

# Nitrogen emissions to the air in the Baltic Sea area

HELCOM Baltic Sea Environment Fact Sheet (BSEFS), 2021

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## Key Message

For all HELCOM Contracting Parties, *oxidized* nitrogen emissions were lower in 2019 than in 1995, with the largest reductions in Denmark (66%), followed by Finland (56%), Sweden (49%) and Germany (48%).

Concerning *reduced* nitrogen (ammonia), annual emissions were lower in 2019 than in 1995 in six out of the nine HELCOM Contracting Parties, with the largest reductions in Denmark (30%), followed by Poland (13%) and Sweden (13%). In Lithuania, Russia and Latvia ammonia emissions increased from 1995 to 2019 by 12%, 9% and 7%, respectively.

For all HELCOM Contracting Parties, *total* nitrogen emissions were lower in 2019 than in 1995, with the largest reductions in Denmark (48%), followed by Finland (43%) and Sweden (35%).

## Results and Assessment

### Relevance of the BSEFS for describing developments in the environment

This fact sheet presents the changes in annual emissions of nitrogen oxides (NO and NO<sub>2</sub>) and ammonia (NH<sub>3</sub>) from anthropogenic sources during the 1995 to 2019 period, which are the basis for the model calculations of the deposition on the Baltic Sea. The data include emissions from HELCOM Countries, Baltic and North Sea shipping and other sources outside the HELCOM area.

### Policy relevance and policy references

The HELCOM Copenhagen Ministerial Declaration of 2013 on taking further action to implement the Baltic Sea Action Plan reconfirmed the need of reaching good environmental status for a healthy Baltic Sea. The declaration includes nutrient reduction targets, and thus also concerns airborne nitrogen input to the Baltic Sea. The Declaration sets targets on Maximum Allowed Inputs (MAI) covering both water- and airborne inputs. These targets are maintained in the updated Baltic Sea Action Plan of 2021.

The relevant policy to the control of emissions of nitrogen oxides and ammonia to the atmosphere on a global scale is set in the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). For EU member states the policy frame is set by the EU NEC and IED Directives. For the Russian Federation the corresponding policy frame is embraced by Federal Acts on Environment Protection and the Protection of Atmospheric Air. The Gothenburg Protocol (1999, and revised in 2012) requires that nitrogen oxides emissions in 2020 should be reduced by between 18% and 56% in 31 countries with respect to 2005 annual emissions, with the largest relative reductions in Denmark (56%), the United Kingdom (55%) and France (50%). Ammonia emissions should also be reduced, but by smaller percentages (1% to 24%). The largest relative reductions of ammonia emissions should be in Denmark (24%), Finland (20%) and Sweden (15%). In the European Union, the revised Gothenburg Protocol is implemented by the EU NEC Directive 2016/2284/EU, which sets 2020 and 2030 emission reduction commitments for five main air pollutants, including nitrogen oxides and ammonia. It is worth noting that in the case of ammonia, the commitments set for 2030 are much stricter than the Gothenburg Protocol reductions that were set for 2020. The Gothenburg Protocol currently undergoes a review process that will most likely result in a new revision.

## Assessment

In this fact sheet we present and discuss nitrogen emission data as used in the EMEP MSC-W model calculations performed for the 1995-2019 period. For all years, the gridded distributions of emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP) on 0.1° x 0.1° resolution. Details about the methods of gridding and gap-filling emission data done by CEIP can be found in the EMEP status report 1/2021 (EMEP, 2021, their section 3.5), which is publicly available on the web.

The gridded emission data used in the EMEP MSC-W model calculations are available on CEIP's WebDab at: <https://www.ceip.at/webdab-emission-database/emissions-as-used-in-emep-models>.

Time series of nitrogen oxides and ammonia annual emissions in the period 1995 – 2019, as used in the EMEP MSC-W model calculations, are shown for all HELCOM Contracting Parties in Figure 1. The figure also shows emissions from shipping in the North Sea and the Baltic Sea, as well as all other sources within the EMEP MSC-W model domain. For the first time this year, the coefficients for the best-fit linear trend are added, showing an increase or a decrease. “R-squared” is a measure of how much of the variability can be explained by the (linear trend) model. The R-squared values are written in bold font if the trend is statistically significant at the 5% level (Mann-Kendall test). Time series of nitrogen oxides, ammonia and total nitrogen annual emissions, expressed as percentage of 1995 emissions, are shown for the same period in Figure 2. Emissions from Russia are included only for the part of Russia that is included in the EMEP MSC-W model domain.

