International Council for the exploration of the Sea

C.M.1975/C:24
Hydrographical Committee

Results of Polish hydrographical investigations in the southern Baltic for 1971-1975 /May/

by

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Introduction

This contribution reports the observation results obtained for two routine stations of relative greatest importance as representatives for the western and eastern parts of the southern Baltic, viz., the Bornholm Deep area /station B_1, 55°20'N 15°45'E/ and Gdańsk Deep /G_2, 54°50'N 19°20'E/. The observations concerned temperature, salinity, oxygen and phosphate-phosphorus contents. Apart from these factors the observations on nitrogen content have been made since the second half of 1972.

Results of investigations

In the reported period an extremely strong influx of the North Sea waters into the Baltic took place in spring 1972. Due to it there was a direct renewal of bottom waters of the Arkona Sea and Bornholm Deep, and an indirect one in the Słupsk Furrow and Gdańsk Deep. The most important effect of the water renewal was the fact that the oxygen

conditions, very poor before the influx at the bottom of the Bornholm Deep, notably improved. Also the bottom salinity there markedly rose whereas the bottom temperature at first rose and then rapidly fell by several degrees as the new water originated from the winter North Sea surface waters. The oxygen concentration of bottom waters increased everywhere but only for a short time as it got again below 2ml/l as soon as in 1973, dropping even below 1ml/l in the second part of that year. In the first half of 1974 there was observed some increase in the oxygen amount there, but in autumn /October/ a complete absence of oxygen was observed in the vast Bornholm area below 70m depth. At the same time in the eastern part of the sea the oxygen conditions appeared to be better, the bottom water there showing though relatively strong oscillations but remaining over 1ml/l until March 1975. In March and May only 0.2-0.4ml/l were found in the Gdańsk Deep, and even less in the Bornholm Deep. Thus the oxygen situation seemed to be quite disastrous again at least till May 1975.

At the beginning of the period reported the bottom salinity of the Bornholm Deep was relatively low /15-16‰/ but due to the above mentioned influx of saline waters it increased till May 1972 to nearly 19‰ being still in February of that year as low as 15,2‰. In the Gdańsk Deep the bottom salinity, amounting to 12-13‰ till August 1971, decreased in autumn below 12‰, but in May 1972 there was an increase exceeding 13‰. After that month, in the western part of the Baltic the salinity at the bottom dropped steadily though with slight oscillations, till May 1975. In the Gdańsk Deep area the bottom salinity

decreased after May 1972 to 12‰ in December. During the following period there were: a salinity peak of nearly 13‰ in May 1973, a minimum in February 1974 /11,7‰/ and two maxima of 13.2 and 13.4‰ in late May and late October 1974, respectively. At the beginning of 1975 slight oscillations of bottom salinity about 12‰ were noted. These oscillations of bottom salinity at about 105m depth in the Gdańsk Deep were caused by another but relatively small salt water influx to the Baltic in 1974.

The bottom water temperature amounting at B_1 to 6-7°C during 1971 increased at the end of that year from 6.8° in November to 8° in February 1972, after then, however, it rather rapidly fell to nearly 3°C in April 1972. Since this date the bottom temperature at B_1 has steadily risen reaching a value of 7.3°C in May 1975. On the contrary, the bottom temperature at G_2 underwent frequent and relatively marked oscillations: in 1971 it oscillated about 6°; in February 1972 it was found to have increased to over 8°C, then it rapidly fell so that in May it was as low as 4.1°C /the minimum of temperature appeared here about one months later than in the Bornholm Deep/. From this point of time the bottom temperature at G_2 - generally taken - increased with time to about 6.5° in April 1973, and remained over 6° till the end of the year. In February 1974 nearly 7°C were noted but during June it decreased by more than one degree. In the period between mid August and late October a new increment, by about 3.5° /to 9°C/ was observed. In February and May 1975 7.0°-7.4° and 6.2° were noted, respectively. The increase in bottom temperature, the same as that in bottom salinity at G_2 have to be

adscribed to the other, already mentioned influx of saline waters in 1974. This influx, however, was not strong enough to replace the bottom water of the Bornholm Deep and push them to the East, only the water at intermediate depths of this deep must have been driven eastward under the pression of the inflowing new water. In this way some changes in salinity, temperature and oxygen content of the bottom water of the Słupsk Furrow and Gdańsk Deep were brought about.

