The ice winter of 2013/14 on the German North and Baltic Sea coasts and a brief description of ice conditions in the entire Baltic Sea region

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Southern beach at Thiessow in the Bay of Greifswald Courtesy of Frank Sakuth

Status of the ice winter of 2013/14 in long-term comparison

In view of the degree of ice formation and duration of ice cover along the German coastline, the winter of 2013/14 resulted in a weak ice season. The indices for the intensity of an ice winter are calculated from observation data from the 13 climatological stations at the Baltic Sea coast and 13 climatological stations at the North Sea coast and are expressed in terms of the *reduced ice sum*, or, respectively, the *accumulated areal ice volume* ($V_{A\Sigma}$); an explanation of terminology is available on http://www.bsh.de/de/Meeresdaten/Beobachtungen/Eis/Kuesten.jsp.

The calculated indices for the ice winter of 2013/14 are summarised in Table 1.

Table1. Reduced ice sum and accumulated areal ice volume on the German coasts in the winter of 2013/14

Area	Reduced ice sum	Accumulated areal ice volume
North Sea coast	**4.2**	**0.14** m
Baltic Sea coast	**6.0**	**0.37** m
Coast of Mecklenburg/Vorpommern	7.7	0.56 m
Coast of Schleswig-Holstein	4.0	0.14 m

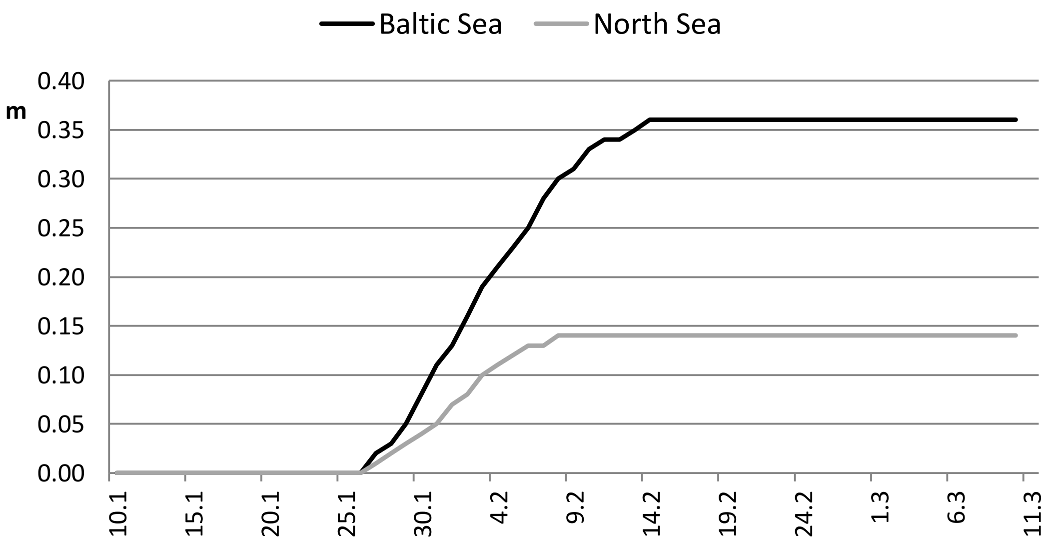


Fig.1. Accumulated areal ice volume on the German coasts in the winter of 2013/14

As in every winter, ice formation was more abundant in the eastern sections of the German Baltic Sea than in the western part, which can be generally explained by the stronger influence of the continental climate. The winter of 2013/14 was a very weak ice winter at the coast of Schleswig-Holstein; however, it is classified within the lower range of moderate ice winters for the coast of Mecklenburg-Vorpommern (cf. Table 1).

The status of the ice winter 2013/14 in long-term comparison is illustrated in Figures 2 and 3. Within the observation series since 1896/97 (119 years), 39 ice winters on the German North Sea coast and 42 ice winters on the Baltic Sea coast were weaker than the ice season 2013/14.

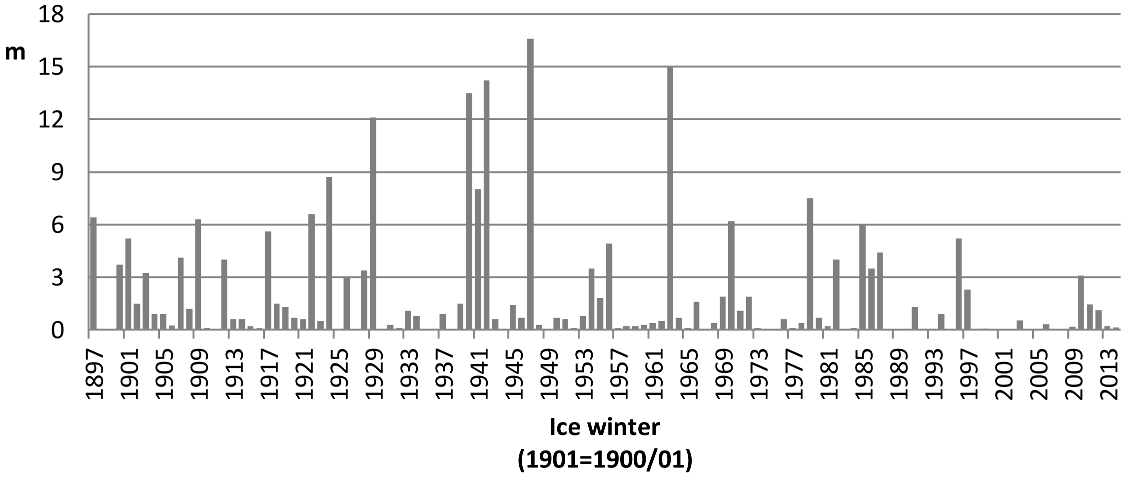


Fig.2. Distribution of accumulated areal ice volume for the German North Sea coast

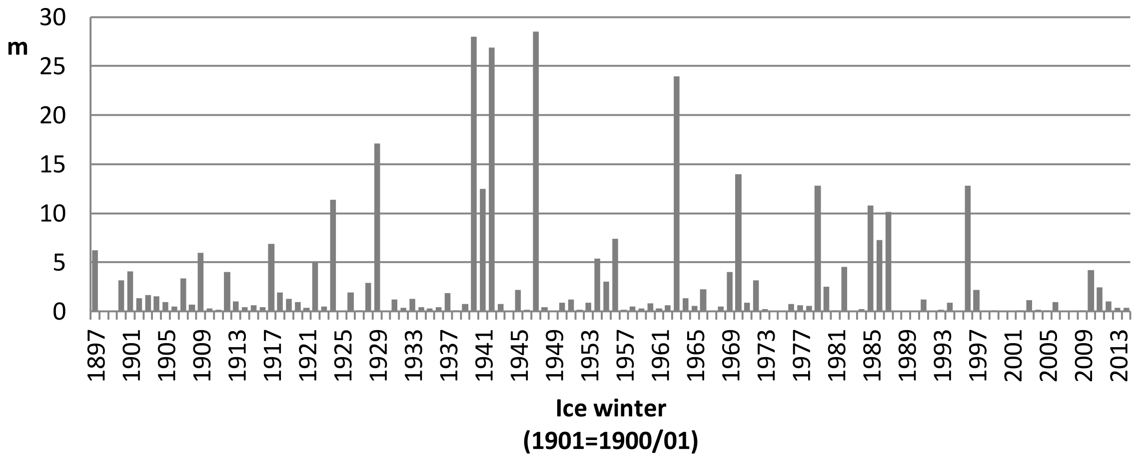


Fig.3. Distribution of accumulated areal ice volume for the German Baltic Sea coast

The maximum ice extent in the entire Baltic Sea region was reached during the first 10 days of February and comprised about 95,000 km^2. The corresponding maximum ice volume is 15.7 km^3. The ice winter of 2013/14 can be classified as a weak or extremely weak ice winter also for the entire Baltic Sea; cf. also section "Maximum ice extent and maximum ice volume in the Baltic Sea" on page 9 of this report.

The BSH reported on ice conditions and expected ice development in the entire Baltic Sea region and German coastal waters in the ice winter **2013/14** by way of

111 ice reports (official reports issued Monday – Friday),
28 German Ice Reports (international exchange, issued when ice forms in German shipping lanes),
about 20 NAVTEX reports (in German and English for the German North and Baltic Sea coasts),
21 ice reports “German Baltic Sea coast“(detailed description of ice situation for German users),
10 ice reports “German North Sea coast“(detailed description of ice situation for German users),
24 weekly reports (information for the Federal Ministry of Transport, Building and Urban Development and for MURSYS),
19 general ice charts (once a week, as a reference ice chart for the entire Baltic Sea),
21 special ice charts (German Baltic Sea coast).

