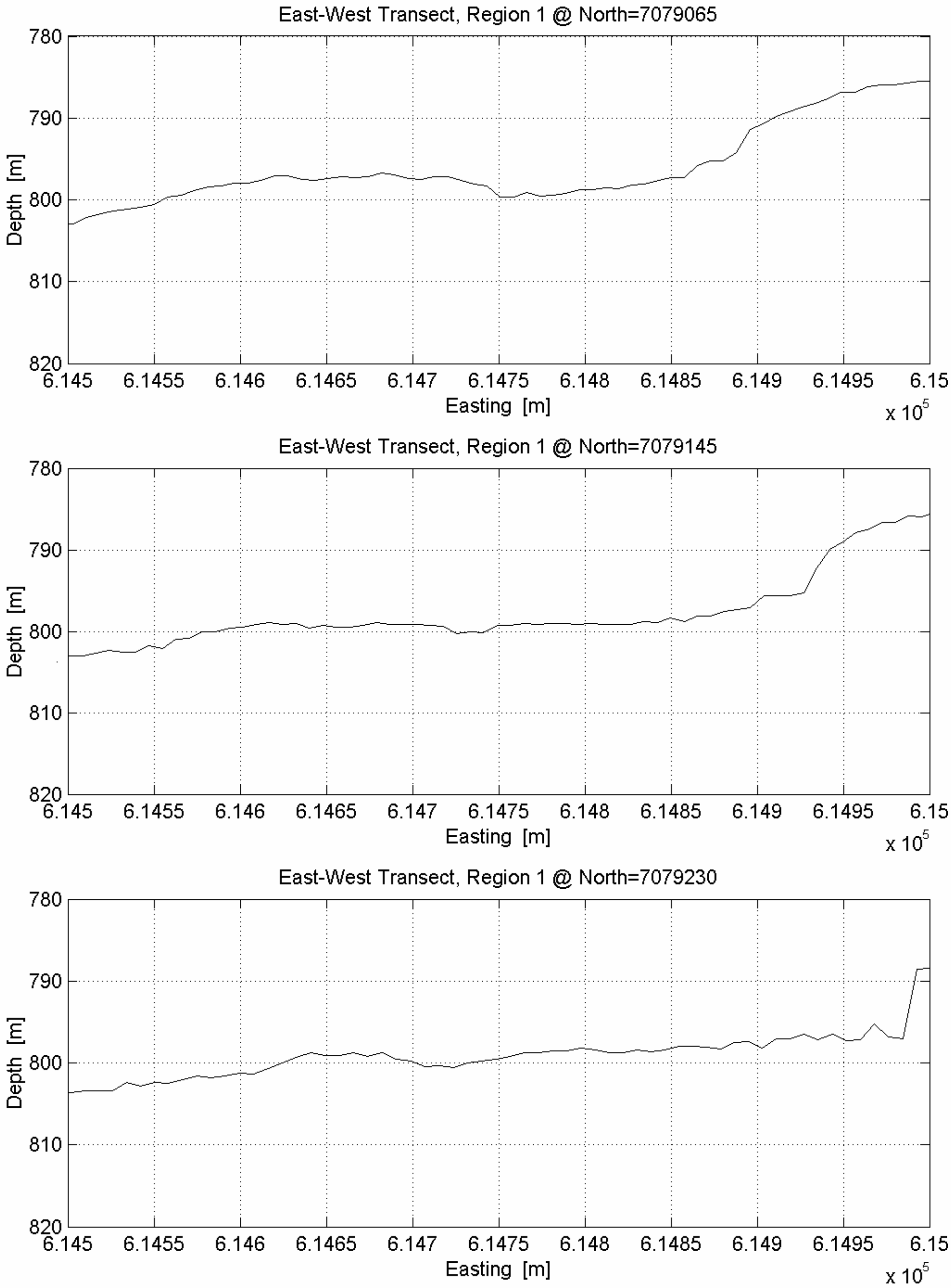


Figure A9: East-West transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

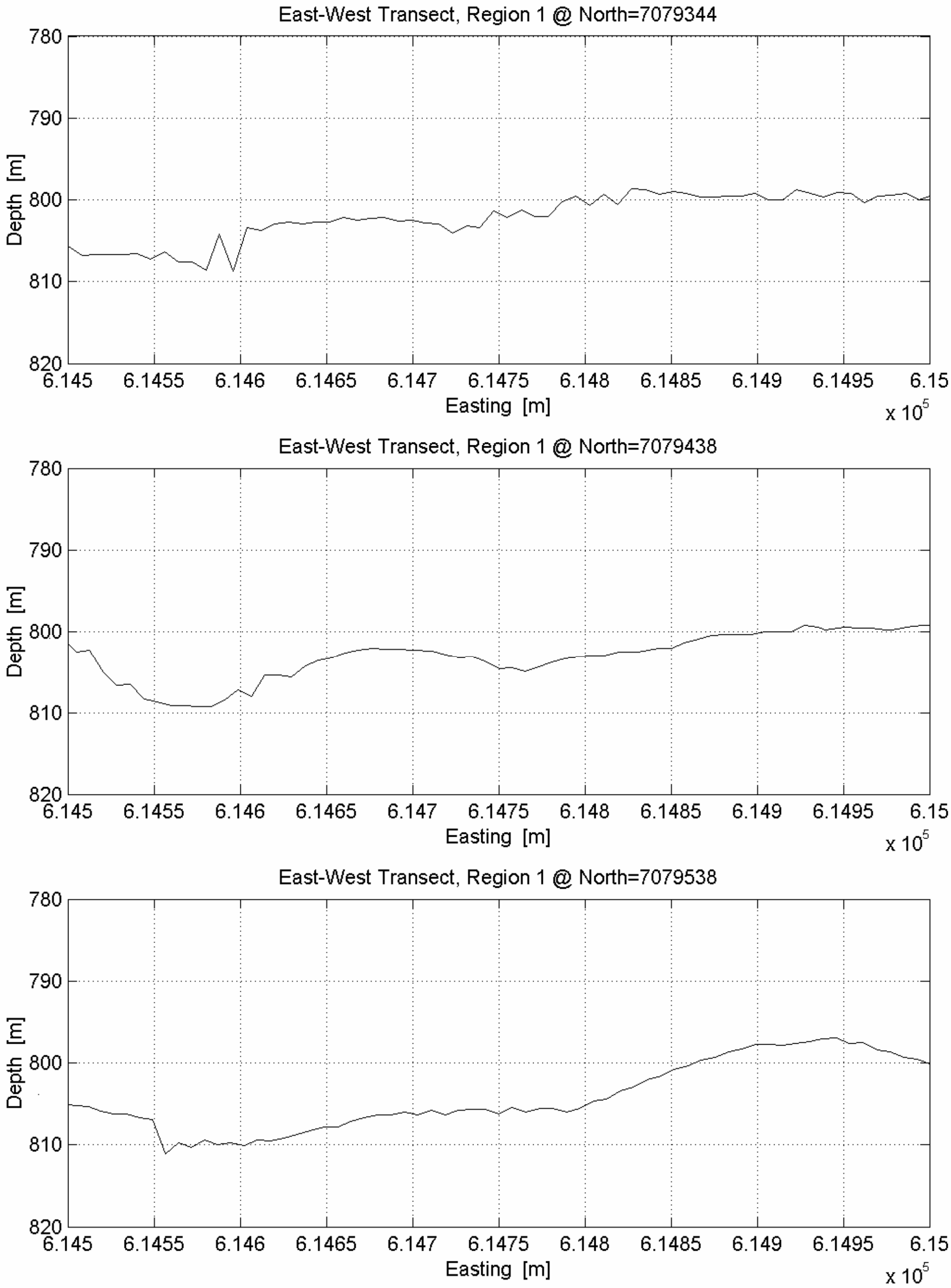


Figure A10: East-West transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

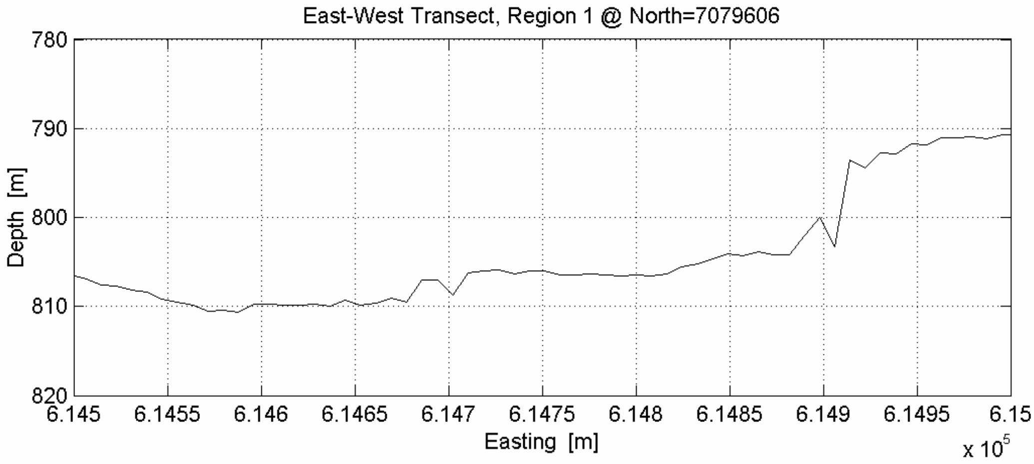


Figure A11: East-West transects through Region 1 showing the non-interpolated depth data collected from individual surveys.

