Bornö Hydrographic Station with R/V Skagerak (I)

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HYDROGRAPHY OF THE GULLMAR FJORD

(GULLMARSFJORDENS HYDROGRAFI)

BY

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Fyll bara i en sida. Bifoga om möjligt ett ex av rapporten !

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The paper is a synopsis, mainly based on processed data collected by SHBK and the Board of Fisheries. These data are partly temperature, salinity and current from Bornö station from 1930 and onwards and partly temperature, salinity, oxygen, nutrients etc from research vessels. Four Water Masses (WM) are described, the fourth one (WM4) being the periodically stagnant water under sill depth. It is discussed whether there is a net transport of nutrients from the Skagerrak, but it is not possible to give a final answer to that question.

Arbetet är en sammanställning, som till större delen grundar sig på bearbetning av SHBK:s och Fiskeristyrelsens mätningar dels av temperatur, salthalt och ström på Bornö station från 1930 och framåt dels av temperatur, salthalt, syrgas, närsalter mm från undersökningsfartyg. Det skiljs på fyra vattenmassor (WM), varav WM4 är det tidvas stagnanta vattnet under tröskelnivå. Det diskuteras huruvida en del av närsaltstillförseln kommer ifrån Skagerrak men något definitivt svar kan ej ges.

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HYDROGRAPHY OF THE GULLMAR FJORD

Contents:

1. Introduction.

In 1968 the present author wrote a paper about the hydrography of the Gullmar Fjord: Om Gullmarfjordens hydrografi, MHL nr 44. The present paper is a revised and enlarged version of this paper, now in English language. It can also be looked upon as part of a volume on coastal conditions in the Skagerrak and the Kattegat, "promised" in Svansson (1975).

2. Topography.

The Gullmar Fjord has the typical properties of a fjord. It is oblong and it has its maximum depth far inside the fjord mouth with its sill. The narrow mouth between Skaftö in the south and Stångenäset in the north has a sill depth of 56 m in relation to the fjord inside of it. Outside this sill there are deeper parts between the Lysekil peninsula (Stångehuvud) and Flatholmen (max 77 m). Further out in this direction the depth decreases again to 42 m between Berggylteskär and Byxeskär. A depth of 42 m seems to be the maximum penetration depth at a large area outside this point. The sill depths being slightly less than 40 m in all the other entrances, Gåsö Ränna inclusive, the real sill of the Gullmar Fjord is thereby 42 m.

Most parts of the Gullmar Fjord have a SSW-NNE direction. At the inner part the fjord is branched into two, or even three subfjords: Färlevfjorden (with a S-N direction), Saltkällefjorden and the very short Gullmarsvik. Only Saltkällefjorden has a sill at its mouth, which is furthermore very narrow. From the mouth of the Gullmar Fjord to the innermost end of the Färlevfjord the distance is 29 km and to the innermost end of the Saltkällefjord 26 km. The width of the Gullmar Fjord varies between 1 and 3 km; only at Bredungen, N of the islands of Bornö, is it 4 km. Skaftön is separated from the mainland (Bokenäset) by a very narrow waterway, Strömmarna, where the tidal currents are rather strong. There may be a small net transport of nutrients to the Gullmar Fjord through Strömmarna due to the fact that the nutrient concentration is higher in the Koljöfjord than in the Gullmar Fjord (Söderström pers. comm.).

The area of the Gullmar Fjord is about 50 km^2 (from the mouth inwards). The area delimited by the 50 m isobath is 17.9 km^2. That part which is limited by the 100 m isobath is 3.6 km^2 and is situated between Finsbo bight and Kolvik. The maximum depth, 125 m, lies in a very confined deep at the outher part of that area. Further inwards opposite "Alsbäck", there is a large area with depths slightly greater than 110 m. At the mouth of Saltkällefjorden the threshold has deeper parts at the eastern side making the sill depth equal to 45 m. The maximum depth of the Saltkällefjord, 66 m, is situated very near the sill. At the W sides of the Bornö islands and at Bredungen the depths are slightly less than 40 m. In a small constricted deep W of Stora Bornö the depth is 50 m, however. Table 1 shows details of areas and volumes. Areas below 50 m were determined by planimeter. Between 50 m depth and sea surface values were interpolated making use of the common figure of the Gullmar Fjord area i.e. 50 km^2. - A longitudinal section is shown in Fig. 6.

3. Data.

There are two large data sets available: 1) daily (6 days/week) measurements of temperature and salinity at Bornö Hydrographic Station from about 1931 (one set available also from 1909-1911). In 1964 also current measurements were introduced. The other data set (2) originates from measurements made a few times a year of temperature, salinity, oxygen and nutrients from research vessels. There are data already from the beginning of the Swedish sea investigations 1869 (Table 3) and most of them are from the Alsbäck position, but during later years also the stations Tröskeln and Saltkällefjorden have been visited. From 1980 a few more stations have been added (to totally 6 stations) in the framework of the pilot study of a future control program of the Gullmar Fjord being a protected marine area according to legislation.

Various data products are shown in Fig:s 2-5. They are shortly described in this chapter but will be referred to again later in the text.

3.1. Temperature (t), salinity (s) and density (sigma t).

Fig:s 2 a, b and c show isolines of t, S and sigma-t means of data 1961-1970 measured at the Bornö Station. Table 2a and b present the 1961-70 data as mean values and standard deviations. Fig:s 3a, b and c from the Alsbäck data set show similar distributions in the surface layers. Comparison between Fig:s 2 and the corresponding Fig:s 3 sometimes results in differences. Then of course the Bornö data have a higher accuracy due to higher sampling frequency and also sampling in all kinds of weather (storms, ice cover, etc.) Fig. 4a displays geographical differences. Surface salinities decrease from the fjord mouth to the mouth of the Örekil river.

3.2. Oxygen.

There are very few oxygen data before 1951, see Table 3, but a low value of 0.75 ml/l in 1906 is noted. The data from 1951 and onwards (Alsbäck) have been arranged monthly, see Fig:s 3 d and e. Fig. 5 contains deep water data as a time series 1966-1980 for Alsbäck and 1968-1980 for Saltkällefjorden. Fig. 4b shows that at most depths there is an oxygen decrease from the fjord mouth inwards.

3.3. Phosphorus Compounds.

We have reliable phosphate (PO_4) data from 1959 and Fig 3 f shows monthly means similar to O_2 in Fig 3 d. There are total phosphorus (Tot.P) data from 1968 and onwards (Fig. 3g). The annual variation of Tot.P is probably partly due to the fact that some zooplankton escape the water bottle sampler.

As shown in Fig:s 4c and 4d there is a general increase from the fjord mouth inwards. At station Saltkällefjorden there is a surface maximum apparently originating from the Örekil river.

3.4. Nitrogen Compounds (Fig. 3h).

The six stations program 1980-1983 mentioned above include nitrogen compounds as additional parameters (Fig. 6 and Table 5) During 1969 and 1970 Sen Gupta (1974, 1976) made frequent measurement of oxygen and nutrients including nitrogen compounds. (Fig. 10).

4. Sea level variations, tides, internal waves etc.

As shown below the tides are similar at Bornö and Smögen. We ma therefore as well use sea level data from Smögen, where the tide gaug has been well checked all the time since recording started in 1911.

The land upheaval in this area is 0.237 cm/year (Rossiter 1967) The monthly deviations at Smögen are as follows (Ann. 1957) in cm:

Month	1	2	3	4	5	6	7	8	9	10	11	12
	-1	-6	-11	-9	-10	-1	+4	+6	+7	+6	+7	+6

Low levels in the spring and high levels in the autumn is a genera phenomenon in the whole of the North Atlantic Area.

Another concept of interest is the sea levels duration, i.e. th time during which the levels have been attained or surpassed expressed in percentage of all observations, see Bergsten (1950). Hi Smögen values are:

+90 cm	+60 cm	+30 cm	0 cm	-30 cm	-60 cm
0.1 %	1.0 %	8.9 %	49.8 %	93.8 %	99.9 %

Highest recorded level was +148 cm (1920) and lowest level -112 c (1976).

A few tidal constants for Smögen and Bornö are shown in Table 4 The Bornö figures were taken from Bernung (1945). The Smögen value were calculated by the Liverpool Tidal Institute. There is much simi larity between the amplitudes and phases of the two stations. On important reason is the fact that the characteristic period of th Gullmar Fjord is 1.83 hours (Zeilon 1913), i.e. far from the tida periods. Zeilon (l.c.) also found a 13 minute period in the Born level data which he assumed to be the characteristic period of th Saltkällefjord.

Phases are presented in relation to Greenwich. The tides are predo minantly semidiurnal. High water comes about 4 hours after the moon' culmination in the Greenwich meridian (e.g. (111 x 12.42) / 360 hour where 111 is the phase of M2). Fig. 7a pictures high water levels (tw times a day) at Smögen 1984. The computation was done with the data i Table 4. Longer periods which are less accurate with only one year' data were not included. Adjustment to 1984, 1st January was done wit Schuremann's (1924) tables. Fig. 7b shows some hourly values.

Zeilon (l.c.) also investigated internal waves from recordings of the level variations of an instrument balanced at a density of 1.024 g/cm^3. He found the periods 12.42 hours, 1.83 hours, 2-3 days and longer periods. The period 1.83 hours, is the same as the characteristic barotropic period. Zeilon is of the opinion that it is a secondary phenomenon of the surface period and is created when the barotropic 1.83 hour-wave is disturbed by bottom irregularities. In Chapter 6 longer periods waves are dicussed e.g. that one of 2-3 days.

5. Water masses.

It is convenient to differ between 4 water masses (WM):

WM 1 : is a thin surface layer of river water often not recognizable due to wind mixing especially far from the river mouths.

VM 2 : is often called Baltic water because a considerable part of it is of Baltic origin. WM 2 lies under WM 1 down to an approximate depth of 15 m.

WM 3: This WM which lies below 15 m depth consists of water of higher salinity from the Skagerrak and possibly also from the Kattegat.

WM 4: This is water of similar type and origin as WM 3 but below sill depth, where it suffers stagnation during half part of the year.

Fig. 2 c shows 10 year monthly means of density measured at Bornö station 0 m - 33 m depth. There is no distinct barrier to be seen between WMs 2 and 3 at 15 m, a fact which however is partly due to the mean value procedure. Strong internal movements are normal in the Gullmar Fjord (see below) with the real barrier between WMs 2 and 3 moving up and down, see Fig:s 8 and 9.

Table 6 presents temperature statistics with special weight on negative temperatures. Negative temperatures are frequent only in cold winters. In e.g. February 1963 temperatures were often near the state of freezing sometimes down to 25 m depth. The freezing temperatures are -0.54 ^{o}C, at S=10, -1.08 ^{o}C at S=20 and -1.64 at S=30. At 33 m in WM 3 there were no negative temperatures recorded.

Fig. 3 c with the R/V data set from Alsbäck shows a similar distribution in the surface layers as the Bornö means. Deeper down the stagnation phenomenon modifies the picture. It is noteworthy that the deeper layers are much less stratified than the upper layers. That stagnation nevertheless takes place is coupled to the much smaller time variations of density at 30-50 m depth.

The stagnation gives rise to great variations in oxygen and nutrients content. Fig:s 3 d and f show that the stagnation period is about June- November whereas December-May is a period of more or less continuous renewal. In spite of the fact that the sill depth is situated at not more than 45 m depth (see above), typical stagnation does not exist higher up than about 55 m. Fig. 10 depicts Sen Gupta's (l.c.) 1969-1970 data in two different ways. - A more detailed description of the four water masses is presented below.

5.1. The Surface Water (WM1).

The main river water supply comes from the Örekil River (Örekilsälven). According to Melin (1955) its precipitation area is 1300 km^2. The mean river discharge 1931-50 was 21 m^3/s. As the total precipitation area of the Gullmar Fjord is about 1600 km^2 (Grönquist 1978) the total discharge may be raised to 25 m^3/s. The Örekil values were above normal during October-February and in April and below normal in May-September and in March. There is not much storage capacity of lakes and the river water supply is thereby rather dependent upon momentary rainfall.

River water, direct precipitation and fresh water from melting ice often floats as a thin cover on the Baltic water. At calm weather and especially under an ice cover the low salinities may prevail for some time. In January 1924 the salinity was as low as 2 promille at Kristineberg (Gislén 1929): "When the strongly freshened water is flowing out the fjord water is non-transparent, yellowish or brown, but more clear Baltic water is easily mixed up with a boat propeller". There is a natural brown colour due to humus substances but before 1966 a paper pulp industry added brown lignin compounds to the surface waters (Rosenberg 1976), see also Chapter 7. At occassions with wind a foam streak is formed near the rocky coast of Bornö (and probably elsewhere in the Gullmar Fjord). Sandström (1905) found the streak to have a very steady position in relation to the coast and presented an explanation for it. The foam streak was more developed before the paper pulp production was discontinued in 1966.

Fig:s 4 and 6 show that in the Saltkällefjord surface conditions are often extreme, low salinity and high nutrient concentrations. This may be explained by the river discharges, which together with exchange conditions create the distribution picture.

5.2. The Baltic Water (WM 2) and Water Mass 3 (WM 3).

As already mentioned there is not a distinct pycnocline between WM 2 and WM 3 especially when looking at mean values. Due to many reasons, however, a depth of 15 meters is the best value to assign to the lower limit of WM 2. As we shall see not only WM 4 but also WM 3 suffers low oxygen concentrations during parts of the year. Down to the 15 m depth the O_2 percentage is generally above 100 (Fig. 3e). It is moreover convenient to put the borderline at the lower limit of the euphotic layer (Kwiecinski et al 1962).

Like WM 2 water mass 3 has many similarities with water at the same depth interval in the northern Kattegat. The deep Kattegat water is supposed to originate from the Skagerrak (NE of Skagen?) and as shown by Möller and Svansson (1982) some of this water may return to the Swedish Skagerrak coast, after having circulated in the Kattegat, probably with lower oxygen content than at the entrance to the Kattegat. This water may then partly continue to the Gullmar Fjord. Like the conditions in the Kattegat, also in the Gullmar Fjord the nutrients (at least phosphate) are not increasing simultaneously with the oxygen decrease but are instead decreasing (Fig.11). The only explanation the present author can give is that this water was originally in the Skagerrak a surface water, where nutrients disappeared due to primary production.

As said before internal movements are frequent in the Gullmar Fjord. There are apparently long progressive waves, but far more stronger are Otto Pettersson's "moon waves": the surface layer is more or less sucked out from the fjord and its place is taken by water mass 3. Or the opposite: the fjord is filled with WM2 water at the same time as WM3 water is forced to leave the fjord.

The low oxygen content is further noticeable as there are large internal movements. Apparently these movements are not effective enough to raise the oxygen values, but maybe these values would have been still lower without the internal movements.

5.3. The Deep Water (WM 4).

We expect water mass 4 to be situated below sill depth (42 m) but most parameters start to behave differently first at 60 m (i.e. between 50 and 60 m). The oxygen diminishes like it does at higher levels in late summer but attains its minimum later, about November. In WM 4 the phosphate increases simultaneously with oxygen decrease in the later half of the year. Looking at the mean values 1951-81 (Fig. 3 d) we find in the water volume between 55 m depth and bottom a mean oxygen decrease during June-November of 230 ton O_2 pr month (0.38 ml/l and month). The mean PO_4-P increase during the same time is 1.5 ton P. The ratio 230:1.5 = 153 is rather near the value quoted in literature, 144 (Redfield et al 1963). Actually there should be a correction for turbulent diffusion through the "roof" at 55 m. From temperature data (Fig. 3 a) we may derive an exchange coefficient of 3 x 10^{-3} km^2/year (=0.03 cm^2/s) (disregarding any flow of water through the system a la Shaffer (1979)), which would result in a downtransport of 9 ton O_2/month. This should be added to the 230 ton resulting in a decomposition decrease of 239 ton. The corresponding correction of the PO_4-P figure would result in an addition to 1.6 ton P. The ratio is still 153 however. 239 tons of O_2 corresponds to 70 tons of carbon or 4.2 g C/m^2 and month. This figure is about one third of the primary production measured (Kwiecinski et al 1962) but as the Gullmar Fjord deep probably is a sedimentation trap for a larger area the ratio to primary production measured is still greater. Every spring about 10 ton P comes up from WM 4 to WM 3.

Fig. 3 c shows that the vertical density gradient is rather small at the roof especially if compared with conditions at higher levels. It may therefore seem surprising that the stagnation is so substantial every later half of the year. The explanation is probably that there is a very distinct annual variation in the density at sill depth. Fig. 3c shows that at 50 m depth sigma-t has its maximum in April-May and minimum in October-November. Therefore there is a more or less continuous renewal between minimum and maximum. Disturbances in the maximum density may cause a change in the winter-spring inflow. Let us look at sigma-t at Bornö 33 m in the years 1970-81. The maximum sigma ts 1970-72 were 27.15, 27.21 and 27.28 respectively all nearly equal and thereby giving good possibilities for the autumnal density lowering diffusion process to make the deep water ready for a renewal. In 1973, however the max. density was only 26.69 and this may explain the low oxygen level of that whole year (Fig. 5). The next time something similar happened was 1975 and 1976, when however 1976 was better than expected. One would again expect similar conditions in 1979 and actually this was a very bad year (Fig. 5). The reason for year-to-year variations in sigma-t may be Dickson's (1973) 5-6 year periodicity in salinity. Table 10d shows that salinities were below normal in spring in many of the years in the 70ies.

Table 5 shows typical nitrogen compound differences between spring renewal and autumn stagnation. Nitrate behaves similar as phosphate. Ammonia is practically nil in November probably indicating that the decomposition has terminated. This process starts with the formation of ammonia, which gradually is converted into nitrate.

6. Water and Matter Exchange.

Otto Pettersson (1914) presented daily observations of salinity made at Bornö Station 1909-1911. He found the great vertical variations of the isolines (see e.g. Fig:s 8 and 9) and described them as internal waves driven by tidal forces, the period of importance being around a fortnight (Moon waves). Later Hans Pettersson (1916 and 1920) showed rather high correlation with the wind. The present author has shown (1972 and 1975) that long-term Baltic Sea level variations (order of magnitude a fortnight or more) cause the Kattegat water to be drawn alternatively into the Baltic or out into the Skagerrak, which event creates great salinity variations in the Kattegat and along the Swedish and Norwegian coast of the Skagerrak (Fig. 12, Landsort levels can be assumed to represent the mean levels of the Baltic). A possible connection could be: high air pressure = low level of the Baltic = low salinities in the Kattegat and along the Swedish and Norwegian Skagerrak coasts = surplus of WM 2 in the Gullmar Fjord. Vice versa at low air pressure. Jerlov (= Johnsson 1943) showed the opposite, that an abnormally large amount of WM 3 was simultaneous with a high atmospheric pressure. Johnsson (l.c.) tells how at the end of January 1942 a radio warning was sent about ice melting. From 1942-01-24 to 1942-01-28 water of salinity 30 units rose from 24 to 4 m. In spite of strong coldness (-20 $^{\circ}$C) the ice melted between Hållö and Smögen.

The characteristic period of the variations is probably of great importance. For longer periods we have a high correlation between air pressure and surplus of Baltic WM2 water, for short periods an opposite connection. The latter case is what is most often met with, see Fig. 13 (from Möller and Svansson 1978). Lybeck (1968) made some studies in this direction but did not come to any final conclusion.

One explanation to the shorter-term variations is that one put forward in Möller and Svansson (l.c.) and also in Aure and Saetre (1981) that W-ly winds may stop the outflow of Baltic surface water whereby it is stacked in the Skagerrak-Kattegat. W-ly wind also give rise to inflows (towards the Baltic) of water into the Kattegat at all levels.

Recently Shaffer and Djurfeldt (1983) processed a total of 15 Aanderaa current meter recordings, 4 of the meters being anchored at one site in the Gullmar Fjord, near "Tröskeln" (Fig. 1), and the remaining ones in the Skagerrak off Smögen. They made a statistical analysis and came to the following conclusions.

The fluctuations with periods less than 4 days appeared to be driven directly by the wind over the fjord and not by interaction with the coastal zone of the Skagerrak. The authors found internal seiches around periods of 27 and 56 hours. At periods 5-6 days fluctuations were mainly coupled to those of local adjusted sea level and northern North Sea winds. No clear statistical relationships emerged for the very long (2 weeks or more) period motions.

The flow was found to be essentially baroclinic (i.e. density-dependant) often with flows in two opposite directions. The authors did not find support for a 3-layer flow, which is discussed by Rydberg (1977) and Long (1977). It is probable that a 3-layer flow appears only when the fresh water supply is weak. Whereas Zeilon (1913) interpreted observed 2 day period oscillations in terms of a first vertical mode internal seiche, Shaffer and Djurfeldt (lc) interpret it as the second vertical mode, the first one having a period of only 27 hours.

Current measurements are being made once a day at Bornö Station since 1963. Fig. 14 shows 5 and 25 m depth currents during July 1963. What we see is probably the inflowing WM2 at 5 m and outflowing WM3 at 25 m or vice versa.

There are many similarities between the Gullmar Fjord and the (northern?) Kattegat. For the Kattegat the present author (1984) has interpreted current measurements (Möller and Svansson 1982) in such a way that in the lower layer there is an inflow of Skagerrak water, one part of which is sucked up by wind erosion into the upper layer. The second part is flowing back to the Skagerrak. Also in the Gullmar Fjord we may consider a wind erosion current. If in the Kattegat with a (reduced) surface of 10^4 km^2 the erosion transport is 1 000 km^3/y (Stigebrandt 1983) then in the the Gullmar Fjord it would be 5 km^3/y (150 m^3/s). As the winds are less effective in the Gullmar Fjord than in the Kattegat, the figure probably is even lower. There may be a circulating component in WM3: At Bornö Station the current (see Table 7 and Fig. 15) between 5 and 30 m is outgoing as a mean, about 0.5 cm/s. In any case there is a high degree of probability that Kattegat deep water partly continues into the Gullmar Fjord.

Table 8 shows that there are similarities also in the temperatures between the Kattegat and the Gullmar Fjord, but a further study reveals lags in the Bornö data related to Vinga. As Lindquist (1964) pointed out, this fact is of great importance for the sprat in the autumn. Because the water is a little warmer in the fjord during January-March than in the open Skagerrak (see e.g. Table 8), the sprat prefers to dwell in the fjord(s) in the winter. Lindquist (l.c.) showed another example from Saltkällefjorden, where the temperature contrast was even larger.

Johansson and Svansson (1974) made an attempt to compute the turn-over time of the Gullmar Fjord. A value of 0.04 years (2 weeks) was achieved. From data it is however evident that there is a great difference between the Saltkällefjord and the Gullmar Proper. Another approach may be to use weighted mean salinities 0-45 m of the 3 stations Tröskeln, Alsbäck and Saltkällefjord, see Fig. 16. For the period 1968-1976 the mean salinities were 30.68, 30.35 and 30.11 units with corresponding Tot P's being 0.698, 0.712 and 0.814 micromoles/l. Fig.16 shows that if this approach is valid there should be a supply of some 100 ton P/year to satisfy the given figures of salinity, fresh water and total phosphorus. The method is rather rough, which e.g. can be seen from the fact that the expected P-supply to Gullmaren Proper + Saltkällefjorden is smaller (87 ton/year) than the one to Saltkälle-fjorden alone (165 ton/year). The actual river supply is not more than 30 ton P/year, 25 ton/year being the Örekil river contribution and 5 from the remaining rivers (Per Olsén pers. comm.). The upward spring transport from WM4 of 10 ton/year (Ch. 5.3) is probably balanced by a nearly equal amount of downward transport of organic P-compounds during the autumn. Rydberg (1983) derived a net inward transport from the Skagerrak of some 100 ton/year PO_4-P, mostly via WM3 in the wind erosion compensation current. But probably most of also this phosphorus is returned as organic compounds (in this case back to the Skagerrak). In the most extreme case however the 10 ton P/year upward spring transport is all external. For the missing phosphorus (about 60 tons/year) the incompleteness of the box model might be the cause. - Playing around with very few data of the Tot-N-difference between Saltkällefjorden and the Gullmar Proper (Alsbäck), we arrive at some 1000 ton N/year. The real river water supply is about 825 ton N/year (Per Olsén pers. comm.).

7. Primary Production. Optics.

7.1. Some Primary Productions Studies.

Primary production of plankton algae is mainly a function of nutrients and irradiant sun's energy (quanta). Steele (1956) tried to compute primary production from changes in phosphate content taking into account the upward transport of phosphate by turbulent diffusion. The exchange coefficient was computed by the assumption that the same coefficient can transport heat likewise. Kwiecinski et al (1962) tried the same procedure. The exchange coefficient was about 0.2 cm^2/s and the primary production 10 g c/m^2 a month during spring-summer. These authors found about the same order of magnitude from five C14 measurements during May-August 1963.

The Steele method does not include a re-circulation of nutrients (and there is no net transport of water as in the erosion theory). This phenomenon may well be much more important than transport through the pycnocline. Temperature changes may arise from advective transport of heat by currents rather than by vertical turbulent diffusion transport.

7.2. Optics.

The following table presents annual means of Secchi disc depth (D) determinations 1969-1982.

Station	Secchi depth m	Surface observations of TP ugat/l	S units	Number of observations
Smedjepricken	7.1	0.57	24.6	23
Tröskeln	6.3	0.67	23.2	24
Alsbäck	6.3	0.85	22.0	29
O~mestad	5.8	0.81	21.4	28
Saltkällefjorden	4.8	0.90	18.6	27
Örekilsälven	3.8	0.97	14.9	26

The secchi depth decreases from the fjord mouth to the entrance of the Örekil river. There is an apparent correlation with salinity. Fig. 17 shows the individual data measured at Alsbäck together with simultaneous surface salinities. The low salinities are due to river water mainly from the Örekil River and as this water usually is rich in phosphorus (see Table above) and nitrogen, Söderström (1976 and 1979) has put forward the idea that lowering of the transparency is due to higher amounts of detritus. But it is also probable that the river water has a low transparency due to high amounts of humus. Bladh (1972) published data of absorption in 380 nm determined on filtered samples in 5 cm cells (yellow substance) on one occasion 1972. At that occasion he also measured conditions in the Gullmar Fjord (unpublished data). He found values between 0 and 0.2 m^{-1} in the high saline water, but very high values in the surface: 2.6 at Tröskeln where salinity was 18.3, 4.2 at Alsbäck with S = 13.8 and 9.8 m^{-1} at the mouth of the Örekil river where S was only 2.9. Unfortunately we do not have enough data to establish a possible relation between Secchi depth and yellow substance. Munthe Kaas (1968) showed that for the Oslofjord the effect of turbidity (particles) was a little higher than dissolved substances on the secchi disc depth.

Sometimes the euphotic layer is defined as the level where there is 1 % of surface level quanta. We can use the rough formula of z(q 1%) 2D. For D=7 meter z(q 1%) is 14 m. A rough value of irradiance transparency in green, would be 75 % pr m.

8. Long-term variations.

8.1. Bornö data of temperature and salinity.

Table 9 shows that there are rather good correlations between Bornö and northern Kattegat data. Anholt data have been used extensively to display climatic changes (e.g. Malmberg and Svansson 1982 from which Fig. 18 has been reproduced). Fig. 19 (a b c d) shows annual means 1938-1982 for Bornö and 1938-1978 for Anholt. It seems clear that Bornö data have about the same climatic variations as the Anholt ones. Bornö annual means should have a higher precision because lightships were now and then withdrawn due to ice.

Table 10 contains monthly means deviations of temperature and salinity measured at 5 m and 33 m depths at Bornö. Fig. 20 shows one of these 33 m deviations, temperature 33 m, with months on one axis and year on the other.

8.2. Trends in oxygen and nutrient data.

Fig:s 21a - e show Alsbäck data plotted as function of time. They are presented as deviation from monthly means. These means were computed by the use of all the parameter data.

Fig:s 21a and b show oxygen trends of some 100 measurements. There is a decreasing trend at both 50 m and 100 m depth. Fig. 21c show the regression lines only of some 70 total phosphorus data. Data from 10 and 15 m are similar with 0 m (and 20 m), i.e. no increase or decrease. Trends of increase are seen at 30 (40 and 50 similar) and 80 m (90, 100 and 110 similar). Fig. 21d depicts regression lines of some

80 phosphate measurements. Only 4 depths data were analysed. There are clear increase trends at 0 m and 50 m.

NO_3-trends were computed from about 40 measurements. The data are very scattered and there are clear (upward) trends only at 80 m and deeper. Fig. 21e shows 17 total nitrogen points with an upward trend.

One must be cautious to interpret trends constructed from so few data. If it is true that the trends of decreasing oxygen and increasing nutrients are correct, it points towards eutrophication. A study of simultaneous salinity and temperature data could possibly reveal if this has a natural cause (climatic variations) or is man-made.

9. Sammanfattning.

Denna sammanställning om Gullmarfjordens hydrografi kan betraktas som en avsevärt utvidgad version av "Om Gullmarfjordens hydrografi", som jag publicerade 1968.

Med hydrografi menas här fysikalisk och kemisk havsvatten-beskrivning. Huvudvikten är lagd på bearbetning av Svenska Hydrografisk-Biologiska Kommissionens och senare Fiskeristyrelsens mätningar av temperatur, salthalt, syrgas, närsalter mm dels på Bornö station dels från undersökningsfartyg. Av de mätningar, som från 1980 utföres i ett kontrollprogram med anledning av att Gullmarfjorden blivit ett naturvårdsområde, har endast de medtagits som Fiskeri-styrelsen utfört, däremot inte sådana föroreningsparametrar som tunga metaller, klorerade kolväten, olja mm. Likaledes saknas i det stora hela sambandet mellan å ena sidan hydrografiska och å andra sidan biologiska, sedimentologiska mm fenomen.

Av kapitel två framgår det bl.a. att tröskeln ligger utanför egentliga Gullmarfjorden och är på c:a 42 m. Det finns en tröskel mellan egentliga Gullmarfjorden och Saltkällefjorden och dess djup är c:a 45 m. Fig. 1 är en karta över området och ett längdsnitt med bottenprofil har använts i fig. 6.

Kapitel 3 med sina tillhörande figurer och tabeller presenterar data som sedan diskuteras mera i kapitlen 5 och 6. Många figurer visar månadsmedelvärden för varje mätdjup. Antalet mätningar är ganska få på Alsbäck, vilket bl.a. framgår av trendfigurerna (Fig. 21), medan Bornömätningarna varit dagliga (6 ggr/vecka). Sämst är det med kväve-parametrarna, men en förbättring skedde under det omtalade förunder-sökningsprogrammet 1980-1983.

Kapitel 4 handlar mest om tidvatten, varvid data från den registrerande vattenståndsmätaren på Smögen utnyttjats. Fig. 7 visar tidvattnet för 1:a halvåret 1984 såsom det kan beräknas ur s.k. harmoniska konstanter, vilka i sin tur beräknats ur 1959 års data.

Kapitel 5 behandlar de 4 viktigaste vattentyperna eller vatten-massorna i Gullmarfjorden. Den första, WM1, är ett mer eller mindre utblandat älvvatten. I medeltal är sötvattentillrinningen 25 m^3/s, varav det mesta, 21 m^3/s, kommer från Örekilsälven. Som det bl.a. framgår av figurerna 4 och 6 är inte bara salthalten låg i ytan på station Saltkällefjorden (och ännu mer Örekilsälven); närsaltsvärdena är förhöjda och secchidjupet litet (kapitel 7).

Under WM1 identifierar vi WM2 som ett vatten som vi kallar baltiskt. Det är en vattentyp, som också finns i Kattegatt och karakteriseras av stark salthaltsskiktning i synnerhet i medelvärdesbilder. Man anger ofta 15 m:s nivån som undre gränsen, men som figurerna 2c och 3c visar, skulle man lika gärna kunna välja ett något större djup.

Den tredje typen, WM3, liknar det vatten som i Kattegatt rinner in dit som en underström från Skagerrak. Likheten kan bero på att vattnet ibland eller alltid först varit i Kattegatt innan det kommer till Gullmaren. Fig. 11 visar att syrgas och fosfat följer varandra i stället för att som normalt, t.ex. i WM4, vara varandras spegelbilder.

En förklaring kan vara att närsalterna minskat på grund av primärproduktion, när vattnet låg uppe i eufotiska skiktet i Skagerrak. Syrgasminskningen har sedan skett på det nya större djupet ev. först i Kattegatt.

Vattenmassa nr 4 ligger under tröskeldjupet. Det typiska är att detta vatten stagnerar under juni-november, medan under övriga delar av året vattnet byts ut mer eller mindre regelbundet. Fig. 3c visar hur densiteten är minst om senhösten och sedan ökar seccessivt fram till april-maj. Tyngre vatten tränger då undan lättare vatten, medan under stagnationsperioden lättare vatten lägger sig ovanpå det tyngre. Några år har vattenförnyelsen inte varit så effektiv som vanligt och då räcker syrgasförrådet nätt och jämt till för nedbrytningen av organisk substans. Sådana år har varit 1973 och 1979 (Fig. 5).

I 5.3. presenteras en del överslag som visar att under hösten närsaltsökningen motsvarar 4.2 g C/m^2 och månad. Primärproduktion är c:a 3 ggr så stor men sambandet kompliceras ytterligare av att fjordbassängen sannolikt utgör en uppsamlingsplats för organiskt material som producerats utanför Gullmaren.

Under den speciella perioden 1980-83 gjordes mätningar av kvävekomponenter på sex stationer två ggr om året, maj och november. I maj när förnyelsen av bottenvatten just är avslutad är NO_3 som lägst medan NH_4 är måttlig till hög. I november är däremot NO_3 nära maximum och NH_4 har gått ned till noll. Det senare indikerar att nedbrytningen, som går via NH_4 till NO_3, har avslutats.

Kapitel 6 går närmare in på vattenrörelser och vattenutbyte. Figurerna 8 och 9 visar isohalinernas mycket stora variationer, vilket Otto Pettersson (1914) tolkade som ett internt huvudsakligen halvmånatligt tidvatten, och talade om Månvågor. Som syns i fig. 14 och också framgår av Shaffer och Djurfeldts (1983) strömmätningar karakteriseras fenomenet bl.a. av att antingen WM2 minskar (rinner ut) och ersätts av överskott på WM3 (som rinner in), t.ex. 17-19 februari 1965 (Fig. 9) eller tvärtom, t.ex. början av februari i fig. 9. Alla är numera ense om att det är vindar och lufttryck, som driver månvågorna, men det råder osäkerhet om hur det går till i detalj. Jag själv menar (1975) att för långa perioder (c:a halvmånatliga) kan man tänka sig följande sambandskedja: högt lufttryck (över Skandinavien) = lågt vattenstånd i Östersjön = låga salthalter i Kattegatt och längs Bohuslän = överskott på baltiskt (WM2) vatten i Gullmaren.