The current ice reports and ice charts of the BSH are available free of charge online under http://www.bsh.de/de/Meeresdaten/Beobachtungen/Eis/. The archive with all ice charts heretofore issued is available at ftp://ftp.bsh.de/outgoing/Eisbericht/.

Progression of the ice winter at the German North and Baltic Sea coasts

Weather conditions in the German coastal areas

The seasonal cooling of the air and water in November and December 2013 progressed slower than usual, because low-pressure systems moving from West to East across Northern Scandinavia frequently introduced mild air masses from West and South to the German coastal areas. In December, the monthly mean temperatures at the coastal areas were significantly above the values of the reference period 1961 – 1990 (Ch. Lefebvre, 2013).

Table2. Monthly mean air temperatures (°C) in the winter of 2013/14 and their deviation from the 1961 – 1990 (K) climate means (courtesy of Deutscher Wetterdienst, www.dwd.de)

Station	November		December		January		February		March	
	°C	K	°C	K	°C	K	°C	K	°C	K
Greifswald	5.7	1.1	4.7	3.6	0.0	0.6	4.6	4.6	6.5	3.8
Rostock-Warnemünde	6.7	1.4	5.4	3.5	0.9	0.7	5.2	4.5	6.6	3.5
Schleswig	5.6	0.7	4.7	3.0	1.8	1.5	5.0	4.4	6.4	3.6
Norderney	7.9	1.6	5.9	2.7	3.2	1.6	5.5	3.7	7.0	3.0

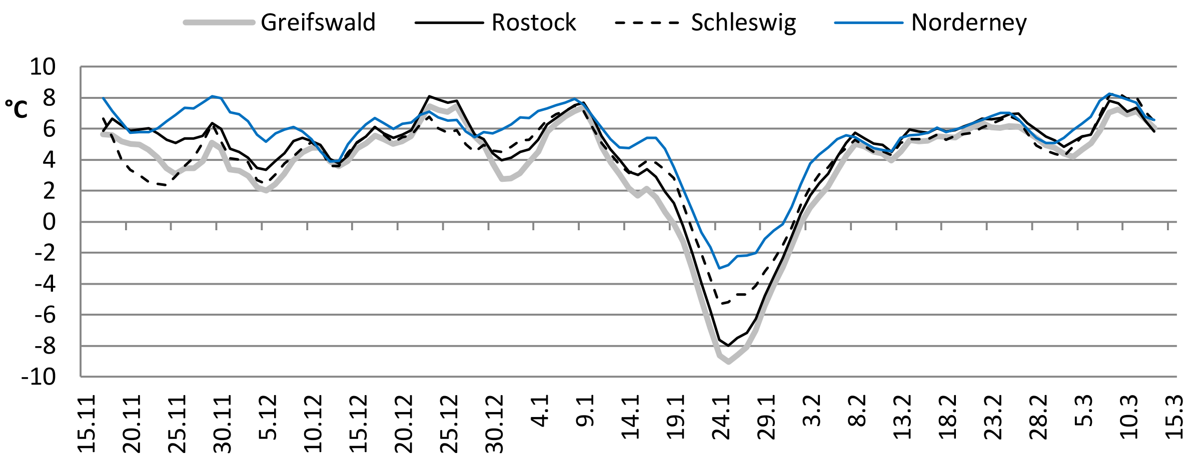


Fig.4. 5-day running mean of air temperatures in the winter of 2013/14 (courtesy of Deutscher Wetterdienst, www.dwd.de)

January was the coldest month in the winter of 2013/14. As of about the middle of the month, the weather in the Baltic Sea region was determined by a high-pressure area above Northern Scandinavia. Northerly and north-easterly winds transported polar cold air first to the sections of the Northern Baltic Sea region and by end of the month also to the Southern Baltic Sea regions. The winter was comprised of one single cold spell from mid-January to early February 2014. The German coasts were subjected to continuous frost. During this period, the lowest values of mean daily temperatures were between -7 and -12 °C (with the North-East being the coldest area) and were reached on 26 January. During the first days of February, the high-pressure area slowly moved east and settled over Russia. As of 3 February, between this high and a low-pressure system above the Northern Atlantic, mild air was introduced by southerly winds to the coastal zones. This terminated the sole frost period in the winter of 2013/14.

The propensity of the water to freeze was reached by 20 January for the internal waters of the Baltic Sea coast and by 26 January on the external coast in immediate vicinity to the shore. At the North Sea coast, the water only briefly cooled down to freezing point in the final days of January and only in protected areas (cf. Fig. 5).

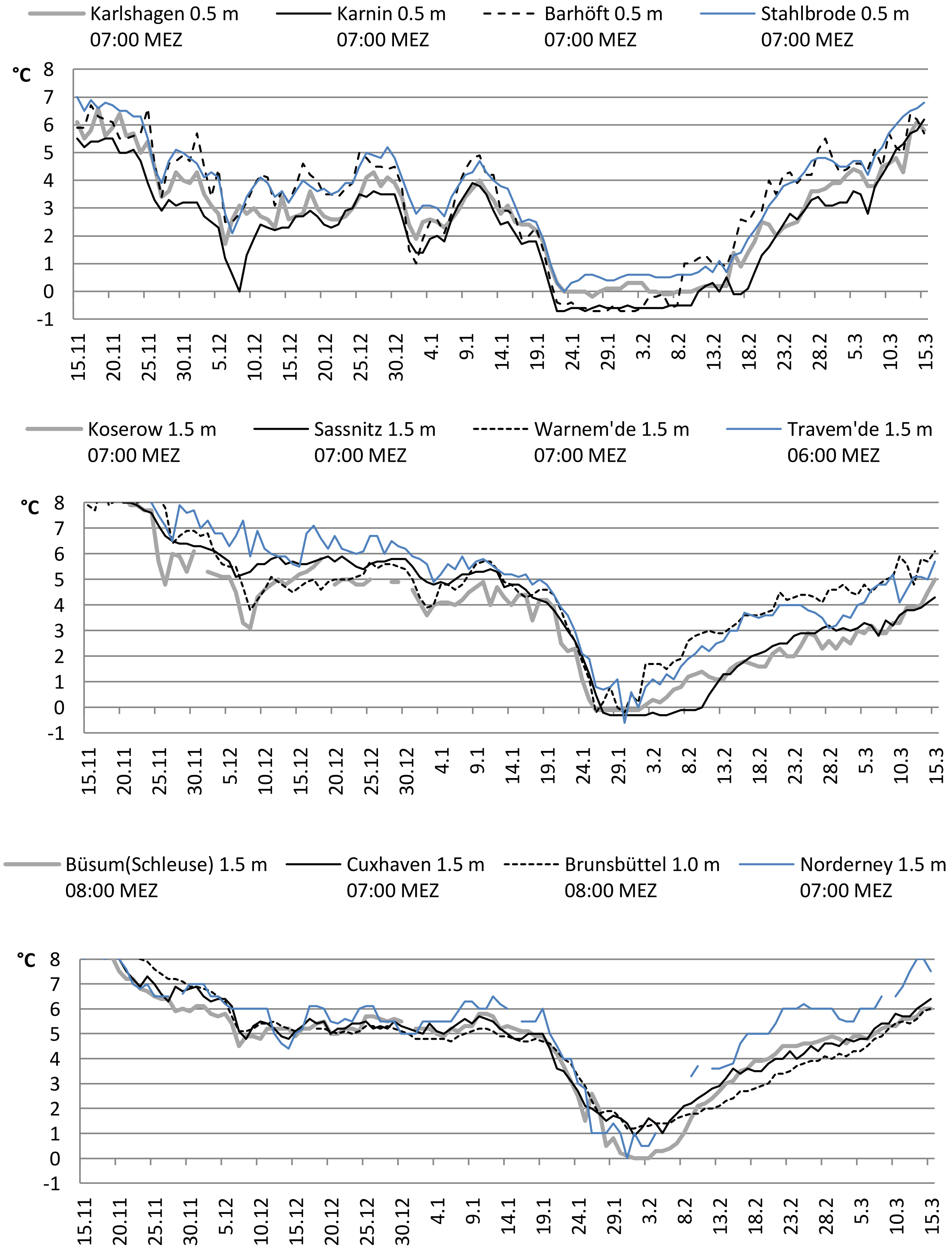


Fig.5. Water temperatures of German coastal waters

Measurement sources: Karlshagen, Karnin, Barhöft, Stahlbrode, Koserow, Sassnitz and Warnemünde – WSA Stralsund; Travemünde – WSA Lübeck; Büsum – Schleuse Büsum; Cuxhaven und Norderney – Deutscher Wetterdienst; Brunsbüttel – WSA Brunsbüttel.