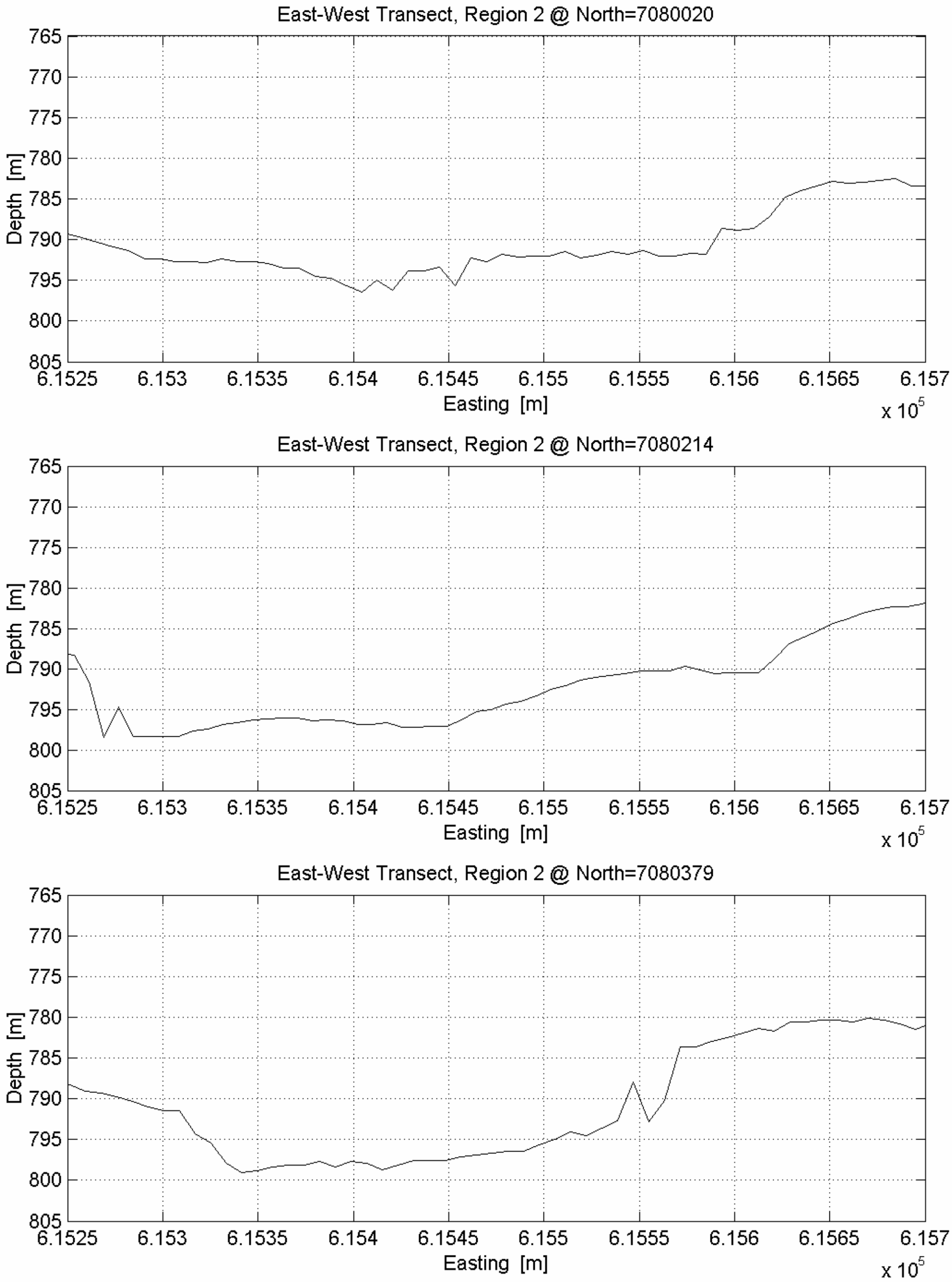
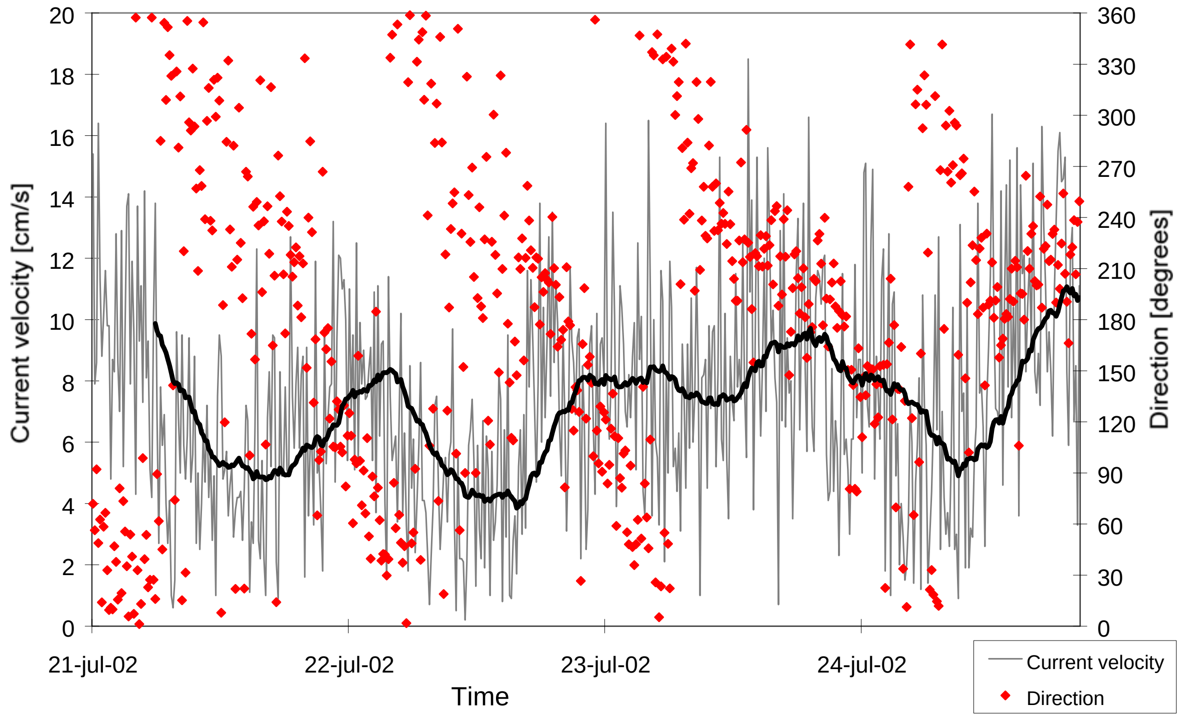


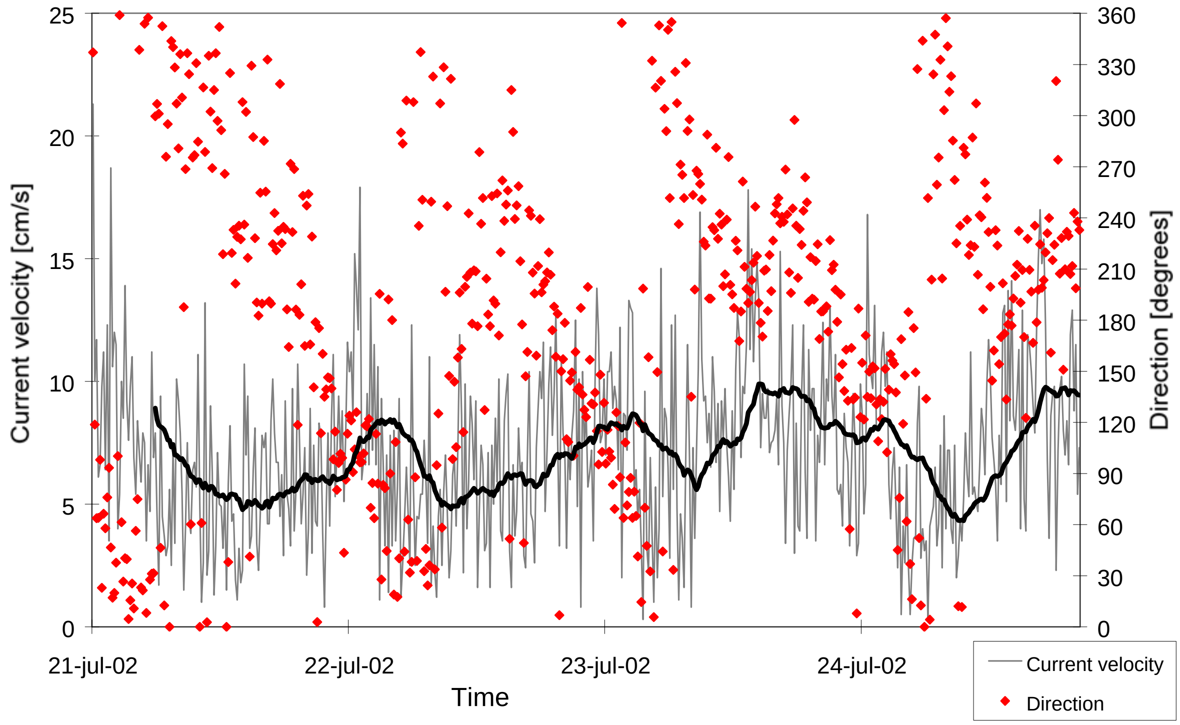
Figure A12: East-West transects through Region 2 showing the non-interpolated depth data collected from individual surveys.

Appendix B. ADCP current velocity and direction.