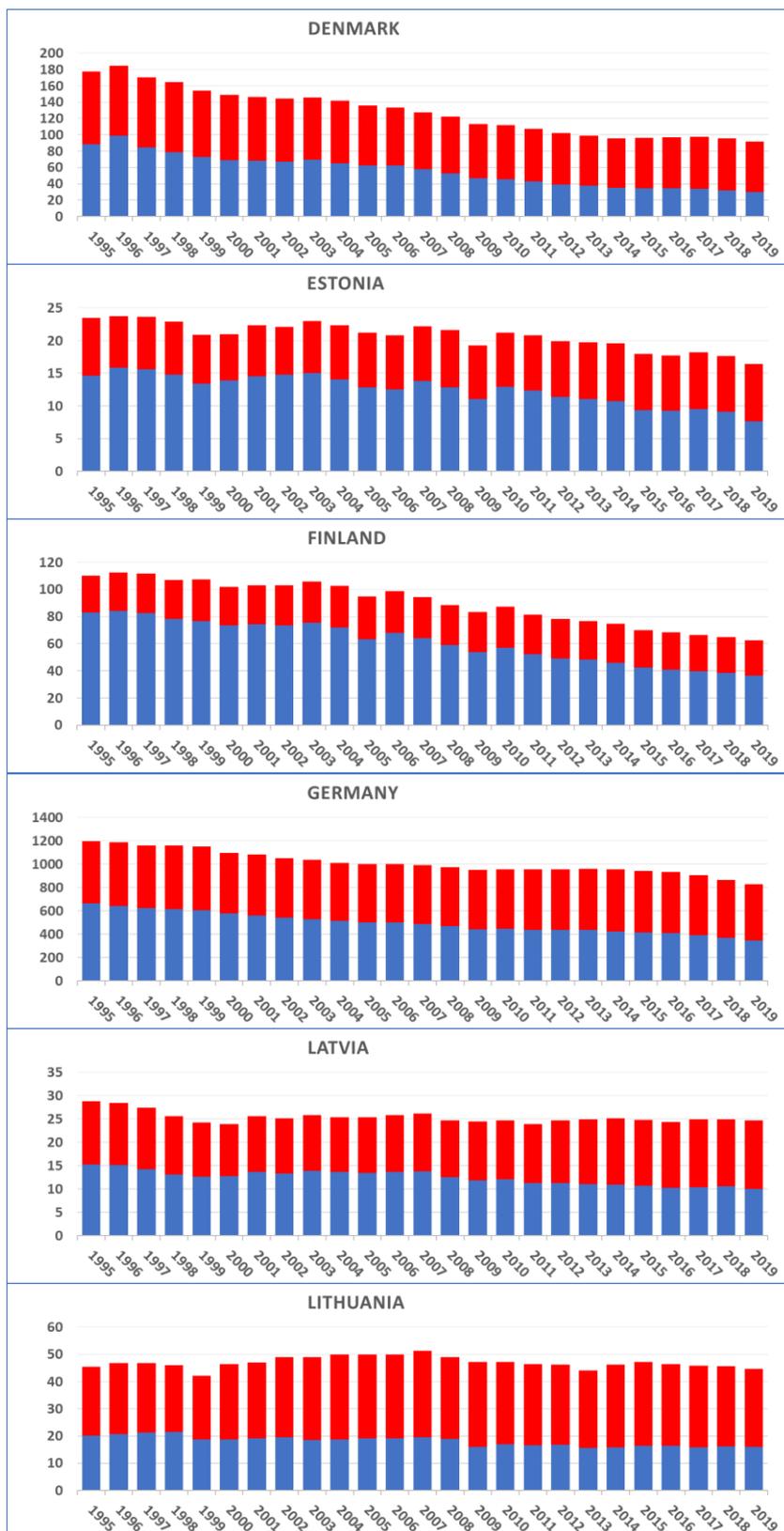
According to the work plan of the EMEP Programme, not all historical years of the considered period (starting in the 1990s) are gridded and gap-filled every year. Having to rely on data based on different data submissions is thus not unusual and, in most cases, does not lead to any major inconsistencies.

Nevertheless, it is important to note that the emission data for the years 1995 – 1999 are still based on the 2019 official data submissions to CEIP (as of February 2019), while the emission data for the period 2000 – 2019 have been updated this year, i.e. they are based on official data submissions to CEIP as of June 2021.

