Spatial Distribution of the Winter Nutrient Pool

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Key message

Good news:
Dissolved inorganic nitrogen (DIN) levels remain well below the 1993 – 2002 average, except in some nearshore areas.

Bad news:
Winter levels of dissolved inorganic phosphorus (DIP) remain above the 1993 - 2002 average in the surface waters from the Western Gotland Basin Baltic Proper to the Bothnian Bay.

Less data was available to make this assessment compared to previous years, despite data mining through ICES and SeaDataNet.

Results and assessments

Relevance of the indicator for describing developments in the environment
Dissolved inorganic nutrients are essential for phytoplankton development. While rivers deliver phosphorus to the Baltic, most of this phosphorus is chemically bound to particles, and is not directly available for biological use. Some dissolved inogranic phosphorus (DIP) enters the Baltic with inflows of salt water, but the most significant source at present appears to be that released from bottom sediments during periods of anoxia. Deep water DIP can become bio-available if it is transported to the surface waters, but this transport is hampered by the permanent stratification. After the inflows of winter 2002 – 3, phosphorus concentrations in the surface water of the Baltic Proper increased significantly, and concentrations remain high today. The Baltic Sea Action Plan requires countries around the Baltic to reduce discharges of phosphorus to the marine environment.

Dissolved Inorganic Nitrogen (DIN) is composed of nitrate, nitrite and ammonium compounds, which are also required by phytoplankton. While DIN concentrations are much higher than DIP in surface waters, marine phytoplankton require 15 - 16 times as much DIN as DIP, often causing a lack of DIN to limit phytoplankton activity. Where DIN is used up, those bacteria that can fix nitrogen from the air can still flourish, making use of the remaining DIP, and causing blooms. Cyanobacteria have this ability, and so flourish in the Baltic. Nitrogen is cycled within the water column and sediment, while ‘fresh’ nitrogen is also supplied, directly or via rivers, by agricultural run-off and sewage discharges, and also through atmospheric deposition. The Baltic Sea Action Plan requires countries around the Baltic to reduce discharge of nitrogen to the marine environment.

Silicate is supplied to the Baltic via rivers, as a result of weathering processes. It is recycled in the marine system. An excess of silicate is typical of the Baltic, because of the large supply of river water, and the high concentrations present in the deep anoxic water. Excess silicate is not considered problematic in the Baltic.

Eutrophication is the supply of excessive amounts of nutrients. The spatial distribution of the primary bio-available nutrients (surface waters, during winter) highlights problem areas, and shows the availability of nutrients for the spring bloom. Changes in the spatial distribution may indicate changes in the hydrography, or the effect of remedial works. Mapping the excess winter:DIP may serve as a warning for areas where cyanobacteria blooms are likely. Some cyanobacteria are toxic. Policy relevance and policy references