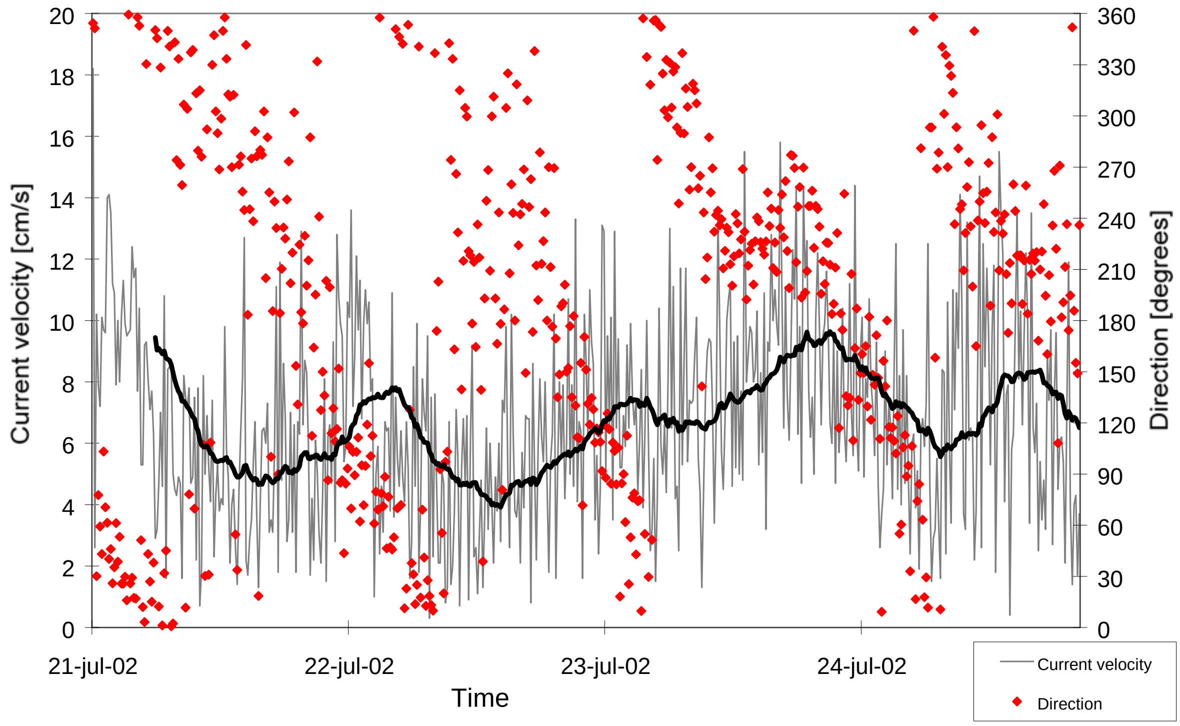
790 m



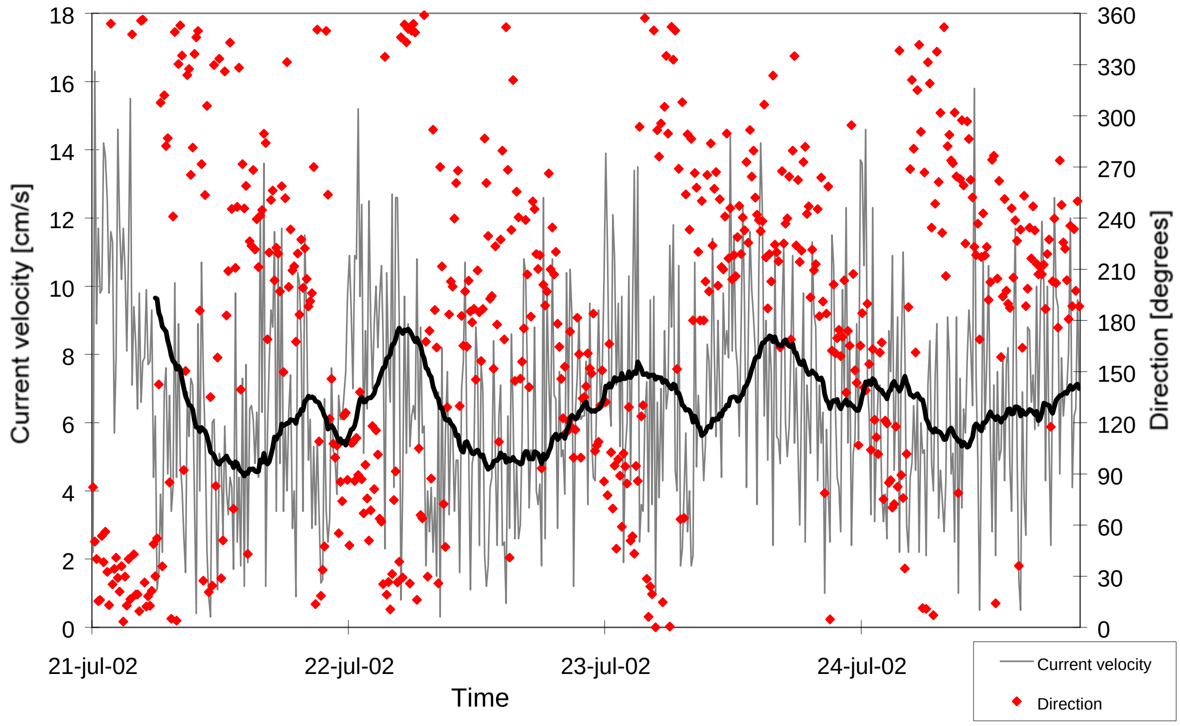
750 m



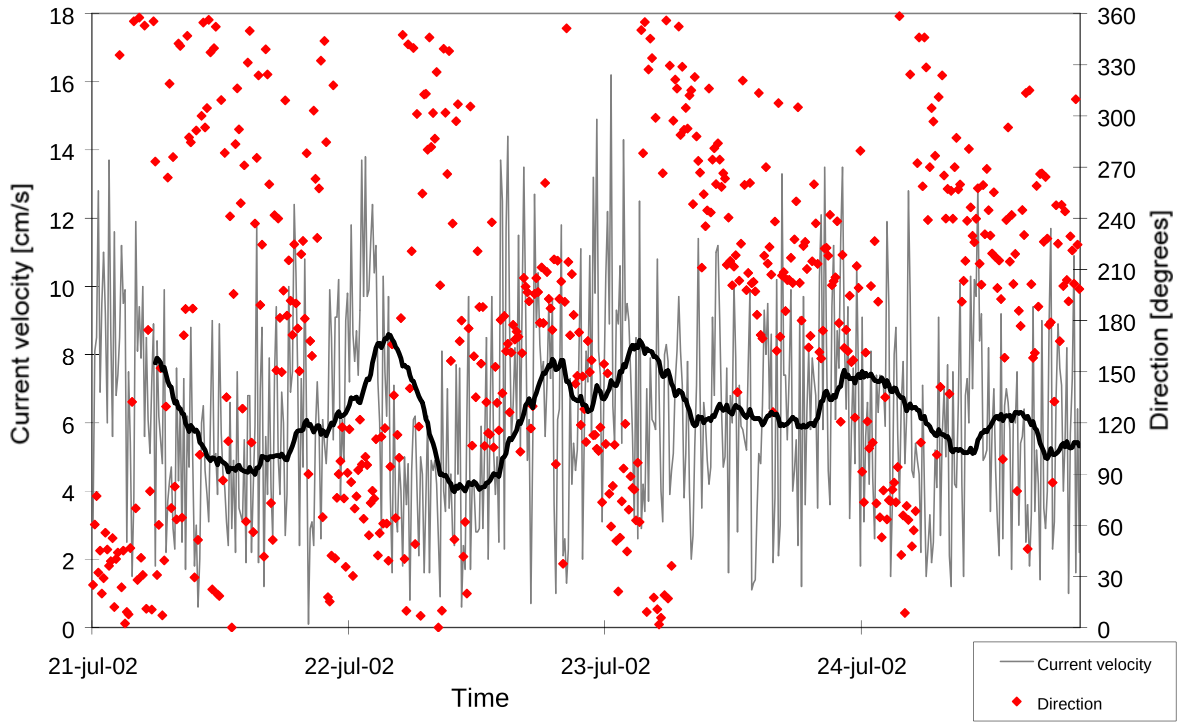
700 m


20
18
16
14
12
10
8
6
4
2
0
Current velocity [cm/s]
360
330
300
270
240
210
180
150
120
90
60
30
0
Direction [degrees]
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Time
Current velocity
Direction

650 m

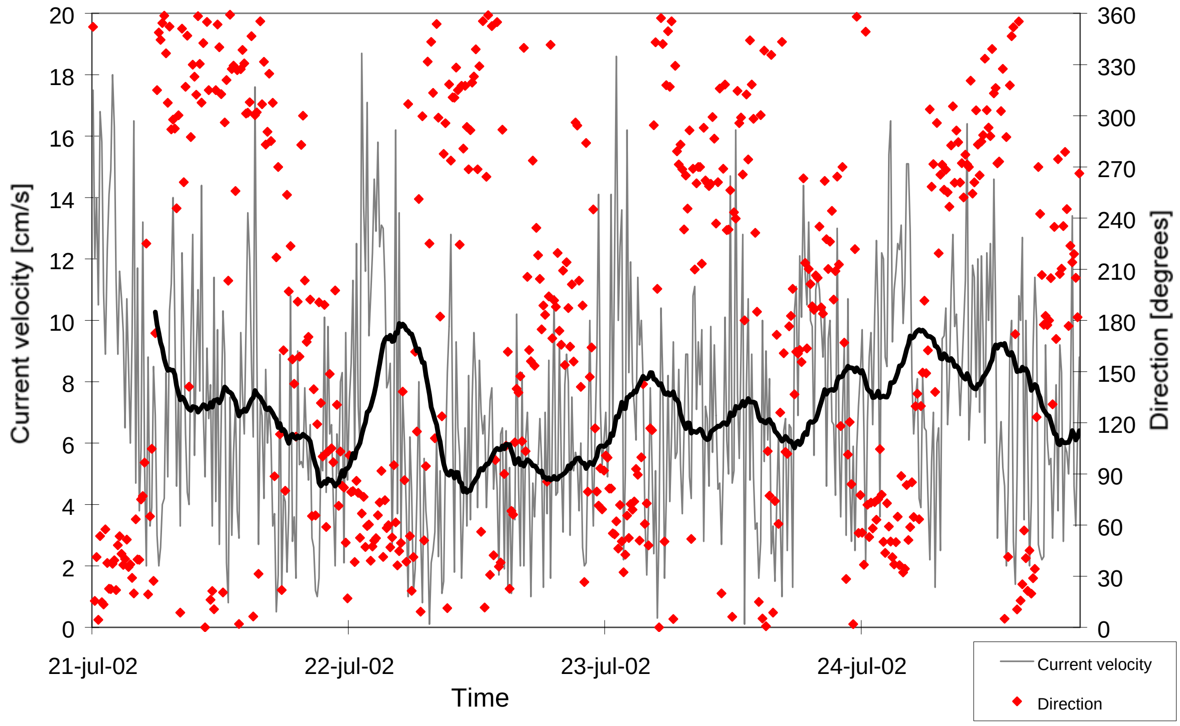

18
16
14
12
10
8
6
4
2
0
Current velocity [cm/s]
360
330
300
270
240
210
180
150
120
90
60
30
0
Direction [degrees]
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Time
Current velocity
Direction

