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Currents in the Skagerack II.

by

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Introduction.

Last year Svansson (1961) reported on measurements along the Norwegian coast with a geomagnetic electrokinetograph (GEK). The surface current was also measured by the ship's driftage. The ratio between the value of the current measured in this way and by GEK was considerably higher than one, and this was interpreted to be due to the existance of a mean current from surface to bottom which was not small compared with the surface current.

This year GEK-measurements were carried out on the whole section Hirtshals - Arendal. The measurements were however not very good and the main interest in this paper is devoted some parachute drogue measurements. The result from one of the drogues' drift (on 100 m) is used as reference in a computation of the geostrophic current. From the ship's drift measured at more than one occasion references for the remaining parts of section are deduced. Thereby we have got a picture of the currents in the whole section and the total transport has been computed.

The parachute drogues.

During the first and last week of the month of June experiments with parachute drogues (See e.g. Volkmann, Knauss and Vine 1956) were carried out north of Jylland. The connection between the parachute and the surface buoy (with pole and radar reflector) consisted of a one mm nylon line. On the 5th of June one drogue was set out on 110 m between the stations 69 and 70 on the section Hirtshals-Arendal (See Fig. 1). Its position was determined by Decca 6 times during the 3 days of the drift. The results are to be seen in Table 1.

Table 1.

Parachute drogue 100 m 5.6 - 7.6 1962

		Speed in knots	Direction against
5.6.62	15^h38		
	20 30	0.36	80°
6.6.	03 07	0.40	65
	22 00	0.48	75
7.6.	06 00	0.45	70

Because of the small variations in direction and speed it was rather simple to find the surface buoy even after so long a time as 18 hours. Furthermore the wind speed never exceeded 6 m/s. Therefor it was possible to take up the drogue on board on the last day.

According to the picture of the relative geostrophic current (see e.g. on Table 3) between the stations 70 and 71 the speed perpendicular to the section is decreasing towards the surface. If the currents between the drogue and the surface have about the same direction as the current on the drogue level, the error in our determinations is not more than 2.5 %. Due to possible difference in direction this figure has to be increased, but surely not more than to 5 %.

During the last week of the month 3 parachutes were laid out. The positions of 2 of them can be seen in Fig. 1. The nylon line of the third one on 200 m depth was nearly at once cut by the wire of a trawler. The line of second one on 100 m was destroyed after some time by the waves, but according to the wind conditions it is possible that this had happened just before the accident was observed. The current speed is about 0.4 knots during the whole time. The third parachute on 50 m depth was followed according to Fig. 1. Its line was broken when we tried to take it up. The currents deduced from the drift of this parachute is presented in Table 2.

Table 2.

Parachute drogue 50 m 27/6 - 28/6 1962.

		Speed in knots	Direction against
27.6	12^h 48		
	17 30	0.42	115°
28.6	08 03	0.44	135
	13 27	0.53	140

Since there is no hydrography at this time it is hard to estimate the error in the way it was done above.

The drift of the first drogue is used in the geostrophic computation below. Furthermore is to observe that all drogues have a tendency to follow the isobaths, the one of the first week nearly completely. Such a movement is not surprising because in that way the potential vorticity is conserved. But nevertheless is it curious that the trajectories can bend so charply as they do according to the neasurements during the last week. More measurements must be carried out in this region. But also theoretical computations might be possible. A model in which the geostrophic section below is used as boundary value and equations in which bottom topography and bottem friction are possible to be taken into account, might give an interesting solution.

R/V Skagerak made during the same month investigations of hydrography, transparancy and sprat eggs. On the stations the ship's free drift was determined from Decca. The currents computed from this drift are presented on Fig. 2.

During the month some measurements with airborne infrared thermometer was also done. Troubles with rainy and windy weather but also troubles with the instrument make it hard to interpret the results. As an example what can be measured and observed from the air over the Skagerack Fig. 3 is presented from a flight in April 1962. The very thick lines are visual observations of foam bands, which can be seen in good weather.

Geostrophic currents and transports Hirtshals - Arendal.

