February 2022

# Fact Sheet

Baltic Sea Centre | Stockholm University

# Understanding how eutrophication is quantified in the HELCOM BSAP

Through the HELCOM Baltic Sea Action Plan, BSAP, the riparian countries and the EU established a joint view on the environmental problems of their shared sea, and agreed to take specific actions to restore it to a healthy and resilient state. This factsheet describes the scientific basis of the eutrophication segment of the plan; how the political vision of a healthy Baltic Sea can be reached via the basin-wise Maximum Allowable Inputs (MAI) and country-wise Nutrient Input Ceilings (NIC).

In the 1970s and 1980s, turbid water, extensive algal blooms, dead seals and contaminated fish led to the realisation that eutrophication was not a local problem in coastal areas, but affected the entire Baltic Sea. Environmental degradation of the sea could no longer be ignored and the surrounding countries formulated a vision: a healthy and resilient Baltic Sea with diverse biological components functioning in balance. More specifically, the Baltic Sea should be unaffected by eutrophication, hazardous substances and litter, and sea-based activities should be sustainable.

The Baltic Sea coastal countries signed the Helsinki Convention (1974 and 1992) and HELCOM Baltic Sea Action Plan (2007 and 2021), indicating their agreement with the environmental goals and the specific actions to reach them. Eight EU countries – Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden – as well as Russia, and the EU are signatories to the Helsinki Convention and BSAP.

The visionary goal of a Baltic Sea unaffected by eutrophication was substantiated by five ecological objectives: *Clear waters, Concentrations of nutrients close to natural levels, Natural level of algal blooms, Natural distribution and occurrence of plants and animals,* and *Natural oxygen levels*. These objectives are directly or indirectly impacted by human nutrient inputs to the sea and are also interrelated. Inorganic nutrients drive algal blooms that decrease water clarity and, when decomposed, have a negative impact on oxygen levels, which in turn disturb the occurrence of aquatic plants and animals.

## Setting quantifiable targets

The BSAP establishes quantitative targets and indicators to realise its ambitious goals and qualitative objectives. As the environment naturally varies around the Baltic Sea, it is divided into seven sub-basins for which different targets have been set: Kattegat, Danish Straits, Baltic Proper, Bothnian Sea, Bothnian Bay, Gulf of Riga and Gulf of Finland.

The target values were defined as the level where natural variation in the pre-eutrophic period (the period before 1940) was exceeded. Natural variation was quantified as the 95 percent confidence interval in the distribution of the observations of the indicators. Pre-eutrophic water clarity (measured as Secchi depth) and oxygen concentrations were obtained directly from historical observations available for all sub-basins since the late 19th century. Defining the natural concentrations of nutrients and chlorophyll-a (a measure of algal blooms) was more difficult, because data collection for these parameters began in the late 1960s and early 1970s, after the sea was already affected by eutrophication.

Target levels were set for Secchi depth, nutrients (winter concentrations of dissolved inorganic phosphorus, DIP, and dissolved inorganic nitrogen, DIN respectively) and chlorophyll-a. In case of oxygen conditions, target levels were set for oxygen dept (i.e. the amount of oxygen per volume of deepwater that needs to be added to make the deepwater completely oxic) in the deep basins of Baltic Proper and Gulf of Finland solely. No indicator has been defined for the objective *Natural distribution of plant of animals*.

## From targets to loads

Having quantified the desired state of the Baltic Sea with the targets, the next challenge was quantifying how to reach them. What are the sustainable levels of human nutrient inputs to the Baltic Sea? What are the environmentally and economically optimal spatial distribution of the needed reductions in nutrient inputs? Answers to these questions cannot be found in historical observations, but through computer modelling. Researchers at Stockholm University developed the Baltic Sea Long-Term Large-Scale Eutrophication Model (BALTSEM), to quantify the impact of nutrient inputs on eutrophication. BALTSEM uses time-series data for weather, river runoff, and nutrient inputs to estimate the timing and spatial distribution of nutrient, oxygen, and phytoplankton concentrations, as well as Secchi depth.

Scientists performed numerous BALTSEM simulations with different combinations of nitrogen and phosphorus inputs to the sub-basins to estimate the *Maximum Allowable Inputs* (MAI) of nutrients that could allow the indicators eventually to reach their target values. For the Baltic Sea as a whole, the MAI means a reduction in the nitrogen load by about 13 percent and in the phosphorus load by about 40 percent, compared to the mean values in the 1997-2003 reference period.

## Dividing the burden – who should do the work?

Having identified the MAI for all sub-basins, the intricate political question remained: how should the necessary reductions of nutrient inputs be divided among the HELCOM countries? Should all countries have the same load? Should the larger countries be allowed larger inputs? Or the populous ones? The ones with longer coastline? Agricultural-dependent ones? Or should the richer ones take the heaviest burden of reducing inputs?

