Document title	Emissions from Baltic Sea shipping in 2014
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Background

The emission estimates for the year 2014 are based on over 1.54 billion AIS-messages sent by 21283 different ships, of which 8510 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 4-6 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).

For 2014 the temporal coverage was close to 100% without any significant data gaps. For the first time, this factsheet contains emissions from Baltic Sea shipping as well as the contribution from inland waterways (region 'Other') separately. Particulate matter emissions are reported as dry mass and do not include associated water.

Emissions from Baltic Sea Shipping in 2014

Total emissions from all vessels in the Baltic Sea in 2014 were 320 kt of NO_x, 81 kt of SO_x, 16 kt of PM, 34 kt of CO and 15.0 Mt of CO_2. The CO_2 amount corresponds to 4750 kilotons of fuel, of which 22% was associated to auxiliary engines. The fuel consumption of inland waterway traffic sending AIS-messages was only 51 kilotons.

The most significant contribution to emissions can be associated with ropax vessels, tankers, cargo ships and container ships. In terms of fuel consumption, the respective shares for these vessel types in the presented order are 1370, 920, 760 and 690 kt of fuel consumed.

The emissions of all pollutants except CO have decreased 2.2% to 2.8% when compared to year 2013. For CO a slight increase was observed due to the increasing number of small vessels visible in the AIS-data. In 2014, small vessels constitute 60% of the number of AIS transceivers in the Baltic Sea area. However, the contribution of these small vessels to the total emissions has remained small in comparison to IMO-registered traffic.

Overall transport work (vessel type dependent fraction of DWT*km) has increased by 2.2% while the total travelling distance of IMO-registered vessels have decreased 1.2%. The transport work of containership segment increased by +5.5% and cargo ships respectively by 7.3%. For RoPaX vessels a decrease of 5.4% was observed. The simultaneous increase of transport work and the decrease in travel amount indicates an increase in vessel transport capacity on average.

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. However, **during 2011 – 2014 when no additional requirements were imposed, SOx and PM2.5 emissions from IMO-registered traffic have decreased by 8.4% and 7.6% respectively.**

During this period the number if IMO-registered vessels has decreased by 3.5% and the total travel amount decreased by 4.5%.

More detailed information can be found in the attached report of the Finnish Meteorological Institute.

Action required

The MARITIME 15 meeting is invited to take note of the information.

Emissions from Baltic Sea shipping in 2014

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Key ***Messages***

1. **Total emissions from all vessels in the Baltic Sea in 2014 were 320 kt of NO_x, 81 kt of SO_x, 16 kt of PM, 34 kt of CO and 15.0 Mt of CO_2.** The CO_2 amount corresponds to 4750 kilotons of fuel, of which 22% was associated to auxiliary engines. The fuel consumption of inland waterway traffic sending AIS-messages was only 51 kilotons.

2. **The most significant contribution to emissions can be associated with RoPaX vessels, tankers, cargo ships and container ships.** In terms of fuel consumption, the respective shares for these vessel types in the presented order are 1370, 920, 760 and 690 kt of fuel consumed.

3. **The emissions of all pollutants except CO have decreased 2.2% to 2.8% when compared to year 2013. For CO a slight increase was observed due to the increasing number of small vessels visible in the AIS-data**. In 2014, small vessels constitute 60% of the number of AIS transceivers in the Baltic Sea area. However, the contribution of these small vessels to emission totals has remained small in comparison to IMO-registered traffic.

4. **Overall transport work (vessel type dependent fraction of DWT*km) has increased by 2.2% while the total travelling distance of IMO-registered vessels have decreased 1.2%**. The transport work of containership segment increased by +5.5% and cargo ships respectively by 7.3%. For RoPaX vessels a decrease of 5.4% was observed. The simultaneous increase of transport work and the decrease in travel amount indicates an increase in vessel transport capacity in average.

5. 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. However, **during 2011 – 2014 when no additional requirements were imposed, SOx and PM2.5 emissions from IMO-registered traffic have decreased by 8.4% and 7.6% respectively.** During this period the amount if IMO-registered vessels has decreased by 3.5% and the total travel amount decreased by 4.5%.

