Emissions from the Baltic Sea shipping

Authors: Jukka-Pekka Jalkanen, Finnish Meteorological Institute
Tapani Stipa, Finnish Institute of Marine Research

Key messages

Emissions from Baltic Sea shipping during 2006 were found to be larger than previously reported.

Baltic Sea ship emissions from 2006 are comparable with:

- NO_x, 370 kt/year: Combined land-based emission sources of Finland and Sweden (382 kt/year)
- SO_x, 159 kt/year: Combined land-based emission sources of Finland, Sweden, Denmark and Norway (155 kt/year)
- CO_2, 17.4 Mt/year: Combined emission of all modes of transport (air, sea, road, rail) in Finland (14.4 Mt/year)
- Energy consumption, 226 PJ: Combined energy consumption of all modes of transport in Finland (227 PJ)

Results and assessment

Relevance of the indicator for describing the developments This indicator shows the annual emission levels of NO_x, SO_x and CO_2 arising from ship traffic in the Baltic Sea area.

Policy relevance and policy reference

Roughly a third of the nitrogen loads to the Baltic Sea arrives through atmospheric deposition. In contrast to the waterborne load, the atmospheric load is estimated to be almost entirely anthropogenic (Stipa et al, in prep). The atmospheric deposition is also readily available for the eutrophication of offshore marine areas. Therefore, reductions in the atmospheric load are expected to result in rapid changes to the Baltic Sea state (e.g. Stipa et al, 2003). HELCOM is currently in the process of incorporating atmospheric load data into calculations of nutrient reduction allocations necessary for good environmental status, as identified in the HELCOM Baltic Sea Action Plan.

Shipping has been identified as the source of atmospheric NO_x deposition with a Baltic-wide share of 16% (Bartnicki, 2007), with the share reaching 50% of the NO_x deposition in the summertime in northern Baltic Sea (Stipa et al, 2007). Utilising the report of Stipa et al. (2007) HELCOM countries made a joint submission to 57th session of the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) regarding ship emissions. Revised MARPOL Annex VI was outlined and stricter limits for ship emissions were agreed (Table 1).

Table 1. Emission limits agreed by IMO, subject to final approval by MEPC 58 in 2008. First column shows the schedule of changes, second column shows emission limits for NO_x in Emission Control Areas, third column shows emission limits for SO_x in SECA areas. The last two columns show planned limits on a global scale.

Time	NO_x(ECA)	SO_x(SECA)	NO_x(global)	SO_x(global)
Current	17 g/kWh	1.5 mass-% S	-	4.5 mass-% S
1.3.2010		1.0 mass-% S	-	
1.1.2011	14.4 g/kWh		-	
1.1.2012			-	3.5 mass-% S
1.1.2015		0.1 mass-% S	-	
1.1.2016	3.4 g/kWh		-	
2018			-	Fuel review
1.1.2020			-	0.5 mass-% S(*)
2025			-	0.5 mass-% S

(*) Subject to feasibility review for production of low-sulphur fuel. If the result is negative, then the time limit will be pushed to year 2025.

Future limitations in Emission Control Areas (ECA)

In the 57th session of MEPC it was agreed to cut emissions from shipping in several stages in the near future. Future limits are shown in Table 1. It is noteworthy that also old engines, built during 1.1.1990 – 1.1.2000 will have to conform to current (Tier I) NO_x limit of 17 g/kWh. Global restrictions outside ECA areas are not planned. To decrease sulphur emissions from shipping, MEPC decided to restrict the sulphur content of fuel in SO_x Emission Control Areas down to 1.0 % (currently 1.5 mass-% of S) starting from 1.3.2010. This limit is tightened further, to 0.1 mass-% of sulphur, from 1.1.2015.

Future global limitations

Global limits for sulphur will be 3.5 % (currently 4.5 %) starting from 1.1.2012. Global sulphur limit of 0.5 % will be enforced in 1.1.2020, subject to a feasibility review of low sulphur fuel availability on 2018. If the review is negative, then the 0.5 % limit will be postponed to 2025.

