SEA SHIPPING EMISSIONS 2012: NETHERLANDS CONTINENTAL SHELF, 12-MILE ZONE, PORT AREAS AND OSPAR REGION II

Final Report

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GLOSSARY OF DEFINITIONS AND ABBREVIATIONS

Definitions:

Voyage database	Database consisting of all voyages crossing the North Sea in 2012 collected by Lloyd's List Intelligence
SAMSON Traffic database	Database that contains the number of ship movements per year for each traffic link divided over ship type and size classes. It is based on the Lloyd's List Intelligence voyage database
Ship characteristics database	This database contains vessel characteristics of over 106,000 seagoing merchant vessels larger than 100 GT operating worldwide. The information includes year of built, vessel type, vessel size, service speed, installed power of main and auxiliary engine.
Netherlands sea area	NCS and 12-mile zone

Abbreviations/Substances:

VOC	*V*olatile organic carbons. Substance number **1237**
Sulphur dioxide (SO_2)	Gas formed from the combustion of fuels that contain sulphur. Substance number **4001**
Nitrogen oxides (NO_x)	The gases nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO is predominantly formed in high temperature combustion processes and can subsequently be converted to NO_2 in the atmosphere. Substance number **4013**
Carbon Monoxide (CO)	A highly toxic colourless gas, formed from the combustion of fuel. Particularly harmful to humans. Substance number **4031**
Carbon Dioxide (CO_2)	Gas formed from the combustion of fuel. Substance number **4032**
PM	Particulates from marine diesel engines irrespective of fuel type. Substance number **6598**
PM-MDO	Particulates from marine diesel engines operated with distillate fuel oil. Substance number **6601**
PM-HFO	Particulates from marine diesel engines operated with residual fuel oil. Substance number **6602**

Abbreviations/Other:

AIS	Automatic Identification System
EMS	Emissieregistratie en Monitoring Scheepvaart (Emission inventory and Monitoring for the shipping sector)
GT	Gross Tonnage
IMO	International Maritime Organization
LLI	Lloyd's List Intelligence (previously LLG and LMIU)
m	meter
MMSI	Maritime Mobile Service Identity is a unique number to call a ship. The number is added to each AIS message.
NCS	Netherlands Continental Shelf
nm	nautical mile or sea mile is 1852m
SAMSON	Safety Assessment Model for Shipping and Offshore on the North Sea

1 INTRODUCTION

1.1 Objective

This study aims to determine the emissions to air of seagoing vessels above 100 GT for 2012. The totals and the spatial distribution for the Netherlands Continental Shelf, the 12-mile zone and the port areas Western Scheldt, Rotterdam, Amsterdam, the Ems, Den Helder and Harlingen are based on AIS data. In addition, the information contained in the AIS data for the Netherlands sea area and in the SAMSON traffic database for the whole of the North Sea are used to determine the emissions for 2012 in the OSPAR region II area. The grid size for the port area emissions and the 12-mile zone is 500 x 500 m, for the other areas a grid size of 5000 x 5000 m has been used.

The emissions for 2012 are determined for VOC, SO_2, NO_x, CO, CO_2 and Particulate Matter (PM). A distinction is made between ships sailing under EU-flag and non-EU flag and between ships sailing in the NCS or in the Dutch 12-mile zone.

1.2 Report structure

Chapter 2 describes the emission databases that were compiled for 2012.
Chapter 3 describes the procedure that was used for the emission calculation based on AIS data.
Chapter 4 describes the procedure used for the emission calculations based on the SAMSON database.
Chapter 5 describes the completeness of the AIS data, both with respect to missing files and with respect to spots that are not fully covered by base stations.
Chapter 6 contains the level of shipping activity in the Dutch port areas and the Netherlands sea area.
Chapter 7 summarises the emissions for 2012 for the Dutch port areas and the Netherlands sea area and makes a comparison with 2011.
Chapter 8 summarises the 2012 emissions for OSPAR region II. It also contains a comparison with 2011.
Chapter 9 presents conclusions and recommendations.

2 2012 EMISSION DATABASES

2.1 General information

Different access databases with the calculated emissions to air from sea shipping have been delivered for:

- the Netherlands sea area (NCS and 12-mile zone);
- the six Dutch port areas;
- the OSPAR region II at sea;

For the information on what can be found in the different databases, reference is made to [1].

2.2 Netherlands sea area and Dutch port areas

The emissions in the Netherlands sea area and the six Dutch port areas based on AIS data have been stored in:

- Emissions_2012_MARIN_12Miles_updated.mdb
- Emissions_2012_MARIN_NCP_updated.accdb
- Emissions_2012_MARIN_Dutch_port_areas.mdb

The databases contain the fishing vessels that are observed in the AIS data and that could be connected with the ship characteristics database. However, all figures and tables in the report are based on the data excluding fishing vessels.

The emissions have been calculated on a 5000 x 5000 m grid for the NCS and on a 500 x 500 m grid in the 12-mile zone and in the port areas.

The Netherlands sea area and the port areas are presented in Figure 2-1. The dark grey lines represent the traffic separations schemes and the squares represent offshore platforms. The different areas are indicated by plotting the centre points of the grid cells with different colours:

- The green points at sea are the cells outside the 12-mile zone;
- The yellow points at sea are the cells within the 12-mile zone;
- The orange points within the port areas are the cells that are included in the database if there is any emission.

The six port areas are illustrated in more detail in Figure 2-2 to Figure 2-7. At some places, there are orange points on land. There are several reasons for this. In general, the detail of the charts presented here is such that not all existing waterways and/or quays are visible, though they do exist. Also, it has been observed that the determination of the GPS position is disturbed by container cranes, so that the AIS message is not fed with the correct position. When, for whatever reason, AIS signals are disturbed or lost, positions are extrapolated and this is done before MARIN receives the data.

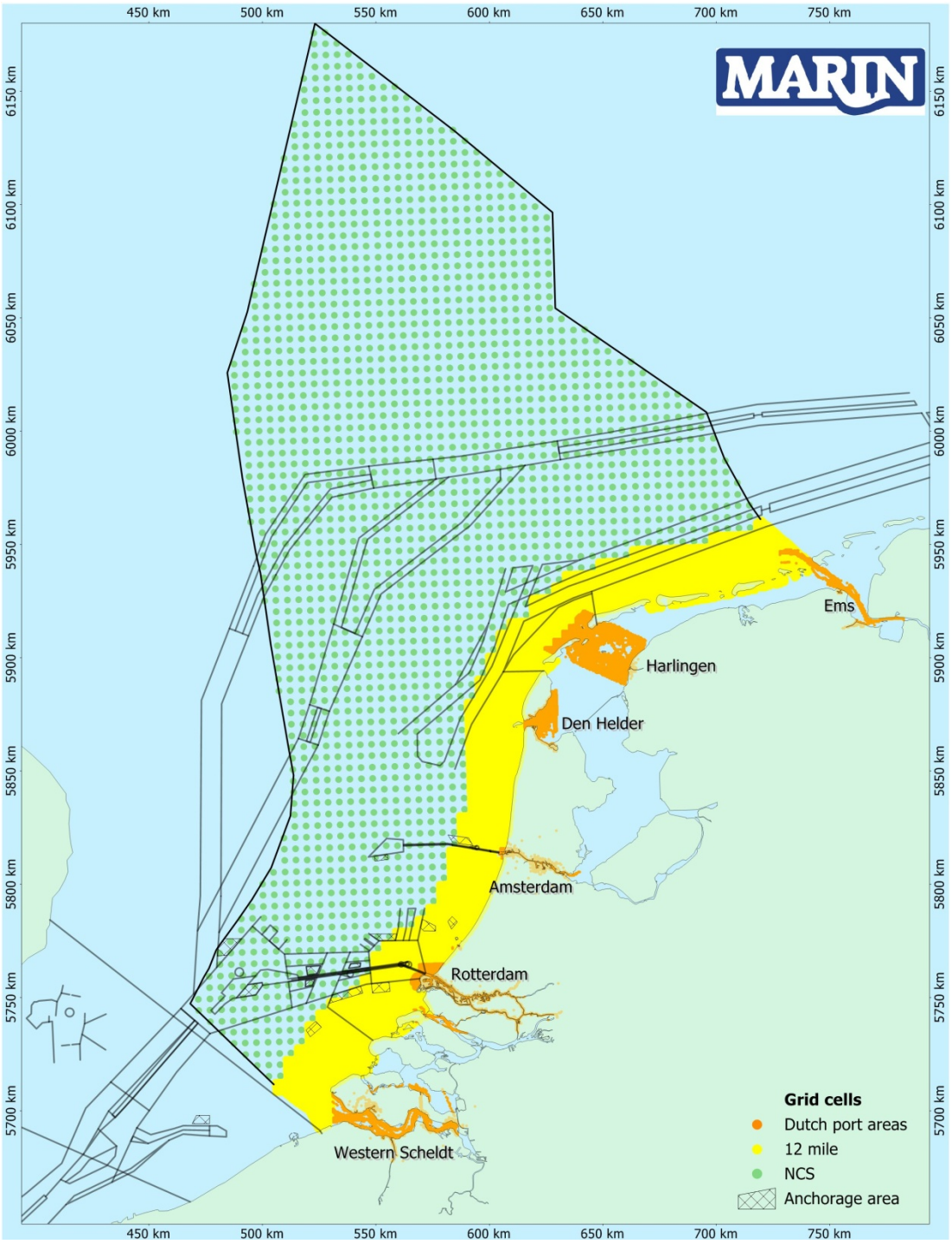

Figure 2-1 The Netherlands Continental Shelf, 12-mile zone and six port areas

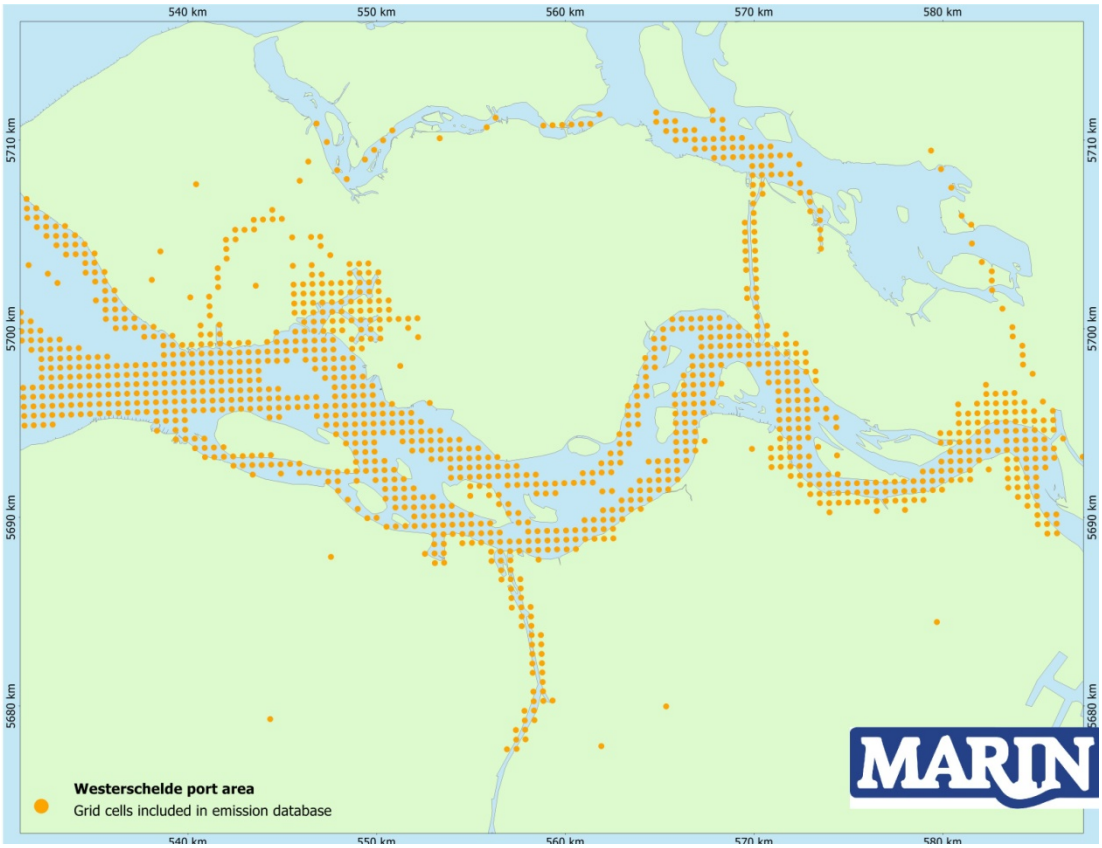

Figure 2-2 **Western Scheldt: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