Ice conditions on the German North and Baltic Sea coasts

Corresponding to the meteorological conditions, the ice winter of 2013/14 consisted of only one ice period at the German coasts, which lasted in total from 23 January to 28 February. The progression of the ice winter is illustrated in Fig.A1 in the appendix. The tables A1 and A2 of the appendix present a summary of the most important ice parameters.

The first formation of ice started in smaller harbours and protected waters on both coasts at more or less the same time between 22 and 28 January and continuously progressed until early February. At the time of maximum ice formation on 3 February 2014 (Fig. 6), close to open ice occurred locally at the North Frisian coast and on the Elbe; very open new ice drifted off the coast. Ice thickness reached values of 5 to 15 cm; in some areas, the ice was pushed together to 20 or even 30 cm. Very close to close ice with a thickness of 5 to 15 cm covered the Schlei, Lower Trave, Neustadt Bay and Wismar Bay. At the coast of Vorpommern, all internal waters were covered by about 15 cm thick ice. In the Pomeranian Bight, the coasts of Rügen and Usedom were encircled by close ice of 5 to 10 cm thickness. In the first days of February, southerly winds gradually warmed up the air in the coastal regions and introduced the melting of the ice. The North Sea coast was completely free of ice on 7 February; the Baltic Sea coast off Schleswig-Holstein was ice-free on 13 February. In the bodden waters of Mecklenburg-Vorpommern, the thawing ice broke up and was pushed together by southerly winds to accumulate at the northern coasts, which considerably delayed ice reduction: complete disappearance of ice was not achieved until 28 February. The number of days with ice varied significantly also in the ice winter of 2013/14: from 3 days at the East Frisian coast to 36 days at the northern coasts of the Bay of Greifswald and the Kleines Haff. On the Elbe, ice occurred on 11 days; on the external coasts of the islands of Rügen and Usedom on 5 days. The Ems and Weser as well as the Kiel Canal and the sea off the German coast remained free of ice in the winter of 2013/14.

Navigational conditions on the German Baltic Sea coast (cf. also Table A3)

In the past winter, navigation was not impeded to any mentionable degree along the German North Sea coast and on the western internal navigation channels. Ice formation did cause some problems in the coastal waters off Vorpommern. In the period between 27 January and 11 February, ice breaking escort operations in the eastern approach to Stralsund, in the Bay of Greifswald and on the northern Peenestrom were granted only to those vessels suitable for navigation in ice-covered waters and classified as E1 (IC) or higher. The engine power of these vessels had to be at least 1,000 KW. In addition, the shipping industry was advised to navigate the above-mentioned areas only during the day (WSA Stralsund, 2014).

In the period between 30 January and 17 February, the northern approach to Stralsund (including western bodden waters), the internal bodden waters of Rügen, the southern Peenestrom and the Kleines Haff were closed for navigation (WSA Stralsund, 2014).

ARKONA works in the Bay of Greifswald Courtesy of Frank Sakuth

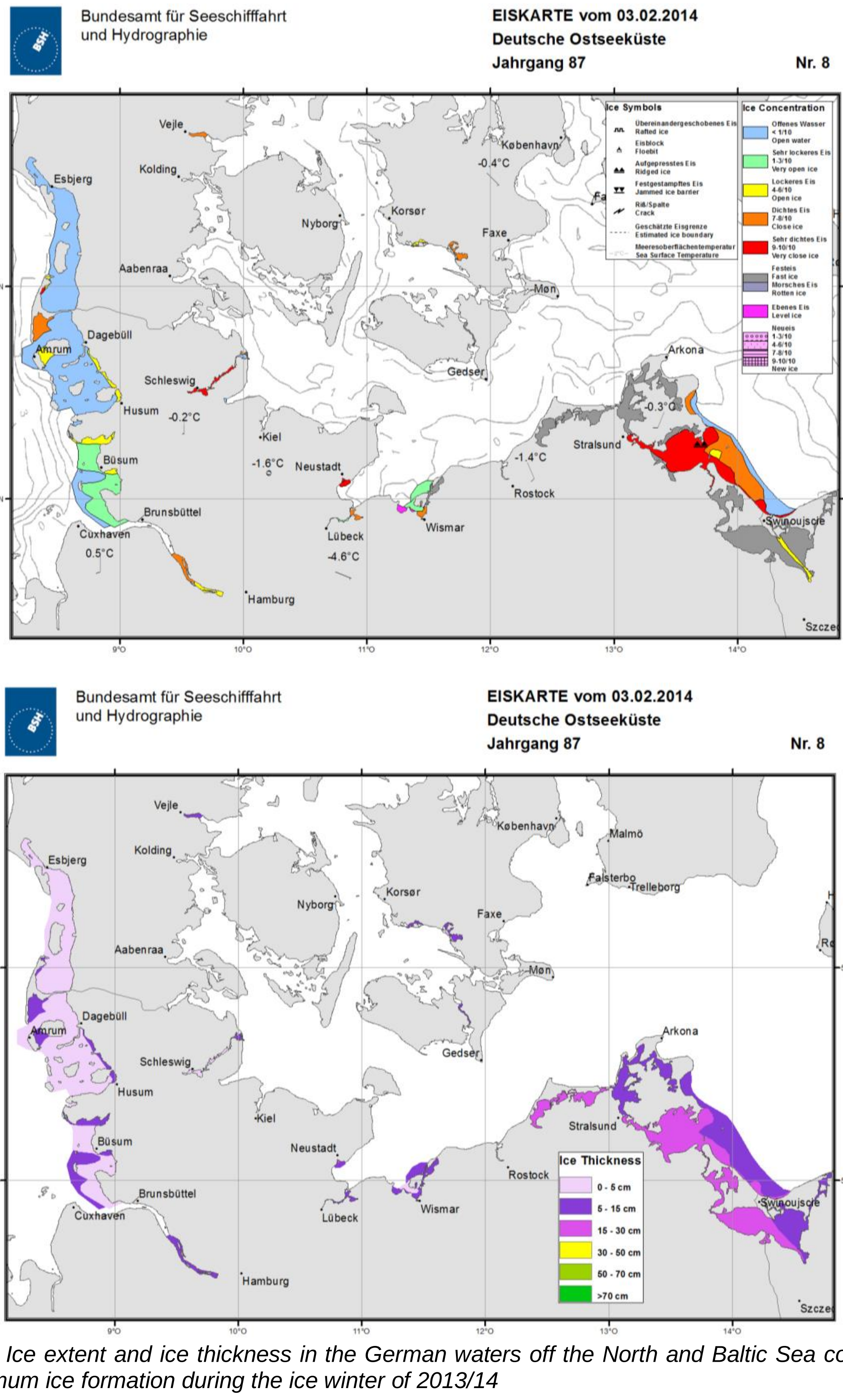


Fig.6. Ice extent and ice thickness in the German waters off the North and Baltic Sea coasts at the time of maximum ice formation during the ice winter of 2013/14

Starting with the winter of 2013/14, the BSH ice charts will be published in new design. One map shows the amount and arrangements of the ice as well as its topography or form, the areas of icebreaker operation, the air temperature and wind conditions at the coastal stations as well as isotherms of water temperature. The other map illustrates ice thickness and restrictions to navigation.

Ice conditions in the Western and Southern Baltic Sea

In the Danish waters of the Western Baltic Sea, 5 to 15 cm thick ice of varying ice concentration occurred on some days between 28 January and 11 February in smaller harbours and shallow, protected sections of the coastline. Major navigation was not impeded. In the Southern Baltic Sea, 10 to 15 cm thick fast ice was present in the Szczecin Lagoon as early as on 27 January; it fully disappeared only as late as on 22 February. Level ice with a thickness of 5 to 10 cm occurred in the Bay of Puck (Zatoka Pucka).
At the time of maximum ice formation, the Vistula Lagoon and the Curonian Lagoon were covered by 15 to 30 cm thick fast ice.

Ice conditions in the Northern Baltic Sea region (north of 56 °N)

The first ice formed on the inner archipelago of Luleå around 11 November 2013. In the following days, ice formation intensified due to cold air from the North, but ice cover was limited to the inner archipelago of the Northern Bay of Bothnia. In the Eastern Gulf of Finland, ice formation started only as late as in the second ten days of December. Until mid-January, ice increase progressed very slowly in all areas; compared to the long-term mean values, ice formation lagged behind by about four weeks. As of mid-January, the weather in the Northern Baltic Sea region was determined by a high-pressure area above Northern Scandinavia. The coasts of the Gulf of Bothnia, the Gulf of Finland and the Gulf of Riga were subjected to moderate to very strong frost. Ice formation intensified in all coastal zones and also at sea in the Bay of Bothnia and in Norra Kvarken and further progressed under the influence of weak northerly to easterly winds. Up until the end of January, the Baltic Sea region remained under the influence of a high-pressure and the influx of very cold air from the East and North-East. Intensive ice formation continued, ice extent and ice thickness increased. The climax of ice formation in the Northern Baltic Sea region was reached around 6 February. The Bay of Bothnia and Norra Kvarken were fully covered by ice; thin or new ice beyond the archipelago fast ice had formed in the Sea of Bothnia, the Gulf of Finland and the Gulf of Riga; some strips of new ice drifted off the Baltic coast in the Northern Baltic Sea (cf. the ice chart in Fig. 7).

