The ice season 2010-2011

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Key Message

- The ice season of 2011-2012 was severe in terms of ice extent (**Figure 1**.).
- The largest ice cover – 309,000 km² – was reached a few days earlier than average on the 25th of February.
- The ice extent was the greatest in the Baltic since the record winter of 1986-1987.
- On the 25th May the Baltic Sea was ice-free (**Figure 4**.).
- The duration of the ice winter in the northern sea areas of the Baltic Sea was about one month longer than average.

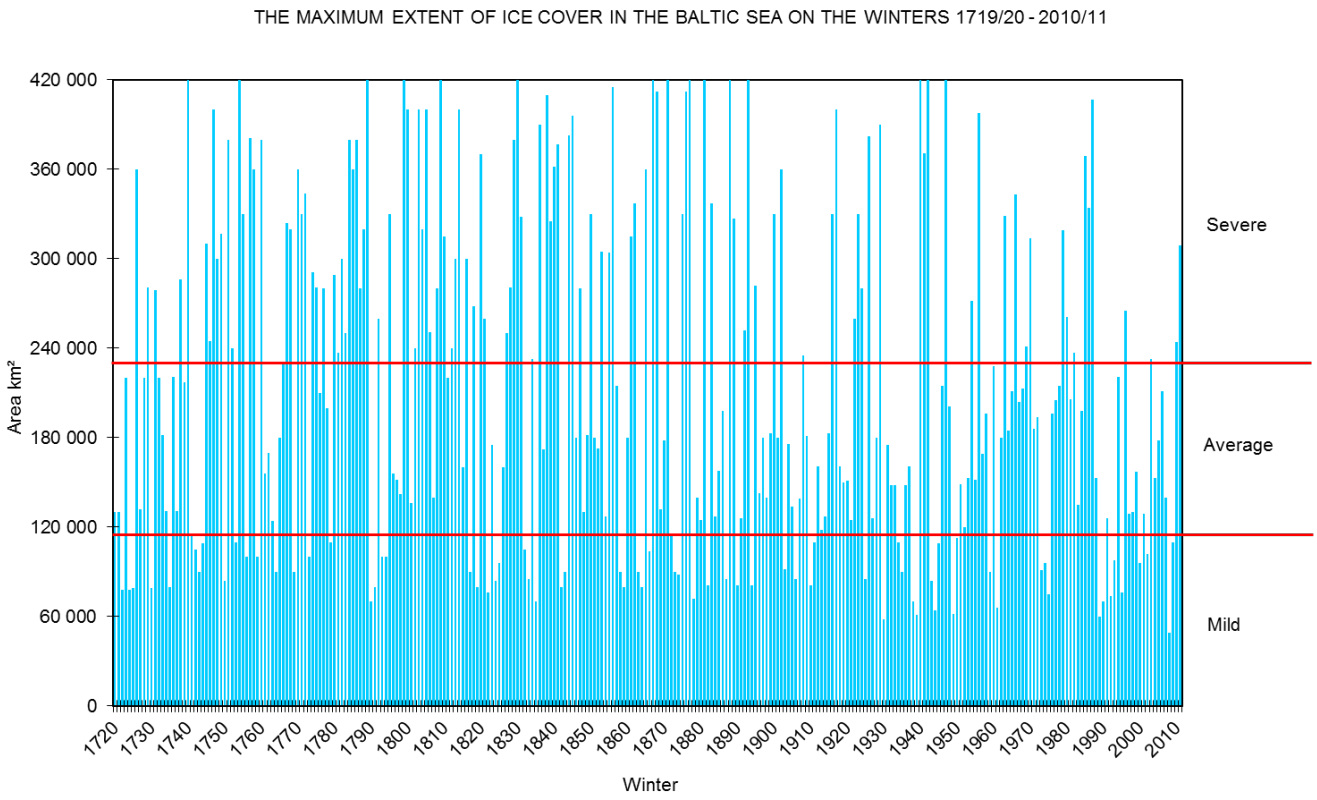

Figure 1. The maximum extents of ice cover in the Baltic Sea in the winters 1719-1720 to 2010-2011 (Courtesy of FMI).