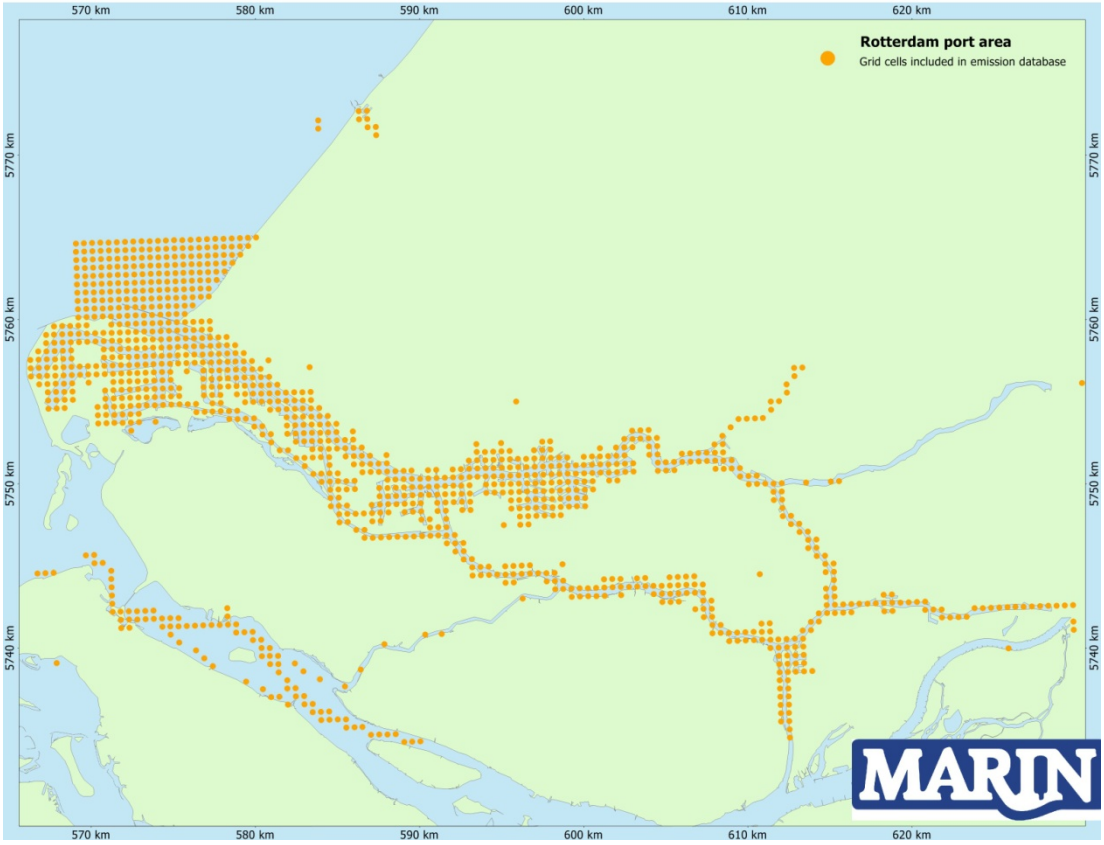

Figure 2-3 **Rotterdam: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

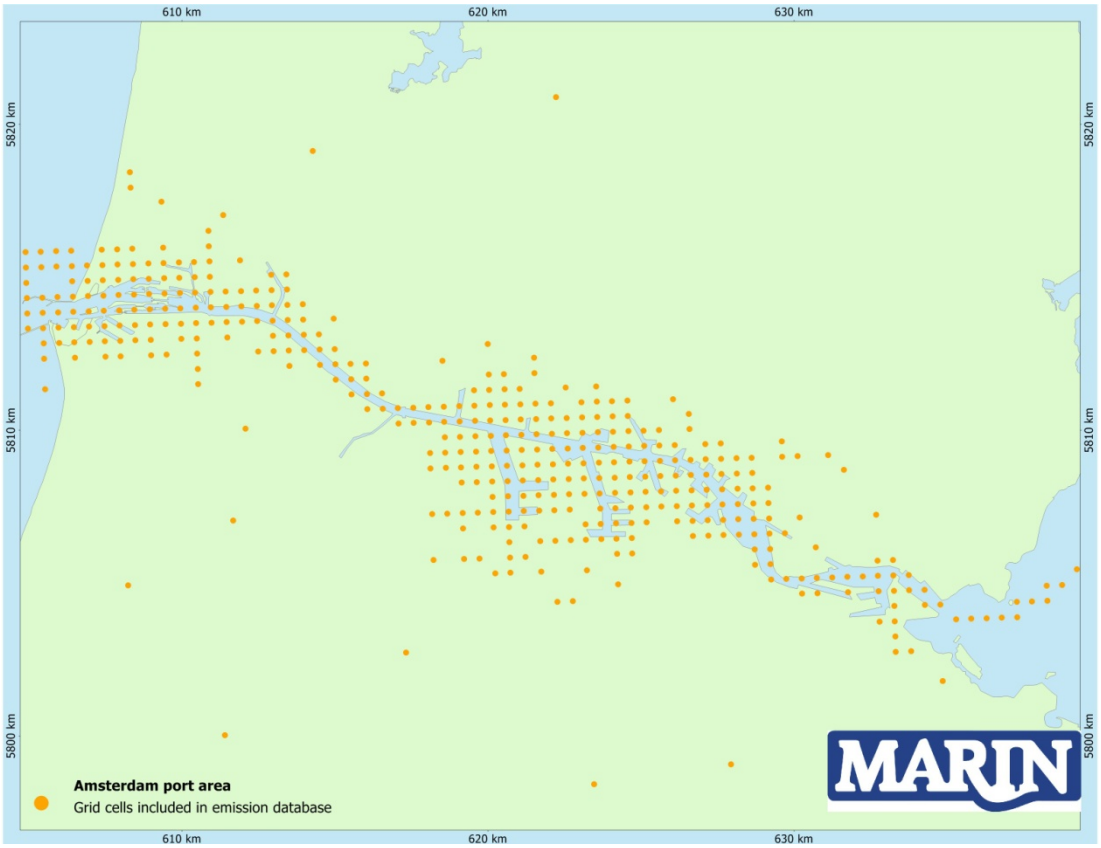

Figure 2-4 **Amsterdam: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

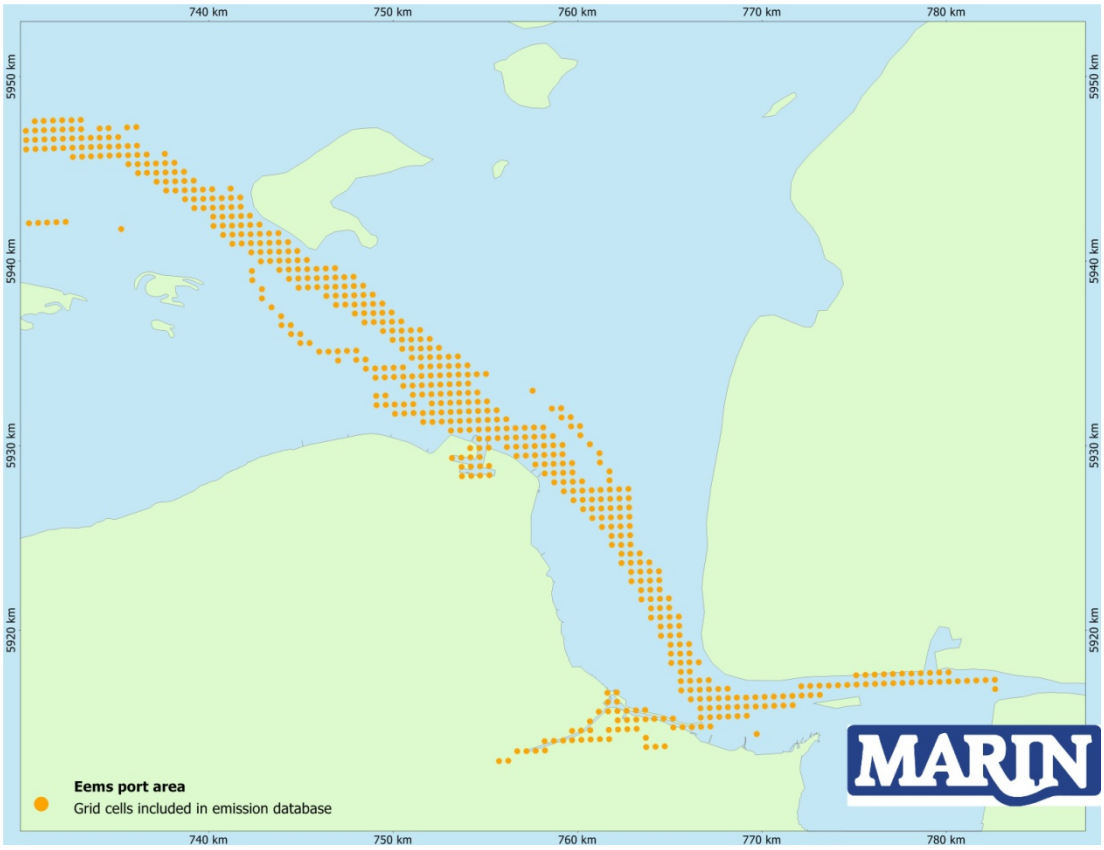

Figure 2-5 **Ems: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

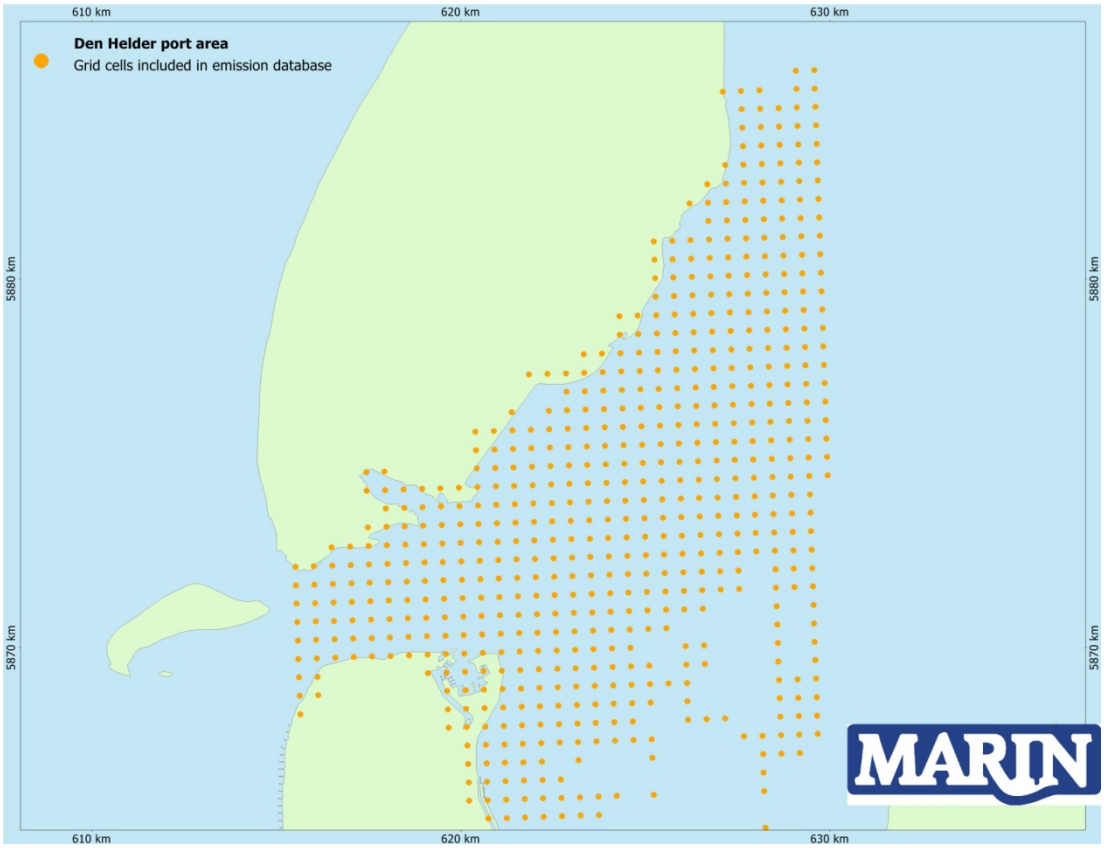

Figure 2-6 **Den Helder: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

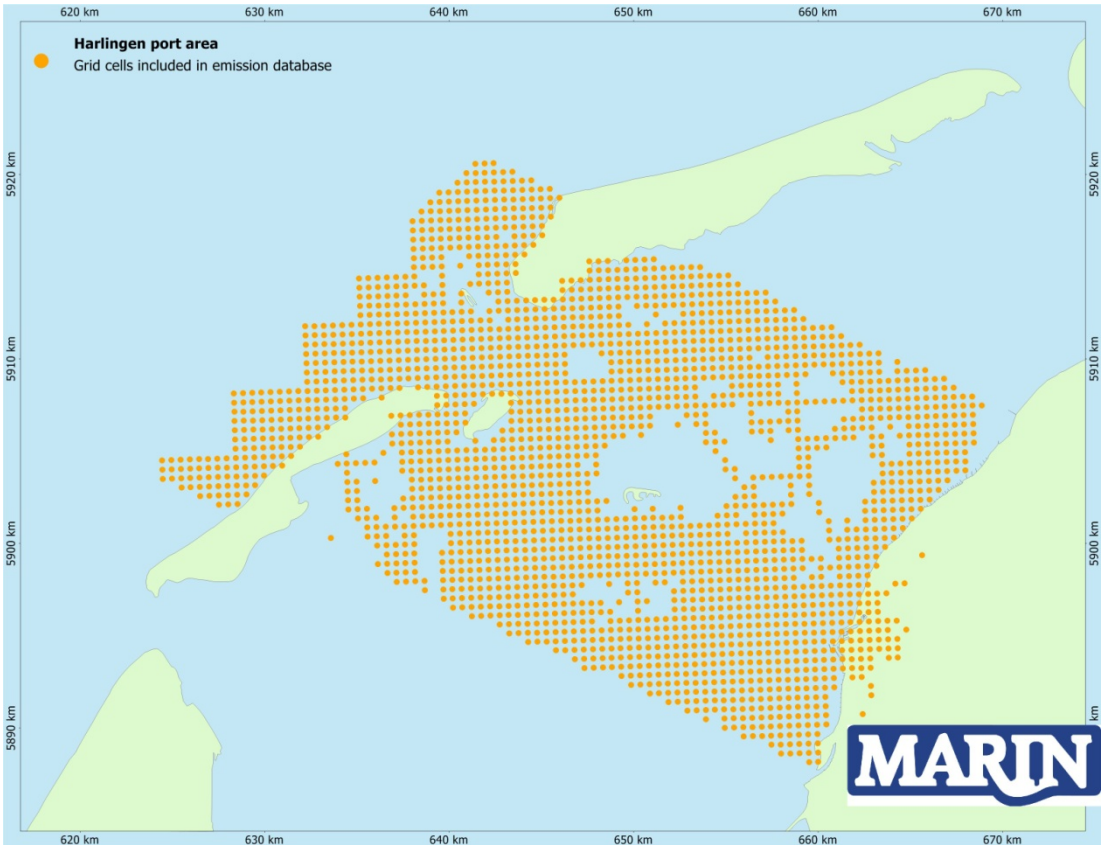

Figure 2-7 **Harlingen: The orange points indicate the centres of grid cells for which emissions are included in the Dutch port areas database**

2.3 OSPAR region II

The emissions in OSPAR region II are stored in:
“Emissions_OSPAR_region_II_2012_MARIN_sea.mdb.
The data is based on the SAMSON traffic database of 2012.

The database contains the fishing vessels that are part of the traffic database. However, all figures and tables in the report are based on the data excluding fishing vessels.

The emissions have been calculated on a 5000 x 5000 m grid. The area covered is shown in Figure 2-8.

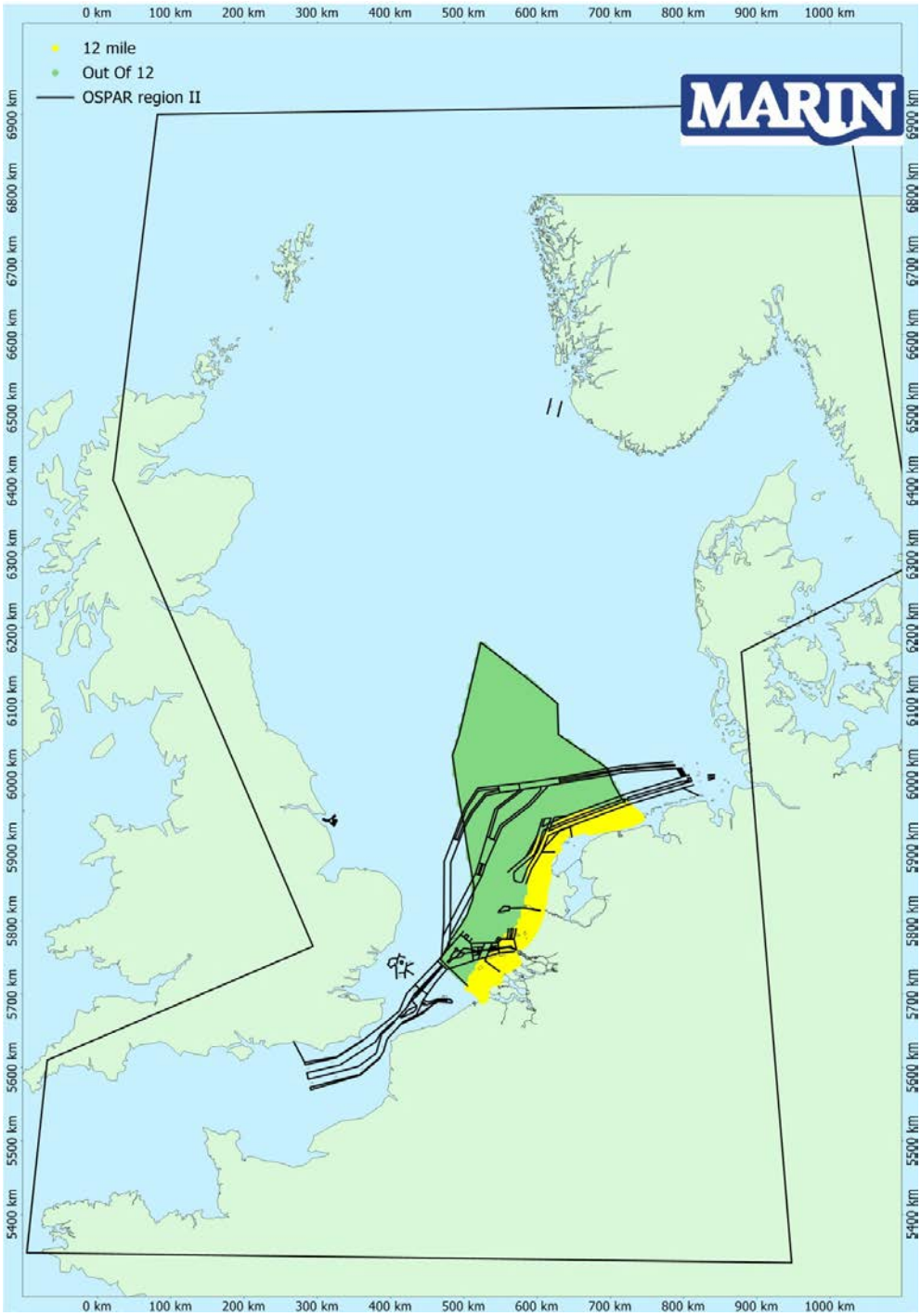

Figure 2-8 Areas within OSPAR region II

3 PROCEDURE FOR EMISSION CALCULATION BASED ON AIS DATA

This chapter describes the method for the emission calculation based on AIS data. This method has been used to calculate the emissions for both NCS, the 12-mile zone and the Dutch port areas. At first, the input used for the calculations will be explained. Then, the procedure for combining the input to obtain emissions will be described.

3.1 Input

AIS data for 2012
In this study, AIS data of 2012 received by the Netherlands Coastguard has been used to calculate the emissions. Refer to [1] for background information about the AIS data.

Ship characteristics database of August 2013
The LLI ship characteristics database of August 2013 has been purchased. This database, combined with earlier issues, contains vessel characteristics of over 106,000 seagoing merchant vessels larger than 100 GT operating worldwide.

3.2 Procedure for combining the input to obtain emissions

Refer to [1] for a description of how the input is combined to obtain emissions.

Results of coupling ships observed in AIS data with ship characteristics database
One of the steps is to find the corresponding ship in the ship characteristics database for each MMSI number in the AIS data of 2012.

For a description of the procedure, refer to [1].

Table 3-1 shows the final result of the process to link an MMSI number to a ship in the ship characteristics database. In the first step all 24,886 unique MMSI numbers in the AIS data of 2012 are divided into a group with 12,815 MMSI numbers with a corresponding IMO number that is not always equal to 0 (so likely a relevant ship) and a group of 12,071 MMSI numbers with a corresponding IMO number that is always 0 (suggesting the ship is not a seagoing vessel >100GT, thus not relevant in the calculations done here). There were 276 vessels with an IMO number that was not always equal to 0 that could not be coupled, because they were not in the ship characteristics database for different reasons; this involved 20 inland ships, 7 pleasure crafts, 52 fishing vessels, 43 ships <100 GT and 154 for other unknown reasons. The ship characteristics database contains all vessels that have an IMO number, i.e. merchant seagoing vessels >100 GT, but is not complete for other types of ships.

Table 3-1 Number of ships in AIS database coupled with ships in LLI ship characteristics database

Different MMSI numbers in AIS data of 2012	IMO number in AIS message	Coupled		Not coupled
		Direct	After search	Ship is not a seagoing ship > 100GT
24,886	12,815 IMO≠0	12,524	15	43 <100GT 7 pleasure 52 fishing 20 inland 154 other reason
	12,071 IMO=0	0	283	11788

From the second group, containing 12,071 ships with IMO always 0, 283 could be coupled with a ship in the LLI database and 11788 could not be coupled with a ship in the LLI database. Probably none or only a few of these ships belong to seagoing ships >100 GT. The 283 ships that could be coupled to the LLI database with seagoing vessels are considered as relevant vessels despite the fact that they have constantly sent AIS messages with IMO = 0. Generally these are small vessels (187 are in size class 1 < 1600GT) with a very small contribution to the emissions, but up to size class 6 there are approximately 15 ships per size class.

Overall, it can be concluded that almost all MMSI numbers of the relevant ships could be coupled with the ship characteristics database of LLI. This link is essential, because the LLI database is the only database that contains data with respect to the engine of the ship, required for the determination of the emissions.

4 PROCEDURE FOR EMISSION CALCULATION BASED ON THE LLOYD'S LIST INTELLIGENCE VOYAGE DATABASE

This chapter describes the method for the emission calculation based on the SAMSON traffic database. This method has been used to calculate the emissions for OSPAR region II.

Because AIS data outside the NCS is not available to MARIN, the emissions in OSPAR region II have been estimated based on all voyages crossing the North Sea in 2012 collected by Lloyd's List Intelligence. This data has been recently processed into a SAMSON traffic database (Figure 4-1). In the 2012 Lloyd's List Intelligence (LLI) voyage database, more voyages of ferries were covered than in the previous voyage database of 2008. However, on the busy ferry routes, voyages were still missing. An inventory of the missing ferry lines has been made and these have been added to the 2012 SAMSON traffic database. Therefore in contrast to earlier studies the ferry movements didn't have to be treated separately for the emission calculation.

The emission calculation in OSPAR region II followed the first 3 steps of the procedure described in [1]. Step 4 consists of a correction for the shipping volume, which is only necessary if the emissions are calculated for a different year than the year for which the SAMSON traffic database is available.

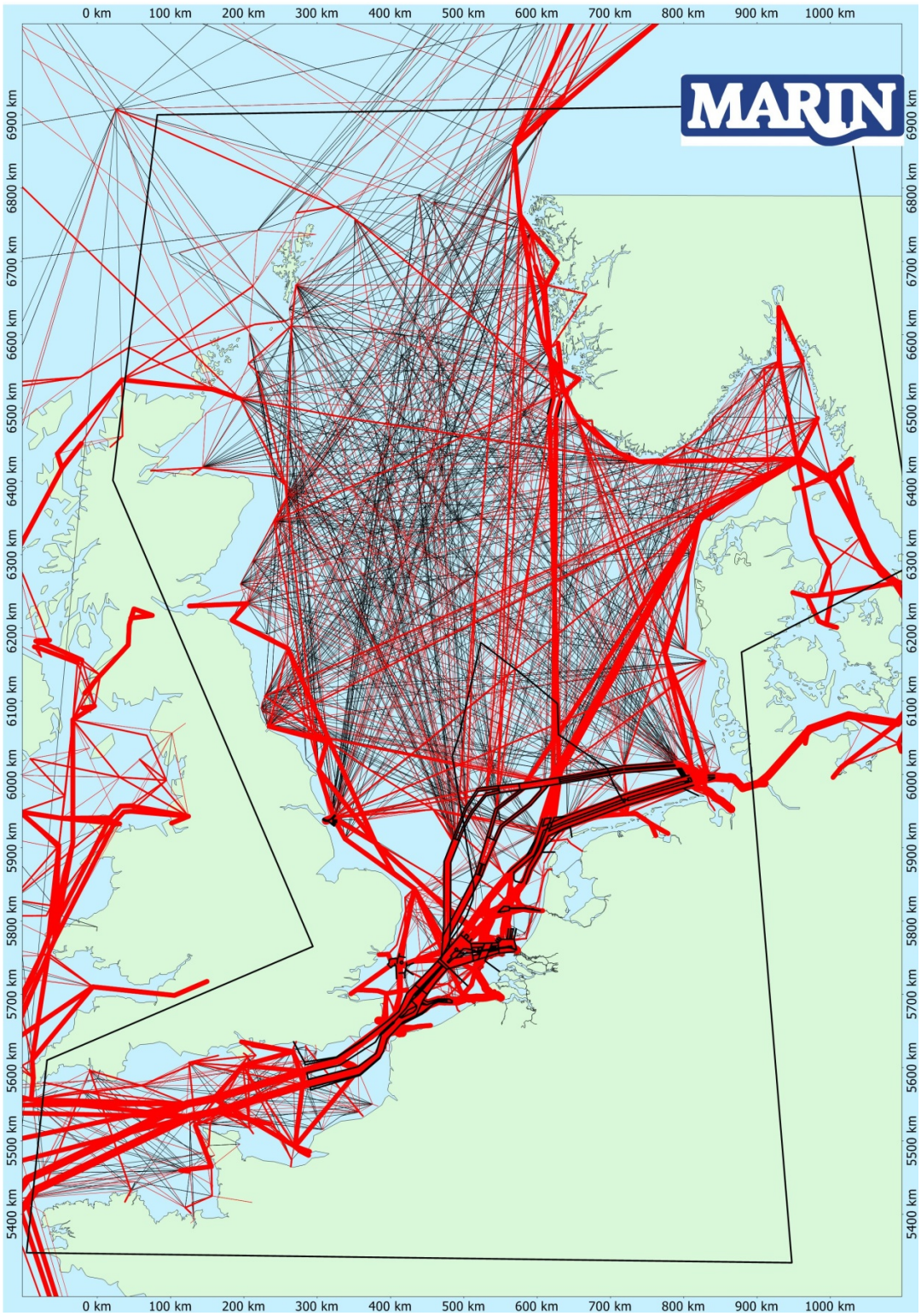

Figure 4-1 **Traffic links of the SAMSON traffic database of 2012 in OSPAR region II, the width of the links indicate the intensity of the ships on the links, red links represent a higher traffic intensity than black links**

5 COMPLETENESS OF AIS DATA

5.1 Missing AIS minute files

Each AIS data file contains the AIS messages of all ships received in exactly one minute. The total collection of the AIS data of 2012 contains 505,287 files, which is 95.87% of the maximum number of 527,040 files (366 days times 24 hours times 60 minutes). Therefore, in total more than 15 days are missing due to failures in the process. However, in case the gap is less than 10 minutes, this has no effect on the results, because each ship is kept in the system until no AIS message has been received during 10 minutes. This approach has been followed to prevent incompleteness for larger distances from the coast for which the reception of AIS messages by the base station decreases. For 2012 a completion factor of 1.0430 (1/0.9587) has been used to correct for missing periods longer than 10 minutes. These periods add up to 362 hours in total. All emissions, in the NCS, the 12-mile zone and in the Dutch port areas have been multiplied with this factor.

5.2 Bad AIS coverage in certain areas

5.2.1 Base stations

In the previous section, the number of files received from the Netherlands Coastguard was used to describe the completeness of the data. This doesn't necessarily mean that the available minutes files cover the total area all the time. This is illustrated in Figure 5-1, in which all base stations that deliver data to the Netherlands Coastguard are plotted. The circle with a radius of 20 nautical miles around each base station illustrates the area covered by that base station.