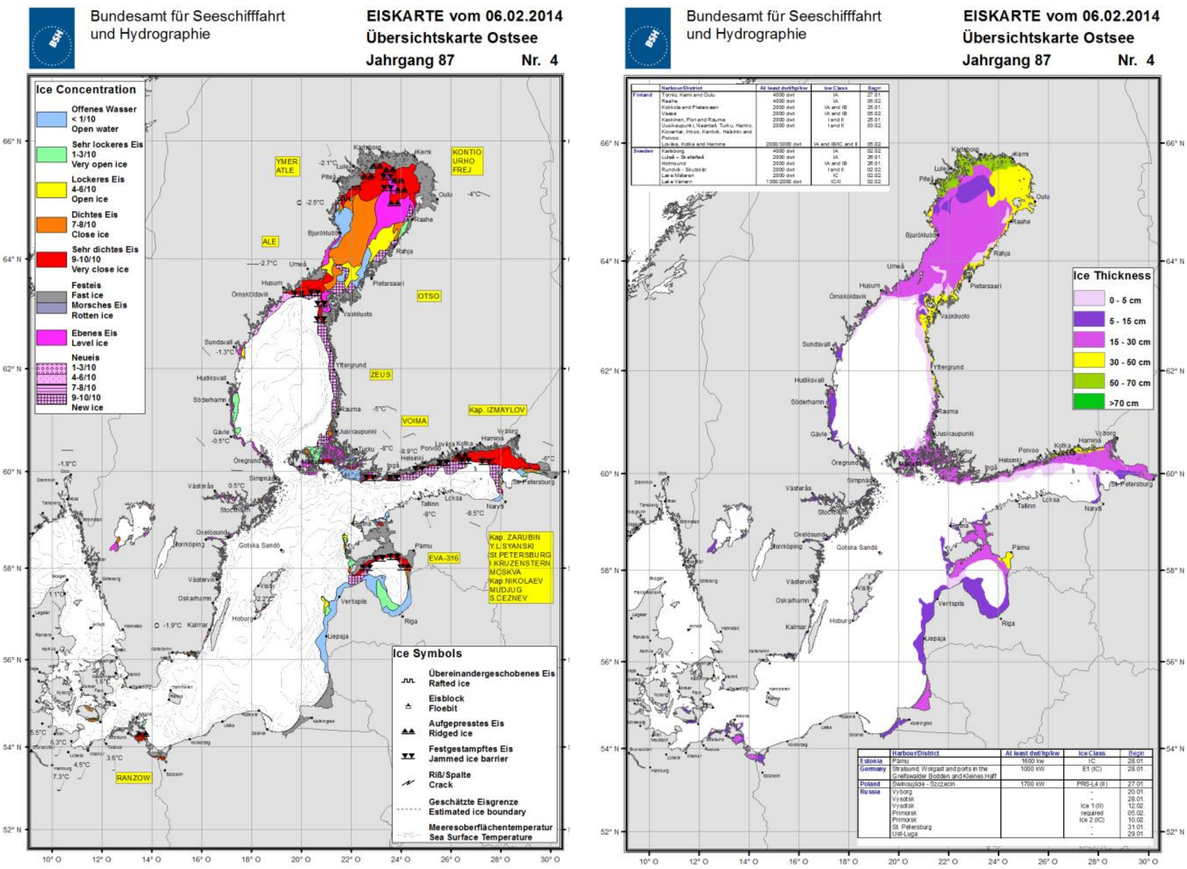
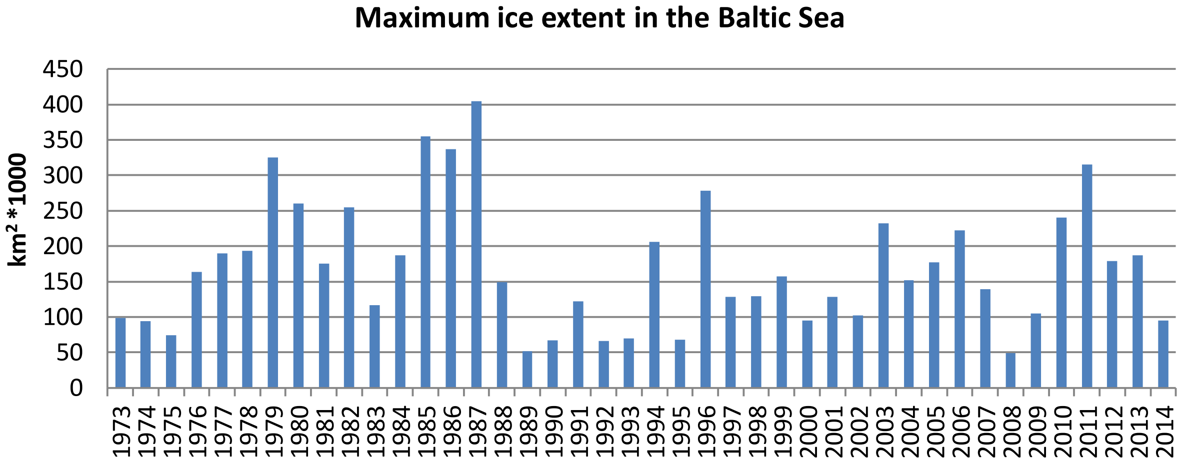


Fig.7. General ice chart for 6 February 2014 with maximum ice extent

At that time, the fast ice in the Bay of Bothnia archipelago was 25 to 60 cm thick; in the Gulf of Bothnia 10 to 30 cm; in the Eastern Gulf of Finland 15 to 35 cm; in the Western Gulf of Finland and in the Archipelago Sea 15 to 20 cm; in the Gulf of Riga 10 to 20 cm. In the further course of the winter, mild weather prevailed in the Northern Baltic Sea region with fresh, mostly southerly winds and mostly wind-induced changes to ice conditions. The sea ice in the Bay of Bothnia, in the Gulf of Finland and in the Gulf of Riga was pushed together or compressed on the northern coasts; thickness increased to 20 to 60 cm in the Bay of Bothnia, to 15 to 35 cm in the Gulf of Finland and to 15 to 30 cm in the Gulf of Riga. Navigation in these parts of the sea was impeded by the formation of hummocks, compressed ice and ice that was pushed together. Navigation was particularly difficult along the Finnish coast of the Bay of Bothnia. Thawing started as early as in mid-March in the Gulf of Finland and the Gulf of Riga; both gulfs were free of ice by the beginning of April – 4 weeks earlier than usual. The last bits of drift ice in the central zone of the Bay of Bothnia had dissolved by mid-May, about 10 days earlier than usual.
Based on the maximum ice extent (about 95,000 km^2) and the Finnish ice winter classification (Seinä and Palosuo, 1996), the ice season 2013/14 belongs to the category of mild ice winters.

Maximum ice extent and maximum ice volume in the Baltic Sea



Max. extent	Min. extent		Max. volume	Min. volume
1000*km^2	1000*km^2		km^3	km^3
405 (1987)	> 380	Extremely strong ice winters	**99.4** (1987)	> 89
380	295	Strong ice winters	89	65
294	171	Moderate ice winters	64	30
170	85	Mild ice winters	29	17
< 85	**49** (2008)	Extremely mild ice winters	< 17	**7.6** (1992)

