

Development of Sea Surface Temperature in the Baltic Sea in 2005

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



Key message

The year 2005 was characterized in the water surface temperature by comparatively warm months January, July as well as October, November and December and was in the annual average the warmest year of the investigation period 1990-2005. January belonged almost in the entire Baltic Sea after 2001 to the warmest since 1990. The July was the warmest month of the year which was observed since 1990 only in the year 2001 otherwise August was always the warmest month of the year. The high temperatures of July initiated an intensive cyanobacteria bloom, which had its maximum expansion and intensity on the warmest day (13 July). The warm autumn contributed to the high annual average.

Background

The water surface temperature is an important basic variable for many processes in the world ocean which influences the marine biology or chemistry in terms of e.g. stabilisation of the top layer leads to plankton development or increases the CO₂ solubility. Therefore, the yearly development and particularities are discussed here in detail.

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 (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 was 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 by Siegel et al. (1999) and Siegel et al. (2006). This fact sheet is based on the results included in the assessment of the year 2005 (Nausch et al. 2006).

The assessment of SST for the year 2005 was performed on the basis of daily and monthly mean values derived from all cloud free pixels and overpasses of the satellites NOAA 16, 17 and 18. 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 2005 and the long-term means of all months of the period 1990 - 2004 anomalies were calculated.

Results and assessment

The yearly development of water temperature was always compared to air temperature of Warnemünde (Nausch et al. 2006). The cold sums of air temperature in Warnemünde showed that the winter 2004/2005 was comparatively warm. Only in March the cold sums lay somewhat over the long-term average value. The heat sum of the summer 2005 lay with 188.5 K over the long-term average value (142.6 K). That was

due to the comparatively warm months May, June, July and September. On the other hand the month August was comparatively cold with 34.6 K (average value 50.4 K). These particularities in the air temperature are reflected also in the sea surface temperature and were partly more pronounced. The anomalies of the monthly means of the year 2005 are represented in Fig. 1.

