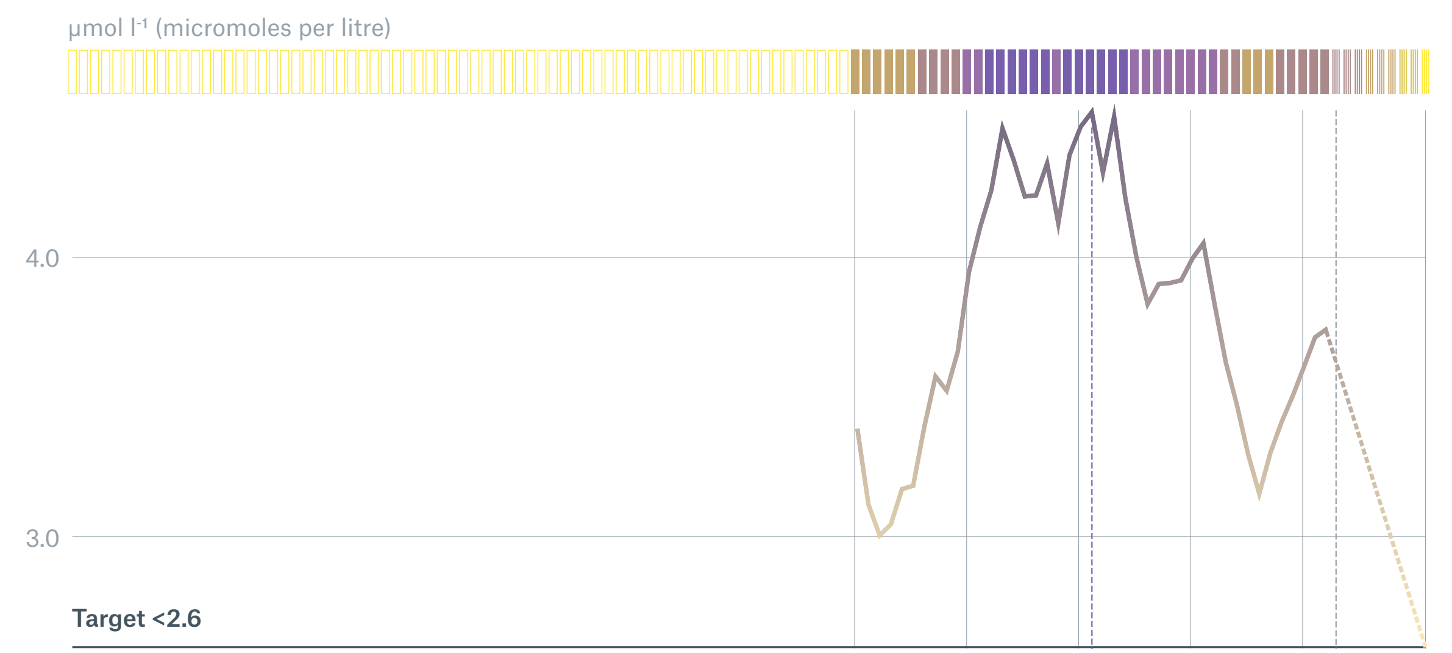
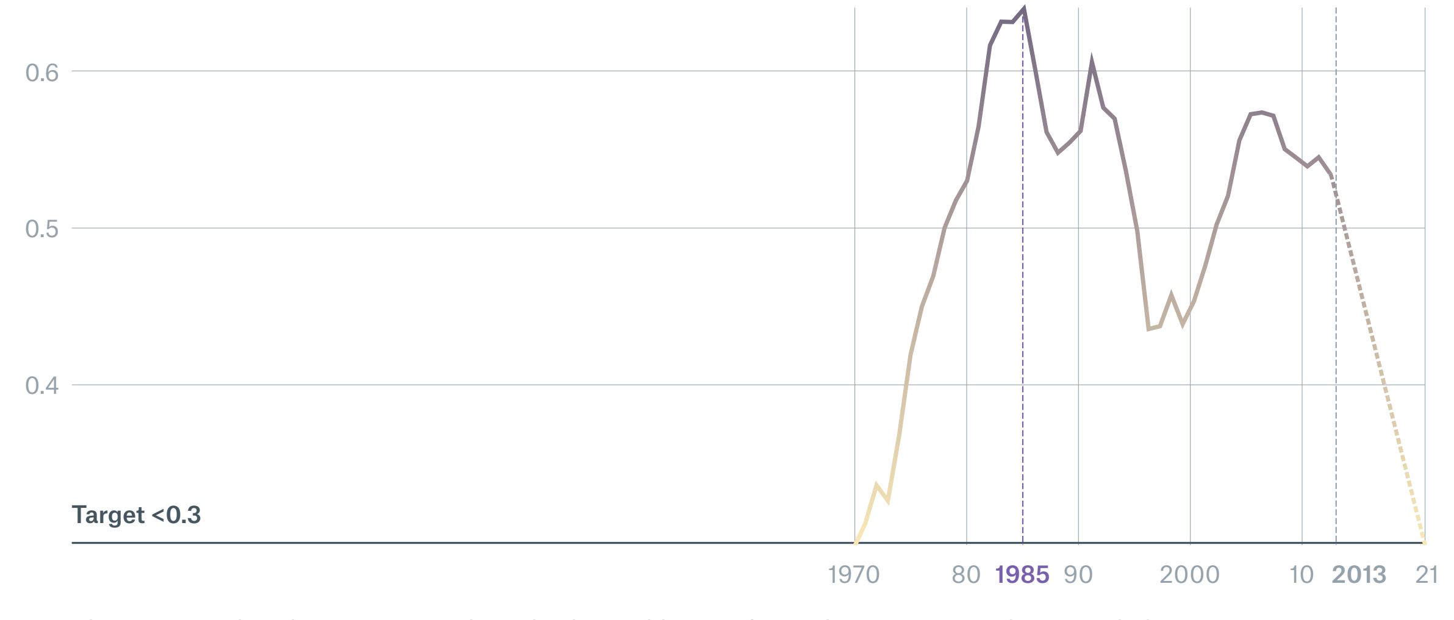
Nitrogen concentration, winter inorganic