5.2.2 Known weak spots

In reality, the covered area varies with the atmospheric conditions. Figure 5-1 shows that some areas are covered by several base stations, while other areas are covered by only one base station and some areas are only covered with favourable atmospheric conditions, when the base stations reach further than 20 nautical miles. This means that there are a few weak spots in the Netherlands sea area and in the Dutch port areas:

- the area in the northern part of the NCS, which is not covered at all. This is not a large shortcoming because the shipping density is very low in this area;
- the area North-West of Texel;
- the Western Scheldt close to the border with Belgium, and
- the spot close to the border with the United Kingdom Continental Shelf, southwest of Rotterdam.

Especially the last location is a shortcoming, because it is a very dense shipping traffic area. MARIN has noticed this also in other projects. Also the Western Scheldt is a waterway with large traffic intensity. As this is an restricted area with clearly defined traffic flows, it is easier to compensate for the missing data and it has more direct influence on the air quality on land. Therefore, 5.2.5 contains a description of the correction for this bad coverage.

The area above the Wadden on the border of the Netherlands sea area and the German sector was not a weak spot in 2011 as it was before, but Figure 5-2 and Figure 5-3 show that it was again weak in 2012.

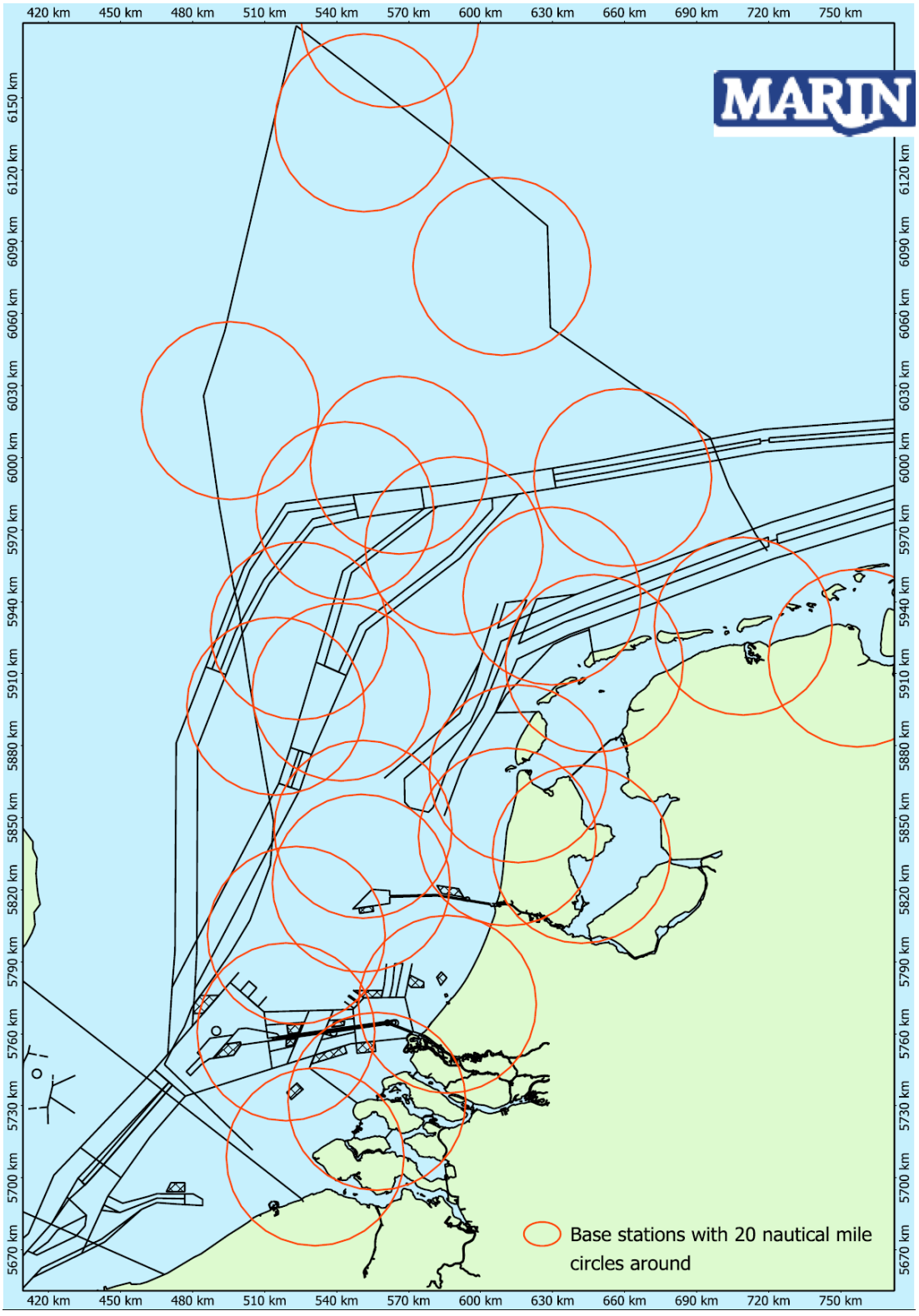

Figure 5-1 **AIS base stations in 2012 delivering data to the Netherlands Coastguard**

5.2.3 Coverage in the Netherlands sea area

For the Netherlands sea area, the weak spots in the collection of the AIS data are identified by the locations where ships lose contact. After 10 minutes without receiving a new AIS message of a ship, the ship is removed from the system. Figure 5-2 and Figure 5-3 show in each cell of 5x5km the relative number of ships that lose AIS contact with Dutch AIS base stations relative to the total number of observations. Sometimes the receipt of AIS messages is recovered after some time, which is the case in the center area of the Netherlands sea area. However, on most locations near the border of the Netherlands sea area it means that the ship has left the system until its next journey over the Netherlands sea area. Thus, the figure shows more or less the locations where ships are removed from the system. The ideal situation would be if the ships that leave the system are located outside the Netherlands sea area, which is the case on the west side of the NCS. The figures shows that AIS messages are missing in the most southwestern point of the NCS and on the route to Skagerrak in the northeastern part of the NCS.

The figures are for March and September 2012. September was chosen because it was known that some base stations were out of service around that time. March was chosen arbitrarily as a month which is expected to give a general idea of the coverage in 2012. In March, the picture is similar to that of 2011. The high traffic region close to the border with the UK and Belgium has a low coverage that month. The other areas with lower coverage lie outside the traffic separation schemes in the North, therefore, they do not contain so much traffic. In September, however, the area close to the border with the UK and Belgium has a better coverage, but there were some other base stations that didn't deliver data to the Netherlands Coastguard. This can be seen because there are many orange grid cells within two red circles higher up north. One of them is located close to the border with Germany and, unfortunately, this area also covers a traffic separation scheme with high traffic intensity.

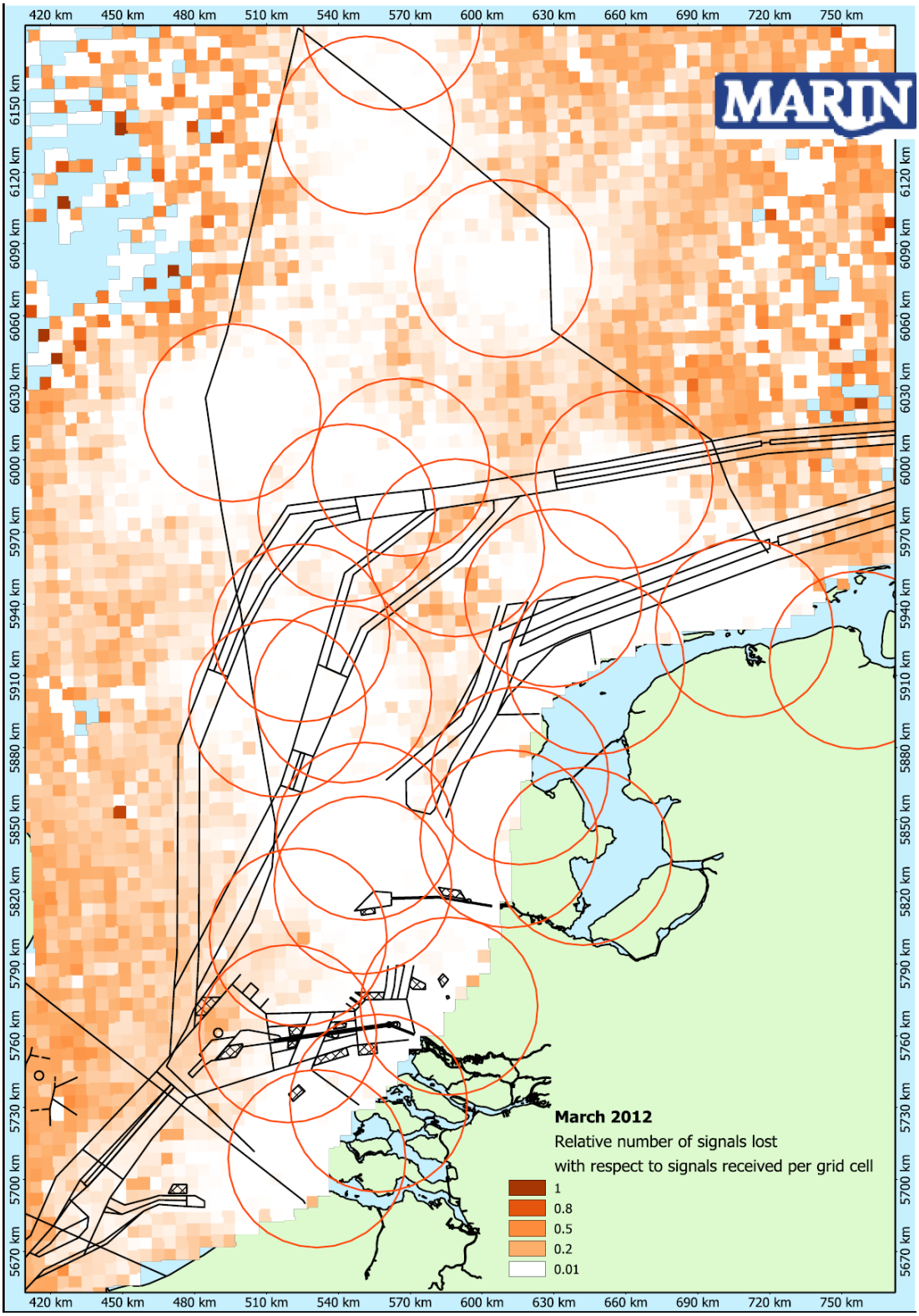

Figure 5-2 March 2012, relative number of signals lost with respect to signals received per grid cell, red circles mark the 20 nautical miles zones around the Dutch base stations

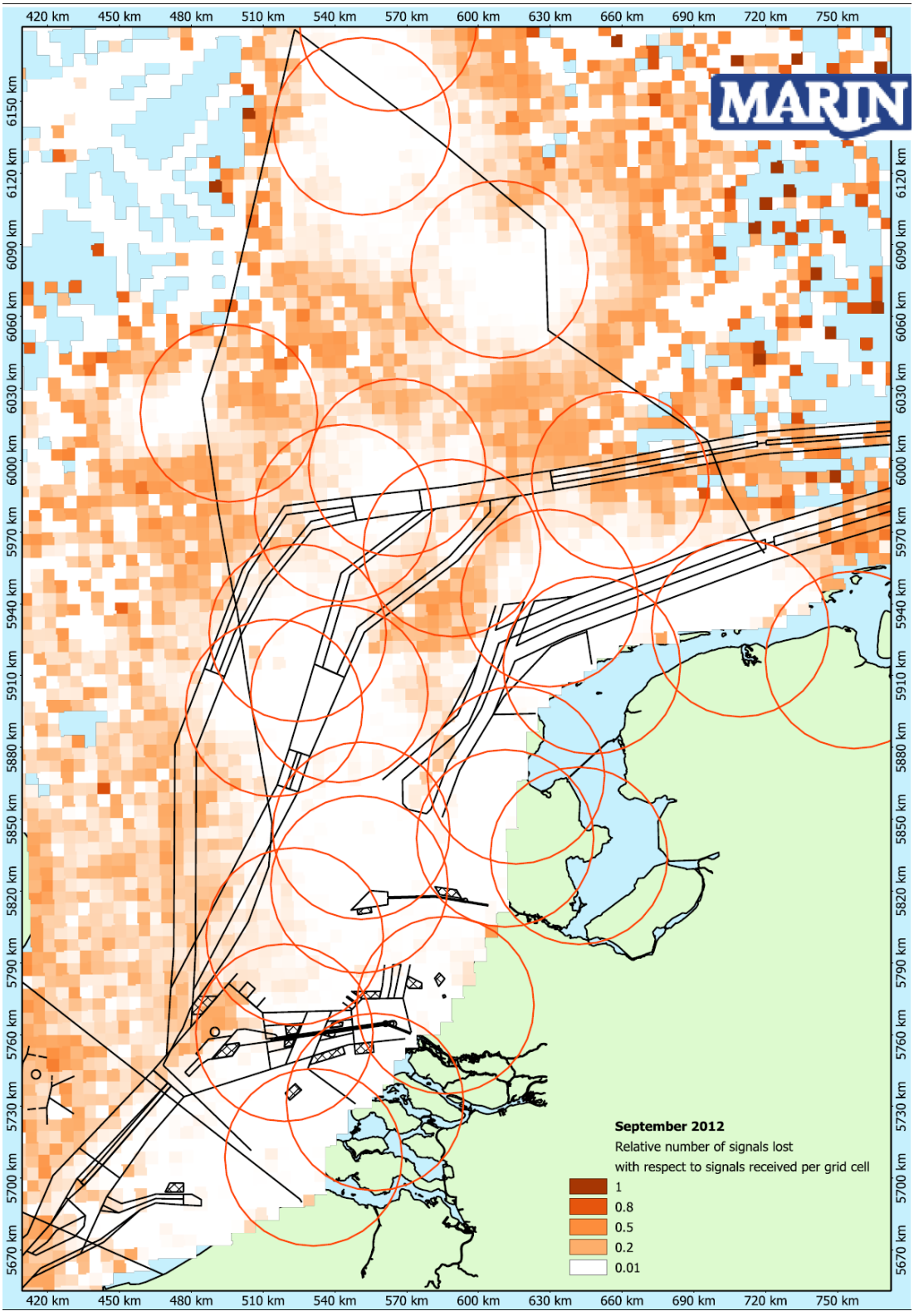

Figure 5-3 September 2012, Relative number of signals lost with respect to signals received per grid cell, red circles mark the 20 nautical miles zones around the Dutch base stations

5.2.4 Coverage in port areas

It was observed that between the 3rd and the 6th of February part of the data of the port areas was missing. Close to the sea some of the data was missing, further inland, more data was missing. Because of that, extra correction factors were introduced for the port areas, depending on the latitude/longitude within the port areas.

Port area	Latitude/Longitude	Correction factor
Western Scheldt		1.0086
Ems	Lat > 53˚15’	1.0086
	Lat > 53˚30’	1.0057
Amsterdam	Long > 4˚40’	1.0057
	Long > 4˚50’	1.0078
	Long > 5˚00’	1.0086
Den Helder		1.0071
Harlingen	Long > 5˚00’	1.0043
	Long > 5˚20’	1.0078
Rotterdam	Long > 4˚00’	1.0074
	Long > 4˚10’	1.0086

As in previous years, the AIS data for the Western Scheldt is corrected for bad coverage (see Section 5.2.5).

5.2.5 Correction for bad AIS coverage of moving ships close to the Belgian border in Western Scheldt

The results for moving ships on the Western Scheldt close to the Belgian border are scaled up to compensate for the bad AIS coverage. For the method used, refer to [1]. A location-based linear regression was used to correct for the decreased AIS coverage from line 2 (Figure 5-4) into Belgium. For each ship type and size class a specific factor was determined. The average multiplication factor over the ship type and size classes is visualized in Figure 5-4. The required factor was larger than in previous years, which means that the coverage decreased faster over the distance.

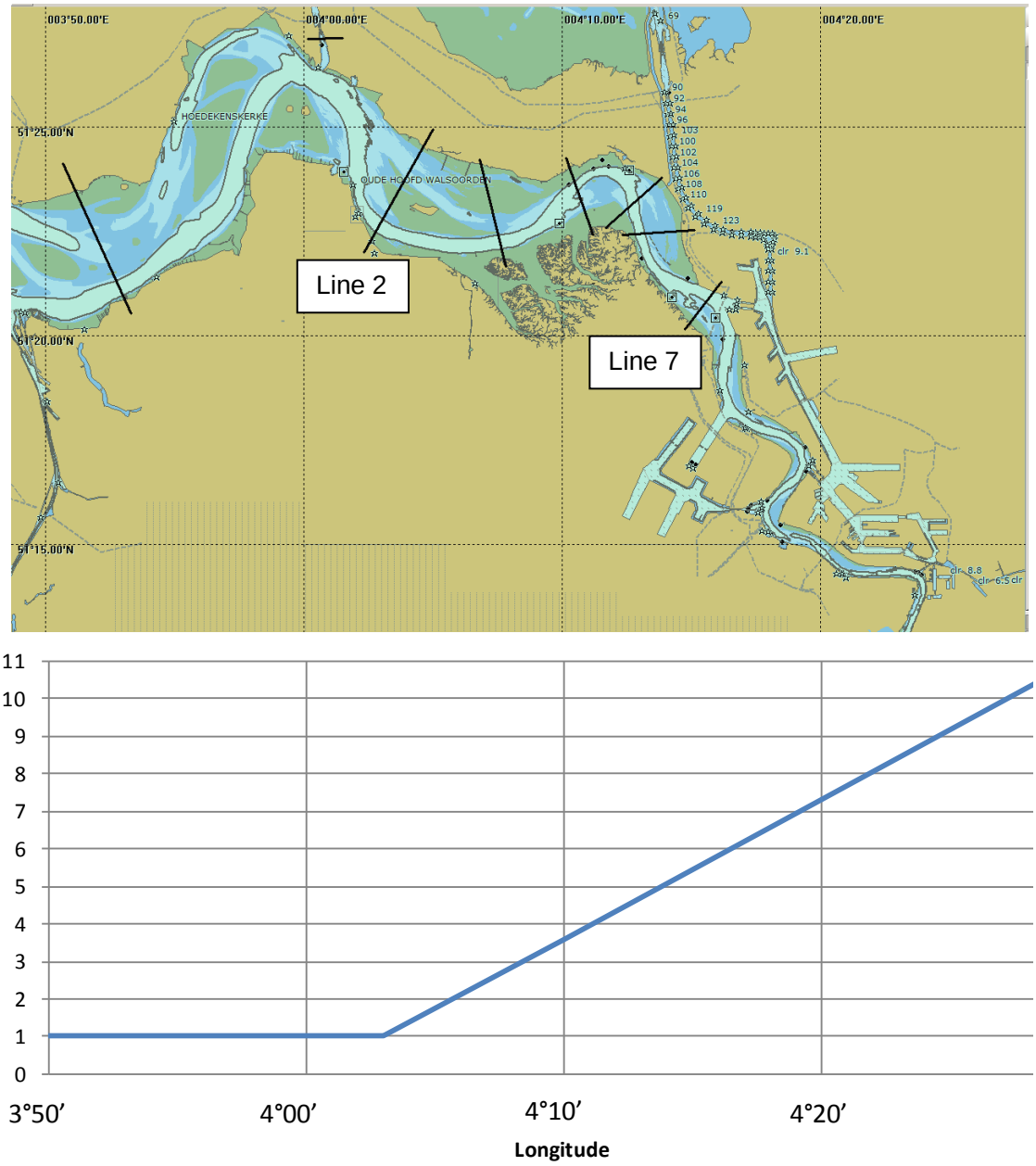

Figure 5-4 Crossing lines used to check coverage of AIS data in the Western Scheldt and average multiplication factor

6 ACTIVITIES OF SEAGOING VESSELS FOR 2012 AND COMPARISON WITH 2011 FOR THE DUTCH PORT AREAS AND THE NETHERLANDS SEA AREA

6.1 Introduction

This chapter presents the activities of seagoing vessels for 2012 in the Dutch port areas and in the Netherlands sea area. The activities of 2012 are compared to those of 2011. Values are presented as calculated and are not rounded off. Section 6.2 describes the activities in the port areas, Section 6.3 the activity in the Netherlands sea area and Section 6.4 the number of ships in these areas.

6.2 Activities of seagoing vessels in the Dutch port areas

Shipping activities in the six Dutch port areas are determined to calculate the emissions in these areas. The activities extracted from AIS are important explanatory parameters for the total emissions. The other parameter is the emission factor, which has been discussed in [1].

Table 6-1 presents activity numbers that could be extracted from the websites of some of the ports. First, the values of 2012 are shown and then the percentages with respect to 2011. The table contains the number of calls and the cargo handling for the main ports in each port area. The number of calls of Zeeland seaports could not be found. Table 6-1 shows a decrease in the number of calls for the Western Scheldt and for Rotterdam, a stable number for Amsterdam and an increase for the Ems.