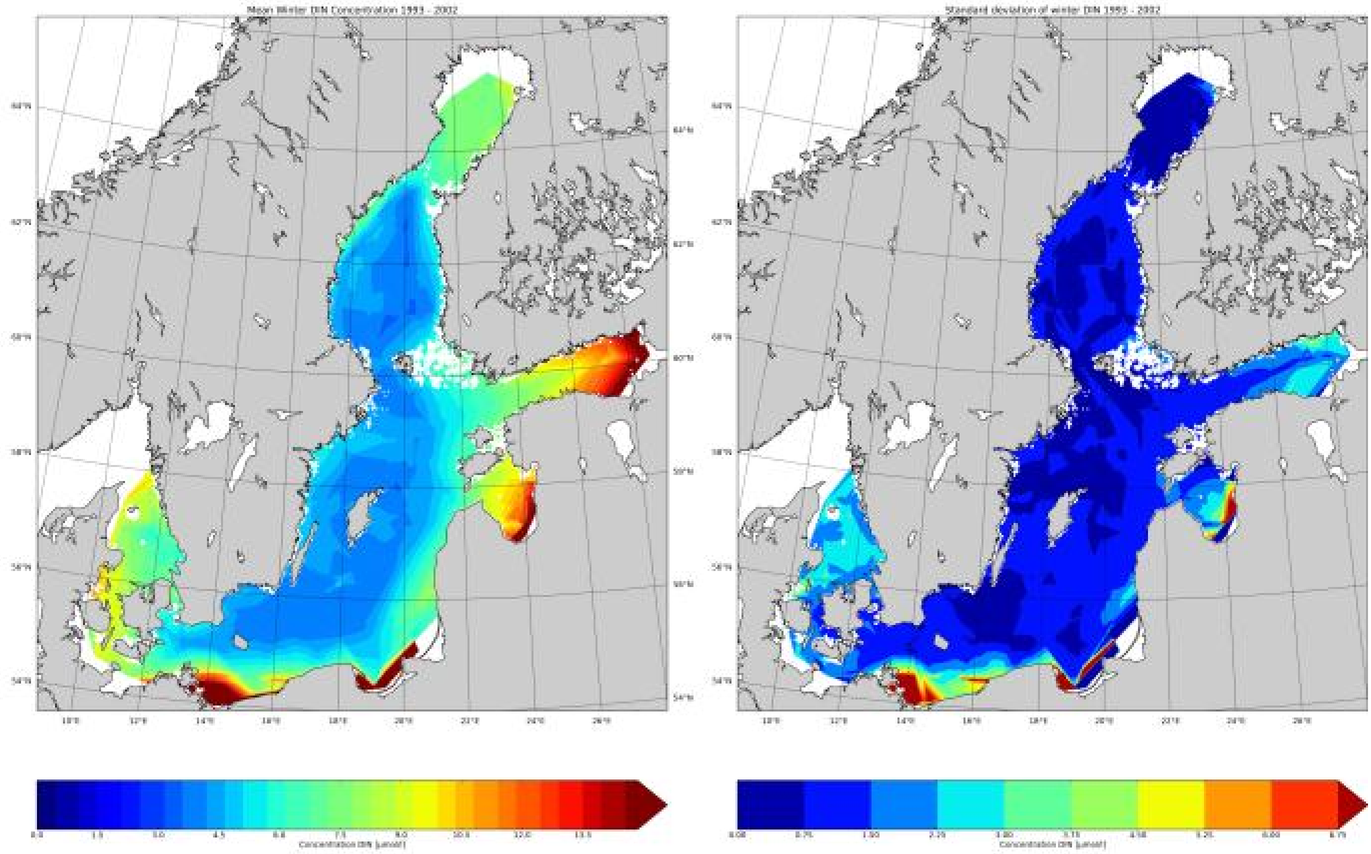
The Helcom COMBINE programme uses nutrient data to help quantify the effects of anthropogenic activities. This Indicator Report contributes to the programme's requirement for information on:

- the winter pool of nutrients
- the supply of nutrients and nutrient limitation in coastal waters

