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## WP5.2. Assessment of air emissions sources in the Port of Barcelona and future scenario



## **Assessment of air emissions sources in the Port of Barcelona and future scenario**

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May 2012**

### **Acknowledgments:**

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## 1.1 Identification of the present time risk activities and vulnerability systems in terms of emissions

### 1.1.1. Description of the docks in Barcelona port

#### A. Containers and multipurpose

The maps show locations of these docks



#### 1. TCB

Along its 1.380 metre wharf and with its 16 metre draft, berthing for a large vessel is secured at all times. The total 54 ha yard extension and 486 reefer plugs, permit a rational distribution and an optimal preservation of the cargo. The capacity of the terminal is of more than 1.3 million TEUs. Through 8 lanes for trucks and with a direct link to the rail terminal, complete intermodal transport connections are easily carried out. Customs offices inside the terminal facilitate an integrated logistic process. All working processes are certified under the regulations of ISO 9001:2008 and ISO 14001 and it counts with a Quality Policy and Environmental Policy.

Location: Moll 24 Sud

Surface: 57,58 ha

Equipment:

| EQUIPMENT                                      | NUM. |
|--|------|
| Container Cranes Babcock & Wilcox Panamax      | 3    |
| Container Cranes Paceco Panamax                | 2    |
| Container Cranes ZPMC Panamax                  | 1    |
| Container Cranes Konecranes Super Post-Panamax | 5    |
| Container Cranes ZPMC Super Post-Panamax       | 3    |
| Straddle Carriers Sisu/Valmet (3-HIGH)         | 19   |
| Straddle Carriers Kalmar (4-HIGH)              | 33   |
| Straddle Carriers Noell (4-HIGH)               | 12   |

|   |    |
|---|----|
| Reach Stackers Sisu/kalmar                      | 2  |
| Empty Container Forklifts Sisu /Kalmar/Fantuzzi | 9  |
| Extra complementary equipment (forklifts)       | 31 |

Operational capacity:

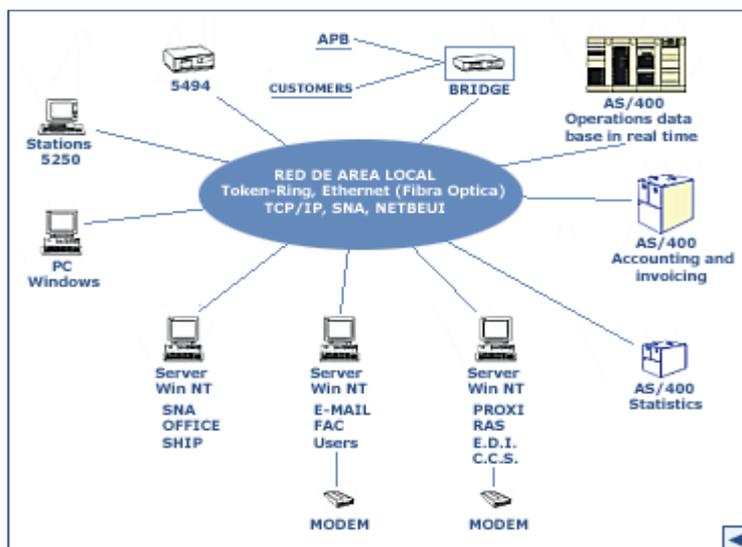
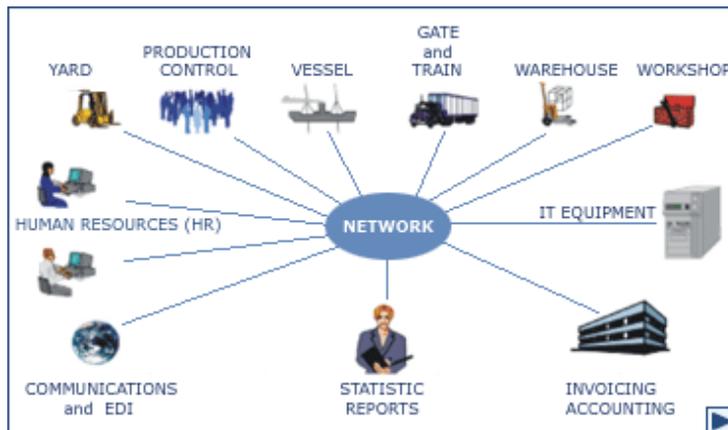
| Year | TEUs      |
|------|-----------|
| 2008 | 1.220.500 |
| 2007 | 1.220.500 |
| 2006 | 1.000.000 |
| 2005 | 1.015.000 |
| 2004 | 934.293   |

Working times:

- Marine operations: 24h/day, 361 days/year
- Land operations: Monday - Friday; 6am - 8pm

Information technology:

TCB has developed the most advanced Information Technology systems for the management of the operation and administration to ensure smooth processes and being able to offer the best service to our customers. Information systems cover all the terminal activities.



Economical information:

Sales (in thousands of euros)

| Year | Sales  |
|------|--------|
| 2008 | 99.877 |
| 2007 | 92.633 |
| 2006 | 69.953 |
| 2005 | 72.174 |
| 2004 | 65.638 |

Investments (in thousands of euros)

| Year | Investment |
|------|------------|
| 2008 | 12.105     |
| 2007 | 21.589     |
| 2006 | 21.600     |
| 2005 | 4.992      |
| 2004 | 6.985      |

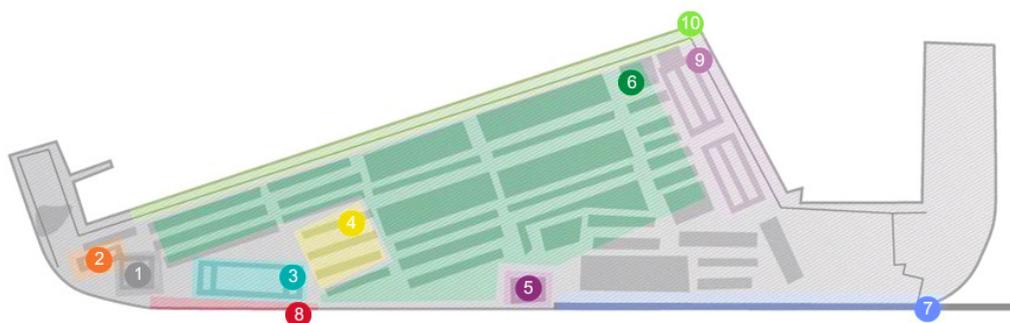
Other Characteristics:

- Rail terminal ferroviària (5 ha)
- Container freight station: 13.800 m<sup>2</sup>
- Covered storages: 3.600 m<sup>2</sup>

## 2. Terminal de Catalunya (TERCAT)

### 2.1. Terminal Muelle Príncipe de España

#### Terminal Layout Muelle Príncipe de España



TERCAT was established in 1990 as the container terminal of “Muelle Príncipe de España”. In 2009, TERCAT handled half the containers that moved through the Port of Barcelona. It operates 24/7.

