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Indicator Report

WATER EXCHANGE BETWEEN THE BALTIC SEA AND THE NORTH SEA AND CONDITIONS IN THE DEEP BASINS

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Key message

In January 2003, a deep-water renewal process in the Baltic Sea commenced by an inflow of about 200 km³ of cold and well oxygenated water from the Kattegat which is considered the most important since 1993. Already in May, the central Gotland Basin was reached by water with near bottom oxygen concentrations belonging to the highest ever recorded there.

Results and assessment

- Deep water renewal processes in the Baltic Sea depend on specific meteorological circumstances, which force substantial amounts of seawater, enriched with salt and oxygen, from the Kattegat through the Danish Straits into the Western Baltic. From there, it slowly moves as a thin bottom layer into the central Baltic basins, replacing aged water masses there. To make this happen, easterly winds have to blow continuously for about 10 days to lower the Baltic fill factor, followed by a sudden turn to westerly gale winds, which again need to last for about 10 days or longer in order to cause the fill factor rising to its maximum.
- Before about 1980, such events were relatively frequent and could be observed on average once a year. In the last two decades, however, they became rather scarce; the last such major inflow took place in 1993. Since then, oxygen levels of Baltic deep waters had dramatically decreased and were still in what is called a 'stagnation state' until recently. This 'pathological' deep water status is displayed in Fig.1.
- The stagnation period was finally terminated by a major Baltic inflow (MBI) in January 2003 of about 200 km³ of cold and well oxygenated water from the Kattegat, half of it with salinities above 17 psu. According to the well accepted classification scheme by Fischer and Matthäus (1996) the intensity can be calculated to $Q_t = 20.3$ which is just at the lower limit of the strong interval $20 < Q_t < 30$.
- The effect of the January inflow was enhanced by preceding smaller events in autumn, 2002. Exceptional weather conditions in late summer 2002 caused the transport of extremely warm waters into layers at and below the permanent pycnocline. Although carrying only small amounts of oxygen, they were capable of completely ventilating the Gdansk Basin by November 2002, and reducing hydrogen sulphide concentrations even up to the Gotland Basin. The succession of salty water batches passing the Darss Sill with different temperatures and oxygen levels has been recorded by the permanent MARNET station DS there, see Fig. 2.
- Already at the end of January, when the inflow had reached the western part of the Bornholm Basin, the whole water column there was well oxygenated with 6.7 ml/l near to the bottom along with salinity measured of 18.7 psu. The dynamical sequence of deep water transformations in this basin (between 50 m depths and the bottom) is reviewed in Fig. 3.
- Afterwards, the effect of the MBI in January was especially amplified by the oxygen-rich and cold waters passing the sill almost all March 2003 long.

- In the Gotland Deep area, the arrival of the inflow was observed at the end of April, accompanied by a substantial decrease in temperature, enhanced basin circulation current, and rise in oxygen level. In May, at the central station 271 (= BMP J1) between 200 m and the bottom, remarkable amounts of oxygen were found with up to 4 ml/l. Similar amounts of oxygen were measured only two times before, in the 1930s and in May, 1994.
- In August the propagation of cold and oxygen-rich waters deeper into the central Gotland Basin was continuing. The ventilation of the water body below the halocline was still in dynamical progress. At the central station 271 the whole water column was oxygenated with lowest concentration of 0.5 ml/l at 100m. Near the bottom, oxygen depletion processes have already reduced the concentration from almost 4 ml/l in May to still 2.3 ml/l in August 2003. The entire deep water between the western Baltic and the Gotland Basin has become 'healed' as displayed in Fig. 4.
- However, at the western side of the eastern Gotland Basin regions with anoxic conditions have still been observed.
- The deep water in the Fårö Deep is presently still completely anoxic but with reduced hydrogen sulphide levels. The western Gotland Basin was not influenced up to now by the major inflow.

References

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Acknowledgments

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Summary (<20 words)

The stagnation period which lasted since 1995 was terminated by the strong major Baltic inflow from January 2003.

