Development of Sea Surface Temperature (SST) in the Baltic Sea 2012

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Key message

The year 2012 was characterized by a relatively mild winter and a cool and changeable summer. The monthly mean SST of the western and southern Baltic was largely in the level or slightly below the long term average values. The northern Baltic Sea was dominated by small positive anomalies. After relatively warm start of the year mid January a stronger cooling occurred in the entire Baltic Sea, which continued until mid-February. February was the coldest month of the year in the western and March in the central and northern Baltic Sea. After a changeable July, the August developed to the warmest month with mean temperatures of 16-18 °C. In summer 2012, there was not a clearly warmest day of the year for the entire Baltic Sea and temperatures of 20 °C were hardly achieved. From mid-September to November westerly winds generated strong upwelling along the Danish and Swedish coasts and a zonal division of the Baltic Sea. The year 2012 was the tenth warmest year since 1990 with an annual average SST of the Baltic Sea slightly above the long term average (1990-2012).

Results and assessment

The seasonal development of air temperature can be characterized by the cold and heat sums. The cold sums of air temperature in Warnemünde showed that the winter 2011/2012 was with 88.9 Kd (mean 105.2 Kd) milder than the long term average. To this cold sum the February particularly contributed with 67.8 Kd (32.2 Kd), twice as high as the long-term average. The heat sum of the summer of 2012 was with 146.8 Kd slightly below the long term average (148.8 Kd). August was the warmest month with 63.5 Kd (52.3 Kd) higher than the long term mean.

The general development of the SST is discussed on the basis of the monthly averages. The monthly mean SST anomalies of the year 2012 are presented for the entire Baltic Sea in Fig. 1.

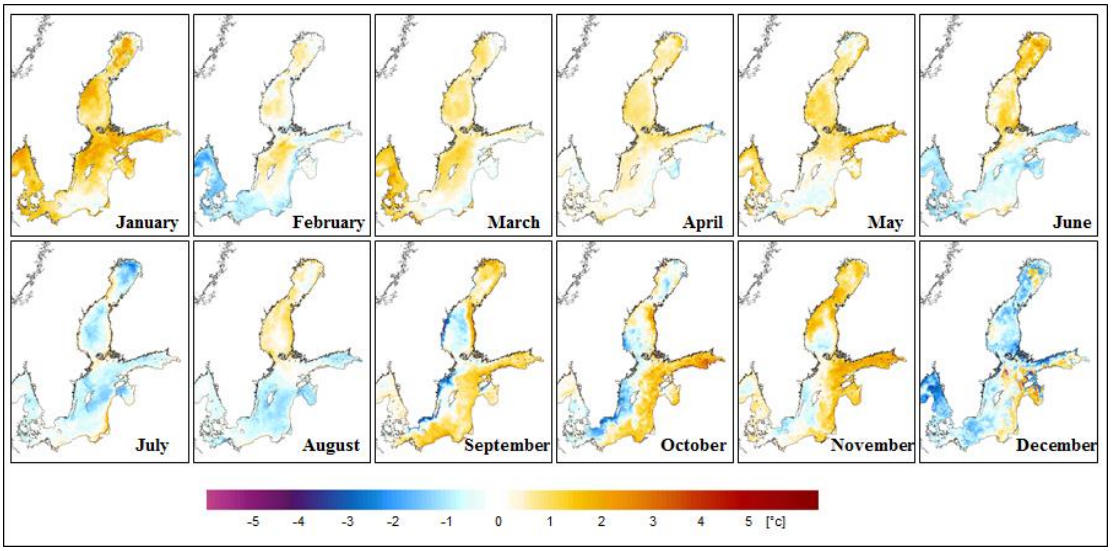

Figure 1. SST- Anomalies of the monthly averages of the Baltic in 2012 referring to the long-term means 1990 – 2010

Seasonal course in the monthly mean temperatures in the central regions of the Arkona-, Gotland- and Bothnia Seas are compared in Fig. 2 to the long-term monthly averages (1990-2010).

