



INSTITUTE OF OCEANOLOGY POLISH ACADEMY OF SCIENCES



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December 10. 2003

Cruise Report R.V. „Oceania”, AREX2003

Ship:	R.V. “Oceania”
Cruise:	Arex2003
Dates:	08.06.2003 – 19.07.2003
Port Calls:	Sopot (Poland) – Longyearbyen (Spitsbergen)
Number of Scientist	11
Chief Scientist	dr. Waldemar Walczowski
Principal Project	ASOF-N, WP1
Research Area	Greenland Sea

WP1. Atlantic Water pathways in the Greenland Sea

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1. Historical data

Institute Oceanology Polish Academy of Sciences is doing oceanographic research in the Norwegian, Greenland and Barents Seas since 1987. During summer cruises hydrographic data were collected, some at the same permanent stations and transects. They will be reanalysed to support ASOF research.

2. Observations 2003

AREX2003 cruise of the R.V Oceania was performed in period of June 08 2003 – July 19 2003. CTD (conductivity, temperature, depth) profiles along 14 sections were done (Fig 1, Tab.1). Sections are perpendicular to the general direction of the Atlantic Water flow. The AW domain in the Greenland Sea is situated between Barents Sea slope and underwater ridges system – Mohns Ridge and Knipovich Ridge. Due to convergence of the isobaths in the northern part, AW domain forms wedge, wide in southern part and narrow in the northern end. Specific bottom topography meaningfully influences the currents pattern and structure. Coverage in the southern part of investigated area is spare in comparison to the northern one. This causes less accurate horizontal distribution of properties in the region south of the Bear Island. Our main effort was concentrated in the northern part of Atlantic Domain, where processes controlling the AW inflow into Arctic Ocean through the Fram Strait and the westward recirculation occur.

For CTD measurements the Seabird SBI9/11plus probe was used. The probe was serviced before the cruise. Temperature and conductivity sensors were calibrated by the Sea-Bird Electronics service. Water samples collected by means of the rosette water sampler SBE32 were analysed at IOPAS laboratory with the Guildline Autosol 8400A.

Currents measurements by means of the lowered Acoustic Doppler Current Profiler (LADCP) were performed at the CTD stations. The self-recording 300 kHz RDI device was used to profile entire water column during the standard CTD casts.

During the whole cruise continuous currents measurements by the ship-mounted ADCP, RDI 150 kHz were conducted.

3. Some preliminary results

2003 cruise results confirm our earlier findings that there are two northward flowing branches of Atlantic Water in the Greenland Sea. The main branch of the West Spitsbergen Current flows along the Barents Sea continental slope and Spitsbergen shelf break. The second, colder and less saline branch continues along the Mohns and Knipovich Ridges as a jet stream of the Arctic Front. Bottom topography forces both branches of AW to converge west of the Spitsbergen coast. Only a part of northward flowing AW enters the Arctic Ocean, mainly along the Spitsbergen slope; AW carried by the western branch generally recirculates westward as Return Atlantic Current

Figure 2 presents salinity distribution, dynamic heights and baroclinic currents at depth of 100 m (calculated for the reference level of 1000 m.) during summer 2003. AW enters into the Greenland Sea as a wide flow of warm and more saline water separated from the Norwegian coast by the less saline Norwegian Coastal Current. To the west, the Arctic Front located over the Mohns Ridge separates AW from colder and less saline Arctic Waters. Considerable part of AW flowing along the Norwegian coast proceeds eastward into the Barents Sea, the rest continue northward as two separated branches. One branch is related to the Barents Sea slope. Jet streams of the Arctic Front form the second branch of AW. Differences between salinity and temperature of the eastern and western branch exist; AW carried by the eastern flow is warmer and more saline than the western one. West of Spitsbergen the bottom topography forces convergence of both northward flowing AW streams. Distance between branches in the southern part of WSC is about 150 km in the northern part only 30 km. In central and northern part of the WSC recirculation of AW occurs. Only part of AW, which flows along the shelf break, continues northward, through the Fram Strait into the Arctic Ocean.

In July 2003 very intensive AW recirculation was observed. The ice edge in the Fram Strait was shifted southward. Baroclinic calculations show westward flow between latitudes $78^{\circ} - 79^{\circ}$ N (Fig.3). However the baroclinic currents do not describe the total flow even in the deep basin. Measurements performed this year by the LADCP show considerable barotropic flows over the shelf and (much lower, but important) over the ridges. On the other hand there is a good agreement in directions of measured and calculated currents. Also good agreement between flow directions and tracers (temperature, salinity) distribution is observed. Therefore flows derived using baroclinic methods are still valuable tool for analysing the AW patterns.

Measurements performed by means of the LADCP provide interesting material. We have obtained relative high-resolution sections of currents measured together with CTD profiles, from the surface to the bottom. It allows calculate total flow cross the sections, transports of heat, salt and fresh water as well as calculating transports for selected water masses. Measurements provide valuable information about the flow structure (Fig 4). It may be helpful for the current meter data analysis; understanding of the flow's field structure may help in data interpolation and data gaps complement. Despite rather low accuracy of volume transport calculations, these results are also interesting. After de-tiding AW transports calculated from several sections are close to the transports estimated for the WSC (Tab.2). Measured flow structure is close to obtained from the baroclinic calculations and measured by means of the ship mounted ADCP (Fig 6). These data – mostly the barotropic component of currents measured in reference to the bottom, coupled with the ship-mounted ADCP output and baroclinic calculations allow calculate total fluxes more precisely.