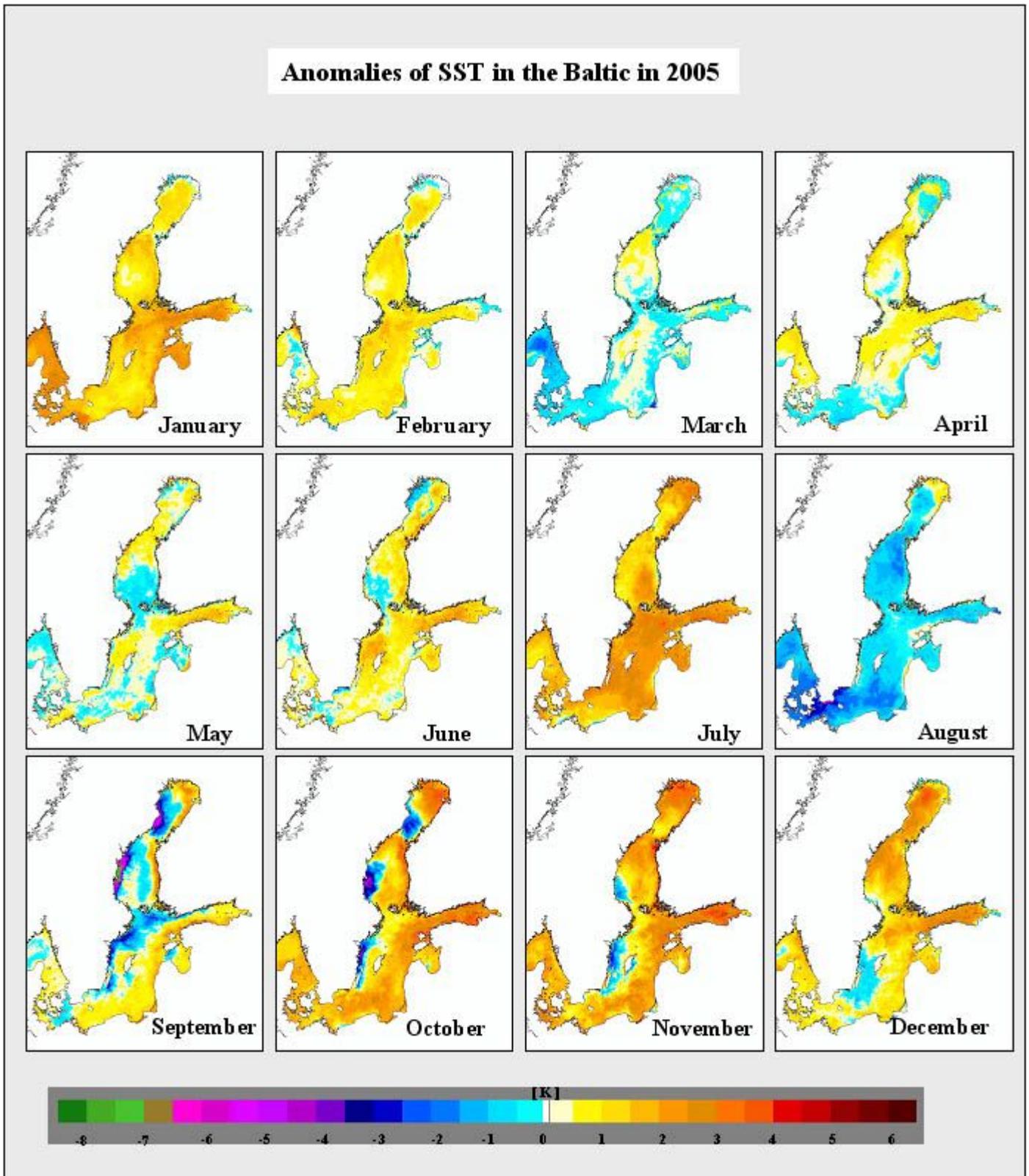


Figure 1. Anomalies of sea surface temperature (SST) in the Baltic Sea in the monthly mean values of the year 2005 referring to the mean values of the years 1990 - 2004

The month January belonged with positive anomalies from +1 to +2 K apart from January 2001 to the warmest in the investigation period. In February the anomalies were approximately +1 K and in March in the Skagerrak up to -2 K and in the western Baltic -1 K. The months April to June differed insignificantly from the respective average values. Only in the western Baltic Sea small negative anomalies arose. July was with monthly average temperatures around 20°C the warmest month of the year and belonged with anomalies from +2 to +3 K in the central Baltic Sea to the warmest of the investigation period. August was comparatively cold with anomalies of -1 K in the northern Baltic Sea and values between -1 K and partial -3 K in the western Baltic Sea. Particularly, the northern parts of the western Baltic Sea have been cold, due to upwelling processes along the Swedish south coast induced by westerly winds.

From September to December the anomalies are characterized by negative values in the western parts of the northern and central Baltic Sea, which were caused by upwelling during frequently arising westerly to south-westerly winds. In September maximum anomalies of up to -7 K arose. On the other hand in the central and western parts of these areas positive anomalies were observed, reaching values between +1 and +3 K in October and November with some maximum values between +3 and +4 K in the Gulf of Finland and Gulf of Bothnia.

The seasonal course of the monthly average temperatures in the Arkona and Gotland Seas confirm the discussed particularities (fig. 2).