A special case are emissions from international shipping: These are not reported by the Parties to the UN ECE LRTAP Convention but taken from the CAMS global ship emission dataset (Granier et al., 2019), which starts in the year 2000 and was developed by the Finnish Meteorological Institute (FMI). Ship emissions for years before 2000 are estimated using CAMS global shipping emissions for 2000, adjusted with trends for global shipping from EDGAR v.4.3.2 (JRC/PBL 2016). Only the emission data for 2019 have been updated this year, and they include a larger number of small (non-IMO) vessels that have started to use AIS (Automatic Identification System) recently. The apparent increase in shipping emissions might thus partly be due to the increased use of AIS (which the emission data are based upon) and not reflect any real increase in ship emissions. Furthermore, reduced nitrogen emissions from ships do not occur in any significant amount and are thus not considered in the model or plotted in Figures 1 and 2.

In most HELCOM Contracting Parties, emissions of total nitrogen have been decreasing during the period 1995 – 2019. The reduction of emissions from the Baltic Sea region in the years 1995 – 2019 is more significant for nitrogen oxides than for ammonia: In all HELCOM Contracting Parties, oxidized nitrogen emissions are by 10 to 66% lower in 2019 than in 1995, with the largest reductions in Denmark (66%), followed by Finland (56%), Sweden (49%), and Germany (48%). Reductions with respect to 1995 are also reported for all the other HELCOM Contracting parties: Estonia (48%), Poland (35%), Latvia (34%), Lithuania (20%), and Russia (10%).

For ammonia, the emissions from seven out of nine HELCOM Contracting Parties were lower in 2019 than in 1995, with the largest reductions in Denmark (30%), followed by Poland (13%), Sweden (13%), and Germany (10%). Reductions with respect to 1995 are also seen for Finland (4%) and Estonia (2%), while Lithuania, Russia and Latvia have increased their ammonia emissions since 1995 (by 12% and 9%, 7%, respectively).



**Figure 1.** Annual atmospheric emissions of nitrogen oxides (NO<sub>x</sub>, blue) and ammonia (NH<sub>3</sub>, red) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea) and from other sources within the EMEP MSC-W model domain from 1995 to 2019. Unit: ktonnes(N)/year. Emission data for 1995 to 1999 are based on 2019 official submissions from EMEP countries, while emission data for 2000-2019 are updated according to this year's (2021) submissions. Break points seen at year 2000 are thus not necessarily real. Also, the ship emission data for 2019 take into account more small vessels than the years before. Coefficients of the linear trend model are added to the right. R-squared values in bold font mean that the indicated trend is significant at the 5% level. (Figure continues on next page)

