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Observations in the Deep Basins of the Baltic in 1983.

Hydrography of the Kattegat and the Skagerrak Area, Swedish Observations, 1983.

(Contribution to ICES "Annales Biologiques")

by S. Engström, S. Fonselius, P. Hognestad and A. Svansson

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Sammanfattning av rapport (fakta med huvudvikt på resultatet)

Under årets första månader skedde ett mycket stort inflöde till Östersjön av vatten från Västerhavet. Syrgassituationen i södra Östersjön förbättrades kraftigt. Tyvärr blev förbättringen kortvarig och situationen med låga mängder syrgas i bottenvattnen återkom och blev bestående hela året.

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OBSERVATIONS IN THE DEEP BASINS OF THE BALTIC IN 1983

Four hydrographic expeditions were carried out in the Baltic Sea by the ARGOS in 1983. During the last expedition in November 1982, very high salinities and oxygen concentrations were found close to the Danish Belts area (St. BY 1). During the winter months 1982-83 a row of low pressure centers passed over Scandinavia with a high frequency of unusually strong westerly winds. This continued in to February and forced large amounts of Kattegat water in to the Baltic Sea. At the end of January the sea level was for some time more than 1 m above the normal.

The oxygen conditions in the southern Baltic Sea were drastically improved. In the Bornholm Deep, which in the autumn had more than 9 µmol/l hydrogen sulphide in the bottom water, around 4 ml/l oxygen was measured at the same depth in January. The old stagnant water had been lifted up and was found at around 60 m depth. It was expected that the oxygen situation in the whole deep water area of the Baltic would improve. During the January expedition the conditions in the main part of the Baltic Sea had not been influenced by the inflowing Kattegat water. East of Gotland and in the northern Baltic Proper there was an area with low oxygen values. The limit for 2 ml/l oxygen was found at around 80 m depth and over large areas hydrogen sulphide was found already at 100 m. The conditions west of Gotland were similar, but hydrogen sulphide was only found in the Landsort Deep below 175 m.

During late winter and spring very small changes occured in the oxygen concentrations, with the exception of the southernmost parts. In the Bornholm basin and south of the Scania coast the oxygen concentration decreased drastically in connection with more normal weather conditions, which caused the surplus of Kattegat water to return through the Belts. At the station BY 1 the oxygen concentration in the bottom water was 2.17 ml/l, or 26 % saturation at the end of May and in the Bornholm Deep only 0.39 ml/l, or 5 % saturation. In the south eastern Baltic Sea the conditions were better. At the station BCS III:10 5.1 ml/l oxygen was found in the bottom water in the middle of June and at BY 9 4.4 ml/l at 126 m depth.

During the summer the oxygen conditions deteriorated still more in the southern Baltic Sea. In September only 0.08 ml/l oxygen was found at 48 m depth in the Arkona basin. The area with oxygen values below 2 ml/l was relatively large south of the Scania coast and in the Bornholm basin. In the main part of the Baltic Proper no remarcable changes were observed. The limit for 2 ml/l oxygen had raised to 70 - 60 m depth.

During the autumn a certain improvment in the oxygen conditions occurred, especially south of the Scania coast, where the whole water mass was oxygen saturated down to the bottom. The limit for 2 ml/l oxygen was found at varying depths, in the north eastern parts of the Baltic Proper at around 100 m, in the Gotland Deep at around 125 m, in the Bornholm basin at depths between 60 and 70 m and in the area west of Gotland at 70 - 80 m.

During the late autumn (as during the whole year), hydrogen sulphide was found in an extensive area east of Gotland. In the Fårö Deep 52 µmol/l was measured at 202 m depth and 39.5 µmol/l was measured at 240 m depth in the Gotland Deep in November. At the same time large amounts of hydrogen sulphide was found in local deep throughs in the north eastern Baltic Proper. At the station BY 28 the amount of hydrogen sulphide was up to 70 µmol/l.

In the area west of Gotland hydrogen sulphide was observed in the Landsort Deep (1.2 µmol/l at 150 m and 15.3 µmol/l at 440 m). In the Norrköping Deep very small amounts of hydrogen sulphide were found close to the bottom, while at the station BY 38 2.5 µmol/l at 100 m and 4.3 µmol/l at 108 m were measured.

In the Bornholm Basin and in the Hanö Bight small amounts of oxygen were found also in the bottom water.

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ARKONA DEEP (BY 2) $55^{o}00'N$ $14^{o}04'E$

Depth m	Temp °C	S	O_2 ml/l	pH	PO_4-P µmol/l	Tot.P µmol/l	Alk mmol/l	SiO_2 µmol/l	NO_2-N µmol/l	NO_3-N µmol/l	NH_4-N µmol/l	Tot.N µmol/l	H_2S
					19 Jan								
0	4.80	9.055	8.28	8.11	0.66	0.98	1.581	15.3	0.07	4.09	0.40	20.3	
10	4.82	9.055	8.40	8.11	0.67	1.00	1.573	15.5	0.06	4.23	0.13	20.4	
30	4.83	9.692	8.26	8.10	0.72	1.01	1.573	16.3	0.06	4.24	0.17	20.3	
49		19.361	4.65	7.73	5.36	6.77	1.903	37.1			1.31	47.5	
					8 March								
0	1.87	8.125	9.18		0.88	1.10						20.1	
10	1.91	8.122	9.16		0.83	1.14						19.0	
30	2.56	8.795	8.84		0.90	1.13						19.6	
48	4.29	15.931	6.36		2.03	3.95						39.2	
					25 May								
0	8.14	8.495	8.15	8.29	0.42	0.95		5.7	<0.02	0.12	0.42	19.5	
10	8.13	8.495	8.06	8.31	0.40	0.95		7.4	<0.02	0.23	0.61	20.7	
30	5.62	8.870	7.49	8.08	0.72	1.09		9.7	<0.02	0.15	0.81	18.9	
47	4.30	13.507	3.88	7.59	2.09	3.43		32.1	0.04	1.11	1.82	18.0	
					19 September								
0	14.68	8.297	6.81	8.16	0.05	0.57	1.583	9.5	<0.02	<0.10	0.18	18.7	
10	14.65	8.295	6.74	8.19	0.17	0.45	1.556	9.6	<0.02	<0.10	0.21	18.1	
30	9.34	10.028	4.71	7.66	0.93	1.15	1.606	20.0	0.03	4.89	0.29	18.6	
48	11.58	16.005	0.08		6.06	6.99		69.3	0.21	1.11	>15	34.9	
					6 December								
0	6.34	9.229	8.18	8.11	0.59	0.74	1.567	10.0	0.48	1.94	<0.05	18.0	
10	6.34	9.244	8.10	8.10	0.52	0.79	1.556	10.1	0.50	2.00	0.42	18.0	
30	6.33	9.350	8.15	8.10	0.54	0.76	1.530	9.9	0.55	2.03	0.65	20.7	
48	9.86	17.591	5.33	7.88	1.69	2.28	1.753	25.3	0.43	4.14	2.10	25.5	

Tabell 1.