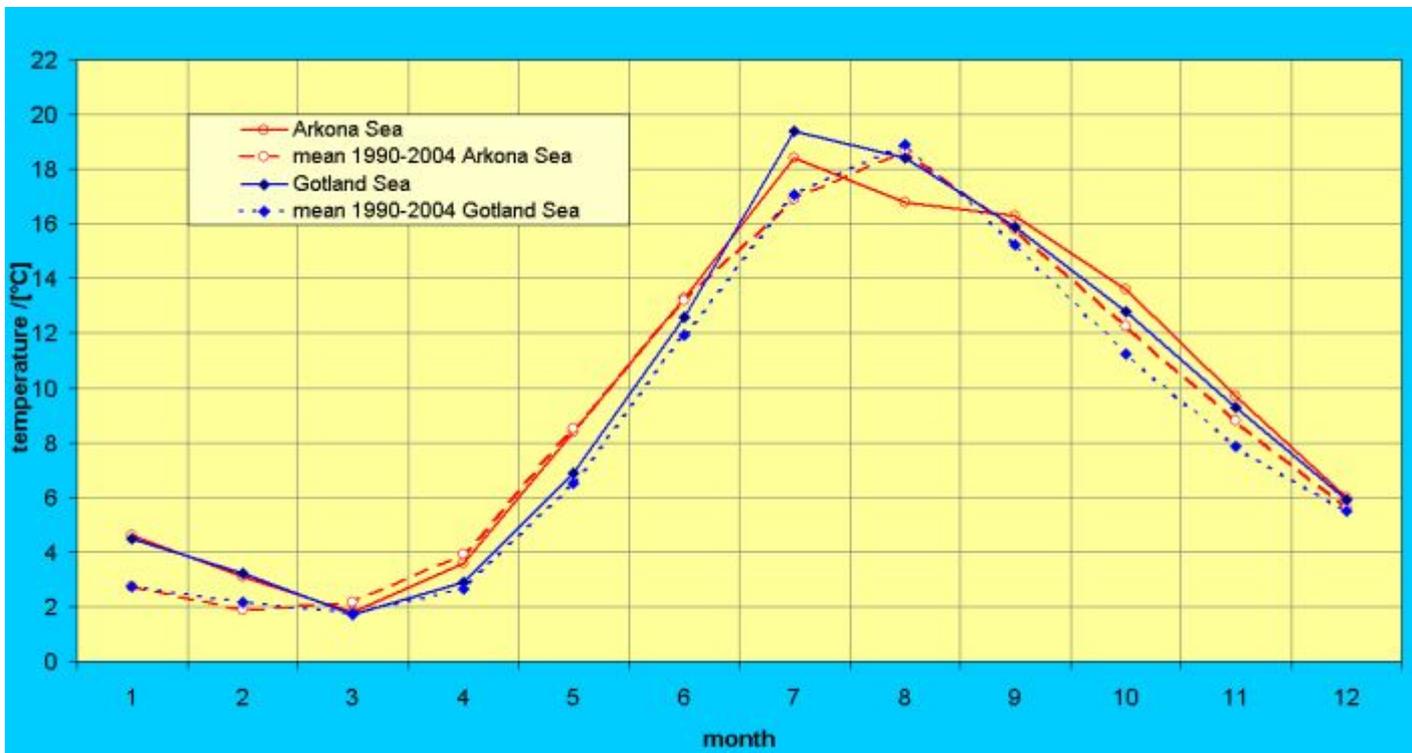


Figure 2. Seasonal course of sea surface temperature (NOAA-SST) in the central Arkona- and Gotland Sea in 2005 in comparison to the mean values of the last 15 years

The months, January (+2 K) and February (+1 K), differ in similar way from the long-term average values. In spring the Arkona Sea is faster heated than the Gotland Sea. The long-term means for July and August are similar, but the Gotland Sea cools down faster in the autumn. In July the Gotland Sea (+2.5 K) had warmed up more strongly than the Arkona Sea (+1.5 K). In the Gotland Sea August temperatures corresponded to the long-term average value, but in the Arkona Sea they were clearly below them (-2 K). The positive anomalies were similar in October (+1.5 K) in both areas and in November the deviations in the Gotland Sea were around 0.5 K higher than in the Arkona Sea (+1 K).