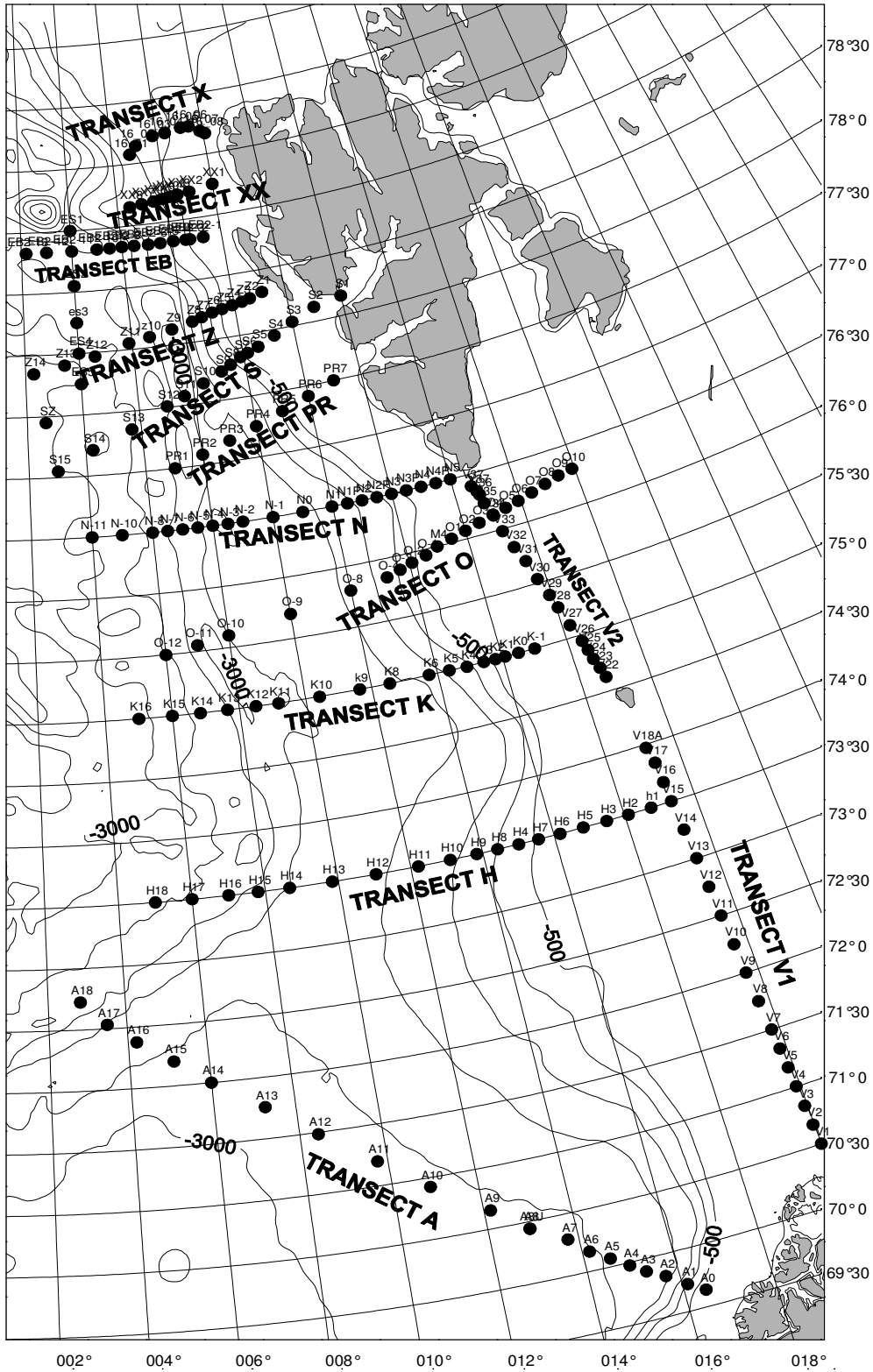


Fig. 1. Position of the CTD stations taken during the AREX 2003 cruise of R.V. Oceania

Table 1. CTD stations carried out during Arc2003 cruise.