BORNHOLM DEEP (BY 5) 55°15'N 15°59'E

Depth m	Temp °C	S	O_2 ml/l	pH	PO_4-P µmol/l	Tot.P µmol/l	Alk mmol/l	SiO_2 µmol/l	NO_2-N µmol/l	NO_3-N µmol/l	NH_4-N µmol/l	Tot.N µmol/l	H_2S µmol/l
					20 January								
0	4.92	8.863	8.15	8.03	0.79	0.93	1.563	18.1	0.03	4.17	0.16	20.0	
10	4.91	8.862	8.22	8.05	0.74	0.88	1.563	16.6	0.03	4.13	0.09	19.0	
30	4.92	8.861	8.20	8.05	0.72	0.98	1.578	17.3	0.03	3.75	0.21	21.3	
50	4.92	8.880	8.22	8.08	0.70	0.96	1.545	16.8	0.03	3.97	0.22	20.8	
70	8.59	14.724	1.65	7.33	3.40	3.76	1.768	55.9	0.02	6.48	0.19	21.3	
90		17.469	3.48	7.66	1.59	2.20	1.814	37.1	0.04	8.26	0.30	26.3	
					10 March								
0	2.74	8.282	9.00		0.86	0.92						21.5	
10	2.75	8.280	8.90		0.87	0.98						21.1	
30	2.78	8.311	8.85		0.87	0.91						18.2	
[illegible]	3.52	9.237	8.31		0.83	1.00						22.8	
70	6.78	[illegible]	4.24		1.55	1.74						22.8	
85	7.92	17.727	1.85		1.15	1.36						28.0	
					14 June								
0	12.28	8.009	8.40	8.46	0.14			0.4	0.02	<0.10	0.18	18.5	
10	10.32	8.034	8.26	8.45	0.16			8.6	<0.02	<0.10	0.20	17.2	
30	6.37	8.181	8.20	8.24	0.55			8.8	0.02	<0.10	0.34	18.4	
50	3.43	8.917	7.67	7.92	1.00			19.6	0.07	0.65	1.18	30.0	
70	6.50	15.227	3.23	7.56	1.83			39.2	0.06	8.64	0.17	30.0	
89	7.58	17.282	0.39	7.44	3.81			72.2	0.39	9.96	0.79	45.5	
					28 September								
0	15.80	7.871	6.44	8.26	0.11	0.48	1.525	7.7	0.05	0.22	0.46	19.1	
10	15.80	7.870	6.44	8.28	0.15	0.31	1.546	7.2	0.04	0.22	0.47	19.0	
30	15.32	7.925	6.22	8.16	0.17	0.44	1.567	8.2	0.06	0.19	0.64	18.2	
50	4.13	8.241	7.06	7.79	0.66	0.92	1.546	13.5	0.03	3.48	0.12	16.6	
70	6.93	15.953	1.20	7.33	1.65	1.81	1.722	48.7	0.03	13.2	0.15	27.2	
89	7.41	16.962	0.44	7.35	4.31	5.96	1.790	77.9	<0.02	8.05	4.46	36.2	

Tabell 7.

BORNHOLM DEEP (BY 5) 55°15'N 15°59'E

Depth m	Temp °C	S	O_2 ml/l	pH	PO_4-P µmol/l	Tot.P µmol/l	Alk mmol/l	SiO_2 µmol/l	NO_2-N µmol/l	NO_3-N µmol/l	NH_4-N µmol/l	Tot.N µmol/l	H_2S µmol/l
						5 December							
0	6.62	8.391	7.98	8.08	0.60	0.79	1.517	13.8	0.07	2.56	0.29	19.8	
10	6.60	8.392	7.97	8.09	0.54	0.79	1.553	13.5	0.06	2.49	0.10	18.0	
30	6.63	8.394	7.96	8.08	0.58	0.80	1.572	13.9	0.07	2.39	0.13	18.0	
50	6.57	8.501	7.83	8.05	0.60	0.83	1.546	14.3	0.07	2.65	0.09	19.2	
70	7.94	15.152	1.37	7.33	1.63	1.92	1.767	52.6	0.08	11.7	0.08	24.0	
89	7.95	16.540	1.27	7.44			1.782						

Tabell 2.