Ice season in the northern Baltic Sea

Ice formation

Autumn and early winter

Following a normal October, sea surface temperatures in the areas surrounding Finland were in line with long-term averages. At the beginning of November, the seawater actually warmed up a bit, but then began to cool down again after the first week of the month. A thin layer of ice formed in Kemi inner harbour and the innermost bays of Raippaluoto in mid-November. At that point sea surface temperatures were equivalent to long term averages.

Ice growth

December

The end of November was unusually, even exceptionally, cold. The cold period that began in November continued in December and the amount of sea ice began to increase. The thick snow cover in southern Finland prevented the ice from thickening and the ice was dangerously thin under the snow. Immediately after mid-December, strong winds “cleaned out” the sea areas and reduced the ice-covered area. Freezing temperatures during the Christmas week caused the ice-covered area to expand rapidly again. Ice covered the entire Bay of Bothnia and the Quark, as well as just about the whole of the Swedish coast, including the West coast. December was exceptionally cold in the northern sea areas.

January

Frosty weather continued at the beginning of the year 2011. The ice-covered area expanded to more than 165,000 km² on January 4th. At that time, ice covered already the Archipelago Sea. The thickness of the fast ice varied from about half a meter in the northern parts of the Bay of Bothnia to ten centimetres in the southern coastal areas.

After this, the frosty weather began to ease its grip and the southerly winds compressed the ice fields. On January 11th, the ice-covered area had decreased to less than 100,000 km². The coldest period in January alternated with milder periods after this. The ice-covered area expanded and compacted according to the cold weather and strong winds. The ice-covered area was 150,000 km² on the last day of January. At this stage of the winter the ice situation corresponded quite closely to the average.

February

February was clearly divided into two parts in terms of temperature conditions. The weather at the beginning of the month was mild and windy, which caused the ice in the Gulf of Finland to drift into the sea areas east of the island of Gogland. While traffic to harbours in southern Finland continued with very little need for icebreaker assistance, Russian traffic had to cope with large problems – at one point more than 100 vessels were waiting for icebreaker assistance.

The weather got colder in the middle of February, when an intensive area of low pressure passed eastwards over Gotland followed by a block of high pressure which controlled the weather for a period of three weeks. The combination of clear skies and gentle winds caused thermometers to show lower and lower temperatures. Ice growth resumed both in the north and the south. Everywhere, except the south

coast of Skåne, was ice covered. By the middle of the month the Gulf of Bothnia was completely ice covered north of the Åland Sea, and at the same time the Gulf of Finland was covered with 10-45 cm thick very close ice.

As temperatures continued to drop, the latter half of the month turned out to be exceptionally cold. This cold period also caused the amount of sea ice to increase rapidly, and **the maximum ice extent was reached on 25th of February with the ice extending over an area of 309,000 km² - the greatest since 1987.** This occurred at nearly the average time[1].