Table 6-1 Number of calls extracted from websites of the ports

Port area	Ports	Number of calls		Cargo handling x 1000 tons	
		2012	2012/2011	2012	2012/2011
Western Scheldt	Antwerp	14552	95.5%	318,473*	100.6%
	Zeeland seaports (Vlissingen en Terneuzen)			33,993	95.7%
Rotterdam	Rijn- en Maasmondgebied	31789	97.1%	441,500	101.6%
Amsterdam	Noordzeekanaalgebied	7281	100.2%	94,268	100.0%
Ems	Delfzijl/Eemshaven	4593	122.7%	3,594	114.7%

* not cargo handling but GT (in 1000 ton)

The emission explaining variables for each port area are presented in a table per ship type and a table per ship size class in Table 6-2 through Table 6-13.

Western Scheldt

For moving ships in the Western Scheldt, the ships towards the port of Antwerp are most important. Table 6-2 and Table 6-3 show that the hours of moving ships decrease and the GT.nm increase. This is in line with the numbers in Table 6-1. The average speed increased with 2.3%. For berthed ships in the Dutch part of the Western Scheldt, the ports of Terneuzen and Vlissingen are important. The cargo handled in Terneuzen and Vlissingen decreases, while the hours and GT.hours at berth increases. When only looking at the ship types that transport cargo, Table 6-2 indeed shows an overall decrease in the hours for berthed ships, although the number of GT.hours still shows an increase.

Rotterdam

Table 6-4 and Table 6-5 for Rotterdam show that most of the activities have decreased in 2012 compared with 2011. This is in line with the reduction in the number of calls in Table 6-1. Only oil tankers, tug/supply and non-merchant ships showed an overall increase. The number of hours of moving ships has increased, which was mainly due to these same ship types that showed an overall increase. With the exception of oil tankers, these ship types have small sizes. Therefore, it is not surprisingly to see that the number of GT.nm of moving ships decreased. The large increase in non-merchant ships can be a real increase, but, more probably, it is caused by more ships that have installed an AIS transponder. The activities of the smallest ship size have increased, but there is a reduction for the slightly larger sizes. The average speed went up with 2%.

Amsterdam

Table 6-6 and Table 6-7 for Amsterdam indicate that bulk carriers are the pre-dominant ship type in this port area, followed by tankers and passenger ships. The activities of bulk carriers have decreased, while the activities of tankers and passenger ships have increased. Table 6-1 shows that the number of calls and cargo handled was very stable. This is in line with the observation that the number of hours was very stable. However, the number of GT.hours and GT.nm have increased with respectively 6.0% and 3.7%, the reason is the growth in size classes 4, 5 and 6 compensating the decrease in the smaller ship size.

Ems

Table 6-1 shows a large increase in the number of calls in Delfzijl and Eemshaven. This is supported by the large increase of berthed hours in Table 6-8 and Table 6-9. The moving ships on the Ems show a smaller increase. This is due to the fact that these values also contain the ships towards Emden. The average speed decreased with 1.2%

Den Helder and Harlingen

Table 6-10 to Table 6-13 for Den Helder and Harlingen show that these port areas contain less activities than the other port areas. Not all ship types and sizes are covered. In both port areas, most GT.nm of moving ships are from passenger vessels. Den Helder is the Dutch offshore port, therefore tugs and supply vessels are very important in this port. In Harlingen, most GT.hours for at berth are from general dry cargo vessels.

Table 6-2 Shipping activities per EMS type for the Dutch part of the Western Scheldt

Ship type	Totals for Western Scheldt in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	6,107	171,915,979	6,353	1,398,384,111	10.54	107.5%	116.9%	98.4%	96.5%	97.7%
Chem.+Gas tanker	32,056	314,059,474	43,908	3,930,506,647	11.13	86.3%	79.8%	97.2%	104.5%	103.1%
Bulk carrier	19,752	660,438,166	8,345	2,113,886,293	9.33	101.5%	109.5%	94.7%	97.9%	101.6%
Container ship	5,941	117,961,645	32,731	16,199,030,359	12.80	89.8%	215.7%	96.2%	105.4%	101.6%
General Dry Cargo	67,147	510,858,966	40,908	2,382,344,949	10.49	96.4%	108.9%	89.0%	100.6%	101.4%
RoRo Cargo / Vehicle	14,084	216,861,618	13,601	6,455,451,929	12.33	83.4%	92.4%	99.7%	108.2%	102.5%
Reefer	8,369	77,110,516	3,576	558,962,321	12.74	88.4%	102.4%	116.2%	118.9%	100.1%
Passenger	16,024	27,111,278	5,993	384,154,226	12.48	135.6%	188.3%	108.9%	174.3%	98.3%
Miscellaneous	108,419	312,428,280	21,443	437,401,571	7.60	93.9%	91.1%	76.7%	71.9%	103.1%
Tug/Supply	101,327	46,327,857	15,782	36,025,774	6.45	128.6%	143.2%	111.7%	109.9%	100.7%
Non Merchant	4,366	5,551,006	111	829,566	7.33	285.0%	291.8%	119.9%	181.5%	135.9%
Total	**383,592**	**2,460,624,785**	**192,750**	**33,896,977,746**	**11.83**	**103.0%**	**103.9%**	**94.1%**	**104.6%**	**102.3%**

Table 6-3 Shipping activities per EMS ships size classes for the Dutch part of the Western Scheldt

Ship size in GT	Totals for Western Scheldt in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	187,221	104,564,916	34,357	213,475,950	8.77	111.8%	104.2%	98.9%	92.5%	101.4%
1,600-3,000	55,464	126,589,791	35,274	784,395,160	9.39	95.6%	93.2%	77.8%	80.8%	102.8%
3,000-5,000	29,460	115,614,099	28,197	1,137,882,319	10.38	73.1%	71.8%	92.9%	92.9%	100.8%
5,000-10,000	40,399	270,080,063	25,819	2,181,166,737	11.56	108.1%	106.6%	98.6%	102.5%	102.2%
10,000-30,000	50,501	893,445,307	36,506	8,159,674,606	11.77	100.4%	111.1%	96.7%	98.3%	101.3%
30,000-60,000	17,664	713,152,942	24,432	12,744,613,926	11.97	110.8%	109.8%	108.1%	110.7%	101.7%
60,000-100,000	2,857	233,003,962	6,798	6,412,192,101	12.36	110.9%	111.0%	103.3%	106.4%	102.4%
>100,000	26	4,173,705	1,367	2,263,576,947	12.33	5.5%	7.7%	106.4%	112.5%	105.5%
Total	**383,592**	**2,460,624,785**	**192,750**	**33,896,977,746**	**11.83**	**103.0%**	**103.9%**	**94.1%**	**104.6%**	**102.3%**

Table 6-4 Shipping activities per EMS type for the Rotterdam port area

Ship type	Totals for Rotterdam in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	62,695	4,277,781,102	6,245	1,905,076,926	6.33	110.1%	107.2%	105.3%	103.8%	104.7%
Chem.+Gas tanker	105,126	1,426,828,175	22,860	1,784,824,989	8.01	97.4%	104.2%	99.9%	102.2%	100.6%
Bulk carrier	70,541	4,390,829,249	3,467	947,184,017	5.96	80.0%	82.7%	83.4%	84.9%	101.6%
Container ship	172,501	6,348,615,081	29,095	5,132,049,134	7.07	97.0%	103.5%	88.2%	89.7%	99.8%
General Dry Cargo	86,716	470,076,740	21,580	721,781,008	8.95	75.8%	79.3%	86.4%	93.4%	104.4%
RoRo Cargo / Vehicle	29,539	701,397,334	7,349	1,694,638,152	9.49	104.6%	101.5%	100.5%	100.6%	100.0%
Reefer	2,067	15,930,783	759	62,625,430	9.59	64.0%	58.5%	71.1%	69.6%	105.6%
Passenger	13,615	705,649,416	1,782	1,020,843,539	10.53	98.5%	100.8%	97.3%	100.4%	102.7%
Miscellaneous	78,046	1,231,100,662	17,630	480,063,631	6.45	81.5%	104.6%	112.2%	112.2%	114.0%
Tug/Supply	194,130	97,680,877	52,373	137,528,181	6.46	106.9%	109.2%	116.8%	129.6%	108.9%
Non Merchant	2,177	551,939	339	1,235,756	7.73	434.4%	239.0%	234.1%	184.4%	93.6%
Total	**817,153**	**19,666,441,358**	**163,480**	**13,887,850,764**	**7.44**	**94.1%**	**97.9%**	**101.0%**	**95.7%**	**102.0%**

Table 6-5 Shipping activities per EMS ships size class for the Rotterdam port area

Ship size in GT	Totals for Rotterdam in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average Speed	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	233,703	104,208,683	64,699	175,022,197	6.45	106.4%	104.3%	112.2%	102.6%	98.1%
1,600-3,000	59,754	146,125,495	17,637	387,741,501	9.03	73.4%	73.3%	86.6%	87.0%	101.1%
3,000-5,000	56,211	227,066,962	16,878	581,391,399	8.51	75.2%	76.8%	107.6%	105.9%	98.6%
5,000-10,000	120,417	898,290,820	24,538	1,630,355,696	8.90	92.4%	92.9%	89.8%	93.4%	103.1%
10,000-30,000	139,676	2,769,553,441	23,247	3,790,019,754	8.48	89.6%	88.6%	101.2%	98.2%	99.5%
30,000-60,000	90,574	3,902,727,518	8,592	2,748,487,783	7.55	100.5%	101.0%	91.3%	93.7%	104.1%
60,000-100,000	78,790	6,309,074,380	5,889	2,996,772,074	6.64	97.9%	97.5%	94.4%	96.4%	102.3%
>100,000	38,029	5,309,394,059	2,000	1,578,060,360	5.59	105.4%	105.0%	90.4%	92.7%	102.5%
Total	**817,153**	**19,666,441,358**	**163,480**	**13,887,850,764**	**7.44**	**94.1%**	**97.9%**	**101.0%**	**95.7%**	**102.0%**

Table 6-6 Shipping activities per EMS type for the Amsterdam port area

Ship type	Totals for Amsterdam in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	26,720	913,652,574	2,131	302,182,762	5.11	134.9%	129.3%	106.7%	103.6%	102.0%
Chem.+Gas tanker	50,585	953,784,694	6,686	549,947,750	5.64	133.0%	145.3%	115.5%	123.2%	101.3%
Bulk carrier	51,515	2,648,670,867	2,569	580,193,748	4.75	86.8%	90.7%	91.1%	92.9%	98.7%
Container ship	748	13,905,035	96	10,344,264	5.65	43.2%	45.4%	90.9%	111.2%	103.6%
General Dry Cargo	98,075	380,977,351	8,112	169,571,140	6.33	99.7%	105.7%	95.0%	100.8%	101.8%
RoRo Cargo / Vehicle	9,647	275,167,456	1,818	239,872,059	5.93	88.8%	95.1%	89.1%	94.4%	101.1%
Reefer	17,245	87,301,434	482	12,204,158	5.17	107.9%	115.7%	106.6%	112.4%	104.5%
Passenger	4,530	186,396,318	1,225	337,499,894	5.96	119.7%	131.6%	104.0%	110.2%	99.1%
Miscellaneous	38,799	252,798,436	2,312	48,530,320	4.89	90.2%	125.2%	76.3%	82.6%	98.9%
Tug/Supply	129,054	73,963,796	19,417	35,809,568	5.27	92.7%	96.7%	101.0%	101.8%	100.3%
Non Merchant	11,512	5,714,262	557	1,171,340	5.24	75.2%	68.5%	134.7%	100.9%	99.1%
Total	**438,431**	**5,792,332,222**	**45,406**	**2,287,327,002**	**5.40**	**98.4%**	**106.0%**	**99.6%**	**103.7%**	**100.8%**

Table 6-7 Shipping activities per EMS ships size classes for the Amsterdam port area

Ship size in GT	Totals for Amsterdam in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	155,378	73,172,668	21,758	46,984,500	5.65	88.5%	79.4%	98.4%	90.0%	100.9%
1,600-3,000	71,802	172,230,556	5,912	92,339,309	6.49	90.3%	93.1%	91.4%	93.3%	102.1%
3,000-5,000	28,157	112,599,348	2,887	75,525,629	6.50	85.1%	85.4%	93.1%	99.5%	107.2%
5,000-10,000	48,504	343,250,874	4,211	194,914,437	6.05	133.9%	131.2%	103.5%	107.1%	100.5%
10,000-30,000	65,919	1,470,484,693	5,911	653,314,599	5.51	120.1%	126.2%	116.0%	118.1%	100.3%
30,000-60,000	49,763	2,017,974,625	3,661	788,942,606	5.27	109.8%	107.0%	102.8%	102.6%	100.2%
60,000-100,000	18,883	1,599,678,057	1,053	427,244,382	4.86	90.4%	92.2%	93.5%	97.5%	101.4%
>100,000	25	2,941,402	12	8,061,541	5.76	24.6%	28.4%	20.1%	22.2%	98.0%
Total	**438,431**	**5,792,332,222**	**45,406**	**2,287,327,002**	**5.40**	**98.4%**	**106.0%**	**99.6%**	**103.7%**	**100.8%**

Table 6-8 Shipping activities per EMS type for the Netherlands part of the Ems area

Ship type	Totals for Ems in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	468	9,001,045	545	14,335,435	8.63	119.3%	999.8%	102.6%	197.9%	90.5%
Chem.+Gas tanker	4,423	25,018,181	2,020	105,313,398	10.48	138.8%	176.5%	112.5%	103.0%	95.9%
Bulk carrier	3,627	68,781,003	693	71,584,599	9.56	107.5%	127.9%	107.9%	100.7%	95.8%
Container ship	1,395	3,800,105	141	10,703,493	11.56	232.1%	164.5%	154.4%	113.6%	97.5%
General Dry Cargo	59,612	225,133,671	8,888	281,547,032	9.86	96.3%	92.9%	94.6%	88.4%	98.9%
RoRo Cargo / Vehicle	14,044	493,387,803	8,034	1,487,768,303	12.52	74.2%	93.2%	100.6%	95.5%	99.9%
Reefer	1,646	5,928,644	179	6,166,240	10.08	84.5%	122.7%	91.2%	99.7%	93.7%
Passenger	1,699	59,738,812	2,584	73,763,148	10.35	137.6%	193.9%	107.3%	120.4%	91.2%
Miscellaneous	35,904	50,339,429	13,647	309,933,376	7.40	109.2%	63.5%	98.6%	112.2%	104.6%
Tug/Supply	118,526	80,019,919	10,485	56,336,746	8.51	141.2%	191.6%	135.3%	180.2%	107.3%
Non Merchant	21	11,091	63	150,326	6.18	7.5%	14.5%	163.5%	131.4%	85.0%
Total	**241,364**	**1,021,159,704**	**47,280**	**2,417,602,095**	**10.80**	**115.7%**	**102.2%**	**105.8%**	**99.0%**	**98.8%**

Table 6-9 Shipping activities per EMS ships size classes for Netherlands part of the Ems area

Ship size in GT	Totals for Ems in 2012					2012 as percentage of 2011				
	Berthed		Moving			Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	134,886	55,053,026	19,406	87,915,775	9.40	136.6%	149.2%	111.5%	115.1%	100.9%
1,600-3,000	58,987	138,337,780	12,284	264,429,127	9.93	117.6%	120.2%	101.8%	102.4%	100.6%
3,000-5,000	17,198	66,573,952	6,366	215,845,067	8.31	69.8%	68.0%	95.6%	89.6%	100.2%
5,000-10,000	13,420	87,251,176	5,617	423,970,354	10.95	68.6%	68.7%	105.3%	99.3%	103.1%
10,000-30,000	6,692	125,604,041	1,908	361,400,960	10.91	119.5%	120.0%	124.2%	98.3%	91.0%
30,000-60,000	8,677	427,711,054	1,433	868,448,479	12.11	100.9%	101.0%	99.5%	97.3%	99.1%
60,000-100,000	1,067	65,698,652	237	172,667,838	11.68	99.3%	98.7%	106.5%	105.2%	99.1%
>100,000	439	54,930,021	28	22,924,494	6.59	191.3%	196.0%	170.8%	152.6%	87.3%
Total	**241,364**	**1,021,159,704**	**47,280**	**2,417,602,095**	**10.80**	**115.7%**	**102.2%**	**105.8%**	**99.0%**	**98.8%**

Table 6-10 Shipping activities per EMS type for the port area of Den Helder

Ship type	Totals for Den Helder in 2012				
	Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	2,773	49,718,184	79	7,421,220	5.25
Chem.+Gas tanker	96	334,504	3.0	160,342	9.52
General Dry Cargo	1,268	3,781,271	142	2,843,148	6.33
Passenger	7,172	78,945,632	2,955	348,517,149	8.99
Miscellaneous	33,880	87,359,323	1,986	14,483,363	4.86
Tug/Supply	77,499	135,808,535	4,940	57,651,186	6.09
Non Merchant	640	289,697	55	185,012	8.73
Total	**123,329**	**356,237,145**	**10,160**	**431,261,420**	**8.12**

Table 6-11 Shipping activities per EMS ships size classes for the port area of Den Helder

Ship size in GT	Totals for Den Helder in 2012				
	Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	55,197	31,888,404	2,727	9,365,860	5.99
1,600-3,000	49,782	112,413,019	3,992	52,077,258	5.83
3,000-5,000	6,550	23,209,402	340	7,402,132	6.00
5,000-10,000	1,095	7,651,184	68	2,514,987	5.60
10,000-30,000	10,705	181,075,136	3,034	359,901,184	8.79
Total	**123,329**	**356,237,145**	**10,160**	**431,261,420**	**8.12**

Table 6-12 Shipping activities per EMS type for the port area of Harlingen

Ship type	Totals for Harlingen in 2012				
	Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed
Chem.+Gas tanker	533	2,484,673	54	2,266,398	8.63
Container ship	61	143,970	15.4	387,854	9.01
General Dry Cargo	24,181	73,473,515	1,451	30,849,880	7.93
RoRo Cargo / Vehicle	5,439	9,525,152	2,394	38,621,111	9.25
Reefer	3,851	20,306,506	290	12,388,796	8.67
Passenger	13,208	24,246,118	5,104	165,599,029	12.23
Miscellaneous	31,625	21,418,884	4,225	32,883,384	7.35
Tug/Supply	18,297	9,472,516	869	3,148,930	7.97
Non Merchant	7,259	6,293,112	216	1,040,422	8.40
Total	104,453	167,364,446	14,618	287,185,805	10.14

Table 6-13 Shipping activities per EMS ships size classes for the port area of Harlingen

Ship size in GT	Totals for Harlingen in 2012				
	Berthed		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed
100-1,600	62,768	31,789,317	6,812	51,054,264	10.57
1,600-3,000	24,151	55,550,496	3,564	62,304,430	8.73
3,000-5,000	12,006	45,714,316	3,849	153,305,868	11.05
5,000-10,000	5,528	34,310,317	392	20,521,243	8.24
Total	104,453	167,364,446	14,618	287,185,805	10.14

6.3 Activities of seagoing vessels in the Netherlands sea area

The shipping activities in the Netherlands sea area are presented in Table 6-14 and Table 6-15. Again, 2012 is compared to 2011. The tables contain per ship type and size class:

- hours and GT.hours for not moving ships (at anchor), and
- hours, GT.nm and average speed for moving ships.

There were quite a number of decreases in the activities in the Netherlands sea area. Although the number of hours of ships at anchor has increased slightly in 2012 the GT.hours have decreased with 3.7% since the ships at anchor were smaller. The number of hours and GT.nm of moving ships have decreased with 5.3% and 3% respectively. the average speed has decreased with 1.4%. The decrease in numbers is partly realistic, reflecting a decrease in activity in Rotterdam, which is the largest port area in the region, and partly artificial, reflecting the fact that some base stations didn't work as well as in 2011.