Chararceristics:

Quay: 1.080 m

Berths: 4

Draft: 14 m

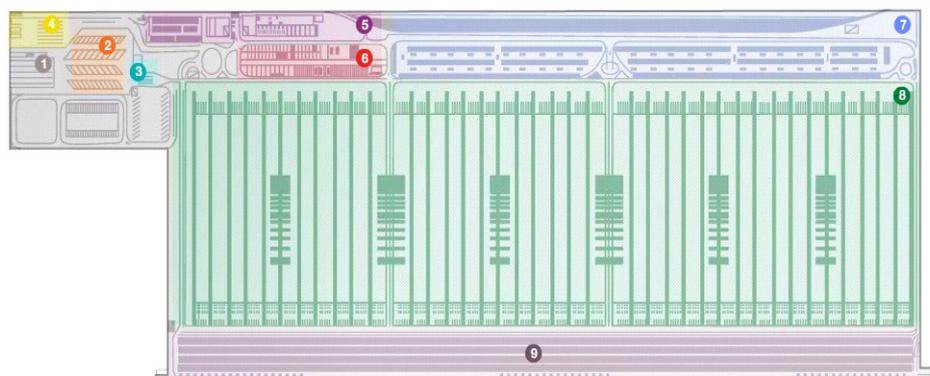
Ro-Ro ramps: 2

Area: 42 ha  
 Quay crane: 8 SuperPostPanamax and 1 PostPanamax  
 RTG (1 over 5; 1 over 4): 11  
 Reachstacker: 33  
 Tractors: 28  
 Reefer Plugs: 470  
 Rail: 2 x 450 m  
 Container freight station: 3.607 m<sup>2</sup>  
 Covered storages: 14.225 m<sup>2</sup>

2.2. Muelle Prat (work in progress, operations start foreseen in June 2012)

Polyvalent terminal:  
 Cranes: 8 mobiles  
 Reach Stacker: 6  
 Frontal machines: 60  
 Fork-lifts: 5  
 Covered storages: 7.920 m<sup>2</sup>

Terminal Layout Muelle Prat



Characteristics:

- Since November 2006, TERCAT has held a 35-year concession to build and operate a new container terminal based at Muelle Prat. The new terminal will be semi-automated.
- This terminal will help HPH develop TERCAT into its principal gateway port for the Western Mediterranean
- The first phase of the development will consist of 1,500 meters of quay with a minimum depth alongside of 16 meters.
- Upon completion of Phase Two, the new terminal will have 132 hectares of area with 2,100 meters of quay and a depth alongside of up to 18 meters.
- Eventually, the terminal will cover over 200 hectares, rivaling with Northern European terminals in size.

| New Prat Terminal   | Total | Phase 1 | Phase 2 |
|---------------------|-------|---------|---------|
| Berth Length (m)    | 2,100 | 1,500   | 600     |
| No. Berths          | 7     | 5       | 2       |
| Total Terminal Area | 132   | 100     | 32      |
| QC                  | 24    | 18      | 6       |
| ASC                 | 112   | 80      | 32      |
| Shuttle Carriers    | 57    | 42      | 15      |

### 3. Port Nou

Port Nou is a multi purpose terminal with capacity to handling any kind of goods: containers, vehicles, semi trailers, general cargo, project cargo, etc.

Characteristics:

surface: 75.000 m<sup>2</sup>

berth line: 450 lineal meters and 12 m. draft

2 warehouses with 1.800 sqm.

2 Ro-Ro ramps.

75 power sources for reefer containers

1 mobile crane Liebherr LHM500S (140 t.)

2 gantry cranes Panamax of 40 t.

2 RTG of 50 t.

8 Reach Stacker of 45 t.

8 Tug masters for platforms and roll-trailers

2 fork-lifts 30 t.

3 fork-lifts 16 t.

3 fork-lifts 6 t.

24 fork-lifts 4 t.

#### B. Passengers terminals



**Moll Adossat:**

Terminal Marítima Internacional A. Turnaround: 4.500 pax

Terminal Marítima Internacional B. Turnaround: 4.500 pax

Terminal Marítima Internacional C. Turnaround: 3.800 pax

Terminal Marítima Internacional D. Turnaround: 4.500 pax

**Moll de Barcelona:**

Terminal Marítima Internacional Nord N

Terminal Marítima Internacional Sud S

Turnaround: 800 pax (Nord) –1.400 pax (Sud) – 1.500 Transit only

**Terminal Marítima Drassanes Z:**

Maritime station for ferries that, sometimes serves as terminal for passengers cruises and therefore it fulfils all safety requirements.

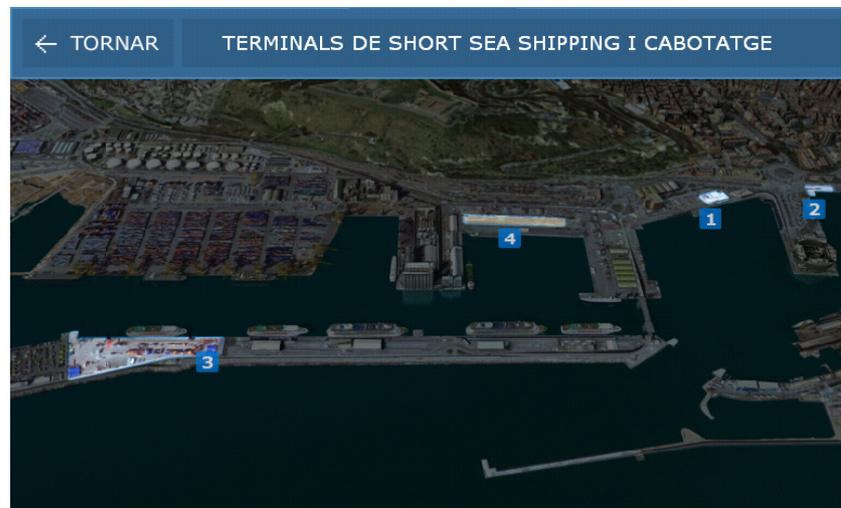
**Moll d'Espanya:**

Terminal Marítima Maremagnum M. Turnaround: 200 pax

**Moll de Sant Bertrà:**

Terminal Ferry de Barcelona T. Turnaround: 250 pax

**C. Short Sea Shipping and coasting trade terminals**

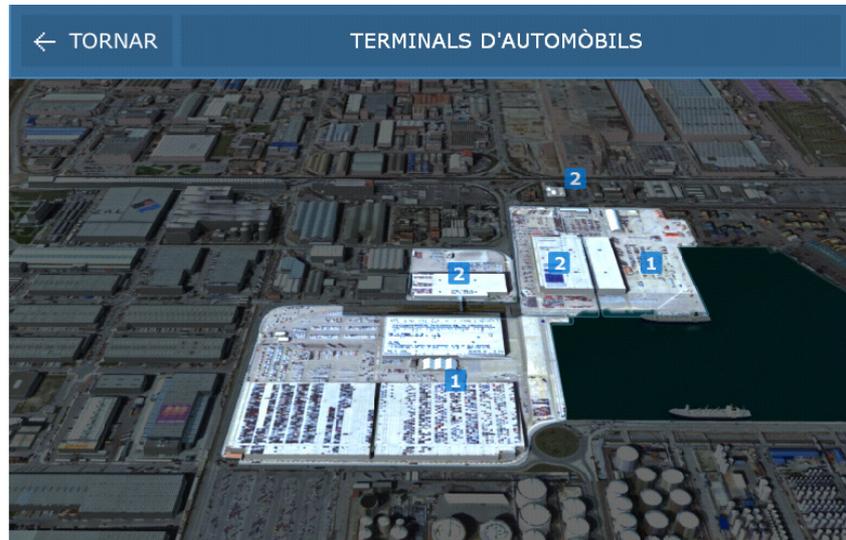


1. Terminal Ferry de Barcelona.  
ro-ro ramps: 6  
Operated by Grandi Navi Veloci, Grimaldi Group Naples, Acciona Trasmediterránea
2. Terminal Marítima de Drassanes: Operated by Balearia
3. Port Nou  
2 ro-ro ramps  
Straddle-carriers: 64  
2 cranes pòrtic Panamax, 2 trastainers, 1 mobile crane and 8 reach stackers

Operated by: Cie Tunisienne de Navigation (Cotunav), Cie National Algerienne Navigation (CNAM) and Fast Line.

