

Development of Sea Surface Temperature in the Baltic Sea in 2002

Authors: Herbert Siegel and Monika Gerth
Baltic Sea Research Institute Warnemünde (IOW)



Key message

The development of Sea Surface Temperature (SST) in the Baltic Sea was characterised in the year 2002 by a very fast warming already in June, rather warm and long summer with water temperatures of more than 20°C until mid September. An abrupt cooling followed in October and a phase with comparably low water temperature continued until the end of the year.

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 2002 (Nausch et al. 2002).

The assessment of the sea surface temperature of the Baltic Sea in the year 2002 was performed on the basis of daily and monthly mean values derived from data of the NOAA weather satellites. The monthly means were used to discuss 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 2002 and the long-term means of all months of the period 1990 - 2000 anomalies were calculated.

Results and assessment

The anomalies of monthly mean SST of 2002 were used to show strong deviation in SST in different months and regional particularities, that appear particularly in January, June, August, September and December, as comprised in **Figure 1**.

January 2002 is with water temperatures lower than 2 °C in the mean value one of the colder since 1990. In general, the anomalies were about –0.5 K, and in the Bornholm Sea approximately –1.5 K. In the Baltic Proper the temperature did not decrease in customary in February and March. Cooling down was only observed in the Bay of Bothnia, where then also an added ice-formation started and the maximum ice coverage occurred mid March. The coldest day was 14 March, where the entire northern part of the Gulf of Bothnia was ice covered.

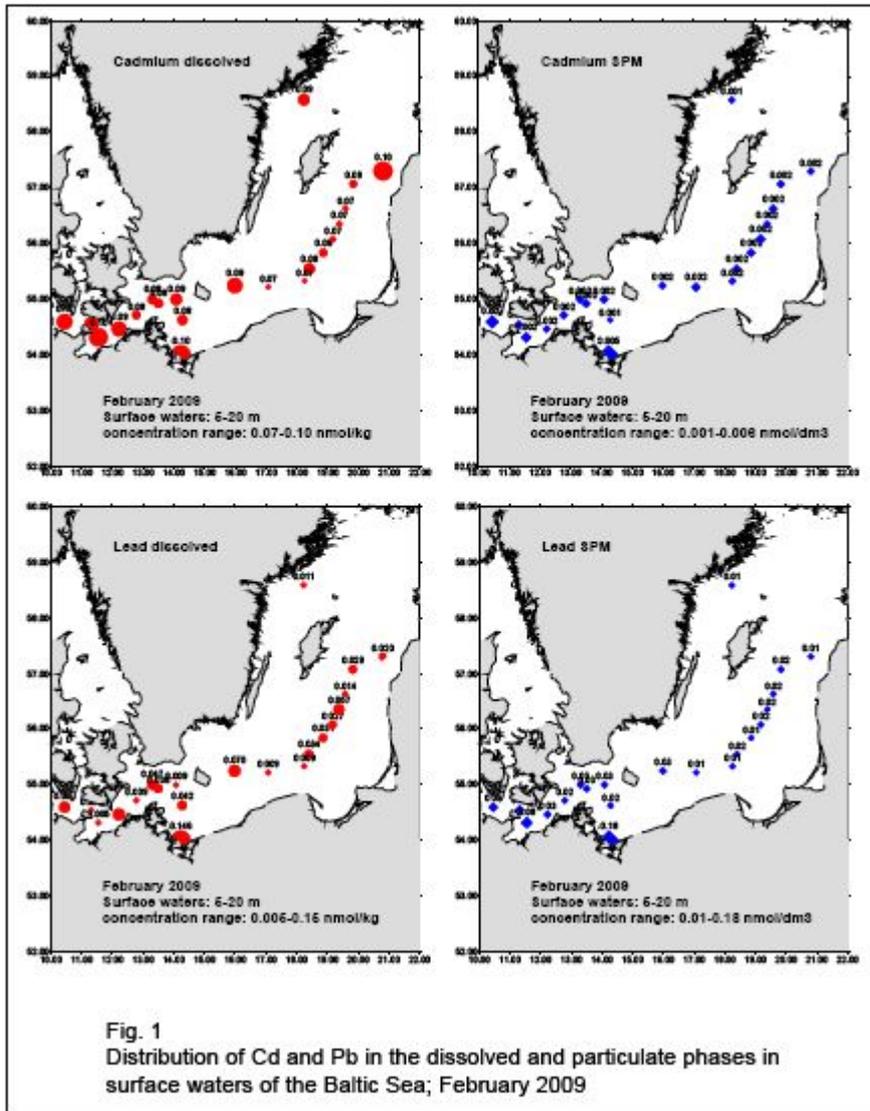


Figure 1. Anomalies of SST in the Baltic Sea in the month January, June, August, September and December 2002 referring to the mean values of the years 1990 - 2000.