Table 6-14 Shipping activities per EMS type for the Netherlands Continental Shelf and 12-mile zone

Ship type	Totals for NCS and 12-mile zone in 2012					2012 as percentage of 2011				
	Not moving / at anchor		Moving			Not moving / at anchor		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average speed
Oil tanker	122,639	5,281,532,325	82,210	40,370,356,734	10.90	93.0%	90.3%	97.4%	97.2%	99.1%
Chem.+Gas tanker	337,014	4,218,606,590	264,763	31,549,110,351	11.44	107.5%	107.3%	96.5%	99.4%	99.0%
Bulk carrier	51,968	2,424,043,339	89,999	32,882,044,780	11.07	84.1%	80.7%	96.3%	96.5%	101.8%
Container ship	79,183	2,217,159,995	183,774	108,346,869,567	14.57	132.1%	131.3%	91.9%	94.7%	95.9%
General Dry Cargo	82,901	413,983,726	417,912	17,295,343,286	10.85	77.3%	92.2%	91.2%	95.4%	100.1%
RoRo Cargo / Vehicle	7,020	235,158,183	119,123	54,021,917,342	15.50	177.8%	146.5%	99.6%	99.6%	97.5%
Reefer	5,342	40,739,123	17,177	2,043,123,871	15.17	82.9%	90.9%	82.1%	81.2%	100.1%
Passenger	5,582	14,923,721	24,089	17,677,477,842	17.27	17419.8%	2439.9%	109.1%	106.8%	98.8%
Miscellaneous	59,111	254,533,909	106,962	3,036,420,599	7.20	108.2%	47.2%	86.1%	81.8%	105.8%
Tug/Supply	83,544	121,595,691	168,421	1,386,099,258	6.74	96.8%	87.4%	103.9%	105.8%	102.3%
Non Merchant	9,191	1,028,415	4,655	33,119,493	11.62	6521.5%	2366.5%	150.7%	120.3%	99.0%
Total	**843,496**	**15,223,305,017**	**1,479,083**	**308,641,883,122**	**13.00**	**102.1%**	**96.3%**	**94.7%**	**97.0%**	**98.6%**

Table 6-15 Shipping activities per ship size class for the Netherlands Continental Shelf and 12-mile zone

Ship size in GT	Totals for NCS and 12-mile zone in 2012					2012 as percentage of 2011				
	Not moving / at anchor		Moving			Not moving / at anchor		Moving		
	Hours	GT.hours	Hours	GT.nm	Average speed	Hours	GT.hours	Hours	GT.nm	Average Speed
100-1,600	99,432	60,097,287	227,607	1,153,198,999	6.66	112.1%	93.0%	96.5%	87.2%	97.8%
1,600-3,000	109,359	264,446,460	337,393	7,320,495,624	9.08	95.0%	94.3%	91.5%	91.4%	99.6%
3,000-5,000	117,889	464,629,653	188,946	7,998,783,674	10.72	104.5%	103.4%	89.9%	90.0%	101.1%
5,000-10,000	122,635	923,170,002	198,738	17,643,705,032	12.23	96.5%	98.8%	93.2%	91.4%	97.8%
10,000-30,000	247,956	4,911,517,921	277,277	68,199,845,725	12.76	108.9%	111.0%	96.3%	92.9%	97.1%
30,000-60,000	92,278	3,863,952,912	150,202	89,811,131,783	13.73	101.7%	95.1%	102.8%	102.0%	98.9%
60,000-100,000	45,169	3,425,979,242	79,180	80,419,659,295	13.38	86.8%	88.3%	97.3%	95.5%	98.2%
>100,000	8,778	1,309,511,541	19,740	36,095,062,989	13.53	75.9%	76.8%	103.3%	102.9%	99.0%
Total	**843,496**	**15,223,305,017**	**1,479,083**	**308,641,883,122**	**13.00**	**102.1%**	**96.3%**	**94.7%**	**97.0%**	**98.6%**

6.4 Overview of ships in the port areas and in the Netherlands sea area

The average number of ships in the port areas and at sea is given in Table 6-16 and graphically depicted in Figure 6-1. Large differences between ports in the ratio of not moving ships over moving ships are observed. This is explained by the length of the route to the berth: the longer the route, the smaller the ratio. For Amsterdam with short routes a high ratio is found, for the Western Scheldt a small ratio is observed due to long sailing distances but also because most ships berth outside the area. Table 6-16 shows in addition that the average speed is quite different between the port areas, with an average of 5.40 knots for Amsterdam and 11.83 knots in the Western Scheldt.

Remark: The percentages in Table 6-16 for the average number of ships in 2012 compared with 2011 are the same as found earlier in Table 6-2 through Table 6-9 and Table 6-15 under the column ”Hours”. This is because the average number of ships has been calculated by dividing the number of hours of ship observations by the number of hours in 2012. The number of moving ships in the Den Helder has, for example, been calculated by diving 10,160 hours of ship observations by 24 x 366 = 8784 hours in 2012. The result is the average number of 1.16 moving ships in the port area.

The average GT of the ships is given in Table 6-17. The average GT of a ship in Rotterdam is more than 4 times higher than that of a ship in the Ems. Den Helder and Harlingen have even smaller vessels visiting their ports. In Rotterdam and Amsterdam, the average GT of not moving (thus mostly berthed) ships is larger than that of moving ships, which is caused by a shorter sailing distance and a longer time needed for cargo handling for larger ships. The average GT shows an increase in four out of five areas, while the average GT in the Ems shows a decrease of more than 10%.

From these figures it can be concluded that due to the large differences in ship types, sizes, and speeds between the different areas, it is absolutely necessary to describe the shipping activities in large detail, in order to determine the emissions in these areas. The AIS data offer the opportunity to incorporate all these characteristics in the calculations.

Table 6-16 Average number of ships in distinguished areas

Area	In 2012				In 2012 as % percentage of 2011			
	Average # ships			Speed	Average # ships			Speed
	Not moving	Moving	Total	Knots	Not moving	Moving	Total	Knots
Western Scheldt	43.79	22.00	65.79	11.83	103.0%	94.1%	99.8%	102.3%
Rotterdam	93.28	18.66	111.94	7.44	94.1%	101.0%	95.2%	102.0%
Amsterdam	50.05	5.18	55.23	5.40	98.4%	99.6%	98.5%	100.8%
Ems	27.55	5.40	32.95	10.80	115.7%	105.8%	113.9%	98.8%
Den Helder	14.08	1.16	15.24	8.12				
Harlingen	11.92	1.67	13.59	10.14				
NCS + 12-mile zone	96.29	168.85	265.13	13.00	102.1%	94.7%	97.2%	98.6%

Table 6-17 Average GT of ships in distinguished areas

Area	In 2012			In 2012 as percentage of 2011		
	Average GT of ships			Average GT of ships		
	Not moving	Moving	Total	Not moving	Moving	Total
Western Scheldt	6,415	14,871	9,243	100.9%	108.6%	103.2%
Rotterdam	24,067	11,420	21,959	104.1%	92.9%	102.5%
Amsterdam	13,212	9,333	12,848	107.7%	103.3%	107.3%
Ems	4,231	4,733	4,313	88.3%	94.7%	89.3%
Den Helder	2,889	5,228	3,067			
Harlingen	1,602	1,938	1,644			
NCS + 12-mile zone	18,048	16,047	16,774	94.3%	103.9%	100.3%

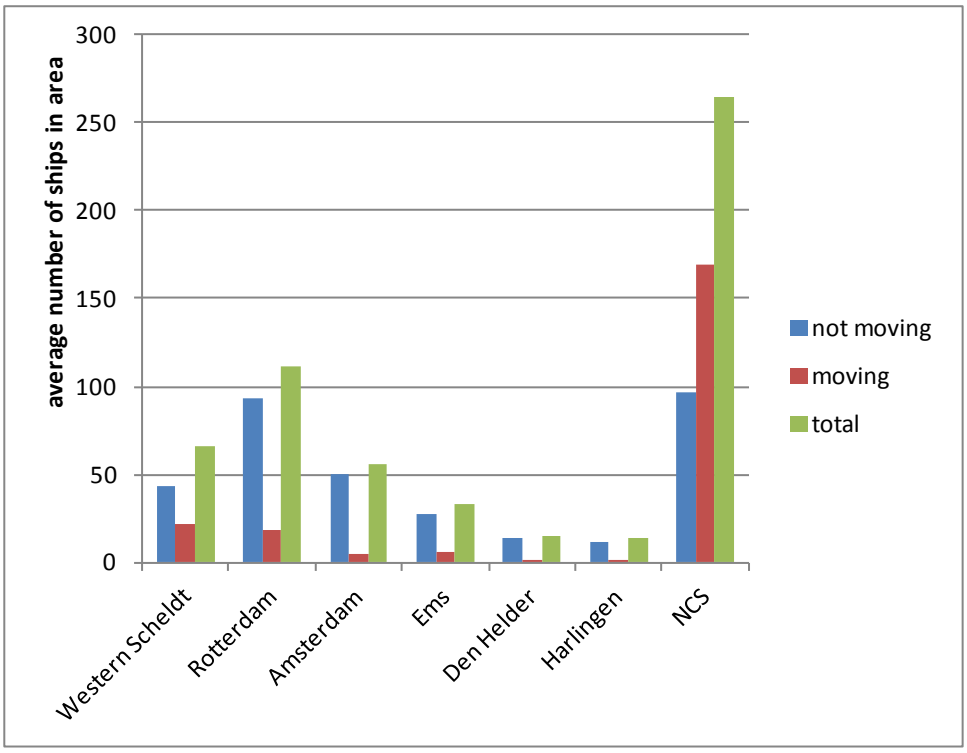

Figure 6-1 Average number of ships in areas considered

7 EMISSIONS FOR THE DUTCH PORT AREAS AND THE NETHERLANDS SEA AREA

7.1 Introduction

This chapter presents the results of the emission calculations for 2012 for the Dutch port areas and the Netherlands sea area. To see how the emissions evolve, all values for 2012 are compared with the values of 2011. Values are presented as calculated and are not rounded off.

The emissions for the port areas are given in Section 7.2 and for the NCS and 12-mile zone in Section 7.3. Section 7.4 presents the spatial distribution of the 2012 NO_x emissions. Also the change in these emissions compared to 2011 is presented.

In 2012 there were no new insights or changes in policy that required adaptation of emission factors. Therefore, there are no changes in emissions due to changed emission factors.

7.2 Emissions in port areas

Table 7-1 contains the emissions for the six Dutch port areas, calculated for ships berthed and sailing within the port area. Table 7-2 contains the same emissions expressed as a percentage of the corresponding emissions in 2011. As the emissions for Harlingen and Den Helder were not calculated in 2011, Table 7-2 only contains four port areas. Note that values for at berth include all vessels with zero speed, so also the vessels at anchor.

When looking at Table 7-2, the following changes in emission between 2011 and 2012 occurred for all substances:

- Amsterdam: a large increase (more than 6%), mainly for ships at berth (more than 14%);
- Ems: a smaller increase (more than 2%), mainly for moving ships (more than 3%);
- Western Scheldt and Rotterdam: only slight changes with respect to 2011, varying between 2% increase and a 2.6% decrease.

When looking at NO_x emissions only, there is an increase in three out of four port areas; only in Rotterdam there is a slight decrease of 0.4%, even though Maasvlakte 2 is for the first time included in these results. Summarized over all port areas there is an increase of 3.7%.

Summarized for the port areas, it can be concluded that without looking at the emission changes per ship type and size, it remains difficult to explain changes in emissions by changes in total number of ships, hours, GT.hours or GT.nm. The reason is that underlying changes in the traffic composition and used speed are not described by these totals. Therefore, it is important that emissions are calculated for each individual ship observed in the AIS data.

Table 7-1 Total emissions in ton in each port area for 2012 based on AIS data

Substance	Source	Western Scheldt	Rotter-dam	Amster-dam	Ems	Den Helder	Harling-en	Total
1237 VOC	Berthed	33	232	69	12	6	3	356
	Sailing	277	163	30	27	4	8	509
	Total	**310**	**395**	**99**	**39**	**11**	**12**	**865**
4001 SO_2	Berthed	62	453	126	27	13	6	687
	Sailing	2,451	1,266	186	193	28	37	4,160
	Total	**2,513**	**1,719**	**312**	**220**	**41**	**43**	**4,847**
4013 NO_x	Berthed	778	4,975	1,497	302	180	88	7,820
	Sailing	9,539	4,544	717	804	111	237	15,952
	Total	**10,316**	**9,519**	**2,215**	**1,105**	**291**	**326**	**23,772**
4031 CO	Berthed	155	1,085	325	62	35	16	1,678
	Sailing	1,884	1,211	210	163	32	42	3,542
	Total	**2,040**	**2,296**	**535**	**224**	**67**	**58**	**5,220**
4032 CO_2	Berthed	66,142	555,023	164,844	22,750	11,784	5,131	825,674
	Sailing	413,203	220,066	34,650	38,713	6,445	11,011	724,089
	Total	**479,345**	**775,089**	**199,494**	**61,463**	**18,229**	**16,143**	**1,549,763**
6601 Aerosols MDO	Berthed	17	121	35	7	3	2	184
	Sailing	68	53	10	10	2	6	149
	Total	**85**	**174**	**44**	**17**	**5**	**8**	**333**
6602 Aerosols HFO	Berthed	0	0	0	0	0	0	0
	Sailing	365	171	24	24	3	1	588
	Total	**365**	**171**	**24**	**24**	**3**	**1**	**588**
6598 Aerosols MDO+HFO	Berthed	17	121	35	7	3	2	184
	Sailing	433	224	33	34	5	7	737
	Total	**450**	**345**	**68**	**41**	**8**	**9**	**921**

Table 7-2 Emissions in each port area for 2012 as percentage of the emissions in 2011

Substance	Source	Western Scheldt	Rotter-dam*	Amster-dam	Ems	Total
1237 VOC	Berthed	100.8%	106.2%	117.3%	102.9%	110.7%
	Sailing	99.4%	93.6%	100.2%	107.3%	100.3%
	Total	***99.5%***	***100.6%***	***111.6%***	***105.9%***	***104.3%***
4001 SO_2	Berthed	103.7%	102.6%	115.4%	102.6%	107.9%
	Sailing	102.0%	95.7%	101.6%	103.8%	101.6%
	Total	***102.0%***	***97.4%***	***106.8%***	***103.7%***	***102.4%***
4013 NO_x	Berthed	102.8%	105.9%	114.0%	102.2%	110.7%
	Sailing	100.4%	93.5%	100.5%	103.2%	100.6%
	Total	***100.5%***	***99.6%***	***109.2%***	***102.9%***	***103.7%***
4031 CO	Berthed	101.8%	104.8%	117.5%	102.8%	110.1%
	Sailing	101.5%	94.8%	101.6%	107.0%	101.4%
	Total	***101.5%***	***99.3%***	***110.7%***	***105.8%***	***104.0%***
4032 CO_2	Berthed	99.6%	103.9%	123.2%	105.7%	109.2%
	Sailing	101.2%	96.0%	102.1%	105.3%	102.3%
	Total	***101.0%***	***101.5%***	***119.0%***	***105.4%***	***105.9%***
6601 Aerosols MDO	Berthed	101.4%	106.4%	114.8%	102.0%	110.2%
	Sailing	100.8%	97.4%	107.1%	107.8%	106.0%
	Total	***100.9%***	***103.4%***	***113.0%***	***105.4%***	***108.3%***
6602 Aerosols HFO	Berthed					
	Sailing	101.5%	94.6%	98.7%	101.3%	99.9%
	Total	***101.5%***	***94.6%***	***98.7%***	***101.3%***	***99.9%***
6598 Aerosols MDO+HFO	Berthed	101.4%	106.4%	114.8%	102.0%	110.2%
	Sailing	101.4%	95.2%	101.0%	103.1%	101.1%
	Total	***101.4%***	***98.9%***	***107.6%***	***102.9%***	***102.8%***

*2011 values are excluding Maasvlakte 2, 2012 values are including Maasvlakte 2

7.3 Emissions in the Netherlands sea area

The emissions in the NCS and the 12-mile zone are calculated for moving and non-moving ships. Ships are counted as non-moving when the speed is less than 1 knot. Mostly this concerns ships at anchor in one of the anchorage areas. However, some ships may have such a low speed for a while when waiting for something (for a pilot, for permission to enter a port or for another reason). Based on the observed speed in AIS, the emission has been calculated for the main engine and for the auxiliary engines.

The calculated emissions for 2012 are summarised in Table 7-3. This table also contains a comparison with 2011. The average number of moving ships has changed significantly with a decrease of 5.3%. The decrease in emissions of these ships is for most substances even higher due to the lower average speed that was observed (-1.4% as described in Section 6.3). Only for CO and Aerosols MDO there was a smaller emission decrease.

The average number of not moving ships (mainly anchored ships) increased with 2.1%. For all substances the increase in emission was larger. A possible explanation is that there was an increase in not moving passenger ships (Table 6-14). The number of hours of this group is still very low, but also without moving, passenger ships still have a considerable energy consumption, and thus emission.

Table 7-3 Emissions of ships in ton in the Netherlands sea area for 2012 compared with 2011

Nr	Substance	Emission in ton in 2012			Emission in 2012 as percentage of 2011		
		Not moving	Moving	Total	Not moving	Moving	Total
1237	VOC	81	2,108	2,189	104.05%	92.52%	92.90%
4001	SO_2	759	20,960	21,718	108.57%	92.92%	93.39%
4013	NO_x	2,428	79,105	81,533	103.74%	91.37%	91.70%
4031	CO	502	13,670	14,172	105.75%	95.79%	96.11%
4032	CO_2	145,626	3,476,123	3,621,749	106.33%	92.85%	93.32%
6601	Aerosols MDO	132	394	526	108.29%	96.66%	99.34%
6602	Aerosols HFO	0	3,256	3,256		92.40%	92.40%
6598	Aerosols MDO+HFO	132	3,650	3,782	108.29%	92.84%	93.30%
Ships		96.29	168.85	265.13	102.14%	94.65%	97.24%

7.4 Spatial distribution of the emissions

Because of the strong relation between shipping routes and location of the emissions, all substances show more or less the same spatial distribution. Therefore, only the spatial distribution of NO_X is presented for the six Dutch port areas and the Netherlands sea area in Figure 7-1 to Figure 7-17.

Three figures are composed for the port areas that were also covered in 2011. The first figure represents the total emission (emissions of auxiliary and main engine of moving and non moving ships together) expressed as NO_x in ton/km^2. The second one shows the *absolute* change in emission between 2011 and 2012 and the third one shows the *relative* change in emission between 2011 and 2012. For Den Helder and Harlingen only the first figure is included. To make a comparison between areas easier the same colour table has been used for all areas.

In the figures, large differences between 2011 and 2012 are visualized by darker colours. Absolute differences are often larger at locations with high traffic intensity, while relative differences are often larger at locations with low traffic intensity. This has to be kept in mind when interpreting the figures.

The area of Rotterdam has been expanded this year to incorporate Maasvlakte 2. This can be seen in Figure 7-4. In July 2012, this area was closed from the sea and in November, the opening with the Yangtze haven was realized. In 2012, the activities in this area still consisted of construction work. In the 2011 report, the activities in Maasvlakte 2 were part of the 12-miles zone.

The comparisons with 2011 for the Western Scheldt and the Netherlands sea require some extra explanations that will be given below.

Figure 7-2 for the Western Scheldt shows an increase in absolute emissions in the most eastern side of the river, while there is a slight decrease at the western side of the river. This is due to the correction for bad AIS coverage that is described in section 5.2.5. It is not certain whether the decrease at the western site or the increase at the eastern site are realistic. After checking the analyses, it turned out, that the coverage for small vessels is already impaired at line 2 (see Figure 5-4). In 2011, the coverage at line 2 was quite good from size class 3 upwards. In 2012 this is only true for size class 5 and upwards. As described in Section 6.2, a slight increase in the GT in the port of Antwerp was seen and the average speed of ships at the Western Scheldt increased with 2.3%. This makes an increase in emissions more likely than the observed decrease at the western side of the river. Figure 7-2 shows that west of the location where the compensation for bad AIS coverage starts, the green colour turns darker towards the east. This means that the emissions decrease more towards the east. Probably, this decrease is already caused by bad coverage. In general it can be concluded that the coverage problems in the Western Scheldt are more complicated in 2012 than in previous years, which means that a correct compensation would become a study on its own.

Figure 7-16 shows that there is a large absolute emission reduction on the busiest routes of the Netherlands sea area. This corresponds with the 8% emission reduction that is reported in Table 7-3. Table 7-2 doesn't show a similar reduction in the Dutch port areas. Moreover, Figure 7-16 shows that the reduction is mainly caused by ships crossing the Netherland sea area without calling a Dutch port. These are for example ships from the Channel to the Baltic and vice versa. It means that there have been less ships or cleaner ships on these routes.

Figure 7-17 shows that there also are some areas with a large relative emission decrease. These areas correspond with the areas with bad AIS coverage from Figure 5-3 for September 2012. Unfortunately, this implies that part of the emission reduction is due to decreased coverage of the AIS base stations. A large improvement of the coverage is not expected for 2013, but in the beginning of 2014. Five new base stations that have been planned for a long time have been added in February 2014 and some other base stations have been turned into service again.

