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SECULAR CHANGES IN THE SKAGERRACK

by

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Secular hydrographical series are needed if the great changes in the seas to the West of Sweden are to be studied. There are no such observation series referring to the Swedish coast of the Skagerrack. Two observation points have existed, the lightship "Grisbådarne" and the hydrographical station Bornö in the Gullmar Fjord. The former made observations during the period 1923 - 1929, and observations were commenced at the latter in 1935. There are a number of observation points in the Kattegatt, however - Danish and Swedish lightships. The Danish lightship "Skagens Rev" began making measurements in the 1880's, but its situation, sometimes in the Jutland current, sometimes in the Baltic current, at a point exposed to variations in the currents, seems hydrographically unfavourable for this problem / cf. O. PETTERSSON and G. EKMAN/.

The following stations have made daily measurements of the temperature of the surface water on the Norwegian coast of the Skagerrack /after FROGNER/:

Ferder	1927 - 1943
Flødevigen	1919 - 1942
Torungen	1867 - 1942

The longest series of observations, that made at Torungen, reveals a remarkable increase in the winter temperature of the surface water, fig. 1. Although Torungen is only one point in the region under consideration, there is no evidence that the rise in temperature is not valid

for the whole of the Skagerrack during more than half a century. The winters have become milder, according to FROGNER:

Torungen	X	XI	XII	I	II	III
1871-1900	10.60	7.18	4.42	2.26	1.38	1.36
1901-1930	10.38	6.98	4.47	2.82	1.47	1.53
Difference	-0.22	-0.20	+0.05	+0.56	+0.09	+0.17 °C

The air temperature, measured at exposed spots such as lighthouses, near the surface of the water may, as is well known, be regarded as very representative of the temperature of the surface water; according to FROGNER the differences between the temperature of the surface water and that of the air in the Skagerrack are as follows:

	X	XI	XII	I	II	III
Ferder	2.7	3.4	3.3	2.5	2.3	1.2
Torungen	2.6	3.3	3.5	2.5	1.9	0.5 °C

It is therefore not unwarranted for the sake of experiment and as a substitute for long series of direct hydrographical observations /which are almost completely lacking in our region/ to make use of a series of observations of the air temperature. Such observations should naturally be made at exposed coastal stations and near the sea surface.

Even though this indirect way of following the changes in the sea surface temperature is accepted, there still remais the problem of the value of the surface temperatures as indications of the hydrographical situation. Generally speaking, we can agree that single measurements of the surface temperature are without value, since they reflect mainly the meteorological situation on the day the measurement was made, or the preceding days. If observations are made in a large area /with scattered observation points/ several times a day for nearly a century without a break, distinct anomalies should indicate that hydrographical and/or meteorological changes have taken place.

O. PETTERSSON and G. EKMAN maintain that the region north of Hållö, fig. 2, that is to say, northern Bohuslän, differs in its hydrography when the Baltic current, for, as they say, topographical reasons south of Hållö, diverges considerably to the west. This implies that the region round the Väderöarna /see fig./ is not so exposed to the colder Baltic

water; northern Bohuslän is warmer. As PETTERSSON and EKMAN say, the excess warmth north of Hållö depends on the direction of the winds. When the wind blows from the east, the Baltic current moves to the west, while deeper and warmer water flows to the north of Hållö. As PETTERSSON and EKMAN and my own material have shown, salinity is also higher in the northern Skagerrack.

It seems apriori likely that the excess warmth north of Hållö is not constant. The coastal stations with the longest series of observations of air temperatures on the Swedish west coast are the lighthouses at Väderöbod, Hållö and Vinga /beginning 1881, 1859 and 1881 respectively/. Comparisons of air temperatures are possible between the stations from and including the five-year period 1881/5, annual comparisons from 1901. /In 1908 the observation point Måseskär was established, and from that year it is possible to calculate the average of Hållö and Måseskär and compare it with Väderöbod./

