Fram Strait September 2006 R/V Lance

Cruise report

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Background

Three disciplines were represented onboard; oceanography, sea ice and marine biology, with participants from the Norwegian Polar Institute (NPI), Marine Hydrophysical Institute of Ukraine (MHI), the Arctic and Antarctic Research Institute (AARI), the University Studies on Svalbard (UNIS), Finnish Institute of Marine Research (FIMR) and the Norwegian College of Fisheries (NFH). The main purpose of the cruise was to recover and redeploy the NPI mooring array in the western Fram Strait, and to perform the annual CTD sections. The moorings and CTD sections are part of the ASOF programme, presently funded by NPI and the EU project DAMOCLES. The oceanographic programme is particularly targeting the freshwater fluxes from the Arctic Ocean to subarctic seas. In addition the NPI sea ice group performed sea ice work during the first cruise leg, in collaboration with the UNIS and FIMR participants. The NFH participants did their biological sampling mainly in the outflow region in the East Greenland Current (EGC) and over the east Greenland shelf region. The cruise started in Longyearbyen Thursday 31/8, and ended in Tromsø Wednesday 27/9. The first leg ended in NyÅlesund 16/9.

Scientific participants

Edmond Hansen, NPI, oceanography, chief scientist
Vladimir Pavlov, NPI, oceanography
Aleksei Morozov, MHI, oceanography
Ruslan May, AARI/Fram Laboratory, oceanography
Kristen Fossan, NPI, oceanography
Sebastian Gerland, NPI, sea ice (first leg)
Harvey Goodwin, NPI, sea ice (first leg)
Sebastien Barrault, UNIS, sea ice (first leg)
Eero Rinne, FIMR, sea ice (first leg)
Kimmo Karell, FIMR, sea ice (first leg)
Camilla Svensen, NFH, biology (first leg)
Lena Seuthe, NFH, biology (first leg)

Cruise activity log

Date	Activity
31.08.06	Loading, unpacking. Checking equipment, mounting instruments. Departure LYB 1430. Steaming directly towards F11.
01.09.06	Arrival ice edge 1030. F11 two nm inside ice edge. Ice work on ice floe at 78°56.1 N 003 15.3 W. VMADCP started 1130. F11 released 1235. Observed on surface directly after. On deck 1320. CTD no 12.
02.09.06	At F12 0650. Released 0720. Observed directly after. On deck 0830. Ice work on ice floe and biological full station on 78 50° N 004° 00 W (CTD no 5). CTD no. 36

03.09.06	At F13 0600. To much ice to release. Circling around, trying to make contact and looking at echo sounder. No contact, nothing seen. Waiting for divergence and openings in the ice field. Ice map shows better conditions around F4, steaming to this position. At F14 0845. Releases the mooring, F14 on deck 1140. Sea ice work at 78° 50 N 005° 00 W. CTD no 710. Moving back to F13 during the night.
04.09.06	At F13 0600. Still much ice, but releases the mooring 0610. It surfaces under the ice. Triangulating with the deck unit/releaser, locates the releaser 100 m in under a large and thick ice floe. Lance breaks the ice until some flotation surfaces in a crack. Uses a Zodiac to hook onto the flotation. F13 on deck 0900. Steaming towards F17 and F182 (the latter from the 2004 deployment). F17 released 1500, on deck 1515. F182 released 1530, on deck 1545. The tube on the top is missing. CTDs westwards along 78 50 and then northwards along 11 W. CTD no 1115.
05.09.06	Full biological station (CTD no 20) and sea ice work at 79° 20 N 011° 00 W until 1600. Then continuing CTDs northwards along 11° W. Following the fast ice border. CTD no 1625.
06.09.06	CTDs northwards (section 2) until 80° 30 N and then west (section 3) along this latitude. Arrival Amdrups Land 1000. CTDs eastward along 80° 30 N (section 3) resumed 1400. CTD no 2633.
07.09.06	Section 3 continued. Then CTDs south along 008° W (section 4). Steaming towards F19 from the 2004 deployment. Too much ice, can not release. No contact made either. Steaming towards deployment position for F17 and 18. CTD no 3443
08.09.06	Deploying F18 0650. Position 78° 49.884 N 007° 59.276 W. Depth 210 m. Deploying F17 0740. Position 78° 49.939 N 008° 04.562 W. Depth 218 m. Then sea ice work and full biology station (CTD no 43) at position 78° 53.1 N 008° 26.4 W until 1600. Deploying F149 1955. Position 78° 49.055 N 006° 26.802 W, depth 281 m.
09.09.06	Ice station near F13 while mooring is prepared. Deploying F139 1730. Position 78° 50.210 N 005° 00.083 W. Depth 1020 m. CTDs north along 5° W. CTD no 4445
10.09.06	Ice work from 0700 at 79° 12 N 005° 25 W. CTD stations west along 79° 10 N while remaining moorings are prepared. Heavy and compact ice prevents further CTD work. CTD no 4648
11.09.06	Ice station at 79° 18.4 N 009° 31.5 W. Steaming towards deployment site of F12. CTD no 4951
12.09.06	Starting F12 deployment by locating correct depth before breakfast. Deploying F129 0835. Position 78° 49.188 N 004° 00.708 W. Depth 1858 m. Biology station after mooring deployment at 78° 49 N 002° 001 W. CTD no 5254.

13.09.06	Ice station after breakfast at 78° 48.1 N 003° 17.2 W. Then steaming towards deployment site of F11. F119 deployed 1820 in position 78° 49.439 N 003° 15.216 W, depth 2380 m. Cleaning and drying equipment while within the ice, packing and storing. Starting CTD section across Fram Strait towards NyÅlesund. CTD no 55
14.09.06	Section across Fram Strait. CTD no 5662
15.09.06	Section across Fram Strait. Kongsfjord stations KB1 and KB2. Arrival NyÅlesund late evening. At the pier during night. CTD no 6375
16.09.06	Biological station at KB3, position 78° 58.2 N 011° 56.1 E. CTD no 76. Cruise dinner and excellent party at Mellageret.
17.09.06	Departure NyÅlesund 08:00. Steaming towards Yermak Plateau sections. Makes only one station, aborts work due to bad weather. Steaming west towards the ice edge. CTD no 77.
18.09.06	Trying to do the 80°N zonal section. Too much ice. Starting meridional section along 0° W. CTD no 7880.
19.09.06	Doing CTD at 79° 10 N 0° W. Trying to move westward to continue the CTD work in the polynya. Too much ice also at this latitude. Decides to steam south and around the ice tongue penetrating south. CTD no 8183.
20.09.06	Nearly locked in heavy and compact ice while trying to penetrate west. Through the most compact ice at around 1300. Stemaing north towards polynya. Recahes the ice edge, the polynya is closed due to prevailing northwesterly winds. Steaming towards 78° 00 N 012° 00 W. Starting a zonal section along 78° N.
21.09.06	Zonal section along 78° N. CTD no 8495
22.09.06	Ending section along 78° N. Steaming south to 77° N 0° W to start zonal section along 77° N.CTD no 96101
23.09.06	Heavy ice, but continuing section. CTD no 102110
24.09.06	Ending section along 77° N. CTD no 111112 . Steaming home
25.09.06	Steaming home.
26.09.06	Steaming home.
27.09.06	Arrival Tromsø 0600.

1. Oceanographic work

Participants:
Edmond Hansen (data responsible)
Vladimir Pavlov
Aleksei Morozov
Ruslan May
Kristen Fossan

Moorings
Five moorings were deployed in 2005. In addition two moorings from the 2004 deployment were presumably still out there. All five moorings (F118, F128, F138, F148, F173) from the 2005 deployment were recovered in excellent shape. F182 from the 2004 deployment were found and recovered, although the two microcats in the tube on the top was lost. F192 from the 2004 deployment was not found. The sea ice was very heavy at this site, with a high concentration. Trying to communicate with the mooring from a position 250 m away from the mooring position gave no result.

Mooring F138 was recovered within heavy ice. The mooring surfaced under a large ice floe, but triangulation with the deck unit and the releaser pointed to a location 100 m inside the floe. Lance gradually broke the ice, by repeated ramming of the floe. A segment of the mooring finally appeared in a crack and was hooked to the winch using a Zodiac.

The recovered moorings and its detailed instrumentation are listed in Table 1.1 below. Schematic drawings of the recovered moorings are shown in Appendix 1.

Table 1.1: Recovered moorings

Mooring	Latitude Longitude	Water depth (m)	Date and time of deployment	Instrument type	Serial number	Instrument depth (m)
F118	78N49.94 03W15.47	2379	06.09.05 12:30 14:00	ES300 RDCP600 SBE37 RCM11 RCM11 RCM8 AR861	51 28 3996 494 228 10071 287	60 60 62 261 1465 2369 2372
F128	78N49.615 04W00.767	1853	05.09.05 17:30 21:10	SBE37 RCM9 RCM7 RCM11 RCM8 AR861	3995 1046 11475 235 11625 053	68 71 335 1539 1843 1846
F138	78N50.213 05W00.093	1018	04.09.05 13:10 13:46	SBE37 RCM7 RCM7 RCM8 AR861	3994 7718 1175 12733 182	68 76 235 1008 1011
F148	78N49.002 06W26.561	285	03.09.05 15:40 16:14	ES300 DCM12 SBE37 RCM9 RCM7 AR661	37 17 3993 834 375 290	52 52 55 61 275 278
F173	78N49.893 07W59.237	197	03.09.05 6:496:54	WHS300 SBE16 AR861	727 3992 410	100 103 194
F182	78N49.981 08W04.646	225	07.09.2004 10:00	SBE37[1] SBE37[1] AR661	3490 3491 110	21 62 218

[1] Lost instruments

Six new moorings were deployed, F11F18. F19 was not deployed. There will not be any further deployments at this site, as ice conditions in this region close to the fast ice edge in general are difficult for ships of Lances size. In addition comes the relatively high number of icebergs observed in this region. The deployed moorings are listed in Table 1.2, and schematic drawings are provided in Appendix 1.

Table 1.2: Deployed moorings

Mooring	Latitude Longitude	Water depth (m)	Date and time of deployment	Instrument type	Serial number	Instrument depth (m)
F119	78 49.439 N 03 15.216 W	2380		SBE37 RCM7 RCM9 RCM11 RCM8 AR861	2158 9464 1049 538 10069 499	75 78 262 1466 2370 2380
F129	78 49.188 N 04 00.708 W	1858		ES300 DCM12 SBE37 RCM9 RCM9 RCM11 RCM11 AR861	55 17 3551 1325 836 556 117 500	108 108 110 116 340 1544 1848 1858
F139	78 50.210 N 05 00.083 W	1020		IPS SBE37 RDCP600 RCM9 RCM11 AR861	1047 3552 118 1327 561 506	62 66 70 236 1010 1020
F149	78 49.055 N 06 26.802 W	281		IPS SBE37 RDCP600 RCM9 AR861	1048 3554 71 1326 568	58 62 66 271 281
F174	78 49.939 N 08 04.562 W	218		WHS300 AR861	727 501	104 218
F183	78 49.884 N 07 59.276 W	209		DL7 AR861	1632 553	55106 209

CTD and LADCP stations

This CTD survey of the Fram Strait continues the annual NP hydrographic observation and monitoring of this region. All data were acquired using a 'Seabird 911 plus' fitted with pressure, temperature and conductivity sensors and a pump. The CTD was installed at the bottom of a CTD frame which included a carousal water sampler above it. Water samples for salinity calibration were obtained at most stations.

The scientific personnel worked in two shifts. Team 1, Edmond and Ruslan, performed the 6 to 12 shift whilst Team 2, Vladimir and Aleksey, ran the 12 – 6 shift. An extra person from the crew helped both teams with the CTD operations.

Once in the water the logging was initiated using SeaSave, the Seabird data acquisition software. The salinity and temperature values were monitored until they were stable, after that the CTD was lowered at about 1m/s. Water samples were taken during the upcast.

At the end of each station the CTD was lifted back onto the deck, wheeled into the shelter and secured before Lance headed to the next station. After the data was downloaded, the data was transformed to ASCII using Data Conversion (DatConv) in the SBE data processing software. The resulting CNV file was used for plotting and closer inspection of the TS vertical profiles and transects. At this stage no further processing was performed on the data.

Figure 1.1 below shows the location of all the CTD/LADCP stations.

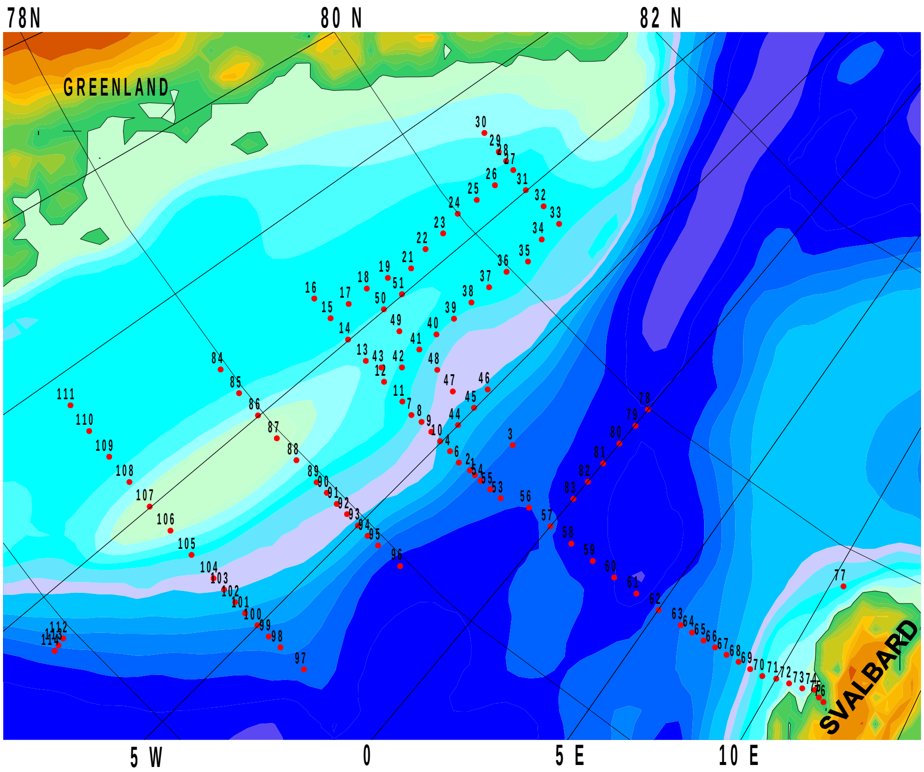


Figure 1.1: CTD/LADCP station positions

The main goal of the oceanographic work on the cruise was to characterise the oceanographic properties of the Western part of Fram Strait, in particular the East Greenland Current (EGC).

Several transects were performed. The CTD data from these transects (Fig. 1.1) allows us to identify the pathways of the Arctic waters and will be used in the process to calculate the liquid fresh water flux trough Fram Strait.

In the core of the EGC the temperatures were in the range 1.5 to 1.7° C, while salinities ranged from 31.5 to 32.7. The main branch of the EGC is located over the continental slope, and several eddies were observed over the Greenland shelf.

The transect across Fram Strait from Greenland to Svalbard along the latitude 78° 50' N provided the hydrography of both the southbound EGC and the northbound West Spitsbergen Current (WSC). The maximum temperature in the core of the WSC (7.553ºC) was observed at station Fs067 (78° 55' N 07° 59'E) at the depth 37 m. The salinity in this point was 34.992.

Comparing the maximum temperature in the core of the Atlantic Water with previous measurements in this area from August to September (Figure 1.2), one may observe that the present temperature is high (7.553ºC). Only on one earlier occasion have higher temperatures been observed in this region. This occurred in 2002, where a temperature as high as 7.74ºC was observed.

The potential temperature and salinity of the transects are given in Appendix 2. Appendix 3 gives the full list of stations, positions and time.

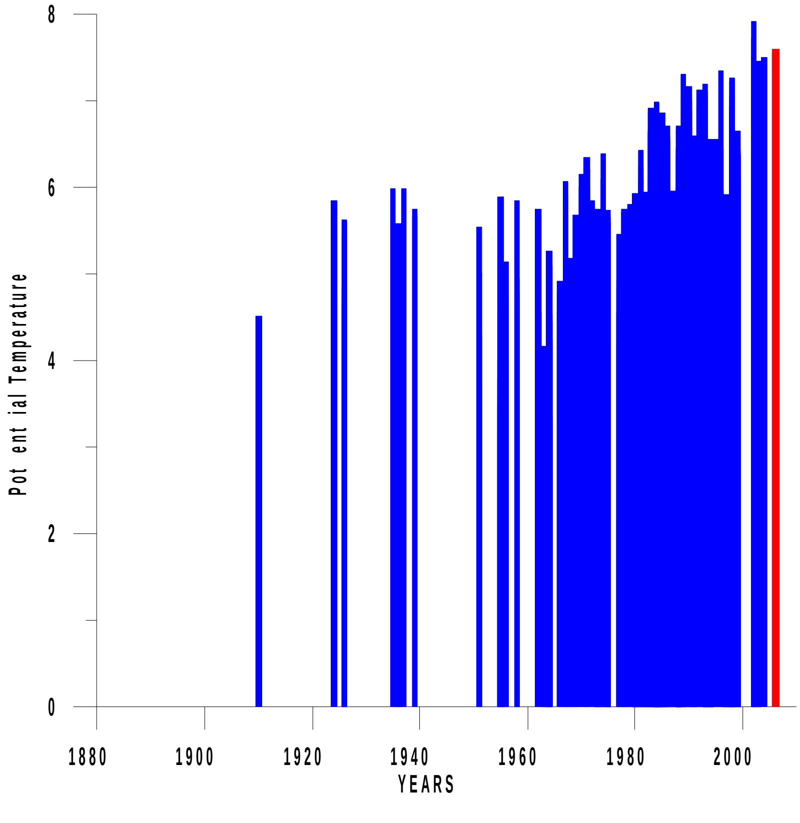
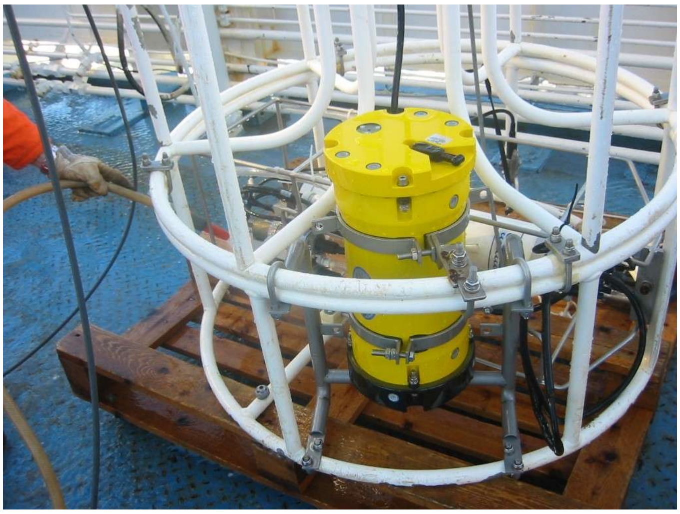


Figure 1.2: Maximum temperature in the core of the West Spitsbergen Current at latitude 79ºN in this cruise (red bar) and in previous years (blue bars).