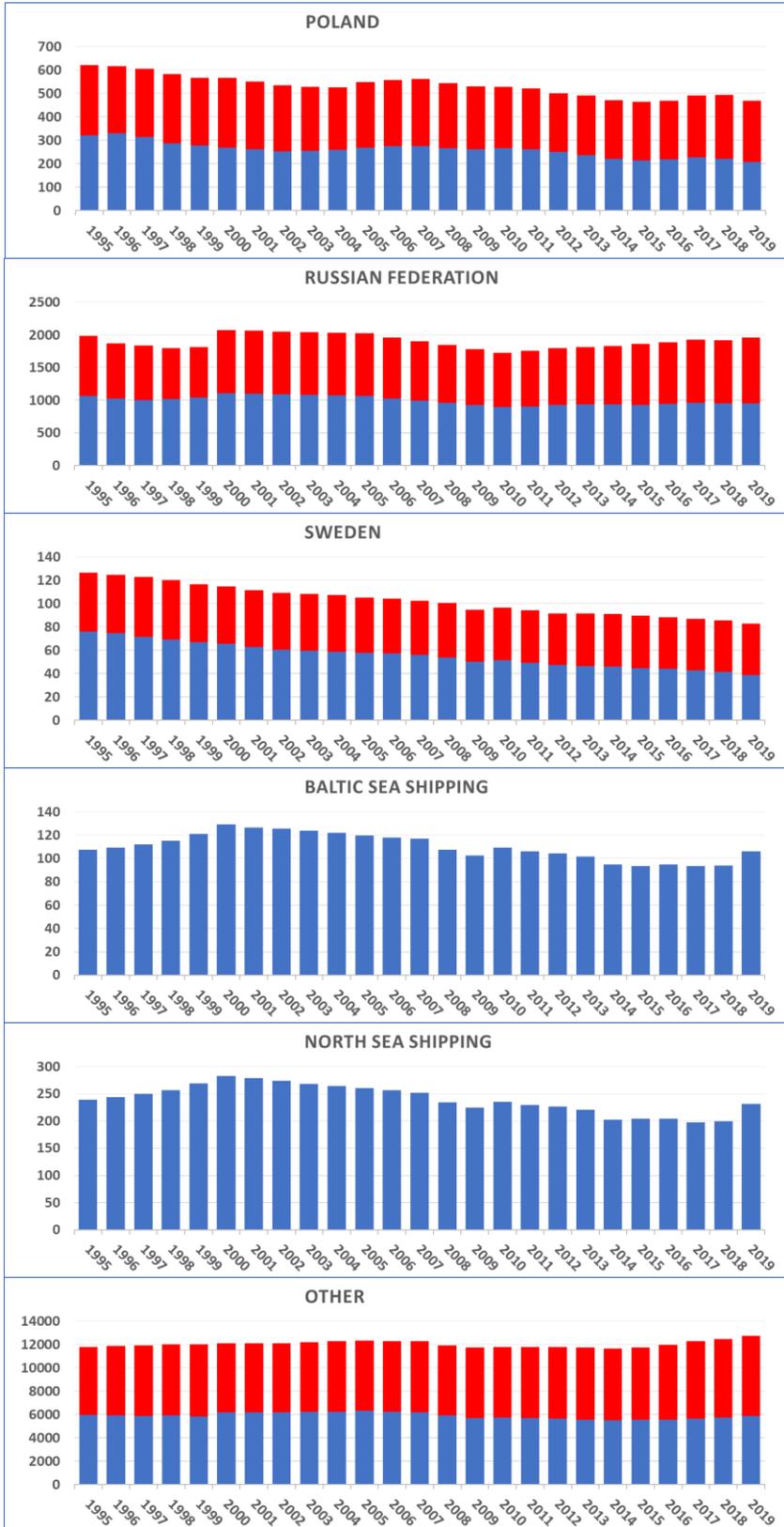
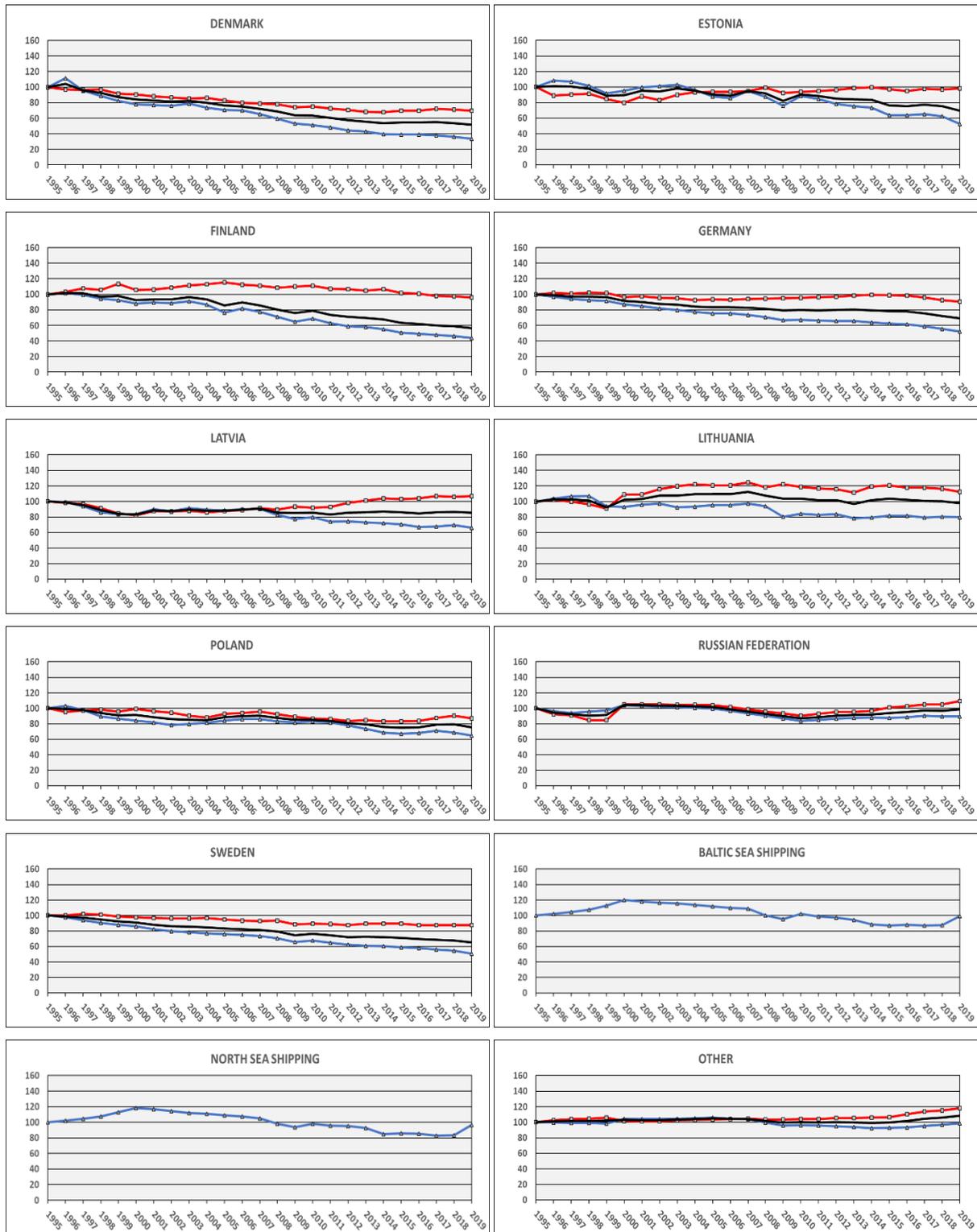


