Cruise report FS2008

Physical Oceanography and Sea-Ice Physics in the EGC and Fram Strait with R/V Lance

30 August - 19 September 2008

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1 Introduction

The annual Fram Strait cruise in September with R/V Lance is a long standing tradition at Norwegian Polar Institute (NPI). Since 1997 NPI has been deploying 4 to 6 oceanographic moorings (containing around 20-24 instruments in total) in the East Greenland Current to measure temperature, salinity and velocities. The purpose is to monitor the outflow of Arctic water masses, specifically of freshwater fluxes, into the Nordic Seas and Atlantic Ocean. Due to anomalously heavy sea-ice conditions in 2007 NPI was not able to recover any of the 6 moorings in that year. Hence, this year's priority was to retrieve the moorings from the EGC and to redeploy them with new instruments. The annual CTD section from Svalbard to the East Greenland Shelf along 78º50'N was repeated again as well as 4 additional sections across the shelf. New to this years cruise was sampling of oxygen isotopes and nutrients to identify the origin of the polar freshwater in the East Greenland Current and on the East Greenland Shelf.

In addition, this years Fram Strait cruise contained a large component of sea-ice physics investigating sea-ice optics, snow and sea-ice profiles and mechanics. In total 11 stations carried out on ice floes in the vicinity of the ship.

Sea-ice concentration maps (AMSR-E) and Radarsat (SAR SCW) satellite images of sea-ice cover were obtained almost daily. These images were extremely useful and made it possible to coordinate the different activities and schedule the sailing plan optimally throughout the cruise.

Laura de Steur

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3Physical Oceanography

Participants: Laura de Steur (NPI), Kristen Fossan (NPI), Paul Dodd (NPI), Malin Rue (UiO), Vibeke Sundfjord (UiO)

3.1 Moorings

Laura de Steur (NPI), Kristen Fossan (NPI)

Leaving Longyearbyen on Saturday August 30 we steamed straight to the 1st mooring location (F11) at 78º50'N, 3º15W since both the weather forecast and sea-ice maps looked very promising. Tight planning, hard work and very fortunate sea-ice conditions made it possible for us to recover all 6 Fram Strait moorings (Figure 1) within 3 days. All instruments were found to be in great shape and sometimes still running, implying that the instruments have monitored the East Greenland Current for 2 years in a row during the anomalous Arctic summers of 2007 and 2008 that showed a dramatic reduction in perennial sea-ice extent. We expect that the huge Arctic sea-ice retreat and recent warm Arctic summers have had an imprint on the Polar Waters.

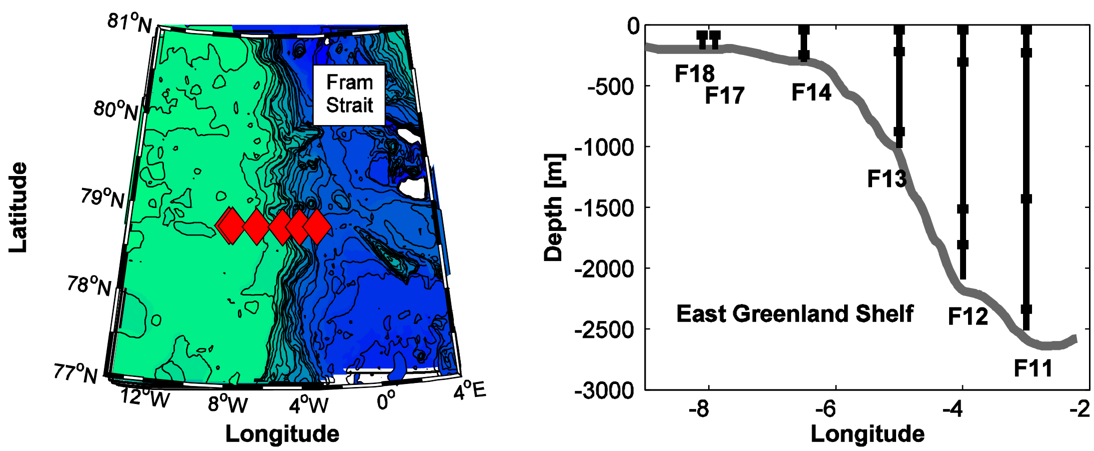


Figure 1: Mooring locations in the EGC at the East Greenland shelf slope.

The battery from one of the RDCP600 instruments had stopped working after approximately 5 months (January 2007) for unclear reasons. The instrument will be sent back for maintenance. All the SBE37 microcats were in great shape and had been running up to September 2008. They will be sent away for calibration after the cruise. An overview of the recovered moorings and their instruments is given in Appendix A. The salinity F14 in the upper ocean as a function of time measured by the 4 microcats at F11 through F14 is shown Figure 2.

The moorings F18, F17, F14, F13 and F12 were redeployed at ~8ºW, 8ºW, 6º30W, 5ºW and 4ºW respectively, which are the same positions as previous years. F11 was deployed further west (at 3º38W) than usual since we could not reach the original planned position due to very high sea-ice concentration. The distance is approximately 4.4 nautical miles west from its original position. The exact mooring positions, date and time of deployment and instrument details are given in Appendix B. In addition, the instrument set up for each single mooring is provided in a technical drawing.

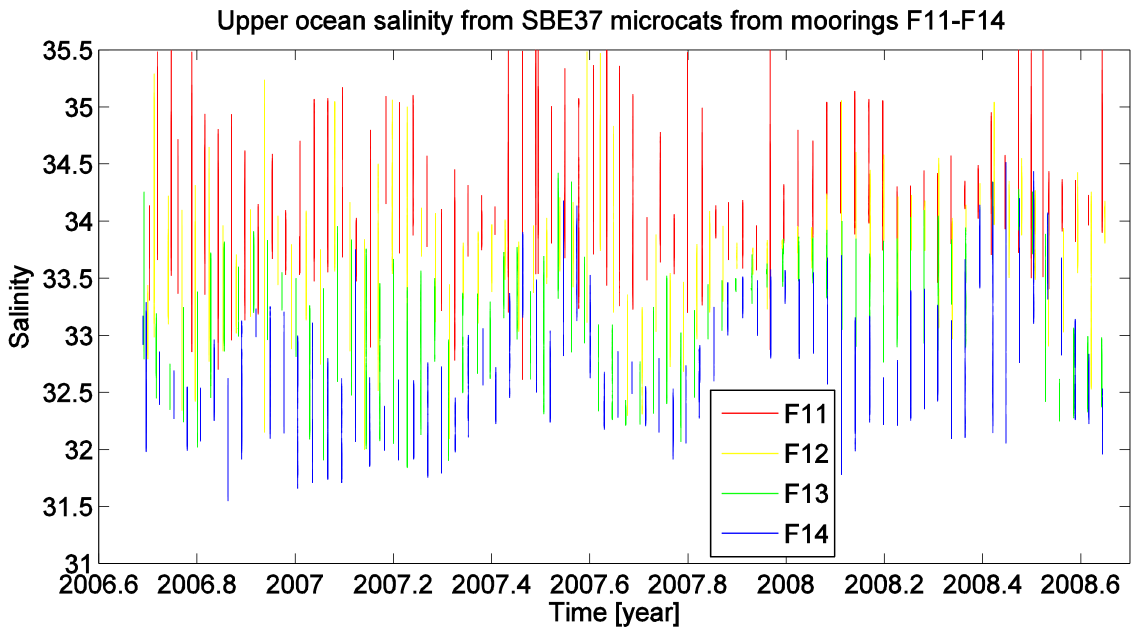


Figure 2: Salinity measured by the microcats in the upper ocean at ~60-80dbar.

A new mooring on the iAOOS project was planned to be deployed at the shelf edge further south at ~76ºN, 10ºW. However, the bottom anchor was lost while trying to get out of the sea-ice and hence we needed to postpone this deployment until next year

3.2 CTD measurements

Laura de Steur (NPI), Paul Dodd (NPI), Vibeke Sundfjord (UiO), Malin Rue (UiO)

Whenever possible we continued with CTD (Conductivity Temperature Depth) measurements along similar sections as previous years. The CTD system onboard was a SBE911plus with new temperature and conductivity cells added at the start of this cruise. Figure 2 shows the location of CTD stations occupied during FS2008. The time, date and position of each station along with the depth determined from the ship echo sounder are provided in table 3 in Appendix C. CTD stations were organized along 6 transects:

- **An east-west transect along the mooring array line at 78º50´N** has been sampled annually in late summer since 2001, and also during April-May 2008. This section was extended as far west as Lance was able to penetrate through the ice.
- **An east-west transect at 79º50´N** provides a view of the circulation on the East Greenland Shelf at 79º50N and also gives insight into the possible properties of similar shelf waters beyond the western end of the 79º50N transect.
- **A east-west transect at 80º30´N** provides a view of the circulation on the East Greenland Shelf at 80 30º N
- **An east-west transect along 77º40´N** repeats a transect from the KVS2007 and KVS2008 cruises in April/May 2007 and 2008
- **Two north-south transects along 8ºW and 11ºW** are designed to give insight into the shelf circulation at this latitude and also to investigate polynya processes in this area.

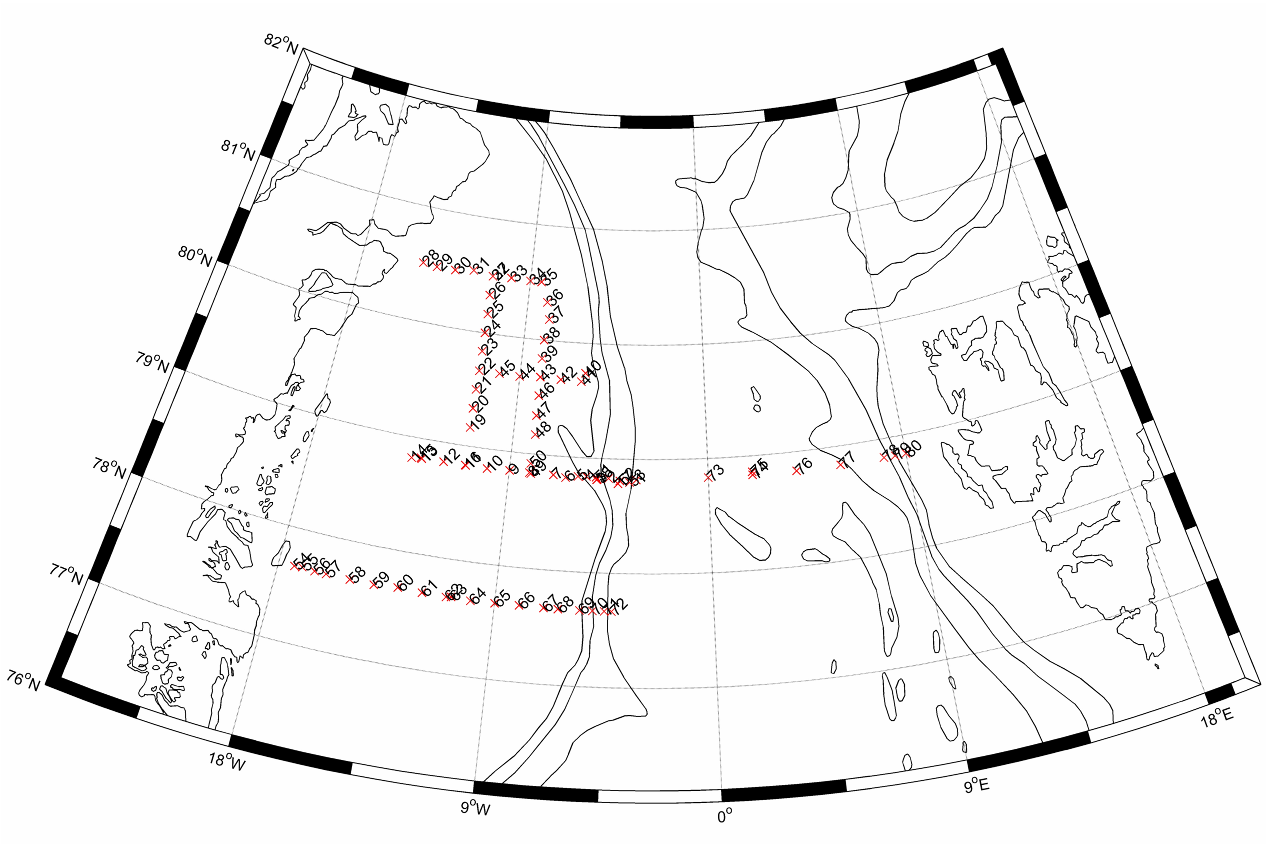


Figure 3: Map of CTD stations occupied during fs2008

3.3 CTD sensor calibration

Paul Dodd (NPI)

Water samples for laboratory salinity measurement were collected at all CTD stations. Where tracer samples were collected, salinity samples were collected at standard depths of 5, 15, 25, 50, 75, 100, 150, 200 and 300 dbar, plus two samples from the bottom of the water column. Where tracer samples were not collected, samples for salinity measurement were collected from deep parts of the water column where the salinity gradient was shallow. Deep regions provide the best data for conductivity sensor calibration as the water trapped in the Niskin bottles is the most similar to that sampled by the CTD. However as many CTD stations were over the shallow (typically 250 m) East Greenland Shelf relatively few deep samples could be collected.