600 m



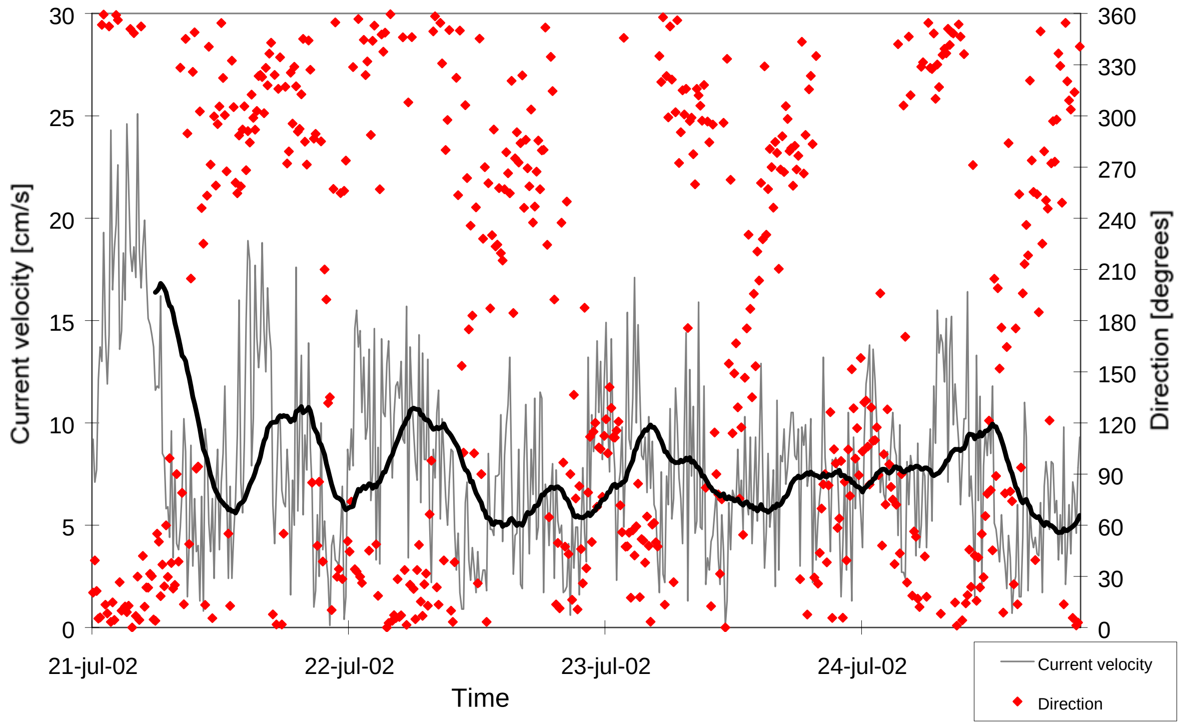
Current velocity [cm/s]
Direction [degrees]
Time
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Current velocity
Direction

550 m

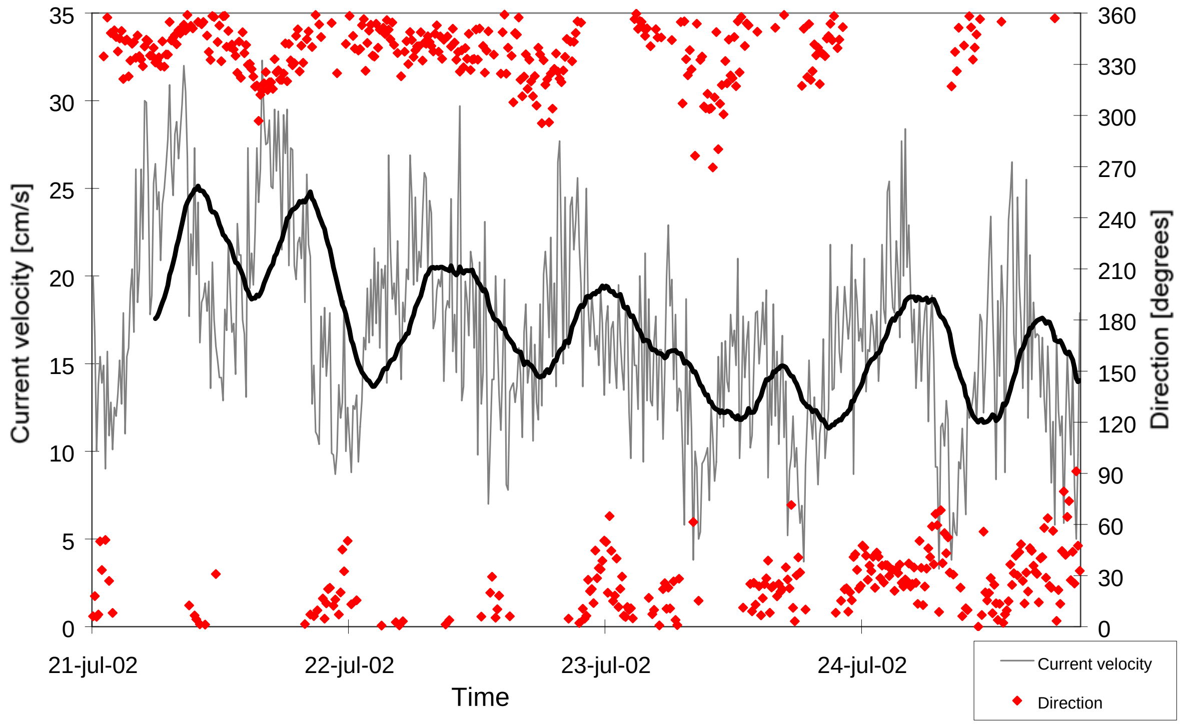


Current velocity [cm/s]
Direction [degrees]
Time
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Current velocity
Direction

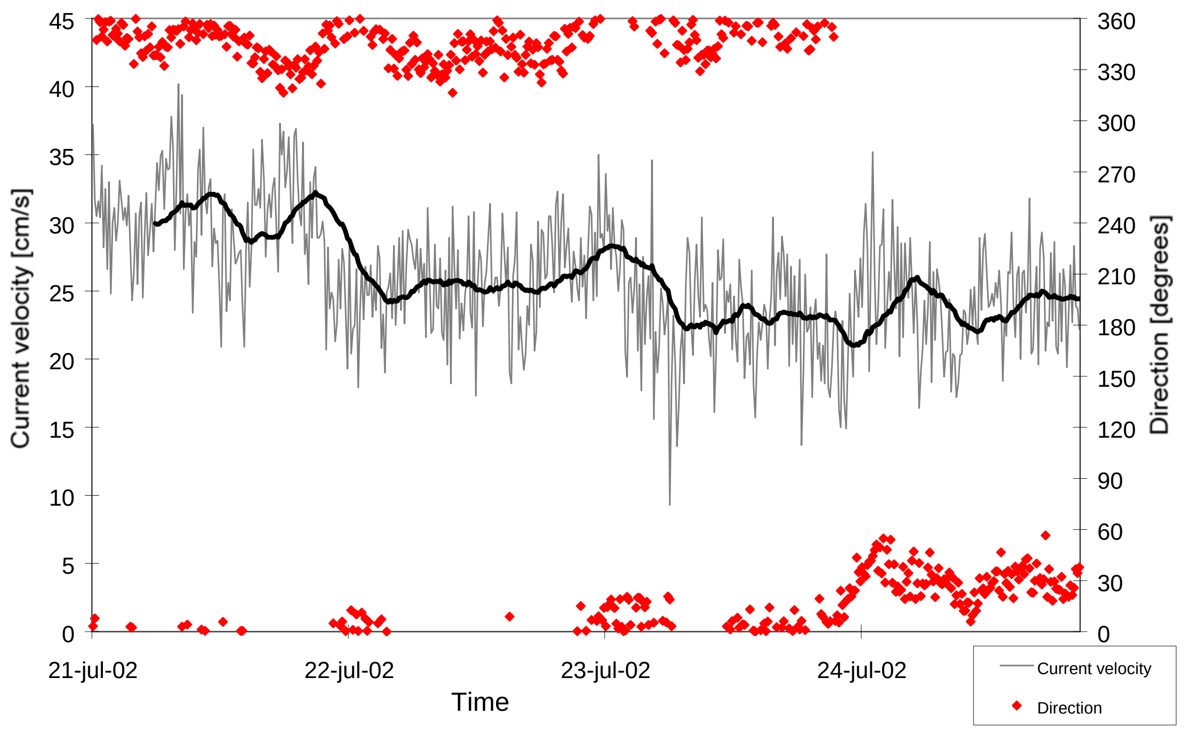
500 m


Current velocity [cm/s]
Direction [degrees]
Time
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Current velocity
Direction

400 m


Current velocity [cm/s]
Direction [degrees]
Time
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Current velocity
Direction