Both the precautionary and polluter-pays principles are written into the Helsinki Convention. Under precautionary principle, no country

# Baltic Sea unaffected by eutrophication

## Environmental objectives

### What is the goal?

The countries agree on a vision of a healthy Baltic Sea environment, including the goal of a sea unaffected by eutrophication, which is concretised in five objectives.

- Clear waters
- Concentrations of nutrients close to natural levels
- Natural distribution and occurrence of plants and animals
- Natural levels of algal blooms
- Natural oxygen levels

## Targets

### What does that mean?

The objectives are quantified by target values for measurable indicators in the environment.

**Secchi depth, summer (m):**

| | | |
|---|---|---|
| Kattegat | 7.6 | ✓ |
| Danish Straits | 7.8 | ✓✗ |
| Baltic Proper | 7.4 | ✗ |
| Bothnian Sea | 6.8 | ✗ |
| Bothnian Bay | 5.8 | ✗ |
| Gulf of Riga | 5.0 | ✗ |
| Gulf of Finland | 5.5 | ✗ |

**DIN / DIP winter (µmol/litre)**

| | DIN | | DIP | |
|---|---|---|---|---|
| Kattegat | 5,0 | ✗ | 0.49 | ✗ |
| Danish Straits | 5.0 | ✗ | 0.56 | ✗ |
| Baltic Proper | 2,6 | ✗ | 0.30 | ✗ |
| Bothnian Sea | 2.8 | ✗ | 0.19 | ✗ |
| Bothnian Bay | 5.2 | ✗ | 0.07 | ✓ |
| Gulf of Riga | 5.2 | ✗ | 0.41 | ✗ |
| Gulf of Finland | 3.8 | ✗ | 0.59 | ✗ |

**Chlorofyll *a*, summer (µg/litre)**

| | | |
|---|---|---|
| Kattegat | 1.5 | ✓ |
| Danish Straits | 1.9 | ✗ |
| Baltic Proper | 1.7 | ✗ |
| Bothnian Sea | 1.5 | ✗ |
| Bothnian Bay | 2.0 | ✗ |
| Gulf of Riga | 2.7 | ✗ |
| Gulf of Finland | 2.0 | ✗ |

**Oxygen debt, (mg/litre):**

| | | |
|---|---|---|
| Kattegat | | |
| Danish Straits | | |
| Baltic Proper | 6.4/8.7 | ✗ |
| Bothnian Sea | | |
| Bothnian Bay | | |
| Gulf of Riga | | |
| Gulf of Finland | 8.7 | ✗ |

# Maximum Allowable Inputs

## What do we need to do to get there?

Scientists calculate the maximum annual nutrient inputs to the sea that allow the targets to eventually be met.

# Nutrient Input Ceilings

## Who should do what?

The total Maximum Allowable Inputs is divided among the countries, in proportion to their historical inputs.

**Maximum allowable inputs of nutrients**

| | Total nitrogen (tonnes) | Total phosphorus (tonnes) |
|---|---|---|
| Kattegat | 74,000 ✓ | 1,687 ✓ |
| Danish Straits | 65,998 ✓ | 1,601 ✓ |
| Baltic Proper | 325,000 ✗ | 7,360 ✗ |
| Bothnian Sea | 79,372 ✓ | 2,773 ✓ |
| Bothnian Bay | 57,622 ✓ | 2,675 ✓ |
| Gulf of Riga | 88,417 ✗ | 2,020 ✗ |
| Gulf of Finland | 101,800 ✗ | 3,600 – |

**Kattegat**

| | TN | TP |
|---|---|---|
| Germany | 4,661 ✓ | - |
| Denmark | 28,538 ✓ | 815 ✓ |
| Estonia | 24 ✓ | - |
| Finland | 89 ✓ | - |
| Lithuania | 80 ✗ | - |
| Latvia | 34 ✗ | - |
| Poland | 1,443 ✓ | - |
| Russia | 245 – | - |
| Sweden | 32,799 ✓ | 753 – |

**Danish Straits**

| | TN | TP |
|---|---|---|
| Germany | 23,647 ✓ | 401 ✓ |
| Denmark | 28,067 ✓ | 979 ✓ |
| Estonia | 22 ✓ | - |
| Finland | 76 ✓ | - |
| Lithuania | 66 – | - |
| Latvia | 31 ✓ | - |
| Poland | 1,480 ✓ | - |
| Russia | 238 ✓ | - |
| Sweden | 6,056 ✓ | 116 ✓ |