PETTERSSON and EKMAN drew attention to the fact that the mean air temperature at Väderöbod lighthouse during the winter is higher than at all other lighthouses in Bohuslän. Väderöbod has a rather more exposed situation than the other lighthouses, and it may be suspected, that it has a more maritime climate. This is of subordinate interest for our investigation, for comparisons are made of the deviations between the stations from five-year period to five-year period /and from year to year/. According to the observation material, the deviations at Väderöbod /northern Bohuslän/ are mainly positive, i.e. the station is warmer than the stations to the south. Exceptions are month II and III, where the frequency of negative deviations is greater. Deviation curves have been plotted for:

A. Five-year periods 1881/5 - 1956/60
   a. X - III, separate, Väderöbod - Hållö — fig. 3
   b. X+XI+XII, I+II+III, Väderöbod - Hållö — fig. "
   c. X - III, separate, Väderöbod - Vinga — fig. 4
B. Single years 1901 - 1960 — fig. 5

The curves show:

1. Up to the 1900's the positive deviations for Väderöbod were very high.

2. At the beginning of the 1940's the positive deviations for Väderöbod were again high, followed by great variations, after which they were high again in the middle of the 1950's during I - III

The variations in the deviations must originate from climatological and/or hydrographical changes in the northern and/or southern Skagerrack. In order to be able to compare the observations of the temperature of the air, the material may be divided into three periods:

A. 1881/1886 - 1905

B. 1901 - 1930

C. 1931 - 1960

A study of the mean values for Väderöbod gives the following, table 1:

Table 1 a. Differences in temperature between periods A and B

	X+XI+XII	I+II+III	I+ ... XII
Torungen	+0.4	+1.6	+2.0
Ferder	+0.2	+1.5	+1.7
Väderöbod	-0.8	+1.1	+0.3
Hållö	+0.9	+2.4	+3.3
Vinga	+0.1	+1.8	+1.9

b. Differences in temperature between periods B and C

Väderöbod	+2.3	+2.1	+0.2
Hållö	+2.3	-2.2	+0.1
Vinga	+2.3	-2.2	+0.1

This means that

1. During period B the air temperature during X - XII:

dropped at Väderöbod
rose at Hållö
varied only slightly at Vinga

during I - III:

rose at all stations, most at Hållö, i.e. the changes were not uniform over the whole area

2. During period C the air temperature during X - XII:

rose at all stations with exactly the same value for all months

during I - III:

dropped at all stations with nearly the same value for all months, i.e. the changes were uniform over the whole area

The following questions are of very great interest to our investigation. /a/ Are the positive deviations valid for the whole of the northern Skagerrack or only for Väderöbod ? /b/ Are there older series of suitable measurements of the air temperature in the area ?

A study of the air temperature measurements made at two Norwegian stations, Ferder and Torungen, may help us to discover whether the positive anomalies reflected the situation over the whole of the northern part of the Skagerrack. Observations were begun at Torungen as long ago as 1866, which provides a valuable complement to our material.

A glance at fig. 6 & 7 shows that the whole of the northern Skagerrack had great positive deviations at the end of the 19th century. A valuable detail that will be discerned is that the deviations between Hållö and Torungen were greatest during the periods 1896/1900 - 1901/05. A certain dissimilarity is found between Hållö/Torungen, Ferder on the one hand and Hållö/Väderöbod, Vinga/Väderöbod on the other: the anomalies between the last-mentioned stations were neutralized much more slowly.

Thus Väderöbod and Hållö seem to be the stations where changes have taken place and where the reason for the deviations is to be sought in the first place. If it is considered that the air temperature in the case first mentioned here was sufficiently representative of the temperature of the surface water in the Skagerrack, the phenomenon of the anomalies between stations found here must be regarded as confirmation of the view that certain meteorological/hydrographical changes have taken place in the Skagerrack during the last 100 years.

During period C, table 1, warming up and cooling down respectively were more uniform over the whole region, which was not the case during period B, which is also evidence supporting the theory of secular changes.

SVANSSON, in an unpublished paper, has studied the hydrographical observation material available from this area. He presents a number of facts in favour of changes in the hydrography of the area during the last 100 years.

Our investigation is a consequence of a study of the localization of sprat fishing on the west coast of Sweden; fishing was carried on in northern

Bohuslän often in years with great positive anomalies. The greatest positive deviations also occured during the period when Bohuslän experienced its hitherto last herring fishing period.