Running No.	CTD-Station No.	Cast No.	Data	Time (UTC)	Latitude	Longitude	Sounding depth [m]
1	A1	1	03-20-06	6:10:08	69° 43.02' N	016° 06.91' E	660
2	A2	1	03-20-06	8:34:48	69° 49.37' N	015° 41.68' E	2275
3	A3	1	03-20-06	13:11:28	69° 53.83' N	015° 17.95' E	2355
4	A4	1	03-20-06	15:58:14	69° 58.54' N	014° 58.25' E	2445
5	A5	1	03-20-06	18:51:00	70° 03.97' N	014° 35.05' E	2545
6	A6	1	03-20-06	21:32:46	70° 09.53' N	014° 09.87' E	2585
7	A7	1	03-21-06	0:32:30	70° 17.55' N	013° 44.92' E	2650
8	A8	1	03-21-06	4:32:46	70° 26.50' N	012° 57.19' E	2660
9	A9	1	03-21-06	8:38:10	70° 38.96' N	012° 09.23' E	2655
10	A10	1	03-21-06	14:14:10	70° 55.48' N	010° 52.93' E	2655
11	A11	1	03-21-06	20:20:05	71° 11.88' N	009° 45.06' E	2680
12	A12	1	03-22-06	2:34:10	71° 29.10' N	008° 26.93' E	2775
13	A13	1	03-22-06	8:08:51	71° 45.41' N	007° 15.00' E	2825
14	A14	1	03-22-06	13:40:00	72° 00.00' N	005° 59.91' E	2895
15	A15	1	03-22-06	18:12:00	72° 11.86' N	005° 06.92' E	2815
16	A16	1	03-22-06	23:00:00	72° 22.35' N	004° 12.56' E	2520
17	A17	1	03-23-06	2:20:00	72° 32.00' N	003° 29.60' E	2370
18	A18	1	03-23-06	5:55:00	72° 43.50' N	002° 50.15' E	1770
19	H8	1	03-25-06	16:12:00	73° 30.00' N	014° 25.00' E	1005
20	H4	1	03-25-06	18:52:59	73° 29.93' N	015° 00.51' E	660
21	H7	1	03-25-06	21:16:03	73° 30.01' N	015° 33.74' E	485
22	H6	1	03-25-06	23:23:33	73° 29.96' N	016° 10.23' E	450
23	H5	1	03-26-06	1:16:00	73° 30.00' N	016° 49.48' E	430
24	H3	1	03-26-06	3:07:01	73° 29.88' N	017° 29.42' E	415
25	H2	1	03-26-06	4:47:01	73° 29.95' N	018° 06.42' E	400
26	H1	1	03-26-06	6:36:01	73° 29.95' N	018° 45.29' E	420
27	V1	1	03-27-06	4:56:51	70° 30.04' N	020° 00.04' E	120
28	V2	1	03-27-06	6:28:17	70° 40.07' N	019° 58.04' E	155
29	V3	1	03-27-06	7:56:13	70° 49.98' N	019° 55.96' E	170
30	V4	1	03-27-06	9:38:53	71° 00.20' N	019° 53.98' E	175
31	V5	1	03-27-06	11:12:44	71° 10.10' N	019° 52.11' E	200
32	V6	1	03-27-06	12:56:18	71° 20.01' N	019° 50.12' E	205
33	V7	1	03-27-06	14:37:00	71° 30.20' N	019° 40.00' E	240
34	V8	1	03-27-06	16:52:00	71° 45.20' N	019° 44.00' E	265
35	V9	1	03-27-06	19:17:07	72° 00.00' N	019° 44.66' E	305
36	V10	1	03-27-06	21:39:12	72° 14.84' N	019° 37.09' E	315
37	V11	1	03-28-06	0:05:02	72° 29.98' N	019° 34.05' E	390
38	V12	1	03-28-06	2:32:29	72° 45.02' N	019° 31.05' E	400
39	V13	1	03-28-06	5:02:12	73° 00.01' N	019° 28.01' E	410
40	V14	1	03-28-06	7:24:02	73° 15.07' N	019° 24.00' E	445
41	V15	1	03-28-06	9:47:54	73° 30.03' N	019° 20.05' E	475
42	V16	1	03-28-06	11:31:42	73° 40.00' N	019° 18.16' E	345
43	V17	1	03-28-06	13:20:42	73° 50.00' N	019° 19.16' E	225
44	V18	1	03-28-06	15:50:42	73° 58.30' N	019° 09.63' E	140
45	V22	1	03-29-06	8:46:16	74° 36.95' N	018° 45.03' E	60

46	V23	1	03-29-06	9:59:30	74°42.02' N	018°40.07' E	90
47	V24	1	03-29-06	11:01:22	74°47.09' N	018°33.93' E	215
48	V25	1	03-29-06	12:15:22	74°52.04' N	018°30.12' E	200
49	V26	1	03-29-06	13:23:09	74°57.03' N	018°25.20' E	70
50	V27	1	03-29-06	15:21:41	75°06.02' N	018°13.51' E	70
51	V28	1	03-29-06	17:15:41	75°15.07' N	018°03.51' E	60
52	V29	1	03-29-06	18:52:41	75°22.90' N	017°55.51' E	100
53	V30	1	03-29-06	20:38:46	75°31.98' N	017°43.29' E	125
54	V31	1	03-29-06	22:49:03	75°41.95' N	017°33.09' E	205
55	V32	1	03-30-06	0:34:40	75°50.02' N	017°20.03' E	280
56	V33	1	03-30-06	02:31:12	75°59.00' N	017°08.19' E	310
57	V35	1	03-30-06	6:20:13	76°14.51' N	016°50.34' E	215
58	V36	1	03-30-06	7:19:13	76°19.00' N	016°46.90' E	100
59	V37	1	03-30-06	8:03:13	76°21.11' N	016°43.34' E	55
60	V38	1	03-30-06	08:50:30	76°24.09' N	016°35.78' E	30
61	O10	1	03-30-06	15:32:14	76°18.00' N	019°55.02' E	220
62	O9	1	03-30-06	17:32:32	76°17.01' N	019°25.20' E	250
63	O8	1	03-30-06	19:24:38	76°15.03' N	018°55.21' E	255
64	O7	1	03-30-06	21:00:38	76°12.98' N	018°25.04' E	240
65	O6	1	03-30-06	22:38:25	76°10.27' N	017°54.96' E	280
66	O5	1	03-01-07	0:08:25	76°09.49' N	017°27.57' E	310
67	O4	1	03-01-07	0:01:44	76°08.00' N	017°00.09' E	285
68	O3	1	03-01-07	3:56:07	76°05.96' N	016°30.03' E	330
69	O2	1	03-01-07	5:40:07	76°03.90' N	016°00.23' E	375
70	O1	1	03-01-07	7:22:42	76°01.91' N	015°30.30' E	355
71	M4	1	03-01-07	8:54:09	75°59.97' N	014°59.72' E	320
72	O-1	1	03-01-07	10:52:23	75°57.04' N	014°34.51' E	320
73	O-2	1	03-01-07	12:28:35	75°55.07' N	014°05.05' E	565
74	O-3	1	03-01-07	14:14:35	75°53.01' N	013°40.05' E	955
75	O-4	1	03-01-07	16:15:35	75°50.01' N	013°12.00' E	1205
76	O-11	1	03-02-07	12:45:05	75°33.00' N	007°00.15' E	1800
77	O-12	1	03-02-07	16:42:35	75°29.90' N	006°00.12' E	2505
78	K15	1	03-02-07	22:27:05	75°00.00' N	006°00.00' E	2705
79	K16	1	03-03-07	2:50:05	75°00.00' N	005°00.15' E	2505
80	K14	1	03-03-07	8:53:54	74°59.93' N	006°50.16' E	2110
81	K13	1	03-03-07	12:30:59	75°00.09' N	007°38.85' E	2210
82	K12	1	03-03-07	16:02:10	75°00.00' N	008°30.05' E	2705
83	K11	1	03-03-07	19:30:10	75°00.00' N	009°10.05' E	2505
84	K10	1	03-04-07	00:34:26	74°59.85' N	010°25.11' E	2510
85	K9	1	03-04-07	06:55:42	74°59.98' N	011°38.10' E	1205
86	K8	1	03-04-07	11:47:42	74°59.96' N	012°33.00' E	2005
87	K6	1	03-04-07	18:05:39	75°00.06' N	013°44.86' E	1815
88	K5	1	03-04-07	21:25:28	74°59.99' N	014°22.05' E	1525
89	K4	1	03-05-07	0:58:28	74°59.71' N	014°54.05' E	1055
90	K3	1	03-05-07	5:06:28	75°00.20' N	015°25.62' E	805
91	K2	1	03-05-07	6:46:54	74°59.94' N	015°47.18' E	330
92	K1	1	03-05-07	6:46:54	75°00.60' N	016°04.57' E	215
93	K0	1	03-05-07	8:59:10	75°00.02' N	016°30.15' E	220

