

## Development of Sea Surface Temperature in the Baltic Sea in 2004

**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 in 2004 was characterised by rather cold months of June and July and by a warm August. In July in the entire Baltic Sea negative anomalies were determined except the Bothnian Sea and Bothnian Bay. According to the annual mean SST of the entire Baltic Sea the year 2004 belonged to the average years.

### 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 CO<sub>2</sub> 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 (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 2004 (Nausch et al. 2004).

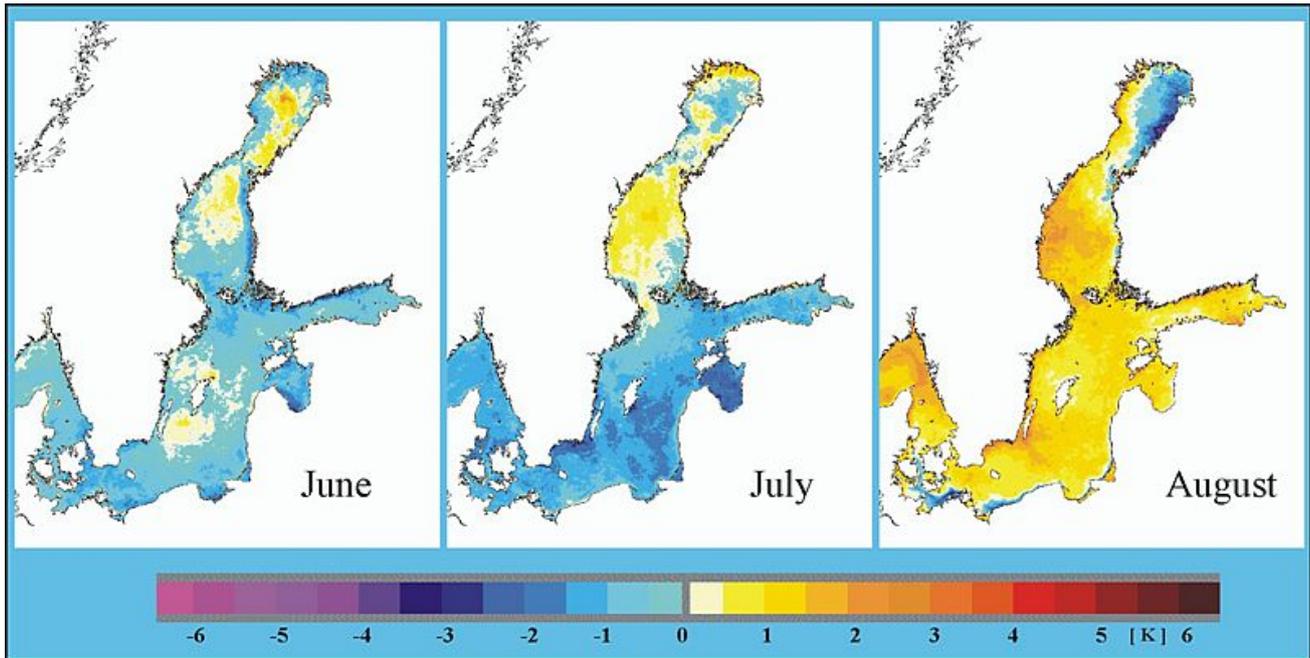
The assessment of the sea surface temperature of the Baltic Sea in the year 2004 was performed on the basis of daily and monthly mean values. The monthly means were used to investigate the seasonal development and inter-annual variations. The daily mean values were applied to retrieve particularities in the detailed thermal development. Based on the monthly mean values of the year 2004 and the long-term means of all months of the period 1990 - 2004 anomalies were calculated.

### Results and assessment

The seasonal development of the cold sum of air temperature in Warnemünde shows that the winter 2003/2004 has been comparable warm. Only in January the cold sums lay within the range of the long term mean values. The heat sum of the summer 2004 was also in the range of the long term means however it was distributed very differently on the individual months.