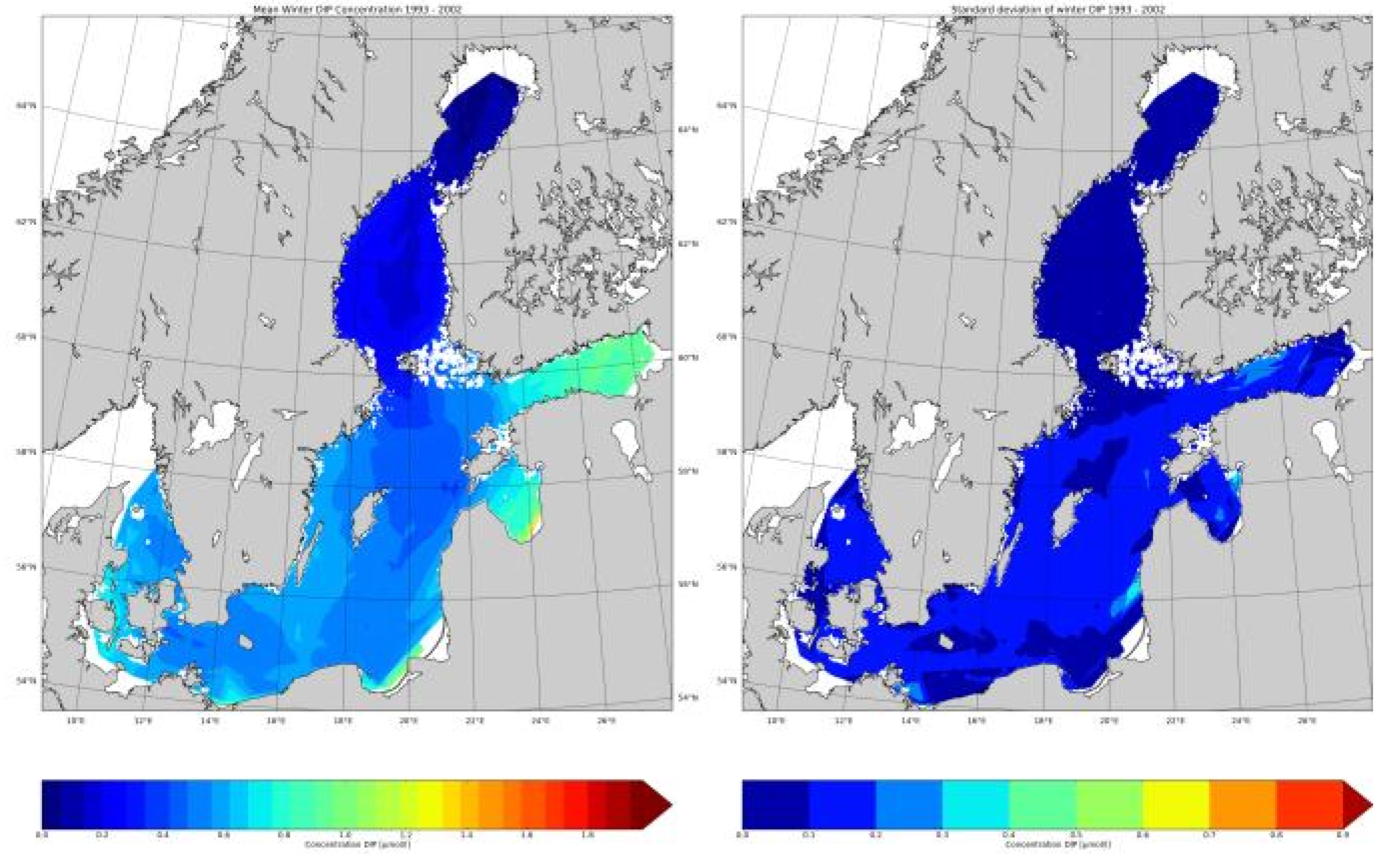
Assessment

Concentrations of DIN are highest in coastal waters from the southern Belt Sea to the inner Gulf of Finland. Levels are also high in the Bothnian Bay. This is unsurprising as the major source of DIN to the Baltic is land run-off. Variability in winter DIN (indicated by the standard deviation plot in Figure 1) is predominantly due to variability in land run-off, so is highest near the sources of DIN. Variability is higher also in the Kattegat, due to the dynamic frontal activity here.

