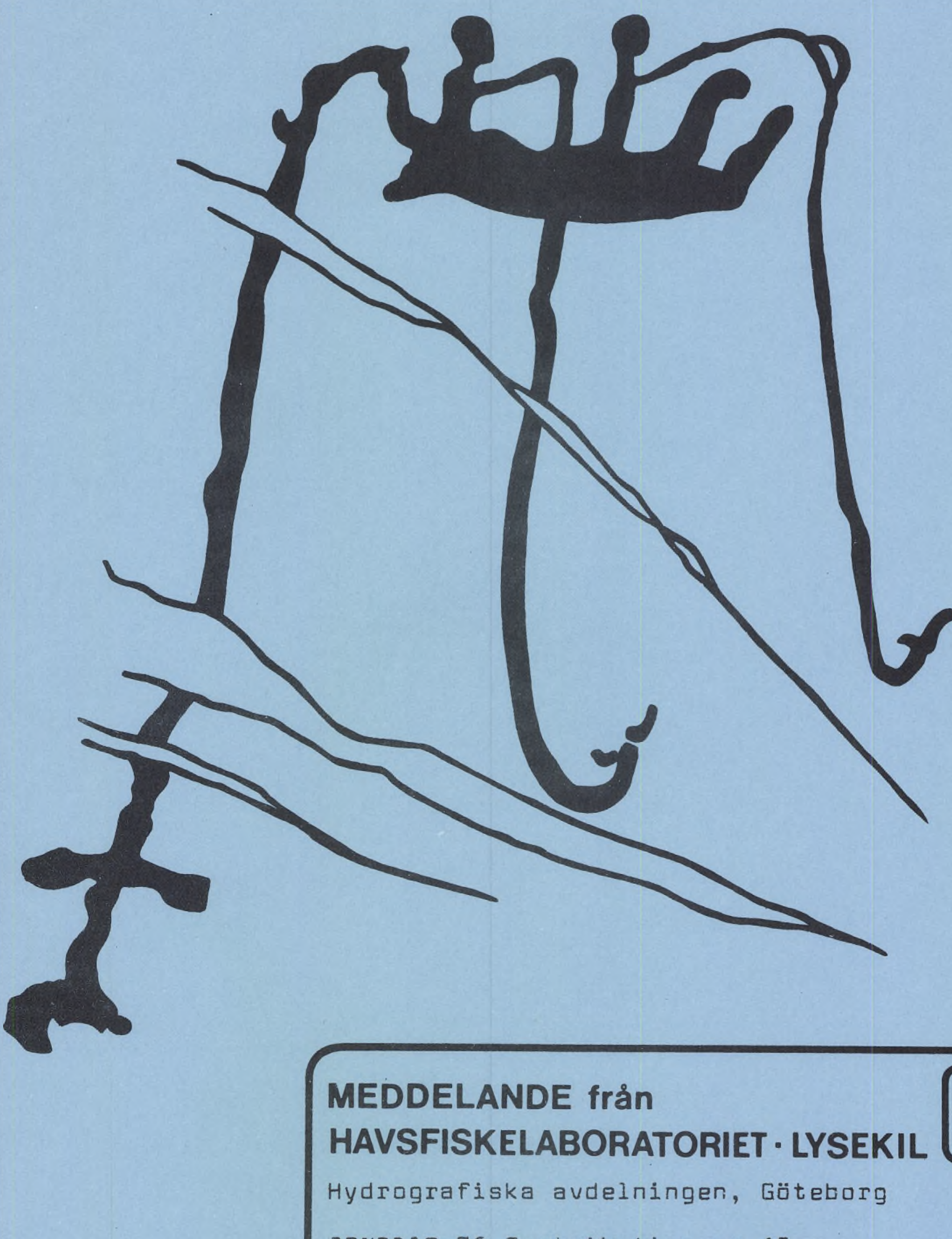
Ödsmål, Kville sn, Bohuslän

Hällristning Fiskare från bronsåldern	**Rock carving Bronze age fishermen**



MEDDELANDE från HAVSFISKELABORATORIET · LYSEKIL

nr 243

Hydrografiska avdelningen, Göteborg

JONSDAP-76 Contribution no 15.

Investigations in the Northern Kattegat during the International JONSDAP-76 Period INOUT, March-April 1976.

by

Peter Möller and Artur Svansson

December 1978

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☐ PROJEKTBESKRIVNING
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2 REF

PR

3 Datum
1978-12-30

4 Ärendebeteckning (Diarienr)

5

6

7 MI projektnr

8 Projekt

☐ 1 Uppläggning ☐ 2 Komplettering ☐ 3 Avslutat

9 MI rapportnr

10

11 Kontraktnr

12 Startar

13 Slutår

14 MI projektnr (i förek fall)
1258

15 Finansierande organ

SNV FO-nämnd, kontrakt nr 7-182/74 -78

16 Projektbeskrivning/Rapportens titel och undertitel

Investigations in the Northern Kattegat during the International JONSDAP 76 Period INOUT, March-April 1976.

17 Projektledare/Författare

Svansson, Artur, Möller; Peter

18 Sammandrag (ange gärna målsättning, metod, teknik, resultat m m)

During the INOUT period of JONSDAP 76 some 200 current meters were recording, mostly in the North Sea but also at the Göteborg-Frederikshavn (G-F) section, here as part of the 5 year project "The Baltic Entrance Project: the G-F Section". A compilation of the results of measurements in the NE North Sea Proper as well as at the G-F section is presented. Also some relevant data from 1967 is included.

As a result the material can be divided in two classes with mainly E-wind or W-wind situations (para. 8).

Under INOUT perioden utfördes strömmätning med c:a 200 instrument mest i Nordsjön men även på snittet Göteborg-Frederikshavn, här som en del i 5års projektet "Undersökning av vatten- och materialbalansen i norra Kattegatt". En sammanställning av resultat från mätningar i östra egentliga Nordsjön och sådana i norra Kattegatt presenteras tillsammans med en del äldre data från 1967. Som ett resultat kan materialet delas upp i två klasser med huvudsakligen ost- eller västvindssituationer.

19 Sammandraget skrivet av
A. Svansson

20 Förslag till nyckelord

Y, hydrografi, strömmar, vattenstånd, JONSDAP 76, Kattegatt, Skagerrak

21 Klassifikationssystem och klass

22 Indexterm (ange källa)

23 Övriga bibliografiska uppgifter

Meddelande från Havsfiskelaboratoriet no 243 , Göteborg 1978

24 ISSN

25 ISBN

26 Hemligt

☒ Nej ☐ Ja jämlikt paragraf § sekretesslagen

27 Språk
eng

28 Antal sidor
6 + 14 fig

29 Pris

30 Projektbeskrivning/Rapporten beställs hos

Se ovan 1.

Försöksversion MDN 5 1975-02 15 000

Blanketten beställs hos
MILJÖDATANÄMNDEN

Postadress
Jordbruksdepartementet
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103 20 STOCKHOLM

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Investigations in the Northern Kattegat during the International JONSDAP-76 Period INOUT, March-April 1976.

by Peter Möller and Artur Svansson, National Board of Fisheries,
Hydrographic Department
Fack, S-403 10 Göteborg, Sweden

1. Introduction: During March-June 1976, some countries mostly surrounding the North Sea, made in this sea a big survey JONSDAP 76 or even shorter J76. One of the purposes of the survey was to collect information for the determination of the water transports in and out of the sea. This part of the investigation, named INOUT, was concentrated to a 40 day period during 1976-03-15 -- 76-04-25.

The planning of the INOUT campaign was made with the intention that the data should be used also for numerical models for computation of water transports. For a barotropic model boundary conditions are needed, either of sea levels or of water transports. Levels are usually measured on shore but between Scotland and Norway also deep sea gauges were deployed. Alan Davies (1976) made a numerical investigation to choose the best location for these instruments, actually measuring pressure at bottom. Water transports were calculated by means of measurements of current made by some 200 automatically recording instruments (Fig. 1).

At an early stage of the planning it was the intention that the Göteborg - Frederikshavn (G-F) section (Fig. 2) in the Northern Kattegat should constitute the Eastern boundary of the J76 area. Later it has been proven better to use levels in the Belt Sea as boundary conditions. Instead the G-F measurements will be used as test data for the models.

Current meters were anchored according to Fig. 3, J7665 near Läsö N L/V at depths 15 and 30 m, J7666 actually launched by the Institute of Phys. Oceanography, Copenhagen, at depths 15 and 30 m, and J7667 at the deepest part of the section, depths 8 and 30 m. Only data from system no J7667 will be used below as the other records were rather short.

2. Wind Conditions

Fig. 4 contains E- and N- components of the wind measured at Utsira (Furnes and Saelen, 1977). During 76-03-10 -- 76-04-25 there are some five peaks of W-wind.