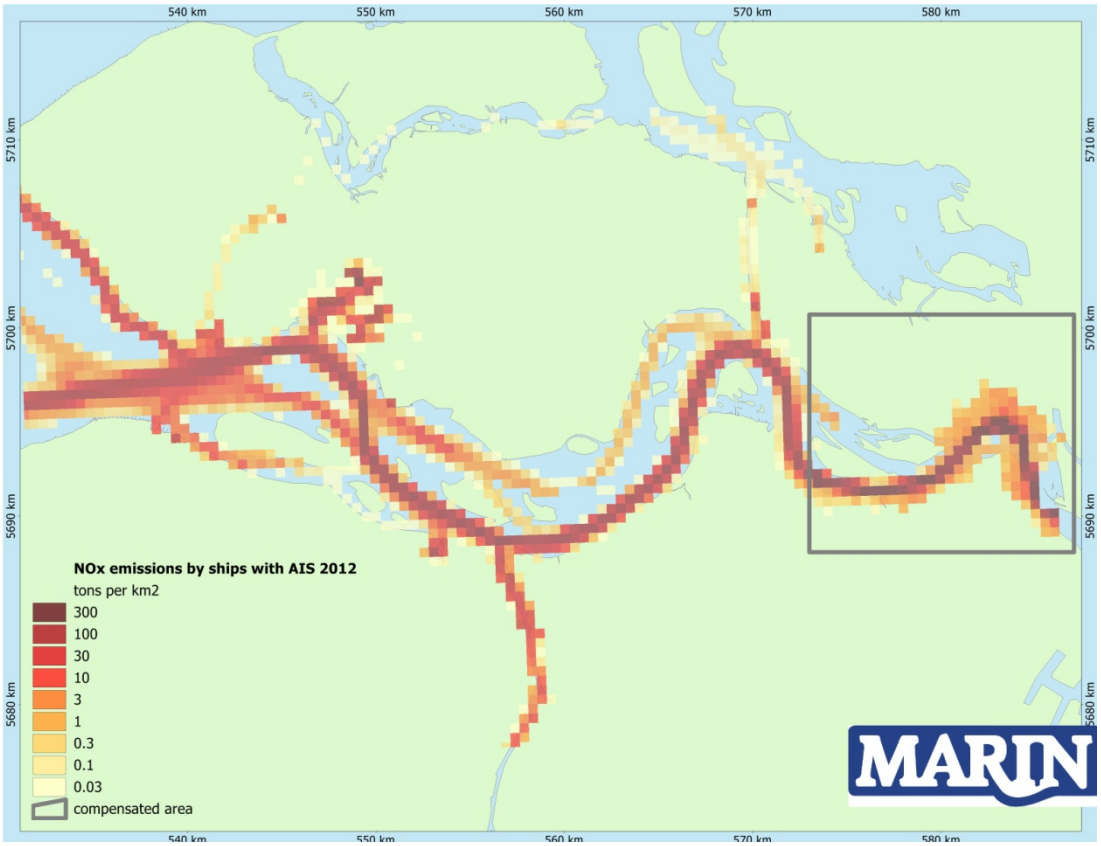

Figure 7-1 NO_x emission in 2012 in the Dutch part of the Western Scheldt by ships with AIS. The emissions have been corrected for bad AIS coverage

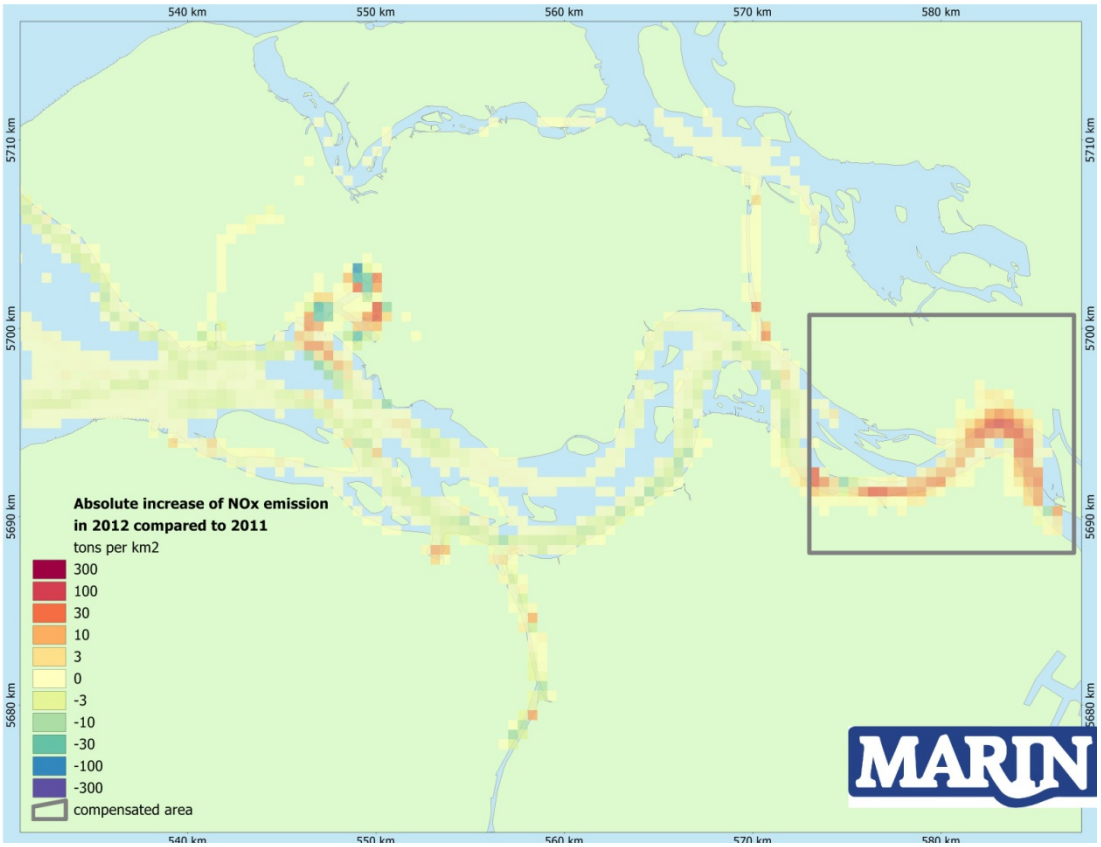

Figure 7-2 **Change in NO_x emission from 2011 to 2012 in the Dutch part of the Western Scheldt by ships with AIS**

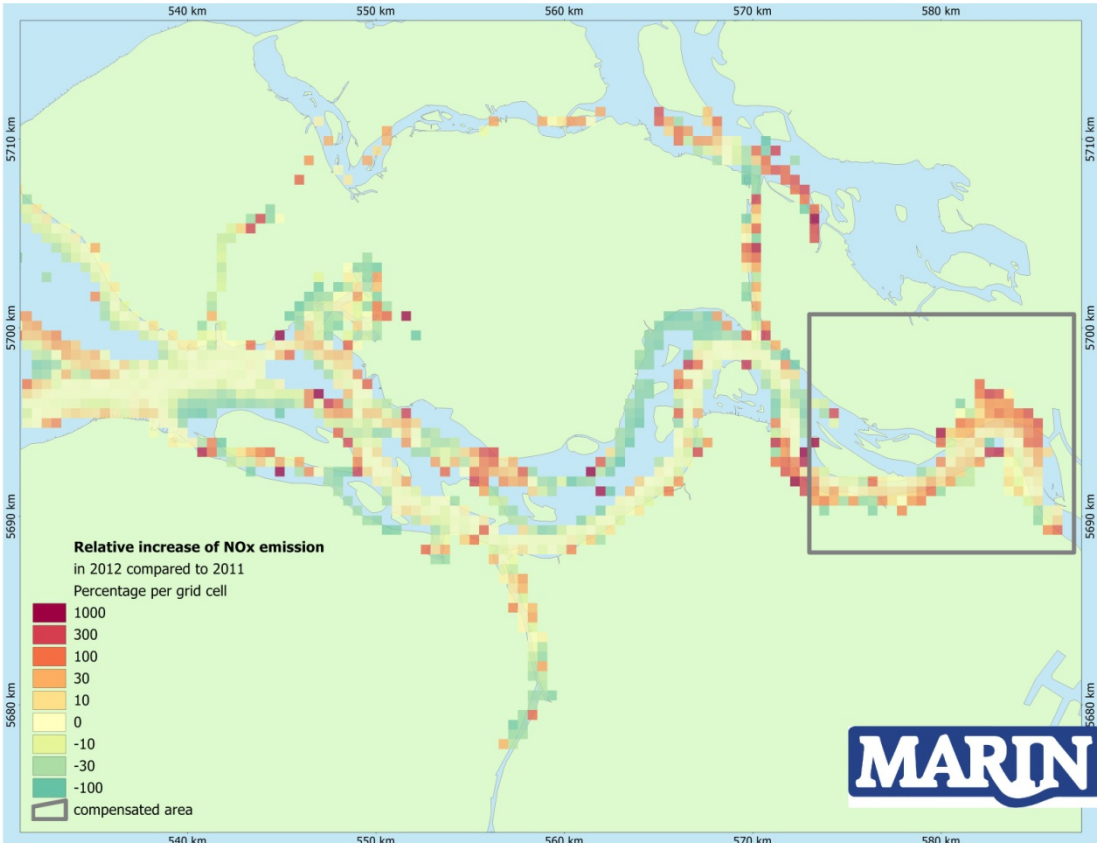

Figure 7-3 **Relative change in NOx emission from 2011 to 2012 in the Dutch part of the Western Scheldt by ships with AIS**

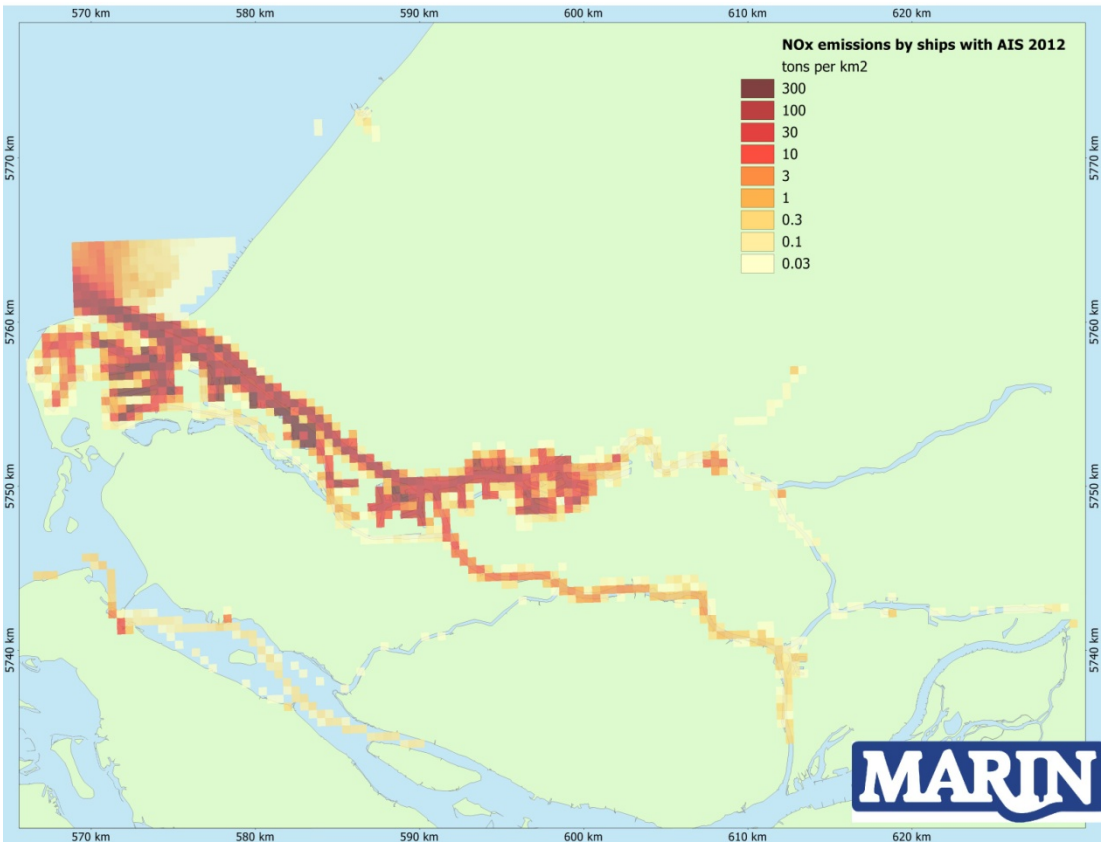

Figure 7-4 **NO_x emission in 2012 in the port area of Rotterdam by ships with AIS. The area has been enlarged in 2012 to incorporate Maasvlakte 2.**

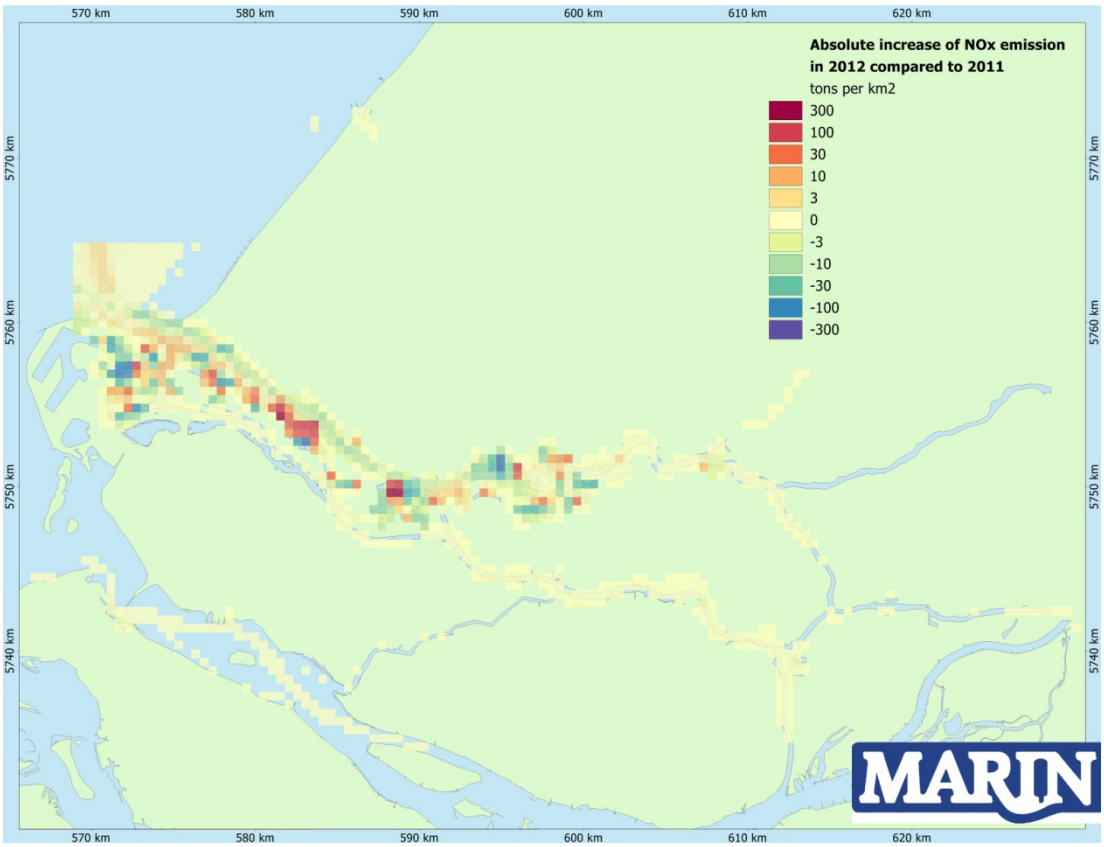

Figure 7-5 **Absolute change in NO_x emission from 2011 to 2012 in the port area of Rotterdam by ships with AIS, for the port area in 2011**

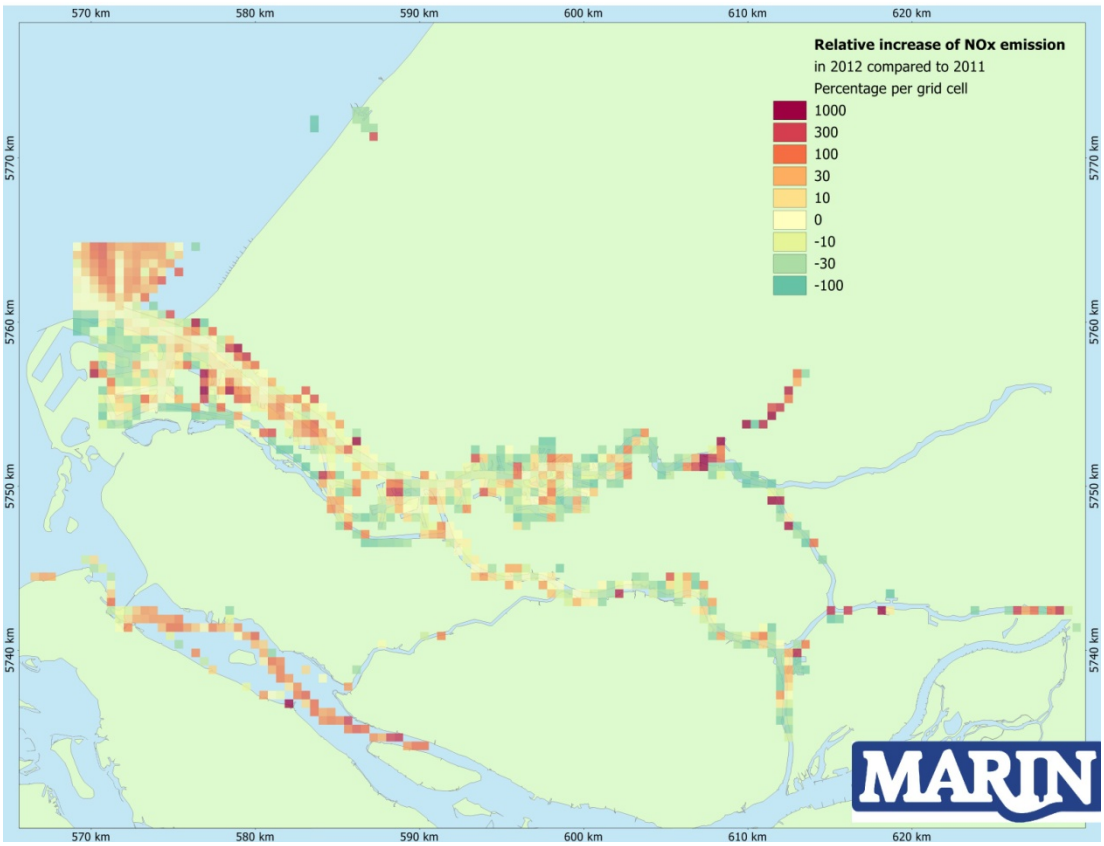

Figure 7-6 **Relative change in NO_x emission from 2011 to 2012 in the port area of Rotterdam by ships with AIS, for the port area in 2011**

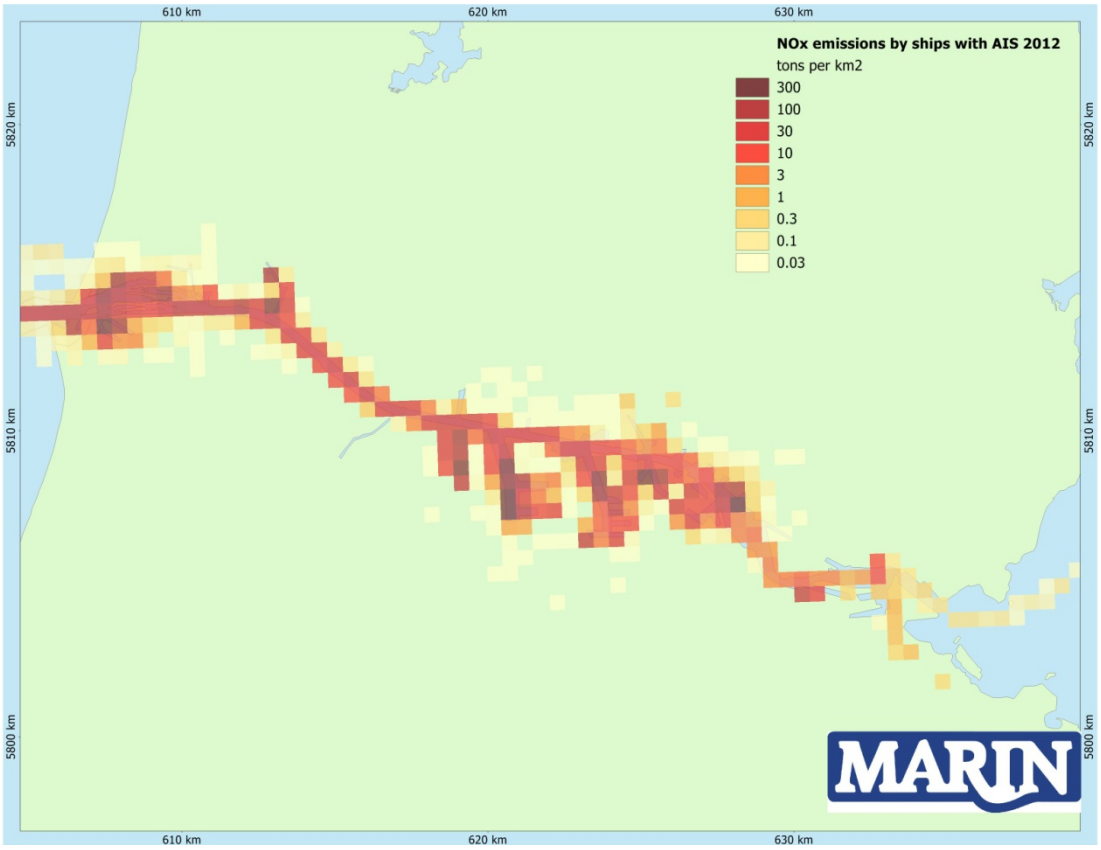

Figure 7-7 **NO_x emission in 2012 in the port area of Amsterdam by ships with AIS**