Jerlov (1943 som då hette Johnsson) fann ett motsatt samband, nämligen att högt lufttryck ger underskott av WM2 (och överskott av WM3). Som bl.a. Shaffer och Djurfeldt (1983) visat är det den karakteristiska perioden på skeendet som är avgörande. För kortperiodiska förlopp är det viktigt hur det blåser över Skagerrak. En västlig vind ökar vattentransporten både i Skagerrak- snurran och till Östersjön via Kattegatt. Därvid blir det baltiska ytvattnet (till en början) så hindrat att gå sin normala väg att det stackas upp vid Bohuslän och i Gullmaren, se fig. 13. - Ett intressant problem är likheten mellan WM3 och Kattegatts djupvatten. Möjligheten finns att en del av WM3 härrör från Kattegatt. Alternativet är att processerna är så likartade att de ger upphov till samma typ av vatten.

Fig. 16 visar en boxmodellberäkning. Med de data vi har borde enl detta grova förfarande det rinna till c:a 100 ton fosfor pr år. Enligt J. Söderström och P. Olsén (pers. medd) är nog denna siffra mer än dubbelt så stor som den verkliga tillförseln (30 ton P/år). Boxmodellens tillflöde av 1000 ton N/år stämmer bättre med verklighetens 825 ton/år. En nettotransport av närsalter från Skagerrak kan emellertid inte uteslutas.

Kapitel 7 berör primärproduktion så tillvida som att Kwiecinski et al (1962) använde fosfatdata för att beräkna produktion enl Steele (1956). - Kapitlet om optik innehåller en statistik över secchi-skiv-djup. Detta minskar från fjordmynning till Örekilsälvens mynning. Detsamma gör salthalten medan totalfosforn har ett motsatt förlopp.

Kapitel 8 behandlar tidsvariationer i de data som använts för att få medelvärden mm. Först visas att Bornödata samvarierar rätt bra med data från fyrskepp i Kattegatt (Tabell 9, fig. 19a-d). Sedan undersökes i fig. 21a-e ev. trender i syrgas och närsalts-data. Frånvaron av trend i Tot.P data i ytskiktet skiljer sig från motsvarande i Kattegatt (Svansson 1984).

10. Acknowledgements

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Tabell-texter.

Tabell 1. Ytor och volymer för Gullmaren uppdelat i 10 m tjocka skivor lagda på varandra.

Tabell 2. Medelvärden och standardavvikelser för dagliga mätningar vid Bornö 1961-1970
a) temperatur b) salthalt c) sigma t (beräknad)

Tabell 3. Mätningar på stort djup vid Alsbäck 1869-1919.

Tabell 4. Tidvattenkonstanter beräknade ur vattenståndsdata från Smögen 1959 och Bornö 1942.

Tabell 5. Kvävekomponenter uppmätta vid Alsbäck 1981 05 05 och 1981 12 02.

Tabell 6. Temperaturstatistik av Bornödata 1960-69. Positiva temperaturer i 5°-intervall, negativa i halvgradsintervall.

Tabell 7. Medelvärden och standardavvikelse för ström som uppmätts 1 gg/dygn vid Bornö 1971-80 (minustecken för ström som går in i Gullmaren.

Tabell 8. Månadsmedelvärden av temperatur uppmätt 1951-60 på 30 m djup vid Bornö och Vinga.

Tabell 9. Korrelationskoefficienter av månadsmedelvärden av temperatur och salthalt vid Vinga och Anholts fyrskepp samt Bornö

Tabell 10. Månadsmedelvärdenas (Bornö) avvikelse från 30-åriga medelvärden av
a) temperatur 5 m
b) salthalt 5 m
c) temperatur 33 m
d) salthalt 33 m

Figurtexter.

Figur 1. Karta över Gullmarsfjorden och dess omgivningar.

Figur 2. Månadsmedelvärden av dagliga Bornömätningar 1961-70,
a) temperatur
b) salthalt
c) beräknad sigma t (densiteten = 1 + sigma t x 10^{-3}).

Figur 3. Månadsmedelvärden av mätningar c:a 5 ggr/år från mätstation Alsbäck
a) temperatur 1950-1981
b) salthalt 1950-1981
c) sigma t (ber) 1950-1981
d) syrgas ml/l 1950-1981
e) syrgasmättnad 1950-1981
f) fosfatfosfor 1959-1981
g) totalfosfor 1968-1982
h) nitratkväve 1968-1981

Figur 4. Totalmedelvärden av mätningar på de tre mätstationerna Tröskeln, Alsbäck och Saltkällefjorden 1968-1976
a) salthalt
b) syrgasmättnad
c) fosfatfosfor
d) totalfosfor.

Figur 5. Tidsserie av syrgaskoncentration uppmätt vid mätpositionerna Alsbäck 100 m, Ormestad fyr 90 m och Saltkällefjorden 50 m.

Figur 6. Längssnitt med kvävekomponenter uppmätta 1980 11 27
a) total-kväve
b) nitrat-kväve
c) nitrit-kväve
d) ammoniak-kväve
allt i mikromoler/dm^3.

Figur 7. Beräknat tidvatten för 1984 vid Smögen med hjälp av harmoniska konstanter, som framtagits ur 1959 års vattenståndsdata för Smögen
a) högsta och lägsta högvatten under jan-juli
b) timvärden för 1-9 januari.

Figur 8. Tidsutveckling för sigma t under februari-8 mars 1963 vid Kristineberg och Bornö.

Figur 9. Tidsutveckling för salthalt uppmätt vid Bornö under februari 1965.

Figur 10. Sen Guptas Alsbäckmätningar 1969-70
a) temperatur 40, 50, 60, 70, 80, 90, 100 och 110 m.
syrgasmättnad - " - " - " -
b) sigma t - " - " - " -
salthalt - " - " - " -
c) fosfatfosfor - " - " - " -
totalfosfor - " - " - " -
d) silikat-kisel - " - " - " -
nitrat-kväve - " - " - " -
e) temperatur, salthalt, syrgasmättnad, syrgaskoncentration, fosfatfosfor, totalfosfor, nitratkväve och silikat-kisel på 40 och 50 m
f) d:o på 60 och 70 m
g) d:o på 80 och 90 m
h) d:o på 100 och 110 m.

Figur 11. Jämförelse av månadsmedelvärdena på 30 m Alsbäck av syrgaskoncentration, syrgasmättnad och fosfatfosfor.

Figur 12. Dygnsmedelvärden av vattenstånd uppmätt vid Landsort ("mitt i Östersjön") samt dagliga värden av salthalt uppmätta på 5 m djup vid Bornö 1964 (ur Svansson 1975).

Figur 13. Mätningar juni-juli 1967 av djupet till 22 isohalinen vid Bornö
strömhastigheten vid Halsskov Rev fyrskepp, nordkomp. ytan
strömhastigheten vid SW Smögen, nordkomp. 50 m djup
strömhastigheten vid Skagens Rev fyrskepp, ostkomp. ytan
(ur Möller och Svansson 1978).

Figur 14. Strömmätningar vid Bornö (1gg/dygn) vid 5 m och 25 m djup.

Figur 15. Medelström vid Bornö enl mätningar 1 gg/dygn under 1971-80

Figur 16. Boxberäkningar. S = salthalt, TP = totalfosfor
Fresh water supply = sötvattentillrinning.

Figur 17. Secchi-djup mot salthalten, Alsbäck.

Figur 18. Tidsserie av utjämnade årsmedelvärden av temperatur och salthalt uppmätta vid Anholts fyrskepp 1880-1980, 0 m och 30 m djup.

Figur 19. Jämförelse mellan årstidsmedelvärden av data som uppmätts vid Anholts fyrskepp (A) och Bornö (B),
a) temperatur 0 m (A), 5 m (B)
b) temperatur 30 m (A), 33 m (B)
c) salthalt 0 m (A), 5 m (B)
d) salthalt 30 m (A), 33 m (B)

Figur 20. Temperaturens avvikelse från månadsmedelvärden 1931-60.

Figur 21. Trender i Alsbäcksdata. Avvikelse från månadsmedelvärden, beräknade ur samma material
a) syrgaskoncentrationer 50 m
b) - " - 100 m
c) totalfosfor 0 (10,15), 20, 30 (40,50), 60, 70, 80 (90,100,110) m. Linjerna för djupen inom parentes praktiskt taget lika som dem för djupet före parentesen.
d) totalfosfor 0, 10, 50 och 100 m
e) totalfosfor (ej avvikelse utan originalvärden) 0 m.

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11.2. Data availability

BORNÖ

1909-1911 : CF
1930-1938 : CF
1939-1950 : CF, P: SHBK, fyrskepp
1951-1969 : CF, P: Fishery Board, Ser. Hydr. Report
1970-1972 : CF, P: Medd. Havsfiskelab. nr 148
1972-1983 : CF

RESEARCH VESSEL STATIONS

-1962 : PC, P: ICES
1963-1972 : PC, P: Medd. Havsfiskelab., Hydr.data (IHR, Red series)
1973-1977 : PC, P: Hydr. data (IHR, Red series)
1978-1983 : CF, P: Hydr. data (IHR, Red series)

CF = Computer File at IHR

ICES = International Council for the Exploration of the Sea

IHR = Institute of Hydrographic Research of the Board of Fisheries

P = Publication

PC = Punch Cards

HBK = Svenska Hydrografisk Biologiska Kommissionen

Table 1

Table 1

Area km^2			Volume km^3		from bottom up to	
at 0 m depth	50		0-10 m	0.44	0 m	2.053
10 m	40		10-20 m	0.36	10 m	1.613
20 m	33		20-30 m	0.30	20 m	1.253
30 m	27		30-40 m	0.25	30 m	0.953
40 m	22		40-50 m	0.20	40 m	0.703
50 m	17.9		50-60 m	0.16	50 m	0.503
60 m	13.9		60-70 m	0.12	60 m	0.343
70 m	10.8		70-80 m	0.09	70 m	0.223
80 m	7.76		80-90 m	0.065	80 m	0.133
90 m	5.45		90-100 m	0.042	90 m	0.068
100 m	3.62		100-110 m	0.021	100 m	0.026
110 m	1.33		110-125 m	0.005	110 m	0.005
125 m	0					

Table 2a

Table 2 a

Mean value and standard deviation of temperature at Bornö 1961-1970

Depth		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0 m	MV	0.3	0.4	0.8	4.0	10.0	16.2	17.3	17.4	14.8	10.8	6.3	2.3	8.3
	DEV	0.9	1.2	1.4	2.8	2.3	2.4	1.3	1.6	1.6	1.7	2.0	2.0	6.9
2.5	MV	1.8	1.0	0.7	3.9	9.3	15.8	17.2	17.5	15.2	11.5	7.8	4.1	9.0
	DEV	2.0	1.9	1.4	2.1	2.1	2.6	1.2	1.5	1.4	1.2	1.9	1.9	6.5
5	MV	2.4	1.5	1.3	4.0	8.6	14.8	16.7	17.4	15.3	11.9	8.5	4.8	8.9
	DEV	2.2	2.1	1.9	2.0	2.1	3.0	1.5	1.6	1.4	1.1	2.0	2.2	6.2
10	MV	3.3	2.4	1.8	3.8	7.6	12.5	15.2	16.3	15.1	12.3	9.4	5.8	8.8
	DEV	2.4	2.3	2.0	1.6	2.1	3.6	2.0	1.9	1.4	1.1	2.0	2.5	5.6
15	MV	4.4	3.3	2.5	4.2	6.6	10.2	13.7	14.8	14.6	12.6	10.2	6.8	8.6
	DEV	2.5	2.2	2.1	1.4	1.9	3.2	2.1	1.6	1.4	1.1	1.8	2.5	4.9
20	MV	5.4	4.4	3.7	4.5	5.8	8.4	12.3	13.5	14.0	12.7	10.7	7.8	8.6
	DEV	2.3	1.9	2.0	1.2	1.3	2.6	1.9	1.5	1.3	0.9	1.6	2.3	4.1
25	MV	6.6	5.2	4.7	4.8	5.4	7.3	11.2	12.5	13.2	12.8	11.2	8.5	8.6
	DEV	1.6	1.5	1.6	1.1	1.0	2.0	1.8	1.5	1.3	0.8	1.4	1.8	3.5
33	MV	7.4	6.1	5.6	5.2	5.3	6.2	9.2	11.0	12.0	12.5	11.3	9.0	8.4
	DEV	0.8	0.8	1.1	0.9	0.7	1.3	1.9	1.6	1.5	0.8	1.1	1.1	2.9

Table 2b

Table 2 b

Mean value and standard deviation of salinity at Bornö 1961-1970

Depth		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0 m	MV	12.46	11.91	11.27	14.68	19.09	20.89	22.50	20.90	21.89	20.60	19.70	17.43	17.79
	DEV	8.19	10.74	9.62	8.59	4.94	2.36	2.59	4.37	4.97	6.00	6.60	8.68	8.01
2.5	MV	26.27	26.64	23.73	21.90	21.63	21.68	23.32	22.46	23.94	23.61	24.67	25.44	23.77
	DEV	2.75	2.83	4.10	4.71	3.77	2.53	2.07	2.72	2.92	3.77	3.46	2.58	3.63
5	MV	26.98	27.42	25.56	23.99	23.13	22.78	24.43	23.76	24.99	25.03	26.20	26.59	25.09
	DEV	2.83	2.86	3.30	3.96	3.88	3.10	2.48	2.57	3.18	2.77	3.17	2.43	3.40
10	MV	28.39	28.98	27.65	26.83	26.01	25.81	26.76	26.24	27.02	26.91	28.02	28.12	27.23
	DEV	2.96	2.96	3.35	4.08	4.34	3.80	3.29	3.01	3.17	3.09	3.19	2.68	3.49
15	MV	29.78	30.33	29.46	29.58	28.83	28.91	28.88	28.82	28.74	28.50	29.56	29.53	29.24
	DEV	2.83	2.80	3.47	3.62	3.75	3.03	2.62	2.46	2.88	3.09	2.93	2.57	3.07
20	MV	31.09	31.67	31.57	31.62	31.34	30.92	30.22	30.40	30.19	29.96	30.81	30.99	30.89
	DEV	2.51	2.40	2.35	2.65	2.29	1.75	1.94	1.55	2.21	2.77	2.43	2.19	2.35
25	MV	32.40	32.61	32.76	32.78	32.52	31.86	31.02	31.23	31.30	31.17	31.82	31.99	31.95
	DEV	1.67	1.77	1.57	1.67	1.02	1.11	1.46	0.80	1.17	1.98	1.70	1.77	1.64
33	MV	33.49	33.56	33.62	33.61	33.27	32.75	31.72	31.88	32.12	32.40	32.75	33.09	32.85
	DEV	0.70	0.81	0.95	0.95	0.75	0.78	1.45	0.69	0.70	0.56	0.82	0.92	1.10

Table 2 c

Mean value and standard deviation of sigma t at Bornö 1961-1970
(Density = 1 + (sigma t) x 10^{-3})

Depth		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0 m	MV	9.99	9.57	9.01	11.62	14.60	14.93	15.93	14.68	15.98	15.65	15.49	13.91	13.46
	DEV	6.58	8.62	7.72	6.81	3.90	2.02	2.06	3.19	3.78	4.56	5.13	6.89	6.07
2,5 m	MV	21.00	21.33	19.04	17.43	16.67	15.61	16.58	15.84	17.46	17.88	19.23	20.20	18.16
	DEV	2.09	2.19	3.26	3.77	3.02	2.25	1.72	2.06	2.32	2.90	2.67	1.99	3.17
5 m	MV	21.53	21.93	20.47	19.07	17.93	16.63	17.54	16.87	18.25	18.91	20.32	21.04	19.22
	DEV	2.12	2.19	2.58	3.16	3.13	2.79	2.11	2.09	2.55	2.15	2.40	1.79	3.01
10 m	MV	22.57	23.11	22.10	21.34	20.30	19.39	19.61	18.99	19.85	20.30	21.60	22.13	20.95
	DEV	2.17	2.23	2.58	3.22	3.54	3.43	2.82	2.58	2.60	2.37	2.36	1.92	2.99
15 m	MV	23.58	24.11	23.50	23.48	22.66	22.17	21.55	21.28	21.26	21.48	22.68	23.13	22.57
	DEV	2.05	2.09	2.66	2.83	3.08	2.79	2.32	2.16	2.39	2.37	2.14	1.80	2.60
20 m	MV	24.51	25.09	25.07	25.06	24.71	24.01	22.84	22.75	22.50	22.58	23.57	24.14	23.90
	DEV	1.80	1.78	1.73	2.05	1.87	1.68	1.71	1.43	1.88	2.14	1.79	1.51	2.04
25 m	MV	25.43	25.76	25.93	25.96	25.68	24.91	23.66	23.59	23.50	23.50	24.28	24.84	24.75
	DEV	1.20	1.29	1.12	1.27	0.83	1.09	1.25	0.82	1.07	1.55	1.27	1.24	1.52
33 m	MV	26.20	26.42	26.53	26.55	26.29	25.76	24.53	24.37	24.38	24.50	24.98	25.63	25.51
	DEV	0.55	0.58	0.65	0.68	0.58	0.70	1.23	0.74	0.75	0.53	0.72	0.74	1.13

Table 2c

Table 3

Table 3

Measurements from Alsbäck deep 1869-1919

Year	Date	Depth,m	Temp. °C	Salinity	O_2 ml/l
1869	18 Aug	145		34.7	
1890	17 Feb	130	4.2	33.91	1.88
1891	24 Feb	130	6.7	34.72	4.14
1893	4 May	100	3.74	34.31	4.83
	1 Aug	120	5.04	34.55	4.02
	13 Nov	120	4.65	34.43	3.60
1894	11 Feb	120	4.85	34.48	2.73
	27 Jul	110	5.14	34.84	4.48
	12 Sep	100	5.14	34.76	
1896	11 Feb	100	6.47	34.64	4.22
	17 Aug	100	5.18	34.28	
	17 Dec	100	7.48	34.93	
1897	31 Jul	120	5.45	34.69	
	10 Sep	100	5.70	34.60	
	17 Dec	100	5.77	33.46	
1898	1 Feb	100	5.80	34.41	
	31 Aug	100	5.45	34.57	
	20 Dec	100	5.70	34.41	
1899	20 Jul	100	6.	34.45	
1900	14 Jan	100	6.10	34.26	
	1 Aug	120	4.65	34.76	
1901	13 Aug	105	4.56		
1902	4 Feb	ca 100	4.95	34.54	
	25 Aug	116	4.48	34.58	3.46
1903	19 Feb	110	5.01	34.61	
	14 May	100	5.61	34.45	5.48
1904	19 Feb	100	5.64	34.43	5.64
	14 Nov	100	5.28	34.45	2.45
1905	18 Feb	100	4.74	34.27	4.98
	15 May	115	4.55	34.20	5.04
	7 Aug	100	4.52	34.11	3.87
	16 Nov	114	4.71	34.07	2.83
1906	10 Mar	115	7.49	34.87	2.87
	22 May	116	6.96	34.65	2.91
	14 Aug	117	6.43		0.75
	18 Nov	120	7.69	34.83	4.77
1907	2 May	100	4.34	34.49	
1908	18 May	100	4.60	34.56	
	23 Oct	100	4.68	34.42	
1909	7 Jan	100	6.95	34.85	
	12 Feb	100	6.30	34.74	
	23 Feb	115	6.84	34.69	
	10 Mar	100	5.32	34.45	
	28 May	110	5.58	34.87	
	10 Jul	100	5.78	34.74	
	18 Nov	100	5.70	34.52	
	16 Dec	100	5.80	34.56	
1910	17 Jan	100	5.95	34.54	
	15 Feb	100	5.78	34.56	
	14 Jun	100	5.45	34.23	
	27 Aug	117	5.38	34.27	
1911	22 Feb	100	6.39	34.20	
	8 Mar	100	6.38	34.11	
	12 May	116	5.67		

1913	22 Jan	100	6.71	34.40
	8 Mar	100	5.73	34.11
	24 Apr	106	4.90	34.47
1914	28 Feb	100	5.89	34.29
1919	20 May	118	5.70	

Table 4

TIDAL CONSTANTS

Constant	Period hours	SMÖGEN 1959 Amplitude cm	SMÖGEN 1959 Phase (Greenwich)	BORNÖ 1942 Amplitude cm	BORNÖ 1942 Phase (Greenwich)
O1	25.82	2.5	283°	1.9	283°
2N2	12.91	0.9	25°		
MY2	12.87	2.4	296°		
N2	12.66	2.4	63°	3.1	50°
M2	12.42	9.6	111°	10.5	104°
S2	12.00	2.9	60°	2.9	54°
M4	6.21	1.1	311°		

Table 5

NITROGEN COMPOUNDS ALSBÄCK

µmolar/l

	1981 05 05						1981 12 02					
Depth	NO_2	NO_3	NH_4	SN	PO_4	SN:PO_4	NO_2	NO_3	NH_4	SN	PO_4	SN:PO_4
0	0.13	0.64	0.59	1.36	0.06	23	0.43	6.37	1.14	7.94	0.61	13.0
5	0.06	2.38	0.58	3.02	0.13	23	0.54	5.76	0.96	7.26	0.67	10.8
10	0.09	2.70	0.64	3.43	0.26	13	0.63	5.57	1.05	7.25	0.73	9.9
15	0.09	8.51	0.08	8.68	0.81	11	0.66	6.09	0.65	7.40	0.71	10.4
20	0.14	4.06	0	4.20	1.10	4	0.76	5.09	1.47	7.32	0.65	11.3
30	0.07	3.83	0.11	4.01	1.15	3	0.72	5.03	0.98	6.73	0.50	13.5
40	0.06	2.87	0.07	3.00	1.49	2	0.84	4.76	1.63	7.23	0.64	11.3
50	0.03	8.52	0.64	9.19	1.05	9	0.86	4.64	1.96	7.46	0.60	12.4
60	0.03	9.07	1.19	10.29	0.90	11	0.77	5.83	1.26	7.86	0.73	10.8
70	0.05	9.15	1.17	10.37	0.94	11	0.04	17.81	0	17.85	1.95	9.2
80	0.03	9.27	1.28	10.58	0.84	13	0.02	18.03	0	18.05	1.92	9.4
90	0.04	8.71	1.20	9.95	0.84	12	0	17.85	0	17.85	1.97	9.1
100	0.03	10.10	1.21	11.34	0.85	13	0	18.15	0.07	18.22	2.14	8.5
110	0.05	9.75	3.38	13.18	2.44	5	0.19	17.96	0.29	18.44	2.98	6.2

$SN = NO_2 + NO_3 + NH_4$

Table 6 a

BORNÖ 1960–1969 TEMPERATURE STATISTICS (^{o}C)

		< -1.1 ^{o}C	-1.0 – -0.6 ^{o}C	-0.5 – -0.1 ^{o}C	0.0 – 4.9 ^{o}C	5.0 – 9.9 ^{o}C	10.0 – 14.9 ^{o}C	15.0 – 19.9 ^{o}C	-20 ^{o}C
0 m	Jan	5 %	7 %	15 %	69 %	4 %			
	Feb	8	2	21	68				
	Mar	2	5	11	82	1			
	Apr			1	61	34	4		
	May					50	44	6	
	Jun					0	27	66	6
	Jul						2	95	3
	Aug						8	83	9
	Sep						50	50	
	Oct				1	27	73		
	Nov				29	70	2		
	Dec	0	2	4	82	12			
2,5 m	Jan	4 %	3 %	12 %	72 %	9 %			
	Feb	12	11	11	61	5			
	Mar	4	19	6	71	1			
	Apr		1	1	66	31	1		
	May					62	36	3	
	Jun					2	28	67	3
	Jul						1	98	1
	Aug						3	84	12
	Sep						34	66	
	Oct					11	89		
	Nov				11	75	15		
	Dec				68	32	1		

Table 6 a

Table 6 b

Table 6 b

BORNÖ 1960-1969 TEMPERATURE STATISTICS (^{o}C)

		< -1.1 ^{o}C	-1.0 - -0.6 ^{o}C	-0.5 - -0.1 ^{o}C	0.0 - 4.9 ^{o}C	5.0 - 9.9 ^{o}C	10.0 - 14.9 ^{o}C	15.0 - 19.9 ^{o}C	-20 ^{o}C
5 m	Jan	3 %	1 %	4 %	75 %	17 %			
	Feb	12	4	10	68	6			
	Mar	5	13	8	73	3			
	Apr			2	72	26	0		
	May				3	66	31	1	
	Jun					7	38	54	1
	Jul						15	85	0
	Aug						7	84	9
	Sep						38	62	
	Oct					5	95		
	Nov				8	72	20		
	Dec				54	45	1		
10 m	Jan	2 %	0 %	2 %	64 %	32 %			
	Feb	8	2	6	59	24			
	Mar	3	8	6	77	5			
	Apr			2	74	24			
	May				7	76	17		
	Jun				1	22	54	22	0
	Jul					4	34	61	1
	Aug						31	67	2
	Sep						46	54	
	Oct					2	98	0	
	Nov				3	53	44		
	Dec				38	56	6		

Table 6 c

BORNÖ 1960-1969 TEMPERATURE STATISTICS (^oC)

		<-1.1 ^oC	-1.0 - -0.6 ^oC	-0.5 - -0.1 ^oC	0.0 - 4.9 ^oC	5.0 - 9.9 ^oC	10.0 - 14.9 ^oC	15.0 - 19.9 ^oC	-20 ^oC
15 m	Jan	2 %	1 %	0 %	49 %	48 %			
	Feb	2	3	3	70	22			
	Mar		4	6	78	12			
	Apr			1	67	32			
	May				11	81	8		
	Jun					42	52	7	
	Jul					10	65	25	
	Aug						58	42	
	Sep						59	41	
	Oct					2	98	0	
	Nov				1	41	58		
	Dec				25	65	10		
20 m	Jan	1 %	1 %	1 %	33 %	64 %			
	Feb	1	0	0	52	47			
	Mar		1	0	63	36			
	Apr			0	56	44			
	May				18	80	2		
	Jun					62	37	0	
	Jul					18	76	7	
	Aug					2	87	11	
	Sep						74	26	
	Oct					1	97	2	
	Nov				1	28	71		
	Dec				14	71	15		

Table 6c

Table 6 d

Table 6d

BORNÖ 1960-1969 TEMPERATURE STATISTICS (^{o}C)

		< -1.1 ^{o}C	-1.0 - -0.6 ^{o}C	-0.5 - -0.1 ^{o}C	0.0 - 4.9 ^{o}C	5.0 - 9.9 ^{o}C	10.0 - 14.9 ^{o}C	15.0 - 19.9 ^{o}C
25 m	Jan	0 %	0 %	0 %	13 %	86 %		
	Feb				31	69		
	Mar				47	53		
	Apr				46	54		
	May				22	77	1	
	Jun					76	24	
	Jul					29	70	1
	Aug					8	90	2
	Sep					3	90	7
	Oct					1	99	
	Nov					20	80	
	Dec				7	75	18	
33 m	Jan				1 %	99 %		
	Feb				10	90		
	Mar				28	72		
	Apr				37	63		
	May				17	83		
	Jun				0	92	8	
	Jul					64	36	
	Aug					21	79	
	Sep					3	90	7
	Oct					2	98	
	Nov					17	83	
	Dec					81	19	

Table 7

Mean value standard deviation of current at Bornö 1971-1980

Depth		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0 m	MV	0.7	0.0	-0.1	-0.3	-1.0	0.4	0.2	-0.5	-0.7	-1.4	-0.5	-1.0	-0.4
	DEV	7.0	5.0	5.7	6.2	6.3	6.5	6.0	6.0	6.4	6.9	6.9	7.2	6.4
2.5 m	MV	-0.7	-1.3	-1.2	-0.7	-1.6	0.0	-0.3	-0.4	-0.6	-1.4	-0.4	-0.8	-0.8
	DEV	5.7	5.4	5.3	5.2	5.2	4.9	4.4	4.6	5.5	5.8	5.4	5.1	5.2
5 m	MV	-0.5	-0.5	-0.9	-0.3	-0.9	0.0	0.3	0.5	0.0	-0.6	0.3	-0.4	-0.2
	DEV	5.1	4.3	4.4	4.3	4.5	4.1	3.6	3.7	4.4	4.8	4.4	4.5	4.4
10 m	MV	0.2	0.5	0.1	0.6	0.7	0.3	0.5	1.1	0.6	1.3	0.8	-0.1	0.6
	DEV	4.1	3.8	3.8	3.7	3.8	4.2	3.3	3.7	3.6	3.5	3.7	3.4	3.7
15 m	MV	0.6	0.7	0.7	0.6	0.7	0.4	0.7	1.0	0.4	1.4	0.6	0.2	0.7
	DEV	3.3	3.3	3.2	3.1	3.4	3.5	3.4	3.7	3.9	3.4	3.7	3.3	3.5
20 m	MV	0.6	0.5	0.4	0.4	0.4	0.5	0.8	0.9	0.7	1.6	0.8	0.4	0.7
	DEV	3.3	3.1	3.0	2.9	2.7	3.1	2.8	2.7	3.3	2.9	3.0	3.0	3.0
25 m	MV	0.4	-0.3	0.2	0.4	-0.1	0.5	0.7	0.7	0.7	0.6	0.0	0.1	0.4
	DEV	2.9	3.0	2.7	2.9	2.8	2.5	2.6	2.8	2.9	3.0	2.9	3.0	2.8
33 m	MV	0.3	0.3	0.3	0.7	0.5	0.5	1.0	0.8	1.0	0.9	0.3	0.4	0.6
	DEV	3.0	3.3	3.1	2.6	3.1	3.0	2.9	3.1	3.0	3.2	3.1	2.9	3.0

cm/s

\- = inwards

Table 8

Table 8

Temperature 30 m

	BORNÖ 1951-60	VINGA 1951-60
January	6.7	5.6
February	5.0	4.5
March	5.0	4.3
April	4.7	4.6
May	5.3	5.6
June	7.1	7.7
July	9.5	10.7
August	12.2	13.1
September	13.3	13.9
October	12.5	12.6
November	11.0	10.1
December	8.7	7.8

Table 9

Table 9

CORRELATION COEFFICIENTS OF MONTHLY MEAN VALUES
(some 170 pairs of data)

S:	Vinga 0 m / Bornö 5 m	0.78
	Anholt 0 m / Bornö 5 m	0.76
	Anholt 0 m / Vinga 0 m	0.88
t:	Vinga 5 m / Bornö 5 m	0.99
S:	Vinga 5 m / Bornö 5 m	0.79
t:	Vinga 20 m / Bornö 20 m	0.97
S:	Vinga 20 m / Bornö 20 m	0.72
S:	Vinga 30 m / Bornö 33 m	0.68
S:	Anholt 30 m / Bornö 33 m	0.76
S:	Anholt 30 m / Vinga 30 m	0.81

Table 10a

BORNÖ 5 m TEMPERATUREDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1931	-0.4	-1.4	1.0	-0.9	-1.0	-2.6	-1.9	-1.0	-1.8	0.2	-0.1	0.9
32	0.3	1.1	0.1	0.3	-0.5	-0.1	0.5	1.1	0.4	-0.1	-1.3	0.4
33	-0.5	1.4	-0.6	1.2	-0.2	1.2	-0.2	-0.1	1.2	0.3	0.3	-2.6
34	-1.1	1.8	1.5	0.9	0.8	-0.4	-0.4	0.0	0.9	1.6	0.7	
35	0.6	2.2	0.6	1.5	-0.4	0.0	0.8	0.1	-1.1	-0.5	-0.4	-0.1
36	0.6	0.7	0.9	0.6	-0.3	0.9	1.8	0.0	-0.4	-1.4	-0.7	0.9
37	-0.1	-0.8	-1.4	-0.5	1.0	0.6	-0.7	0.9	0.6	0.1	1.2	-1.5
38	-1.4	0.6	1.9		-0.3	-0.5	-0.5	1.7	-0.1	1.1	1.7	1.9
39	-0.2	1.1	1.8	1.4	0.1	0.3	-0.6	0.9	1.7	-1.5	-1.6	-1.3
1940	0.5	-2.6	-1.4	-2.7	-1.3	-0.4	0.2	-0.9	-1.5	-1.4	-1.4	-0.9
41	-3.9	-2.2	-1.3	-2.5	-1.6	0.5	0.7	1.0	-0.8	-0.5	-2.6	-1.7
42	-1.0	-0.6	-2.9	-3.4	-1.8	-2.2	-1.5	-1.3	-0.5	0.5	0.9	0.4
43	-0.5	0.6	1.7	2.0	1.3	1.2	0.5	-0.4	0.2	0.0	0.7	-0.4
44	2.0	1.3	0.8	-0.2	-0.8	-1.1	0.1	1.6	0.2	0.4	0.7	-0.6
45	0.6	-1.8	1.4	1.8	-0.1	-0.1	0.8	0.5	0.7	0.8	0.8	0.3
46	-0.1	1.3	-1.8	-0.1	1.1	-0.2	0.0	-0.3	0.2	-0.4	-0.8	-0.4
47	2.1	-2.2	2.1	-1.8	2.0	1.0	1.1			1.1	-0.1	-0.3
48	-1.5	-0.4	-1.1	2.5	1.5	0.8	0.2	0.8	0.0	-0.2	-0.2	0.2
49	1.0	2.1	0.8	1.6	1.5	-1.7	1.2	-0.2	1.0	0.9		2.3
1950	-0.2	-0.1	0.9	0.8	2.5	1.1	-1.3	0.0	0.3	1.1	0.5	-0.8
51	-0.9	-1.1	0.1	-0.9	-0.7	-0.3	-1.2	-0.3	0.0	0.3	0.7	1.5
52	1.6	0.9	0.0	-0.2	-1.0	-1.0	-0.6	-1.2	-1.1	-2.3	-1.4	-1.2
53	-1.0	0.6	0.1	1.3	0.5	0.7	1.1	-0.7	-0.4	0.8	1.5	1.3
54	2.5	-1.9	-2.5	-0.1	-0.1	1.2	-1.7	-1.2	-0.4	-0.9	0.7	0.3
55	-0.3	-0.3	-0.7	-0.7	-2.1	-0.1	1.2	2.3	1.5	0.4	0.3	0.3