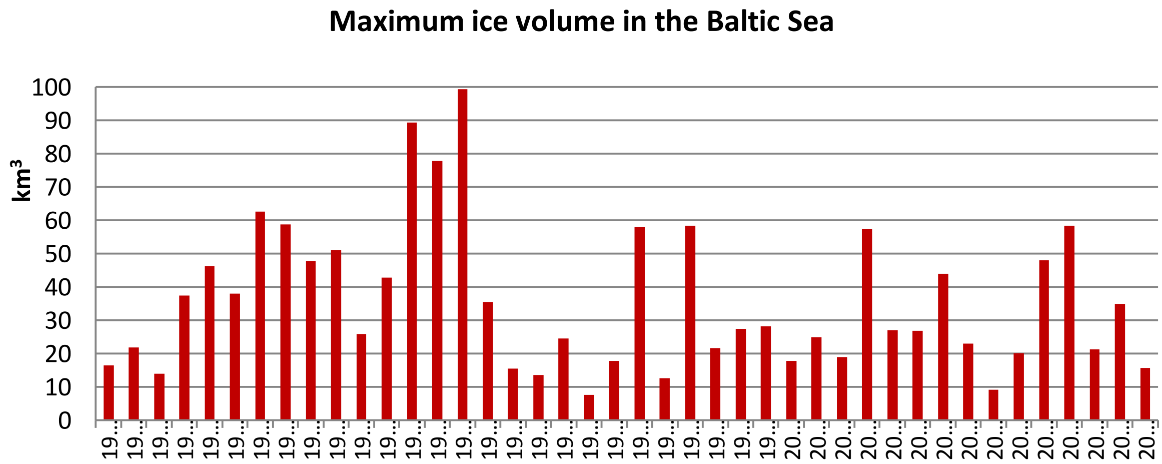
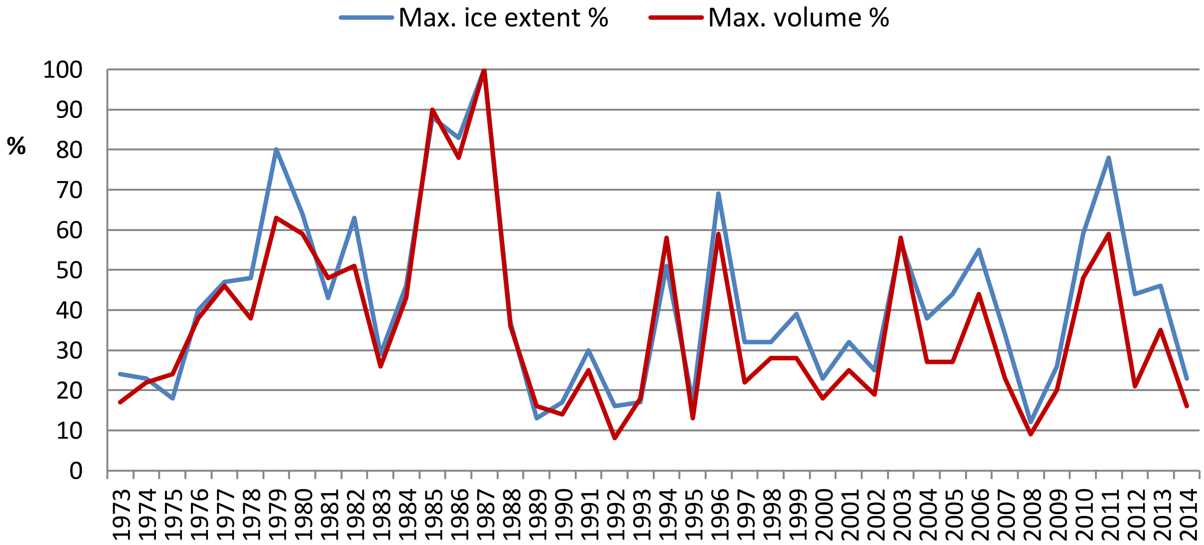


Fig.8. Maximum ice extent and maximum ice volume in the Baltic Sea with class boundaries of various types of ice winters; period 1973 – 2014

For classifying the intensity of an ice winter, the Finnish ice service uses the reconstructed or computed data of annual maximum ice extent in the Baltic Sea (Seinä and Palosuo, 1996). This data series comprises the period from 1720 to today. Maximum annual ice volume for the entire Baltic Sea was computed at the ice service of the BSH on the basis of the data that contains ice concentration and ice thickness for the grid 0.5°x0.5° (Feistel et al, 2008). Since reliable data on ice thickness is available only for the years as of 1973, the 42-year series (1973 – 2014) of extent and volume is analysed here. Fig.9 illustrates maximum ice extent and maximum ice volume for each winter from 1973 to today as well as the class boundaries of the 5 ice winter types as determined by the Nusser method (Nusser, 1948). These two values vary significantly from winter to winter: in the winter of 1986/87, the Baltic Sea was almost entirely covered by ice (405,000 km^2), compared to only 12% (49,000 km^2) in the winter of 2007/08. It is a very similar picture with regards to maximum ice volume; however, the lowest volume of ice formed in the winter 1991/92 and not in 2007/08. To compare these two measures, a percentage relative to maximum coverage and, respectively, to maximum volume was computed in the series 1973 – 2014 (cf. Fig. 9).



Max. extent	Min. extent		Max. volume	Min. volume
%	%		%	%
	> 94	Extremely strong ice winters		> 90
94	73	Strong ice winters	90	65
72	42	Moderate ice winters	64	30
41	21	Mild ice winters	29	17
< 21		Extremely mild ice winters	< 17	

Fig.9. Maximum ice extent and maximum ice volume in the Baltic Sea relative to the strongest ice winter in the period 1973 – 2014 and class boundaries of various types of ice winter in %

Apart from three extremely mild winters in the early 1970s and 1990s, the two measures remain consistent: with increasing extent, volume increases as well. What is remarkable is the fact that maximum extent often turns out to be significantly greater than maximum volume, especially in the past 20 years. This can be explained by short-term, major expansion of thin ice, often less than 5 cm in thickness; however, these results in an ice winter being classified into different classes. For example, the winter of 1978/79 is classified as strong on the basis of extent and moderate on the basis of volume. Much the same is true for the winters of 2004/05, 2010/11 and 2011/12.

As the maximum annual ice volume takes into consideration not only ice extent, but also ice thickness, this is a better measure for describing the intensity of an ice winter. Classification of ice winters could be considerably improved also by including the duration of ice formation.

Comparison of theoretically computed ice thickness values and those reported by ice observers in some regions of the German Baltic Sea coast

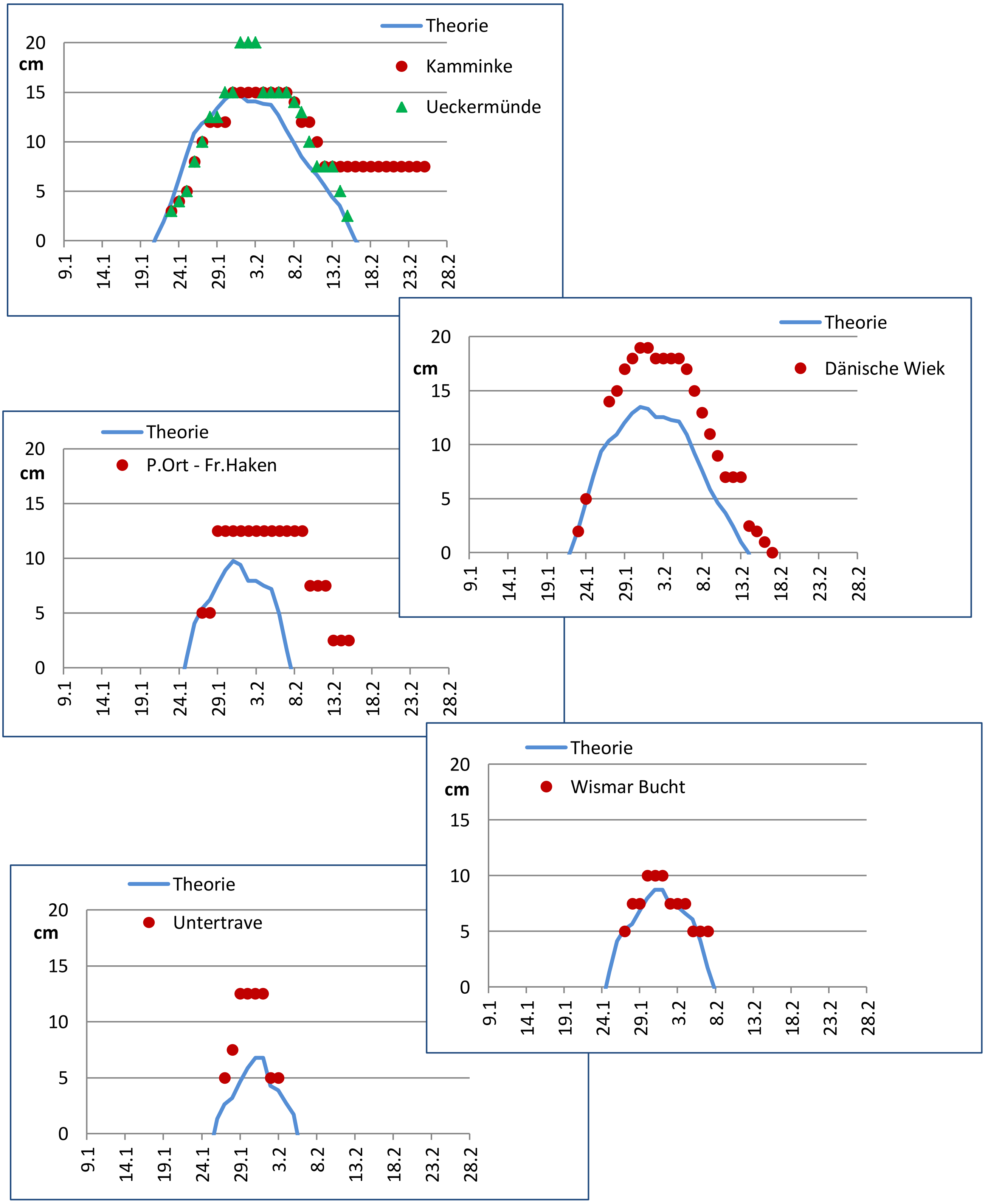


Fig.10. Theoretically computed ice thickness values and corresponding values as reported by ice observers for some regions of the German Baltic Sea coast in the winter of 2013/14

