Flow through Fram Strait and in the entrance to the Arctic Ocean.

Agnieszka Beszczynska-Möller, Rainer Graupner, Florian Greil, Kerstin Hans, Wolfgang Hayek, Matthias Monsees, Ekkehard Schütt, Andreas Wisotzki
(AWI, OPTIMARE)

Scientific objectives

Exchanges between the North Atlantic and the Arctic Ocean result in the most dramatic water mass conversions in the World Ocean: warm and saline Atlantic waters, flowing through the Nordic Seas into the Arctic Ocean, are modified by cooling, freezing and melting to become shallow fresh waters, ice and saline deep waters. The outflow from the Nordic Seas to the south provides the initial driving of the global thermohaline circulation cell. Knowledge of these fluxes and understanding of the modification processes is a major prerequisite for the quantification of the rate of overturning within the large circulation cells of the Arctic and the Atlantic Oceans, and is also a basic requirement for understanding the role of these ocean areas in climate variability on interannual to decadal time scales.

The Fram Strait represents the only deep connection between the Arctic Ocean and the Nordic Seas. Just as the freshwater transport from the Arctic Ocean is of major influence on convection in the Nordic Seas and further south, the transport of warm and saline Atlantic water affects the water mass characteristics in the Arctic Ocean which has consequences for the internal circulation and possibly influences also ice and atmosphere.

The complicated topographic structure of the Fram Strait leads to a splitting of the West Spitsbergen Current carrying Atlantic Water northward into at least three branches. One current branch follows the shelf edge and enters the Arctic Ocean north of Svalbard. This part has to cross the Yermak Plateau which poses a sill for the flow with a depth of approximately 700 m. A second branch flows northward along the north-western slope of the Yermak Plateau and the third one recirculates immediately in Fram Strait at about 79°N. Evidently, the size and strength of the different branches largely determine the input of oceanic heat to the inner Arctic Ocean. The East Greenland Current, carrying water from the Arctic Ocean southwards has a concentrated core above the continental slope.

It is our aim to measure the oceanic fluxes through Fram Strait and to determine their variability in seasonal to decadal time scales. Since 1997, year-round velocity, temperature and salinity measurements are carried out in Fram Strait with moored instruments. Hydrographic sections exist since 1980. Through a combination of both data sets estimates of mass, heat and salt fluxes through the strait are provided. Fluxes of nutrients and tracers like the oxygen isotope O^{18} could only be obtained occasionally. From 1997 to 2000 intensive fieldwork occurred in the framework of the European Union project VEINS (Variability of Exchanges in Northern Seas). After the end of VEINS it was maintained under national programmes. Since 2003, the work is carried out as part of the international Programme ASOF (Arctic-Subarctic Ocean Flux Study) and is partly funded in the ASOF-N project by the European Union “Energy, Environment and Sustainable Development” Programme as Proposal No EVK2-2001-00215 (ASOF-N). The mooring line is maintained in close co-operation with the Norwegian Polar Institute and the University of Hamburg. The results of the measurements will be used in combination with regional models, to investigate the nature and origin of the transport fluctuations on seasonal to decadal time scales.

Work at Sea

The oceanographic work at sea during ARKXXI/1b included two main activities: the recovery and redeployment of the array of moorings and measurements of CTD (Conductivity, Temperature, Depth) profiles. The standard section in Fram Strait at 78°50’N, which has been occupied regularly since 1997, was measured with the high resolution coverage by 77 CTD stations, extending exceptionally far to the west (017°30’W). Additionally, 28 CTD stations were performed in the Storfjord area during the first part of the cruise. During activities in the area of Hausgarten and for the needs of the geology program at Yermak Plateau, CTD profiles and water samples were also obtained on 28 stations.

The mooring array passes through the deep part of the Fram Strait from the eastern to the western shelf edge and was in 2003 was extended on the East Greenland shelf. RV POLARSTERN recovered 12 moorings east of 3°W, which had been deployed in autumn 2004 during ARKXX/2 along 78°50’N (Fig. 1). Each tall subsurface mooring carried 3 to 7 instruments including rotor and acoustic current meters from Aanderaa Instruments and Falmouth Scientific Inc. (FSI), acoustic current profilers from RD Instruments, temperature and salinity probes from Sea-Bird Electronics Inc. (Sea-Bird) and two bottom pressure recorders from Sea-Bird. In parallel to the ARKXXI/1b cruise, RV LANCE made the attempt to recover five Norwegian moorings and two from the University of Hamburg, which are the complementary part of the Fram Strait mooring array and were deployed in 2004 between 3° and 12°30’W. During the second part of the ARKXXI/1b cruise RV POLARSTERN also performed a thorough but unsuccessful searching of the Norwegian tube mooring F19 which was located within ice covered waters, inaccessible for LANCE. Most likely the lost mooring had been taken away by one of icebergs, which were observed in a great abundance in 2005.

The mooring work was split into two parts to avoid the tight time schedule for the preparing of new deployments and to allow the exchange of the part of scientific group in Lonyearbyen. During the first part of the cruise 7 of 12 moorings were recovered and redeployed in the eastern and middle part of Fram Strait together with recovery and redeployment of two Pressure Inverted Echo Sounders (PIES). The remaining 5 western moorings and one PIES were recovered and deployed during the second part of the cruise. All work occurred under favourable weather conditions and in ice-free waters. The use of the Posidonia system for those moorings, which were equipped with Posidonia capable releases was of a great help and assured a safe recovery.

The mooring recovery rate was 100%. 78 of 80 prior deployed instruments including PIES delivered the data what makes obtained data rate of 97%. One Seabird TS sensor SBE16, located at the mooring anchor was lost during recovery and another one (also SBE16 instrument) recorded no data, the most likely due to the mechanical damage during deployment last year. Retrieving the data from one BB-ADCP was not possible because of the low battery status, thus the instrument will be read out after exchange of batteries at AWI. The recovered and deployed instruments and the obtained data are summarized in Tab. 1 and 2. The distribution of the instruments at the moorings is displayed in Fig. 2.

The positions of the deployed moorings were kept as closely as possible. The instrumentation agrees in general to the one of the recovered moorings (Tab. 2). Some additional instruments were added in order to obtain better vertical resolution and additional information by new sensor types. Each mooring carries 3 to 8 instruments. Five moorings are equipped with bottom pressure recorders from Sea-Bird Electronics to obtain changes of the sea level inclination indicative of barotropic velocity changes, two of them with the sea level gauges

SBE26 and next three with SBE16 with the pressure sensor. Two moorings are equipped with the upper looking ADCPs (Acoustic Doppler Current Profiler). During the ARKXXI/1b deployment of moorings, all FSI current meters, which had been used in previous years and proved to be extremely unreliable were replaced by the Aanderaa acoustic current meters RCM11.