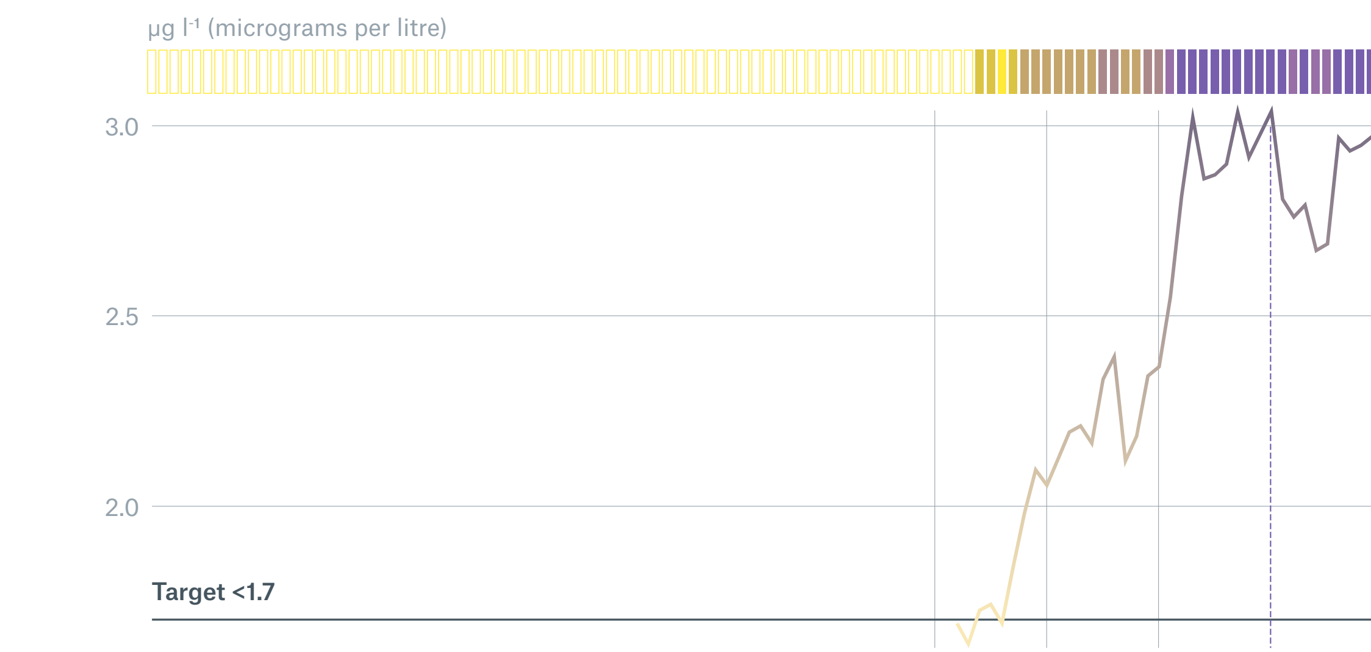
Nitrogen is a plant nutrient and a crucial basic element for all life forms. In the Baltic Sea, too much nitrogen drives an excess growth of algae and plants. Both algal blooms and nuisance filamentous algae on the coast are undesirable symptoms of eutrophication caused by too high concentrations of nutrients, nitrogen and phosphorus. The nitrogen cycle in the Baltic Sea is complex and involves not just inputs to the sea and burial in the sediments, but also nitrogen fixation by planktonic cyanobacteria and the release of nitrogen from the sea by denitrificating bacteria. Since less nitrogen is bound in biological structures in winter, concentrations of inorganic nitrogen are usually measured then.