Figures

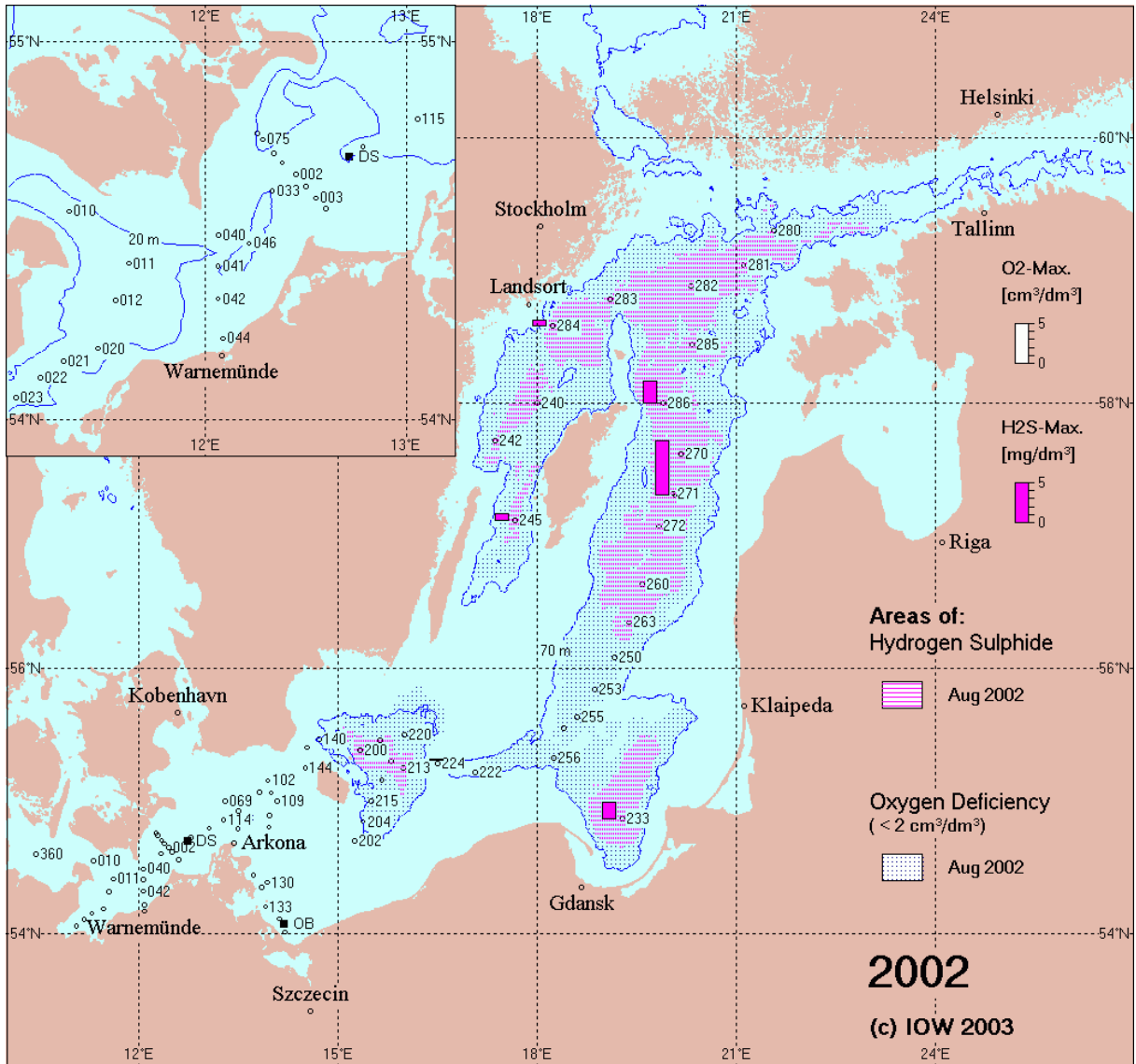


Fig. 1: Location of stations (■ MARNET-stations) and areas with oxygen deficiency and hydrogen sulphide in the near bottom layer of the Baltic Sea in August 2002, i.e. at the stagnation period summit before the inflow events of 2002 and 2003. Histograms show the maximum oxygen and hydrogen sulphide concentrations of this layer. The figure contains additionally the 70 m resp. 20 m (small picture) isobaths.