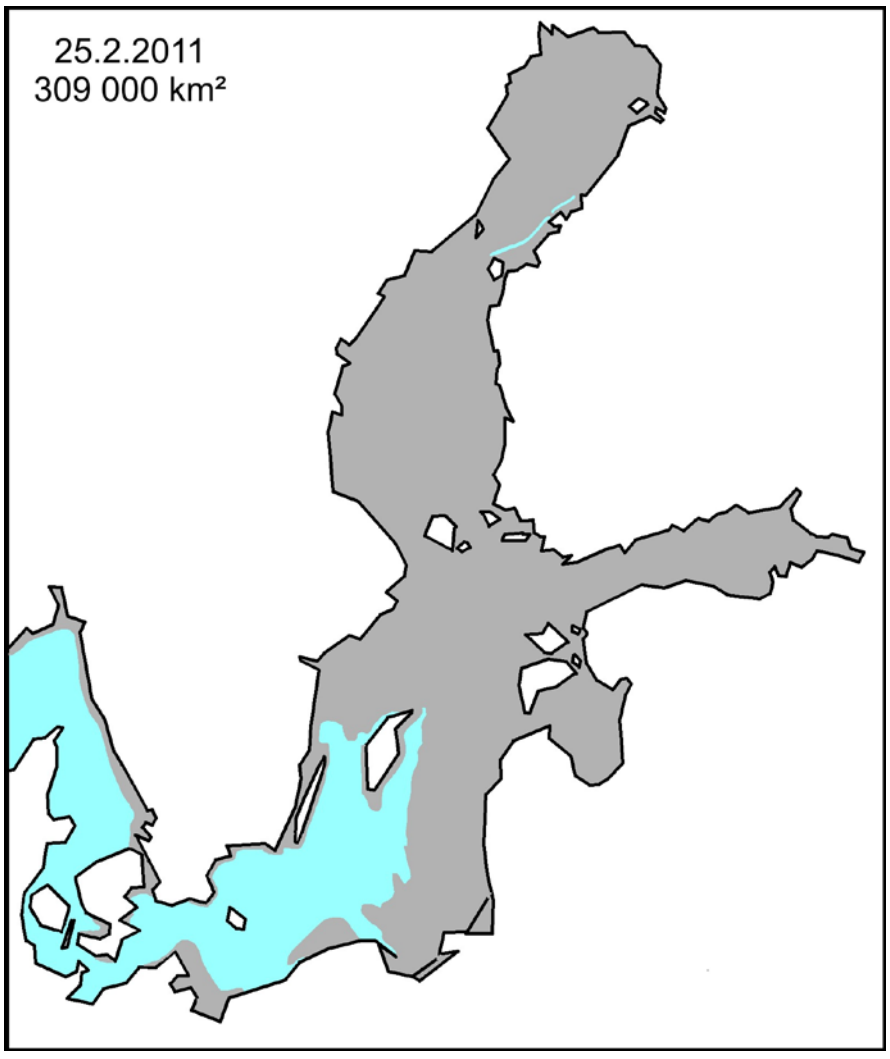

Figure 2. The largest ice extent – 309,000 km² – was reached on the 25th of February (Courtesy of FMI).

At that point, both the Gulf of Bothnia and the Gulf of Finland were completely covered by ice. The Gulf of Riga and the northern Baltic Sea were also completely ice-covered. The ice edge ran from Öland to Gotland and from the northern tip of Gotland south to Cape Rozewie on the coast of Poland. In the southern Baltic Sea, there was new ice off the coasts of Poland and in the Bay of Pomerania, as well as in Öresund and on the Swedish west coast.

[1] As the reference period, the 30-year period from ice winter 1980-1981 till ice winter 2009-2010, is used.

At the end of February, the winds began to blow from the south and became stronger. Pressure in the ice fields was detected in all Finnish sea areas, and at times it reached dangerously intense levels. When the situation was at its worst, dozens of commercial vessels were waiting for icebreaker assistance on both sides of the Quark and ships were assisted one at a time.

Figure 3. Stuck in ice (Courtesy of the Finnish Coast Guard).

Ice melting

March

The situation eased temporarily at the beginning of March as the winds calmed. However, this did not last long, as south-westerly winds strengthened on March 3rd and the ice began to drift eastwards. Pressure developed once again in the ice fields, causing severe compression and a rapid decrease in the size of the ice-covered area. On March 10th, the extent of the ice-covered area was 165,000 km². The winds blew from the Swedish side for another week and the ice in the Gulf of Bothnia was compressed against the Finnish coast. The pressure ridges were so difficult that several vessels en route to the Finnish harbours in the Bay of Bothnia came to a standstill further south, and had to wait for the winds to die down. Russian traffic in the eastern Gulf of Finland experienced so much difficulty that a nuclear-powered icebreaker had to be called in from the Arctic Ocean. It was not until the middle of March that the traffic was back to normal.