GOTLAND DEEP (BY 15) 57°20'N 20°03'E

Depth m	Temp °C	S	O_2 ml/l	pH	PO_4-P µmol/l	Tot.P µmol/l	Alk mmol/l	SiO_2 µmol/l	NO_2-N µmol/l	NO_3-N µmol/l	NH_4-N µmol/l	Tot.N µmol/l	H_2S µmol/l
					21 January								
0	4.18	7.729	8.69	8.06	0.49	0.71	1.545	15.1	0.05	3.11	0.17	19.0	
70	3.73	8.936	3.62	7.44	1.80	2.12	1.617	38.4	0.04	6.60	0.12	23.4	
100	4.47	10.374	0.47	7.22	2.95	3.27	1.606	63.1	0.02	5.83	0.13	20.5	
150	5.16	11.940		7.25	3.67	4.86	1.683	90.1	<0.02	0.10	5.44	21.2	>0
200	5.46	12.378		7.28	3.23	5.90	1.770	<100	<0.02	<0.10	8.50	27.8	>0
240	5.55	12.452		7.32	2.80	6.90	1.775	<100	<0.02	<0.10	11.5	39.6	0
					13 June								
0	11.39	7.678	8.15	8.64	0.07	0.40		4.0	<0.02	<0.10	0.23	20.0	
70	3.89	8.830	5.81	7.70	1.47	1.57		28.3	0.10	5.45	0.21	23.3	
100	4.63	10.464	0.45	7.25	3.14	3.42		59.4	0.03	4.90	0.19	18.0	
150	5.33	11.995		7.27	4.39	4.95		73.3	0.02	<0.10	5.91	21.6	21.4
200	5.66	12.469		7.29	4.32	5.00		90.4	<0.02	<0.10	9.04	26.6	26.7
240	5.89	12.754		7.28	4.10	5.31		91.2	<0.02	<0.10	10.3	30.7	32.2
					21 September								
0	14.78	7.280	6.65	8.18	0.07	0.72	1.509	6.4	0.05	<0.10	0.24	21.6	
70	3.64	8.461	6.41	7.68	1.08	1.49	1.538	24.5	0.04	6.16	0.16	21.1	
100	4.56	10.288	1.36	7.24	2.57	3.11	1.614	48.5	0.03	8.22	0.15	22.6	
150	5.32	12.036		7.22	3.47	5.39	1.696	88.5	<0.02	<0.10	6.53	24.0	20.5
200	5.62	12.449		7.25	2.86	5.77	1.759	87.7	<0.02	<0.10	9.77	28.2	31.5
240	5.84	12.707		7.25	1.99	6.01	1.772	114.4	<0.02	<0.10	12.5	34.5	49.5
					16 November								
0	7.15	7.462	7.94	8.05	0.34	0.67	1.457	12.3	0.23	1.41	0.68	18.0	
70	3.76	8.543	5.81	7.62	1.15	1.69	1.546	26.0	0.02	7.28	0.26	21.5	
100	4.02	9.498	5.57	7.59	1.47	1.88	1.535	29.0	0.04	8.66	0.29	20.2	
150	5.10	11.664	0.17	7.21	2.53	3.37	1.646	73.9	0.04	1.74	1.09	16.6	0
200	5.44	12.334		7.25	3.21	6.28	1.682	>100	<0.02	<0.10	8.95	25.8	38.5
240	5.73	12.542		7.24	3.54	8.15	1.743	>100		<0.10	10.6	32.3	39.5

Tabell 3.

LANDSORT DEEP (BY 31) 58°35'N 18°14'E

Depth m	Temp °C	S	O_2 ml/l	pH	PO_4-P µmol/l	Tot.P µmol/l	Alk mmol/l	SiO_2 µmol/l	NO_2-N µmol/l	NO_3-N µmol/l	NH_4-N µmol/l	Tot.N µmol/l	H_2S µmol/l
					22 January								
0	4.36	7.420	8.44	8.03	0.57	0.73	1.463	12.7	0.14	3.78	<0.05	20.8	
70	4.25	7.530	8.30	8.02	0.67	0.84	1.476	16.1	0.08	3.93	0.05	19.9	
100	4.31	9.793	1.33	7.25	2.76	3.10	1.491	53.7	0.04	3.48	0.17	19.9	
150	4.46	10.456	0.40	7.22	3.32	3.78	1.640	65.1	0.04	0.10	0.95	15.1	
200	4.50	10.577		7.22	3.50	3.99	1.665	68.5	0.03	<0.10	1.81	17.5	>0
440	4.61	10.794		7.23	3.67	4.37	1.619	70.6	0.03	0.61	3.15	19.6	>0
					27 May								
0	6.34	6.957	8.97	8.50	0.11	0.32		10.1	0.02	0.17	0.28	17.1	
70	2.71	7.839	7.71	7.94	0.93	1.13		21.5	0.15	2.55	0.25	19.9	
100	4.38	10.043	0.62	7.30	3.37	3.43		59.3	0.03	3.02	0.23	18.1	
150	4.48	10.374	0.17	7.27	3.52	3.57		65.1	0.43	0.39	0.39	17.3	
200	4.44	10.489		7.28	3.82	3.93		66.8	0.02	<0.10	1.40	18.6	2.8
440	4.60	10.734		7.29	4.11	4.43		69.8	<0.02	<0.10	3.42	19.6	15.2
					22 September								
0	12.53	6.986	7.08	8.05	0.13	0.60	1.375	12.5	0.04	<0.10	0.19	17.7	
70	3.55	8.316	5.78	7.60	1.18	1.65	1.517	28.2	0.02	4.68	0.14	20.1	
100	4.35	9.843	1.17	7.23	2.68	3.93	1.614	57.1	0.03	4.97	0.12	17.1	
150	4.46	10.396	0.27	7.22	3.06	3.39	1.656	66.2	0.04	1.23	0.55	15.2	
200	4.56	10.522	0.20	7.22	3.28	3.74	1.693	69.7	0.02	<0.10	1.89	16.6	
440	4.64	10.667		7.28	3.24	4.55	1.664	74.4	<0.02	<0.10	4.53	19.3	16.5
					15 November								
0	5.54	7.416	8.35	8.03	0.46	0.70	1.425	14.5	0.17	1.38	0.64	18.6	
70	3.96	8.651	4.40	7.44	1.63	1.89	1.543	31.6	0.03	5.62	0.18	18.2	
100	4.40	10.041	0.50	7.18	3.09	3.64	1.577	48.3	0.05	2.88	0.31	13.5	
150	4.58	10.407		7.18	3.38	3.84	1.619	54.8	0.02	<0.10	1.50	14.5	1.2
200	4.58	10.448		7.18	3.43	3.91	1.630	55.9	0.04	<0.10	1.87	15.6	2.6
440	4.64	10.588		7.20	3.77	4.51	1.643	60.0	<0.02	<0.10	4.07	18.5	15.3

Tabell 4.

