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Sea ice in the Baltic

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For over a century, ice services in the Baltic have looked at the sea ice in the Baltic, and the German ice service is no exception. The main purpose was and is the secure and easy winter navigation in ice infested waters. Over the time, the work has amassed a plethora of ice information, which again can be used for climatological purposes. This climatological information is then again used from other persons to better analyse themes far away from winter navigation like fish spawning (not covered here). In general, the sea ice occurrence, the sea ice extent as well as the sea ice volume is diminishing and most probably will also continue to do so in the future.

Baltic Sea | ice service | ice chart | sea ice cover | ice volume
Ostsee | Eisdienst | Eiskarte | Meereisbedeckung | Eismenge

Seit über einem Jahrhundert kümmern sich Eisdienste rund um die Ostsee um das Meereis in der Ostsee, und der deutsche Eisdienst ist da keine Ausnahme. Der Hauptzweck war und ist die Sicherheit und Leichtigkeit der Schifffahrt in eisbedeckten Gebieten. Im Laufe der Zeit hat sich eine Fülle von Eisinformationen angesammelt, die wiederum für klimatologische Zwecke genutzt werden können. Diese klimatologischen Informationen werden dann wiederum von anderen Personen genutzt, um Themen fernab der Winterschifffahrt wie z. B. das Laichen von Fischen (hier nicht behandelt) besser zu analysieren. Generell ist das Meereisvorkommen, die Meereisausdehnung sowie das Meereisvolumen rückläufig und wird dies höchstwahrscheinlich auch in Zukunft sein.

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Much has been written in recent years about sea ice in the Arctic and how sea ice extent and area have declined over time and will continue to decline in the future in a world that continues to warm due to anthropogenic climate change. Sea ice plays a major role in the climate system by regulating the interaction between the atmosphere and the oceans. One of the many societal themes of sea ice loss in the Arctic are the economic consequences, such as new shipping routes and better extraction of natural resources. But sea ice is not only a hindrance for navigation but also a possible way to travel (from walking over skidoos to ice roads), a place for ice-fishing or hunting, a recreational space and much more. Understanding past changes of sea ice cover is necessary to predict the future developments and the consequences for the climate system, the ecosystem and environment people are living in. In this short paper, we will present the work of the German Ice Service at the Federal Maritime and Hydrographic Agency of Germany (BSH) regarding recent changes in the sea ice cover of the Baltic with special emphasis on the German Baltic Sea coast.

Before regular observations, the impact of sea ice on to the life of humans in coastal areas can be found in historical written accounts, i.e. church records, newspapers, ships' logs and many others. That made it possible to reconstruct a time series of a sea ice severity index for the German Baltic coast dating back to 1300 (Koslowski and Glaser 1995, 1999; Schmelzer and Holfort 2011) with a rough classification for weak-normal and strong ice winters. Also from historical records and a time series of temperature in Stockholm it was possible to reconstruct the yearly maximum ice extent for the whole Baltic Sea since 1720 (Seinä and Palosuo 1996).

On the German coast, as in many other parts of the Baltic Sea, operational ice observations started in the end of the 19th century. These observations started when economic interests together with technological progress in shipbuilding increased the interest in ice information for winter navigation. The information about the sea ice came from ice observers along the coast and from some ships. Some of the ice observing stations are still active today, contributing to long time series of ice information.

In 1925, representatives of all Baltic states met in Hamburg to discuss systematic ice observations in a common format and how to share this information. This is considered the beginning of the Baltic Sea Ice Meetings (BSIM, see www.bsis-ice.de), and since then ice information are in large parts standardised and exchanged regularly. The next Baltic Sea Ice Meeting, celebrating 100 years of cooperation, will take place in Germany in 2025, setting a step forwards to the next 100 years of cooperation.

Based on this first exchange in 1925, the first German operational ice charts were produced in 1926, based mainly on observations from land (Fig. 1). The limitation to coastal areas, however, limited the use for navigation and with advances in aviation reconnaissance flights became an invaluable source of information. Satellite remote sensing was the next big advance to retrieve information about offshore sea ice cover. Today synthetic aperture radar (SAR) imagery is the primary information source for sea ice in the Baltic Sea. Optical remote sensing data adds high-resolution information if cloud cover is low.