In mid-March, the winds calmed briefly and the frosty weather caused new ice to form in open places and cracks in the ice fields. Mild spring weather reached southern Sweden in the middle of March, starting the end of the ice season south of Landsort with the gradual breakdown of the archipelago ice in the increasingly stronger sunshine. In the northern parts the signs of spring appeared at the end of March and the ice-covered area decreased steadily. Even gentle winds caused pressure in the heavily ridged ice fields.

Disappearance of the ice

April

The average temperature in April was unusually high in nearly all parts of the Finland. Rainfall at the beginning of April darkened the ice and the coastal ice began to rot. Very warm weather at Easter (21st - 25th April) melted the ice on the Finnish southern coast. The coastal areas of the Gulf of Finland were almost completely free of ice, and the ice that remained was dangerously rotten. In contrast, ice in the pelagic areas of the eastern parts of the Gulf of Finland continued to disturb Russian sea traffic. The coastal ice in the Sea of Bothnia north of Uusikaupunki rotted, but farther off the shore a heavily ridged 20-30 kilometre wide ice field interfered with shipping traffic. The ice winter also continued in the Bay of Bothnia although the coastal ice slowly began to darken and subsequently rot. The ice in the pelagic areas was still strong.

May

A high-pressure system established itself over northern Scandinavia at the beginning of May, and the final melting stage began. Intermittent strong north-easterly winds broke up the ice out at sea into smaller and smaller floes. On May 14th, the Gulf of Finland was ice-free and the last pieces of ice in the Sea of Bothnia also melted at the end of the following week. In mid-May, the ice in the Bay of Bothnia was mainly on the Finnish side of the fishery zone limit. Although the ice in the archipelago areas had rotted and, in many areas, also melted, ice in the pelagic area still interfered with shipping in many places. The winter finally ended and summer began when the Bay of Bothnia was ice-free on May 25th.

The time of the final melting of the ice varied greatly in comparison to average values. In the coastal waters of the northern Bay of Bothnia, the date of the final disappearance of ice took place from a few days earlier to about one week later than average. Melting in the Sea of Bothnia took place from approximately one week to nearly three weeks later than on average, and in the Gulf of Finland from average times to some two weeks later than normal.

The ice disappeared more than one week later than average in the northern Baltic Sea; however, ice formation also began nearly one month earlier than usual.

Maximum thickness of sea ice (Finnish territorial waters)

The maximum thickness of the fast ice was 40-80 cm in the Bay of Bothnia, 35-75 cm in the Sea of Bothnia, 25-55 cm in the Archipelago Sea and 25-65 cm in the Gulf of Finland. The thickness of the pelagic ice was 35-85 cm in the Bay of Bothnia, 20-50 cm in the Sea of Bothnia, 25-60 cm in the Gulf of Finland, 10-25 cm in the Sea of Åland and 5-30 cm in the northern Baltic Sea.

Length of the ice winter (Finnish territorial waters)

The duration of the ice winter in the northern Bay of Bothnia was nearly two weeks shorter than average. The ice winter in the southern Bay of Bothnia and Vaasa Archipelago was from one and a half weeks to nearly a month longer than average. The ice winter in the Sea of Bothnia, northern Baltic Sea and Gulf of Finland was from two weeks (in the Helsinki region) to more than six weeks (in the Rauma region) longer than average.

The ice season in Latvian waters (Gulf or Riga)

The first ice formation in Latvian marine waters occurred the 30th of November. New ice formation firstly occurred in the southern part of the Gulf of Riga. New ice forms appeared along the western coast of the Gulf of Riga on the 5th of December and along the eastern coast of the Gulf – in the second half of December. Due to light winds in the third decade of December a narrow belt of fast ice formed only in several areas of Latvian coastal zone. In the port of Riga the first ice formed on December 12th, in the port of Ventspils – on December 21st and in the port of Liepaja on December 1st.