Table 3 contains an attempt to compute the geostrophic current and transports from the hydrographic data 4-5/6 (See also Fig. 4) and all the absolute currents which were determined during the time 4-7/6. The choice of referent currents between stations has been done in the following way. Between stations number 67 and 68: Only one measurement of four shows a current not zero. Because it seems resonable not to have too much transport in this outgoing "countercurrent", the surface value is put = 0. 68 and 69: Also here a little lower value than the measured surface one is used, 5 cm/s instead of 10 cm/s. In this way the values fit better with the part between 69 and 70.

69 and 70: The current at 100 m has the value 18 cm/s according to the drogue.

70 and 71: This section is very hard to estimate. If we accept the surface measurements there would be a very high outgoing transport. So far we suggest here to have about zero net transport.

71 and 72: It seems quite unreasonable that the figure -15 cm/sec is correct. If a figur 27,0 cm/sec is chosen for the surface we need not assume an ingoing current at about on hundred meter.

72 and 73; 73 and 74; Here the mean values of the directly measured surface currents have been used.

The total outgoing transport is 572 x 10^3 m^3/sec, and the total ingoing transport 580 x 10^3 m^3/sec. (Note that from the Baltic comes about 20 x 10^3 m^3/sec during this time of the year.) In this computation we have not taken in acount the transport between Hirtshals and station 67 resp. Arendal and station 74 and the parts below 400 m depth.

GEK-measurements.

On the section Hirthals - Arendal GEK-measurements were carried out on the 6th and 7th of June, but on the first of these two days the apparatus did not function well more than on a very small part of the section. The result of the second day is presented in Fig. 5. But also this curve is hard to analyse due to the large zero-drift. The zero-point was determined every hour in such a way, that the ship turned 180° during 10 minutes. After that it turned again to the old course. In this way we got two determinations of the zero-point. At one occasion the two zeros did not coincide at all. It is possible that the big variations in temperature at this moment indicate some disturbance of importance. During the last three hours the zero-drift was, however, rather small. During the last but one hour it is quite clear that the GEK values are much smaller than the drift values. According to Table 3 of the geostrophic computation this is a place where the mean current from surface to bottom is not small. During the last hour, however, the ratio GEK/drift is about one.

References.

Svansson A. 1961: Currents in the Skagerack. ICES Hydrographical Committee No. 127.

Volkmann, G., Knauss, J., and Vine, A. 1956: The use of parachute drogues in the measurement of subsurface ocean currents. Trans. Am. Geoph. Un. Vol. 37, No. 5.

Kobe, G. 1934: Der hydrographische Aufbau und die dadurch bedingten Strömungen im Skagerrak. Veröff. Inst. Meeresk. Berlin; N.F.A.

Table 3.

Geostrophic currents in cm/s Hirtshals-Arendal June 1962.

(Minus sign means currents and transports inwards towards 55 degrees)

Station number:	67 (70m)		68 (35m)		69 (140m)		70 (500m)		71 (645m)		72 (400m)		73 (400m)		74 (200m)
Surface current in cm/s															
4-5/6 drift on hydr.stations	0		0		-		-		23		43		23		35
6/6 drift during GEK		0		-18		5		20		-15		20		20	
7/6 " " "		15		-15		-20		0		23		40		30	
Depth m															
0		0		-5.0		-3.4		-1,0		27.0		30.0		30,0	
5		1.2		-11.2		-6.2		-0,2		20.6		28.6		24,9	
10		2.5		-15.4		-7.6		+0,4		13.9		28.7		17,6	
15		2.4		-14.4		-7.6		0,2		4.9		34.6		11,7	
20		2.5		-12.3		-8.1		0		5.5		34.4		8,3	
30		7.2		-10.8		-9.6		-0,4		3.5		31.0		6,4	
40		(0)		-10.0		-11.2		-1,0		2.0		27.6		10,9	
50				-8.4		-12.6		-1,0		1.2		25.4		9,5	
60				-7.3		-13.5		-0,9		0.6		23.0		7,9	
70				-6.1		-15.1		-0,8		0.3		20.5		6,5	
80				-5.0		-16.1		-0,6		0.2		18.0		5,2	
90				-3.9				-0,4		0.1		16.0			
100				-2.8		-18.0		-0,2		-0.2		14.1		2,1	
125				0		-20.5		0		0.3		9.5		-0,8	
150						(-18.5)		+0,1		1.0		7.2		-3,5	
175						(-15.6)								-4,2	
200						(-13.0)		0,4		2.8		7.1			
300						(0)		0,9		5.9		2.0			
400								2,8		(0)		0			
500															
Transport $10^3 \times m^3/s$		15		-104		-476		31		220		264		42	