In 2004 three pressure inverted echo sounders (PIES Model 6.1E) from the University of Rhode Island were deployed for the second time at the mooring section. By combining historical hydrography with the acoustic travel time measurements they give the opportunity to obtain time series of full water column profiles of temperature and specific volume anomaly. Due to that they can be used to estimate the baroclinic flow and the heat transport. During ARKXXI/1b all three PIES were recovered. All instruments provided full data sets although bottom temperature records seem to be out of the correct range. During the last year deployment all PIES were equipped with the POSIDONIA transponders ET861G what made recovery in 2005 much easier as compared to the standard procedure. Using the POSIDONIA transponders allowed also obtaining the accurate positions and depths of deployed instruments. Additionally four Sonobuoys were prepared for the communication with PIES from the helicopter deck if necessary, but successful recovery with POSIDONIA transponders eliminated such a need. Nevertheless, it is recommended for future years to be prepared for using Sonobuoys as the auxiliary method to communicate with PIES in a case of the POSIDONIA system failure. Using the PIES Acoustic Command System (ACS) in the standard mode from board of POLARSTERN is inefficient due to the high level of the ship noise.

The CTD measurements at the Fram Strait section occurred mostly during the nights between mooring work and similarly to the mooring work were split into two periods. Therefore the sequence of stations is rather irregular. Altogether 144 CTD profiles were taken at 135 stations and water samples were collected during all casts (Fig. 1, Tab. 3). Two CTD systems from Sea-Bird Electronics Inc SBE911+ were used. Mainly SN 561 with duplicate T and C sensors (temperature sensors SBE3, SN 2678 and 2685, conductivity sensors SBE4, SN 2446 and 2618 and pressure sensor Digiquartz 410K-105 SN 75659) was in service. For the control of the temperature sensors a SBE35 RT digital reversing thermometer, SN 27 was applied. The CTD was connected to a SBE32 Carousel Water Sampler, SN 273 (24 12-liter bottles). Additionally Benthos Altimeter Model 2110-2 SN 189, and Wetlabs C-Star Transmissometer SN 267 was mounted on the carousels. The SBE 43 dissolved oxygen sensor SN 880 was used. The SBE 43 uses a membrane polarographic oxygen detector in its oxygen sensor. The algorithm to compute oxygen concentration requires also measurements of temperature, salinity and pressure. When the oxygen sensor is interfaced with a Sea-Bird CTD, all of these parameters are measured by the system. The oxygen in water samples was also measured onboard with Winkler tritration for a calibration of the oxygen sensor. The continuous profiles of the chlorophyll a concentration were obtained with a use of the Dr Haardt fluorometer, SN 8060. Salinity of 321 water samples was measured using the Guidline salinometer with Standard Water Batch P145 for calibration of the salinity sensor. In addition 16 water samples á 5 l were collected at 4 stations in the western part of Fram Strait for technetium measurements.

Underway measurements with a vessel-mounted narrow band 150 kHz ADCP from RD Instruments and a Sea-Bird SBE45 thermosalinograph measurements were conducted along the transect to supply temperature, salinity and current data at a much higher spatial resolution than given through the moorings. Two thermosalinograph were in use, one in 6 m depth in the bow thruster tunnel and one in 11 m depth in the keel. Both instruments are controlled by taking water samples, which are measured on board.

Preliminary Results

The data from the moored instruments were read out from the memories but need to be carefully processed in Bremerhaven. Therefore no results can be given here. The preliminary evaluation of the raw data is promising, especially with the extremely good obtained data rate. A very first insight into current meter time series suggests an intensification of the flow in the recirculation area and continuation of the Atlantic water layer warming, observed the year before. The analysis of the hydrographic data occurred on the basis of preliminary data available on board. The post-cruise calibration might result in minor changes.

The temperature and salinity sections across the Fram Strait are shown in Fig. 3. The main core of northward flowing warm and saline Atlantic Water is found at the eastern side of the transect in the shallow to intermediate layers. The West Spitsbergen Current is visible at the eastern slope by downward sloping isolines. The AW in the main core of the West Spitsbergen Current above the slope is slightly shallower that the year before while in the recirculation area the amount of AW is significantly greater. The temperature of the AW in the main WSC core is on average similar to last year value, still high as compared to the long term mean. It is the intermediate layer below the AW in the eastern part of Fram Strait where the slight cooling has occurred since last year. The outer branch of WSC is less pronounced and much shallower that in 2004 and the isotherm 2°C in the recirculation area is shifted down even deeper (down to ca. 600m) than in the outer WSC branch. The recirculating Atlantic Water also extends significantly further to the west than in previous years and can be seen as a big pattern of warm (1 ÷ 3°C) and highly saline (34.92 ÷ 35.0) water down to 700m, reaching the slope east of Greenland. On the western side in the shallow shelf area, the cold and low saline Polar Waters of the East Greenland Current can be seen with temperatures significantly lower than in 2004. The Polar Water above the Greenland shelf was also slightly fresher than in 2004 and amount and extent of ice was significantly higher than observed the last year.

The differences of temperature and salinity between observed in 2005 and 2004 are shown in Fig. 4. As mentioned above, the colder temperatures can be found in the western part of the East Greenland Current above the shelf and within the intermediate layer below the AW in the West Spitsbergen Current. A warming signal is present in the whole water column in the middle and western deep part of Fram Strait, being the strongest in the recirculating AW layer. A change in salinity distribution is accordant with temperature changes, however there is no significant change in the intermediate and deep layers. The most pronounced rise in salinity is observed within the Atlantic water recirculating in the western part of the strait. The observed changes can be possibly related to the shift in the location and strength of the West Spitsbergen Current branch, recirculating directly in Fram Strait.

To identify the longer-term variability, time series of mean temperatures and salinities for typical water masses were derived for two depth intervals (5 ÷ 30 m and 50 ÷ 500 m) (Fig. 5). Three characteristic areas were distinguished in relation to the main flows: the West Spitsbergen Current (WSC) between the shelf edge and 5°E, the Return Atlantic Current (RAC) between 3°W and 5°E, and Polar Water in the East Greenland Current (EGC) between 3°W and the Greenland Shelf. The temperature of the near surface layer in the West Spitsbergen Current increased significantly as compared to the last year. At the same time the surface waters both in the RAW and EGC domains were colder than in 2004. The mean salinity of the surface layer increased in all three domains with the biggest rise in the western area. Since the earlier data were collected in different seasons from spring to autumn, they are affected by the annual cycle which is most pronounced in the upper layers. In the layer between 50 and 500 m both temperature and salinity are higher than the year before and this increase is observed across the whole Fram Strait. The strongest change is found in the East Greenland Current, despite the significant cooling observed in the surface and subsurface waters in the main core of the East Greenland Current. However, after the westward extension of the recirculating AW observed in 2005, the EGC domain defined as west of 003°W covers now also the modified AW in the western Fram Strait with relatively high temperature (1 ÷ 3°C) and salinity (34.92 ÷ 35.0). In the West Spitsbergen Current the increase of temperature in the AW layer is much less than between 2003 and 2004 while the mean salinity is significantly higher than the year before. Summarizing, the most pronounced warming and salinification is observed in the Return Atlantic Water in the middle and western part of the deep basin. Properties of the AW in the West Spitsbergen Current are close to the last year values while the slight cooling is found in the intermediate waters laying below.