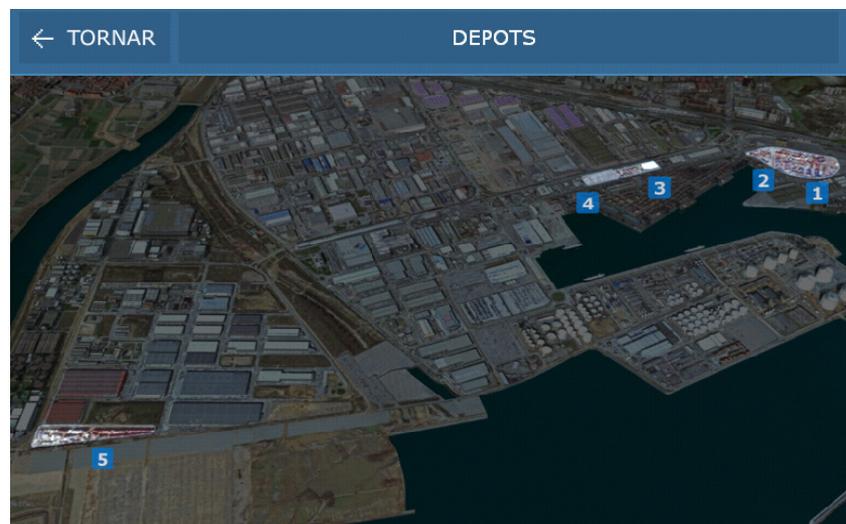
4. Moll Costa. Future maritime station with 3 connection ganways. Vertical space for storage. Direct rail access.

#### D. Cars terminals



1. **Autoterminal, SA**  
 Surface: 33 ha  
 Vertical space: 37,8 ha and 26.981 places  
 Autoterminal initiated its activity in 1991 and it has an administrative concession to operate until 2020
2. **Setram, SA**  
 Surface: 8,7 ha  
 Vertical space: 17 ha and i 8.934 places

#### E. Depots terminals



**1. Progeco**

Surface: 68.000 m<sup>2</sup>

General services:

- Handling empty
- Estimates IICL-ACC In-service criterion
- Repairs IICL-ACC norms
- Cleaning
- Stock control

Other services:

- Reefer maintenance (depot equipped with reefer plugs for pre-trip inspections at 38° V and 220 V)
- Tank services (check and maintenance tank containers including systematic pressing test, test 2,5/5 years)
- Bulk bags and flexitanks (they can be installed on shipping containers)

Lifting equipment:

- 4 lifts truck spreader 20'/40' – 6 stacking
- 2 lifts truck spreader 20'/40' – 4 stacking
- 3 forklift 20' – 3 stacking

**2. Martainer**

- Surface: 65.200 m<sup>2</sup>
- Equipment: 6 spreaders

**3. Damex**

- Uncovered surface: 25.000 m<sup>2</sup>
- Covered surface: 8.000 m<sup>2</sup>
- Cranes up to 35 Tn

**4. MSC Depots**

Surface: 24.700 m<sup>2</sup>

**5. Cimat**

Uncovered surface: 40.000 m<sup>2</sup>

Covered surface: 1.850 m<sup>2</sup>

**F. Liquid bulk terminals**



**Companies operating within this terminal:**

1. Enagas

2. Relisa
3. Tepsa
4. Terquimsa
5. Decal
6. Quimidroga
7. Trabede
8. Koalagas
9. Meroil
10. CLH
11. Bunge

### G. Solid bulk terminals



#### Companies operating within this terminal:

1. Portcemen
2. Tramer
3. Ergransa
4. Bunge
5. Cargill
6. Cemex
7. Sal Costa

## H. Food products terminals



### Fruit terminal

1. Barcelona Reefer Terminal  
Surface: 5.556 m<sup>2</sup> fridge storage  
Simultaneous storage of 6000 palets

### Coffee and cocoa terminals

2. BIT, SA  
Surface: 17.000 m<sup>2</sup>  
Capacity: 20.000 t
3. Molenbergnatie  
Surface: 25.000 m<sup>2</sup>  
Capacity: 22.500 t
4. Viorvi  
Surface: 10.000 m<sup>2</sup>
5. Pacorini  
Surface: 9.100 m<sup>2</sup> + 4.000 m<sup>2</sup> (ZAL II)

## I. Rail terminals



### Containers terminal

1. Morrot
2. Moll Sud
3. Príncep d'Espanya

### Cars terminals

4. Dàrsena sud
5. Campa Z
6. Moll de l'Energia

### Bulks terminals

7. Moll contradic
8. Moll de l'Energia

### In-progress terminals

8. ZAL Prat – Contenidors
9. Contenidors
10. Contenidors
11. Costa Dic sud
12. Nou Llobregat
13. Trafimar

## J. Logistics Activities Zone (ZAL)



### 1. ZAL Barcelona. It includes these companies:

- Agility Spain
- Aldeasa
- APP Italia
- Ati
- Bofill & Arnan
- Catalgrup, SA
- Cebecen
- Cisam
- Condeminas Servicios Logísticos, SA
- Control Financiero e Informático, SL
- CTC
- Dalteco Group
- Decoexsa
- DHL
- Eis Marítimo
- Embarmar
- Explotaciones Turísticas Gaditanas, SA
- Fundación Cares
- Globelink
- Uniexco
- Grupo Marmedsa
- Grupo Transcoma
- GV Express, SA
- Honda Logísticos, SA
- IFS Internacional Forwarding, SL
- Integral de Negocios
- J. Gibert, SL
- Jas Forwarding
- Just Logística, SL
- Kühne & Nagel
- Lauson, SA
- Lo Trans
- Logipoint, SL
- Marítima del Mediterráneo, SA
- Mascaró Morera, SA
- Mediterranean Fresh Supplier
- Multimodal Spain
- Oliver Getransa, SA
- Operinter
- Red Car, SA
- Salvat Logística, SA
- Servinter
- Space Cargo
- Steinweg Iberia
- Stock Cargo
- Trafimar
- Transmec De Bortoli Group España, SA
- Transportes Quiñonero
- Transportes y Consignaciones Marítimas, SA
- Travima
- Trebig Handling, SL
- Universal Marítima
- Whirlpool Iberia

### 2. ZAL Prat. . It includes these companies:

- Airfarm
- Alfil Logistics
- Barnatrans

- Carrefour
- CFS
- Clariant
- DAMM
- DDB Schenker
- Decathlon
- Fagor
- Fornes Barcelona de Grupatges, SA
- Gefco España, SA
- Hellman Worldwide
- MCC
- Nippon Express de España, SA
- NYK Logistics
- SEUR
- Sparber Transport, SA
- TIPSA
- Total Petrochemical Ibérica, SLU
- Transabadell – Transterrassa
- GV Express, SA
- Transglory
- Transnatur, SA
- Universal Forwarding, SL

**Service Center.** . It includes these companies:

- 3-80 Nous Associats
- Acciona Forwarding, SA
- Atlantic Forwarding
- Bergé Marítima, SA
- Buffer Logistica
- Capsa
- Cilsa
- CHT
- Clasquin España
- CMA-CGM, SA
- Concatel – Vanture
- Delongui España
- Fahrner Iberia
- Fremap
- Fundación Logística Justa
- GV Sea Freight
- Hansa Meyer Global Transport, SL
- Ingeniería de Instrumentación y Control SA
- Logismar
- NYC Conveyors
- Polar
- Polar Fruit Europa
- TCE – Transconti
- TIC Solutions
- Transportes Magalhaes
- Vasco Catalana
- Vetri Speciali, SRL
- Yudigar

### 1.1.2. Risk activities in terms of air emissions

Note: Emissions are specific for the Port of Barcelona (100x100 km scale includes Port of Tarragona), so it is reflected in model BCN005.