Figure 1. continued



**Figure 2.** Changes in annual atmospheric emissions of nitrogen oxides (NO<sub>x</sub>, blue/triangles), ammonia (NH<sub>3</sub>, red/squares) and total nitrogen (NO<sub>x</sub>+ NH<sub>3</sub>, black solid) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea) and from other sources within the EMEP MSC-W model domain from 1995 to 2019, plotted as percentage of the 1995 value. Unit: %. Emission data for 1995 to 1999 are based on 2019 official submissions from EMEP countries, while emission data for 2000-2019 are updated according to this year's (2021) submissions. Break points seen at year 2000 are thus not necessarily real. Also, the ship emission data for 2019 take into account more small vessels than the years before. See text for more details.

## References

EMEP, 2021: EMEP Status Report 1/2021. "Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components" Joint MSC-W & CCC & CEIP Report. Link for direct download: [https://emep.int/publ/reports/2021/EMEP\\_Status\\_Report\\_1\\_2021.pdf](https://emep.int/publ/reports/2021/EMEP_Status_Report_1_2021.pdf)

Granier, C., Darras, S., Denier van der Gon, H., Doubalova, J., Elguindi, N., Galle, B., Gauss, M., Guevara, M., Jalkanen, J.-P., Kuenen, J., Liousse, C., Quack, B., Simpson, D., and Sindelarova, K.: The Copernicus Atmosphere Monitoring Service global and regional emissions (April 2019 version), doi:10.24380/d0bn-kx16, Link for direct download: [https://atmosphere.copernicus.eu/sites/default/files/201906/cams\\_emissions\\_general\\_document\\_apr2019\\_v7.pdf](https://atmosphere.copernicus.eu/sites/default/files/201906/cams_emissions_general_document_apr2019_v7.pdf).

JRC/PBL: Emission Database for Global Atmospheric Research (EDGAR), Global Emissions EDGAR v4.3.1, European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL), URL <http://edgar.jrc.ec.europa.eu>, 2016.