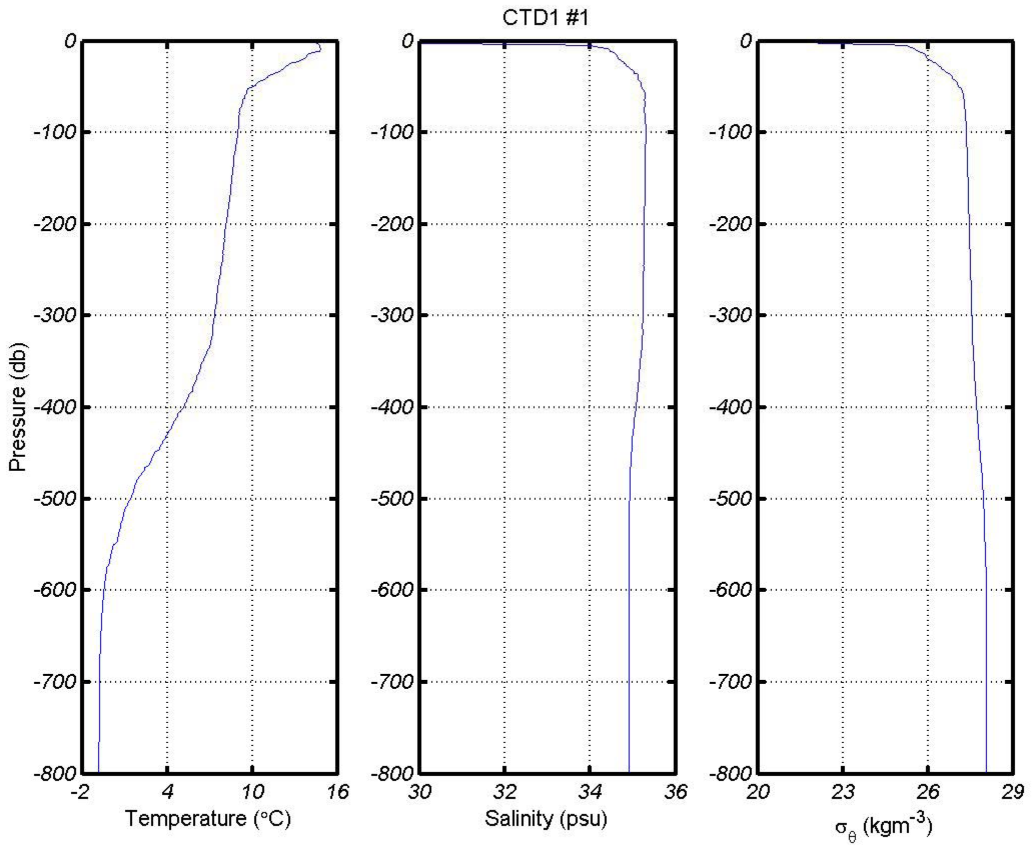
300 m


45
40
35
30
25
20
15
10
5
0
Current velocity [cm/s]
360
330
300
270
240
210
180
150
120
90
60
30
0
Direction [degrees]
21-jul-02
22-jul-02
23-jul-02
24-jul-02
Time
Current velocity
Direction

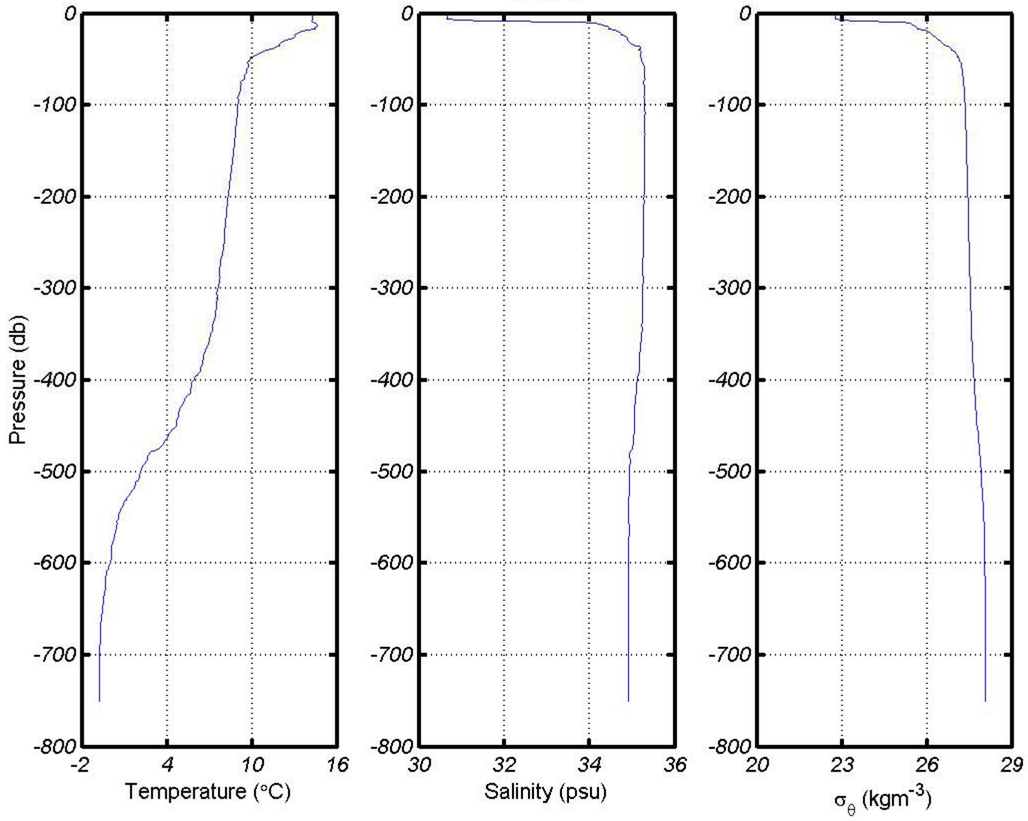
Appendix C. CTD profiles

Individual CTD profiles from Stations 1 (7 profiles), E, W, N and S. Identification of each profile is given on top of the figures. Please note that Station 1, #2, and Station W have been manually corrected for spikes.

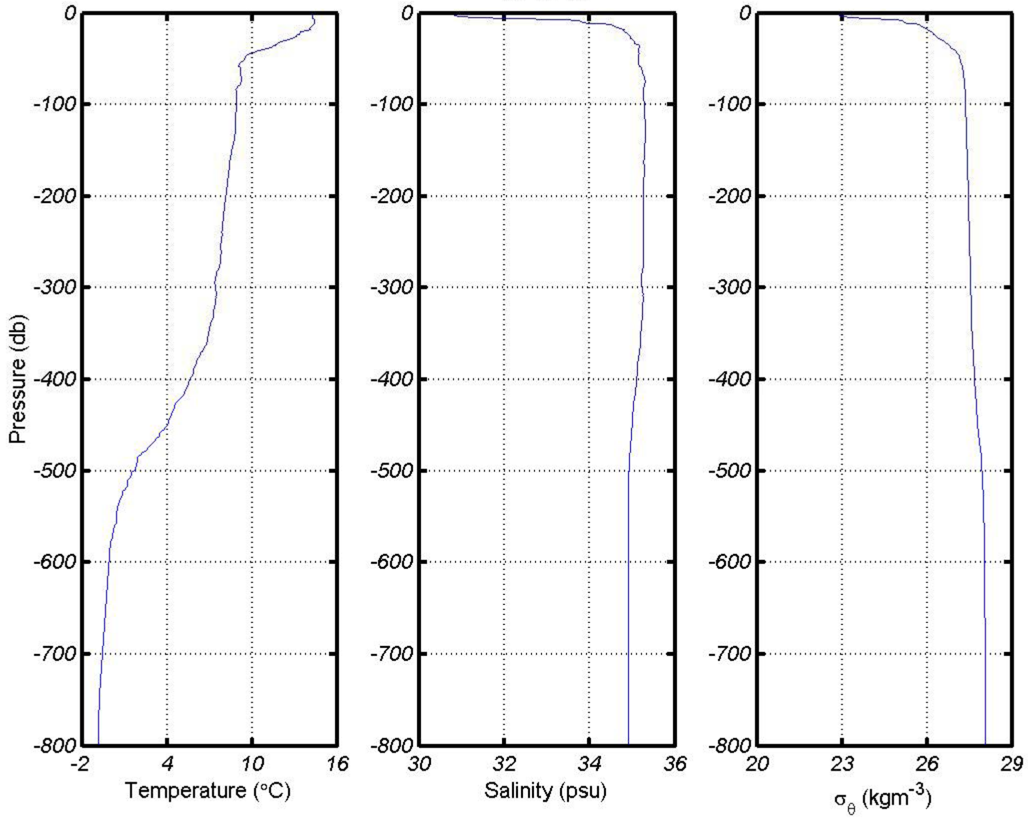
pH measurements from all profiles (except #2 at Station 1 which was contained large errors) from RV Håkon Mosby's standard pH sensor is shown in the last figure.



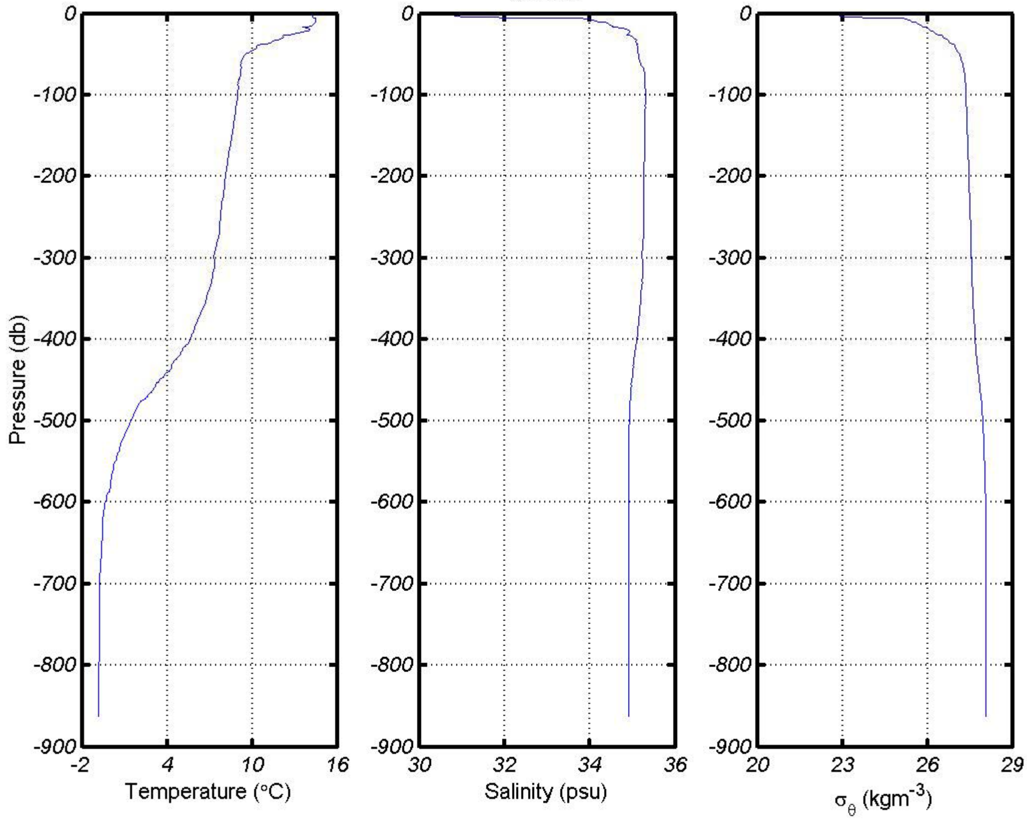
CTD E


Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σ_θ (kgm^{-3})

