Emissions from Baltic Sea shipping in 2013

Authors: Jukka-Pekka Jalkanen, Lasse Johansson
Finnish Meteorological Institute, Atmospheric Composition Research, P.O Box 503, FI-00101 Helsinki, Finland

Key message

1. Total emissions from all vessels in the Baltic Sea in 2013 were 323 kt of NO_x, 80 kt of SO_x, 16 kt of PM, 35 kt of CO and 15.3 Mt of CO_2. The CO_2 amount corresponds to 4862 kilotons of fuel and 209 PJ of energy used. **The emissions of all pollutants have decreased when compared to year 2012, except CO, for which an increase of +1.3% was observed**. **The emissions of inland waterway traffic have been excluded from this report.**
2. **Emissions, ship numbers and fuel consumption from IMO registered, large vessels showed slight change with respect to 2012.** (NO_x: 306 kt, -1.5 %, SO_x: 76 kt -0.7%, $PM_{2.5}$: 15.1, -0.5%, CO: 33 kt, +1.3%, CO_2: 14.3 Mt, -0.7 %, fuel consumption: 4523 kt, -0.7 %). Total number of IMO-registered ships was 7883 (0 %) which is very close to 2012 number (7885).
3. Activities from non-IMO registered traffic (presumably small boats) increased significantly with respect to 2012. The number of small boats was 7465, increase of +27.2% from 2012. Thus, **small vessels constitute more than half (54.6%) of the number of AIS transceivers in the Baltic Sea area**. The amount of small vessels, and their contribution to emissions, has been steadily increasing from 2006. In 2012, the overall contributions of small vessels to emissions are as follows NO_x: 5.2%, SO_x: 4.6 %, CO: 9.3 %, PM: 6.2% and CO_2: 6.0 %. The addition of AIS transceivers to small boats will increase the fraction of pleasure craft traffic included in emission calculations. The annual increase of small vessels included in AIS data will inevitably also increase the total emissions from the Baltic Sea shipping.
4. **Overall transport work (DWT*km) has increased by +1.8% while the number of large vessels has remained nearly constant at the same time**. The transport work of containership segment remained almost constant (+0.3 %, change of -0.5% in vessel numbers). Tankers increased their transport work (+2.0 %, change of -0.5% in vessels numbers) while passenger ships showed a decrease of -2.8% in transport work. Other cargo transport work (bulk, unitized, vehicles) increased +3.8%.

Results and assessment

The emissions of particulate matter and sulphur from Baltic Sea shipping have decreased gradually since 2006 because of the tightening SO_x emission regulations of the MARPOL Convention in the Baltic Sea SECA area. Also EU sulphur directive requirements, which limit the fuel sulphur to 0.1% during harbor stays, contributed to this result. Only slight changes in PM and SO_x emissions between 2012 and 2013 were observed. The geographical distribution of CO_2 emissions in 2013 is illustrated in **Figure 1**.

Figure 1. The geographical distribution of CO_2 emissions from Baltic Sea shipping in 2013. Emissions are reported in kilograms per grid cell.