List of figures:

Fig. 1: Map with the position of moorings (triangles) and CTD stations (dots) taken during ARKXXI/1b.

Fig. 2: Transect across Fram Strait with the moored instruments recovered (a) and deployed (b) during ARXXI/1b.

Fig. 3: Vertical distribution of potential temperature (a) and salinity (b) across the Fram Strait measured during ARKXXI/1b.

Fig. 4: Temperature (a) and salinity (b) differences between 2005 and 2004.

Fig. 5: The variations of the mean temperatures and salinities in the Fram Strait in the West Spitsbergen Current (WSC), Return Atlantic Current (RAW) and East Greenland Current (EGC).

Tab. 1: Moorings recovered during ARKXXI/1b

Mooring	Latitude Longitude	Water depth (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)	Time series length (days)
F1-7	78° 49.94’ N 08° 39.84’ E	243	20.07.04 08:00	AVTP	8048	61	392.8
			20.07.04 08:00	SBE 37	221	63	392.8
			20.07.04 08:00	SBE 37	217	226	392.8
			20.07.04 08:00	AVTP	9402	232	392.8
F2-8	78° 50.14’ N 08° 19.64’ E	780	20.07.04 10:00	AVTP	8050	59	392.8
			20.07.04 10:00	SBE 37	212	61	392.8
			20.07.04 10:00	AVT	3517	255	392.8
			20.07.04 10:00	SBE 16	2419	771	392.8
			20.07.04 10:00	AVT	9403	773	392.8
			20.07.04 10:00	SBE 26	258	778	392.8
PIES_E	78°50.14’N 08°19.72’E	785	03.09.04 03:00	PIES	062	784	348.3
F3-7	78° 50.30’ N 07° 59.55’ E	1016	20.07.04 12:00	AVTP	8403	60	392.8
			20.07.04 12:00	SBE 37P	1228	62	392.8
			20.07.04 12:00	AVTP	9786	252	392.8
			20.07.04 12:00	RCM 11	294	753	384.4
			20.07.04 12:00	RCM 11	295	999	392.8
			20.07.04 12:00	SBE 16/Trans	2421/446	1001	392.8
F4-7	78° 50.17’ N 07° 00.01’ E	1427	18.07.04 10:00	SBE 37 CTD	1229	63	394.9
			18.07.04 10:00	ADCP	1368	93	394.9
			18.07.04 10:00	AVTPC	9213	249	394.9
			18.07.04 10:00	RCM 11	296	755	394.9
			18.07.04 10:00	SBE 16/Trans	2418/435	1419	394.9
			18.07.04 10:00	RCM 11	297	1421	394.9
F5-7	78° 49.93’ N 06° 00.10’ E	2418	19.07.04 10:00	AVT	6856	61	395.2
			19.07.04 10:00	SBE 16	2414	63	395.2
			19.07.04 10:00	AVTP	8417	253	395.2
			19.07.04 10:00	AVTP	9212	749	395.2
			19.07.04 10:00	RCM 11	298	1505	395.2
			19.07.04 10:00	RCM 11	311	2401	395.2
F6-8	78° 49.80’ N 05° 01.33’ E	2645	19.07.04 14:00	AVT	9179	59	400.0
			19.07.04 14:00	SBE 16	1253	61	400.0
			19.07.04 14:00	AVTP	9192	255	400.0
			19.07.04 14:00	AVTP	9997	751	400.0
			19.07.04 14:00	RCM 11	312	1507	400.0
			19.07.04 14:00	RCM 11	313	2638	400.0
			19.07.04 14:00	SBE 16	1978	2644	1)
PIES_C	78°49.72’N 05°01.17’E	2685	03.09.04 00 :00	PIES	141	2684	349.8
F7-6	78° 49.99’ N 04° 00.03’ E	2294	22.07.04 08:00	AVT	9184	61	397.3
			22.07.04 08:00	SBE 16	2413	63	397.3
			22.07.04 08:00	AVTP	9194	253	397.3
			22.07.04 08:00	RCM 11	314	759	397.3
			22.07.04 08:00	AVTP	12332	1503	397.3
			22.07.04 08:00	RCM11	315	2281	397.3
F8-7	78° 50.05’ N 02° 48.09’ E	2443	22.07.04 12:00	AVT	9185	60	402.7
			22.07.04 12:00	SBE 16	2415	62	402.7
			22.07.04 12:00	AVTP	9195	247	402.7
			22.07.04 12:00	AVTP	9219	753	402.7
			22.07.04 12:00	AVTP	12328	1499	402.7
			22.07.04 12:00	AVT	10530	2435	402.7
			22.07.04 12:00	SBE 26	259	2441	402.7
PIES_W	78°50.32’E 02°47.74’E	2480	02.09.04 22 :00	PIES	071	2479	360.4

F15-3	78° 50.00' N 01° 36.59' E	2497	23.08.04 20:00 23.08.04 20:00 23.08.04 20:00 23.08.04 20:00 23.08.04 20:00 23.08.04 20:00 23.08.04 20:00	AVT SBE 16 ACM ACM AVTP AVT AVT	9187 2416 1391 1389 10492 10531 9206	57 59 248 249 755 1501 2487	370.6 370.6 370.6 370.6 370.6 370.6 370.6
F16-3	78° 50.05' N 00° 23.81' E	2532	22.08.04 12:00 22.08.04 12:00 22.08.04 12:00 22.08.04 12:00 22.08.04 12:00 22.08.04 12:00 22.08.04 12:00	AVTP SBE 16 AVTP AVT ACM ACM RCM 11	9207 1976 10872 9782 1442 1443 20	59 61 251 757 1502 1503 2519	372.0 372.0 372.0 372.0 372.0 372.0 372.0
F9-6	78° 50.33' N 00° 48.74' W	2610	21.08.04 18:00 21.08.04 18:00 21.08.04 18:00 21.08.04 18:00 21.08.04 18:00 21.08.04 18:00 21.08.04 18:00 21.08.04 18:00	AVTP SBE 16 AVTP RCM 11 ACM ACM RCM 11 SBE 16	10002 1977 11889 217 1447 1449 212 1979	58 60 250 756 1506 1507 2603 2609	372.8 372.8 372.8 372.8 372.8 372.8 372.8 [2]
F10-7	78° 49.88' N 02° 00.06' W	2666	24.08.04 08:00 24.08.04 08:00 24.08.04 08:00 24.08.04 08:00 24.08.04 08:00 24.08.04 08:00	AVTP SBE 16 ADCP-UP AVTP ACM AVTP	11888 2422 1561 11613 1450 12333	61 63 253 750 1505 2652	370.3 370.3 370.3 370.3 370.3 370.3