Ice charts of the western Baltic Sea are available in digital form since the end of the 1950s. These data, together with observational data, have been used to produce a climatological atlas of the western and southern Baltic Sea (Schmelzer et al. 2012). The period 1960 to 2010 was divided into three 30-year periods, which nicely show the decreasing trend in ice occurrence (Fig. 2). The same can be seen in the North Sea (Schmelzer and Holfort 2015). The following 30-year period 1990 to 2020 is not yet fully processed, but shows the same

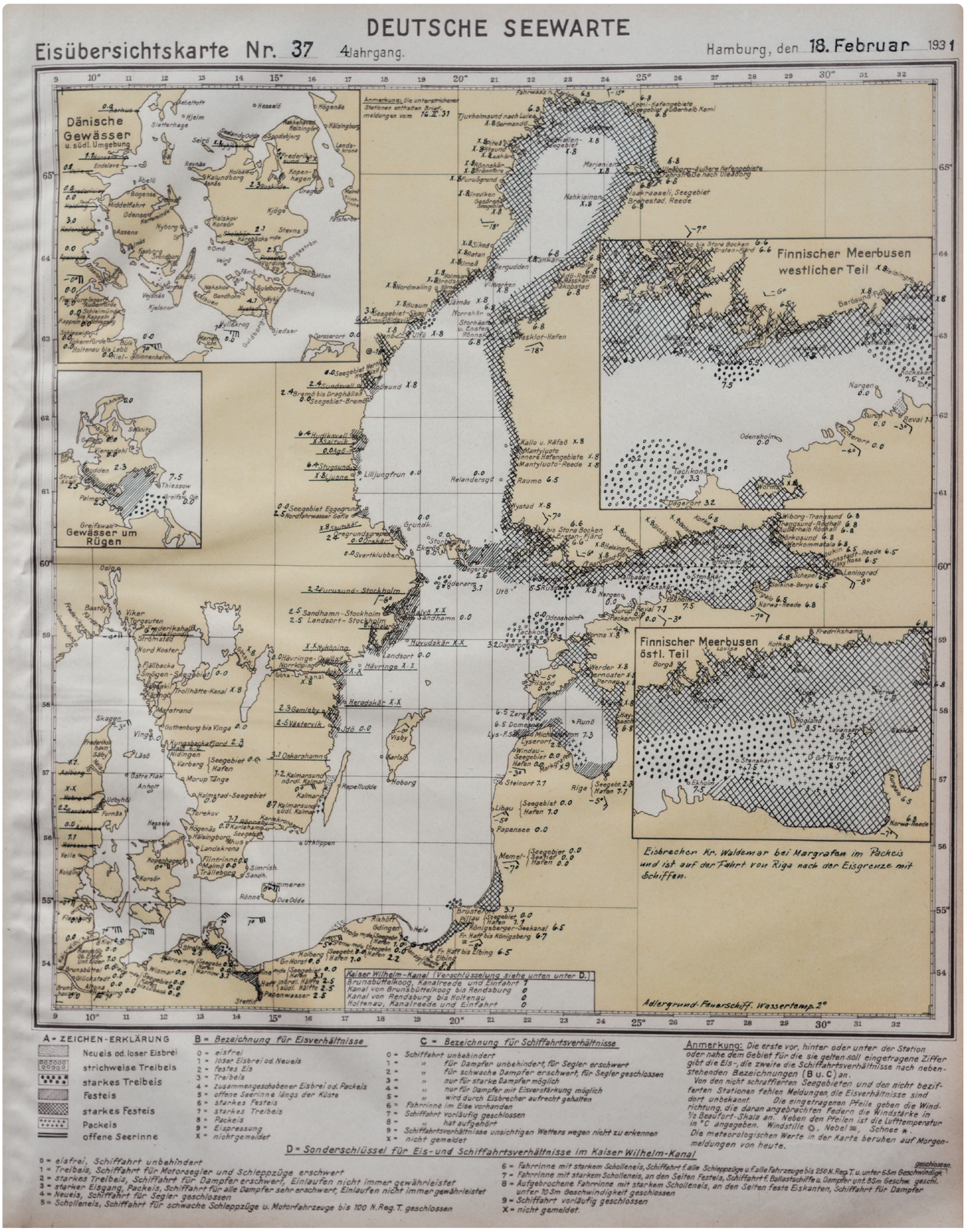

Fig. 1: An example of an ice chart from the beginning of the operational production (18th of February 1931). As mostly only coastal information were available, no ice depicted at sea does not mean that there was no ice (most probably there was ice at sea in the Bay of Bothnia, but with no ships entering the Bay no information was available)