In the following the thermal development in 2005 in the Baltic Sea will be described in detail. Beginning of January the central and western parts were characterized by temperatures around 5°C. Starting from 25 January the Baltic Sea cooled slightly down during a high air-pressure situation and reached end of February temperatures between 2 and 3°C. The lowest temperatures around 2°C occurred in the western Baltic Sea in the second week of March and in the central Baltic Sea in the third week. The maximum ice coverage was reached in the northern Baltic Sea on 17 March. In the western Baltic Sea a heating up already began and started on 21 March in the central Baltic Sea. The heating up continues in the very cloud-poor month April in particular after 16 April during a high pressure situation with easterly winds in the Arkona Sea at the end of the month. On 24 April the highest temperatures for this month between 7 and 8°C were determined in the Kattegat. At the end of the month values between 5 and 7°C are reached and in the Gotland Sea around 5°C. The water of the western Baltic Sea warmed up until 14 May on values around 9-12°C and cooled down then again to approx. 8°C. This situation continued until 24 May. By this first warming up phase in May the central Baltic Sea is hardly concerned. Starting from 24 May a renewed heating up begins in the western Baltic Sea, which took place also in the southern parts and within coastal regions of the central Baltic Sea. The monthly maximum was reached approximately on 29 May with values around 10-12°C in the western Baltic Sea and around 10°C in the central Gotland Sea. In the case of very changing cloud coverage the thermal development stagnated to approx. 7 June. Afterwards began a slow heating up, which became more substantial starting from 13 June. From 25 June temperatures between 15 and 18°C were observed in coastal areas of the western and southern Baltic Sea. In the Gulf of Bothnia the water temperatures lay between 8 and 13°C. Starting from 4 July the Baltic Sea warmed up during a continuous high pressure situation very fast from approx. 17°C to 20-23°C in the central Baltic Sea and in the northern parts. The warmest day of the year was the 13 July 2005 (fig. 5). Along the east coast of the central Baltic Sea and the south coast of the western Baltic Sea arise upwelling events, caused by north-easterly winds, which permitted only temperatures within the range of 10-15°C. In this phase the cyanobacteria bloom also developed in the central Baltic Sea and its maximum intensity and expansion of surface accumulations achieved on the warmest day. A weather conversion connected with low air pressure situation and westerly winds provided a cooling, so that at the end of July temperatures around 18°C were registered in the entire Baltic Sea. In the Gulf of Bothnia the water already cooled down to 12-15°C. How the thermal development affected the monthly means of July in the different areas is shown in Fig. 3.

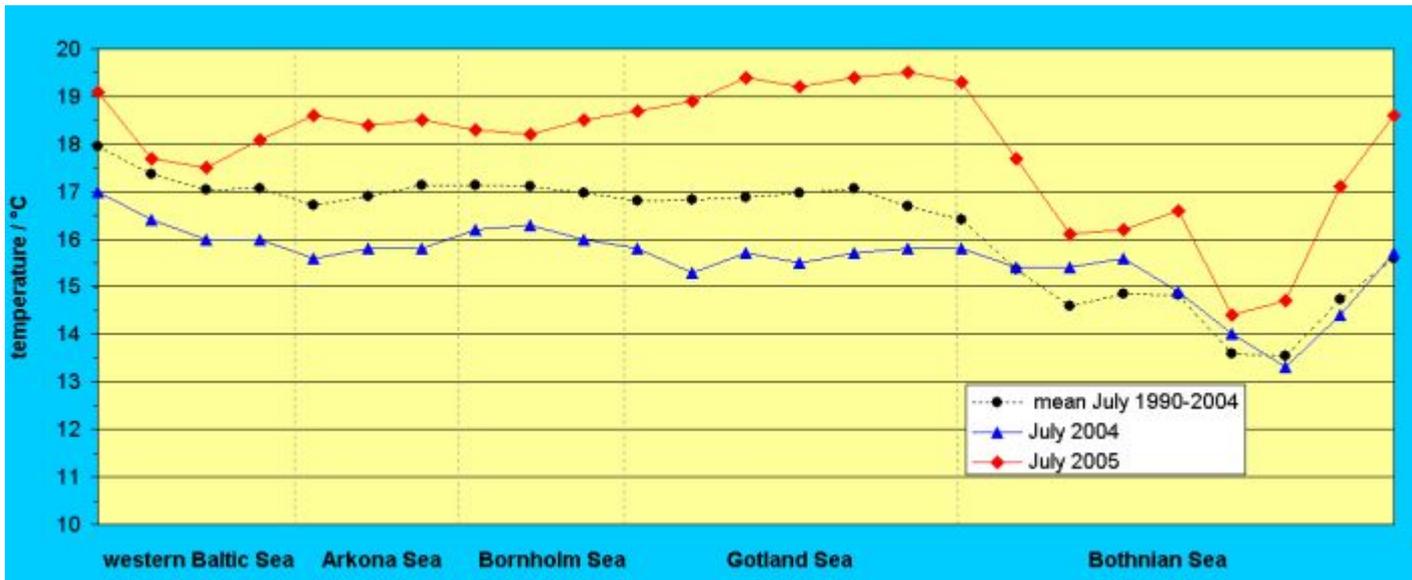


Figure 3. Temperature distribution along the transect through the central basins of the Baltic Sea in July 2005 in comparison to the mean value of 1990 – 2004 and to July of the previous year

