

## IMPACT OF ICE ON SWEDISH OFFSHORE LIGHTHOUSES

Ice drift conditions in the area at Sydostbrotten  
ice season 1986/87



INTRODUCTION:

The caissunlight Sydstbrotten is situated in an area with rather great ice motions due to currents and winds, but also intensive navigation. The main vessel traffic runs east of it. However, in severe ice conditions the icebreakers break a channel in a more shallow fairway west of the caissunlight (Bonden fairway). As the vessel traffic is rather great the icebreaker working in the area often pass in the vicinity of the caissunlight. Ice observations are continuously done on board the icebreaker from the area it passes. Reports of ice concentration, ice thickness and ice drift are sent 4 times a day per telex. At times air reconnaissance from helicopter is done. Further more satellite images are treated to make a good picture of the ice situation.

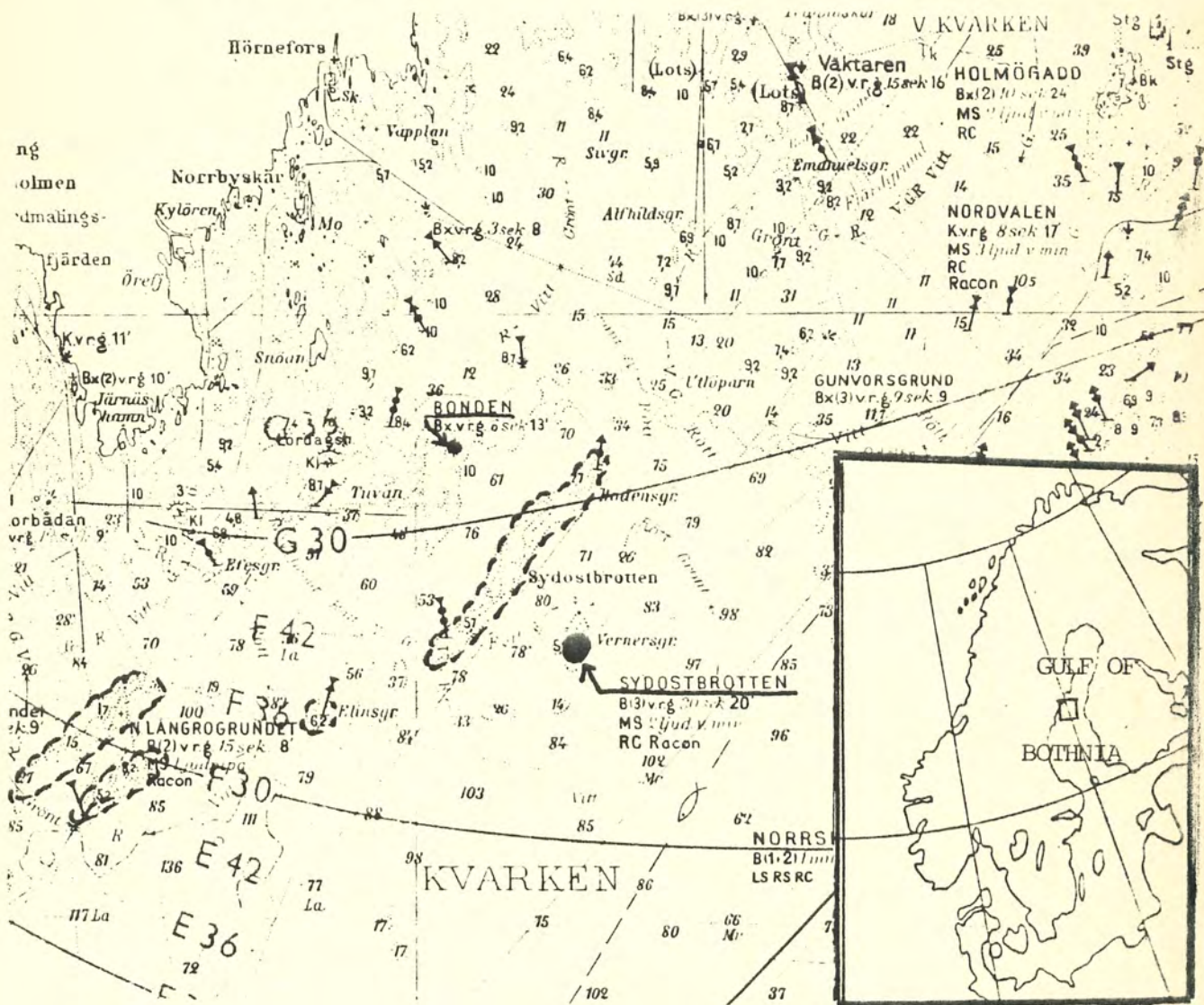


Fig 1. Map of the Gulf of Bothnia with detail of Sydstbrotten and environments.