The first strong, influx of the North Sea waters in 1972 caused a considerable increase in salinity not only at the bottom of the Bornholm and Gdańsk Deeps, but in the whole of the water mass of the sea, as it might be concluded from the salinity increase of the surface water layer all over the investigated area. Thus in the Bornholm Deep the surface salinity increased from about 7.3‰ in January 1971 to about 8‰ in April-May 1972, slightly oscillating in the meantime. During 1972 it only sporadically, for short times and slightly descended beneath 7.5‰, whereas in 1973 and 1974 it never was less than 7.7‰ even exceeding 8‰ in May and November-December. During the year of 1974 it oscillated between 7.75‰ and 8.10‰ . In May 1975 it was near to 8‰. In the area of the Gdańsk Deep the surface salinity oscillated about 7.5‰ descending sometimes even below 7.0‰ under influence of the Wistula water discharge, but there was a distinct rise in the salinity in spring of 1972 and from October 1973 the surface salinity here was steadily higher than 7.6‰ with a maximum of 8‰ in June-July and in late October. In May 1975 it was found that the surface salinity dropped to nearly 7.4‰.

The surface temperature indicated all the 5 winters to be rather mild, the lowest temperature observed being 1.5°C. Of all these winters that in 1975 was the warmest one, though the winter of 1973 was also nearly so mild. The first two winters were relatively the coldest, and that of 1974 - an intermediate one with respect to winter temperatures of surface water. The highest summer temperature was noted at G_2 in 1972 /20.8°C/, the lowest, 17.5°C, in 1971 at G_2 and in 1974 in the Bornholm area. The summer maxima were somewhat higher /by about 0.5 - 1.0°C/ in the eastern part of the sea, whereas the winter minima were nearly the same all over the open southern Baltic.

The oxygen content of surface water showed maxima in February-April. In the Gdańsk Deep, they were exceeding 9ml/l and reaching even 10ml/l, whereas in the Bornholm Deep they seemed to be a little lower. The minima of surface oxygen content were observed from late July to September and amounted to 6.0-6.5 ml O_2/l.

Phosphate-phosphorus content of the bottom water in the southern Baltic deeps

Bornholm Deep

For the first two months of 1971 the P-content oscillated between 1 and 2 µqat/l. In following months of that year, however, extremely high P-contents were observed the maximum of which exceeded 10 uqat/l in early September. Still in October it amounted to as much as 9.5 uqat/l. Afterwards there was further decrease to 0.7 uqat/l noted in April and May 1972. In the period of July 1972 to at least

August 1973 the P-content kept rather evenly within the limits of 1.0 and 1.4 µgat/l. In November-December 1973 the factor in question was rather high as reaching above 3 µgat/l. The first P-content measurements in 1974 were taken as late as at the and of April, and at that time 1.5 µgat/l were found. From that point of time the P-content oscillated rather strongly showing the lowest values of about 1 µgat/l in May and October and in May 1975, whereas the highest P-concentrations, viz, 3.4 and 4.4 µgat/l, were noted in January-February and in May 1975, respectively.

Gdańsk Deep

P-content of the bottom water of that deep behaved still more extraordinarily than in the Bornholm Deep, especially in 1971. The values of 1-2 µgat/l during the first four months of 1971 made room for values as high as over 12 /in August/ and 14.6 µgat/l in November 1971. Between the above peaks of bottom P-content there was a quite low concentration amounting to only 3 µgat/l noted in October. As bottom temperature and bottom salinity also were lower at the same time, the cause of that event was to be looked for in the west wind action, due to which the upper iso-haline water layer grew thicker forcing out the deepest water of the Gdańsk Deep outside it for some time. For 1972 values of 3 to 2 µgat/l were observed from January to May, but afterwards the P-content remained almost steady, though oscillating weakly about 1.5 µgat/l until May 1973. From this months to at least November 1973 the P-content rose there to nearly 4 µgat/l. From April 1974 when a value of 1.9 µgat P/l was noted the

P-concentration showed rather strong oscillations between the extrema of 0.6 /in October 1974/ and 3.4 µgat/l /July 1974/. In May 1975 it amounted to 2 µgat/l. Thus the period since the end of 1973 has been peculiar because of relatively strong oscillations of P-content at bottom in both the areas of the southern Baltic.

Vertical distribution of mean phosphate-phosphorus contents

The author calculated the mean phosphate-phosphorus contents for three water layers using data obtained directly for every 10 m depth and those obtained by interpolation by means of curves expressing the P-content as function of depth. These mean refer to particular cruises.

The mean P-contents for the upper water layer of the Bornholm Deep /0-40 m depth/ only exceptionally exceeded 0.5 µgat/l as, for instance, throughout the second half of 1971 till February 1972. The mean P-values for the intermediate water layer /40-70 m/ usually ranged between 0.5 and 1.0 µgat/l except the period from May 1971 to April 1972, autumn of 1973 and winter of 1975. In the bottom water layer /70-95 m/ those mean values usually ranged between 1.0 and 1.5 µgat/l but in 1971 when there was an abnormal increase in P-content of the whole of the southern Baltic waters the mean P-concentrations of the bottom water layer were higher then 1.5 µgat/l from April 1971 to April 1972 with a peak of 6.9 µgat/l in September 1971. Another exceptionally high value /2.6 µgat/l/ was noted in November 1973, and again in February and May 1975 /3.2 and 2.9 µgat/l, respectively/.