The highest temperatures (19°C) and anomalies (2 K) were determined in the central and northern Gotland Sea as well as in the transition area to the Gulf of Bothnia. Compared to 2004 particularly in the Gotlandsee enormous inter-annual differences occurred. In entire August the temperatures remained almost unchanged, western Baltic Sea 13-17°C, central Baltic Sea 15-18°C and Gulf of Bothnia 13 -15°C. That affected the monthly mean value of August. The temperature distribution along the transect through the central the Baltic Sea for the month August 2005 compared to the means of the period 1990 - 2004 and to the previous year are represented in Fig. 4. Nearly in the entire Baltic Sea the surface temperature was below the long-term average value, which already the anomalies in fig. 1 have shown. The maximum monthly average temperature did not exceed 18°C. In the western Baltic Sea the monthly mean values were only 16°C, which is more than 2.5 K below the long-term average value. To 10 September the situation remained unchanged.

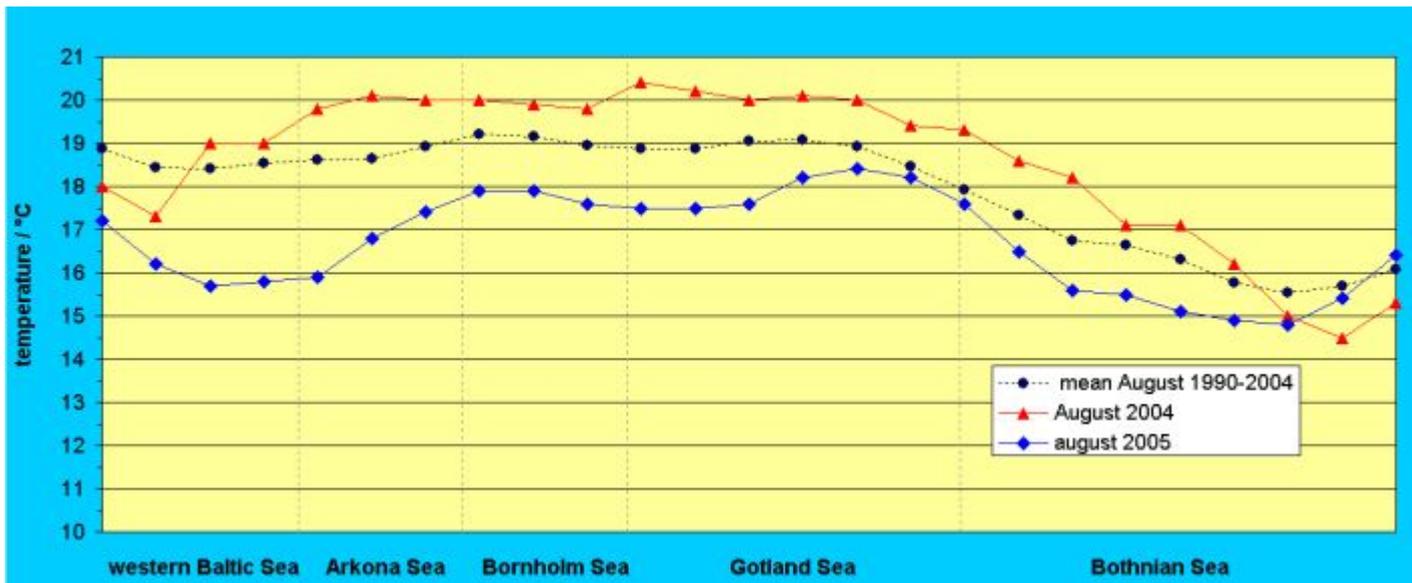


Figure 4. Temperature distribution along the transect through the central Baltic Sea in August 2005 in comparison to the mean value of 1990 – 2004 and to August of the previous year