In the Port of Barcelona, the activities presenting risks regarding air emissions are as it follows:

1. Vessels: maneuvering, hotelling, etc.
2. Harbor craft: tug boats and auxiliary means
3. Land traffic: heavy-duty vehicles
4. Land traffic: locomotives
5. Terminal equipment: cargo handling
6. Solid bulks
7. Enlargement and maintenance works

#### ACTIVITIES OF SHIPS AND VESSELS

The table shows emissions by type of vessel in 2008 (provided by Generalitat de Catalunya).

|                              | CO   | NOx     | SOx     | NMVOCs | NH3 | PM10   | PM2.5 |
|------------------------------|------|---------|---------|--------|-----|--------|-------|
| CAR-CARRIER                  |      | 384.07  |         | 18.66  |     | 29.62  |       |
| CARGO LO-LO                  |      | 157.66  |         | 6.57   |     | 10.79  |       |
| FRIDGE CARGO                 |      | 10.66   |         | 0.47   |     | 0.76   |       |
| DRY BULK CARRIERS            |      | 201.09  |         | 7.27   |     | 12.96  |       |
| PASSENGERS                   |      | 684.76  |         | 29.54  |     | 50.28  |       |
| PETROL ER (LIQUID BULK)      |      | 10.70   |         | 0.79   |     | 1.17   |       |
| CONTAINER                    |      | 2214.89 |         | 109.76 |     | 176.69 |       |
| RO-RO CARGO                  |      | 191.46  |         | 8.91   |     | 14.34  |       |
| LIQUID BULK CARGO            |      | 1028.97 |         | 76.11  |     | 112.21 |       |
| FERRY (PASSENGER)            |      | 701.65  |         | 35.06  |     | 58.58  |       |
| HIGH SPEED FERRY (PASSENGER) |      | 16.65   |         | 1.10   |     | 1.78   |       |
| TOTAL                        | 3619 | 5602.56 | 6768,37 | 294.24 |     | 469.17 |       |

In red, estimated emissions respect to NOx considering ratios in other port areas (Marseille, Thessaloniki and Venice).

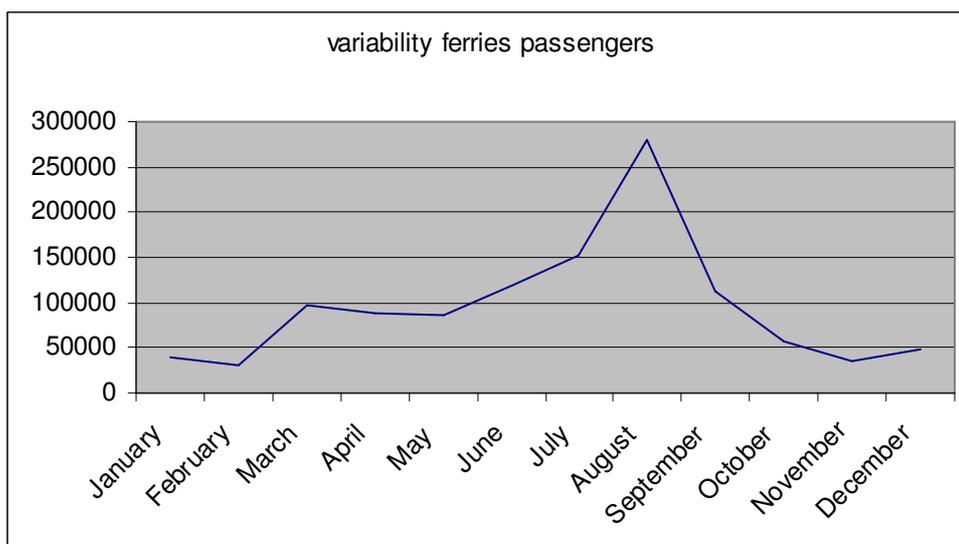
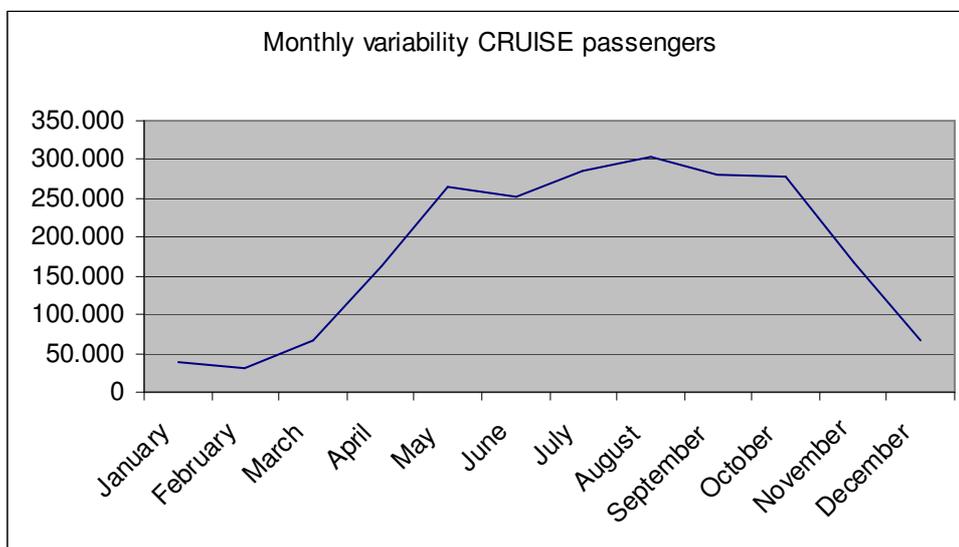
Emissions have been calculated for manoeuvring and hotelling phases, but not for on-route. This table shows the emissions distributions by phase:

| Phase        | Emissions NOx (t/a) | Emissions PM10 (t/a) |
|--------------|---------------------|----------------------|
| Manoeuvring  | 1.326,4             | 160,8                |
| Hotelling    | 4.276,1             | 308,3                |
| <b>Total</b> | <b>5.602,6</b>      | <b>469,2</b>         |