Assessment

Emission inventories for shipping were prepared using the data from HELCOM Automatic Identification System (AIS) database. More information regarding the calculation method can be found in Stipa et al. (2007). An analysis for a time period of 1st of March 2006 – 28th of February 2007 was performed and annual emission levels were determined. There were 3500-5000 ships sailing the Baltic Sea each month and at any given moment there were >2000 vessels. NO_x emission from ships alone reached 370 kilotons during the analysis time period. Table 2 shows nitrogen loads of different sources compared to NO_x emitted by ships in the Baltic Sea area.

Table 2. Emission of nitrogen from various sources in the Baltic Sea area (Tarrason 2007).

Nitrogen load to the Baltic Sea from HELCOM countries (water borne)	736.7 ktons of N
Total nitrogen emission from land to air (NO_x + NH_4) in HELCOM area	3331.0 ktons of N
Land based NO_x emission of HELCOM countries	1840.1 ktons of N
NO_x emission from Baltic Sea shipping (370 kt of NO_2 corresponds to 112.6 ktons of N)	112.6 ktons of N
Share of shipping emissions from total NO_x emissions	6.12 %
Share of shipping emissions compared to total release of airbone N of HELCOM countries	3.38 %
Share of shipping emissions compared to water borne nitrogen	15.29 %

Fuel consumption was estimated as 5581 kilotons, which corresponds to 226 Petajoules of energy consumed and 17.4 megatons of CO_2 produced by ships. To put these numbers in perspective, combined NO_x emissions of Finland and Sweden was 382 kilotons in 2005 (Tarrason et al., 2007). Detailed analysis of ship specific SO_x emissions are in progress, but using the current limit of 1.5 mass-% of sulphur and knowing the amount of fuel burned, one can estimate the SO_x emission from the Baltic Sea shipping as 159 kilotons (counted as SO_2) during the analysis period (Jalkanen et al., 2007). This is roughly the same as the combined SO_2 emissions (155 kt) of Finland, Sweden, Norway and Denmark in 2005. The CO_2 emissions and energy consumption of Baltic Sea shipping are roughly comparable to emissions of Finland. Energy consumption in 2006 of all transport modes (air, sea, road, rail) was 227 PJ (Technical Research Center of Finland, 2007) and CO_2 emissions were estimated as 14.4 Mt (Statistics Finland, 2007).