FIG. 1

Broken line: area with oxygen concentration less than 2 ml/l

Shading: area containing hydrogen sulfide

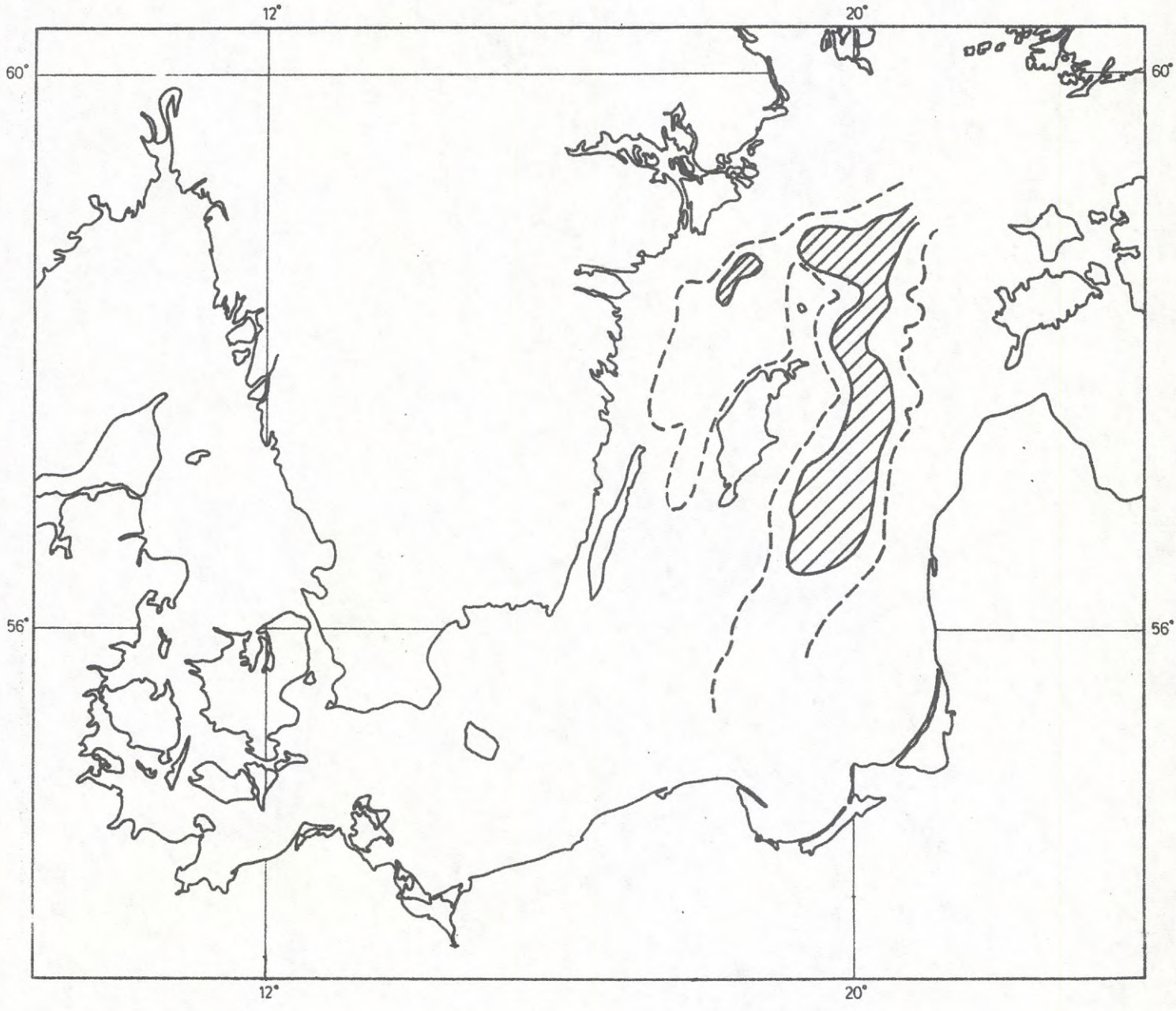

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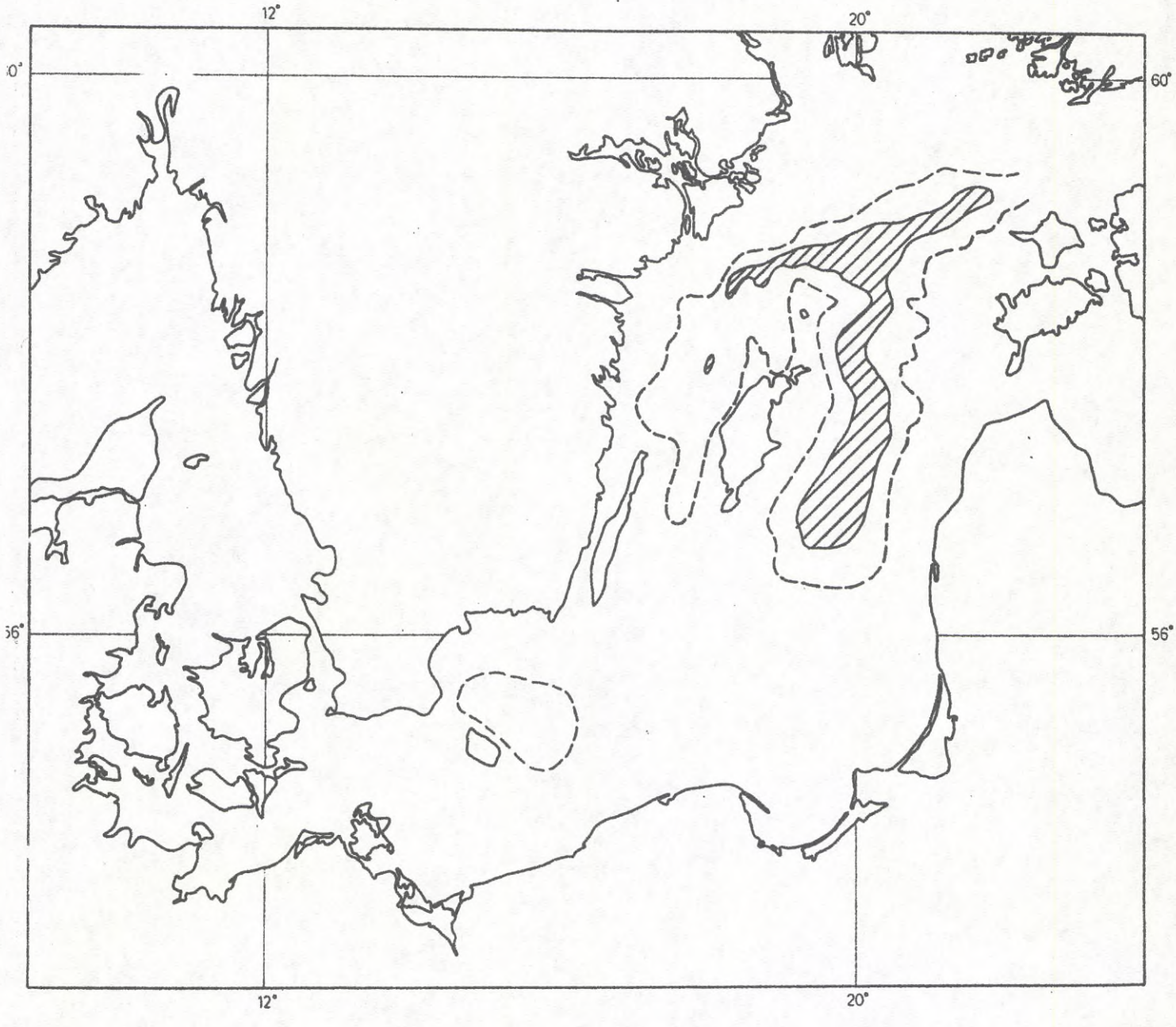
FIG. 2