**Baltic Proper**

| | TN | TP |
|---|---|---|
| Germany | 34,077 ✗ | 109 ✗ |
| Denmark | 9,025 ✓ | 21 ✗ |
| Estonia | 1,478 ✗ | 9 ✗ |
| Finland | 1,827 ✓ | - |
| Lithuania | 25,878 ✗ | 703 ✗ |
| Latvia | 6,457 ✗ | 167 ✗ |
| Poland | 151,997 ✗ | 4,291 ✗ |
| Russia | 10,317 ✗ | 242 ✗ |
| Sweden | 30,690 ✗ | 318 ✗ |

**Bothnian Sea**

| | TN | TP |
|---|---|---|
| Germany | 3,920 ✓ | - |
| Denmark | 1,148 ✓ | - |
| Estonia | 404 ✓ | - |
| Finland | 28,700 ✓ | 1,246 ✗ |
| Lithuania | 495 ✗ | - |
| Latvia | 330 – | - |
| Poland | 3,125 ✓ | - |
| Russia | 1,993 – | - |
| Sweden | 32,633 ✓ | 1,133 ✓ |

**Bothnian Bay**

| | TN | TP |
|---|---|---|
| Germany | 947 ✓ | - |
| Denmark | 280 ✓ | - |
| Estonia | 113 ✓ | - |
| Finland | 35,087 – | 1,683 ✓ |
| Lithuania | 108 ✗ | - |
| Latvia | 73 ✗ | - |
| Poland | 668 ✓ | - |
| Russia | 839 ✗ | - |
| Sweden | 17,718 ✓ | 811 – |

**Gulf of Riga**

| | TN | TP |
|---|---|---|
| Germany | 1,747 ✓ | - |
| Denmark | 462 ✓ | - |
| Estonia | 13,099 – | 185 ✗ |
| Finland | 295 ✓ | - |
| Lithuania | 8,820 ✗ | 175 ✓ |
| Latvia | 43,074 ✗ | 1,061 ✗ |
| Poland | 1,596 ✓ | - |
| Russia | 3,296 ✗ | 99 ✗ |
| Sweden | 525 ✓ | - |

**Gulf of Finland**

| | TN | TP |
|---|---|---|
| Germany | 1,645 ✓ | - |
| Denmark | 421 ✓ | - |
| Estonia | 11,334 ✗ | 225 ✗ |
| Finland | 20,457 ✗ | 315 ✗ |
| Lithuania | 305 ✗ | - |
| Latvi | 246 ✗ | - |
| Poland | 1,407 ✗ | - |
| Russia | 61,503 ✗ | 2,909 – |
| Sweden | 626 ✓ | - |

Green check mark indicates that the target/ceiling is reached, a red cross indicates that it is not yet reached and a yellow hyphen means that Inputs are below the ceiling, but the margin is less than the uncertainty. The classification of the fulfillment of the NIC by the countries is made by comparing the estimated inputs (including uncertainty) published by HELCOM with the updated BSAP NIC. Thus, this classification is unofficial and provisional pending a proper updated assessment by HELCOM.

is allowed to increase nutrient inputs to any sub-basin. Under the polluter-pays principle, the countries should take responsibility for their share of the nutrient pollution. However, implementing the polluter-pays principle is not straight-forward. It is difficult to disentangle the portion of nutrient inputs that constitute pollution from "natural" background nutrient inputs. Indeed, there is controversy over how these types of inputs should be defined. In addition, it is not obvious that the sources of pollution can be managed given the many practical, economic, political and cultural considerations. Some simple allocation schemes were tested and rejected. For example, a per capita nutrient quota failed because neither human-caused nor background nutrient inputs are proportional to population size; densely populated areas tend to have relatively low per capita inputs when efficient sewage treatment is implemented.

The HELCOM countries agreed to allocate the MAI in proportion to their inputs during the 1997-2003 reference period. These allocations or quotas are called *Nutrient input ceilings* (NIC) and form the other component of the HELCOM Nutrient Reduction Scheme. However, some of the waterborne nutrients originate upstream from countries that are not HELCOM parties. These inputs are referred to as transboundary waterborne inputs, and the largest are from Belarus, Czech Republic, and Ukraine. NICs were assigned to these countries as well, according to their nutrient inputs during the reference period. Further, a considerable part of atmospheric nitrogen deposition originates from international shipping in the Baltic Sea and the North Sea. Other activities in non-HELCOM countries also result in atmospheric nitrogen that is deposited on the Baltic Sea.