The most severe ice situation firstly has been observed on the fairway in the Irbe Strait during the first decade of January 2011. The Irbe Strait was covered by the drifting of 10-15 cm thick very close ice. New ice temporarily formed in the Latvian fairways in the second half of January, but assistance of the icebreaker was not necessary. Due to warm and stormy westerly winds fast ice was broken up along the western coast of the Gulf of Riga and in the coastal area of Liepaja. At the same time there was up to 4 km wide fast ice with ridges along the eastern coast of the Gulf.

In the first decade of February no significant changes in the ice conditions occurred on the fairways. The ice was drifting only in the coastal zone and the ports of Latvia. In the second decade of February, under the influence of an anticyclone, very cold air penetrated to the Baltic Sea region and the ice formation occurred rapidly in all Latvian marine waters. The ice grew thicker particularly in the Gulf of Riga and in the Irbe Strait until the end of February and at the beginning of March.

In the second half of February the Gulf of Riga was completely ice covered. In the Gulf of Riga there was 28-45 cm thick fast ice and further out in the central part of the Gulf of Riga as well as on the fairway between the port of Riga and Mērsrags there was compact or consolidated 30-50 cm thick ice with heavy ridges. On the fairway between Mērsrags and Kolka there was very close and rafted 15-30 cm thick ice. The Irbe Strait was covered by very close drift ice 10-30 cm thick. There was compact 20-30 cm thick ice in the port of Riga and pressure ridges were present in the entrance to the port. During the second half of February there was new ice at the Latvian coast of the Baltic Sea and further out mostly close to very close 5-15 cm thick ice up to 30-50 nautical miles away from the Latvian coast as well as on the fairway port of Ventspils – port of Liepaja – the sea border of Lithuania.

Navigation became easier on the fairways during the second and third decades of March. Due to gusty westerly winds the fast ice was partly broken up and the ice in the Gulf of Riga and the Irbe Strait was drifting eastwards. Therefore in the western and southern parts of the Gulf of Riga a 15-30 nautical miles wide lead, where the vessels could go without the assistance of the icebreaker, appeared and remained until April. At the same time, very close to compact 20-40 cm thick ice with pressure ridges remained in the central and eastern parts of the Gulf of Riga.

The ports of Riga, Ventspils and Liepaja were ice-free starting from the third decade of March. At the end of March and during April the Irbe Strait and the Latvian coast of the Baltic Sea were ice-free.

In April the ice in the Gulf of Riga was melting rapidly. Due to the winds of northerly and easterly directions the ice was gradually drifting to the south of the Gulf of Riga and by the end of April close to very close 10-30 cm thick ice remained in the south-eastern part of the Gulf of Riga.

At the beginning of May the ice melting continued. On May 7th the Gulf of Riga as well as all Latvian marine waters became ice-free.

The ice season in the southern Baltic Sea, Danish Straits and Kattegat

Ice conditions in the Polish coastal waters in the southern Baltic Sea

The ice season 2010-2011 on the Polish Baltic Sea coast was a moderate one. The ice season started relatively early, at the end of November (Vistula Lagoon and then Puck Bay). In open waters ice started to form in the second half of December (16.12. sea near Świnoujście) in the Pomeranian Bay.

November was warm, but in the last days of the month it became quite cool, and the air temperature decreased, even considerably, below zero. This resulted in an appearance of first ice in the Vistula Lagoon. Throughout December until first days of January air temperatures were below zero. December was very cold. Freezing air temperatures were conductive to the development of ice phenomena over internal waters (such as bays, lagoons) and in harbours and also over coastal zone. There was mainly shuga, and coastal ice, locally ice cover or pack ice. Over some water areas ice remained even to the end of the month.

In January 2011 only in the beginning as well as near the end of the month there were periods of freezing temperatures, but January was classified as warm. Temperatures were mainly above zero, which resulted with ice melting processes and ice disappearance. In the last days of January ice appeared again.