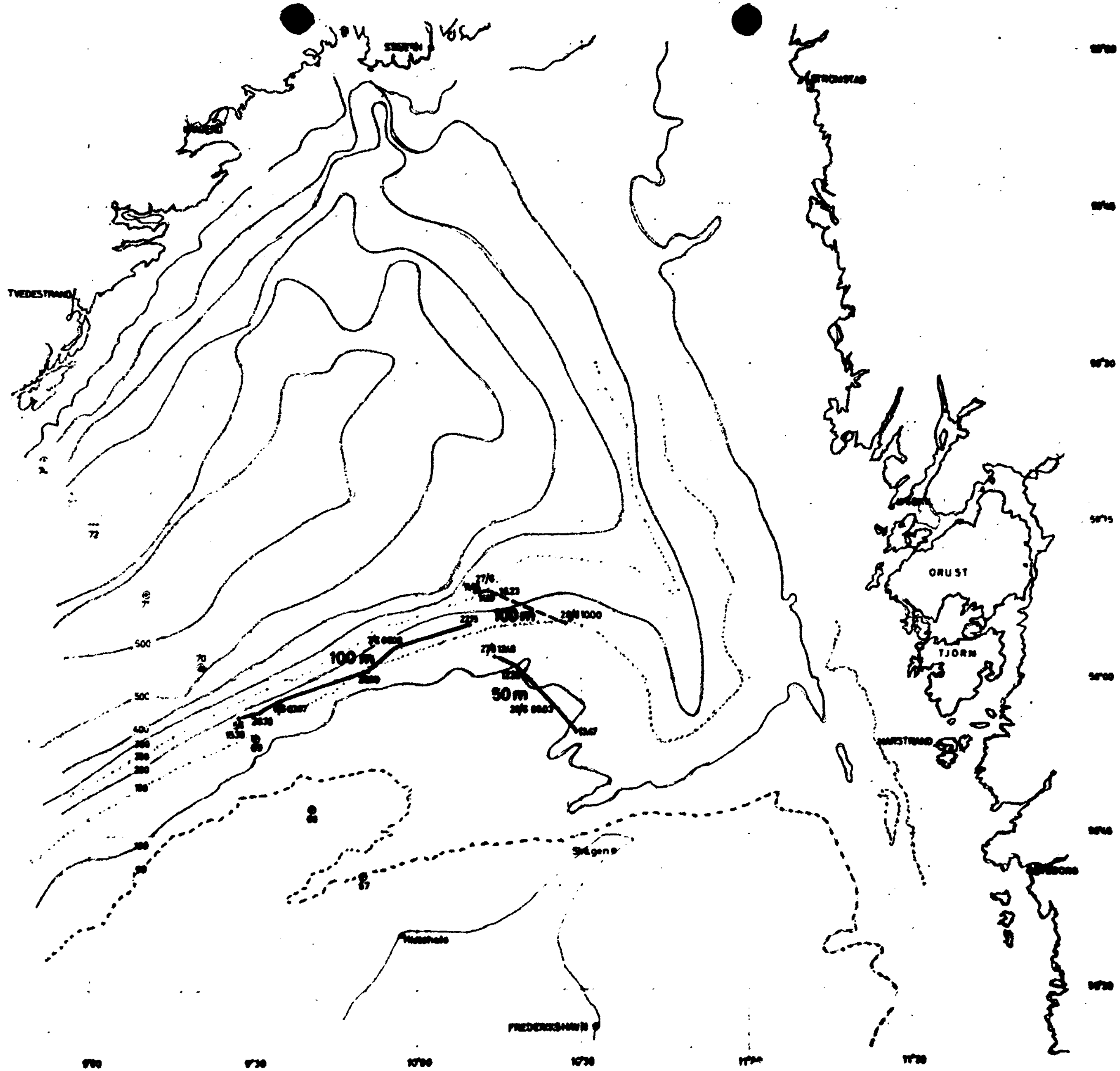
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Fig. 1

