Ödsmål, Kville sn, Bohuslän

Hällristning
Fiskare från
bronsåldern

Rock carving
Bronze age
fishermen

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Processing Historical Data from the Gullmar Fjord and the Brofjorden Area.

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Abstract

An oil refinery is under construction at the Brofjorden and a program to investigate the environmental conditions is being carried out. As part of this investigation a study of old data from earlier work in this area has been done. Most data originate from the Gullmar Fjord, particularly the Bornö Station, but also measurements from other stations, regularly visited, could be included and presented as mean values 1962 - 1971.

It is an important task to predict the fate of a pollution discharged into the sea area. As a first rough step daily series of salinity are used to compute these concentrations by means of a simple diffusion model.

Contents.

1. Older Hydrographical Data, Exclusive Bornö Station Data.

1.1. Data Not Punched, 1893 - 1961.

A compilation of old data (1893 - 1966) was made by Engström (1970). Included were data from stations visited regularly during the last 20 years. The oldest data are from the stations situated inside the isle of Orust and in the Gullmar Fjord. Originally only temperature and salinity were determined exept for a few measurements of oxygen in the beginning of the centuary. From about 1950 oxygen (O_2) and pH were determined more regularly and from the end of the 50'ies also phosphate (PO_4-P).

There are numerous publications dealing with the Gullmar Fjord. Classical is the work by Gislén (1929). More recently Svansson (1968) updated the information. In this publication among other things, the conditions of the partly stagnant deep water was considered, a problem which is not taken up in the present paper.

1.2. Data on Punched Cards, 1962 - 1971.

From 1962 hydrographical data have been punched on ICES punch cards (Anon. 1973), "Hydro Master", "Hydro Depth" and "Hydro Chemistry". Since the "Hydro Chemistry" card contains all information from a station where chemical parameters were measured, only this card has been used in a processing of data (1962 - 1971) from 52 stations in the Kattegat and the Skagerrak (See Fig. 1).

Mean values were computed of the following parameters, which are punched on the "Hydro Chemistry" card: temperature (T, degrees centrigade), oxygen (in micromols at NTP per dm^3 of water at 20°C, but in the print out in ml/l), phosphate phosphorus, silicate-silicon, nitrate-nitrogen, nitrite-nitrogen, ammonium-nitrogen, organic nitrogen (all in microgramatoms per dm^3 of water at 20°C), pH and alkalinity (microval per dm^3 of water at 20°C).

The following parameters were computed from some of the punched ones, viz. salinity (‰), σ_t , sound velocity (m/s) and oxygen saturation percentage.

Salinity (S) was computed from the formula

$$Cl = Cls \cdot (1 - 0.0012 \cdot Cls)$$
$$S = Cl \cdot 1.80655$$

where

Cl = chlorinity (parts per thousand)
Cls = chlorosity (grams per dm^3 at 20°C)

The factor 0.0012 was determined as R/Cls^2 where $R = Cls - Cl$ is tabulated in Anon. (1973, page 12).

σ_t was computed from the formulas in Knudsen (1901).

The sound velocity (SV) was computed from the formula

$$SV = 1402.9 + 4.98 \cdot T - 0.05 \cdot T^2 + 1.34 \cdot S - 0.011 \cdot S \cdot T + 0.018 \cdot DP$$

where
DP = depth in metres.

The oxygen saturation percentage was computed according to Weiss (1970, page 721).

1.2.1. The Computer Program.

Since the chemistry-card material consists of measurements from expeditions in the Skagerrak, the Kattegat and the Baltic, we first have to select all cards with stations inside the rectangle which encloses the 52 given ones. Then these cards are sorted with respect to latitude and longitude and saved on magnetic tape. A problem in the computing is that some stations are situated very close to each other and therefore we exclude every card wich contain a position that doesn't agree exactly with any of the 52 given positions. When all this is done we compute ten-years mean values, standard deviations and number of observations of all the parameters for every depth on each station. All results are printed both quarterly and annually.

1.2.2. Results.

From the large amount of mean values we select only some, viz those from the Gullmar Fjord, Brofjorden, the Åby Fjord and Malmödrag. Table 1 (a - e) presents PO_4-P and O_2 from these stations both quarterly and annually. The tables are discussed below as well as the longitudinal sections of PO_4-P, O_2 and S.

1.2.2.1. PO_4-P.

At all stations there is surface minimum in Quarter 3 and surface maximum in Quarter 1. Usually this is also the case at 20 m depth.

Fig. 2 shows a longitudinal section through the Gullmar Fjord and the area outside it (positions in Fig. 1). It is apparent that the concentrations increase from the open sea inwards.

1.2.2.2. O_2.

Most striking is the oxygen minimum at larger depths. At 20 m it occurs usually in Quarter 3.

Fig. 3 shows the same section as in 1.2.2.1. with oxygen. A phospate increase is usually associated with an oxygen decrease.

1.2.2.3. Salinity.

Fig. 4 shows the salinity section. The values decrease at all depths from the open sea inwards.

2. Data from Bornö Station.

2.1. Decade Means of Temperature, Salinity, Density (σ_t) and Sound Velocity, 1961 - 1970.

At the Bornö station temperature and salinty are determined once every day. Temperature is read from a reversing thermometer and salinity is determined by means of a gold chain hydrometer. Data are published regularly (See references).

By means of data from the depths 0, 5, 10, 15, 20, 25 and 33 metres, on punched cards (national system, "Lightvessel cards"), decade means were computed both monthly and annually. Except temperature and salinity, also means of σ_t and sound velocity (See chapter 1.2.) were computed.

2.2. Results of the Computation Presented in 2.1. and a Comparison with Earlier Decade Means of Salinity.

2.2.1. Temperature.

Fig. 5 presents the monthly decade means of temperature. Whereas the surface minimum occurs in February and maximum in August, at 33 m these extremes have moved to April and October respectively. The annual decade means are strikingly equal, see Table 2.

Table 2.

Annual means and standard deviations (SD) of temperature at Bornö 1961-1970.

Depth m	T°C	SD
0	8.45	6.97
5	8.92	6.22
10	8.78	5.61
15	8.65	4.86
20	8.62	4.13
25	8.63	3.53
33	8.42	2.88

2.2.2. Salinity.

Fig. 6 presents the monthly decade means of salinity. At the surface which is strongly influenced by local river water, the minimum occurs in March and the maximum in July. At 5 m depth, in Baltic water, the minimum occurs in June and the maximum in February. At 33 m finally, where the salinities are above 30 ‰, the minimum occurs in July and the maximum in March.

Decade means of salinity, 1931 - 1970, can be found in Svansson (1974). The annual means are here presented in Table 3.

Table 3.

Annual means of salinity (‰) at Bornö.

	0 m	5 m	33 m
1931 - 1940	28.80	26.23	32.85
1941 - 1950	22.55	26.02	32.92
1951 - 1960	21.92	25.75	32.92
1961 - 1970	17.80	25.07	32.86
1931 - 1960	22.42	26.00	32.90

The long term changes at 5 m depth are probably rather similar to those recorded at L/V Schultz'Grund (Svansson 1972, page 58), but at this lightvessel the maximum occured probably 1941 - 1950.

2.2.3. Sigma-t (σ_t).

We see (Fig. 7) that in a long term mean picture the pycnocline supposed to be situated at about 15 m is practically extinguished. In the winter time the influence of local river water is well seen in the surface with the lightest water in January.

2.2.4. Sound Velocity.

The monthly mean distribution can be seen in Fig. 8. We note particularly the May values, where there is sound velocity homogeneity from surface to bottom.

2.3. A Temperature - Salinity Relation.

It was assumed to be of interst to get a knowledge of the correlation between temperature and salinity. Temperature is usually easier to determine particularly in automatically recording instruments. Therefore it is desirable to find a relation between S and T. This can be done with linear regression, $S = K \cdot T + L$. The coefficients of regression (K and L) and correlation are determined by means of data measured at the depths 5, 10, 15, 20, 25 and 33 m. To get continous curves of the coefficients we use floating means over seven days, representing the middle day (day no 4). In this way the coefficients are determined for every day from January 4 to December 28. The computation was made mainly for the period 1961 - 1970, but also for an individual year, 1970. Fig. 9 shows the day by day variation of the two coefficients, K and L, as well as the correlation coefficient. This latter one is rather good during a large part of the year, but not during spring and autumn.

Fig. 10 shows the difference in K and L between the two cases:

1) when all data 1961 - 1970 were used and
2) for 1970 only. Selfevidently there are larger variations if only one year's data are used.

A computation of salinities (at 10 m depth) was made for the month of July during 1970 by means of the temperatures (1970) and the K and L's of 1961 - 1970. A mean square deviation of 1.65 ‰ was derived between computed and measured salinities.

3. A Diffusion Model of the Gullmar Fjord.

A very important question in pollution studies is the determination of concentrations of a pollutant and its variation in time and space. A rough way of computing such concentrations is to use a diffusion model, e.g.

$$\frac{\partial (AC)}{\partial t} = \frac{\partial}{\partial x} \left(AK \frac{\partial C}{\partial x}\right) + R \qquad (3:1)$$

where

A = cross section area (m^2)
C = concentrations (mg/m^3)
t = time (s)
x = longitudinal coordinate (m)
K = diffusion coefficient (m^2/s)
R = discharge $(mg/s \cdot m)$

A model was constructed with sections taken from Zeilon (1914), see Fig. 11. However, we do not use the entire cross section area but only that part which corresponds to a depth of 50 m, assuming that the deep water takes very little part in the exchange. (This is of course only a first approximation, in the long run the deeps may be seriously polluted).

In the model the Gullmar Fjord is assumed to form a system of 3 canals, the Färlev Fjord (1), the Saltkälle Fjord (2) and the outer part of the fjord (3), divided into 8, 6 and 21 sections respectively with a constant distance (Δx) of 1000 m. To solve the equation (3:1) we use an implicit difference method.

$$A_j \frac{C_j^{n+1} - C_j^n}{\Delta t} = \tag{3:2}$$

$$= K \cdot \frac{A_{j+\frac{1}{2}} \dfrac{C_{j+1}^{n+1} + C_{j+1}^{n} - C_j^{n+1} - C_j^n}{2\Delta x_j} - A_{j-\frac{1}{2}} \dfrac{C_j^{n+1} + C_j^n - C_{j-1}^{n+1} - C_{j-1}^n}{2\Delta x_{j-1}}}{\dfrac{\Delta x_j + \Delta x_{j-1}}{2}}$$

Note that we assume K to be constant in all sections. After rewriting the equation we get the following recurrence formula, referred to as the "Proganka" method (Svansson 1972, page 42).

$$C_j^{n+1} = C_{j+1}^{n+1} \cdot E_j + F_j \tag{3:3}$$

where j and n are the indices in space and time respectively.

