The ice season 2009-2010

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Key Message

- The ice season 2009-2010 was average in terms of ice extent.
- The largest ice cover – 244,000 km² – was reached almost two weeks earlier than average on the 17th of February.
- The ice winter was, by the extent of the ice cover, classified as average (**Figure 1**.)
- The ice winter was in the Bay of Bothnia over month shorter than normal. In the Quark season was two weeks longer than normal and the Gulf of Finland the ice winter was from week to more than month longer than normal.
- On the 31st May the Baltic Sea was ice free.

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Figure 1. The maximum extents of ice cover in the Baltic Sea on the winters 1719/20 – 2009/10 (Courtesy of FMI).

Figure 2. The largest ice cover – 244 000 km² – was reached on the 17th of February (Courtesy of FMI). Click image to enlarge.

Figure 3. Satellite image of the 18th of February 2010 (Courtesy of BSH). Click image to enlarge.

Figure 4. Sea ice off Helsinki on the 7th March 2010 (Courtesy of Dr. Stefan Hendricks, AWI).

ICE SEASON 2009/2010

ICE FORMATION

Autumn and early winter

At the end of summer 2009, sea surface temperatures in the Baltic Sea region were 1-2°C higher than normal, and remained so during the early part of autumn.

In autumn the weather was variable, as a warm September was followed by a colder than normal October, which in turn was followed by a mild November. The coastal waters cooled down by the end of October, which was cold considering the time of year; the first ice was observed at the end of October/beginning of November in the inner bays of the Hailuoto and Kokkola regions. At the beginning of November, sea surface temperatures in the pelagic areas were about one degree above seasonal average.

The first half of November was slightly colder than normal, whereas the second half was considerably milder than normal, which was reflected in the very slow cooling of the marine waters and in the melting of the first ice. When November changed to December, only the innermost bay ends were covered with ice. Compared to average temperatures, at the end of November the seawater temperatures were one degree above the long-term values.

Under normal circumstances, ice appears in the northern archipelagos in Bay of Bothnia in mid November. Year 2009 however, ice formation started relatively late. It was not until early December that an established ice cover started to take shape in the archipelagos and along the coast of Bay of Bothnia and the Quark. Further out surface temperatures were still above normal.

Early December was still quite mild, but soon the weather got colder and ice began to form in the sea areas. In mid-December Finland was hit by an "Arctic cold" and the formation of ice in the sea areas quickly began. In mid-December there was ice in the northernmost part of the Gulf of Bothnia, the Vaasa archipelago and the ends of the Gulf of Finland. Compared to the long-term averages, the sea surface temperatures were still a half degree to one and a half degrees higher than normal. The colder than average weather lasted until the end of the month.

Southern Baltic Sea

In the southern part of the Baltic Sea the first ice formed in the eastern bodden waters on 16 December 2009, in the inner navigation channels of the western Baltic Sea around 20 December, and on the North Frisian coast and Lower Elbe between 16 and 23 December. Because of thawing temperatures over Christmas, ice development in the Baltic Sea stagnated, and the thin ice cover that had formed in the North Sea coastal waters disappeared completely.

ICE GROWTH

January

After a slow start, very cold weather conditions over Scandinavia ensured a rapid development of the ice cover during the end of 2009 and beginning of 2010. On January 8, the entire Bay of Bothnia was covered with ice; a week later the amount of ice also increased in the Gulf of Finland and Gulf of Riga. During this period, ice also started to form along the coast in Sea of Bothnia and in the Stockholm archipelago.

Further west, cold weather in combination with weak north-easterly winds ensured ideal conditions for ice formation. Around January 14 – 15 most of the inner archipelagos of the Swedish west coast were ice covered, and the first reports came of pancake ice at sea outside Kattegat and Skagerrak.

After mid-January, southern winds made the ice field in the Bay of Bothnia drift towards northeast and an open water zone was created in the pelagic area on the Swedish side.

An intense low pressure passing over Scandinavia on January 27-28 brought southerly gale force winds which pressed most of the ice in Skagerrak towards the Norwegian coast. In the Bay of Bothnia, the ice drifted rapidly to the north-northeast, causing severe pressure in the ice field. In the Quark conditions were so severe that the area was temporarily closed for all traffic. During the following days, the ice drift also caused intense ice pressure in the Gulf of Finland.

After the storm, the cold weather came back and ice growth speed up again, particularly in Sea of Bothnia, northern Baltic Sea and Kattegat. Ice started to form outside the archipelagos in northern Baltic Sea and along the east coast of Gotland.

The low January temperatures, which in some places were abnormally low, ended with freezing temperatures and, on the last day of the month, the ice-covered area amounted to 175,000 km². That time thin fast ice covered the entire Swedish coastline as far south as Kalmar strait.

Southern Baltic Sea

In the southern Baltic Sea the ice formation resumed in the eastern waters in early January and spread quickly westward on the sheltered inner coastal waters. Ice formation continued until mid-February. By the end of January, new ice had also formed on the outer coasts, and the Pomeranian Bight was completely covered with ice.