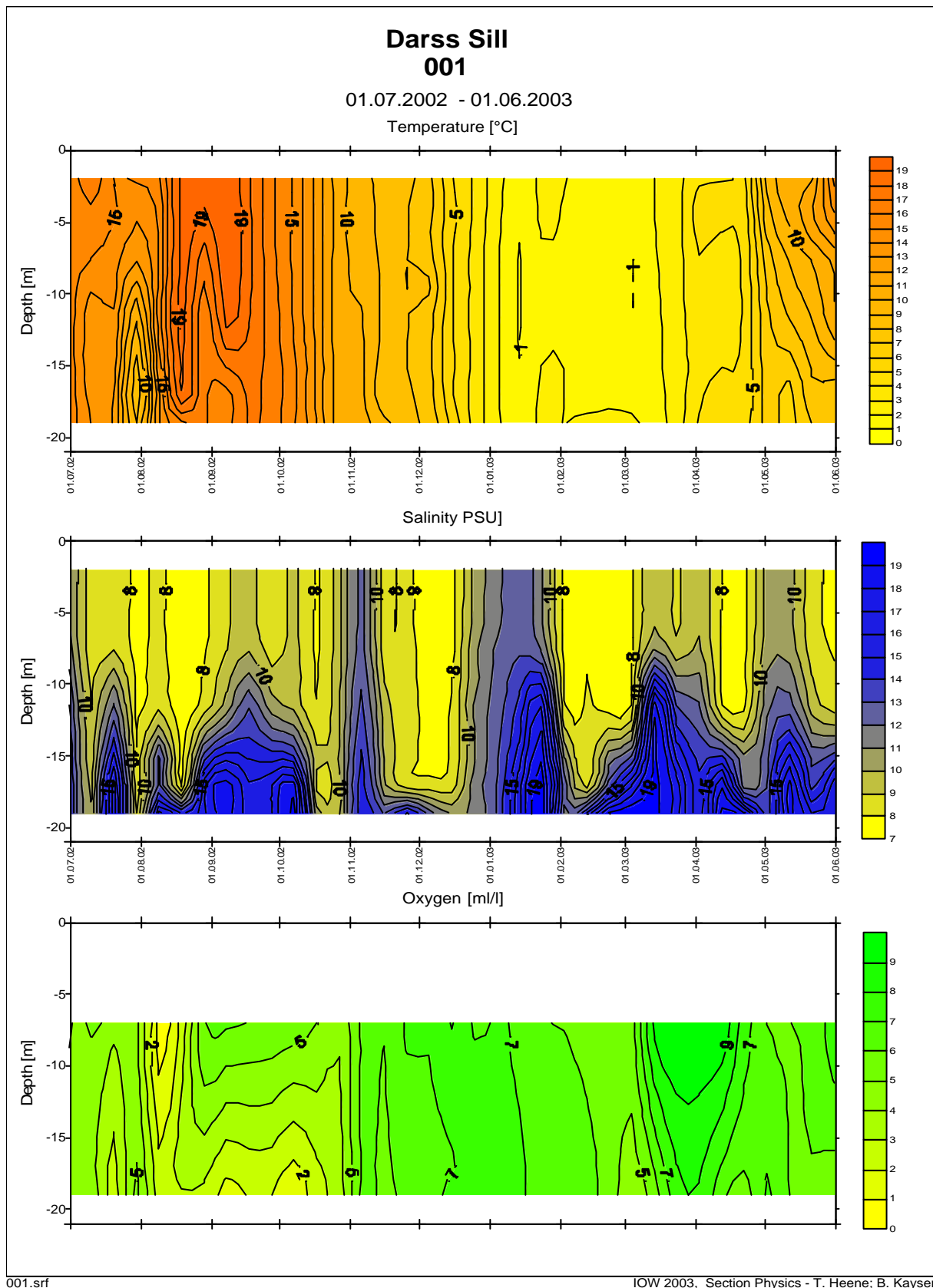


Fig. 2: Vertical profiles of temperature, salinity and oxygen recorded at the MARNET station Darss Sill between July 1st, 2002 and June 1st, 2003. The January inflow is marked especially by its lasting high surface salinity (January, 16th to 25th, 2003). Note the accompanying weaker inflow signals in September and November, 2002, and in March and May, 2003.