In every timestep we first compute E_j and F_j in all sections. Since the concentration is the same in all canals in the branching point (B) and $\sum_{1}^{3} AK \frac{\partial C}{\partial x} = 0$ here, we can compute the value (C_B) in this point. We then use C_B and the recurrence formula (3:3) to compute all the remaining concentrations backwards.

3.1. Determination of the Diffusion Coefficient K.

One way of determining the diffusion coefficient K is to use time series of salinity ($C = S$, $R = 0$ in equation (3:1)), one in the interior and one corresponding at the open boundary. The boundary conditions at the closed ends are assumed to be $\frac{\partial AC}{\partial x} = 0$.

At the open boundary we now make a very rough assumption: Since there is no measurements at the mouth of the fjord, we use the time series from Vinga L/V (See Fig. 1, in the vicinity of SW Vinga), assuming the conditions to be rather alike. This is not unrealistic as both positions are in the open sea and in "Baltic" water.

As initial values we take some roughly interpolated values. The timestep was chosen to be one day and the period May - July 1965 was processed. To determine K we compute the mean square deviation (MSD) between computed and measured salinities at Bornö (10 m depth). K was then given the value that corresponded to a minimum of MSD. A value of 2000 m^2/s was found to fulfil this condition.

Fig. 12 shows the two curves of computed and measured salinities. The coincidence is not too good and improved models are necessary for the next step.

3.2. Computation of the Concentrations Caused by a Discharge.

We now investigate by the same diffusion equation (3:1) how a discharge of 1000 tons/year of a conservative pollutant behaves in time and space. Boundary conditions are the same at the closed ends, at the open boundary we assume C = 0. Initially C = 0 everywhere. This time we use a timestep of 12 hours.

3.2.1. Discharge in Section (2,1).

We first assume that the discharge takes place in the innermost part of canal 2. Fig. 13 shows the distribution after 6.5 days when steady state was reached.

3.2.2. Discharge in Section (3,17).

As a second example the discharge was made in section (3,17), south of Bornö station. There is now no difference between the canals 1 and 2, see Fig. 14.

3.2.3. Time Variations.

Fig. 15 shows the time evolution in the branching point in both cases (3.2.1. and 3.2.2.). There is apparently a slight numerical instability.

4. Conclusions and Discussions.

In Ch. 1 the data obtained during 1962 - 1971 at stations visited some 4 times a year are presented as quarterly and annual mean values. There is a clear variation from one quarter to the other, e.g. the minimum of oxygen at larger depths in quarter 3. It would be interesting to have such a frequency of observations that the month to month variation of e.g. phosphate and oxygen could be studied.

In Ch. 2. the Bornö data are specially studied. As measurements of temperature and salinity have been done here once every day since 1930, these parameters and also some computed ones, σ_t and sound velocity, can be presented with in relatively high details. It is clear that the conditions are very much similar to those prevailing in northern Kattegat with so called Baltic water at the top.

In Ch. 2.3. a computation of a temperature - salinty relation is presented. Temperature is usually easier to determine and it is of interest to study a possible relation. It is clear that a high correlation is prevailing during a large part of the year, but particularly during spring and autumn it breaks down.

In Ch. 3. is made a trial of applying a simple diffusion model. Two time series, viz of Bornö and Vinga L/V, were used to compute a coefficient of diffusion. Later are shown the consequential concentrations of a discharge of 1000 tons/year of a conservative pollution. The work may be looked upon as the first step in a future treatment of recent Brofjorden data, in which case there are real measurements at the outher boundary in contrast to the present treatment, where data from a distant place, Vinga L/V, had to be used.

The present work contains some treatment of data from the Gullmar Fjord and the Brofjorden area. It does not mean, of course, that the data material is completely used up. On the contrary a lot of approachments are possible.

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Table 1a.

Quarterly and Annual Means, 1962 - 1971.

Alsbäck (Fj. 26) PO_4-P μg-at/dm^3

Quarter Depth	1	2	3	4	1-4
0	0.48 (11)	0.15 (14)	0.12 (9)	0.29 (10)	0.26 (44)
5	0.40 (10)	0.20 (9)	0.07 (4)	0.30 (10)	0.28 (33)
10	0.51 (11)	0.16 (14)	0.15 (9)	0.34 (10)	0.29 (44)
15	0.65 (10)	0.28 (9)	0.15 (4)	0.37 (9)	0.40 (32)
20	0.75 (11)	0.33 (13)	0.24 (9)	0.41 (9)	0.44 (42)
30	0.81 (11)	0.43 (14)	0.41 (9)	0.66 (10)	0.57 (44)
40	0.82 (11)	0.72 (9)	0.55 (4)	0.65 (10)	0.71 (34)
50	0.87 (11)	0.87 (14)	0.85 (9)	0.69 (10)	0.82 (44)
75	1.16 (33)	1.16 (32)	1.44 (17)	1.61 (30)	1.33 (112)
100	1.99 (22)	1.44 (18)	1.71 (8)	2.02 (20)	1.82 (68)
125	2.40 (10)	1.50 (14)	2.00 (9)	2.53 (10)	2.05 (43)

Alsbäck (Fj. 26) O_2 %

Quarter Depth	1	2	3	4	1-4
0	94.5 (10)	107.8 (12)	106.9 (9)	96.4 (10)	101.6 (41)
5	97.0 (3)	103.4 (5)	109.4 (5)	97.5 (5)	102.4 (18)
10	95.3 (11)	103.9 (13)	91.9 (11)	94.5 (10)	96.8 (45)
15	91.7 (3)	99.1 (5)	94.0 (5)	91.8 (5)	94.4 (18)
20	88.4 (4)	102.2 (12)	84.3 (11)	89.7 (6)	92.3 (33)
30	87.6 (11)	88.6 (14)	77.6 (11)	80.4 (10)	84.0 (46)
40	88.1 (4)	84.2 (7)	71.7 (5)	72.0 (6)	78.7 (22)
50	89.3 (11)	81.5 (14)	61.9 (11)	72.8 (10)	76.8 (46)
75	78.2 (21)	75.3 (30)	60.7 (21)	52.0 (26)	66.6 (98)
100	55.6 (18)	71.3 (18)	58.1 (10)	46.2 (20)	57.4 (66)
125	48.3 (11)	70.4 (14)	47.5 (11)	39.1 (10)	52.8 (46)

Number of observations in brackets. The depths are standard depths. The values at 75 m and 100 m are computed by means of observations at 60, 70 and 80 m respectively 90 and 100 m.

Table 1b.

Quartely and Annual Means, 1962 - 1971.

Tröskeln (Fj. 28) PO_4-P µg-at/dm^3

Quarter	1	2	3	4	1-4
Depth					
0	0.41 (13)	0.16 (8)	0.10 (4)	0.30 (11)	0.29 (36)
5	0.36 (12)	0.17 (8)	0.09 (4)	0.31 (11)	0.27 (35)
10	0.46 (13)	0.18 (8)	0.09 (4)	0.32 (11)	0.31 (36)
15	0.58 (12)	0.21 (8)	0.11 (4)	0.35 (11)	0.37 (35)
20	0.71 (13)	0.34 (8)	0.13 (4)	0.36 (10)	0.46 (35)
30	0.72 (13)	0.47 (8)	0.35 (4)	0.52 (11)	0.56 (36)
40	0.80 (13)	0.60 (8)	0.46 (4)	0.58 (11)	0.65 (36)
50	0.74 (11)	0.82 (9)	0.96 (3)	0.75 (11)	0.78 (34)

Tröskeln (Fj. 28) O_2 %

Quarter	1	2	3	4	1-4
Depth					
0	101.4 (10)	105.2 (7)	107.6 (5)	99.3 (9)	102.6 (31)
5	106.0 (5)	104.9 (5)	105.8 (4)	98.5 (5)	103.6 (19)
10	97.9 (10)	105.0 (7)	101.9 (5)	99.2 (8)	100.6 (30)
15	94.7 (5)	102.2 (5)	96.3 (4)	94.3 (5)	96.9 (19)
20	90.5 (6)	97.8 (7)	87.3 (5)	84.8 (4)	91.1 (22)
30	92.9 (9)	91.3 (6)	80.7 (5)	79.6 (8)	86.6 (28)
40	89.7 (7)	88.3 (7)	77.8 (5)	79.7 (6)	84.5 (25)
50	91.3 (9)	83.5 (8)	67.0 (4)	75.2 (8)	81.4 (29)

Number of observations in brackets.

Table 1c.

Quartely and Annual Means, 1962 -1971.

Brofjorden (Fj. 62) PO_4-P µg-at/dm^3

Quarter Depth	1	2	3	4	1-4
0	0.47 (10)	0.21 (8)	0.09 (3)	0.35 (9)	0.33 (30)
5	0.42 (11)	0.17 (8)	0.07 (3)	0.34 (9)	0.30 (31)
10	0.43 (11)	0.19 (8)	0.15 (3)	0.34 (9)	0.32 (31)
15	0.54 (11)	0.27 (8)	0.19 (3)	0.36 (9)	0.38 (31)
20	0.63 (15)	0.42 (11)	0.34 (4)	0.54 (10)	0.54 (40)

Brofjorden (Fj. 62) O_2 %

Quarter Depth	1	2	3	4	1-4
0	101.1 (10)	107.6 (8)	108.5 (4)	99.5 (7)	103.5 (29)
5	101.3 (3)	109.6 (5)	106.8 (3)	99.9 (3)	105.2 (15)
10	98.6 (11)	107.9 (8)	95.2 (4)	100.8 (7)	101.1 (30)
15	100.5 (3)	104.3 (5)	95.4 (3)	100.0 (3)	100.6 (14)
20	92.0 (12)	88.4 (11)	82.4 (5)	96.2 (10)	90.8 (38)

Number of observations in brackets.

Table 1d.

Quarterly and Annual Means, 1962 - 1971.