This report is an attempt to make a statistical review of the ice drift around the caissunlight using all this ice information and the weather observations from the automatic weather station at Sydostbrotten.

### 1. General ice information and statistic.

The ice winter 1986/87 was somewhat more severe than normal in the area. The ice formation started normal time but the ice breaking up was about 10 days later than normal. The maximum ice thickness may be compared with some of the severe winters. However, the winter was not extreme, the frequency of ice pressure with ridges rather small and a lot of cases with broken ice and leads occurred. Fig. 2 shows the development during the winter. During the period of ice formation the new formed ice drifted southwards due to northerly winds and followed by further ice formation. This often occurred in January and February. Also periods with open ice occurred. During March the ice was maximum. The ice was often stationary, grew thicker and became more ridged due to partly heavy ice pressure. At the end of April the ice broke up and a lead was formed. However, close or open drift ice drifted into the area in the beginning of May. The ice was broken into small rotten floes among big heavy floes. From 17 May almost ice free.

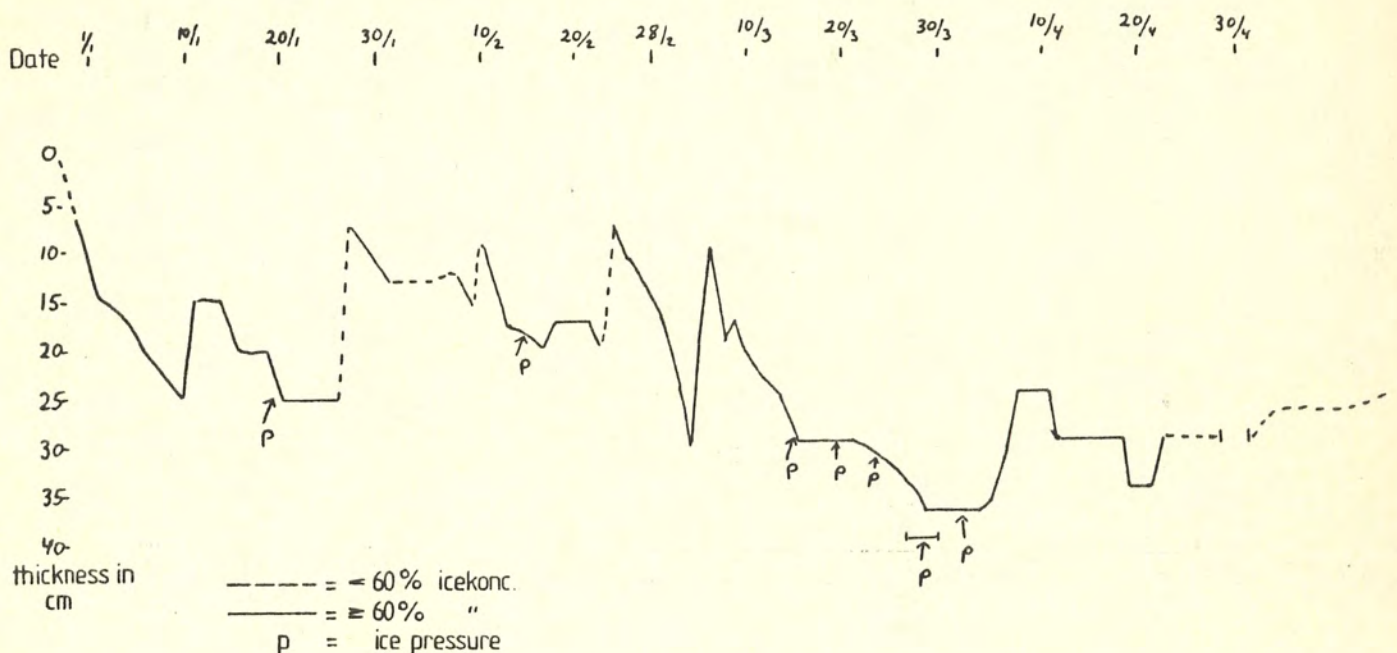


Fig 2. Ice development during the winter 1986/87.



## 2. Ice drift.

The ice drift has been observed, calculated and estimated, based upon wind- and temperature-observations registrated at Sydostbrotten. The current is estimated from the water-level changes. Data from regular ice drift forecasts are checked up. (A numerical model for forecasting the ice motion in the Bay and Sea of Bothnia. I. Udin and A. Ullerstig 1977, Research Report No 18, serie WINTER NAVIGATION Research Board.)