February

Around February 10 a period of intensive new ice formation started in the Sea of Åland, closing off almost the whole Sea of Bothnia. At the same time, large areas of up to 15 cm thick pancake ice formed in Kattegat, past Skagen and north towards Norway. The very cold weather continued in the second half of February, when arctic air flowed from the east into the northern Baltic Sea. On February 15, the western seas reached maximum ice extent. A few days later, o**n February 17, the area covered in ice expanded to**

244,000km², marking the maximum area for the winter. This took place almost two weeks earlier than normal. (Fig 2. and Fig. 3.).

At that time, the Gulf of Finland and the Gulf of Bothnia were covered with ice, with the exception of an approximately 6,500 km²-wide area in the eastern Sea of Bothnia off Rauma and Pori. The Gulf of Riga was also thoroughly covered with ice. In the northern Baltic Sea the ice edge ran from near Almagrundet to Glotovi and further on to the south-southwest. The central Baltic Sea off the coastline had a thin ice cover north of Öland and Klaipeda. The southern Baltic Sea off the coast of Germany was covered with thin fast ice in the insular areas. There was also thin ice and new ice in the Kattegat and Skagerrak.

On the third weekend of February (19 to 21/02/2010), the wind increased to storm readings and dangerously strong ice pressure occurred in the ice field of the Gulf of Finland. These stormy winds reduced the frozen area considerably. As the wintry weather continued, the frozen area expanded again, reaching nearly 244,000 km² on February 25. At the end of February a short period of strong winds substantially reduced the ice along the west coast. Due to mixing, surface water temperature increased and no new ice was formed at sea in the western basins this season.

In winter 2009/2010, the temperature remained below zero for an unusually long period of time without a break - a total of 60 days. The frosty winter ended on February 26 and, with the winds blowing from the south, the frozen area began to decrease.

Southern Baltic Sea

Strong snowfall in early February led to the formation of large areas of grease ice and slush in the offshore waters of the Kiel and Mecklenburg Bights, parts of which froze and formed aggregates during the cold nights. However, the formation of a closed ice cover was prevented by wind and water motion. At the time of maximum ice development, on 17 February 2010, all inner waters of the German North and Baltic Sea coasts were covered with ice. In the outer coastal waters, ice occurred in the Bay of Lübeck, Fehmarnsund, and in the Wadden Sea areas of the North Sea.

In the third decade of February, southwesterly winds brought warmer air into the coastal region, causing the ice to retreat gradually.

ICE MELTING

March

March was the fourth consecutive month which was colder than normal in Finland. Frost and strong winds alternated; with the frost, the frozen area expanded from time to time, only to decrease again because of the strong winds.

(Fig. 4)

During the first week of March, strong northerly winds affected the Baltic Sea, causing ice to move away from the coast from Stockholm to Kalmar strait. This left room for new ice to form outside the fast ice, while the thicker ice drifted further out to sea.

In Sea of Bothnia, the strong winds ripped large holes in the ice field in the northern part, and caused ridging and rafting in the south. During this time ice pressure in southern Sea of Bothnia and Sea of Åland was so severe it caused substantial problems for the traffic. On March 3-4 conditions were particularly difficult in Sea of Åland. A brash ice barrier outside of the Stockholm archipelago caught a number of passenger ferries and commercial ships, and icebreaking activities were intense.

During the second half of March westerly winds dominated, pushing the ice in Sea of Bothnia toward the Finnish coast. The cold weather lingered in this region and new ice rapidly formed on open areas. Along the west- and southeast coasts of Sweden however, the fast ice started to rot. Mild weather and rainfall melted the ice in the northern Baltic Sea and the Gulf of Finland. The fast ice in the coastal regions of the Gulf of Finland and the southern Sea of Bothnia began to rot, while open spots appeared in the inner archipelago. In turn of the month, there were large areas of open water close to the Estonian coast.

Southern Baltic Sea

The North Sea coast, its tributaries, and Kiel Canal were completely free of ice by 7 March, the Baltic Sea waters of Schleswig-Holstein by 20 March, and the bodden waters along the coast of Mecklenburg-Vorpommern by 25 March. The numbers of days with ice varied considerably in the different areas: in the river Weser near Brake, ice occurred only on one day, compared to 96 days in the harbour of Neuendorf on the island of Hiddensee. Only a few stations, most of them located in the German Bight, remained free of ice throughout the winter of 2009/10.

DISSAPPEARANCE OF THE ICE

April

In April, the sea ice continued to rot and melt. The last of the fast ice on the west coast of Sweden melted during the first week of April, and open areas formed in lake Vänern. The ice edge in the Gulf of Finland quickly shifted to the line Tiiskeri - Gogland - Bolshoy Tyters. In the Sea of Bothnia, the ice field was compressed, and areas of open water appeared off the coastal regions.