After comparatively warm month of December 2011 and January 2012, in February the western and southern Baltic cooled down stronger than the northern areas. The cooling led to negative anomalies in the monthly average that February was the coldest month in the Arkona Sea (AS) and March in the Gotland Sea (GS) and Bornholm Sea (BS). In the Gulf of Bothnia, the temperatures were from January to June higher than the long term mean value, and in the AS and GS from March to May in the same order of magnitude. In June, the typical strong warming in the Baltic Proper did not occur. Temperatures were from Mecklenburg Bight (MB) to Gulf of Finland in the range or slightly below long term averages. The northern Baltic Sea was characterized by positive anomalies. The passage of low pressure systems prevented a calming of the weather and a warming leading to mean SST 1-1.5 K below the long-term averages. Even in July and August, the weather was determined by frequent low pressure influence, which caused strong variations as mentioned in the detailed description. The mean SST was with 16-18 °C in the range or below the long-term averages. This had already hinted in the heat sums of the air temperature which was also below the long-term average. From mid September to November persistent westerly winds generated upwelling along the entire Danish and Swedish Baltic Sea coast. This caused negative anomalies and a zonal division of the Baltic with positive anomalies in the eastern parts of the entire Baltic Sea. In December, the cooling continued from north and west, that only small residual areas in the eastern Gotland showed positive anomalies.

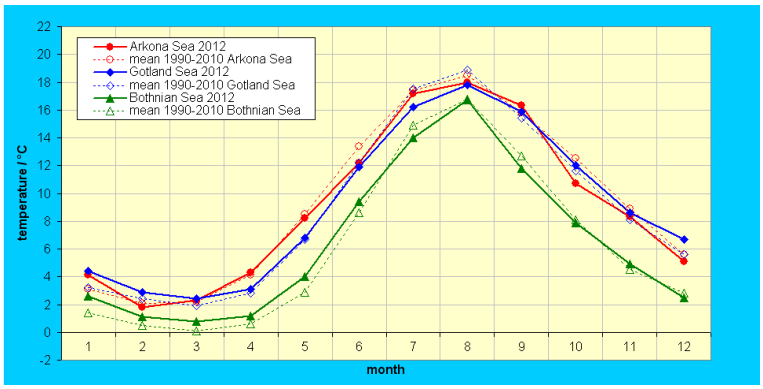

Figure 2. Seasonal course of sea surface temperature (NOAA-SST) in the central Arkona-, Gotland- and Bothnian Sea in 2012 in comparison to the mean values of the last 21 years (1990-2010)

The following detailed description of the thermal evolution of the Baltic Sea in 2012 based on daily mean SST characterizes the major phases during the year. The warm December 2011 ended with temperatures of 5 °C from the western Baltic Sea to the northern Gotland Sea and 2-3 °C in the northern Baltic Sea. After the 15 January 2012 a somewhat stronger cooling began and particularly in the shallow Pomeranian Bight (PB) and in the northern Baltic Sea. In the open western Baltic Sea, temperatures were still at 2-3 °C as in the PB and in the northern Baltic Sea 0°C were already reached. At this stage, the icing began in the inner German coastal waters.

The Baltic Sea cooled further down and reached the minimum temperatures of about 0 °C in the MB around the 10 February and in the AS on 20 February 2012. The maximum ice cover fell in the entire Baltic Sea in the period from 08 to 15 February (Schmelzer, Holfort, Tegtmeier, 2012). In this phase the central Baltic Sea was cooled to 1-3 °C. Especially in the PB, the ice was particularly pronounced with the maximum coverage on 14 February and two days later it was gone again. From 20 February the temperature of the western Baltic Sea increased and reached values of up to 2.5 °C end of February and in the central Baltic Sea up to 3 °C. The monthly mean SST of February along the section through the central basins of the Baltic Sea from the Mecklenburg Bay to the Gulf of Bothnia is compared in Fig. 3 to last year, the long-term average of 1990 - 2010 and its range of variation.