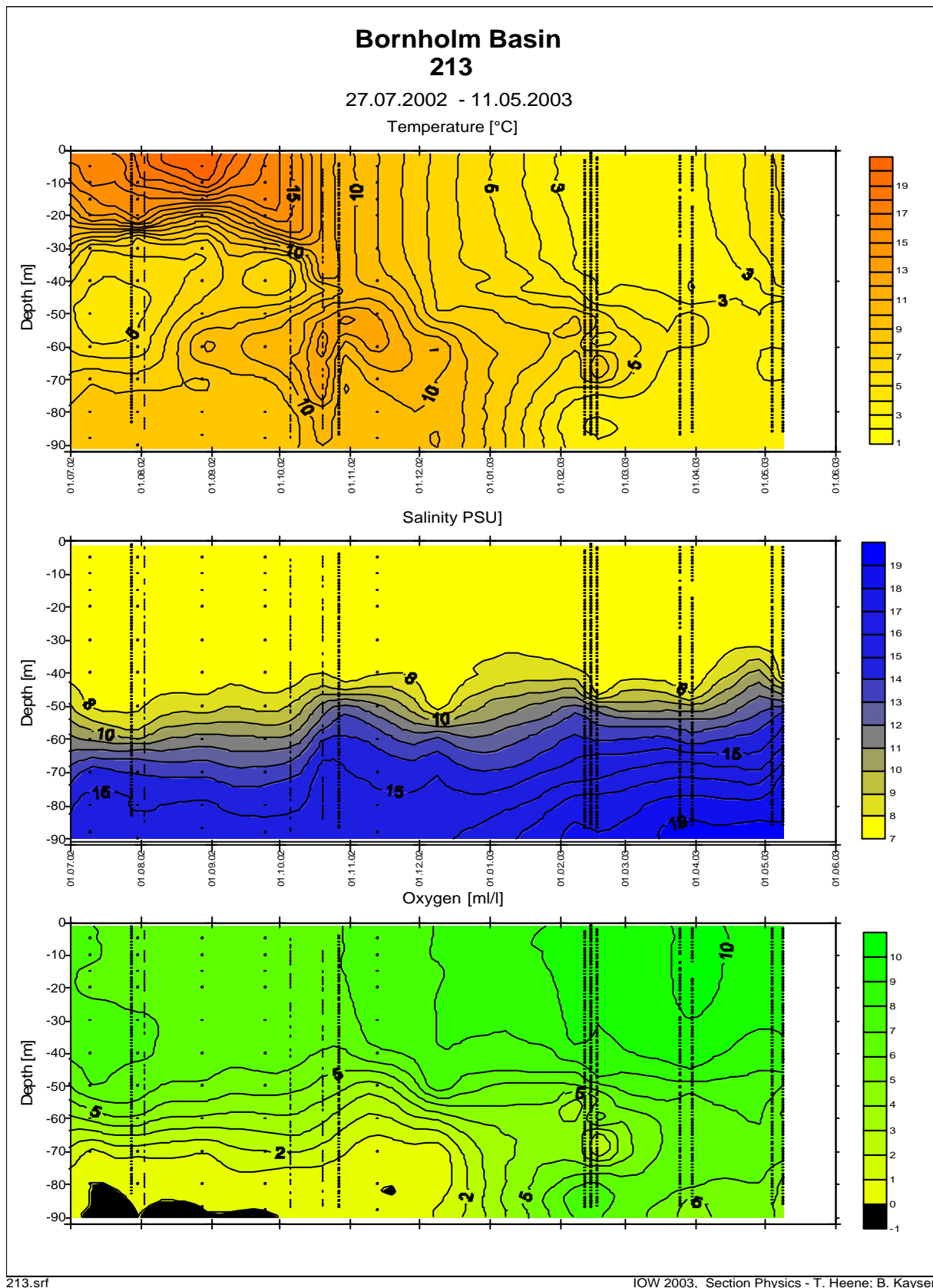


Fig. 3: Vertical profiles of temperature, salinity and oxygen measured in the Bornholm Basin between July 27th, 2002, and May 11th, 2003. Note the effects of the warm water inflow visible in October/November and those of the cold January inflow.