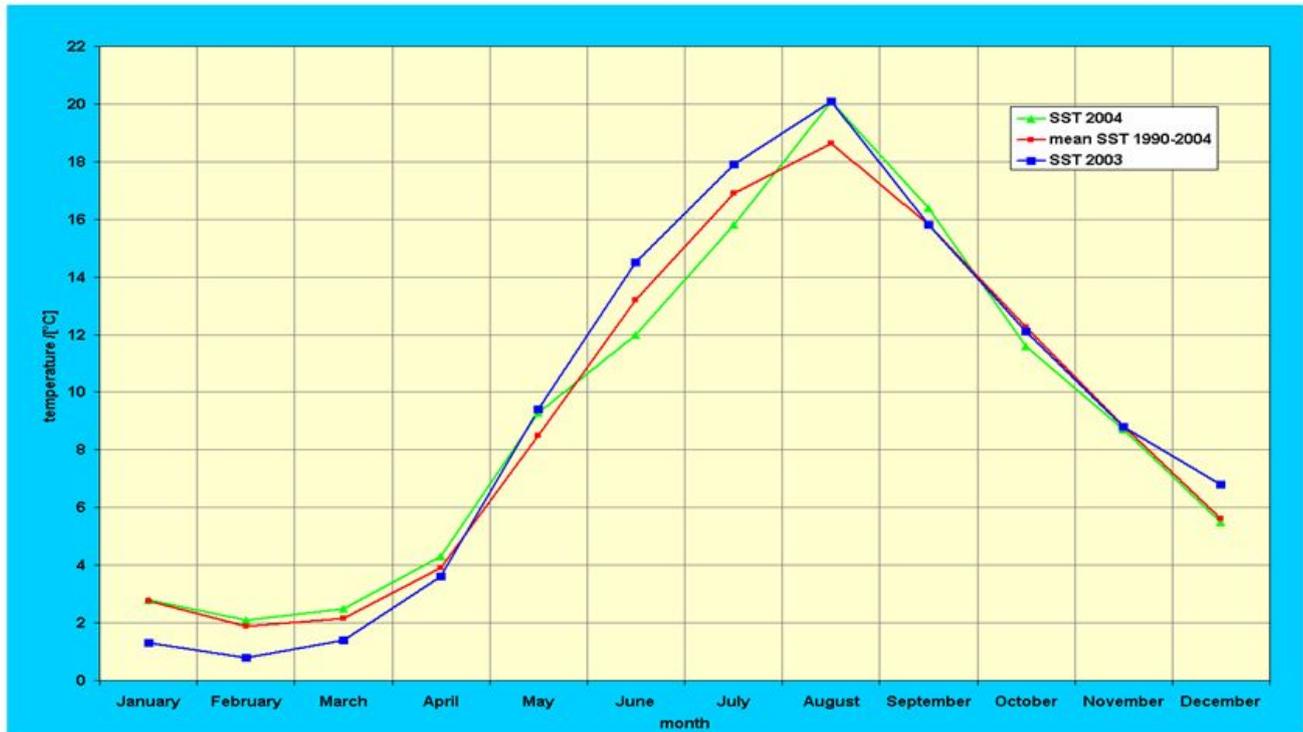
If the heat sums of the months April-July were below the long term means, the August and Septembers were comparatively warm. That concerned in particular the cool months June with 4.3 K (average value 23 K) and July with 33.7 K (average value 50,7 K) and on the other hand the warm August with 87.5 K (average

value 50,7 K). These characteristics in the air temperature were reflected also in the water surface temperature, as the Fig. 1 shows. However, that essentially concerns the Baltic Proper and not the northern part, the Bothnian Sea and Bothnian Bay. In July the differences became clearly visible. If the temperatures were in the central Baltic Sea with anomalies up to -1.5 K below the average value, the Bothnian Sea with up to +1.5 K was very warm. In August then the entire Baltic Sea achieves the positive anomalies, which were already found in the Bothnian Sea in July. In the open Baltic Sea anomalies up to +2 K were reached. The Bothnian Bay, the south coast of Bornholm Sea and the western Baltic Sea are excluded. In these areas, particularly along the German and Polish Baltic Sea coast a strong upwelling is induced by the long continuing east wind phase from 4 to 13 August, which provides anomalies of temperature up to -2 K.