Abbreviations:

ADCP	RDI Inc. Self-Contained Acoustic Doppler Current Profiler
ACM	Falmouth Scientific Inc. 3-dimensional acoustic current meter
AVTCP	Aanderaa current meter with temperature, conductivity and pressure sensor
AVTP	Aanderaa current meter with temperature and pressure sensor
AVT	Aanderaa current meter with temperature sensor
RCM 11	Aanderaa Doppler current meter with temperature sensor
SBE 16	Seabird Electronics SBE16 recording temperature, conductivity, and pressure
SBE 26	Seabird Electronics SBE26 bottom pressure recorder
SBE 37	Seabird Electronics SBE37 recording temperature and conductivity (optionally pressure SBE 37 P)
PIES	Pressure Inverted Echo Sounder (optionally with current meter C-PIES)

Remarks:

[1] Instrument lost.

[2] Instrument failure, no data.

[3] Rotor lost during recovery.

Tab. 2: Moorings deployed during ARKXXI/1b

Mooring	Latitude Longitude	Water depth DWS (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)
F1-8	78°49.95'N 08°39.85'E	251	17.08.05 08:00	RCM7 VTP1000,tlow SBE 37 CTP SBE 37 CT RCM8 VTP1000,tlow	8367 2610 2086 10004	61 63 232 233
F2-9	78°50.14'N 08°19.64'E	798	18.08.05 10:00	RCM7 VTP1000,tlow SBE 37 CTP RCM11VTP3500,tlow SBE 37 CT RCM8 VT SBE 16	8400 250 455 2088 10498 630	60 62 256 766 772 798
PIES_E	78°50.36'N 08°19.63'E	785	18.08.05 11:00	PIES	067	784
F3-8	78°50.32'N 07°59.52'E	1037	18.08.05 14:00	RCM7 VTP1000,tlow SBE 37 CTP RCM11VTP3500,tlow RCM8 VT RCM11 VTP3500 SBE 16	8401 2236 457 10499 458 1167	62 64 253 754 999 1001
F4-8	78°50.18'N 07°00.14'E	1452	18.08.05 16:00	SBE 37 CTP ADCP RCM11VTP3500,tlow RCM11 VTP3500 SBE 37 RCM11 VT	2237 951 461 462 2090 145	64 93 249 755 1415 1421
F5-8	78°49.97'N 06°00.21'E	2465	23.08.05 14:00	RCM7 VTP1000,tlow SBE 16 P1000 RCM8 VT,tlow RCM11 VTP3500 RCM8 VTP3000 RCM11 VT	8402 1975 9768 501 9783 486	62 64 253 749 1505 2401
F6-9	78°49.82'N 05°01.34'E	2690	26.08.05 16:00	RCM7 VTP1000,tlow SBE 16 P1000 RCM11VTCP3500,tlow SBE37 RCM8 VTP3000 RCM11 VTP3500 RCM11 VT	8405 1973 452 2089 9215 513 102	59 61 255 257 751 1507 2633
PIES_C	78°49.97'N 04°54.60'E	2598	26.08.05 16:00	PIES	062	2597
F7-7	78°50.00'N 04°00.00'E	2342	26.08.05 12:00	RCM8 VTP1000,tlow SBE 16 P3000 RCM8 VT,tlow RCM7 VTP20MPa RCM11 VTP3500 RCM11 VT	9201 2420 10503 8395 469 127	62 64 253 759 1503 2281
F8-8	78°50.05'N 02°48.10'E	2491	31.08.05 16:00	RCM8 VT,tlow SBE 37P RCM11 VTP3500,tlow RCM7 VTP20MPa, RCM8 VTP20MPa RCM11 VT SBE26	9390 2392 472 10925 9995 134 276	60 62 247 753 1499 2435 2491

PIES_W	78°49.88'N 02°50.63'E	2488	31.08.05 17:00	PIES	141	2487
F15-4	78°49.98'N 01°36.60'E	2547	30.08.05 20:00	RCM8 VTP1000,tlow SBE 37P RCM11VTP3500,tlow RCM11 VTP3500 RCM8 VTP(blind) RCM11 VT	11887 2393 474 504 10005 133	57 59 249 755 1501 2487
F16-4	78°50.10'N 00°24.07'E	2582	30.08.05 14:00	RCM8 VTP1000,tlow SBE 37P RCM11VTP3500,tlow RCM11 VTP3500 RCM11 VTP3500 RCM11 VT	11892 2395 475 506 500 135	59 61 251 757 1503 2519
F9-7	78°50.30'N 00°48.66'W	2662	30.08.05 10:00	RCM7 VTP2000,tlow SBE 37P RCM11VTP3500,tlow RCM11 VTP3500 RCM11 VTP3500 RCM11 VT SBE 16 P10000	10491 2396 491 512 509 144 631	58 60 250 756 1502 2598 2662
F10-8	78°49.90'N 01°59.99'W	2715	06.09.05 10:00	RCM8 VTP1000,tlow SBE 37P ADCP RCM11 VTP3500 RCM11 VTP3500 RCM8 VT	8396 2609 1563 489 465 9389	61 63 253 750 1506 2652

Abbreviations:

ADCP RDI Inc. Self-Contained Acoustic Doppler Current Profiler
ACM Falmouth Scientific Inc. 3-dimensional acoustic current meter
VTCP Aanderaa current meter with temperature, conductivity and pressure sensor
VTP Aanderaa current meter with temperature and pressure sensor
VT Aanderaa current meter with temperature sensor
tlow Aanderaa current meter with Low Range temperature sensor setup
P1000/2000/3500/20MPa Maximum range of pressure sensor (Aanderaa current meter or SBE)
RCM7 Aanderaa current meter type RCM7
RCM8 Aanderaa current meter type RCM8
RCM 11 Aanderaa Doppler current meter with temperature sensor
SBE 16 Seabird Electronics SBE16 recording temperature, conductivity, and pressure
SBE 26 Seabird Electronics SBE26 bottom pressure recorder
SBE 37 Seabird Electronics SBE37 recording temperature and conductivity (optionally pressure SBE 37 P)
PIES Pressure Inverted Echo Sounder