3. Currents in North Sea Proper during JONSDAP 76

Riepma (1978) presented a first picture of transports calculated by means of current recordings during the INOUT period. The positions are shown in Fig. 1,and in Fig. 5 transports are presented in Sverdrups ($10^6 m^3/s$) at section 61-64 along Norway (origin Furnes and Saelen, 1977) as well as at section 43-45 at the other side of the Rinne. The two curves are rather nicely reflected in each other. There is a rough positive correlation between W-winds (Fig. 4) and northward transport at rigs 61-64 along Norway. The current directions in the two sections are those prevailing in the picture of permanent currents. Surprising is the fact that also the variations, apparently caused by wind and atmospheric pressure variations, appear in this manner. Davies (so far unpubliched) has shown, however, that a barotropic model can give results of this kind.

The upper curve in Fig. 5 is redrawn in Fig. 6 where the time scale is the same as in the figures from the Kattegat and the Skagerrak below.

4. Surface currents as measured at lightvessels in the Kattegat.

Svansson (1972 and 1975) showed that daily means of surface currents measured at L/V:s show similar pictures in the Belt Sea and the Kattegat (L/V Skagens Rev differs however, displaying definitely Skagerrak conditions). The surface currents at Läsö N (Fig. 7) is roughly negatively correlated with the transport along Norway (Fig. 6). Fig. 8 is similar to Fig. 7, both display surface water conditions. Fig. 9, 30 m depth shows the same types of variations. The mean current at this depth, however, is opposite to the surface layer current.

5. Variation in the water content of the Baltic.

The sea level variations recorded at Landsort (Fig. 12) roughly reflect the net water exchange of the Baltic (see e.g. Svansson, 1972). The surface of the Baltic Sea area (Kattegat included) is about $400.10^9 m^2$. Therefore a level fall of 0.01 m/day corresponds to an outward transport in the northern Kattegat of 4 km^3/day (equivalent to 50 000 m^3/s). Fig. 10 shows the variations during March-April 1976. At the month shift there is an inflow of about 100 km^3 during 7 days.

6. Sea level variations in the Kattegat and the Skagerrak.

Fig. 11 shows the mean of levels measured in Frederikshavn and Göteborg (daily means). All level curves in the Skagerrak and the Kattegat were similar. The levels are roughly negatively correlated with the currents (e.g. Fig. 7). In southern Baltic (e.g. Ystad, Fig. 12) the conditions were opposite. In the Belt Sea there were very small time variations.

7. Comparison with conditions prevailing in 1967.

In 1967, an instrument was recording currents off Smögen for many months. Also surface currents measured simultaneously at L/V Skagens Rev have been decomposed in N- and

E- components (for the INOUT period there are such data from Skagens Rev but are so far untreated). Fig:s 13 and 14 show some 1967 conditions. Fig. 13b is depicting the daily means of surface currents measured at Halsskov Rev L/V in the Great Belt (Fig. 2). Comparing with levels in Fig. 13a there is approximately the same phase in Ystad (Fig. 12) and the opposite in Smögen data. Concerning the Landsort level data, it is clear that long-term variations are discernible but not short-term ones.

From Fig. 13c we find that when there is a maximum of inflow passing Halsskov Rev towards the Baltic there is also a maximum of northerly flowing current along Sweden in the Skagerrak. Fig. 13d, finally, gives the Jutland current variations: maximum current towards east simultaneously with peaks of north flowing water off Smögen and south flowing at Halsskov Rev. Fig. 14b summarizes Fig:s 13b-d.

8. E-wind and W-Wind situations.

Combining the results of the INOUT compaign 1976 with the 1967 results we may imagine the following explanation of the variations in levels and transports. It seems appropriate to differ between two situations being the opposite of each other, e.g. W-wind situations and E-wind situations. A W-wind situation[x)] would be characterized (opposite for a E-wind situation):

a) The sea levels are high in the Skagerrak and the Kattegat (Fig. 13a Smögen).

b) The outflowing current in the Skagerrak along Sweden and Norway is amplified (Fig:s 6 and 13c). This is the case with the E-component of the Skagens Rev L/V surface current as well (Fig. 13d).

c) The water is flowing southwards in the Kattegat, implying turning surface current from normally northflowing to southflowing (Fig. 8 and 13b) and amplifying the southflowing deep current (Fig. 9).

x) indicated W in Fig:s 13 and 14. In Fig:s 4-9 reference is made to the W-wind situation at the end of March

d) There is more low saline water of Baltic typ than normal in the Gullmar fjord probably due to westerly winds piling up this water (Fig.14a). This might indicate that along Norway in the Skagerrak the surface outflowing current is weakened at the same time as the deeper outflowing current is amplified. The explanation is probably valid only for short-term variations. If the sea level of the Baltic is raising considerably it has been shown to cause smaller amounts of low saline water in the Kattegat and Swedish Skagerrak fjords i.e. opposite to the present explanation of short-term variations (Svansson, 1972).

9. Conclusions.

The characterization of the atmospheric influence to be either an E or a W-wind situation is of course a strong oversimplification, however, apparently a tolerable first approximation. Models, probably already a barotropic one, can afford a more detailed explanation of the connections between important parameters. Model work is therefore highly desirable.

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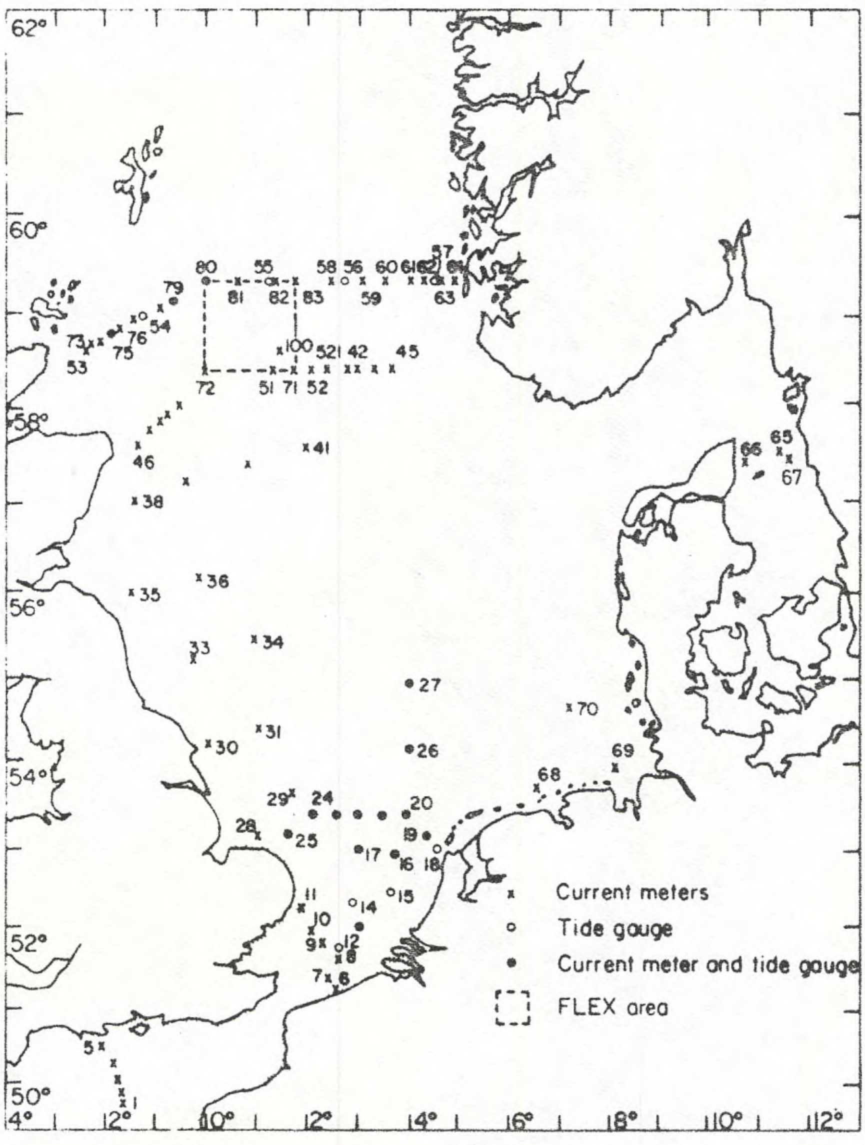
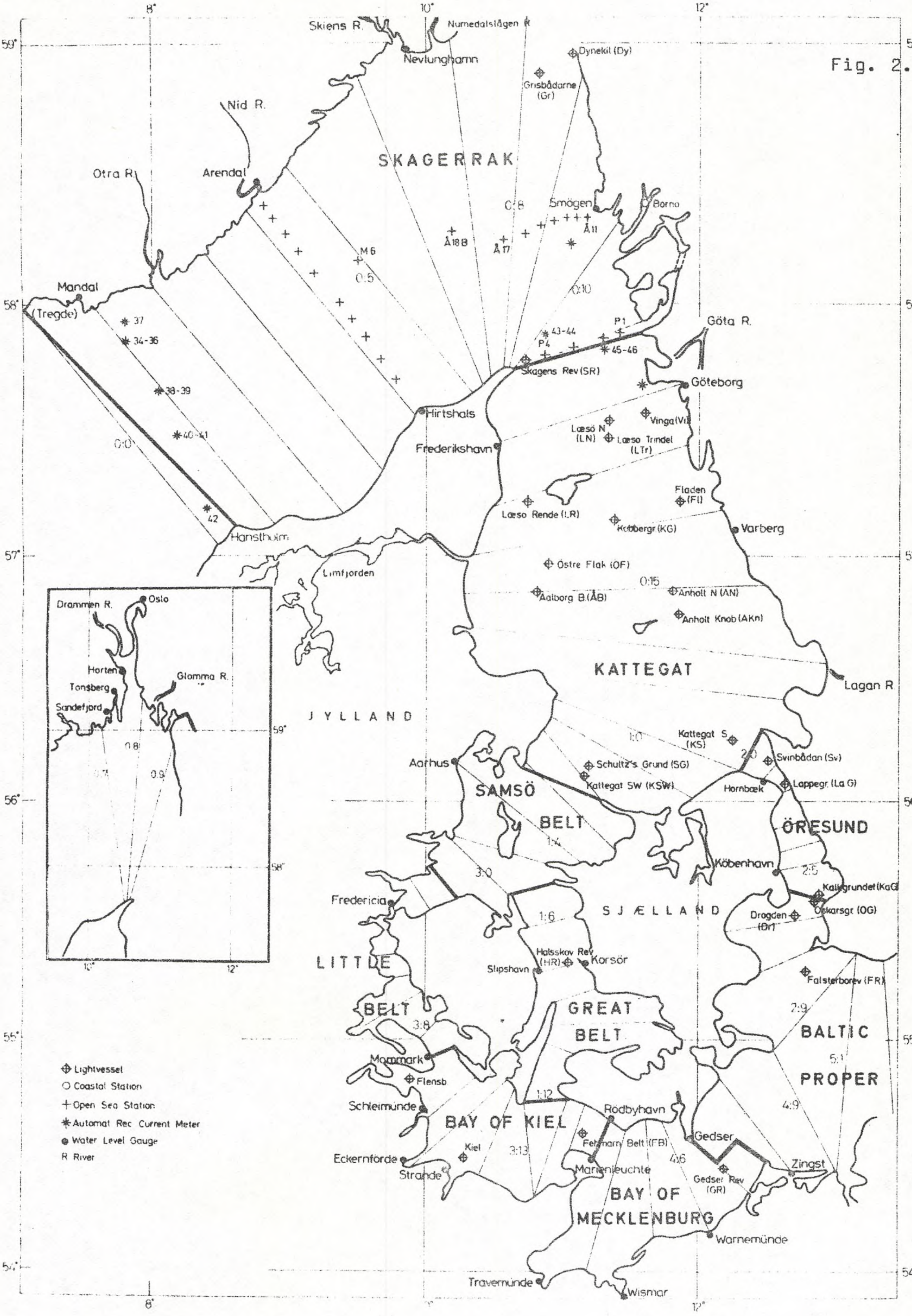
Fig. 1.