Also observations on board icebreaker passing in the vicinity are checked as well as data calculated from videotape used by LTH (Luleå Tekniska Högskola). The ice thickness and ice concentration represent the area close the caissunlight Sydostbrotten.

In the figures 3, 4 and 5 the ice drift is presented in drift roses for different ice thickness. As the ice thickness varies a lot with thin ice among thicker floes the thickness intervals overlap each other. The ice thickness may represent a sort of mean ice thickness. The rose shows the ice drift towards a direction, i.e. southwesterly ice drift the ice is drifting towards southwest. The velocity is in cm/s with three intervals showing the total number of cases. In fig 3, i.e 20,3% of the observations are in the directions 202,5 degrees and velocity above zero. About 11,5% of the cases are velocity above 20 cm/s of the same direction. The data is four observations/day, in other words every 6-hour.

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## OCEANOGRAFISKA OBSERVATIONER Sydostbrotten 5-15 cm ICE THICKNESS sort cm/s

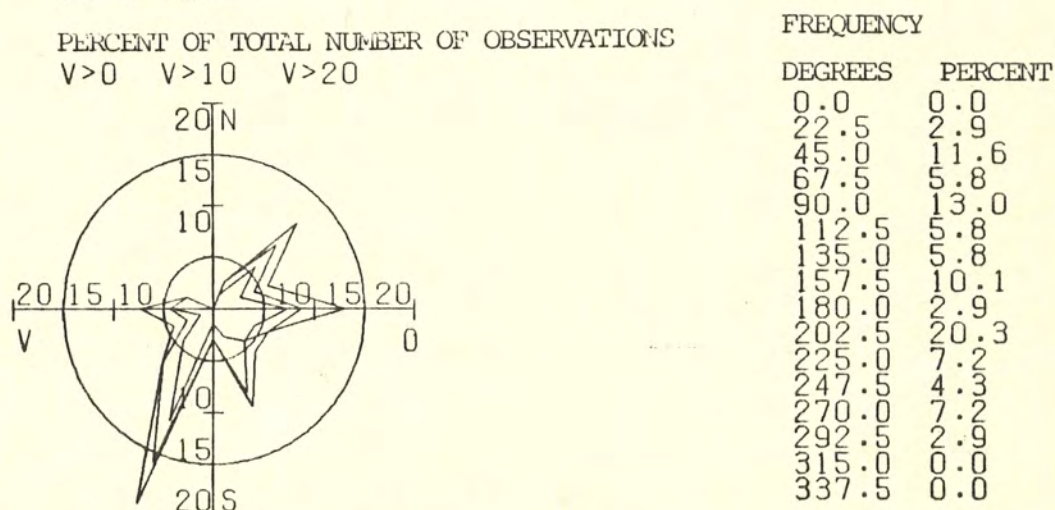


Fig 3. Ice drift. Ice thickness 5-15 cm.

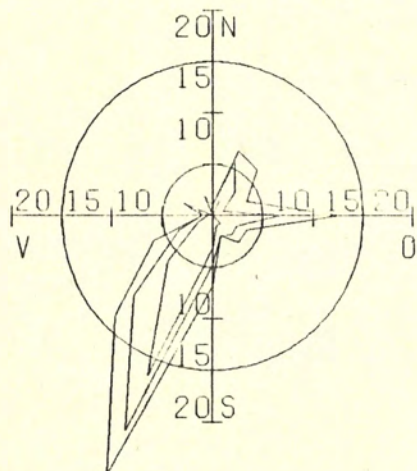




SMHI OCEANOGRAFISKA OBSERVATIONER  
 H0 Sydostbrotten 10-30 cm ICE THICKNESS  
 sort cm/s

PERCENT OF TOTAL NUMBER OF OBSERVATIONS

V>0 V>10 V>20



FREQUENCY

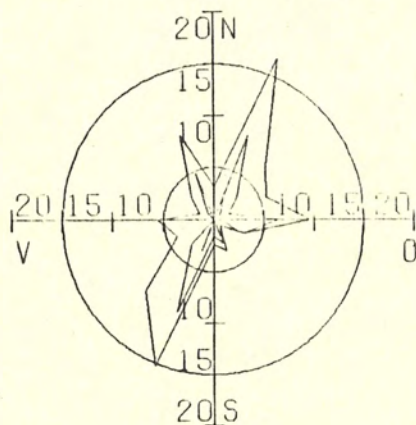
DEGREES	PERCENT
0.0	1.0
22.5	6.8
45.0	6.3
67.5	3.7
90.0	12.6
112.5	3.7
135.0	3.7
157.5	2.1
180.0	6.8
202.5	27.2
225.0	13.6
247.5	6.3
270.0	1.0
292.5	3.1
315.0	0.0
337.5	2.1

Fig 4. Ice drift. Ice thickness 10-13 cm.