The Åby Fjord (Fj. 61) PO_4-P µg-at/dm^3

Quarter Depth	1	2	3	4	1-4
0	0.42 (10)	0.23 (7)	0.07 (3)	0.34 (9)	0.31 (29)
5	0.36 (10)	0.18 (7)	0.08 (3)	0.33 (9)	0.28 (29)
10	0.39 (10)	0.19 (7)	0.10 (3)	0.34 (9)	0.30 (29)
15	0.51 (10)	0.29 (7)	0.23 (3)	0.37 (9)	0.38 (29)
20	0.68 (13)	0.49 (9)	0.51 (5)	0.38 (10)	0.53 (37)

The Åby Fjord (Fj. 61) O_2 %

Quarter Depth	1	2	3	4	1-4
0	100.5 (7)	106.4 (8)	107.6 (4)	98.2 (6)	103.0 (25)
5	102.9 (3)	108.3 (5)	108.4 (3)	100.6 (3)	105.5 (14)
10	99.6 (10)	106.8 (8)	97.5 (4)	99.5 (7)	101.2 (29)
15	99.4 (3)	101.9 (5)	92.1 (3)	99.4 (4)	98.8 (15)
20	90.9 (8)	88.1 (11)	68.5 (7)	92.4 (8)	85.7 (34)

Number of observations in brackets

Table 1e.

Quarterly and Annual Means, 1962 - 1971.

Malmödrag (Fj. 63) PO_4-P µg-at/dm^3

Quarter	1	2	3	4	1-4
Depth					
0	0.39 (11)	0.15 (8)	0.13 (2)	0.33 (9)	0.29 (30)
5	0.39 (11)	0.14 (8)	0.09 (3)	0.32 (9)	0.28 (31)
10	0.41 (11)	0.15 (8)	0.12 (3)	0.34 (9)	0.29 (31)
15	0.52 (11)	0.22 (8)	0.14 (3)	0.34 (9)	0.35 (31)
20	0.61 (11)	0.32 (8)	0.22 (3)	0.33 (9)	0.42 (31)
30	0.71 (13)	0.46 (9)	0.37 (3)	0.39 (10)	0.53 (35)

Malmödrag (Fj. 63) O_2 %

Quarter	1	2	3	4	1-4
Depth					
0	100.9 (10)	107.0 (8)	106.5 (4)	100.9 (7)	103.3 (29)
5	103.2 (3)	109.7 (5)	104.8 (3)	101.5 (3)	105.5 (14)
10	100.2 (10)	107.1 (8)	96.6 (4)	101.4 (6)	102.3 (28)
15	101.0 (3)	105.9 (5)	103.2 (3)	102.1 (3)	103.5 (14)
20	97.3 (6)	98.3 (8)	92.8 (4)	99.2 (6)	97.4 (24)
30	92.5 (11)	89.6 (8)	81.6 (4)	94.2 (9)	90.9 (32)

Number of observations in brackets

Fig. 1

52 Stations in the Kattegat and the Skagerrak

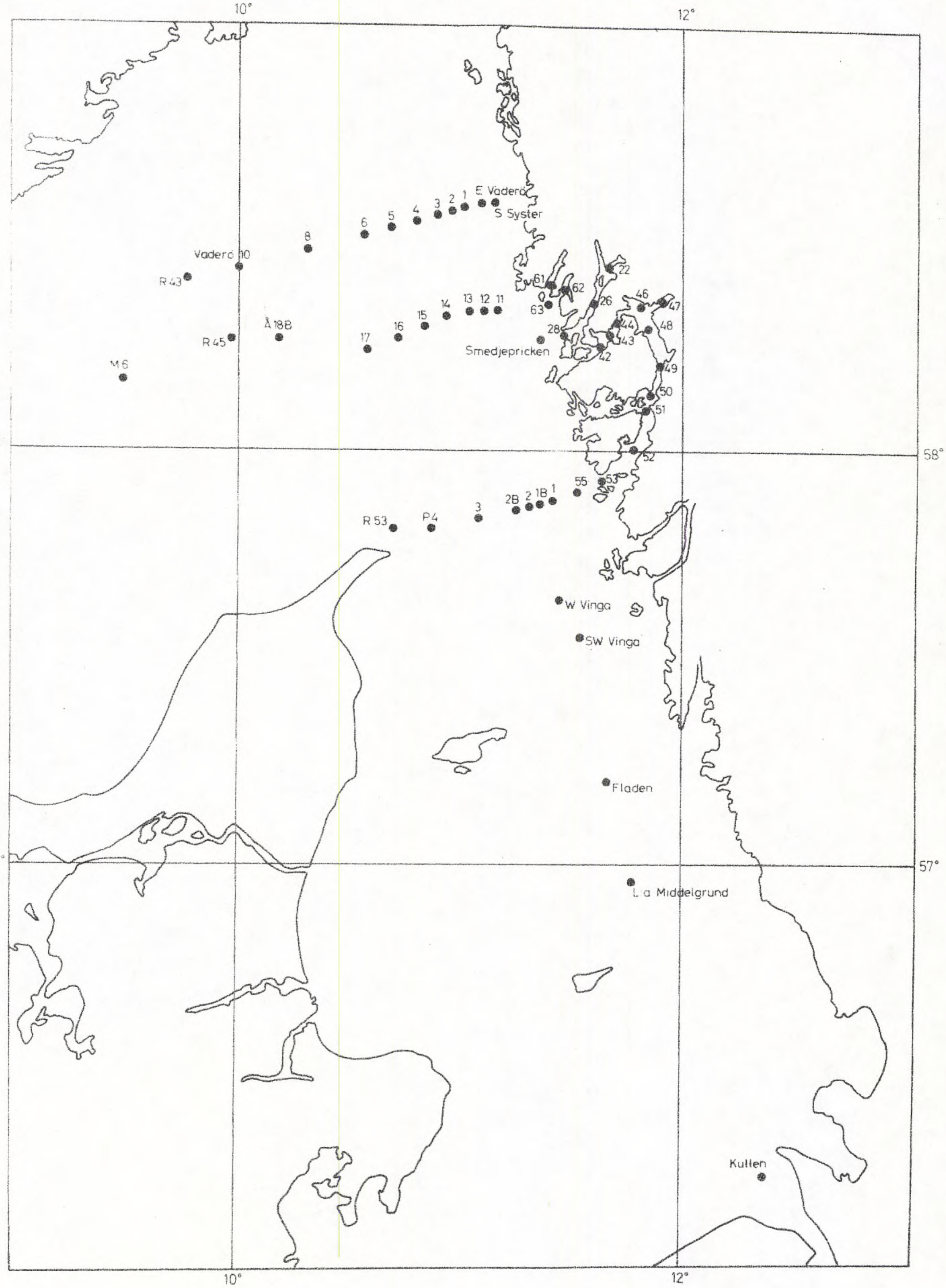
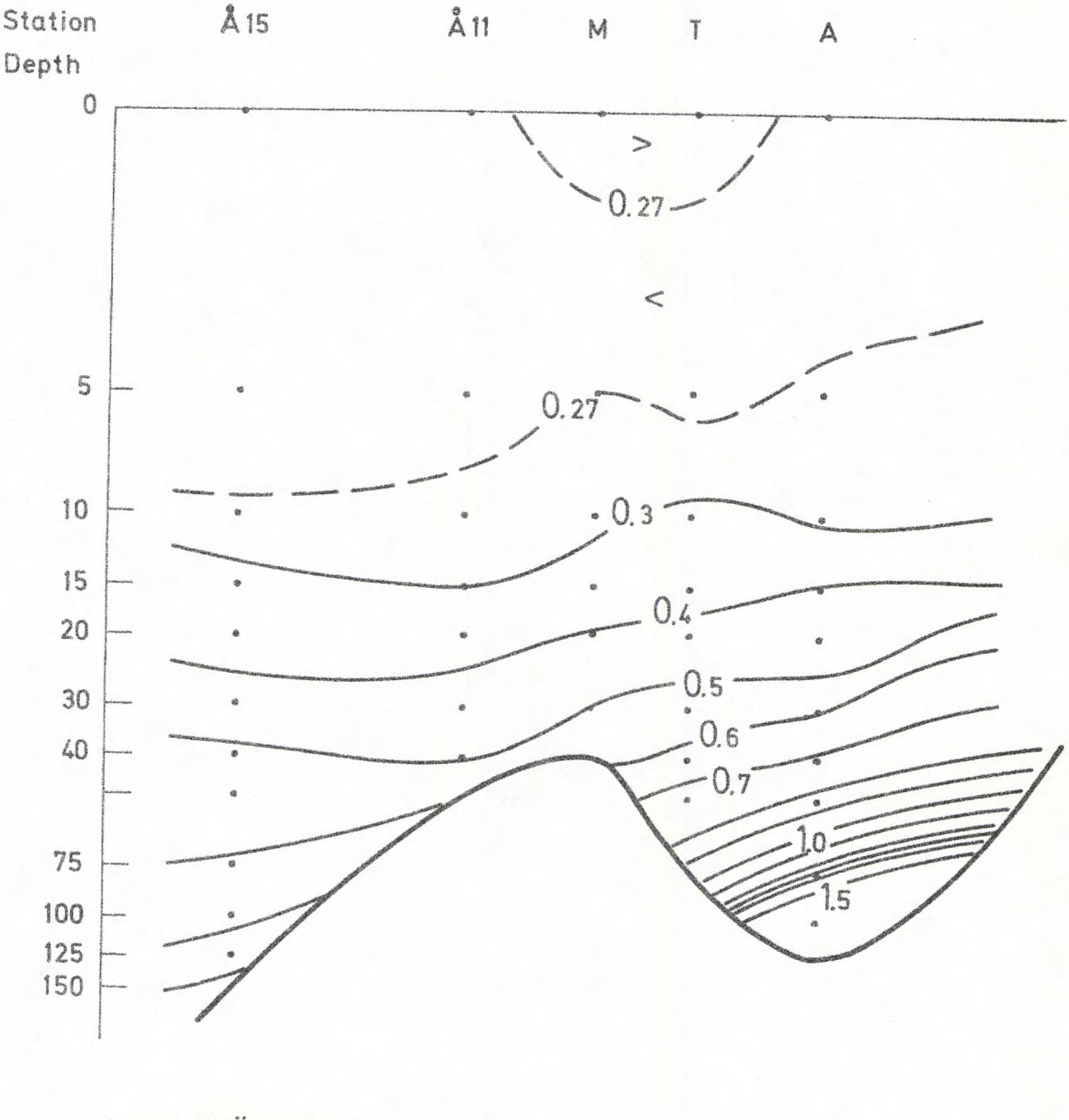


Fig. 2

A longitudinal section of PO_4-P (μgat/dm^3) 1962–71.