Phosphorus concentration, winter inorganic



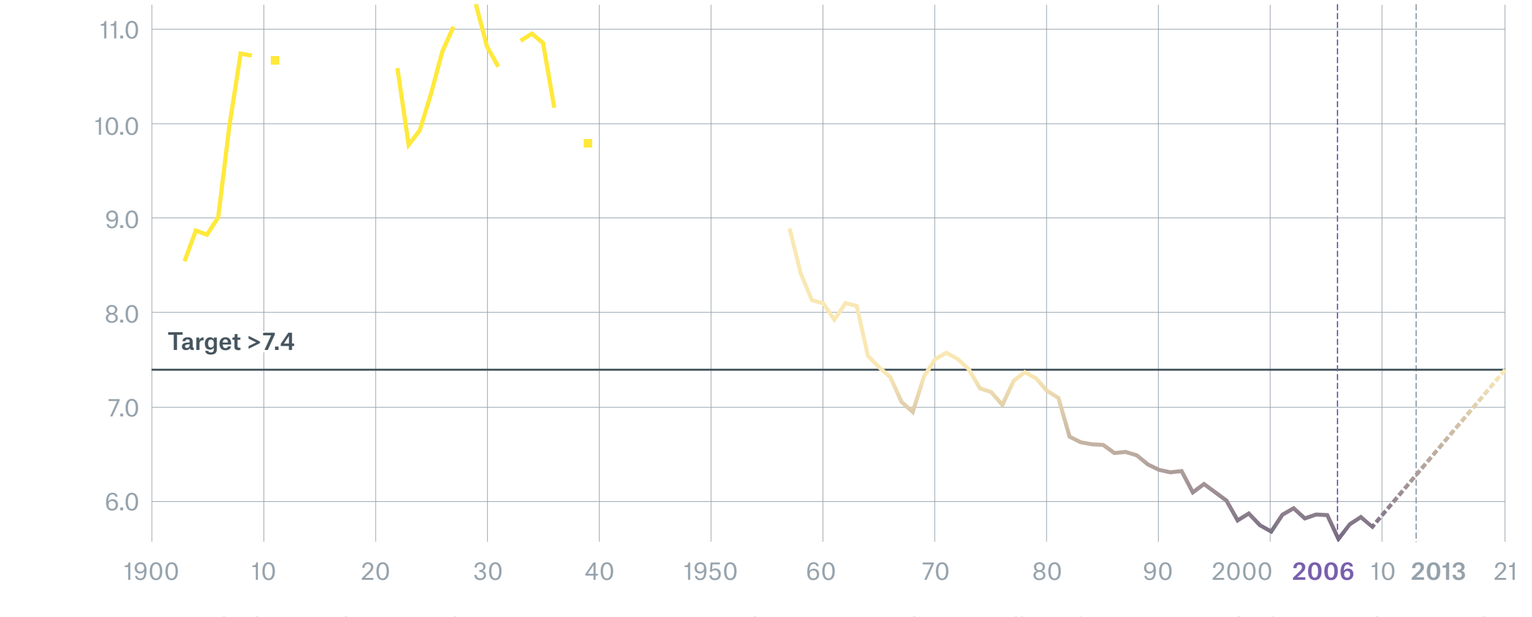
Like nitrogen, phosphorus is a crucial basic element of all life forms; however, too much phosphorus drives an excess growth of algae and plants. The availability of one of the forms of phosphorus, the phosphate phosphorus, limits the growth of bloom-forming nitrogen-fixing cyanobacteria with too much phosphate leading to blooms of cyanobacteria. In the presence of oxygen, surface sediments can retain phosphorus while in the absence of oxygen, phosphate is released from the bottom sediments and can make its way to the surface layer where it is accessible for phytoplankton and may drive blooms of algae. Similarly to nitrogen, concentrations of phosphate phosphorus are measured in winter when more nitrogen is in an inorganic form than in summer.