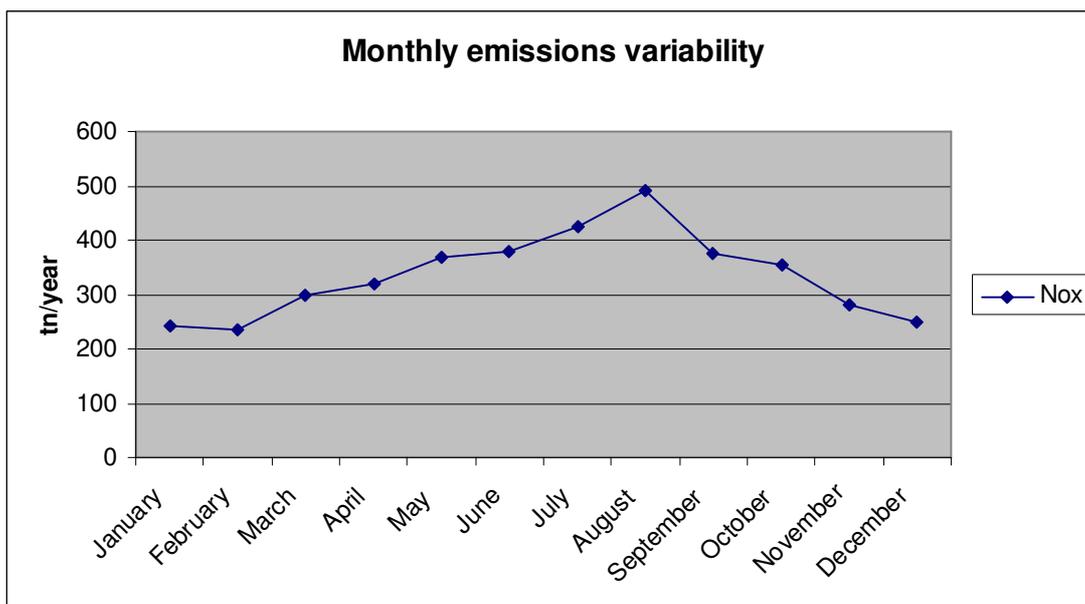
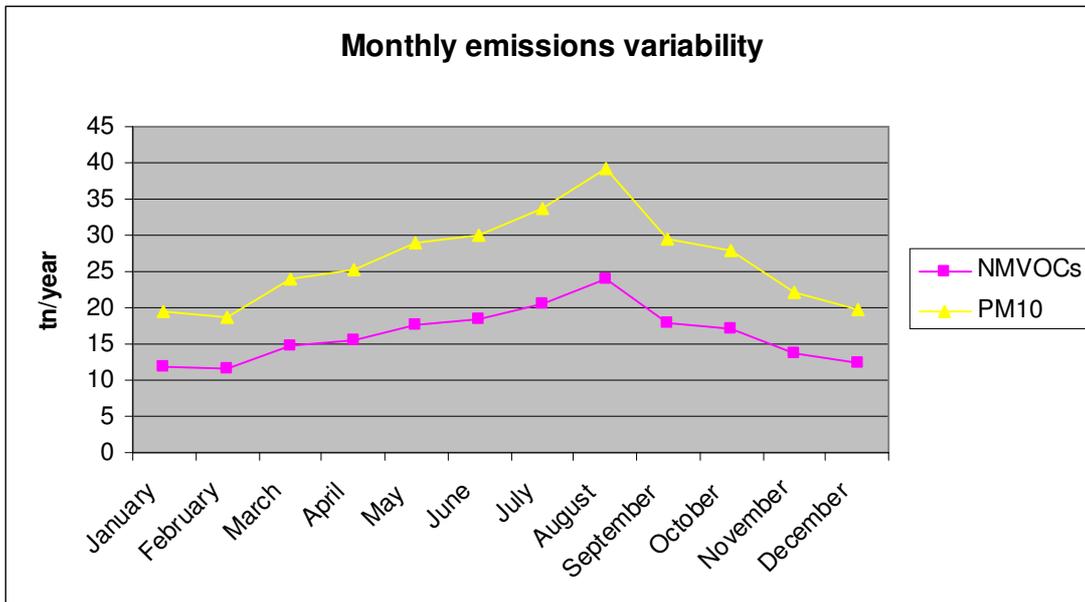
Source: Generalitat de Catalunya

Seasonal emissions

The monthly variability has been assessed for these vessels. It has been found that it is important for cruises and ferries transporting passengers. The following figures show the average fluctuation over the period 2007-2011.



Taking into account the monthly variability, pollutants emissions have been investigated and presented in the following figures for these vessel types: containers, car-carriers, cruises and ferries.



## HARBOR CRAFT

Following tables show the crafts and data for the year 2008.

### 1. Tug boats

| Name          | Owner               | Type         | Working hours per year (hours/year) | Average power (kW) | Moderate activity | Number of services provided | Number of engines |
|---------------|---------------------|--------------|-------------------------------------|--------------------|-------------------|-----------------------------|-------------------|
| MONTRAS       | Remolcadores de Bcn | Ship IMO NOX | 1585,00                             | 2400,00            | 0,5               | 1468                        | 2                 |
| CATALUNYA     | Remolcadores de Bcn | Ship IMO NOX | 1585,00                             | 2400,00            | 0,5               | 1468                        | 2                 |
| MONTBRIO      | Remolcadores de Bcn | Ship IMO NOX | 1585,00                             | 2400,00            | 0,5               | 1468                        | 2                 |
| MONTFORT      | Remolcadores de Bcn | Ship IMO NOX | 1585,00                             | 2400,00            | 0,5               | 1468                        | 2                 |
| SALVADOR DALI | SAR REMOLCADORES    | Ship IMO NOX | 1585,00                             | 1865,00            | 0,5               | 1468                        | 2                 |
| RAMON CASAS   | SAR REMOLCADORES    | Ship IMO NOX | 1585,00                             | 1865,00            | 0,5               | 1468                        | 2                 |
| WILLY-T       | SAR REMOLCADORES    | Ship IMO NOX | 1585,00                             | 1865,00            | 0,5               | 1468                        | 2                 |

### 2. Auxiliary means

| Name                 | Type         | Working hours per year (hours/year) | Average power (kW) | Moderate activity | Number of services provided | Number of engines |
|----------------------|--------------|-------------------------------------|--------------------|-------------------|-----------------------------|-------------------|
| Gabarra Barnoil      | Ship IMO NOX | 2000                                | 1000               | 0,50              | 2000                        | 2                 |
| Gabarra Spabunker 41 | Ship IMO NOX | 2000                                | 1130               | 0,50              | 2000                        | 2                 |

|                  |                                |      |     |      |      |   |
|------------------|--------------------------------|------|-----|------|------|---|
| Practics ALNILAM | Ship without monitoring system | 2000 | 180 | 0,75 | 2000 | 2 |
| Practics NIAL    | Ship without monitoring system | 2000 | 180 | 0,75 | 2000 | 2 |
| Practics P UNO   | Ship without monitoring system | 2000 | 96  | 0,75 | 2000 | 2 |
| Practics NUNKI   | Ship without monitoring system | 2000 | 152 | 0,75 | 2000 | 2 |
| Practics POLAR   | Ship IMO NOX                   | 2000 | 202 | 0,75 | 2000 | 2 |
| Spra Marpol 1    | Ship without monitoring system | 2000 | 308 | 0,50 | 2000 | 2 |

Emissions calculation based on CORINAIR

(<http://www.eea.europa.eu/publications/EMEPCORINAIR4>), ship movement methodology

[Table 8.5: Emission rates for medium and slow speed diesel engines (kg/hours)

|                    | Medium speed & auxiliary engines                | Slow speed                                     |
|--------------------|---|--|
| NO <sub>x</sub>    | $4.25 \times 10^{-3} \times P^{1.15} \times N$  | $17.50 \times 10^{-3} \times P \times N$       |
| CO                 | $15.32 \times 10^{-3} \times P^{0.68} \times N$ | $0.68 \times 10^{-3} \times P^{1.08} \times N$ |
| HC                 | $4.86 \times 10^{-3} \times P^{0.69} \times N$  | $0.28 \times 10^{-3} \times P \times N$        |
| SO <sub>2</sub> *  | $2.31 \times 10^{-3} \times P \times N$         | -  |
| SO <sub>2</sub> ** | $12.47 \times 10^{-3} \times P \times N$        | $11.34 \times 10^{-3} \times P \times N$       |

P is the engine power (kW) x engine load (85% MCR), N is the number of engines

\* is valid for engines < 2000 kW

\*\* is valid for engines ≥ 2000 kW.