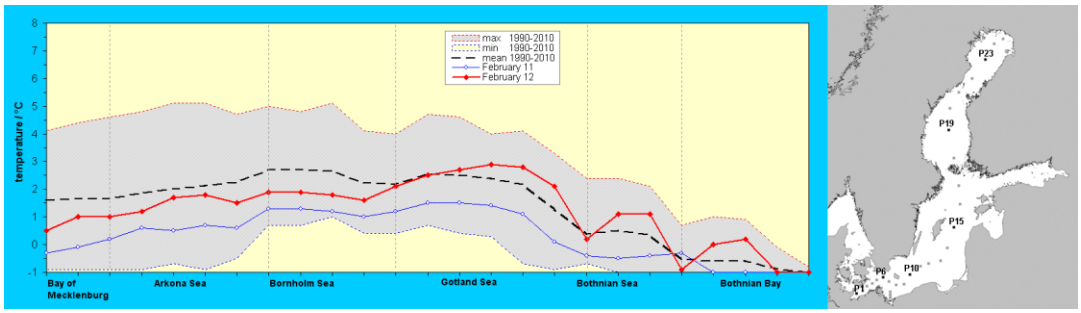

Figure 3. SST distribution along the transect through the Baltic Sea in February 2012 in comparison to the previous year, to the long-term mean value of 1990 – 2010, and to the variation range of the investigation period.

The SST was in the western and southern Baltic Sea below the long term average and in the northern Gotland Sea and in the central areas of the Bothnian Sea and Bothnian Bay above the average.

In the first half of March, the thermal development stagnated before from about 15 March a warming started from the west. On 21 March the Skagerrak / Kattegat had already SST of 3-5 °C, which was achieved by the end of March in the MB and PB. The AS was at 3-5 °C and the Gulfs of Bothnia and of Finland had 1-3 °C.

The April started with SST stagnation in the entire Baltic Sea before a warming from the west continued after 17 April. This was interrupted by low-pressure systems passing from 25 to 27 April. End of the month, temperatures were 7-9 °C in PB, 5-7 °C in the open western Baltic, 3-5 °C in the central parts and 0-3 °C in the northern Gulfs.

First half of May was marked by low-pressure systems. After 18 May, warm early summer weather heated at first the western Baltic and after 24 May the entire Baltic Proper. The maximum SST of the month was reached on 25 May with 10-13 °C except the Gulf of Bothnia with 2-6 °C. Since 22 May the western Baltic was dominated by easterly winds leading to upwelling along the German coast which influence the open parts of MB and AS until end of the month. The central Baltic also cooled down again.
In the first week of June, low pressure systems with partially storm character accounted for a thermal stagnation before on 14, 18 and 30 June warming events took place. The warming on 30 June was combined with mild westerly winds leading to maximum temperatures of 15-18 °C in the MB and PB, and 12-15 °C from the central Baltic Sea to the Gulf of Finland. Only the central areas of the Gulf of Bothnia were still at 8-12 °C.

From early July, anticyclones provide further heating particularly in the northern Baltic Sea. Migrating low pressure areas and the inflow of polar air masses on 20 July cooled down the western Baltic to central Gotland Sea to 15-16 °C. Since the Gulf of Bothnia had warmed to 15 °C, the area from Gotland to the Aland Sea was warmest with 16-17 °C. A calming of the weather condition provided a SST increase, that on 27 July SSTs of 18-20°C were achieved from the western Baltic to Gotland. On 29 and 30 July, a storm mixed the surface water again and lowered the SST to 16-18°C in the entire Baltic. The

mean SST of July is compared in Fig. 4 to the average of July 2011, the long-term average from 1990 to 2010 and the variation range on the longitudinal section through the Baltic Sea. From the western Baltic to the central Gotland Sea SSTs are in the range of the long-term averages and slightly below more northerly.