Table 10a

BORNÖ 5 m TEMPERATUREDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1956	-0.7	-1.5	-1.3	-1.4	0.5	0.1	-1.1	-1.3	1.3	-0.1	-1.0	0.2
57	0.1	1.1	0.0	0.4	-1.3	0.2	0.0	0.3	-0.4	-0.3	0.2	0.3
58	-0.8	1.0	-2.0	-2.4	-1.5	0.9	0.8	-1.0	0.9	1.2	0.9	0.6
59	0.7	-0.4	1.3	1.6	1.3	-0.5	2.0	2.0	0.2	0.5	0.5	-0.7
1960	2.3	-1.4	1.7	-0.2	1.0	0.2	-2.4	-0.6	-0.3	-1.2	-1.1	0.6
61	-0.4	0.9	2.1	2.4	0.4	2.2	-0.6	-0.9	0.2	1.2	1.7	-0.1
62	0.2	1.4	-1.3	-0.3	-0.9	-0.6	-1.2	-2.8	-1.8	0.0	0.1	-0.9
63	0.3	-1.6	-2.9	-2.1	-1.5	0.0	-0.7	-0.9	0.2	-0.1	1.6	-0.4
64	0.4	1.3	-1.0	-0.2	0.1	-0.6	-1.6	-0.9	-1.3	-0.5	0.8	0.6
65	0.7	2.1	-1.1	-0.3	-1.2	0.5	-1.6	-1.3	-0.6	0.6	-0.4	-2.5
66	-0.9	-2.1	-1.3	-1.4	-2.0	0.6	0.2	-0.7	-0.3	-0.6	0.4	0.3
67	-0.2	-0.3	0.9	1.1	-0.6	0.3	-0.2	0.4	0.8	1.0	1.7	0.3
68	-0.3	0.2	1.4	1.5	0.3	1.4	-0.4	1.4	1.4	-0.4	-0.4	1.1
69	-1.9	0.5	-1.5	-0.7	-1.4	0.0	0.1	2.0	0.2	-0.1	0.6	-2.6
1970	-2.7	-2.4	-1.5	-0.4	-1.1	0.9	-0.2	0.0	-0.3	0.4	0.5	0.5
71	-1.2	0.7	-0.2	0.0	0.6	-0.5	-0.3	-0.2	-1.0	0.1	0.8	0.3
72	-1.1	-1.1	-1.0	0.8	0.0	-0.9	0.2	-1.0	-0.4	-0.7	0.4	0.6
73	0.7	2.1	1.7	1.8	0.1	1.0	1.2	0.3	-0.6	-1.4	0.3	-0.5
74	-0.7	1.3	0.9	1.6	1.5	-0.2	-0.1	(-0.8)	0.3	1.0	0.3	0.6
75	2.1	1.7	1.3	1.4	1.0	-0.2	0.4	2.4	1.5	0.5	1.3	0.4
76	1.8	-1.3	-0.6	-0.1	0.2	-0.4	1.7	0.4	-0.8	-1.5	0.7	1.4
77	-0.8	-1.2	-0.5	0.2	-0.5	0.4	-0.9	-0.5	-1.4	-0.6	-1.9	-1.1
78	1.0	-0.2	-0.7	0.4	-0.7	1.5	-0.6	0.4	-2.1	-0.9	1.6	-1.8
79	-1.0	-0.9	-2.1	-1.2	-2.3	-0.2	-2.7	-1.8	-1.3	-1.0	-1.2	-0.9
1980	-1.6	-1.9	-0.5	-0.6	0.9	-0.2	-0.3	0.0	-0.6	0.2	-0.4	0.4

Table 10b

BORNÖ 5 m SALINITYDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1931	-0.16	-2.92	4.36	2.43	-0.52	0.67	-0.73	-0.53	1.93	-0.64	-0.20	-1.42
32	-1.90	1.97	0.36	-2.42	0.99	-0.14	0.18	--	-0.35	--	--	--
33	--	2.74	0.19	3.07	--	--	3.12	2.60	0.54	0.99	4.21	0.02
34	-1.01	2.63	1.07	-4.51	--	0.67	1.85	1.06	-2.37	-0.29	-1.16	--
35	-2.40	2.66	--	0.68	-1.25	-1.53	-0.06	0.50	1.20	-1.19	-0.81	-2.78
36	-0.63	0.84	1.70	2.18	-0.94	-1.03	-3.04	-0.89	1.12	3.60	-1.27	-1.17
37	--	--	--	--	--	--	0.83	1.40	1.14	-0.97	1.66	3.07
38	-1.11	-1.32	0.83	--	1.08	-0.62	-0.90	-1.47	1.16	-3.54	-0.52	-2.38
39	-1.48	-1.45	2.98	-1.87	-0.49	0.91	-1.05	-1.13	0.41	3.87	1.16	1.12
1940	3.49	2.16	3.55	1.64	0.81	--	-0.09	3.21	2.41	-0.68	-2.98	0.30
41	-1.25	-2.24	-0.09	0.84	1.98	-0.39	1.78	-1.58	1.86	-0.53	1.27	-1.05
42	0.61	0.70	-2.91	0.09	1.35	2.34	1.39	0.15	0.73	1.73	1.58	1.56
43	-0.45	-2.06	-0.63	2.85	0.72	0.17	0.94	0.22	-3.21	-3.00	-1.99	-0.36
44	1.45	0.70	1.31	-1.75	2.30	-1.04	-1.66	-3.75	0.77	-3.88	0.65	-3.50
45	0.13	-1.38	0.69	0.51	0.59	-1.89	-2.21	1.38	-3.00	-0.68	0.19	1.47
46	0.99	2.20	-0.53	-1.45	-1.38	-1.00	-0.44	-0.66	-2.09	-1.15	-4.06	-3.38
47	--	--	--	--	0.44	2.81	1.20	--	1.46	4.27	3.83	3.38
48	1.54	-1.60	-1.65	-0.62	-0.44	-0.48	-0.04	-0.87	1.03	1.77	2.39	0.51
49	-0.83	2.34	1.78	2.13	-0.68	0.85	0.07	0.79	-3.82	-1.27	--	2.19
1950	0.82	-1.38	0.89	-0.89	-2.84	-0.56	1.88	-0.65	-0.39	0.56	1.21	-1.18
51	-1.34	-3.12	0.49	-0.60	0.38	-0.34	-0.22	-1.01	-0.09	-4.91	-1.33	0.95
52	-0.08	1.52	-0.37	-2.16	0.28	3.03	1.55	0.55	1.51	1.07	-0.54	--
53	-1.92	1.48	-1.58	-0.83	-2.06	-1.49	-2.42	0.97	0.18	-0.89	-3.04	-2.28
54	3.55	-2.99	-4.79	2.50	2.58	-0.69	1.50	0.37	-1.25	0.10	0.54	-0.88
55	-0.81	-0.92	-0.31	2.46	0.11	-1.66	-1.65	-1.85	-0.86	1.61	1.74	3.89

Table 10 b

BORNÖ 5 m SALINITYDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1956	-0.81	-0.74	-2.88	-1.60	-3.10	-1.57	-2.72	0.49	-0.45	1.78	0.38	1.28
57	-0.31	-0.66	-2.46	2.02	3.31	-0.22	-0.74	0.64	-0.83	0.73	-1.43	1.24
58	-0.70	2.28	-1.09	-4.26	0.34	-2.02	-1.40	-1.70	-4.30	-0.73	-0.64	0.76
59	0.72	-2.83	-2.93	-2.34	-3.59	1.67	-0.08	0.56	5.71	0.52	-0.73	-2.85
1960	3.92	1.28	0.97	1.83	1.94	2.29	3.12	1.27	-0.17	1.66	-0.17	1.57
61	-2.57	-1.61	-0.88	-0.32	1.21	-1.13	-0.42	-0.40	-2.56	-5.80	-1.65	-0.52
62	-0.17	2.00	-2.60	-3.07	0.48	-1.85	-1.38	-4.24	-1.20	-3.58	-2.54	-1.07
63	1.78	0.27	-2.78	-2.95	-3.52	-1.84	-0.65	0.65	-2.18	-1.38	-0.30	-1.97
64	-1.33	2.11	-4.41	-3.73	-1.38	1.64	0.10	0.86	2.12	-1.10	-1.00	-0.51
65	-1.21	2.63	0.23	-2.98	-0.49	-1.32	0.70	-0.77	-1.27	-2.79	-0.05	-0.76
66	1.03	-1.99	0.04	0.00	-3.22	0.09	-0.46	-0.75	-0.19	-2.45	-2.64	-0.73
67	0.95	-0.14	-0.22	-1.83	-3.97	-3.52	-2.78	-1.26	-2.67	-3.66	-1.94	-0.07
68	-0.22	-1.51	1.43	-2.74	-1.83	-2.72	-0.38	-1.74	-3.41	-0.61	1.21	-3.17
69	-2.58	2.07	0.32	0.96	-0.19	-0.32	-0.29	0.25	2.73	1.06	2.68	-0.99
1970	-3.54	-3.06	-0.32	3.94	-2.00	0.86	0.75	-0.07	0.80	-0.39	2.30	0.05
71	-1.69	-1.88	1.86	-1.83	-2.20	0.46	2.32	-1.87	2.45	1.47	2.60	0.27
72	-2.55	-3.75	-3.66	0.93	0.59	-1.13	0.02	1.68	1.63	2.98	3.66	-1.87
73	-3.55	-0.75	-2.42	2.29	-0.76	-1.35	-0.51	1.33	1.84	-0.41	2.65	3.14
74	-3.18	-3.10	-4.89	0.91	0.76	3.51	3.19	3.60	-2.93	2.11	1.17	-0.27
75	-0.73	-3.89	-4.14	-0.78	-0.60	0.09	0.06	-0.77	-1.60	0.48	0.22	0.41
76	3.67	-5.49	-0.74	0.48	0.55	0.85	1.05	2.66	1.48	-3.73	0.22	4.18
77	1.37	-0.28	1.18	2.64	-1.01	-0.75	3.15	-0.87	-0.92	-2.06	-0.60	-2.78
78	-0.22	-0.73	-0.87	0.98	-1.11	0.29	1.10	1.10	4.54	-0.22	1.35	-2.04
79	0.54	0.61	0.13	-1.59	-3.70	-1.85	2.92	0.16	1.54	-0.07	-1.51	0.30
1980	-2.37	-3.32	-0.77	1.77	0.07	0.65	-1.24	0.52	-0.51	-0.01	0.33	1.84

Table 10c

BORNÖ 33 m TEMPERATUREDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1931												
32												
33	--	--	--	--	0.1	-0.7	-0.6	2.8	1.0	-0.5	-1.6	-0.7
34	0.6	0.2	-0.2	0.7	0.5	0.5	-0.8	0.9	0.6	1.1	1.5	--
35	1.5	0.7	0.7	1.2	0.5	0.2	0.3	0.6	-0.1	0.5	0.6	0.3
36	0.4	0.3	0.7	0.7	0.4	-0.2	0.1	0.9	0.0	-2.5	-0.7	0.1
37	-0.6	0.3	0.4	0.4	0.1	1.2	0.5	-1.2	-0.7	-0.3	-0.8	-1.9
38	-2.4	-1.5	-0.4	--	1.1	1.2	2.7	0.0	-0.2	1.0	1.4	2.1
39	0.9	1.2	0.1	0.8	0.5	0.6	2.2	0.0	-0.7	-2.7	-3.3	-1.8
1940	-0.9	-0.2	0.3	-2.1	-1.2	-2.5	-2.8	-0.3	0.5	-0.9	-0.7	-0.5
41	0.6	1.3	1.4	0.0	-0.4	-1.5	-2.1	-0.8	-0.5	-1.3	-2.4	-1.5
42	-0.8	0.2	0.7	0.1	-0.6	-1.2	-1.0	-0.6	-0.3	0.2	0.7	0.0
43	0.4	-0.2	-0.4	0.5	0.8	0.4	-0.1	-0.4	-0.8	0.8	1.1	1.3
44	0.4	0.4	0.3	0.1	-0.1	-0.4	-1.5	-2.9	-0.5	0.3	-0.1	0.4
45	0.2	0.6	-0.4	-0.4	0.0	1.9	-0.1	-2.3	-0.9	1.0	0.6	0.1
46	-0.4	0.5	0.1	0.5	0.2	0.2	0.2	1.0	1.1	0.5	0.4	1.0
47	1.1	0.0	0.5	0.0	-0.8	-0.7	-0.3	-3.0	-1.6	0.6	-1.0	-0.4
48	-1.2	-0.5	-0.2	-0.3	-0.1	-0.4	0.7	0.0	1.0	0.2	-0.3	0.0
49	0.3	0.2	0.0	0.2	0.1	0.1	-1.3	1.2	0.3	0.3	--	0.7
1950	0.6	0.4	-0.4	-0.4	0.0	0.5	2.1	0.7	0.7	1.3	1.6	0.6
51	1.4	1.0	0.9	-0.2	-0.8	-1.5	-0.3	0.7	0.2	0.3	0.8	0.1
52	-0.1	-0.8	-1.0	-0.2	-0.5	2.0	0.9	0.5	0.5	-1.0	0.0	-0.1
53	0.7	0.1	-1.1	-1.1	-0.9	-1.2	-0.3	1.4	1.4	0.9	1.4	1.5
54	0.6	-1.3	1.3	1.0	-0.2	-0.3	1.1	1.1	0.6	0.5	0.4	0.1
55	0.2	0.1	-0.5	-0.1	-0.3	0.2	-0.3	-2.5	-1.7	0.4	-0.5	-1.5

Table 10 c

BORNÖ 33 m TEMPERATUREDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1956	-1.7	-0.9	-0.1	-0.3	0.5	1.0	-0.9	-0.6	0.2	-0.1	0.0	-1.0
57	-1.2	-0.2	-0.3	-0.2	-0.1	0.9	0.1	0.6	0.6	0.1	0.1	-0.6
58	-1.1	-1.1	-1.1	-1.0	-0.3	-0.5	-1.8	0.9	-0.4	0.3	1.4	0.4
59	1.1	0.9	0.2	0.5	0.6	0.7	1.6	-0.5	0.4	0.6	1.4	1.6
1960	0.0	-0.7	-0.1	-0.5	0.3	-0.1	0.6	-0.1	0.2	-1.4	-0.9	-0.4
61	0.3	0.2	0.1	0.5	0.8	2.2	2.4	0.9	0.3	0.6	1.7	0.7
62	0.5	-0.1	-1.0	0.1	0.1	0.6	0.3	0.0	-0.2	-0.6	0.0	0.0
63	0.1	0.7	1.1	1.5	-0.4	-1.1	0.2	-0.3	-0.5	0.3	0.8	1.1
64	1.8	0.1	0.7	1.2	0.5	0.2	1.5	0.3	-0.5	0.0	0.8	0.4
65	0.5	0.9	0.5	0.9	0.2	-0.5	1.3	0.1	-0.5	-0.1	1.2	0.0
66	-0.2	0.1	-0.6	-1.4	-0.5	-0.6	-1.0	0.8	-0.1	0.2	0.7	0.8
67	0.4	0.1	-1.0	-0.3	-0.2	-0.3	0.4	-0.3	-0.2	0.6	1.8	0.5
68	0.3	0.0	-0.1	-0.7	-0.3	-0.9	-1.3	-3.6	-4.4	-1.4	0.1	-1.5
69	0.8	1.0	1.3	0.8	-0.3	-0.6	-0.1	-2.7	-1.8	-0.3	-0.1	0.2
1970	0.6	1.5	1.5	-0.1	-1.3	-1.9	-0.9	0.4	0.2	0.5	0.4	0.2
71	0.0	0.4	-0.8	-0.1	-0.4	-1.1	-0.4	-0.2	-0.2	-0.1	0.1	-0.6
72	-1.0	0.7	1.1	0.9	0.6	0.2	-0.5	-2.2	-0.7	-1.1	-0.7	-0.9
73	1.1	1.2	1.0	0.9	0.9	0.6	-0.7	-0.3	0.5	-1.5	-0.1	-1.9
74	-0.9	-0.1	0.3	0.7	0.7	2.1	2.3	(2.0)	1.4	0.8	-1.0	0.3
75	0.3	0.8	1.4	1.5	0.8	0.5	-0.9	-0.6	0.3	1.0	0.9	0.2
76	-0.4	-0.5	0.3	0.2	1.6	1.6	0.1	-1.7	-1.5	-1.4	-0.7	-0.1
77	-1.1	--	-0.2	-0.4	-0.7	-1.4	-1.8	-2.2	-2.1	-0.5	0.7	0.8
78	0.4	1.0	0.6	-0.2	0.1	0.2	1.2	-0.8	-0.4	-0.7	0.2	0.4
79	0.4	0.9	0.1	-1.0	-2.4	-2.5	-2.1	-1.1	-0.6	-0.4	-0.3	-0.3
1980	0.4	0.8	1.0	0.5	0.2	-0.8	-1.2	-0.9	0.0	-0.1	0.6	-0.9

BORNÖ 33 m SALINITYDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1931	--	--	--	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--
33	--	--	--	--	0.32	0.76	1.12	0.13	0.30	0.48	0.92	1.15
34	0.11	-0.06	-0.46	-0.12	-0.10	-0.01	0.68	-0.31	-0.31	0.16	0.22	--
35	0.86	-0.17	--	0.13	0.56	0.20	-0.18	-0.52	-0.86	-0.74	-1.00	0.14
36	0.00	-0.36	-0.07	0.46	0.15	1.11	0.30	-0.23	-0.08	0.50	-0.73	-2.50
37	--	--	--	--	--	--	-0.41	-0.23	-0.36	-0.35	0.33	0.65
38	-0.57	-1.38	-1.38	--	-1.12	-0.41	-0.54	0.29	-0.69	-1.06	-0.54	-0.90
39	0.54	0.18	-0.23	0.32	0.38	0.62	-0.15	0.16	0.68	1.43	0.97	-0.17
1940	0.32	0.69	0.63	-0.95	0.30	--	0.32	-0.14	-0.55	-0.26	0.17	-0.56
41	0.34	0.99	0.41	0.08	0.70	0.23	0.20	0.00	-0.21	0.14	0.16	0.06
42	-0.42	1.03	0.85	0.28	0.57	-0.08	0.27	-0.11	-0.05	-0.13	-0.20	0.05
43	0.24	-0.83	-1.11	-0.94	-1.31	-0.64	-0.12	-0.19	-0.12	-0.35	0.02	0.53
44	0.09	-0.08	0.20	0.15	0.04	-0.10	-1.10	-0.84	-1.64	-1.61	-0.92	-1.49
45	-0.70	0.04	-0.65	-0.80	-0.89	-1.36	-0.42	0.88	0.00	0.07	0.40	0.66
46	-0.22	0.09	-0.09	-0.06	0.18	0.56	0.23	0.05	0.15	-0.09	-0.14	-0.10
47	0.08	0.51	0.88	0.61	0.72	0.79	0.66	1.18	1.80	0.87	0.83	1.08
48	0.20	0.11	-0.18	-0.95	-0.30	-0.01	-0.08	0.07	-0.30	0.02	0.14	0.04
49	-0.75	-0.33	0.00	-0.01	-0.28	0.14	0.66	-0.21	0.59	0.24	--	0.13
1950	0.17	0.43	-0.35	-0.38	0.05	-0.28	-0.66	0.30	0.48	0.35	0.47	0.80
51	0.79	0.02	0.76	-0.43	0.06	1.00	-0.34	-0.59	0.10	0.38	0.96	-0.22
52	-1.56	-0.45	-0.25	0.40	0.08	-1.00	-0.22	0.02	0.24	0.37	0.40	0.42
53	0.33	0.48	-0.34	-1.03	-0.34	0.11	-0.20	-0.59	-0.21	-0.23	-0.38	-0.29
54	0.76	-1.34	0.69	0.75	0.58	0.58	0.30	0.19	0.25	-0.11	-0.19	-0.26
55	0.01	0.62	0.58	0.60	-0.16	-0.39	-0.08	0.67	0.02	-0.75	-0.20	0.10

Table 10 d

BORNÖ 33 m SALINITYDEVIATION (M=1931-60)

	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1956	-0.32	-0.40	0.41	0.46	-0.74	-1.05	-0.43	-0.59	-0.72	-0.62	-0.26	-0.30
57	-0.96	-0.34	-0.50	0.17	0.51	-0.21	-0.04	-0.24	-0.26	-0.69	-1.00	-0.07
58	-0.37	0.15	0.15	0.76	-0.63	-0.47	0.08	-0.55	0.60	0.19	-0.46	0.47
59	0.37	0.13	-0.32	0.01	0.23	0.02	-0.11	0.67	0.63	0.30	-0.60	0.41
1960	0.78	0.35	0.48	0.60	0.42	-0.12	0.27	0.83	0.63	1.52	0.63	0.29
61	-0.39	-0.36	-0.51	-0.69	-0.10	-0.43	-0.58	-0.42	-0.64	-0.92	-0.72	-0.13
62	-0.17	-0.32	-0.73	0.07	0.58	-0.36	-0.64	-0.91	-0.80	-0.06	-0.11	0.14
63	0.94	0.95	0.85	0.99	0.25	0.44	-0.31	0.17	0.22	0.15	0.15	0.74
64	0.60	-0.11	0.82	1.25	0.04	0.37	-0.02	0.25	0.26	0.17	0.54	-0.54
65	-0.43	0.75	0.07	0.41	0.26	0.22	-0.19	-0.03	-0.28	-0.12	-0.29	0.84
66	0.62	0.98	0.08	-0.47	0.30	-0.63	-0.39	-0.49	-0.21	-0.60	-0.08	0.26
67	0.11	-0.34	-1.23	-1.10	-0.94	-0.90	-1.22	-0.71	-0.59	-0.31	-1.13	-0.37
68	0.32	-0.19	-0.36	-1.43	-1.33	-0.11	0.31	0.95	0.94	-0.21	0.03	1.12
69	0.51	0.46	0.73	0.78	0.43	0.54	-0.18	0.68	0.26	-0.20	-0.38	-0.78
1970	0.51	0.78	0.61	0.38	-0.11	-0.01	-0.79	-0.30	-0.29	-0.49	-0.60	-0.45
71	-1.68	-0.84	-0.87	-0.23	-0.07	0.27	-0.63	0.36	-0.12	-0.64	-0.88	-0.32
72	-4.13	0.72	0.73	-1.27	0.57	-0.77	-0.38	1.15	0.84	0.56	-0.25	-1.22
73	-2.43	-0.84	-0.93	-1.77	-1.76	-1.48	-0.62	0.18	-0.07	0.59	-0.02	-0.28
74	-1.48	-1.09	-0.76	0.88	0.59	-1.17	-0.35	-0.30	0.04	0.89	0.59	0.43
75	-2.32	-2.69	-1.02	0.29	-1.01	-1.44	-1.55	-0.73	-0.79	-0.49	0.17	-0.17
76	-0.57	-3.06	-0.70	-0.64	-0.99	-0.36	-0.42	0.70	0.60	0.67	0.65	0.50
77	-1.63	0.50	0.00	-0.95	-1.17	-1.19	-1.20	-0.10	0.11	-0.13	-0.23	-0.32
78	-1.57	-0.44	-0.40	-1.01	0.31	-0.21	-0.46	0.40	0.80	-0.11	-0.49	-0.16
79	-0.16	0.51	-1.33	-1.46	-2.09	-1.59	-1.11	-0.44	-0.39	0.12	-0.43	-0.61
1980	-1.78	-0.56	-1.21	0.36	-1.35	-0.40	-0.27	0.21	0.07	0.09	0.36	-0.92

Fig. 1


E 11°10'
11°20'
11°30'
11°40'
Örekils- älven
Färlev- fjorden
Saltkällefjorden
58°25' N
Bredungen
BORNÖ
Sta
Gullmarsvik
Ormestad fyr
Ormestad
STÅNGENÄSET
Smögen
Å 11
Kolvik
58°20'
Alsbäck
The Gullmar Fjord
Malmö drag
BOKENÄSET
Finsbo bight
Lysekil
Berggylte- skär
Smedjepricken
Byxeskär
Tröskeln
Flatholmen
Kristineberg
58°15'
Strömmarna
Koljö- fjorden
Gåsö ränna
SKAFTÖ
HYLAB 83 AT
E 11°10'
11°20'
11°30'
11°40'

Fig. 2a

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

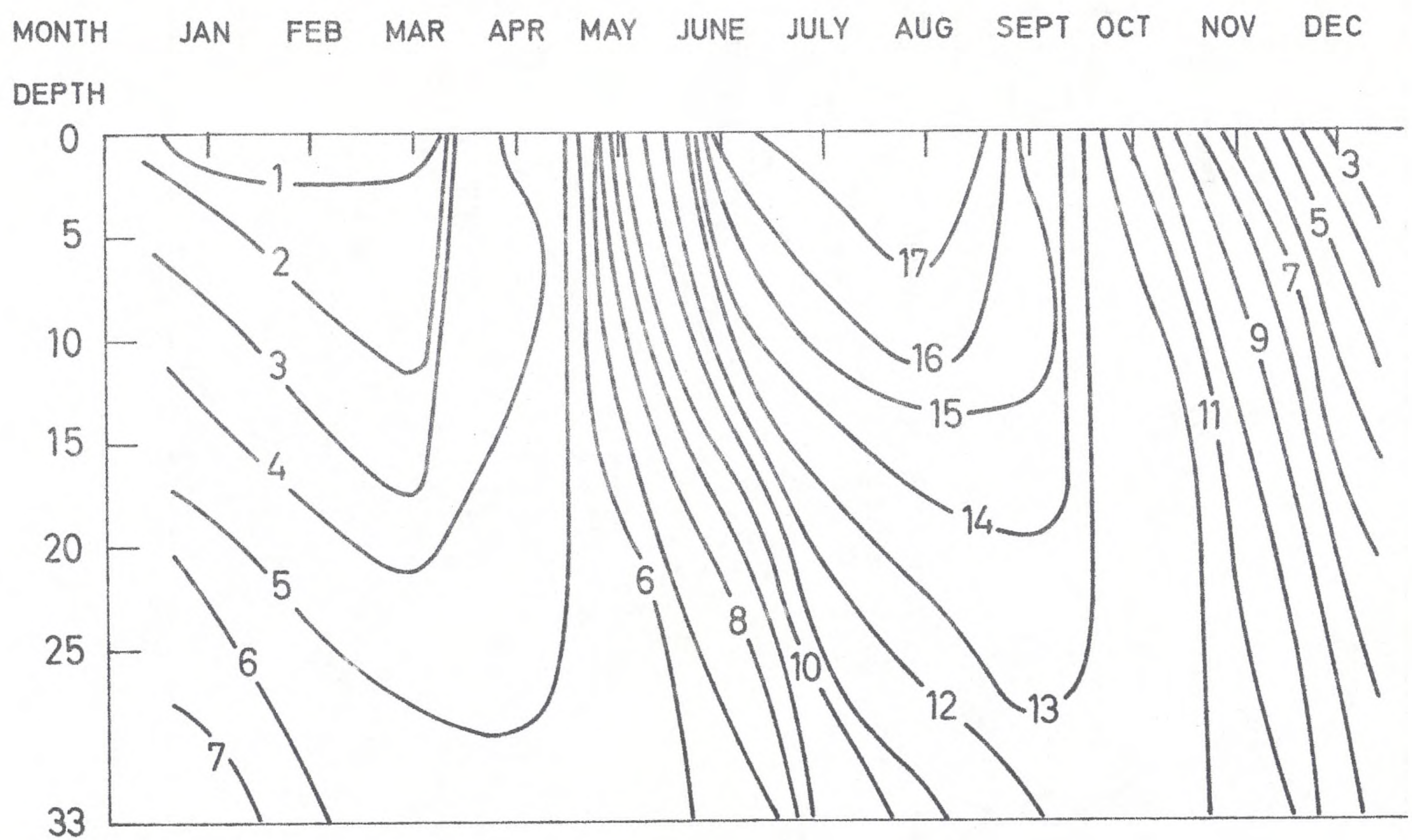


Fig. 2b

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

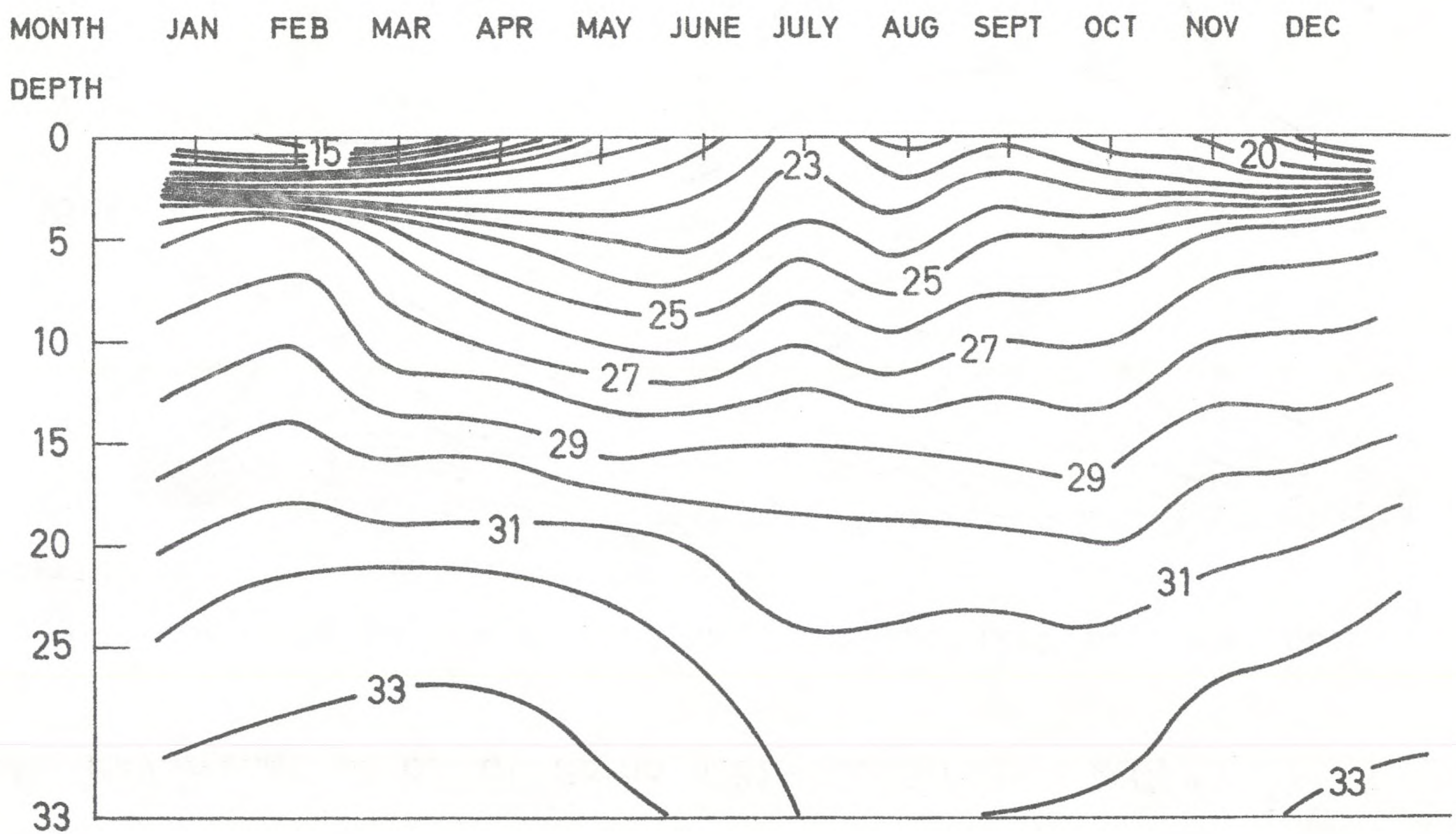
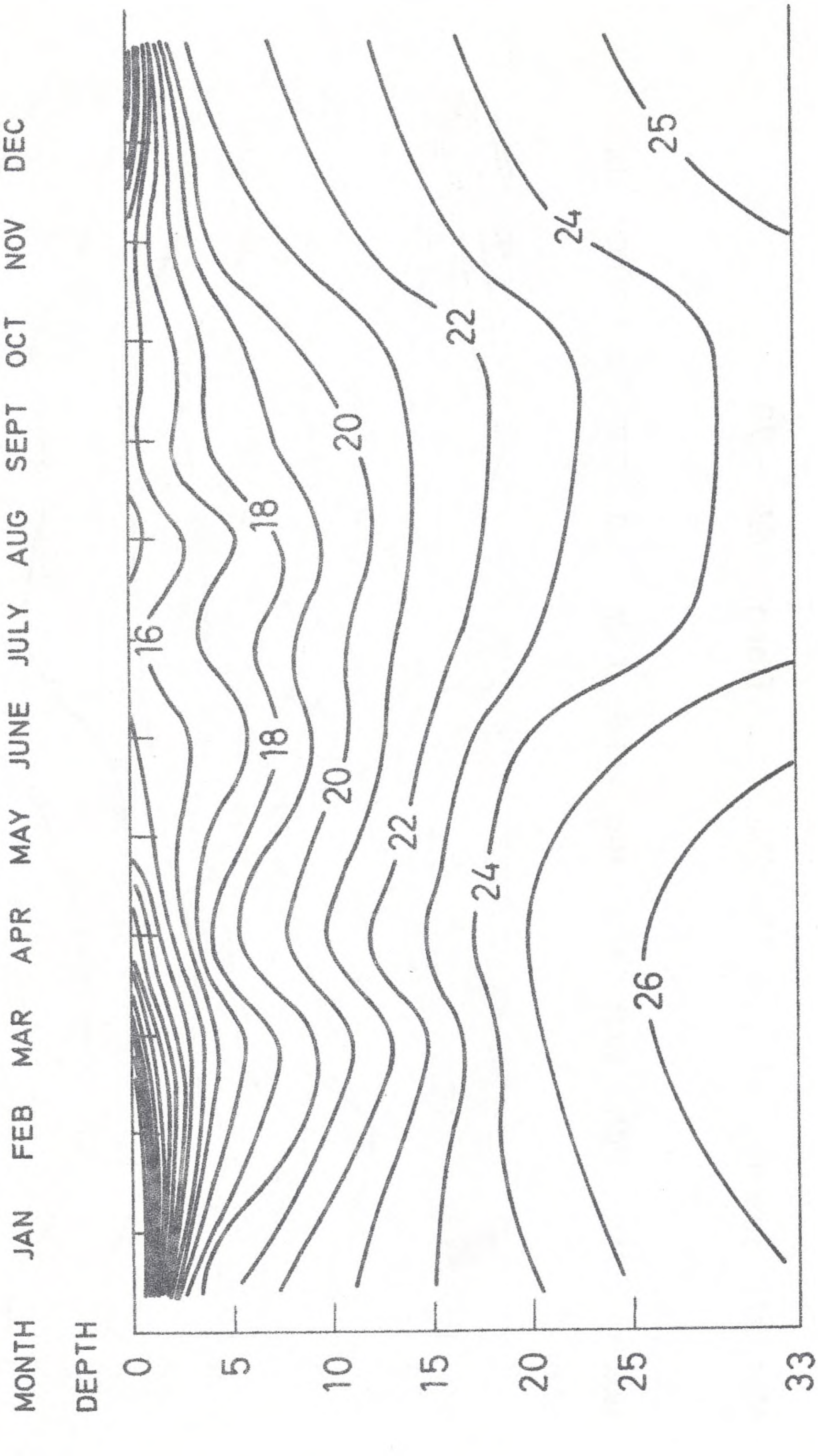