Algae biomass, chlorophyll *a* summer concentrations



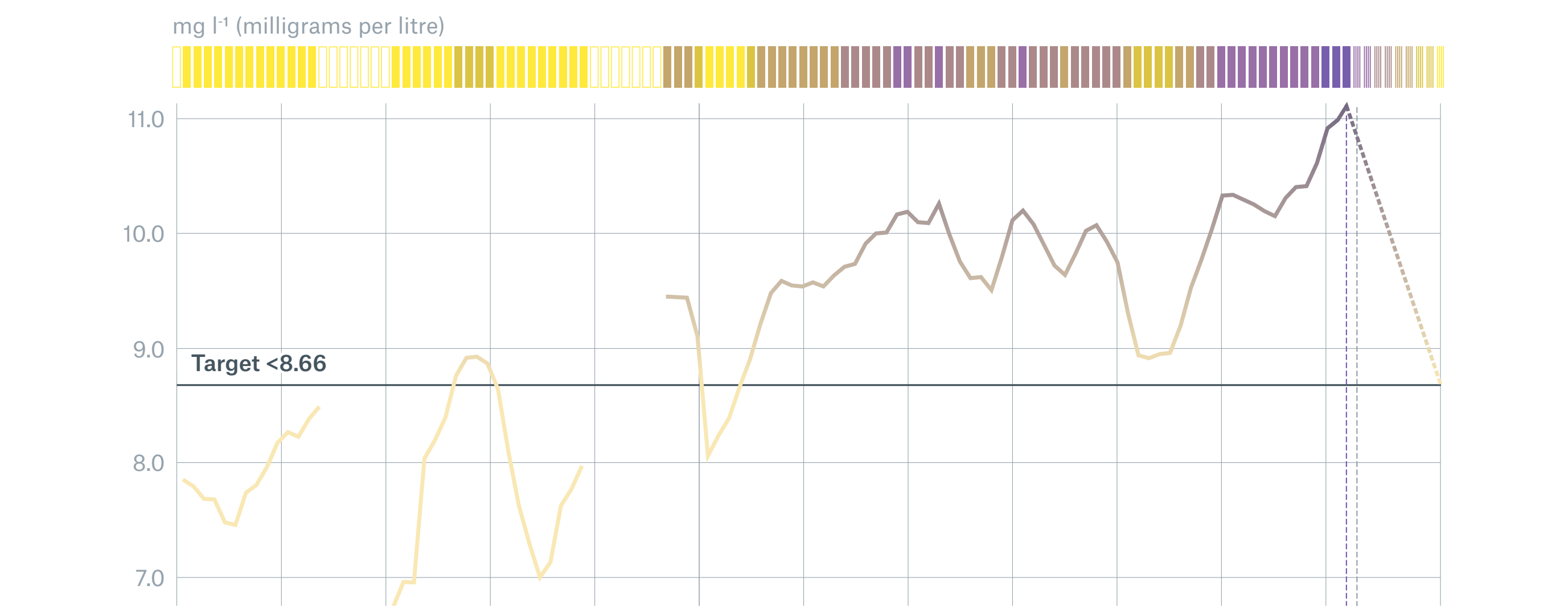
Chlorophyll *a* is a pigment for the photosynthesis of plants. It is used as a straightforward summative measure of the quantities of planktonic algae present in the water. Chlorophyll *a* does not give any information about the types of algae present in the water. For this purpose, microscopy or genetic methods are needed. Annually, there is clear cycle of plankton biomass where a short and intensive spring bloom takes place in April–May, while summer blooms of cyanobacteria are prevalent in July–August; a smaller autumn peak can take place later. For long-term assessment, summer chlorophyll *a* concentrations are used since the spring blooms are so short that they often go unmeasured.

