Spatial distribution of the winter nutrient pool

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Key message

High levels of dissolved inorganic phosphorus remain in the surface waters of the Baltic Proper. This phosphorus has spread along the Finnish coast into the eastern Bothnian Sea, and out through the Belt Sea into the Kattegat. Dissolved inorganic nitrogen levels remain below the 1993 – 2002 average in the offshore Baltic. Heavy rainfall during winter 2006 – 7 has led to higher than usual DIN concentrations in south Swedish coastal waters, the Belt Sea and Kattegat.

Results and assessments

Relevance of the indicator for describing developments in the environment

Dissolved Inorganic Phosphorus (DIP) is 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. Large amounts of DIP enter the Baltic with inflows of salt water, and phosphorus is also 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.

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 exhibit this behaviour, 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.

Silicate is supplied to the Baltic via rivers, as a result of weathering processes and 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.

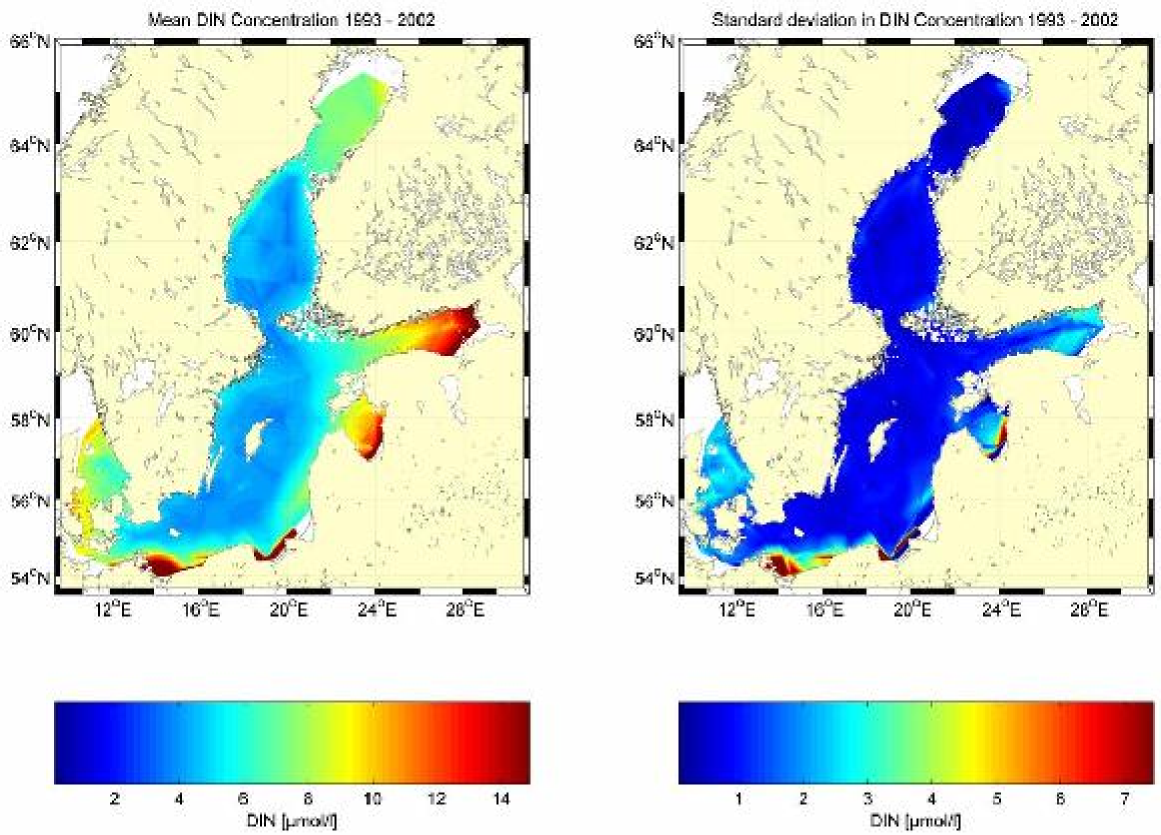
Policy relevance and policy references

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:

