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Hydrografiska avdelningen, Göteborg.

Observations at Swedish Lightships and in
the Central Baltic.

Hydrography of the Kattegatt and the Skagerrak
Area, Swedish Observations, 1969.

(Contribution to ICES "Annales Biologiques" 1970)

by
Stig H. Fonselius and Artur Svansson

June 1970

Observations at Swedish Lightships and in the Central Baltic in 1969.

During the year the lightship "Finngrundet" has been replaced by an unmanned lighthouse built on a caisson. Hydrographic observations have instead been taken up at the lightship "Västra Banken" at the western border of the Finngrundsbankarna. The position of the "Västra Banken" is $60^{\circ} 54' N$ and $17^{\circ} 56' E$. The measurements began in July and are carried out to a depth of 25 m. Table 1 shows monthly means of salinity and temperature in 1969 at surface and bottom at Swedish lightships with deviations from the 30-year means. The monthly means at "Västra Banken" have been compared to the 30-year means at "Finngrundet" and the deviations from these means are given in the table. The 25 m values have been compared to the corresponding 30 m long time value at "Finngrundet". The deviation are small, but longer series may be needed in order to be able to conclude if the "Västra Banken" values can be considered as a continuation of the values from "Finngrundet". No general conclusions concerning the conditions in the Baltic, can be drawn from the lightship observations.

Table 2 shows the hydrographic parameters in the Arkona basin, the Bornholm basin, the Gotland basin and the Landsort Deep during 1969. It was mentioned in the report for 1968 (Fonselius 1969a) that new high saline water began to stream in to the Baltic at the end of 1968. This inflow is demonstrated in fig. 1 which shows the changes in density in the Arkona basin from September 1968 to November 1969. It can be seen that there has occurred two different inflows of high saline water, the first in October-December 1968 and the second in February-April 1969. Fig. 2 shows the density changes in the Bornholm basin during the same period. It can be seen that the first inflow did not penetrate to the bottom of the Bornholm basin. The second inflow, however, renewed the bottom water, forcing out the H_2S . Table 2b shows that there was 2.39 ml oxygen per liter in the deep water in January 1969. In April the oxygen value had increased to 6.30 ml/l at 87 m depth. Fig. 3 shows the salinity changes in the Gotland Deep from September 1968 to January 1970. During the autumn the high saline water obviously has penetrated to the bottom of the Gotland Deep. From table 2c it can be seen that the H_2S in November has been driven out from the bottom of the basin and that the new water at 240 m contains 1.81 ml oxygen/l. Lower values are found in the water above that level. Fig. 4 shows the development of the oxygen and hydrogen sulfide conditions in the Gotland basin from 1966 to January 1970. A total renewal of the deep water has occurred during 1969. The old stagnant water has been driven out from the basin and has been forced

northwards to the northern Central basin. High H_2S values are now found in the Landsort Deep. From table 2d it can be seen that the H_2S values increase continuously in the Landsort Deep and that the H_2S contaminated water in November extends up to above 150 m.

It may be concluded that the deep water of the Baltic proper, probably will be totally renewed during 1970. All the accumulated nutrients will eventually be brought to the surface water "fertilizing" it. This will increase the primary production enormously and will cause an increased oxygen utilization in the deep water (Fonselius 1969b). The final result will be a new H_2S formation in the deep water of the Baltic proper.

It has to be pointed out that the total P values in the deep water of the Landsort Deep in January and April are considerably lower than corresponding the phosphate-phosphorus values (table 2d). The reason for this error has not been found. It is not possible at present to judge if the PO_4 -P or the Total-P values are erroneous. Therefore the author has preferred to publish both values.

References.

- Fonselius Stig H. 1969a. Observations at Swedish Lightships and in the Central Baltic in 1968. *Annales Biologiques* Vol XXV p. 74.
- 1969b. On the stagnant Conditions in the Baltic. *Abstracts of Gothenburg Dissertations in Science* nr 14 p 14.

Stig H. Fonselius

Table 1.

Monthly means of salinity and temperature in 1969 at surface and bottom at Swedish lightships with deviations from the 30-year means.

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
<u>"Finngrundet"</u>														
Salinity	Surface	5.5	---	---	---	5.6	5.6							
Deviation		+0.1				+0.2	+0.1							
Salinity	Bottom 30m	5.5	---	---	---	5.6	5.6							
Deviation		-0.3				-0.1	-0.1							
Temperature	Surface	1.0	---	---	---	1.7	7.9							
Deviation		-0.6				-1.5	+0.6							
Temperature	Bottom 30 m	1.1	---	---	---	1.6	3.2							
Deviation		-0.5				-1.2	-1.3							
<u>"Västra Banken"</u>														
Salinity	Surface							^x (5.1)	5.1	5.3	5.3	---	5.5	
Deviation								-0.3	-0.2	+0.1	⁺ 0		+0.2	
Salinity	Bottom 30 m							(5.5)	5.6	5.5	5.4	---	5.6	
Deviation								-0.3	-0.1	-0.3	-0.3		-0.1	
Temperature	Surface							(15.8)	17.5	12.4	8.4	5.0	1.7	
Deviation								+2.0	+1.9	+0.3	+0.4	-0.1	-1.3	
Temperature	Bottom 30 m							(4.9)	4.2	6.6	8.0	5.0	2.0	
Deviation								-0.3	-1.1	+0.8	+1.5	-0.1	-0.9	
x() = 18-31/7														
<u>"Falsterborev"</u>														
Salinity	Surface	7.8	7.7	7.4	8.0	7.6	7.4	7.9	7.6	7.9	9.2	12.2	9.2	8.3
Deviation		-0.4	-0.4	-0.4	+0.5	+0.2	-0.1	⁺ 0	-0.3	-0.1	+0.8	+3.9	+0.9	+0.4
Salinity	Bottom 10 m	7.8	7.8	7.4	8.2	7.6	7.5	8.1	7.6	8.0	9.2	12.8	9.2	8.4
Deviation		-0.7	-0.5	-0.4	+0.6	+0.1	-0.1	⁺ 0	-0.6	-0.2	+0.5	+4.5	+0.7	+0.3
Temperature	Surface	2.8	1.0	0.4	2.6	6.1	13.2	16.2	18.9	16.4	12.9	8.9	4.1	8.7
Deviation		-0.1	-0.8	-1.6	-1.1	-1.7	+0.8	+0.4	+2.4	+1.7	+1.2	+0.5	-1.0	+0.1
Temperature	Bottom 10 m	2.8	1.2	0.4	2.6	6.0	12.0	15.1	18.8	15.9	12.8	9.1	4.1	8.5
Deviation		-0.1	-0.6	-1.6	-1.0	-1.5	+0.2	+0.5	+3.1	+1.3	+1.1	+0.7	-1.0	+0.2