**Figure 1.** Anomalies of sea surface temperature (SST) in the Baltic Sea in the months June, July and August 2004 referring to the mean values of the years 1990 – 2004. [Click image to enlarge.](#)

As an example the seasonal development of SST on the basis of monthly average temperature is given in Figure 2 from the central Arkona Sea. Except in the months June, July and August the mean SST was in the range of the long term monthly means. In June and July anomalies of approx. -1.5 K and in August +1.5 K were determined. The winter temperatures correspond to the long term mean values in the Baltic Proper.

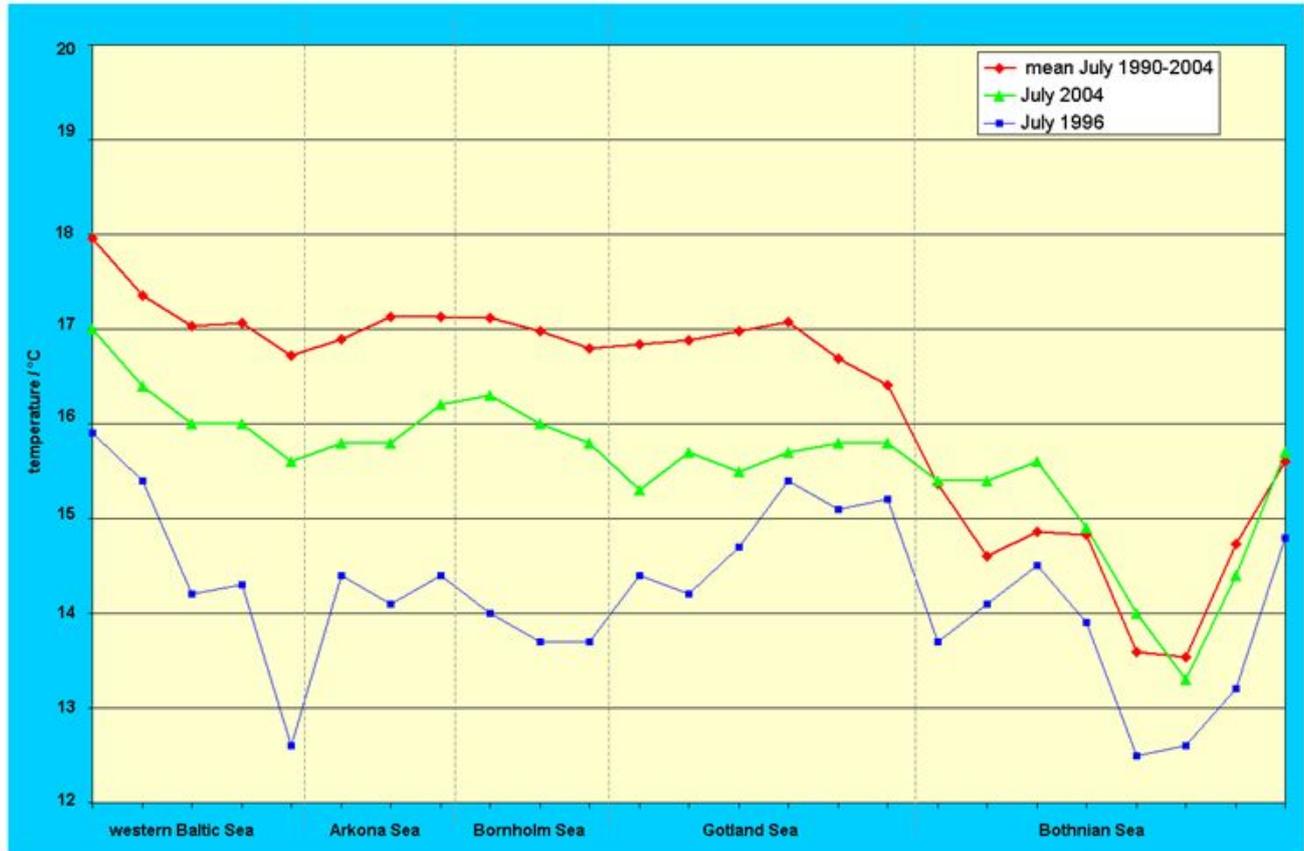


**Figure 2.** Seasonal course of sea surface temperature (NOAA-SST) in the central Arkona Sea in 2004 in comparison to 2003 and to the mean values of the last 15 years. [Click image to enlarge.](#)