Water clarity, summer Secchi depth



A Secchi disc is a device used to measure water clarity. The disc is simply attached to a rope and lowered into the water. The depth at which the disc can no longer be seen is then taken as a measure of water clarity. Water clarity is influenced by different kinds of particles, such as planktonic algae and zooplankton, inorganic and organic particles, as well as other coloured substances. Water clarity is considered a good indicator of eutrophication in conditions where a large fraction of the loss of clarity results from algae rather than from other factors. This is also one of the reasons why only summer observations (June–September) are used. Due to the simplicity of the method, measurements exist from the beginning of the 20th century.

Oxygen debt



Decomposing organic matter consumes oxygen, which leads first to oxygen loss–hypoxia, and finally to complete depletion of oxygen–anoxia. Hypoxia and anoxia are prevalent problems in the deeper water layers of the Baltic Sea under the physical barrier or halocline, especially in the bottoms of deep basins. Eutrophication in the Baltic Sea has led to hypoxia and anoxia in the deeps of the Baltic Proper and the Bornholm basin. Oxygen debt provides a measure of the quantity of oxygen absent from the water in comparison to saturated conditions where eutrophication would have no effect.

This poster was produced for the 2013 HELCOM Ministerial Meeting which took place on 3 October 2013 in Copenhagen, Denmark (Eigtveds Pakhus).

Please note that all the seven time series of data presented in this poster represent the situation in the largest basin, the Baltic Proper, reflecting the situation for the Baltic Sea at large.

Source for eutrophication data
Joint coordinated monitoring under the HELCOM COMBINE programme

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HELCOM.FI

BALTIC SEA IS ON ITS WAY TO RECOVERY

The evolution of Baltic Sea pollution

When working on something difficult, it is helpful to take a step back and look at the big picture. This is also true for the work carried out since the 1970s for a cleaner Baltic Sea.

This poster tells you about the evolution of the pollution of the Baltic Sea over the past 100 years.

The story is told through the specific case of nutrient pollution, which is caused by an excess of nitrogen (N) and phosphorus (P). These two substances flow into the sea from our city sewers, traffic and industrial exhaust gases as well as agricultural activities.

Pollution has dramatically changed the marine life in the Baltic Sea. Some of the signs are algal blooms, which reduce the clarity of the water and consume oxygen causing dead sea beds.

Many steps already taken–some remain

People have inhabited in the Baltic Sea region since the last ice age, fishing, cultivating land and felling forests. However, the rapid technological and social developments since the 1950s have considerably increased the rate at which we pollute the Baltic Sea. Such developments include intensive agriculture with the use of mineral fertilisers, urbanisation and the increase in population, growing meat consumption and more cars and combustion engines.

Since the 1970s, environmental awareness, investments and hard work have reduced the pollution deriving from many of these processes.

A slow reply from the sea

There is a long delay between cause and effect. Due to its natural features, the Baltic Sea recovers slowly.