94	K-1	1	03-05-07	10:27:10	74°59.92' N	017°00.09' E	120
95	N5	1	03-05-07	22:39:42	76°29.97' N	016°00.01' E	50
96	N4P	1	03-06-07	0:08:26	76°29.98' N	015°30.08' E	140
97	N4	1	03-06-07	1:25:14	76°30.00' N	014°59.97' E	160
98	N3P	1	03-06-07	3:19:06	76°30.01' N	014°29.92' E	210
99	N3	1	03-06-07	4:46:21	76°29.98' N	013°59.81' E	750
100	N2P	1	03-06-07	6:10:14	76°29.97' N	013°29.74' E	1250
101	N2	1	03-06-07	8:05:14	76°29.98' N	012°59.60' E	1505
102	N1P	1	03-06-07	10:20:14	76°30.02' N	012°30.19' E	1705
103	N1	1	03-06-07	12:53:14	76°29.96' N	011°59.19' E	1855
104	N0	1	03-06-07	16:21:28	76°29.98' N	011°00.07' E	2100
105	N-1	1	03-06-07	19:50:09	76°29.93' N	010°00.21' E	2235
106	N-2	1	03-06-07	23:40:09	76°29.98' N	008°56.66' E	2205
107	N-3	1	03-07-07	2:13:38	76°29.99' N	008°29.91' E	2205
108	N-4	1	03-07-07	4:54:38	76°30.04' N	007°59.64' E	1800
109	N-5	1	03-07-07	7:10:30	76°30.02' N	007°29.75' E	2515
110	N-6	1	03-07-07	9:50:00	76°29.98' N	006°59.56' E	2785
111	N-7	1	03-07-07	12:49:35	76°30.03' N	006°29.94' E	2405
112	N-8	1	03-07-07	15:35:40	76°29.96' N	005°59.88' E	2505
113	N-10	1	03-07-07	19:16:41	76°30.04' N	004°59.67' E	2350
114	N-11	1	03-07-07	22:51:26	76°30.02' N	003°59.86' E	2600
115	S15	1	03-08-07	5:20:00	77°03.01' N	003°00.03' E	3005
116	S14	1	03-08-07	10:44:09	77°12.51' N	004°14.91' E	2155
117	S13	1	03-08-07	15:40:32	77°21.02' N	005°39.90' E	2600
118	PR1	1	03-08-07	21:34:50	77°00.06' N	006°59.97' E	2100
119	PR2	1	03-09-07	1:27:40	77°05.04' N	008°00.14' E	2505
120	PR3	1	03-09-07	5:32:40	77°10.04' N	008°59.85' E	2000
121	PR4	1	03-09-07	9:10:36	77°15.01' N	009°59.93' E	1805
122	PR5	1	03-09-07	12:46:02	77°20.10' N	010°59.76' E	1000
123	PR6	1	03-09-07	15:41:57	77°25.01' N	012°00.09' E	110
124	PR7	1	03-09-07	17:45:47	77°30.04' N	012°59.95' E	145
125	S1	1	03-11-07	12:43:36	78°09.52' N	013°59.91' E	285
126	S2	1	03-11-07	15:10:36	78°06.98' N	012°54.96' E	255
127	S3	1	03-11-07	17:03:20	78°01.98' N	012°00.00' E	260
128	S4	1	03-11-07	19:13:20	77°57.06' N	011°14.83' E	170
129	S5	1	03-11-07	20:55:20	77°53.10' N	010°35.02' E	155
130	S6	1	03-11-07	21:56:20	77°50.93' N	010°09.63' E	180
131	S7	1	03-11-07	22:45:00	77°49.48' N	009°52.56' E	620
132	S8	1	03-12-07	0:15:11	77°46.54' N	009°28.63' E	1200
133	S9	1	03-12-07	1:53:11	77°43.96' N	009°06.76' E	1540
134	S10	1	03-12-07	4:23:13	77°39.50' N	008°23.75' E	2225
135	S11	1	03-12-07	7:26:13	77°34.46' N	007°39.56' E	3250
136	S12	1	03-12-07	11:10:13	77°30.49' N	006°59.59' E	2150
137	SZ	1	03-12-07	19:27:05	77°26.94' N	002°39.43' E	3105
138	Z14	1	03-13-07	1:39:42	77°50.97' N	002°17.59' E	3020
139	Z13	1	03-13-07	6:30:00	77°54.54' N	003°26.50' E	3155
140	Z12	1	03-13-07	10:59:00	77°58.00' N	004°34.79' E	2705
141	Z11	1	03-13-07	15:31:52	78°03.04' N	005°52.77' E	2350