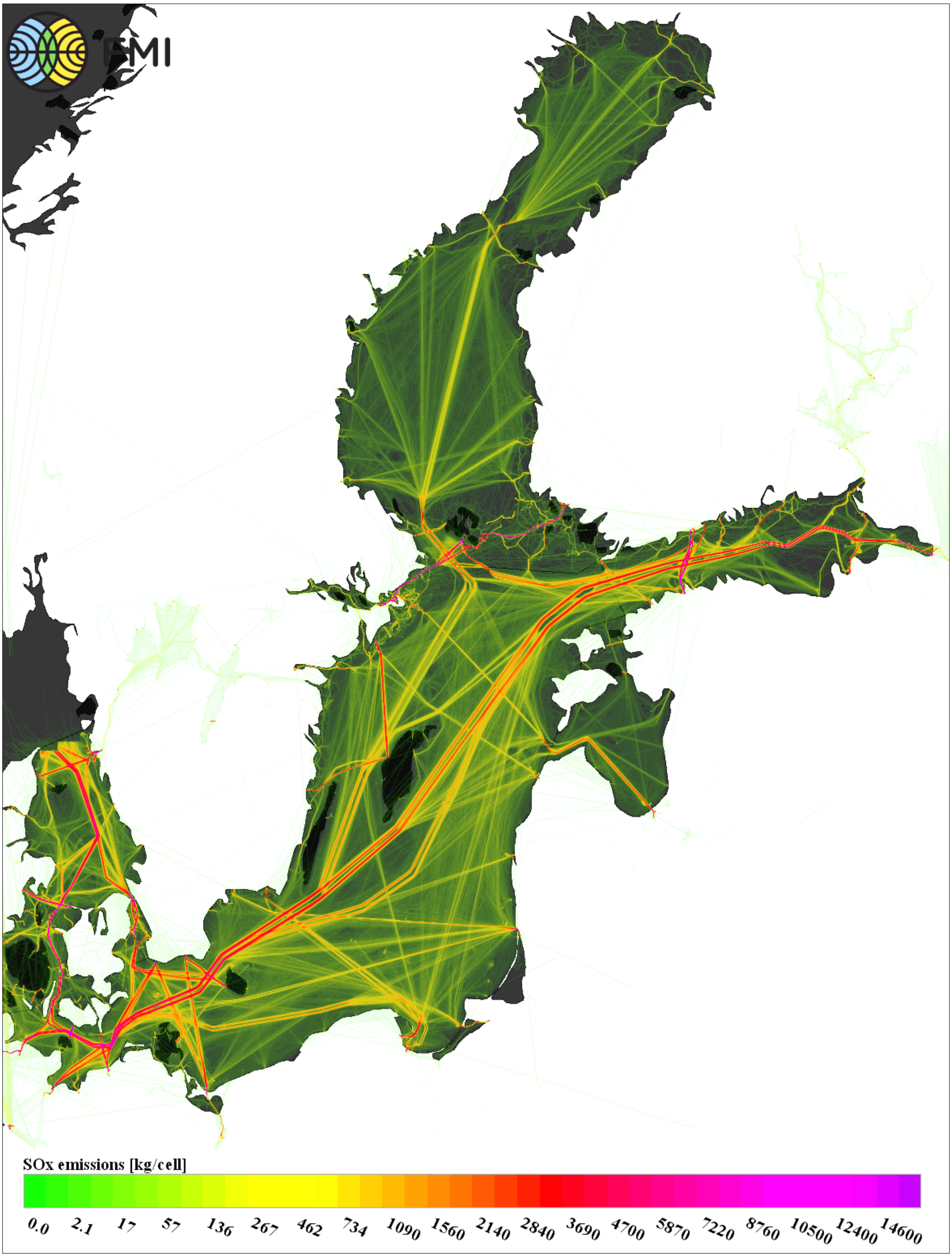

Figure 1: The geographical distribution of SO_x emissions from Baltic Sea shipping in 2014. Emissions are reported in kilograms per grid cell.