Broken line: area with oxygen concentration less than 2 ml/l

Shading: area containing hydrogen sulfide



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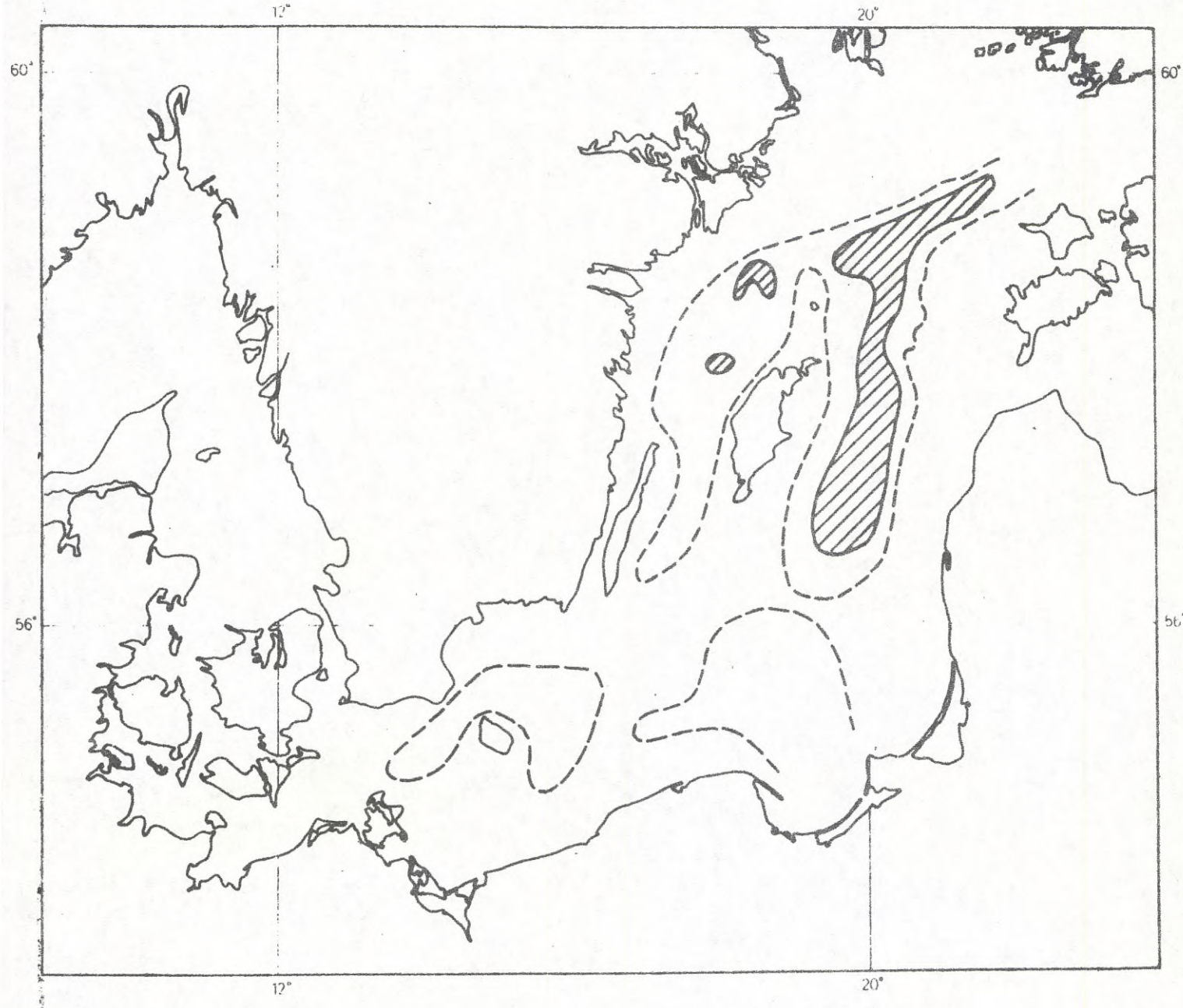
Broken line: area with oxygen concentration less than 2 ml/l