Source: Lloyd's Register (1995)

|                        |            |    |            |    |                  |                    |
|------------------------|------------|----|------------|----|------------------|--------------------|
| TUG MONTRAS (X4)       | 86202,9829 | kg | 86,2029829 | tn | 344,81193        |                    |
|                        |            |    | 0          |    | 2                |                    |
| Tug Salvador Dali (X3) | 64500,1327 | kg | 64,5001327 |    | 193,50039        |                    |
|                        |            |    | 0          |    | 8                |                    |
|                        |            |    |            |    | <b>538,31233</b> | <b>tn for tugs</b> |
|                        |            |    | 0          |    |                  |                    |
| Auxiliary means        |            |    | 0          |    |                  |                    |
|                        |            |    | 0          |    |                  |                    |
| Gabarra Barnoil        | 39744,81   | kg | 39,74481   | tn |                  |                    |
| Gabarra Spabunker 41   | 45715,21   | kg | 45,71521   | tn |                  |                    |
| Practics ALNILAM       | 5531,46    | kg | 5,53146    | tn |                  |                    |
| Practics NIAL          | 5531,46    | kg | 5,53146    | tn |                  |                    |
| Practics P UNO         | 2684,64    | kg | 2,68464    | tn |                  |                    |

|                          |          |    |          |    |                  |                         |
|--------------------------|----------|----|----------|----|------------------|-------------------------|
| Practics NUNKI           | 4553,96  | kg | 4,55396  | tn |                  |                         |
| Practics POLAR           | 6315,84  | kg | 6,31584  | tn |                  |                         |
| Spra Marpol 1            | 10259,16 | kg | 10,25916 | tn |                  |                         |
| Total auxiliary          |          |    |          |    | <b>120,33654</b> | <b>tn for auxiliary</b> |
| <b>Total inner fleet</b> |          |    |          |    | <b>658,64887</b> | <b>tn Nox</b>           |

Example calculation:

$$\text{MONTRAS (NOx kg)} = ((4.25 \cdot 10^{-3}) \times (2400 \times 0.85)^{1.15} \times 2) \times 1585 = 86202,9829 \text{ kg} = 86,2029829 \text{ tn}$$

Companies providing the service:

Grupo Rebarsa:

- Remolcadores de Barcelona, S.A.

Grupo REYSER:

- SAR REMOLCADORES S.L. 932 256 545

These two companies work in the port through a temporary union of companies.

Interviews have been hold with both of them in order to find out more input on the risk assessment and future scenario.

In the case of Remoldadores de Barcelona, MONTRAS is not operative anymore but nowadays there are two other on work: MONTALT and MONTCLAR, from 2009 onwards. In 2008 there were 6 tug boats, now there are 5. The auxiliary boat Spra Marpol 1 belongs also to this company.

Tub boats are tied up in dock Príncipe de España (next to TCB container terminal) and electrified since 2001 (see picture). Remolcadores de Barcelona has a tug boat in bocana north. Port Authority designates where these tug boats must be located while tied up.



Photo: Willy-T tug boat electrified while tied up (Pedro Fernández)

Tug boats operate everyday 24h, with a slight activity reduction in August.

The Port Authority released in July 2010 a new version of terms of reference for towage activity, although companies report no major change occurred. Regarding air emissions, port Authority only demands IMO-NOx certificate for operating at the port. This certificate is delivered by national Merchant Navy when acquiring each tug boat.

It is not foreseen to renew the fleet since they are relatively new, the oldest ones dating from 2005 (Tier I). Once the Muelle del Prat will be operative (June 2012), there can be a change on location of tug boats, maybe some of them will move there. It is not foreseen to increase the fleet. It is not known whether this dock will provide electrification (it depends on Port Authority).

Both companies are assessed annually yearly to get the Lloyd's register certification (quality programme), which is done in a voluntary basis. However the Port Authority demands this certificate to operate at the port. In order to get this certificate, air emissions are assessed and improvement measures are proposed and monitored.

In principle, there are not on-board air pollutants emissions measures, though they have been done punctually.

At Remolcadores de Barcelona, emissions are estimated according to fuel consumption and then applying emission factors. This is reported to the audit.

In the case of SAR, on-board measurements took place in order to follow the Monitoring and Control of its manual of Environmental Management System according to UNE EN ISO 14001/04. According to this study, it is verified whether the engines emit below the limits established by MARPOL. It is expressed in g/KWh.

Regarding fuel consumption, SAR informs that their boats consume 165 l/hour at work. It has provided extensive information on this. For 2008, total consumption was 276.600 l for 3.950 work hours. The company uses as (efficiency) indicator: total consumption/engine hours. It also uses, for management purposes, the indicator: tug fuel consumption/number of services. The objective is to maintain fuel consumption compared to previous year.

In Remolcadores de Barcelona, it is reported 350 l/h.

Fuel contains 0.1% S, as indicated by legislation. It is gasoil C/DMA

#### LAND TRAFFIC: HEAVY-DUTY VEHICLES

Trucks movement generated by maritime traffic is high and still very important compared to goods transported by rail. Furthermore, the area around the port is highly condensed, being one of the main accesses to Barcelona city, which means that high emissions result from this.

Emissions from heavy duty vehicles related to port activity have been estimated considering the data provided by the Generalitat de Catalunya, which in turn entrusted a specific study to a consultancy. The NOx and PM10 emissions factors were calculated by the consultancy

considering an average fleet. The following table shows data and emissions, which related to the amount of tones transported.

|  | 2008          |            |
|--|---------------|------------|
| Tranported tones by road               | 32687121      | tn         |
| Average load                           | 19,8          | tn/vehicle |
| Average distance within Plan area      | 30            | km         |
| Average distance at port               | 4             | km         |
| Truck movements                        | 1650865       | movements  |
| EF Nox                                 | 12,1          | g/km       |
| EF PM10                                | 0,52          | g/km       |
| <b>Nox emissions wihin port</b>        | <b>79,90</b>  | <b>tn</b>  |
| <b>PM10 emissions within port</b>      | <b>3,43</b>   | <b>tn</b>  |
| <b>Nox emissions within Plan area</b>  | <b>599,26</b> | <b>tn</b>  |
| <b>PM10 emissions within Plan area</b> | <b>25,75</b>  | <b>tn</b>  |

Note that emissions have been calculated for:

- emissions released within the port
- emissions generated by maritime transport within the area considered in the Catalan Plan for improving air quality.

It is important to note two initiatives regarding the inner road transport system:

- Strategy to optimize the port terrestrial transport system, signed by Port Authority and Generalitat de Catalunya.
- Collaboration agreement to implement training and sustainable mobility actions, signed by the Logistic Activities Zone, Barcelona-Catalunya Logistic Centre and Royal Automobile Club of Catalonia.

#### LAND TRAFFIC: LOCOMOTIVES

Rail traffic is progressively increasing in the Port of Barcelona and it is expected to play a very important role in the near future. Locomotives working within the port use diesel (although it changes to electric traction once out of the port, at Can Tunis station). In this section we describe emissions resulting from the use of diesel.

It has been calculated considering CORINAIR methodology Tier III and the results are showed in the following table. As for the emission factors, it has been considered an average from the study *Status and future development of the diesel fleet*<sup>1</sup>.

<sup>1</sup> Retrieved from

<http://www.google.es/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCKQFjAA&url=http%3A>

|  | 2008        |           |
|--|-------------|-----------|
| Number of trains movements               | 1665        | movements |
| Average time within port                 | 0,25        | h         |
| Average time within Plan area            | 0,5         | h         |
| Average nominal power output             | 800         | kW        |
| Average load factor                      | 0,5         |           |
| Average EF Nox                           | 11,73       | g/kW      |
| Average EF PM                            | 0,32        | g/kW      |
| <b>Nox emissions within port</b>         | <b>1,95</b> | <b>tn</b> |
| <b>PM emissions within port</b>          | <b>0,05</b> | <b>tn</b> |
| <b>Nox emission induced in Plan area</b> | <b>3,91</b> | <b>tn</b> |
| <b>PM emissions induced in Plan area</b> | <b>0,11</b> | <b>tn</b> |

It is interesting to know the units of merchandise transported by train, which is shown in the following table (data for year 2011):

|                             | Num trens | Ratio Sortida<br>Unitats/tren | Ratio entrada<br>Unitats/tren | Ratio Sortida<br>tn/tren | Ratio entrada<br>tn/tren |
|-----------------------------|-----------|-------------------------------|-------------------------------|--------------------------|--------------------------|
| Contenedores EU (TEU/tren)  | 222       | 42,6                          | 14,2                          | 553,6                    | 184,7                    |
| Contenedores (TEU/tren)     | 3032      | 46,5                          | 46,1                          | 604,2                    | 599,6                    |
| Automobils SEAT (Veh./tren) | 1034      | 0,0                           | 175,3                         | 0,0                      | 210,3                    |
| Automobils (Veh./tren)      | 800       | 6,8                           | 179,8                         | 8,2                      | 215,7                    |
| Granel solid (tn/tren)      | 896       | 0,0                           | 838,4                         | 0,0                      | 838,4                    |
| Granel liquid (tn/tren)     | 188       | 823,1                         | 0,0                           | 823,1                    | 0,0                      |

It is important to note that trains work to maximal capacity and therefore increasing goods would mean increasing number of trains.