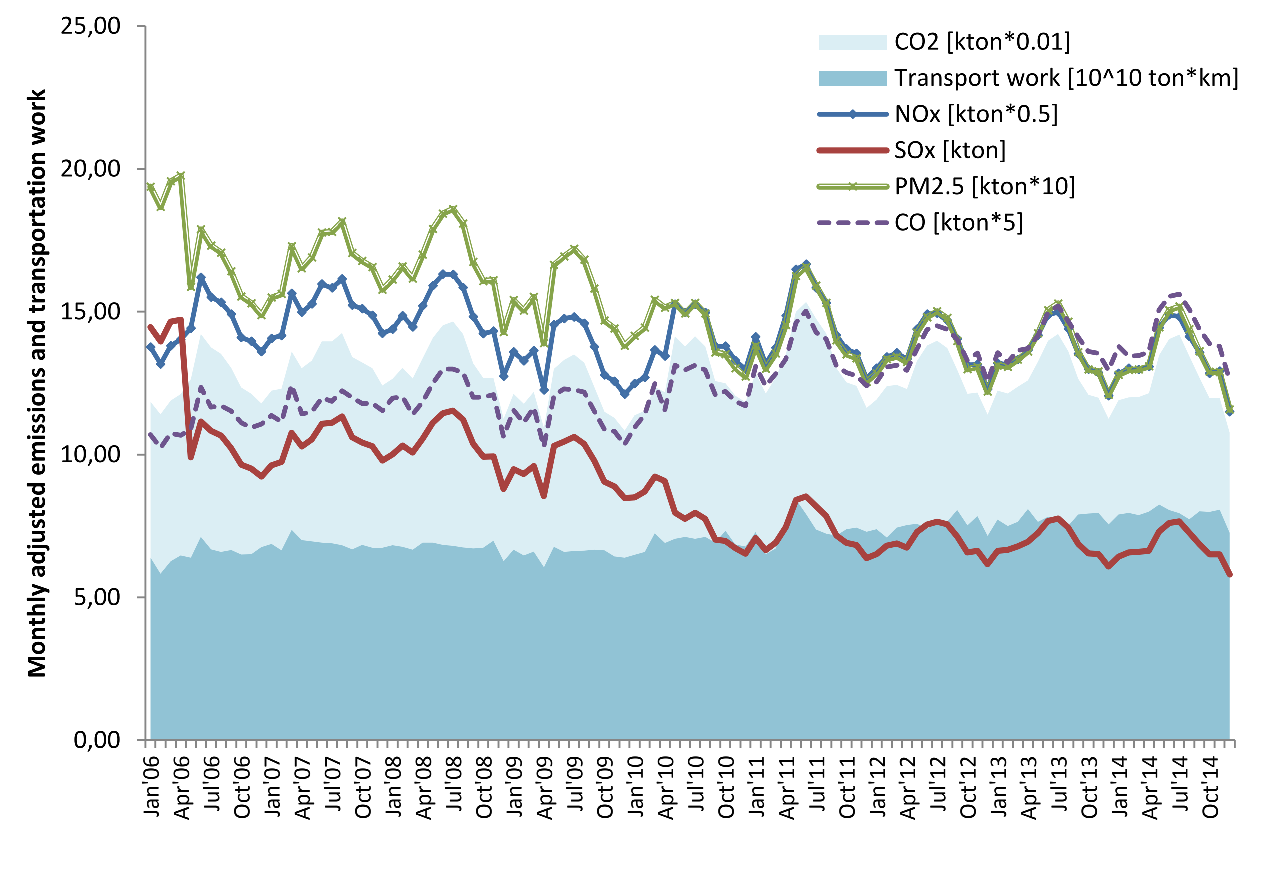

Figure 2: Seasonal variation of ship emissions in the Baltic Sea during the period 2006-2014. CO2 and transportation work is shown as area plots. All monthly values have been AIS-coverage corrected and normalized according to the total amount of days in the month. Note, that PM emissions do not contain 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 2006-2014. SOx and PM emissions have decreased significantly during this time, while the emissions of CO have increased. Overall transport work across the Baltic has experienced a steady yet small growth during 2010 – 2014.

The summary of results for 2014 has been collected to Table 1a-b. In Table 1a, the estimated annual total emissions are shown for different parts of the Baltic Sea and by vessel type. Most of the emissions are produced in the main body of the Baltic Sea although the much smaller areas of Kattegat and the Gulf of Finland constitute a fair share of the total emissions. In Table 1b, the fuel consumption statistics, travel amounts, transportation work and the number of ships is shown. The total number of ships is 21 434 in 2014, of which 60% are small and unidentified vessels that are not IMO-registered.

Table 1a-b: Summary of key results from Baltic Sea shipping in 2014.

Baltic - 2014		NOx [ton]	SOx [ton]	PM2.5 [ton]	CO [ton]	CO2 [kton]
All		322 529	81 845	16 210	34 092	15 088
	IMO	308 839	79 620	15 489	32 435	14 243
Baltic Sea	**Baltic Sea**	184 609	48 021	9 309	18 971	8 529
	Kattegat	60 230	13 949	2 861	6 372	2 705
	Gulf of Fin.	47 544	10 902	2 295	5 191	2 206
	Gulf of Both.	22 440	6 910	1 343	2 563	1 267
	Gulf of Riga	4 613	975	212	550	218
Other		3 094	1 087	189	446	162
RoPaX_ships		82 274	25 690	4 773	7 095	4 300
Passenger_Cruisers		9 530	2 942	556	938	500
Passengers_Ferries		1 079	301	56	204	61
Service_ships		1 027	171	45	141	53
Cargo_ships		53 576	13 549	2 569	6 883	2 395
Container_ships		52 396	11 891	2 400	5 634	2 170
Tankers		71 128	15 146	3 123	7 180	2 889
Other_ships		7 481	1 513	364	1 228	405
Fishing_ships		1 965	413	90	290	108
Vehicle_Carriers		28 383	8 003	1 514	2 842	1 363
Unknown_ships		13 691	2 224	721	1 657	845