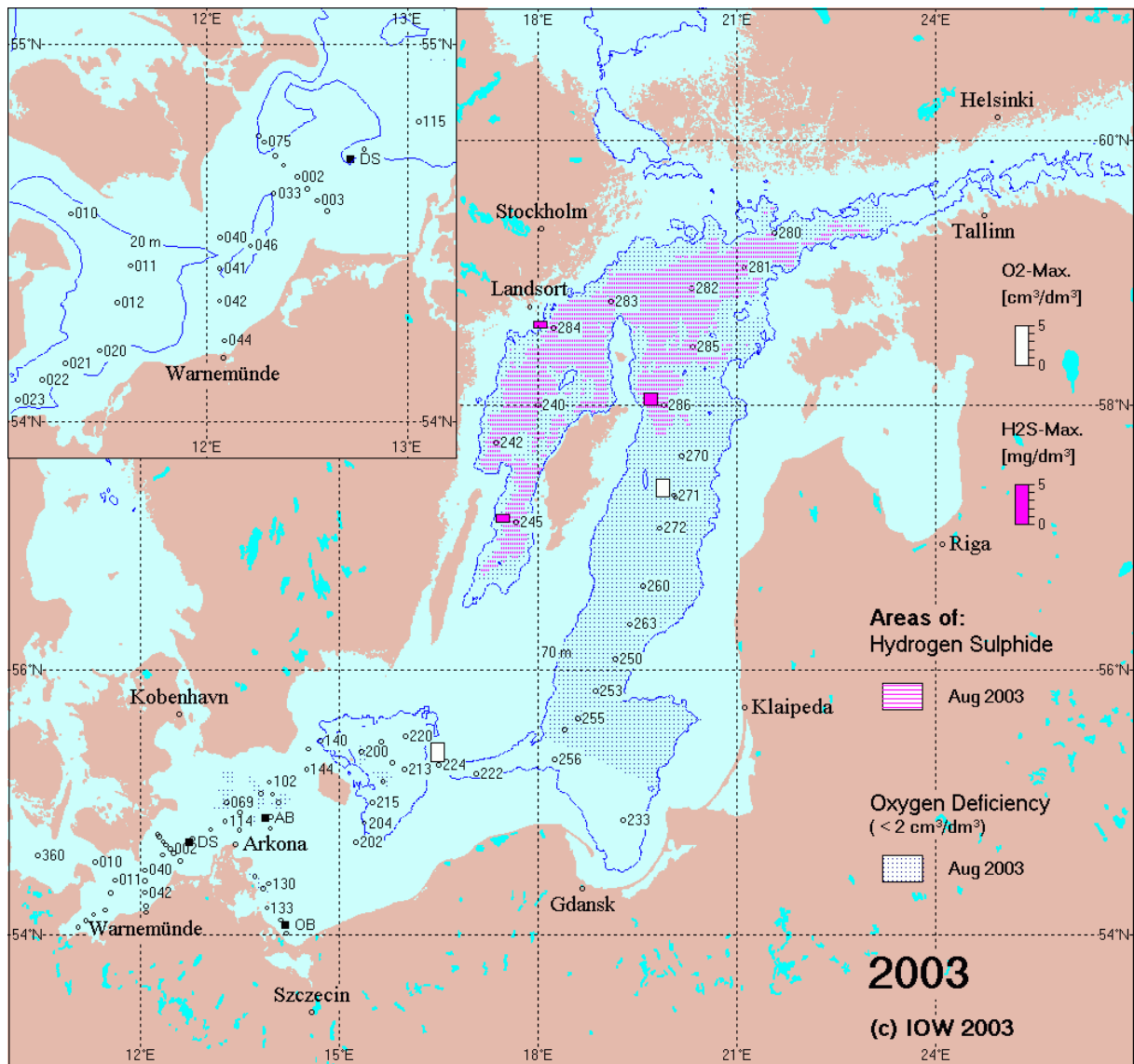


Fig. 4: Location of stations (■ MARNET-stations) and areas with oxygen deficiency and hydrogen sulphide in the near bottom layer of the Baltic Sea in August 2003, in a stage of progressing deep water ventilation. Histograms show the maximum oxygen and hydrogen sulphide concentrations of this layer. The figure contains additionally the 70 m resp. 20 m (small picture) isobaths.