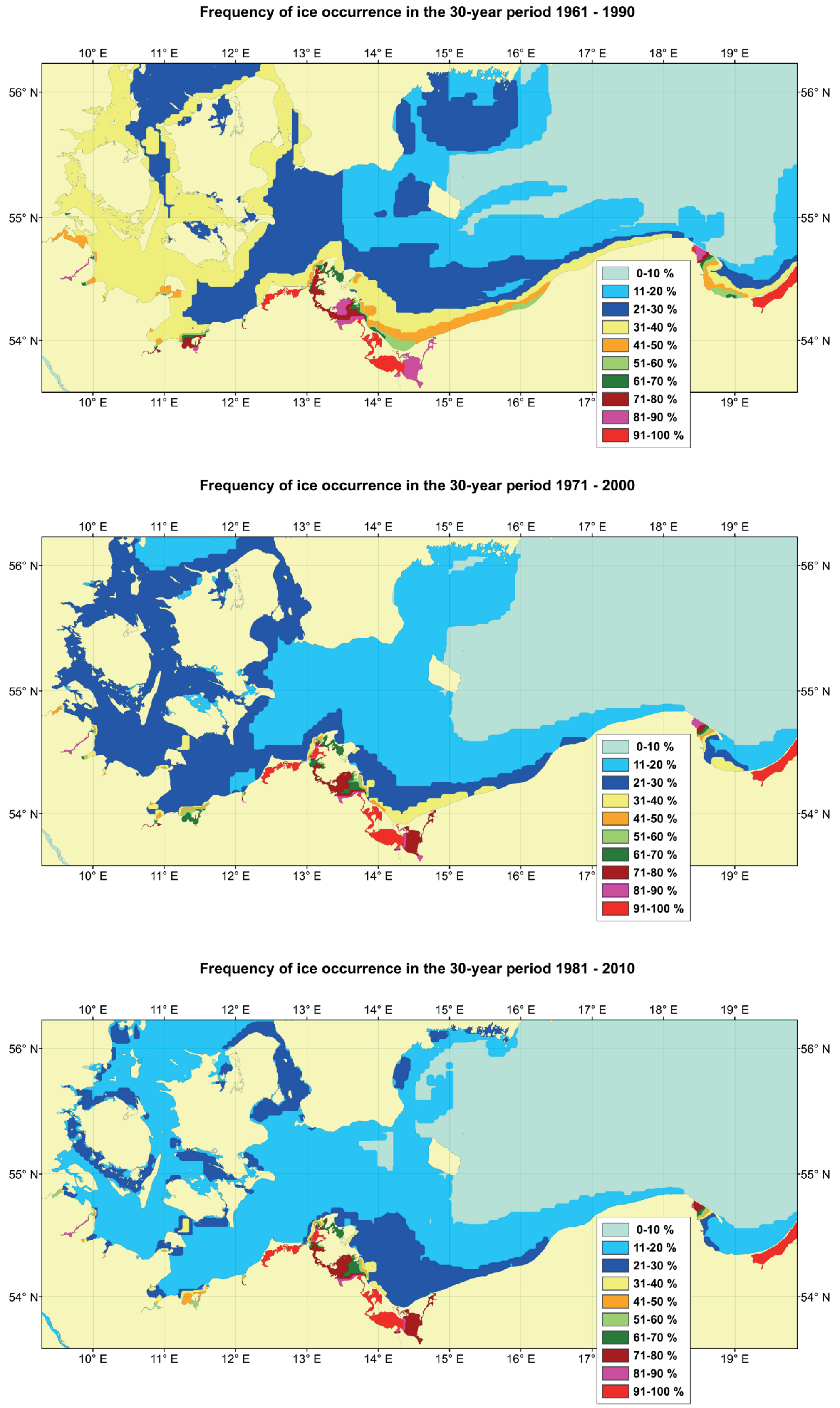

Fig. 2: Charts of ice occurrence in three overlapping 30-year time periods. For each point ice occurrence in a single season means that there was at least one day with ice (but could also have been more days). 50 % occurrence within a 30-year period therefore means that there was ice at least on a single day in 15 years

decreasing trend. In the same time frame, a trend towards smaller ice volumes in winter can be seen in the whole Baltic Sea, although this is based only on coarser digitised ice charts (Schwegmann and Holfort 2015). However, more historical ice charts are being digitised at higher resolution in other Baltic Sea ice services, so we can expect a more detailed view of past Baltic Sea ice changes in the future.

The annual ice cover at the German Baltic Sea coast is evaluated since 1879 based on the areal ice volume sum, a measure for the strength of an ice winter depending on the ice thickness, the ice concentration and the number of days with ice (Koslowski 1989). For the layman, the cumulative volume sum is the final height of sea ice in a 1 m^2 bucket, in which a representative 1 m^2 of ice cover is emptied each day during an ice winter. This is a better indicator of winter severity than ice occurrence or maximum ice, as a short strong winter can have the same value as a longer winter with thinner ice. The time series is shown in Fig. 3. The ice cover generally shows a large interannual variability. In the 1940s a series of extremely severe winters occurred. A declining trend in ice at the German coast is visible since the mid-1980s. The last very severe winter was 1996 and in the recent century, only one severe winter occurred. This is on par with the information from the ice charts. And an inspection of the ice winter severity of the whole Baltic Sea according to the maximum sea ice extent (Fig. 4) reveals a similar decreasing trend, with more extremely weak or weak winters in the last 30 years.