62°
60°
58°
56°
54°
52°
50°
4°
2°
0°
2°
4°
6°
8°
10°
12°
Current meters
Tide gauge
Current meter and tide gauge
FLEX area



Skiens R.
Numedalslågen R.
Nevlunghamn
Dynekil (Dy)
Grisbådarne (Gr)
Nid R.
SKAGERRAK
Otra R.
Arendal
Smögen
Borno
Å 11
Å 18 B
Å 17
M 6
Mandal (Tregde)
37
34-36
38-39
40-41
42
P 1
P 4
43-44
45-46
Göta R.
Skagens Rev (SR)
Göteborg
Hirtshals
Vinga (Vi)
Læsö N (LN)
Læso Trindel (LTr)
Frederikshavn
Fladen (Fl)
Læso Rende (LR)
Kobbergr. (KG)
Varberg
Hanstholm
Limfjorden
Östre Flak (OF)
Aalborg B. (ÅB)
Anholt N (AN)
Anholt Knob (AKn)
Drammen R.
Oslo
Horten
Glomma R.
Tønsberg
Sandefjord
KATTEGAT
Lagan R.
JYLLAND
Kattegat S (KS)
Svinbådan (Sv)
Aarhus
Schultz's Grund (SG)
Kattegat SW (KSW)
Hornbæk
Lappegr. (La G)
SAMSÖ
BELT
ÖRESUND
København
Kalkgrundet (KaG)
Oskarsgr. (OG)
Fredericia
SJÆLLAND
Drogden (Dr)
Halsskov Rev (HR)
Korsör
Slipshavn
LITTLE
BELT
Falsterborev (FR)
GREAT
BELT
BALTIC
PROPER
Mommark
Flensb
Schleimünde
BAY OF KIEL
Rödbyhavn
Gedser
Zingst
Kiel
Fehmarn Belt (FB)
Eckernförde
Strande
Marienleuchte
Gedser Rev (GR)
BAY OF
MECKLENBURG
Warnemünde
Travemünde
Wismar
Lightvessel
Coastal Station
Open Sea Station
Automat Rec Current Meter
Water Level Gauge
R River

Fig. 2.

Fig. 3.