After processing data from the station 001 it was apparent that profiles were 0.02 to 0.03 fresher than historical data collected at 1500-2500 dbar at the foot of the East Greenland Shelf. A difference of this magnitude is unlikely in this depth range.

Salinity samples were analysed aboard Lance using a Guildline Portasal portable salinometer which was standardised after every 24 measurements using IAPSO standard seawater. Comparison of laboratory salinity measurements and CTD-salinity measurements revealed an offset of around 0.029 similar to that suggested by comparison with historical data (Figure 4). The offset did not seem to vary in response to increasing salinity.

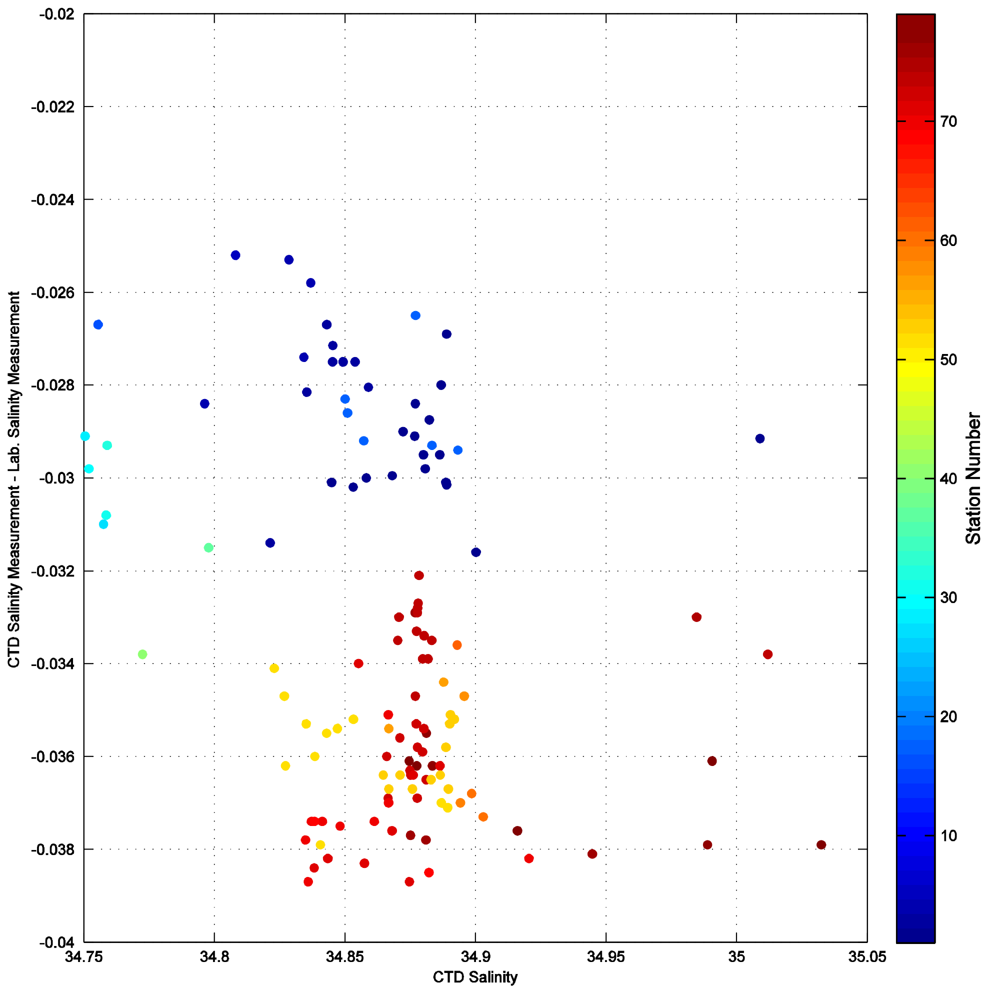


Figure 4: Measured salinity offset for all stations during fs2008.

Plotting the difference between laboratory salinity measurements and CTD-salinity measurements against depth reveals that the offset varies slightly (±0.002) with the pressure at which CTD measurements were made. The pressure dependent part of the offset is an order of magnitude smaller than the total offset (Figure 5). Pressure dependency is not considered in the final calibration due to the large scatter in data points due to limited number of deep CTD stations.

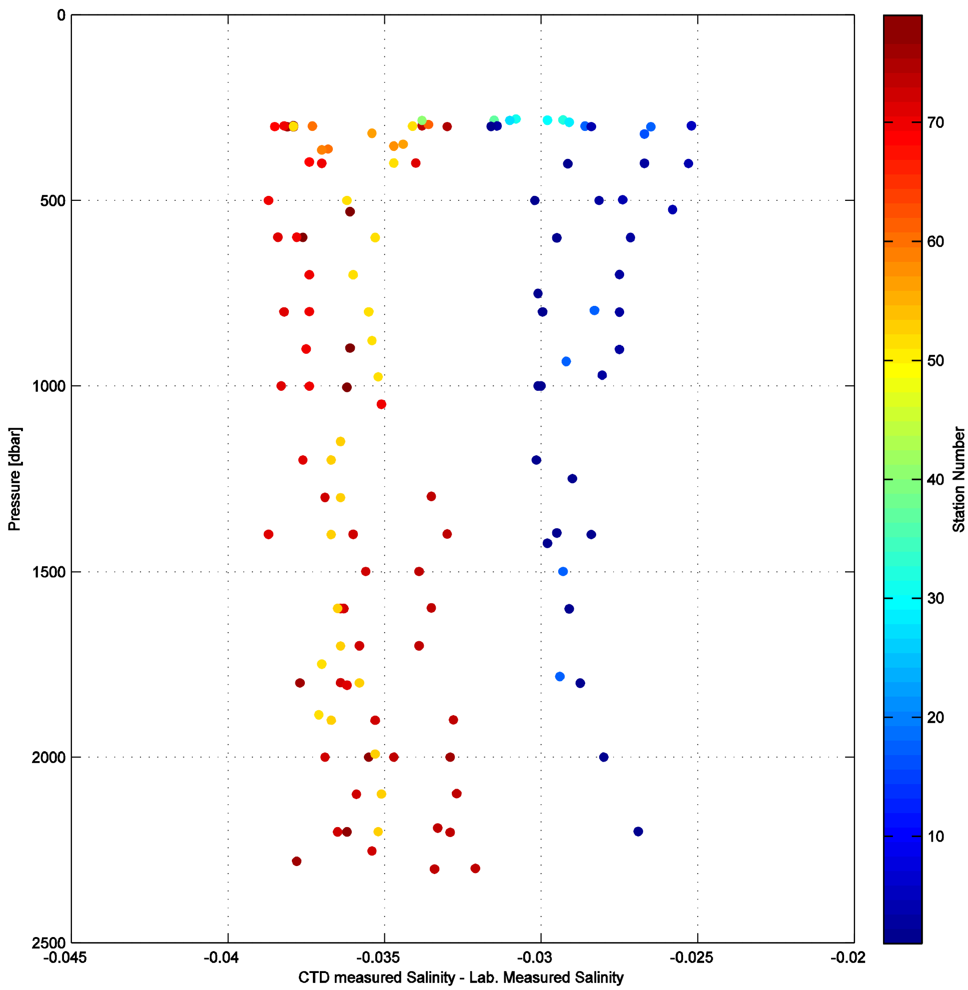


Figure 5: Pressure dependency of the measured salinity offset during fs2008.

Over the course of the cruise the diffference between CTD measurements and laboratory salinity measurements steadily increased from a mean of 0.028 at station 001 to a mean of 0.037 at station 080. Figure 6 shows the mean offset at each CTD station where water samples for laboratory salinity measurement were collected from deeper than 380 m. Above 400 m salinity samples were not suitable for CTD calibration as salinity gradients led to the CTD sampling water of a significantly different salinity to that trapped in Niskin bottles.

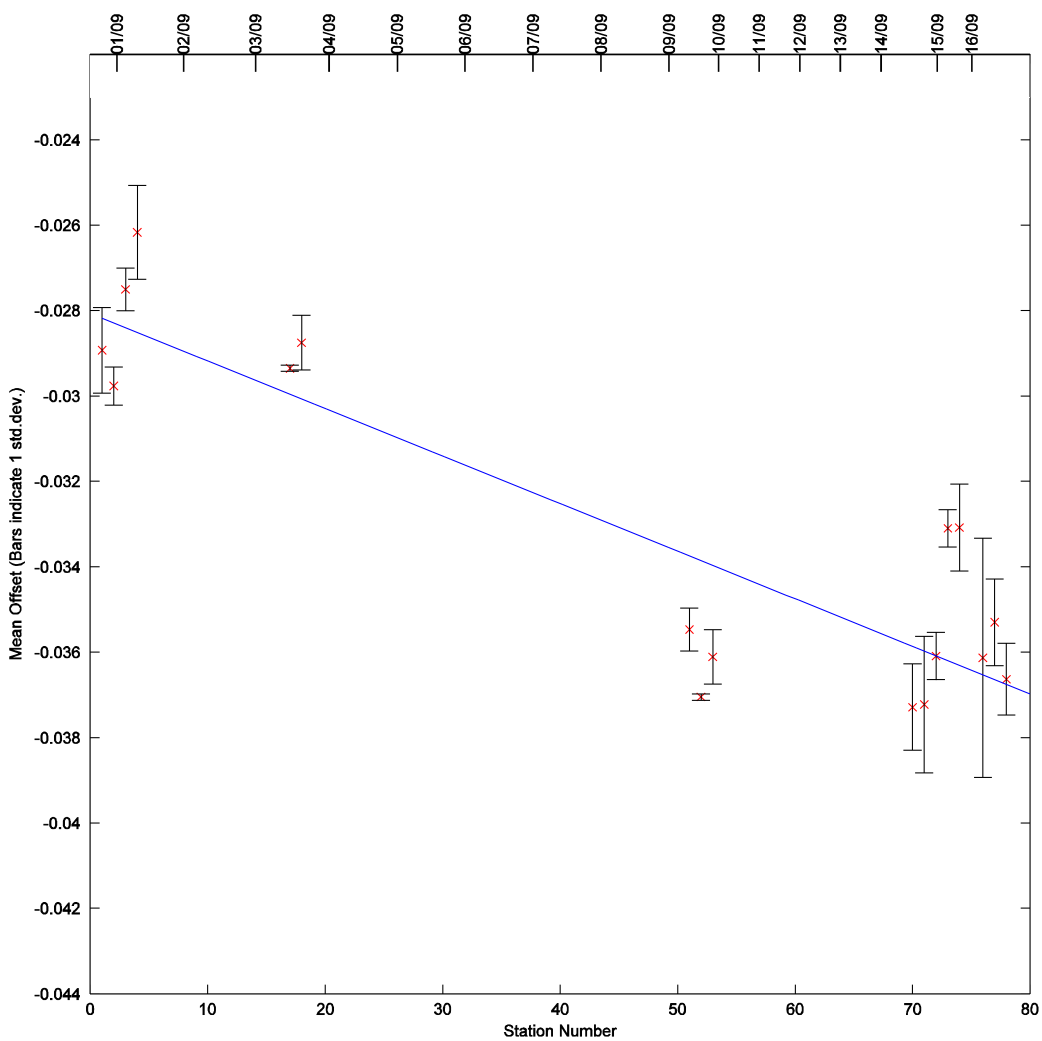
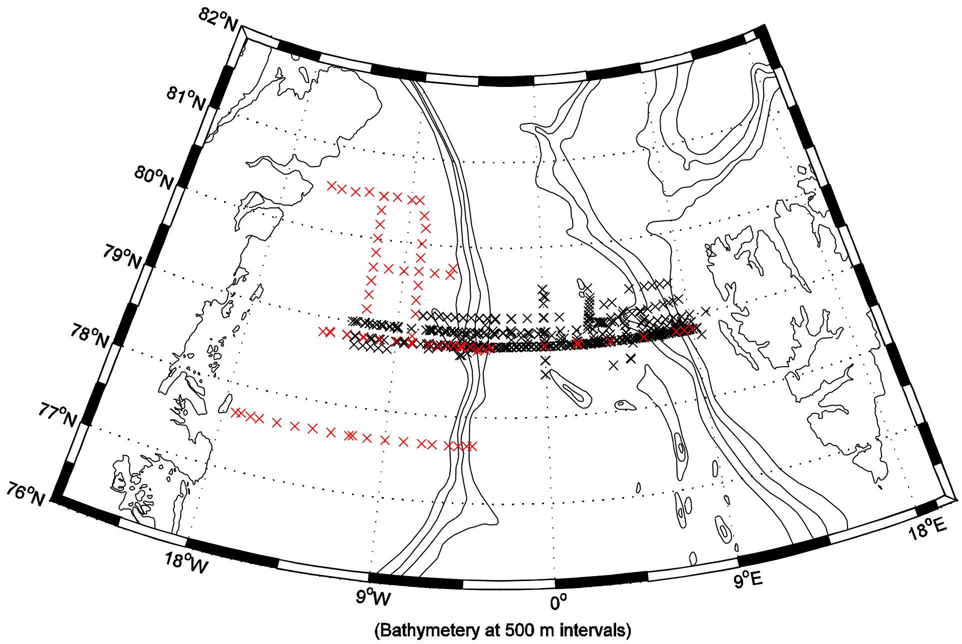


Figure 6: Mean CTD-salinometer differences at CTD stations occupied during fs2008. Bars indicate the standard deviation of CTD-salinometer differences at stations.