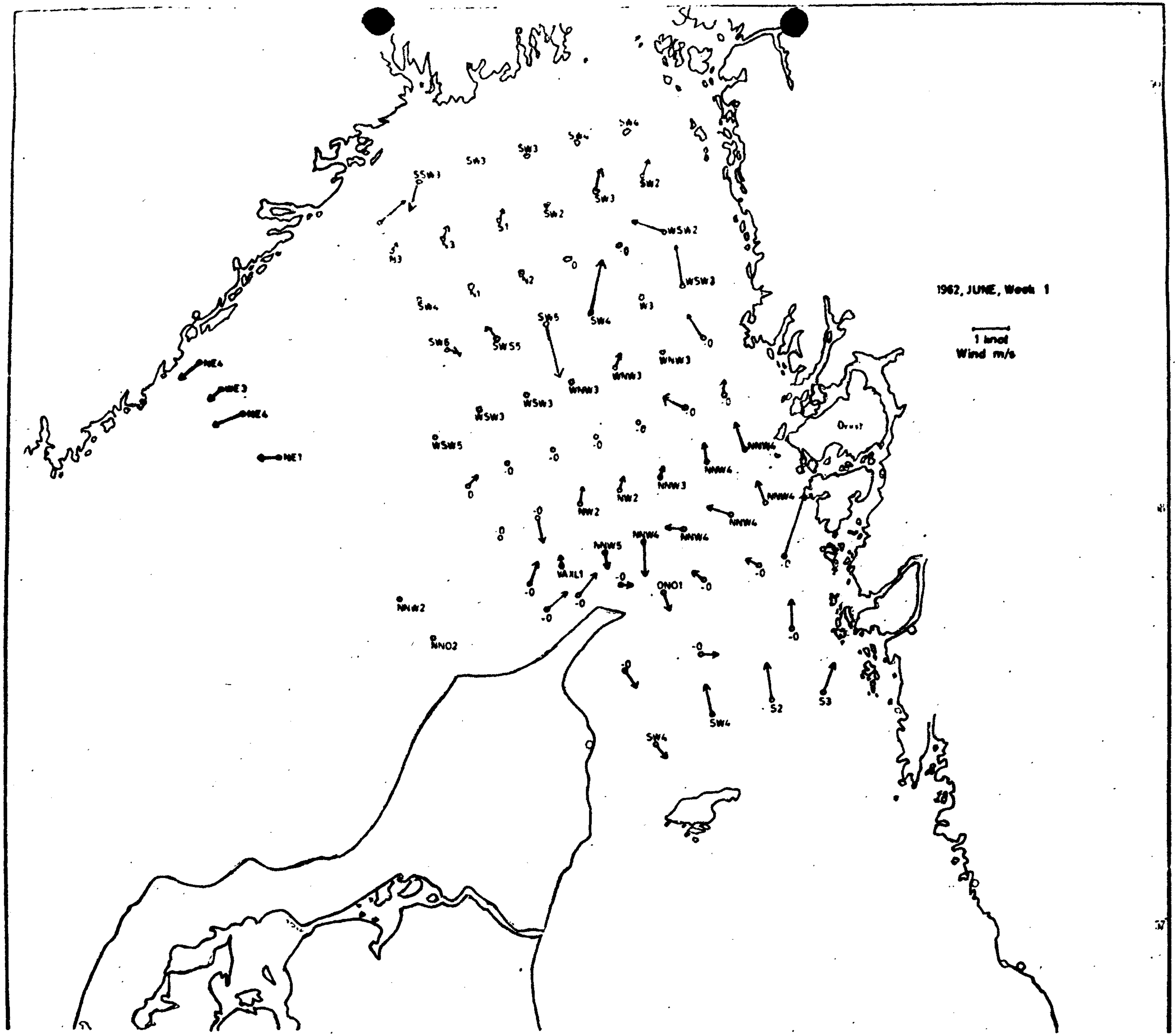