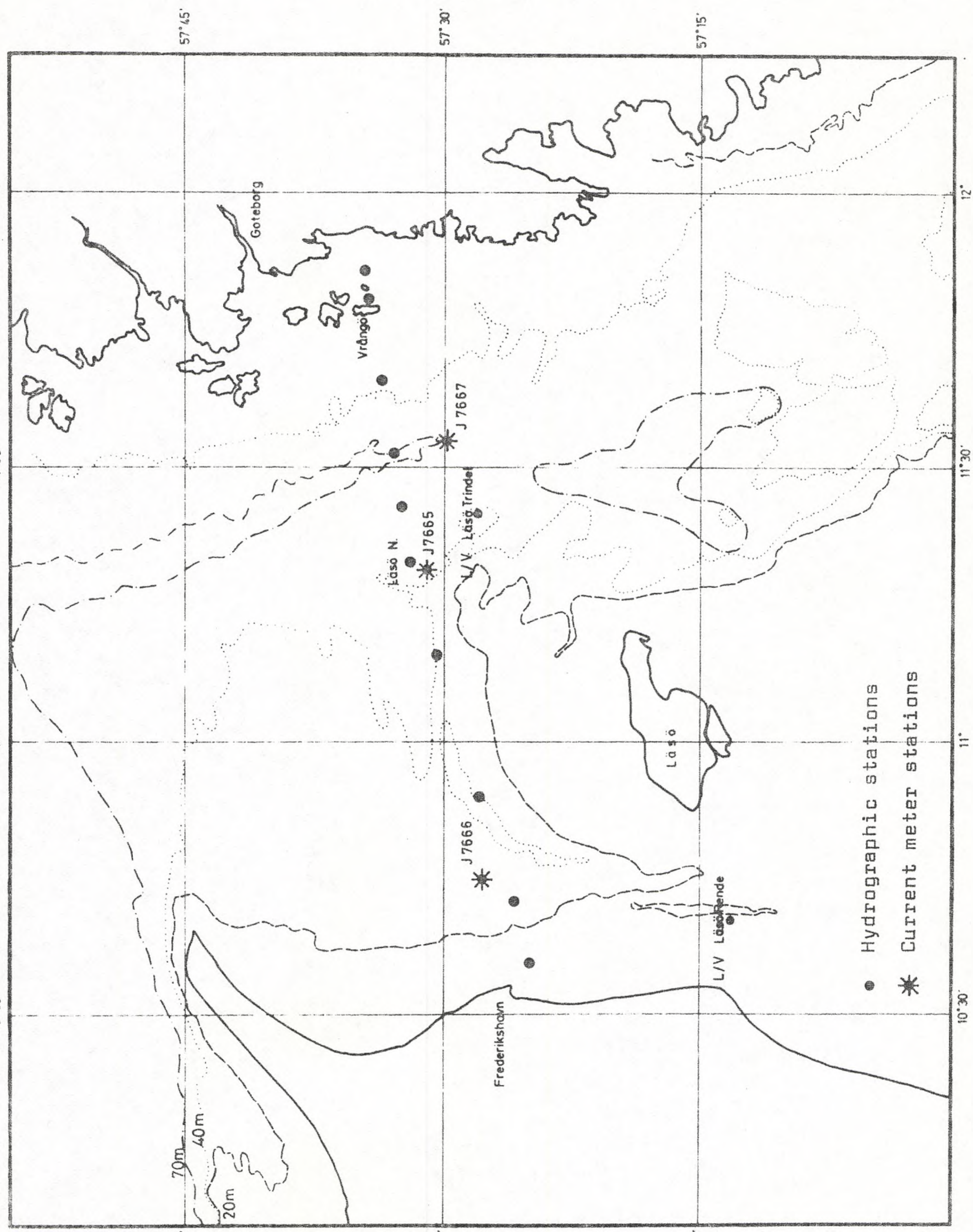
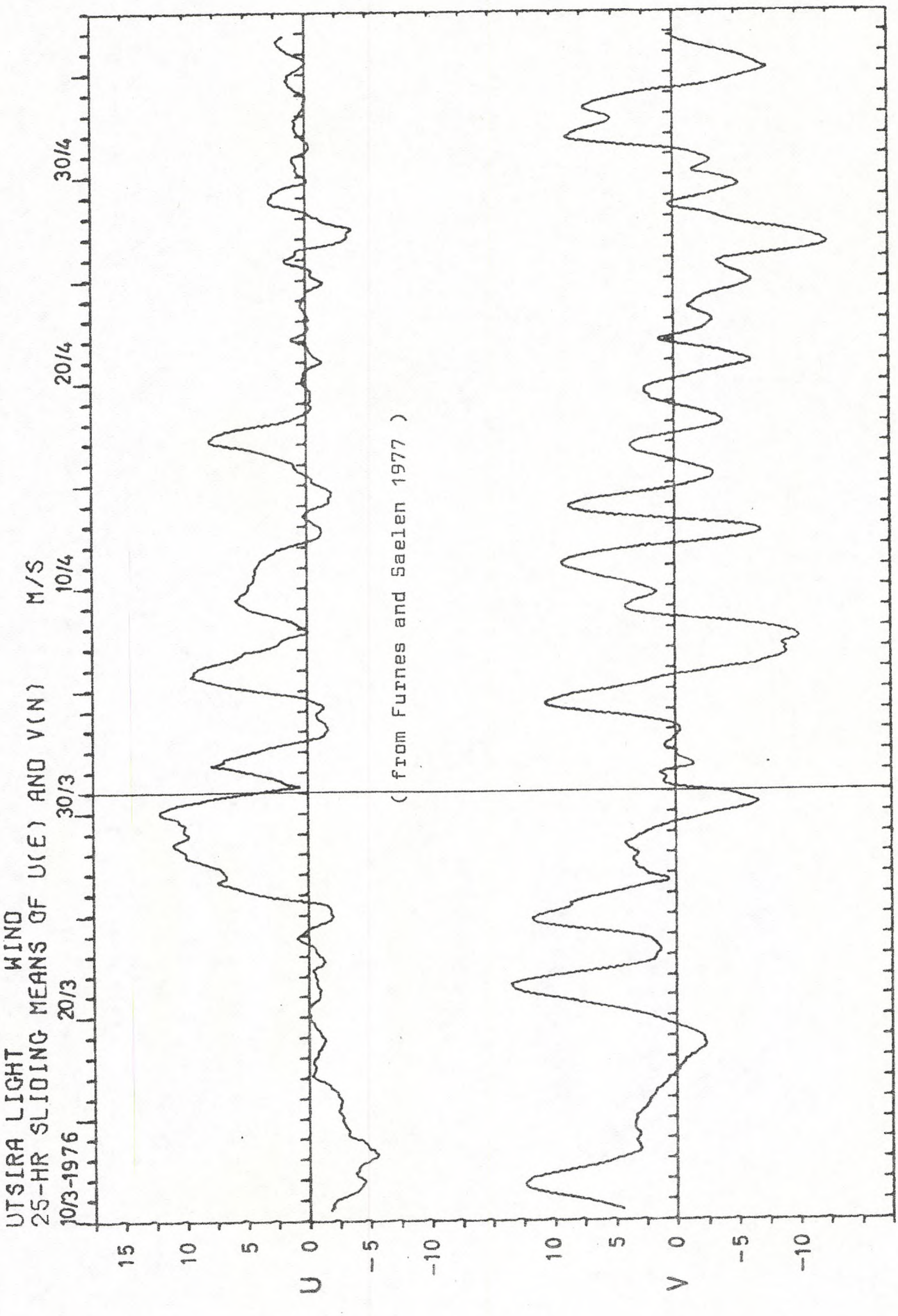
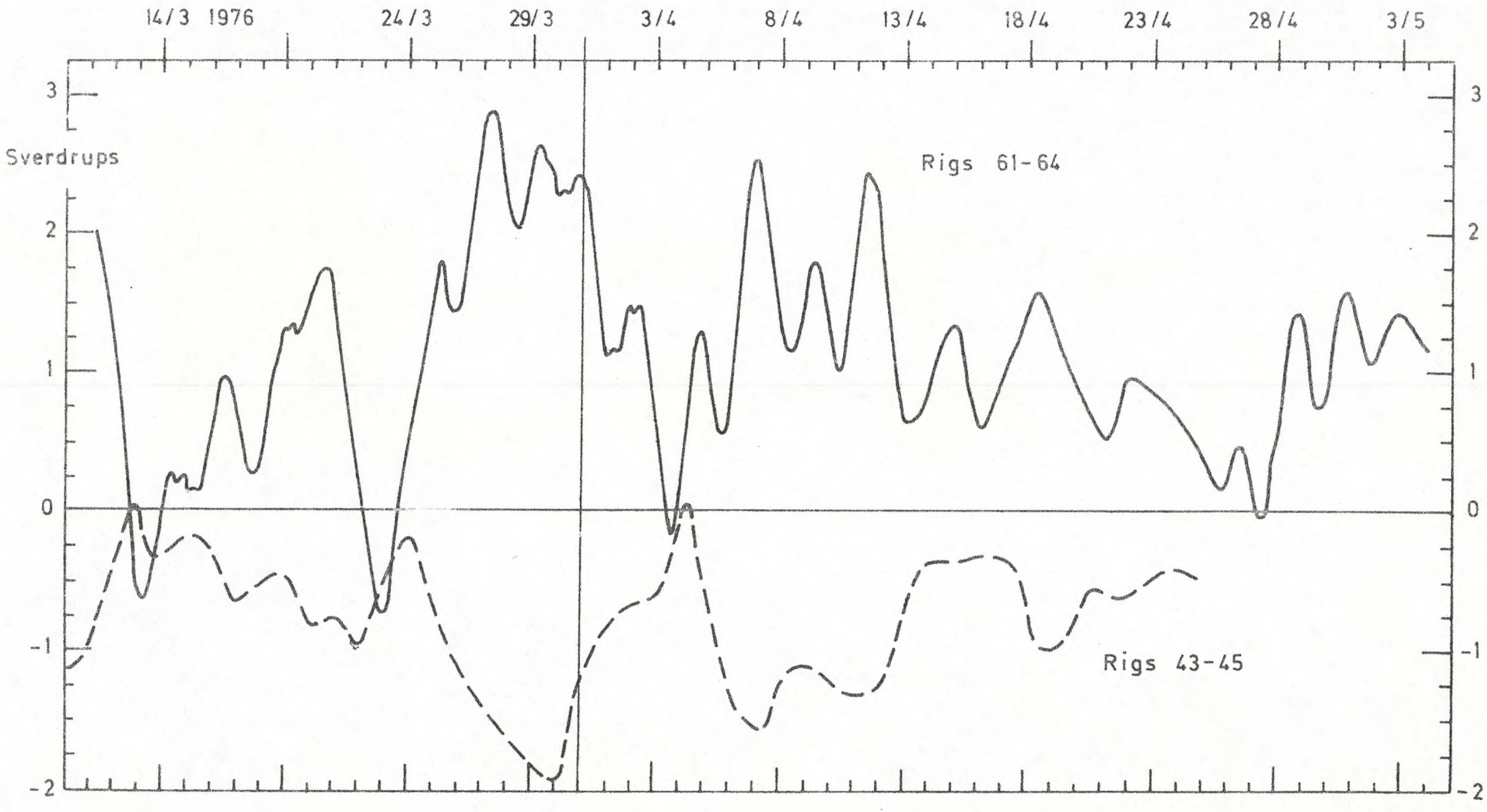

57°45'
57°30'
57°15'
12°
11°30'
11°
10°30'
Goteborg
Vrångö
J7667
J7665
J7666
Läsö N.
L/V Läsö Trindel
Läsö
Frederikshavn
L/V Läsö Rende
70m
40m
20m
Hydrographic stations
Current meter stations

Fig. 4.