The Baltic Sea is like a big swimming pool with a very small drain–what goes in eventually comes out, but only after three or so decades. This natural cleansing is further slowed down by feedback mechanisms, such as the tendency of phosphorus to be locked in 'internal circulation'. This means that nutrient pollution does not reduce over time, but continues to circulate between the dark, dead sea bed and the sunlit surface where algae grow.

Even if relatively large cuts in nutrient pollution have been achieved since the 1970s, it is only today that all the extensive work is starting to pay off. We can already see the first signs of less concentrations of nitrogen and phosphorus in the water. Moreover, through knowledge achieved from modeling of future scenarios, we can also expect these good signs to show in other descriptors of eutrophication, such as quantities of algae, water clarity and oxygen conditions.

The regional dimension of global climate change causes additional challenges in the work to reach a healthier sea.

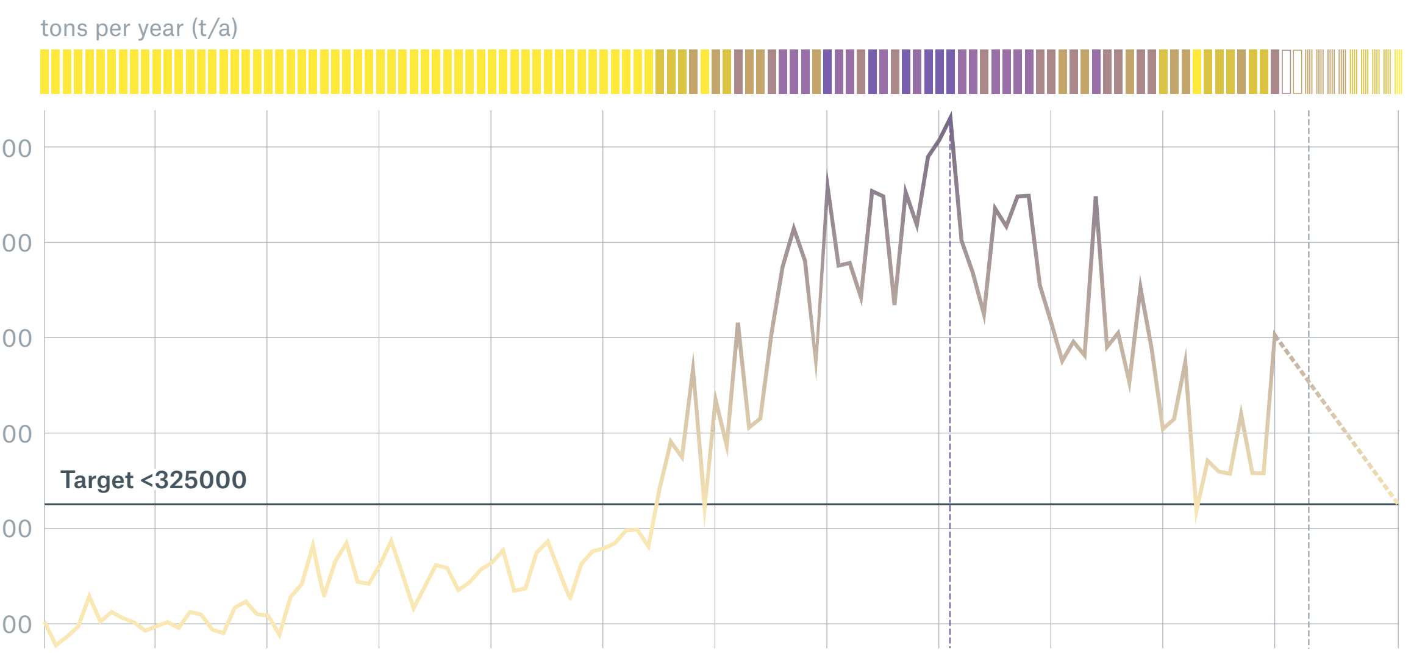
Managing requires measurements

Since the 1970s, HELCOM has been working to create and collect reliable information. This forms the jointly agreed basis for reaching a political consensus on environmental measures needed for a cleaner Baltic Sea.