Shading: area containing hydrogen sulfide

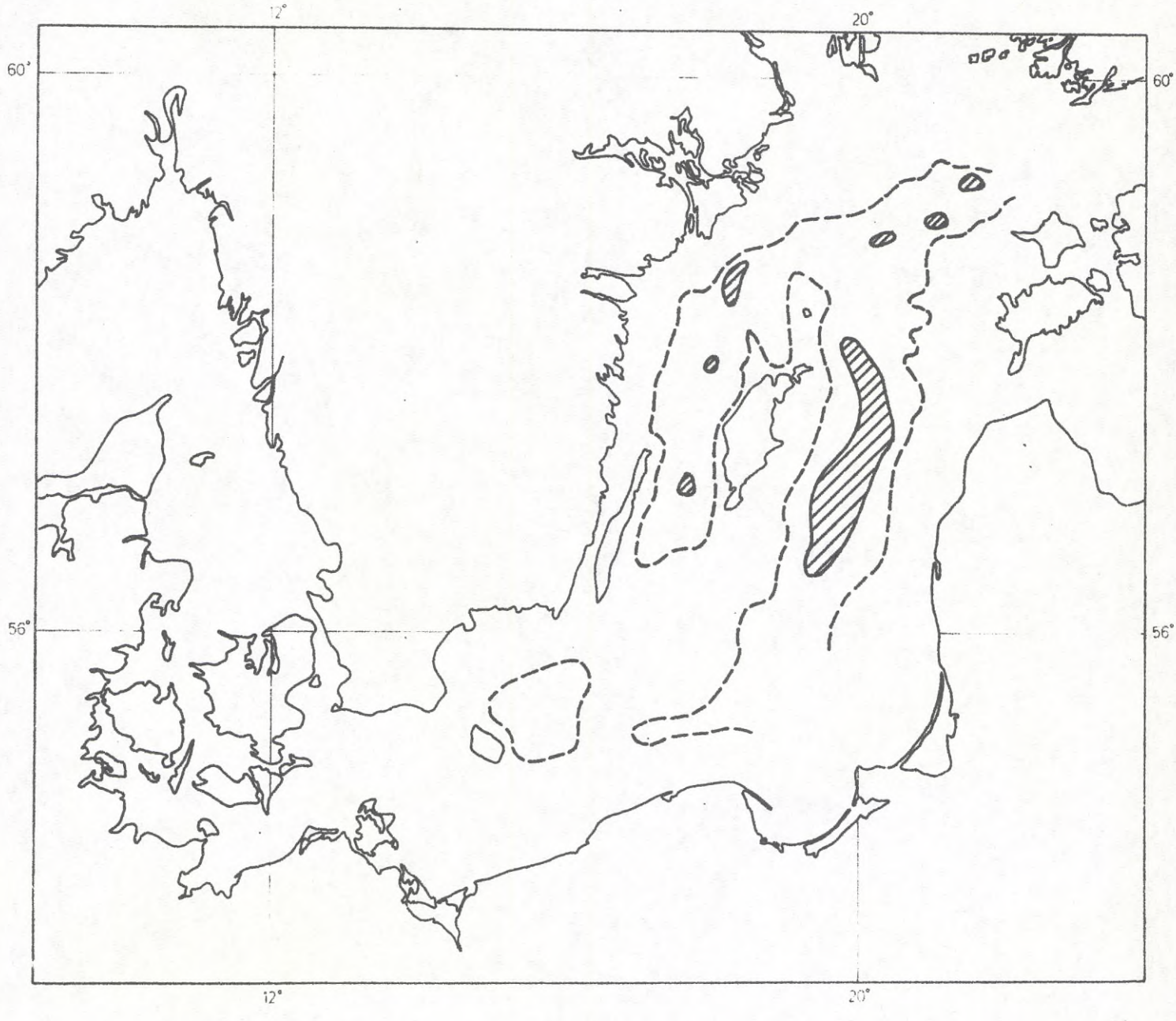


R/V 1983 09 18- 09 23

Fig. 4

Broken line: area with oxygen concentration less than 2 ml/l

Shading: area containing hydrogen sulfide



R/V ARGOS 1983 11 14 – 12 05

Hydrography of the Kattegat and the Skagerrak area 1983.

The results of daily measurements of temperature and salinity made at the Swedish hydrogragphical station Bornö in the Gullmar Fjord (Fig. 1) are presented in Fig:s 2 and 3 as deviations from the mean values 1931 - 1960. Generally salinity was lower than normal in the first part of the year but higher than normal in the latter half.

Just as last year some data from the deepest station of the Norwegian section Torungen - Hirtshals are presented (Table 1). There are no large changes in the deepest parts of the Skagerrak. Salinity at 200 m in the Jutland current continuation (Fig. 1 : Å 17) had risen to its normal value after the minimum in 1977 according to Swedish measurements.

Table 2 shows oxygen saturation values in the Kattegat. Related to means 1966 - 80 (Ann. Biol. 1980) negative anomalies were found in July and August. Conditions in the Laholm Bight were this year same or somewhat better than in 1982 (Rydberg pers. comm.).

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Torungen-Hirtshals (58°08'N 09°11'E)

Depth m	Temp °C	S	Sigma-t	O_2 ml/l	O_2 %
		17 Jan			
200	7.48	35.083	27.436		
300	6.78	35.140	27.580	5.67	82.5
400	5.88	35.096	27.665	6.30	89.9
500	5.38	35.086	27.719	6.51	91.8
600	5.14	35.081	27.744	6.42	90.1
		15 Mar			
200	7.14	35.136	27.527		
300	6.44	35.128	27.617	6.10	88.2
400	5.64	35.088	27.687	6.34	90.0
500	5.33	35.088	27.727	6.50	91.6
600	5.19	35.069	27.728	6.48	91.0
		11 May			
200	6.53	35.105	27.586		
300	7.13	35.112	27.509	6.42	
400	5.88	35.098	27.666	6.43	
500	5.45	35.088	27.713	6.17	
600	5.22	35.069	27.725	6.26	
		17 Aug			
200	6.31	35.124	27.631		
300	6.15	35.144	27.667	6.27	90.1
400	5.21	35.094	27.746	6.38	89.6
500	5.44	35.102	27.725	5.66	79.9
600	5.39	(35.279)	(27.871)	6.05	85.5
		11 Oct			
200	6.38	35.116	27.616		
300	6.33	35.151	27.650	6.24	89.9
400	6.02	35.130	27.673	6.29	90.0
500	5.65	35.100	27.697	6.19	87.8
600	5.34	35.090	27.728	6.03	85.3
		12 Dec			
200	7.29	35.177	27.538		
300	6.90	35.173	27.589	5.77	84.3
400	6.44	35.161	27.643	6.08	87.9
500	5.92	35.124	27.682	6.12	87.5
600	5.48	35.094	27.713	6.01	85.0

Depth m	Temp °C	S	Sigma-t	O_2 ml/l	O_2 %
		15 Feb			
200	7.34	35.142	27.503		
300	6.86	35.140	27.569	6.07	88.6
400	5.87	35.106	27.674	6.19	88.2
500	5.55	35.096	27.706	6.37	90.2
600	5.25	35.073	27.724	6.37	89.6
		4 Apr			
200	6.86	35.122	27.555		
300	6.11	35.118	27.652	6.74	96.7
400	5.30	35.075	27.720	6.40	90.0
500	6.00	35.094	27.648	6.38	91.3
600	5.18	35.079	27.737	6.43	90.2
		5 Jul			
200	6.41	34.951	27.481		
300	6.34	35.081	27.593	6.40	92.3
400	6.11	35.096	27.635	6.41	93.1
500	5.98	35.126	27.675	6.41	91.7
600	5.65	35.106	27.702	6.40	90.8
		12 Sep			
200	6.36	35.134	27.632		
300	6.22	35.136	27.652	6.33	91.1
400	5.75	35.100	27.685	6.60	93.8
500	5.39	35.088	27.720	6.26	88.3
600	5.27	35.086	27.733	6.31	88.8
		23 Nov			
200	7.21	35.195	27.563		
300	6.52	35.163	27.634	6.01	87.0
400	6.25	35.159	27.667	6.22	89.5
500	5.77	35.134	27.708	6.10	86.9
600	5.37	35.096	27.729	5.88	82.9