UTSIRA LIGHT WIND
25-HR SLIDING MEANS OF U(E) AND V(N) M/S
(from Furnes and Saelen 1977)
10/3-1976
20/3
30/3
10/4
20/4
30/4
U
V
15
10
5
0
-5
-10



(from Riepma 1978)

Fig 5.

Fig. 6.

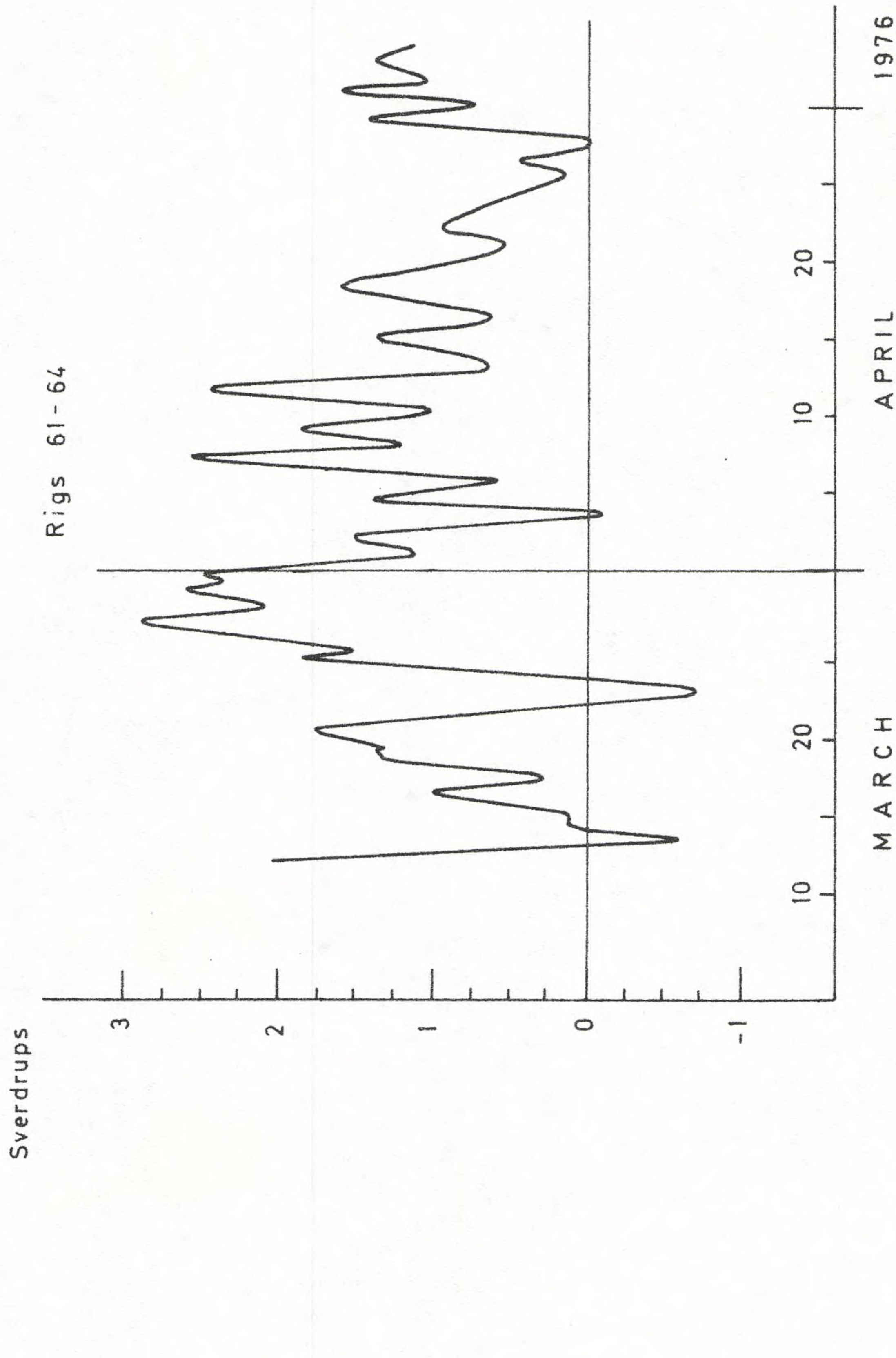
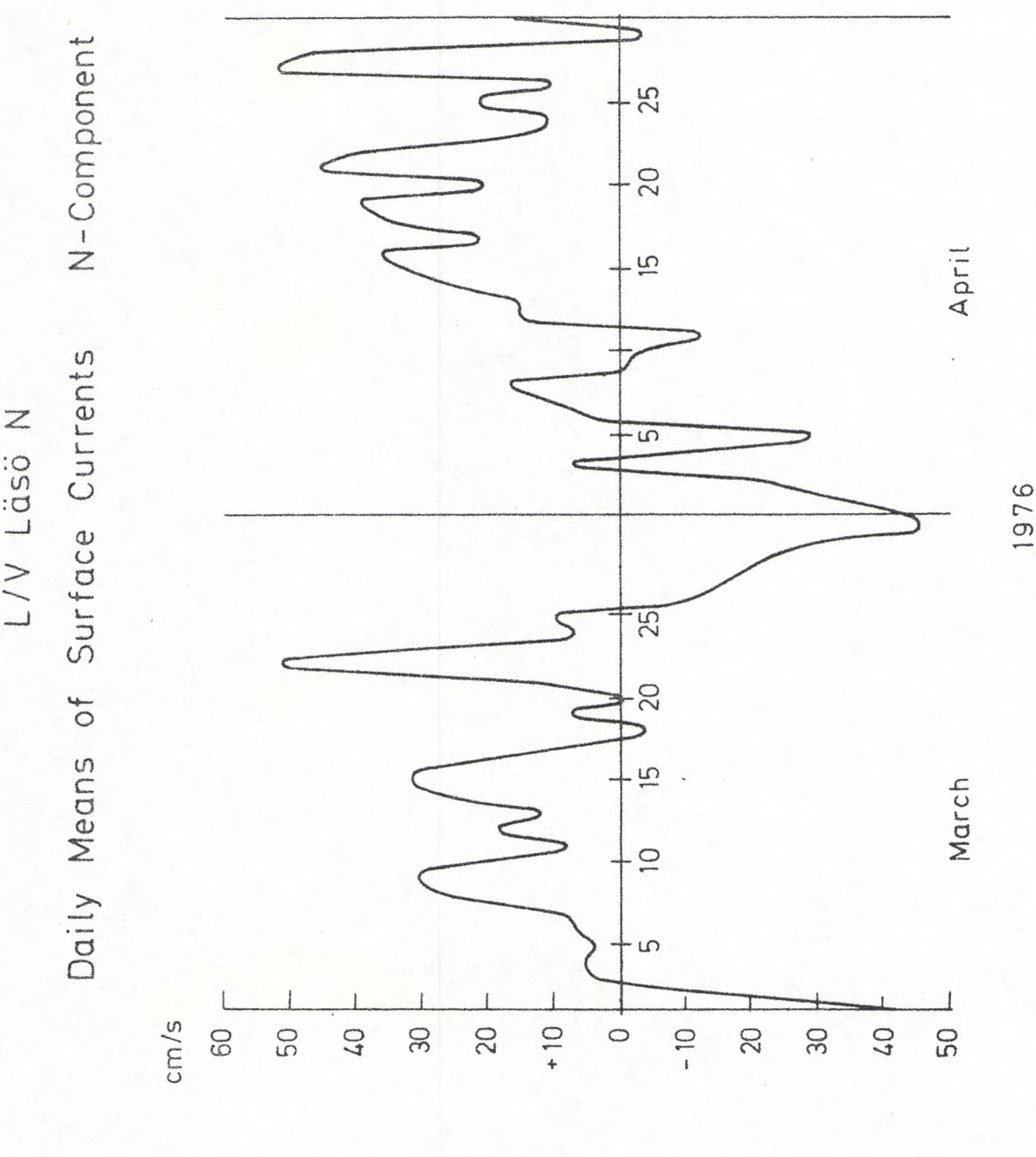


Fig. 7.


L/V Läsö N
Daily Means of Surface Currents
N-Component
cm/s
60
50
40
30
20
+10
0
-10
20
30
40
50
5
10
15
20
25
5
15
20
25
March
April
1976

CM Rig J 76 651 57° 30.'0 N 11° 33.'0 E

Daily Means of Currents at 8 m Depth N-Comp.