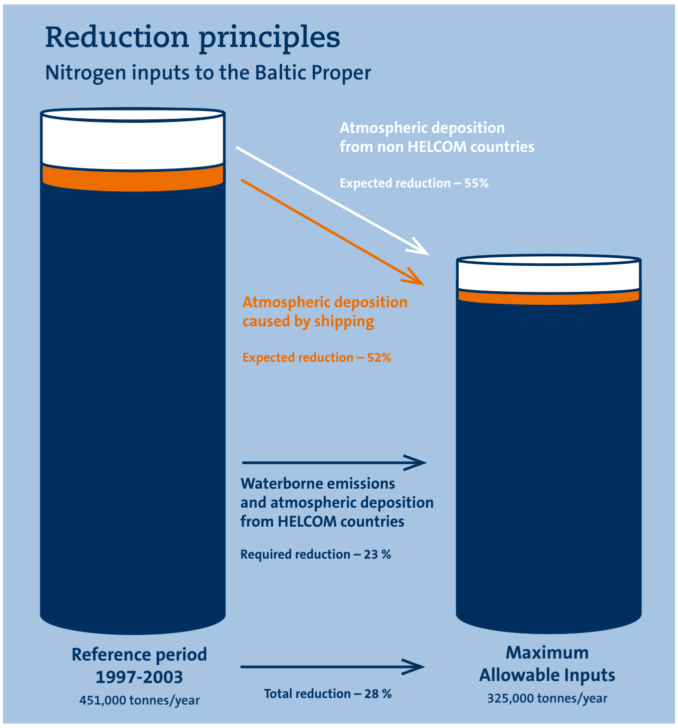
The Baltic Sea and North Sea have been designated as NOX Emission Control Areas (NECA). As a result, nitrogen inputs from shipping should decrease by over 50 percent. Atmospheric deposition from non-HELCOM countries should also decrease under the Gothenburg Protocol, which aims to reduce transboundary air pollution including nitrogen oxides (NOX) and ammonia ($NH_3$). For phosphorus, atmospheric deposition constitutes a minor part of the total load and is expected to remain at its reference level.

The large transboundary rivers Vistula, Oder, Neva, Nemunas, and Daugava contribute nearly a third of total waterborne nitrogen inputs to the Baltic Sea and half of total phosphorus inputs. Given the significance of these rivers and four other large rivers to Baltic Sea nutrient loads, they have been assigned separate NICs of their own.

So that countries have flexibility to optimise their measures, a reduction below the NIC to one sub-basin can be taken into account when assessing whether a country is achieving its ceiling in another sub-basin, through a so-called reallocation of extra reduction. However, the country needs to show that the shift of reduction between sub-basins still leads to the same (or better) conditions in the Baltic Sea.

## Taking action and follow up

The BSAP includes some actions to be taken by the signatories; however, these actions are fairly general and it is the responsibility of each country to plan and implement measures necessary to reach their NICs. In the most recent BSAP update, no date was set for when the Baltic Sea should reach the state of being unaffected by eutrophication. However, the contracting parties are obliged to have implemented the necessary measures no later than 2027.




HELCOM regularly monitors progress towards MAI and NIC. Each year, the contracting parties report riverine nutrient inputs and direct point sources to the HELCOM Pollution Load Compilation (PLC) database, hosted by Stockholm University. HELCOM uses these data and data on atmospheric nitrogen deposition from the European Monitoring and Evaluation Programme to report progress in the annual report "Inputs of nutrients (nitrogen and phosphorus) to the sub-basins". Progress by individual countries in reaching their NIC will now be reported bi-annually. The progress reports use a traffic-light system that takes into account variability in the data, which means that nutrient input needs to be statistically significantly below MAI (or NIC) to be classified as achieving the goal (green). If the nutrient input is below MAI (or NIC), but not statistically significantly below, it is classified as yellow. Even though reductions have been substantial, so far, no country reached their NICs in all sub-basins. The annual nutrient inputs exceed MAI for the Baltic Proper, Gulf of Finland, and Gulf of Riga.

HELCOM also follows the eutrophication state of the sea and provides regular progress reports on the individual indicators mentioned above. While promising trends have been observed, particularly in Kattegat, the sea remains affected by eutrophication. The slow response of the Baltic Sea to reductions in nutrient input means that it will be decades before significant improvements are observed more broadly.

**TO BRIDGE THE GAP BETWEEN SCIENCE AND POLICY**

This fact sheet is produced by Stockholm University Baltic Sea Centre.

Scientists, policy and communication experts work together to bridge the gap between science and policy.

We compile, analyse and synthesise scientific research on Baltic Sea related issues and communicate it at the right moment to the right actor in society.

**CONTACT**

Bo Gustafsson, Baltic Sea Centre
bo.gustafsson@su.se