SMHI OCEANOGRAFISKA OBSERVATIONER  
 H0 Sydostbrotten 20-50 cm ICE THICKNESS  
 sort cm/s

PERCENT OF TOTAL NUMBER OF OBSERVATIONS

V>0 V>10 V>20



FREQUENCY

DEGREES	PERCENT
0.0	3.2
22.5	16.8
45.0	7.2
67.5	5.6
90.0	9.6
112.5	3.2
135.0	0.8
157.5	3.2
180.0	2.4
202.5	15.2
225.0	9.6
247.5	4.0
270.0	5.6
292.5	1.6
315.0	3.2
337.5	8.8

Fig 5. Ice drift. Ice thickness 20-50 cm.



The three figures have some similarities. The southwesterly and northeasterly ice drift dominates. Very few northwesterly ice drift occur. However, in a period in March moderate or heavy ice pressure occurred. The ice pressure was northwesterly which is shown in figure 5. When ice pressure occur the ice drift is very small and irregular. The ice is ridging and the ridges may have formed in the environments. That means the ice drift may have been overestimated. (Fig.1.). Looking at the bottom topography in the area one will find that the conditions is great for ice ridging. Fast ice often occur insides the shoals northwest of Sydostbrotten.

This winter westerly or northwesterly winds have occurred more than normal and leads have formed west of the lighthouse partly due to icebreaker breaking the Bonden fairway. This is shown as an easterly and southeasterly arrow.

The figures also show a wellknown fact, the thicker ice and high ice concentration cause less velocity.

In figure 5 only a few cases with velocity above 20 cm/s are noted compared with the 5-15 cm ice.

This conditions can be illustrated in a table below

Ice thickness	5-15 cm		10-20 cm		20-50 cm	
	mean		mean		mean	
	cases	ice	cases	ice	cases	ice
		conc.		conc.		conc.
stationary	16		70		55	
0-10 cm/s	14	57%	55	93%	67	92%
10-20 cm/s	18	67%	73	87%	43	73%
> 20 cm/s	36	45%	63	82%	17	72%
total	84	55%	261	85%	182	83%

In the last column 17 cases 20-50 cm ice with rather rapid ice motion is mostly broken small and big floes.



### 3. Summary.

The ice drift at Sydostbrotten and also generally in the Sea of Bothnia is caused by the wind. Combined with an often weak current, which may change the direction for some 10:ths of degrees.

The report shows a statistical review of the ice drift, ice thickness and ice concentration in the area close Sydostbrotten. It may not give the absolute ice mass transport at the construction.

One may draw one conclusion: southwesterly and northeasterly ice drift dominates. This conditions may be compared with the normal wind statistic where these wind sectors are frequent. Southerly current dominates during winter period January - April.



The calculated ice drift values are listed below. The tables refer to the ice thickness 5-15cm, 10-30 and 20-50 cm. The data presented are the date, ice drift speed in cm/s and the direction towards, i.e. 180° means southrunning icedrift.

## Sydostbrotten 5-15 cm

cm/s	degrees		
27/12	40 270	8/2	40 210
	40 260		40 210
	40 260		30 220
	40 250	9/2	30 210
30/12	55 220		15 210
	55 200	11/2	15 290
	40 200		15 290
	25 200		
31/12	05 200		
	05 240		
		24/2	05 150
			05 200
			15 240
27/1	05 270	25/2	10 200
	05 270		05 200
28/1	15 180		05 140
	20 210		05 080
	15 230	26/2	20 030
29/1	10 160		
	20 140		10 150
	40 120	27/2	10 150
	15 120		15 150
30/1	10 070		20 160
	10 030		50 190
31/1	20 100		
	40 110		
	30 150		
	30 140	5/3	05 050
1/2	20 130		
	20 120		
	10 090		
	20 090		
2/2	20 100		
	05 100		
	05 080		
	05 060		
3/2	05 040		
	15 040		
	30 050		
	40 050		
4/2	50 050		
	40 090		
	20 090		
5/2	20 060		
	20 060		
	20 050		
	15 050		
6/2	15 220		