Figure 7 shows the raw CTD data collected during fs2008 in potential temperature – salinity space (blue points) along with data collected since 2000 (extracted from the HydroBase database) in the same region (black points). The red points show CTD data collected during fs2008 after calibration offsets were applied. Calibration offsets for each station were determined by linear regression of the mean offset determined at stations deeper than 380 m.



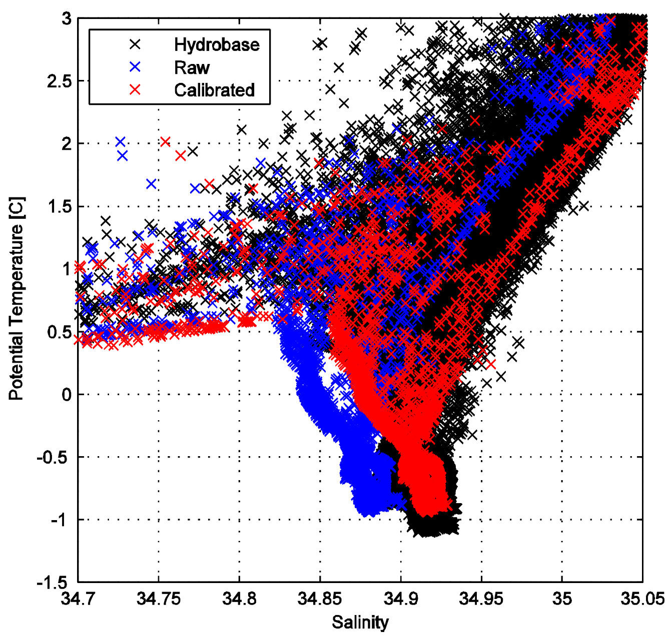


Figure 7: CTD data collected during fs2008 in potential temperature – salinity space along with historical data extracted from the HydroBase.

3.4 Tracer program

Paul Dodd (NPI)

Samples for $\delta^{18}O$ isotope ratio analysis were collected along the east-west transect at 79º 50 N which follows the mooring line and along the east-west transect at 80º N which crosses the East Greenland Shelf. These samples will be used to distinguish between freshwater originating from sea ice melting and freshwater of meteoric origin (such as river water, glacial ice meltwater, precipitation). The primary reason for collecting these samples is to further constrain the freshwater budget of the East Greenland Current.

Samples for Nitrate, Nitrite and Phosphate concentration measurement were collected only along the east-west transect at 79º 50 N which follows the mooring line. The ratio of (Nitrate + Nitrate): Phosphate can be used to identify freshwater of pacific origin which reaches Fram Strait primarily via the transpolar drift after passing through the Bearing Strait.

Samples for $\delta^{18}O$ isotope ratio analysis and nutrient concentration measurement were collected at standard pressures of 5, 15, 25, 50, 75, 100, 150, 200 and 300 decibars with an additional sample being collected from the bottom of the water column. Figure 8 shows the locations of CTD stations at which tracer samples were collected. Table 4 in Appendix D lists the time, date and position of each station along with the echo sounder depth.

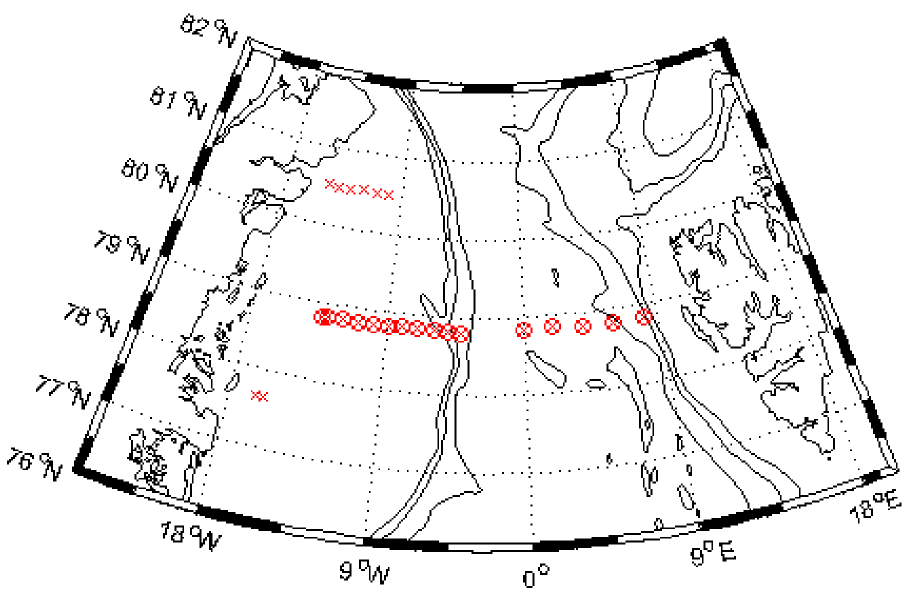


Figure 8: Map of stations at which samples were collected for tracer analysis during fs2008. Red crosses indicate where oxygen isotope samples were collected; red circles indicate where nutrient samples were collected

3.5 LADCP

Laura de Steur (NPI)

The LADPC processing was done with IFM-GEOMAR/LDEO processing software V10.0 (beta) maintained by G. Krahmann. (gkrahmann@ifm-geomar.de). Navigation data for processing was obtained from the ships navigation system every second. Data from several stations could not be processed well due to a lack of good data ensembles. During the last 4 to 6 CTD stations the LADCP gave errors regarding the internal compass indicating that that probably has not worked well at station 77-80.

The processed data has been corrected for magnetic declination but has not been corrected for tides, hence, post processing may be necessary.

In principle the LADCP was running on all CTD stations, however after processing, it can be concluded that at the following stations we did not obtain good data for different reasons:

- No raw data at station: 15, 16, 36, 70
- Erroneous (bad quality) data at station: 19, 21, 23, 41, 46, 64, 80
- Processing errors at station: 75, 78, 79

And, there were

- Dubious (quite large) velocity values after processing at station: 10, 17, 18, 27, 31, 76

Of all other remaining stations the processed data seemed OK.

The LADPC data could be compared with VMADCP data. The latter was running most of the time and is available at NPI but it has not been processed at the time of writing of this report.

4Sea Ice Studies: Snow and Ice Physics, and Ice Mechanics

Participants: Harvey Goodwin (NPI), Stephen Hudson (NPI), Angelika Renner (BAS), Sébastien Barrault (UNIS), Lucie Strub-Klein (UNIS)

In situ sea ice studies were performed during the entire cruise to the Fram Strait on RV "Lance", starting in Longyearbyen 30th August 2008, returning to Tromsø 19th September 2008. The NPI and BAS staff followed up work as a part of the long term monitoring of sea ice properties in the Fram Strait (project "Sea ice physics in the Fram Strait"), and sea ice thermodynamics in the EU project "DAMOCLES", see www.damocles-eu.org). In addition ship time on Lance also provided the opportunity to test a new satellite image service provided by KSAT for delivering Radarsat images in NRT. The UNIS participants studied the thermo-mechanical properties of sea ice, with focus on ridges. This was a continuation of work begun in 2006 and 2007.

Work at 11 sea ice stations (see Table 1 and Figure 9) on drift ice with duration up to 10 hours was carried out. The ice stations were approached either using two Zodiac rubber boats, or by working on an ice floe next to RV "Lance" accessing the ice by ladder.

Date	Station ID	Lat	Lon	Ice coring	Black carbon	Snow pits	Ridge studies	Sea ice density	Ice Mechanics	Thickness profiles	measurementsOptical
31.08.2008	FS08-01	78.828	-3.262			x				x	
31.08.2008	FS08-02	78.822	-3.272			x				x	
01.09.2008	FS08-03	78.824	-5.007			x				x	
02.09.2008	FS08-04	77.823	-13.452	x	x	x	x	x		x	x
03.09.2008	FS08-05	78.809	-4.039			x				x	x
05.09.2008	FS08-06	80.454	-8.320	x	x	x	x	x		x	x
07.09.2008	FS08-07	78.916	-8.035			x					x
08.09.2008	FS08-08	78.936	-8.144	x	x	x	x	x	x	x	x
09.09.2008	FS08-09	78.843	-4.294	x		x	x	x	x	x	x
10.09.2008	FS08-10	78.855	-4.122	x		x				x	x
12.09.2008	FS08-11	78.415	-4.896	x		x	x	x	x	x	x

Table 1: Overview of ice stations with position and type of measurements made.

On each ice station, a position was measured with GPS at the beginning and at the end of the station, in order to determine the average drift of the floe. For each site a general description of the floe and weather conditions were made.

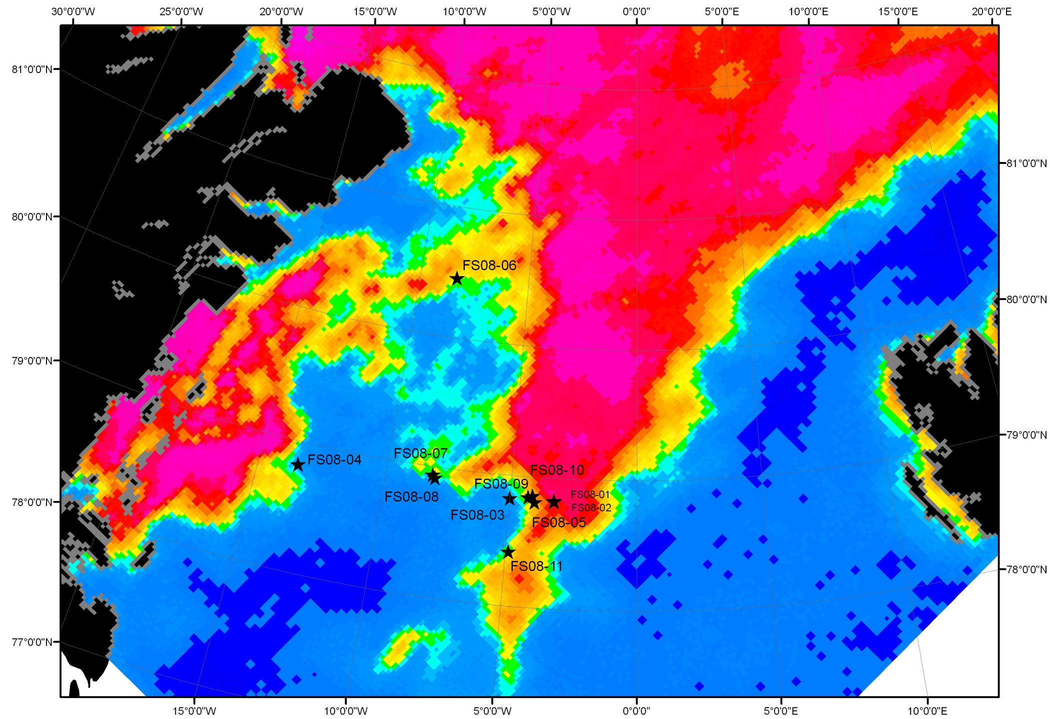


Figure 9: Map of sea ice concentration from AMSR-E 10th September 2008 with sea ice stations during the cruise FS08. The labels correspond with the station IDs in Table 1.

Ice observations from the bridge

In total 88 regular ice observations were made (every 3 hrs in areas with sea ice) by filling out a sheet with various sea ice parameters (ice types, floe sizes, snow cover, ridges, rafting, etc.), digital photography (3 images, port, bow, and starboard, see example in Figure 10), available meteorological data (air and water temperature, air pressure) plus ship data (position, speed, heading). Towards the end of the cruise the night observations were dropped when it became too dark. In addition the IceCam, an automatic system installed onboard Lance that takes images every 5 minutes in front/starboard direction (with parallel logging of position), was operative. A few small icebergs were observed this year but not noted due to extremely poor visibility due to fog.

Figure 10: Example of a sea ice observation image (from 10 Sept. 06, 19:00 UTC)

4.1 Mass and energy balance of Fram Strait sea ice (NPI)
(Harvey Goodwin, Stephen Hudson, Angelika Renner)

Snow and ice thickness profiling

Snow and ice thickness was measured directly (drillings) and indirectly (Geonics EM31, see Figure 11) for quantifying the ice thickness of sea ice in the research area. The data is also used for validation purposes of the upward-looking sonar (ULS, see Vinje et al. 1998) recordings from moorings. By doing corresponding surveys every year in September in the Fram Strait, the inter-annual variability can be documented. The measurement principle of the indirect measurements is electromagnetic induction. By measuring the electrical conductivity in the half-space under the instrument (penetration depth over sea ice about 6 m), distance of the instrument to the seawater and by that, the ice plus snow thickness can be derived. Thickness drilling was made on selected spots for calibration and validation purposes. The ice plus snow thickness is calculated using an empirical function. In total 26 profiles were measured covering a total of 3110 m of electromagnetic profiles (commonly one measurement every 5 m, but on transects crossing ridges which UNIS were working on we measured every 2.5m). Along these profiles snow thickness were measured with a metal pole for each EM31 thickness reading. In total 55 holes were drilled for direct thickness measurements, using a Kovacs thickness gauge (measurement of snow thickness, ice thickness and freeboard).