Furthermore, all trains are directed with diesel traction to Can Tunis station, next to the Port, from there the traction is electrical. As for the trains with cars to SEAT factory, diesel traction is until Sant Boi (around 3 km far from the port) and from there it uses electric traction. Solid bulk is transported totally by diesel traction to the potash mineries. Liquid bulk corresponds to bleach transport.

#### TERMINAL EQUIPMENT: CONTAINERS (CARGO HANDLING EQUIPMENT)

Useful information regarding air emissions figures have been found at Information in EMAS III declaration (2010) from TCB

[www.uic.org/download.php?environment%2F2006-01-diesel-study-wp1.pdf&ei=hgCYT7WYI46DhQeCuMDhBQ&usg=AFQjCNEU\\_Un1H3d4XvG4WNUWrLw9887krQ&sig2=B0rC3pN3gGvcWJbNNzky0A](http://www.uic.org/download.php?environment%2F2006-01-diesel-study-wp1.pdf&ei=hgCYT7WYI46DhQeCuMDhBQ&usg=AFQjCNEU_Un1H3d4XvG4WNUWrLw9887krQ&sig2=B0rC3pN3gGvcWJbNNzky0A)

(<http://www.tcbcn.com/web/tcb/DECLARACION%20AMBIENTAL%20EMAS%20III%202011%20CON%20NUM%20REGISTRO.pdf>):

Annual air emissions due to cargo handling equipment fuel:

| tn/year         | 2008  | 2009  | 2010 |
|-----------------|-------|-------|------|
| CO              | 26,44 | 13,69 | 3,89 |
| SO <sub>2</sub> | 9,40  | 5,37  | 7,19 |
| NO <sub>x</sub> | 57,53 | 30,41 | 2,06 |

TCB reports the following operational capacity:

| Year | TEUs      |
|------|-----------|
| 2008 | 1.220.500 |
| 2007 | 1.220.500 |
| 2006 | 1.000.000 |
| 2005 | 1.015.000 |
| 2004 | 934.293   |

Taking into account the year 2008, air emissions are calculated in terms of TEUs:

CO: 0,0216 kg/TEU

SO<sub>2</sub>: 0,0077 kg /TEU

NO<sub>x</sub>: 0,0471 kg/TEU

Then we consider total TEU transport in the port (summing up TERCAT activity). Total TEU traffic port of Barcelona 2008: 2.569.549

Finally, air emissions for the year 2008 are calculated:

CO: 55, 50 tn

SO<sub>2</sub>: 19,79 tn

NO<sub>x</sub>: 121,03 tn

TCB EMAS 2010 includes the following measures to be implemented:

- Replacement of 7 straddle Carriers, improving energy efficiency
- Optimization of machinery movements within the termina, avoiding unnecessary movements through informatics' systems.
- Gasoil has been changed to Repsol technodiesel or agrodiesel (10 ppm S)

TCB is member of the working team on Quality and Environment of the Port of Barcelona

## SOLID BULKS

At the inventory published by the Catalan Government in 2003 from Generalitat it was considered that port solid bulks were responsible PM10 178,85 tn/year. The governmental plan considered a set of measures that would allow reducing emissions by 133 tn/year. The Port Authority through annual reporting shows that most of these measures have been applied.

Thus, for 2008, we consider that 75% of these measures have been applied. Considering the figure of solid bulks movement for that year, PM10 emissions in 2008 are estimated in 79,97 tn. The following table summarizes this:

| <b>solid bulks</b>           |               |              |
|------------------------------|---------------|--------------|
|                              | 2003          | 2008         |
| total bulk                   | 3468306       | 3.506.472    |
| related PM10                 | 178,85        | 180,82       |
|                              | no measures   | measures 75% |
| reduction PM10 with measures |               | 100,85       |
| <b>PM10</b>                  | <b>178,85</b> | <b>79,97</b> |

It is important to note that the Port Authority has drafted guidelines for solid bulk operations which may come soon into force. This would support emissions reduction.

### ENLARGEMENT AND MAINTENANCE WORKS

In the last years, the port has gone through an enlargement process which has involved a great amount of construction material movements, as well as trucks traffic. Besides, maintenance works at dock is done regularly. Related emissions have not been estimated but they should be considered in future APICE activities and emissions abatement plan, particularly regarding PM10.

### OTHER PUNCTUAL SOURCES

Within the port, there are other concrete air emissions sources such as the wastewater treatment plant, power generation plants and industries. Another significant source is the construction works, whether they are aimed at enlarging the harbour or maintenance. These sources are not considered in the estimation of emissions as the other port sources.

In the case of power generation plants and industries, they are considered under the Air Quality Improvement Plan of the Catalan Government ([http://www20.gencat.cat/docs/dmah/Home/Ambits%20dactuacio/Atmosfera/Qualitat%20de%20laire/Oficina%20Tecnica%20de%20Plans%20de%20Millora/document%20base/docs/4\\_%20mesures%20Generalitat.pdf](http://www20.gencat.cat/docs/dmah/Home/Ambits%20dactuacio/Atmosfera/Qualitat%20de%20laire/Oficina%20Tecnica%20de%20Plans%20de%20Millora/document%20base/docs/4_%20mesures%20Generalitat.pdf)).

Concerning the wastewater treatment plant located within the port, PRTP inventory in Spain states the following emissions:

| Pollutant | Year | Kg/year |
|-----------|------|---------|
| NMVOC     | 2007 | 333.000 |
|           | 2010 | 207.000 |
| NOx       | 2008 | 694.000 |

At this regard, it is important to note that the long monitoring campaign carried out by CSIC-IDAEA in the frame of this project shows that NH<sub>3</sub> levels are higher around the WWTP.

Finally, regarding the construction works, they have a heavy influence on particulate matter, which also shown by the sampling campaign.