142	Z10	1	03-13-07	19:07:52	78°05.03' N	006°40.16' E	2305
143	Z9	1	03-13-07	23:40:38	78°07.52' N	007°31.93' E	3400
144	Z8	1	03-14-07	3:13:04	78°10.05' N	008°19.98' E	1905
145	Z7	1	03-14-07	5:03:25	78°11.54' N	008°42.10' E	1520
146	Z6	1	03-14-07	7:00:05	78°13.72' N	009°06.55' E	850
147	Z5	1	03-14-07	8:22:10	78°14.03' N	009°30.78' E	310
148	Z4	1	03-14-07	9:39:10	78°15.11' N	009°55.10' E	300
149	Z3	1	03-14-07	10:51:10	78°16.01' N	010°17.98' E	295
150	Z2	1	03-14-07	12:00:10	78°17.15' N	010°36.36' E	295
151	Z1	1	03-14-07	13:36:10	78°19.02' N	011°07.09' E	145
152	EB2-1	1	03-14-07	18:12:36	78°50.09' N	009°16.05' E	200
153	EB2-2	1	03-14-07	19:25:34	78°49.98' N	008°43.73' E	210
154	EB2-3	1	03-14-07	20:02:46	78°50.06' N	008°33.77' E	470
155	EB2-4	1	03-14-07	21:23:23	78°50.19' N	008°03.85' E	970
156	EB2-5	1	03-14-07	23:05:23	78°50.07' N	007°32.08' E	1055
157	EB2-6	1	03-15-07	00:45:23	78°50.02' N	007°03.39' E	1305
158	EB2-7	1	03-15-07	03:25:23	78°50.06' N	006°29.84' E	1900
159	EB2-8	1	03-15-07	05:40:23	78°50.06' N	006°00.39' E	2405
160	EB2-9	1	03-15-07	08:36:11	78°50.04' N	005°30.84' E	2500
161	EB2-10	1	03-15-07	11:49:12	78°50.03' N	005°00.38' E	2650
162	EB2-11	1	03-15-07	16:00:03	78°49.98' N	004°00.15' E	2225
163	EB2-12	1	03-15-07	20:15:03	78°50.02' N	003°00.09' E	2355
164	EB2-13	1	03-15-07	23:49:20	78°49.90' N	002°11.42' E	2505
165	16_01	1	03-16-07	12:20:20	79°34.54' N	006°44.09' E	1005
166	16_02	1	03-16-07	13:39:32	79°38.51' N	007°03.40' E	800
167	16_03	1	03-16-07	15:52:27	79°42.34' N	007°49.55' E	700
168	16_04	1	03-16-07	17:16:36	79°42.99' N	008°22.13' E	505
169	16_05	1	03-16-07	18:49:38	79°44.49' N	009°04.72' E	405
170	16_06	1	03-16-07	19:43:37	79°44.56' N	009°25.57' E	380
171	16_07	1	03-16-07	21:02:58	79°41.53' N	009°52.68' E	265
172	16_08	1	03-16-07	21:48:31	79°40.03' N	010°04.66' E	100
173	XX1	1	03-17-07	2:18:05	79°15.02' N	010°00.01' E	160
174	XX2	1	03-17-07	4:16:32	79°13.02' N	009°00.12' E	110
175	XX3	1	03-17-07	5:24:20	79°12.40' N	008°30.00' E	225
176	XX4	1	03-17-07	6:22:21	79°11.83' N	008°10.31' E	600
177	XX5	1	03-17-07	7:37:09	79°11.22' N	007°50.81' E	995
178	XX6	1	03-17-07	9:11:18	79°10.54' N	007°29.97' E	1235
179	XX7	1	03-17-07	11:07:06	79°09.88' N	007°00.12' E	1360
180	XX8	1	03-17-07	13:11:51	79°09.10' N	006°30.15' E	1425
181	XX9	1	03-17-07	15:02:05	79°08.35' N	006°00.17' E	1205
182	XX10	1	03-17-07	17:02:05	79°08.09' N	005°31.18' E	1255
183	17_01	1	03-17-07	19:52:05	79°03.04' N	005°00.00' E	1500
184	ES1	1	03-17-07	23:13:45	79°00.01' N	004°00.03' E	2755
185	ES2	1	03-18-07	07:23:45	78°33.01' N	003°59.95' E	2355
186	ES3	1	03-18-07	13:00:45	78°15.01' N	003°59.95' E	2305
187	ES4	1	03-18-07	17:25:56	77°59.98' N	004°00.00' E	2500