Figure 11: Use of the Geonics EM31 for indirect ice plus snow thickness measurements.

Snow pits

On all major ice stations a snow pit was dug for snow classification, stratigraphy, grain size, and temperature. Salinity, density, moisture, and hardness measurements were not possible due to thin snow cover. Typical snow thicknesses were approximately 0.05 m. Snow classes were defined using the scheme of LaChapelle from 1982. Snow grains were inspected with a magnifying class on a mm pad, and they were also photographed (Figure 12). Snow types and grain sizes are important for the spectral albedo of the snow & sea ice surface.


Figure 12: Example of snow pit stratigraphy and instruments.

Ice coring in level ice

At 6 stations (see Table 1) level sea ice, ice cores (4” diameter) were obtained in order to quantify the vertical distribution of sea ice salinity and temperature, as well as for texture analysis. A simple stratigraphic description of the cores was made in the field. Some cores were kept frozen at temperatures below -18°C and transported to the ice lab in Tromsø. Temperature of the ice was measured in small drill holes using an electronic thermometer (spacing 5-10 cm). Sea ice salinity is derived from electrolytic measurements on melted ice samples (typically 6-7 cm thick), using a conductivity meter (WTW 340) in the laboratory on RV Lance.

Spectral radiation

Optical properties of snow and sea ice influence the energy balance within the coupled atmosphere-ice-ocean system. They control the amount of solar short-wave radiation reflected at the surface (albedo), scattered and absorbed within snow, and transmitted into the ice and ocean underneath (transmission). During the cruise optical measurements were performed at eight ice stations (Table 1).

Spectral albedo and transmission were measured with TriOS Ramses spectral radiometers (cosine receptor, 320-950 nm) at 13 and 8 measurement sites, respectively. Albedo measurements lasted between 10 minutes and 4 hours per site, to either observe different locations or temporal variations. For albedo measurements, two sensors were mounted over an undisturbed surface, as shown in Figure 13. For transmission measurements, the under-ice sensor was lowered through an approximately 10-cm hole cut in a refrozen melt pond or over the floe edge, while the upwards-looking reference sensor was the same as for albedo measurements. The under-ice sensor was placed at a constant depth of approx. 1m below the ice. Additional depth profiles were recorded by lowering the sensor down to 80 m, either over the edge of a floe, or through a hole in the floe interior.

Figure 13: Albedo measurements, using two TriOS Ramses spectral radiometers, mounted on a 3m long pole between two tripods.

4.2 Sea ice mechanics: Thermo-mechanical properties of ridges (UNIS)

(Sébastien Barrault and Lucie Strub-Klein)

Multiyear ice ridges are an essential part of pack-ice cover and from an engineering point of view they represent the highest loads on offshore structures, scour the sea bottom, and influence ice traffic conditions. Neither their morphology nor their thermo-mechanical properties are well known despite of work done by Kovacs and Cox in the late seventies and early eighties.

Today, a topic of particular interest to investigate is how the multiyear ridges consolidate during the summer. In order to draw a first hypothesis and develop models, data collection of temperature, salinity and density profiles, on strength and on morphology is needed.

Measurements

Basically we did three types of measurements; we drilled profiles to examine keel depth and macro-porosity of the ridges, we took cores and measured salinity, density and temperature, and we sampled ice for mechanical testing and ice texture examination.
We drilled for keel depth with 2” augers, and made from 5 to 9 holes in 5 ridges. The ridges were medium sized with keel depths from 3.5 m to 8.2 m. The drillings confirm that the macro-porosity almost disappears during the summer. Figure 14 shows profile of FS08-09.

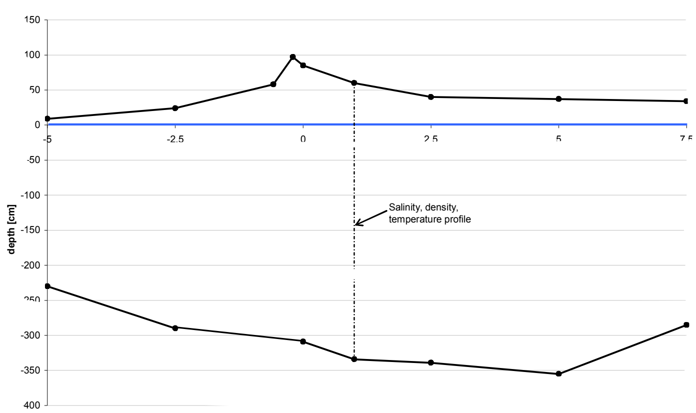


Figure 14: The geometry profile from FS08-09

The cores for salinity, density and temperature were taken with a 75 mm core drill. We measured all three variables on the same core. Temperature was measured with an electronic thermometer in small holes (spaced at 10 cm) made using a hand drill. Density was calculated from the mass of cylindrical ice pieces and the length of the samples. Salinity data was collected from melted ice samples (8 cm thick) with a salinometer. Figure 15, 16 and 17 give examples of the 3 measurements done on one vertical core.

In addition, three vertical cores (75 mm) were sampled at three different stations (see Ice Mechanics column in Table 1) for mechanical testing and stored in a freezer at -20°C. Mechanical testing will be performed later in a cold laboratory at UNIS.

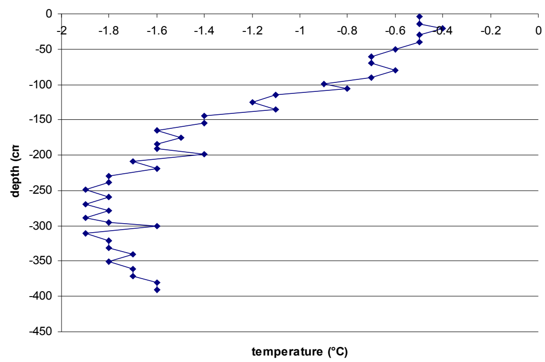


Figure 15: Temperature profile from FS08-09

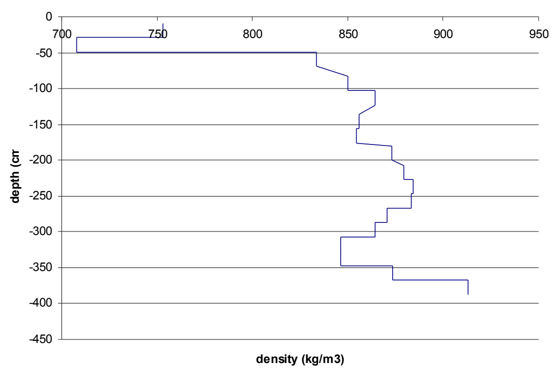


Figure 16: Density profile from FS08-09

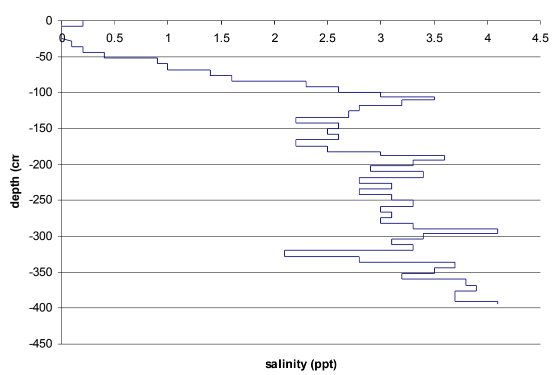


Figure 17: Salinity profile from FS08-09

4.3 Satellite Images Obtained During the Cruise (NPI)

(Harvey Goodwin)

Satellite images have been readily available to aid navigation in ice infested waters for several years now. We continue to use the satellite image viewing software developed by the Danish Technical University www.seaice.dk . The system allows the user / ship to access and download small images specific to the area of interest via the ships internet connection. They can then be viewed offline by the captain on the bridge displaying the ships position in real time.

Available imagery consisted of daily AMSR ice concentration with a resolution of 3.25km.

In addition we also had access to almost daily Radarsat images available via KSATs new IAS Java viewer which allows the user to download high resolution imagery over low band widths

See Table 2 for the list of imagery available, and Figures 18 and 19 for examples of AMSR-E imagery and Radarsat SCW imagery, respectively.

Satellite	Sensor	Resolution	Date	Source
Aqua	AMSR-E	3.25km	daily	http://www.seaice.dk/zipfiles/Fram/
Radarsat	SAR SCW	500m	daily	KSAT IAS Web Viewer

Table 2: List of satellites images.

To view the AMSR files either install the software available here http://www.seaice.dk/zipfiles/install/ and download the images you want or view them in the online browser. Some of the Radarsat SCW images maybe available from NPI at a later date.

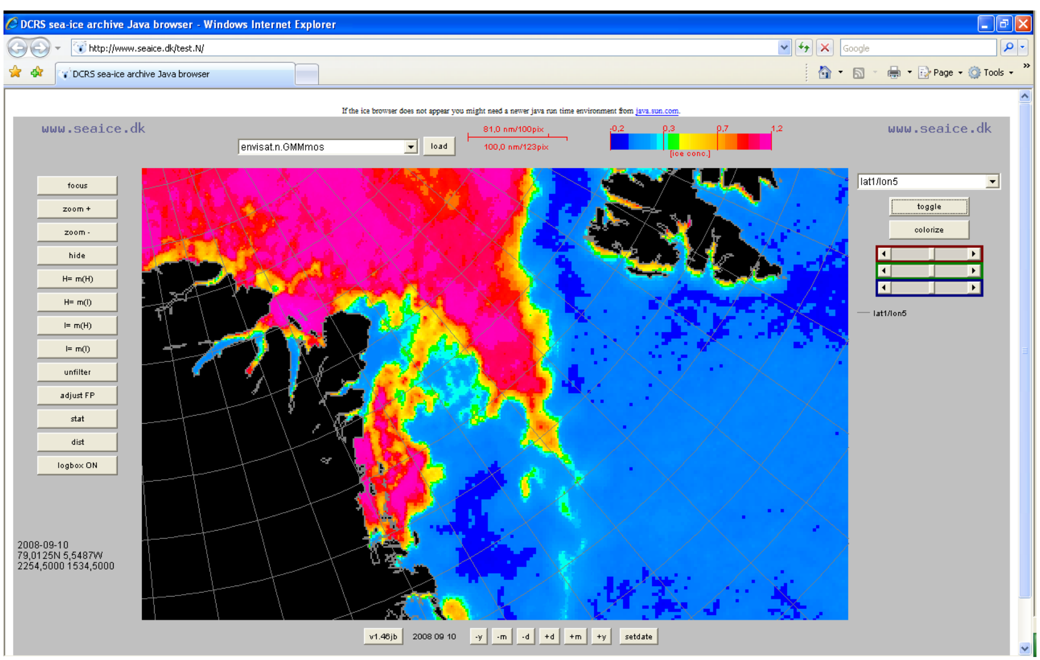


Figure 18: Example of AMSR-E data in the Fram Strait.

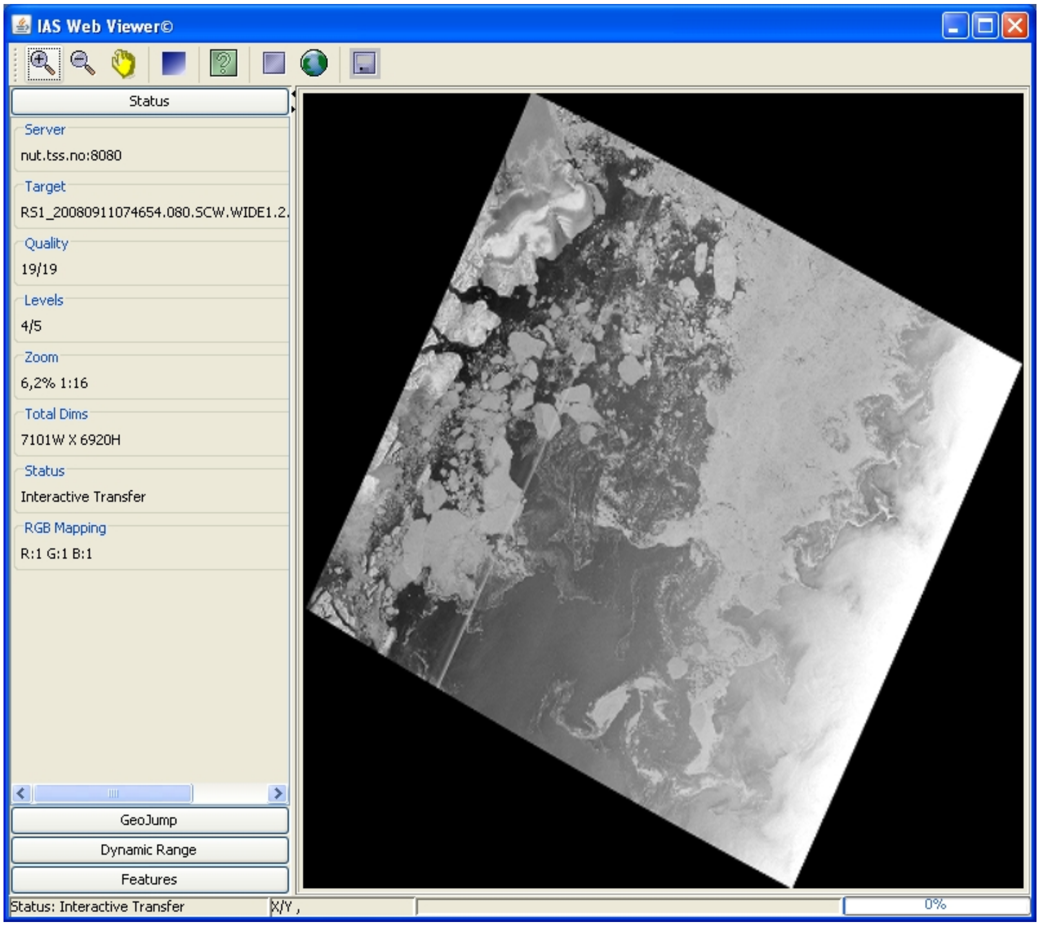


Figure 19: Example of Radarsat SCW imagery.