Overall, the summer 2002 was very warm and besides 1997 and 1999 one of the warmest since 1990. The mean temperatures have been already remarkable high in June with values of about 14°C measured in the central Baltic Sea. Similar temperatures were only observed in June 1992. The anomalies in the Arkona- and Bornholm Sea have been about +1 K, but in the northern Gotland Sea between +3.5 and +4 K and in the Gulf of Bothnia values up to +5 K were reached. The July was relatively warm, but the August and September delivered extreme mean temperatures. In August high sea surface temperatures were recorded in the entire Baltic Sea, but they did not reached in the western and central Baltic the maximum values from 1994 and 1997. In the northern Baltic the August 2002 was the warmest since 1990. In relation to the long-term mean value anomalies between +1.5 and +2 K appeared in the entire southern and western Baltic. In the northern Gotland Sea and in Gulf of Bothnia the anomalies extended up to +4 K. Long lasting high pressure situations combined with easterly winds produced upwelling along the Polish coast leading to negative anomalies with values of -1.5 K. September 2002 was in the entire Baltic Sea by far the warmest since 1990. The second warmest was in 1999. The anomalies in September 1999 were about 2K less than in September 2002. Thus, most parts of the central Baltic were characterised by anomalies between +4 K and

the Gotland Sea by up to +5 K. In October the temperature was rather normalised, but a dichotomy occurred. The western Baltic is still rather warm, but the northern parts in the Skagerrak and in the Baltic cooled fast down, which continued in November and December. The early winter in Northern Europe induced in December the lowest water temperatures since 1990. Particularly, in the areas of Skagerrak, Kattegatt and northern Gotland Sea temperatures decrease down to values below 2°C and in the Gulf of Bothnia a strengthened ice-formation started. That is also expressed in the negative anomalies in the entire Baltic. The maximum values of < -4K were found for Skagerrak, Kattegatt and northern Gotland Sea.

The annual cycle of the surface temperature at the central stations in the Arkona and eastern Gotland Sea in comparison to the 11-years mean values (**Figure 2**) emphasise the high temperatures in June and August and the exceptional high values in September. Furthermore, the graph points out the extreme cooling in the northern Baltic in October to December.