Svdostbrotten 10-30 cm  
cm/s degrees

10	340		05	060	23/1	10	120	25/4	10	230	
15	360		05	030		20	180		10	230	
20	210	19/1	10	030		40	200		20	230	
25	220	1/1	10	020		60	200		15	210	
30	220		10	020		23/2	50	180	26/7	10	220
20	210		10	030	26/1	40	160		05	250	
05	210		05	040		20	160	27/7	05	040	
05	220	2/1	05	130	22/1	10	120		10	030	
05	220		15	160		30	210		10	040	
10	210		15	190					10	060	
10	210		05	190					28/4	25	090
30	190	3/1	24/1	05	060	28/2	40	200	15	090	
40	200		05	070		20	210		15	090	
50	200		05	080		20	230				
40	200		05	090		20	230				
40	200	4/1	25/1	05	120	1/3	20	220			
40	210		10	200		10	220				
20	230		40	210		05	220				
20	240		50	200		05	200				
15	250	5/1	26/1	50	200	2/3	20	230			
20	260		50	200		40	230				
15	250		20	220		40	230				
20	250		05	200		40	220				
30	210	6/1	27/1	05	300	3/3	20	210			
20	210		6/2	25	240	4/3	20	210			
05	180		40	200		20	210				
10	150		40	200		10	190				
20	140	7/1	7/2	10	200	6/3	05	340			
40	200		10	200		05	340				
15	200		20	180		10	350				
05	200		20	180		7/3	05	330			
05	300	8/1	8/2	50	180	05	240				
05	230		50	210		15	220				
20	200					10	220				
40	200	9/1	11/2	30	290	8/3	10	210			
40	200		15	280		05	210				
30	210		12/2	05	250	05	060				
10	220	10/1	15	200		15	080				
10	220		05	200		10	070				
20	210		13/2	05	250	10/3	05	060			
20	210		05	250		05	050				
10	190		05	300		12/3	05	210			
10	240	11/1	10	290		13/3	05	040			
10	240		14/2	15	300	14/3	15	030			
05	110	12/1	20	030		20	030				
10	100		20	090		25	020				
10	100		20	090		10	020				
05	090	13/1	15/2	10	090						
05	090		05	090							
05	090	14/1	16/2	10	020						
10	100		05	030							
10	100		17/2	05	210	7/1	05	040			
10	090	15/1	10	220		05	230				
10	120		20	210		10	210				
10	120		20	210		05	170				
10	120		18/2	15	210	10/1	10	050			
10	120		05	200		10	040				
15	130	16/1	19/2	05	100	10	040				
20	140		10	100							
10	140		20/2	05	040						
05	140		10	040							
05	140		10	040							
05	090	18/1	21/2	10	040						
05	090		05	080							
			15	130							



## Sydostbrotten 20-50 cm

cm/s degrees

3/3	40 210		05 030	2/5	20 030
	20 210		05 020		20 090
	20 210		05 030		10 090
			05 030	3/5	10 230
15/3	10 020	12/4	05 030		10 210
	10 020		05 030		10 210
	05 010	13/4	05 040		15 200
18/3	05 360		05 040	4/5	05 200
	05 330	14/4	05 060		05 240
	05 320		10 080		05 200
	05 320	15/4	10 030	5/5	10 040
	05 320		10 030		10 040
19/3	05 300		10 060		10 040
	05 290		15 090		10 030
20/3	05 210	16/4	10 090	6/5	10 030
	05 200		15 090		10 030
			15 070		05 060
			20 120		20 150
23/3	05 360	17/4	15 120	7/5	20 160
	05 350		10 190		15 210
24/3	05 330		10 210		10 190
	10 340	18/4	25 210	8/5	05 270
	20 340		10 210		05 230
27/3	10 340	19/4	05 150		10 270
	05 330		05 230		10 270
28/3	20 310	20/4	05 210	10/5	10 230
	15 340		05 250		15 230
	10 340		05 240		15 230
	10 340		05 220		15 210
29/3	05 320	21/4	05 250		
	05 330		05 270		
	05 330		05 280		
30/3	02 100	22/4	05 280		
	05 100		05 020		
	05 100		20 040		
3/3	05 050	23/4	15 090		
	02 040		15 100		
	02 020		20 120		
	05 020		20 120		
1/4	20 020		20 140		
	20 020	24/4	15 150		
	10 020		05 170		
	05 020				
2/4	02 280				
	05 230				
	05 230				
	02 230				
3/4	02 250				
	05 090				
4/4	05 070				
	05 040				
	05 060				
	05 060				
5/4	05 210				
	05 200				
6/4	10 200				
	05 230				
	05 220				





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