Tab. 3: CTD stations carried out during ARKXXI/1b

Station	Cast	Latitude	Longitude	Day	Month	Year	Hour	Minute	Water Depth	Max. Pressure
185	1	77.086	13.866	14	8	2005	2	31	116	113
186	1	76.596	15.679	14	8	2005	6	34	38	38
187	1	76.536	15.38	14	8	2005	7	33	123	122
188	1	76.454	15.001	14	8	2005	8	44	224	222
189	1	76.192	16.932	14	8	2005	12	17	281	280
190	1	76.28	16.928	14	8	2005	13	37	201	199
191	1	76.383	16.944	14	8	2005	14	52	59	56
192	1	76.836	19.042	14	8	2005	19	43	115	111
193	1	76.826	19.296	14	8	2005	20	37	138	135
194	1	76.826	19.508	14	8	2005	21	29	156	153
195	1	76.832	19.72	14	8	2005	22	13	156	153
196	1	76.832	20.377	14	8	2005	23	26	124	121
197	1	76.914	20.349	15	8	2005	0	16	123	120
198	1	77.079	20.375	15	8	2005	1	30	89	85
199	1	77.219	20.459	15	8	2005	3	42	85	81
200	1	77.326	20.253	15	8	2005	4	57	97	93
201	1	77.432	20.476	15	8	2005	6	5	69	65
202	1	77.576	20.555	15	8	2005	7	56	68	64
203	1	77.629	20.412	15	8	2005	9	12	89	85
204	1	77.518	19.438	15	8	2005	10	58	148	145
205	1	77.497	19.159	15	8	2005	11	50	181	178
206	1	77.457	18.533	15	8	2005	13	12	102	98
207	1	77.437	19.788	15	8	2005	15	30	133	128
208	1	77.269	20	15	8	2005	17	2	130	126
209	1	77.252	19.535	15	8	2005	18	11	170	166
210	1	77.199	19.279	15	8	2005	19	14	166	163
211	1	77.15	18.827	15	8	2005	20	22	120	117
212	1	78.835	8.999	16	8	2005	22	22	216	214
212	2	78.832	9.012	16	8	2005	23	24	113	124
213	1	78.834	8.84	17	8	2005	0	16	240	238
215	1	78.833	8.5	17	8	2005	2	25	22	32
219	1	78.835	7.008	17	8	2005	14	18	1417	1432
220	1	78.833	5.667	17	8	2005	16	54	2524	2561
221	1	78.842	6.001	17	8	2005	19	12	2424	2461
222	1	78.834	6.332	17	8	2005	21	10	2142	2171
223	1	78.834	6.658	17	8	2005	22	59	1752	1773
224	1	78.837	7.005	18	8	2005	0	38	1420	1435
225	1	78.834	7.332	18	8	2005	2	7	1207	1219
226	1	78.833	7.667	18	8	2005	3	27	1082	1091
227	1	78.839	7.995	18	8	2005	4	47	1012	1020
228	1	78.833	8.206	18	8	2005	5	53	893	899
229	1	78.836	8.328	18	8	2005	7	0	784	788
230	1	78.832	8.495	18	8	2005	8	51	588	589
231	1	78.84	8.666	18	8	2005	9	40	232	230
236	2	78.836	5.054	18	8	2005	20	43	2647	2691
237	1	78.835	5.319	18	8	2005	23	4	2581	2623
238	1	79.065	4.176	19	8	2005	2	43	2421	2456
242	1	79.132	2.842	19	8	2005	14	35	5547	5676
244	1	79.063	3.354	19	8	2005	23	58	5128	5237
245	1	79.064	4.182	20	8	2005	7	44	1103	1016
249	1	79.411	4.683	20	8	2005	23	59	2509	2549
250	1	79.604	5.173	21	8	2005	4	57	2738	2783
250	4	79.597	5.142	21	8	2005	9	56	1106	1019
251	1	79.283	4.341	21	8	2005	14	49	2351	2387
252	1	79.059	3.572	21	8	2005	21	27	3530	3594

253	1	78.834	3.498	22	8	2005	3	27	2296	2328
254	1	79.063	3.653	22	8	2005	6	30	3093	3144
267	1	79.06	3.469	23	8	2005	20	38	3988	4064
271	1	79.107	4.608	24	8	2005	11	9	1907	1931
273	1	78.919	4.993	24	8	2005	18	56	2582	2621
274	1	78.78	5.325	24	8	2005	23	44	2426	2461
275	1	78.61	5.069	25	8	2005	3	59	2289	2322
275	5	78.599	5.081	25	8	2005	10	58	1101	1014
276	2	79.132	4.922	25	8	2005	21	23	1497	1513
277	1	79.133	6.091	26	8	2005	1	27	1249	1261
280	1	78.829	5.024	26	8	2005	12	4	2642	2683
281	1	78.832	4.662	26	8	2005	16	54	2506	2541
282	1	78.833	4.321	26	8	2005	19	0	2352	2385
283	1	78.832	3.98	26	8	2005	20	55	2277	2311
284	1	78.831	3.692	26	8	2005	22	39	2240	2273
285	1	78.835	3.406	27	8	2005	0	27	2319	2354
286	1	78.834	2.999	28	8	2005	18	57	2407	2442
287	1	78.826	2.799	28	8	2005	20	54	2450	2487
288	1	78.831	2.487	28	8	2005	22	55	2472	2510
289	1	78.833	2.195	29	8	2005	0	44	2493	2530
290	1	78.834	1.892	29	8	2005	2	53	2506	2543
296	1	78.833	-1.707	29	8	2005	21	40	2657	2698
297	1	78.833	-1.398	29	8	2005	23	46	2629	2671
298	1	78.833	-1.103	30	8	2005	1	42	2516	2557
298	2	78.834	-1.097	30	8	2005	3	40	1112	1025
299	1	78.838	-0.814	30	8	2005	4	58	2609	2649
300	2	78.841	0.4	30	8	2005	13	45	2527	2565
301	2	78.837	1.61	30	8	2005	18	46	2495	2532
302	1	78.832	1.294	30	8	2005	20	49	2476	2514
303	1	78.833	0.991	30	8	2005	22	37	2435	2471
304	1	78.832	0.705	31	8	2005	0	28	2418	2454
305	1	78.834	0.093	31	8	2005	2	52	2576	2615
306	1	78.833	-0.202	31	8	2005	4	57	2591	2630
307	1	78.834	-0.497	31	8	2005	7	4	2635	2676
309	1	79.693	5.733	31	8	2005	23	35	1555	1573
310	1	79.742	6.263	1	9	2005	1	22	1079	1090
311	1	79.837	7.205	1	9	2005	3	25	783	788
312	1	79.949	8.352	1	9	2005	5	30	490	491
313	1	80.664	8.431	1	9	2005	10	19	836	842
318	3	81.104	8.307	2	9	2005	7	35	1127	1137
318	4	81.094	8.274	2	9	2005	9	10	1059	1071
321	1	81.584	6.125	3	9	2005	8	3	798	803
327	1	80.787	7.535	4	9	2005	23	39	132	32
327	2	80.793	7.539	5	9	2005	0	10	967	976
328	1	80.477	5.882	5	9	2005	3	33	592	594
329	1	80.33	4.922	5	9	2005	6	3	783	788
330	1	80.231	4.287	5	9	2005	7	58	1083	1093
331	1	80.147	3.76	5	9	2005	9	34	1576	1594
332	1	78.831	-3.001	5	9	2005	23	31	2478	2514
333	1	78.834	-2.668	6	9	2005	1	42	2559	2600
334	1	78.835	-2.333	6	9	2005	3	57	2618	2659
335	1	78.831	-2.008	6	9	2005	6	18	2662	2705
336	1	78.832	-3.346	6	9	2005	11	28	2331	2364
337	1	78.834	-3.656	6	9	2005	13	34	2140	2172
338	1	78.833	-3.998	6	9	2005	15	33	1881	1905
338	2	78.832	-3.991	6	9	2005	17	15	1891	1829
339	1	78.833	-4.334	6	9	2005	19	45	1606	1625
339	2	78.829	-4.314	6	9	2005	21	22	1101	1014
340	1	78.828	-4.668	6	9	2005	22	44	1309	1323

