Baltic Sea ship emissions in 2010

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Key messages

1. **SO_x and particulate matter emissions** from Baltic Sea shipping have **decreased** by -20 % and -9.5 % to 99.5 and 25.6 kilotons. From the -20 % decrease in SO_x about one third is because of the requirement for 0.1 % S fuel use inside harbor areas.

2. Significant **increase** (+12 %) in carbon monoxide (**CO**) emissions was predicted because of a strong increase in the number of small vessels

3. **NO_x emissions have increased by +2.6 %** to 382 kt, whereas the **number of vessels has increased by +3.4 %**. The NO_x emissions already surpass those before the 2008-2009 recession. Number of vessels in the Baltic Sea was 7632 (with an IMO registry number), but the number of small vessels was 2 753. Increase of +3.4 % can be observed with the former and +48 % in the latter group.

4. **CO_2 emissions, fuel and energy consumption have all increased by 9 %** and were 19.5 Mt, 6268 kt and 268 Petajoules.

Results and assessment

In 2010 a strong increase of emissions from ship traffic was predicted because of the recovery of the economy in the Baltic Sea area. Emissions of 2010 already surpass the emission levels of shipping before recession. The number of unique large ships visiting the Baltic Sea has increased by +3.4 %, but a strong increase in the number of small vessels (+48 %) was observed. NO_x, CO and CO_2 emissions as well as the fuel and energy consumption have all increased, but the levels of SO_x and PM have decreased. Reductions can be attributed to significant policy changes, which reduce the maximum allowable sulphur content in marine fuels during voyages and harbor stays. According to the SO_x Emission Control Area requirements, the maximum level of sulphur in marine fuels was decreased to 1.0 %(w/w) starting from July 2010. In harbor areas, maximum sulphur content was decreased to 0.1 %S (w/w) as of Jan 1st 2010. Both of these changes combined have led to decrease in SO_x and PM with -20 % and -9.5 %, respectively. Without the change of sulphur content, the emissions of total PM would have increased, which can be seen in the emitted levels of elementary carbon (EC), Organic Carbon (OC) and Ash.

Table 1. Emissions from Baltic Sea shipping in 2010

Pollutant	2010	2009	Change
NO_x, kt	382.0	359.7	+2.6 %
SO_x, kt	99.5	124.3	-20.0 %

CO, kt	72.0	64.3	+12.0 %
PM*, kt	25.6	28.3	-9.5 %
of which			
Elementary Carbon, kt	*2.6*	*2.4*	*+8.3 %*
Organic Carbon, kt	*6.6*	*6.2*	*+6.5 %*
Ash, kt	*1.9*	*1.7*	*+11.7 %*
SO_4, kt	*8.1*	*10.1*	*-19 %*
Associated H_2O, kt	*6.4*	*7.9***	*-19 %*
CO_2, Mt	19.5	17.9	+9 %
Fuel, kt	6 268	5 734	+9 %
Energy use, PJ	268	245	+9 %
Vessels with IMO number	7 638	7 384	+3.4 %
Small vessels, no IMO number	2 753	1 862	+48 %

** Note, that subspecies of PM should not be added together with total PM emissions, but are alternative to each other.*
*** Note, that the value for Associated H_2O was erroneously lower (3.4 kilotons) in HELCOM Indicator Fact Sheet describing the Baltic Sea emissions from shipping in 2009.*

The decrease of PM will mitigate the detrimental health effects of shipping since most severe implications to human health arise from inhaled particulate matter close to densely populated areas. Engine operation has a large influence on PM emissions. Low engine loads will lead to larger emission factors than those inside the optimal working range of diesel engines (see Jalkanen et al, 2011). To minimize emissions, speed reduction could be used to conserve fuel and minimize emissions from ships. In multi-engine setups unnecessary engines should be switched off if they are not needed.