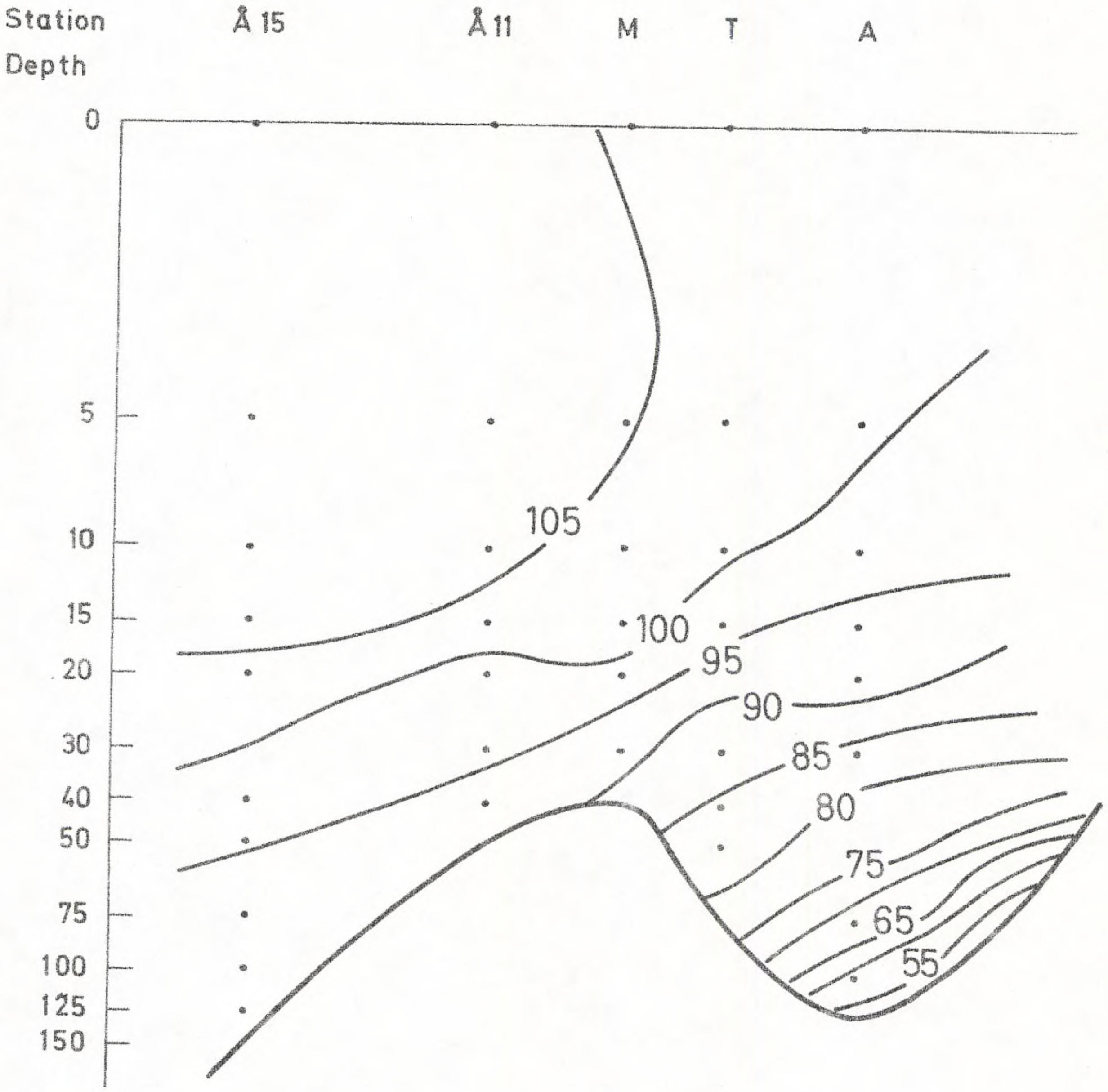


M = MALMÖDRAG (Fj 63)
T = TRÖSKELN (Fj 28)
A = ALSBÄCK (Fj 26)

The positions of the stations in Fig. 1

Fig. 3

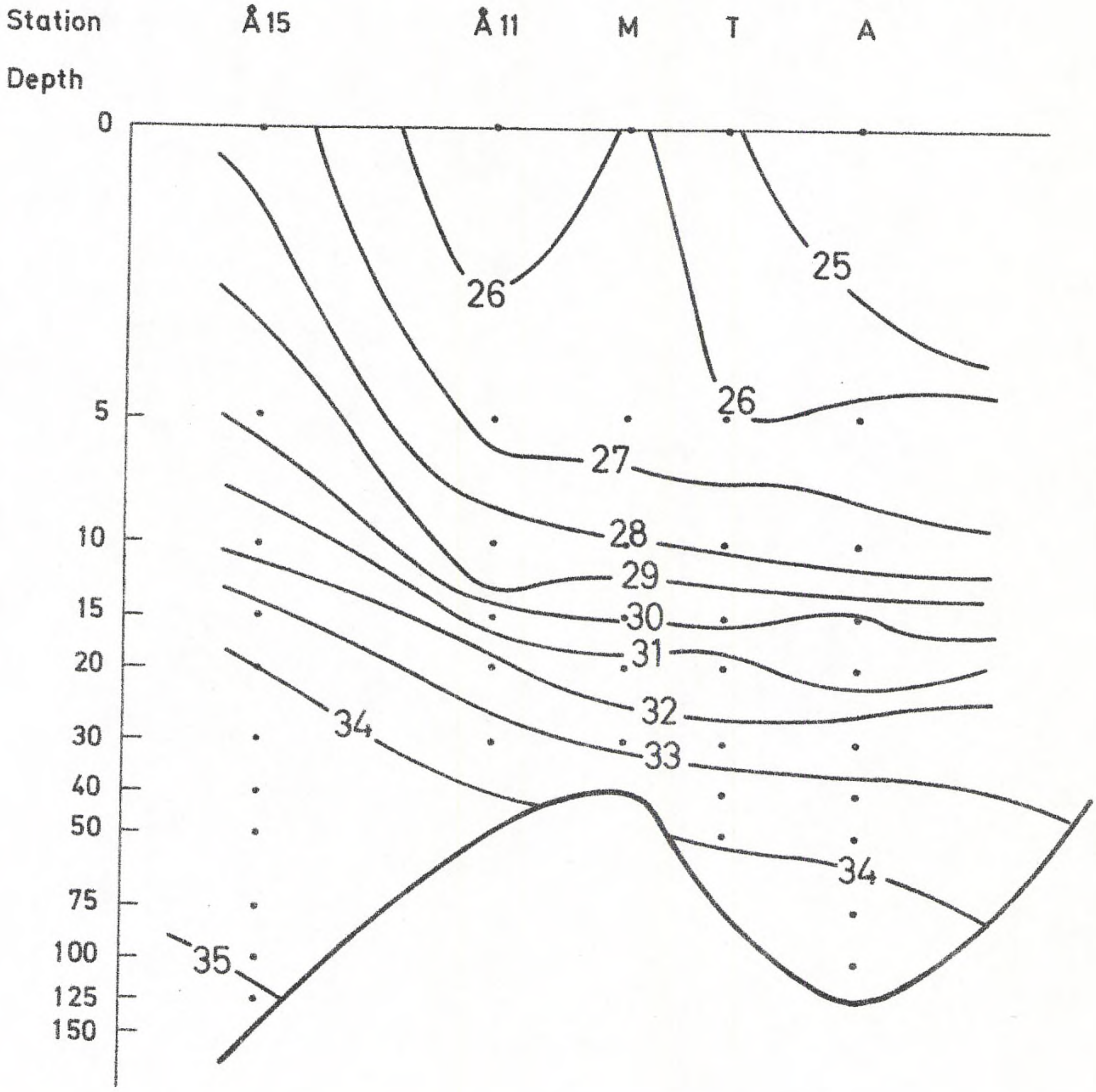
A longitudinal section of oxygen saturation percentage 1962 – 71



M = MALMÖDRAG (Fj 63)
T = TRÖSKELN (Fj 28)
A = ALSBÄCK (Fj 26)

The positions of the stations in Fig. 1

A longitudinal section of salinity (‰) 1962 – 71.