341	1	78.831	-5.003	7	9	2005	0	45	1005	1014
342	1	78.835	-5.33	7	9	2005	3	37	703	706
343	1	78.831	-5.68	7	9	2005	5	45	421	422
344	1	78.839	-6.044	7	9	2005	7	57	338	337
345	1	78.81	-6.506	7	9	2005	9	54	279	277
346	1	78.831	-6.997	7	9	2005	11	55	245	243
347	1	78.833	-7.494	7	9	2005	14	18	190	191
348	1	78.823	-7.988	7	9	2005	16	53	211	209
349	1	78.833	-8.519	7	9	2005	20	36	283	281
350	1	78.828	-8.997	7	9	2005	22	6	214	212
351	1	78.832	-9.491	7	9	2005	23	31	188	185
352	1	78.837	-10.041	8	9	2005	2	1	286	284
352	3	78.833	-10.061	8	9	2005	2	58	319	312
353	1	78.83	-10.476	8	9	2005	4	33	375	374
354	1	78.834	-10.986	8	9	2005	6	29	324	323
355	1	78.832	-11.488	8	9	2005	8	17	226	224
356	1	78.83	-12.014	8	9	2005	10	7	199	197
357	1	78.83	-12.492	8	9	2005	12	6	193	190
358	1	78.832	-12.995	8	9	2005	16	6	190	187
359	1	78.838	-13.496	8	9	2005	18	13	124	120
360	1	78.835	-13.977	8	9	2005	20	3	103	99
361	1	78.829	-14.497	8	9	2005	22	20	84	81
362	1	78.825	-14.996	9	9	2005	0	2	66	61
363	1	78.834	-15.491	9	9	2005	2	13	65	61
364	1	78.843	-16.011	9	9	2005	5	4	234	232
365	1	78.837	-16.526	9	9	2005	6	48	358	358
366	1	78.828	-16.97	9	9	2005	8	20	375	375
367	1	78.833	-17.48	9	9	2005	10	7	550	552
369	1	72.005	14.722	12	9	2005	13	8	1257	1269
371	1	71.959	14.663	12	9	2005	17	51	1319	1333

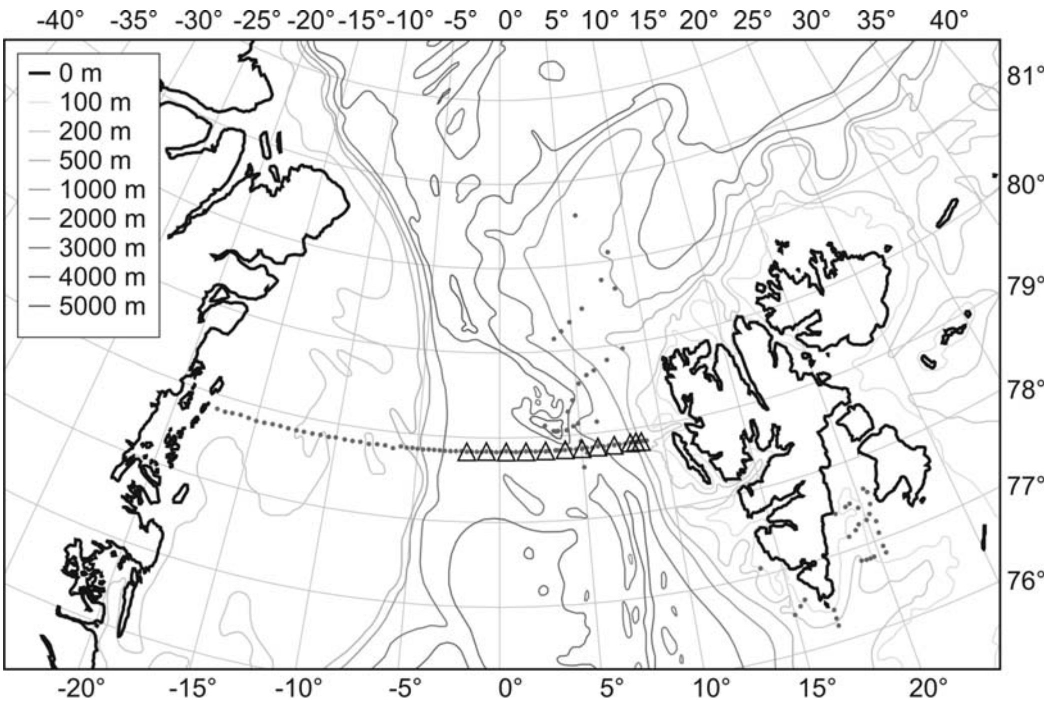


Fig. 1: Map with the position of moorings (triangles) and CTD stations (dots) taken during ARKXXI/1b.