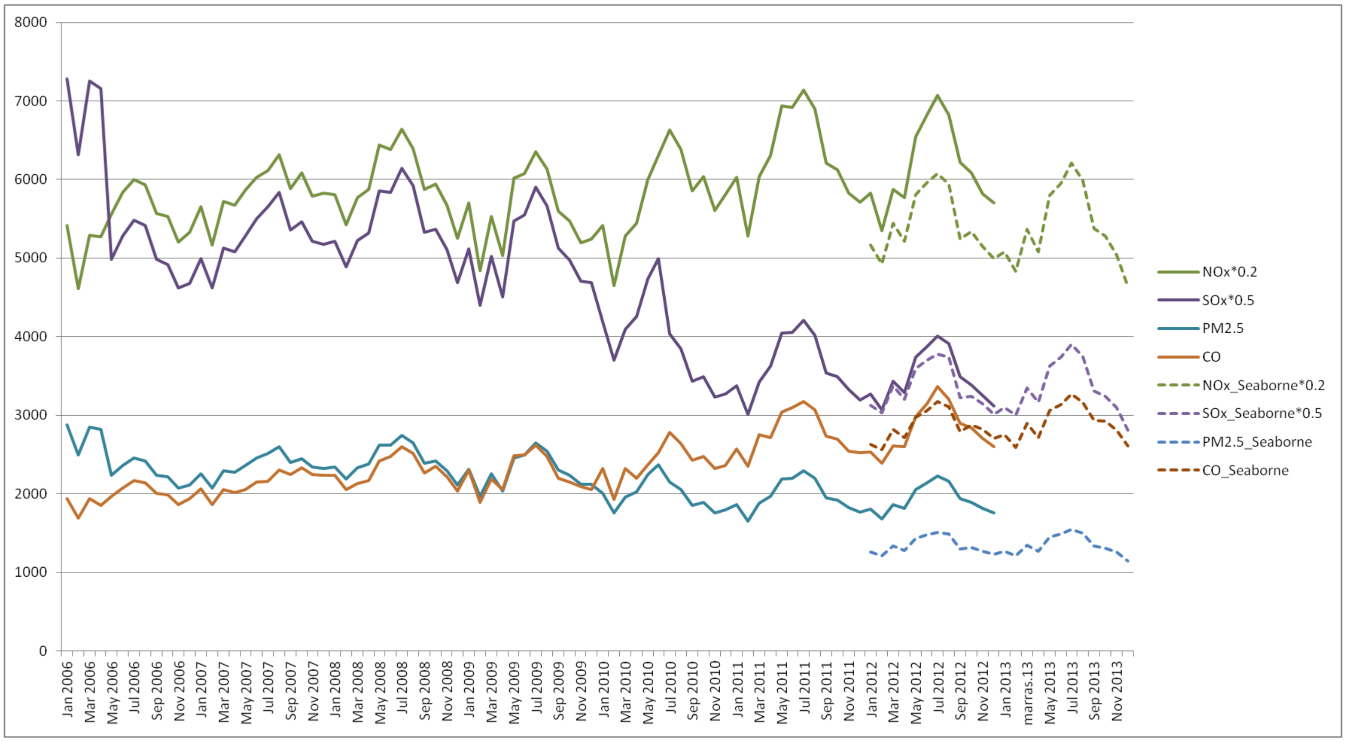

Figure 2. Seasonal variation of ship emissions in the Baltic Sea during the period 2006-2013. Solid lines represent all traffic reported in AIS data, broken lines indicate the emissions from Baltic Sea shipping without the contribution from inland shipping. Note, that PM emissions do not contain the associated water, which was previously reported as part of PM.

Figure 2 illustrates the seasonal variation of ship emissions in the Baltic Sea area during the period 2006-2013. SOx and PM emissions have decreased during this time, but the emissions of CO have increased. The broken lines indicate the contribution of Baltic Sea shipping without the contribution from inland shipping (which is also represented in HELCOM AIS data). The emissions of PM are reported as dry PM mass without the associated water, which can be seen as reduced PM emissions in **Figure 2**.

The emissions from IMO-registered traffic has remained almost at 2012 levels; slight decreases (less than 1.5%) in NO_x, SO_x, PM and CO_2 were observed whereas CO emissions have increased by +1.3%. A significant increase in the number of small vessels (2012: 7465; 2013: 9497, +27%) was observed. However, the contribution of small vessels to SO_x and PM are small, 4-5% and 6% of the total CO emitted comes from small boats. The number of vessels with an IMO number has remained fairly constant (-2 ships) between 2012 and 2013. The summary of results is collected to

Table **1**. The increase of emissions from small vessels is significant (+10 %), whereas the most emissions from large ships have decreased. The overall net effect concerning CO_2 emissions is close to zero.

Table 1. Summary of key results from Baltic Sea shipping in 2012-2013.

		NOx [t]	SOx [t]	PM2.5 [t]	CO [t]	CO2 [t]	Transport work 10^6 ton*km	Ships
2013	**All ships**	323 200	80 200	16 100	34 900	15 343 000	910 000	17 380
	IMO-registered	306 300	76 500	15 100	32 800	14 271 000	910 000	7 883
	non-IMO-registered	16 900	3 700	1 000	2 100	1 100 000		9 497
2012	**All ships**	326 300	80 300	16 100	34 300	15 340 000	894 000	15 350
	IMO-registered	311 000	77 000	15 200	32 400	14 370 000	894 000	7885
	non-IMO-registered	15 400	3 400	900	1 900	971 000		7 465
Changes, %	**All ships**	-1.0	-0.2	+0.1	+1.8	0.0	+1.8	+13.2
	IMO-registered	-1.5	-0.6	-0.6	+1.3	-0.7	+1.8	0.0
	non-IMO-registered	+10.2	+10.1	+11.1	+10.3	+10.5		+27.2

ǂ *Transport work of vessels (DWT*km) with an IMO number. Small vessels are not included. The transport work estimate is based on the methodology described in the second IMO GHG study (IMO, 2009).*

The number of small vessels has increased strongly during the study period. In 2006, about 15% of the AIS transmitters were installed in vessels which did not have an IMO number. Today, the share of small vessels is more than 54% of the total number of vessels and it is expected to increase further if AIS installations in small vessels continue at present rate. This emphasizes the need to differentiate the emissions contribution of small vessels from that of the large ships. It is probable that analysis of emission results of large vessels better reflect the economic development of the region as well as the impact of policy changes regarding marine fuel oil quality.