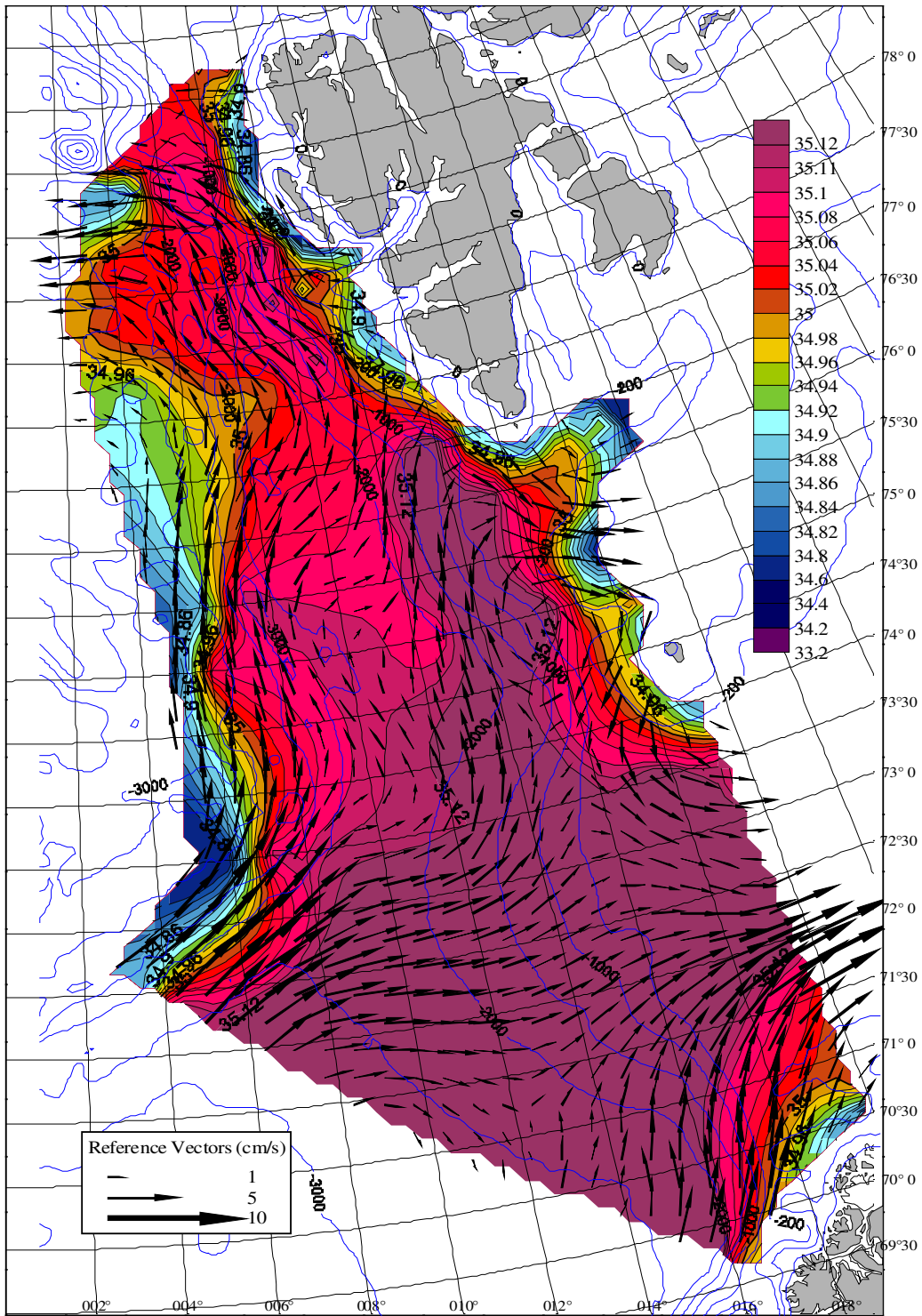


Fig. 2. June-July 2003. Smoothed salinity field and baroclinic currents at level of 100 m showing Atlantic Water movement. Reference level 1000 m.