5Sailing log

30/08/2008 Sa	Departure from LYB 12.30 pm. Steam to mooring location F11 at 78º50'N, 3º15'W.
31/08/2008 Su	Steaming towards mooring location F11. Little sea ice covering EGC compared to last year. Sea ice maps/images look very promising. Recovery of F11 at 15:41. Short sea-ice station + CTD station at the same location. Steaming towards F12. Too much sea ice to recover F12, we wait with recovery. CTD station at 4º30´W.
01/09/08 Mo	Recovery of F13. Short sea-ice station and CTD station. CTDs at 5º30´W and 6ºW. Steam towards F14. Recovery of F14 + CTD, CTD at 7ºW. Recovery of F17 and F18 at ~19:50 + CTD. Continue with CTDs every degree along 78º50N up to 13º27´W.
02/09/08 Tu	Full day sea-ice station. Location: 78º49.37'N, 13º27.24'W. Steam to F12.
03/09/08 We	Arrival north of F12 in opening in sea ice at 79ºN. Drift southward in sea-ice opening until the mooring. Recovery of F12. Short sea-ice station and CTD at some location. CTD at 78º50N, 5ºW. Steam to 11ºW, start CTD section to the north.
04/09/08 Th	CTDs at 11ºW until 80º30´N. Eastward CTD section from ~15ºW to 7ºW at 80º30´N.
05/09/08 Fr	Full day sea-ice station. Location 80º28.01'N, 8º19.85'W. Evening and night start southward CTD section along 8ºW.
06/09/08 Sa	Westward CTD section along 79º40'N from 5ºW to 10ºW. Continue CTDs southward along 8ºW until 79º10'N. Steam to mooring position F17/F18. Evening = break!
07/09/08 Su	Deploy F17 + F18 at ~78º50'N, 8ºW. CTD at same position. Deploy F14 at ~78º50'N, 6º30W. CTD at 79º'N, 8ºW.
08/09/08 Mo	Full day sea-ice station. Location 78º56.163'N, 8º08.700'W. Steam to location of F13.
09/09/08 Tu	CTD at location of F13. Deploy F13 at ~78º50'N, 5ºW. Very good (ice free) deployment condition. Long sea-ice station in the afternoon and evening at the same location. CTDs at 78º50'N, 4ºW and 3º30W respectively.
10/09/08 We	Deploy F12 at ~78º50'N, 4ºW. Little sea ice to disturb deployment but good floes for a short sea-ice station after deployment. Heading towards the location of F11 but very heavy ice conditions make this impossible. Wait around at ice edge until next day.
11/09/08 Th	Steam to F11 through very heavy ice. Deploy F11 further west than initially planned due to very heavy ice conditions at location: 78º49'N, 3º38W. Stuck in the sea ice from approx.18:00-23:45. Steam southward along 5ºW.
12/09/08 Fr	Long sea-ice station at78º25'N, 4º53W in the morning. Steam to 77º40'N, 17ºW.
13/09/08 Sa	CTD section along 77º40'N from 17º20'W to 4ºW.
14/09/08 Su	Continue CTD section along 77º40'N. A lot of ice close to 6º20'W. SAR sea-ice image showed that this would improve further east so we were able to finish the section up to 4ºW. Steam to 78º50'N, 0ºW. Progress was extremely slow due to very bad visibility and a large amount of sea ice (Lance moved with ~2-3 knots only).
15/09/08 Mo	CTDs at to 78º50'N, 0ºW, 2ºW and 4ºW.
16/09/08 Tu	Last CTDs at to 78º50'N, 6ºW, 8ºW and 9ºW. Start steaming to Tromsø around 15:00

17/09/08 We	Steaming to Tromsø.
18/09/08 Th	Steaming to Tromsø.
19/09/08 Fr	Arrival in Tromsø at 06:00. Offloading ship.

6. Suggestions for FS2009:

Discuss with NPI:

- NPI: We should schedule next years cruise 1 week earlier. Harvey will provide an image of mean sea-ice concentration from August 15-30 and from September 1-15 to indicate that if we want to do the full oceanography program we need to get there on time!!
- NPI: We want a full 3-week cruise, not spending almost 3 days heading back to Tromsø and 1 day for offloading. That is *NOT* cruise time!
- Sea-ice group: heating blankets for the Zodiacs engines, the cold gave trouble. (brand: F1)

To do next year:

- FS2009: redeploy F11 directly after recovery (with, of course, some hours in between). It is possible with the instruments we have and it seems best to get F11 out asap regarding the sea-ice concentration in the last 2 summers.
- FS2009: start VMADCP as soon as we leave port.
- FS2009: Lance will have faster iridium connection so we can get SAR images ourselves faster. Harvey needs to make sure he can put a grid on those images on the ship.

Servicing:

- Altimeter from the CTD needs to be serviced.
- SBE37 microcats need to be calibrated.
- The calibration of CTD 911+ sensors at Havforsking in Bergen need to be provided with feedback. Send sensors to SBE instead in the future!
- Salinometer from NFH needs to be serviced.

Appendix A: Recovered moorings

Mooring	Latitude Longitude	Water depth (m)	Date and time of recovery	Instrument type	Serial number	Instrument depth (m)
F11-9	78 49.439 N 03 15.216 W	2380	31/08/08 at 15:41	SBE37 RCM7 RCM9 RCM11 RCM8 AR861	3551 9464 1049 538 10069 499	75 78 262 1466 2370 2380
F12-9	78 49.188 N 04 00.708 W	1858	03/09/08 at 11:55	ES300 DCM12 SBE37 RCM9 RCM9 RCM11 RCM11 AR861	55 17 2158 1325 836 556 117 500	108 108 110 116 340 1544 1848 1858
F13-9	78 50.210 N 05 00.083 W	1020	01/09/08 at 07:55	IPS SBE37 RDCP600 RCM9 RCM11 AR861	1047 3552 118 1327 561 506	62 66 70 236 1010 1020
F14-9	78 49.055 N 06 26.802 W	281	01/09/08 at 15:32	IPS SBE37 RDCP600 RCM9 AR861	1048 3554 71 1326 568	58 62 66 271 281
F17-4	78 49.939 N 08 04.562 W	218	01/09/08 at 20:05	WHS300 AR861	727 501	104 218
F18-3	78 49.884 N 07 59.276 W	209	01/09/08 at 19:26	DL7 AR861	1632 553	55-106 209

Table 1: Moorings that were recovered in 2008 (deployed in 2006).

Appendix B: Deployed moorings

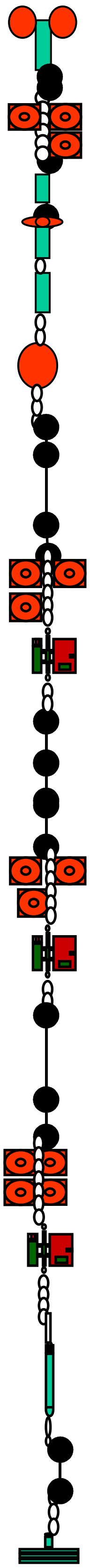
Mooring	Latitude Longitude	Water depth (m)	Date and time of deployment	Instrument type	Serial number	Instrument depth (m)
F11-10	78º 49.517 N 03º 37.925 W	2135	11/09/08 11:35GMT	IPS SBE37 RDCP600 SBE37 RCM11 RCM11 RCM8 AR861	51062 3992 199 2962 228 494 10071 287	55 59 63 148 210 1515 2125 2135
F12-10	78º 49.420 N 03º 59.906 W	1855	10/09/08 09:17GMT	IPS SBE37 RDCP600 SBE37 RCM7 RCM11 RCM8 AR861	51063 3489 198 3993 11475 235 11625 053	50 54 57 110 335 1539 1843 1846
F13-10	78º 49.885 N 04º 59.073 W	1021	09/09/08 09:43GMT	IPS SBE37 RDCP600 whale inst. SBE37 RCM9 RCM8 AR861	1047 3994 28 -- 4702 1175 12733 182	52 56 60 65 154 256 1010 1013
F14-10	78º 49.046 N 06º 26.973 W	280	07/09/08 10:47GMT	IPS SBE37 RDCP600 SBE37 RCM7 AR861	1048 3995 71 4837 12644 110	55 57 61 168 271 274
F17-5	78º 49.942 N 08º 04.518 W	222	07/09/08 06:52GMT	ADCP SBE37 AR661	727 3996 290	114 124 211
F18-4	78º 49.904 N 07º 59.352 W	200	07/09/08 07:54GMT	DL7 AR861	1649 410	115 202

Table 2: Moorings that were deployed in 2008.

Rigg F11-10

78º49,517N, 03º37,925W

Deployed 11 SEP 2008, 11:40 am



		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51062	72	2064	11:36
3 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR. 3992	76	2060	11:34
5 M Kevlar				
RDCP600 SNR: 199		80	2056	11:34
Batteribeholder til RDCP				
Stålkule 37	McLane nr 5	83	2053	
2 m Kjetting galvanisert				
40 m Kevlar				
40 m Kevlar				
SBE37	SNR.2962	165	1971	11:23
50 m Kevlar				
3 Glasskuler				
3 m Kjetting galvanisert				
RCM11	SNR.228	218	1918	11:19
0,5 m Kjetting galv				
200 m Kevlar				
500 m Kevlar				
500 m Kevlar				
3 Glasskuler				
3 m Kjetting galvanisert				
RCM11	SNR.494	1423	713	10:25
0,5 m Kjetting galv				
500 m Kevlar				
200 m Kevlar				
4 Glasskuler				
2 m Kjetting galvanisert				
RCM8	SNR.10071	2126	10	10:09
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 287			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1100/(950) kg	2136	0	

AR861 SNR. 287:

Pinger på: 1412 + 1447

Pinger av: 1412 + 1448

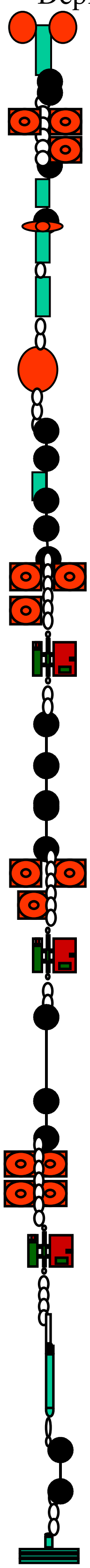
Release: 1412 + 1455

Release m/ping: 1412 + 1456

Rigg F12-10

78º49,420N, 03º59,906W

Deployed 10 SEP 2008, 09:20 am



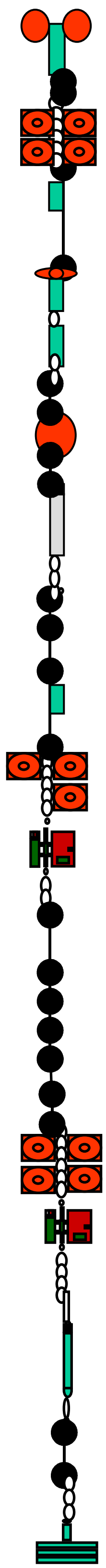
		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51063	50	1805	09:17
3 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR. 3489	55	1800	09:05
5 M Kevlar				
RDCP600	SNR: 198	59	1796	09:05
Batteribeholder til RDCP				
Stålkule 37	SNR 596	62	1793	
2 m Kjetting galvanisert				
10 m Kevlar				
40 m Kevlar				
SBE37	SNR.3993	115	1740	08:59
200 m Kevlar				
20 m Kevlar				
3 Glasskuler				
3 m Kjetting galvanisert				
RCM7	SNR.11475	337	1518	08:55
0,5 m Kjetting galv				
500 m Kevlar				
500 m Kevlar				
200 m Kevlar				
3 Glasskuler				
3 m Kjetting galvanisert				
RCM11	SNR.235	1541	314	08:35
0,5 m Kjetting galv				
200 m Kevlar				
100 m Kevlar				
4 Glasskuler				
2 m Kjetting galvanisert				
RCM8	SNR.11625	1845	10	08:25
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 053			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1100/(950) kg	1855	0	