In January the SST was in the western Baltic Sea around 2-3°C and in the eastern Gotland Sea partly up to 5°C. In February the Baltic Sea cools down to 2-3°C. In the northern Baltic Sea ice was already present. In the monthly mean SST there is hardly a change in March. To approx. 10 March the temperatures remain e.g. in the Arkonasee approx. 2°C, before then from 13 March a slow heating up begins. That agrees also well with the time of the maximum freezing up in the northern Baltic Sea on 11 March. Beside the Riga Bay also the Gulf of Finland and the Bothnian Bay are covered by ice and in the Bothnian Sea only the central areas are ice-free.

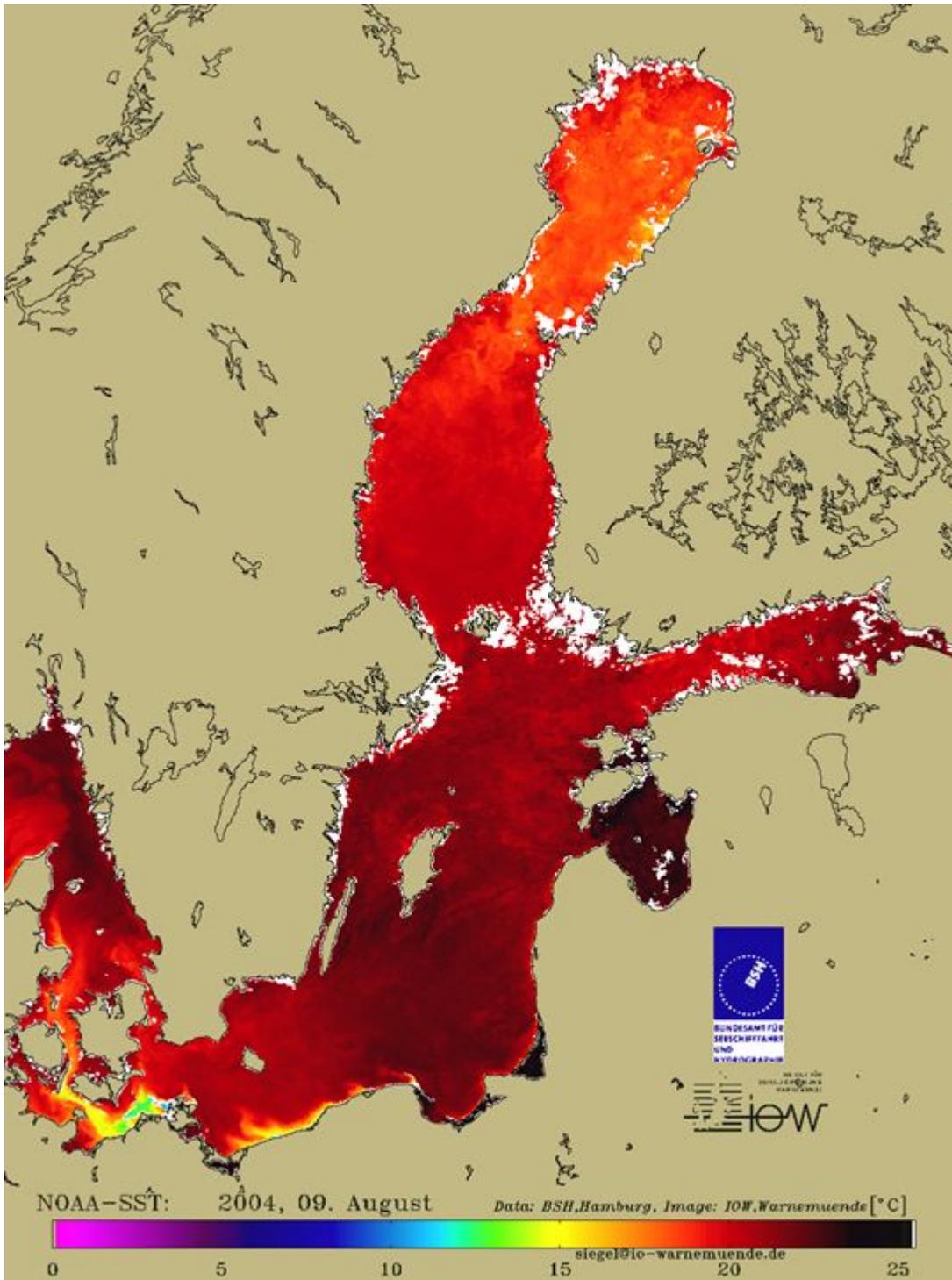
At the end of March in the western Baltic Sea the temperature reached to a large extent 5°C and also in the eastern Gotlandsee the temperatures are between 3 and 5°C. The northern Baltic Sea, which is further colder due to the ice coverage, is excluded. To 10 April the temperatures do not rise significantly. In the following weak wind phase the temperatures raise noticeably beginning from the west. It develops in this phase e.g. in the Arkonasee a thermal stratification, which continues to favour the temperature rise. At the end of April to a large extent temperatures of 6-8°C were reached in the western Baltic Sea, in the Gotland Sea and in the Gulf of Finland they are in the range of 4-7°C and also the Bothnian Sea has itself noticeably warmed up. In the first half of May the temperature in the western Baltic Sea increases continuously and around 17 May more than 10°C are reached. After 25 May these are also reached in the Gotlandsee. In June the temperature rises up to 13°C from the western Baltic Sea to southern Gotlandsee to 15°C and stagnates then after a strong wind event between 12 and 14°C to end of the month. The northern Baltic Sea was not concerned by this stagnation, so that at the end of June in the entire Baltic Sea water temperatures of 12-15°C were present. The missing further rise of the temperature in June has led then also to anomalies of the monthly average values of -1.5 K as represented in Fig. 1. This phase continues in similar way with 12-16°C to 14 July. Thereafter, a further heating up began in the northern Gotlandsee, in the Bothnian Sea and in the Gulf of Finland, which then continued to the south.