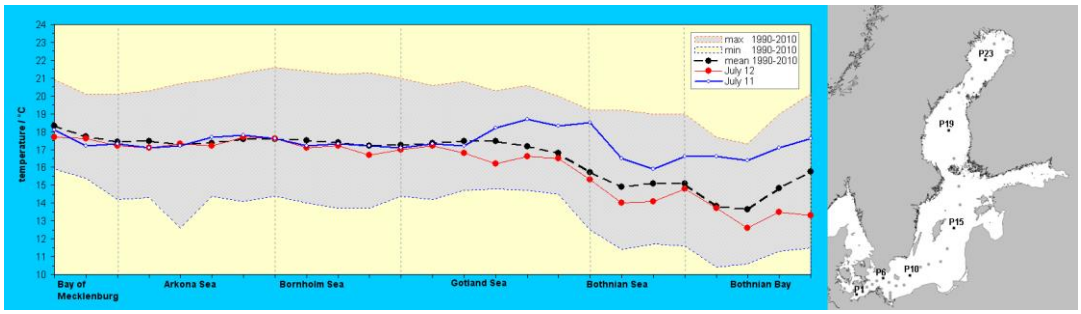

Figure 4. SST distribution along the transect through the Baltic Sea in July 2012 (b) in comparison to the previous year, the long-term mean value of 1990–2010, and the variation range of the investigation period.

In early August the weather calmed down and the SST rose on 5 August to 17-20°C before low pressure systems dominated the following days and cooled down the SST again. From 17 August hot dry air masses were transported from the south-western Mediterranean Sea into our area, which had a direct impact on the SST leading to 17-19°C. During a phase of easterly winds the 19 August developed similar to the 27 July and 5 August with approximately 18-20°C to one of the warmest days of the year in the southern Baltic Sea. The Bothnian Bay was already cooled to 15-17°C. Therefore, the 5 August was selected as the warmest day for the entire Baltic (Fig. 5). From 20 August the cooling started in the entire Baltic Sea. End of the month, temperatures were in the northern Baltic Sea 13-15°C and from the western Baltic to the Gulf of Finland 16-18°C.

The situation remained similar until about 10 September before westerly winds initiated mixing and upwelling along the entire Swedish coast. End of the month, large areas of the western parts of the entire Baltic were affected. This reduced the SST in the western, southern and eastern Baltic to 13-15 °C and in the upwelling areas and in the northern Baltic Sea to below 10 °C.

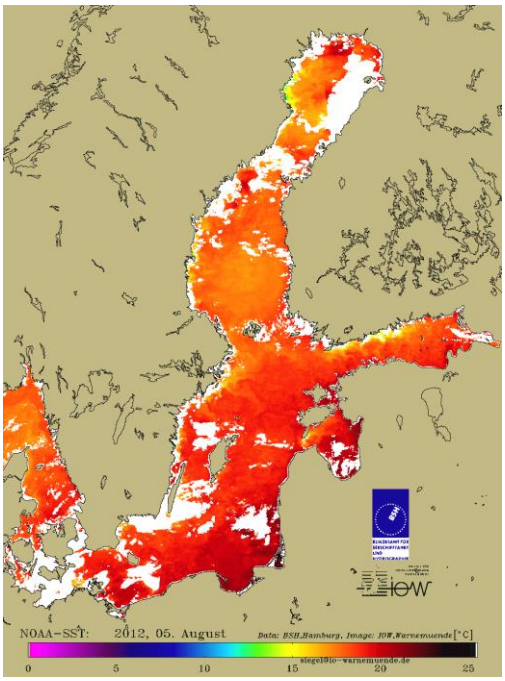

Figure 5. Temperature distribution in the Baltic Sea on the warmest day of the year (5 August 2012)