The melting process proceeded rapidly in the south and the Baltic Sea coast south of Stockholm was ice free around April 15. Lake Vänern was ice free around the 18th.

In Sea of Bothnia, the ice also started to rot in April, and due to increasing sun radiation and warm winds it happened fast. On April 20 only scattered floes and parts of old ridges remained at sea. The week after most coastal ice was also gone.

May

The remaining ice of the Sea of Bothnia disappeared at the end of April, while in the Gulf of Finland and the Bay of Vyborg it melted on May 2. At the time, in the Bay of Bothnia,

winter lingered on: the coasts remained in 30-80 cm thick fast ice, and east of the line Rödkallen - the Quark there was 30-60 cm thick, compact and ridged drift ice.

In mid-May, there was an unusually long and widespread heat wave, considering the time of year. It also caused the ice field in the Bay of Bothnia to rot and melt away at a high speed. On May 17, the coastal ice in the Bay of Bothnia was gone, while large areas of even thick ice in places still remained in the pelagic areas. The impact of the heat continued and, consequently, made the water warm up and the ice to melt. One week later, on May 24, only a few thicker floes of ice remained in the Quark, while there were some slightly larger areas of drift ice in the central part of the northern Bay of Bothnia. The last ice in the Bay of Bothnia melted at the end of May and the Bay of Bothnia was ice free on May 31.

LENGTH OF THE ICE WINTER (Finnish waters)

The time of the final melting, compared to normal, varied greatly. In the coastal waters of the northern Bay of Bothnia the final disappearance of ice took place two to four weeks earlier than average and in the Gulf of Finland about one week to more than a month later than average.

The duration of the ice winter in the northern Bay of Bothnia was over a month shorter than average. In the southern Bay of Bothnia and in the Vaasa archipelago the ice winter was one and a half to two weeks shorter than average, whereas it in the Quark was two weeks longer than average. In the other sea areas surrounding Finland the length of the ice winter was a week (the metropolitan area) to more than a month (western Gulf of Finland) longer than normal.

MAXIMUM THICKNESSES OF SEA ICE (Finnish waters)

In the Finnish part of the Bay of Bothnia, the maximum thickness of the fast ice was between 40 and 85 cm, in the Sea of Bothnia between 30 and 60 cm, in the Archipelago Sea between 15 and 50 cm and in the Gulf of Finland between 20 and 60 cm. The thickness of the ice in the pelagic Bay of Bothnia was 30-60 cm, in the Sea of Bothnia 10-40 cm, in the Gulf of Finland 30-45 cm, in the Sea of Åland 10-35 cm and in the northern Baltic Sea 10-35 cm.

ICE CONDITIONS IN THE NORTH SEA, SKAGERRAK, AND KATTEGAT

On the Dutch North Sea coast, loose thin ice occurred only on a few days in January and February. In the Limfjord in Denmark, ice formed at the end of December in some sheltered areas. In the course of January, this ice developed to fast ice the last remnants of which melted as late as the third decade of March. Ice thicknesses ranged from 20 to 40 cm. In the Skagerrak, the last winter with major ice formation and obstructions to shipping was 1995/96. In the winter of 2009/10, some small fjords on the Norwegian coast were completely covered with ice from early January to late March, and a few of them were closed to shipping. Left undisturbed, the ice cover in places reached thicknesses over 50 cm. Major quantities of ice occurred temporarily in the navigation channel to Kristiansand and in the Oslofjord. In February, ice belts which only high-powered ice-class vessels were able to navigate floated off the coasts.

In smaller harbours and fjords on the Danish coast in Kattegat, the ice reached 10 – 30 cm thickness. In mid-February, 20 – 45 cm fast ice was observed in the skerries and sheltered bays of the Swedish coast north of Gothenburg, and 10 – 25 cm south of it. Areas with thin ice or new ice occurred in the offshore waters, and in the Belts and Sound.

Maximum thermal ice growth on the southern Baltic Sea coast was 15 – 35 cm in the eastern bodden waters, between 10 and 20 cm in the inner coastal waters on the western Baltic coast, and between 5 and 15 cm in the Kiel Canal and offshore waters. The term „thermal ice growth“ is not suitable for the Wadden Sea areas of the North Sea including its tributaries because tidal influence in these areas causes ice rafting and ridging, which may result in the formation of thicker ice floes at freezing temperatures. In the winter of 2009/2010, level ice reached thicknesses of 15 – 50 cm on the North Frisian coast, 5 – 30 cm in the river Elbe, and 5 – 15 cm in most parts of the East Frisian coast. Rafting and ridging were also observed, as were sporadic ice blocks of 60 cm to 2 m height. In the inner navigation channels and inshore waters of the Baltic Sea, ice ridging and rafting up to 2 m height occurred on coasts affected by frequent strong onshore winds, at the fast-ice edge, and on shoals, e.g. along the coasts of the Darss/Zingst peninsula and in Greifswalder Bodden.

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/.