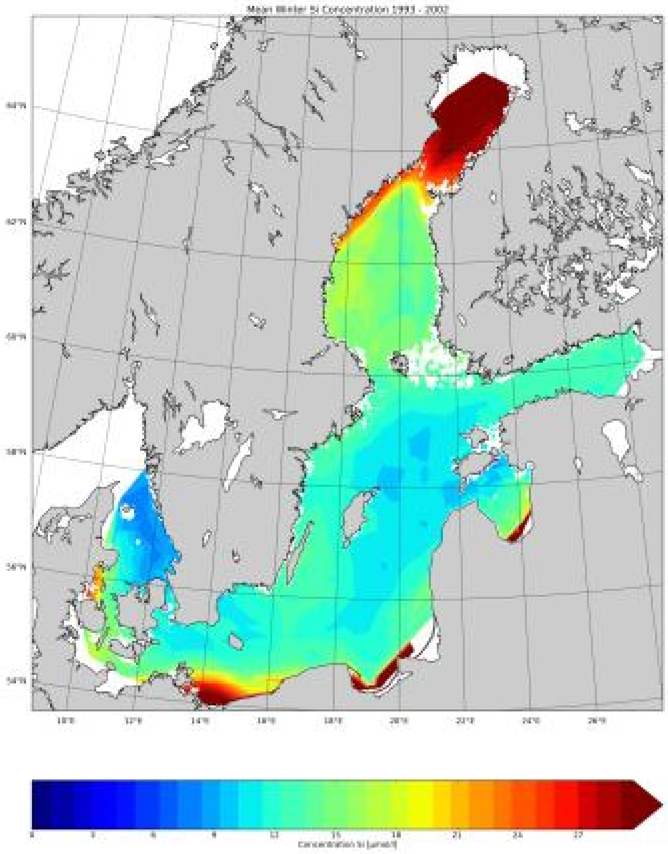
Mean winter surface DIN (left) and standard deviation (right) are based on each year's gridded winter surface observations from 1993 - 2002 inclusive. Surface refers to the upper 0 - 10 m. Units are micro-moles/litre. Figure 1. Mean winter surface DIN (left) and standard deviation (right) based on each year's gridded winter surface observations from 1993 - 2002 inclusive. Surface refers to the upper 0 - 10 m. Units are micro-moles/litre.

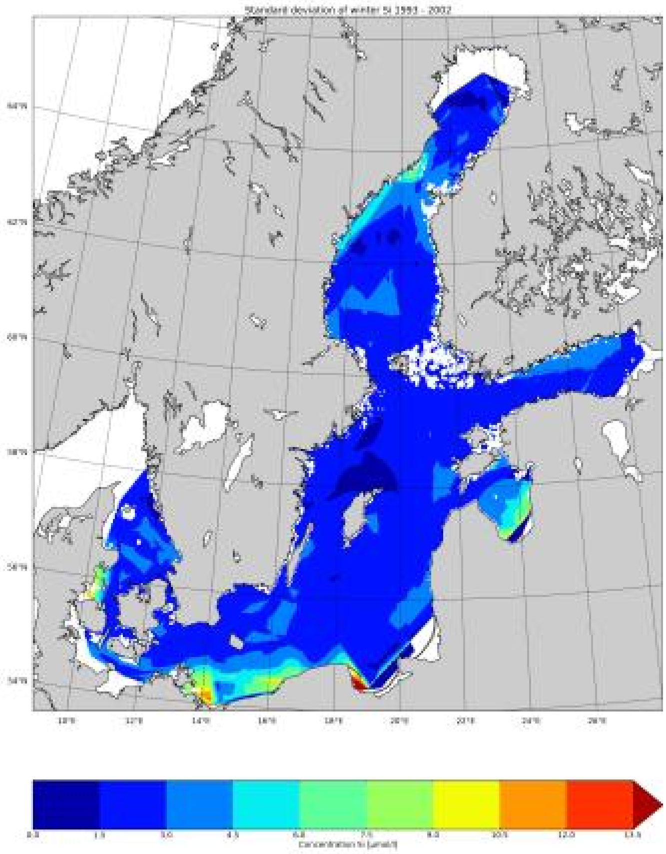


Highest DIP concentrations are usually also found in the Belt Sea, the southern Baltic coast and the inner Gulf of Finland, though levels are also significant along the Swedish east coast and in the Kattegat. Lowest levels are found offshore, in particular in the Gulf of Bothnia. This is because while some DIP originates from land sources, a large reservoir also exists in the deep water of the Baltic, which can come to the surface during upwelling events, which occur near the coasts.