The anomalies of the air temperature have been very great, about 1°C per month and five-year period, and can hardly be ignored in discussions of the hydrography of the Skagerrack. A detailed study of the relationship between air, surface water and wind will be needed to reveal the causes of the deviations. There will probably be a good correlation with winds from east; this has to be proved but a study of the actual mechanism is beyond the scope of biological studies and the problem has again shown how important long series of observations are for biological oceanography.

Figs. 1, 4, and 7 will be shown as slides.

Fig 2

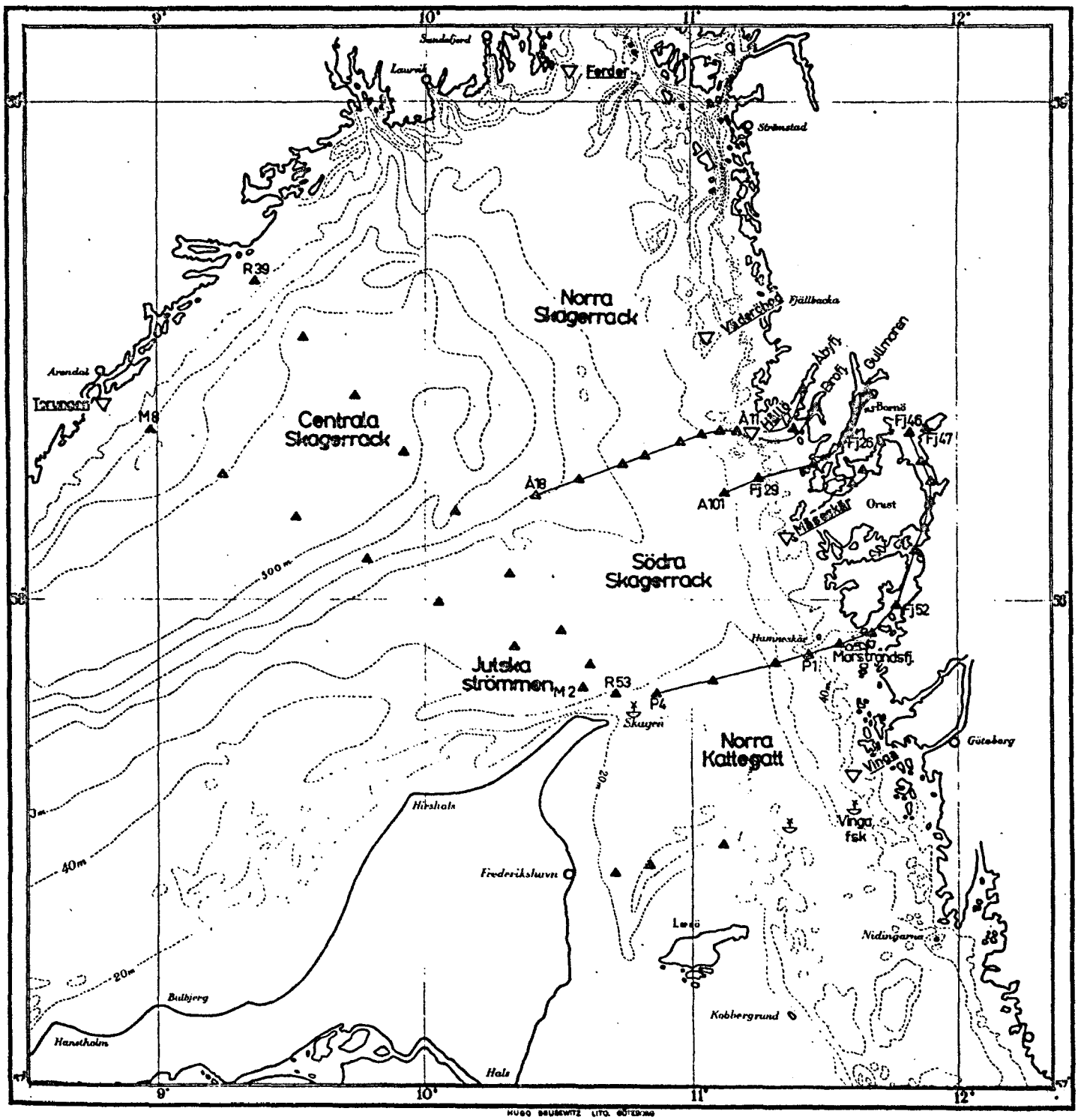
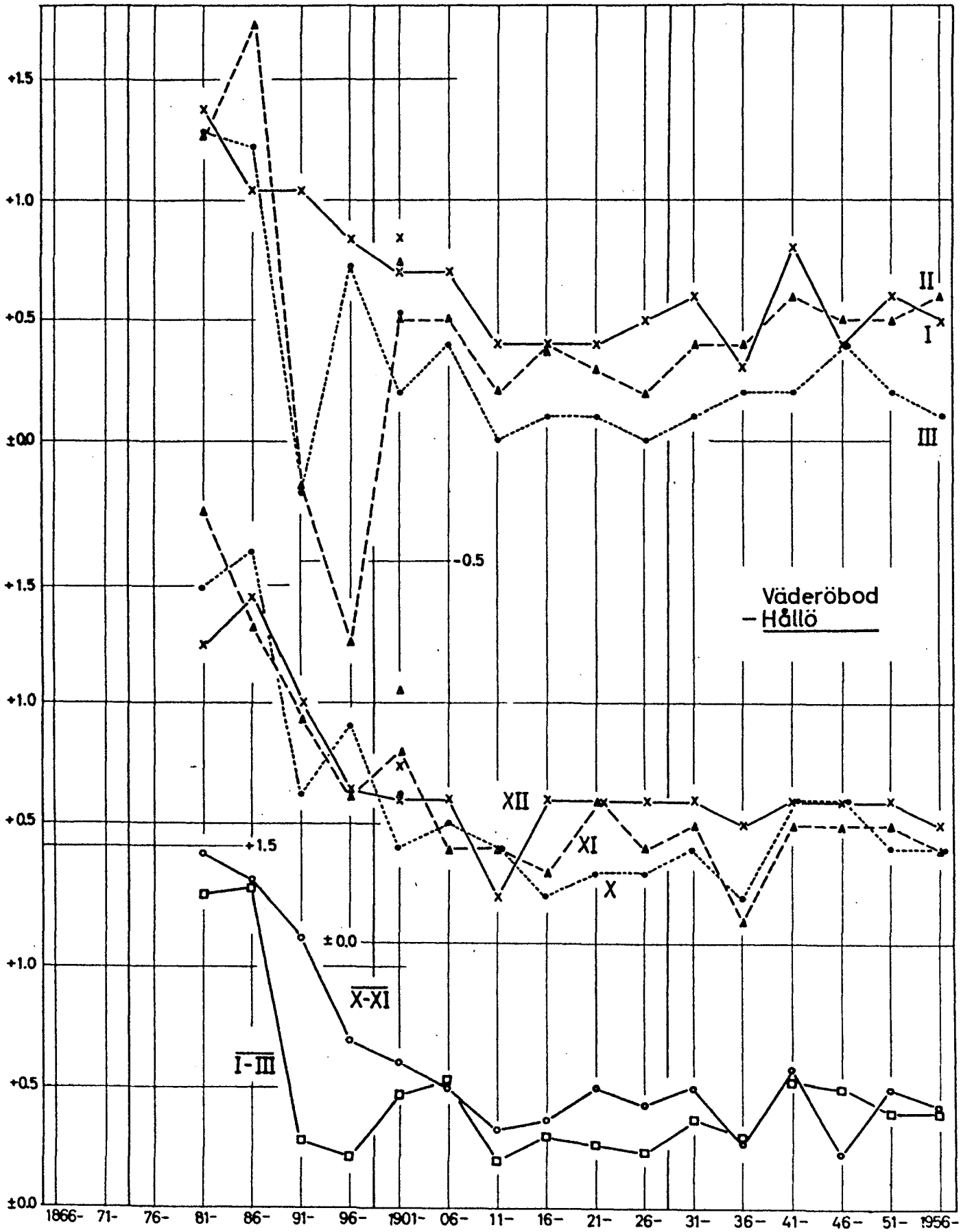