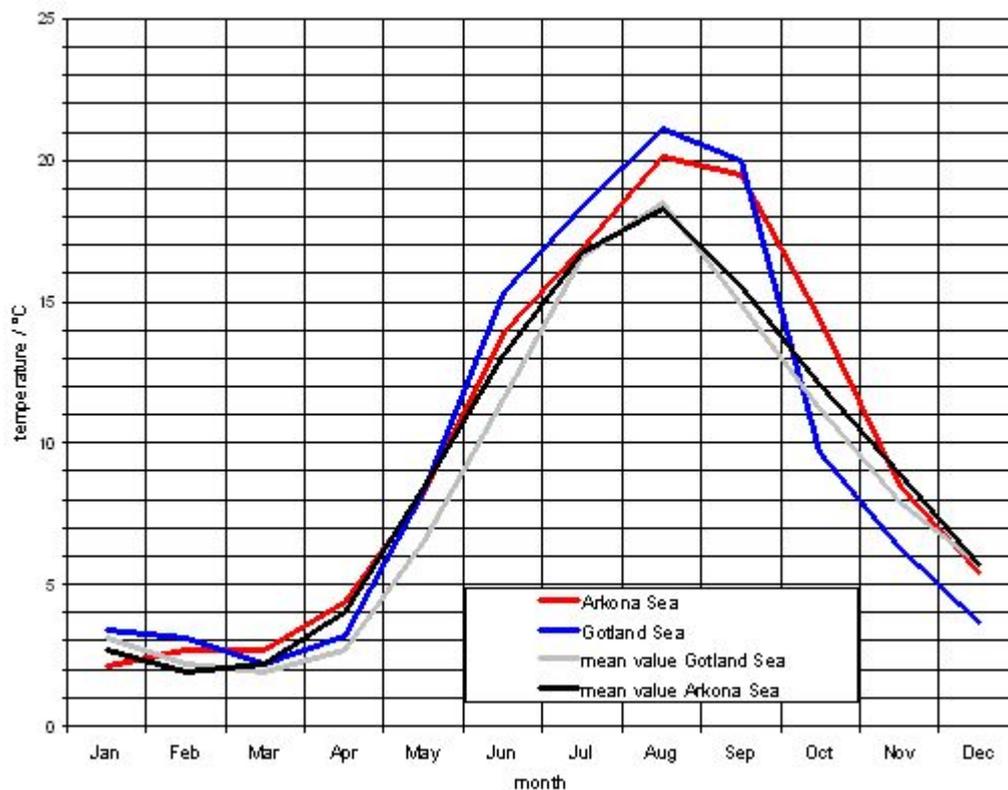


Figure 2. Seasonal course of sea surface temperature (NOAA-SST) at stations in the Arkona- and eastern Gotland Sea in 2002 in comparison to the mean values of the last 11 years on the basis of monthly mean SST.

The specific conditions in summer 2002 are once more shown by means of SST for the months June, August and September along a transect through the central basins compared with the long-term mean values (1990 - 2000) and the extreme values of other years (see **Figure 3**). The high temperatures north of the Bornholm Sea up to the Gulf of Bothnia may be identified. In August the temperatures in the entire Baltic were higher than the long term means. In comparison to the warmest August (1997) in the nineties a considerable warming in the northern Baltic can be recognised. In September the SST values of the entire Baltic have been higher than the long term mean and the data from the warmest September since 1990.