## Data

**Table 1.** National total emissions of nitrogen oxides from HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1995 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Unit: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1995	88.5	14.6	83.0	664	15.2	20.0	321	1064	76.2	2346	107	239	5953
1996	98.9	15.8	84.3	642	15.1	20.7	330	1023	74.5	2304	109	244	5927
1997	84.6	15.6	82.5	623	14.3	21.3	314	1000	71.6	2226	112	250	5890
1998	78.5	14.8	78.2	615	13.1	21.5	287	1018	69.1	2196	115	257	5903
1999	72.9	13.4	76.8	608	12.7	18.8	278	1037	66.9	2184	121	269	5844
2000	68.9	13.9	73.4	580	12.7	18.7	269	1105	65.6	2207	129	283	6210
2001	68.1	14.5	74.4	562	13.6	19.2	262	1096	62.8	2173	126	279	6204
2002	67.2	14.8	73.7	544	13.3	19.5	252	1088	60.7	2132	125	273	6191
2003	69.9	15.0	75.7	530	13.9	18.5	255	1079	59.6	2117	124	268	6217
2004	65.0	14.0	72.2	515	13.6	18.7	261	1071	58.5	2089	122	264	6255
2005	62.5	12.9	63.3	500	13.4	19.1	270	1062	57.7	2061	120	260	6310
2006	62.3	12.5	68.1	503	13.7	19.1	276	1028	57.2	2040	118	256	6225
2007	57.8	13.8	64.2	489	13.7	19.5	275	994	55.8	1984	117	251	6186
2008	52.9	12.8	58.9	470	12.6	18.8	267	960	53.6	1907	107	234	5921
2009	47.1	11.1	53.7	443	11.8	16.1	262	926	49.9	1821	102	224	5690
2010	45.6	12.9	57.0	448	12.1	16.9	267	892	51.4	1803	109	235	5728
2011	42.7	12.4	52.1	440	11.3	16.6	261	905	49.3	1791	106	229	5692
2012	39.4	11.4	49.2	437	11.3	16.8	249	924	47.4	1786	104	227	5651
2013	38.0	11.0	48.2	437	11.1	15.7	236	933	46.5	1777	101	221	5577
2014	35.1	10.7	45.9	424	11.0	15.9	220	936	46.0	1744	95	202	5488
2015	34.7	9.3	42.2	415	10.7	16.4	215	930	44.8	1718	93	204	5540
2016	34.7	9.3	41.0	408	10.2	16.4	218	944	44.1	1725	95	204	5551
2017	33.7	9.5	39.6	393	10.3	15.9	228	960	42.6	1733	93	198	5662
2018	32.1	9.1	38.6	368	10.5	16.1	221	953	41.6	1691	94	199	5752
2019	30.0	7.7	36.5	346	10.1	16.0	207	953	38.7	1646	106	231	5870

**Table 2.** National total emissions of ammonia from HELCOM Contracting Parties and from other sources within the EMEP MSC-W model domain in the period 1995 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Unit: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Other
1995	88.7	8.87	27.2	535	13.6	25.5	301	920	50.3	1969	5830
1996	85.9	7.90	28.0	543	13.4	26.1	287	849	50.4	1892	5970
1997	85.6	8.01	29.3	538	13.2	25.5	292	837	51.4	1880	6053
1998	85.8	8.09	28.7	545	12.5	24.6	295	779	50.9	1831	6090
1999	81.4	7.50	30.8	545	11.5	23.2	288	779	49.7	1816	6183
2000	80.2	7.08	28.7	516	11.2	27.8	298	967	49.2	1985	5908
2001	78.3	7.78	28.8	520	11.9	27.8	289	965	48.7	1978	5885
2002	76.9	7.38	29.5	510	11.9	29.5	284	963	48.5	1961	5895
2003	75.6	7.96	30.3	507	12.0	30.5	272	961	48.6	1946	5968
2004	76.5	8.28	30.7	495	11.7	31.2	264	959	48.8	1925	6014
2005	73.5	8.31	31.3	500	11.9	30.8	279	958	47.6	1940	6036
2006	70.8	8.32	30.5	496	12.1	30.8	282	933	47.0	1911	6067
2007	69.9	8.41	30.1	503	12.4	31.7	287	908	46.8	1897	6095
2008	69.2	8.79	29.4	506	12.2	30.2	277	883	46.9	1862	6022
2009	65.8	8.18	29.9	508	12.7	31.2	267	858	44.6	1825	6032
2010	66.5	8.31	30.1	510	12.5	30.3	261	833	45.0	1796	6064
2011	64.4	8.41	29.1	515	12.6	29.7	259	852	44.7	1815	6072
2012	62.8	8.54	29.0	519	13.4	29.5	251	875	44.0	1832	6133
2013	60.7	8.74	28.5	525	13.8	28.4	255	878	44.9	1842	6161
2014	60.3	8.84	28.9	531	14.2	30.4	251	892	44.9	1861	6181
2015	61.8	8.61	27.6	528	14.0	30.7	250	929	44.9	1894	6215
2016	61.9	8.40	27.3	526	14.2	30.0	251	943	44.0	1905	6417
2017	64.1	8.67	26.6	514	14.6	30.1	263	964	44.1	1929	6630
2018	63.3	8.59	26.5	495	14.4	29.6	272	964	44.2	1917	6723
2019	62.0	8.72	26.0	483	14.6	28.6	261	1004	44.0	1932	6872