Baltic - 2014		Main F. [kton]	Aux F. [kton]	TRAVEL [tkm]	Transport w.[1] [10^6 ton km]	Ships
All		3 716	1 067	141 156	951 462	21 434
	IMO	3 658	860	119 043	951 462	8 570
Baltic Sea	**Baltic Sea**	2 212	494	81 071	562 118	-
	Kattegat	622	235	26 970	188 526	-
	Gulf of Finland	504	195	15 417	135 002	-
	Gulf of Bothnia	314	88	12 879	48 293	-
	Gulf of Riga	42	26	2 674	12 444	-
Other		22	29	2 145	5 080	-
RoPaX_ships		1 203	163	17 523	33 680	242
Passenger_Cruisers		126	32	1 433	0[2]	103
Passengers_Ferries		13	6	2 300	0[2]	144
Service_ships		6	11	430	0[2]	106
Cargo_ships		629	131	43 664	299 640	3 786
Container_ships		517	171	13 760	158 362	869
Tankers		687	228	20 603	398 695	1 737
Other_ships		72	55	6 986	0[2]	910
Fishing_ships		15	19	3 983	0[2]	388
Vehicle_Carriers		390	42	8 362	61 086	286
Unknown_ships		58	208	22 113	0	12 864

[1] 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).
[2] Incomplete technical data prohibits transport work calculation

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. It should be noted that average travel distance of such small and unidentified ship is only 1700 km annually and these vessels typically spend their time berthing in harbour areas according to the AIS-data. The contribution of small vessels sending AIS-data to emissions is more likely to be overestimated than underestimated (they have been assumed to be 500 GT ships with a 1000kW main engine).

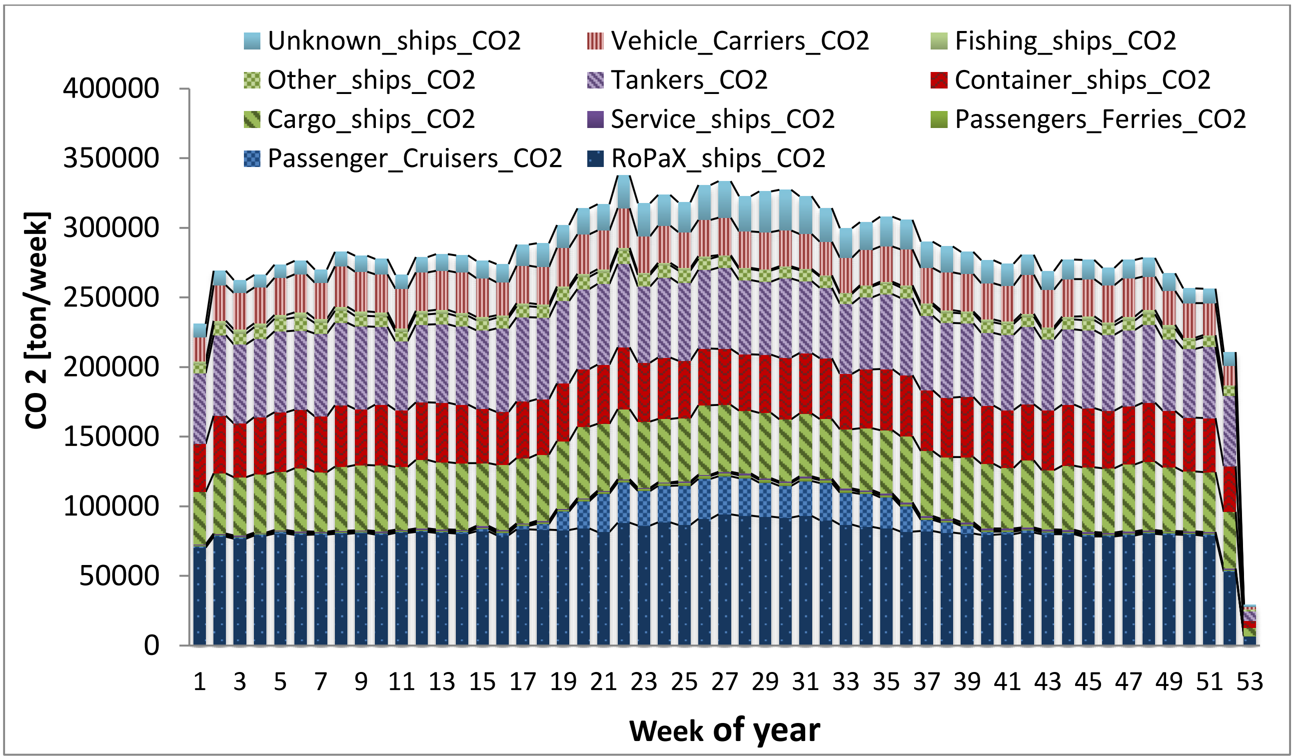

Figure 3: CO2 weekly emissions for classified by ship category. Vehicle carriers include RoRo vessels. Category 'Other' includes tugs, dredgers, barges, S&R, ice breakers and law enforcement vessels.