The methodology for theoretical determination of ice thickness for some regions of the German Baltic Sea coast was presented in the account of the ice winter of 2012/13 (Schmelzer et al, 2013).
Figure 10 shows the comparison between theoretical and reported ice thickness values in the winter of 2013/14.
The ice thickness values were computed for the ice observation stations Kamminke and Ueckermünde in the Kleines Haff, Dänische Wiek and Palmer Ort – Freesendorfer Haken in the Bay of Greifswald, Wismar – Walfisch (Wismar Bay), Lübeck – Travemünde (Lower Trave) The computation used the daily mean air temperatures (data courtesy of Deutscher Wetterdienst, www.dwd.de) from the stations Greifswald and Rostock-Warnemünde.
Since the ice winter of 2013/14 consisted of only one cold spell, the behaviour of ice thickness levels in a given area is described by a theoretical curve. The maximum computed thickness of level ice reached values between 10 and 15 cm. The reported values from the areas Ueckermünde and Lower Trave are 5 to 10 cm more. One of the reasons for this difference may be the fact that the air temperatures were not measured exactly at each of the ice observation stations in question. For instance, the temperatures in Ueckermünde towards the end of January were lower than the used data from Greifswald. The thawing process in Kamminke went on for longer than was expected on the basis of the increase in temperature. Here, other weather factors played a greater role: towards the end of the ice period, the rotten ice in the Kleines Haff was broken up and pushed together at the northern coast by freshening southerly winds. Warmth alone was not sufficient to thaw this compact belt of ice by the computed point in time. At the southern coast of the Kleines Haff (Ueckermünde), the thawing process progressed according to the thermal conditions.

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Appendix

Table A1. Ice conditions on the German North Sea coast in the winter of 2013/14

Observation station	Beginning of ice occurrence	End of ice occurrence	Number of days with ice	Max. thickness of level ice, cm
Ellenbogen (Sylt), List Deep	26.1	4.2	10	10-15 cm
Sylt, harbour List	23.1	7.2	16	10-15 cm
Dagebüll, fairway	3.2	5.2	3	< 5 cm
Wyk on Föhr, harbour	28.1	4.2	8	15 cm*
Wyk on Föhr, Norderaue	30.1	3.2	5	5-10 cm*
Amrum, Wittdün harbour	28.1	7.2	11	15 cm*
Amrum, Vortrapp Deep	28.1	7.2	11	10-15 cm
Amrum, Schmal Deep	28.1	7.2	11	10-15 cm
Husum, harbour	27.1	3.2	8	5 cm
Husum, Au	27.1	3.2	8	5 cm
Nordstrand, Hever	1.2	5.2	5	5-10 cm**
Tönning, harbour	26.1	7.2	13	5-10 cm
Eiderdamm, sea area	25.1	5.2	12	5 cm
Büsum, harbour	25.1	6.2	13	5-10 cm
Büsum, Norderpiep	25.1	5.2	12	5-10 cm
Büsum, Süderpiep	25.1	5.2	12	5-10 cm
Harburg, Elbe	27.1	6.2	11	5-10 cm
Hamburg, Landing Pier –Kehrwieder	27.1	6.2	11	5-10 cm
Hamburg – Landing Pier, Elbe	27.1	6.2	11	5-10 cm
Altona, Elbe	27.1	6.2	11	5-10 cm
Stadersand, Elbe	29.1	5.2	8	5-10 cm
Glückstadt, harbour and entrance	3.2	3.2	1	10-15 cm
Norderney, Wadden	26.1	28.1	3	5-10 cm
Norderney, Seegat	26.1	28.1	3	5-10 cm

* compacted up to 20 cm

** compacted to 15-30 cm

Table A2. Ice conditions on the German Baltic Sea coast in the winter of 2013/14

Observation station	Beginning of ice occurrence	End of ice occurrence	Number of the days with ice	Max. ice thickness, cm
Kamminke, harbour and environment	23.1	27.2	36	15 cm
Ueckermünde, harbour	23.1	12.2	21	15 cm
Ueckermünde, harbour to Uecker mouth	23.1	12.2	21	15 cm
Ueckermünde, Szczecin Lagoon	23.1	15.2	24	25 cm
Karnin, Szczecin Lagoon	24.1	16.2	24	15 cm
Karnin, Peenestrom	24.1	16.2	24	15 cm
Anklam, harbour	25.1	9.2	16	10 cm
Anklam, harbour – Peenestrom	25.1	9.2	16	10 cm
Bridge Zecherin, Peenestrom	24.1	14.2	22	15-20 cm
Rankwitz, Peenestrom	23.1	16.2	25	15 cm
Warthe, Peenestrom	24.1	17.2	25	18 cm
Wolgast – Peenemünde	24.1	13.2	21	10-15 cm
Peenemünde – Ruden	28.1	12.2	16	10-15 cm
Koserow, sea area	30.1	3.2	5	5-15 cm
Stralsund, harbour	26.1	18.2	24	15 cm
Stralsund – Palmer Ort	24.1	18.2	26	10-15 cm
Palmer Ort – Freesendorfer Haken	27.1	15.2	20	10-20 cm
Greifswald-Wieck, harbour	23.1	16.2	24	14 cm
Dänische Wiek	22.1	16.2	26	19 cm
Greifswald-Ladebow, harbour	24.1	12.2	20	18 cm
Osttief	30.1	12.2	14	10-15 cm
Landtief channel	27.1	12.2	16	10-20 cm
Thiessow, bodden area	24.1	23.2	29	19 cm**
Thiessow, sea area	27.1	19.2	20	21 cm**
Lauterbach, harbour and vicinity	24.1	28.2	36	10 cm
Greifswalder Oie, eastern sea area	31.1	3.2	4	5 cm
Sassnitz ferry, harbour and vicinity	29.1	12.2	15	10-15 cm
Sassnitz ferry harbour, sea area	3.2	7.2	5	5-10 cm
Sassnitz, harbour and environment	29.1	15.2	18	15 cm
Sassnitz, sea area	1.2	8.2	8	15 cm
Stralsund – Bessiner Haken	28.1	18.2	22	10-15 cm
Vierendehlrinne	26.1	18.2	24	10-15 cm
Barhöft – Gellen, fairway	28.1	17.2	21	10-15 cm
Neuendorf, harbour and vicinity	23.1	18.2	27	10-15 cm
Schaprode – Hiddensee, fairway	24.1	16.2	24	13 cm
Kloster, bodden area	23.1	16.2	25	14 cm
Dranske, bodden area	24.1	16.2	24	10-15 cm
Wittow, ferry	23.1	8.2	17	10-12 cm
Althagen, harbour and vicinity	24.1	20.2	28	16 cm
Zingst, Zingster Strom	24.1	9.2	17	16 cm
Barth, Harbour and vicinity	24.1	16.2	24	16 cm
Rostock, city harbour	26.1	30.1	4	< 5 cm
Wismar, harbour	27.1	9.2	14	5 cm
Wismar – Walfisch	27.1	9.2	14	10-12 cm
Walfisch – Timmendorf	27.1	6.2	10	3 cm
Lübeck – Travemünde	27.1	7.2	12	10-15 cm
Travemünde, harbour	27.1	28.1	2	5 cm
Neustadt, harbour	24.1	13.2	21	16 cm
Neustadt, sea area	27.1	11.2	16	7 cm*
Kiel, inner harbour	26.1	31.1	6	< 5 cm
Heiligenhafen, harbour	25.1	8.2	15	5-7 cm
Eckernförde, harbour	26.1	6.2	12	3 cm
Schlei, Schleswig – Kappeln	26.11	11.2	21	5 cm
Schlei, Kappeln – Schleimünde	26.1	6.2	12	5-10 cm

* compacted up to 17 cm
** in the ridged areas > 30 cm

Table A3. Navigational conditions on the German Baltic Sea coast in the winter of 2013/14

