

## Development of Sea Surface Temperature in the Baltic Sea in 2003

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### Key message

The development of Sea Surface Temperature (SST) in the Baltic Sea in the year 2003 was characterised by a rather cold winter and a warm summer. Particularly, the winter in the northern part of the Baltic Sea was very cold with long ice coverage. The strong warming occurred in July in the entire Baltic Sea which induced high water temperature in the entire Baltic Sea and the highest of the last 14 years in the northern part.

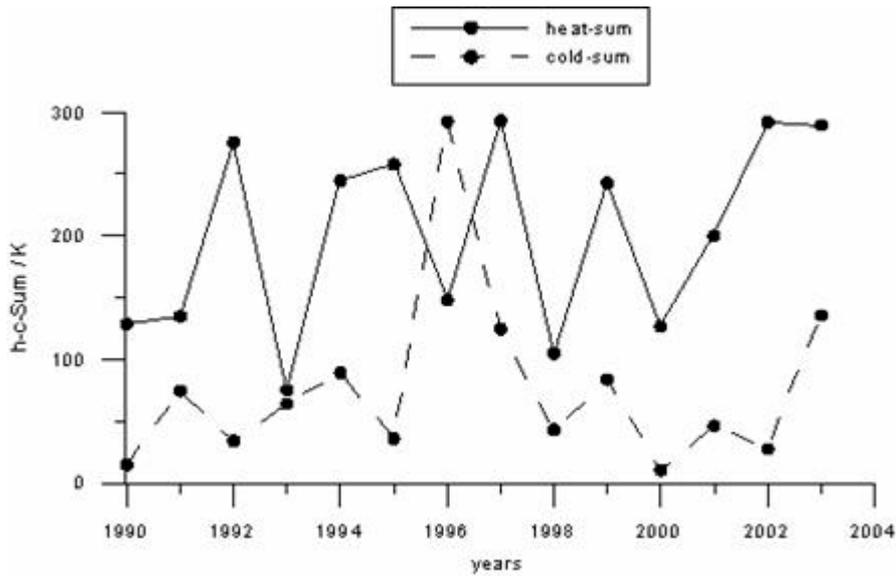
### Background

Sea Surface Temperature (SST) derived from data of the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) weather satellites were provided by the German Federal Maritime and Hydrographic Agency Hamburg (Bundesamt für Seeschifffahrt und Hydrographie Hamburg, BSH). The BSH operates a SeaSpace HRPT (High Resolution Picture Transmission) receiving station and receives data from two NOAA satellites with up to seven daily records of the Baltic Sea. The SST data evaluation procedure is described by Siegel et al. 1994. SST data were implemented in the yearly assessment of the Baltic Sea since 1996 provided by the Baltic Sea Research Institute Warnemünde (Matthäus et al. 1997). Systematic studies on seasonal and inter-annual variations in SST are published in Siegel et al. 1999. This report is based on the results included in the assessment of the year 2003 (Nausch et al. 2004).

The assessment of the sea surface temperature of the Baltic Sea in the year 2003 was performed on the basis of daily and monthly mean values. The monthly means were used to investigate the seasonal development and inter-annual variations. The daily mean values were applied to retrieve particularities in the detailed thermal development. Based on the monthly mean values of the year 2003 and the long-term means of all months of the period 1990 - 2003 anomalies were calculated.