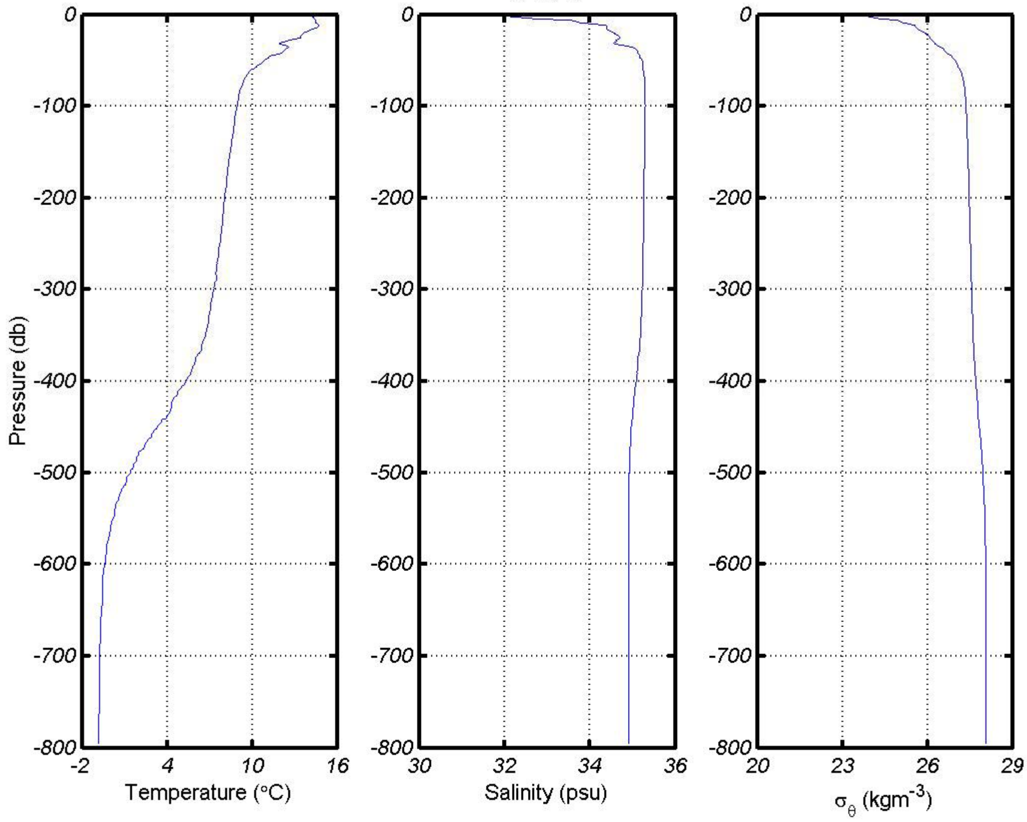
CTD1 #2

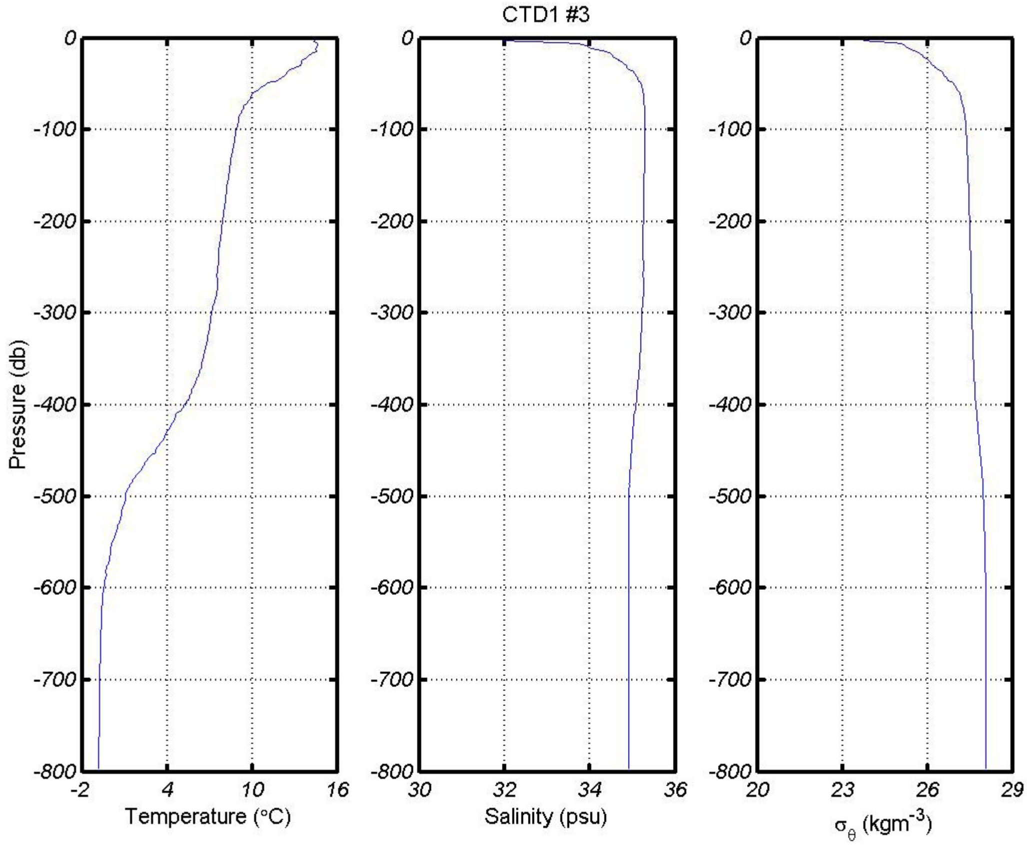

Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σ_θ (kgm^{-3})