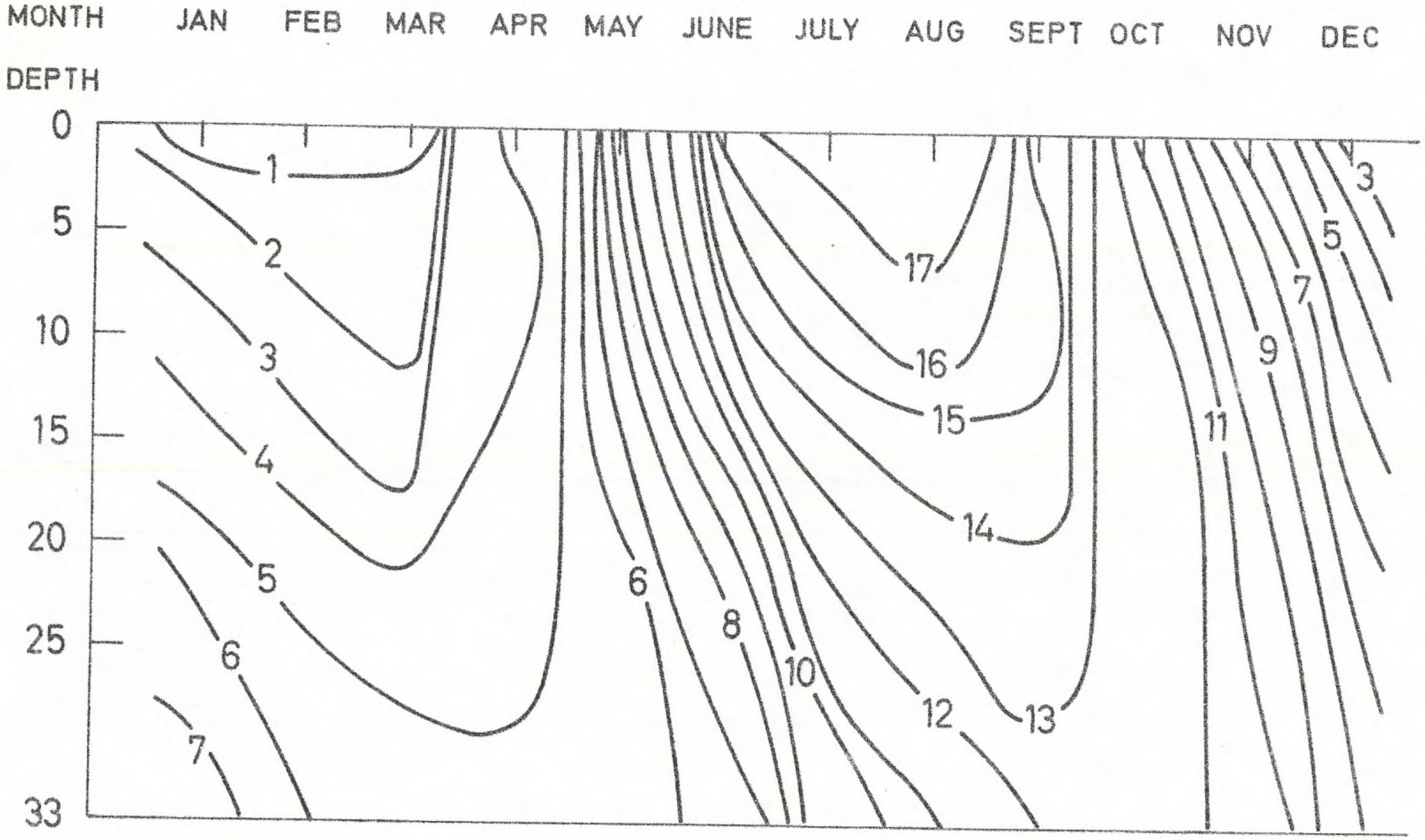


M = MALMÖDRAG (Fj 63)
T = TRÖSKELN (Fj 28)
A = ALSBÄCK (Fj 26)

The positions of the stations in Fig. 1

Fig. 5

Monthly means of temperature (°C) at Bornö 1961 – 70



Monthly means of salinity (‰) at Bornö 1961–70.

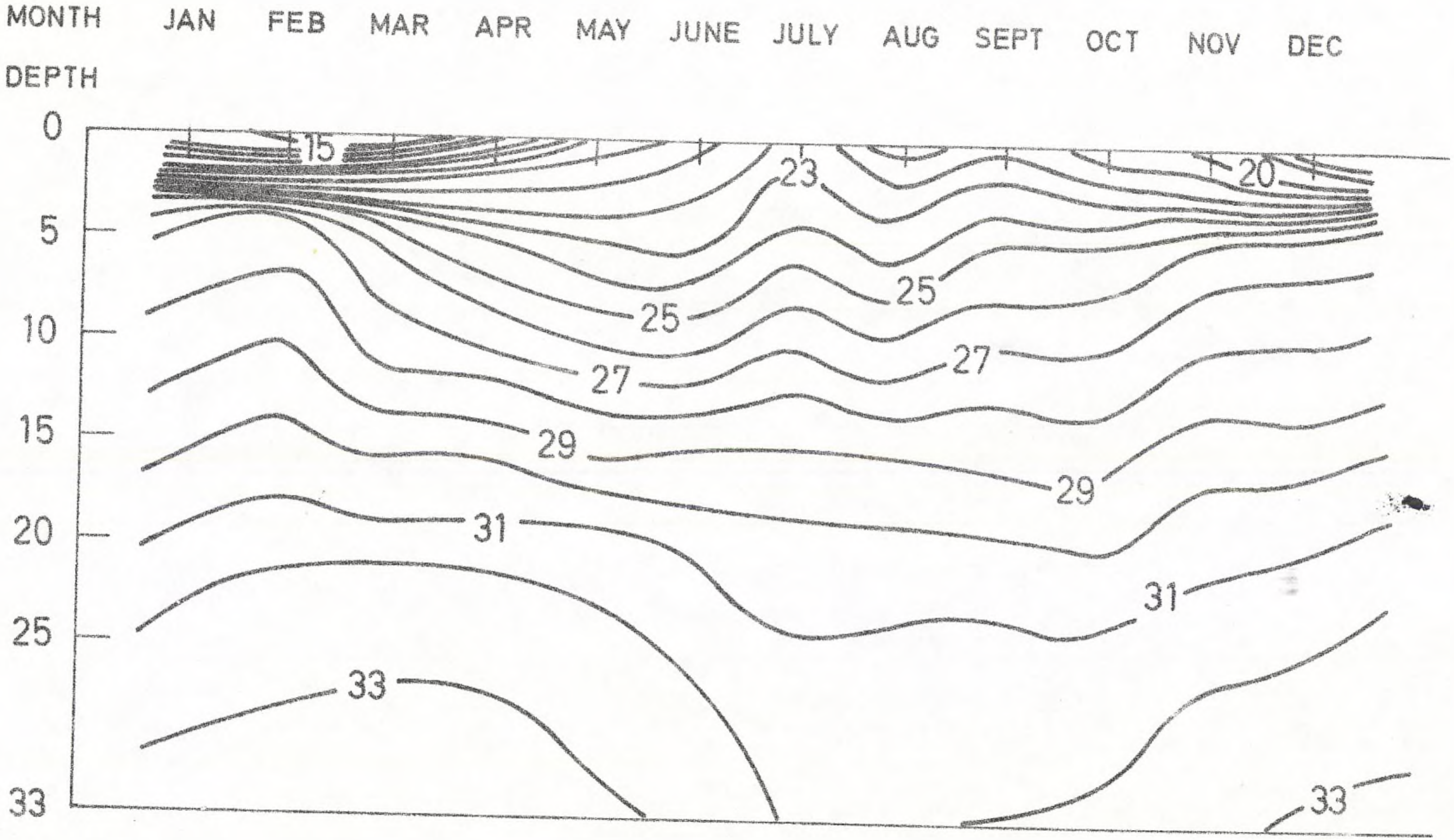


Fig. 6

Monthly means of σ_t at Bornö 1961 – 70

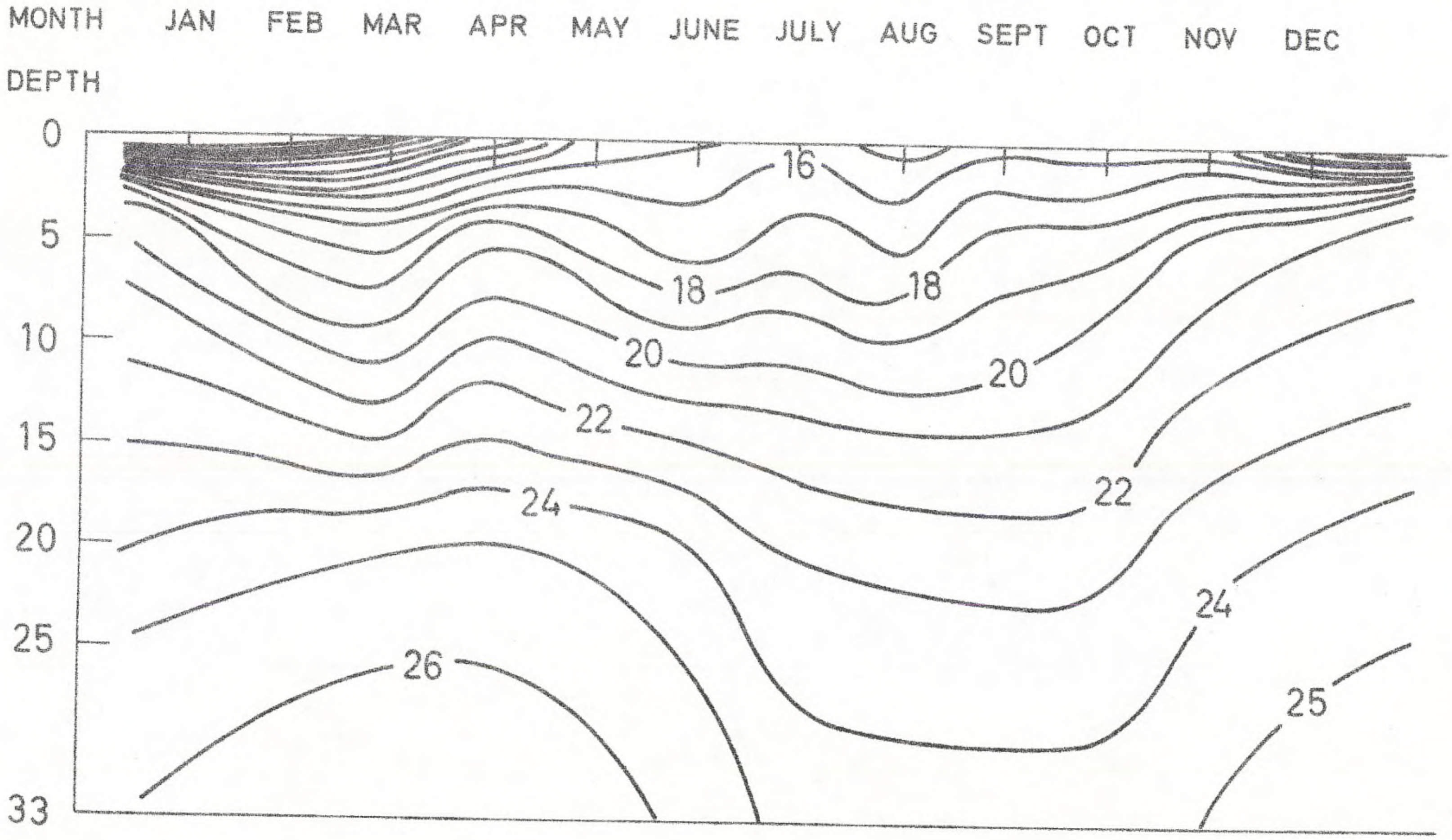
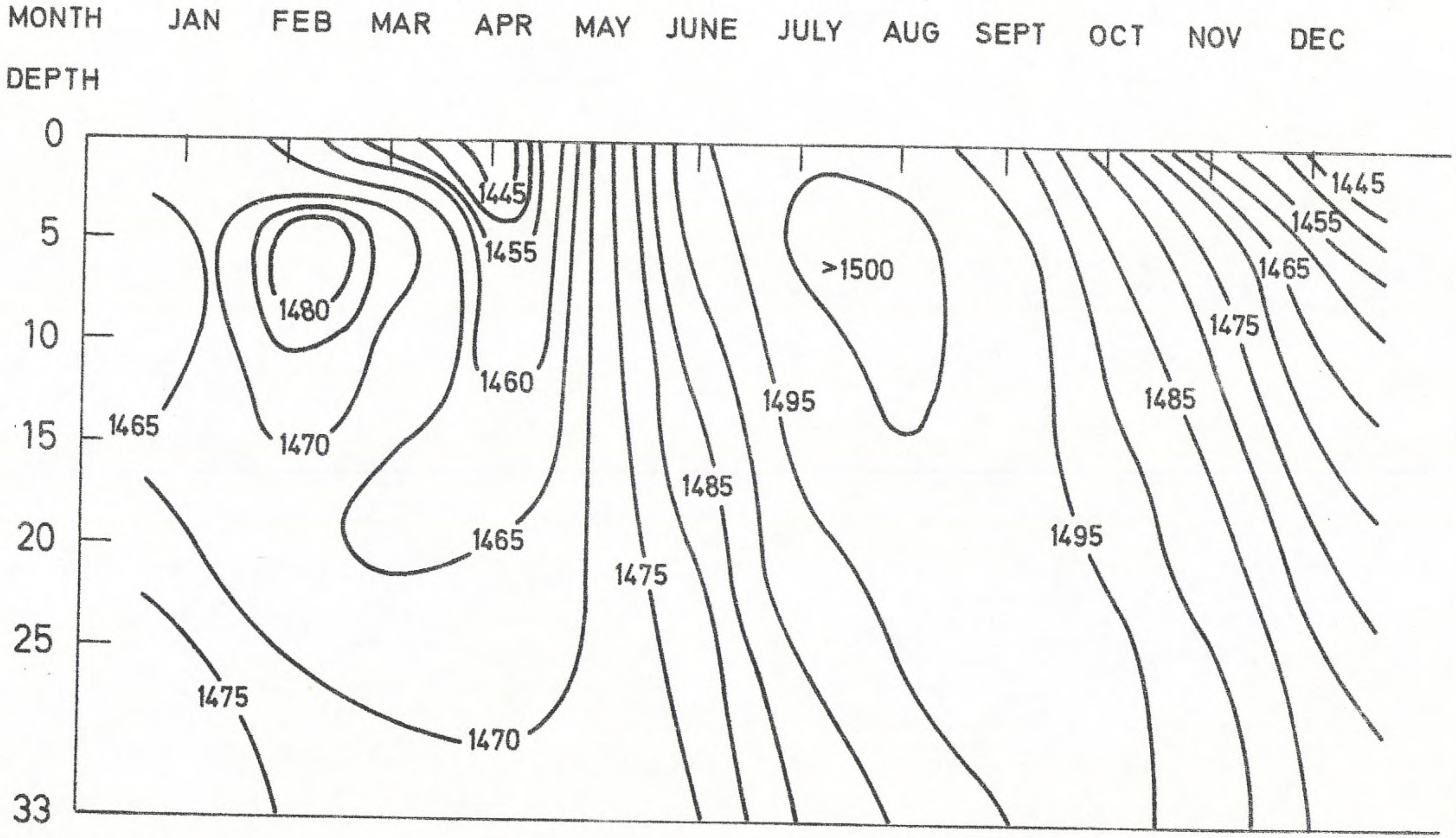