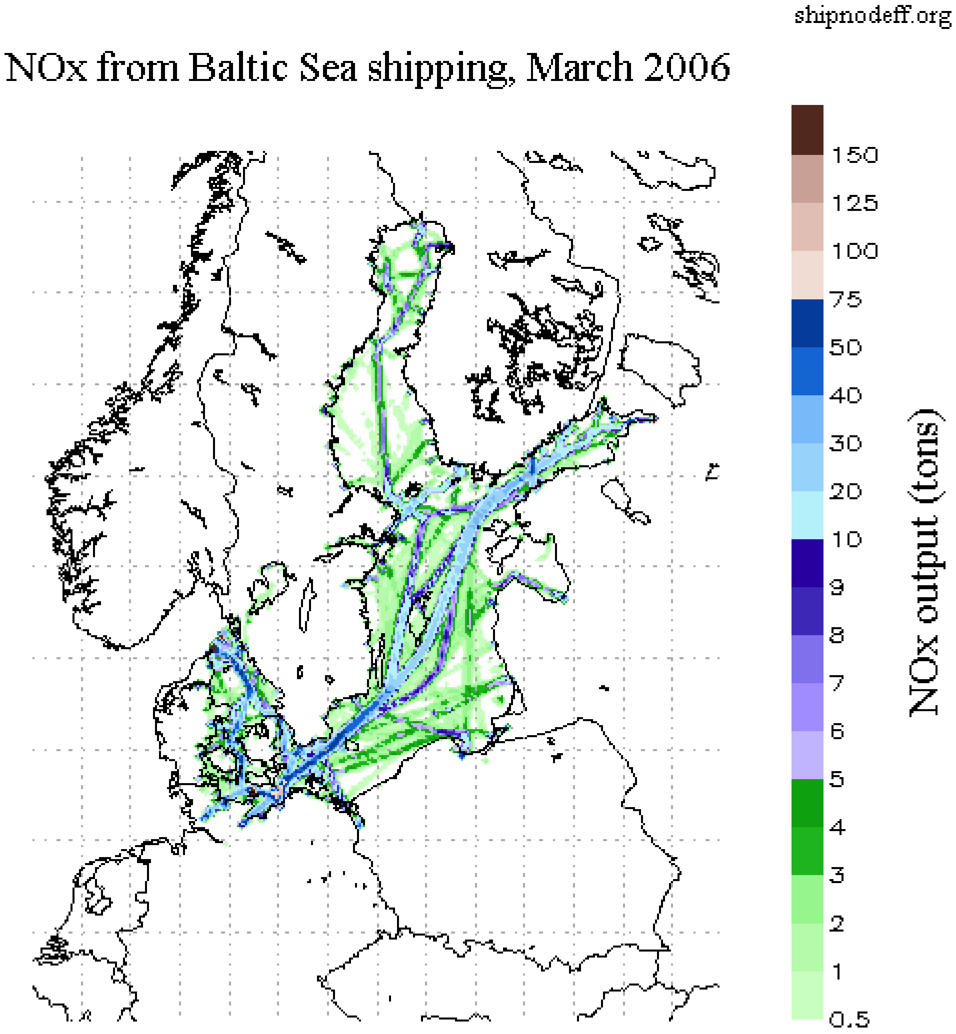

Figure 1. NO_x emission from ships during March 2006.

The NO_x emission from March 2006 yields 32.3 kilotons for the HELCOM convention area. The monthly variation in emissions during the analysis period can be found in HELCOM submission to IMO.(Stipa et al., 2007) As can be seen from Figure 1, most of the emission occurs in the Southwestern Baltic Sea and in the Gulf of Finland.

AIS facilitates the determination of the flag state of the vessel, since the Mobile Maritime Service Identity (MMSI) numbers are assigned by the national authorities and reveal the country where the ship is registered to. Based on this information ship emissions can be classified based on flag state, summary of which is shown in Figure 2

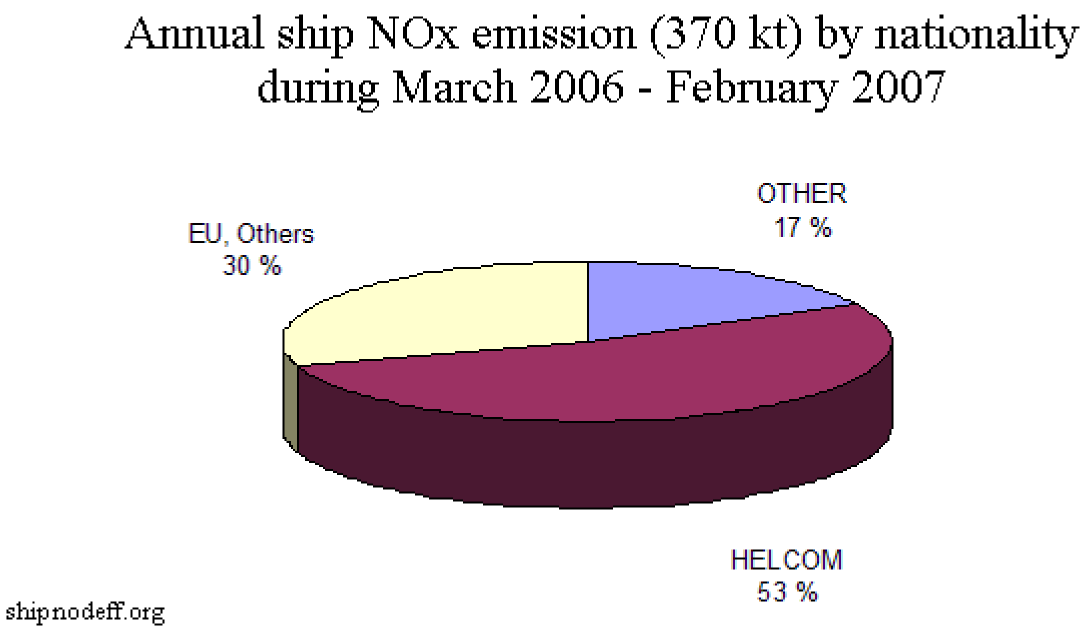

Figure 2. Ship NO_x emission by flag state. Annual NO_x output from ships is 370 kt.

Most of the NO_x emissions (~53 %) arising from the Baltic Sea shipping come from ships that are registered to HELCOM member states. Only ~17 % of NO_x is produced by ships registered outside the EU member states.