February in turn was a very cold month, especially near eastern coast area. After the initial warming in the first decade of February and disappearance of ice over whole coastal zone (except the Vistula Lagoon). In the second half of February as a result of an inflow of cold air masses there were significant temperature drops. Again over Puck Bay, Szczecin Lagoon, in harbours of western coast, ice started to develop, and near 18th of February in other harbours of middle and eastern coast, and also along the coast over an open sea except the Pomeranian Bay (Świnoujście, where ice appeared in the last days of February). With the persistence of the freezing temperatures there were even further developments of ice over Puck Bay and the Gulf of Gdańsk, Pomeranian Bay and along the rest of the coast. The whole Gulf of Gdańsk had been covered with ice.

The maximum ice extent in Polish coastal zone was on 25th -26th February 2011. The maximum of ice development was reached in the third decade of February. At that time, fast ice of 10-15 cm thickness covered Szczecin Lagoon on the coast of Poland, and close to very close, up to 20 thick ice or new ice was observed in the harbours along the coast. In the Pomeranian Bight and on the outer Baltic coasts, a belt of locally close 5-12 cm thick ice extended eastward. Ice of 10-20 cm thickness occurred off the coasts of the Gulf of Gdańsk. Vistula Lagoon and Curonian Lagoon were covered with 20-54 cm thick fast ice. The offshore waters east of 19°E were covered with close to very close 5-15 cm thick drift ice. Till the end of the February ice situation did not change.

In the beginning of March ice still covered open sea areas, only in the middle of first decade it started, because of wind and water motion, to flow away into the open sea. Additionally an increase of air temperature stopped the process of further ice development. The air temperature since then has been gradually increasing, and daily mean air temperatures were above zero till the end of the month, which favoured ice melting and disappearing processes. At the end of March all water areas were ice free.

Ice conditions and navigation on the German Baltic Sea coast

In terms of ice volume and duration of the ice cover in the German coastal waters, the winter of 2010-2011 was a moderate ice season.

From late November to early January, the entire Baltic Sea region was under the influence of cold polar air from northerly, north-easterly or easterly directions. This cold spell was interrupted by several short periods during which warmer air masses flowed into the area from the west or south, mostly with precipitation in the form of snow.

In the beginning of the December, the German inner coastal waters were close to freezing, and also on the outer coasts water temperatures reached freezing point in the third decade of December. Ice formation in the sheltered areas (bodden waters, Schlei) began during the last days of November or first days of December, 3 - 4 weeks earlier than normal. In the last week of the year ice also formed on the outer coasts and temporarily in the offshore waters of the Kiel and Mecklenburg Bights. After just a few days, the ice had largely disappeared due to water level fluctuations and wind forcing.

The ice cover of the Baltic Sea in early January corresponded to conditions which normally prevail at the end of January or early February. On the January 5th the winter of 2010-2011 in the western and southern Baltic Sea already met the criteria for a moderate ice winter. January and February, the typical winter months, were mild in comparison with December. At the beginning of the year, south-westerly winds caused an inflow of mild maritime air on the front side of the low over Norway, marking the beginning of a warm spell. The development of ice was slow during the first five weeks of year, with an initially weak decreasing trend followed by a faster melt-down of ice.

In the second decade of February, a high-pressure zone developed over Scandinavia which grew stronger as it slowly moved east. This anticyclone influenced weather in the coastal region until early March, with mostly calm, cold winter weather. The water surface cooled quickly, not only in the sheltered inner coastal waters but also offshore, especially in the Pomeranian Bight. The predominantly easterly winds freshened only on a few days. New ice began to form in the inner coastal waters along the eastern Baltic coast. Decreasing wind and falling temperatures during the next few days led to increasing ice formation, also in the inner coastal waters of the western part of the coast. However, the strongest ice formation was recorded on the eastern coast, where the inner waters soon were covered completely with ice. Pancake ice which had newly formed in the Pomeranian Bight quickly formed a closed ice cover. The ice forming during the second cold spell disappeared as quickly as it had developed: by mid-March, all German Baltic Sea waters were free of ice.