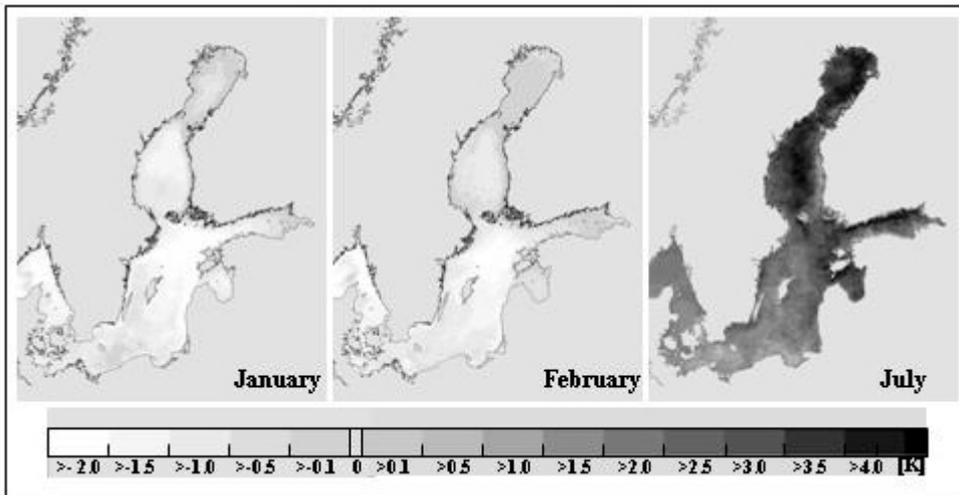
### Results and assessment

The year 2003 was essentially characterized by two particularities in the thermal development of the Baltic Sea, a comparatively cold winter and a warm summer. On the basis of the cooling and heat sums of air temperature of Warnemünde the winter 2002/2003 was the second coldest after 1995/1996 since 1990 and the summer 2003 the third-warmest after 1997 and 2002 (see Fig. 1).

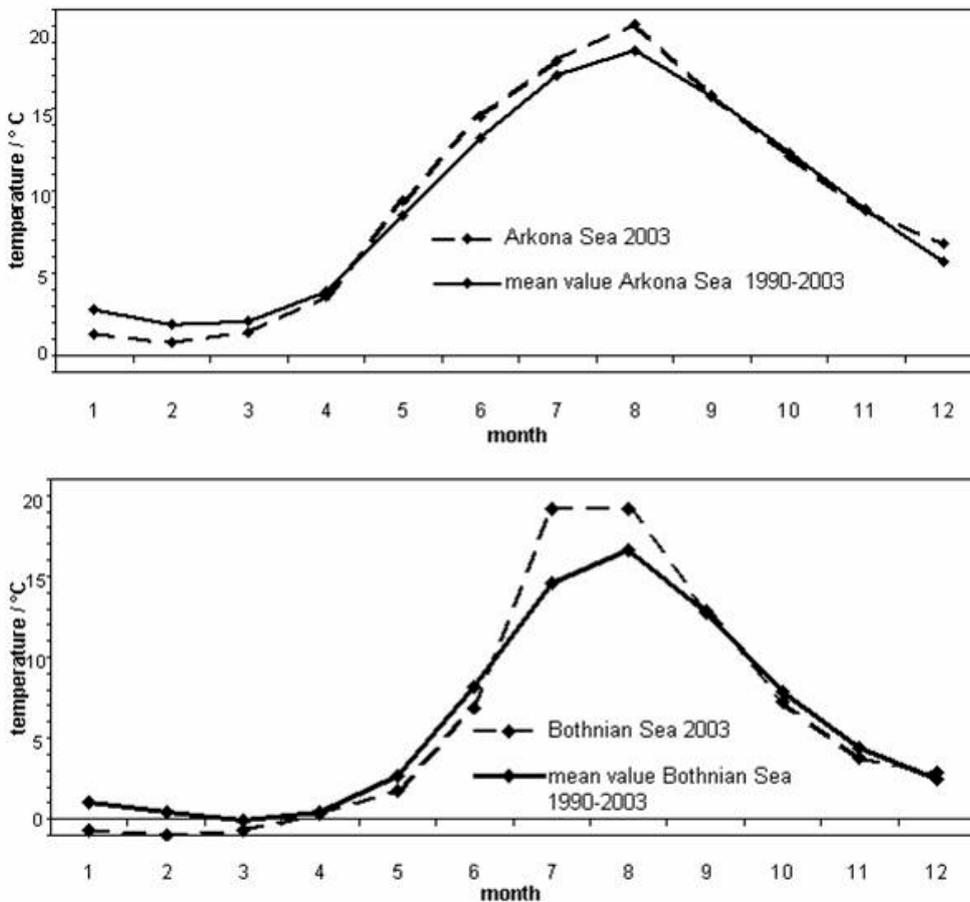


**Figure 1.** Heat and cold sums of air temperature of Warnemünde for 1990-2003

The impact on the SST of the Baltic Sea and the spatial and temporal particularities are discussed on the basis of the anomalies of the months January, February and July (Fig. 2), of the seasonal course at central stations in the Arkona- and Bothnian Sea compared with the mean values of the last 14 years (Fig. 3) and based on SST distribution along the monitoring transect through the central basins of the Baltic Sea in January, February, and July in comparison to the 14 years means and other extreme years (Fig. 4).