Predictions for the future show a decrease in sea ice in the Baltic Sea (Helcom 2021), although ice will be present in the northern Baltic Sea every winter within this century, so sea ice services will still be needed for winter navigation. As the methods of collecting and presenting sea ice information have changed in the last century, they will change in the future. Today, much information is gathered from satellite data, but still requires human skills for interpretation (Fig. 5). However, the ability to automatically classify sea ice from satellite data will increase in the future. These data can be assimilated into numerical prediction models to arrive at predicted sea ice maps, which will be available on the bridge of ships due to the already existing S-411 standard for sea ice information in ECDIS (IHO 2014). However, this would also require improvements in the numerical algorithms, as sea ice as a brittle material is not adequately represented in current operational models. It is not possible to develop all these skills alone, therefore there is the cooperation of the Baltic sea ice services within BSIM and of all services in the world within the International Ice Charting Working Group (IICWG, see nsidc.org/noaa/iicwg). Moreover, these groups again cooperate with science, satellite providers and other relevant stakeholders.

One caveat at the end. An in general lesser ice concentration does not automatically imply easier navigation. At lower concentrations, ice tends to be more mobile and the ice drift can lead to more or more pronounced ridges, or the formation of brash ice barriers. Both are more difficult to force then level ice. Both features are also harder to resolve in satellite data and even much harder to represent adequately in numerical models. So also in the future knowledgeable ice persons are needed on the ship's bridges as well as on land at the ice services. //

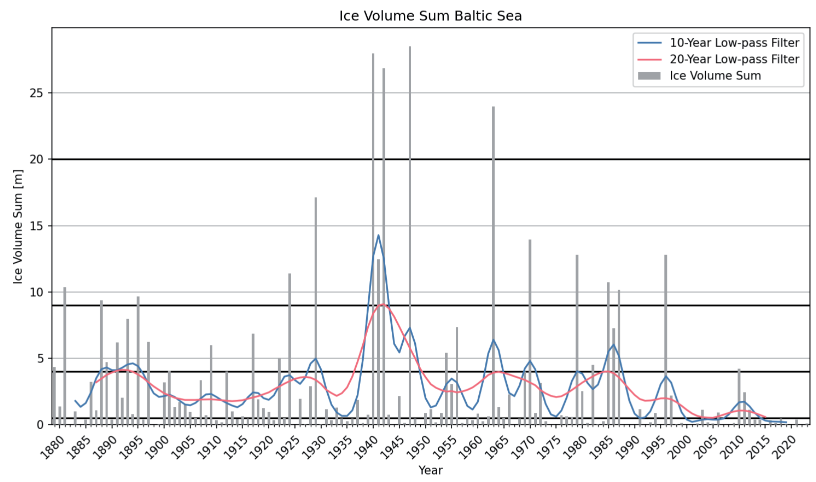

Fig. 3: Time series of ice volume sum at the German Baltic Sea coast since 1879. The black lines denote the boundaries for weak, moderate, severe, very severe and extremely severe ice winters

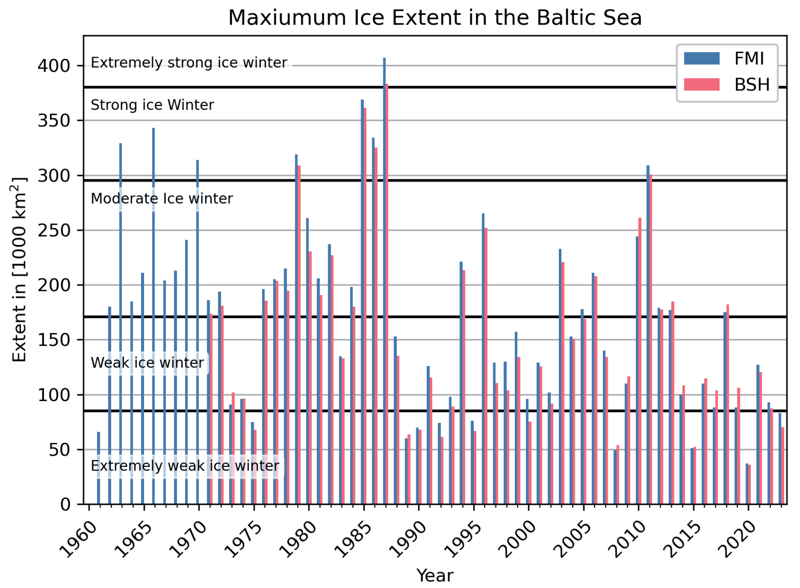

Fig. 4: Maximum ice extent from the Finnish ice service and the BSH 1961 to 2022. The horizontal lines denote the boundaries for extremely weak, weak, moderate and strong ice winters