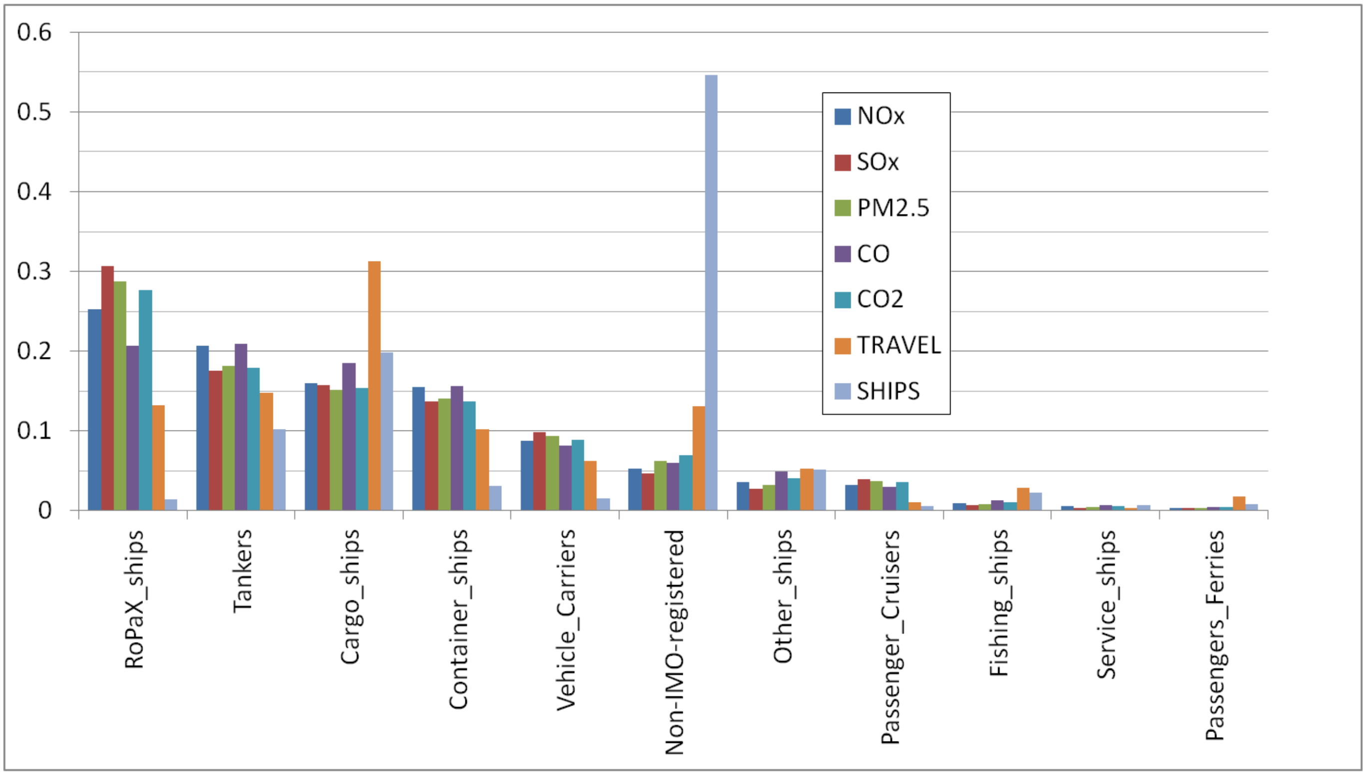

Figure 3. Share of emissions from Baltic Sea total, classified by ship type. Note, passenger ferry class describes small vessels carrying both vehicles and passengers on short (domestic) routes.

The containership cargo transport work (145 000 million ton km) in 2013 has remained close to 2012 value (change -0.4%). The transport work of tankers and other cargo (not vehicles) has increased by +2.0% and +3.8%, respectively. **Figure 3** illustrates the relative contribution of various ship classes to total emissions. The share of non-IMO registered vessels (over 54%) is clearly visible. The distance traveled by vessels in various ship categories is also included, because it facilitates the comparison of unit emissions. The distance traveled by vessels of each type was determined from AIS position reports and the amount of cargo carried was determined according to the methodology described in the 2nd IMO GHG study (IMO, 2009).