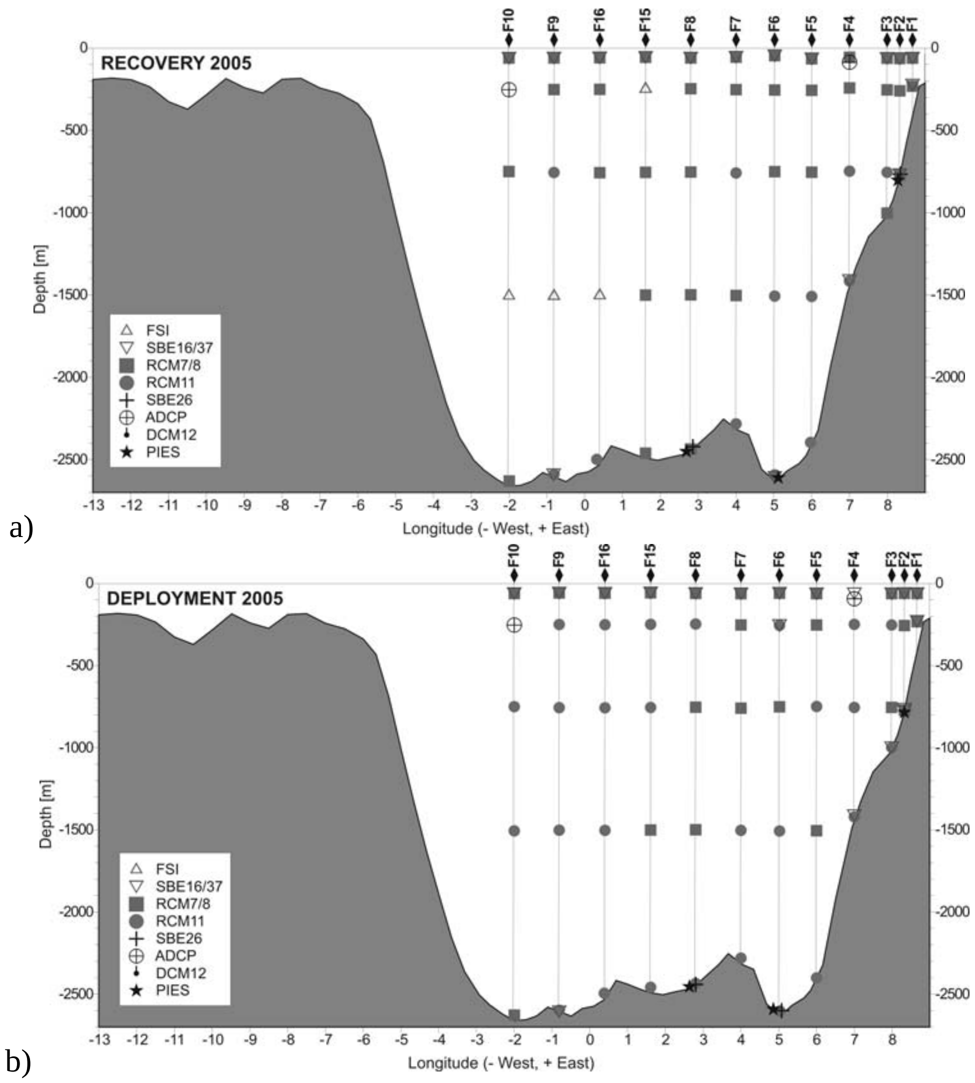
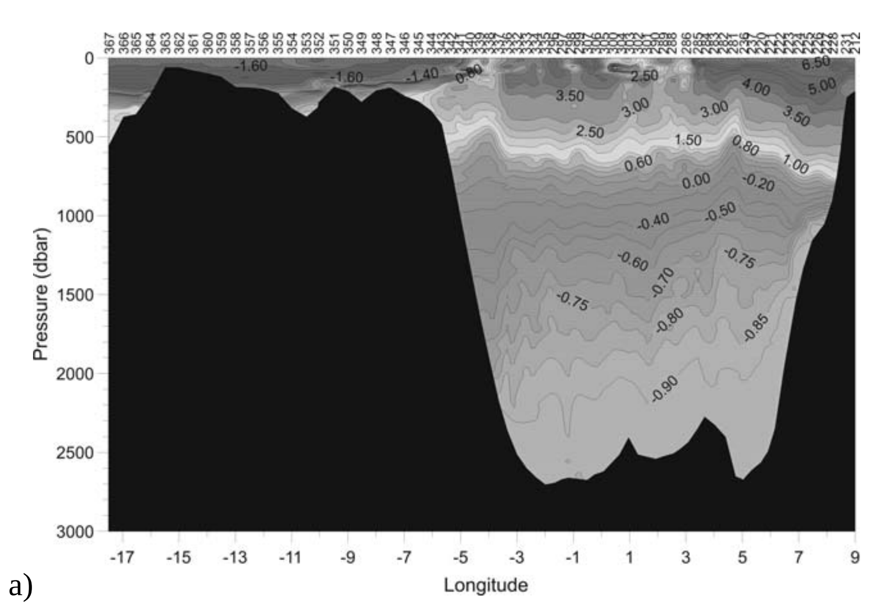
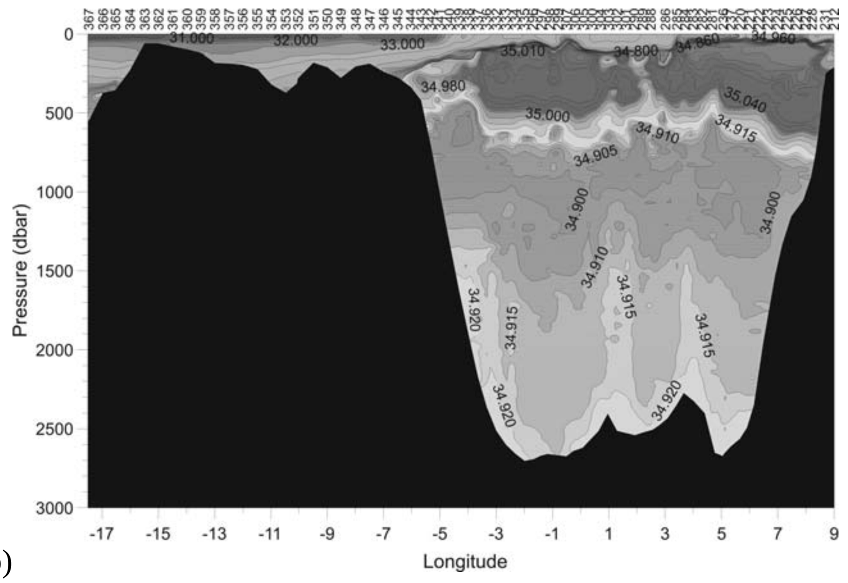