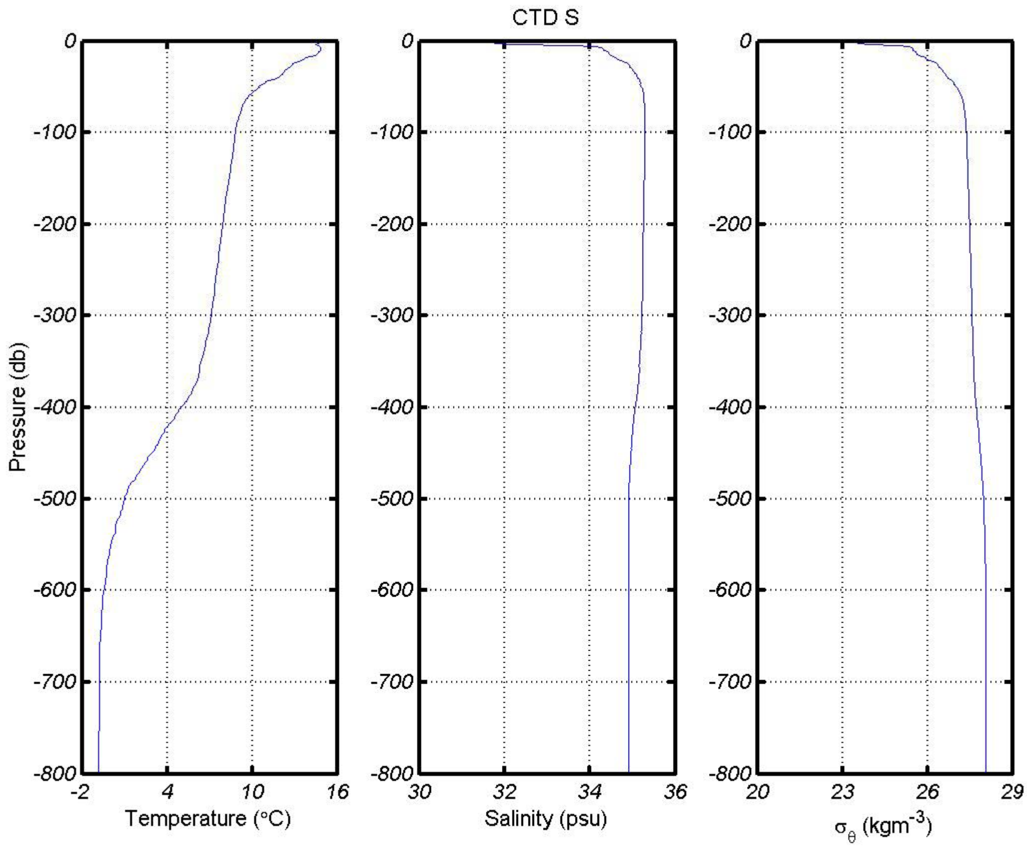
CTD W

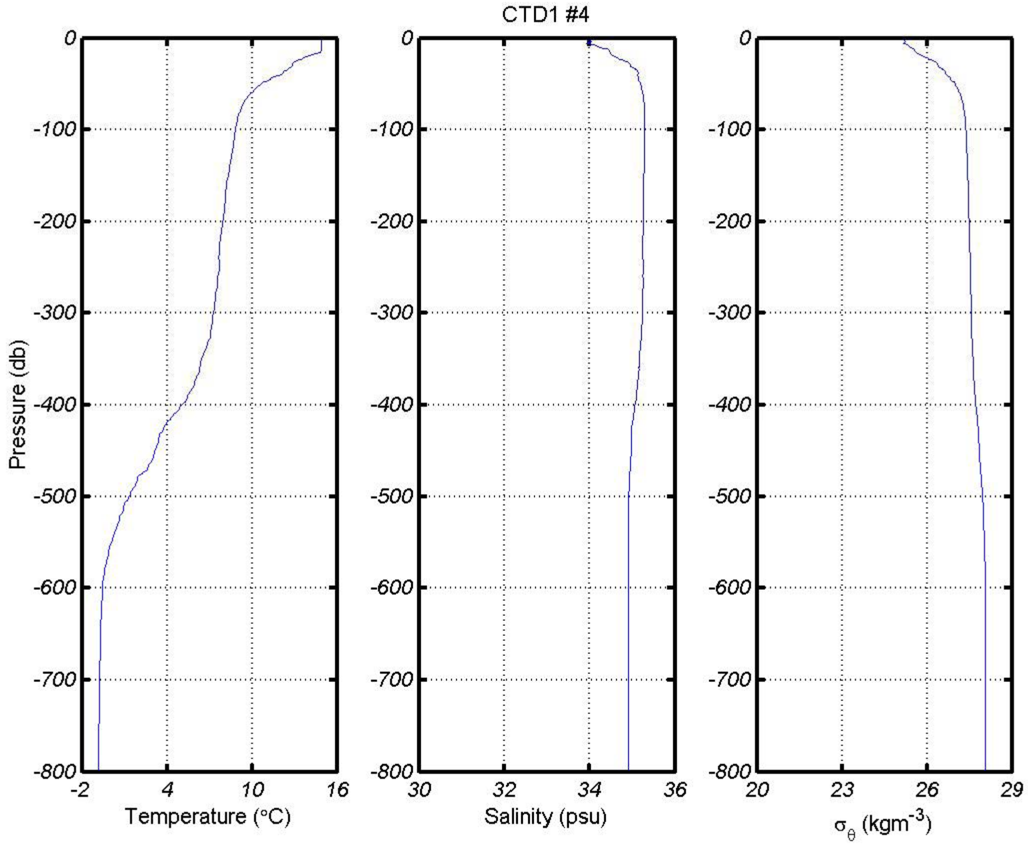

Pressure (db)
Temperature (°C)
Salinity (psu)
σ_θ (kgm^{-3})

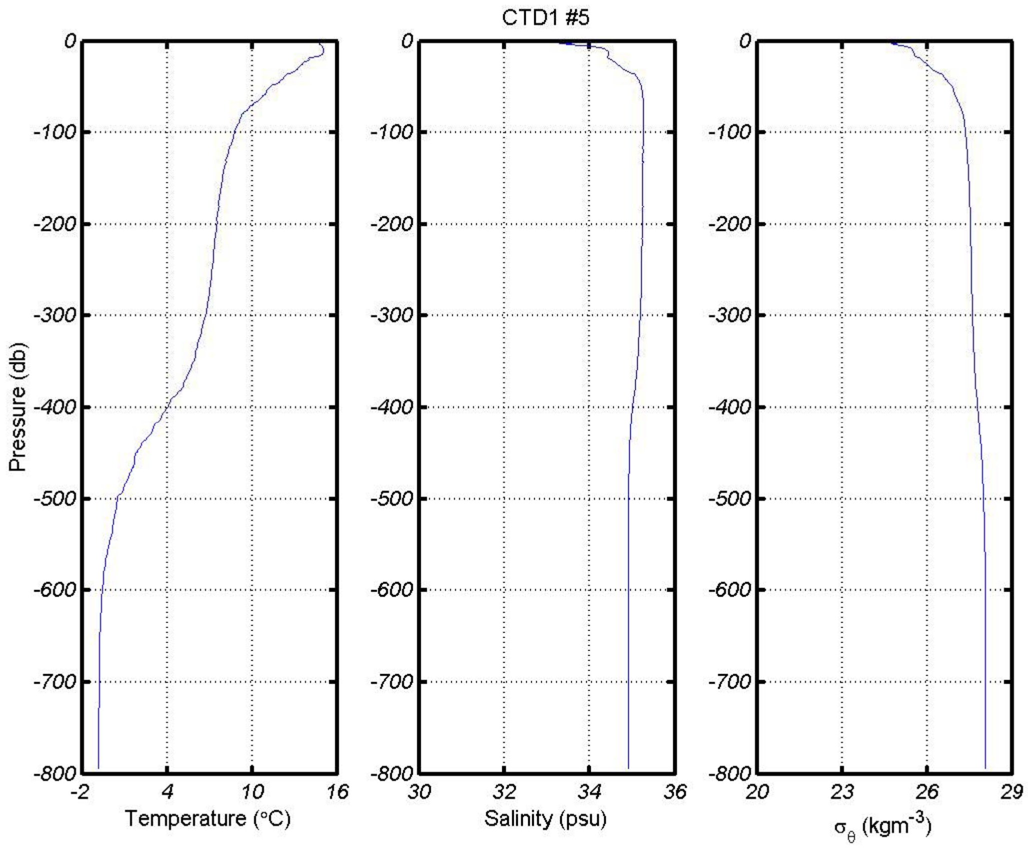
CTD N

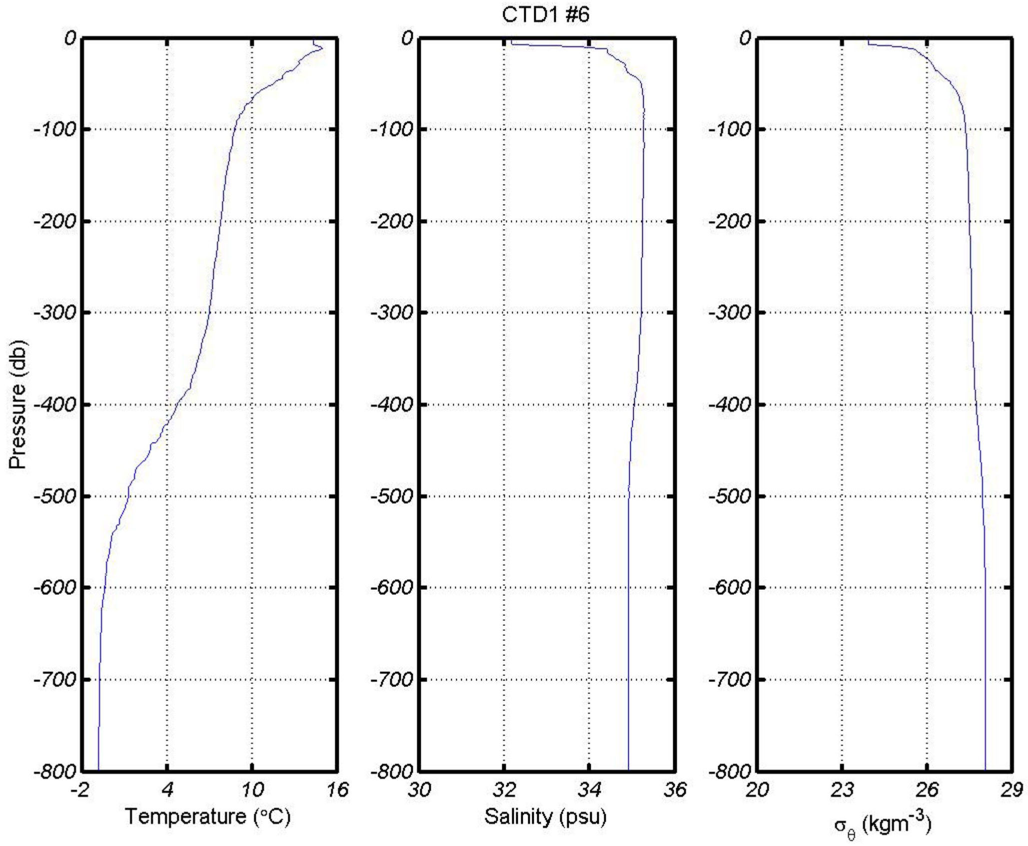

Pressure (db)
Temperature (°C)
Salinity (psu)
σ_θ (kgm^{-3})

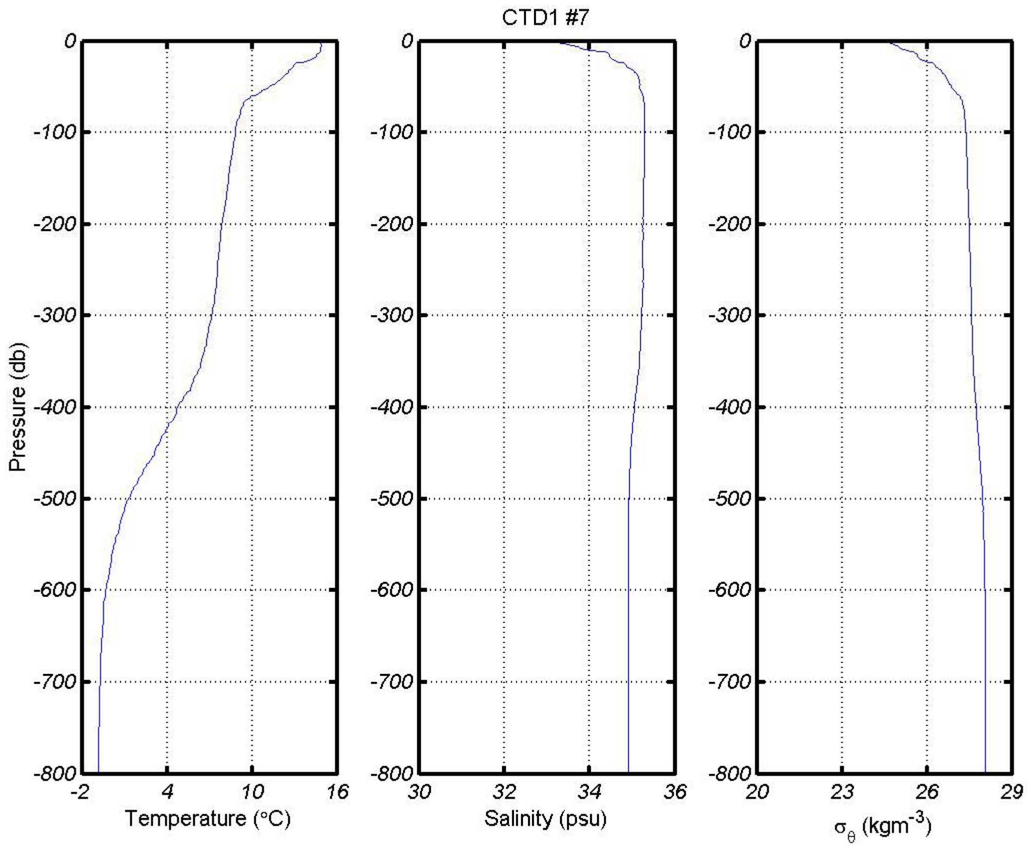

CTD1 #3
Pressure (db)
Temperature (°C)
Salinity (psu)
σθ (kgm-3)