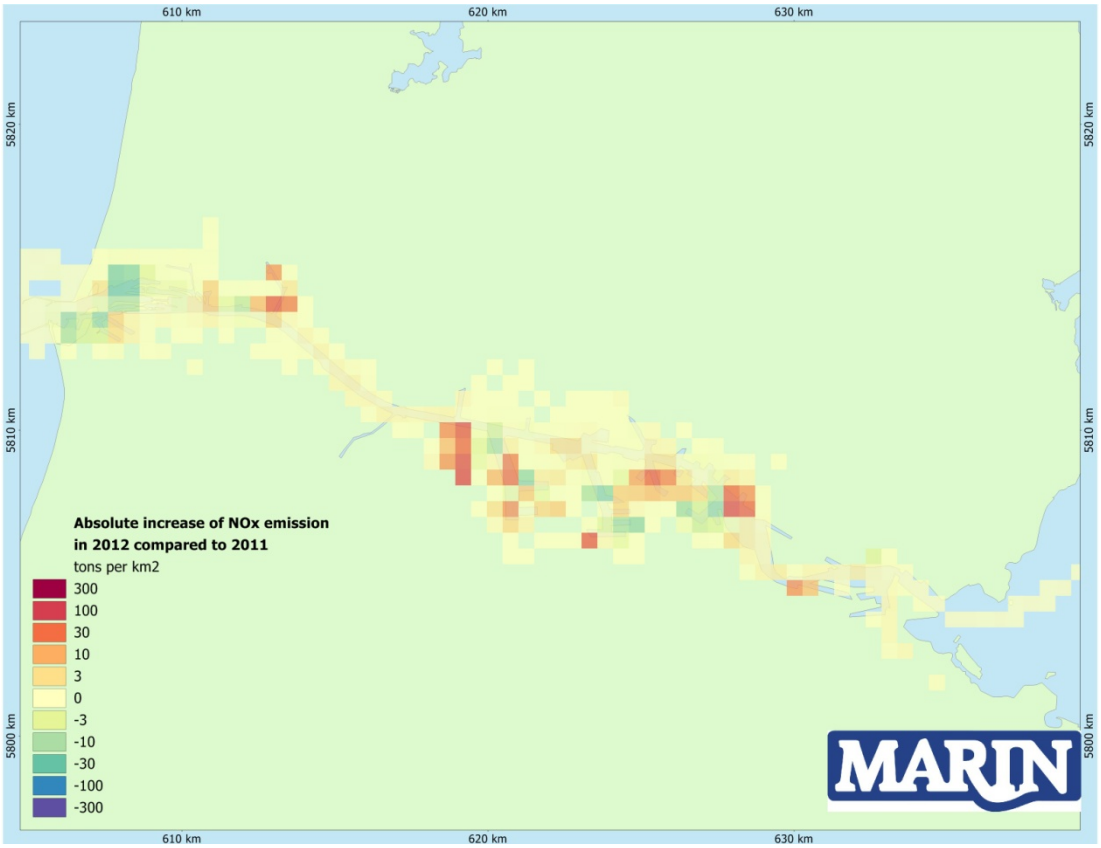

Figure 7-8 **Absolute change in NOx emission from 2011 to 2012 in the port area of Amsterdam by ships with AIS**

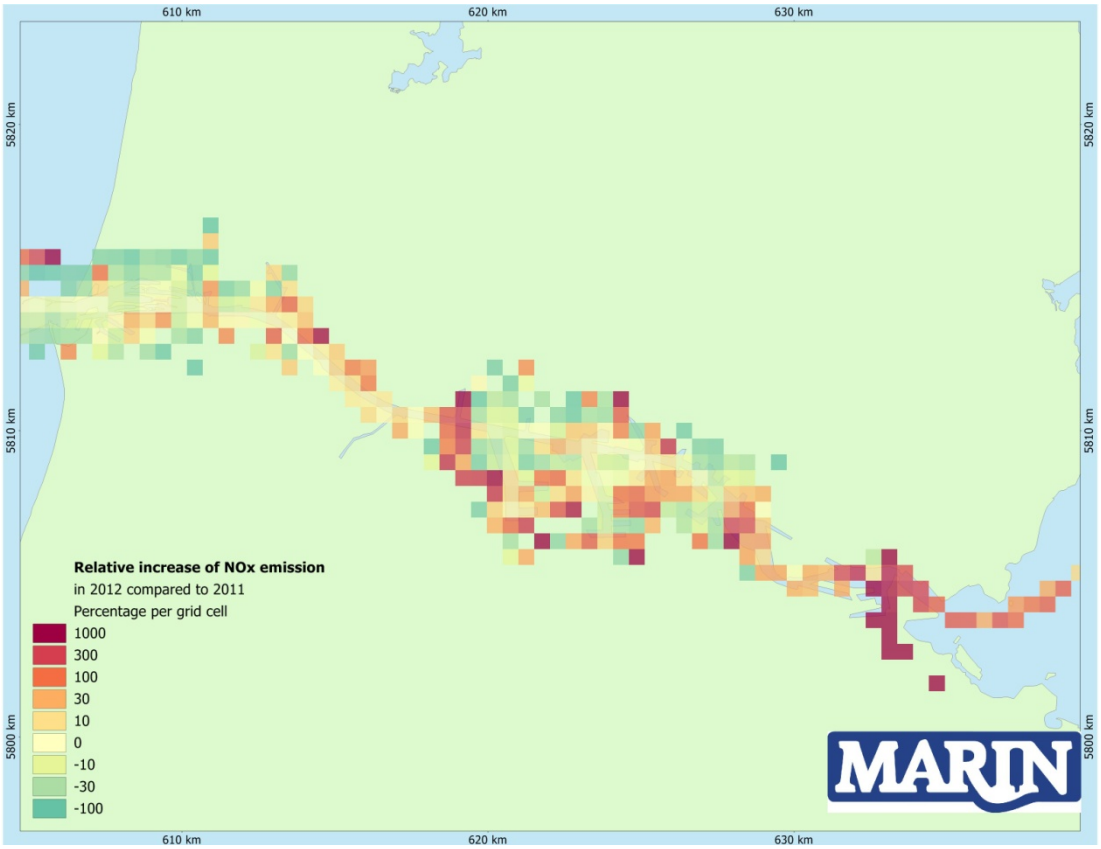

Figure 7-9 **Relative change in NOx emission from 2011 to 2012 in the port area of Amsterdam by ships with AIS**

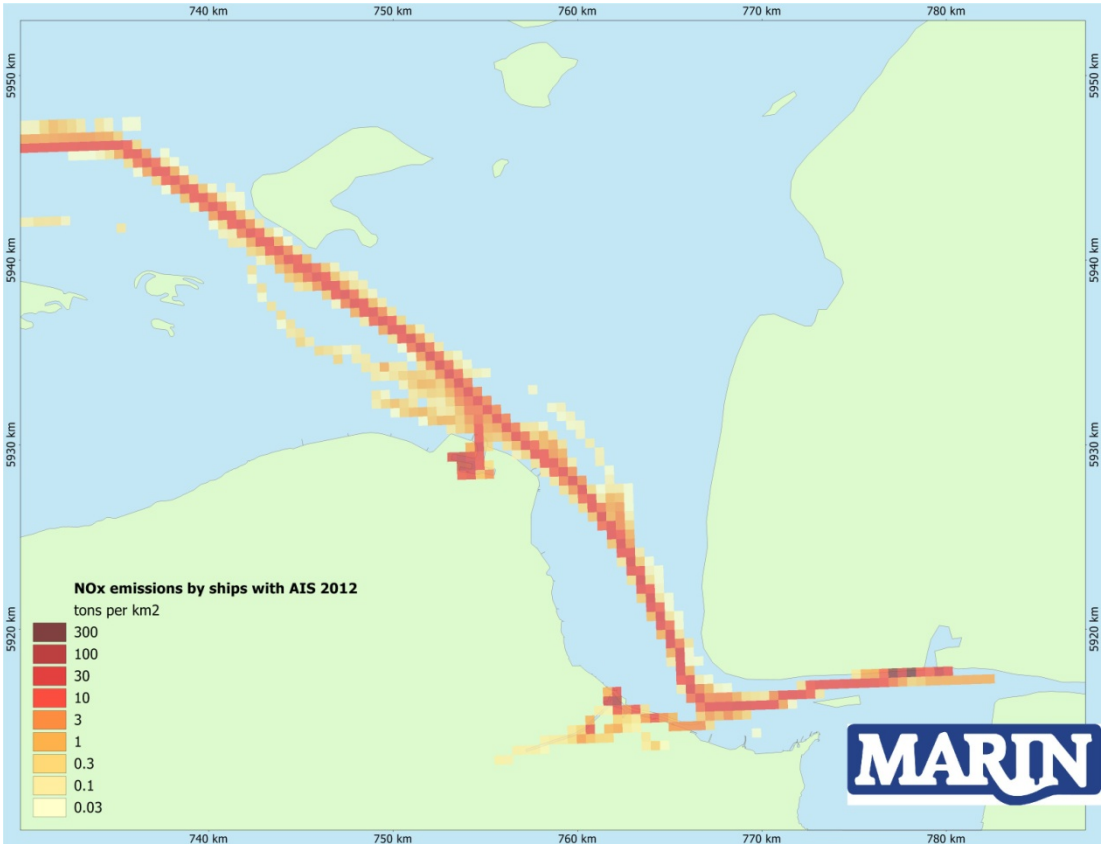

Figure 7-10 NO_x emission in 2012 in the Ems area by ships with AIS

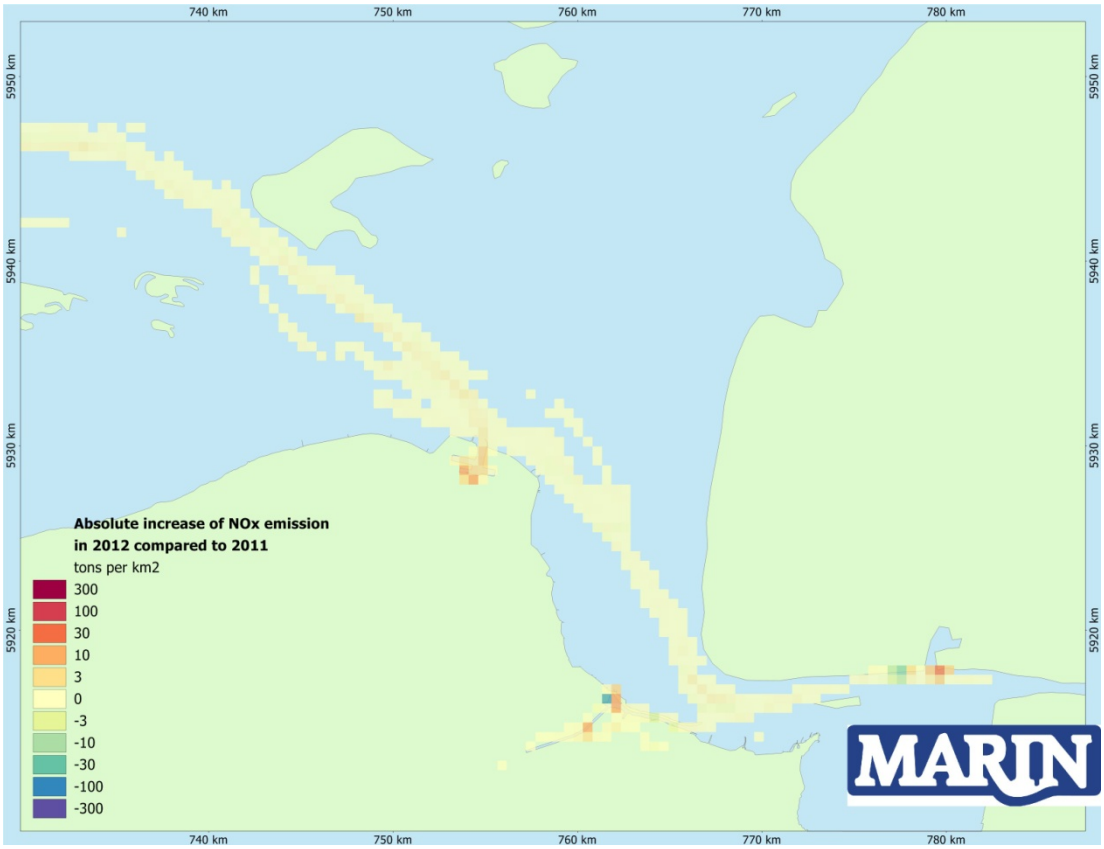

Figure 7-11 Absolute change in NOx emission from 2011 to 2012 in the Ems area by ships with AIS

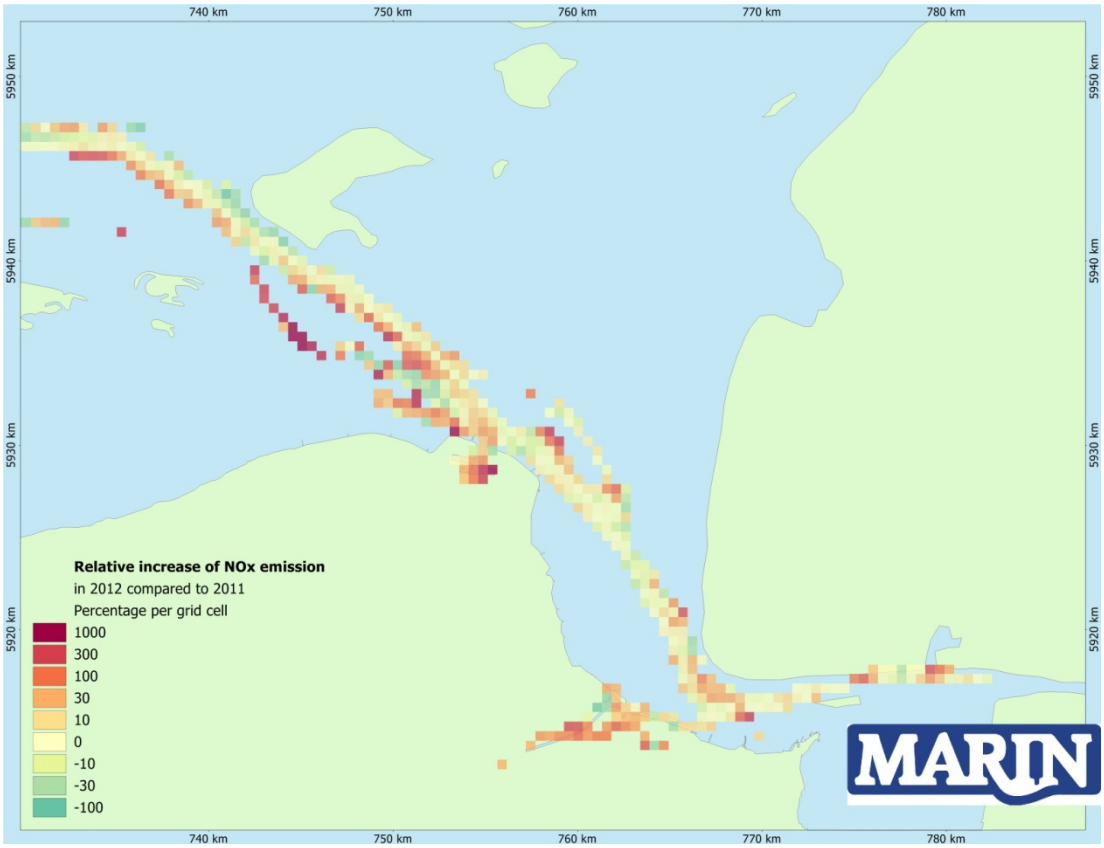

Figure 7-12 **Relative change in NOx emission from 2011 to 2012 in the Ems area by ships with AIS**

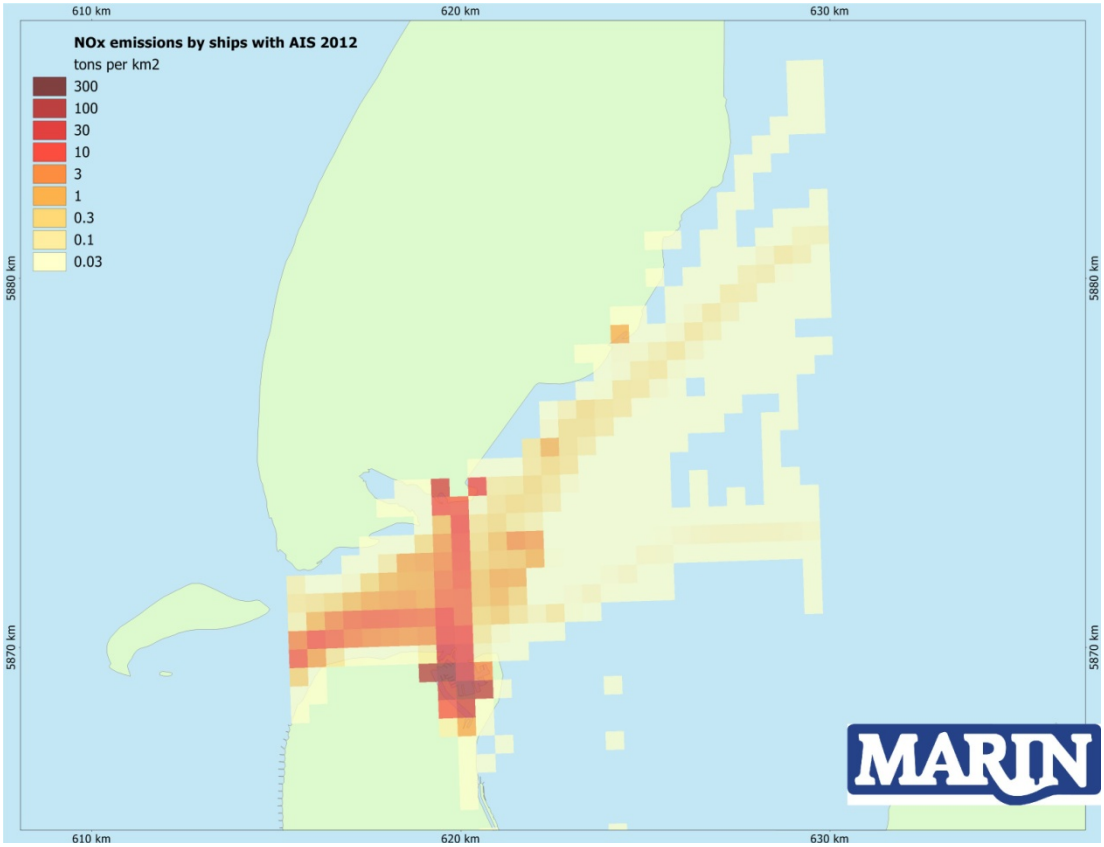

Figure 7-13 **NOx emission in 2012 in the port area of Den Helder by ships with AIS**