Ice conditions in the German Bight, Kattegat, Skagerrak, and in the Danish and Swedish waters of the western Baltic Sea

In the *Kattegat*, ice occurred only during the first cold spell in December and January in some smaller harbours and fjords on the coast of Denmark. The skerries and sheltered bays along the Swedish coast were covered continuously with ice of different concentrations from late December to mid-March. Ice thicknesses reached 10 - 30 cm. In offshore waters and in the Belts and Sounds, major quantities of ice occurred only at the end of December.

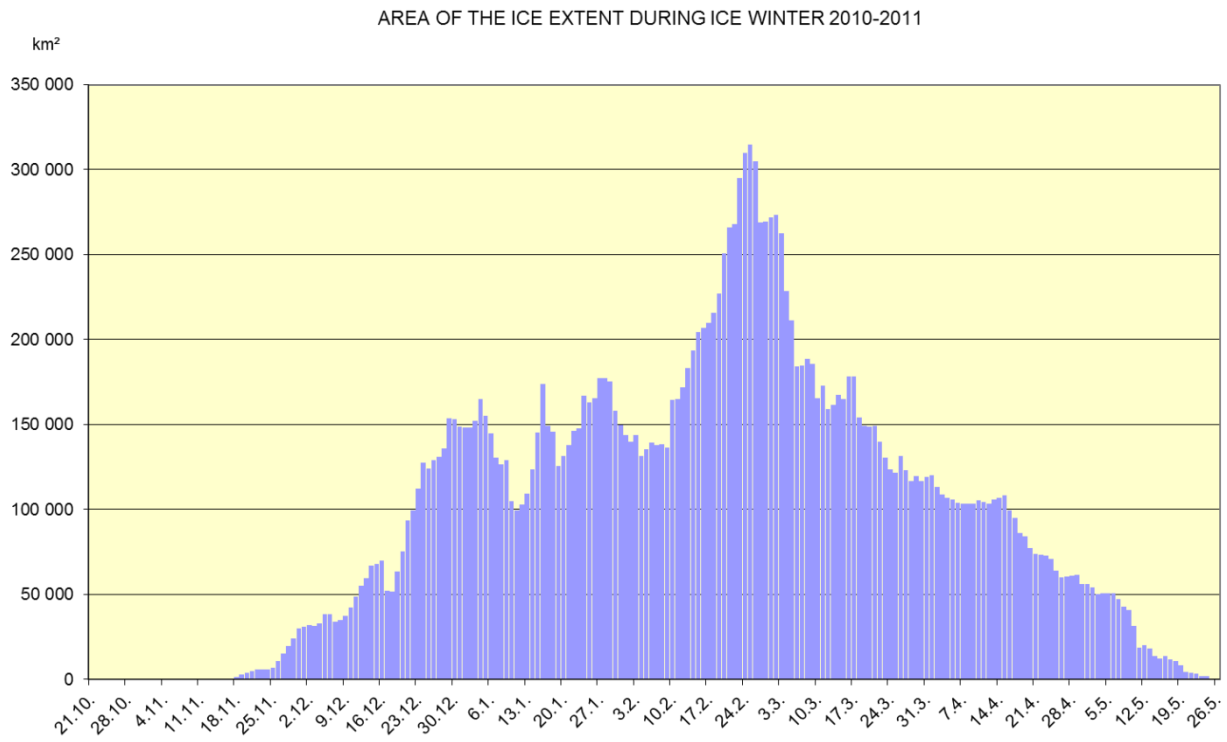

Figure 4. The daily ice extents in the Baltic Sea during the ice winter 2010-2011 (Courtesy of FMI).

[1] Finnish Meteorological Institute (FMI), Ice Service, Finland

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