AR861 SNR. 053 — Pinger på: 043F + 0447
Pinger av: 043F + 0448
Release: 043F + 0455
Release m/ping: 043F + 0456

Rigg F13-10

78º49.885N, 04º59.074W

Deployed 9 SEP 2008, 09:43 am

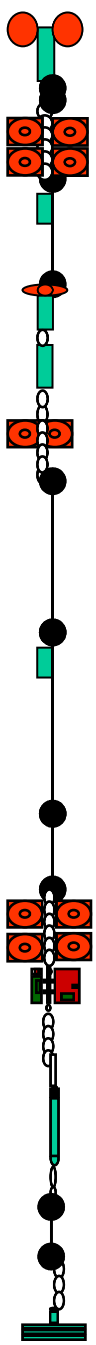


		Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 1047	50	971	09:24
4 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR. 3994	54	967	09:13
5 M Kevlar				
RDCP600	SNR: 28	58	963	09:08
Batteribeholder til RDCP				
0,5 m Kjetting galv.				
20 m Kevlar				
Stålkule 37	SNR.McLaneE 8	80	941	
2 m Kevlar				
Hvallydopptaker		82	939	09:03
2 m Kjetting galv				
20 m Kevlar				
50 m Kevlar				
SBE37	SNR.4702	155	866	08:51
100 mKevlar				
3 Glasskuler				
3 m Kjetting galv.				
RCM9	SNR.1175	257	764	08:47
0,5 m Kjetting galv				
500 m Kevlar				
10 m Kevlar				
100 m Kevlar				
50 m Kevlar				
40 m Kevlar				
50 m Kevlar				
4 Glasskuler				
2 m Kjetting galv.				
RCM8	SNR. 12733	1011	10	08:27
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 182 Ping på: 04AF + 0447 Ping av: 04AF + 0448 Release: 04AF + 0455 Release m/ping: 04AF + 0456			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1050/(920) kg	1021	0	

Rigg F14-10

78º49.046N, 06º26,973W

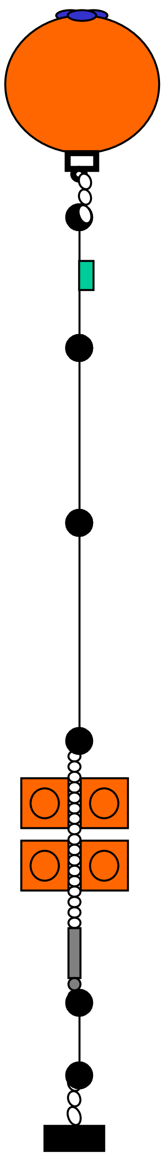
Deployed 7 SEP 2008, 10:47 am



		Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 1048	51	229	10:45
4 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR. 3995	55	225	10:40
5 M Kevlar				
RDCP600	SNR: 71	59	221	10:40
Batteribeholder til RDCP				
2 Glasskuler				
1 m Kjetting Galv.				
100 m Kevlar				
SBE37	SNR.4837	163	117	10:35
100 m Kevlar				
5 m Kevlar				
4 Glasskuler				
3 m Kjetting Galv.				
RCM7	SNR. 12644	271	10	10:30
Svivel				
AR861	SNR. 110 Range: 6151 Release: 6152			
5 m Kevlar				
2 m Kjetting				
ANKER	580/(520) kg	280	0	

Rigg F17-5
78º49.942N, 08º04.518W
Deployed 7 SEP 2008, 06:48 am

Dyp: Fra bunn: Ned i vann:



ADCP SNR.727 109 113 06:45

1 m Kjetting rustfri

SBE37 SNR.3996 112 110 06:45

10 m Kevlar

40 m Kevlar

50 m Kevlar

2 m Kjetting galv.

4 GLASSKULER 211 11

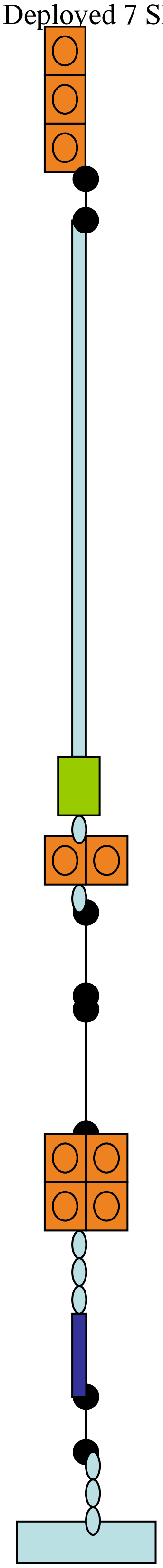
AR661 SNR. 290 Range: C343
Release: C344

5 m Kevlar.

2 m Kjetting galv.

ANKER 540/(460)kg 222 0

Rigg F18-4
78º49.904N, 07º59.352W
Deployed 7 SEP 2008, 07:54 am



Dyp: Fra bunn: Ned i vann:

3 Glasskuler 41 159
5 m Kevlar 46 154

DL7 Snr. 1649 96 104 07:32

2 Glasskuler
1 m Kjetting galv.

40 m Kevlar

50 m Kevlar

4 Glasskuler

3 m Kjetting galv.

AR861 Snr. 410 Arm/range 146E. 9
Release ARM + 1455
5 m Kevlar Ping on ARM + 1447
2 m Kjetting

Anker 650/(530) Kg 200 0

Appendix C: List of CTD stations

Station	Latitude	Longitude	Date	Time (GMT)	Echo [m]
001	78.8219	-3.2492	31/08/08	16:46:28	2358
002	78.8292	-4.5057	31/08/08	21:24:41	1446
003	78.8180	-5.0178	01/09/08	07:12:19	969
004	78.8387	-5.5068	01/09/08	08:37:26	545
005	78.8347	-5.8883	01/09/08	10:09:06	366
006	78.8185	-6.4483	01/09/08	14:07:28	283
007	78.8342	-7.0040	01/09/08	15:52:34	247
008	78.8358	-8.0929	01/09/08	18:36:31	225
009	78.8369	-8.9947	01/09/08	20:02:01	234
010	78.8299	-10.0077	01/09/08	21:32:24	234
011	78.8309	-10.9918	01/09/08	23:01:56	136
012	78.8333	-12.0004	02/09/08	00:31:57	202
013	78.8276	-12.9907	02/09/08	02:23:34	183
014	78.8208	-13.4462	02/09/08	04:04:13	68
015	78.8336	-13.0376	02/09/08	17:43:18	214
016	78.8341	-11.0065	02/09/08	20:27:53	330
017	78.7851	-4.0793	03/09/08	11:30:24	1759
018	78.8133	-5.0407	03/09/08	14:21:27	938
019	79.1652	-11.0353	03/09/08	23:09:01	265
020	79.3340	-11.0411	04/09/08	00:34:36	243
021	79.5015	-11.0230	04/09/08	01:52:26	248
022	79.6667	-10.9998	04/09/08	03:26:13	242
023	79.8381	-10.9965	04/09/08	05:52:03	264
024	80.0020	-10.9930	04/09/08	07:30:40	118
025	80.1670	-10.9865	04/09/08	09:08:40	112
026	80.3338	-11.0292	04/09/08	10:36:13	256
027	80.5012	-11.0084	04/09/08	12:01:40	290
028	80.5112	-14.7619	04/09/08	17:58:04	233
029	80.4984	-14.0101	04/09/08	19:09:03	291
030	80.5016	-13.0275	04/09/08	20:28:47	286
031	80.5263	-12.0551	04/09/08	22:11:08	286
032	80.5015	-11.0045	04/09/08	23:48:01	290
033	80.5078	-10.0243	05/09/08	01:11:43	256
034	80.5028	-9.0035	05/09/08	02:42:58	276
035	80.5032	-8.4095	05/09/08	04:07:14	257
036	80.3315	-8.0060	05/09/08	16:19:17	251
037	80.1832	-7.8261	05/09/08	18:14:33	251
038	80.0002	-7.9911	05/09/08	20:41:48	213
039	79.8381	-8.0069	05/09/08	22:11:37	185
040	79.7384	-5.8086	06/09/08	01:45:07	287
041	79.6637	-5.9903	06/09/08	02:37:26	280
042	79.6693	-6.9955	06/09/08	04:17:24	224
043	79.6762	-8.0071	06/09/08	07:58:00	266
044	79.6621	-9.0076	06/09/08	10:29:46	213
045	79.6654	-10.0034	06/09/08	12:17:42	204
046	79.5133	-7.9920	06/09/08	15:28:11	208
047	79.3378	-8.0165	06/09/08	18:07:09	229
048	79.1719	-7.9870	06/09/08	19:30:43	207

049	78.8282	-8.0237	07/09/08	08:06:47	183
050	78.9159	-8.0674	07/09/08	14:30:09	180
051	78.8359	-5.0724	09/09/08	07:11:00	952
052	78.8103	-3.9943	09/09/08	18:23:40	1844
053	78.7993	-3.5594	09/09/08	20:39:41	2152
054	77.6715	-17.3438	13/09/08	11:42:04	75
055	77.6788	-17.0194	13/09/08	12:35:10	245
056	77.6695	-16.4855	13/09/08	13:38:58	324
057	77.6692	-16.0030	13/09/08	14:51:26	352
058	77.6681	-15.0105	13/09/08	16:39:29	357
059	77.6662	-14.0001	13/09/08	18:17:36	368
060	77.6816	-13.0191	13/09/08	19:53:12	366
061	77.6731	-11.9992	13/09/08	21:33:24	299
062	77.6683	-11.0035	13/09/08	23:46:28	217
063	77.6749	-10.7983	14/09/08	00:31:36	227
064	77.6647	-9.9955	14/09/08	02:34:19	241
065	77.6685	-8.9953	14/09/08	04:57:38	227
066	77.6722	-7.9962	14/09/08	08:21:39	248
067	77.6671	-6.9909	14/09/08	10:00:56	228
068	77.6666	-6.3941	14/09/08	12:23:46	269
069	77.6660	-5.5077	14/09/08	17:14:56	386
070	77.6671	-4.9871	14/09/08	18:35:14	1028
071	77.6674	-4.4973	14/09/08	20:19:12	1750
072	77.6671	-4.2065	14/09/08	22:26:12	2237
073	78.8340	-0.0046	15/09/08	17:39:42	2554
074	78.8345	2.0006	15/09/08	21:31:50	2485
075	78.8608	1.9901	15/09/08	23:30:27	2484
076	78.8328	3.9990	16/09/08	02:17:29	2280
077	78.8358	6.0047	16/09/08	06:05:15	2404
078	78.8371	7.9919	16/09/08	09:44:37	1012
079	78.8351	8.4972	16/09/08	11:06:25	570
080	78.8382	9.0013	16/09/08	12:12:40	213

Table 3: List of CTD stations occupied during fs2008

Appendix D: List stations where tracer samples were taken

Station	Latitude	Longitude	Date	Time (GMT)	Echo [m]
005	78.8347	-5.8883	01/09/08	10:09:06	366
007	78.8342	-7.0040	01/09/08	15:52:34	247
008	78.8358	-8.0929	01/09/08	18:36:31	225
009	78.8369	-8.9947	01/09/08	20:02:01	234
010	78.8299	-10.0077	01/09/08	21:32:24	234
012	78.8333	-12.0004	02/09/08	00:31:57	202
014	78.8208	-13.4462	02/09/08	04:04:13	68
015	78.8336	-13.0376	02/09/08	17:43:18	214
016	78.8341	-11.0065	02/09/08	20:27:53	330
017	78.7851	-4.0793	03/09/08	11:30:24	1759
018	78.8133	-5.0407	03/09/08	14:21:27	938
028	80.5112	-14.7619	04/09/08	17:58:04	233
029	80.4984	-14.0101	04/09/08	19:09:03	291
030	80.5016	-13.0275	04/09/08	20:28:47	286
031	80.5263	-12.0551	04/09/08	22:11:08	286
032	80.5015	-11.0045	04/09/08	23:48:01	290
033	80.5078	-10.0243	05/09/08	01:11:43	256
056	77.6695	-16.4855	13/09/08	13:38:58	324
057	77.6692	-16.0030	13/09/08	14:51:26	352
073	78.8340	-0.0046	15/09/08	17:39:42	2554
075	78.8608	1.9901	15/09/08	23:30:27	2484
076	78.8328	3.9990	16/09/08	02:17:29	2280
077	78.8358	6.0047	16/09/08	06:05:15	2404
078	78.8371	7.9919	16/09/08	09:44:37	1012