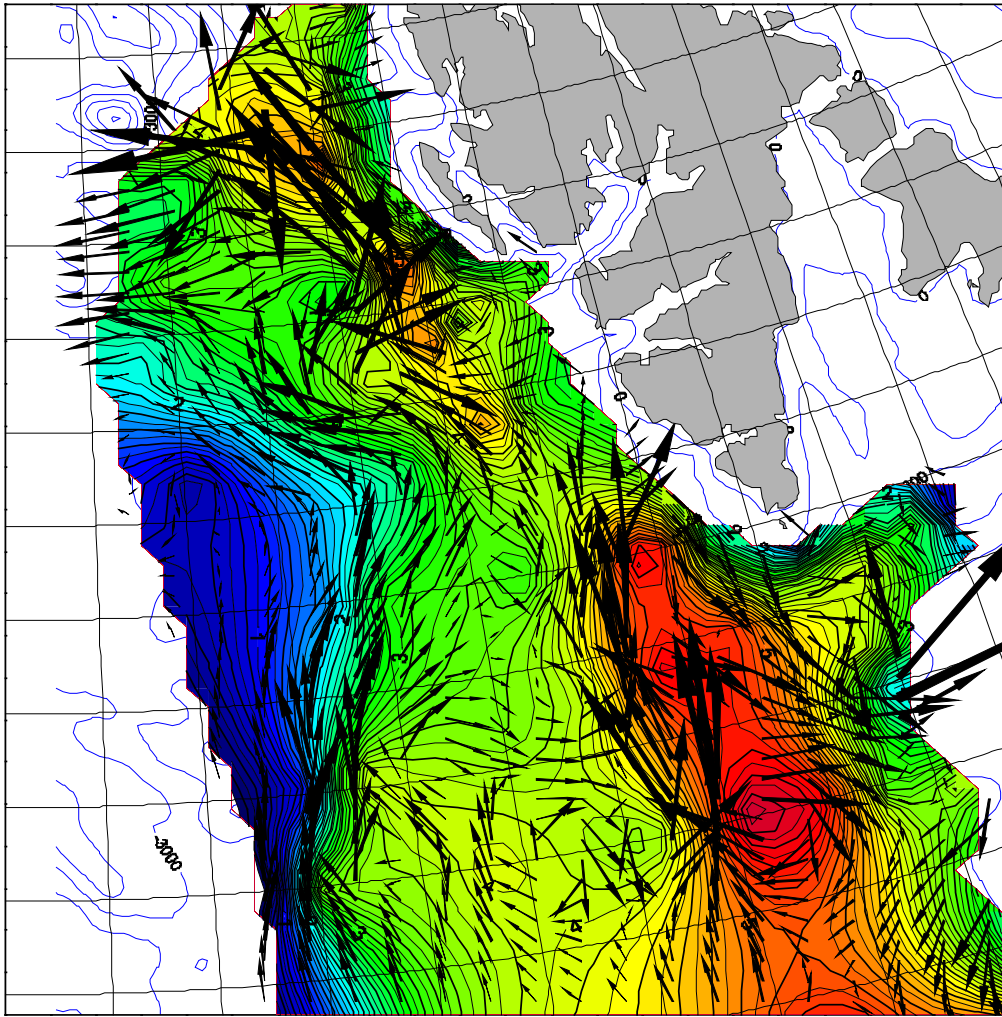


Fig. 3. The West Spitsbergen Current. Temperature and baroclinic currents at level of 100 m. in June 2003.

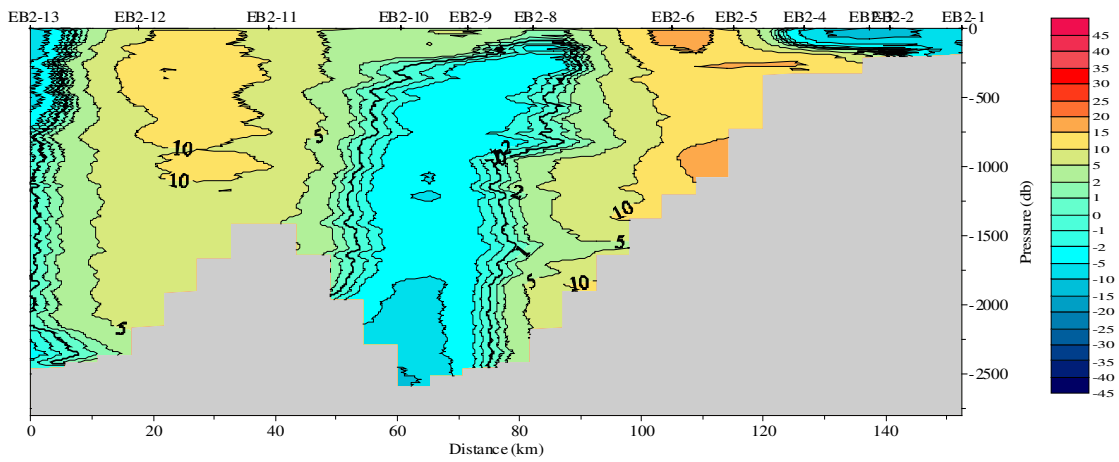


Fig.4 LADCP measured currents perpendicular to the section along the 78° 50' N parallel. Positive velocities indicate northward flow.

Table 2

The volume transport across the selected sections.

Positive transport indicates northward flow. Atlantic Water calculated against salinity $S > 34.92$ psu. Detailed data from LADCP were used.

Section	Net Vol. transport	Northward Vol (+)	Southward Vol (-)	AW_Vol	AW+	AW-
K (75 °N)	28.801	33.187	4.386	9.55	12.256	2.706
N (76° 30'N)	13.976	20.493	6.517	6.64	7.810	1.174
S (77- 78°N)	21.286	24.468	3.182	6.99	8.273	1.275
Z (78-78°20'N)	27.756	32.326	4.570	4.54	5.858	1.318
EB2 (78° 50' N)	9.657	12.282	2.624	4.20	4.950	0.747