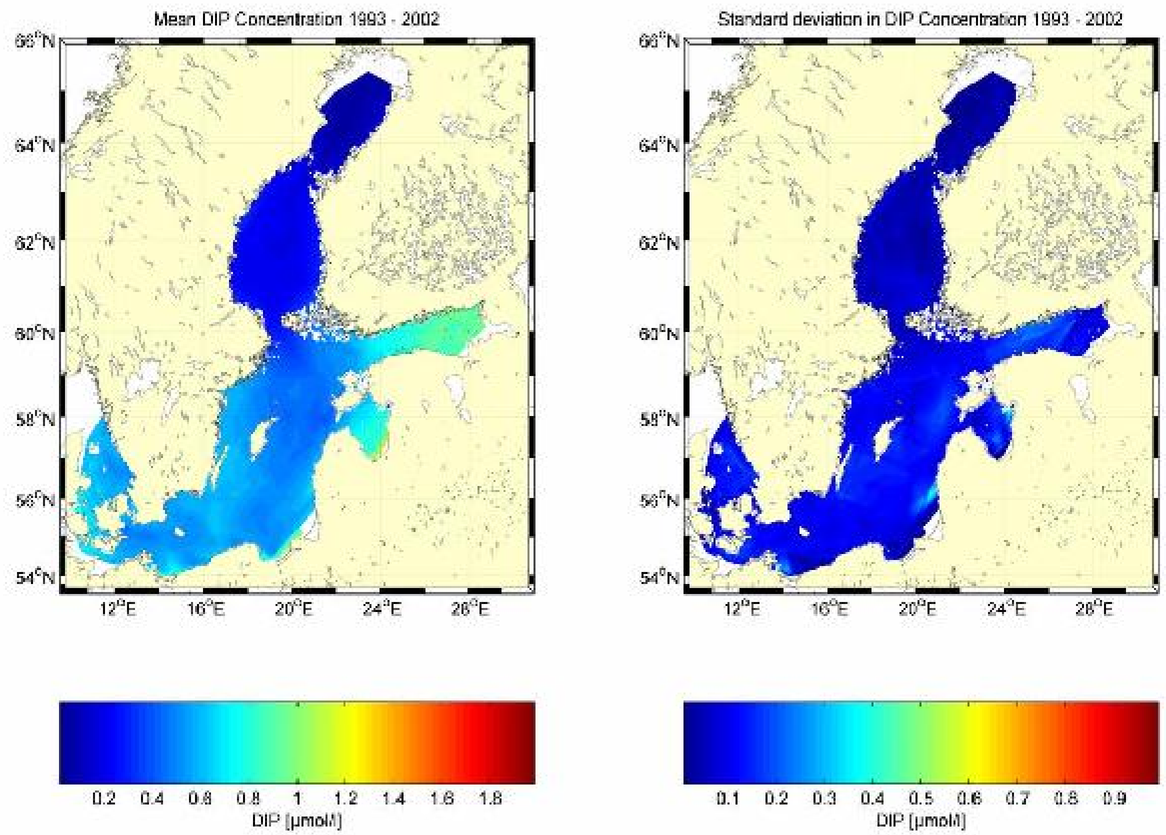
- the winter pool of nutrients
- the supply of nutrients and nutrient limitation in coastal waters