Fig. 2c

Monthly means of σ_t at Bornö 1961 – 70. (Density = $1 + \sigma_t \times 10^{-3}$)



ALSBÄCK 1950 – 1981 Temperature

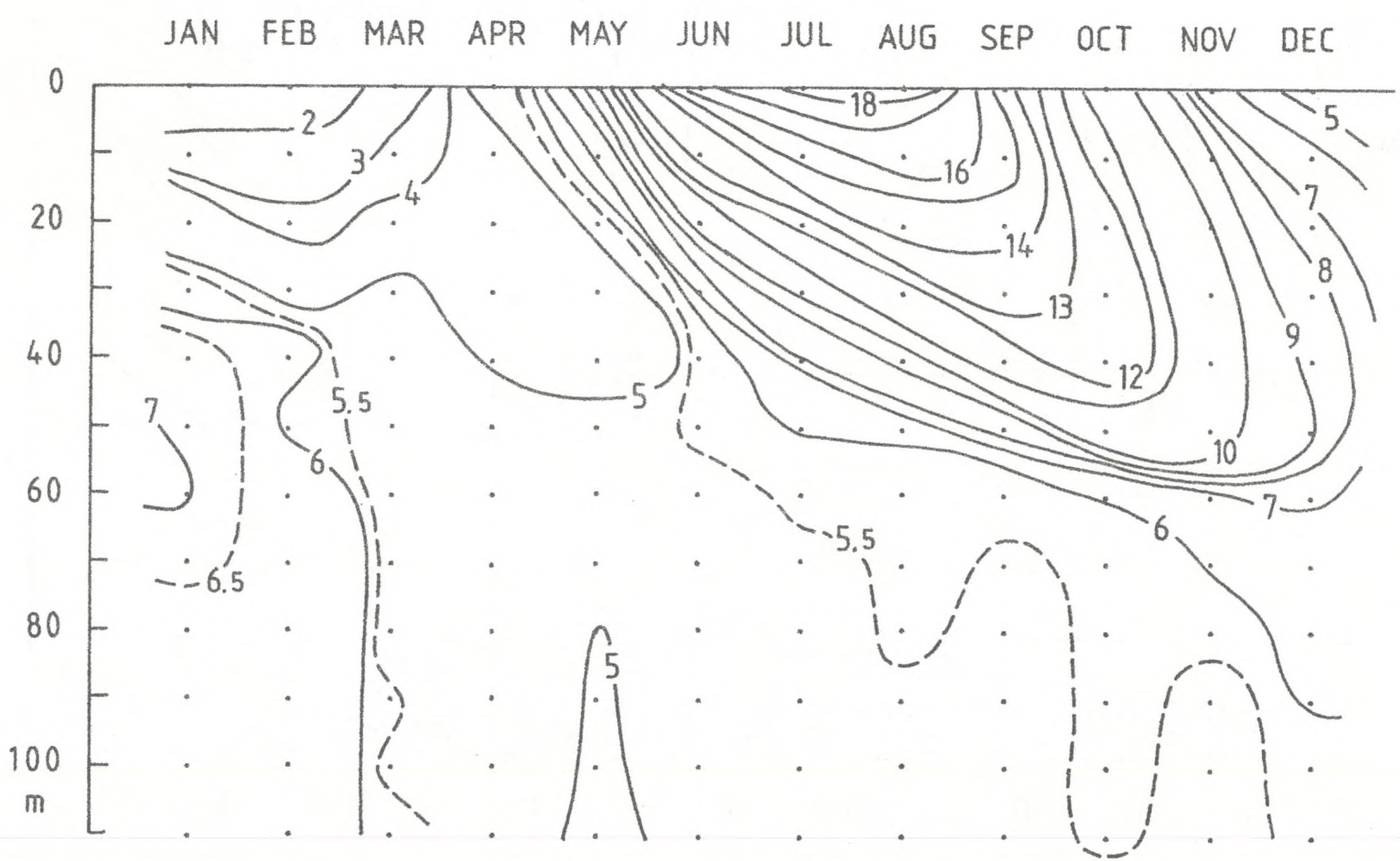


Fig. 3a

HYLAB 83 AT

Fig. 3 b

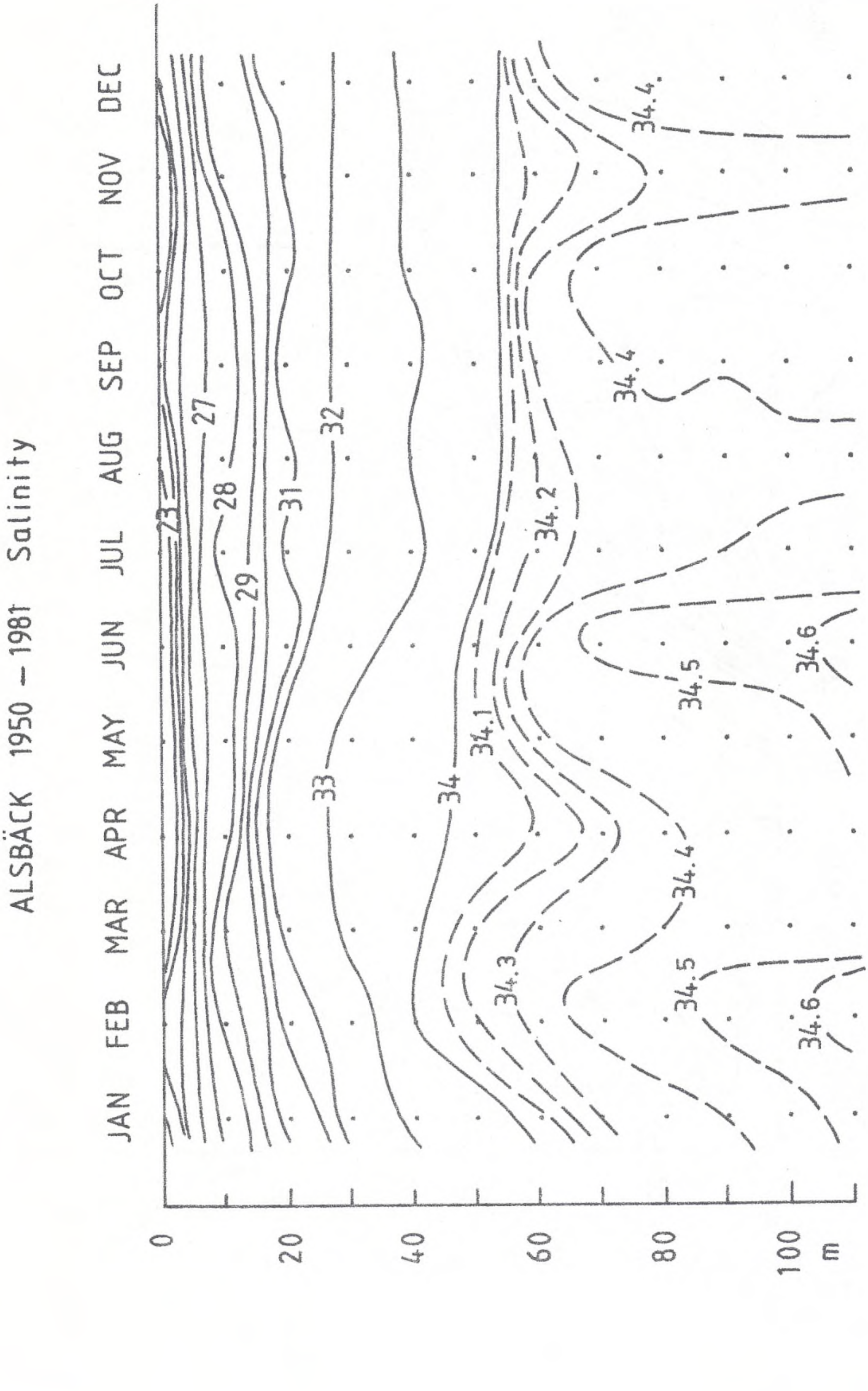
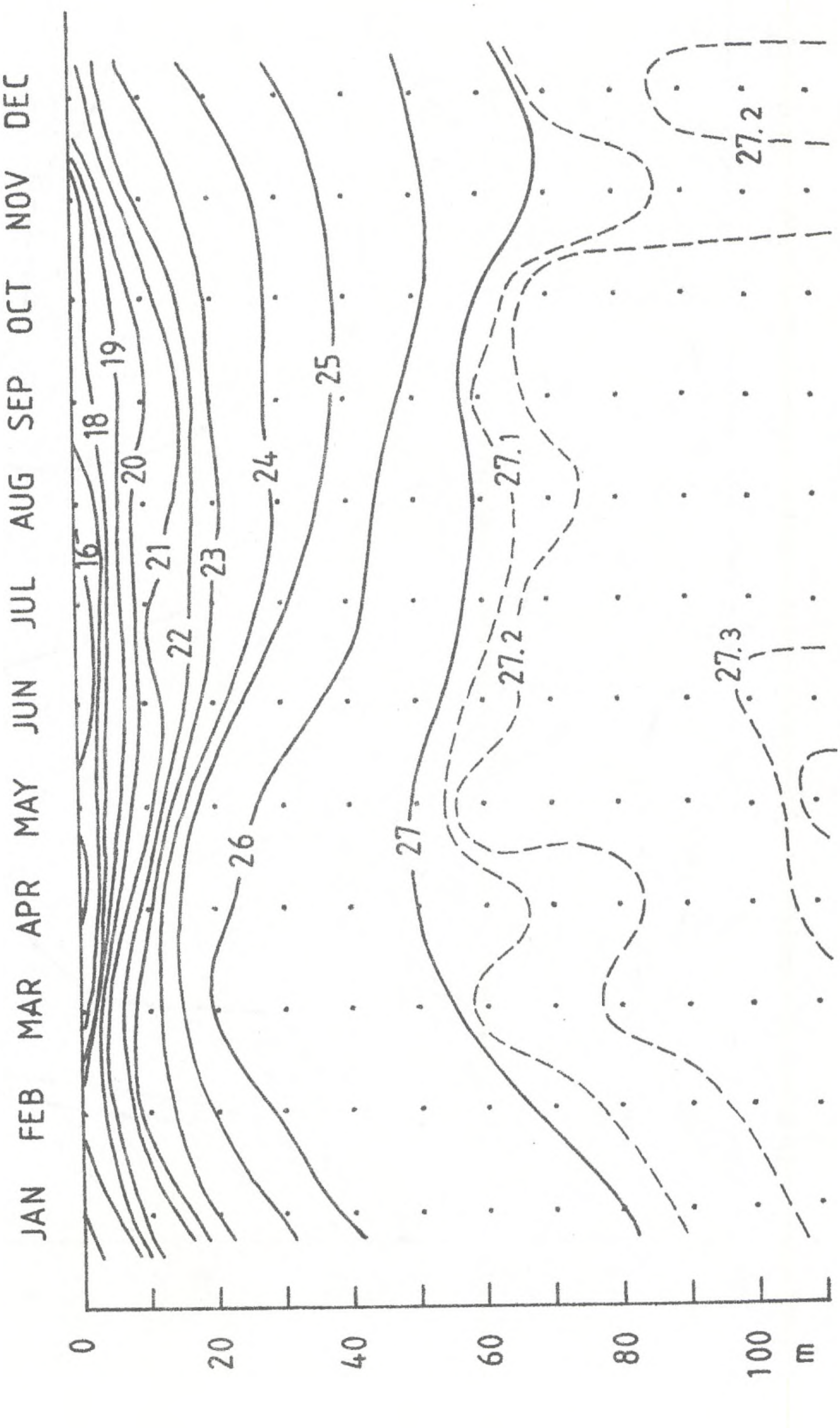

ALSBÄCK 1950 – 1981 Salinity
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0
20
40
60
80
100
m
23
27
28
29
31
32
33
34
34.1
34.2
34.3
34.4
34.5
34.6

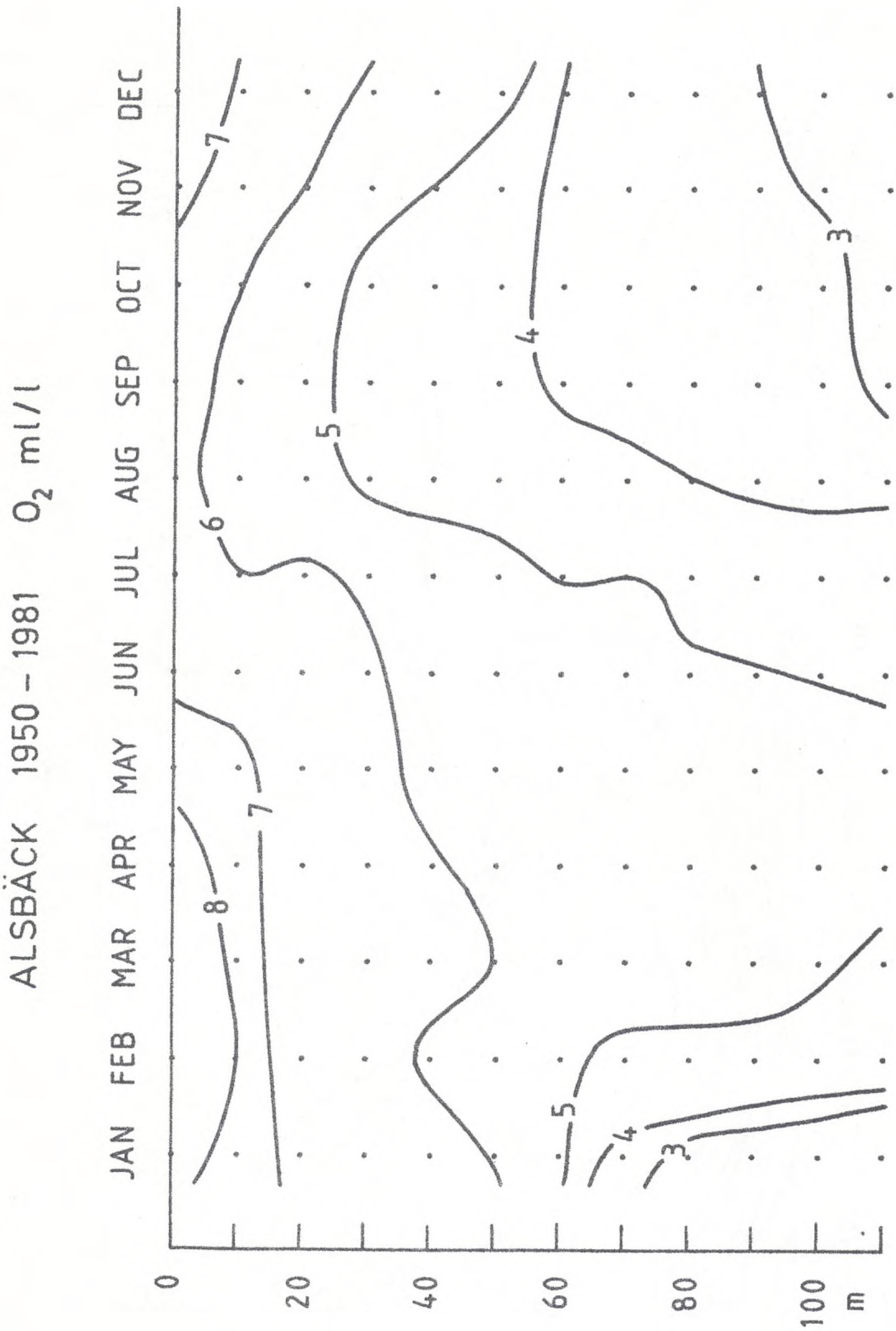
Fig. 3c

ALSBÄCK 1950 – 1981 Sigma t. (Density 1 + (sigma t) × 10^{-3})



HYLAB 83 AT

Fig. 3 d



HYLAB AT

Fig. 3 e

ALSBÄCK 1950 – 1981 O_2 %

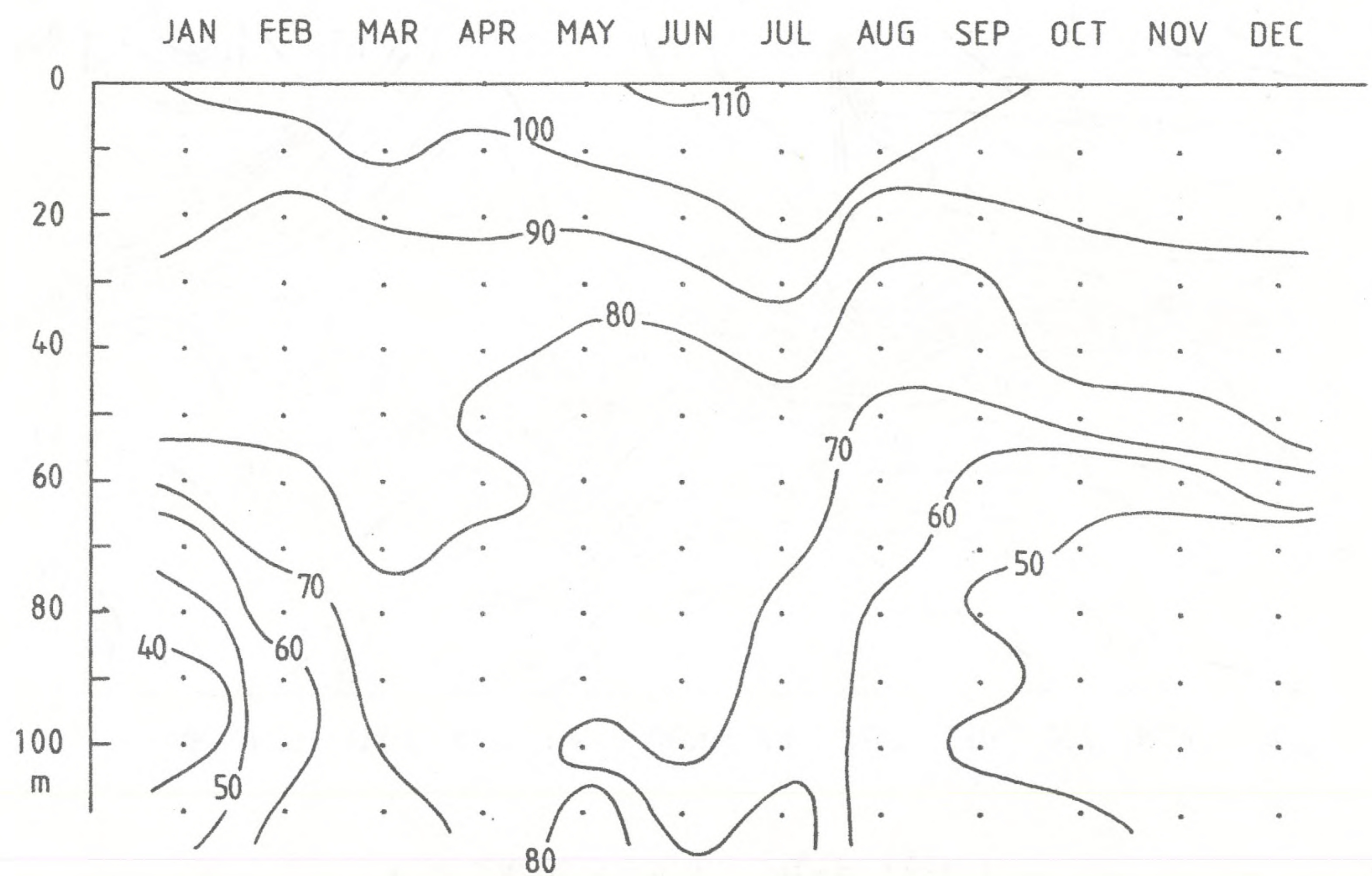
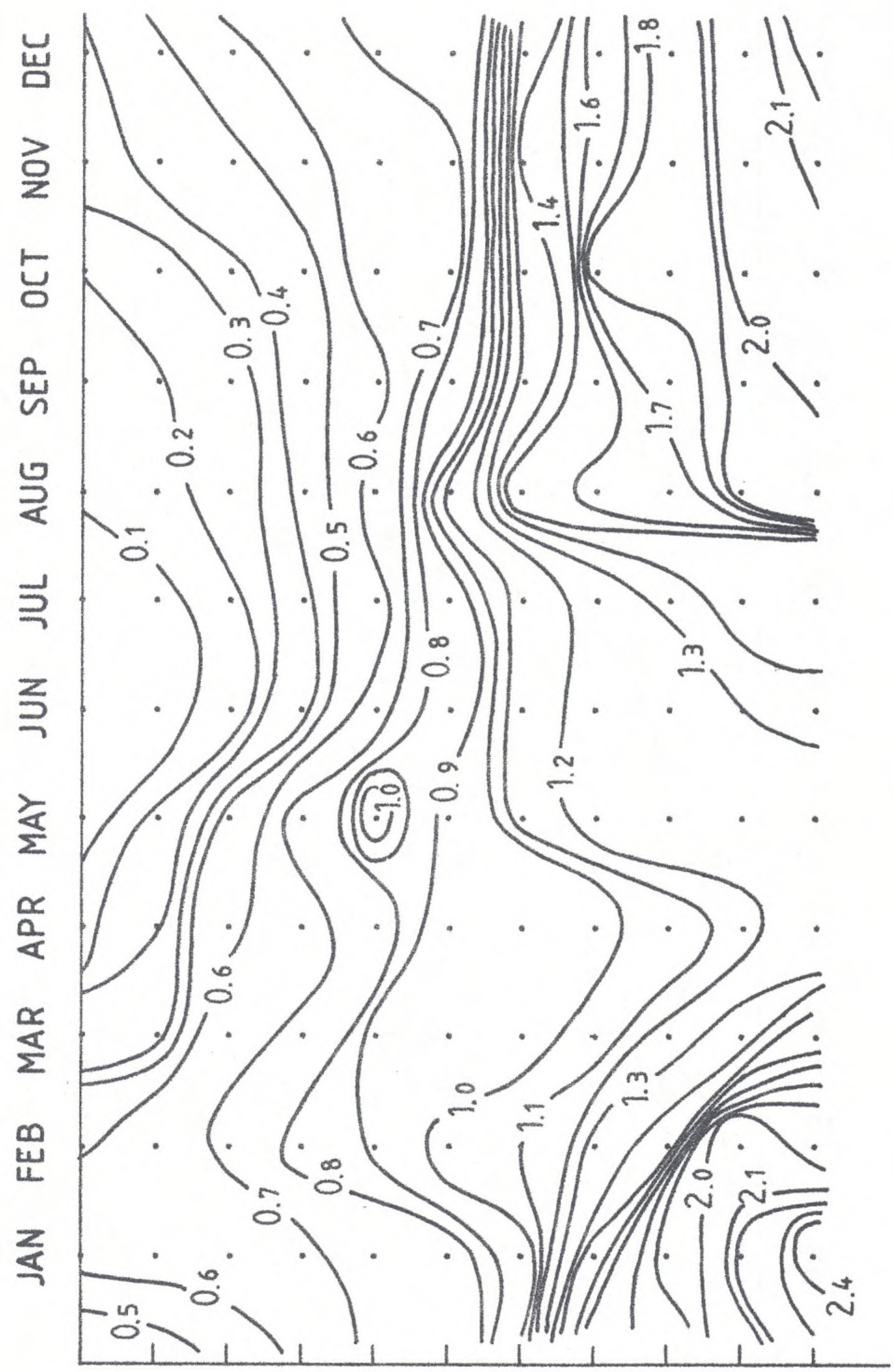


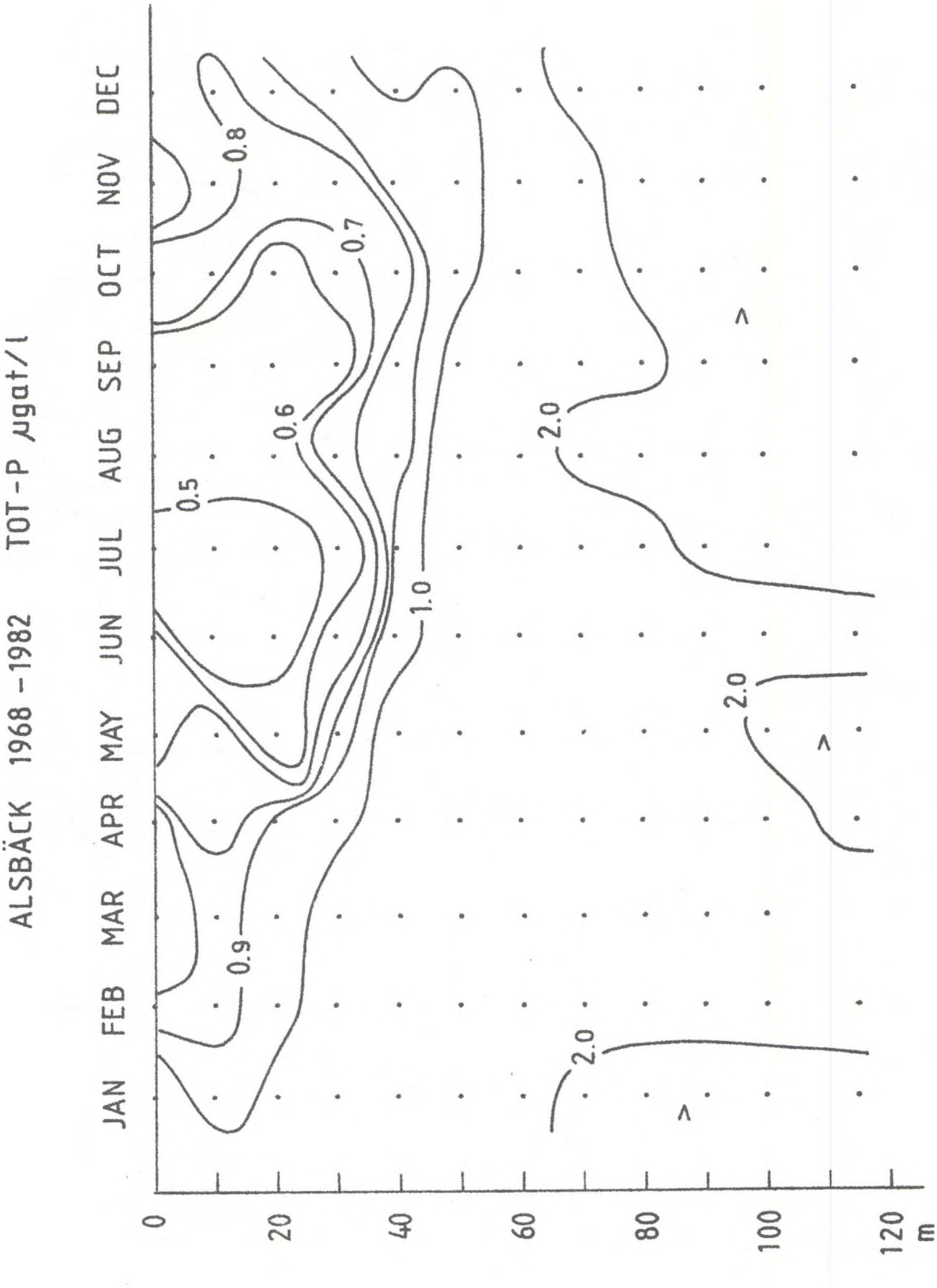
Fig. 3f

ALSBÄCK 1959 - 1981 PO_4-P µgat/l



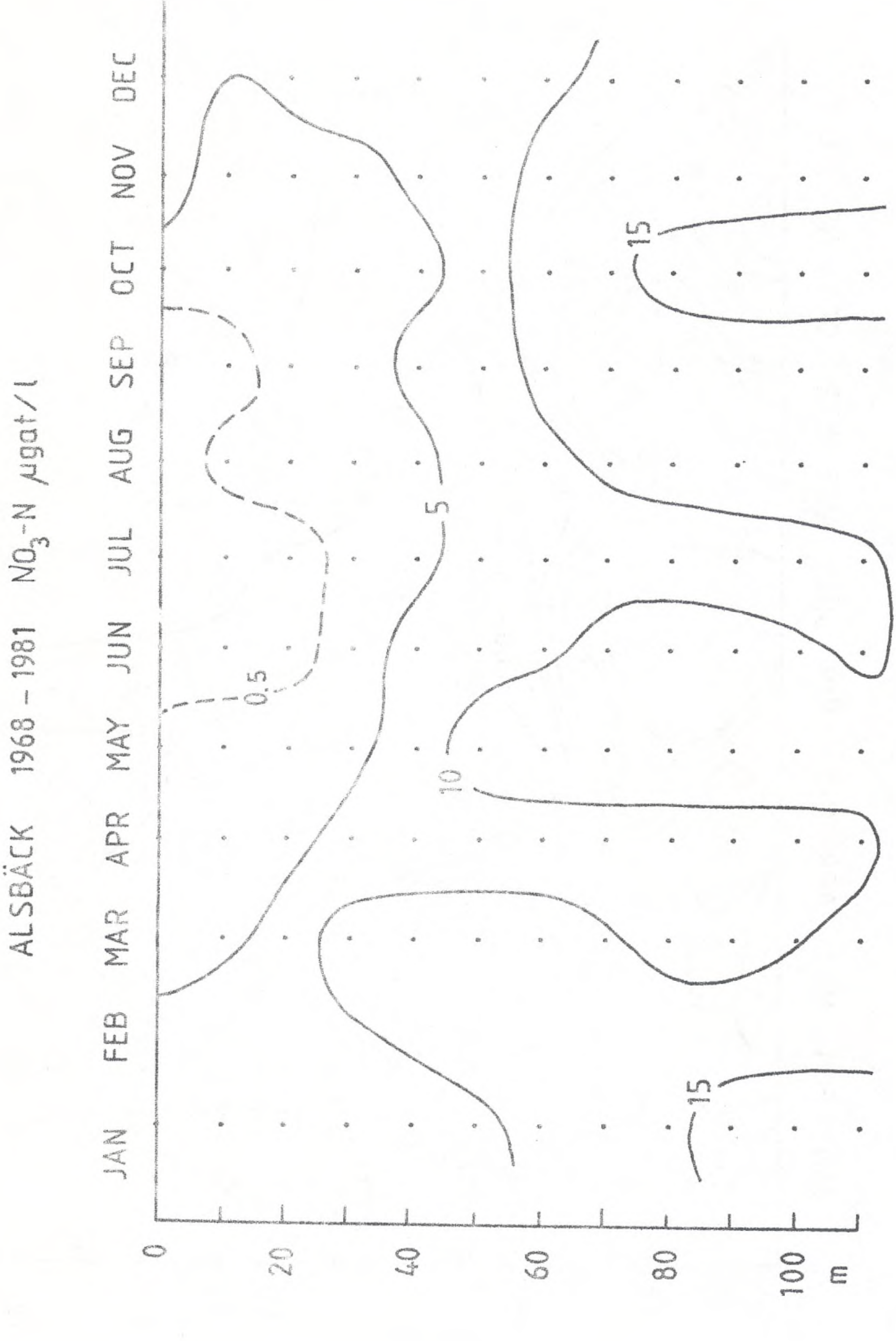
HyLab mars 82 AT

Fig. 3g



ALSBÄCK 1968 -1982 TOT-P µgat/l
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0
20
40
60
80
100
120 m
0.5
0.6
0.7
0.8
0.9
1.0
2.0
2.0
2.0
>
>
>