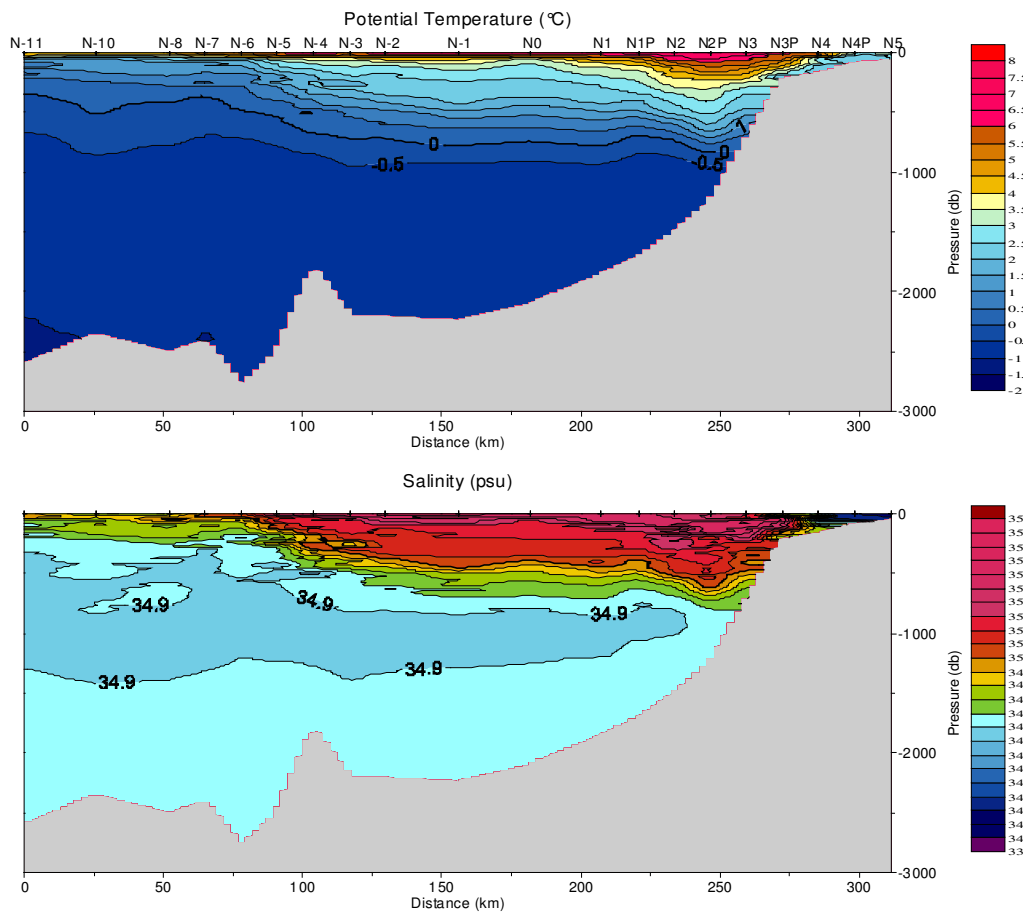


Fig. 5. Section N (76° 30'N). Temperature and salinity distribution.

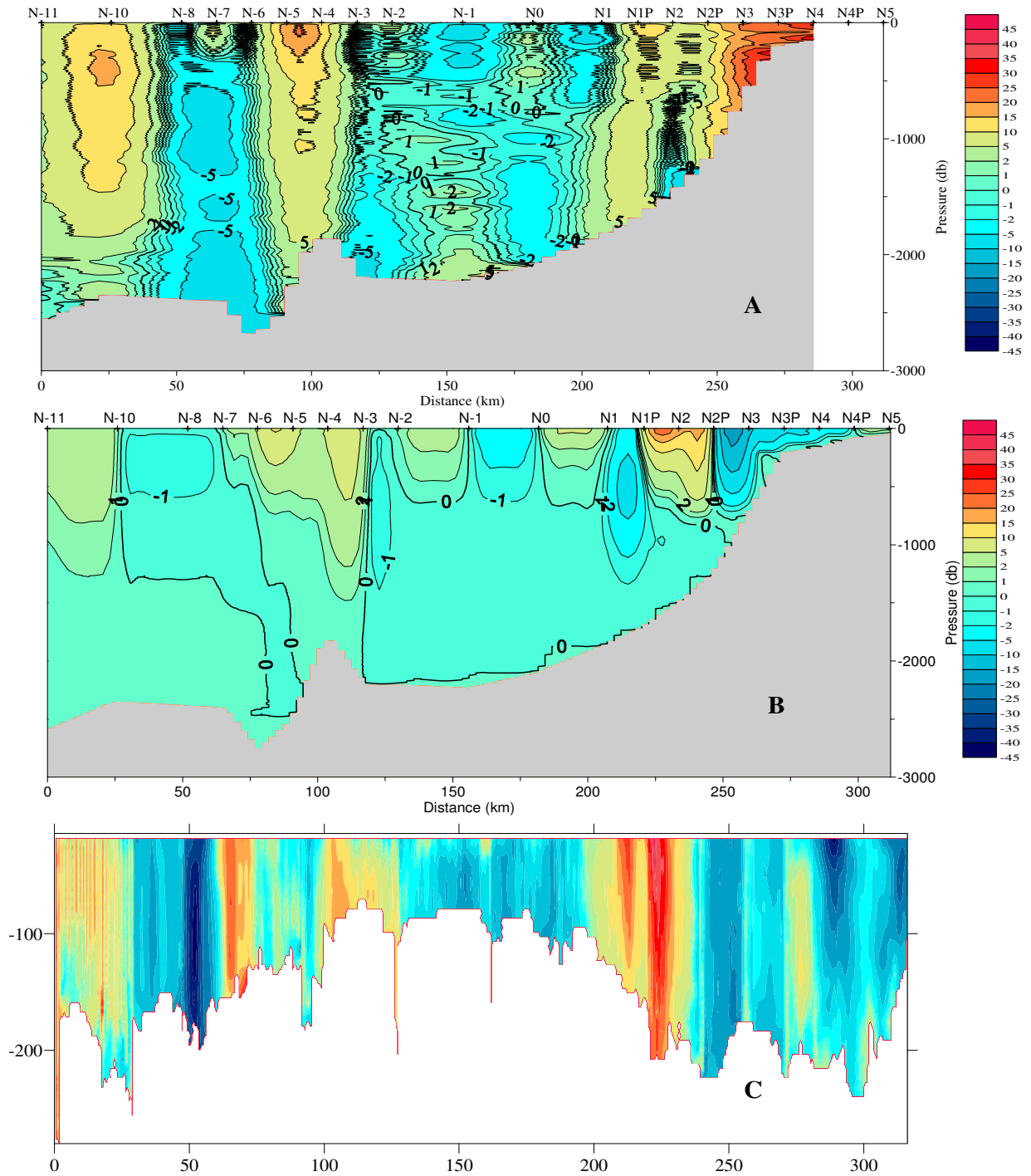


Fig . 6. Section N (76° 30'N) Currents perpendicular to the section:
 A. Lowered ADCP measured ;
 B. Obtained from the baroclinic calculations;
 C. Ship mounted ADCP measured (different vertical scale).