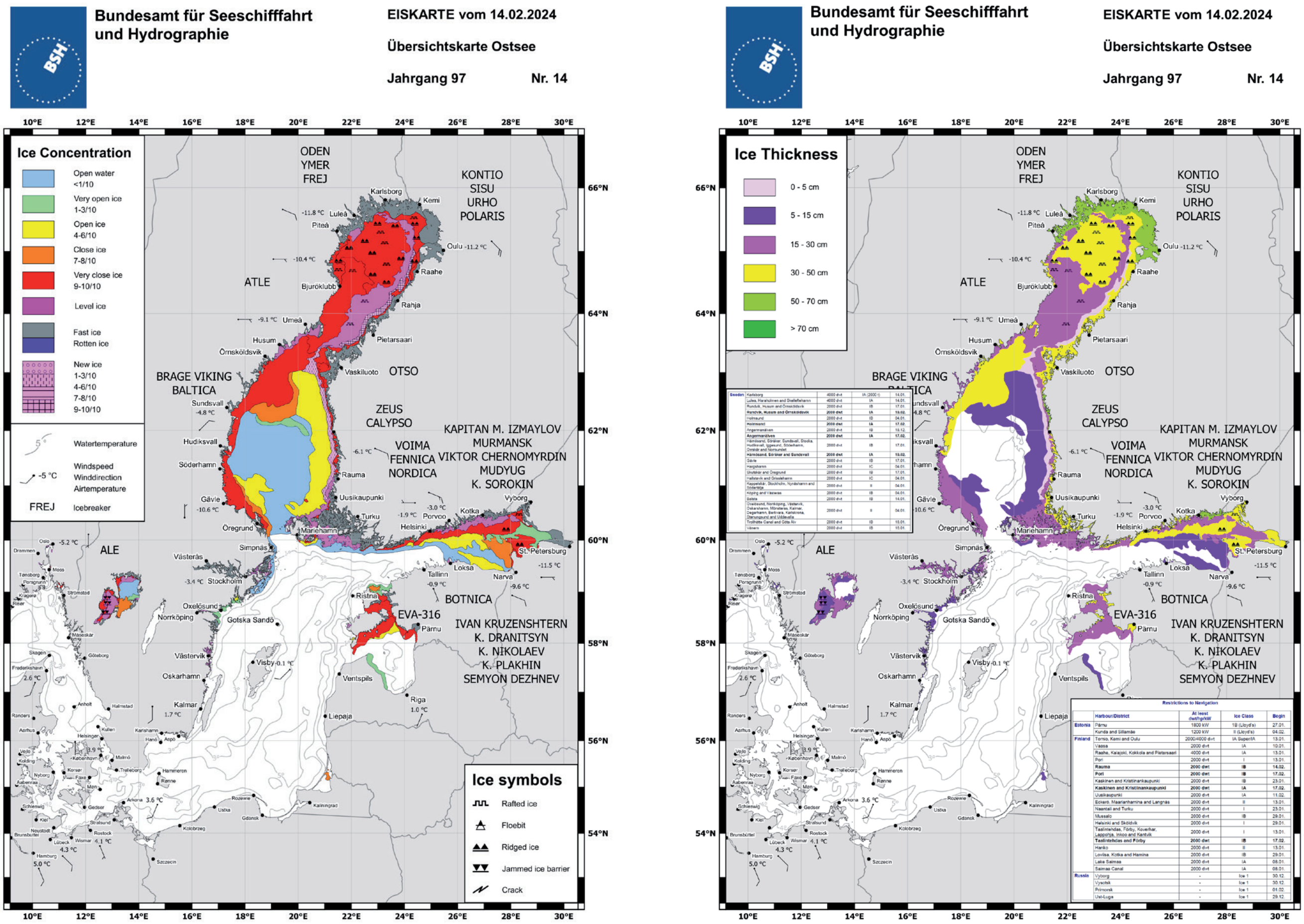

Fig. 5: A recent ice chart of the Baltic depicting the ice situation on Valentine's day in 2024 (14 February 2024)

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