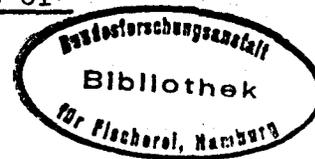


Effect of Oxygen Shortage in Deep Waters on
the Biology of Zoobenthos in the Deeps of
the Southern Baltic

by

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One of the inherent features of the Baltic Sea as of other mixohaline environments is a stable stratification of its sufficiently deep waters. The deep water layer, the so-called hypothalassa is distinguished by a generally low and rather uniform temperature, and especially by a comparatively high salinity which depends upon the intensity of the oceanic influx to the Baltic through the Transition Area. These influxes, however, are not continuous and therefore periods of stagnation exist during which a dilution of the waters of the hypothalassa takes place, due to their contact with the upper highly dilute waters of the so-called metathalassa.

The stagnation periods of longer duration cause above all a rapid depletion of the dissolved oxygen, especially in deeper waters of the hypothalassa immediately above the muddy sediments which are rich in dead organic matter.

According to my observations the rate of decrease in the oxygen content under the conditions found in the Bornholm Deep, amounts to nearly 1 milliliter per liter and month. In the Gdańsk Deep the oxygen consumption rate is generally twice as high. It may be added that the oxygen consumption rate is nearly always higher in cases of high oxygen content, while by lower concentrations the decrease rate may be as low as 0.1 - 0.5 ml/l/month.

Since the maximum oxygen content in the bottom waters of the central parts of the deeps hardly exceeds 6 ml/l, it follows that in a period of only half a year a considerable deficiency of oxygen may take place. The content often decreases to a degree as low as some tenths of ml/l, and sometimes even 0 ml/l is observed.

A strong deficit of oxygen would cause catastrophic results in respect of the qualitative and quantitative composition of the bottom communities, and sometimes leads to complete dying away of zoobenthos over wide bottom areas. Such biological processes are inherent in the character of the two deepest regions of the southern Baltic, e.g. of the Bornholm and Gdańsk Deeps. It may be emphasised, however, that the stagnation of deep waters and the related oxygen deficit generally are of longer duration in the Bornholm Deep in comparison with the Gdańsk Deep. This is undoubtedly connected with a relatively greater isolation of the Bornholm Deep which is separated from adjoining areas by rather high thresholds of maximal depth 50-60 m, the maximal depths of this Deep itself being about 100 m.

In comparison with that, the Deep of Gdańsk, with its maximum depth of about 110 m, is separated in the north by a weakly marked ridge of minimum depth near to 90 m. Therefore, the isolated bottom water layer in the Deep of Gdańsk is only about 20 m thick, while in the Bornholm Deep the corresponding thickness is twice as big, namely nearly 40 m.

The stagnation periods and the related oxygen deficit exert a highly destructive effect on the bottom fauna. Above all they cause a far going selection in respect of species, and they also restrict their quantitative occurrence considerably.

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In conditions of high oxygen deficiency only few oligoxybiotic species are able to exist in the Baltic, among which the comparatively most numerous are the polychaet Scoloplos armiger and the bivalve Astarte borealis. It may be added that this last species seems to avoid the Gdańsk Deep because of insufficient salinity. These two species survive the oxygen decrease to nearly 1 ml/l, and for short periods they can survive even at lower oxygen concentrations.

During longer stagnation periods, however, the oxygen content often falls beneath 0.5% ml/l. Particularly low values are observed in the Bornholm Deep, since the oxygen amount frequently falls below 0.2 ml/l and there can even be cases of entire lack of oxygen in the bottom water.

Longer stagnation periods in the Bornholm Deep, such as those of 16-20 months duration, during which the oxygen content falls nearly to traces, were noted four times in the last two decades; namely rather soon after the big oceanic influx from the end of 1952 to the beginning of 1954, and afterwards during the years 1955-1956, 1962-1963 and 1965-1966. Besides, a series of shorter stagnation periods were observed in that Deep. As a rule they also resulted in a marked decimation of the bottom fauna and, in extreme cases, all animals died away over wide bottom areas.

Such a cemetery was found in 1950, 1953, 1954, 1963 and 1964. It is characteristic that cemeteries like that were observed not only in periods of oxygen deficits but also sometimes for some months after the stagnation had passed by, that is under relatively better oxygen conditions. This shows that a rather long time is needed for the bottom fauna to recover.

It depends, however, chiefly on the season in which the aeration of the deep bottom waters takes place. If the oxygen deficit comes to an end in spring or summer, that is, in the period of mass development of pelagic larvae of some benthic species, there is a considerable greater chance for the bottom fauna community to regenerate. On the contrary, in cases when the renewal of waters takes place in the advanced autumn or in winter, and that is most frequently the case with respect to the Baltic, several months are sometimes needed before the deeper places are settled anew by more numerous benthic animals. Such a situation was noted by Pavo Tulkki in the winter of 1964, and by our scientists in the winter of 1949.

It is a pity that hitherto zoobenthic investigations have been carried out only sporadically and irregularly. Therefore our knowledge of the bottom fauna is not representative enough, since the patchy distribution found has not always enabled us to judge the degree of changes which have occurred in the Bornholm Deep. It has namely been ascertained that even under conditions of high oxygen deficiencies, some few bottom animals have survived on some more or less restricted spots of the Bornholm Deep. This may be connected with the somewhat differentiated bottom sediments, since grounds with relatively low content of organic matter seem to favour the survival.

In the Deep of Gdańsk the renewal of bottom waters is more frequent and in connection with that the stagnation periods are of shorter duration. As mentioned above they do not exceed 5-7 months. On the other hand, a more rapid exhaustion of oxygen is observed here, possibly because of concentrations of larger fish, especially cod, on a rather small area of this Deep. Finally, high oxygen deficits occurring here give oxygen values near to 1 ml/l. Values lower than 0.5 or 0.2 ml/l must be considered rather a rarity.

Nevertheless, in some periods a mass dying-away of bottom fauna on wide areas is observed also in this Deep.

Unfortunately, also in this Deep studies on the distribution of the bottom fauna have been irregular. It is, however, significant that the periods where the bottom fauna disappeared did not always concur with those of high oxygen depletion. Such a lack of concurrence was particularly conspicuous in 1956 and at the beginning of 1957 when in the central part of the Gdańsk Deep (at depths greater than 95 m) the proper bottom fauna was entirely absent while the oxygen content ranged between 2 and 3 ml/l. It may be said, however, that in the period previous to the benthic studies (New Year 1955/56) a considerable oxygen deficiency was observed. Afterwards the oxygen conditions improved, but in spite of that the proper fauna did not, for nearly a year, develop at all. The chief cause for this may have been the temperature of the bottom waters, which was lower than usual, and this low temperature negatively influenced the development of larval forms of the benthic animals.

Generally, however, after a renewal of bottom waters the bottom fauna developed rather quickly and abundantly. The renewal of waters is accompanied by a simultaneous increase in salinity which favours the development of several marine species. Such a case was especially distinctly observed in the Bornholm Deep immediately after the big oceanic influx at New Years time 1951/52. At that time the nemertineans and molluscs (for example Macoma calcarea and Astarte borealis) were developing exceptionally abundantly.

When a renewal of deep waters takes place in the Deep of Gdańsk, the kryophile species develop most frequently in the central part of the Deep, especially those belonging to the Priapulidae (Priapulus caudatus and Halicryptus spinulosus).

Generally it may be stated that both the qualitative composition and the quantity of individuals of particular species inhabiting the central parts of both Deeps, vary in very wide ranges, in accordance with the very variable and intricate hydrographical situation of the southern Baltic.