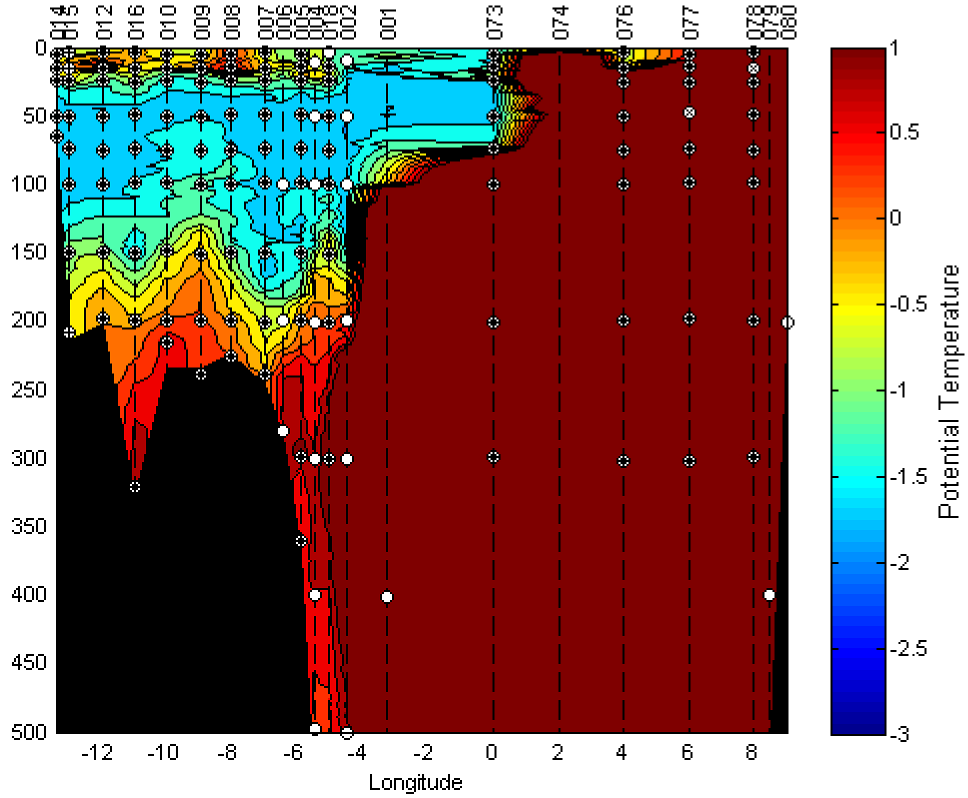
Table 4: List of stations at which samples were collected for oxygen isotope ratio analysis

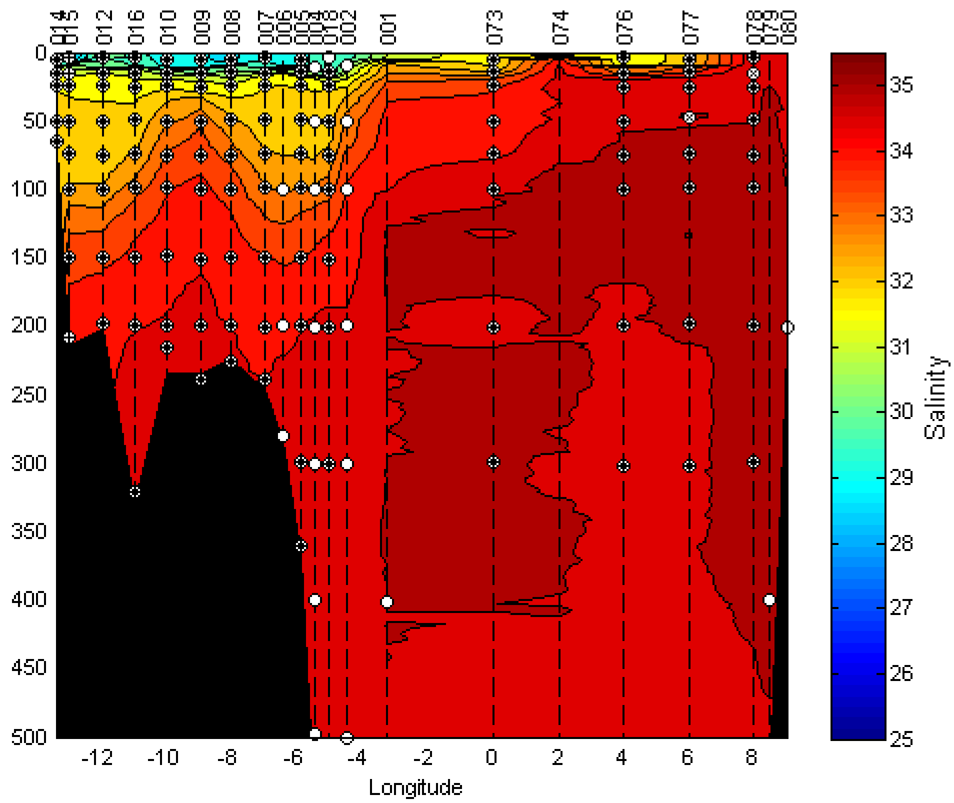
Station	Latitude	Longitude	Date	Time (GMT)	Echo [m]
005	78.8347	-5.8883	01/09/08	10:09:06	366
007	78.8342	-7.0040	01/09/08	15:52:34	247
008	78.8358	-8.0929	01/09/08	18:36:31	225
009	78.8369	-8.9947	01/09/08	20:02:01	234
010	78.8299	-10.0077	01/09/08	21:32:24	234
012	78.8333	-12.0004	02/09/08	00:31:57	202
014	78.8208	-13.4462	02/09/08	04:04:13	68
015	78.8336	-13.0376	02/09/08	17:43:18	214
016	78.8341	-11.0065	02/09/08	20:27:53	330
017	78.7851	-4.0793	03/09/08	11:30:24	1759
018	78.8133	-5.0407	03/09/08	14:21:27	938
073	78.8340	-0.0046	15/09/08	17:39:42	2554
075	78.8608	1.9901	15/09/08	23:30:27	2484
076	78.8328	3.9990	16/09/08	02:17:29	2280
077	78.8358	6.0047	16/09/08	06:05:15	2404
078	78.8371	7.9919	16/09/08	09:44:37	1012

Table 5: List of stations at which samples were collected for nutrient concentration measurement

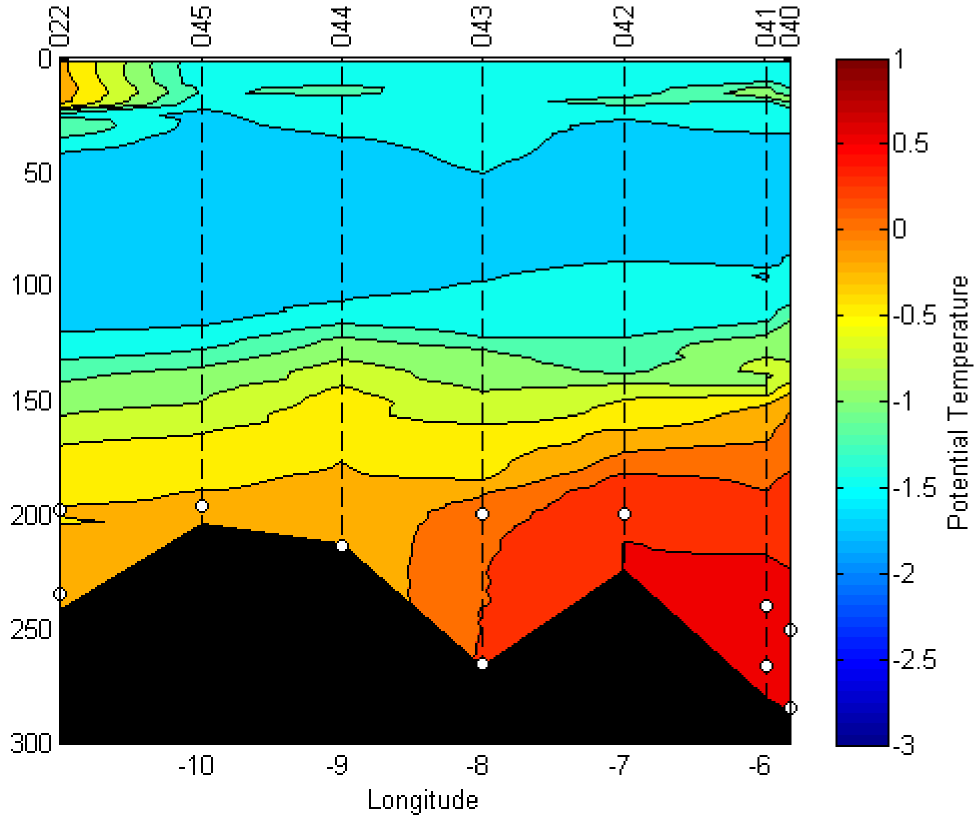
Appendix E: Cross sections of CTD Potential Temperature and Salinity

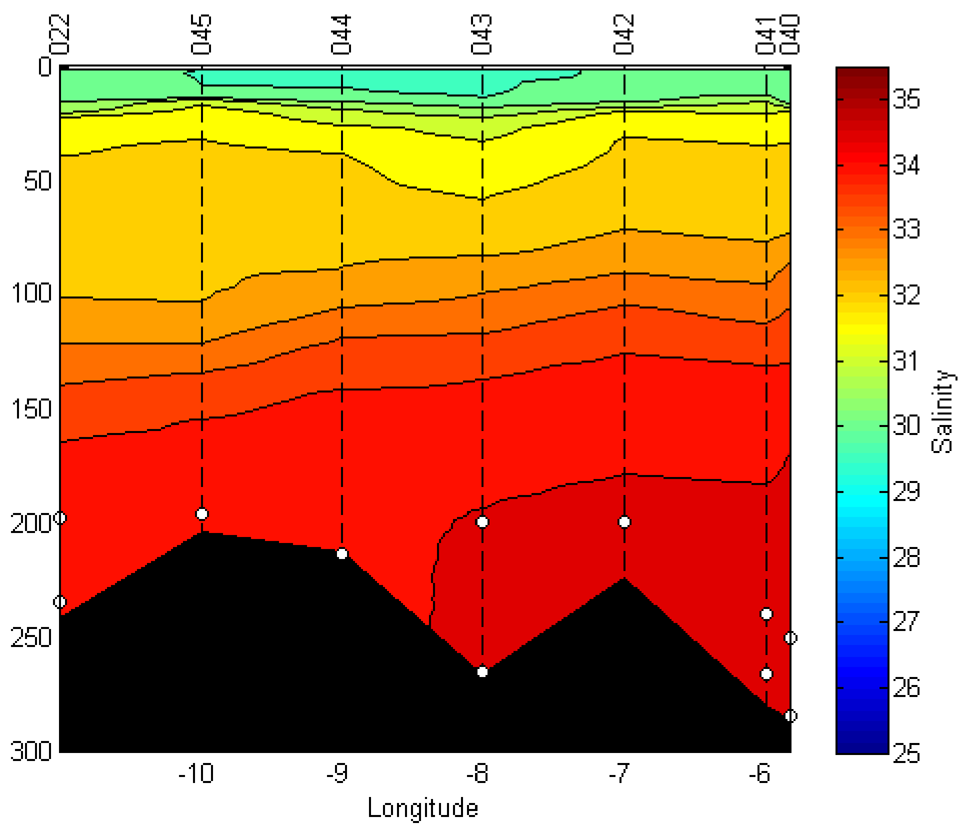
78º 50 N (east\west section)



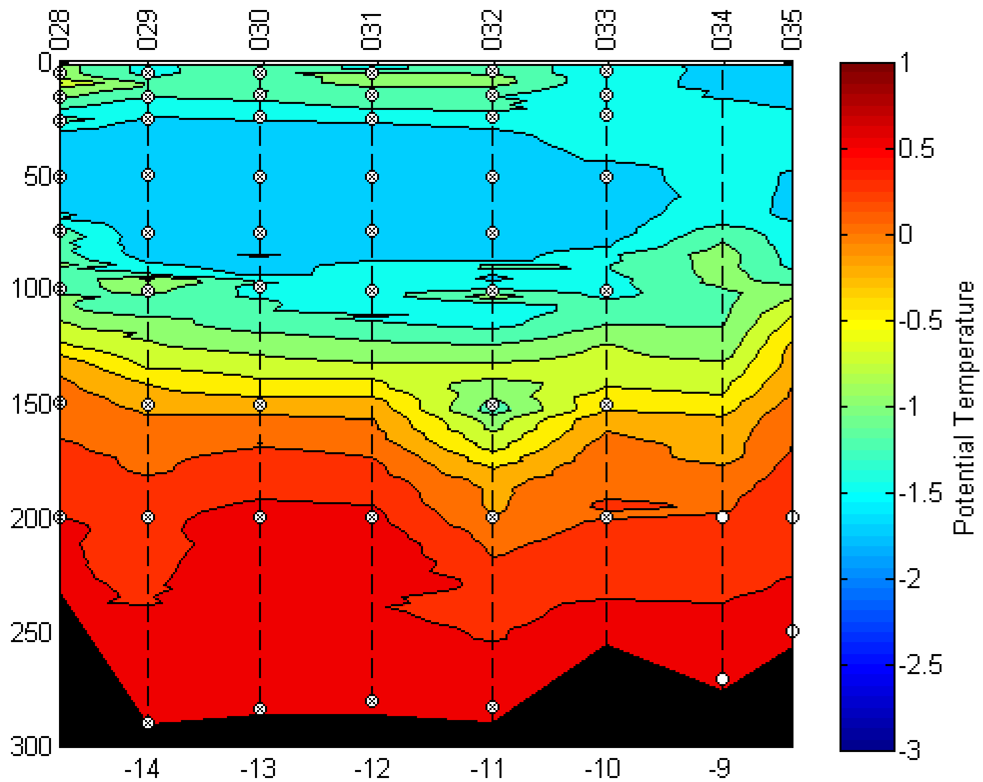

014
015
012
016
010
009
008
007
006
005
004
018
002
001
073
074
076
077
078
079
080
Longitude
Salinity