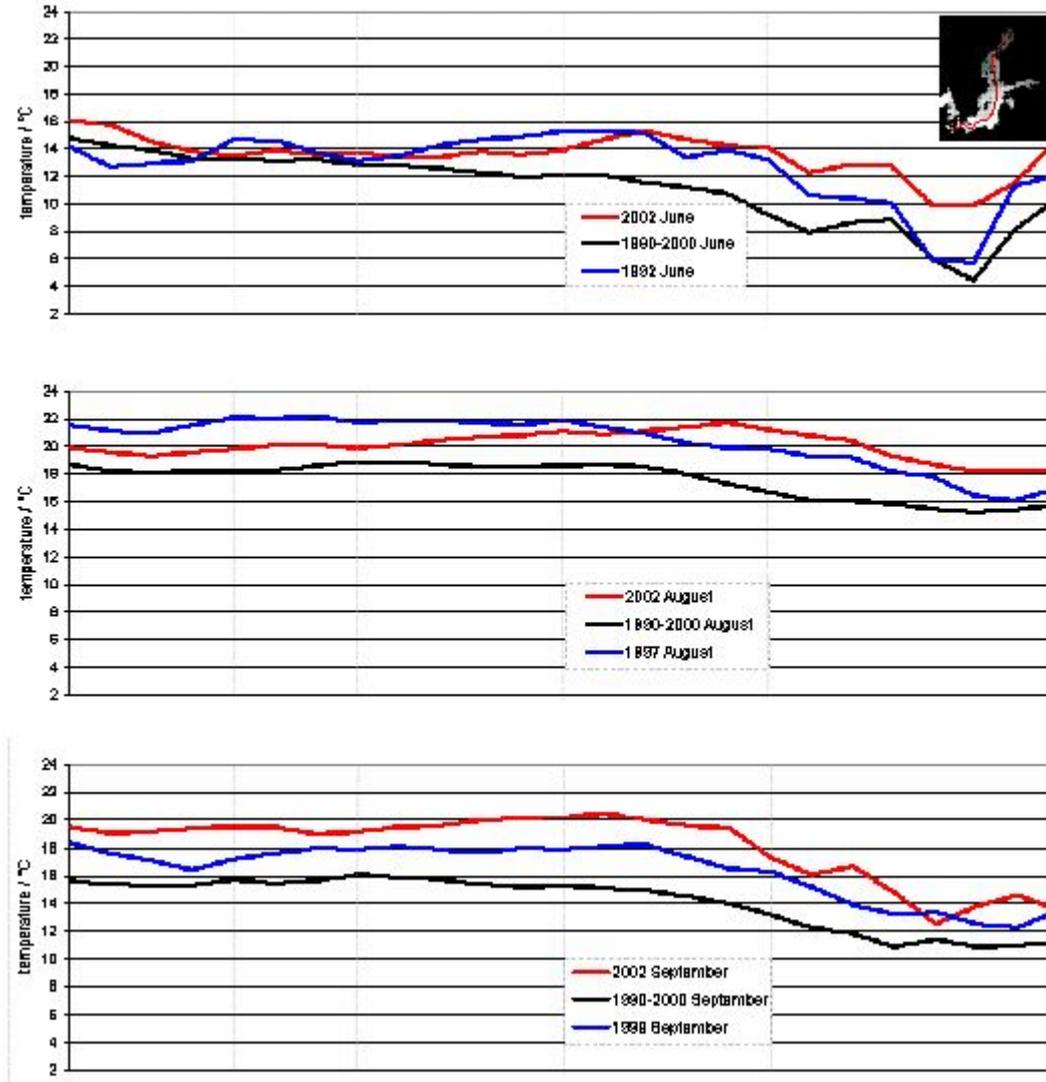


Figure 3. Temperature distribution along the monitoring transect through the central basins of the Baltic Sea in June, August and September in comparison to the mean value of 1990 – 2000 and to extreme values of other years on the basis of monthly mean SST.

The following paragraph describes the main particularities in the spatial-temporal development of SST in 2002 in detail. During a high pressure situation with stable easterly winds from 1 April to 20 April 2002 mixed Oder discharge water spread from 5 to 10 April 2002 into the central Arkona Sea, as verified already in May 2000, was observed also by satellite ocean colour data (SeaWiFS). After that period the water temperature increased around 21 April between 3 and 5 °C, and after 25 April > 5°C. The warming phase was interrupted by increasing winds of more than 10m/s beginning on 27 April. The wind mixing reduced the temperature end of April / beginning of May to values lower than 5°C. The decreasing winds induced the next warming phase after 13 May and at the Darß Sill values of more than 10°C were already reached on 18 May.

On 6 June started the development of upwelling along the Polish coast and in front of Hiddensee Island. The Oder mixed water spread again into the Arkona Sea until 15 June. During this high pressure phase a strong heating occurred and the temperature exceeded 15°C on 8 June in the central Baltic and reached up to 18°C on 10 June. A strong wind mixing between 13 and 14 June reduced the temperatures below 13°C,

before the heating continues. Mid July outside the upwelling, the water temperature was between 18 and 20°C. From the end of July until beginning of September extended parts of the Baltic exceeded 20°C. The warmest day of the year was 29 August 2002 with SST higher than 22°C in the Baltic Proper. The high temperature in summer 2002 connected with long low wind periods induced an extended development of cyanobacteria in the Baltic. The bloom started around 20 June and persisted until about 19 August, discussed in Wasmund et al. 2003.

Temperatures around 20°C were observed still to 13 September, before from 14 Sept. 2002 the wind started to turn from east over north to west, speeded up to 15 m/s and thus