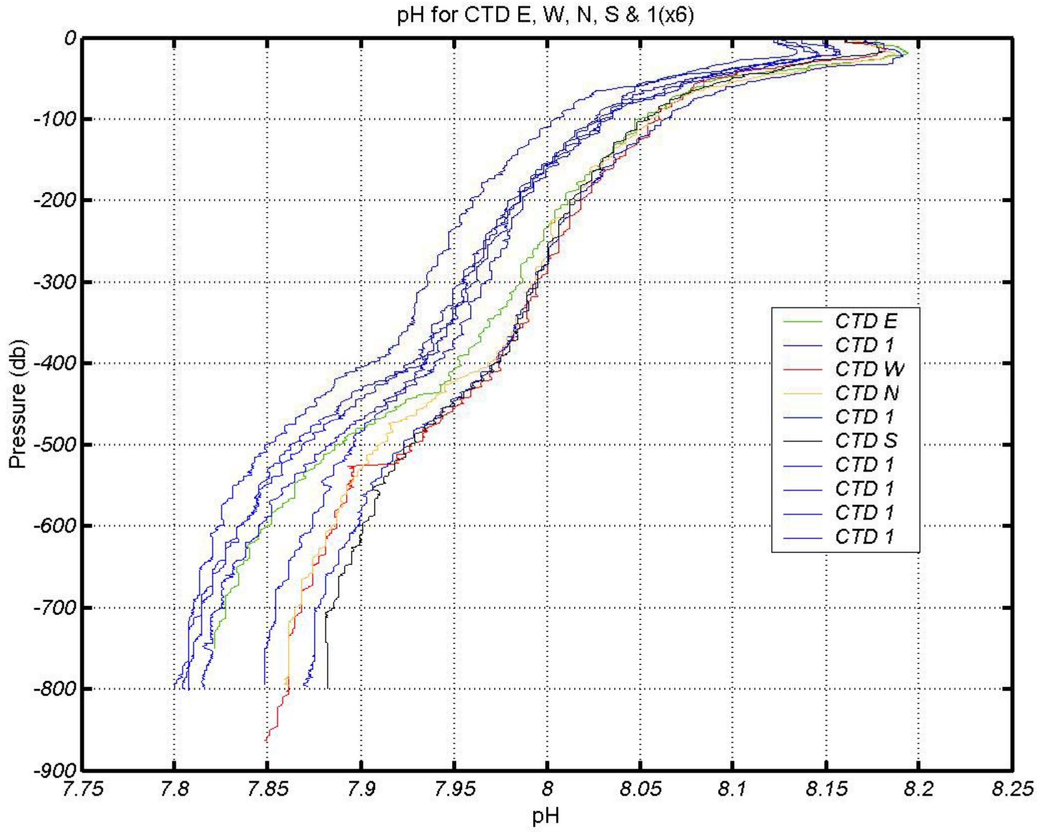

CTD S
Pressure (db)
Temperature (°C)
Salinity (psu)
σθ (kgm-3)


CTD1 #4
Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σ_θ (kgm^{-3})


CTD1 #5
Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σ_θ (kgm^{-3})


CTD1 #6
Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σθ (kgm-3)


CTD1 #7
Pressure (db)
0
-100
-200
-300
-400
-500
-600
-700
-800
-2
4
10
16
Temperature (°C)
30
32
34
36
Salinity (psu)
20
23
26
29
σθ (kgm-3)


pH for CTD E, W, N, S & 1(x6)
Pressure (db)
pH
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
7.75
7.8
7.85
7.9
7.95
8
8.05
8.1
8.15
8.2
8.25
CTD E
CTD 1
CTD W
CTD N
CTD 1
CTD S
CTD 1
CTD 1
CTD 1
CTD 1

Appendix D. Smøgen sediment samples

1) 7/22/02
   - Lat: 63°50.599, Long: 05°21.514
   - Sediment highly deformed, no top water
   - Shirayama: vertical samples: 0-0.5, 0.5-1, 1-2, 2-3, 3-4, 4-5
   - Arild: one small bottle
   - Buffered in 10-15% formalin

2) 7/22/02
   - Lat: 63°50.600, Long: 05°21.514
   - Intact with muddy water on top
   - Shirayama: top water and vertical samples: 0-0.5, 0.5-1, 1-2, 2-3, 3-4, 4-5
   - Arild: one large bottle

3) 7/22/02
   - Lat: 63°50.599, Long: 05°21.515
   - Intact with muddy top water
   - Shirayama: top water and vertical samples: 0-0.5, 0.5-1, 1-2, 2-3, 3-4, 4-5
   - Arild: added animals to bottle from grab #2
   - Smith/Vetter: two macrofauna samples, each with top 5 cm

4) 7/23/02
   - Centre of Region 3
   - Intact with muddy top water
   - Granulometry samples- 0-1, 1-2, 2-3, 3-4, 4-6, 6-8, 8-10 cm fractions
   - CRS: mud samples for microbiology

5) 7/23/02
   - Centre of Region 3
   - Intact with muddy top water
   - CRS: mud samples for microbiology

6) 7/23/02
   - Centre of Region 3
   - Clear water over highly deformed mud
   - CRS: mud samples for microbiology

7) 7/25/02
   - Centre of Region 1
   - Lat: 63°49.338, Long: 05°19.909
   - intact with muddy water
   - Granulometry samples - 0-1, 1-2, 2-3, 3-4, 4-6, 6-8, 8-10 cm fractions
   - CRS: mud samples for microbiology

8) 7/25/02
   - Centre of Region 1
   - Lat: 63° 49.338, Long: 05°19.909
   - intact with muddy water
   - CRS: mud samples for microbiology

Appendix E. Summary cruise schedule

19. July

0800 Repairs and testing of ROV, Marineholmen
1330 Loading and setting up equipment at Nykirkekaien
Afternoon & evening ROV repairs/testing
2230 Last arrivals!
2300 Meeting/briefing with cruise participants
2330 Safety tour of vessel
2400 To Marineholmen, load trawl

20. July

0025 Depart from Marineholmen
0100 ROV testing near Bergen, 320 m depth
0200 ROV tested successfully.
0300 Unload ROV support crew in Bergen (2 remain on board), final departure
0845 Meeting between ROV operators and scientists – general info and plans
Daytime Preparation of equipment for ROV (corer + scavenger traps)
Daytime Prep of ADCP rig
1230 Safety meeting with Captain and safety ombudsmen (Ship's + scientist's; Magnus J.)
1500 Bathymetry & CTD preparations meeting
1530 Arrival Torvik, pickup of N-R Hareide
1600 Life boat drill
1630 Meeting with detailed work plan for next 20 hrs + last safety issues
Evening final ADCP preps, ROV adjustments

21. July

0230 Arrival at 63°45N, 05°15E, start bathymetric transects
0600 ADCP deployment – at bottom 0725
0800 Bathymetric transects
0009 Long line deployment from F/V 63°47.50 N, 05°17.50 E, 823 m depth
1000 CTD profile 1 (file #253); water depth 814, sample depths 800, 750, 700, 650, 600, 400, 200, n.s.
1100 preps for ROV survey 1; from pos: 63°50.6 N, 05°21.5 E, N along depth contour 800 m
1300 ROV deployment; bottom at around 1330
1450 ROV systems blank – power fault suspected
1600 ROV on deck – check/repairs
1900 Mocness plankton hauls. At first attempt, trouble with the signal cable drum, system retrieved and redeployed at 2100. Depth intervals 700-650-600-500-400-300-200-100-surface
2300 Long line haul

22. July

0100 Bathymetry – echo sounding transects
0500 Traps deployment at 800 m, 1.5 Nm south of ADCP
0600 CTD casts at stations E (750+ m, file #254), 1 (800+ m, #255) and W (850+ m, #256). Winch drum was bad – erratic lowering of CTD and spiky data. Bottle sample depths OK. Winch needs repair/adjustments!
0900 CTD winch adjustments
1015 Grab sampling at 1st ROV survey site
1330 Trawl at 700, 650 and 600 m

1700 CTD casts stations N, 1, S (all 800+ m, file #s 257, 258,259)
1930 MOCNESS plankton haul
2230 Retrieve and redeploy bottom fish traps
All day – ROV repairs

23. July

0100 Bathymetry – echo sounding transects
0600 CTD station 1 – full profile of water samples (as day 1, file # 260)
0800 ROV survey of Area A (northernmost)
ROV in water ca. 0930, on bottom ca 1005, disrupted ca. 1240, on deck ca. 1330 (?)
1300 Planning meeting for remainder of cruise with Rick, Scott, Craig and Eric
1400 Sediment grabs in centre of Area N
1630 CTD 1 – triplicate profiles at depths 800, 750, 700 (file # 261)
1830 Recover fish traps and deploy scavenger traps N of Area S
2000 ROV survey Area S
2400 Recover scavenger traps

24. July

0100 Echo transects
0600 CTD station 1 – full profile including salinity calibration samples at 6 depths (file # 262)
0800 Trawl (700-650-600)
1200 ROV preparations
1630 Echo survey of Area S
1700 ROV dive in Area S – scavenger trap test
2000 MOCNESS
2330 Sediment grabs from centre of Area S

25. July

0245 CTD profile at Station 1 (w/O2 samples, file # 263)
0400 ADCP modem test
0500 ADCP recovery
0700 Redeployment of long lines + pick up passenger from fishing vessel
0800 Steam for port!
1500 Arrival Ålesund, drop of passenger
1630 Arrive at Torvik, drop off N-R Hareide

26. July

0800 Arrive Bergen, unload equipment