Observation station	Beginning of ice occurrence	End of ice occurrence	Number of days with			
			K_B=2	K_B=3	K_B=6	K_B=8.9
Kamminke, harbour and environment	23.01.2014	27.02.2014		10	3	20
Ueckermünde, harbour	23.01.2014	18.02.2014	1		3	20
Ueckermünde, harbour to Uecker mouth	23.01.2014	18.02.2014	1		3	20
Ueckermünde, Szczecin Lagoon	23.01.2014	18.02.2014	1	1	3	20
Karnin, Szczecin Lagoon	24.01.2014	18.02.2014		3	3	20
Karnin, Peenestrom	24.01.2014	18.02.2014		3	3	20
Anklam, harbour	25.01.2014	18.02.2014			3	20
Anklam, harbour – Peenestrom	25.01.2014	18.02.2014			3	20
Bridge Zecherin, Peenestrom	24.01.2014	18.02.2014	1		3	20
Rankwitz, Peenestrom	23.01.2014	18.02.2014			3	20
Warthe, Peenestrom	24.01.2014	18.02.2014	1		3	20
Wolgast – Peenemünde	24.01.2014	13.02.2014	1	1	15	
Peenemünde – Ruden	27.01.2014	12.02.2014			15	
Stralsund, harbour	26.01.2014	18.02.2014			15	
Stralsund – Palmer Ort	24.01.2014	18.02.2014			15	
Palmer Ort – Freesendorfer Haken	27.01.2014	15.02.2014			15	
Greifswald-Wieck, harbour	23.01.2014	16.02.2014			15	
Dänische Wiek	22.01.2014	16.02.2014			15	
Greifswald-Ladebow, harbour	24.01.2014	12.02.2014	1	3	15	
Osttief	27.01.2014	12.02.2014			15	
Landtief channel	27.01.2014	12.02.2014	1		15	
Thiessow, bodden area	24.01.2014	23.02.2014	8		15	
Thiessow, sea area	27.01.2014	19.02.2014			15	
Lauterbach, harbour and vicinity	24.01.2014	28.02.2014	6	1	15	
Stralsund – Bessiner Haken	27.01.2014	18.02.2014			3	20
Vierendehlrinne	26.01.2014	18.02.2014			3	20
Barhöft – Gellen, fairway	27.01.2014	18.02.2014			3	20
Neuendorf, harbour and vicinity	23.01.2014	18.02.2014	5			14
Schaprode – Hiddensee, fairway	24.01.2014	16.02.2014	4	1		
Kloster, bodden area	23.01.2014	16.02.2014	3	1		14
Dranske, bodden area	24.01.2014	18.02.2014		1	3	20
Wittow, ferry	23.01.2014	08.02.2014	4	7		
Althagen, harbour and vicinity	24.01.2014	20.02.2014		1	3	20
Zingst, Zingster Strom	24.01.2014	18.02.2014	2		3	20
Barth, harbour and vicinity	24.01.2014	18.02.2014	1	1	3	20
Neustadt, harbour	24.01.2014	13.02.2014	4	3		
Neustadt, sea area	27.01.2014	11.02.2014		3		

* According to the Baltic Sea ice code

K_B = 2 Navigation difficult for unstrengthened or low-powered vessels built of iron or steel, for wooden vessels even with ice sheathing not advisable

K_B = 3 Navigation without icebreaker assistance possible only for high-powered vessels of strong construction and suitable for navigation in ice

K_B = 6 Navigation without icebreaker assistance possible only for high-powered vessels of strong construction and suitable for navigation in ice

K_B = 8, 9 Navigation temporarily closed or ceased

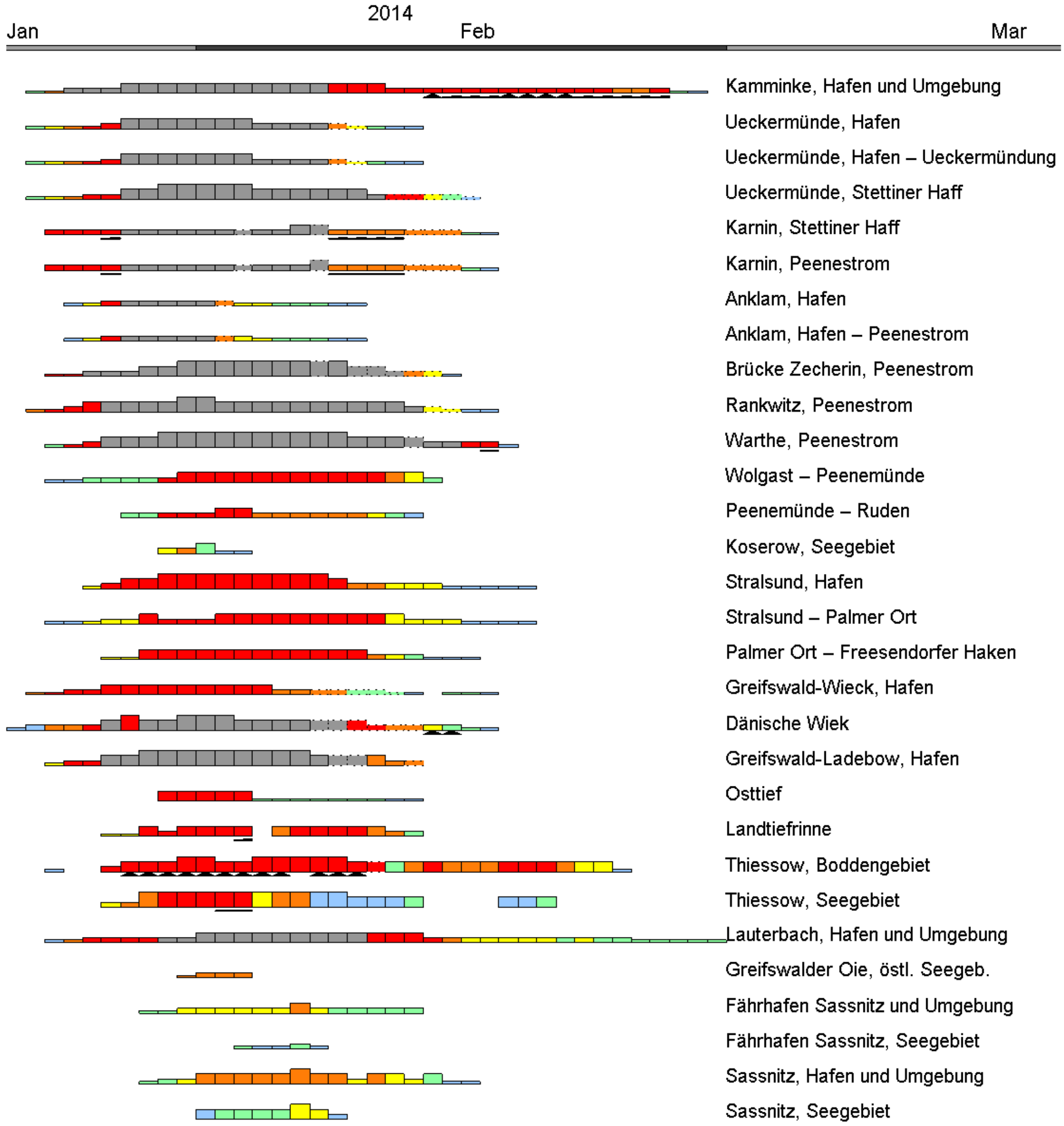


Fig.A1. Daily ice occurrence on the German North and Baltic Sea coasts in the ice winter of 2013/14

Fig.A1, contd.