Arkona Deep
55°00'N 14°03'E

Depth M	Temp. °C	S ‰	O ₂ ml/l	pH	PO ₄ -P µgat/l	Tot.P µgat/l	Alkal. Mval/l	Si µgat/l	NO ₃ -N µgat/l	NO ₂ -N µgat/l	NH ₄ -N µgat/l	Tot.N µgat/l
January 21												
000	1.68	7.87	9.10	8.24	0.25	1.04	1.58	10.15	3.13			
010	1.69	7.87	9.11	8.23	0.29	0.61	1.59	9.31	3.00			
030	2.35	7.92	8.90	8.27	0.24	0.53	1.64	9.41	3.04			
045	5.91	15.07	6.60	8.01	0.69	0.90	1.81	16.77	4.67			
February 4												
000	2.18	8.00	9.11		0.35							
010	2.16	8.00	9.04		0.35							
030	3.49	11.76	7.45		0.62							
045	3.78	20.40	7.10		1.05							
April 15												
000	2.69	7.96	9.65	8.18	0.11	0.50	1.56	7.35	0.00			
010	2.63	7.96	9.64	8.19	0.08	0.44	1.57	4.05	0.10			
030	2.77	12.98	9.97	8.31	0.13	0.43	1.76	1.00	0.35			
045	2.27	21.63	7.61	8.11	0.50	0.71	2.05	4.35	1.45			
November 12												
000	9.44	9.20	7.38	8.19	0.21	0.43	1.65	12.0	1.08	0.38	0.57	22.34
010	9.51	9.32	7.43	8.20	0.22	0.38	1.62	12.0	0.96	0.39	0.66	12.18
030	11.44	13.51	6.14	8.05	0.50	0.56	1.76	18.0	1.30	0.25	0.88	18.12
045	10.54	20.97	5.69	8.07	0.92	1.02	2.00	18.5	1.67	0.31	1.78	20.16

Table 2 b

Bornholm Deep
55°15'N 15°59'E

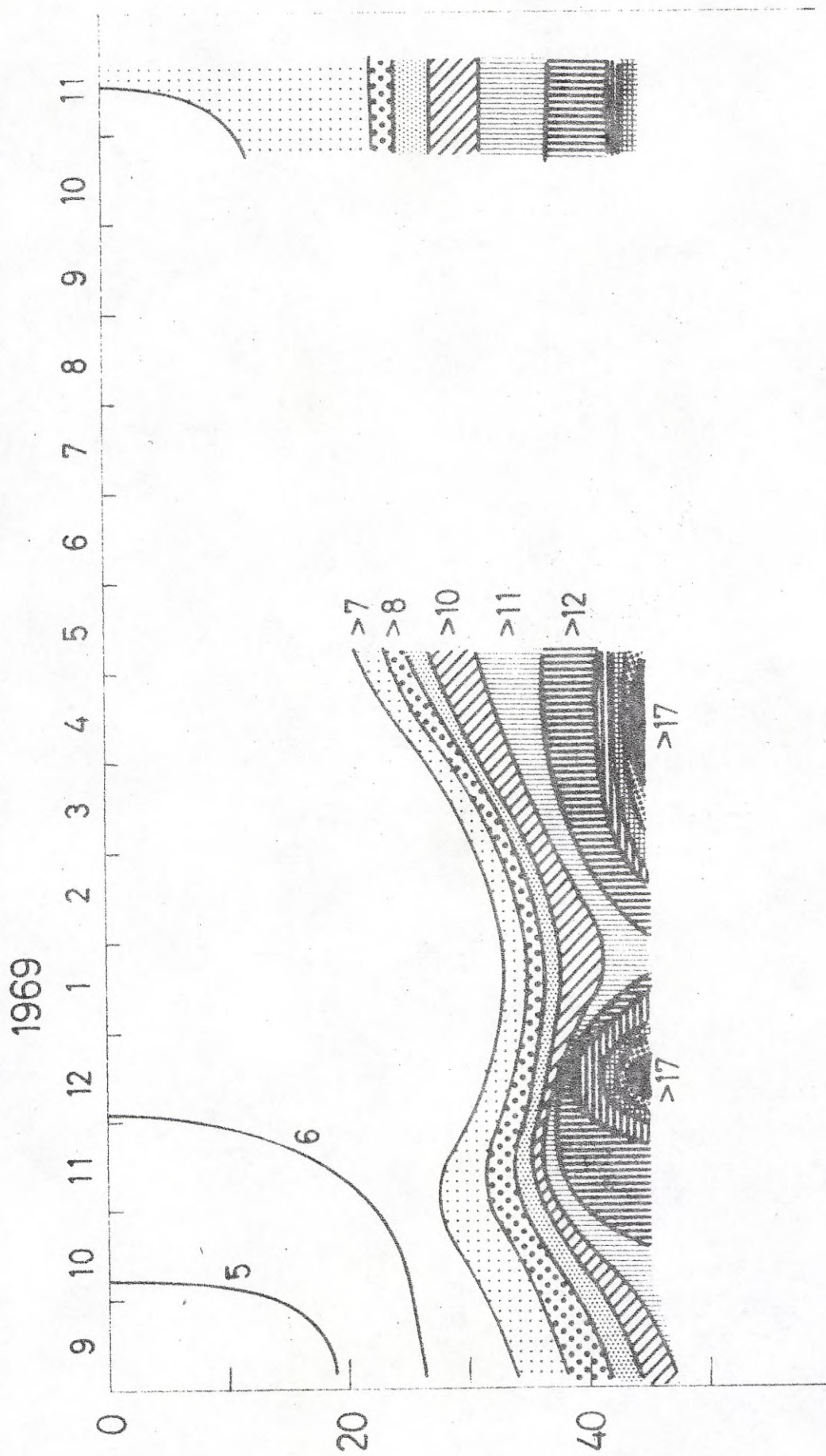
Depth M	Temp. °C	S ‰	O ₂ ml/l	pH	PO ₄ -P µgat/l	Tot.P µgat/l	Alkal. Mval/l	Si µgat/l	NO ₃ -N µgat/l	NO ₂ -N µgat/l	NH ₄ -N µgat/l	Tot.N µgat/l
January 22												
000	3.69	7.58	8.74	8.00	0.14	0.51	1.55	4.99	1.42			
010	3.69	7.58	8.64	8.21	0.12	0.47	1.55	10.05	1.60			
030	3.69	7.59	8.67	8.22	0.23	0.53	1.54	9.22	2.18			
050	8.44	9.58	5.31	7.80	0.58	0.92	1.62	19.18	3.50			
070	9.22	13.86	2.86	7.54	1.21	1.34	1.78	37.22	4.67			
085	8.83	15.44	2.39	7.51	2.41	(6.30)	1.87	44.20	4.84			
February 4												
000	3.39	7.53	8.62		0.37							
010	3.46	7.53	8.70		0.35							
030	3.35	7.53	8.74		0.36							
050	5.97	11.13	6.70		0.58							
070	7.66	14.63	1.72		2.17							
087	7.99	15.60	2.09		2.32							
April 15												
000	1.94	7.59	9.82	7.99	0.07	0.59	1.55	9.60	0.25			
010	1.96	7.59	9.89	8.07	0.26	0.53	1.56	6.90	0.10			
030	1.88	7.60	9.72	8.06	0.07	0.42	1.55	7.35	0.10			
050	0.86	8.47	9.35	7.93	0.38	0.47	1.57	12.20	2.55			
070	5.81	14.99	3.40	7.38	1.45	1.43	1.83	37.40	5.75			
087	3.28	16.90	6.30	7.72	1.04	1.09	1.88	21.15	5.95			
November 14												
000	8.26	7.55	7.65	8.11	0.20	0.36	1.58	11.0	1.03	0.25	1.45	17.34
010	8.24	7.55	7.61	8.12	0.14	0.32	1.56	11.5	--	0.23	1.94	14.06
030	8.14	7.54	7.59	8.10	0.13	0.29	1.56	11.5	0.50	0.22	0.86	14.37
050	8.25	7.55	7.61	8.10	0.14	0.30	1.55	11.5	0.41	0.22	0.88	12.03
070	7.20	15.48	2.53	7.51	0.98	1.13	1.84	43.0	3.01	--	1.34	--
087	5.25	16.63	2.05	7.49	1.21	1.38	1.88	51.0	4.59	0.02	1.81	22.03