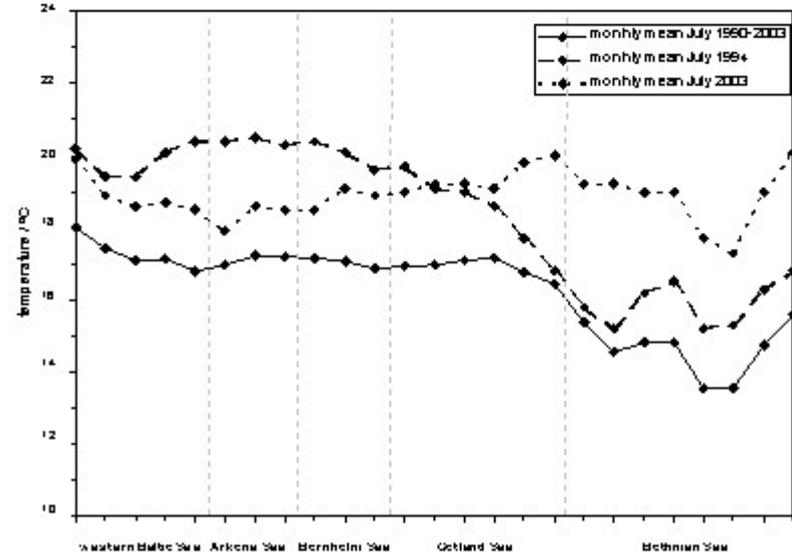
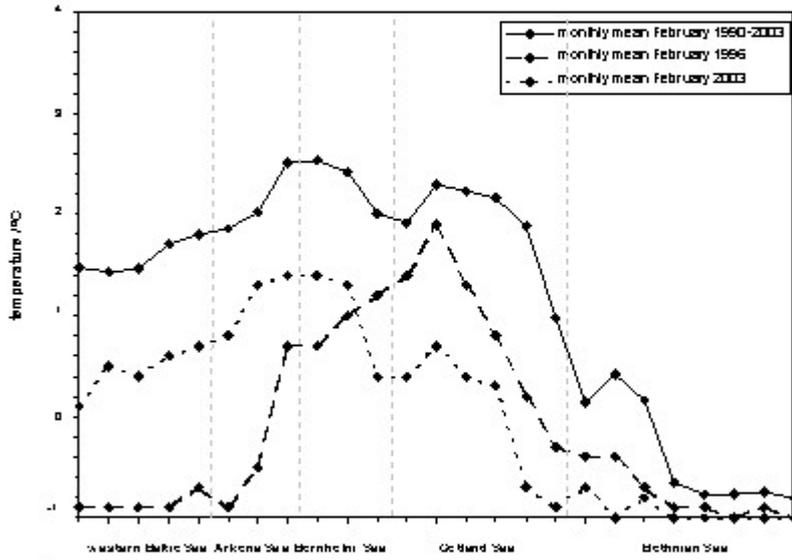
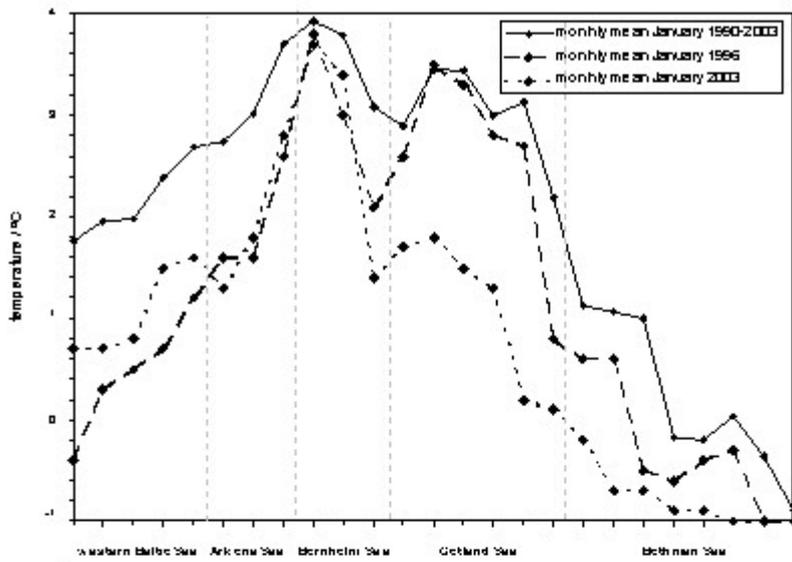
**Figure 2.** Anomalies of SST in the Baltic Sea in the month January, February and July 2003 referring to the mean values of the years 1990 - 2003.