A certain level of nutrient pollution from human population cannot be avoided. With this in mind, in 2007 and 2013 HELCOM defined and agreed on the maximum allowed levels of nutrient pollution that can still lead to a good ecological status of the Baltic Sea, and at the same time divided the necessary reduction targets between the coastal states.

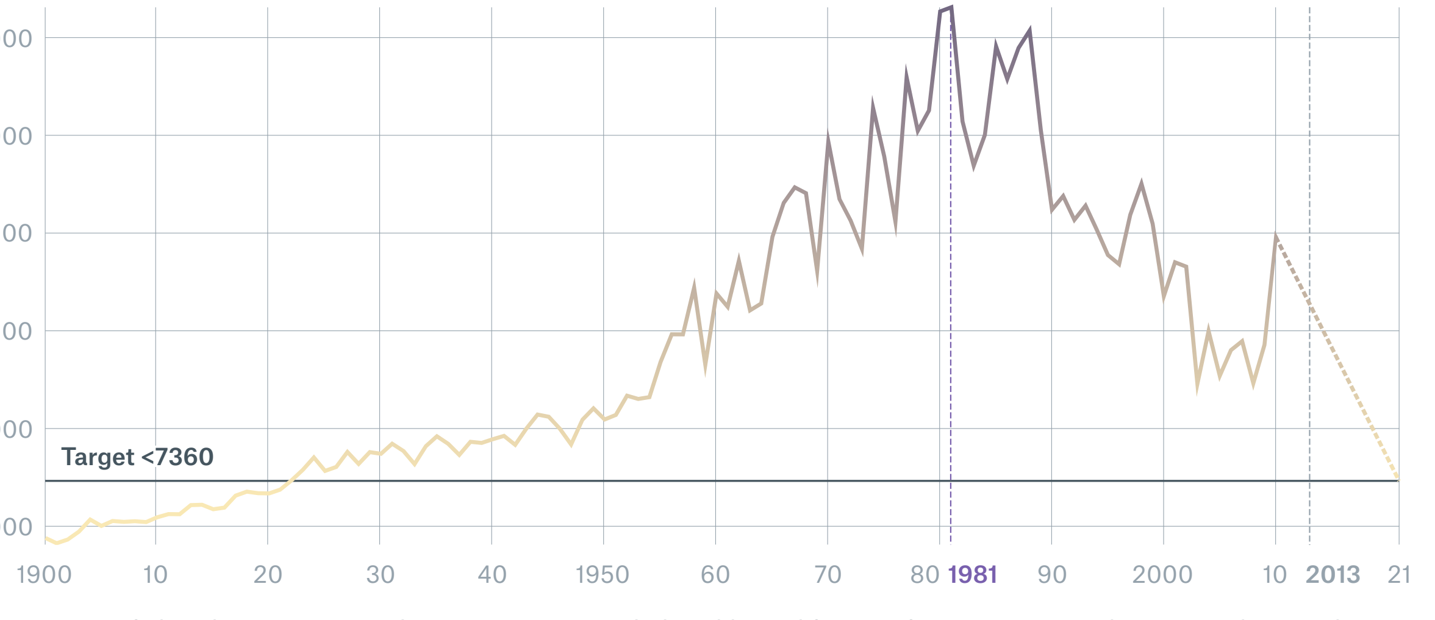
The Baltic Sea region continues to have challenging times ahead, but a healthy sea can be reached if we work as one.

Nitrogen inputs via waterways



Waterborne inputs of nitrogen come from rivers as well as from direct sources–agriculture runoff and municipal wastewater treatment discharges are the most significant. Scattered dwellings and stormwater runoff are also contributing point sources, although much smaller than agriculture. The rapid increase in nitrogen inputs during the 1950s–60s can be connected to the wider application of mineral fertilisers and growth in agricultural production, while the decrease in the 1980s–90s is associated with the introduction of more advanced municipal wastewater treatment and the reduction of diffuse runoff. In recent years, the development of nitrogen inputs has been less positive than for phosphorus with total loads to the sea remaining virtually unchanged. Although progress has been made, it is obvious that the BSAP nutrient reduction targets have not yet been fully reached.