Table 2 c

Gotland Deep													
57°20'N 20°03'E													
Depth	Temp.	S	O ₂	pH	PO ₄ -P	Tot.P	Alkal.	Si	NO ₃ -N	NO ₂ -N	NH ₄ -N	Tot.N	H ₂ S
M	°C	‰	ml/l		µgat/l	µgat/l	Mval/l	µgat/l	µgat/l	µgat/l	µgat/l	µgat/l	µgat/l
January 25													
000	2.31	7.29	9.01	8.00	0.23	0.41	1.56	8.75	1.00				
070	3.48	8.36	4.60	7.37	0.88	1.01	1.59	30.48	2.15				
100	4.66	10.71	0.41	7.05	1.86	1.87	1.74	42.50	4.50				
150	5.48	12.17		7.17	3.77	3.82	1.75	76.30	0.60				11.3
200	5.68	12.56		6.51	4.90	5.03	1.82	84.50	1.05				25.4
240	5.79	12.70		7.22	6.30	6.87	1.86	99.30	0.75				51.0
April 19													
000	0.86	7.30	10.10	8.03	0.09	0.63	1.52	5.75	0.05				
070	4.00	9.53	1.67	7.09	1.87	1.92	1.65	47.60	3.20				
100	5.38	10.81	0.77	6.95	1.81	2.27	1.68	58.00	7.10				
150	5.60	12.24	0	6.99	4.17	4.95	1.72	73.60	0.05				15.2
200	5.71	12.54	0	7.00	5.27	6.03	1.83	83.20	0.05				35.5
240	5.75	12.64	0	7.06	6.36	6.83	1.83	95.60	0.10				50.0
November 15													
000	6.44	7.39	7.96	8.09	0.15	0.27	1.53	11.5	0.38	0.13	0.35	7.25	
070	3.42	9.01	3.10	7.40		1.15	1.65	--	1.18	0.04	0	13.30	
100	5.10	11.13	1.37	7.30	1.73	1.73	1.68	51.0	2.46	0.03	0.10	22.58	
150	5.29	12.32	0.33	7.25	3.35	3.34	1.76	74.0	2.23	0.05	0.52	20.98	
200	5.38	12.61	0.48	7.30	3.80	3.79	1.80	72.5	2.27	0.19	3.21	27.32	0
240	5.71	12.93	1.81	7.39	1.85	2.00	1.77	47.0	2.66	0.07	0.10	31.52	0