Then cooling occurred until 15 September. The central Baltic Sea had 13 -17°C and the Bothnian Sea had 5-12°C due to strong upwelling at the west coast. This situation continued until 25 September. A further cooling particularly from the north led beginning of October to 13-16°C in the central and southern Baltic Sea, at the east coast of Sweden by strong upwelling to only 7-10°C and in Bothnian Sea to 7-12°C. After a stagnation period until 20 October a further cooling reduced the temperature end of October in the western and southern Baltic Sea to 10-12°C, in the Bothnian Sea and western Gotland Sea to 4-7°C, eastern Gotland Sea to 8-11°C. Continued cooling decreased the temperature end of November to 4-7°C to a large extent. After 13 December the temperatures reduced to 3 - 6°C, which remained until the end of December.

In the annual average of the water surface temperature of the Baltic Sea the year 2005 was the warmest year of the investigation period 1990 - 2005. Investigations for the thermal development of the entire Baltic Sea in the period 1990-2004 are summarised by Siegel et al. 2006.

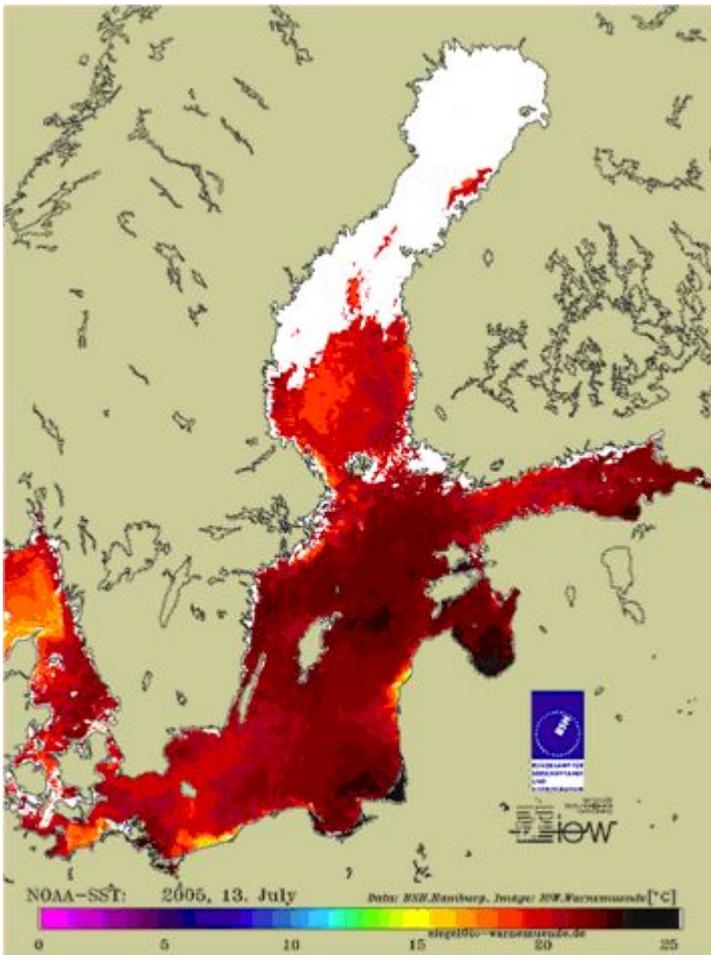


Figure 5. Maximum SST on 13 July of the year 2005

References

Siegel, H., M. Gerth, R. Rudloff, and G. Tschersich, (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 (2006): Hydro-graphisch-chemische Zustandseinschätzung der Ostsee 2005. *Meereswissenschaftliche Berichte, Institut für Ostseeforschung Warnemünde*, 62.

Siegel, H., M. Gerth, G. Tschersich (2006): Sea Surface Temperature development of the Baltic Sea in the period 1990-2004, *Oceanologia*, 48 (S) 119-131.

Acknowledgement

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

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/>.