Unidentified small vessels tend to be the most active during the summer months (Figure 3). The contribution of RoPaX vessels, tankers, cargo ships and container ships remains steady throughout the year. The most significant seasonal variation can be observed with passenger cruisers, which operate almost exclusively during summer.

In Figure 4 the share of emissions are shown for different size categories. It can be seen from the figure that medium sized vessels (10 000GT – 30 0000GT) contribute almost 40% to the total amount of emissions.

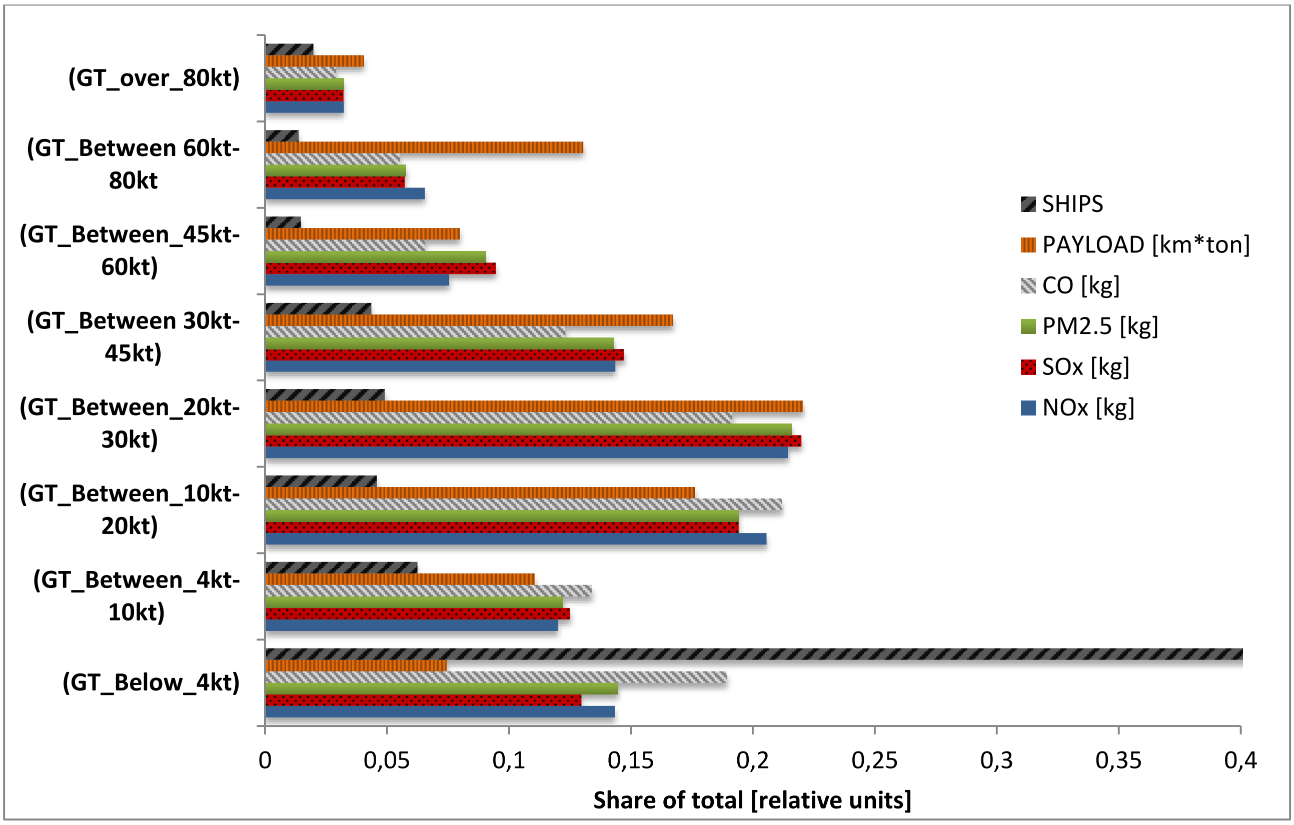

Figure 4: Share of emissions, transport work (payload) and the number of ships from Baltic Sea total in 2014, classified by ship size category (Gross tonnage, GT).