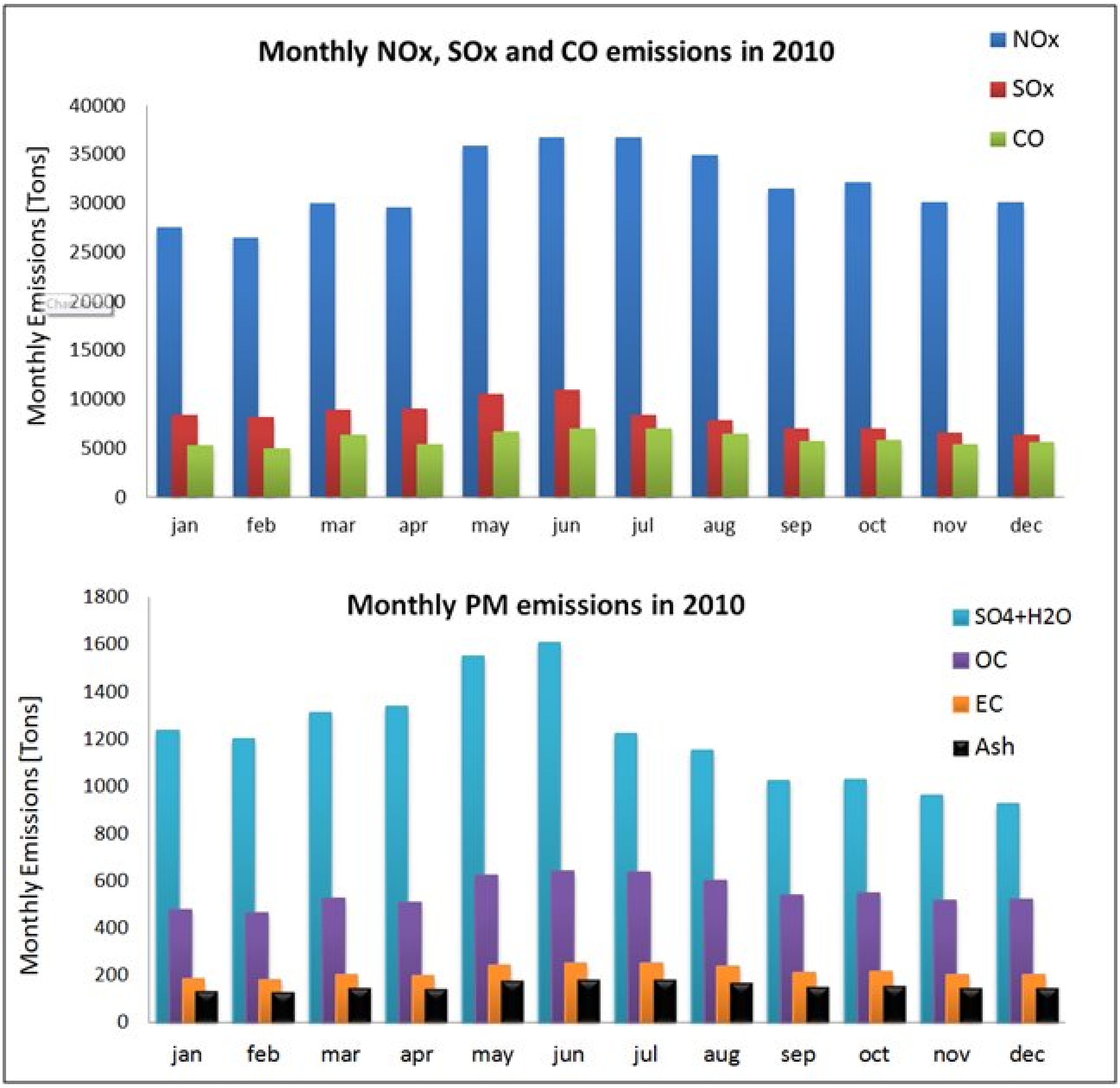

Figure 1. Monthly emissions from Baltic Sea shipping in 2010.

A significant decrease in SO_x and PM emissions is observed as of July 2010 (Figure 1). From this date forward stricter SECA regulations allowed the use of max. 1.0 %S (w/w) marine fuel. This has decreased the SO_x emissions during voyages. Reduction of fuel sulphur content to 0.1 %S (w/w) in harbor areas will have the largest impact on human health in densely populated regions close to port areas.