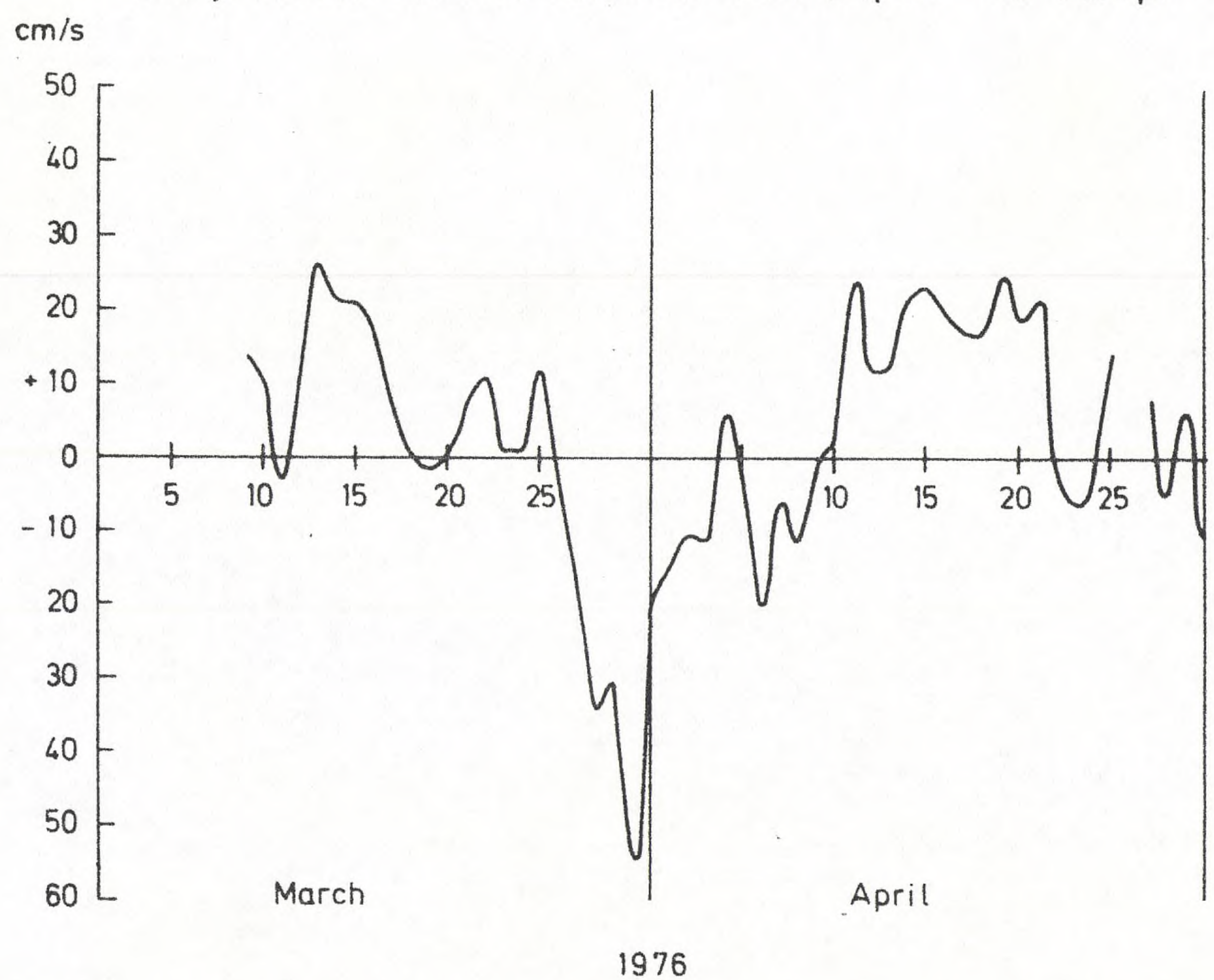
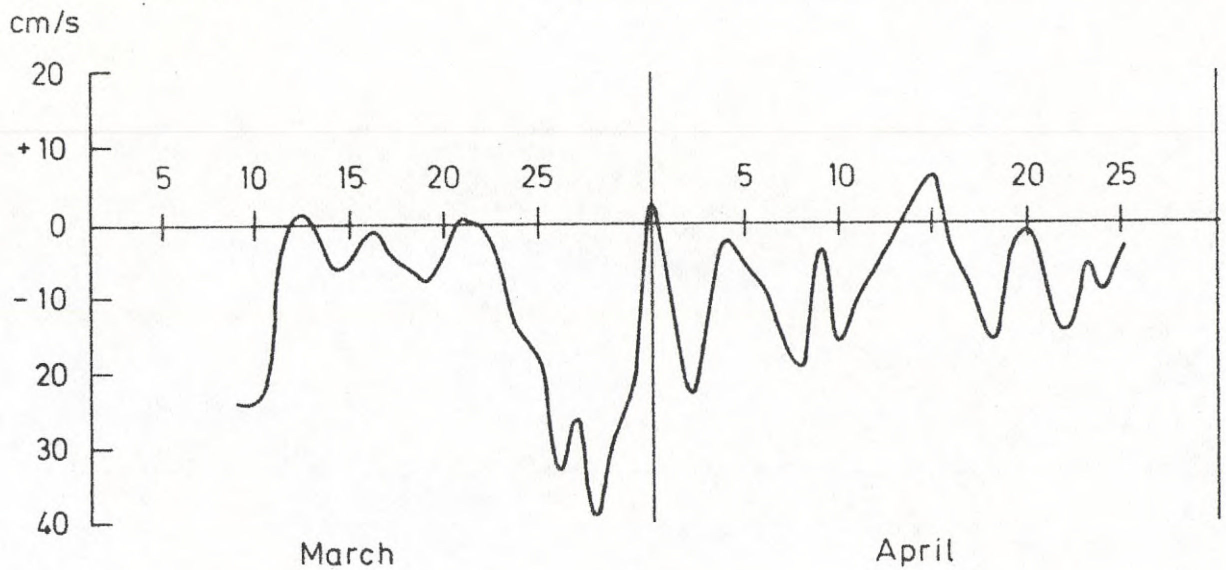


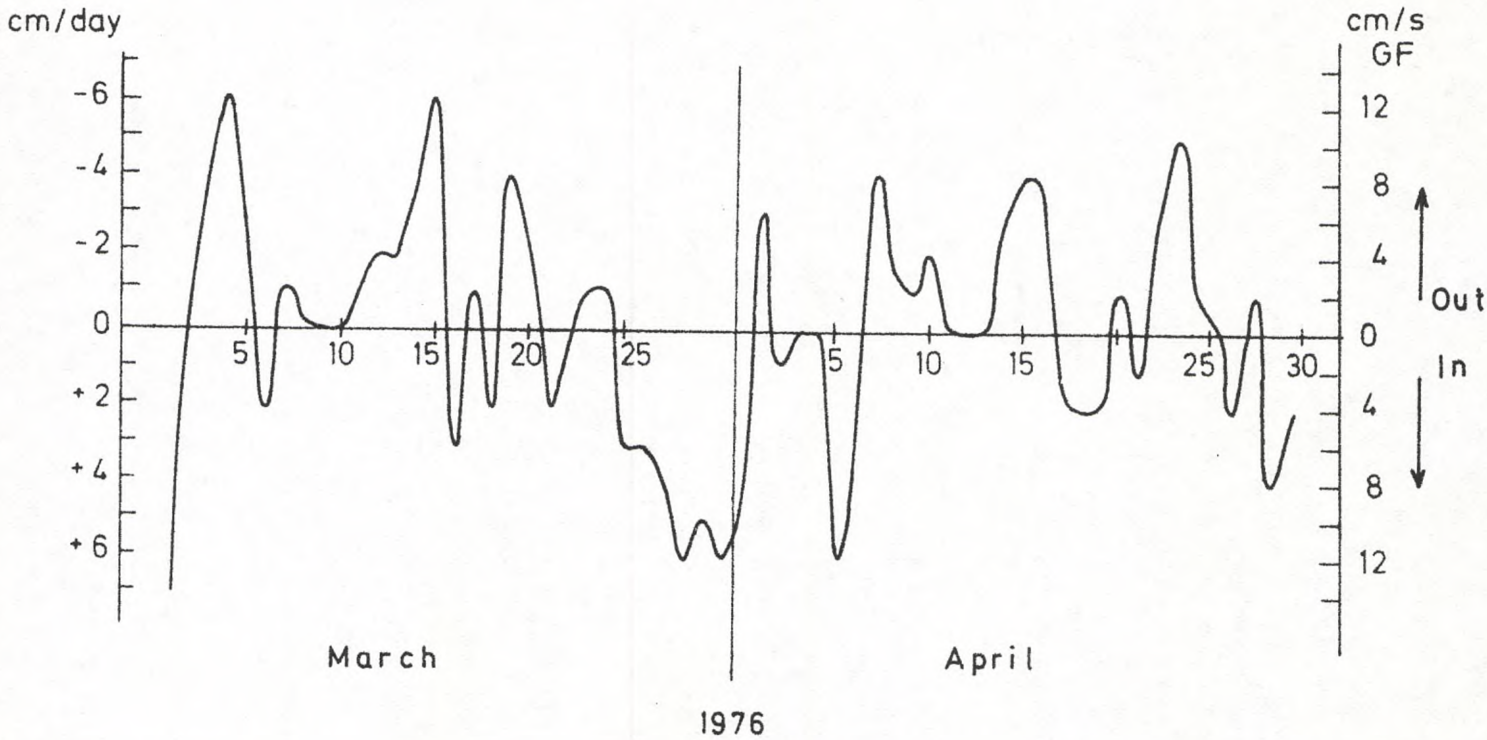
Fig. 8.