This remained until about 3 October before the influence of the upwelling enlarged and covered on 10 October the entire AS and PB. On 15 October the SST were 10-12 °C. From 27 October high pressure impact with the first frosts caused a further cooling to below 10 °C in large parts and to 12 °C in the eastern regions. In the first decade of November, the western Baltic further cooled down, before after 13 November a rapid cooling to 6-7 °C occurred. In the northern Baltic Sea, the SST was already partially below 5 °C. The cooling continued slowly the following days. From about 29 November, a cold phase started, which also brought snow. The SST decreased in the first days of December in the coastal and shallow areas of the MB and PB to 3 °C, whereas it remained in the open Arkona at 5 °C. This continued until the end of the month, so that in the MB and PB 2-3 °C, in the AS 3-4°C, 3-5 °C in the central Baltic Sea and Bothnian Sea 0-3 °C were recorded.

Overall, the year 2012 was due to the relatively mild winter and the changing summer in the annual mean temperature 0.2 K above the long term average (7.64 °C) for the period 1990-2012 and the tenth warmest year since 1990. In Table 1 the annual means of the entire Baltic Sea of the last 5 years are presented including the warmest year 2008. These are compared to the annual means of single points representing the central parts of Arkona, Bornholm, Gotland and Bothnian Seas. Furthermore, the long-term averages of the period 1990-2012 are presented.

Table 1. Annual mean SSTs of the entire Baltic Sea of the last 5 years including the warmest year 2008 and the coldest year 1996 as well as the means of single points representing the central parts of Arkona, Bornholm, Gotland and Bothnian Seas and the standard deviation. The long-term averages of the period 1990-2012 are presented in addition.

year	Baltic	Arkona Sea	Bornholm Sea	Gotland Sea	Bothnian Sea
2008	***8,5***	***10,3*** ± 5,6	***10,3*** ± 5,5	***9,8*** ± 5,6	***7,3*** ± 5,3
2009	8,1	9,5 ± 5,9	9,3 ± 5,8	9,3 ± 5,7	6,9 ± 5,5
2010	7,5	8,5 ± 7,0	8,7 ± 6,6	8,9 ± 6,8	5,8 ± 6,4
2011	7,9	8,6 ± 6,3	8,8 ± 6,4	8,9 ± 6,8	6,5 ± 6,6
2012	7,8	9,0 ± 5,8	9,2 ± 6,2	9,1 ± 5,6	6,4 ± 5,5
mean 90-12	**7,6**	**9,3**	**9,4**	**8,9**	**6,2**

In 2012 the mean SST of the entire Baltic above the long-term average is characterized by the Gotland Sea and Bothnian Sea. After the warm year 2008 stagnation occurred in the entire Baltic, but only the yearly mean SST of 2010 was below the long-term average. The inter-annual variations of the entire Baltic within the last 5 years are dominated by the Bothnian Sea. Both areas show similar inter annual variations. The highest standard deviation was derived for the Arkona Sea which can be due to the cold winter and warm summer in 2010.

Data and Metadata

This HELCOM Baltic Sea Environmental fact sheet is based on satellite derived Sea Surface Temperature (SST) and heat and cold sum of air temperature measured in Warnemünde.

Sea Surface Temperature (SST) of the Baltic Sea derived from data of the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) weather satellites and from the European Weather satellite MetOp-2 was provided by the German Federal Maritime and Hydrographic Agency Hamburg (BSH) since 1990. The data evaluation procedure is described by Siegel et al. (2008). Daily mean values used for detailed description of the temperature development are calculated from up to seven overpasses covering the entire Baltic Sea. Monthly averages calculated from the daily means in each point are implemented for general statements. Yearly average of the entire Baltic are determined from the monthly averages and used for the assessment of the year in relation to the long-term mean values. Systematic studies on seasonal and inter-annual variations in SST are published by Siegel et al. (2006, 2008). 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). This environmental fact sheet is based on the results of the German assessment of the state of the Baltic Sea of 2012 (Nausch et al. 2013).

The air temperature data of Warnemünde provided by the German Weather Service was used to calculate the heat and cold sum which permits to evaluate the intensity of winter and summer.

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