Fig. 3h



HYLAB 83 AT

Fig. 4a

Salinity

1968 - 1976

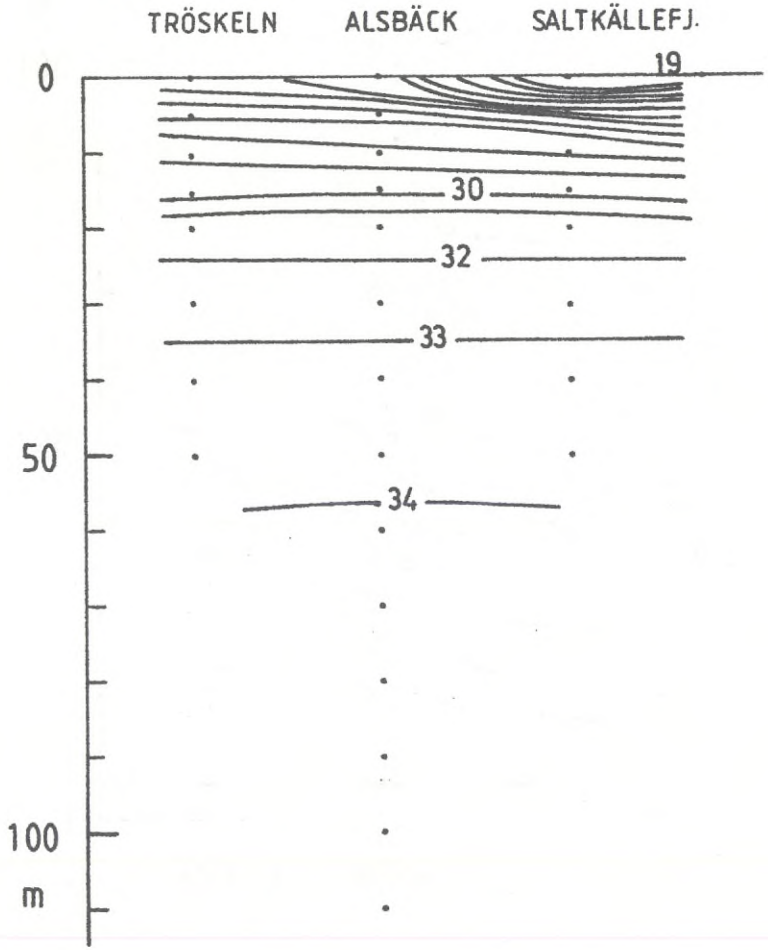


Fig. 4 b

O_2 %

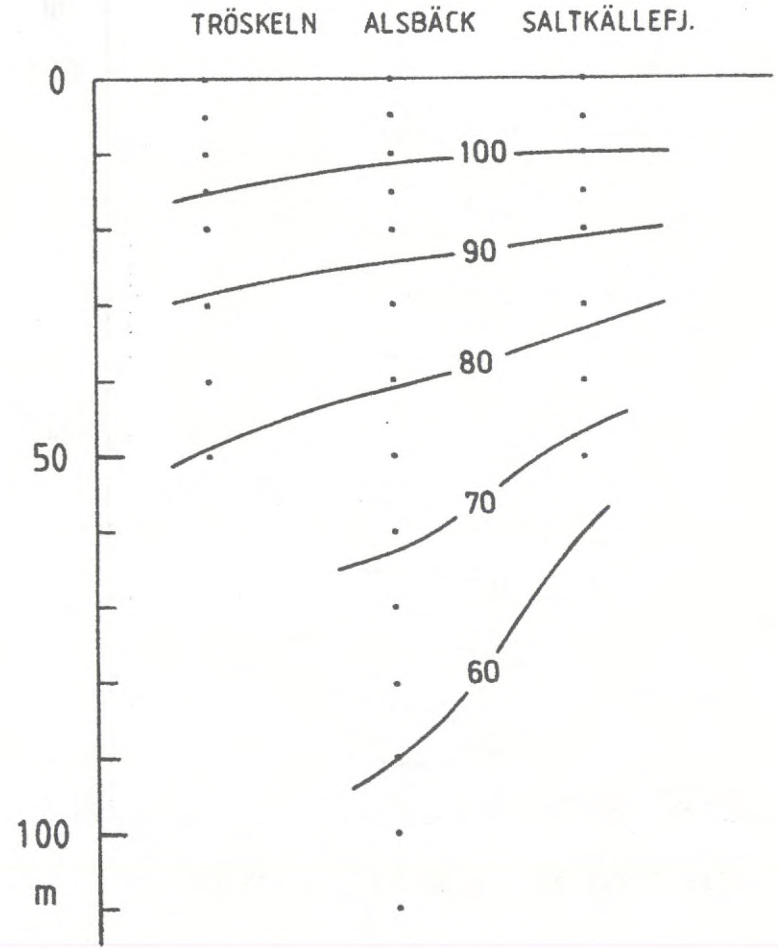


Fig. 4 a + b

HYLAB 83 AT

Fig. 4 c + d

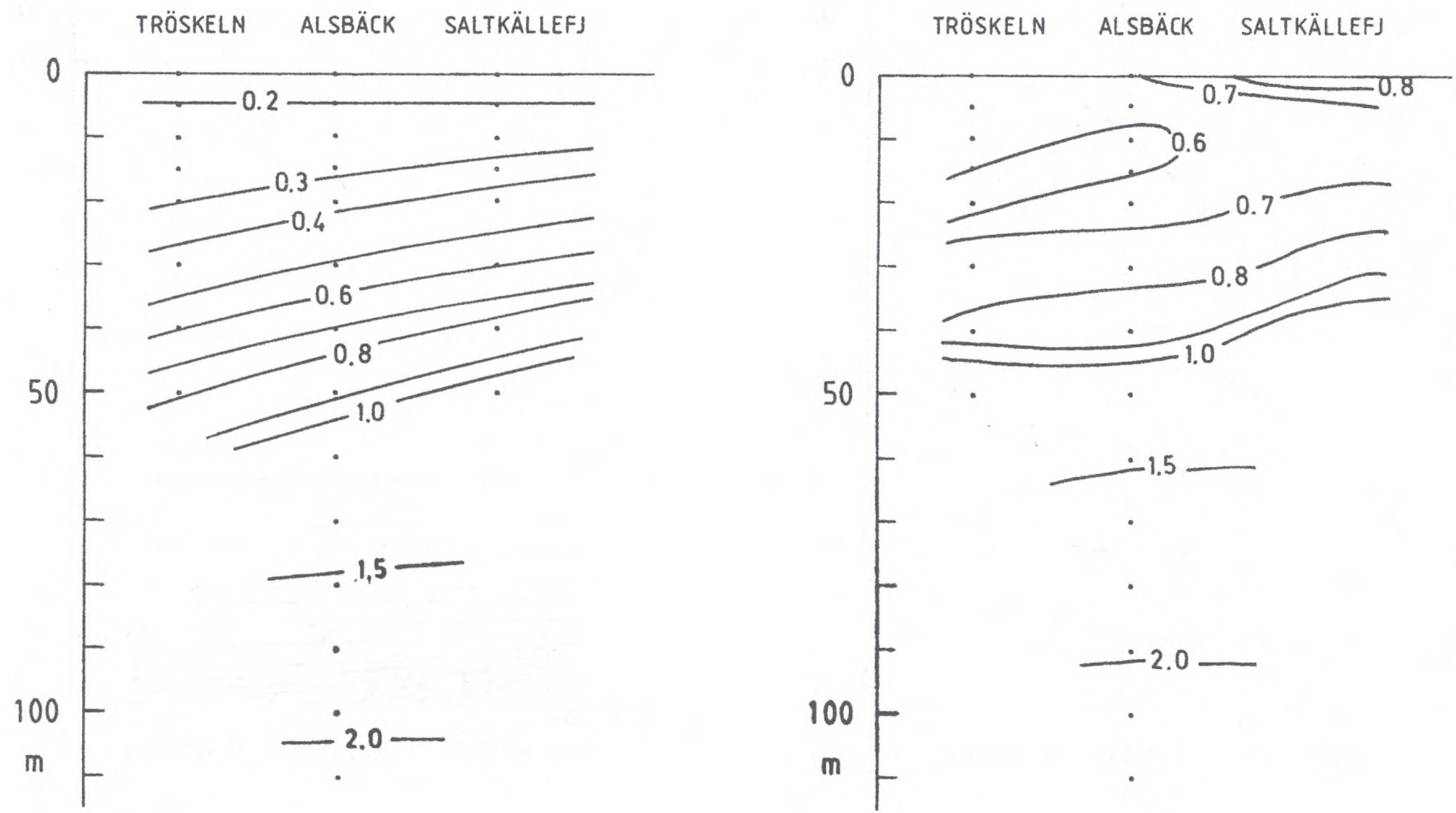
Fig. 4 c

PO_4-P

1968 - 1976

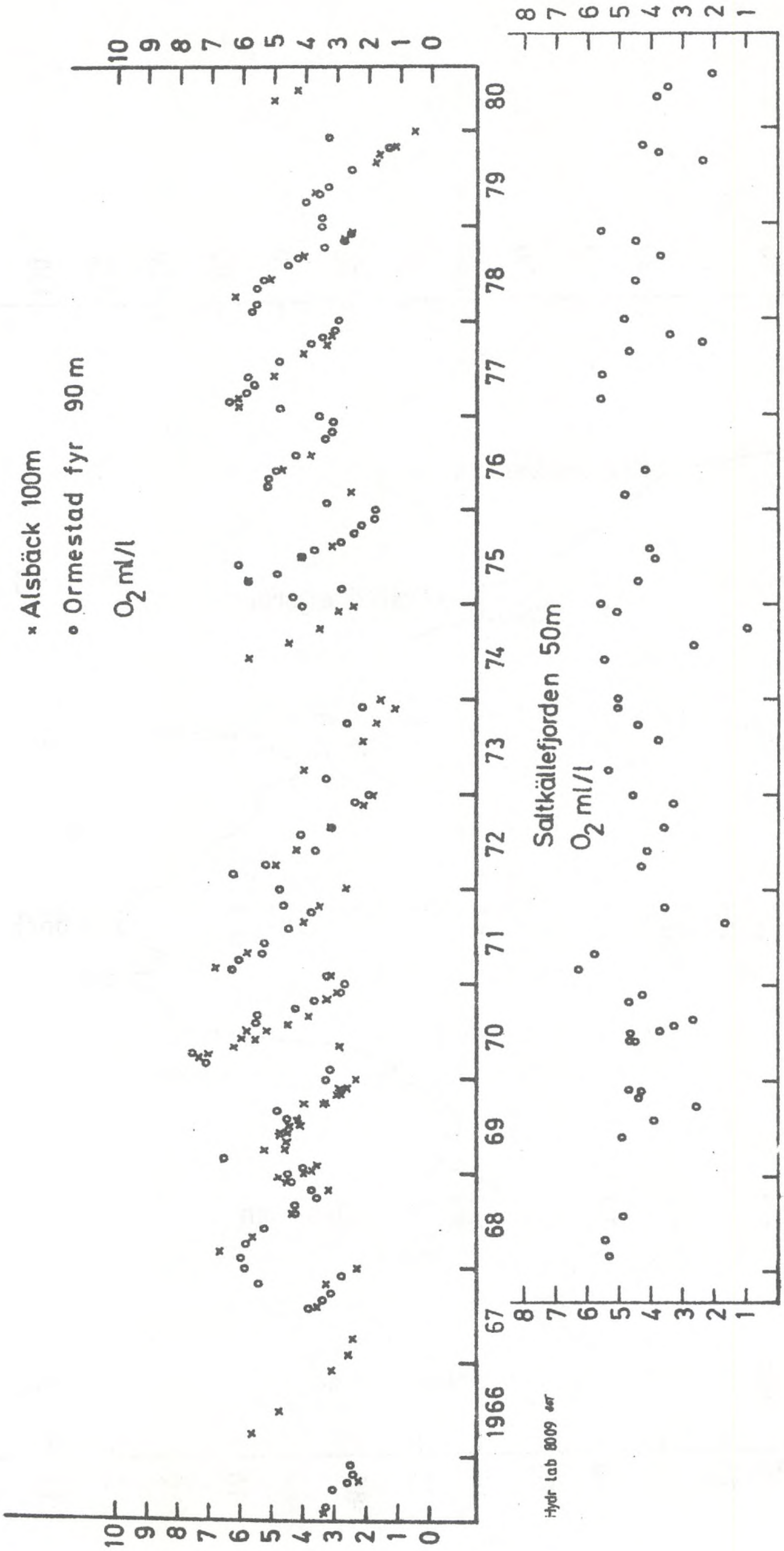
Fig. 4 d

Tot. P



HYLAB 83 AT

Fig. 5



× Alsbäck 100m
∘ Ormestad fyr 90 m
O2 ml/l
Saltkällefjorden 50m
O2 ml/l
1966
67
1968
69
70
71
72
73
74
75
76
77
78
79
80

Fig. 6 a

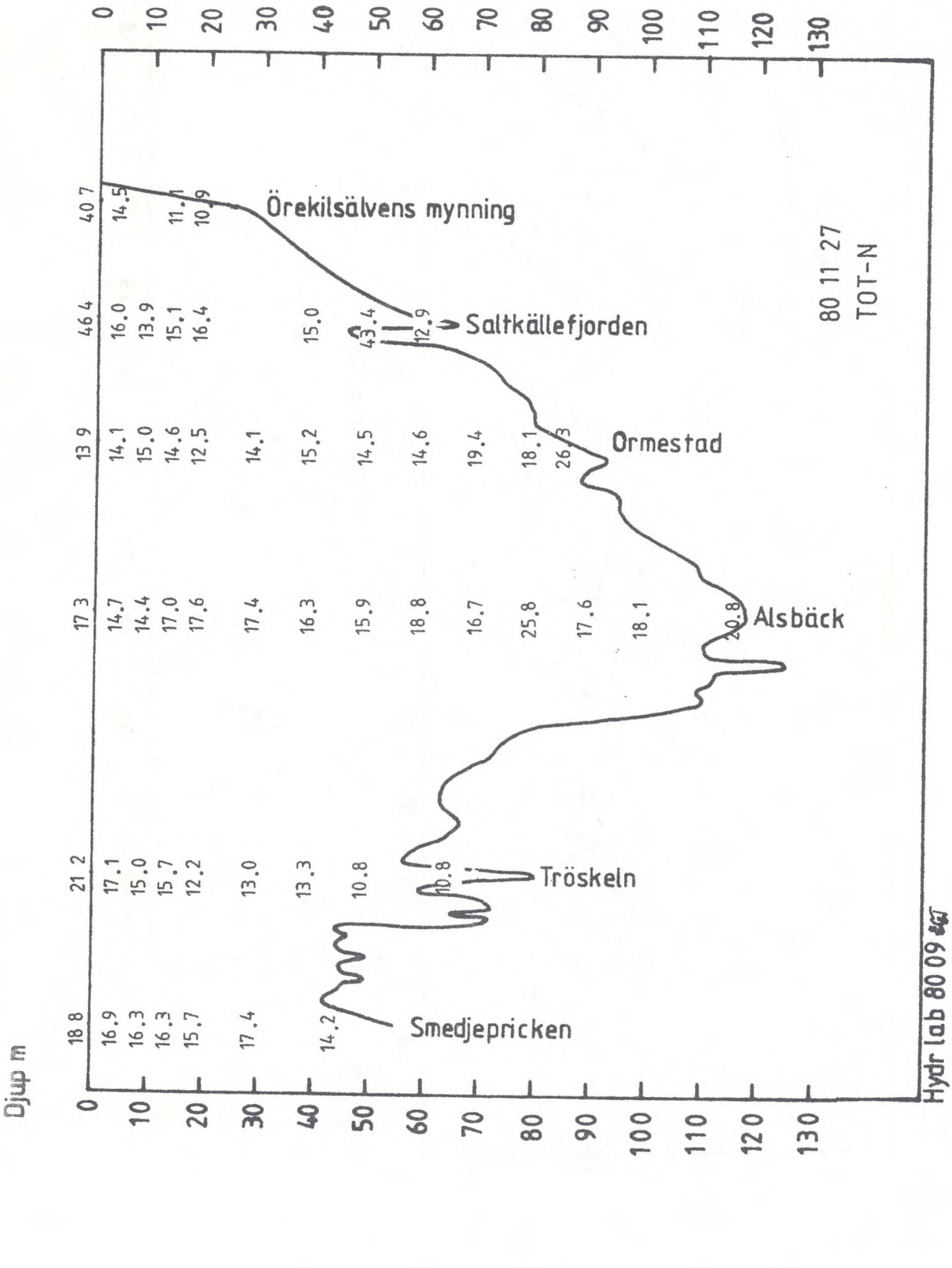
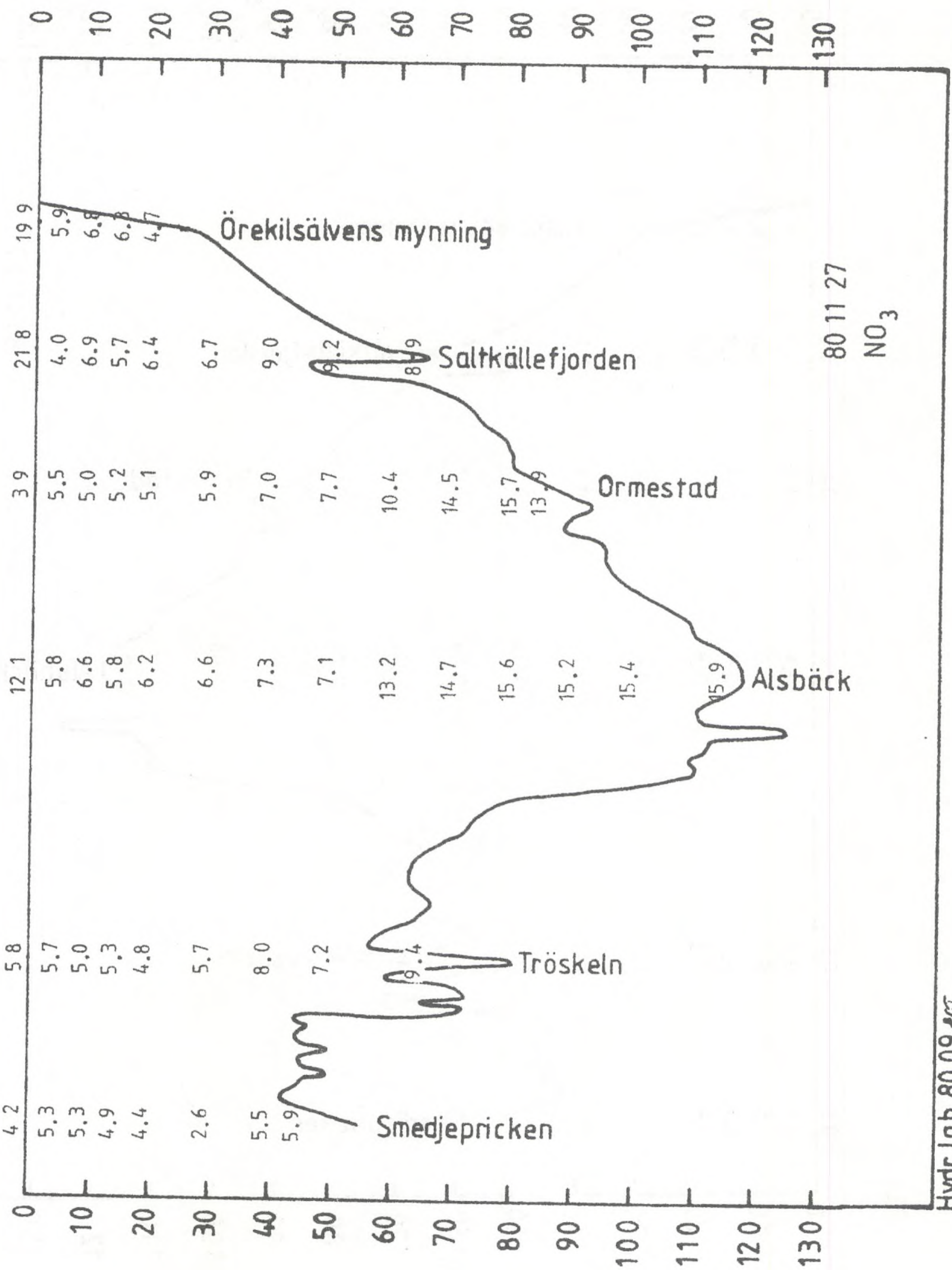

Djup m
Örekilsälvens mynning
Saltkällefjorden
Ormestad
Alsbäck
Tröskeln
Smedjepricken
80 11 27
TOT-N
Hydr lab 80 09

Fig. 6 b



Örekilsälvens mynning
Saltkällefjorden
Ormestad
Alsbäck
Tröskeln
Smedjepricken
80 11 27
NO_3
Hydr lab 80 09

Fig. 6 c

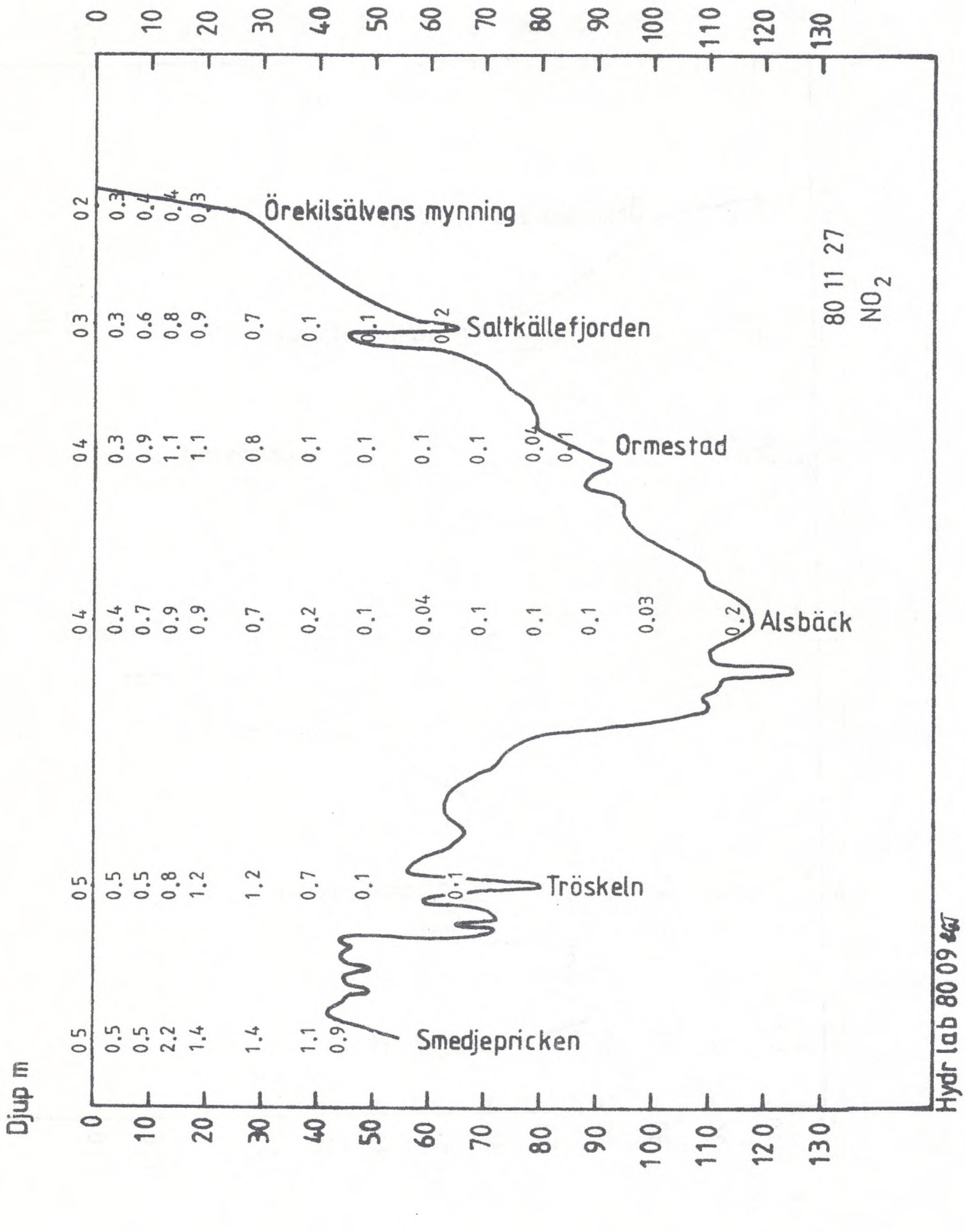
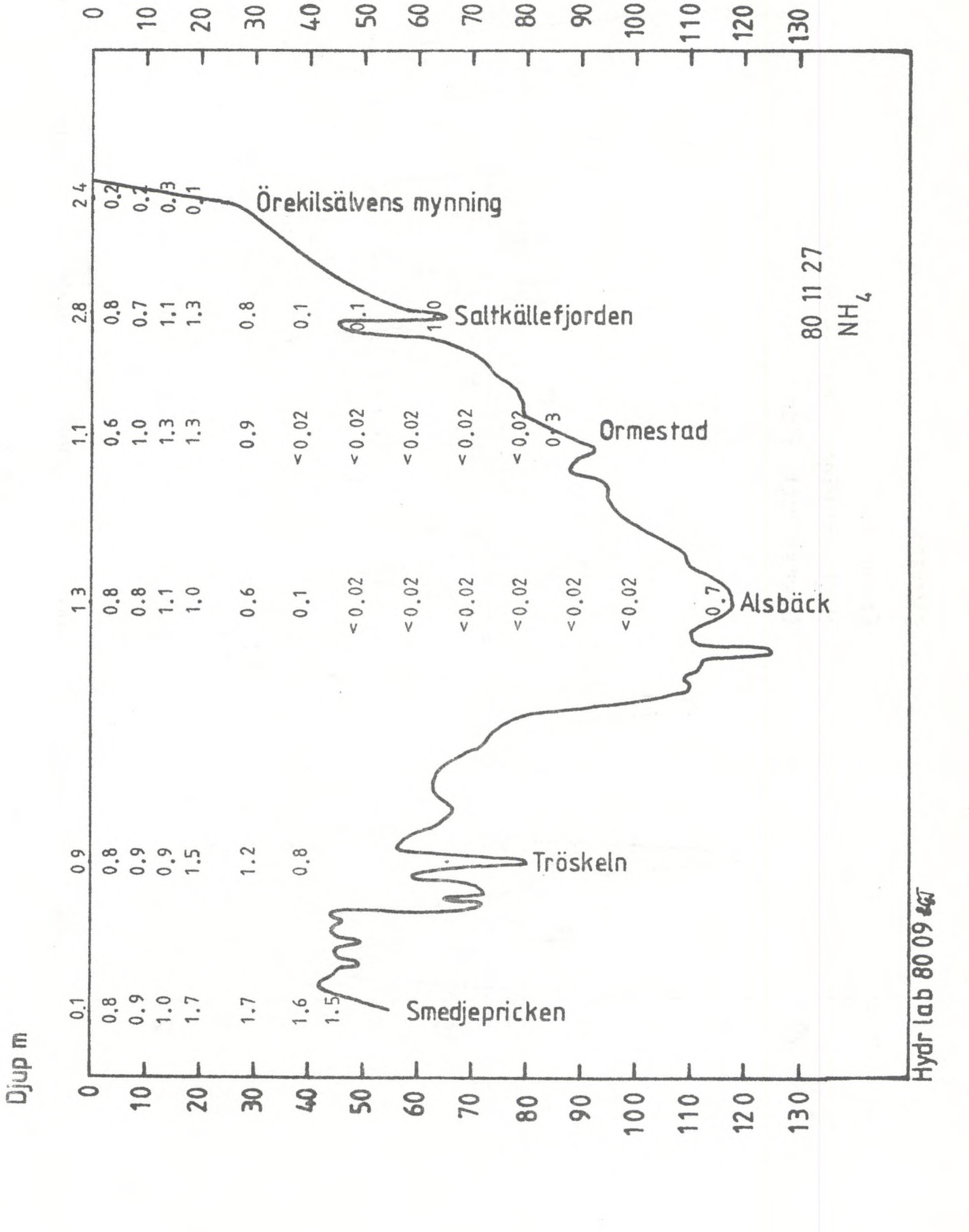
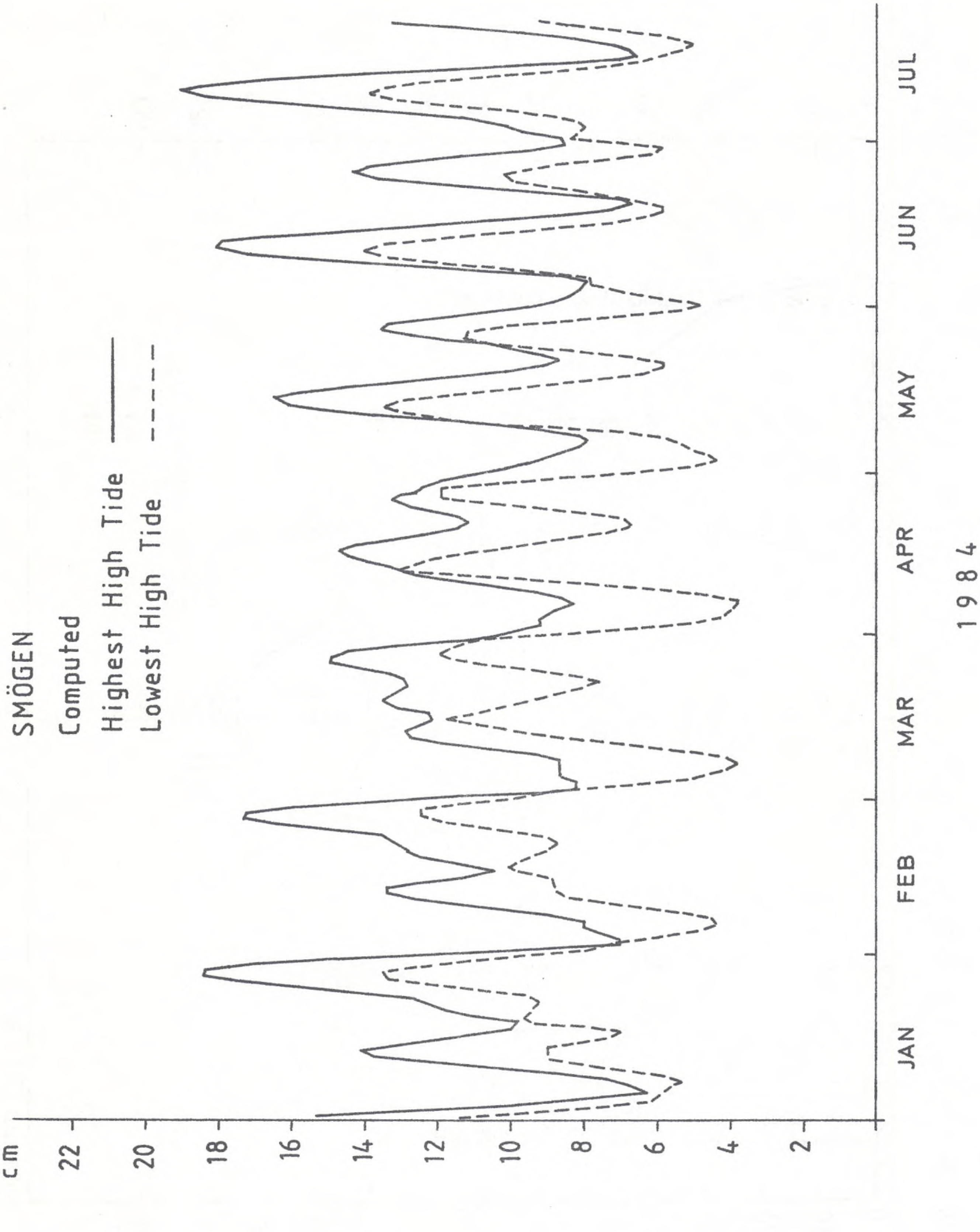

Örekilsälvens mynning
Saltkällefjorden
Ormestad
Alsbäck
Tröskeln
Smedjepricken
80 11 27
NO_2
Djup m
Hydr lab 80 09

Fig. 6 d



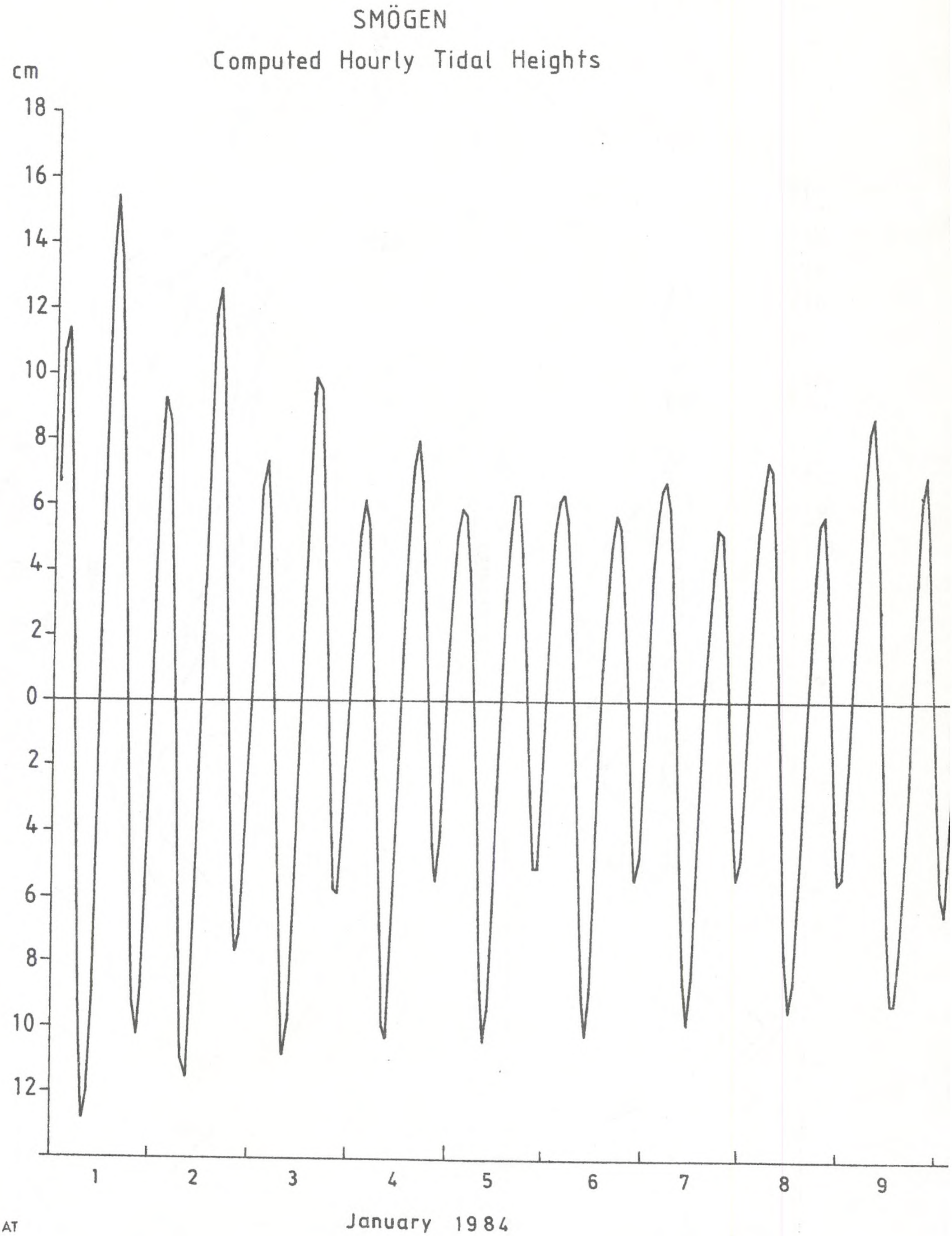
Djup m
Örekilsälvens mynning
Saltkällefjorden
Ormestad
Alsbäck
Tröskeln
Smedjepricken
80 11 27
NH_4
Hydr lab 80 09
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Fig. 7a