In Figure 5 the share of emissions are shown for the top 16 flag sates (based on CO2 output). It can be seen from the figure that vessels under the flag of Finland contribute the most of all the flag states in 2014. During the previous study years 2006 - 2013 Sweden has been the largest contributor and Finland has been the second largest. Interestingly, in 2006 United Kingdom was the 3rd largest contributor and Norway was the 5th largest (CO2, SOx, NOx) but in 2014 their relative contribution has decreased significantly.

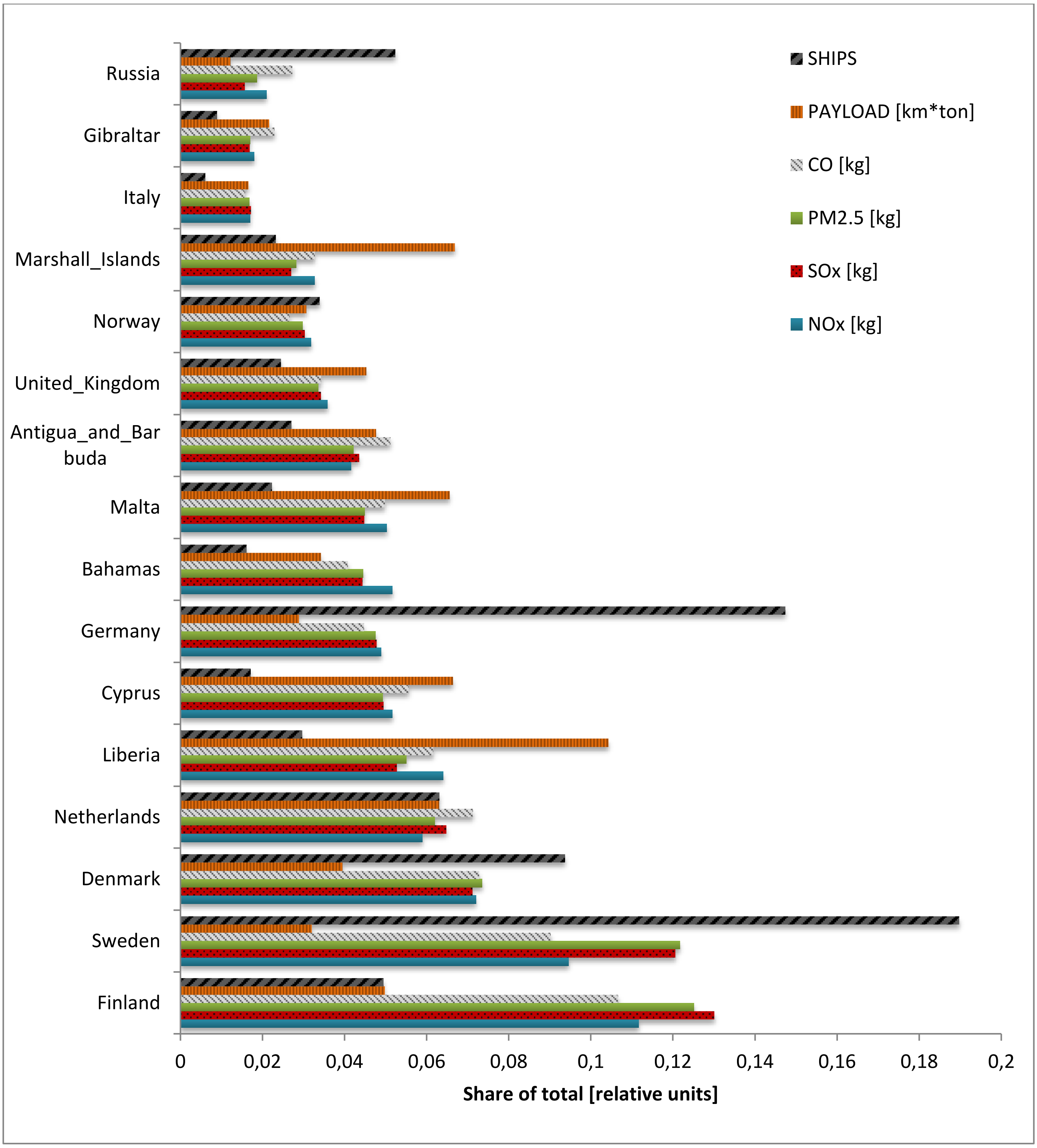

Figure 5: Share of emissions, transport work (payload) and the number of ships of the Baltic Sea total in 2014, classified by flag state.