Fig 3

HAVSFISKELABORATORIET
LYSEKIL



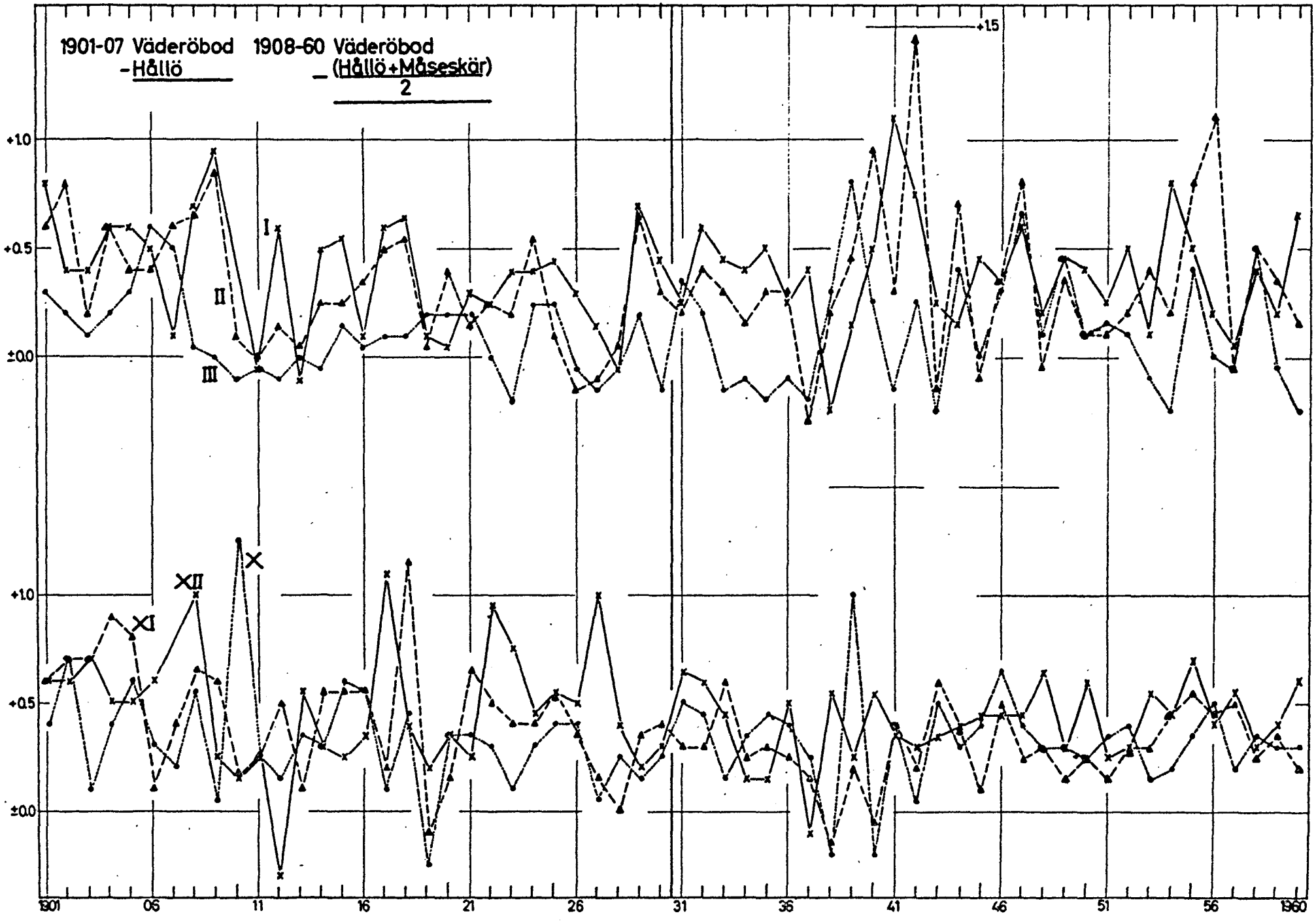
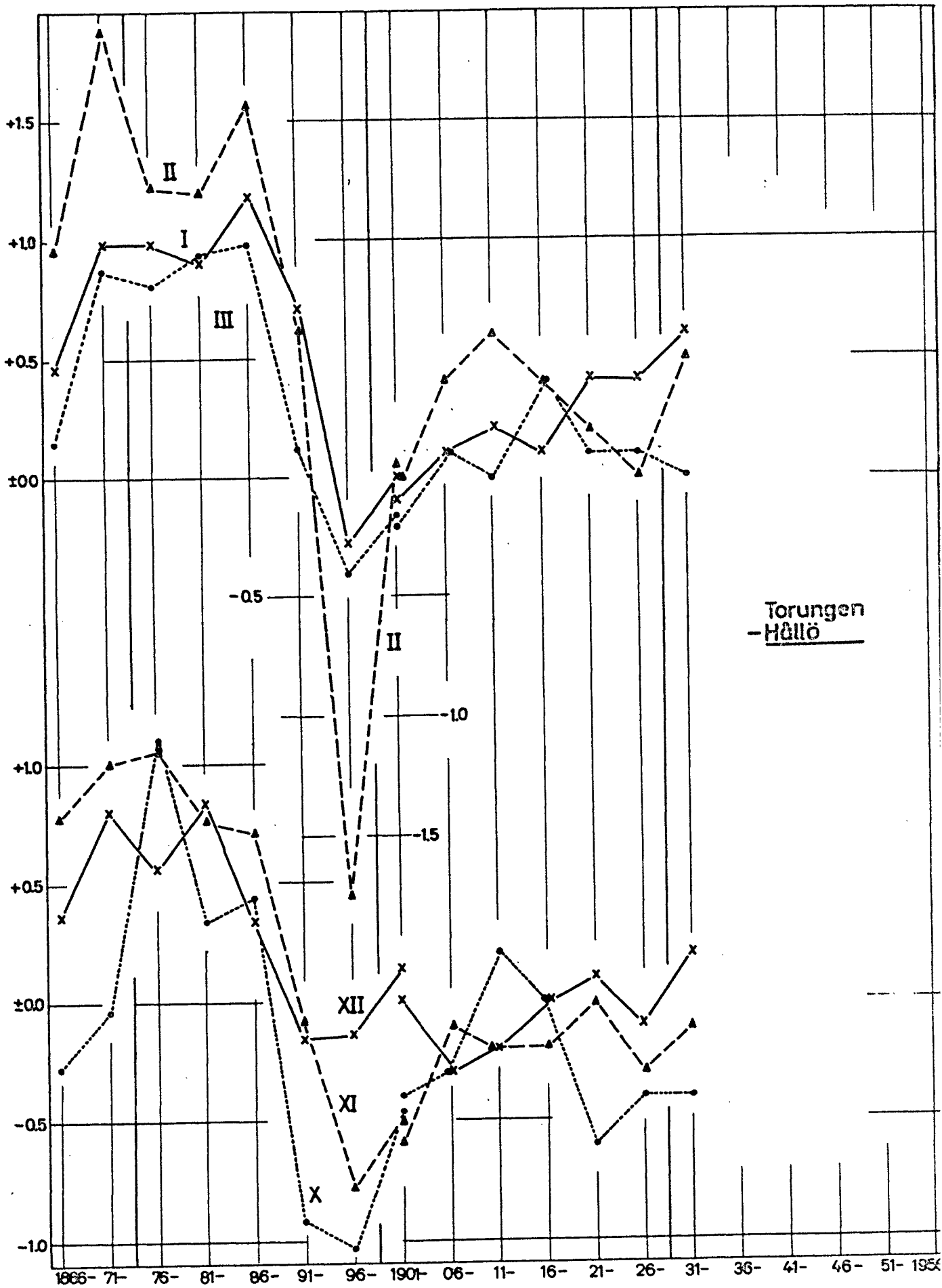

1901-07 Väderöbod - Hållö
1908-60 Väderöbod (Hållö+Måseskär)/2
+1.5
+1.0
+0.5
±0.0
I
II
III
XI
XII
X
1901
06
11
16
21
26
31
36
41
46
51
56
1960

Fig 5

Fig 6


+1.5
+1.0
+0.5
±00
-0.5
-1.0
II
I
III
II
-1.0
-1.5
+1.0
+0.5
±0.0
-0.5
-1.0
XII
XI
X
Torungen
Hållö
1866- 71- 76- 81- 86- 91- 96- 1901- 06- 11- 16- 21- 26- 31- 36- 41- 46- 51- 195