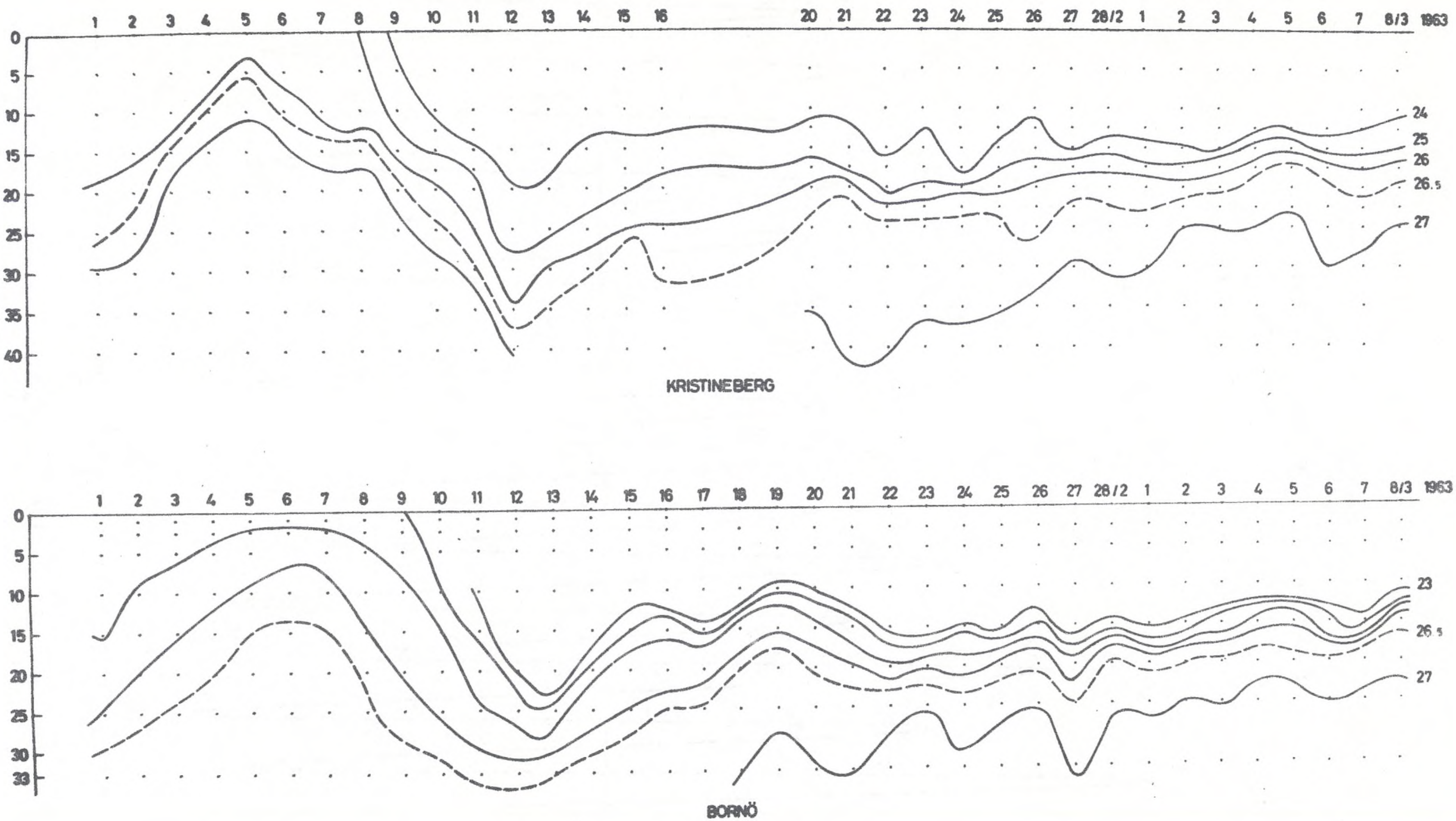


HYLAB 83 AT

Fig. 7b



IYLAB 83 AT



Sigma t versus depth
February - 8 March 1983
(Density $1 + (\text{sigma } t) \times 10^{-3}$)

Bornö February 1965

S ‰

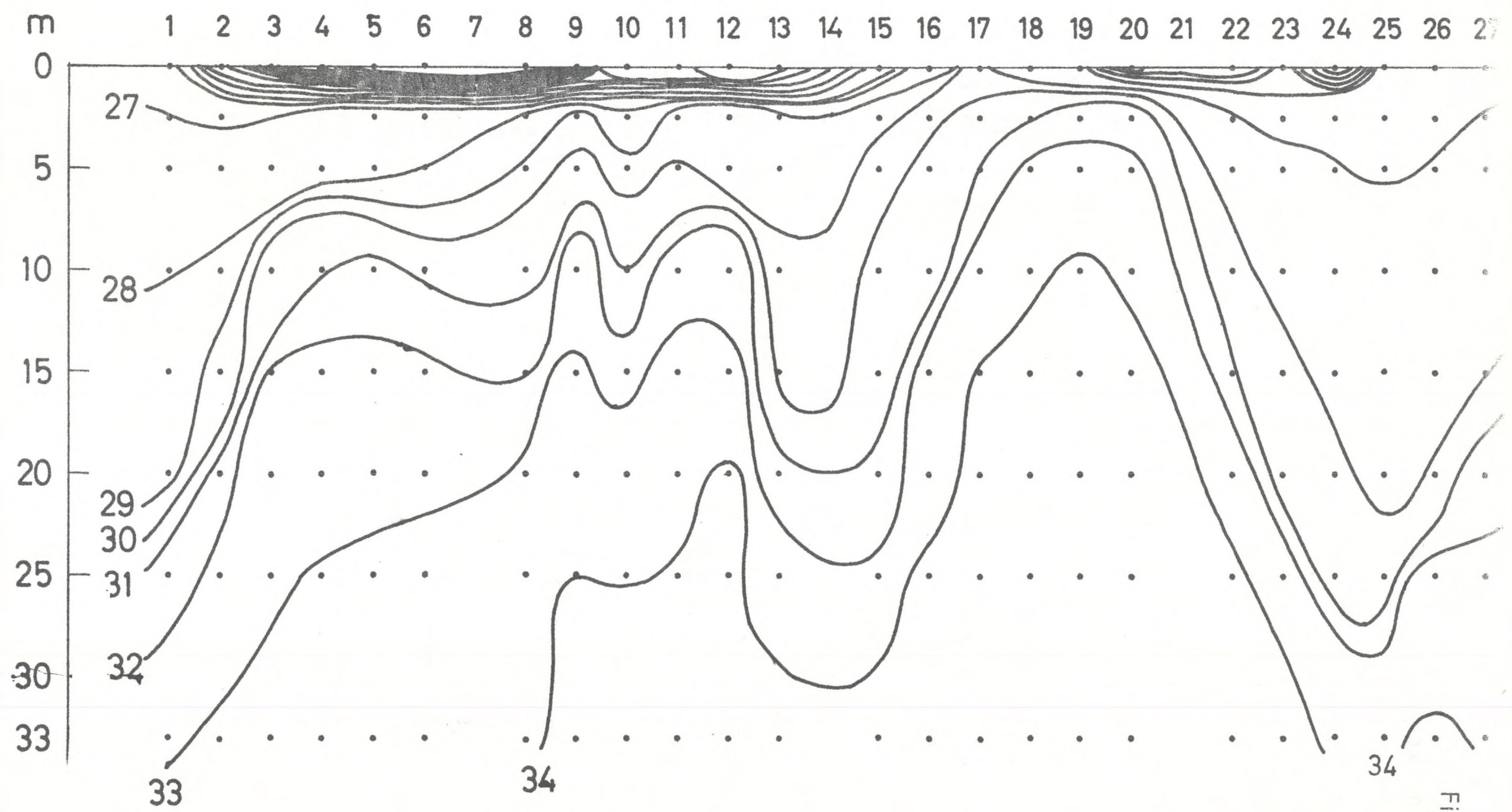


Fig. 9

Fig. 10 a

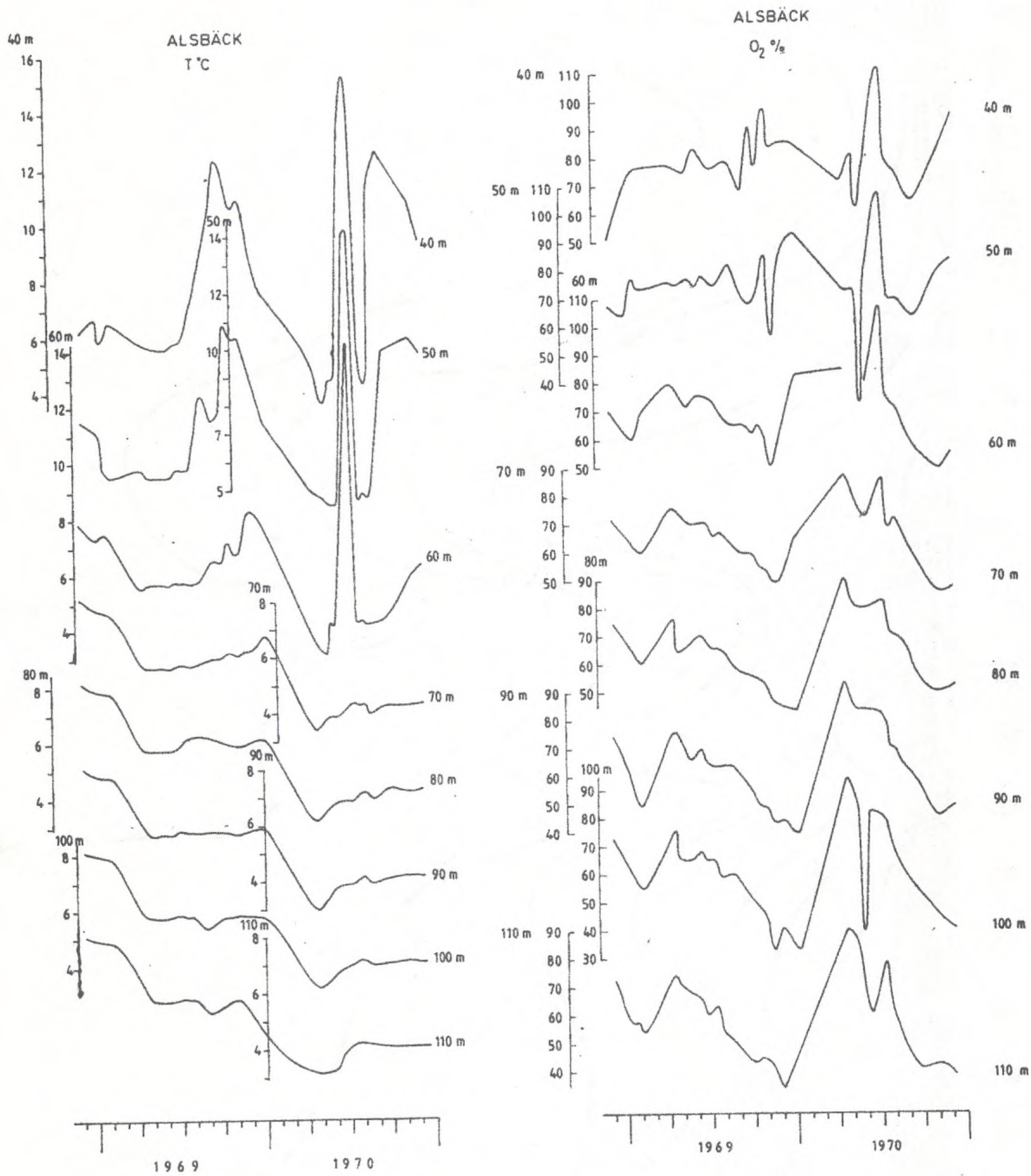
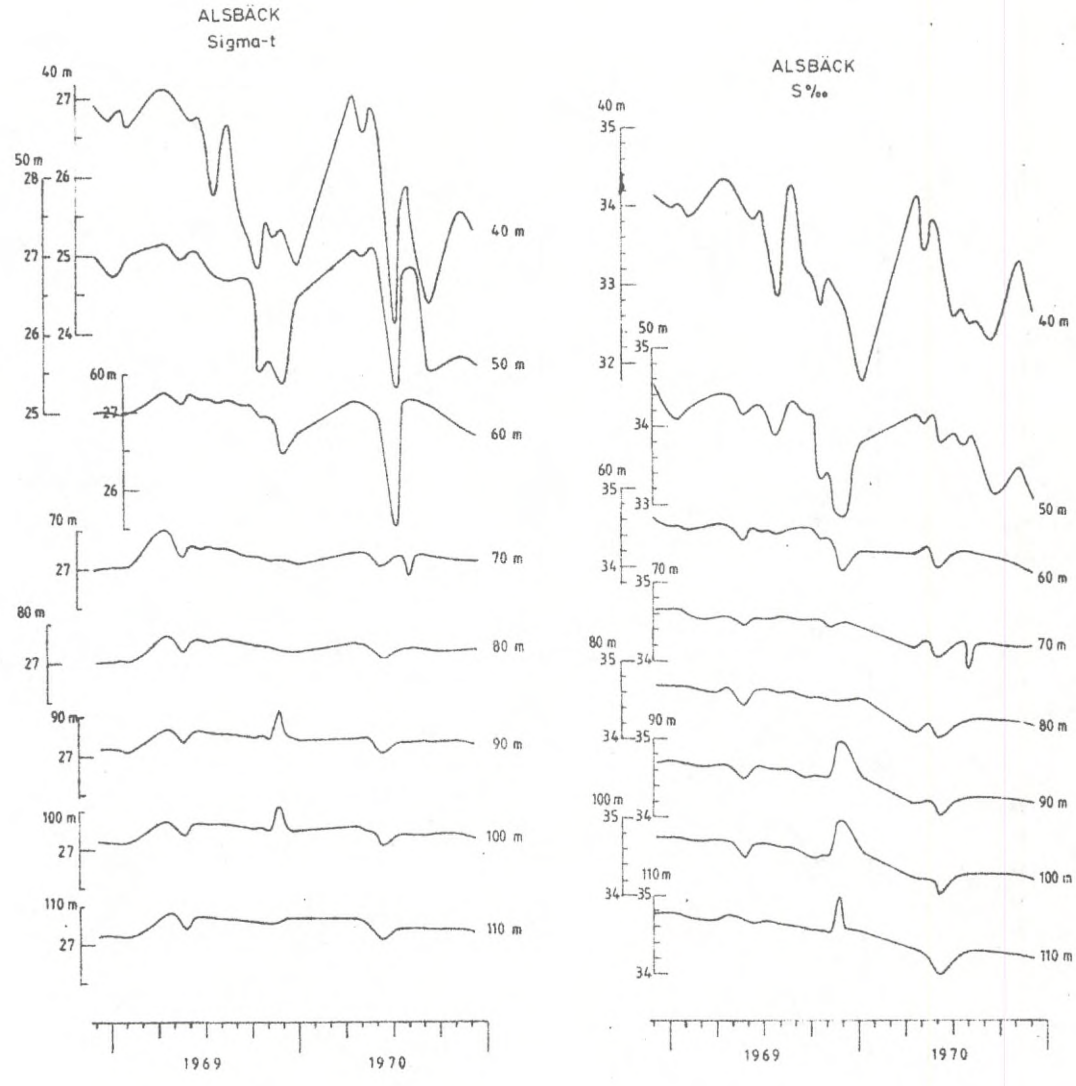

ALSBÄCK
T °C
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970
ALSBÄCK
O_2 %
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970

Fig. 10 b



ALSBÄCK
Sigma-t
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970
ALSBÄCK
S ‰
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970

Fig. 10 c

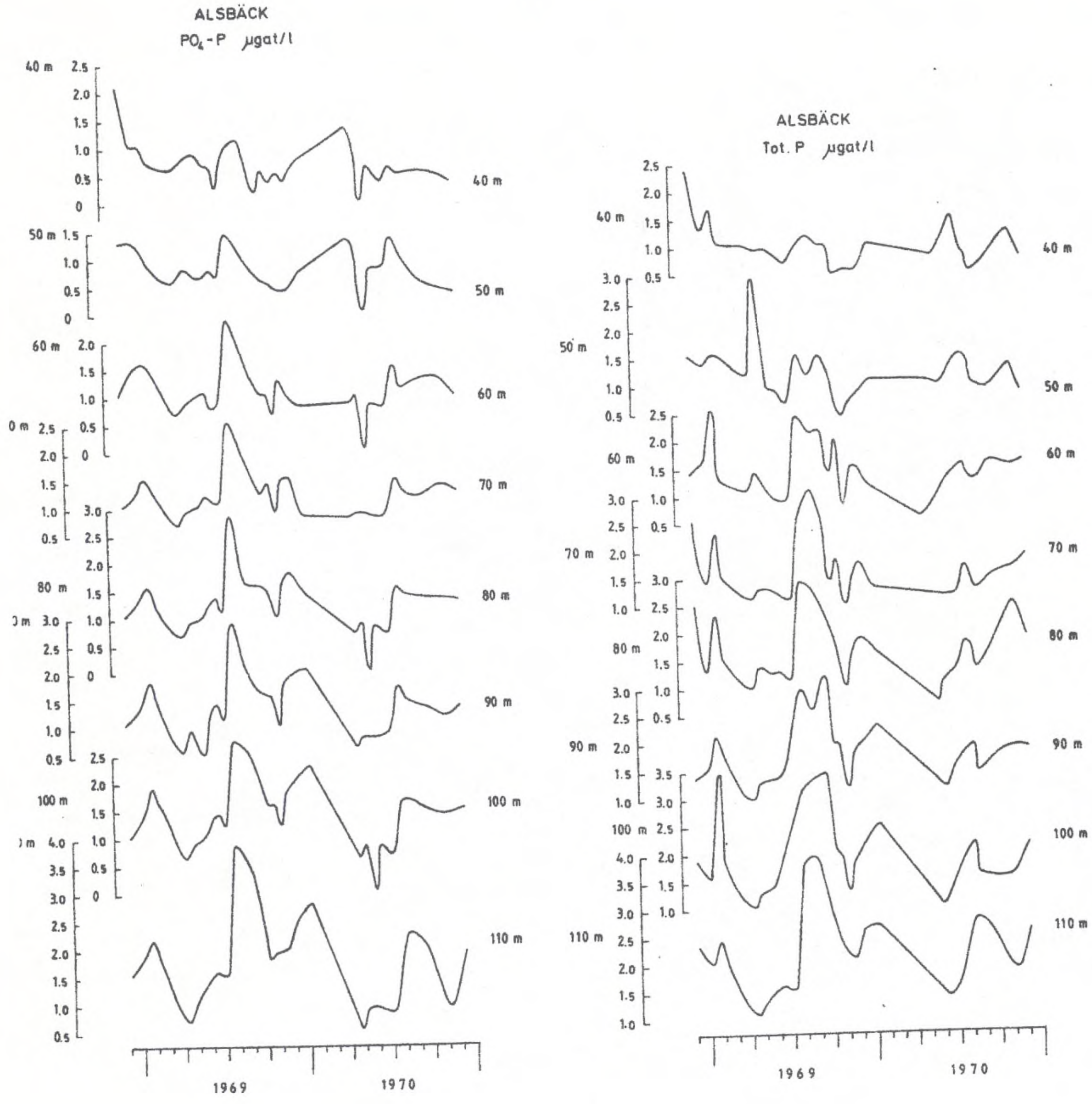
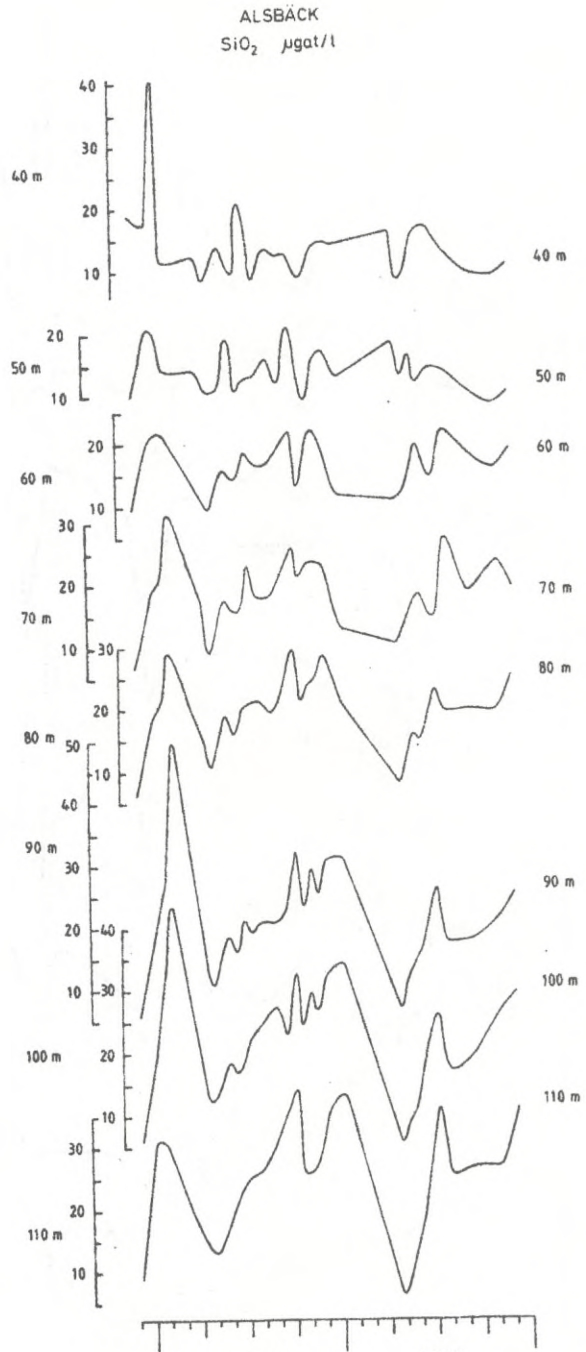

ALSBÄCK
PO_4-P µgat/l
ALSBÄCK
Tot. P µgat/l
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970

Fig. 10d


ALSBÄCK
SiO_2 µgat/l
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970

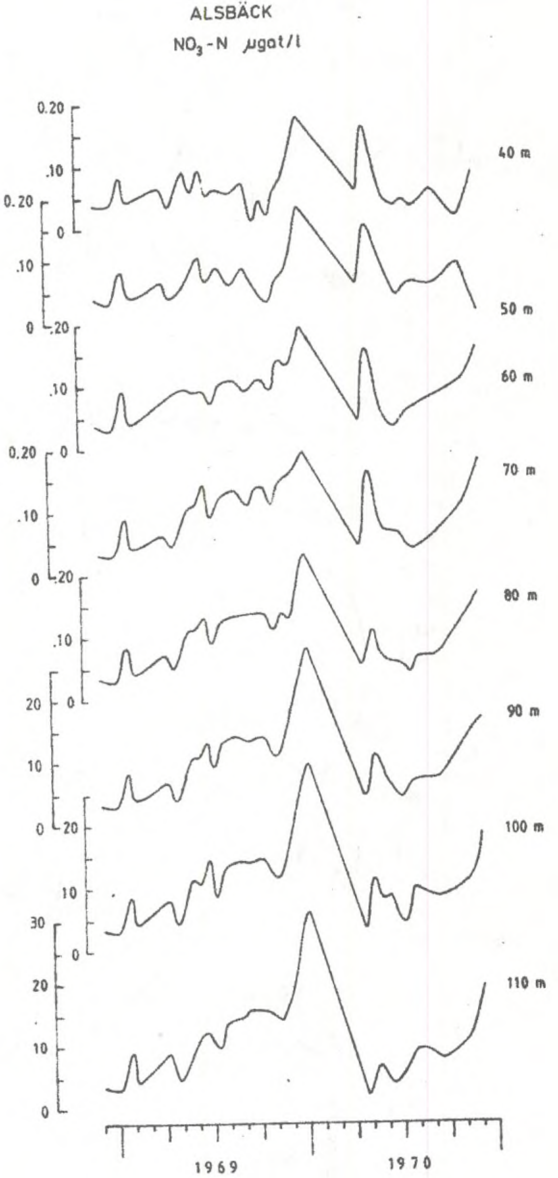
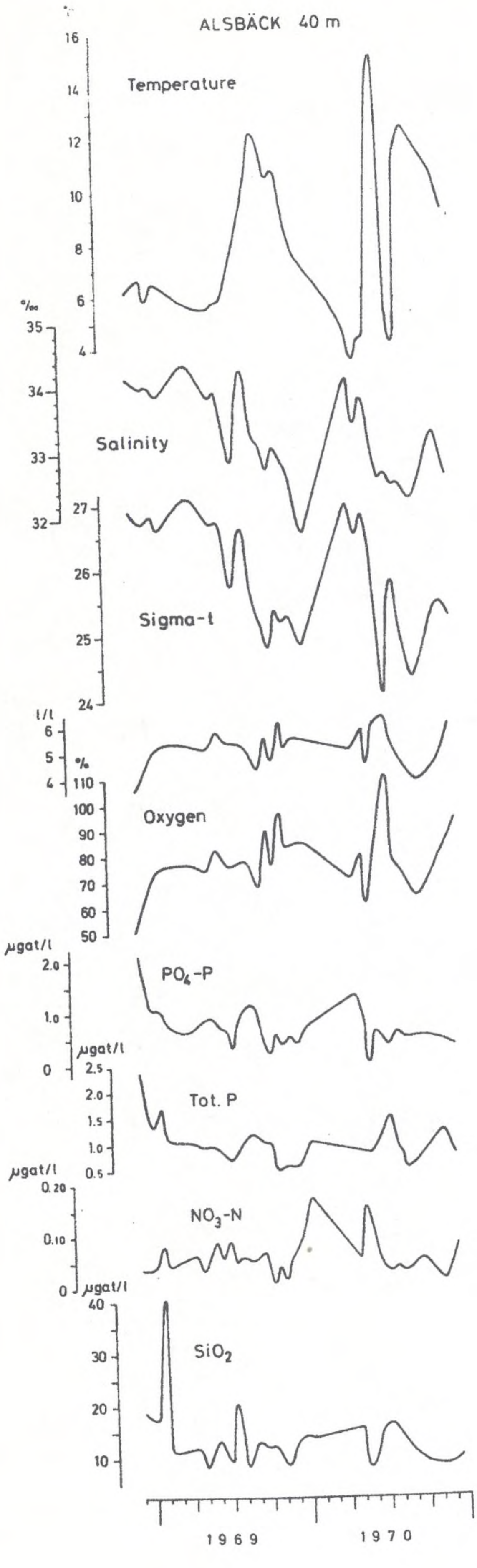

ALSBÄCK
NO_3-N µgat/l
40 m
50 m
60 m
70 m
80 m
90 m
100 m
110 m
1969
1970

Fig. 10 e


ALSBÄCK 40 m
Temperature
Salinity
Sigma-t
Oxygen
PO_4-P
Tot. P
NO_3-N
SiO_2
1969
1970

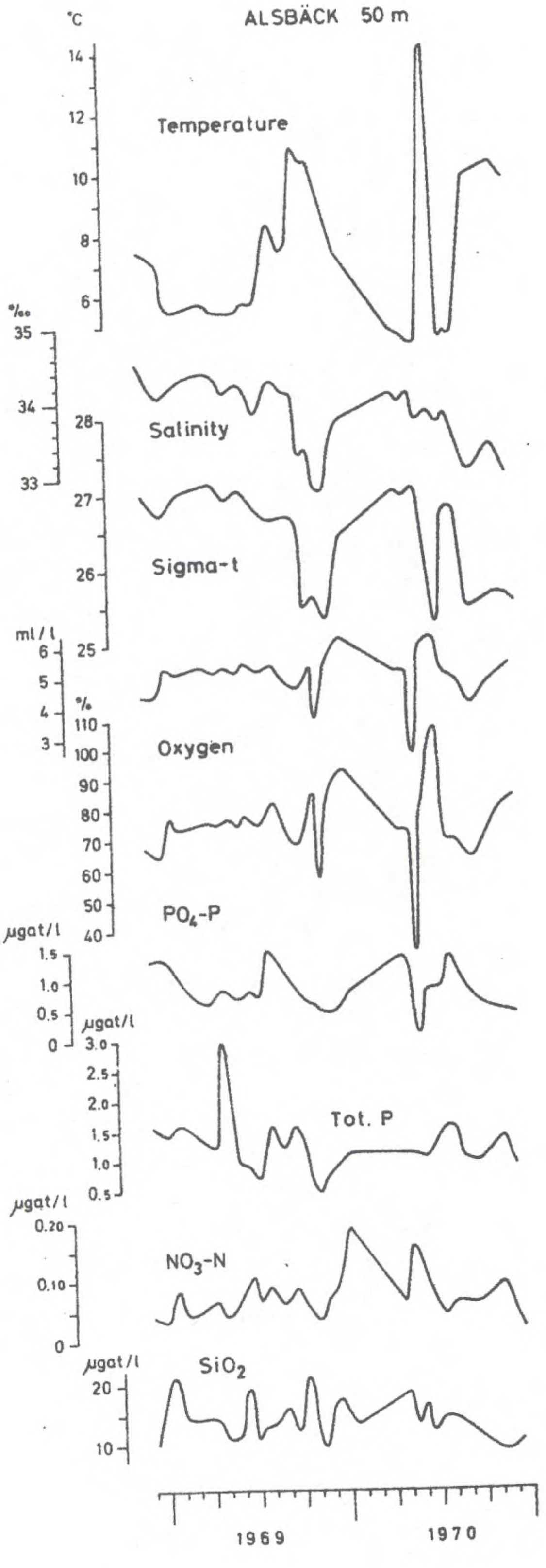
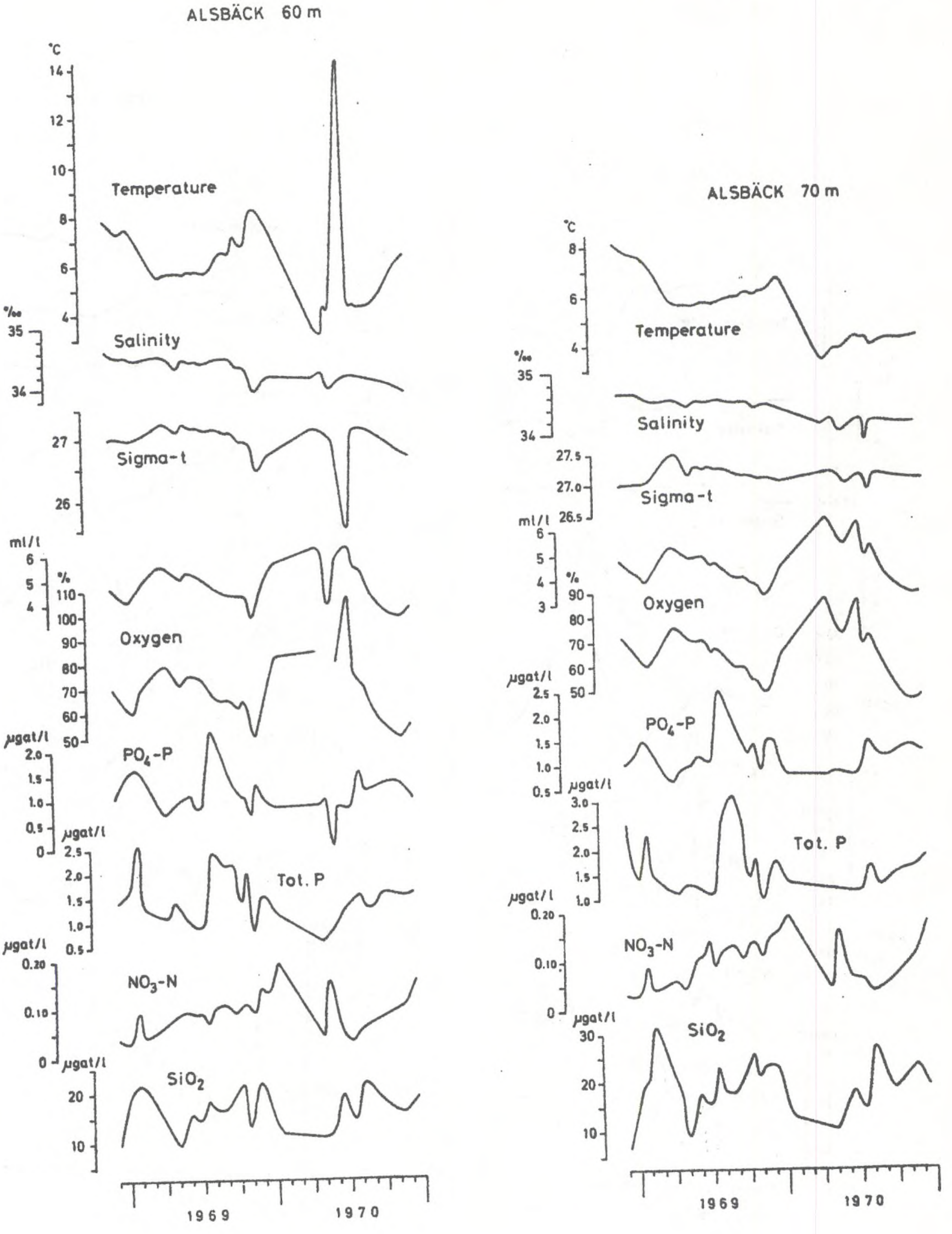

ALSBÄCK 50 m
Temperature
Salinity
Sigma-t
Oxygen
PO_4-P
Tot. P
NO_3-N
SiO_2
1969
1970

Fig. 10 f



ALSBÄCK 60 m
Temperature
Salinity
Sigma-t
Oxygen
PO4-P
Tot. P
NO3-N
SiO2
1969
1970
ALSBÄCK 70 m
Temperature
Salinity
Sigma-t
Oxygen
PO4-P
Tot. P
NO3-N
SiO2
1969
1970