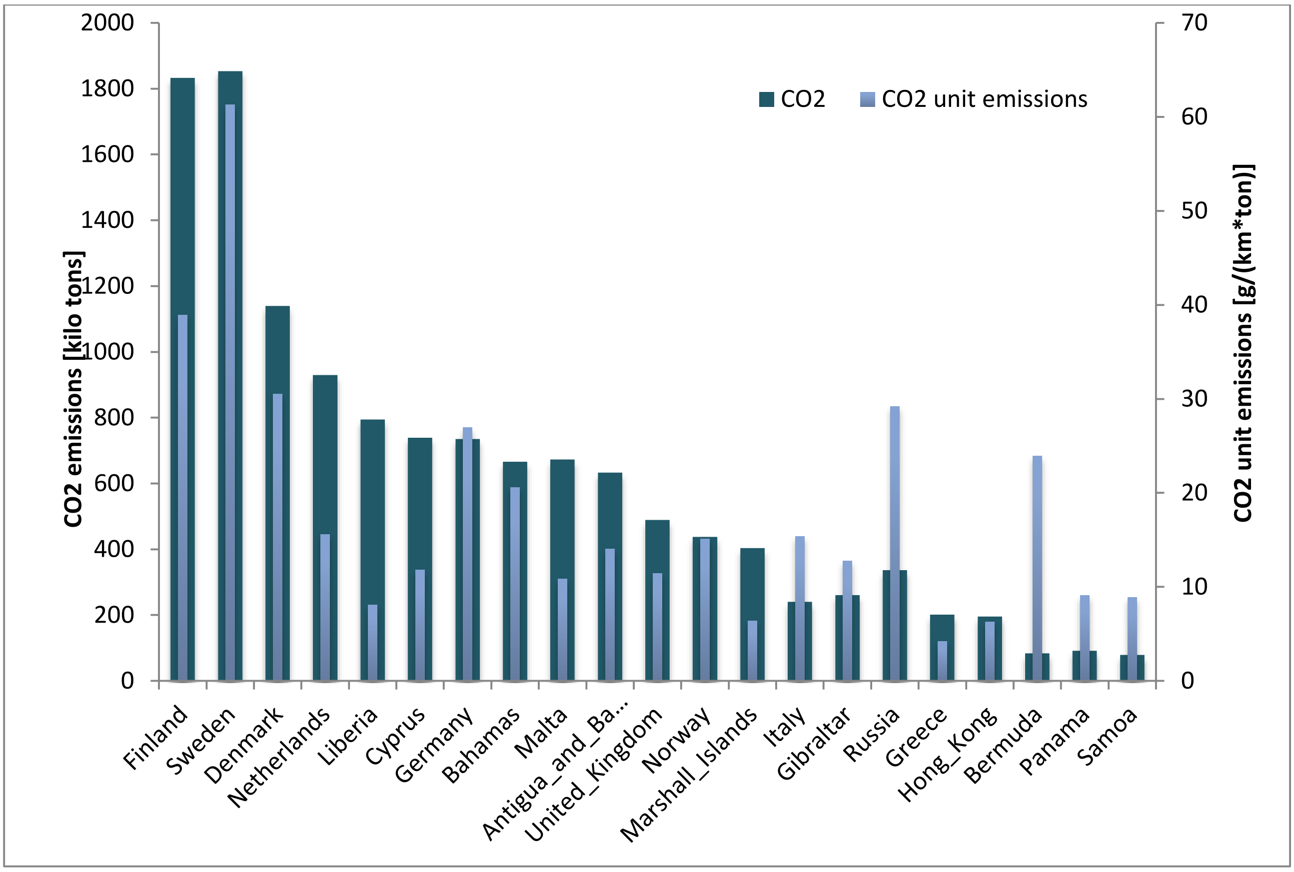

Figure 6: Unit emissions of CO_2 (in g ton^{-1} km^{-1}) and total fuel consumption according to flag state in 2013. The transport work has been calculated as described in the 2nd IMO GHG study (IMO, 2009).

Unit emissions and total fuel consumption were calculated for each flag state (see Figure 6). 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 2014 are based on over 1.54 billion AIS-messages sent by 21283 different ships, of which 8510 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 4-6 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).

For 2014 the temporal coverage was close to 100% without any significant data gaps. Most of the messages originate from South-Western region of the Baltic Sea near the Danish and southern Swedish sea areas (Figure 7). For individual vessels however, data gaps occur regularly but the route segmentation logic of the STEAM model (Johansson et al., 2013) interpolates vessel activities (including berthing activities) between two consecutive AIS-messages in such cases.