Table 2 lists the contribution of various fleets, sorted by flag state. The three Nordic fleets, Swedish, Finnish and the Danish, produce the highest NO_x emissions.

Table 2. Modelled shipping statistics from 2013 AIS-data. The column reporting the number of ships indicates the number of ships, which include both small and large vessels. The top 20 fleets represent 86% of total NO_x emitted by ships.

Baltic - 2012		NO_x [t]	SO_x [t]	$PM_{2.5}$ [t]	CO [t]	CO_2 [t]	Transport work [10^6 ton*km]	Ships
All		323 200	80 200	16 100	34 900	15 343 000	910 000	17 380
	IMO registered	306 300	76 500	15 100	32 800	14 271 000	910 000	7 883
	vessels without IMO	16 900	3 700	1 000	2 100	1 100 000		9 497
Top flags	**Sweden**	35 700	11 300	2 300	3 600	2 182 600	35 500	3 370
	Finland	34 100	9 900	1 900	3 600	1 779 300	49 900	854
	Denmark	23 100	5 300	1 200	2 800	1 162 600	32 400	1 612
	Liberia	20 000	4 100	900	2 100	781 900	105 800	512
	Germany	19 100	4 800	900	1 800	893 700	26 700	2 250
	Netherlands	18 200	4 900	900	2 300	904 000	54 100	1 100
	Malta	17 100	3 800	800	1 800	726 600	66 900	484
	Bahamas	16 600	3 600	700	1 400	677 900	30 800	335
	Cyprus	16 400	3 900	800	1 900	736 200	59 900	321
	Antigua_and_Barbuda	12 500	3 200	600	1 500	588 700	40 600	572
	United_Kingdom	11 300	2 600	500	1 200	491 300	42 300	422
	Norway	10 600	2 500	500	900	467 100	26 300	609
	Russia	8 500	1 700	400	1 100	426 500	12 400	1 096
	Marshall_Islands	8 100	1 700	300	900	315 400	53 700	352
	Gibraltar	7 200	1 700	300	900	317 700	22 800	180
	Greece	6 100	1 200	200	700	219 400	55 900	116
	Italy	4 500	1 200	200	500	203 500	12 900	88
	Hong_Kong	3 900	800	200	400	155 200	24 900	176
	Bermuda	2 300	600	100	200	97 000	4 800	34
	Samoa	1 900	400	100	200	73 500	6 200	57
Ship types	**RoPax ships**	81 400	24 600	4 600	7 200	4 240 600	35 200	252
	Tankers	67 000	14 000	2 900	7 300	2 744 500	398 300	1 768
	Cargo ships	51 700	12 600	2 400	6 500	2 351 700	272 400	3 446
	Containerships	50 100	10 900	2 300	5 500	2 098 900	144 800	533
	Vehicle Carriers	28 300	7 900	1 500	2 800	1 364 000	59 500	255
	Non-IMO-registered	16 900	3 700	1 000	2 100	1 072 900	0[a]	9 497
	Other ships	11 600	2 200	500	1 700	615 400	0[a]	892
	Passenger Cruisers	10 500	3 200	600	1 000	545 600	0[a]	95
	Fishing ships	2 900	500	100	400	160 100	0[a]	385
	Service ships	1 800	200	100	200	91 000	0[a]	127
	Passengers Ferries	1 100	200	0	200	58 800	0[a]	130