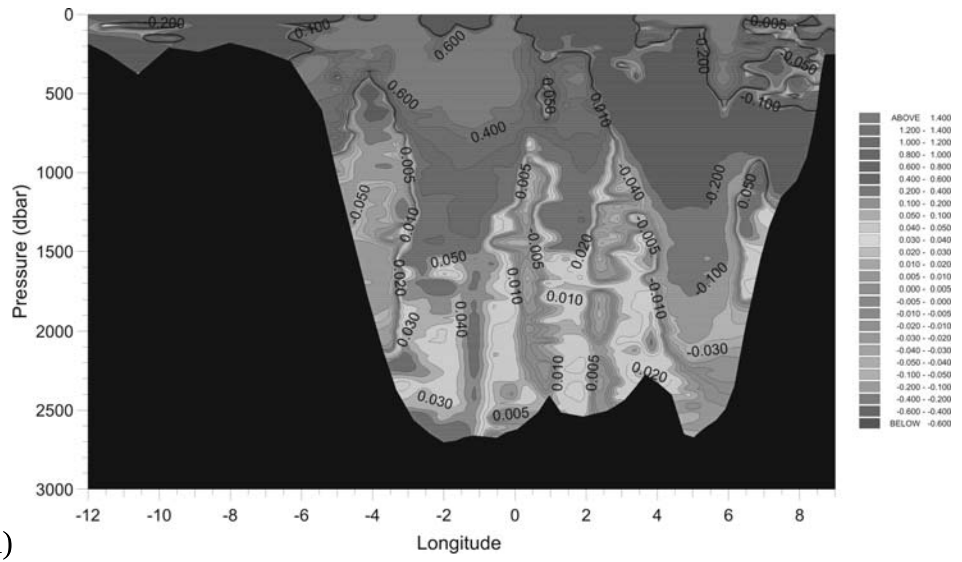
Fig. 2: Transect across Fram Strait with the moored instruments recovered (a) and deployed (b) during ARXXI/1b.



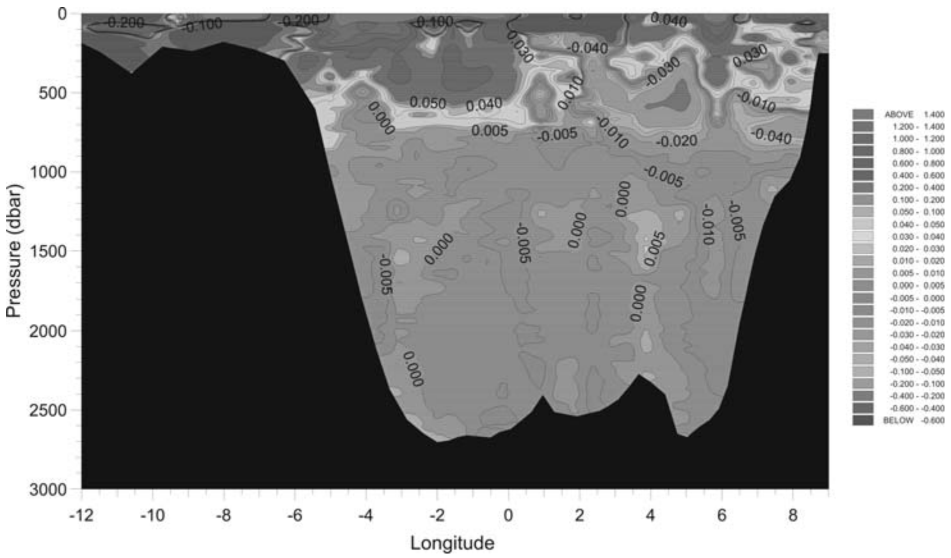


b)

Fig. 3: Vertical distribution of potential temperature (a) and salinity (b) across the Fram Strait measured during ARKXXI/1b



a)



b)

Fig. 3: Differences of potential temperature (a) and salinity (b) across the Fram Strait between 2005 and 2004.

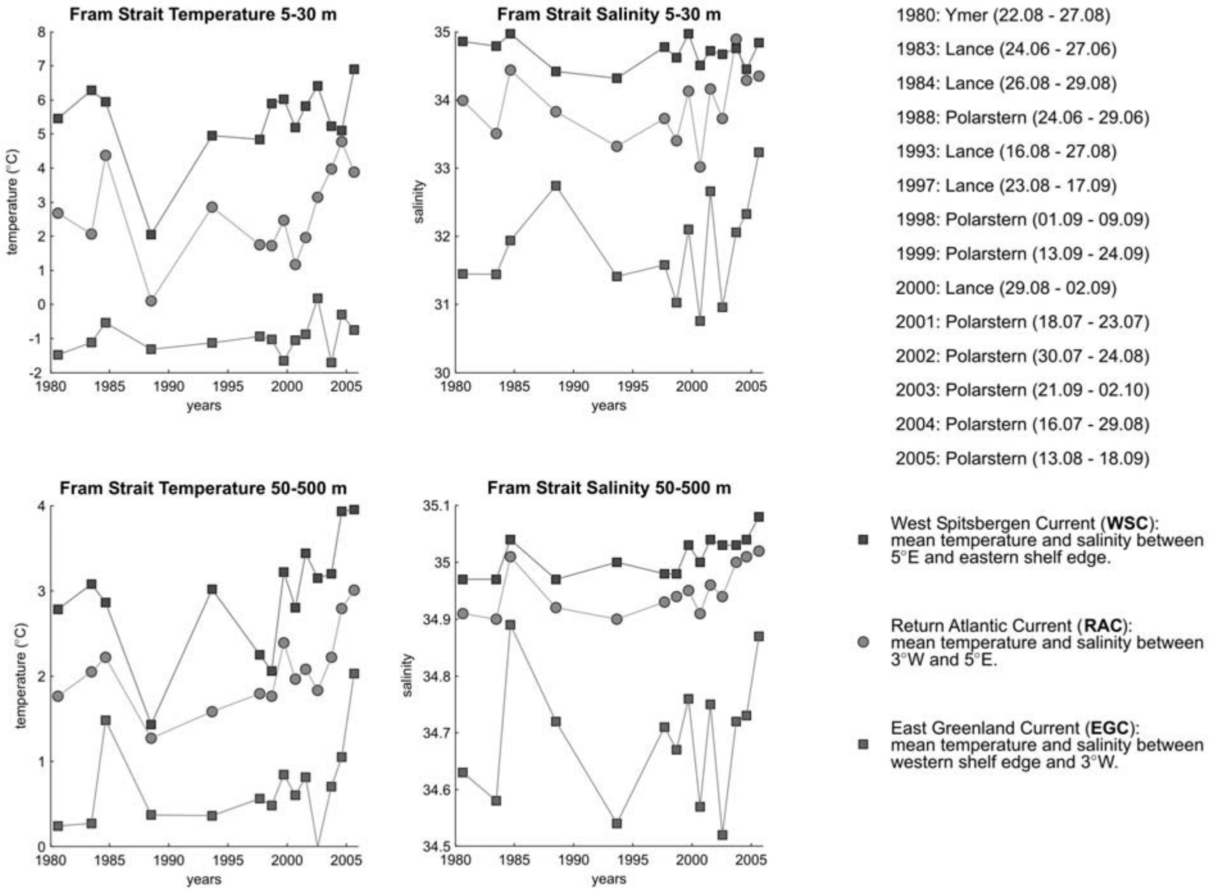


Fig. 5: The variations of the mean temperatures and salinities in the Fram Strait in the West Spitsbergen Current (WSC), Return Atlantic Current (RAW) and East Greenland Current (EGC).