Tab. 1

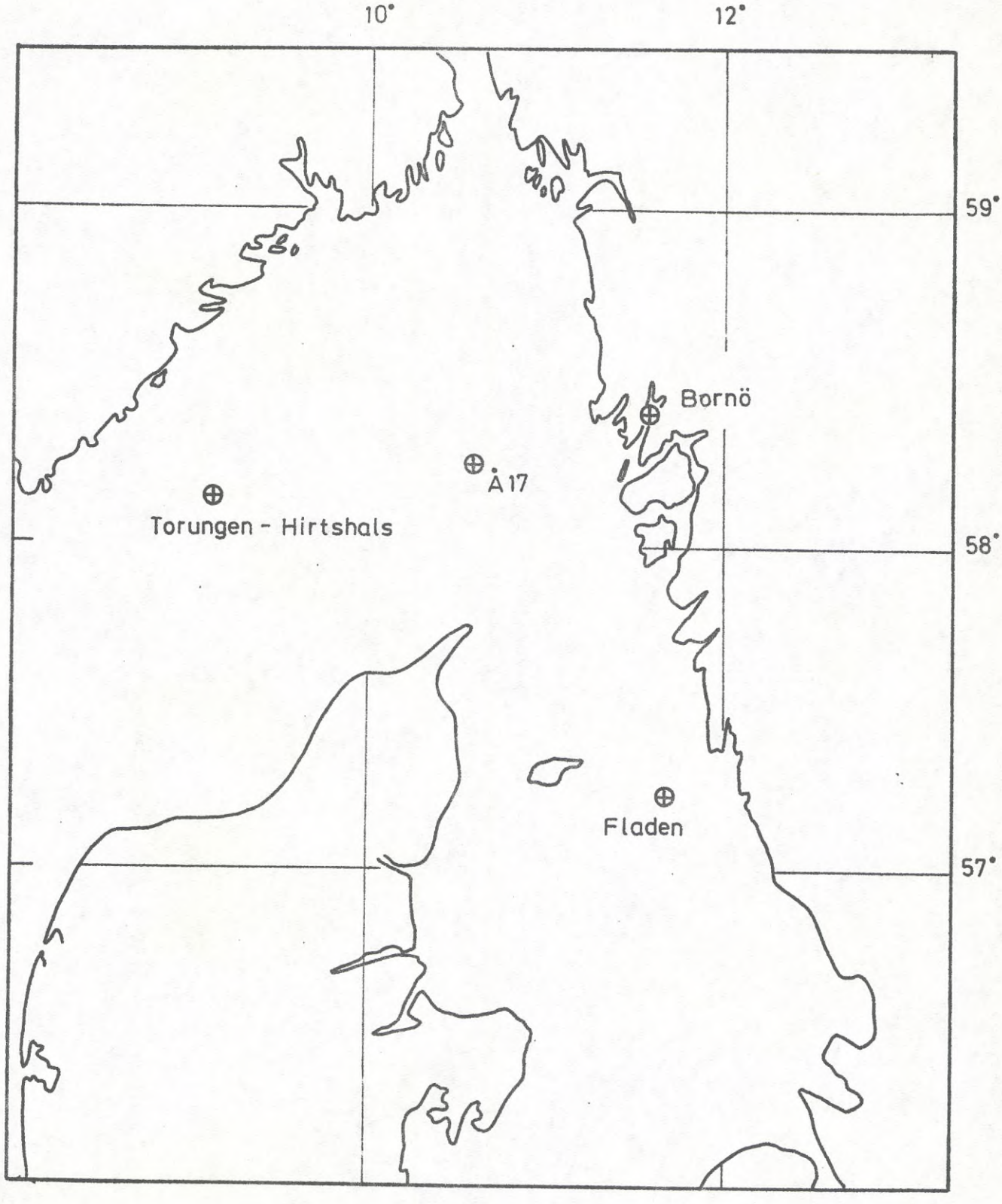
Percentage Oxygen Saturation at $57^{o}11{,}5'N$ $11^{o}40'E$ (Fladen O_2 %)