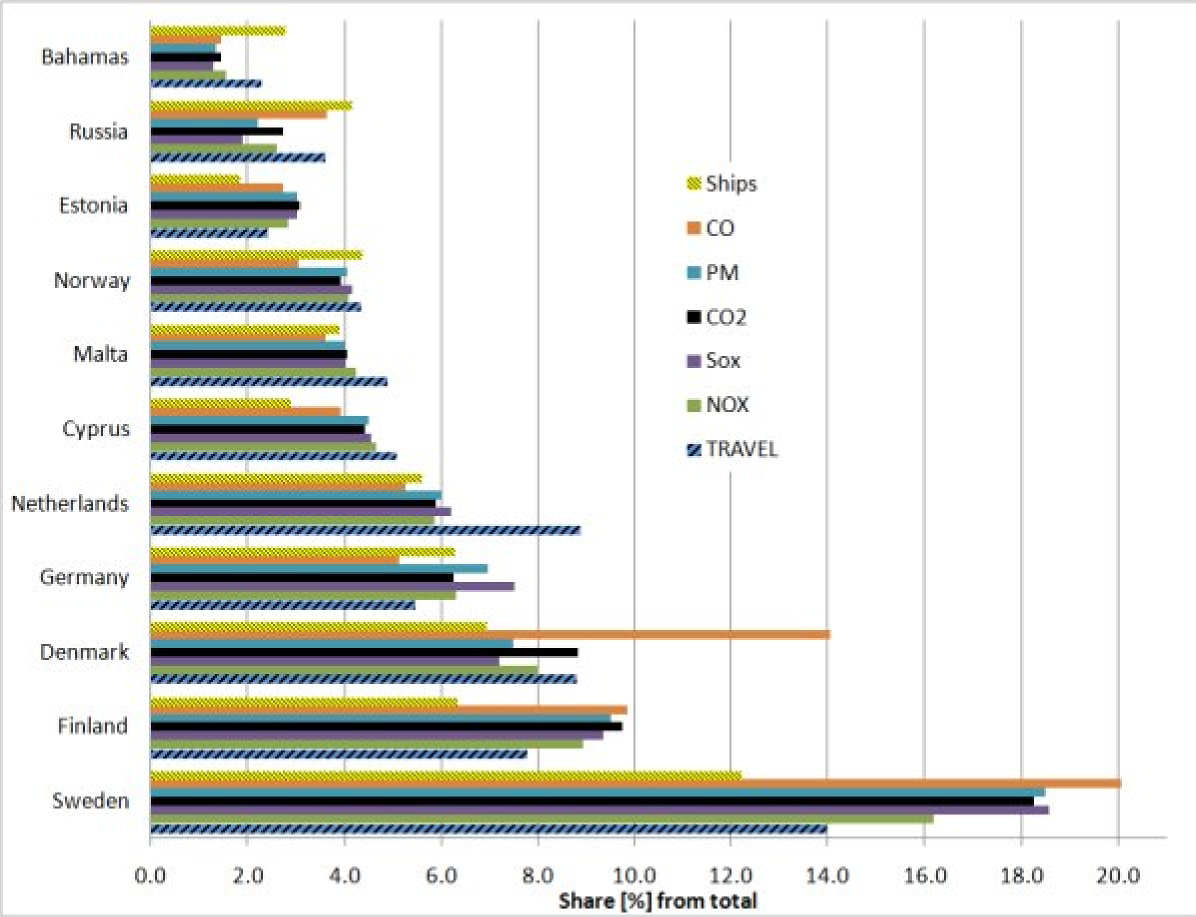

Figure 2. Share of each flag state from total emissions and vessel mileage, Baltic Sea 2010

Flag state analysis includes the vessel mileage as a share of kilometers traveled. Distance calculation allows for the determination of unit emissions based on vessel tonnage which is similar to EEOI (Energy Efficiency Operational Index) index by the IMO. The eleven largest emitting flag states are illustrated in Figure 2, which together represent 2/3 of the total emissions. Large CO emissions comes mostly from small vessels because large diesel engines do not emit significant amounts of CO during steady operation, but can do so during harbor maneuvers.

References

Jalkanen, J.-P., Brink, A., Kalli, J., Pettersson, H., Kukkonen, J. and Stipa, T., ”A modelling system for the exhaust emissions of marine traffic and its application to the Baltic Sea area”, *Atmospheric Chemistry and Physics*, **9** (2009) 9209-9223.

Jalkanen, J.-P., Johansson, L., Kukkonen, J., Brink, A., Kalli, J., and Stipa, T., ”Extension of assessment model of ship traffic exhaust emissions for particulate matter and carbon monoxide”, *Atmospheric Chemistry and Physics Discussions*, **11** (2011) 22129-22172.

Data

About 74 % of the total number of ships represents regular vessels which are equipped with a unique IMO number. Unspecified vessels are assumed to have average attributes of a small tugboat. Small boats have only a small (<5 %) contribution to emissions totals with the exception of CO (9.3 %).

Metadata

The emission estimates for the year 2010 are based on over 230 million AIS-messages sent by 10391 different ships. These were received by terrestrial AIS base stations in the Baltic Sea states and collected to regional HELCOM AIS data server. The HELCOM server contains position updates of every vessel every 5-6 minutes. Temporal coverage is slightly lower than in previous years; AIS signals were received 92 % of the time, most significant data gaps occurring during May and June 2011. In the cases of missing data, routes of each vessel were interpolated between two known points.

Fuel and vessel operational procedures can have a large impact on exhaust emissions. Emission factors for ships are in accordance with the latest literature and are believed to represent a reasonable estimate of the resulting emissions. Marine currents and sea ice will have a significant impact on emissions, but both of these effects have been neglected. Some uncertainties in predicted emission values arise from the large number of small vessels for which technical details are unavailable. These use different fuel than merchant vessels and should be treated separately in future work.

Note, that the STEAM emission model has been updated to reflect best available knowledge and is not directly comparable to the results from 2006-2007. The results of this Indicator Fact sheet are comparable to HELCOM IFS 2009, however.

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

[Author's name(s)], [Year]. [Baltic Sea environment fact sheet title]. HELCOM Baltic Sea Environment Fact Sheets. Online. [Date Viewed], http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/.