[a] Incomplete technical data prohibits transport work calculation

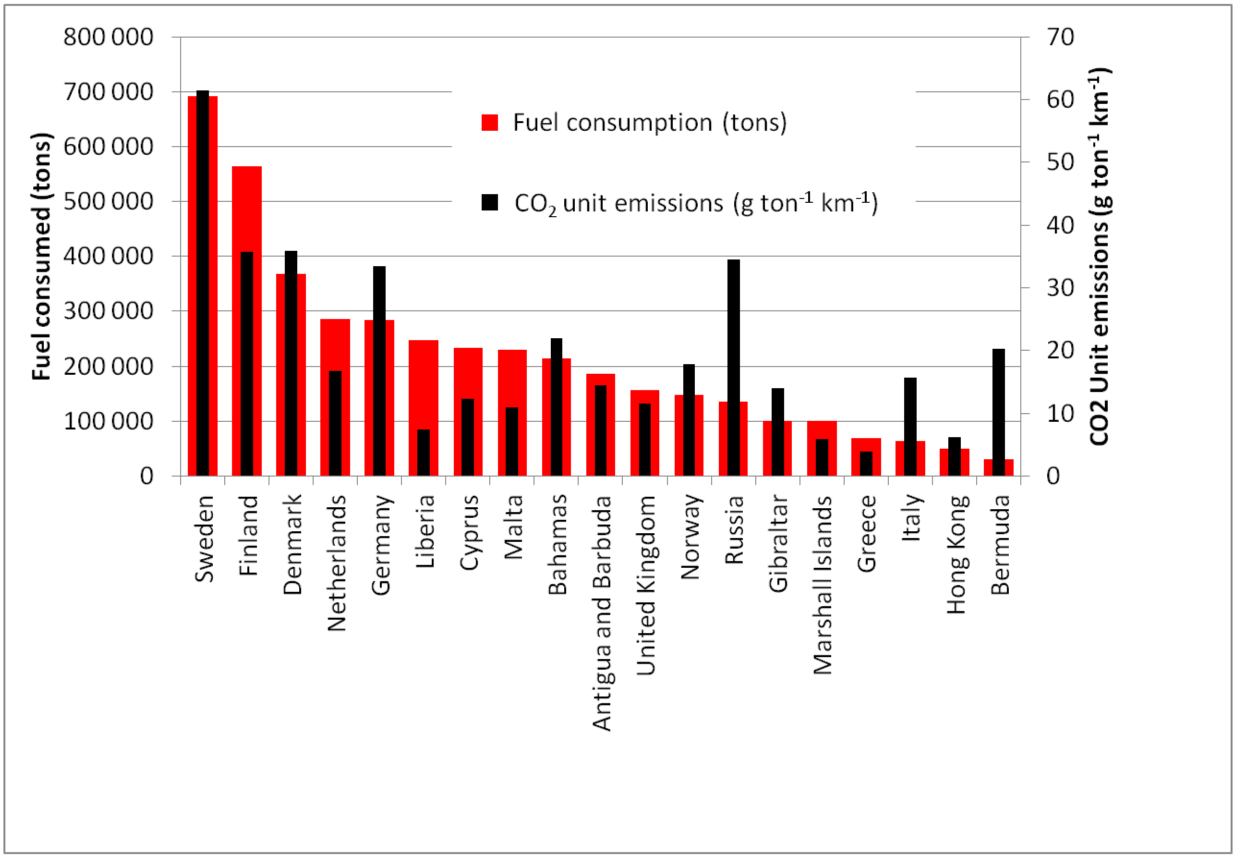

Figure 4. Unit emissions of CO_2 (in g ton^{-1} km^{-1}) and total fuel consumption according to flag state in 2013. The transport work has been calculated as described in the 2nd IMO GHG study (IMO, 2009).

Unit emissions and total fuel consumption were calculated for each flag state (see **Figure 4**). Cargo oriented fleets (Liberia, Hong Kong, Greece, Marshall Islands) have lowest unit emissions. It should be noted, that passenger carrying capacity has no effect on the unit emission calculation, because only DWT of vessels is considered. The net weight of the cargo transport onboard was evaluated with a method described in the 2nd IMO GHG study (IMO, 2009).

References

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Data

The emission estimates for the year 2013 are based on over 780 million AIS-messages sent by 17380 different ships, of which 7883 had an IMO registry number indicating commercial marine traffic. The AIS position reports were received by terrestrial base stations in the Baltic Sea countries and collected to regional HELCOM AIS data server. The HELCOM server contains position updates for each vessel every 5-6 minutes. Emissions are generated using the Ship Traffic Emission Assessment Model (STEAM) of Jalkanen et al. (2009, 2012) and further described in Johansson et al. (2013). Temporal coverage of the data was slightly lower than previously in 2012; AIS signals were received 98.7% of the time, without any significant data gaps. In the limited number of cases with missing data, routes of each vessel were interpolated between two known locations.

Metadata

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 can have a significant impact on emissions, but both of these effects have been neglected. Some uncertainty in predicted emissions arises from the large number of small vessels for which technical details are unavailable.

For the first time, this factsheet contains emissions from Baltic Sea shipping without a contribution from inland waterways. This has reduced the reported vessel numbers and emissions, in contrast with the previous HELCOM ship emission factsheets. Minor changes were made to emission factors and Tier 0 engines have been assigned 10% higher NO_x emission factor than previously. Particulate matter emissions are reported as dry mass and do not include associated water. The installed auxiliary engine power for vessels which lack this data has been modified to use a closest match in ship database instead of average values which were previously used to fill in missing specifications.

In cases of incomplete temporal coverage of AIS data, the values given in this Indicator Fact Sheet have been scaled to reach 100% coverage.

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

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