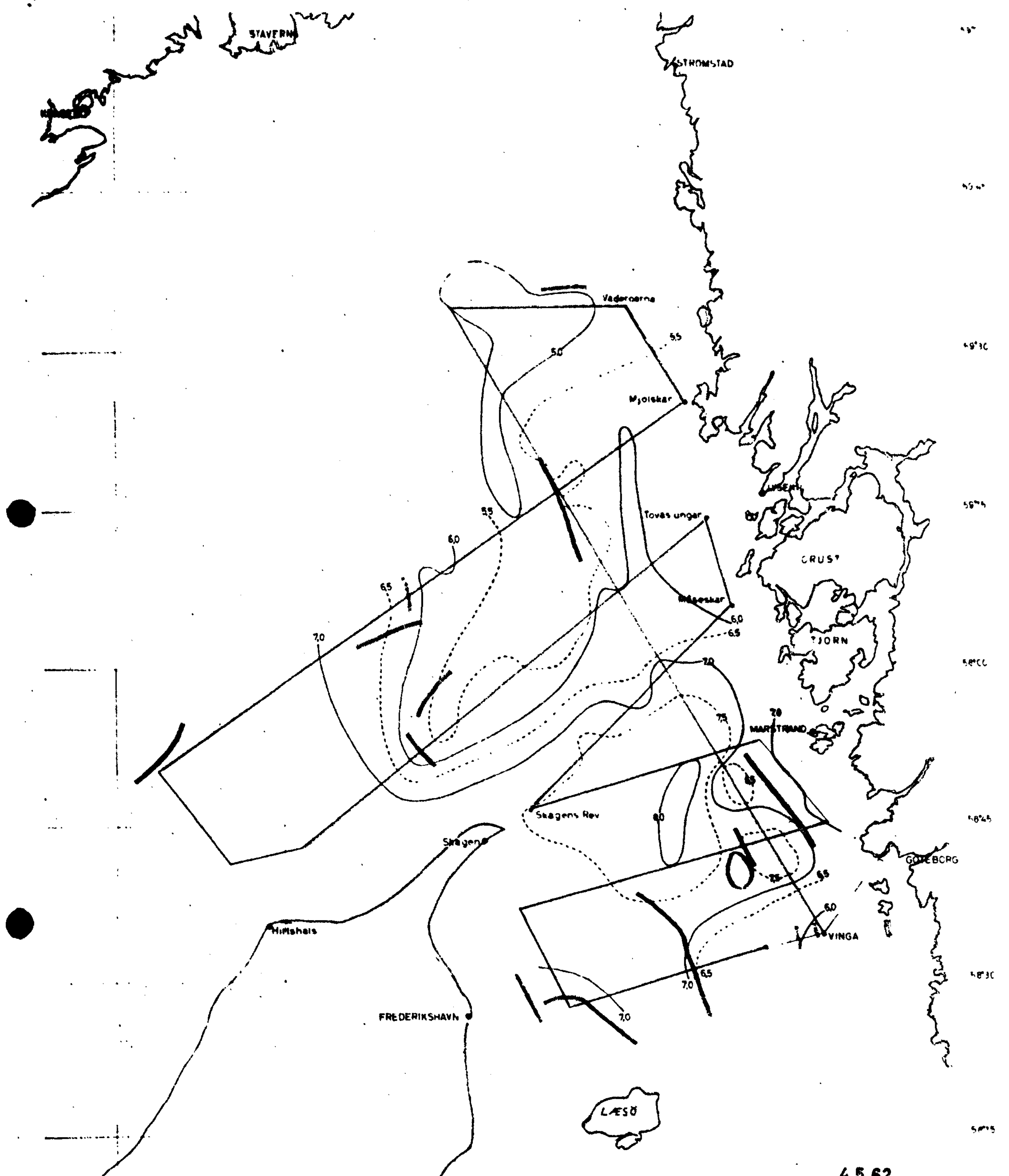