Landsort Deep														
58°35'N 18°14'E														
Depth	Temp.	S	O ₂	pH	PO ₄ -P	Tot.P	Alkal.	Si	NO ₃ -N	NO ₂ -N	NH ₄ -N	Tot.N	H ₂ S	NH ₂ OH
M	°C	‰	ml/l		µgat/l	µgat/l	Mval/l	µgat/l	µgat/l	µgat/l	µgat/l	µgat/l	µgat/l	µgat/l
January 23														
000	1.96	6.86	9.18	8.03	0.27	0.55	1.48	16.56	2.47					
070	4.02	7.83	6.21	7.77	0.61	0.80	1.58	15.19	1.95					
100	5.47	10.03	0.82	7.30	2.56	2.14	1.69	61.90	1.58					
150	4.70	10.74	0.10	7.27	3.18	2.52	1.72	68.30	0.40					
200	4.70	10.77	0.10	7.29	3.24	2.97	1.64	66.80	0.25					
440	4.82	10.93	0	7.35	3.50	2.97	1.74	64.10	0.30				3.58	
April 17														
000	1.21	6.88	10.26	7.99	0.17	0.51	1.50	6.80	0.50					
070	4.09	9.58	1.53	7.07	2.14	1.81	1.70	32.70	2.00					
100	4.40	10.17	0.49	7.09	2.80	2.29	1.71	40.90	1.25					
150	4.68	10.65	0.20	7.03	3.33	2.92	1.73	51.30	0.25					
200	4.77	10.82	0	7.01	3.74	3.14	1.76	45.20	0.05				2.14	
440	4.85	10.89	0	7.06	3.73	3.56	1.77	53.40	0.00				1.30	
November 18														
000	5.61	7.17	7.93	7.92	0.45	0.59	1.48	21.0	0.64	0.21	0	11.08		
070	4.60	9.22	2.37	7.25	1.68	1.84	1.66	48.0	0.66	0.04	0.06	17.53		
100	4.71	10.44	0.22	7.15	2.61	2.87	1.72	66.0	0.52	0.12	0.47	14.48		0.28
150	4.86	10.72	0	7.15	2.63	3.25	1.73	71.0	0.02	--	1.60	--	7.3	0.03
200	4.92	10.88	0	7.14	2.71	3.40	1.74	71.5	0.01	0	2.07	14.28	9.8	0.02
440	4.97	10.92		7.15	2.69	3.60	1.74	72.5	0	0.02	2.54	18.04	15.3	--