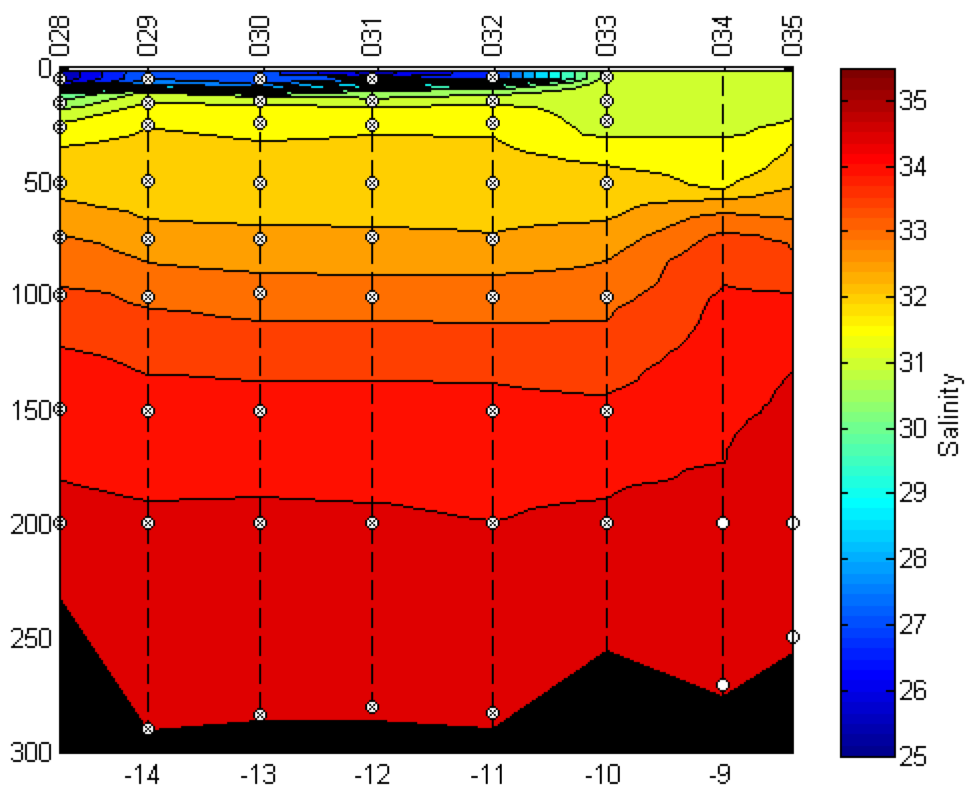
79º 40 N (east\west section)



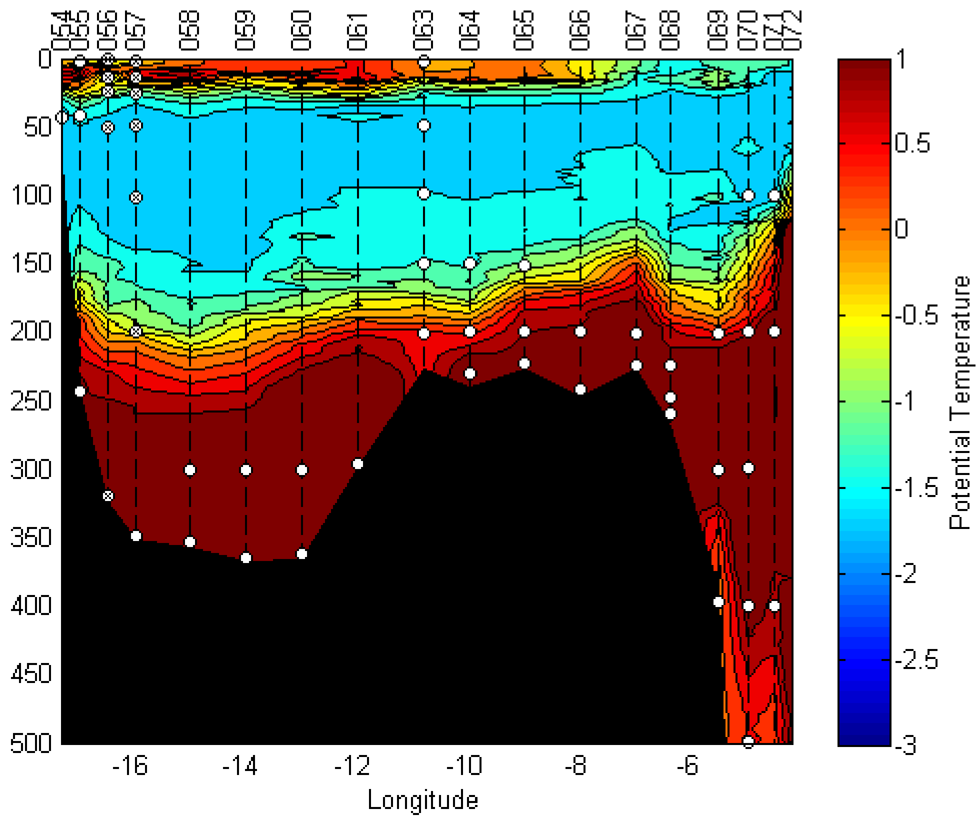


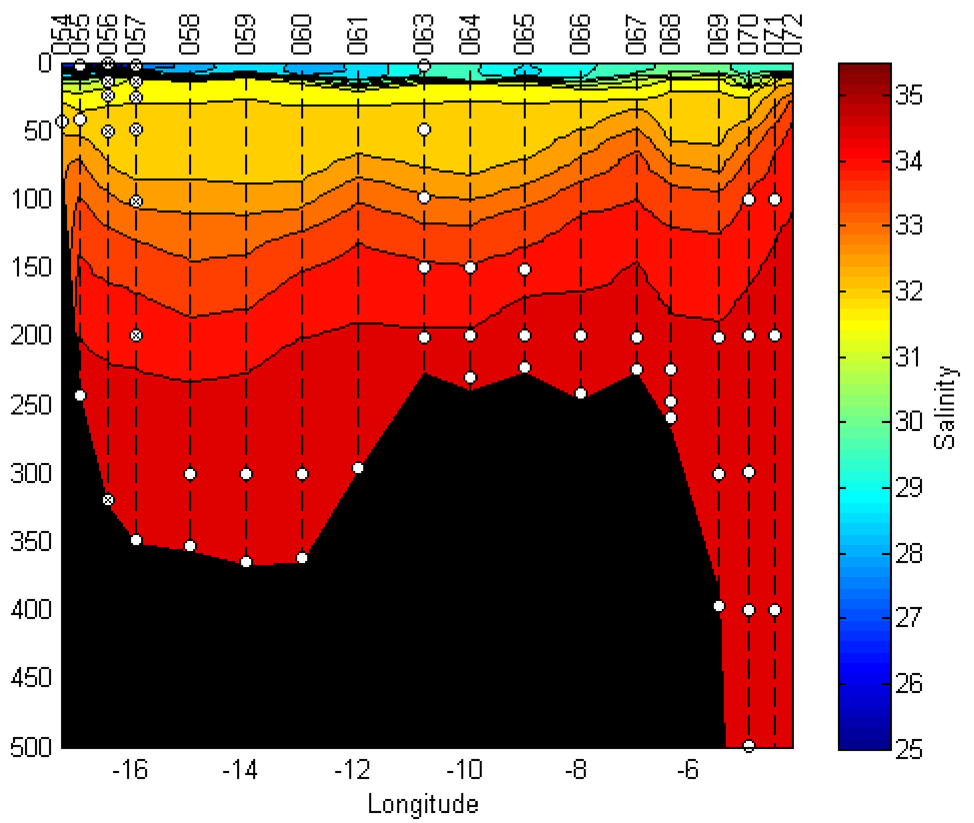
80º 30 N (east\west section)



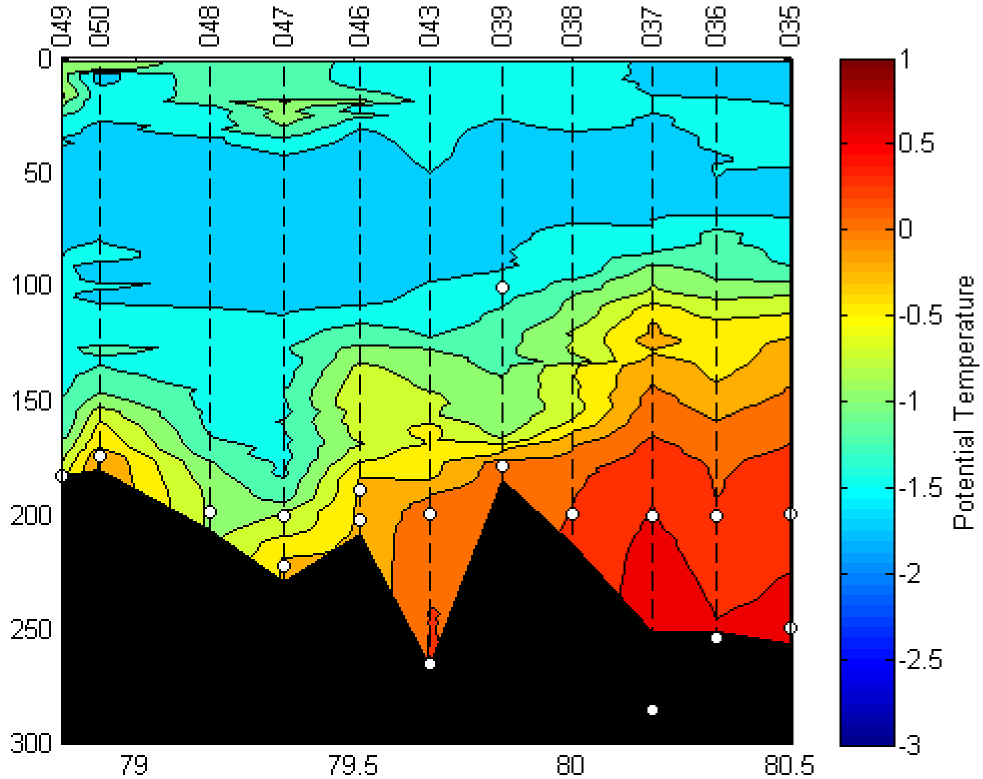


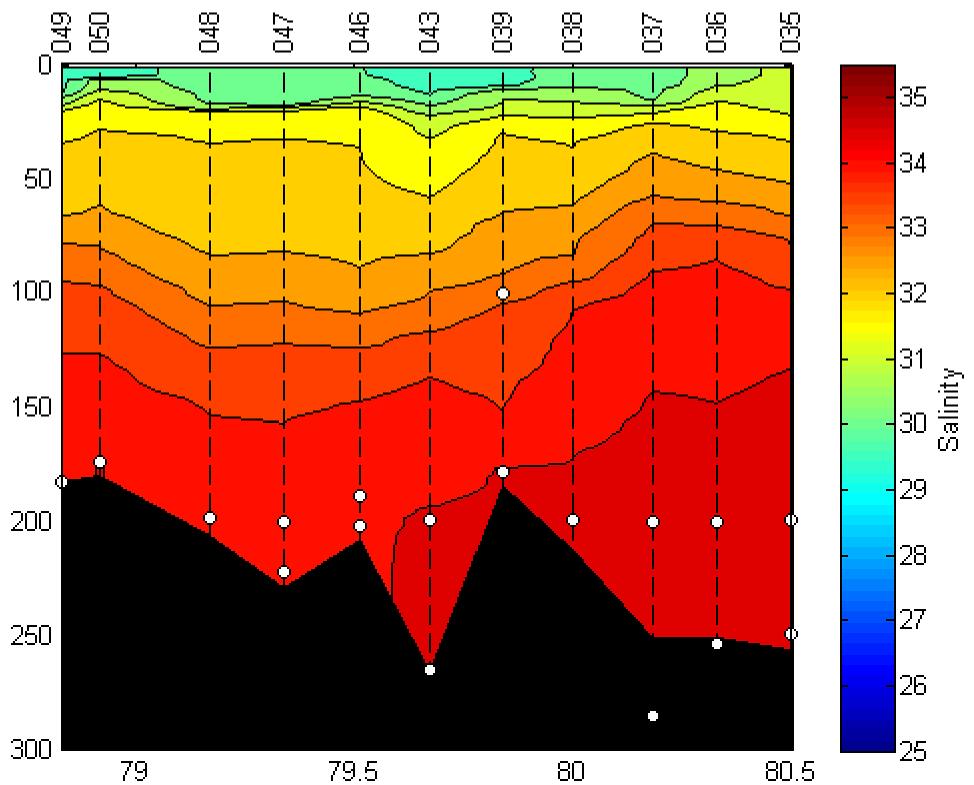
77º 40 N (east\west section)





8º W (north\south section)





11º W (north\south section)