Assessment

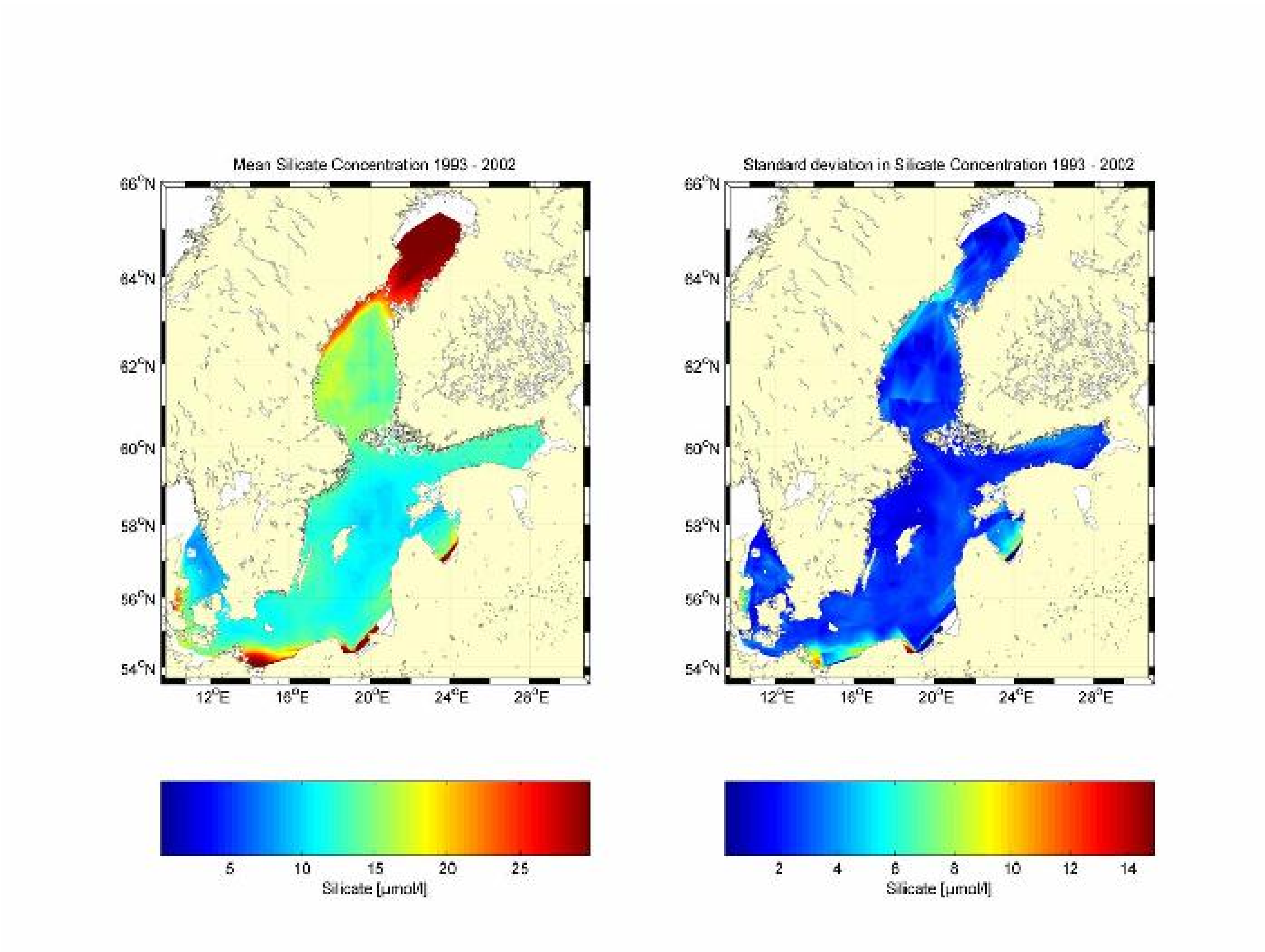
Concentrations of DIN are highest in coastal waters from the southern Belt Sea to the inner Gulf of Finland. Levels are also high in the Bothnian Bay. This is unsurprising as the major source of DIN to the Baltic is land run-off. Variability in winter DIN (indicated by the standard deviation plot in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