Fig. 1



St Arkona Sep. 1968 — Nov. 1969

1969

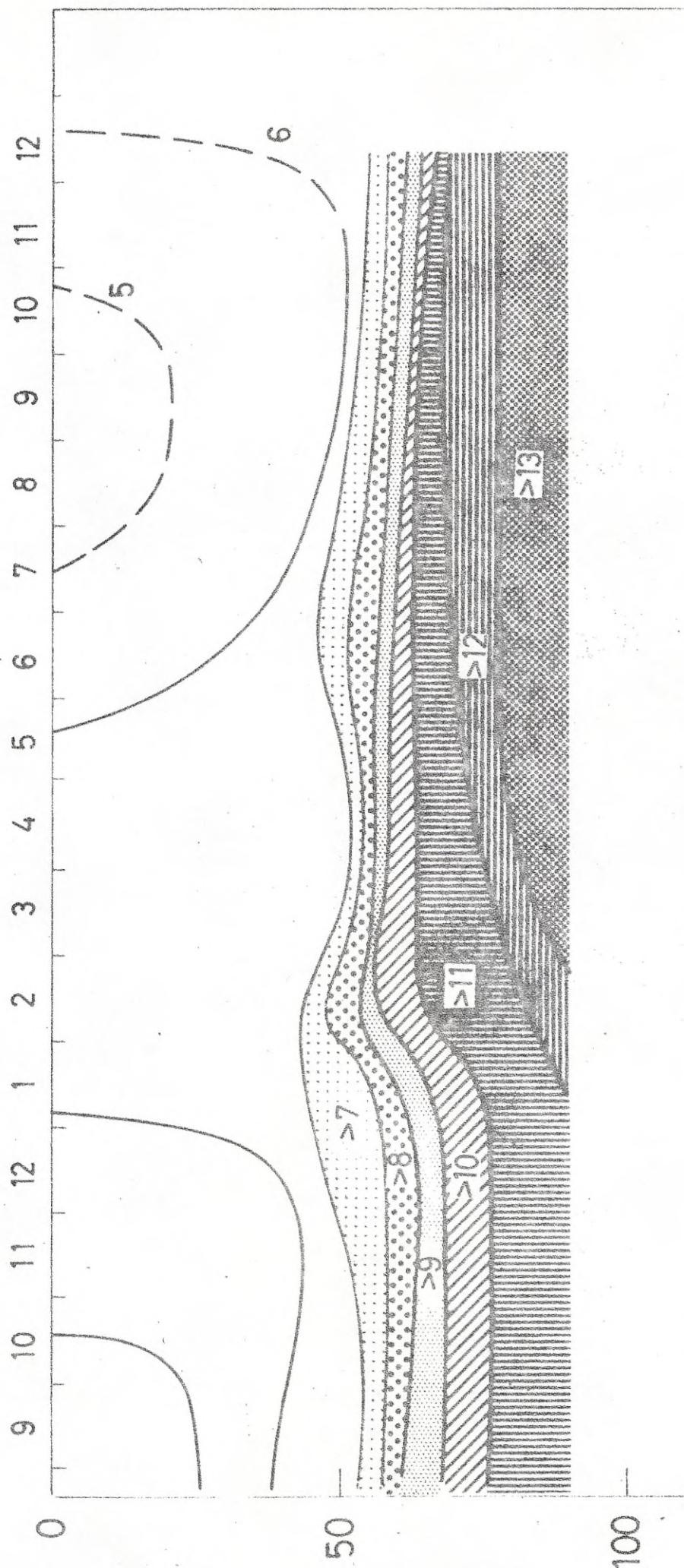


Fig. 2

σ_t Bornholm Deep Sep. 1968 — Nov. 1969

1970

1969

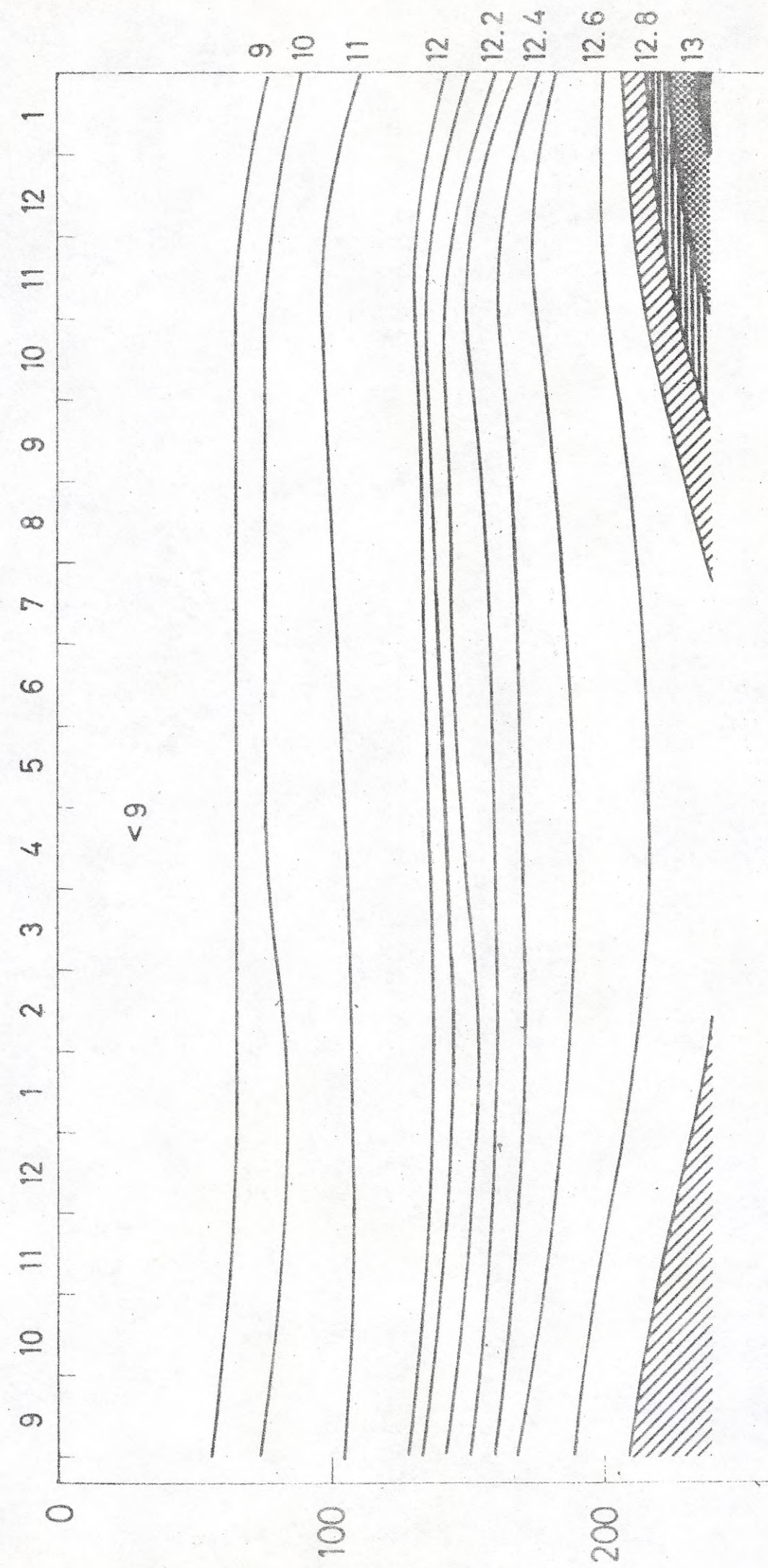
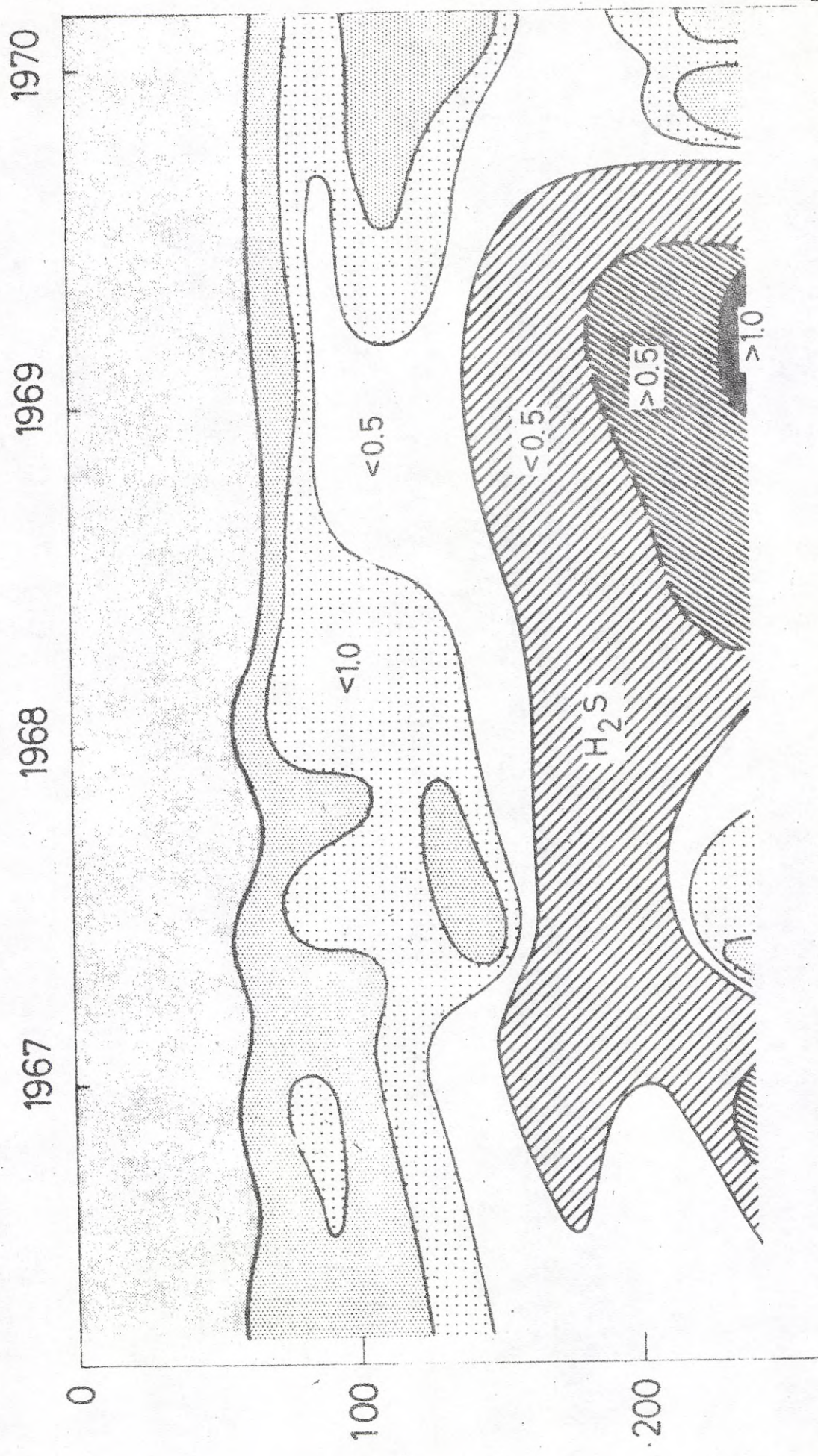


Fig. 3

‰ S Gotland Deep Sep. 1968 - Jan. 1970

Fig. 4



O_2 and H_2S in the Gotland Deep
1966 — 1970

Hydrography of the Kattegat and the Skagerrak Area,
Swedish Observations 1969.