Fig. 7

Fig. 8

Monthly means of sound velocity (m/s) at Bornö 1961 – 70



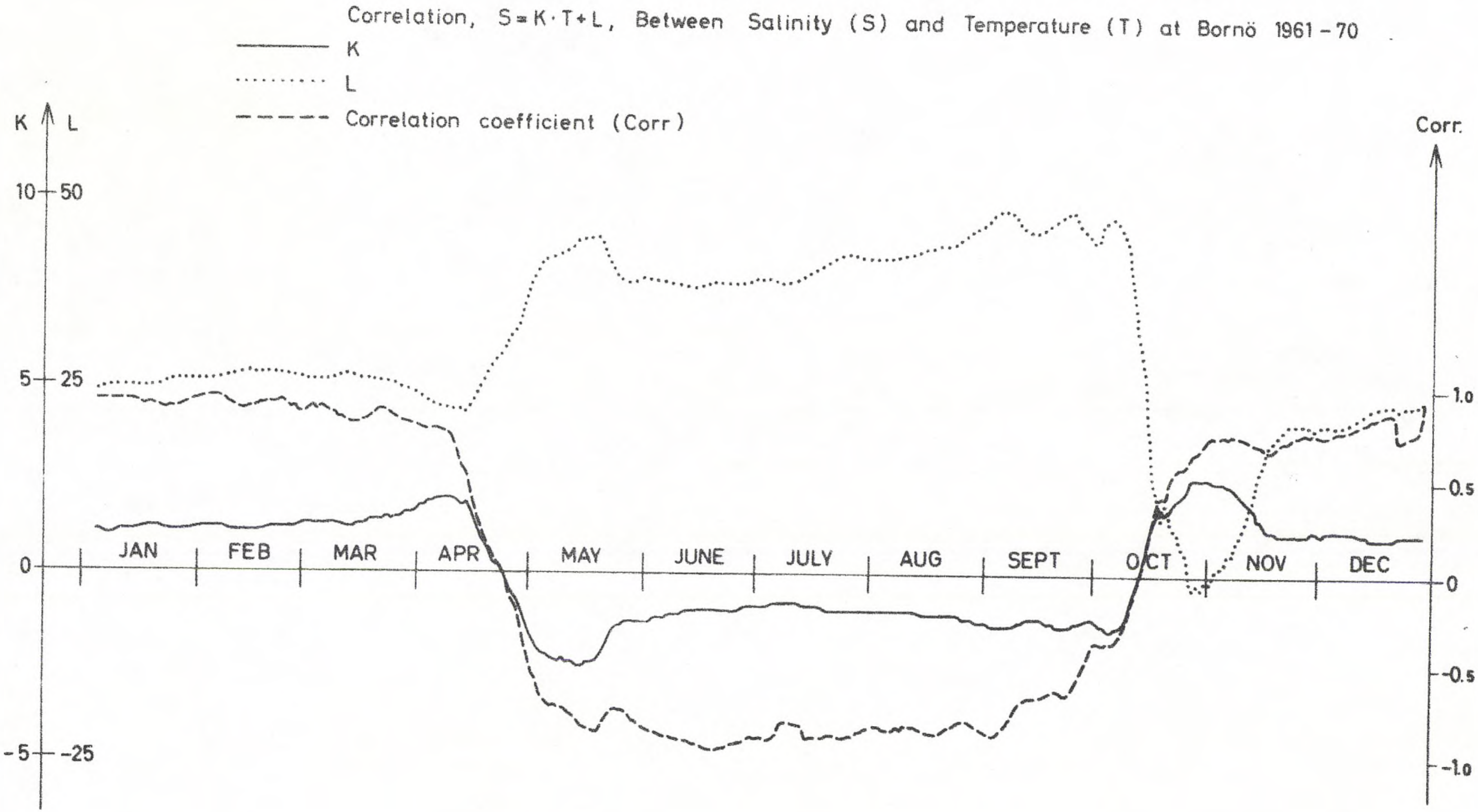

Correlation, S = K · T + L, Between Salinity (S) and Temperature (T) at Bornö 1961 – 70
K
L
Correlation coefficient (Corr)
K
L
10
50
5
25
0
-5
-25
Corr.
1.0
0.5
0
-0.5
-1.0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