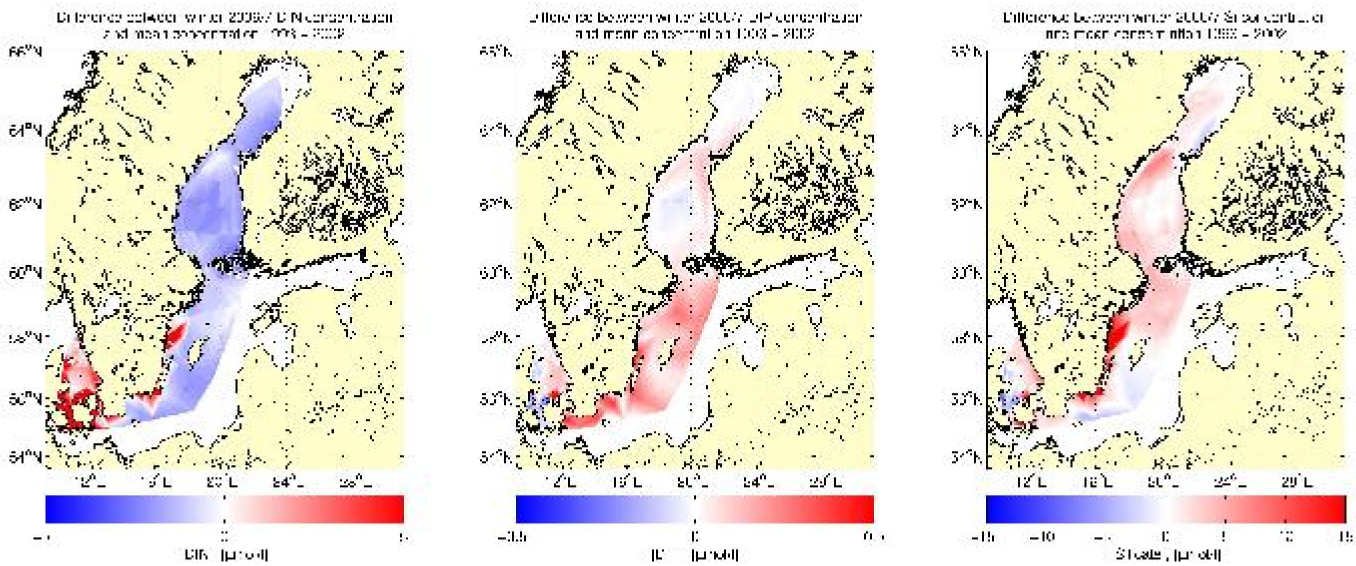


The highest DIP concentrations are usually also found in the Belt Sea, the southern Baltic coast and the inner Gulf of Finland, though levels are also significant along the Swedish east coast and in the Kattegat. Lowest levels are found offshore, in particular in the Gulf of Bothnia. This is because 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.



Highest silicate concentrations are found in the Bothnian Bay. The great rivers surrounding this bay transport large amounts of silicate released through natural processes.





DIN concentrations remain below the 1993 - 2002 average, except in the Belt Sea, Kattegat and in southern Swedish coastal waters (recent data from the eastern Baltic have not been available for this assessment). The low offshore concentrations are similar to what has been observed in previous years, and may be attributable to reductions in nutrient inputs during the 1990's. The higher coastal concentrations in the Belt Sea, Kattegat and southern Swedish coastal waters are attributable to the high rainfall and run-off experienced at the beginning of 2007 (see Run-off fact sheet).

DIP concentrations remain high in the Baltic Proper. The natural Baltic outflow through the Sound and Belt Sea has led to higher DIP levels even in the eastern Kattegat. The western Kattegat and Belt Sea themselves actually had lower than normal DIP levels. DIP has also spread from the northern Baltic Proper into the Bothnian Sea, reaching the northern Quark and south eastern Bothnian Bay. In the central Bothnian Sea levels remain close to or slightly below the 1993 – 2002 average.

Silicate levels remain higher than the 1993 – 2002 mean in the northern Baltic Proper, along the south Swedish coast, in the eastern Kattegat and in the western Gulf of Bothnia. The high levels of the northern Baltic Proper have existed since the winter 2002-3 inflows, introduced both DIP and silicate from the deep water into the surface layers. This silicate has spread with the Baltic surface water outflow, giving higher than normal concentrations in Arkona (between south Sweden and Germany) and in the Kattegat. While DIP has spread into the Gulf of Bothnia along the Finnish coast, silicate levels during winter 2006/7 were higher along the Swedish coast. These, and the high levels in the coastal waters around south Sweden can be attributed to increased run-off after heavy rainfall at the start of 2007.

References

Helcom COMBINE Manual (Annex C), http://www.helcom.fi/groups/monas/CombineManual/AnnexesC/en_GB/annexes/, 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 and FIMR for winter 2005/6.

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