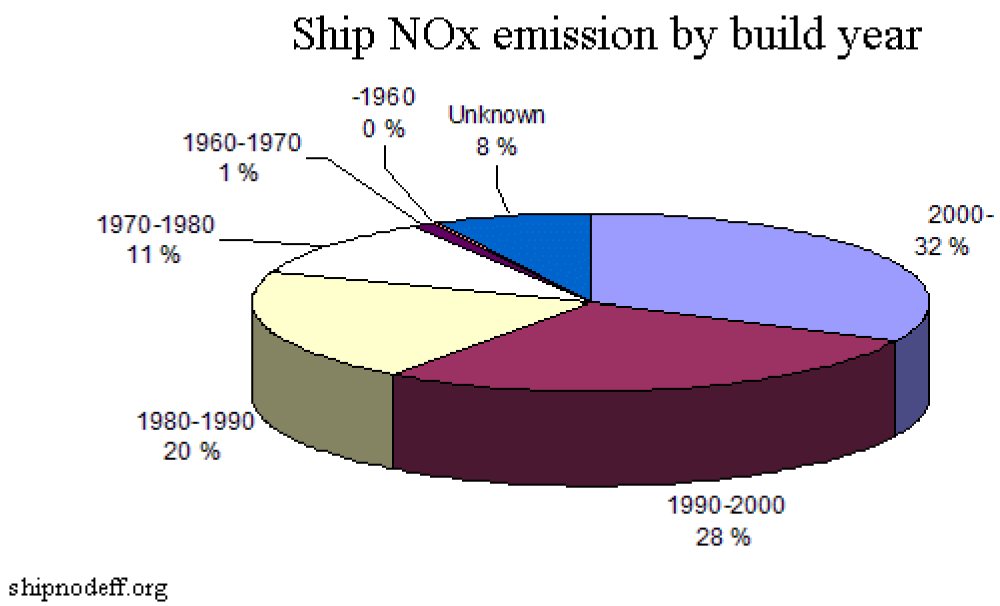

Figure 3. Annual NO_x emission of 370 kt by ship build year.

By looking at the NO_x emitted by each age class of ships (Figure 3), it can be concluded that roughly one third comes from new ships, built after 1.1.2000. Ships built in 1990's and 1980's produce 28 % and 20 % of the NO_x emissions, respectively.

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17th HELCOM AIS EWG meeting documents: "*Inaccuracies in AIS data - effects on usability*", submitted by Finland, available from

http://meeting.helcom.fi/c/document_library/get_file?folderId=97596&name=DLFE-33804.pdf

Metadata

Technical information

Emission estimates for NOx are based on HELCOM AIS-data collected by the member states. It contains detailed information of the position and speed every ship carrying an AIS transmitter required by the IMO. Based on current speed-design speed relation and technical data of ships' engines, an emission estimate can be made based on instantenous power levels of the engines. It is possible to extend emission evaluation to other areas where AIS data is readily available. Thirteen different techniques for emission abatement are included and their impact to emissions are modeled as are ship specific NO_x emission certificates.

Quality information

Reliability of the data

In short: If no AIS data is available, no emissions are calculated either by the program. HELCOM AIS data contains short time periods, up to few days, when no data is available due to technical issues regarding data storage and data transfer between member states and the HELCOM AIS data server (See 17th Helcom AIS EWG meeting document, 2008). The effect of these problems have been decreased by implemeting an interpolation routine that can cope with short data gaps. Future improvements are already planned by HELCOM AIS Expert Working Group to increase the level of availability of the HELCOM AIS data service.

Reliability and the future of emission estimates

The fuel consumption calculations are compared to real-world fuel consumption data from Finnish shipowners. However, a more comprehensive checks are planned to gain better understanding of the development needs of the model. Currently the model produces values that are slightly underestimated and it is likely that in reality the emission levels and fuel consumption are larger than what is described in this document. Uncertainties are downplayed in a way that produce smaller emission estimates in order to get a baseline for NOx emissions. Detailed description of uncertainties and their magnitudes are given in Stipa et al., 2007. Future enhancements include direct measurements of emissions from ships' exhaust pipes and inclusion of other pollutants (e.g. particulate matter) to enhance the accuracy of the emission model.

For reference purposes, please cite this Baltic Sea environment fact sheet as follows:

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