**Figure 3.** Seasonal course of SST at stations in the Arkona- and Bothnian Sea in 2003 compared to the mean values of the last 14 years

After the cold December 2002, in which the Baltic Sea had been cooled down from the north by a long high pressure phase (Nausch et al. 2003), the January 2003 belonged with water temperatures in average below 2 °C to the colder since 1990 (Fig. 3). An exception formed the Bornholm Sea with high values between 3 and 4°C, which was not influenced by the cooling. These values represent nearly the long term mean values (Fig. 4). North of the Stolpe Channel the lowest values since 1990 were present (Fig. 4). The anomalies were highest in the Farö Deep with -2.8K (Fig. 2). The cooling continued also as usual in February. In the western Baltic Sea the monthly means with values below 1°C representing the second lowest temperatures after 1996, but a freezing was not observed. The maximum temperatures were further between the Arkona and Bornholm Seas. In the Gotland Sea the temperatures were up to 2K below the long-time average value. North of the Farö Deep on average negative temperatures were present, which led to the very pronounced maximum freezing. The lowest water temperatures were observed in the southern Baltic Sea at the end of February, but in the northern Baltic Sea the cooling of the water continued and in this year the maximum ice coverage was registered at the 6 March. The first warming phase started from the west in the middle of March. The temperatures increased to 2-4°C. The next phase was then at the beginning of April. The situation with temperatures between 4 and 6°C continued then until approximately 10 May, followed by a further heating. In May the temperature range of the long-term means was again reached and in the western Baltic Sea slightly exceeded. Ice was observed in the North until end of May. At the beginning of

June most parts of the Bothnian Bay had surface temperatures below 2°C. In June the development in the Baltic Proper was also comparable to the long-term means and reached end of the month values around 15°C. In the western Baltic Sea the water temperature approached 17-18°C up to +2K in the anomalies. Around 25 June the temperatures were between 10 and 15°C also in the northern Baltic Sea. After 14 July an intensive warming phase started in the entire Baltic Sea.



**Figure 4.** Temperature distribution along the monitoring transect through the central basins of the Baltic Sea in January, February, and July in comparison to the mean value of 1990 – 2003 and to extreme values of other years. To 25 July the surface temperature (2m) at the MARNET station "Arkonasee" rises from 14°C to 20°C and from 2 August even 22° is reached. After 13 August the temperature decreased within two days by 3°C in consequence of a strong wind period.

In the Gotland Sea and in the northern Baltic Sea this development occurred much faster. Already on 17 July in far parts SST above 20°C were reached. At the end of July in the eastern Gotlandsee and in the Gulf of Finland temperatures exceeded slightly 25°C. In the month of July the anomalies in the Arkona Sea and in the Bornholm Sea were about +1 K; whereas in the northern Gotlandsee values between +3.5 and +4 K were observed and in the Bothnian Sea values up to approximately +4.5 K were reached (Fig. 2). North of the central eastern Gotlandsee the highest monthly mean temperatures were determined since 1990 (Fig. 4). In the warmest July of the last 14 years in 1994 the temperatures have been higher only in the southern part. In August 2003, there was a slight increase of the sea surface temperatures, which reflected also the heat sums of the air temperature which were slightly under those of July. Nevertheless, the August also belonged to the warmest since 1990. In the northern Gotlandsee the extreme values of August 2002 were not reached, but in the Bothnian Bay the highest values had been observed since 1990. The maximum temperatures were determined in this year already on 1 August, earlier than in the previous years, however with values of more than 25°C in the eastern Gotlandsee and in the Gulf of Finland. From 5 August the cooling started and received a new impulse on 14 August identical with the strong wind phase in the Arkona Sea and the temperatures already sank in far parts under 20°C. In the further development the temperatures decrease continuously slowly except in the northern Baltic Sea. If at the end of September temperatures between 15 and 17°C are still present in the southern Baltic Sea, the northern Baltic Sea is already cooled down on values below 5°C. Due to the cooling in the second half of August the monthly means of September were in the range of the average value of the investigation period. Overall the summer 2003 was quite warm and belonged to the warmest since 1990. After 20 October the temperature of the entire Baltic Sea decreased clearly below 10°C. The further thermal development in the year 2003 continued without particularities.

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