Fig. 9

The difference in K and L at Bornö between the two cases 1961 – 70 and 1970

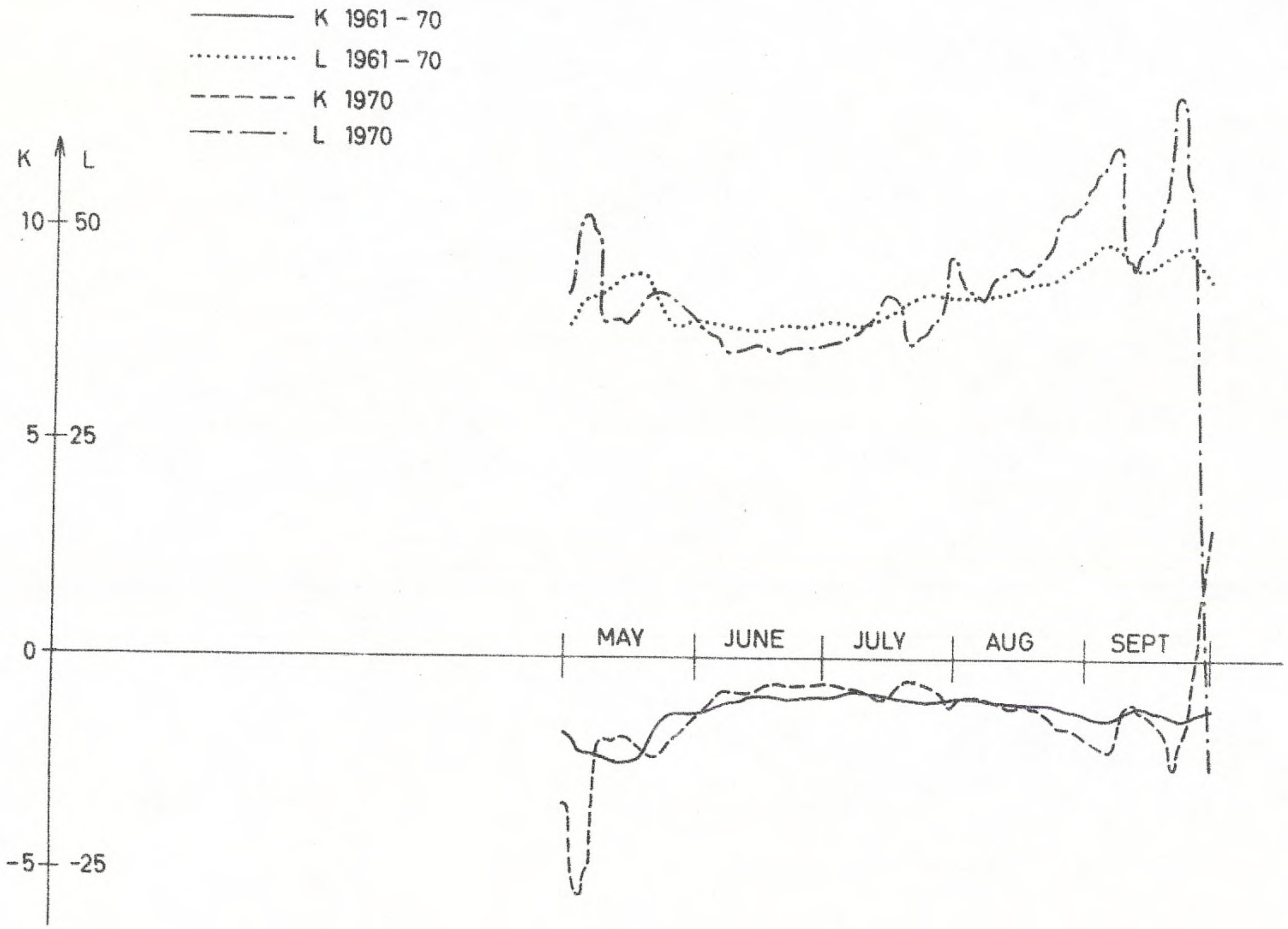
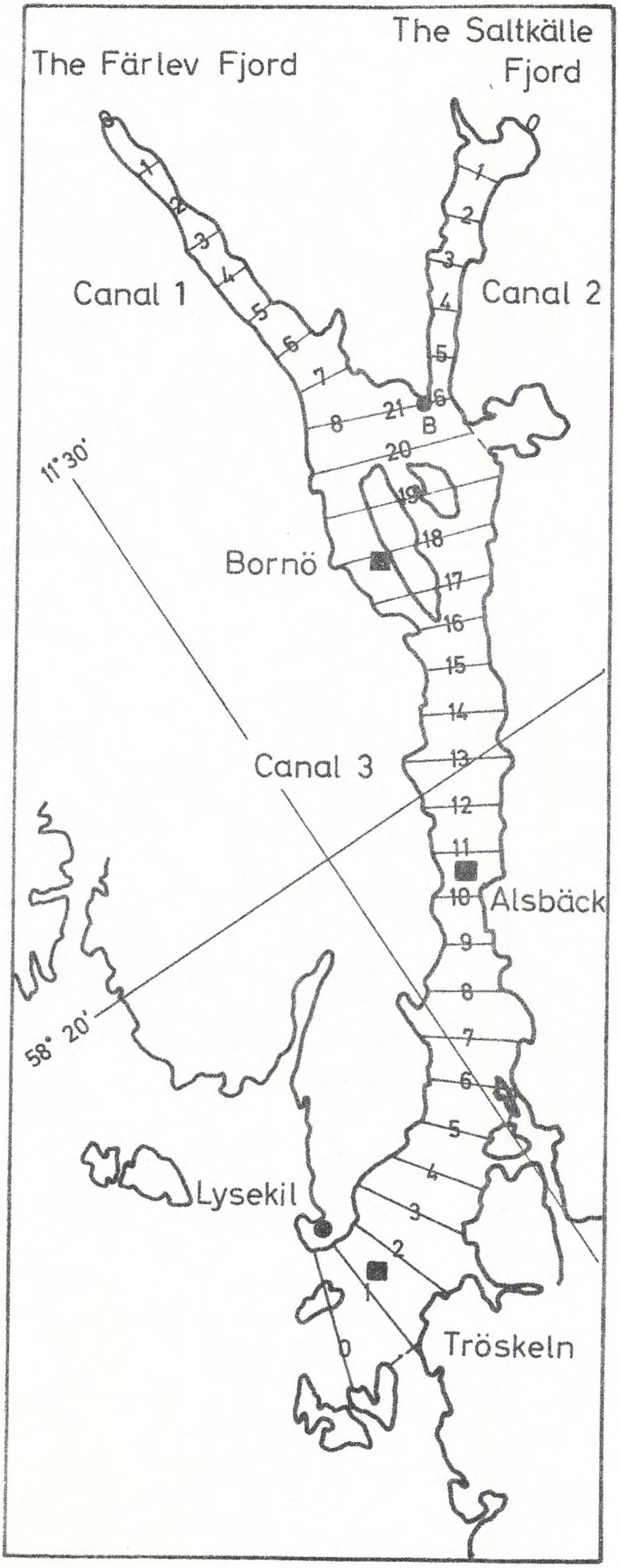
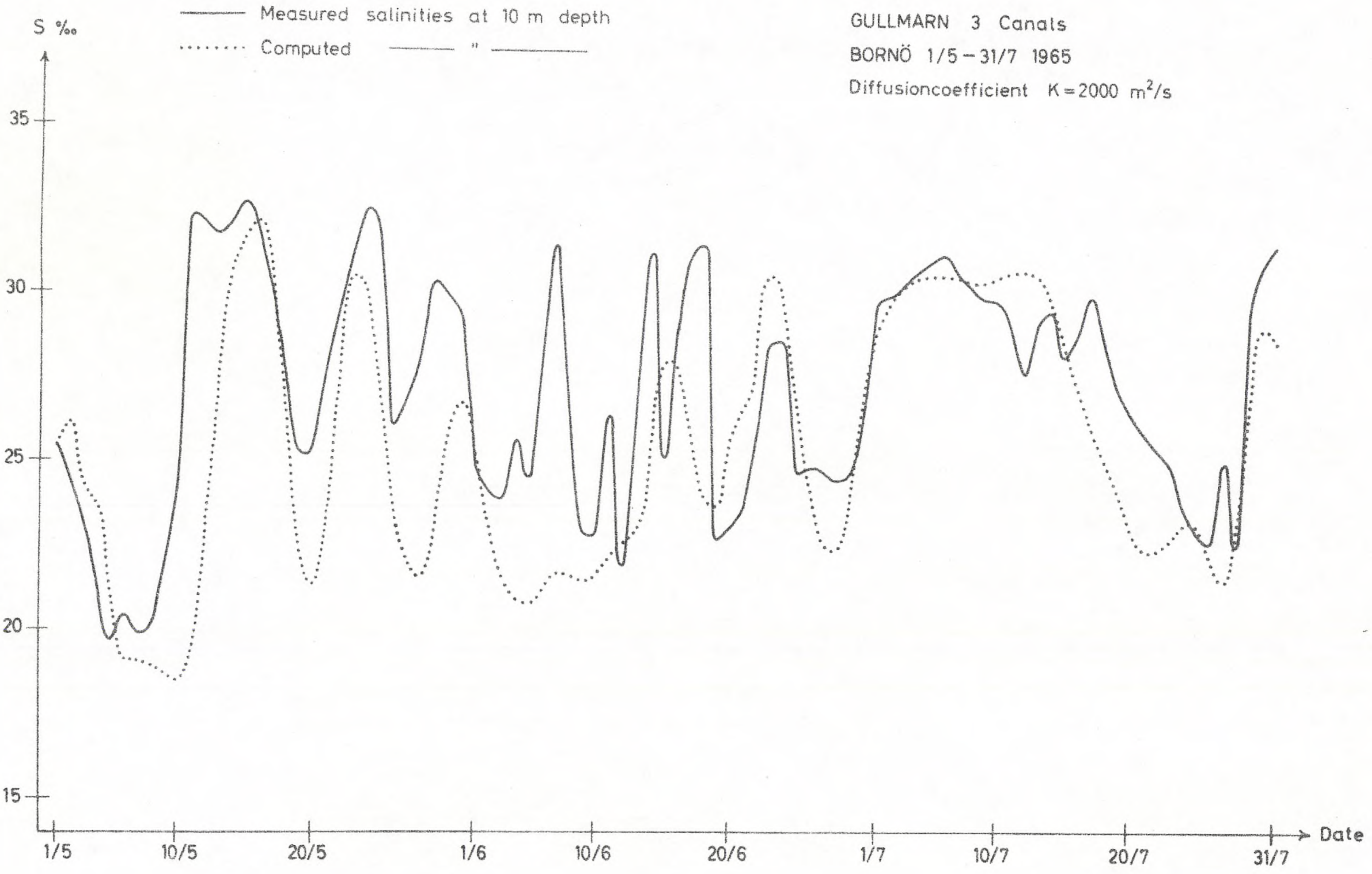