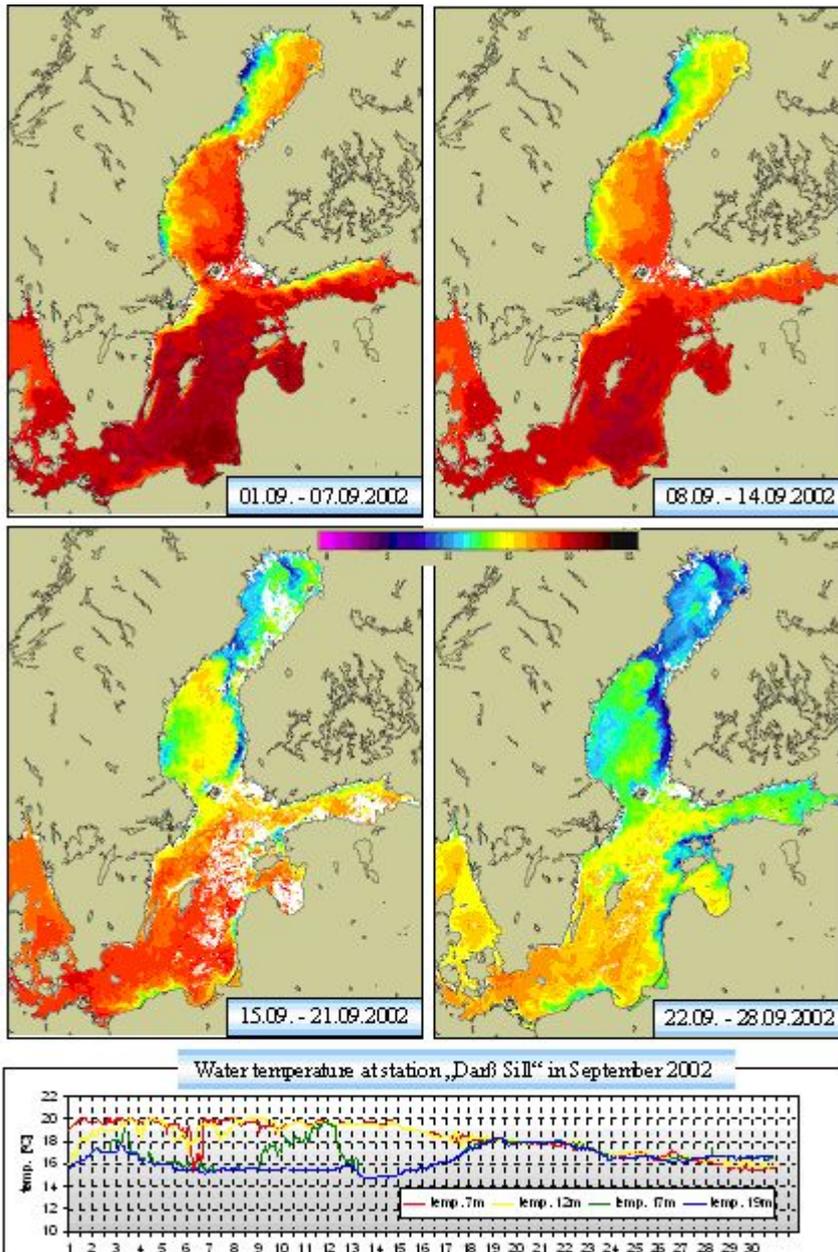


Figure 4. Weekly mean SST in September 2002 in comparison to the temperature development MARNET station Darß Sill.

introduced the cooling phase. Until 14 Sept. temperatures up to 20°C were measured at Darß Sill in 5m water depth, which thereafter continuously dropped down. The weekly means of the water surface temperature of the monthly Septembers in **Figure 4** documents this cooling phase in comparison with measurements at the Marnet Station "Darß Sill" impressively.

From 10 to 20 October the temperatures drop to values around 10°C during a phase of strong cloud coverage. At the end of October the water temperatures are decreased between 3 and 5°C in the northern Baltic Sea, and between 5 and 8°C in the Gotland Sea. Only in the Arkona and Bornholm Seas the values were still between 9 and 12°C. Around 10 November there are only very few areas exceeding 8°C.

References

Siegel, H., Gerth, M., Rudloff, R., Tschersich, G., (1994). Dynamical features in the western Baltic Sea investigated by NOAA- AVHRR- Data. Deutsche Hydrographische Zeitschrift, 3, 191-209.

Matthäus, W., D. Nehring, H.-U. Lass, G. Nausch, K. Nagel, H. Siegel, (1997): Hydrographisch-chemische Zustandseinschätzung der Ostsee 1996, Meereswissenschaftliche Berichte, Institut für Ostseeforschung Warnemünde, 24, 1-49.

Siegel, H., M. Gerth, R. Tiesel and G. Tschersich (1999): Seasonal and interannual variations in satellite derived Sea Surface Temperature of the Baltic Sea in the 1990's, Deutsche Hydrographische Zeitschrift, Vol. 51, H. 4, 407-422.

Nausch, G., R. Feistel, H.U. Lass, K. Nagel, H. Siegel (2003): Hydrographisch-chemische Zustandseinschätzung der Ostsee 2002. Meereswissenschaftliche Berichte, Institut für Ostseeforschung Warnemünde, 55, 1-71.

Wasmund, N., F. Pollehne, L. Postel, H. Siegel, M. Zettler (2003). Biologische Zustandseinschätzung der Ostsee im Jahre 2001. Meereswissenschaftliche Berichte, Institut für Ostseeforschung Warnemünde, in press.

Acknowledgement

The authors would like to thank Mrs G. Tschersich of the BSH Hamburg for providing the NOAA AVHRR images.

For reference purposes, please cite this Baltic Sea environment fact sheet as follows:

[Author's name(s)], [Year]. [Baltic Sea environment fact sheet title]. HELCOM Baltic Sea Environment Fact Sheets. Online. [Date Viewed], <http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/>.