LADCP observations

Throughout the cruise an LADCP recorded data at the each CTD station simultaneously with CTD observations. This was the first cruise where the LADCP setup was tested at NPI. The units came directly from the factory and were delivered just prior to departure. One quicly discovered that there was no Master/Slave X cable for connection of the two LADCPs in the shipment. In addition the special made frames for fastening the LADCPs to the CTD rosette was not applicable for installation of a full Master/Slave setup with one downward and one upward looking LADCP working in pair. On this cruise we therefore used just one downward looking LADCP installed at the lower end of the CTD rosette (photo to the right).



At the stations fs001 to fs006 the instrument sn 7945 was used. After the first data processing and preliminary analysis we found strong 'ringing effects' in the records and the instrument was changed. For the remaining part of the cruise instrument sn 7946 was used. For the data processing we used both RDI WIN SC software and software developed at MHI. The results from the two software packages showed good agreement.

Transects of the vector velocity components are given in Appendix 2. This is preliminary results, since the tidal signal is not removed and the drift of the vessel during the casts have not been corrected for.

2. Sea Ice Studies: Snow and Ice Physics, Ice Mechanics and Ice Biology

<u>Participants:</u>
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Harvey Goodwin (NPI, goodwin@npolar.no)
Edmond Hansen (NPI, edmond.hansen@npolar.no)
Sébastien Barrault (UNIS, sebastien.barrault@unis.no)
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Eero Rinne (FIMR, eero.rinne@fimr.fi)

In situ sea ice studies were performed during the first leg of the Fram Strait RV "Lance" cruise, starting in Longyearbyen 31 st August 2006, and ending in NyÅlesund 16 th September 2006. The NPI 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.damocleseu.org). In addition ship time on Lance also provided the opportunity to test satellite image services provided via the project PolarView. The FIMR scientists worked on physical properties in ice ridges and sea ice biology, and the UNIS study aimed at the thermomechanical properties of sea ice, with a focus on ridges.

Work at 10 sea ice stations (see Table 2.1 and Figure 2.1) with a duration up to 8 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 a ladder. After one rubber boat was damaged by a walrus on ice station FS0604, only one rubber boat could be used, and ice conditions permitting supplemented by use of a Polarsirkel plastic boat.

Date	**Station ID**	**Latitude (N)**	**Longitude (W)**	**Floe or Landfast**	**Thickness profiling**	**Snow inspection**	**Level ice coring**	**Albedo**	**Icemechanics**	**Ridge study**	**Biology**
01.09.2006	FS0601	78.8329	3.257133	F	●	●				●	
02.09.2006	FS0602	78.83037	3.98775	F	●	●	●		●	●	●
03.09.2006	FS0603	78.80803	4.98625	F	●	●					
05.09.2006	FS0604	79.32673	10.89797	LF	●	●	●		●	●	●
08.09.2006	FS0605	78.8852	8.463267	F	●	●	●	●		●	●
09.09.2006	FS0606	78.89688	5.762117	F	●	●		●		●	
10.09.2006	FS0607	79.21055	5.37585	F	●	●					
11.09.2006	FS0608	79.30773	9.521433	F	●	●	●			●	●
11.09.2006	FS0609	79.29527	9.690533	F	●						
13.09.2006	FS0610	78.8026	3.28645	F	●	●	●	●		●	

Table 2.1: Overview of ice stations with position and type of measurements made.

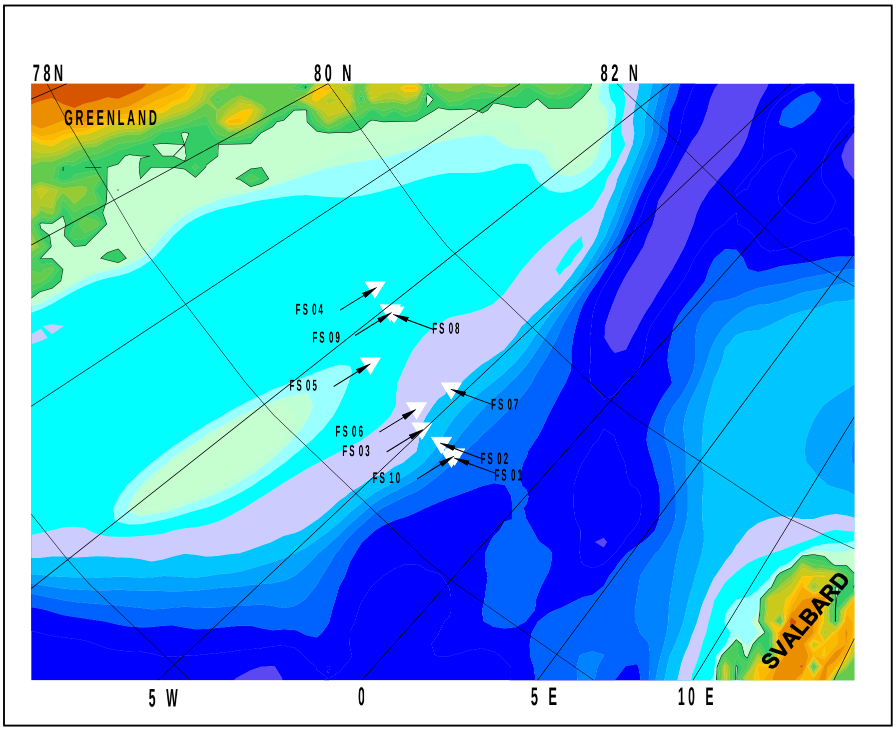

Figure 2.1: Map of sea ice stations during the cruise FS06 (first leg). The last two digits of the labels equal with the corresponding station ID last digits in Table 2.1.

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 averaged drift of the floe.

Ice observation from bridge

In total 89 regular ice observations (every 3 hrs in areas with sea ice) with 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 Fig. 2.2), available meteorological data (air and water temperature, air pressure) plus ship data (position, speed, heading). 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. Whenever icebergs were observed, extra notes were made recording their approximate position and size.

Fig. 2.2: Example of a sea ice observation image (from 10 Sept. 06, 19:00 UTC)

Mass and energy balance of Fram Strait sea ice (NPI)

(Sebastian Gerland, Harvey Goodwin, Edmond Hansen)

Snow and ice thickness profiling

Snow and ice thickness was measured directly (drillings) and indirectly (Geonics EM31, see Fig. 2.3) for quantifying the ice mass of sea ice in the research area. The data is also used for validation purposes of the upwardlooking sonar (ULS, see Vinje et al. 1998) recordings from moorings. By doing corresponding surveys every year in September in the Fram Strait, the interannual variability can be documented. The measurement principle of the indirect measurements is electromagnetic induction. By measuring the electrical conductivity in the halfspace 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. During this cruise a second, new EM31 instrument was used and results compared with the existing EM31. The new instrument consists of a data logger, and a handheld PC (Allegro CX) with GPS option. Both instruments were tested, compared and calibrated with drillings. The instrument results agreed well, but the raw conductivity data show a constant shift (which is eliminated in the ice thickness conversion). In total 3320 m of electromagnetic profiles were measured (commonly one measurement every 5 m, but transects crossing ridges with FIMR and UNIS work were carried out with a 2.5 m spacing). Along these profiles snow thickness were measured with a metal pole for each EM31 thickness reading. In total 33 holes were drilled for direct thickness measurements, using a Kovacs thickness gauge (measurement of snow thickness, ice thickness and freeboard).

Fig. 2.3: 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, temperature, salinity, density, moisture, and hardness measurements. Typical snow thicknesses were approximately 0.10 m. That allowed for commonly one density (weighing of a snowfilled metal tube) and snow moisture measurement (using a capacitive AC device, LEAS Tel 5.01). Vertical snow temperature profiles were measured every 2 cm. Snow hardness was estimated choosing between degrees of what can penetrate the snow (fist, 2 fingers, 1 finger, pencil, knife). 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 (Fig. 2.4). Snow types and grain sizes are important for the spectral albedo of the snow & sea ice surface.

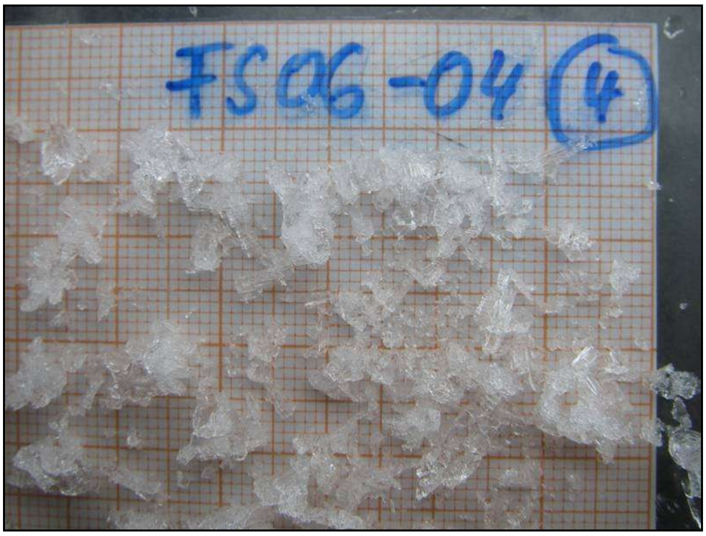

Fig. 2.4: Example of snow layer photography 4th layer from top at station FS0604.

Ice coring in level ice

At 5 stations (see Table 2.1) level sea ice, ice cores (4” diameter) were obtained in order to quantify the vertical distribution of sea ice salinity and the temperature field in the ice. In addition to that, a simple stratigraphic description of the cores was made. For some stations also ice density was measured on level ice (FIMR, see below: ridge studies, physics part). Temperature of the ice was measured in small drill holes (made with a hand drill) using an electronic thermometer (spacing 510 cm). Sea ice salinity is derived from electrolytic measurements on melted ice samples (typically 7 cm thick), using a conductivity meter (WTW 340) in the laboratory on RV Lance.

Spectral surface albedo and reflectance

The surface albedo of snow/sea ice is crucial for the fate of an ice floe, and the albedo feedback process is by now seen to play a key role in polar climate change processes. Surface albedo and reflectance on different surfaces were measured on three stations (see Tables 2.1 and 2.2) using an ASD fieldspec pro spectroradiometer (wavelength range 3502500 nm, resolution 1 nm). It turned out to be a challenge to find favourable conditions for optical measurements (constant atmospheric conditions (clear skies or overcast), and no precipitation during the measurement). However, on the three stations with optical measurements conditions were relatively stable for the roughly 2 hours when measurements were going on. Reflectance measurements were done with an 8° fore optics attached to the spectro radiometer’s optical fibre. The fore optics was mounted on a tripod looking downwards (nadir), and measurements were done over a spectralon reference plate and sea ice surfaces (different snow thickness, surface roughness, icecovered melt ponds with and without snow cover, snow/ice with impurities). Snow pit inspections followed the optical measurements. For each surface, three reference plate measurements and 2 surface measurements were acquired (sequence WRSWRSWR).

Fig. 2.5: Harvey Goodwin adjusts the albedo setup. The spectrometer is in the foreground under the grey protective cover, connected to the fore optics by the black fibre cable, and to the controlling PC via the parallel port.

Surface albedo observations (see Fig. 2.5) have a larger footprint (metre range) than reflectance (decimetre range) was measured using a 2m arm mounted on a tripod and a remotecosine receptor fore optics (RCR). Three measurements with upwards oriented sensor were made, and two with downwards orientation (sequence updownupdownup). One sequence takes about 23 min. to be measured. Comparison of measurements with the same setup in one sequence gives an idea on the stability of conditions.

Station	**File ID**	**Measurement**	**Surface**	**Atmosphere**
FS0605	R1080906	Reflectance	Flat snow surface	Overcast
FS0605	R2080906	Reflectance	Frozen MP with rough snow	Overcast
FS0605	R3080906	Reflectance	Frozen MP with flat snow	Overcast
FS0605	R4080906	Reflectance	Frozen MP without snow	Overcast
FS0605	A1080906	Albedo	Flat snow surface	Overcast
FS0606	R1090906	Reflectance	Flat snow surface	Clear sky
FS0606	R2090906	Reflectance	Slightly rough snow	Clear sky
FS0606	R3090906	Reflectance	“terraces” in snow away from sun	Clear sky
FS0606	R4090906	Reflectance	“terraces” in snow towards sun	Clear sky
FS0606	R5090906	Reflectance	Frozen MP with snow cover	Clear sky
FS0606	A1090906	Albedo	Slightly rough snow	Clear sky
FS0606	A2090906	Albedo	Frozen MP with snow cover	Clear sky
FS0610	R1130906	Reflectance	Flat snow surface	Overcast
FS0610	R2130906	Reflectance	Thin snow layer, impurities	Overcast
FS0610	R3130906	Reflectance	Frozen melt pond without snow	Overcast
FS0610	R4130906	Reflectance	Thin snow layer, impurities	Overcast
FS0610	A1130906	Albedo	Frozen melt pond without snow	Overcast
FS0610	A2130906	Albedo	Flat snow surface	Overcast

Table 2.2: Overview of optical measurements. “MP” stands for melt pond.

Upward looking sonars

Since 1990, two to four NPI moorings were deployed in the Western Fram Strait. Every September they have to be taken up and other moorings are deployed. These moorings run continuously. Two moorings with upward looking sonars were recovered (F11 and F14), and three were deployed (F12, F13, F14). The sonar measures the distance between the ice underside and the sensor. From that valuable ice draft data can be calculated. The data retrieved from ULS measurements allows us to calculate continuous ice draft information.

This year, for the first time a new ULS type (IPS, F14, F13) was used, along with the type used since the early 1990s (CMR ES300, F12). See the oceanography section in this report for further information about the morings.

Sea ice mechanics: Thermomechanical properties of ridges (UNIS)

(Sébastien Barrault)

Multiyear ice ridges are an essential part of packice cover and from an engineering point of view they represent the highest loads on offshore structure, scour the sea bottom and influence onice traffic condition. Nowadays neither their morphology nor the thermomechanical properties are well known in despite of some work done by Kovacs and Cox in the late seventies and early eighties.
Today, a particular topic to investigate is how the multiyear ridges consolidated during the summer. In order to draw first hypothesis and develop models, a data collection on temperature, salinity and density profiles, on strength and on morphology is needed.

Measurements

Profiles for determining ice properties (see section *Sea ice ridge properties and sea ice biology, FIMR*) and surface topography were measured for 6 of the 10 stations and at 2 stations ice was sampled for mechanical tests. For logistic reasons, mechanical tests were not performed on board and samples were stored at low temperature and carried back to UNIS for testing in laboratory.

Ice sampling

A 3'' diameter corer was used to sample ice from a floe (FS0602) and landfast ice (FS0604). At station FS0602, two cores were taken: one from level ice (core length: 2.73 m) and one from a ridge. Because of a corer problem, 2.4 m over 5.07 only were sampled. At station FS0604, one core was taken from the ridge (ice thickness: 7.15 m with a large cavity of about 0.63 m). Samples were then brought on board and stored at about 20 ˚C.

Uniaxial compression test

An electric saw with a predimensioned table cut the 3'' diameter core with a length of 17 cm and keeps both ends parallel. The samples are then weighted for density and crushed with a portable ice crushing device, KOMPIS, designed to perform uniaxial compression tests in situ or in laboratory. It provides ice strength and deformation versus time for a chosen deformation rate. In addition, recording observations give or confirm the mode of failure (brittle, ductile). Right after compression, temperature is measured and ice is then collected in hermetic boxes for melting in order to measure salinity. Density, temperature and salinity data can be later computed for assessing brine and air porosity of the core.

Thin section

Horizontal and vertical sections are cut and glued between to glass plates with distilled water. Sections are then planed with a Microton device until they have a maximum thickness of 0.5 mm. Under polarized light, ice grain size and porosity are finally studied (dimensions, shape, amount, etc).

Morphology

Morphology is an important step for describing ridges. Dimensions of the shown part of ridges have been taken from a reference point on level ice giving the height of the sail, the width and the position of drilled cores. Vertical and horizontal distances were measured with a ruler. The latter was preferred than a theodolite: more convenient for short time ice station and because of short distances to measure. Ice thickness and freeboard were quantified when biology and ice properties coring were carried out and therefore it permitted to adjust the surface topography to the water level. Morphology of station FS0608 is giving as an example in Fig. 2.6.

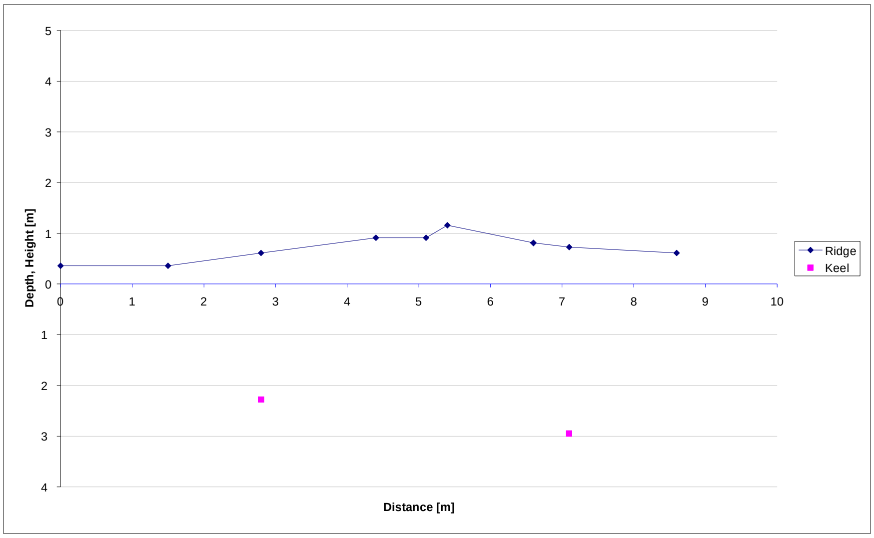

Fig. 2.6: Cross section of a ridge. Xaxis in blue represents the water level.