Table 1 presents monthly mean values of temperature and salinity at the lightship Fladen until the vessel left its position for ever. The anomalies of bottom salinity were positive throughout the whole period January-September. The negative correlation between surface and bottom temperatures is striking.

Tables 2 and 3 contain oxygen values from the Kattegat area (Station D from Town of Göteborg investigations). The fact that the minimum values this year are higher than the year before may be due to the many violent storms in September and October.

The sections P and Å (See map) were visited in March, June, August and December (Section P also in October). Oxygen were determined everywhere when temperature and salinity were measured. Fig. 1 presents the conditions in March. The lowest value at the deeper parts of the P section at this occasion was 81 %, while in June it was 85 %, in August 81 %, October 91 % and in December 90 %.

The present Fig. 2 was already published in *Annales Biologiques* of the year 1967 but is reproduced here brought up to date. The winter period in the beginning of the year was apparently cold enough to lower the temperature down to 600 m.

Artur Svansson

Table 2.

Percentage Oxygen Saturation at 57°11.5'N 11°40'E (A) and at Fladen lightship (B).

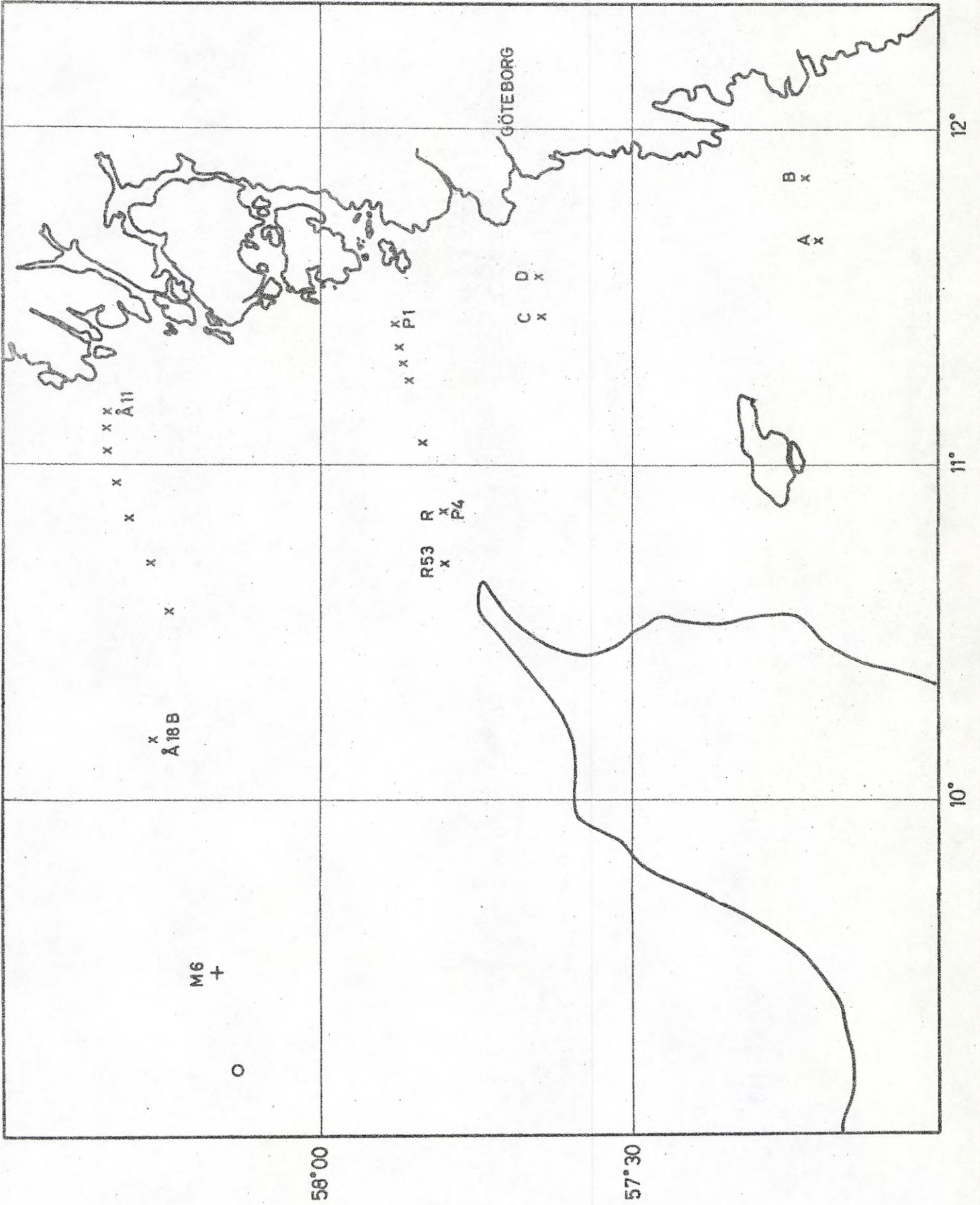
Depth	A	A	B	B	B	B	B	B	B
	Jan. 20	April 14	April 16	May 1	May 16	June 1	June 16	July 1	July 16
30	92.7	84.7	93.9	83.6	93.4	92.2	86.7	83.4	82.9
40	90.6	82.2	99.0	80.4	90.8	91.1	89.0	81.3	75.3
50	91.1	81.0							
60	92.1	80.3							
70	93.1	78.9							

Depth	B	B	B	A	B	B	B	A
	Aug. 1	Aug. 16	Sep. 1	Sep. 11	Sep. 16	Oct. 3	Oct. 18	Nov. 11
30	72.3	91.9	88.2	76.6	110.3	107.8	101.8	96.3
40	76.1	87.6	96.2	73.3	70.5	102.7	94.5	96.5
50				72.8				97.5
60				74.1				95.9
70								95.2

Table 3.