**Table 3.** National total emissions of total nitrogen from HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1995 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Units: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1995	177	23.5	110	1199	28.8	45.5	621	1984	127	4316	107	239	11783
1996	185	23.7	112	1186	28.4	46.8	617	1872	125	4196	109	244	11897
1997	170	23.6	112	1161	27.4	46.8	606	1837	123	4106	112	250	11943
1998	164	22.9	107	1161	25.6	46.0	582	1798	120	4026	115	257	11993
1999	154	20.9	108	1153	24.2	42.1	566	1816	117	4000	121	269	12027
2000	149	21.0	102	1096	23.9	46.4	567	2072	115	4192	129	283	12119
2001	146	22.3	103	1082	25.6	47.0	551	2062	112	4151	126	279	12089
2002	144	22.1	103	1053	25.2	49.0	536	2051	109	4093	125	273	12087
2003	146	23.0	106	1037	25.8	48.9	528	2041	108	4063	124	268	12185
2004	142	22.3	103	1010	25.3	49.9	525	2030	107	4014	122	264	12269
2005	136	21.2	94.6	1000	25.4	49.9	548	2020	105	4000	120	260	12346
2006	133	20.8	98.6	999	25.8	49.9	558	1961	104	3951	118	256	12292
2007	128	22.2	94.3	992	26.2	51.2	563	1902	103	3881	117	251	12281
2008	122	21.6	88.3	976	24.7	49.0	544	1843	101	3769	107	234	11943
2009	113	19.2	83.6	951	24.5	47.2	529	1784	94.5	3646	102	224	11723
2010	112	21.2	87.1	957	24.6	47.2	528	1725	96.4	3598	109	235	11791
2011	107	20.8	81.2	954	23.9	46.3	521	1757	94.0	3605	106	229	11764
2012	102	20.0	78.2	956	24.7	46.3	501	1798	91.4	3618	104	227	11785
2013	98.6	19.8	76.7	962	24.9	44.1	491	1811	91.4	3619	101	221	11738
2014	95.4	19.6	74.8	954	25.1	46.3	471	1827	90.9	3605	94.9	202	11670
2015	96.5	17.9	69.9	943	24.8	47.1	465	1858	89.8	3612	93.2	204	11754
2016	96.6	17.7	68.3	934	24.4	46.4	469	1887	88.1	3631	94.6	204	11968
2017	97.9	18.2	66.3	907	24.9	45.9	491	1924	86.7	3662	93.3	198	12293
2018	95.4	17.7	65.0	864	24.9	45.7	493	1917	85.8	3608	93.9	199	12475
2019	92.0	16.4	62.5	829	24.7	44.6	469	1957	82.7	3578	106	231	12742

## Metadata

### Technical information

1. Source: EMEP Centre on Emission Inventories and Projections (CEIP).
2. Description of data: The gridded distributions of emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP). The emissions for the 1995-1999 period are derived from the 2019 official data submissions to UNECE CLRTAP as of February 2019, while emissions for 2000-2019 are derived from the 2021 official data submissions to UNECE CLRTAP as of June 2021.
3. Geographical coverage: EMEP domain covering Europe, parts of Asia and a part of the Atlantic Ocean.
4. Temporal coverage: Data on emissions of nitrogen oxides and ammonia are presented here for the period 1995 - 2019.
5. Methodology and frequency of data collection: National data on emissions are annually submitted by the Parties to the CLRTAP Convention to the UN ECE Secretariat. The methodology is based on a combination of emission measurements and emission estimates, based on activity data and emission factors. Submitted data undergo a QA/QC procedure and are stored in the WebDab database of the EMEP Centre for Emission inventories and Projections (CEIP) in Vienna, Austria.

### Quality information

6. Strengths and weaknesses: Strength: data on emissions are annually submitted, checked and stored in the CEIP database; Weaknesses: there are gaps in time series of national emissions, which have to be corrected by experts. Delays occur in updating historical emission data submitted by the EMEP Contracting Parties.
7. Uncertainty. No official information about the uncertainty of provided nitrogen emission data is available from CEIP.
8. Further work required: Further work on emission uncertainty is required.