Fig. 2

Fig. 3


STAVERN
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11°30
58°30

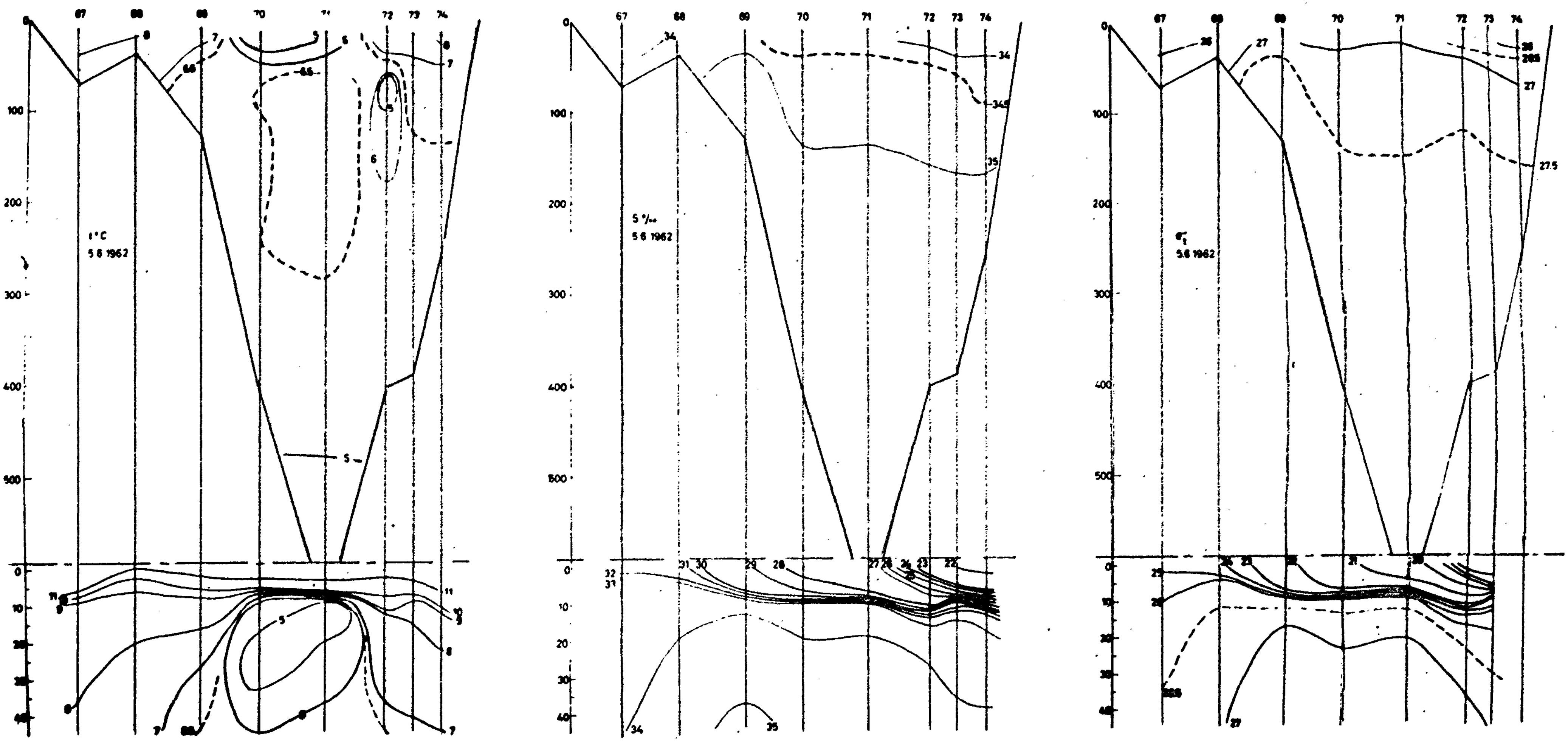