EM transects (see section *Mass and energy balance of Fram Strait sea ice, NPI*) with a resolution of 2.5 m were done across ridges for most of stations (FS0605/06/08/10) starting at the same reference point than surface measurements. EM transects, thickness measurements and surface dimensions can be computed together to give the total cross section morphology. Porosity was also measured when present. Finally a large collection of pictures completed the morphology study in order to observe blocks feature in the sail (Fig. 2.7), number of ridges and size of floe.

1. First Year Ice from Polhavet, Lance Cruise, Arctic Technology UNIS, May 2006

2. Probably Second Year Ice, Fram Strait, FS0606

3. Multi Year Ice Ridge, Fram Strait, in vicinity of FS0608

Fig. 2.7: Ridge evolution: sails from FYI to MYI.

Sea ice ridge properties and sea ice biology (FIMR, University of Helsinki, Tvärminne zoological station)

(Eero Rinne, Kimmo Karell)

Sea ice microbial communities (SIMCO) in MYI pressure ridges (Kimmo Karell)

Numerous technical geophysical studies of first and multi year presssure ridge ice structure, evolution and strenght have been published during the last 30 years. For the first time in Baltic Sea and probably also on a global scale, we put special emphasis on the community structure and abundance of sympagic communities that occur in first year pressure ridge keel ice blocks and water between ice blocks voids. Our recent results from first year ridges in Gulf of Bothnia shows high biological activity in top 1 meter of keel and voids. In Lance Fram Strait 2006 cruise, our goal is to take multiyear pressure ridge keels and their distinction in to focus to study light dependent vertical zonation and the variability in species composition between different habitats.

Sampling and sample processing

A Kovacs motor driven corer (diam. 90 mm) was used to pressure ridge and level ice sampling and pumpsystem 45/2203K(X) (Karell 2006 unpublished) for obtaining subice (0m and 1m) and void water samples.
Ice cores (chl*a* and sympagic organisms) were cut into vertical sections of 5–20 cm thickness and melted in dark +5 GF/F filtered sea water (Garrison & Buck 1992). Water samples and melted ice samples were fixed with acid 5 % Lugol solution for later microscopic analyse.

Chlorophyll a and pheopigment

Duplicate (250500 ml) samples were filtered through a 25mm diameter GF/F glassfiber filters and extracted in 96% ethanol for later analysis with a Shimadzu RF5001PC spectrofluorometer in Tvärminne zoological station. Final chl*a* concentration (with taking dilution coefficient into consideration due to FSW addition) was calculated by HELCOM (1988) instructions.

Enumeration of organisms

Taxonomic composition and enumeration of protists is carried out by using inverted microscope (Uthermöl 1958). First inspection with a 125x final magnification, following by enumeration with a 500x final magnification from 50 random view fields or 500 counting units. Protist cell volume conversion to carbon biomass was followed by recommendations of recent HELCOM (2004) instructions.

Ridge Study, physics part, Eero Rinne (FIMR)

Fig. 2.8: Preparing ice samples for salinity and density measurements.

Total of 9 vertical temperature, density and salinity profiles were obtained from 7 different pressure ridges during the cruise. For temperature measurement, a sample core was obtained using a 9 cm Kovacs sample barrel. Temperature was measured from the middle of the sample core on site with a electrical thermometer. Another sample core was obtained for density and salinity measurements. Density was measured by cutting 1020 cm long cylindrical pieces from the core (see Fig. 2.8). Dimensions of the pieces were measured on site and the pieces were later weighed using a handheld balance. Parts of the core were brought on board RV Lance to be melted. Salinity of melted samples was later measured with a WTW 340 conductivity meter. Example of obtained data is shown as Fig. 11.

In a few cases brine running out from the core when the sample was lifted resulted in ambigious data. Losing brine before salinity and mass of the sample were measured introduced an error in salinity and density. Technical difficulties with corer barrel were experienced on September 10th and thus no ridge measurements were made.

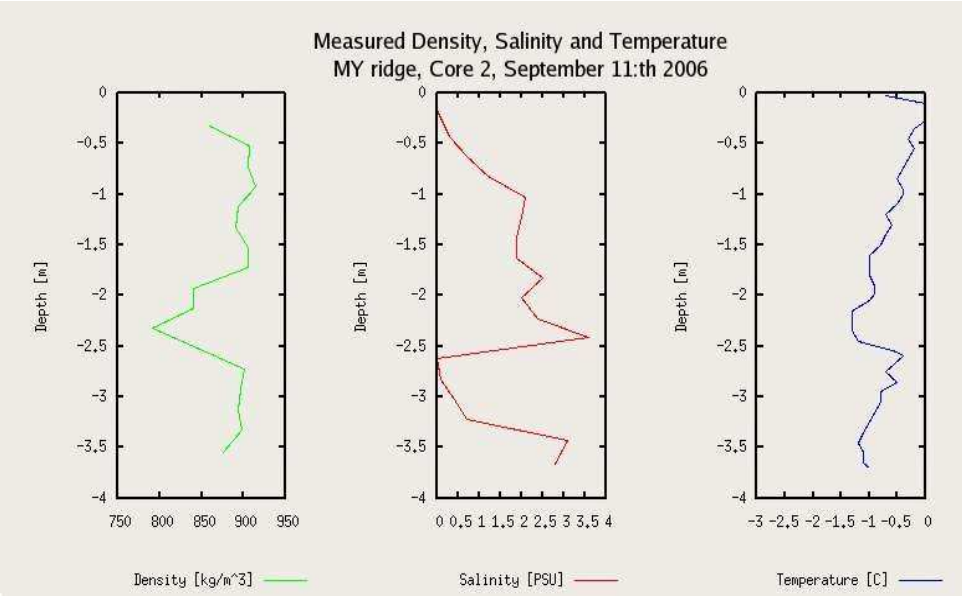

Figure 2.9: Density, salinity and temperature profiles collected on station FS0608.

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. This cruise was able to take advantage of a satellite image viewing software developed by Leif Toudal at 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. This system provided considerable savings in steaming time, and also provided an invaluable tool for helping planning and modifying the cruise plan while at sea. This enabled us to visit the North Eastern Polynya off the coast of NE Greenland at 80°30'N, an area seldom visited due to the heavy ice regime normally experienced in this region.
Available imagery consisted of daily AMSR ice concentration with a resolution of 3.25km. Routine Envisat ASAR Global Mode (1km resolution) data were collected on Envisats background mission when available, and Envisat Wide Swath data processed to a resolution of 300m. There was also a small amount of Envisat Alternating Polarisation data acquired in connection with the project Skipsat which is developing algorithms for ship detection. Unfortunately Envisat experienced technical problems from the 7th – 12th September resulting in no image acquisition during this period.
See Table 2.3 for the list of imagery available, and Figs. 2.10 and 2.11 for examples of AMSRE imagery and Envisat ASAR WS imagery, respectively..

Satellite	Sensor	Resolution	Date	Source	Filename
Aqua	AMSRE	3.25km	daily	http://www.seaice.dk/zipfiles/Fram/	yyyymmdd.amsr.n.comb.zip
Envisat	ASAR GM	1km	daily	http://www.seaice.dk/zipfiles/envisat.cuts/Fram/	yyyymmdd.ASAR.1km.zip
Envisat	ASAR WS	300m	Regularly	http://www.seaice.dk/zipfiles/envisat.wsm/	yyyymmddhhmmss.ASAR.orbit.zip
Envisat	ASARAP	50m	1,3,4,5,6, 12th Sept	KSAT	

Table 2.3: List of satellites images.

To view these 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 Envisat WS images maybe available from NPI at a later date.

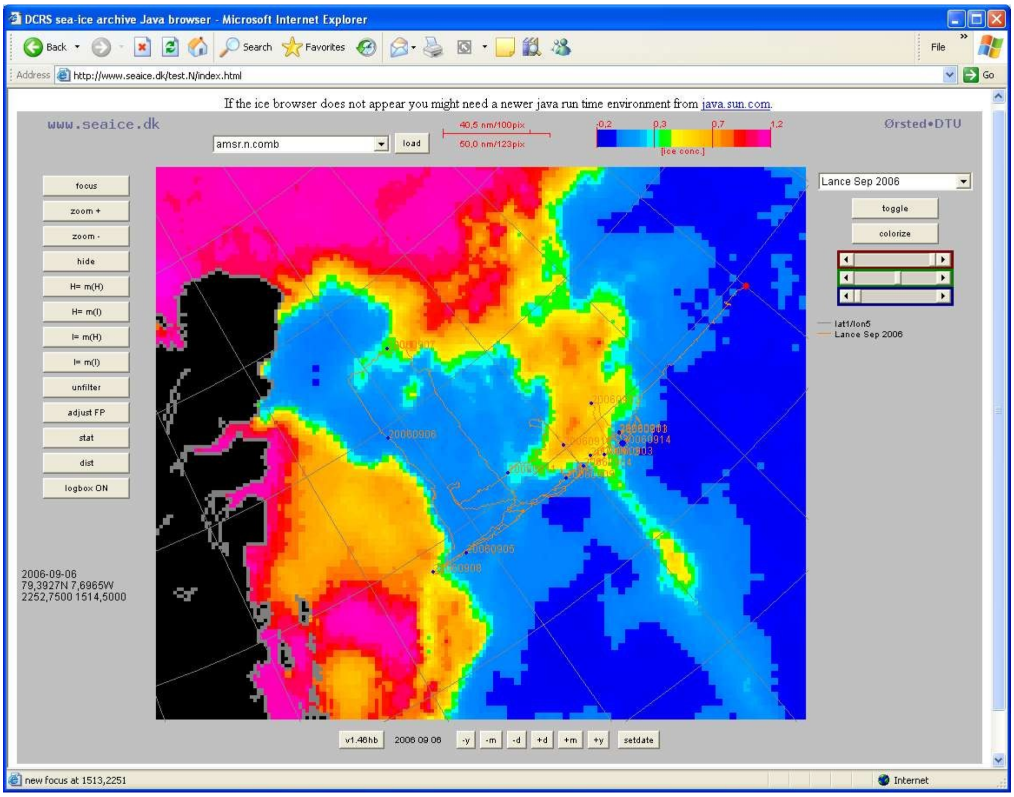

Figure 2.10: Example of AMSRE data in the Fram Strait.

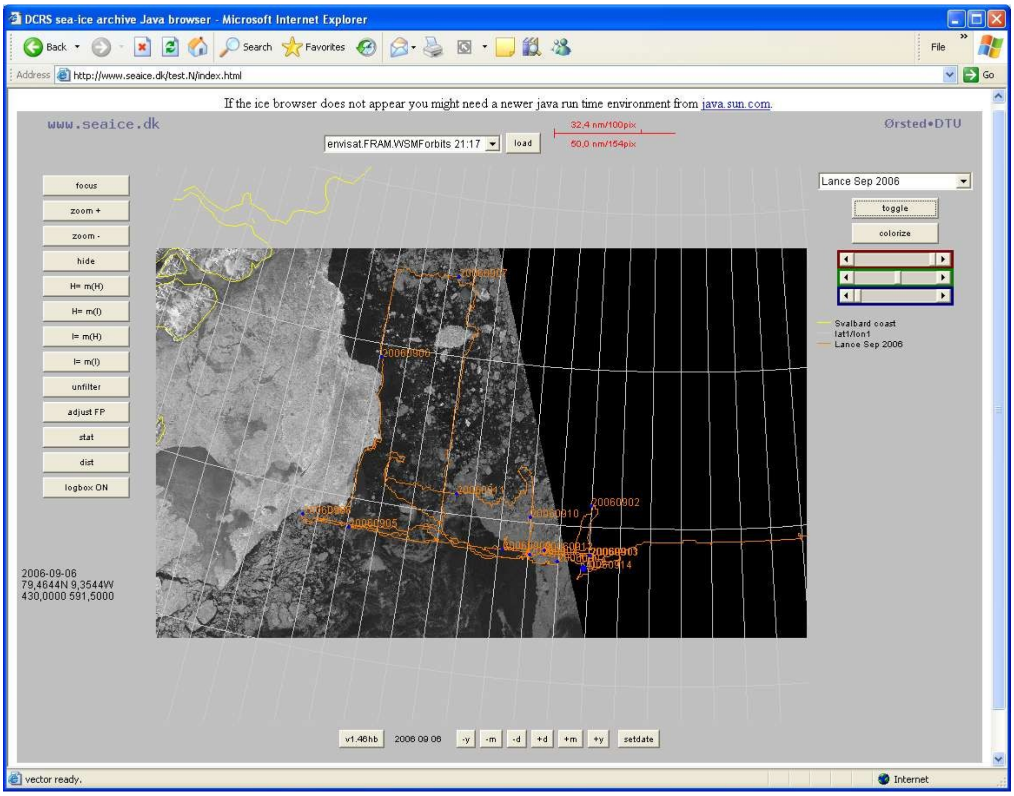

Figure 2.11: Example of Envisat ASARWS imagery with Lances cruise track overlaid.

3. Marine biology work (NFH)

Participants:
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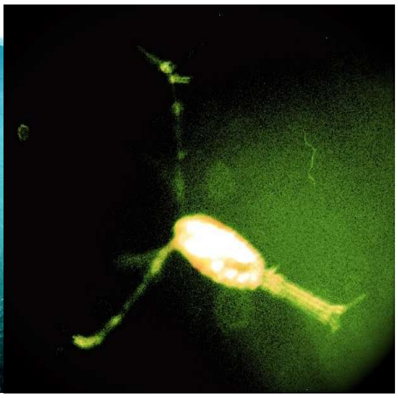
Lena Seuthe (lena.seuthe@nfh.uit.no)

Background and objectives

The traditional description of the pelagic Arctic food web has been the simple and short food chain where lipidrich copepods of the genus *Calanus*graze large chains of diatoms, efficiently channelling the energy from the primary producers up to higher trophic levels such as fish and marine mammals. Contrary to this idea, recent studies stress the importance of smallcelled plankton, such as pico and nanosized (< 20∝m) flagellates, as primary producers, as well as main predators on marine bacteria. For large copepods, such as *Calanus* spp., bacteria and flagellates are not available as food due to mechanical restrictions on their feeding apparatus. However, bacteria and flagellates constitute food for other planktonic organisms, such as ciliates and dinoflagellates. Ciliates and dinoflagellates are singlecelled organisms falling into the same sizerange as diatoms, and are thus large enough to be preyed upon by large copepods. Recent studies have shown that *Calanus* spp. do not only feed on ciliates and dinoflagellates when other food is scarce, but positively select for these organisms during diatom blooms. *Calanus* spp. is the dominating Arctic zooplankton genus in surface waters during spring and summer, while they migrate to deep waters during winter. Throughout the year, the Arctic zooplankton community is numerically dominated by small copepods, such as *Oithona similis*, and thus their grazing may be equivalent or even higher to that of the *Calanus* species.

O. similis is a cosmopolitan, both in its distribution as well as in its food spectrum. It feeds raptorial on sinking and moving particles of a wide sizerange, from small flagellates to diatoms and large aggregates, and thus exploits a larger food spectrum than the *Calanus* species. The wide food spectrum of *O. similis* has been suggested as an explanation for its yearround reproduction. Despite its numerical dominance and its role as predator on many planktonic organisms, only few studies have focused on the ecology of this species. Data on egg production and egg hatching success in *O. similis* at temperatures < 1 ˚C are lacking, and only little is known about the species food selection under different ecological scenarios (e.g. diatom versus flagellate dominated phytoplankton community).

In summary, small copepods and microzooplankton are numerically abundant in Arctic seas but are less frequently studied compared to larger species such as *Calanus* sp.. The role of the small components, i.e. the microbial loop of the arctic carboncycle is poorly understood. During the first leg (1.16. September 2006) of this cruise to the Fram Strait our main objectives were to investigate 1) grazing of the small cyclopoid copepod *Oithona similis* and 2) community growth of microzooplankton.

Water column sampling

Four stations were selected along a transect from the landfast ice on the East coast of Greenland to offshelf crossing the East Greenland Current (EGC) and sampling more Atlantic water masses east of the EGC (Table 3.1). At all stations a vertical profile of particulate organic carbon and nitrogen (POC/PON) and chlorophyll *a* (Chl *a*) was obtained from water from 5, 10, 20, 30, 40, 60, 100 and 200 m collected with Niskin bottles mounted on a CTD rosette (Table 3.2). Subsamples of 200800 ml were filtered in triplicates onto GF/F for total Chl *a* and onto 10 µm membrane filters for estimating Chl *a* >10um. Filters were stored frozen (70 C) and subsequently read fluorometrically after 24 h extraction in 5 ml ethanol at room temperature. Profiles of Chl *a* at the 4 sampled stations are given in Fig. 3.1. For POC/PON analyses triplicate subsamples of 400800 ml was filtered onto pre combusted GF/F filters (450˚C for 5h). Filters were stored frozen (70 C) until analysis with a CHN analyser (440 LabLeeman elemental analyser) after fuming with concentrated HCl to remove inorganic carbonates (data not available yet).

Table 3.1. Main sampling stations

Date	CTD #	Position	St.	Depth (m)	Sampling	Ice cover	Comments
2/9	Fs005	78˚49.562N, 003˚59.909W	1	1852	CTD, profile,WP 2, *Oithona* depth dist, incubation water 20m.	40 % 23 m thick, multiyear	East Greenland Current
5/9	Fs020	79˚19.34N 10˚52.951W	2	250	CTD, profile,WP 2, *Oithona* depth dist, incubation water 20m.	Fast ice, west	Ice edge/ Greenland shelf
8/9	Fs043	78˚53.1N 8˚26.4W	3	301	CTD, profile,WP 2, *Oithona* depth dist, incubation water 50m.	1 % multiyear 13 m thick	On shelf Chl *a* max 5060 m
12/9	Fs052	78˚48.865N 1˚59.120W	4	2865	CTD, profile,WP 2, *Oithona* depth dist, incubation water 50m.	Open water	Offshelf Chl *a* max 20 m warm Many *Ceratium* sp. and *O. atlantica*.

Table 3.2. Sampling

Type	Description	Samples
Profile	Niskin bottles at: 5, 10, 20,30,40,60,100,200	POC/PON, Chla (GF/F + 10 µm), Microzoo 500 ml (except 5,100,200m)
WP2	Discrete depths: 030, 3060, 60100, 100 200 m. Zooplankton biomass: 2000 m Animals for experiments with nonfiltering codend.	Zooplankton abundance, Zooplankton biomass (2000m)
Oithona profile	30 liter Goflos: 10,20,30,40,50 m (60,70 at St. 3)	Formalin fix
Exp inc. Water	Taken at Chl *a* max, 20 m – screened at 90 µm	*Oithona* grazing exp, Microzoo community growth.