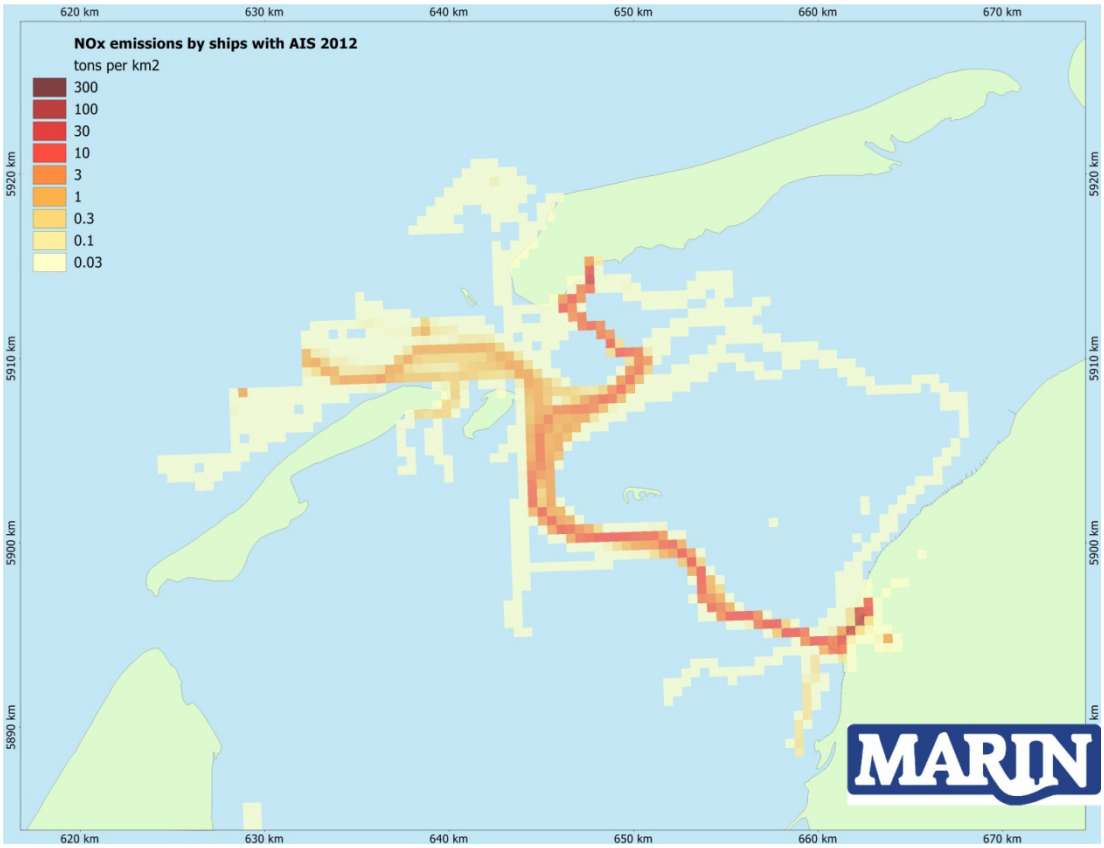

Figure 7-14 NOx emission in 2012 in the port area of Harlingen by ships with AIS

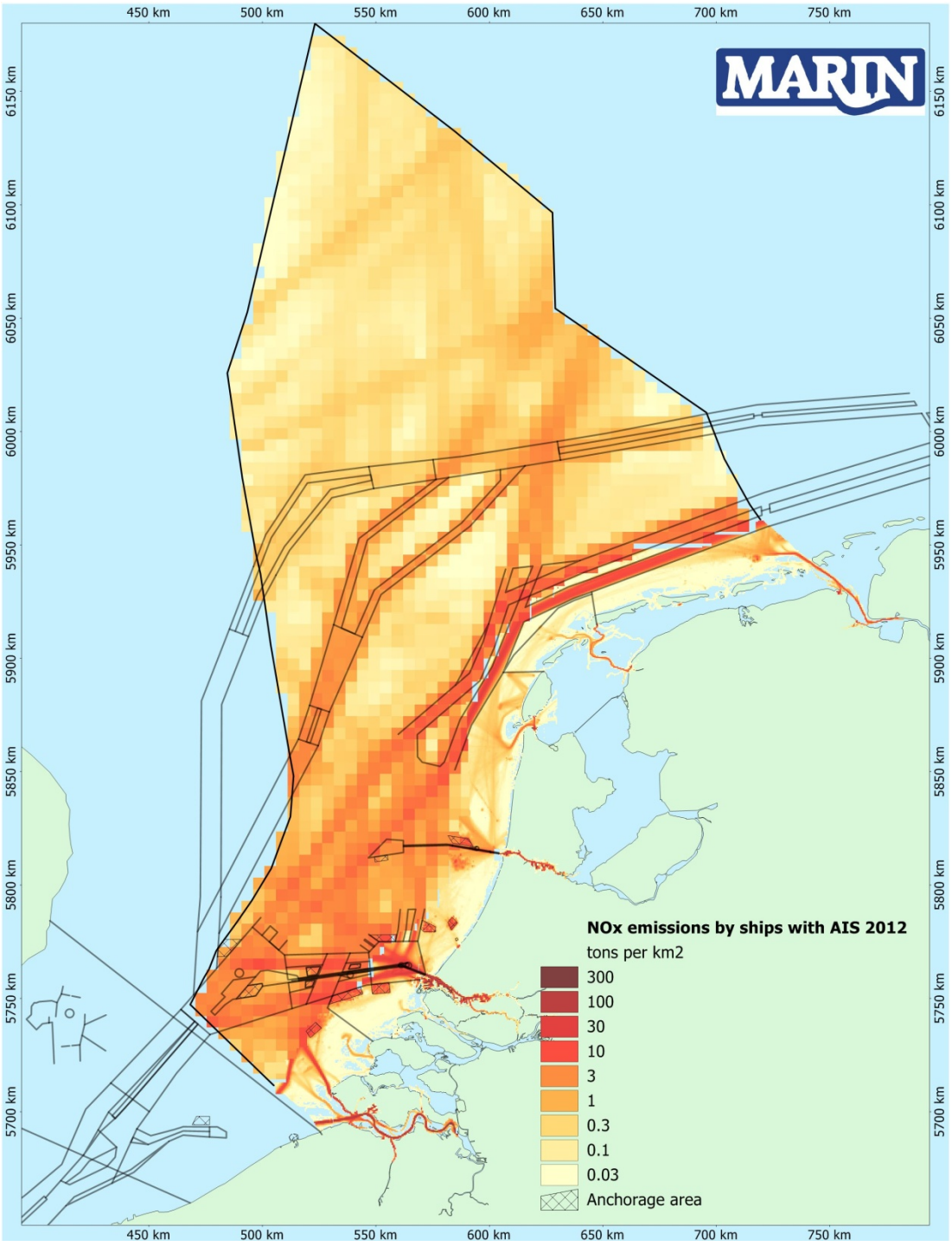

Figure 7-15 **NOx emission in 2012 in the NCS, the 12-mile zone and the Dutch port areas by ships with AIS**

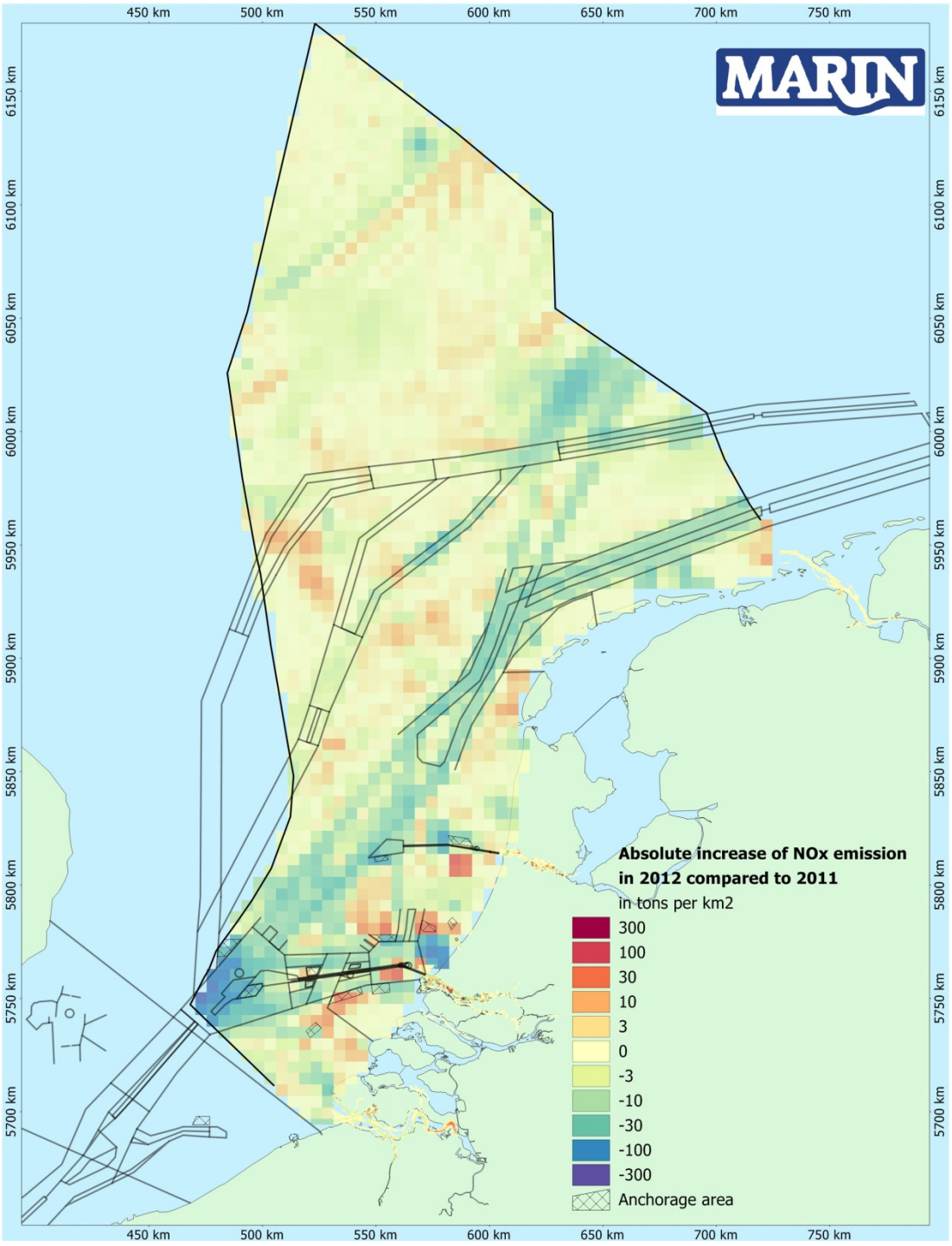

Figure 7-16 **Change in NO_x emission from 2011 to 2012 in the NCS, the 12-mile zone and in the Dutch port areas by ships with AIS**

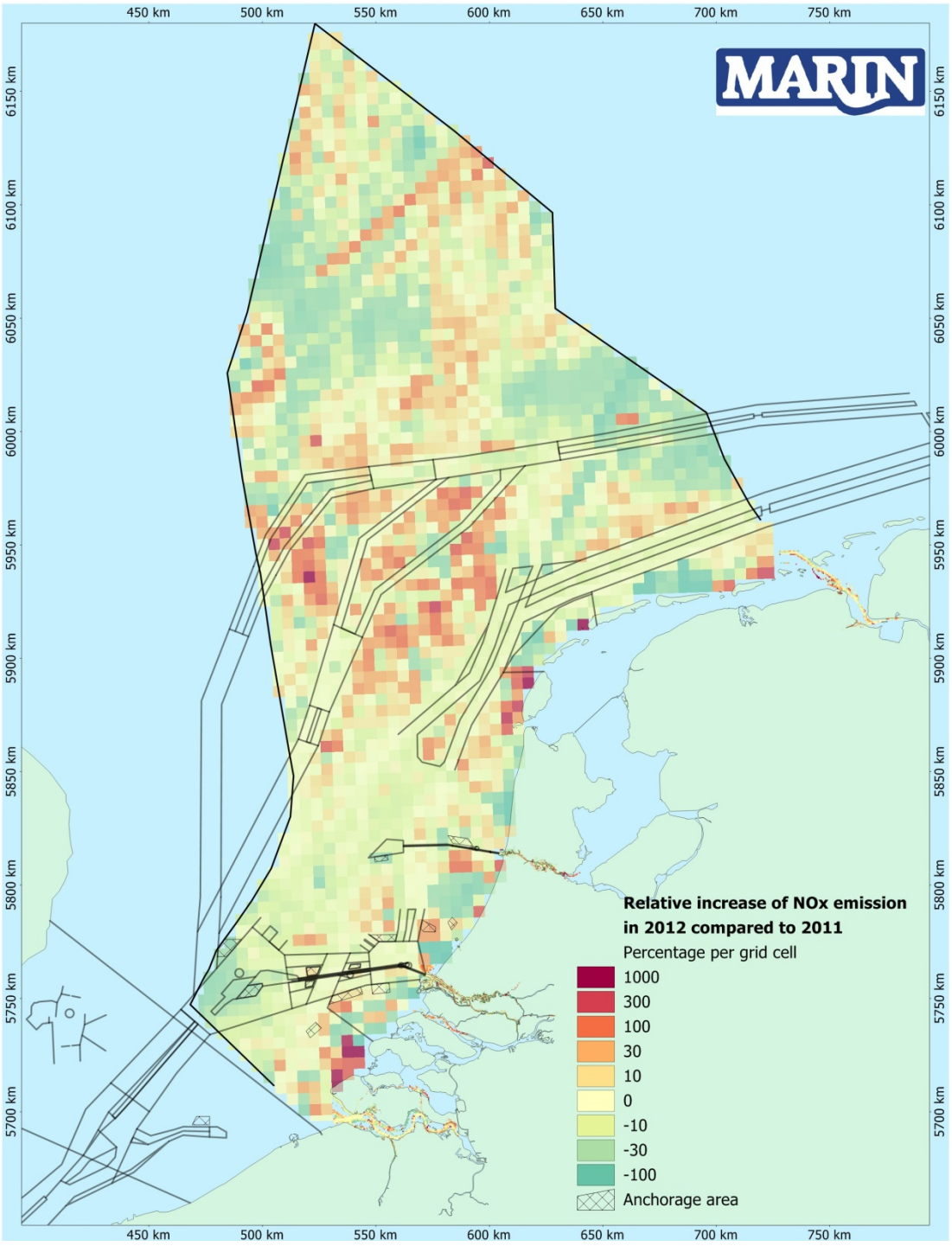

Figure 7-17 **Relative change in NOx emission from 2011 to 2012 in the NCS, the 12-mile zone and in the Dutch port areas by ships with AIS**

8 EMISSIONS IN OSPAR REGION II

The emissions in OSPAR region II are calculated for moving ships, non-moving ships are not modelled in the traffic database.

The calculated emissions for 2012 are summarised in Table 8-1. This table also contains a comparison with 2011. The average number of moving ships in OSPAR region II has decreased with 3.2%. The decrease in emissions is for most substances even higher due to the lower average speed that was observed in the AIS (-1.4% as described in Section 6.3). Only for Aerosols HFO there was a smaller emission decrease.

Figure 8-1 contains the spatial distribution of the NO_X emission in OSPAR region II.

Table 8-1 Emissions at sea in OSPAR region II for 2012, based on SAMSON

Nr	Substance	Emission in ton in 2012 of moving ships	Emission in 2012 as percentage of 2011 for moving ships
1237	VOC	11,430	93.6%
4001	SO2	114,805	94.1%
4013	NOx	429,871	92.3%
4031	CO	72,680	96.6%
4032	CO2	19,114,723	94.0%
6601	Aerosols MDO	2,136	96.0%
6602	Aerosols HFO	18,889	99.5%
6598	Aerosols MDO+HFO	21,025	99.2%
Average number of ships in area		918.69	96.8%

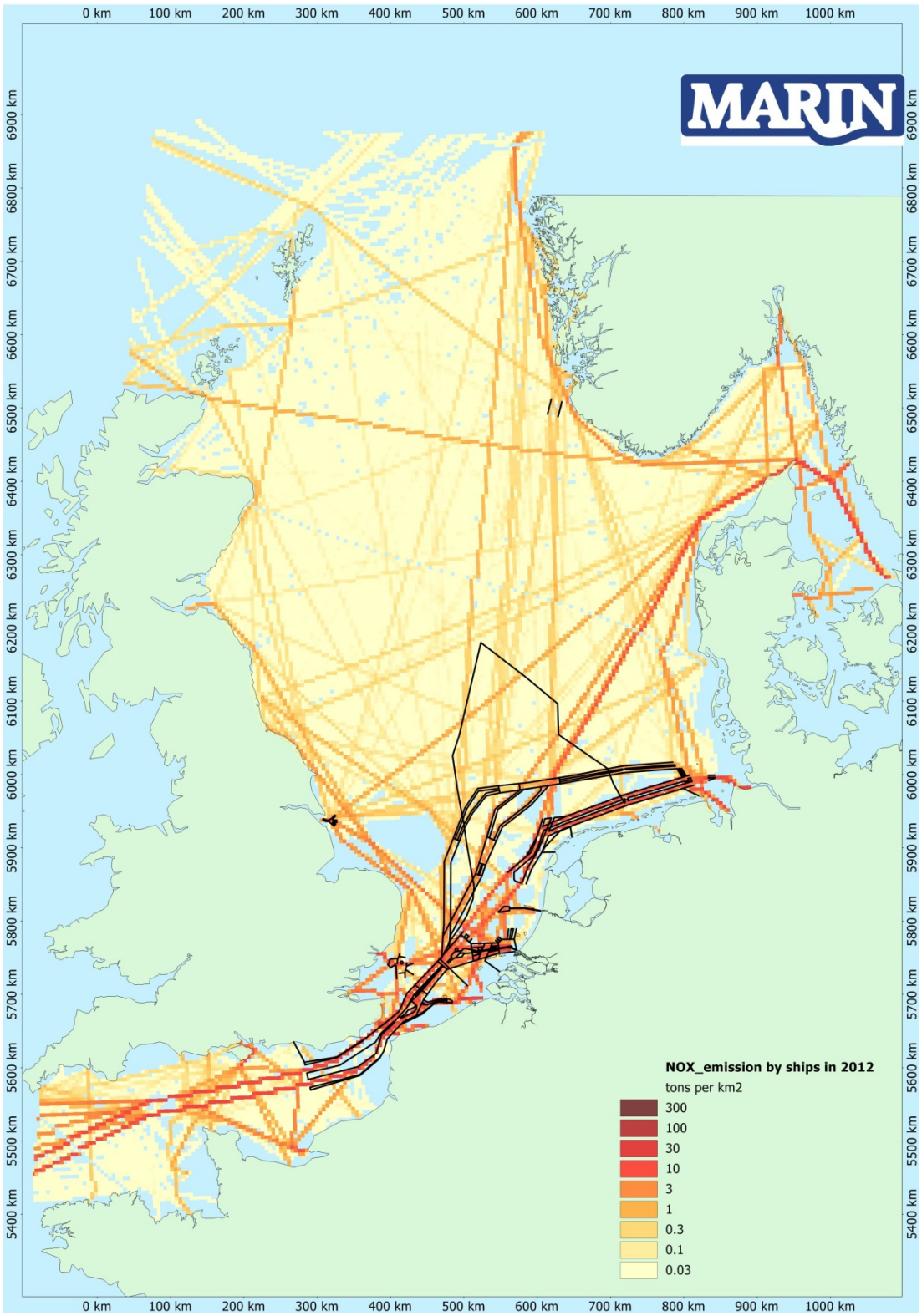

Figure 8-1 **NO_X emission in OSPAR region II at sea by route bound ships**

9 SUMMARY AND CONCLUSIONS

Deliveries
The main delivery of this study is a set of databases containing gridded emissions of seagoing ships at sea and in the Dutch port areas. These emissions are distinguished into ship type and size. Where applicable, the emissions are also distinguished into moving / not moving and EU / non-EU flag. These databases can be used in studies for which a detailed spatial distribution of the emissions is required.

Method changes with respect to 2011
This year, some improvements were performed in the emission calculation for the Netherlands sea area and the Dutch port areas. The emissions of Den Helder and Harlingen were added and the emissions of the 12-miles zone were calculated based on a 500 x 500 m grid instead of a 5000 x 5000 m grid.

For OSPAR region II, a new SAMSON traffic database was used that is based on all movements of seagoing ships above 100 Gross Tonnage in the Lloyd's List Intelligence voyage database of 2012. The voyages of ferries that were not incorporated in the Lloyd's List Intelligence voyage database were added to the SAMSON traffic database.

Ship characteristics database
Almost all relevant ships that were observed in the AIS data could be coupled with a ship in the ship characteristics database of Lloyd's List Intelligence. This is necessary, because the emissions can only be calculated for coupled ships.

Completeness of AIS data
In general, more minute files of the AIS data were missing in 2012 than in previous years. Therefore, a larger correction factor had to be used. For some days, part of the data for port areas was missing. This has been corrected by additional correction factors. As in previous years, a correction factor was used to correct for bad AIS coverage of ships in the Western Scheldt, close to the Belgian border.

Activity data
Comparing 2012 with 2011, there was a decrease in the number of calls for the Western Scheldt and for Rotterdam, a stable number for Amsterdam and an increase for the Ems. At sea, the average number of ships decreased with 3.2%. Also the average speed decreased with 1.4%.

Emission results
The comparison of the emissions for all substances in 2011 and 2012 shows for the port areas:

- Amsterdam: a large increase (more than 6%), mainly for ships at berth (more than 14%);
- Ems: a smaller increase (more than 2%), mainly for moving ships (more than 3%);
- Western Scheldt and Rotterdam: only slight changes with respect to 2011, varying between 2% increase and a 2.6% decrease.

When looking at NOx emissions only, there is an increase in three out of four port areas; only in Rotterdam there is a slight decrease of 0.4%. Summarized over all port areas there is an increase of 3.7%.

In the Netherland sea area the decrease in emissions is for most substances higher than the decrease in the number of moving ships (-5.3%) due to the lower average speed that was observed (-1.4%). Only for CO and Aerosols MDO there was a smaller emission decrease.

REFERENCES

[1] C. van der Tak
Sea Shipping emission 2011: Netherlands Continental Shelf, Port areas and OSPAR region II
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