Fig. 10 g

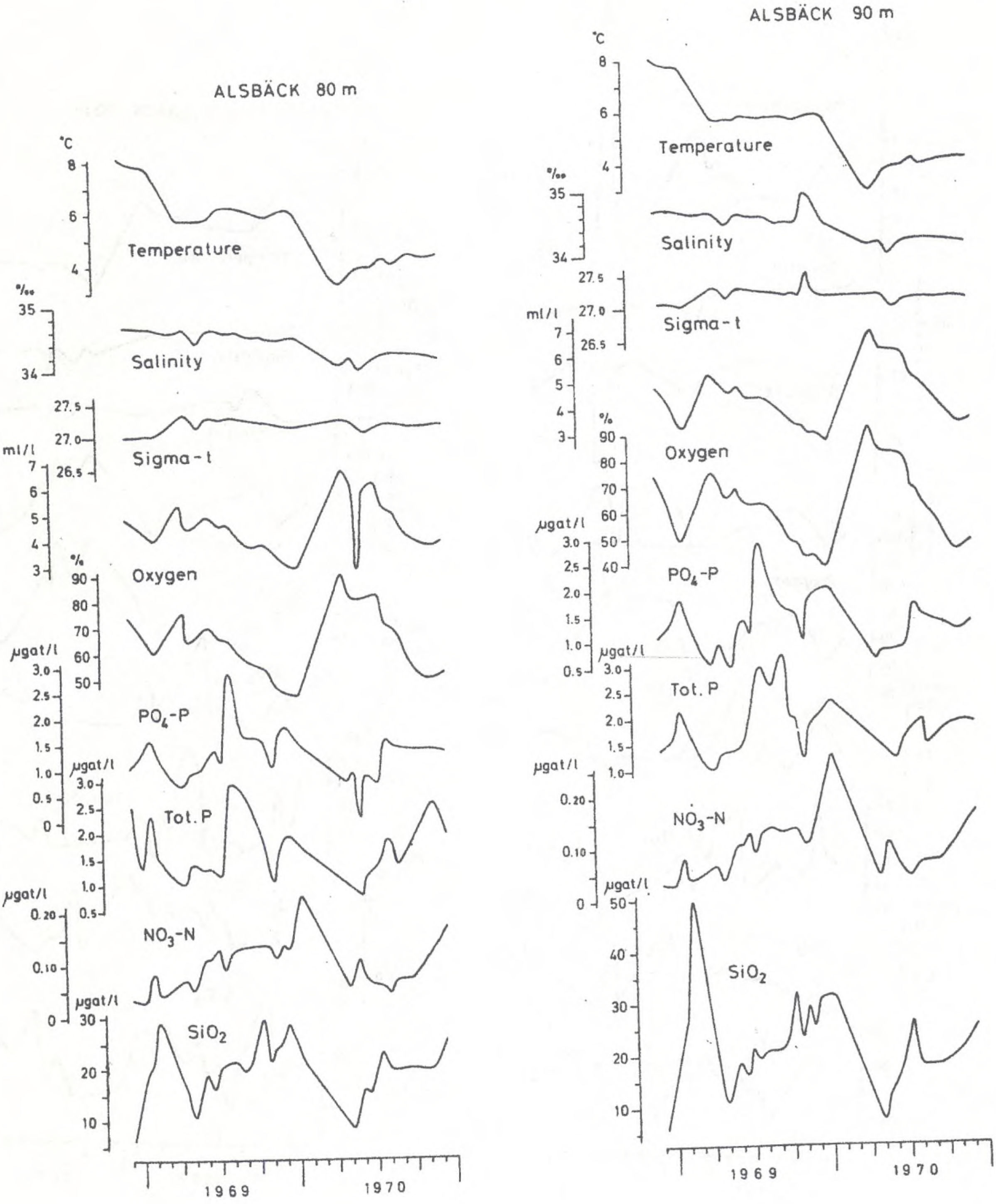
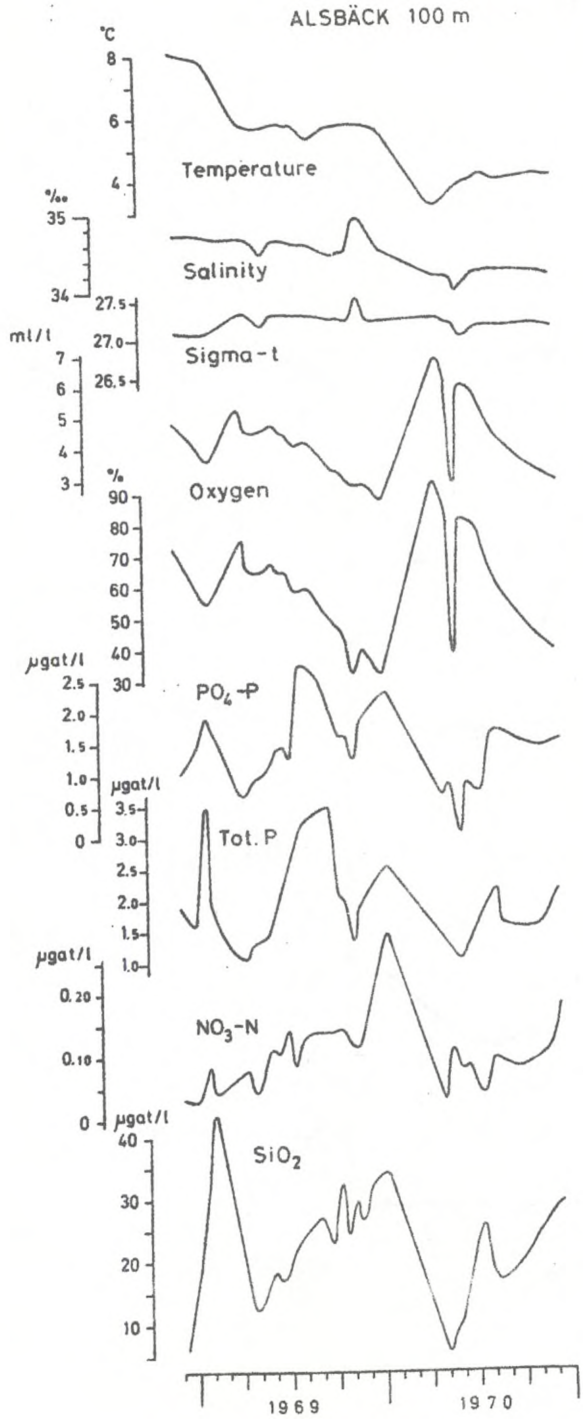
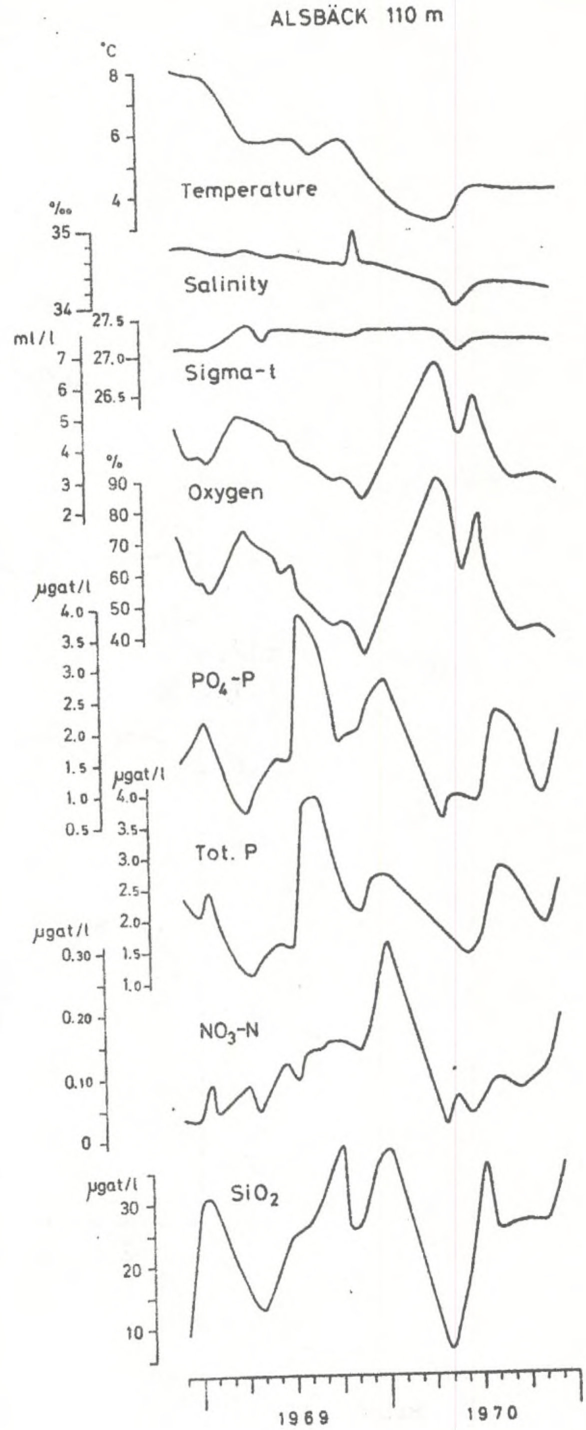

ALSBÄCK 80 m
°C
8
6
4
Temperature
‰
35
34
Salinity
27.5
27.0
26.5
Sigma-t
ml/l
7
6
5
4
3
%
90
80
70
60
50
Oxygen
µgat/l
3.0
2.5
2.0
1.5
1.0
0.5
0
PO4-P
µgat/l
3.0
2.5
2.0
1.5
1.0
0.5
Tot. P
µgat/l
0.20
0.10
0
NO3-N
µgat/l
30
20
10
SiO2
1969
1970
ALSBÄCK 90 m
°C
8
6
4
Temperature
‰
35
34
Salinity
27.5
27.0
26.5
Sigma-t
ml/l
7
6
5
4
3
%
90
80
70
60
50
40
Oxygen
µgat/l
3.0
2.5
2.0
1.5
1.0
0.5
PO4-P
µgat/l
3.0
2.5
2.0
1.5
1.0
Tot. P
µgat/l
0.20
0.10
0
NO3-N
µgat/l
50
40
30
20
10
SiO2
1969
1970

Fig. 10 h

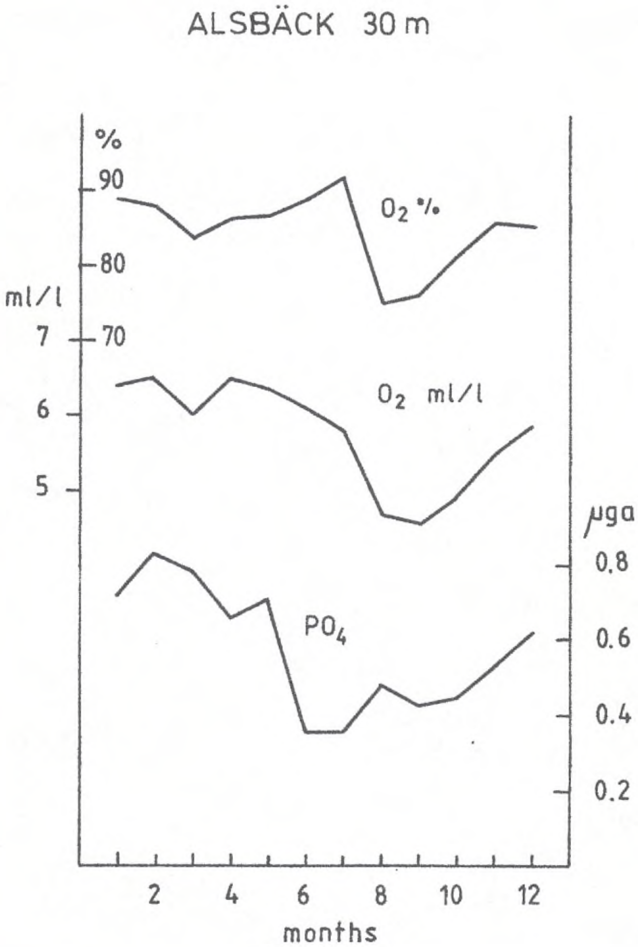


ALSBÄCK 100 m
°C
8
6
4
Temperature
‰
35
34
Salinity
27.5
27.0
26.5
Sigma-t
ml/l
7
6
5
4
3
Oxygen
%
90
80
70
60
50
40
30
µgat/l
2.5
2.0
1.5
1.0
0.5
0
PO4-P
µgat/l
3.5
3.0
2.5
2.0
1.5
1.0
Tot. P
µgat/l
0.20
0.10
0
NO3-N
µgat/l
40
30
20
10
SiO2
1969
1970



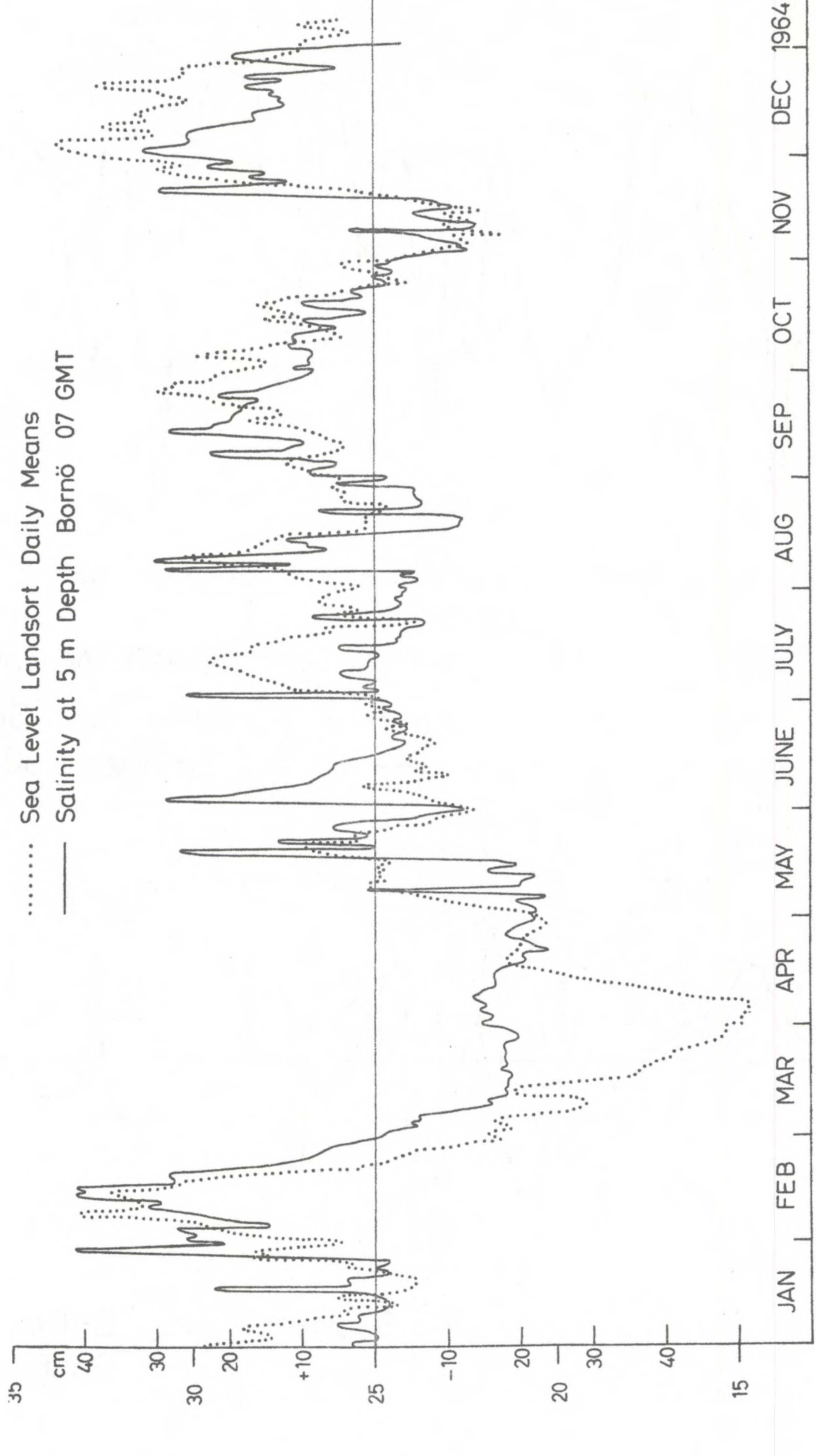
ALSBÄCK 110 m
°C
8
6
4
Temperature
‰
35
34
Salinity
27.5
27.0
26.5
Sigma-t
ml/l
7
6
5
4
3
2
Oxygen
%
90
80
70
60
50
40
µgat/l
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
PO4-P
µgat/l
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Tot. P
µgat/l
0.30
0.20
0.10
0
NO3-N
µgat/l
30
20
10
SiO2
1969
1970

Fig. 11



HYLAB 83 AT

Fig. 12



Sea Level Landsort Daily Means
Salinity at 5 m Depth Bornö 07 GMT
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
1964
cm
40
30
20
+10
-10
-20
-30
-40
35
30
25
20
15

Fig. 13

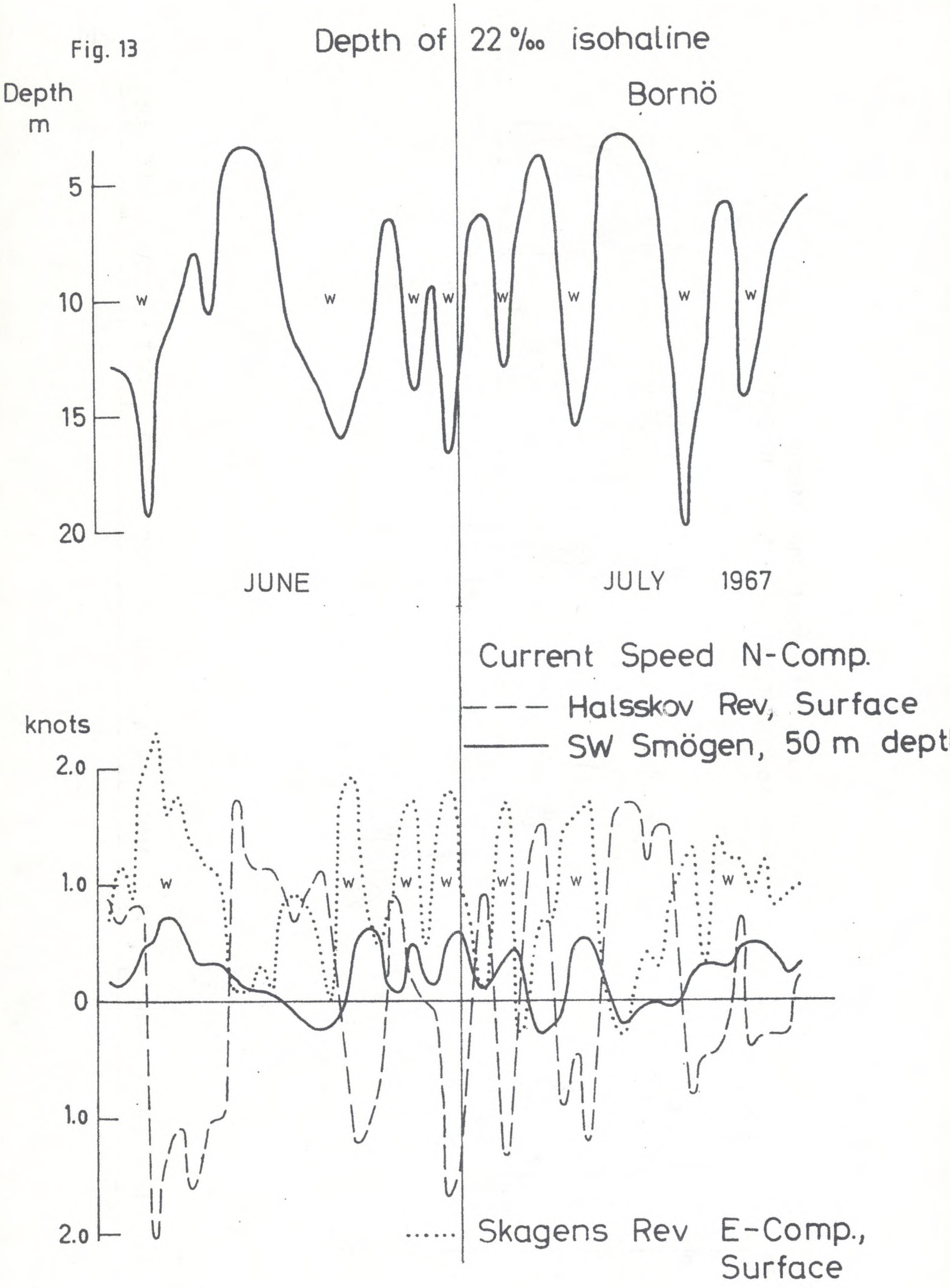
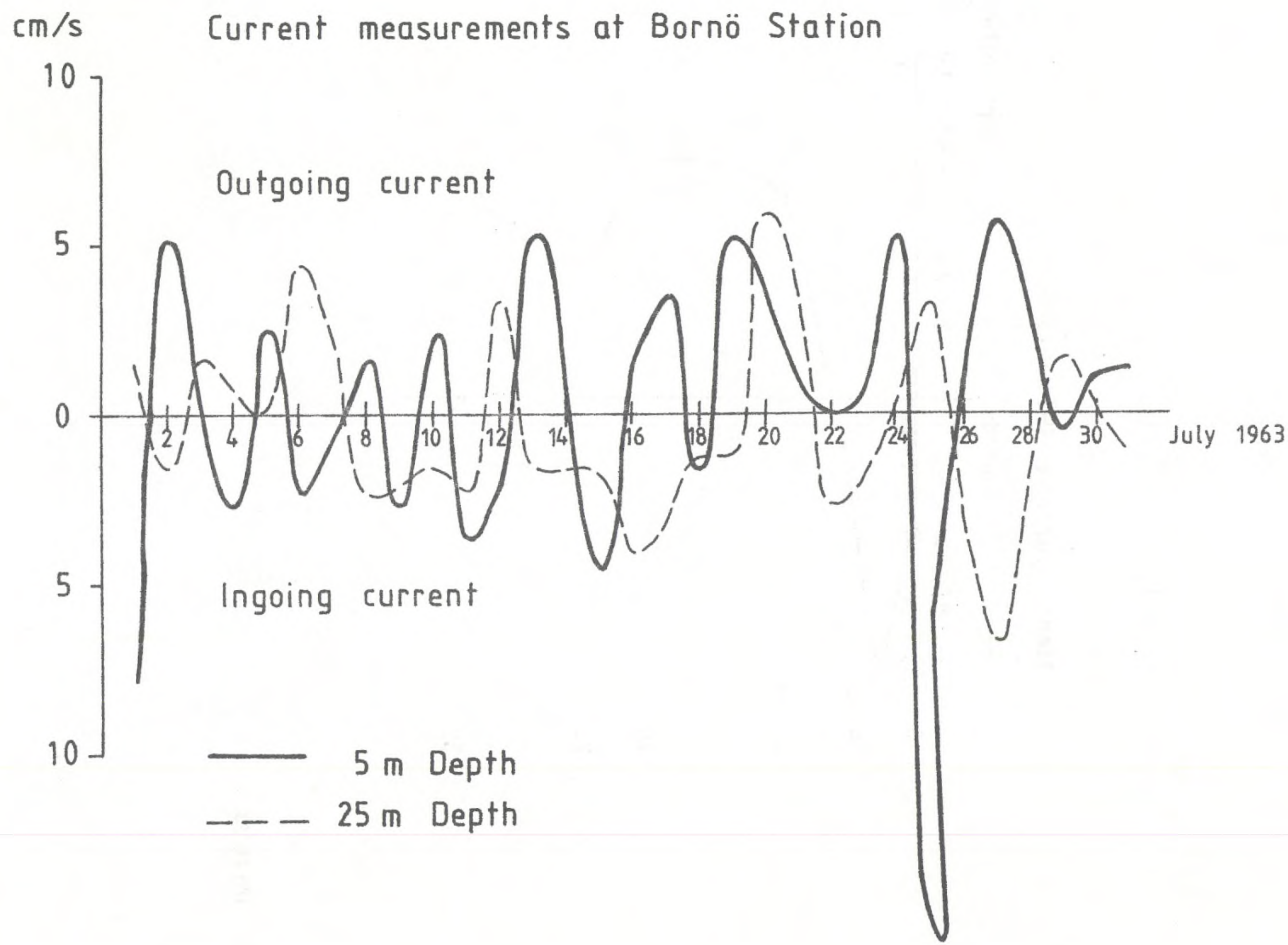
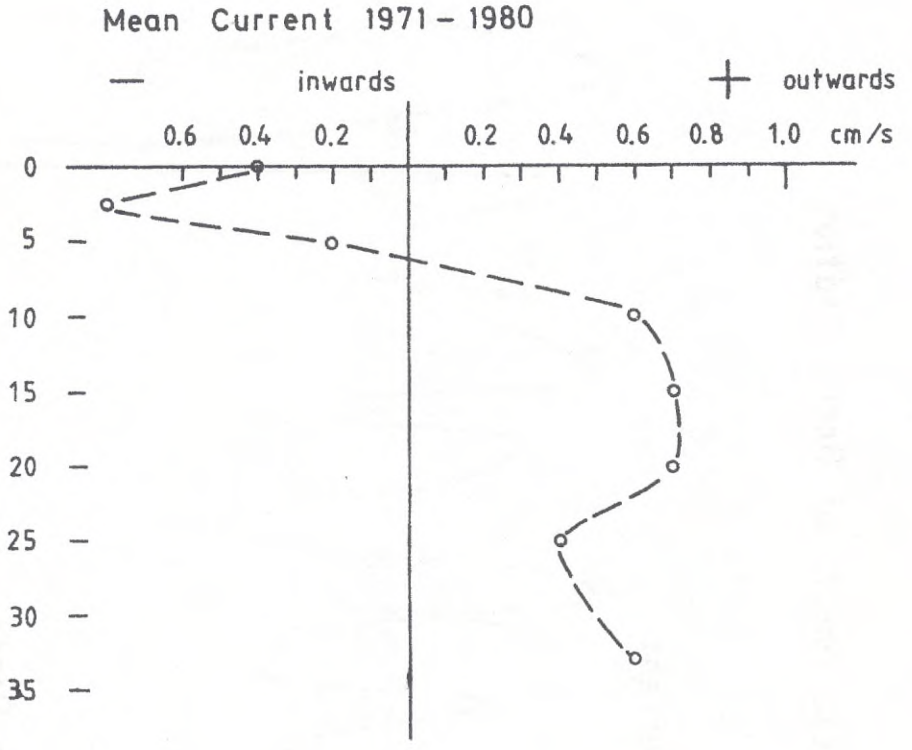

Depth of 22 ‰ isohaline
Bornö
Depth
m
5
10
15
20
w
JUNE
JULY 1967
Current Speed N-Comp.
Halsskov Rev, Surface
SW Smögen, 50 m depth
knots
2.0
1.0
0
1.0
2.0
Skagens Rev E-Comp., Surface

Fig. 14



HYLAB 83 AT

Fig. 15

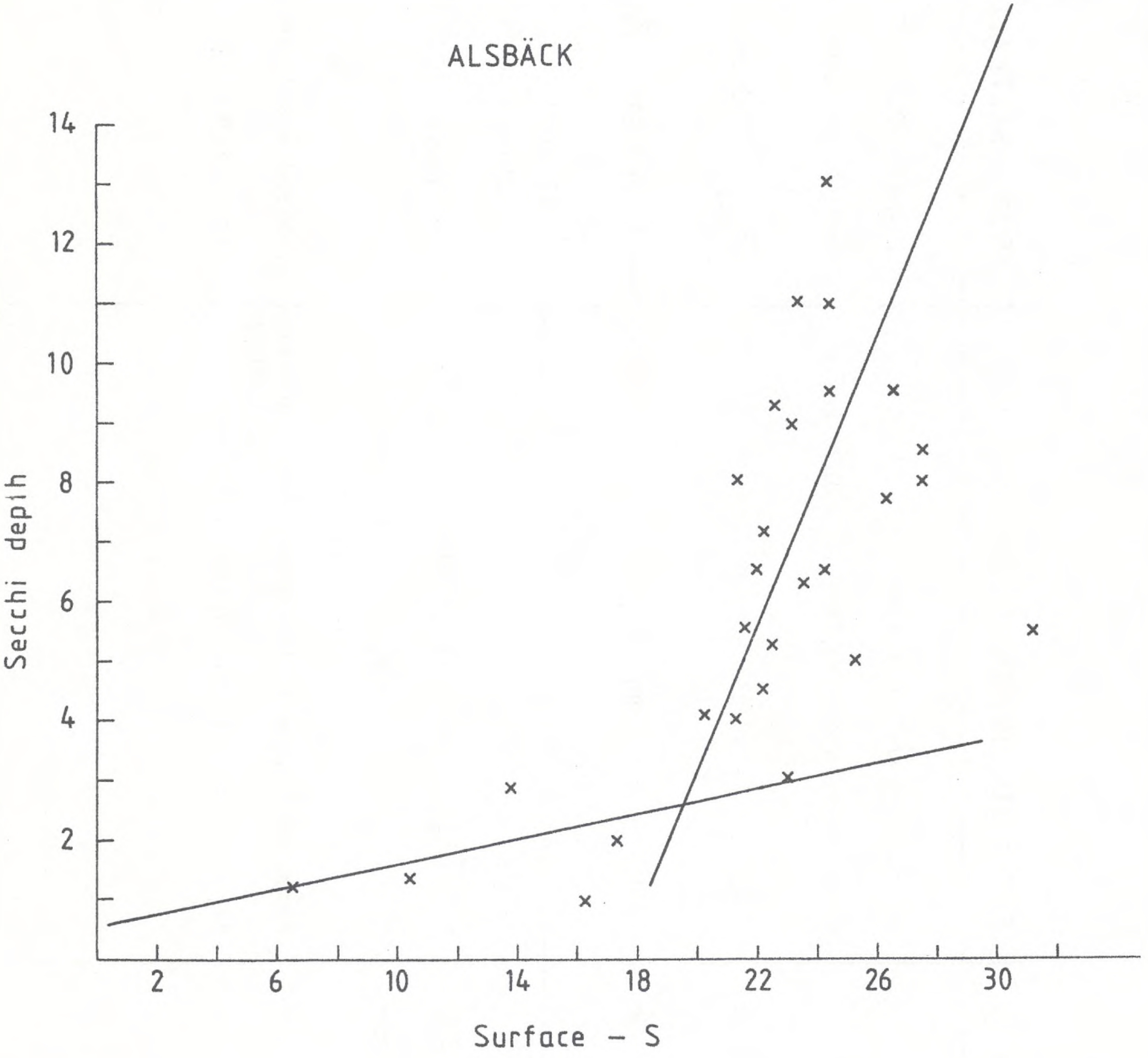


HYLAB 83

(TRÖSKELN)	BOX GULLMAREN PROPER	BOX SALTKÄLLEFJORDEN
	Volume (0-50 m) = 1.2 km^3	Volume = 0.2 km^3
	Fresh water supply = 0.66 + 0.13 = 0.79 km^3/y	Fresh water supply = 0.66 km^3/y (21 m^3/s)
$\overline{S}_{0-45\,m}$ = 30.68	$\overline{S}_{0-45\,m}$ = 30.53	$\overline{S}_{0-45\,m}$ = 30.11
←	(161 + 0 79) km^3/y ←	(47 + 0 66) km^3/y
→	161 km^3/y →	47 km^3/y Turn over time $\frac{0.2}{47}$ = 0.004 (= 2 days)
$\overline{TP}_{0-45\,m}$ = 0.698 $\mu mol/dm^3$	$\overline{TP}_{0-45\,m}$ = 0.712 $\mu mol/dm^3$ = 0.712 · 31 ton/km^3	$\overline{TP}_{0-45\,m}$ = 0.814 $\mu mol/dm^3$
	Expected supply to Saltkällefjorden + Gullmaren proper 31 (0.712 (161 + 0.79) – 0.698 · 161) = = 87 ton P/ year	Expected supply to Saltkällefjorden 31 (0.814 (47 + 0.66) – 0.712 · 47) = = 165 ton P/year

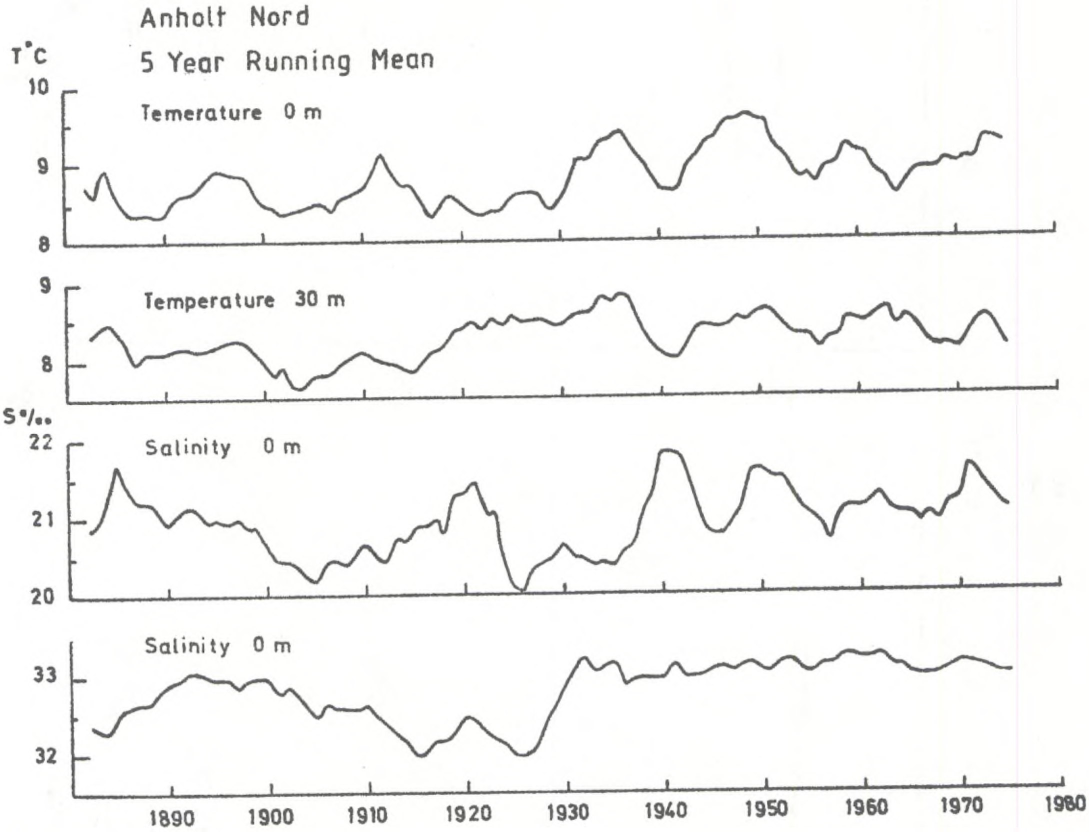
Fig. 16

Fig. 17



HYLAB 83 AT

Fig. 18



Anholt Nord
5 Year Running Mean
T°C
10
9
8
Temerature 0 m
9
8
Temperature 30 m
S°/..
22
21
20
Salinity 0 m
33
32
Salinity 0 m
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980