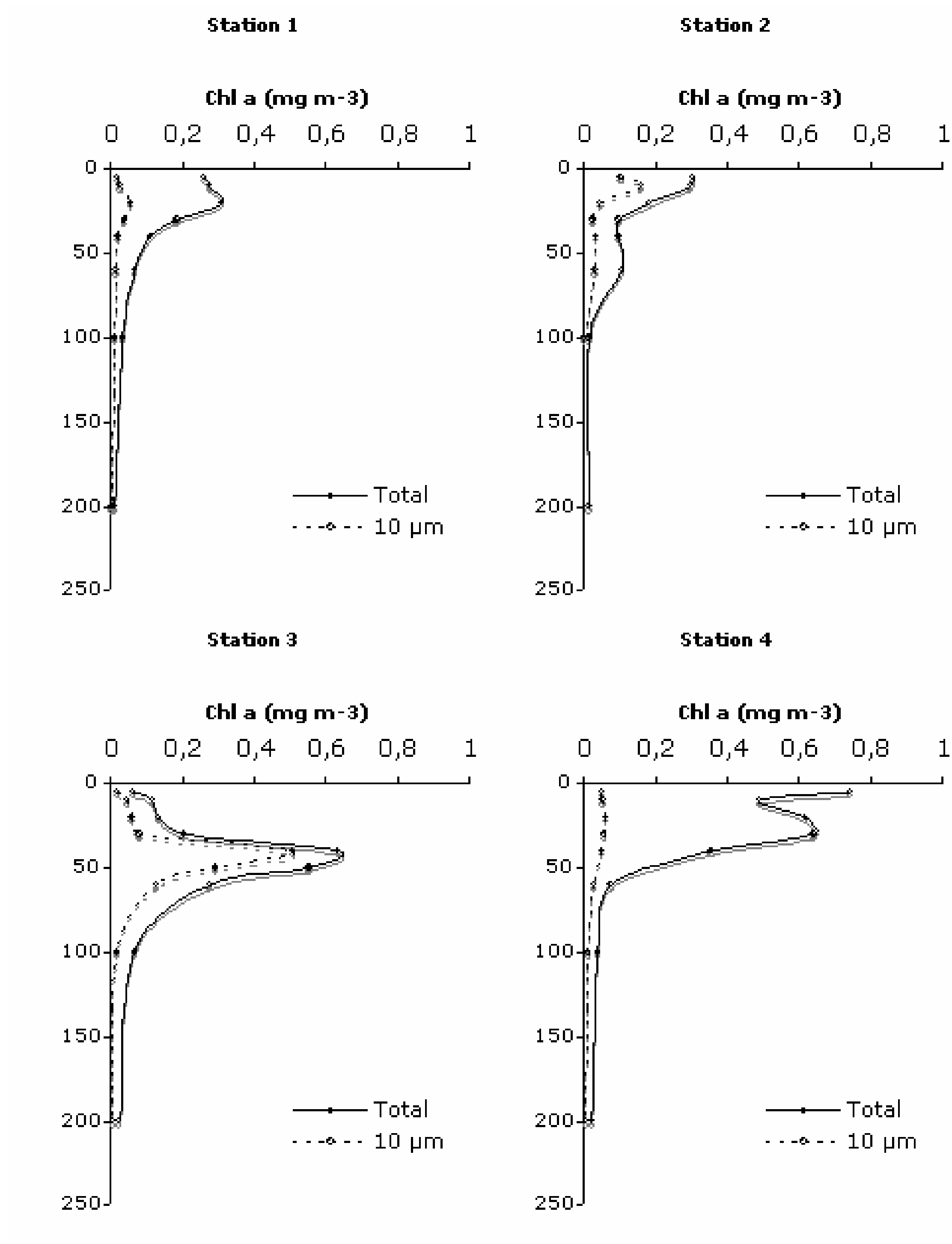


Fig. 3.1. Chlorophyll *a* (mg m^3) at the 4 sampling stations

Samples for protozooplantkon abundance were collected from the same profiles as for Chl *a* and POC at selected depths (10, 20, 30, 40 and 60 m). The protozooplankton samples of 500 ml were preserved using acid Lugol at 2 % final concentration. Samples will be analysed for genus/morphotypes of phytoplankton, dinoflagellates and ciliates in Uthermoehl chambers with an inverted microscope at 400x magnification (n=100 individuals per sample). This will give information on the prevailing plankton community structure (microbial versus large phytoplankton) at the four stations.

Mesozooplankton were collected with a WP2 net with 90 µm mesh size in four depth intervals, 200100 m, 10060 m, 6030 m and 300 m. Samples were preserved in 4 % (final concentration) buffered formaldehyde. Species and stage composition will be analysed with a stereomicroscope and animal prosome length measured. To convert animal prosome length into carbon, different copepod species and stages were picked from live net tows for carbon analysis. Depending on the animal sizes, between 1200 individuals were picked and filtered onto precombusted GF/F filters for subsequent CHN analyses. The filters were stored frozen and will be analysed as described above. Based on the measured species specific carbon content, the copepod community will be converted into carbon units at each station.

An additional tow for total zooplankton biomass was taken from 200 0 m. The biomass samples were concentrated through 90 µm Nitex mesh and ¼ 1/1 of the sample filtered onto a preweighted GF/F filters and stored frozen until the will be dried at 60 C and weighted. These samples will give additional information about the total plankton biomass at the given station.

A detailed depthdistribution of *O.similis* was sampled approx every 10 from surface to 5060 m. Animals were collected using 30 l Goflo water bottles by concentrating the content over a 90 µm nitex mesh. Samples were preserved with buffered formaldehyde.

Table 3.3. Zooplankton samples for carbonanalyses

#	Species	Stage	n	St.	Prosome length
1	*O.similis*	fem	103	Fs020	
2	*O.similis*	fem	106	Fs008	
3	*O.similis*	fem	130	Fs008	
4	*M.longa*	fem	3	Fs020	
5	*Calanus* sp.	fem	4	Fs020	0.71x: 2.5, 2.4, 2.3, 2.6 (1)
6	*Calanus* sp.	CV	3	Fs020	0.71x: 2.4, 2.5, 2.5 (1)
7	*Calanus* sp.	CIV	6	Fs020	1x: 2.4, 2.4, 2.4, 2.3, 2.5, 2.5 (2)
8	*C.hyperboreus*	fem	1	Fs020	1x: 6.5 (2)
9	*C.hyperboreus*	fem	1	Fs020	1x: 6.4 (2)
10	*C.hyperboreus*	fem	1	Fs020	1x: 6.0 (2)
11	*C.hyperboreus*	CV	1	Fs020	1x: 5.2 (2)
12	*C.hyperboreus*	CV	1	Fs020	1x: 5.0 (2)
13	*C.hyperboreus*	CV	1	Fs020	1x: 5.1 (2)
14	*Calanus* sp.	CII/CIII?	6	Fs020	1x: 2.1, 1.9, 2.0, 2.0, 2.0, 1.9 (2)
15	*C.hyperboreus*	CIV	2	Fs042	1x: 3.4, 3.2 (2)
16	*Calanus* sp.	CII?	5	Fs042	1x: 1.2, 1.3, 1.3, 1.2, 1.3 (2)
17	*M. longa*	CV	2	Fs042	1x: 2.0, 2.0 (2)
18	*M. longa*	fem	3	Fs042	1x: 2.65, 2.6, 2.7
19	*Oncaea* sp.	CVCVI	82	11/9	No prosome measurements

Experimental work

Oithona similis grazing experiments

Grazing of *O. similis* was estimated with bottle incubations. Animals were collected with a WP2 (HydroBios) equipped with a 90 µm mesh sized net and a nonfiltering cod end. Several tows were conducted from 100 0 m, and on board the ship the zooplankton were diluted in a large beaker with filtered seawater. Female *O. similis* were sorted using a stereomicroscope (Leica) with cold light. 33 animals were incubated in 330 ml Nalgene bottles in four replicates. Four bottles without animals served as control bottles. Incubation water was collected with a 30 l Goflo bottle at chl *a* maximum, which was determined with a fluorescence sonda (20 or 50 m). Incubation water was screened through a 90 µm mesh by inverse filtration and gently filled into the experimental bottles using a silicon tube. Animals were added to the treatment bottles together with10 ml filtered seawater (FSW). 10 ml FSW were also added to the controls. The bottles were incubated on a plankton wheel (1 rpm) on deck with a flowthrough system for maintaining stable temperature. The incubation temperature was reflecting surface temperatures along the sampling transect. After 24 h the bottles were removed from the plankton wheel and animals checked for viability. No dead animals were observed in the bottles. For analysis of heterotrophs and autotrophs 35 ml was taken for DAPI staining, while 250 ml was preserved with acid lugol at 2 % final concentration for microscopic counts of protozoan abundance.

Table 3.4. *Oithona* grazing experiments

#	Start date Start time	Stop date Stop time	Repl	N *O.similis*	Inc. water	Comments
1	2. sep 23.30	3.sept 23.15	4+4	33	Fs005 , 20 m	Some *Chaetoceros* sp. Lots of *O.similis*
2	5.sept 21.30	6.sept 21.30	4+4	33	Fs020 , 20m	Low chlavalues Few *Oithona* T_0 missing
3	8. Sept 22.00	9. Sept 21.00	4+4	33	Fs043 50m	Many young stages of *Oithona*. Deep chla max
4	12. Sept. 22.30	13. Sept. 22.00	4+4	33	Fs052 20 m	Mostly *O. atlantica*. No fem with eggs obs *Ceratium* bloom?

Protozoan community growth/grazing

Protozoan growth experiments (Table 3.5) were performed in 2L acidcleaned polycarbonate bottles mounted on a plankton wheel (1rpm), incubated in the dark and at *in situ* temperature. Experimental water was sampled with a 30L Goflo bottle from 20m or the depth of the chloropyll maximum, and filtered gently by inverse filtration through a 90 ∝m mesh. Four bottles were filled with the prescreened incubation water. Samples were taken after 24 (t_0), 72 (t_1), and 120 h (t_2) and fixed with 2% acid Lugol. Protozoans will be enumerated and cells measured as described above. The daily specific growth rate will be calculated for the dominating species (>80 individuals l ^{1}) assuming exponential growth [u=ln($Nt_1 Nt_0$)/t] and [u=ln($Nt_2 Nt_1$)/t], where N is number of protozoans and t the incubation time. Grazing will be calculated from the measured growth rates, assuming a growth efficiency of 0.4.

An overview of all samples taken during the cruise is presented in Table 3.6.

Table 3.5. Protozooplankton community growth experiments

Exp.	Bottle #	Inc. water	Filling	T_0	T_1	T_2
1	14	20 m, fs005	2/906 22.00	3/906 22.00	5/906 22.00	7/906 23.00
2	58	20 m, fs020	5/906 21.30	6/906 21.00	8/906 21.00	10/906 21.00
3	912	50 m, fs043	8/906 22.00	9/906 21.00	11/0906 19:40	13/0906 21:00
4	14	20 m fs052	12/906 21.00	13/0906 21:00	15/0906 21:00	17/0906 21:30

Table 3.6. Total samples taken

Type	Description	N stations	Depths/replicates	samples
Chl a, GF/F	filtration	4	8x3	96
Chl a, 10µm	filtration	4	8x3	96
POC/PON	filtration	4	8x3	96
Micro/phyto	500 ml, lugol	4	5	20
Zoopl abundance	WP2, 90 µm	4	4	16
Zoopl biomass	WP2, 90 µm	4	1	4
Zoopl carbon			19 filters	19
Microzoo growth	5 day inc	4	4x3	48
Oithona grazing	24 h inc	4	9	36
Oithona abundance	Goflo 30 l	4	57	22
DAPI		4	9	36

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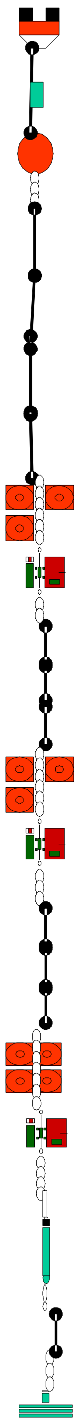
APPENDIX 1: Mooring configurations

Recovered moorings

Rigg F118 78 49,94N

Satt ut 6 SEP 2005, 13:56 003 15,47W



			Dyp:	Fra bunn:	Ut:
ES300	SNR. 51		60	2319	13:25
RDCP 600	SNR. 28				
Kevlar	5 m				
SBE37	SNR. 3996		62	2317	13:25
Stålkule 37	SNR. 596				
2 m Kjetting galvanisert					
40 m Kevlar					
40 m Kevlar					
100 m Kevlar					
10 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM11	SNR.494		261	2118	13:10
0,5 m Kjetting rustfri					
200 m Kevlar					
500 m Kevlar					
500 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM11	SNR.228		1465	914	12:48
0,5 m Kjetting rustfri					
500 m Kevlar					
200 m Kevlar					
200 m Kevlar					
4 Glasskuler					
3 m Kjetting galvanisert					
RCM8	SNR.10071		2369	10	12:31
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 287	Pinger på: Pinger av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1100/(950) kg		2379	0	

Rigg F128

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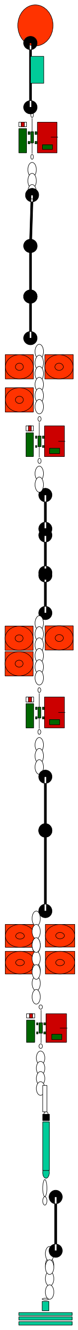
78 49,9N

004 00.767W

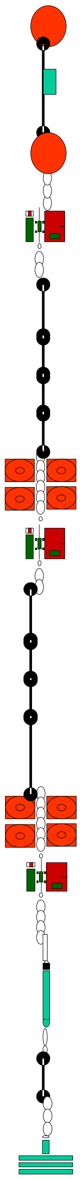


			Dyp:	Fra bunn:	Ned i vann:
Stålkule 37	SNR. McLane				
SBE37	SNR. 3995		68	1785	17:24
5 m Kevlar					
RCM9	SNR.1046		71	1782	17:24
0,5 m Kjetting rustfri					
40 m Kevlar					
200 m Kevlar					
20 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM7	SNR. 11475		335	1518	17:06
0,5 m Kjetting rustfri					
500 m Kevlar					
500 m Kevlar					
200 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM11	SNR. 235		1539	314	16:45
0,5 m Kjetting rustfri					
200 m Kevlar					
100 m Kevlar					
4 Glasskuler					
3 m Kjetting galvanisert					
RCM8	SNR. 11625		1843	10	16:35
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 053	Ping på: Ping av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1100/(950) kg		1853	0	

Rigg F138

Settes ut 4 SEP 2005, 11:47

78 50,21N
005 00,09W

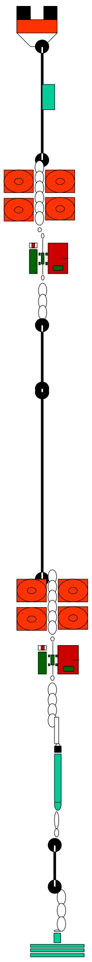


			Dyp:	Fra bunn:	Ned i vann:
Stålkule 37	SNR. Ny Mclane		67	951	11:47
SBE37	SNR. 3994				
Kevlar	5 m				
Stålkule 30	SNR. 597				
2 m Kjetting Galv.					
RCM7	SNR.7718		76	942	11:45
0,5 m Kjetting rustfri					
50 m Kevlar					
100 m Kevlar					
10 mKevlar					
5 m Kevlar					
4 Glasskuler					
3 m Kjetting Galv.					
RCM7	SNR.1175		235	783	11:35
0,5 m Kjetting rustfri					
500 m Kevlar					
200 m Kevlar					
50 m Kevlar					
20 m Kevlar					
4 Glasskuler					
3 m Kjetting Galv.					
RCM8	SNR. 12733		1008	10	11:17
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 182	Ping On: Release:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1000/(900) kg		1018	0	

Rigg F148

Satt ut 3 SEP 2005, 14:14

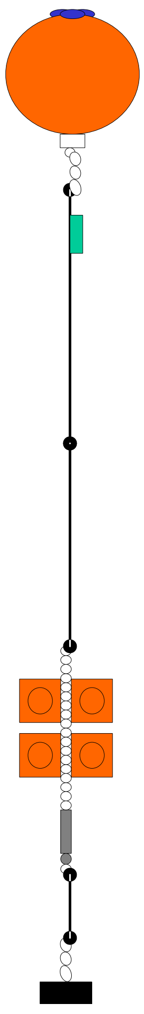
78 49N
006 26,55W



			Dyp:	Fra bunn:	Ned i vann:
ES300 DCM12	SNR. 37 SNR.17		52	233	14:10
5 M Kevlar					
SBE37	SNR: 3993		55	230	14:10
4 Glasskuler					
3 m Kjetting Galv.					
RCM9	SNR. 834		61	224	14:10
0,5 m Kjetting rustfri					
10 m Kevlar					
200 m Kevlar					
4 Glasskuler					
3 m Kjetting Galv.					
RCM7	SNR. 12644		275	10	13:58
Svivel					
AR661	SNR. 290	Int Range: Release:			
5 m Kevlar					
2 m Kjetting					
ANKER	650/(530) kg		285	0	

Rigg F173 78 49.893N Dyp: Fra bunn: Ned i vann:

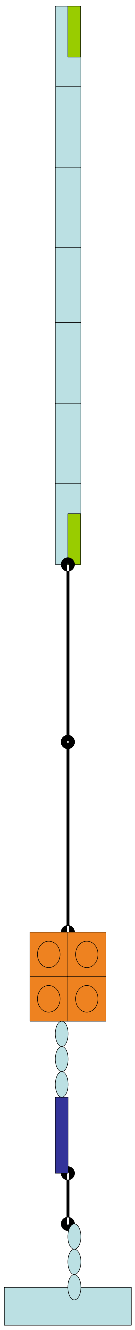
Satt ut 3 SEP 2005, 06:55 007 59.237W



ADCP	SNR.727	101	100	06:55
0.5 m Kjetting rustfri				
SBE 37	SNR. 3992	98	103	06:55
50 m Kevlar				
40 m Kevlar				
3 m Kjetting galv.				
4 GLASSKULER		10	191	
AR861	SNR. 410	Ping on: Release:		
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	650/(540)kg	0	201	

Rigg F182 78 49.981 N Dyp: Fra bunn: Ned i vann:

Satt ut 7 SEP 2004, 10:00 008 04.646 W



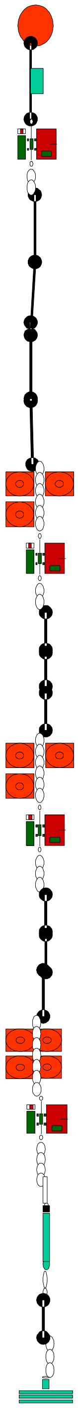
		Dyp:	Fra bunn:	Ned i vann:
SBE37	Snr. 3490	21	204	
7 x 6 m rør				
SBE37	Snr. 3491	62	163	
100 m Kevlar				
50 m Kevlar				
4 Glasskuler				
5 m Kevlar				
AR661	Snr. 110	Int. Release		
5 m Kevlar				
2 m Kjetting				
Anker	640 Kg	225	0	

Deployed moorings

Rigg F119

Satt ut 13 Sep 2006, kl 18:20

78 49,439N
003 15,216W



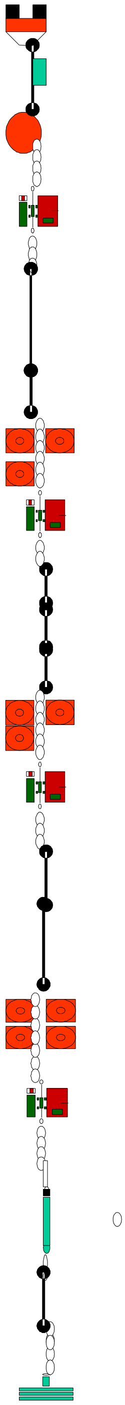
			Dyp:	Fra bunn:	Ut:
Stålkule 37	SNR. 603				
Kevlar	5 m				
SBE37	SNR. 2158		75	2305	17:48
RCM7	SNR.9464		78	2302	17:48
1 m Kjetting galvanisert					
40 m Kevlar					
40 m Kevlar					
100 m Kevlar					
10 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM9	SNR.1049		262	2118	17:34
0,5 m Kjetting galv					
200 m Kevlar					
500 m Kevlar					
500 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM11	SNR.538		1466	914	17:14
0,5 m Kjetting galv					
500 m Kevlar					
200 m Kevlar					
200 m Kevlar					
4 Glasskuler					
3 m Kjetting galvanisert					
RCM8	SNR.10069		2370	10	16:51
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 499	Pinger på: Pinger av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1100/(950) kg		2380	0	

Rigg F129

Satt ut 12 SEP 2006 kl. 08:37

78 49.188N
004 00.708W

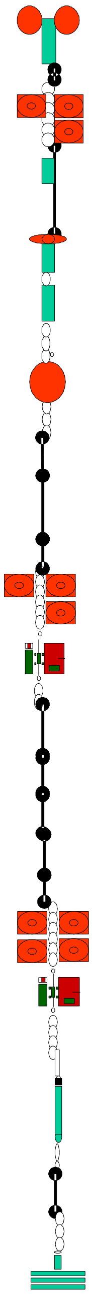
Dyp: Fra bunn: Ned i vann:
Ekkoloddyp er feil! Riktig dyp til topp er ca 60 m.



			Dyp	Fra bunn	Ned i vann
ES300	SNR. 55		108	1750	08:35
DCM12	SNR. 17				
SBE37	SNR. 3551		110	1748	08:35
5 m Kevlar					
Stålkule 37	McLane D				
2 m Kjetting galvanisert					
RCM9	SNR.1325		116	1742	08:34
1 m Kjetting galv					
200 m Kevlar					
20 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM9	SNR. 836		340	1518	08:17 07:07
0,5 m Kjetting galv					
500 m Kevlar					
500 m Kevlar					
200 m Kevlar					
3 Glasskuler					
3 m Kjetting galvanisert					
RCM11	SNR. 556		1544	314	06:49
0,5 m Kjetting galv					
200 m Kevlar					
100 m Kevlar					
4 Glasskuler					
3 m Kjetting galv.					
RCM11	SNR. 117		1848	10	06:33
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 500	Ping på: Ping av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1110/(960) kg		1858	0	

Rigg F139 78 50.210N

Settes ut 9 SEP 2006, kl 17:30 005 00.083W

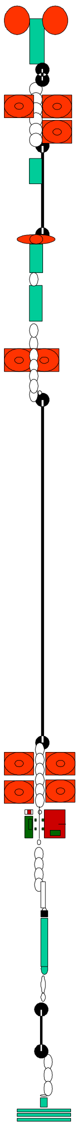


			Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 1047		62	958	17:18
3 Glasskuler 2 m Kjetting galv.					
SBE37	SNR. 3552		66	954	17:18
5 M Kevlar					
RDCP600	SNR: 118		70	950	17:18
Batteribeholder til RDCP					
1 m Kjetting galv.					
Stålkule 37	SNR.McLaneE				
0,5 m Kjetting galv.					
50 m Kevlar					
100 m Kevlar					
10 mKevlar					
3 Glasskuler 3 m Kjetting galv.					
RCM9	SNR.1327		236	784	16:59
0,5 m Kjetting galv					
500 m Kevlar					
200 m Kevlar					
50 m Kevlar					
10 m Kevlar 10 m Kevlar					
4 Glasskuler 3 m Kjetting galv.					
RCM11	SNR. 561		1010	10	16:38
0,5 m Kjetting rustfri					
Svivel					
AR861	SNR. 506	Ping på: Ping av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting galvanisert					
ANKER	1020/(900) kg		1020	0	

Rigg F149

Satt ut 8 SEP 2006, kl 19:55

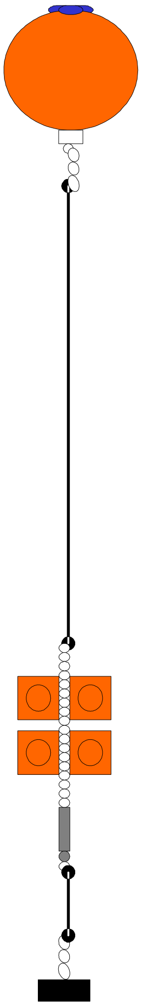
78 49.055N
006 26,802W



			Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 1048		58	223	19:50
3 Glasskuler 2 m Kjetting galv.					
SBE37	SNR. 3554		62	219	19:50
5 M Kevlar					
RDCP600	SNR: 71		66	215	19:50
Batteribeholder til RDCP					
2 Glasskuler 1 m Kjetting Galv.					
200 m Kevlar					
4 Glasskuler					
3 m Kjetting Galv.					
RCM9	SNR. 1326		271	10	19:38
Svivel					
AR861	SNR. 568	Ping på: Ping av: Release: Release m/ping:			
5 m Kevlar					
2 m Kjetting					
ANKER 650/(530) kg			281	0	

Rigg F174 78 49.939N Dyp: Fra bunn: Ned i vann:

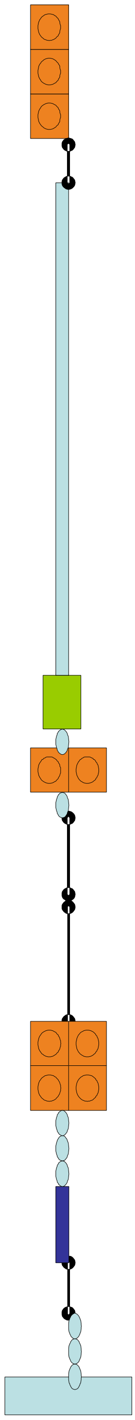
Satt ut 8 SEP 2006, kl 08:03 008 04.562W



		Dyp	Fra bunn	Ned i vann
ADCP	SNR.727	104	114	07:54
0.5 m Kjetting rustfri				
100 m Kevlar				
3 m Kjetting galv.				
4 GLASSKULER		11	207	
AR861	SNR. 501	Ping on: Release:		
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	650/(540)kg	0	218	

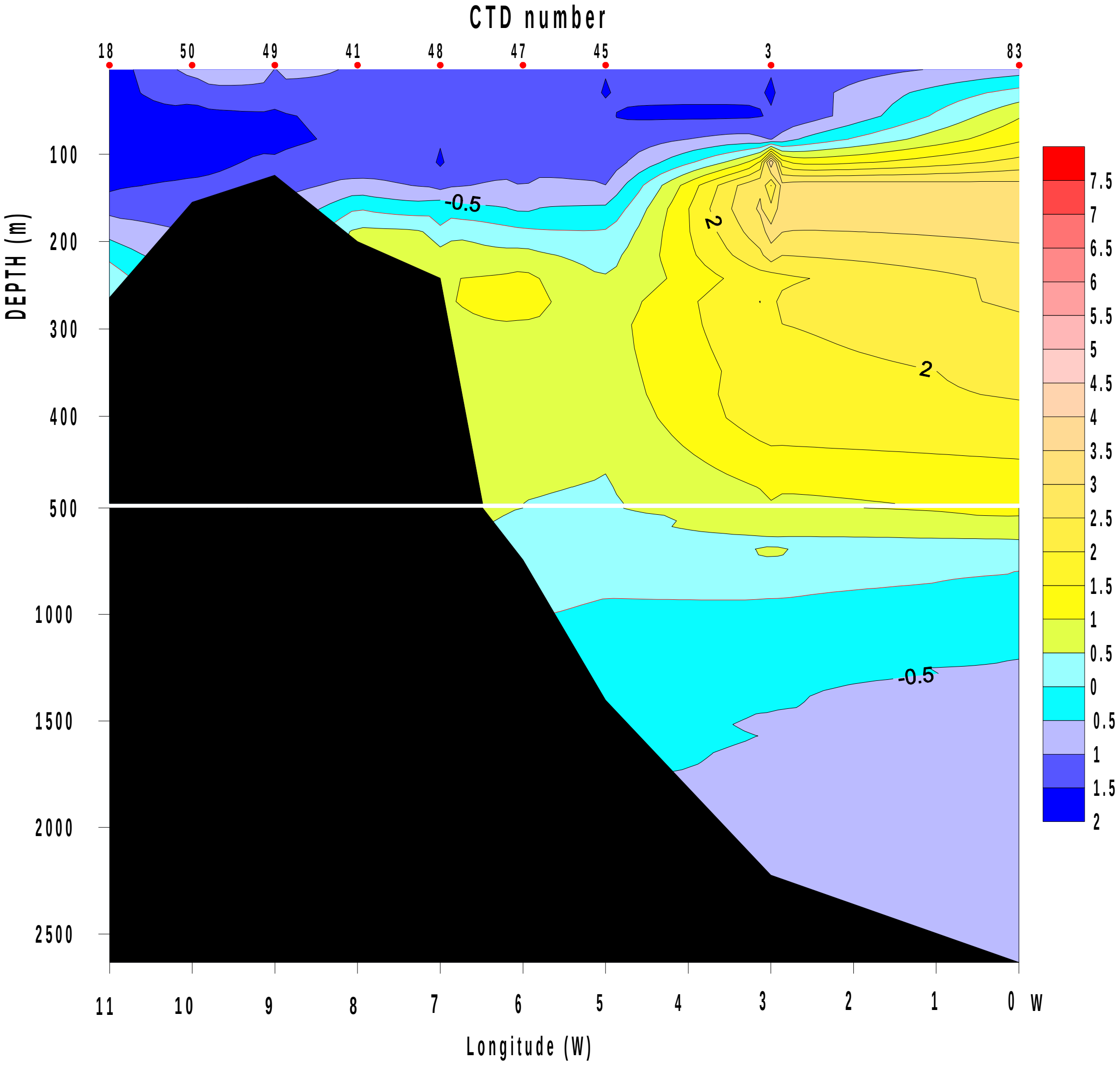
Rigg F183
Satt ut 8 SEP 2006, kl 07:11

78 49.884N
007 59.276W

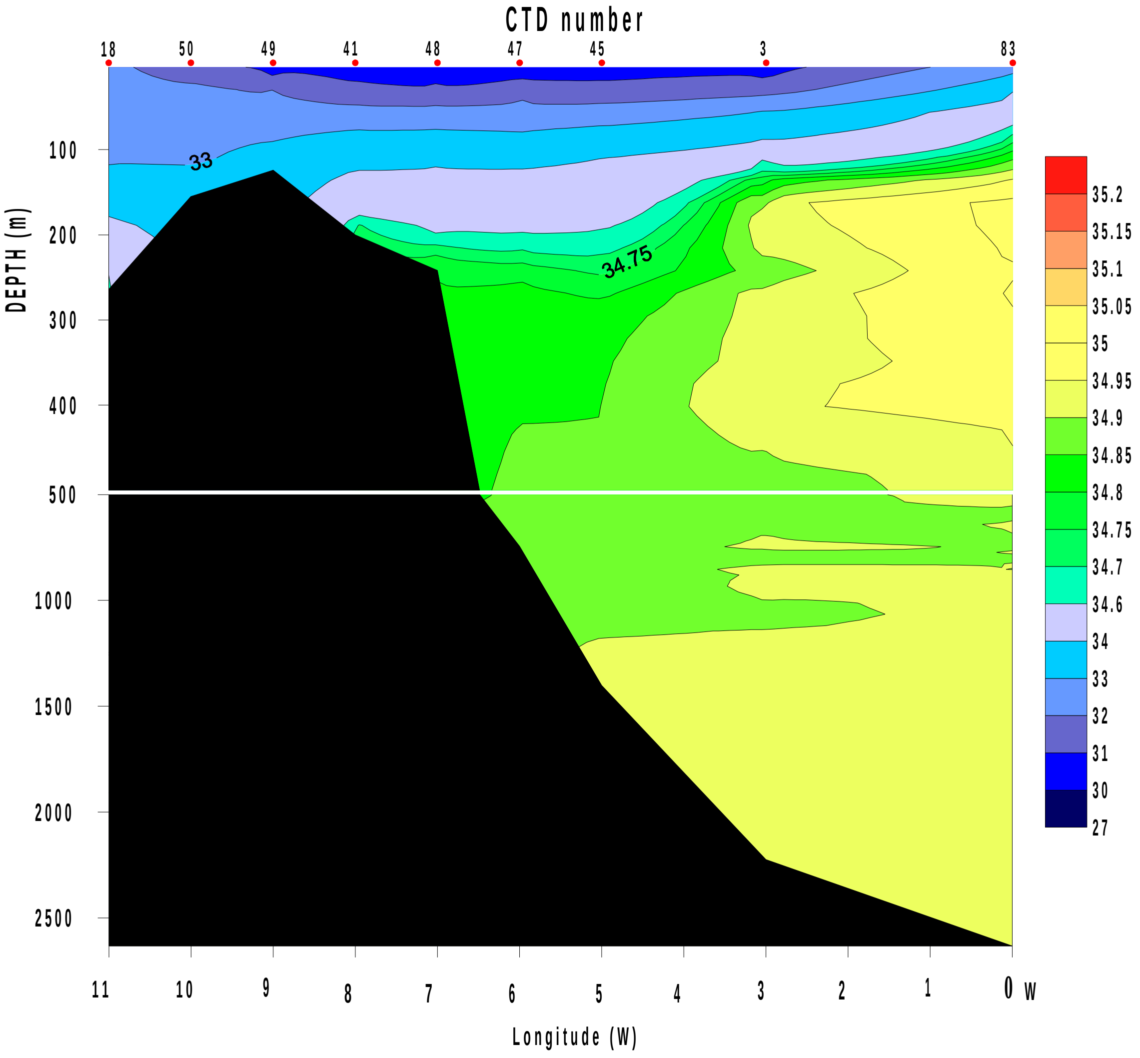


		Dyp:	Fra bunn:	Ned i vann:
		50	159	
3 Glasskuler 5 m Kevlar				
		55	154	
DL7	Snr. 1632	106	103	07:06
2 Glasskuler 1 m Kjetting galv.				
40 m Kevlar				
50 m Kevlar				
4 Glasskuler				
3 m Kjetting galv.				
AR861	Snr. 553	Arm/range Release Ping on		
5 m Kevlar				
2 m Kjetting				
Anker	650/(530) Kg	209	0	

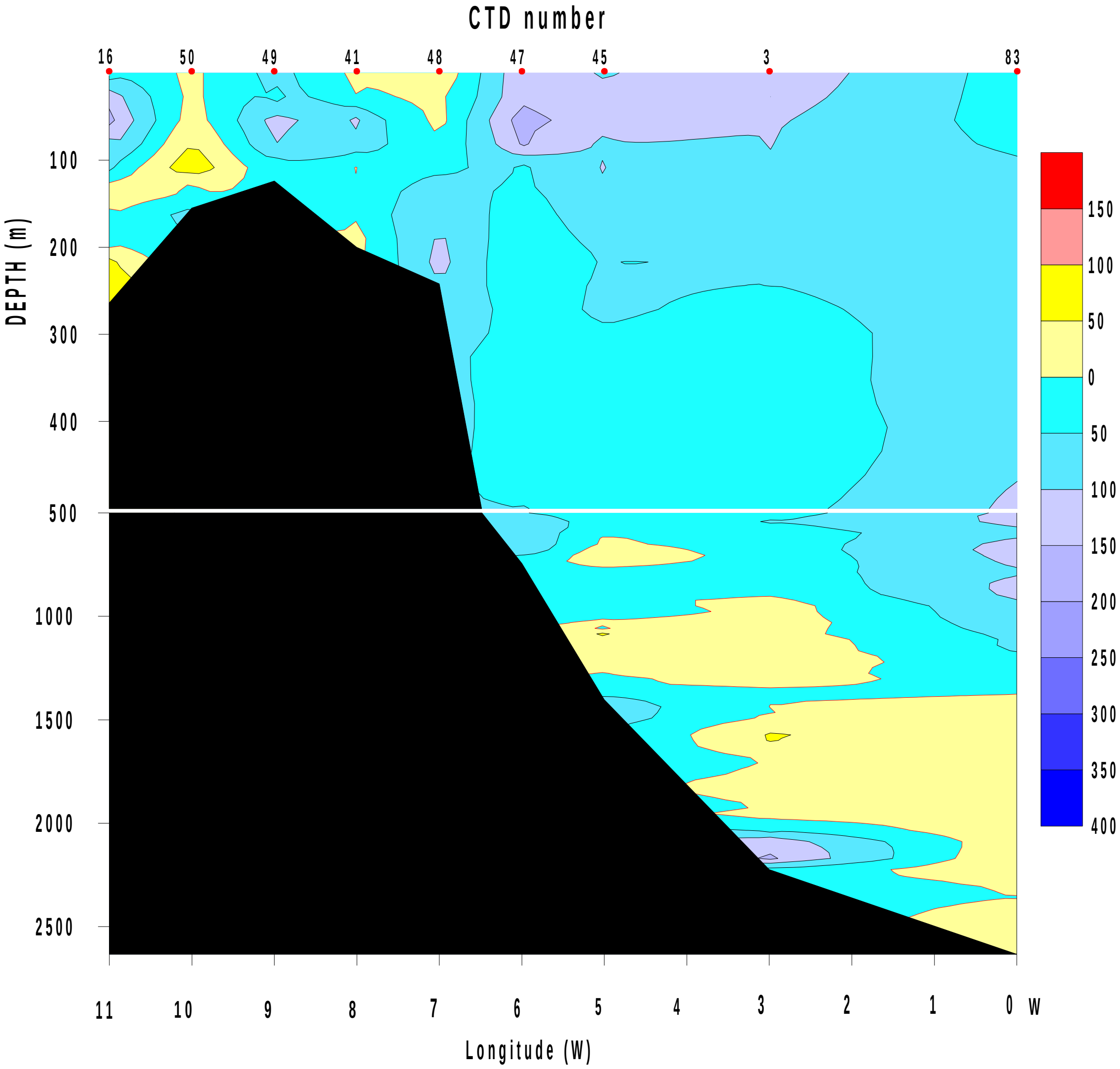
Appendix 2: Figures from the CTD/LADCP sections