On 28 July the entire Baltic Sea with exception of the upwelling areas at the Swedish south coast was rather homogeneous 17-18°C warm. A further intensive heating followed until to the end of the first decade of August, whereby the temperatures already exceeded the 20°C on 31 July in extended parts of Baltic Proper. The small warming phases in July 2004 were reflected already in Fig. 2, in the monthly means and its anomalies. How strong the individual areas of the Baltic Sea were affected shows the transect through the central basins of the Baltic Sea in Fig. 3. The average values of July 2004 are represented in the comparison to the means 1990-2004 and the coldest July of the investigation period in the year 1996.



**Figure 3.** Temperature distribution along the monitoring transect through the central basins of the Baltic Sea in July 2004 in comparison to the mean value of 1990 – 2004 and to July 1996. [Click image to enlarge.](#)

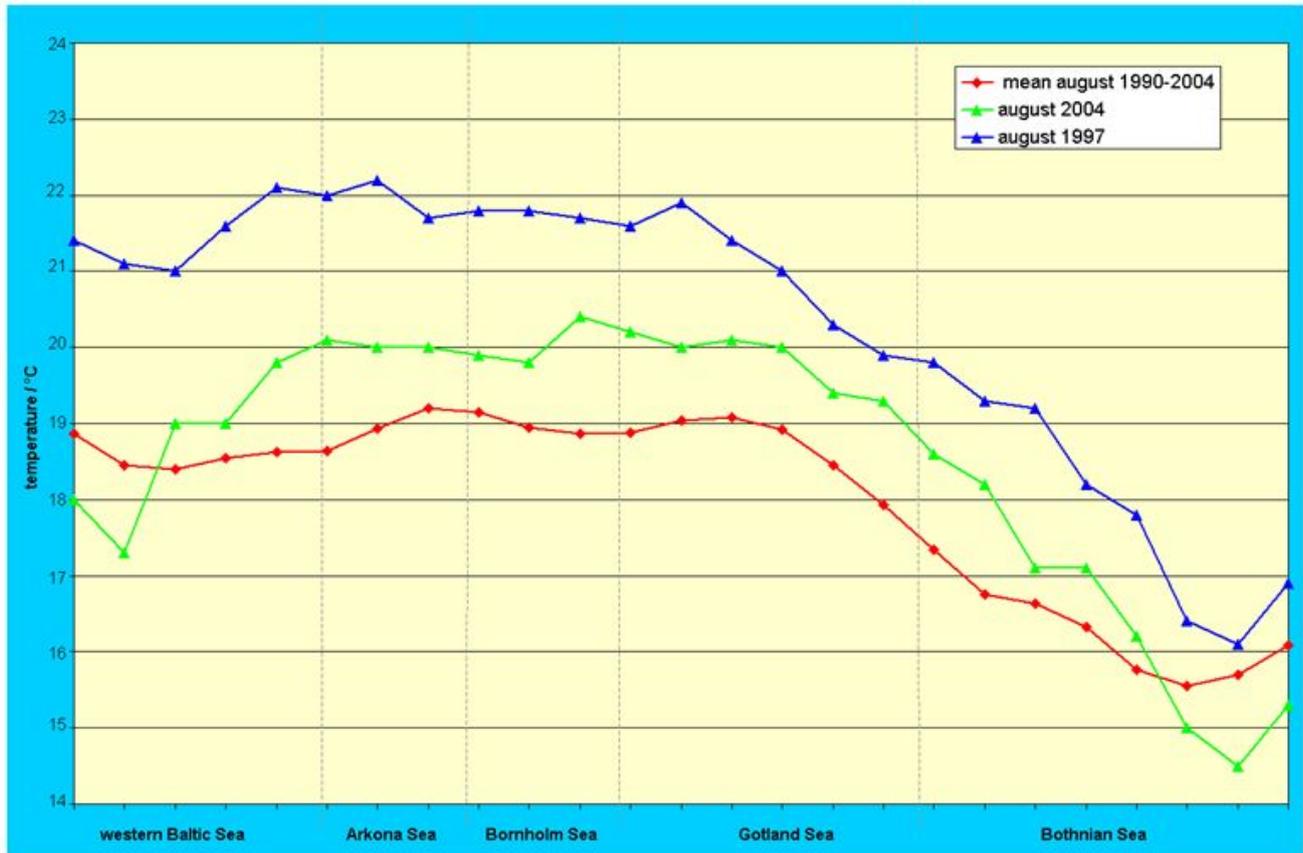
The anomalies amount to -1 K in the western Baltic Sea to the Bornholm Sea and to -1,5 K in the southern Gotland Sea. In the Bothnian Sea the monthly means are in the range of the long term mean values. On 9 August the highest SST of the year (Fig. 4) was then registered in the central Baltic Sea with temperatures around 22°C. The western and the northern Baltic Sea were excluded. The northern Baltic Sea reached only values of 18-20°C and at the south coasts due to easterly winds of upwelling areas had developed. On 9 August the core of the Hiddensee upwelling had only a temperature of 10°C, which was measured also at the MARNET Station "Darß Sill". From 14 August the cooling of the Baltic Sea started, which was more strongly pronounced in the northern Baltic Sea than in the other areas. At the end of August the temperatures still lay in the northern Baltic Sea between 12 and 15°C and in the other parts with 17-18°C. This development led then also to the high positive anomalies in the monthly means (Fig. 2).



**Figure 4.** The warmest day in Baltic Sea on 9 August 2004.

The comparison of the monthly means along the transect through the central basins of the Baltic Sea in August 2004 with the long term mean values and with August 1997 the warmest in the central Baltic Sea in the investigation period, is represented in Fig. 5. From the western Baltic Sea to the Bothnian Sea the August was up to +1.5 K warmer than the long term means. Only in the most western and northern parts the August was colder. In the August 1997 the temperatures were in the entire Baltic Sea more highly, partly up to +3 K. Due to a weak wind phase at the beginning of September the temperature distribution from the end of August remained until approx. 12 September. Thereafter, a further cooling took place. At

the end of September the temperatures were already to a large extent below 15°C. The strong cooling in the second half of September led to a monthly mean only slightly higher than the long term means. The first decade of October was characterized by stagnation, which then the further cooling followed. The monthly mean values for October, November and December did not exhibit any particularities. According to the annual mean SST of the Baltic Sea the year 2004 belonged to the average years.



**Figure 5.** Temperature distribution along the monitoring transect through the central basins of the Baltic Sea in August 2004 in comparison to the mean value of 1990 – 2004 and to August 1997. **Click image to enlarge.**

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