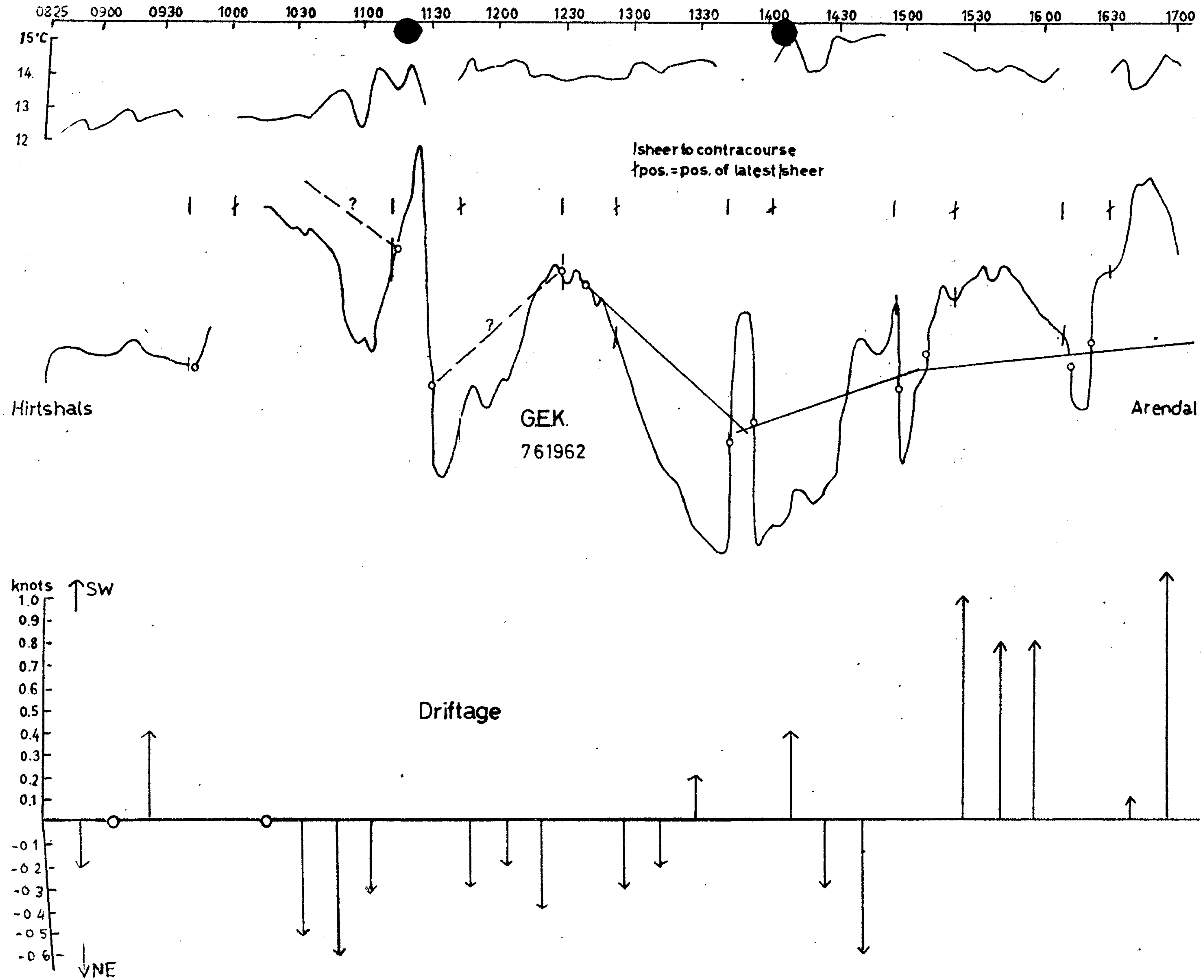


Fig. 4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NE
Driftage

Fig. 5