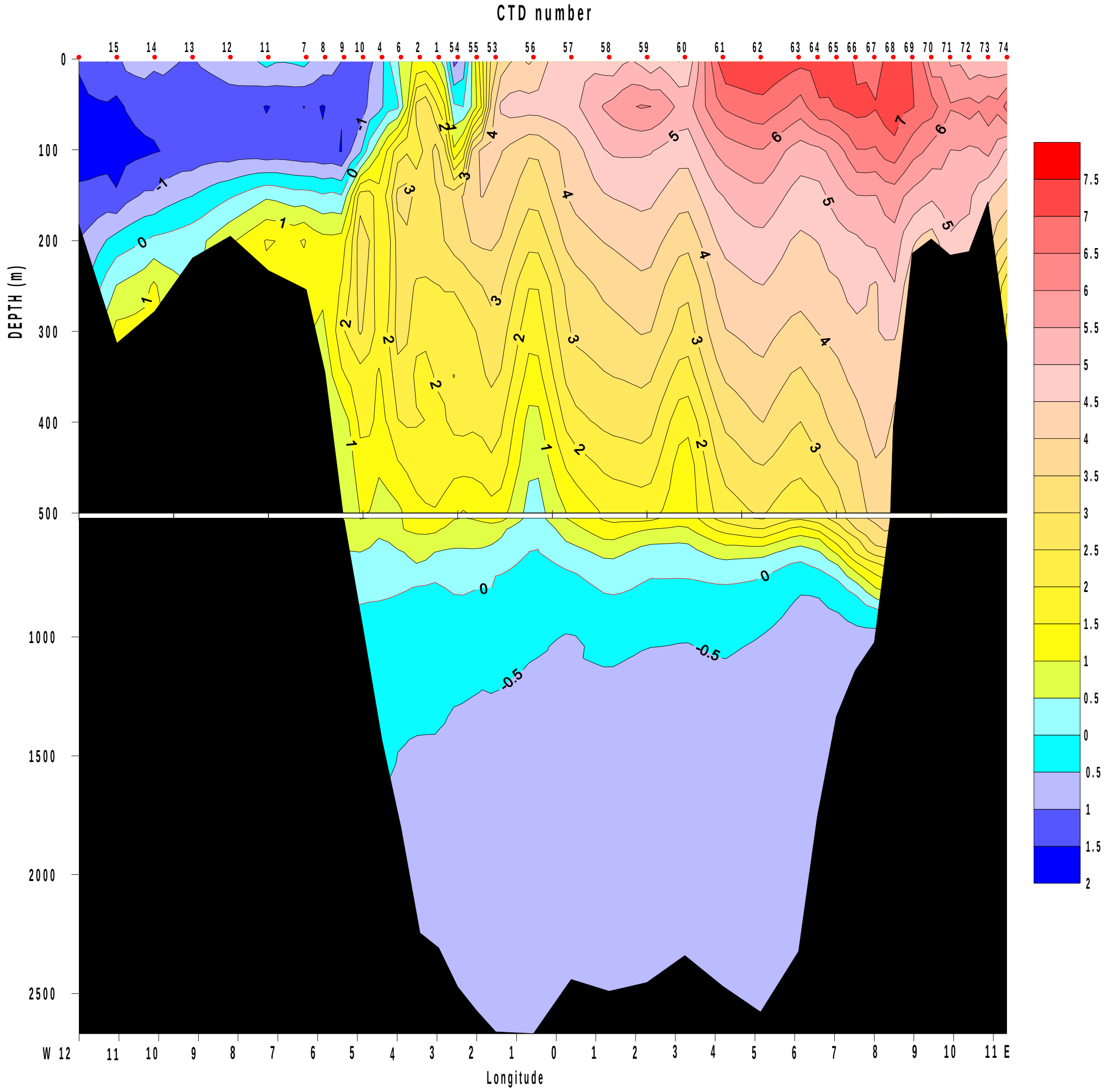
Potential Temperature section CTD 18 – 83



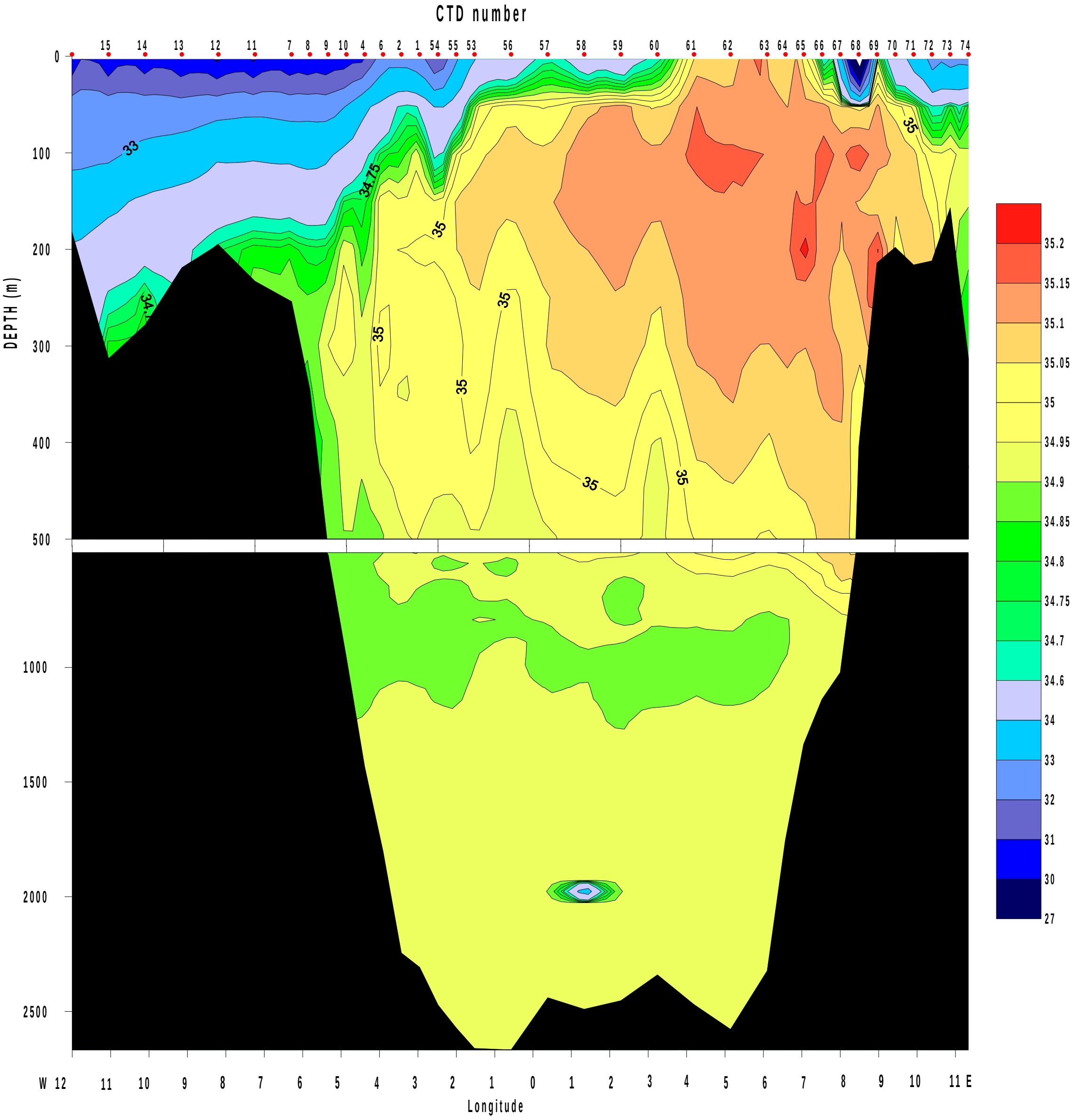
Salinity (psu) section CTD 18 – 83



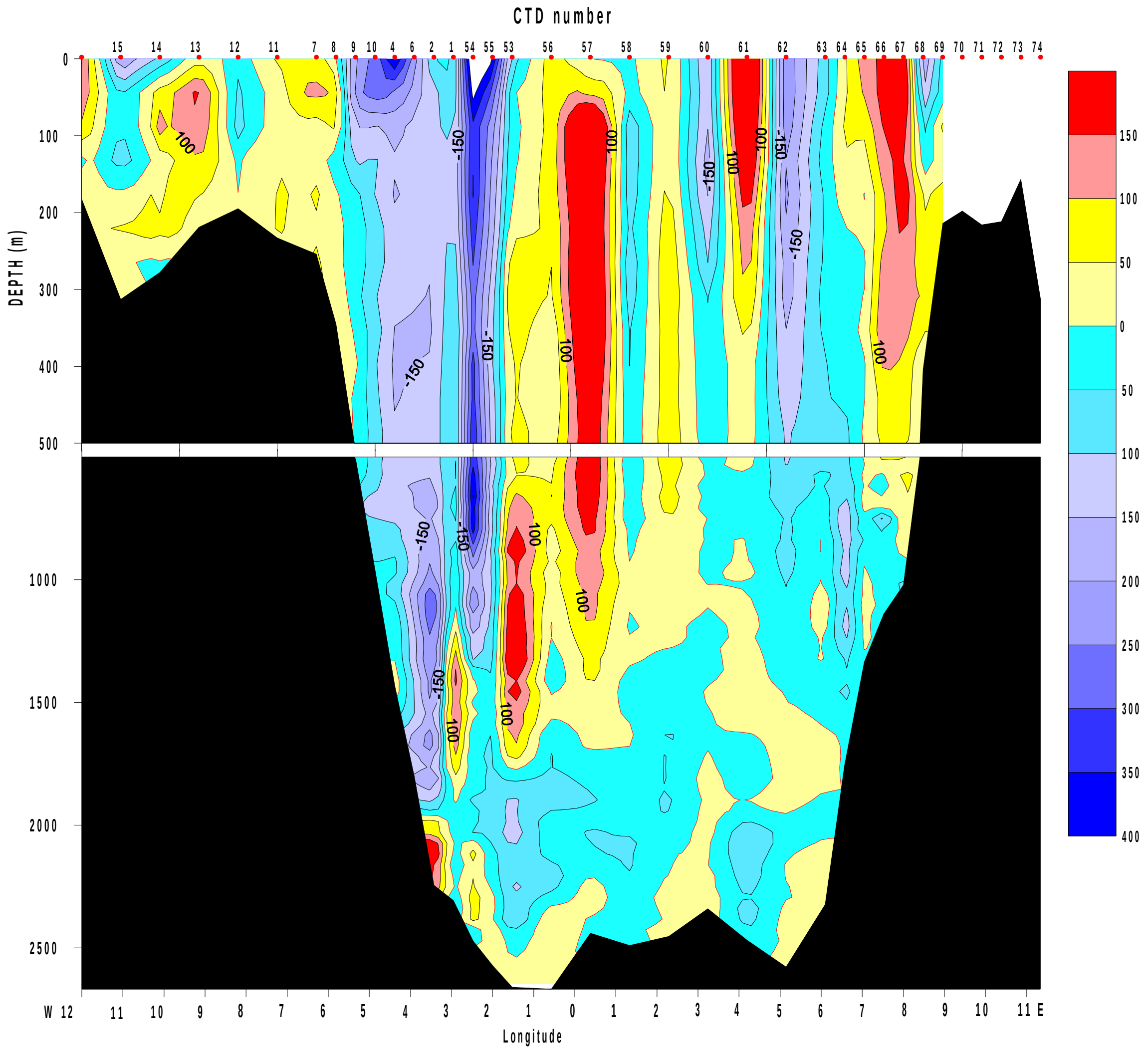
V component (mm/s) vector of current section CTD 18 – 83



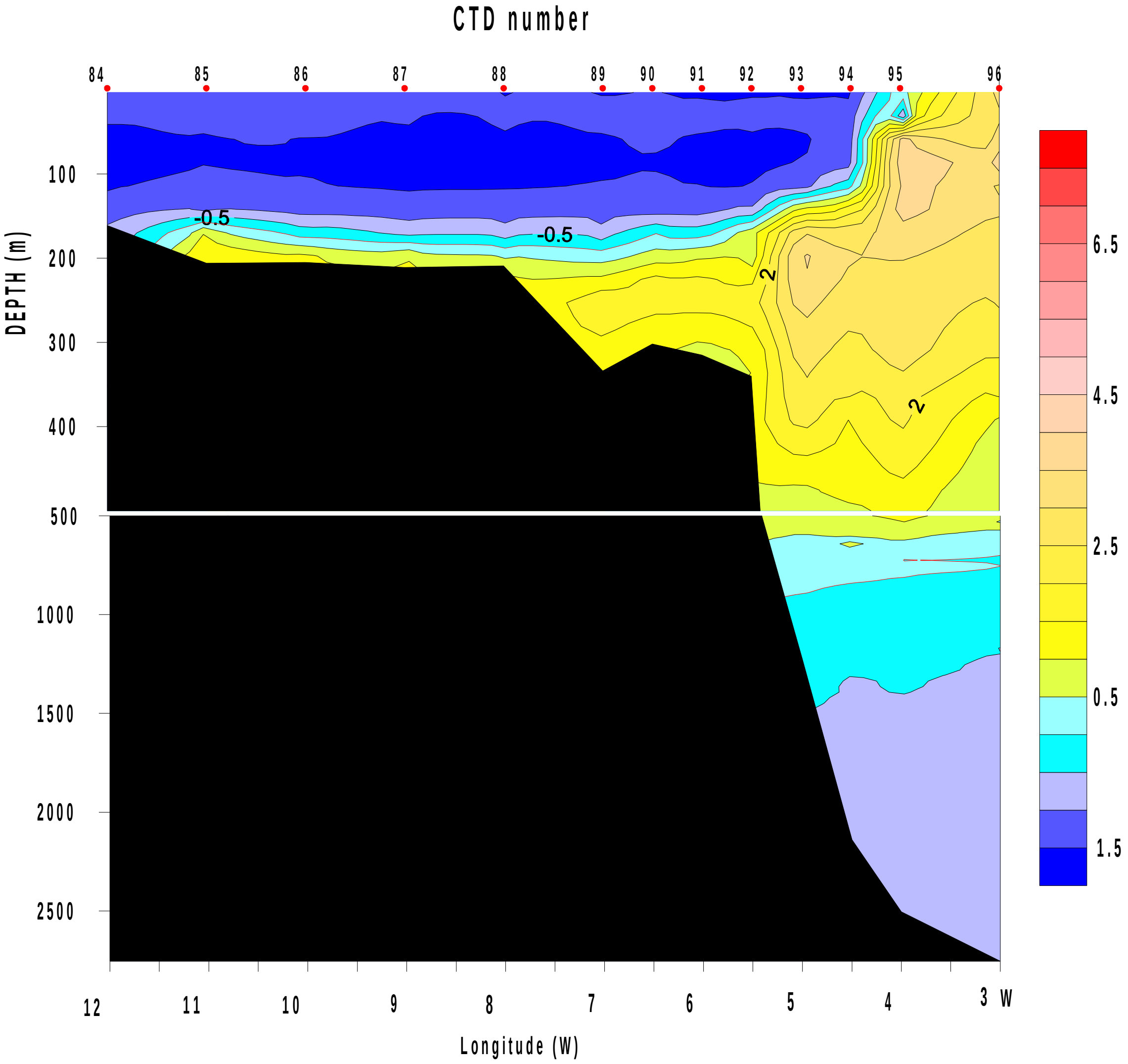
Potential Temperature section CTD 16 – 74