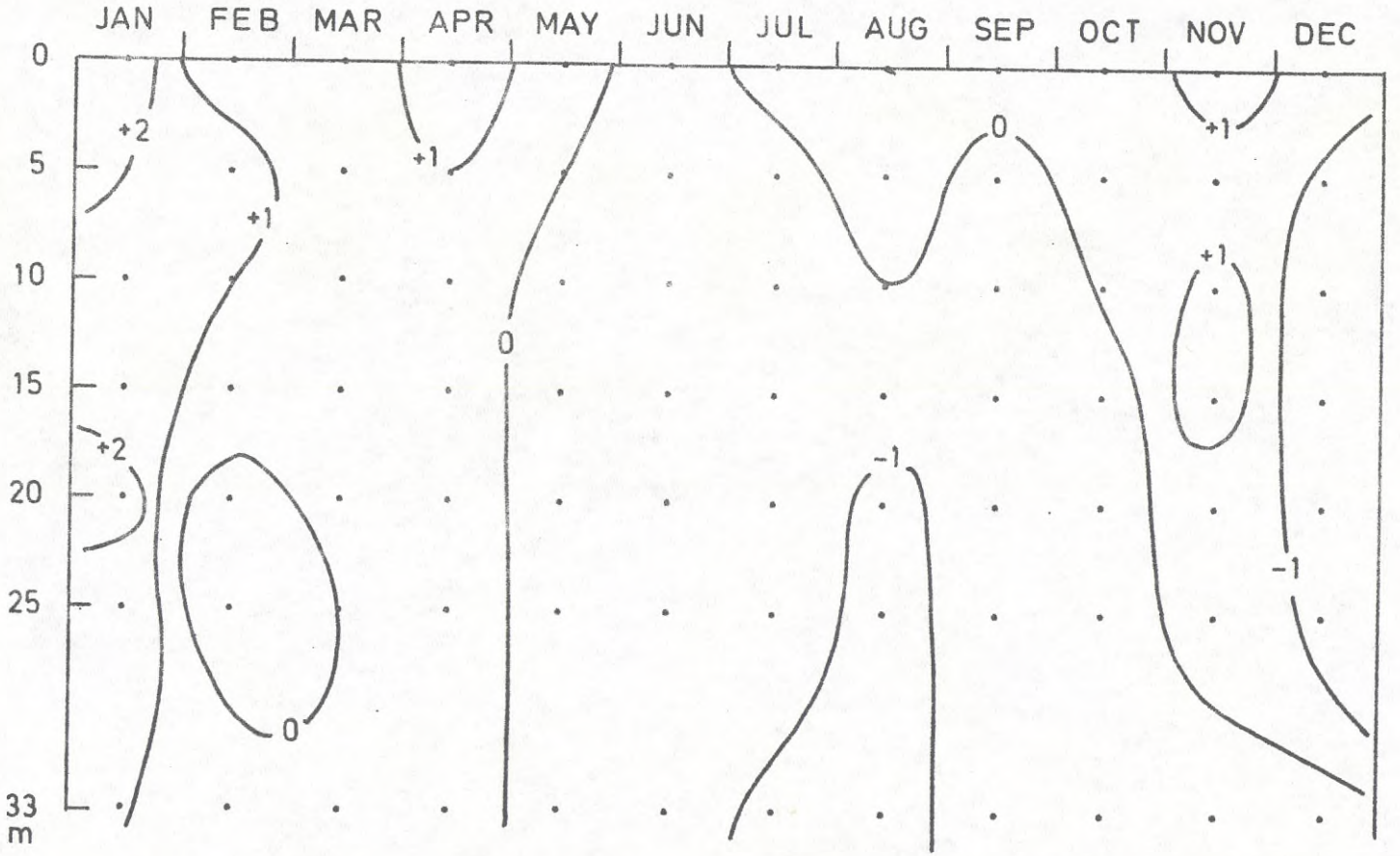
Depth	12 Jan	24 Jan	15 Feb	7 Mar	18 Mar	12 Apr	3 May	6 May
30	105	100	81	98	97	93	100	97
40	103	100	79		94	93	97	93
50	102	98	79	97	92	93	91	89
60	99	98	79	95	93	90	88	88
70	99		78	94	93	90	83	76

Depth	24 May	22 Jun	24 Jul	25 Aug	18 Sep	7 Nov	8 Dec
30	98	88	78	80	98	92	93
40	97	87	74	65	88	89	92
50	95	84	71	57	74	89	93
60	90	82	69	57	64	87	90
70	90	82	69	56	58	88	89

Tab. 2

FIG. 1





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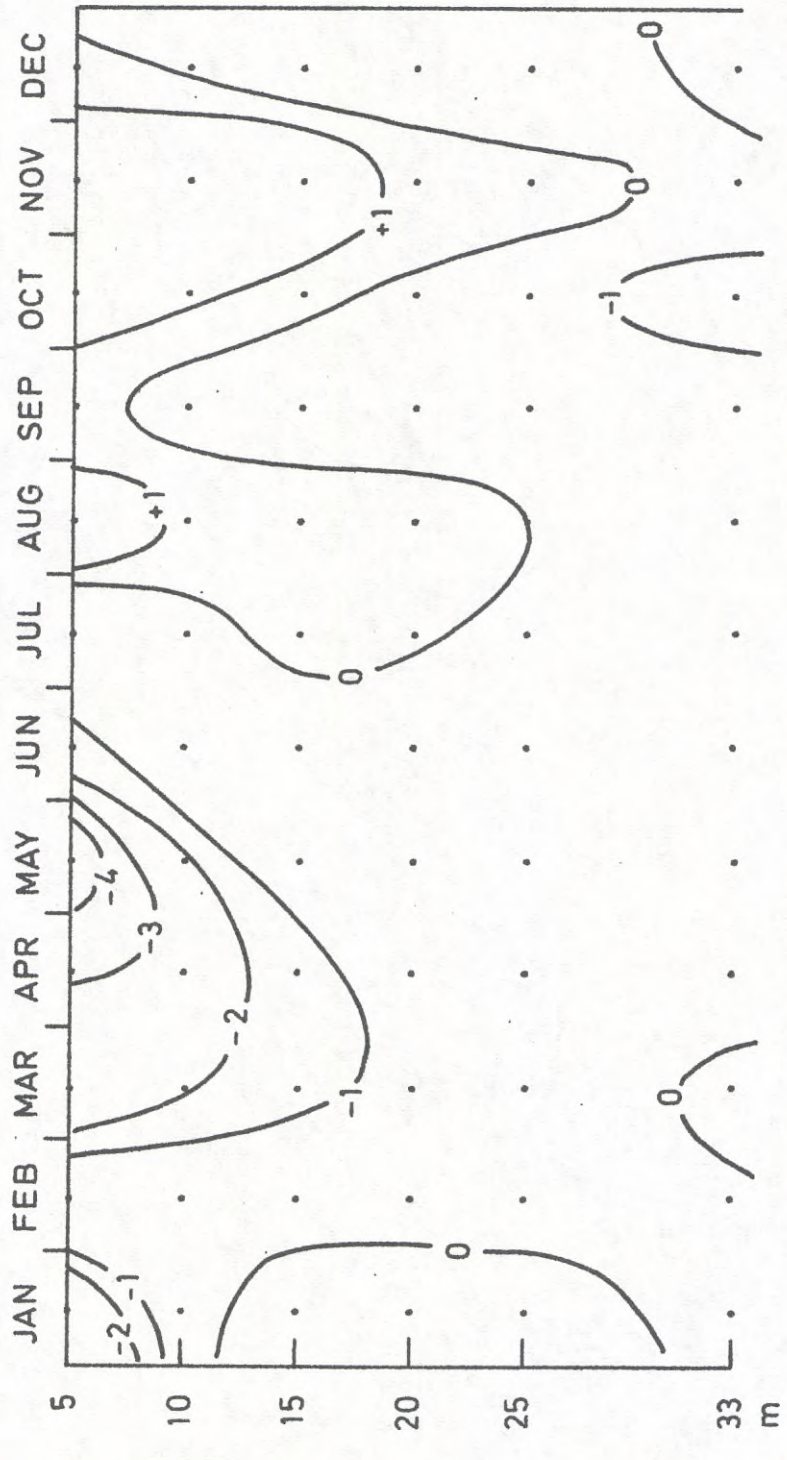
Temperature Deviations °C

FIG. 3



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Salinity Deviations