The mean P-contents of the whole water column /from 0 to 95 m depth/ changed from about 0.35 in January 1971 to about 2.2 µgat/l in the period from September 1971 to February 1972. After that time a rapid fall took place to a value of 0.24 µgat/l in May 1972 /influx of the North Sea waters into the Baltic!/. In the second half of 1972 the mean P-contents oscillated between 0.5 and 0.9 µgat/l until October 1973. From that time throughout the year 1974 it ranged between 1.0 and 1.5 µgat/l reaching a maximum of 1.73 µgat/l in February. In March 1975 - 0.8 and in May - 1.27 µgat/l were observed.
In the Gdańsk Deep the mean P-contents of the upper water layer /0 - 60 m depth/ was in general like that of the Bornholm Deep, i.e., below 0,5 µgat/l, with some exceptions corresponding to those of the Bornholm Deep. The intermediate water layer /60 - 80 m/ showed stronger oscillations compared with the analogous water layer of the Bornholm Deep. The highest mean value was noted in late August 1971 /3.6 µgat/l/. Apart of the above, the mean values for 60 - 80 m layer exceeded 1.5 µgat/l in the period from December 1971 to February 1972. For the remaining time they oscillated about 1 µgat/l /rather somewhat above 1 µgat/l/, except October and November 1971 /0.3 - 0.4 µgat/l/, October 1974 and May 1975 /0.5 and 0.3 µgat/l/.

P-contents of the bottom water layer /80 - 105 m/ were extremely high in the second part of 1971 showing in August a maximum of 9.7 µgat/l. In February 1972 it was found to be already lower than 3 µgat/l and only once more

the P-content exceeded 3 µgat/l viz., in February 1975. For the remaining time the mean values of P-content oscillated between 0.5 and 2.6 µgat/l.

The mean P-contents for the whole column /0 - 105 m/ generally oscillated between 0.5 and 1.0 µgat/l. They were extraordinarily high in the second half of 1971 and futher on till May 1972, the maximum for this period of time being as high as 3.47 µgat/l in August. Another high value refers to February 1975 /1.45 µgat/l/. The minima were noted in March 1971 /0.3/, October 1975 /0.5/ and in October 1974 /0.3 µgat/l/. In May 1975 - 0.58 µgat/l were observed.

Approximately, the mean P-concentrations of the whole water column in both the deeps were like those of the intermediate water layers.

The observations on different forms of nitrogen occurrence in the southern Baltic have been conducted since 1972 /July/, in the Bornholm Deep and 1973 /January/ in the Gdańsk Deep, thus they still are not sufficient to draw more detailed conclusions except the few ones:

1. Nitrate-nitrogen occurred in relatively greatest concentrations which generally increased with increasing depth.
2. They seemed to be highest from October to January-February next year, accumulating more and more in the winter period when the photosynthetic processes ceased to take place.
3. Nitrite-nitrogen contributed only in a relatively least extent to the whole of nitrogen content of waters.

   Its quantitative distribution did not show any dependence on depth.

4. Ammonia-nitrogen is also irregularly distributed, sometimes its maximum concentration being noted at the very surface. This form of occurrence of nitrogen makes up a considerable portion of the whole of the total nitrogen.

T a b l e I

Mean values of the total nitrogen concentration for the whole water column /0 m - bottom/; Contributions of particular forms of nitrogen occurrence to the whole of nitrogen at stations B_1 and G_2 in 1974; P:N - ratio.

Date	Total N µgat/l	N NO_3 %	N NH_3 %	N NO_2 %	P:N
		B_1			
26.IV.	3.49	56.70	40.40	2.90	0.24
13.V.	1.58	55.06	36.71	8.23	0.32
3.VI.	3.53	57.18	39.99	2.83	0.22
14.VII.	3.59	66.02	32.59	1.39	0.17
17.VIII.	4.37	59.04	40.05	0.91	0.19
27.X.	4.00	81.50	11.75	6.75	0.15
		G_2			
2.II.	5.70	69.97	28.62	1.41	-
23.IV.	4.90	55.92	41.84	2.24	0.16
1.VI.	3.47	54.47	42.07	3.46	0.20
3.VII.	3.49	60.75	36.40	2.86	0.24
5.VII.	3.65	71.51	27.12	1.37	0.28
9.VII.	3.35	73.14	25.67	1.19	0.32
28.X.	4.04	72.41	20.94	6.65	0.08