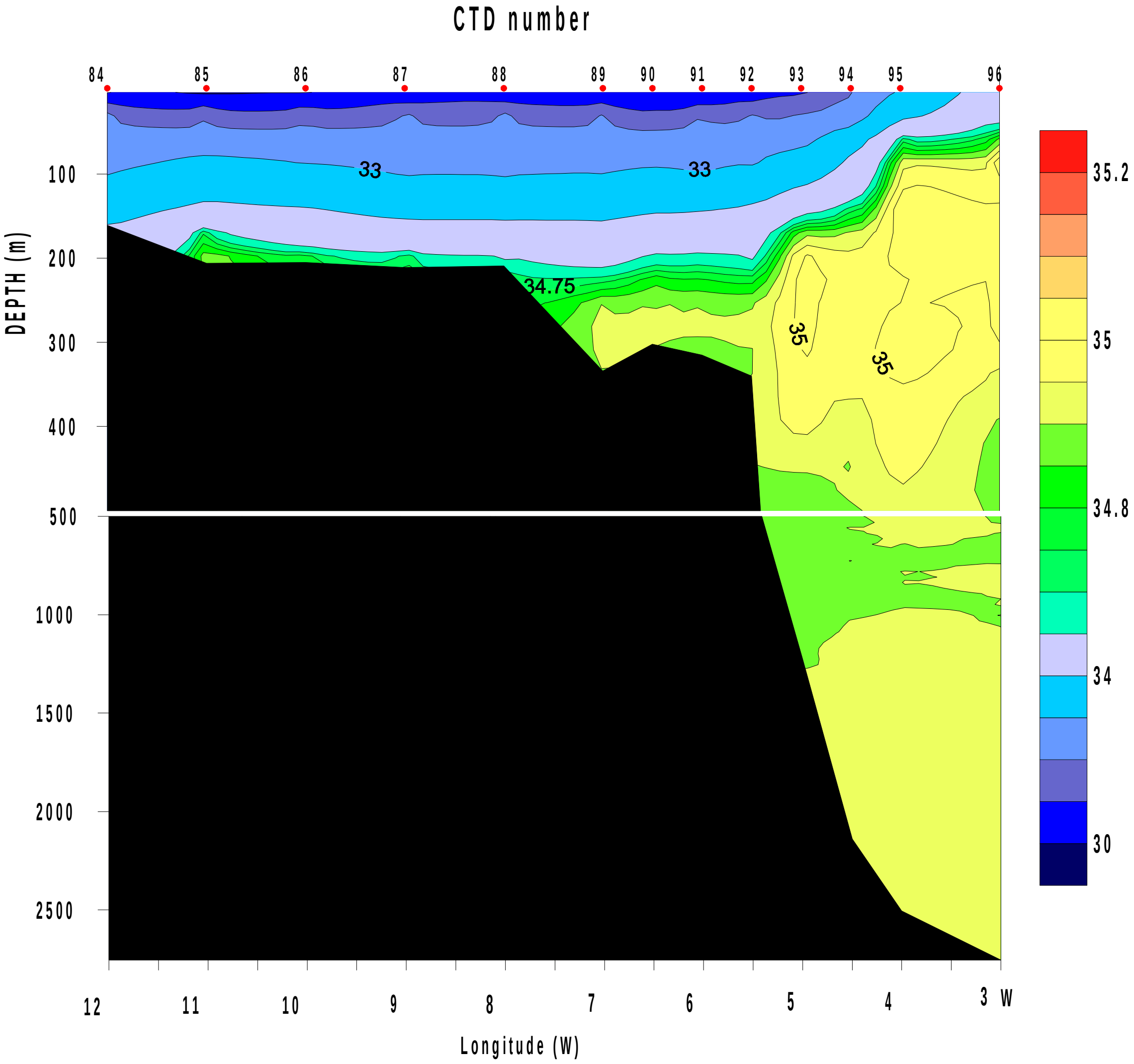
Salinity (psu) section CTD 16 – 74



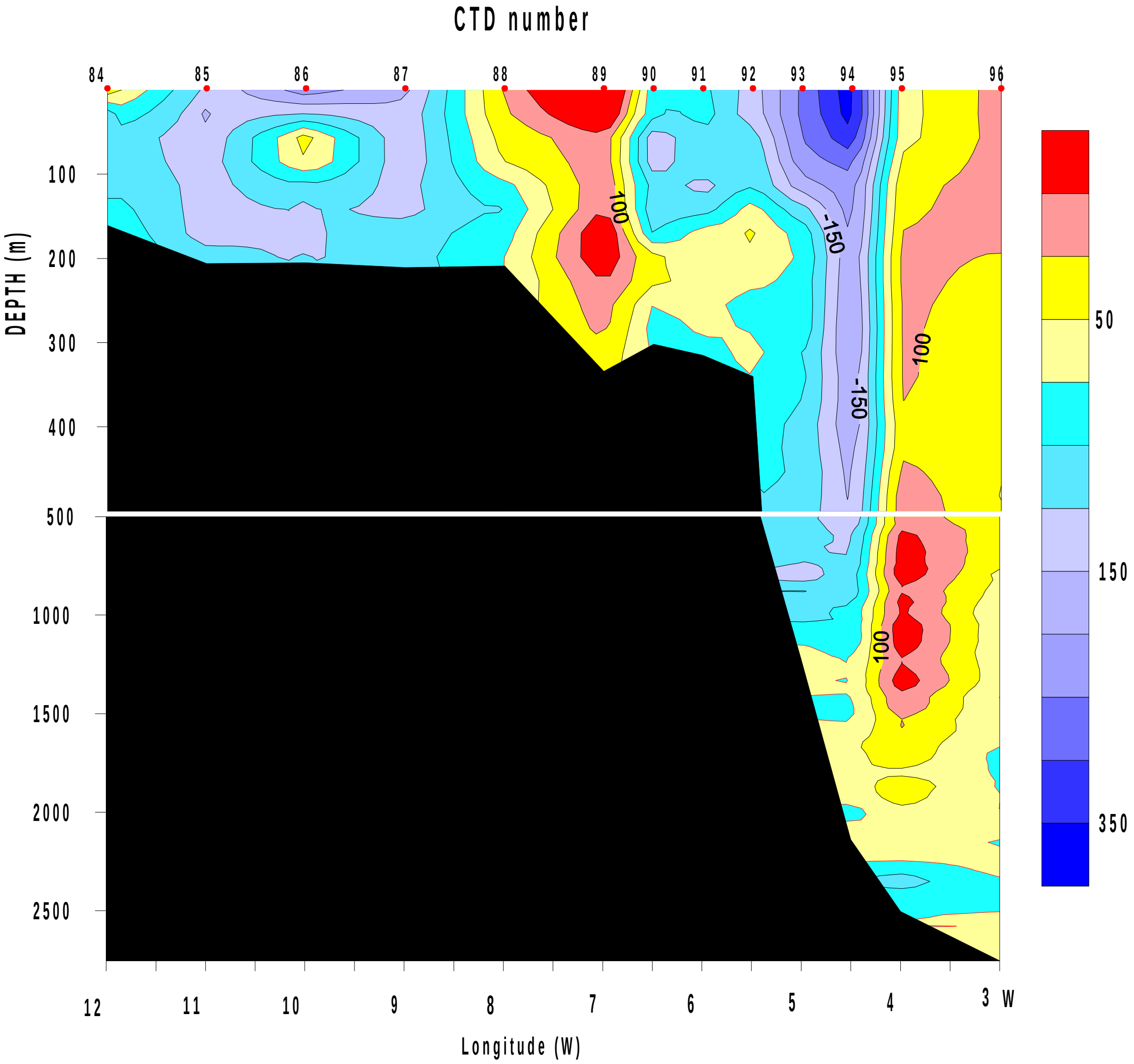
V component (mm/s) vector of current section CTD 16 – 74



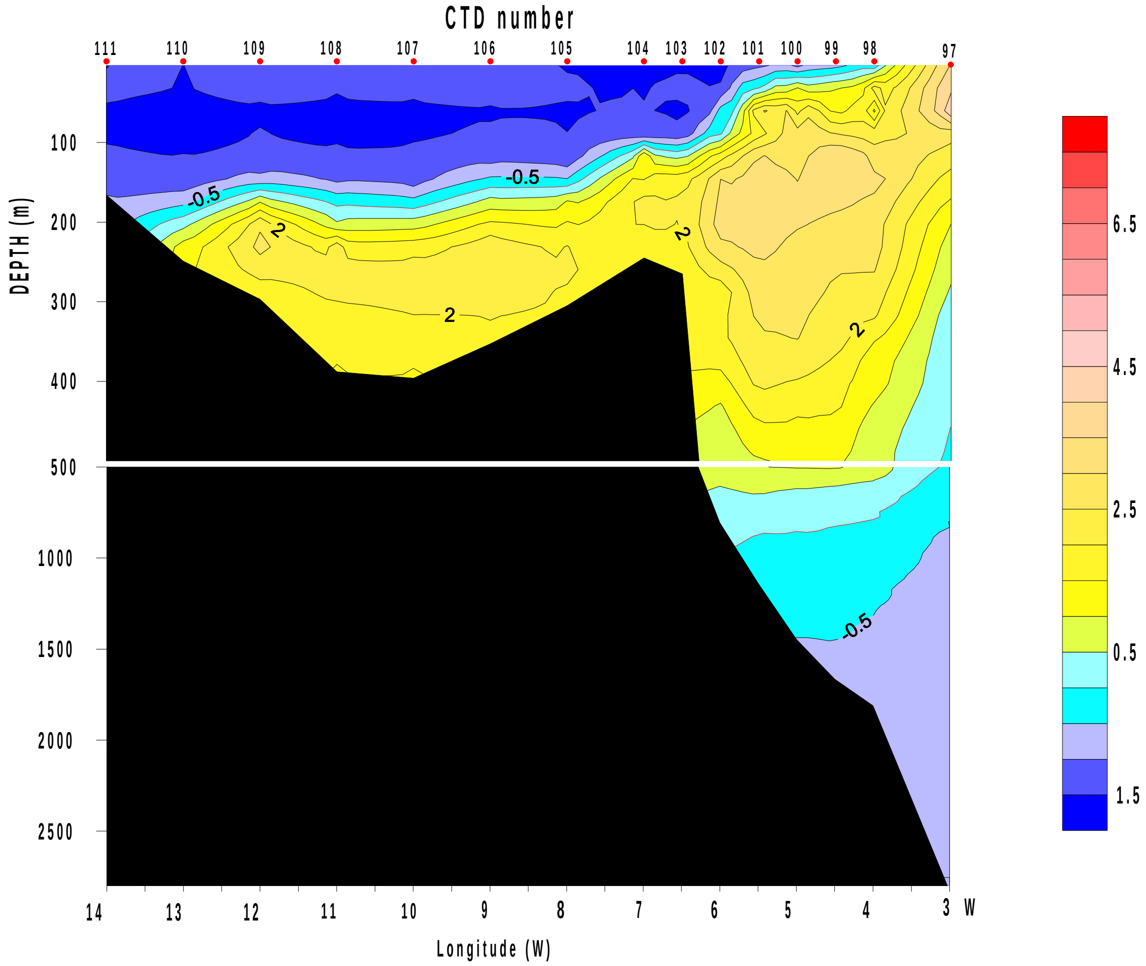
Potential Temperature section CTD 84 – 96



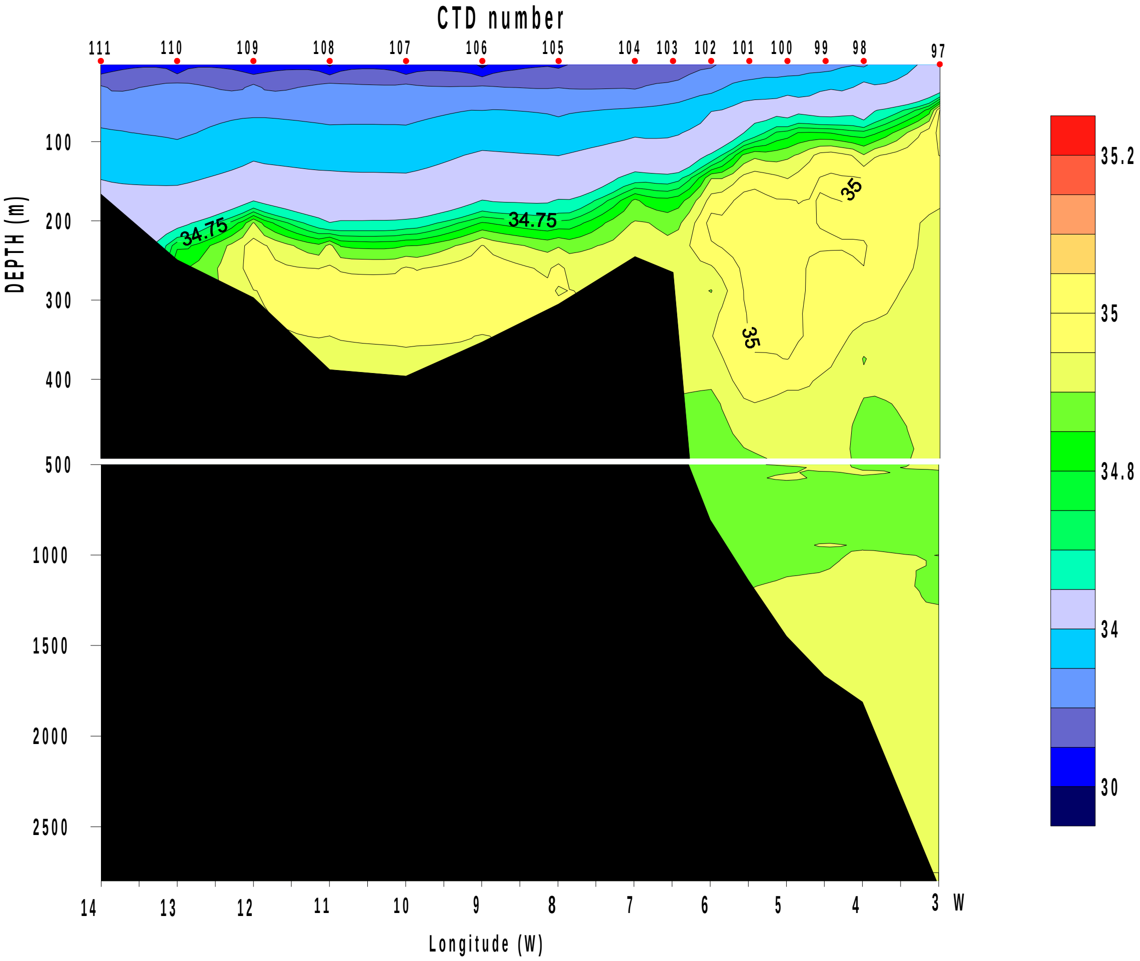
Salinity (psu) section CTD 84 – 96



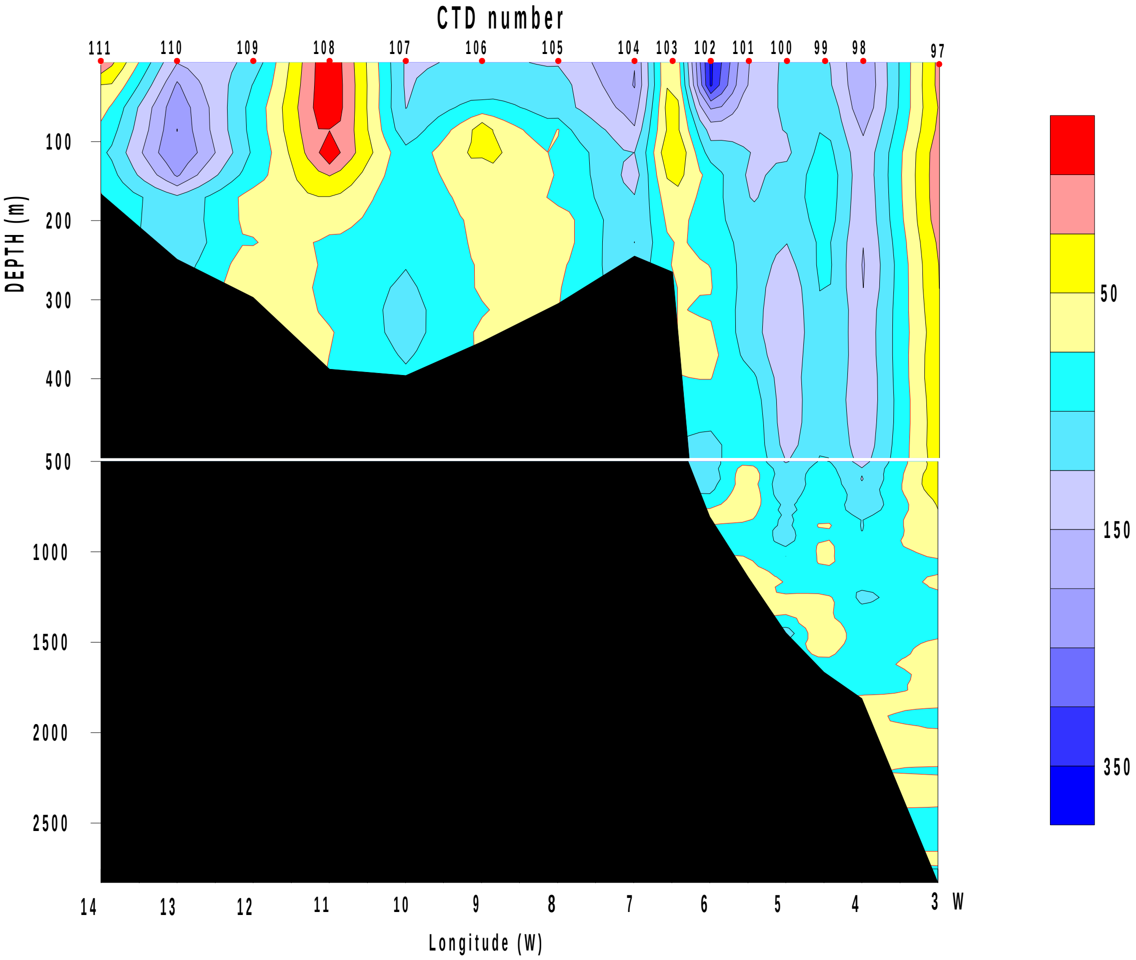
V component (mm/s) vector of current section CTD 84 – 96



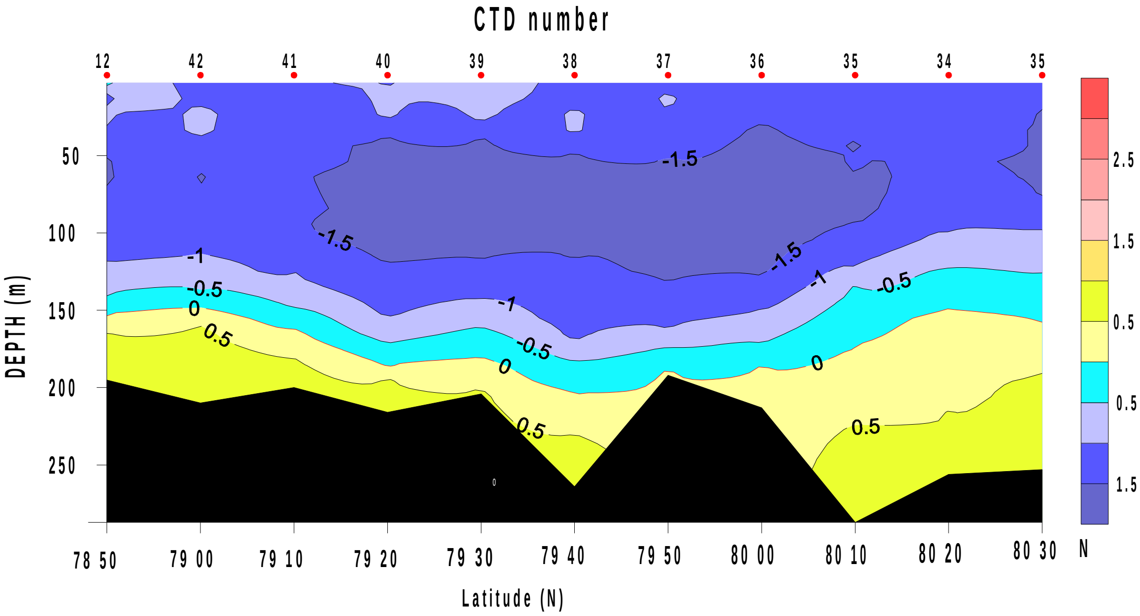
Potential Temperature section CTD 111 – 97