Fig. 19 a

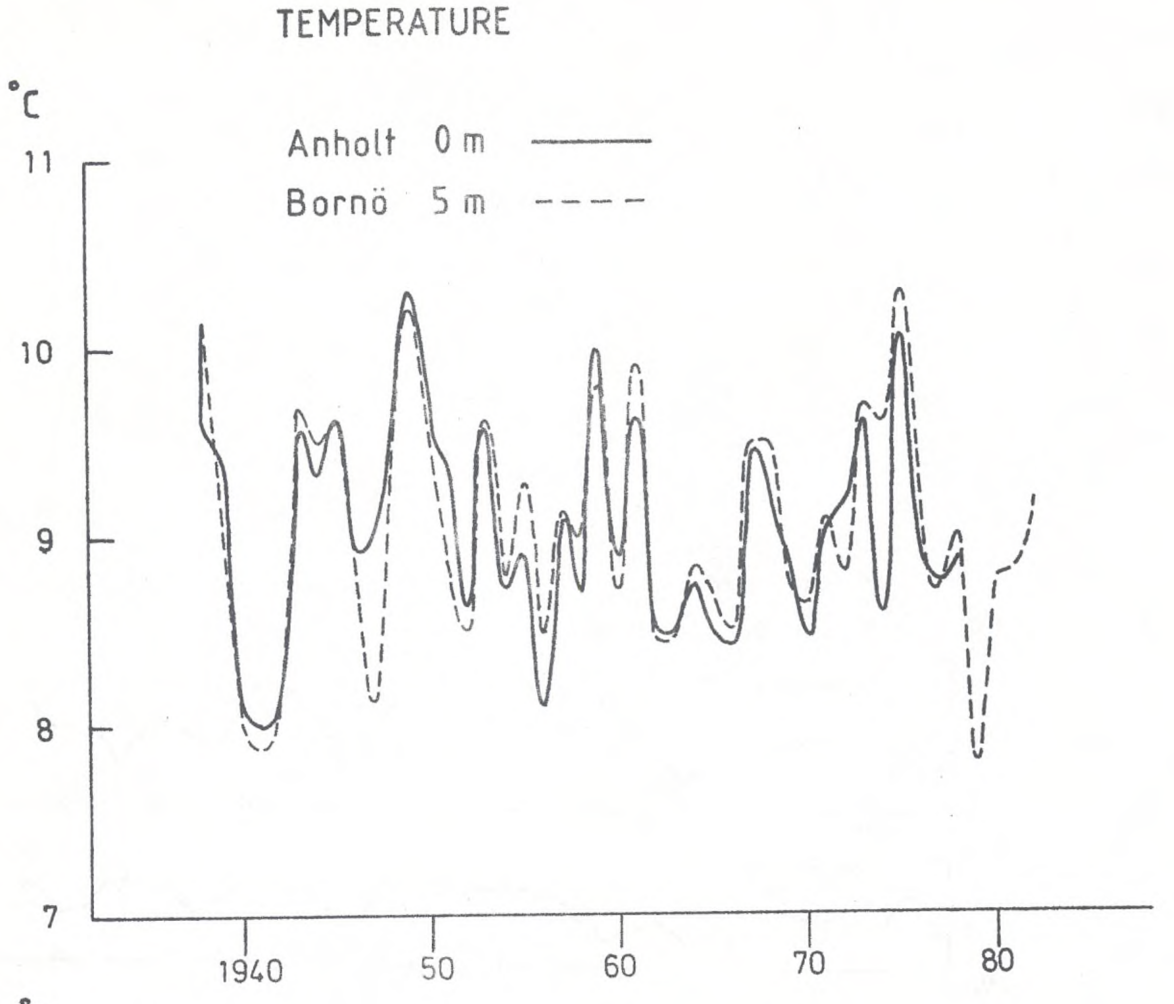
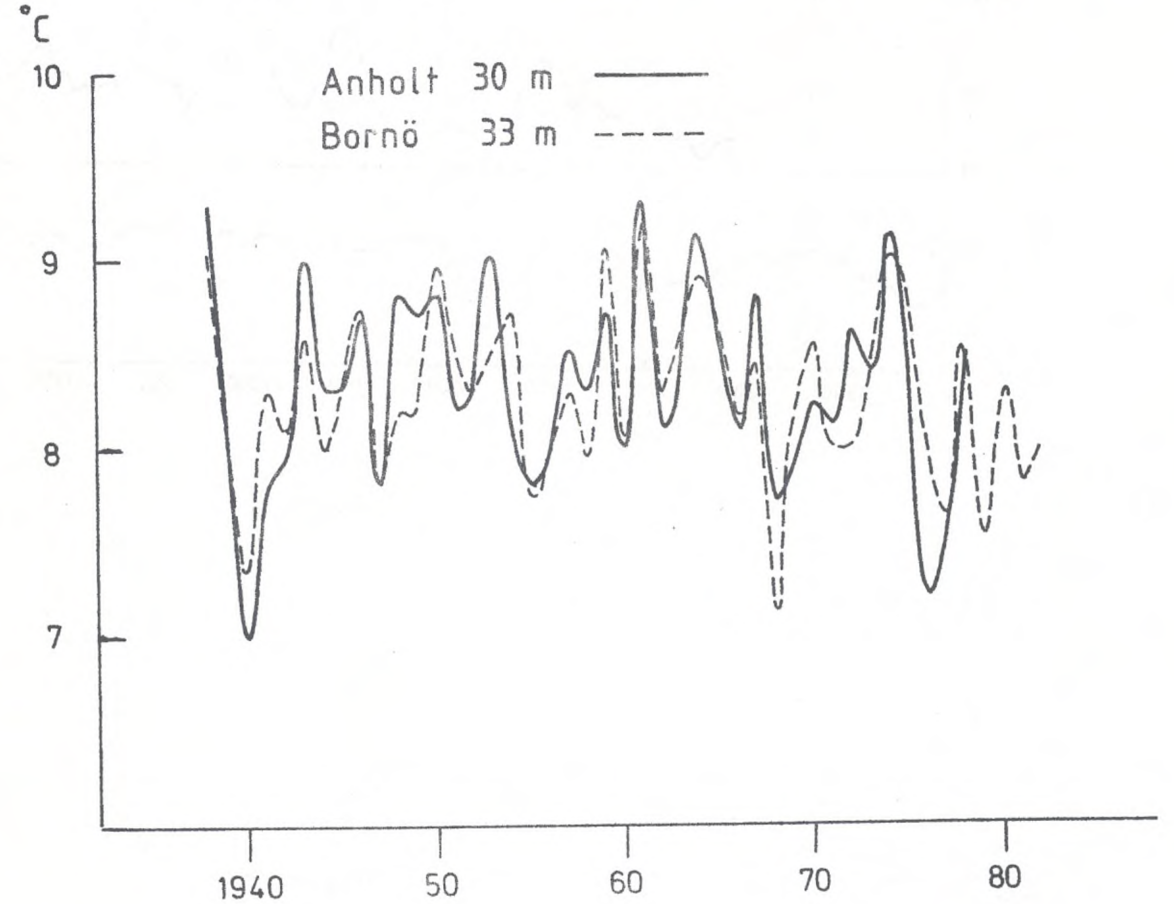


Fig. 19 b



HYLAB 83 AT

Fig. 19 c

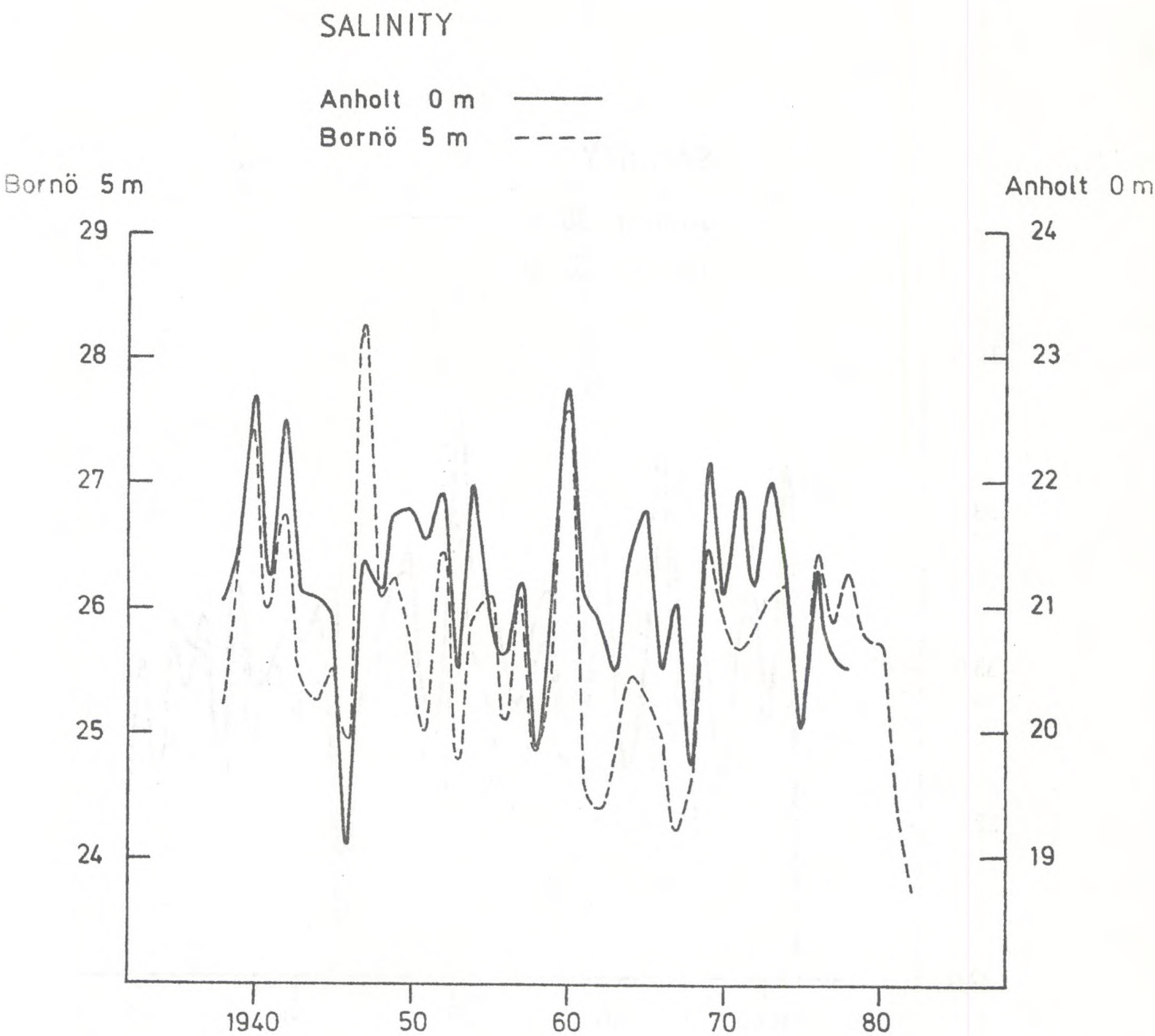
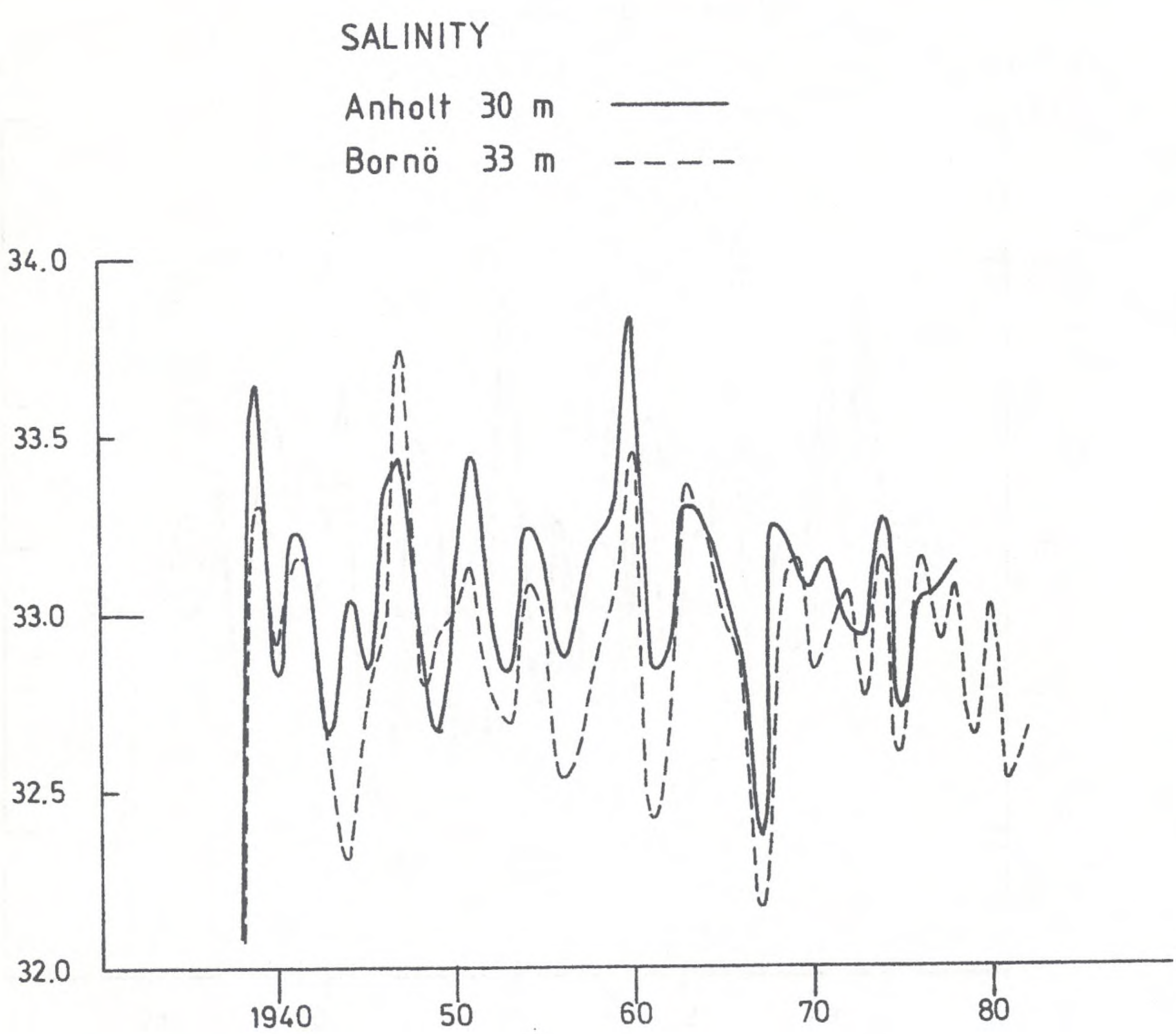

SALINITY
Anholt 0 m
Bornö 5 m
Bornö 5 m
Anholt 0 m
29
28
27
26
25
24
24
23
22
21
20
19
1940
50
60
70
80

Fig. 19 d



HYLAB 83 AT

Fig. 20

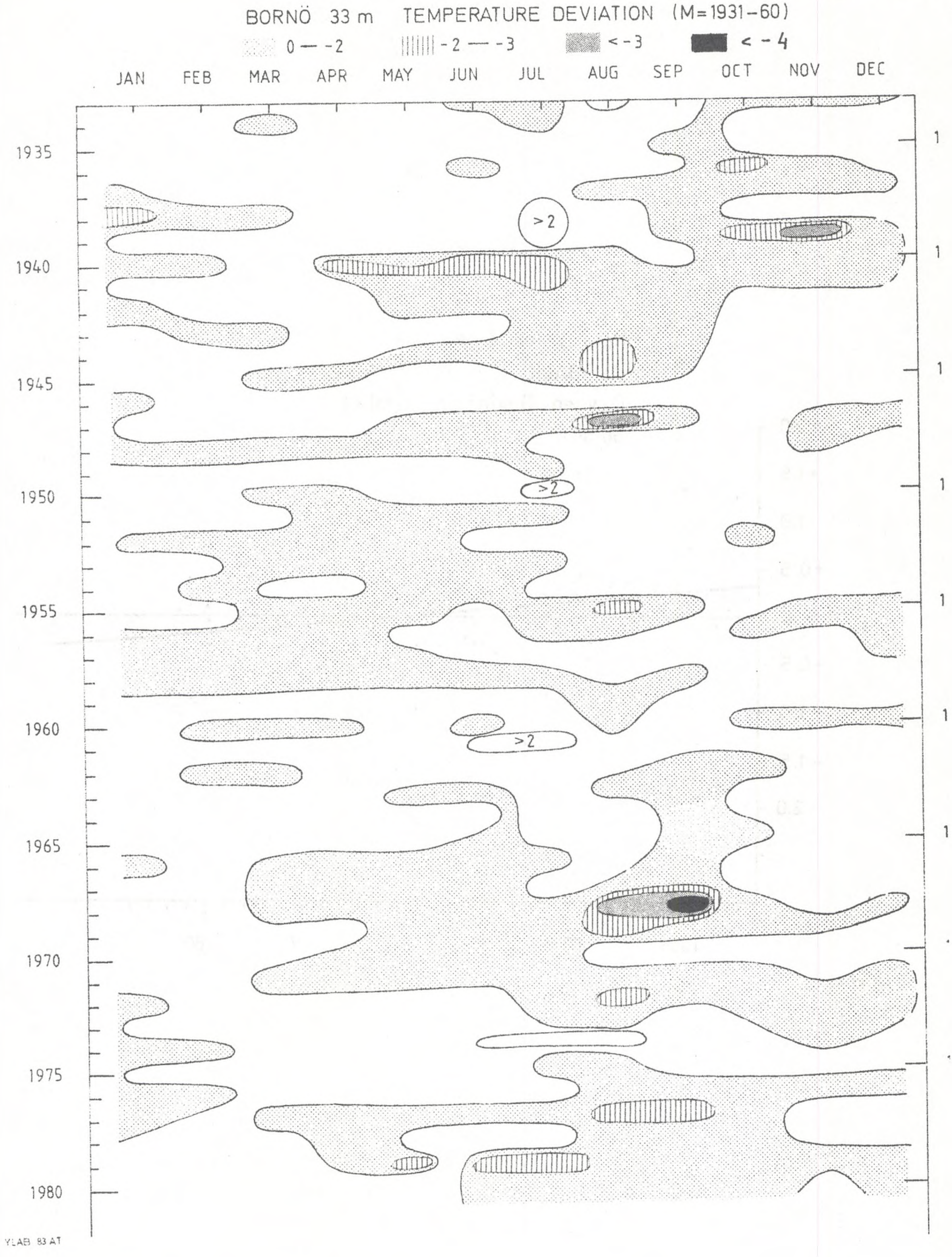
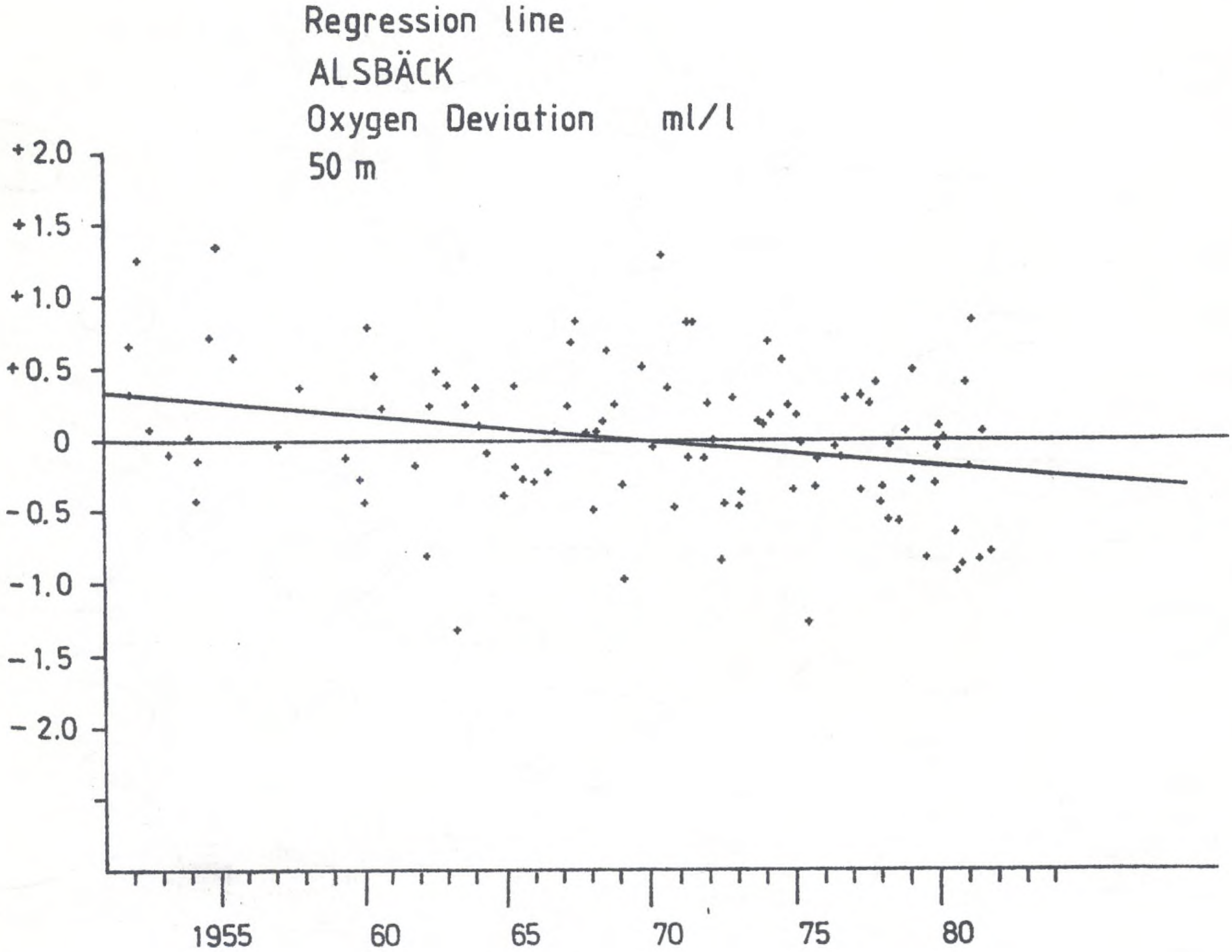
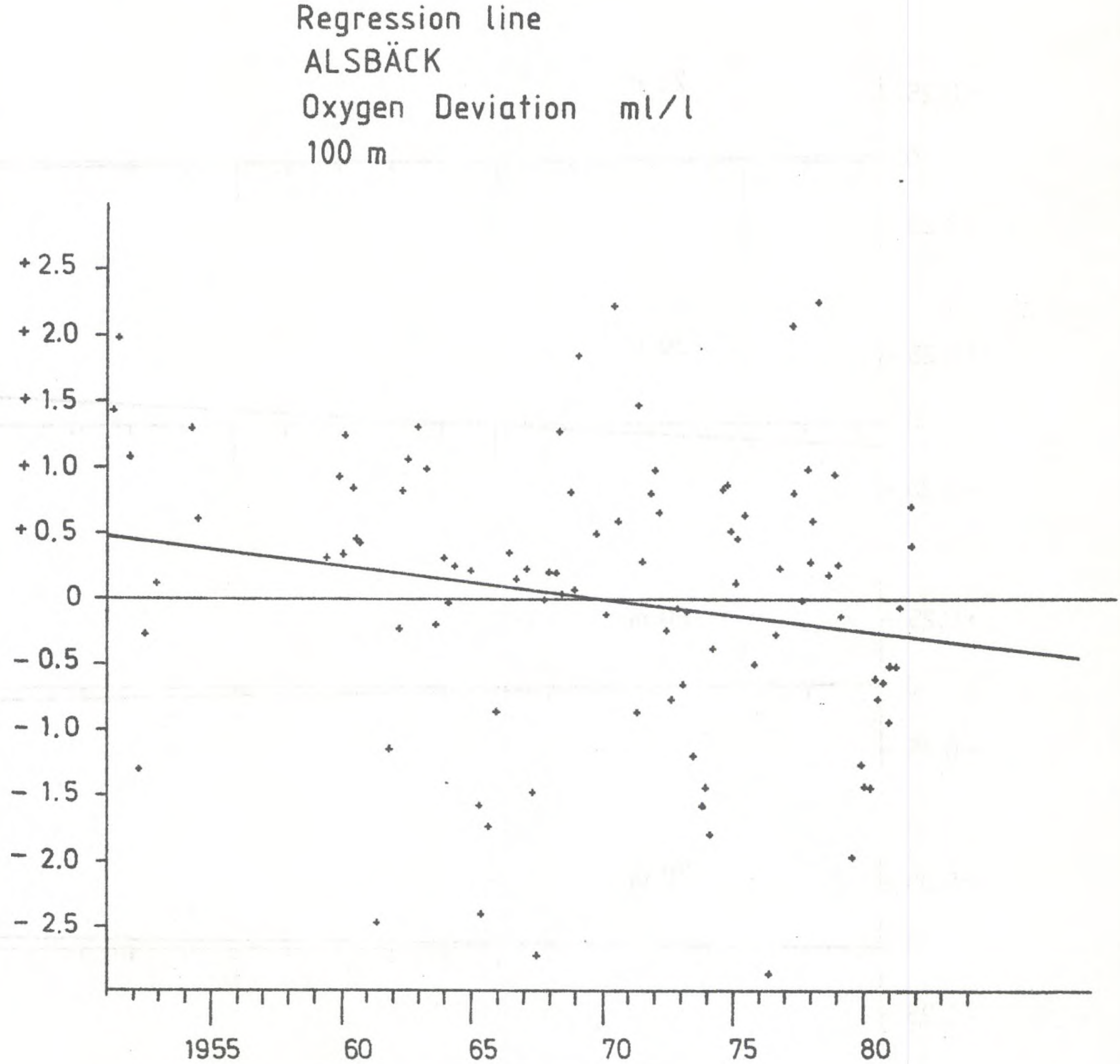

BORNÖ 33 m TEMPERATURE DEVIATION (M=1931-60)
0 — -2
-2 — -3
< -3
< -4
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
>2
>2
>2
1
1
1
1
1
1
1
YLAB 83 AT

Fig. 21a



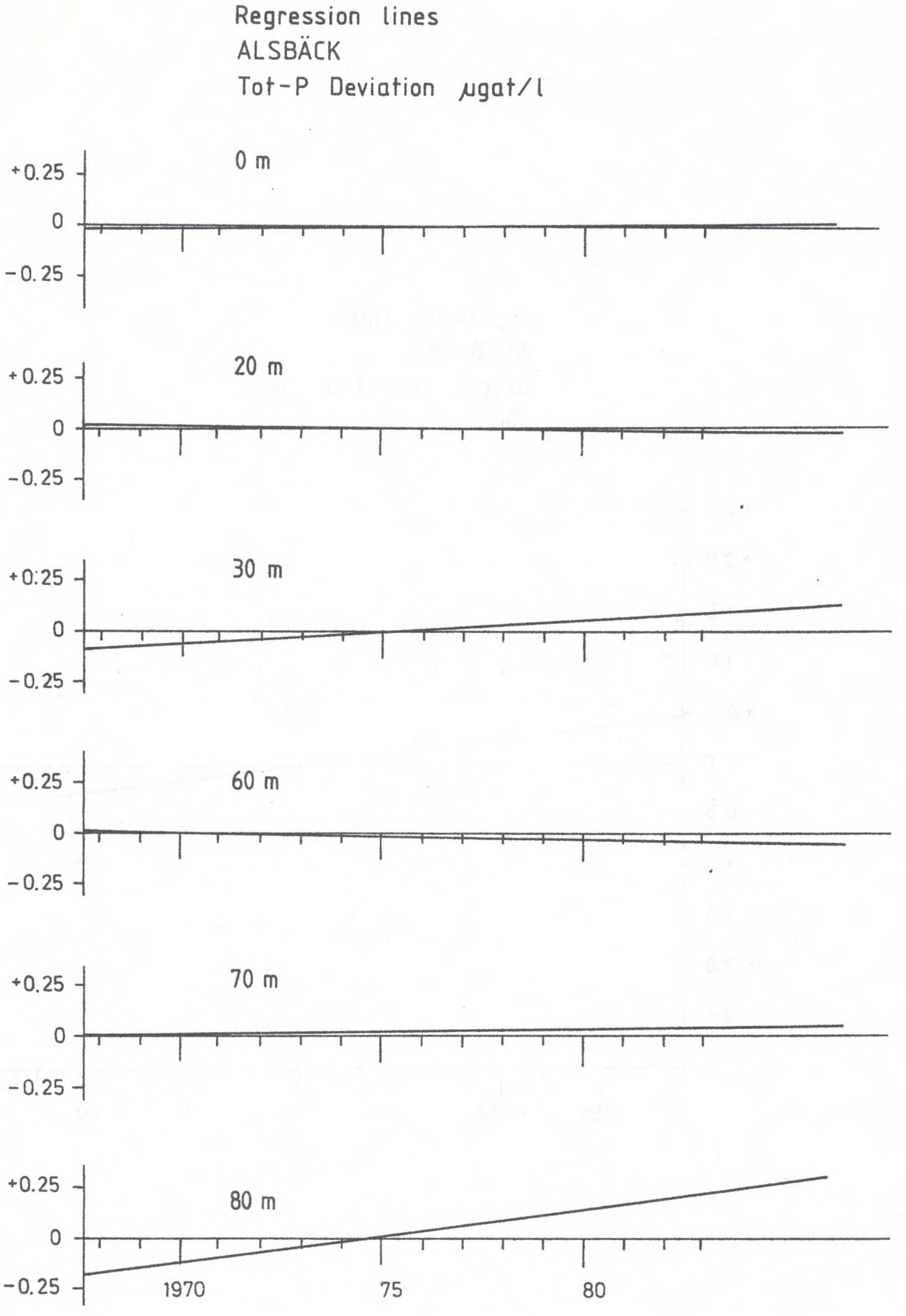
AB 83 AT

Fig. 21 b



AB 83 AT

Fig. 21 c



Regression lines
ALSBÄCK
Tot-P Deviation µgat/l
0 m
+0.25
0
-0.25
20 m
30 m
60 m
70 m
80 m
1970
75
80

83 AT

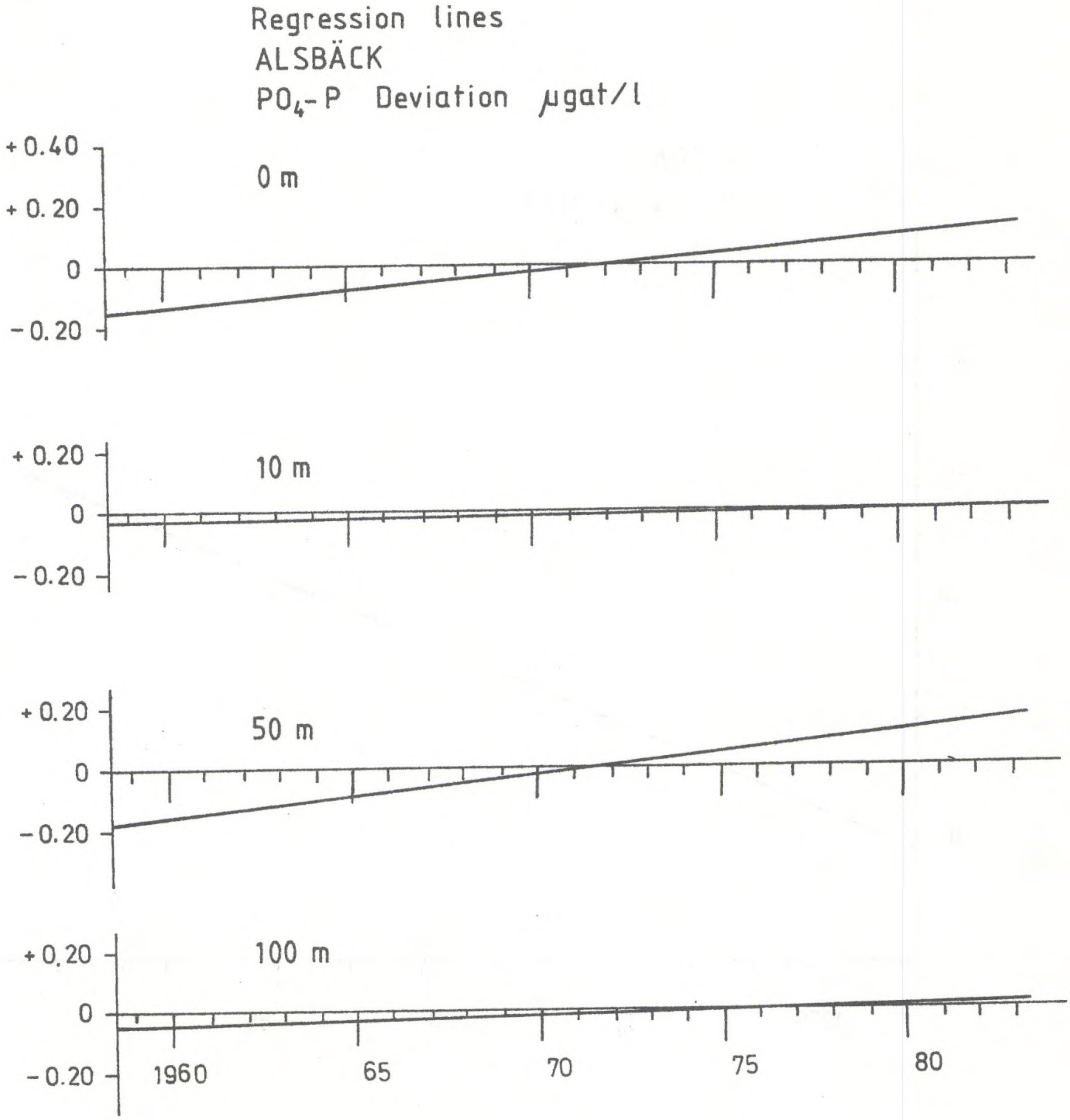

Regression lines
ALSBÄCK
PO4-P Deviation µgat/l
+0.40
+0.20
0
-0.20
0 m
+0.20
0
-0.20
10 m
+0.20
0
-0.20
50 m
+0.20
0
-0.20
100 m
1960
65
70
75
80

Fig. 21 e