Fig. 10

The Gullmar Fjord

Fig. 11





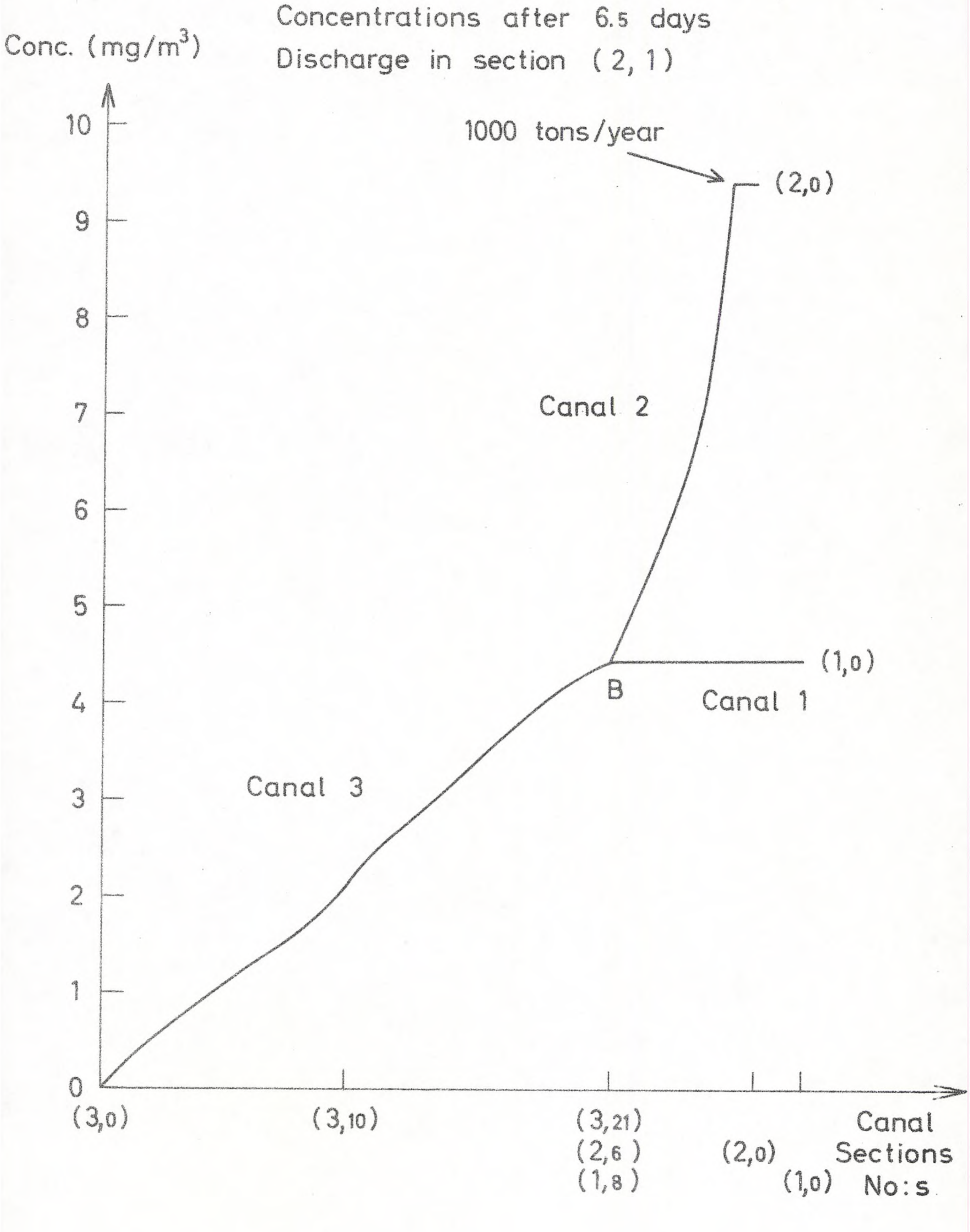
GULLMARN 3 Canals

BORNÖ 1/5 – 31/7 1965

Diffusioncoefficient $K = 2000\ m^2/s$

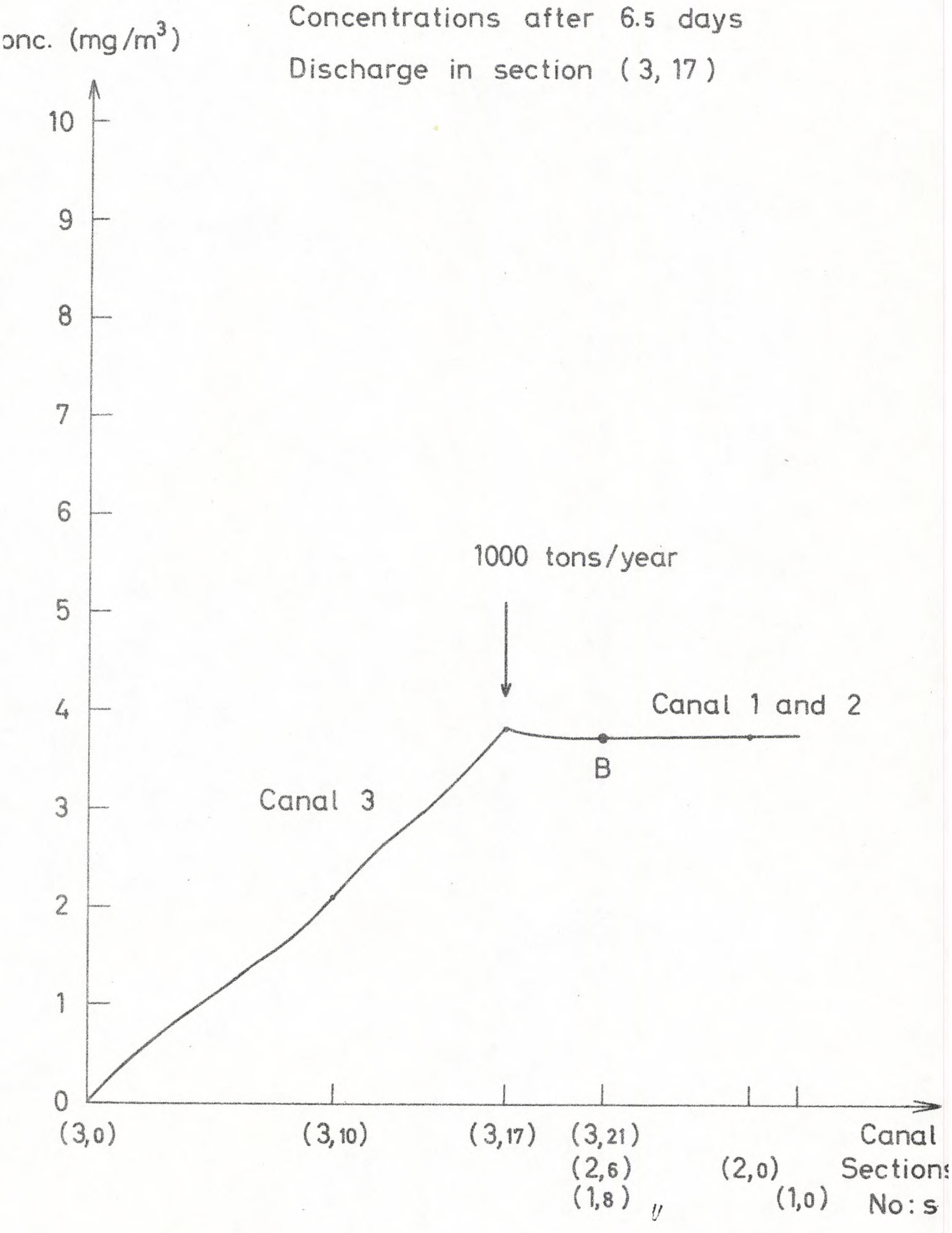
Fig. 12

Fig. 13



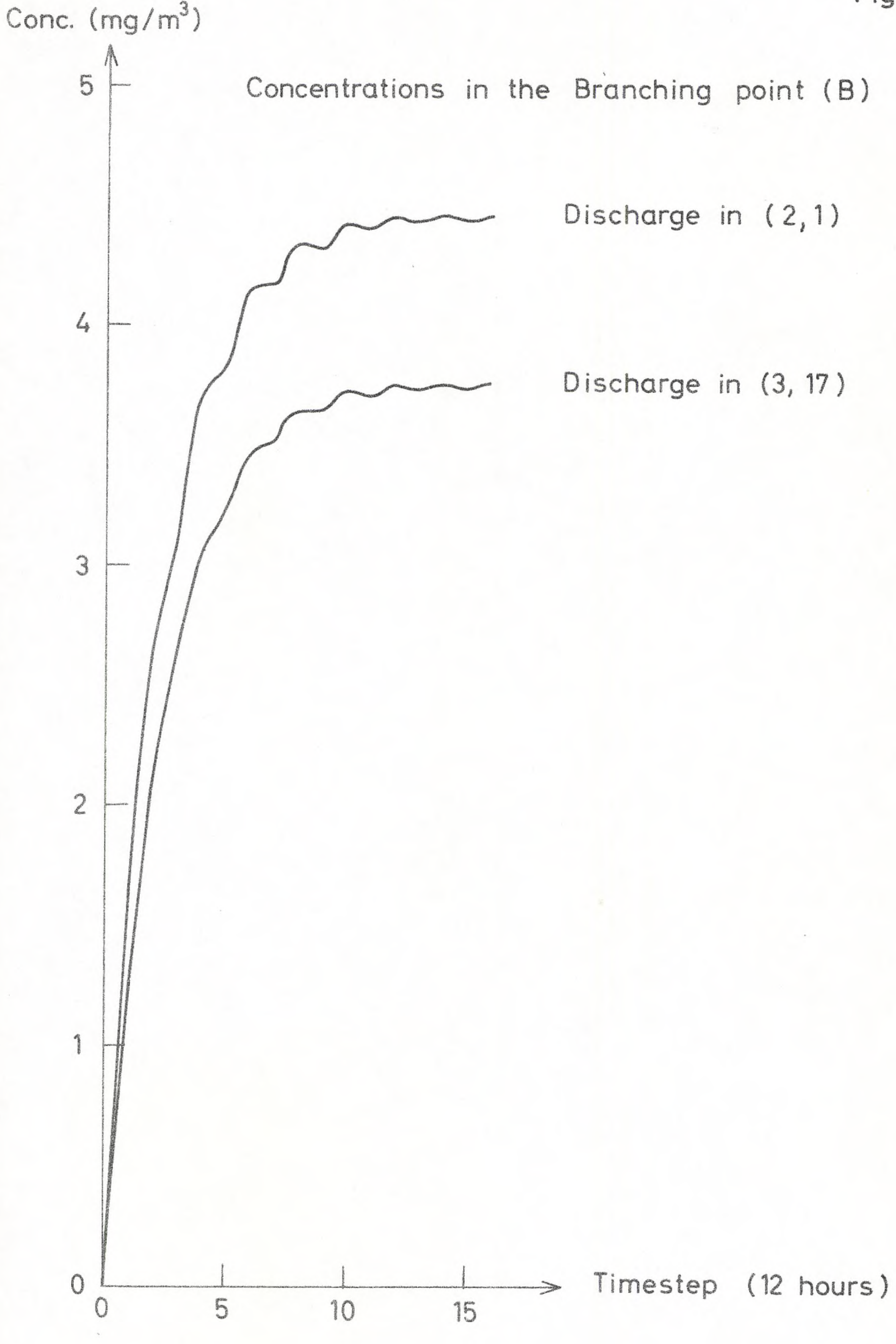
Concentrations after 6.5 days
Discharge in section (2, 1)

Fig. 14



Concentrations after 6.5 days

Discharge in section (3, 17)



Conc. (mg/m³)
Concentrations in the Branching point (B)
Discharge in (2,1)
Discharge in (3, 17)
5
4
3
2
1
0
0
5
10
15
Timestep (12 hours)