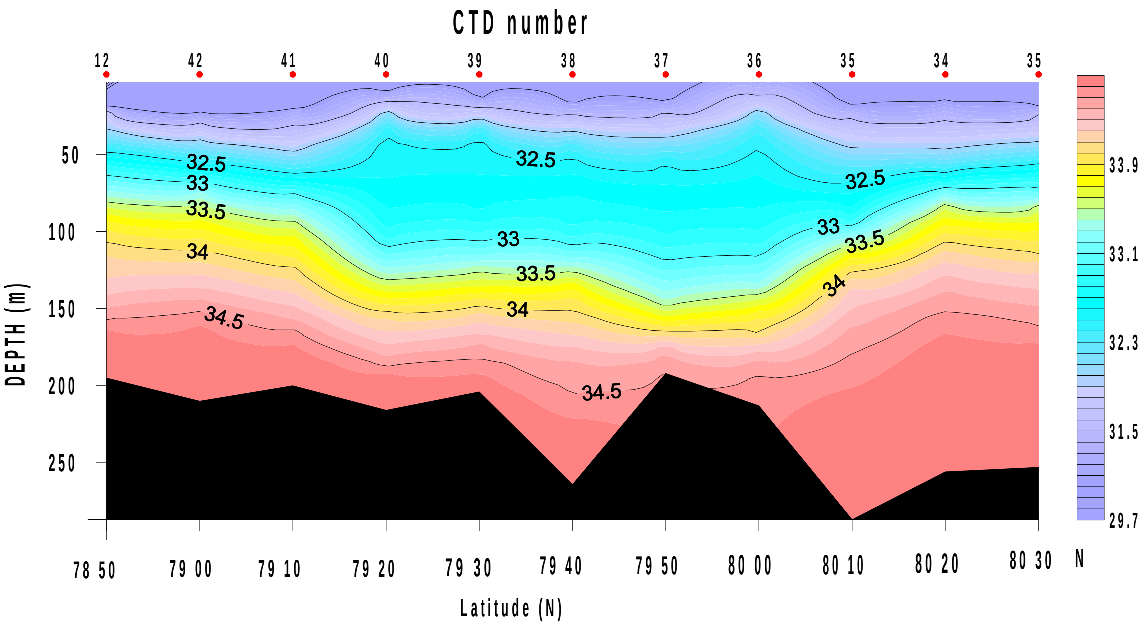
Salinity (psu) section CTD 111 – 97



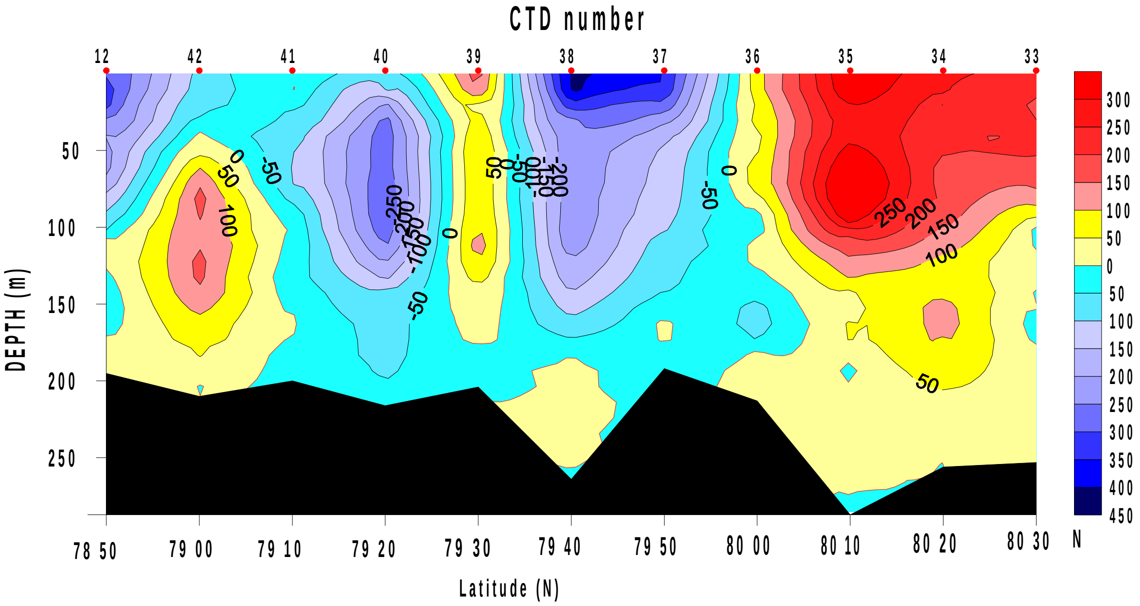
V component (mm/s) vector of current section CTD 111 – 97



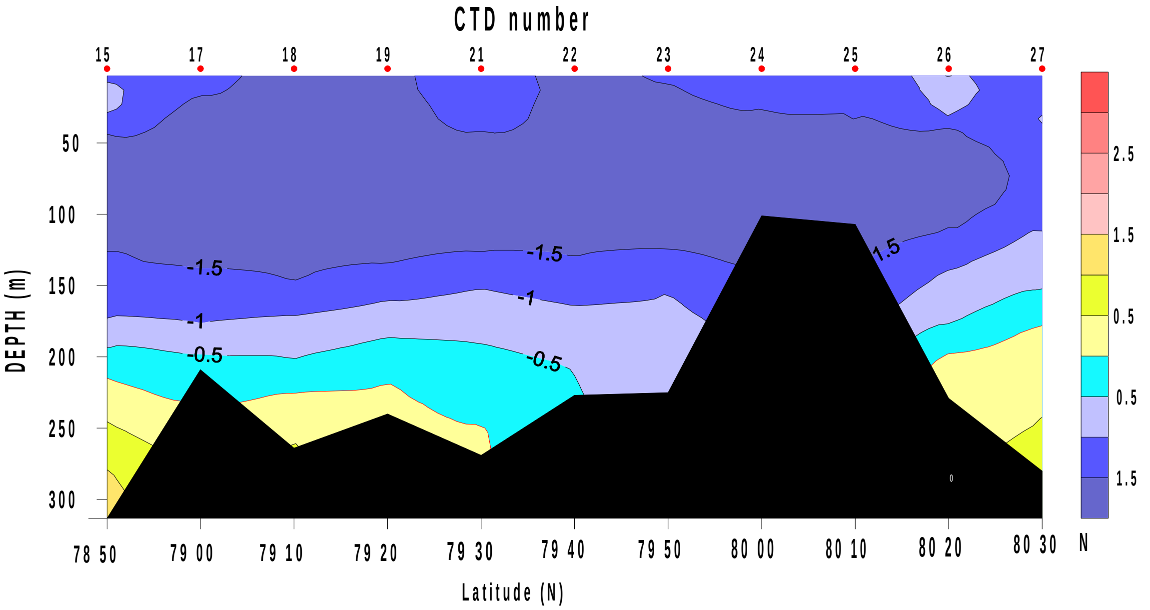
Potential Temperature section CTD12 – 33



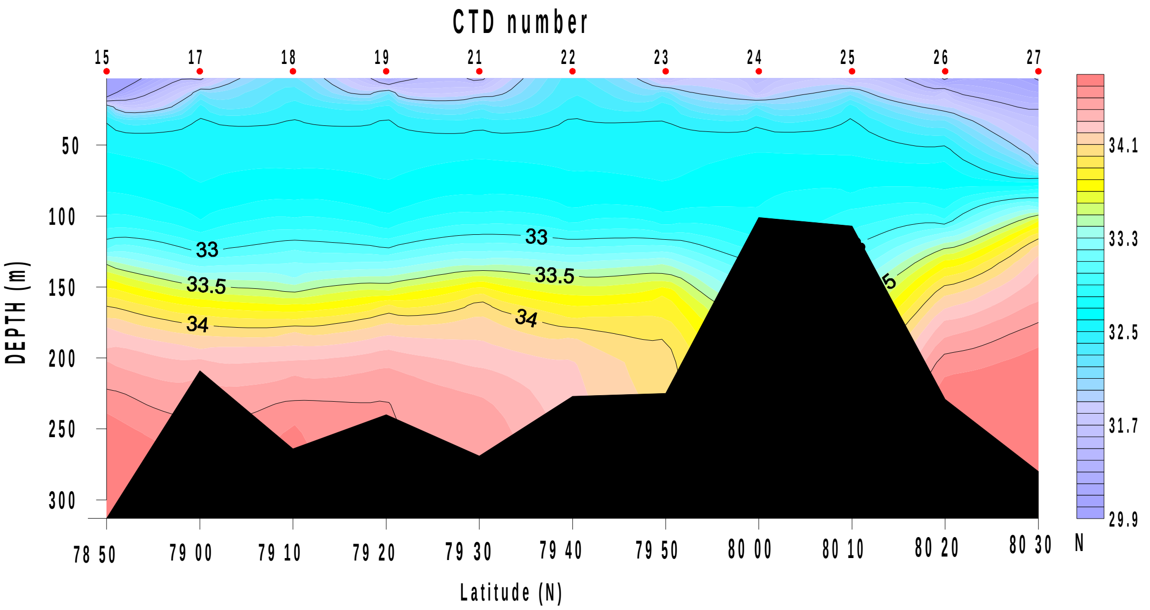
Salinity (psu) section CTD 12 – 33



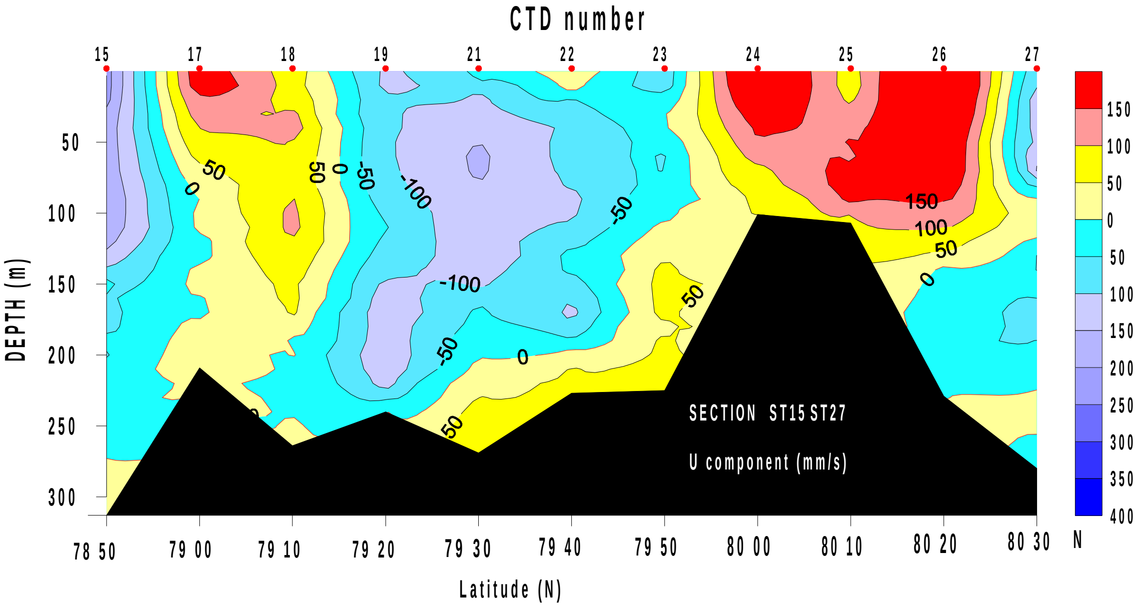
U component (mm/s) vector of current section CTD 12 – 33



Potential Temperature section CTD 15 – 27



Salinity (psu) section CTD 15 – 27



U component (mm/s) vector of current section CTD 15 – 27

Appendix 3: Full list of CTD/LADCP stations

Station	YYYY	MM	DD	HH(UTC)	MIN	Lat	Lon	Depth
1	2006	9	1	14	58	78.832	3.262	2362
2	2006	9	1	17	19	78.832	3.512	2229
3	2006	9	1	22	45	79.168	3.002	2278
4	2006	9	2	4	32	78.830	4.517	1433
5	2006	9	2	9	1	78.827	3.998	1852
6	2006	9	2	10	13	78.817	3.997	1843
7	2006	9	3	10	6	78.815	6.433	279
8	2006	9	3	11	1	78.833	6.000	348
9	2006	9	3	12	40	78.833	5.498	530
10	2006	9	3	14	37	78.832	5.025	982
11	2006	9	4	12	37	78.833	7.012	242
12	2006	9	4	16	48	78.832	7.992	198
13	2006	9	4	18	49	78.833	8.998	220
14	2006	9	4	20	39	78.835	10.005	280
15	2006	9	4	22	14	78.835	11.005	325
16	2006	9	5	0	24	78.832	11.935	189
17	2006	9	5	2	37	78.998	10.997	225
18	2006	9	5	3	51	79.167	11.015	267
19	2006	9	5	5	16	79.330	10.828	250
20	2006	9	5	12	20	79.328	10.877	250
21	2006	9	5	18	20	79.500	10.542	276
22	2006	9	5	19	48	79.665	10.765	231
23	2006	9	5	21	17	79.832	10.807	227
24	2006	9	5	22	42	80.000	11.048	105
25	2006	9	5	23	55	80.167	11.000	112
26	2006	9	6	1	13	80.332	10.997	230
27	2006	9	6	2	39	80.500	11.005	287
28	2006	9	6	3	34	80.500	11.498	247
29	2006	9	6	4	31	80.500	12.003	264
30	2006	9	6	6	12	80.500	13.015	286
31	2006	9	6	19	23	80.478	10.003	258
32	2006	9	6	21	8	80.500	8.990	272
33	2006	9	6	23	1	80.500	7.990	256
34	2006	9	7	0	47	80.335	7.995	260
35	2006	9	7	3	7	80.158	7.697	298
36	2006	9	7	4	31	79.997	7.977	215
37	2006	9	7	6	3	79.832	7.985	193
38	2006	9	7	7	18	79.667	8.005	260
39	2006	9	7	8	44	79.498	7.990	207
40	2006	9	7	10	36	79.332	7.997	222
41	2006	9	7	12	23	79.170	8.003	205
42	2006	9	7	14	27	78.993	7.943	216
43	2006	9	8	10	18	78.885	8.440	301
44	2006	9	9	20	14	79.002	4.982	1307
45	2006	9	9	23	11	79.168	5.012	1428
46	2006	9	10	2	9	79.328	5.140	1428
47	2006	9	10	12	42	79.142	6.007	777
48	2006	9	10	19	36	79.167	6.990	246
49	2006	9	11	0	31	79.165	9.008	246
50	2006	9	11	2	18	79.167	10.013	164
51	2006	9	11	3	33	79.333	10.010	141
52	2006	9	12	14	9	78.815	1.985	2000
53	2006	9	12	18	28	78.835	2.007	2650
54	2006	9	12	22	36	78.830	2.970	2482
55	2006	9	13	23	58	78.832	2.505	2585
56	2006	9	14	3	56	78.918	1.002	2623
57	2006	9	14	7	6	78.917	0.005	2478
58	2006	9	14	9	40	78.917	1.002	2505

59	2006	9	14	12	23	78.915	2.008	2482
60	2006	9	14	15	17	78.915	2.998	2332
61	2006	9	14	18	15	78.917	4.000	2466
62	2006	9	14	21	45	78.913	5.010	2580
63	2006	9	15	1	21	78.915	5.993	2319
64	2006	9	15	4	2	78.915	6.488	1759
65	2006	9	15	6	11	78.913	7.000	1326
66	2006	9	15	8	4	78.917	7.490	1169
67	2006	9	15	9	41	78.915	7.988	1031
68	2006	9	15	11	6	78.918	8.500	436
69	2006	9	15	12	9	78.917	9.002	220
70	2006	9	15	13	2	78.918	9.512	202
71	2006	9	15	13	56	78.952	10.003	222
72	2006	9	15	14	49	78.968	10.498	218
73	2006	9	15	15	41	78.983	11.008	163
74	2006	9	15	16	32	79.017	11.443	312
75	2006	9	15	17	16	78.983	11.708	312
77	2006	9	17	13	54	79.755	10.488	123
78	2006	9	18	11	19	79.993	0.003	2594
79	2006	9	18	16	30	79.848	0.035	2713
80	2006	9	18	20	43	79.678	0.003	2747
81	2006	9	19	2	53	79.497	0.013	2765
82	2006	9	19	7	21	79.328	0.013	2839
83	2006	9	19	11	46	79.170	0.010	2673
84	2006	9	21	2	14	78.000	12.000	165
85	2006	9	21	4	41	77.998	10.990	220
86	2006	9	21	6	38	78.002	10.000	212
87	2006	9	21	8	16	77.998	9.002	222
88	2006	9	21	9	49	78.000	8.007	219
89	2006	9	21	11	31	78.000	7.000	344
90	2006	9	21	12	54	78.002	6.503	310
91	2006	9	21	13	59	77.998	6.000	310
92	2006	9	21	15	23	78.000	5.508	344
93	2006	9	21	16	51	77.998	4.980	1194
94	2006	9	21	18	37	77.995	4.500	2122
95	2006	9	21	23	30	77.998	4.018	2521
96	2006	9	22	3	5	78.000	3.000	2775
97	2006	9	22	10	32	77.002	3.002	2593
98	2006	9	22	14	10	77.000	4.008	1824
99	2006	9	22	16	9	76.997	4.503	1648
100	2006	9	22	18	7	76.998	5.003	1648
101	2006	9	22	22	41	76.995	5.537	1159
102	2006	9	23	4	24	76.998	6.000	805
103	2006	9	23	7	6	77.003	6.522	273
104	2006	9	23	8	14	77.003	7.005	255
105	2006	9	23	10	43	77.000	8.007	310
106	2006	9	23	13	53	77.002	9.008	356
107	2006	9	23	15	32	77.000	9.998	400
108	2006	9	23	17	18	77.000	10.992	396
109	2006	9	23	19	17	76.998	12.000	304
110	2006	9	23	21	1	76.997	13.015	255
111	2006	9	23	22	52	76.998	14.007	172
112	2006	9	24	10	17	75.928	8.697	90
113	2006	9	24	12	19	75.872	8.638	1643
114	2006	9	24	14	16	75.825	8.587	1782