Phosphorus inputs via waterways



Inputs of phosphorus are primarily from point sources, both within the catchments and directly on the coast. They are mainly associated with municipal wastewater and losses of mineral and organic fertilisers from fields. The rapid increase of inputs in the 1950s–60s is similar to that for nitrogen with the additional factors of industrialisation and urban development. Water management in the Baltic Sea catchment has improved over the last decades–in the Nordic countries and Germany already since the 1970s–resulting in a considerable decrease of phosphorus inputs. Poland, the Baltic countries and Russia implemented advanced wastewater treatment later, the effects of which are mainly reflected in reduced inputs after the period 1997–2003.

Nitrogen inputs via waterways
Phosphorus inputs via waterways
Nitrogen concentration, winter inorganic
Phosphorus concentration, winter inorganic
Algae biomass, chlorophyll *a* summer concentrations
Water clarity, summer Secchi depth
Oxygen debt
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2021
clean
polluted

1900 Population in Baltic catchment area ca 50 million

1901 Life expectancy at birth 53 years

1910s Biological waste water treatment begins in cities of Germany, Finland, Denmark

1913 Industrial scale nitrogen (ammonia) production using the Haber-Bosch process starts, leading to nitrogen fertiliser production. Phosphate had been used in fertilisers for a long while (e.g. guano, superphosphates)

1913 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 2547

1914 Start of WWI

1920 Urban population ca 33%

1921 Life expectancy at birth exceeds 60 years

1925 Invention of the nitrophosphate (Odda) process, enabling the production of modern NPK fertilisers

1929 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 3392

1930s Population in Baltic catchment area population ca 60 million

1937 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 4102

1939 Start of WWII

1945 After WWII, the focus of chemical industry turns from explosives to fertiliser production

1948 Life expectancy at birth exceeds 70 years

1950 Population in Baltic catchment area population still ca 60 million

1950 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 4219

1950s Activated sludge sewage treatment becomes common

1960s Population in Baltic catchment area population exceeds 70 million

1962 EC's Common Agriculture Policy launched

1970 Urban population in the catchment area close to 60%

1973 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 10856

1974 Signing of the Helsinki Convention

1980 Regular HELCOM work starts and eutrophication recognized as a problem in the first baseline assessment

1985 Population in Baltic catchment area ca 80 million

1988 HELCOM Ministerial Declaration Agreement to reduce 50% of nutrient discharges by 1995

1989 Centrally planned agriculture starts to collapse in the former socialist-bloc countries

1990 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 16393

1991 EU Urban Waste Water Treatment Directive

1992 New Helsinki Convention – Expansion to catchment area and the newly independent states

1992 Establishment of HELCOM Hot Spot list (JCP)

1996 Human-induced eutrophication is reconfirmed in HELCOM assessment

1996 First Nitrate Vulnerable Zones established

2000 EU Water Framework Directive

2000 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 19226

2000 Urban population in the catchment area close to 70%

2001 Maritime Doctrine of the Russian Federation

2003 One third of HELCOM Hot Spots cleaned

2003 HELCOM Bremen Declaration – Ecosystem approach

2005 South-West waste water treatment plant established in St. Petersburg

2005 Population in Baltic catchment area ca 83 million

2006 New Water Code in Russia adopted

2007 HELCOM Baltic Sea Action Plan adopted

2007 HELCOM Recommendation on improving waste water treatment

2008 EU Marine Strategy Framework Directive

2010 HELCOM Moscow Ministerial commitment

2010 The whole Baltic Sea, except for northernmost areas and North-West Kattegat, is a eutrophication problem area in HELCOM assessment

2010 Median GDP per capita in Baltic Sea countries (in 1990 GK $): 19032

2011 Ban on sewage from passenger ships – Baltic Sea the first such special IMO area in the world

2012 Two thirds of Hot Spots cleaned

2013 HELCOM Copenhagen Ministerial Meeting

2013 98% of sewage treatment in St. Petersburg is meeting HELCOM standards

2014 New EU Common Agricultural and Fisheries Policies implementation starts

2015 Completion of Polish municipal sewage program

2021 HELCOM targets for nutrient inputs and eutrophication status have been reached