Fig. 9.

CM Rig J 76 657 57° 30.'0 N 11° 33.'0 E

Daily Means of Currents at 30 m Depth N-Comp.





Sea level changes at Landsort. Right hand scale is constructed according to 1 cm/day = 2 cm/s through G-F section

Fig. 11.

Daily means of Sea levels : $\frac{\text{Göteborg + Frederikshavn}}{2}$

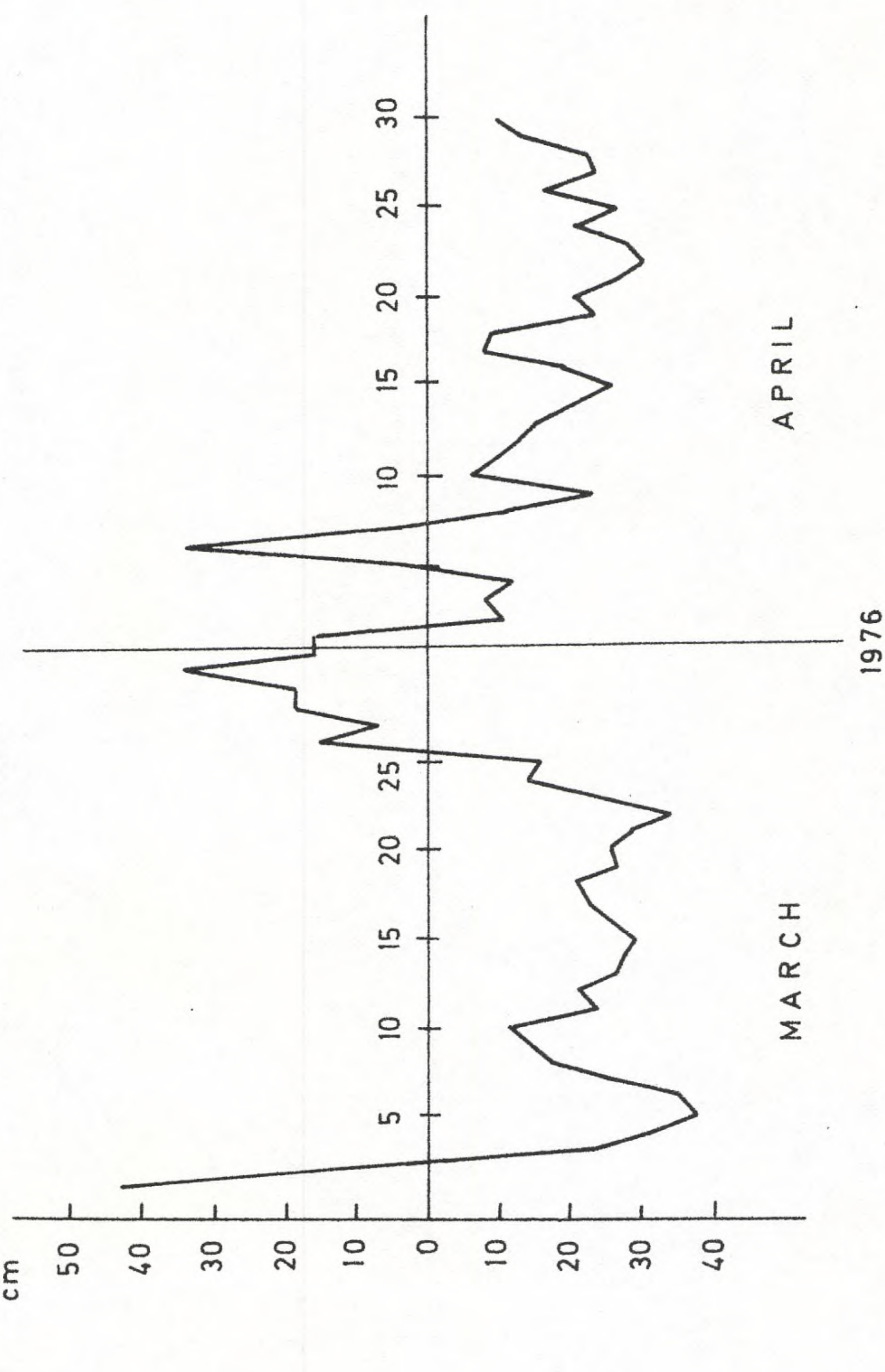
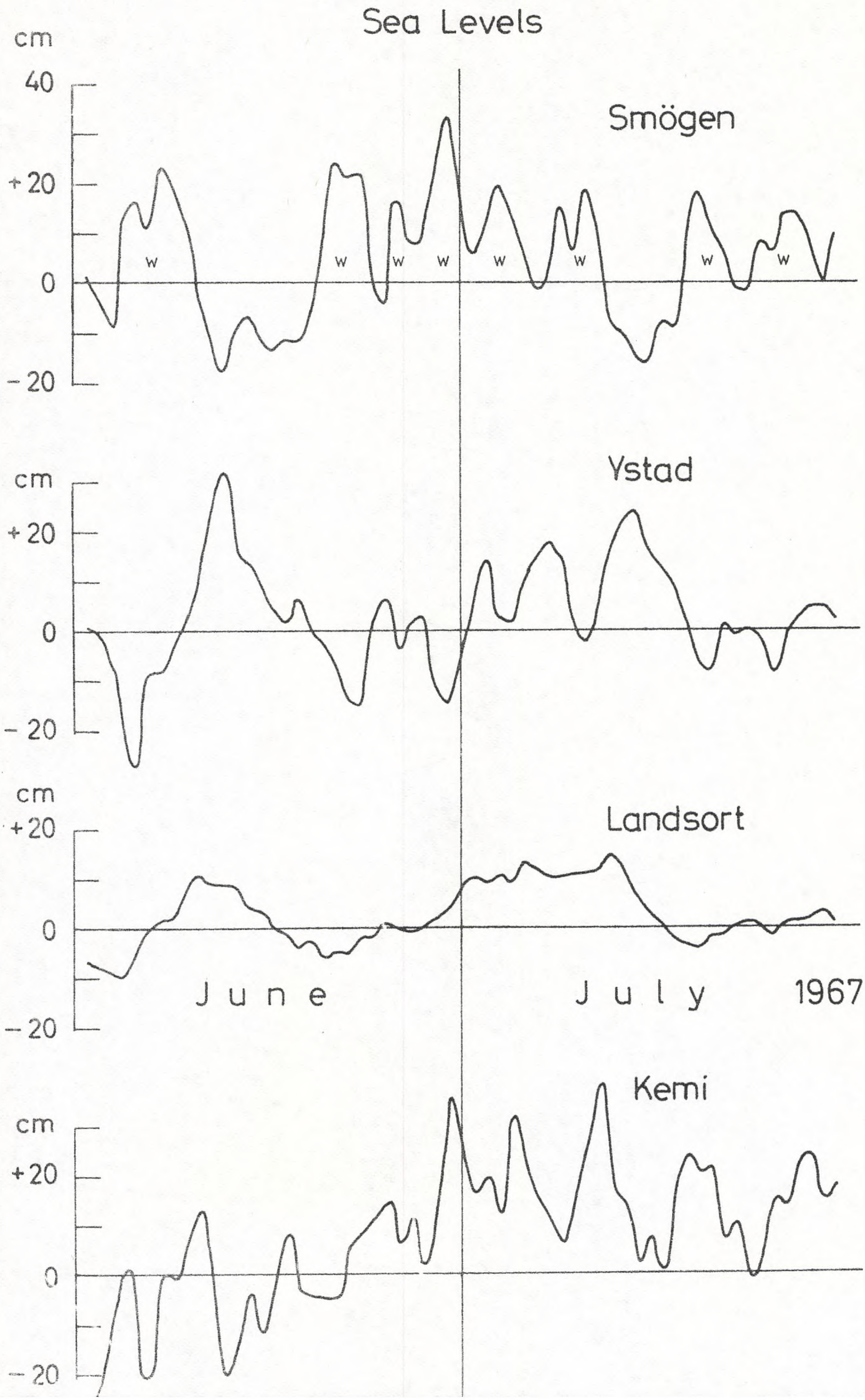
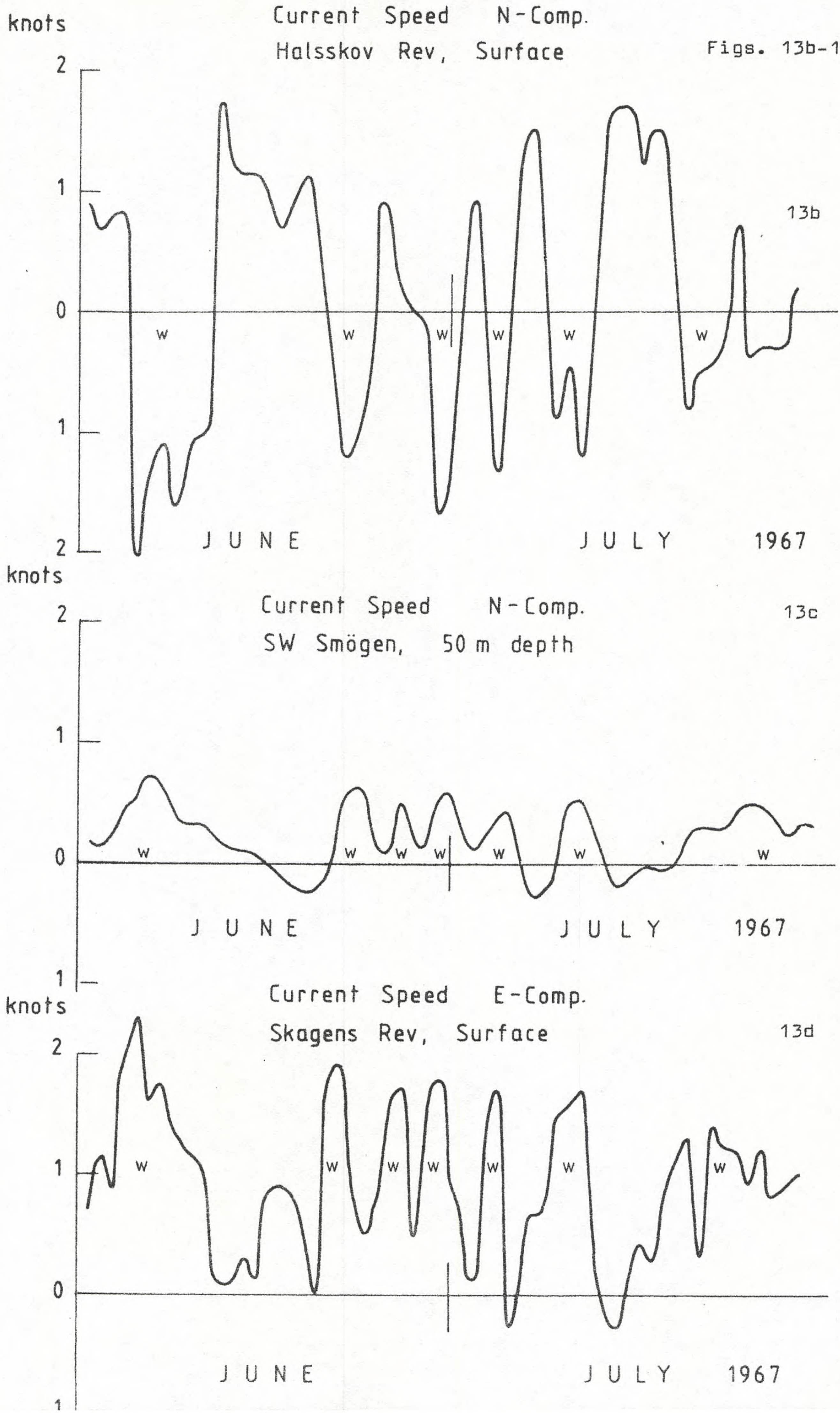