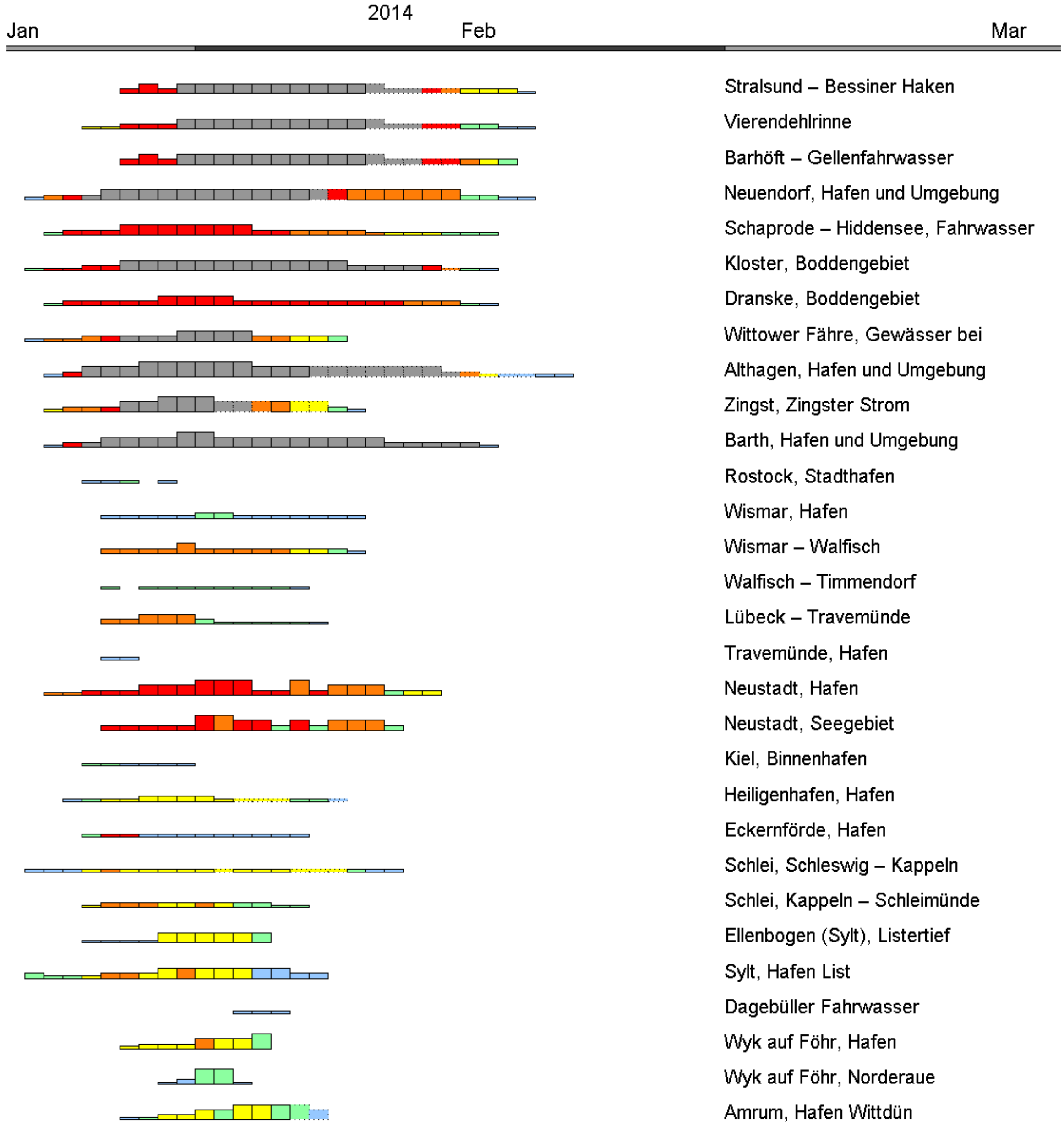
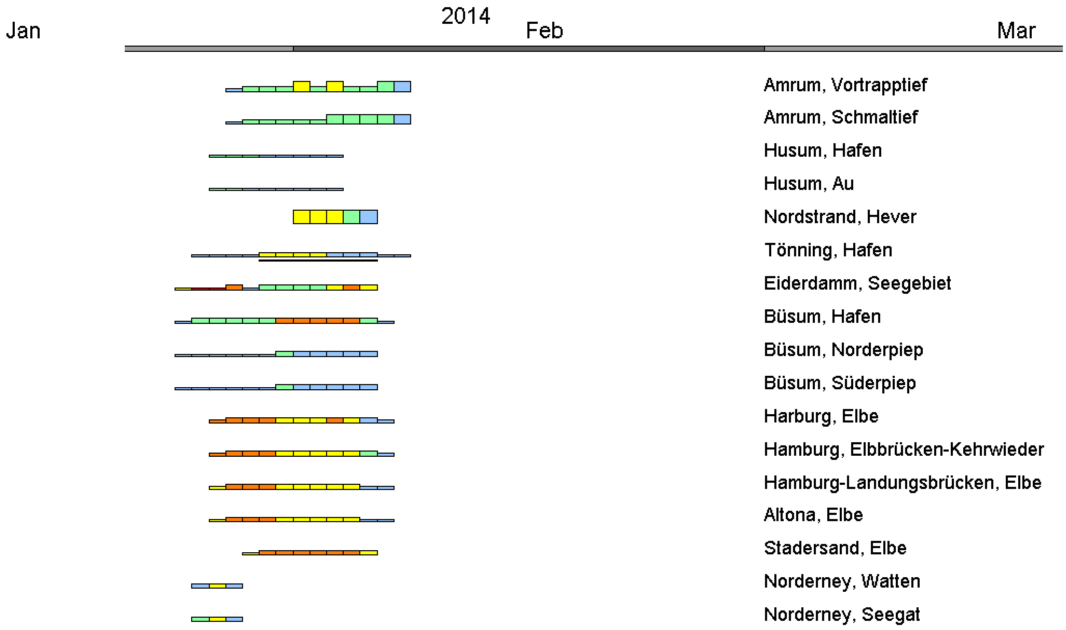
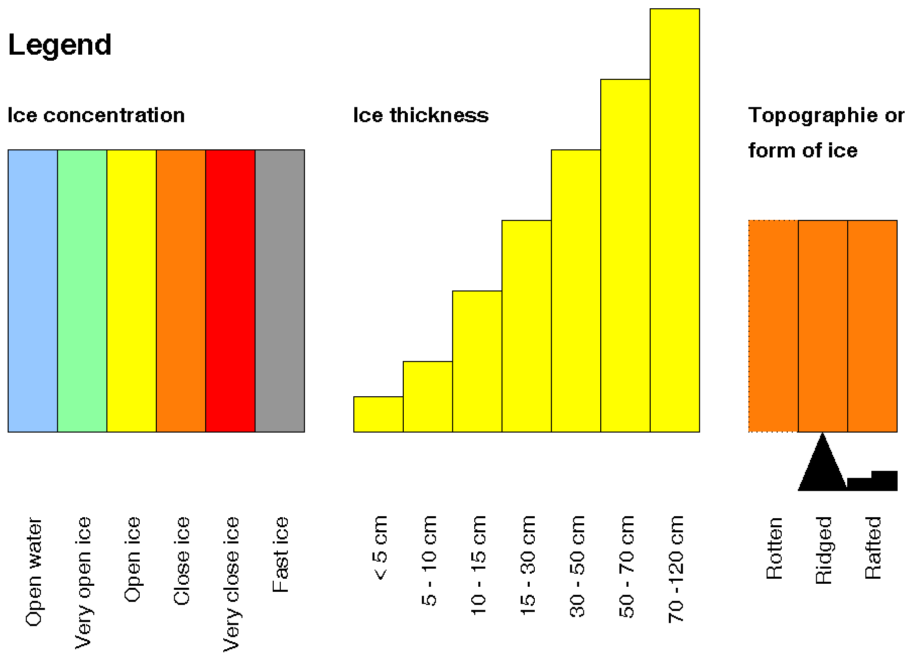

2014
Jan
Feb
Mar
Stralsund – Bessiner Haken
Vierendehlrinne
Barhöft – Gellenfahrwasser
Neuendorf, Hafen und Umgebung
Schaprode – Hiddensee, Fahrwasser
Kloster, Boddengebiet
Dranske, Boddengebiet
Wittower Fähre, Gewässer bei
Althagen, Hafen und Umgebung
Zingst, Zingster Strom
Barth, Hafen und Umgebung
Rostock, Stadthafen
Wismar, Hafen
Wismar – Walfisch
Walfisch – Timmendorf
Lübeck – Travemünde
Travemünde, Hafen
Neustadt, Hafen
Neustadt, Seegebiet
Kiel, Binnenhafen
Heiligenhafen, Hafen
Eckernförde, Hafen
Schlei, Schleswig – Kappeln
Schlei, Kappeln – Schleimünde
Ellenbogen (Sylt), Listertief
Sylt, Hafen List
Dagebüller Fahrwasser
Wyk auf Föhr, Hafen
Wyk auf Föhr, Norderaue
Amrum, Hafen Wittdün

Fig.A1, contd.



2014
Jan
Feb
Mar
Amrum, Vortrapptief
Amrum, Schmaltief
Husum, Hafen
Husum, Au
Nordstrand, Hever
Tönning, Hafen
Eiderdamm, Seegebiet
Büsum, Hafen
Büsum, Norderpiep
Büsum, Süderpiep
Harburg, Elbe
Hamburg, Elbbrücken-Kehrwieder
Hamburg-Landungsbrücken, Elbe
Altona, Elbe
Stadersand, Elbe
Norderney, Watten
Norderney, Seegat



Legend
Ice concentration
Open water
Very open ice
Open ice
Close ice
Very close ice
Fast ice
Ice thickness
< 5 cm
5 - 10 cm
10 - 15 cm
15 - 30 cm
30 - 50 cm
50 - 70 cm
70 -120 cm
Topographie or form of ice
Rotten
Ridged
Rafted