Percentage Oxygen Saturation at Vinga 57°38.5'N 11°26.6'E (C) and at 57°41.2'N 11°25.5'E (D).

Depth m	C	C	C	C	D	C	D	D	C	D
	March 3	April 14	June 9	Aug. 4	Aug. 13	Sep. 11	Sep. 17	Nov. 5	Dec. 8	Dec. 9
30	95.4	96.8	86.6	91.8	100.0	87.9	88.5	96.0	97.1	93.0
40	94.3	104.0	88.9	84.0	99.0	75.6		96.0	95.7	93.5
50	92.2	108.7	85.8	89.5	92.0	73.1	86.0	91.0	95.3	89.0
60	87.5	92.4	85.1	97.8	90.0	79.2		80.0	92.2	
70	82.4	99.6	82.7	93.9		86.7			94.0	
80	82.5		83.4	91.6	85.0			82.0	93.0	92.0



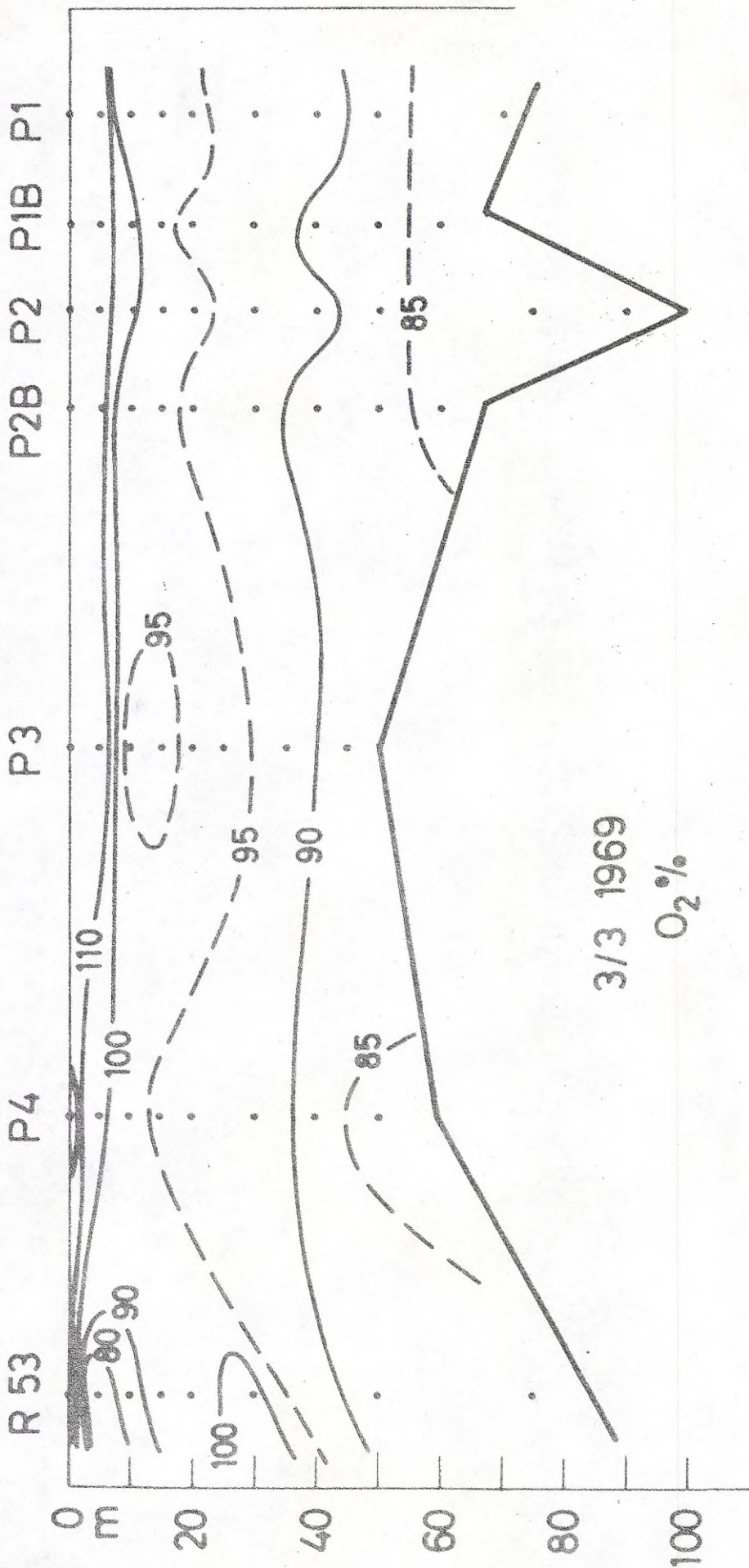


Fig. 1 a

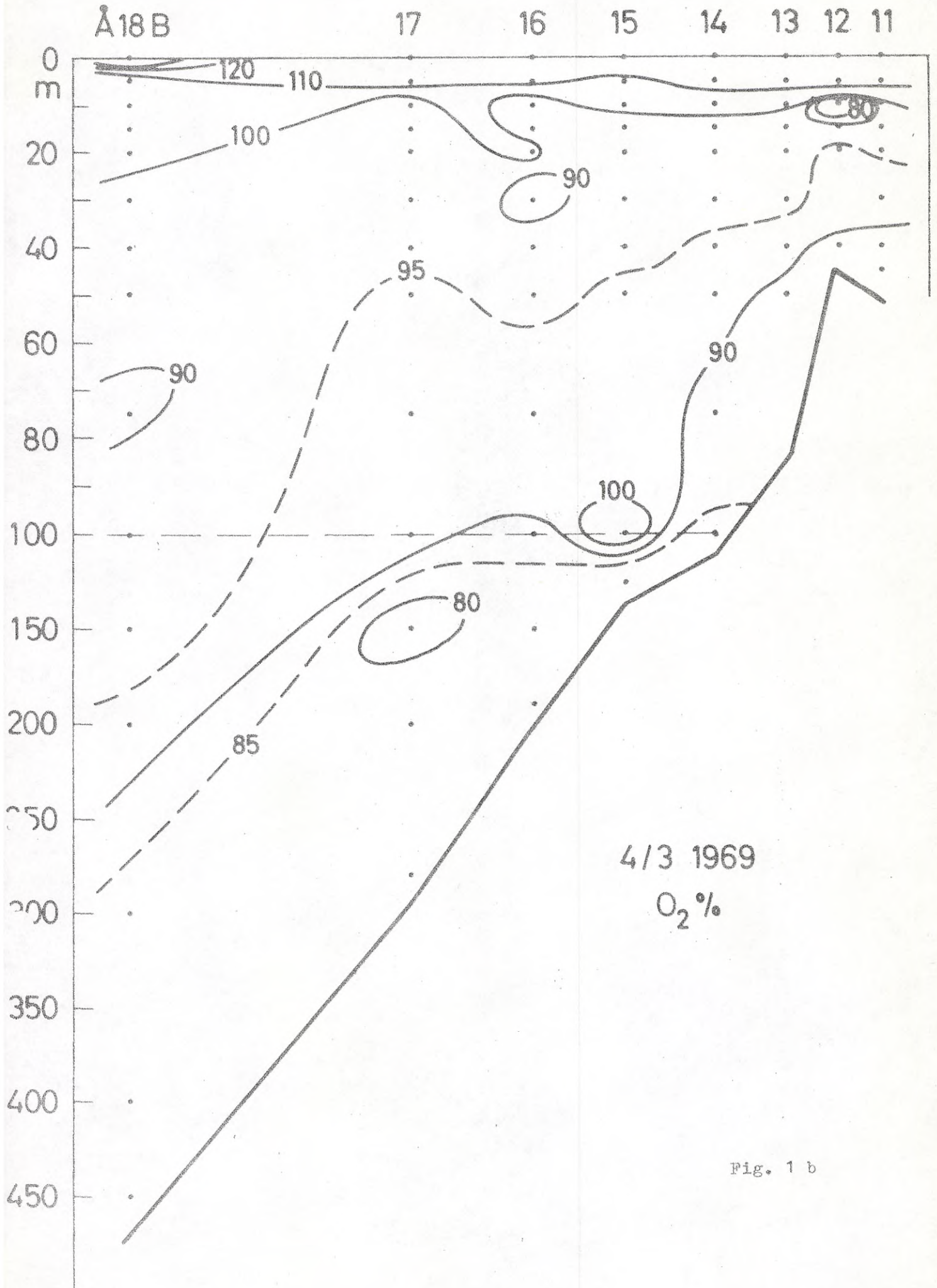


Fig. 1 b

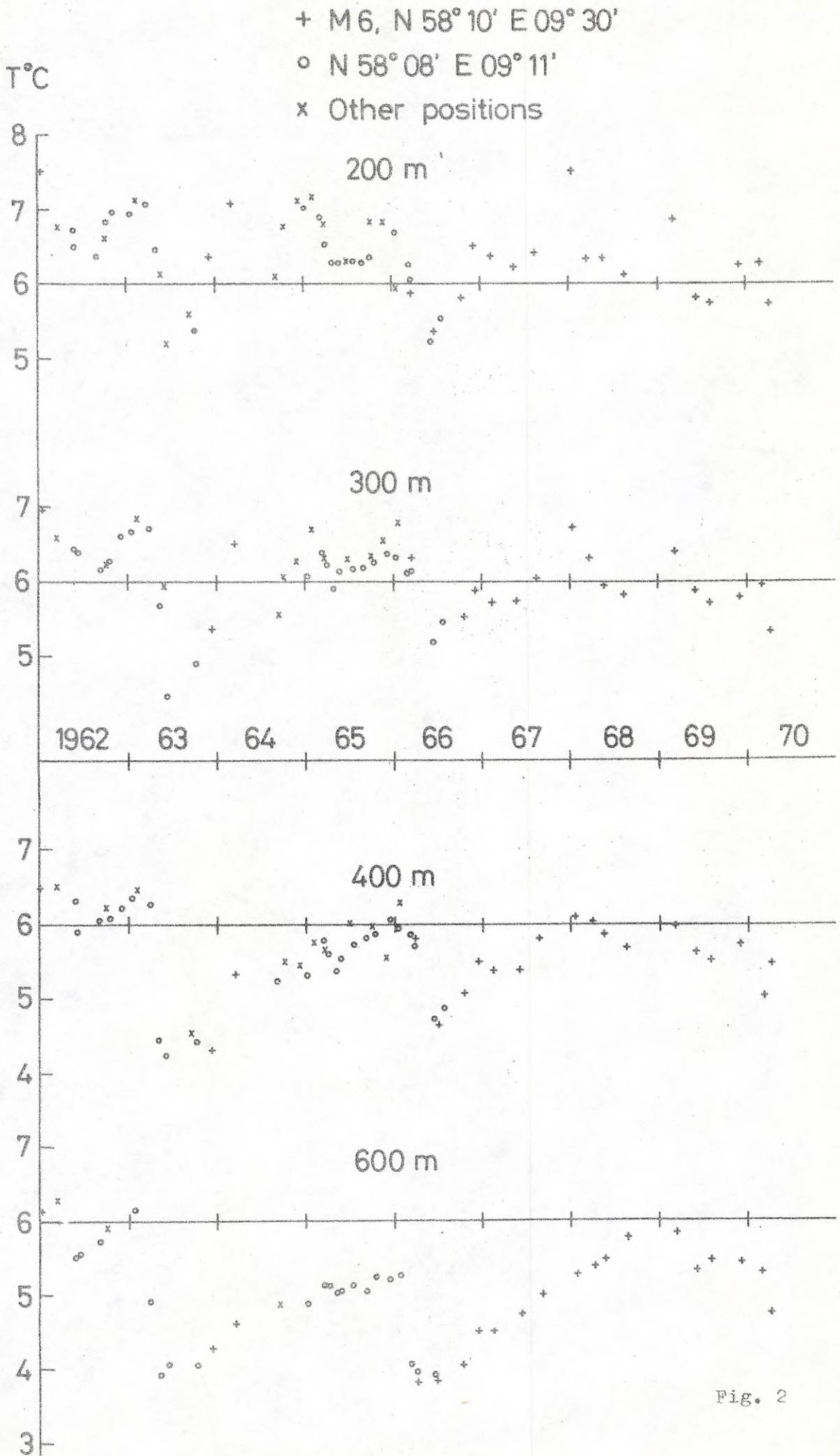


Fig. 2