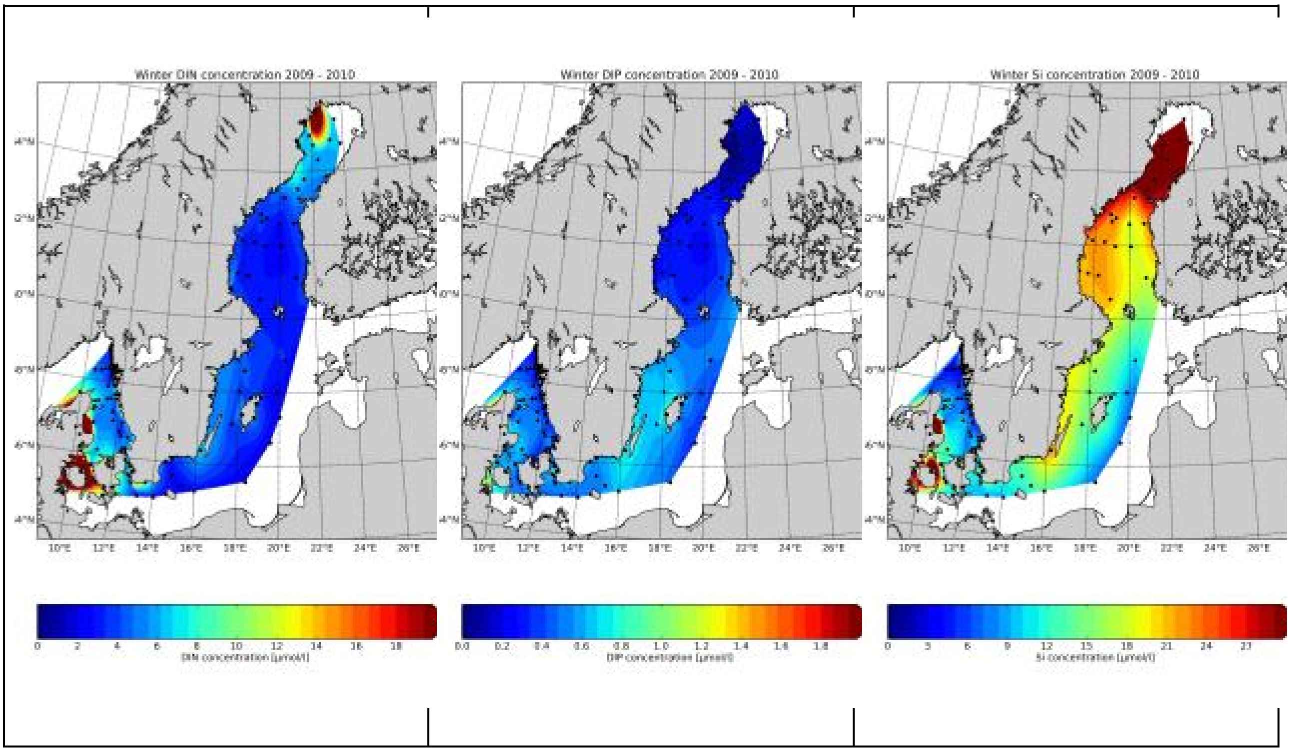
Highest silicate concentrations are found in the Bothnian Bay. The great rivers surrounding this bay transport large amounts of silicate released through natural weathering processes. In many seas, silicate is used up during the spring bloom, and a shortage of silicate can restrict phytoplankton growth. This never happens in the Baltic, because the natural supply of silicate is greater than plankton can use - even after the damming of the rivers in the north, which might have been expected to reduce the flow of silicate to the sea. There are also very high concentrations of silicate in the deep water of the central Baltic