Fig. 12.


12°
20°
28°
64°
60°
56°
KEMI
THE
BALTIC
LANDSORT
SMÖGEN
SKAGERRAK
KATTEGAT
YSTAD


Sea Levels
cm
40
+20
0
-20
Smögen
w
w
w
w
w
w
w
w
w
cm
+20
0
-20
Ystad
cm
+20
0
-20
Landsort
J u n e
J u l y
1967
Kemi
cm
+20
0
-20

Figs. 13b-13d.



knots
Current Speed N-Comp.
Halsskov Rev, Surface
2
1
0
1
2
w
JUNE
JULY
1967
13b
knots
Current Speed N-Comp.
SW Smögen, 50 m depth
13c
2
1
0
1
JUNE
JULY
1967
knots
Current Speed E-Comp.
Skagens Rev, Surface
13d
2
1
0
1
JUNE
JULY
1967

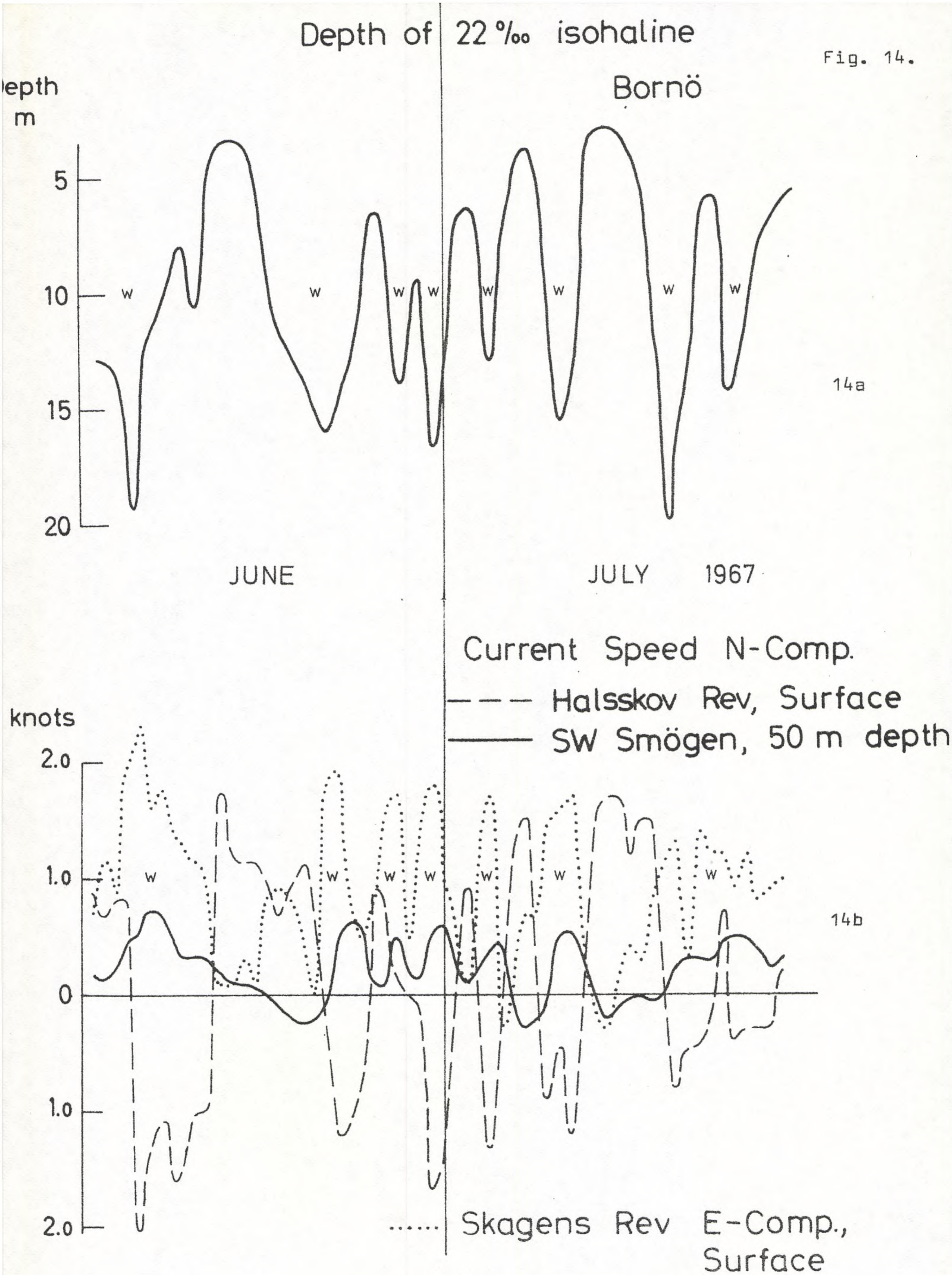

Depth of 22 ‰ isohaline
Bornö
Depth m
5
10
15
20
w
JUNE
JULY 1967
14a
Current Speed N-Comp.
Halsskov Rev, Surface
SW Smögen, 50 m depth
knots
2.0
1.0
0
1.0
2.0
14b
Skagens Rev E-Comp., Surface

Fig. 14.