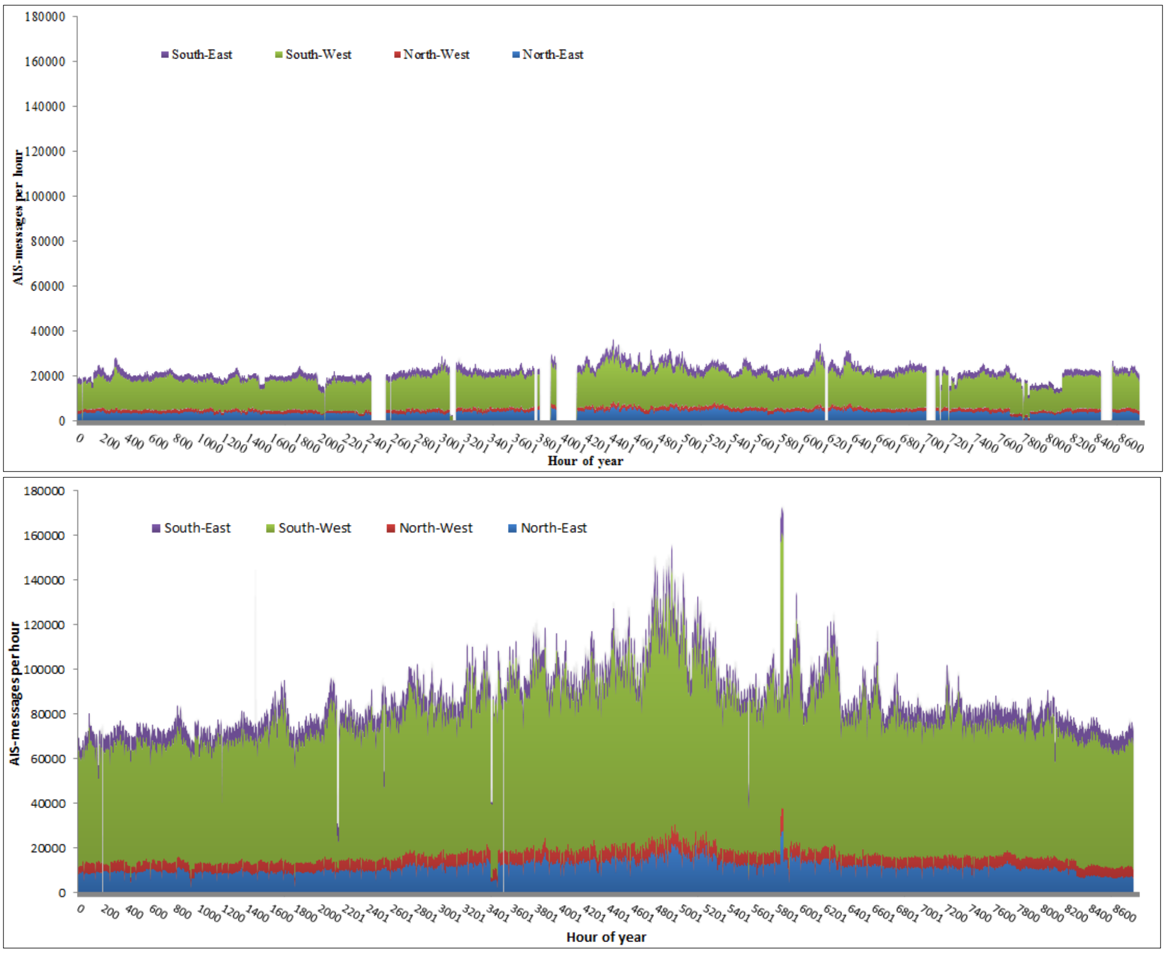

Figure 7a-b: AIS-data hourly coverage in different parts of the modelling region for 2006 (upper) and 2014 (lower).

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, fouling and sea ice can have a significant impact on emissions, but these effects have not been accounted in this study.

Some uncertainty in predicted emissions arises from the large number of small vessels for which technical details are unavailable. However, the internet contains some basic vessel characteristics even for such small and unknown ships[3] and by using an automated vessel characteristics extraction routine, it has been verified that the group of unknown ships are in fact small vessels and as such do not cause significant margins of error for the modelled annual emission totals.

Especially for the years of 2006 and 2010 the temporal coverage of AIS-data was observed to be the lowest and may cause slight estimation errors for the annual total emissions. 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 the first time, this factsheet contains emissions from Baltic Sea shipping as well as the contribution from inland waterways (region ‘Other’) separately. Particulate matter emissions are reported as dry mass and do not include associated water.

The most notable modelling revisions have been applied to auxiliary fuel consumption modelling. Significant improvements have been made, but auxiliary fuel consumption modelling will be revisited further in the next model version and will be tied more carefully to vessel type and operation modes. 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. With the current model version the modelled auxiliary fuel consumption has decreased significantly with respect to older model estimates. The main reason for this is that FMI-STEAM now calculates the berthing time dynamically and limits the estimated auxiliary engine fuel consumption based on the timer. Also, a significant portion of the modelled auxiliary power is now produced by the main engine via shaft generators, if available on ship.

[3]For example, www.marinetraffic.com and www.vesselfinder.com usually yield the ship type and physical dimensions for vessels that have no IMO-number.