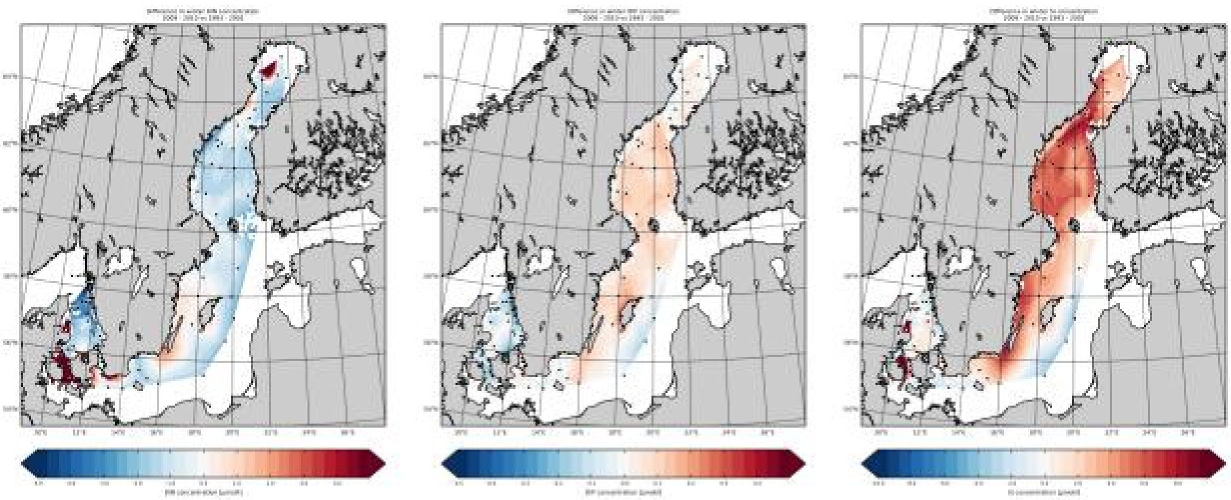


2010 - 2011 results

The following figures show the inorganic nutrient concentrations in surface waters for the period December 2010 to February 2011. Data have come from the HELCOM databank at ICES (for the 2010 data) while the 2010 data have been harvested via the EU project SeaDataNet, which many of the HELCOM Member States contribute to via their National Oceanographic Data Centres. Unfortunately, only Denmark has updated their SeaDataNet repository recently. Swedish coastal data were obtained from the Swedish National Oceanographic Database SHARK.



Highest DIN concentrations qre visible in the Danish fjords and the innermost Bothnian Bay. Concentrations offshore and in the Kattegat were quite low. DIP concentrations were also higher in the Danish fjords, and in the Western Gotland Basin of the Baltic Proper. Silicate levels were, as usual, high in the Bothnian Bay. High levels along the Swedish and Danish east coasts are likely due to run-off (or possibly upwelling) events.



DIN concentrations remain below the 1993 - 2002 average, except for some coastal hotspots along the south eastern coast of Sweden and an area of the Bothnian Sea (which may indicate a bad data point). The extreme increase in DIN concentrations apparent in the inner Danish waters may be an artefact, where data from the inner Danish fjords was not available for creating the mean nutrient field: this needs to be checked.

Particularly low concentrations were found in the Gulf of Bothnia, in the southern and eastern Baltic Proper and in the Kattegat.

DIP concentrations remain high in almost all of the Baltic Proper. Compared to the previous winter (2009 - 2010), high DIP concentrations have spread up into the Bothnian Sea. Levels in the Kattegat are once again below the 1993 - 2002 mean.

Concentrations of both DIN and DIP appear high around the Danish islands. This may well be an artefact of the analysis: the 1993 - 2002 mean concentrations are based on data reported to the HELCOM data bank at ICES. Data from 2009 - 2010 comes both from the data bank and from the respective data centres of the HELCOM Member States participating in the EU SeaDataNet project. This means that more coastal data have been available for this fact sheet - and the Danish coastal fjords do suffer from very high nutrient concentrations.

Silicate levels remain higher than the 1993 – 2002 mean particularly along the Swedish coast. This is most likely due to high run-off events, although in the southern Baltic Proper, upwelling along the Swedish coast may contribute.

References

Helcom COMBINE Manual (Annex C), http://www.helcom.fi/Monas/CombineManual2/CombineHome.htm, December 2003. Data This study used data collected under the HELCOM COMBINE programme, and archived for HELCOM by ICES (http://www.ices.dk), supplemented with data collected by SMHI 2007/8.

Data sources

Data come primarily from the HELCOM data archive held at the International Council for the Exploration of the Sea. Recent data have also been harvested from the respective national oceanographic data centres participating in the EU project SeaDataNet. It is expected that data from the ICES archive have been more thoroughly quality controlled than the newer data obtained through SeaDataNet. Data collected for the HELCOM COMBINE programme are collected and analyzed according to fixed, agreed techniques which are the same for all HELCOM countries. Laboratories participate in quality assurance consortia such as QUASIMEME and are almost uniformly ISO accredited for good laboratory practice.

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