**Summary table 2008 emissions:**

| <b>ACTIVITIES OF SHIPS AND VESSELS</b>                 |               |                |                |               |            |               |              |
|--|---------------|----------------|----------------|---------------|------------|---------------|--------------|
|  | <b>CO</b>     | <b>NOx</b>     | <b>SOx</b>     | <b>NMVOCS</b> | <b>NH3</b> | <b>PM10</b>   | <b>PM2.5</b> |
| CAR-CARRIER  |               | 384.07         |                | 18.66         |            | 29.62         |              |
| CARGO LO-LO  |               | 157.66         |                | 6.57          |            | 10.79         |              |
| FRIDGE CARGO   |               | 10.66          |                | 0.47          |            | 0.76          |              |
| DRY BULK CARRIERS                                      |               | 201.09         |                | 7.27          |            | 12.96         |              |
| PASSENGERS   |               | 684.76         |                | 29.54         |            | 50.28         |              |
| PETROL ER (LIQUID BULK)                                |               | 10.70          |                | 0.79          |            | 1.17          |              |
| CONTAINER  |               | 2214.89        |                | 109.76        |            | 176.69        |              |
| RO-RO CARGO  |               | 191.46         |                | 8.91          |            | 14.34         |              |
| LIQUID BULK CARGO                                      |               | 1028.97        |                | 76.11         |            | 112.21        |              |
| FERRY (PASSENGER)                                      |               | 701.65         |                | 35.06         |            | 58.58         |              |
| HIGH SPEED FERRY (PASSENGER)                           |               | 16.65          |                | 1.10          |            | 1.78          |              |
| <b>TOTAL</b>   | <b>3619</b>   | <b>5602,56</b> | <b>6768,37</b> | <b>294,24</b> |            | <b>469,17</b> |              |
| <b>IN-PORT STORAGE</b>                                 |               |                |                |               |            |               |              |
|  | <b>CO</b>     | <b>NOx</b>     | <b>SOx</b>     | <b>NMVOCS</b> | <b>NH3</b> | <b>PM10</b>   | <b>PM2.5</b> |
| Solid bulk operations                                  |               |                |                |               |            | 79,97         |              |
| etc  |               |                |                |               |            |               |              |
| <b>IN-PORT TRAFFIC LOAD INDUCED BY PORT ACTIVITIES</b> |               |                |                |               |            |               |              |
|  | <b>CO</b>     | <b>NOx</b>     | <b>SOx</b>     | <b>NMVOCS</b> | <b>NH3</b> | <b>PM10</b>   | <b>PM2.5</b> |
| Heavy-duty vehicles                                    |               | 599,26         |                |               |            | 25,75         |              |
| Locomotives  |               | 3,91           |                |               |            | 0,11          |              |
| <b>OTHER ACTIVITIES NOT MENTIONED BEFORE</b>           |               |                |                |               |            |               |              |
|  | <b>CO</b>     | <b>NOx</b>     | <b>SOx</b>     | <b>NMVOCS</b> | <b>NH3</b> | <b>PM10</b>   | <b>PM2.5</b> |
| Tug boats  | <b>360,14</b> | 538,31         | <b>673,53</b>  | <b>29,28</b>  |            | <b>46,70</b>  |              |
| Auxiliary means  | <b>81,62</b>  | 120,33         | <b>152,64</b>  | <b>6,63</b>   |            | <b>10,58</b>  |              |
| Cargo handling   | 55,5          | 121,03         | 19,79          |               |            |               |              |

## 1.2 Identification of the future time risk activities and vulnerability systems in terms of emissions

In this chapter, the **trend scenario 2015** has been built up considering:

- Socioeconomic trends developed within APICE
- Official Port forecast regarding goods and passengers figure in the horizon 2015
- Ongoing or planned changes in infrastructure and operations within the port

Later in the project, another scenario will be considered, the one that considers air emissions abatement strategies in the horizon 2015

For each emission source, specific information is provided.

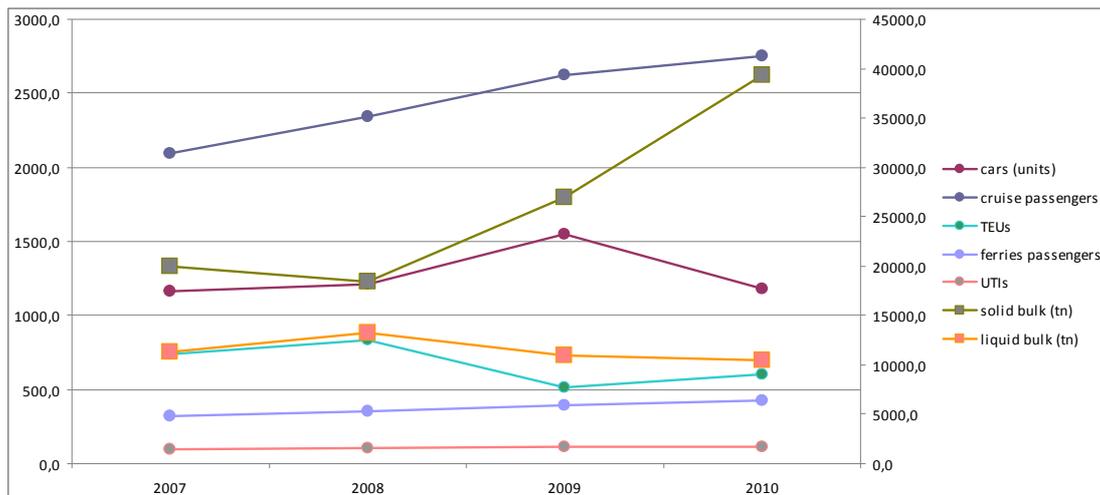
### ACTIVITIES OF SHIPS AND VESSELS

The trend scenario 2015 have been considered by evolution of type of merchandise/passengers, which has been provided by the Strategy Department of Port of Barcelona. These figures have been translated into vessels types and number of calls per vessel type. The following table shows correspondence between merchandise/passengers and vessel types in Spanish (note that some vessels can transport different kind of goods and/or passengers, but they are assigned to a single category in order to make the emission calculation by calls):

| Merchandise/passengers          | Vessel type             |
|---------------------------------|-------------------------|
| Containers (origin/destination) | Portacontenedor y LO-LO |
| Solid bulk                      | Graneleros              |
| Liquid bulk                     | Tanques y petroleros    |
| UTIs                            | RO-RO y transbordadores |
| Cars                            | Car-carrier             |
| Cruise passengers               | Cruceros                |
| Ferries passengers              | Transbordadores         |

When considering the forecast of calls, the ratio merchandise/vessel must be considered, since future vessels may transport more merchandise/passengers. The following table and figure show the evolution of this ratio.

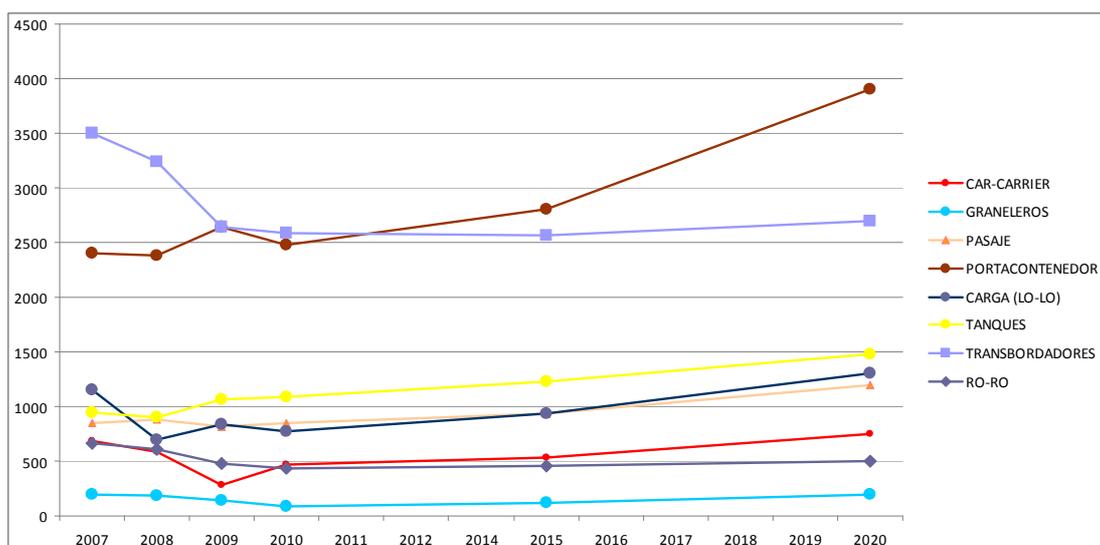
| Merchandise/passengers | 2007     | 2008     | 2009     | 2010     |
|------------------------|----------|----------|----------|----------|
| cars (units)           | 1163,14  | 1214,08  | 1550,01  | 1177,08  |
| solid bulk (tn)        | 19949,76 | 18455,12 | 26987,45 | 39357,98 |
| cruise passengers      | 2089,75  | 2344,13  | 2625,42  | 2755,29  |
| TEUs                   | 735,45   | 834,81   | 516,72   | 598,50   |
| liquid bulk (tn)       | 11330,44 | 13200,74 | 10925,51 | 10478,84 |
| ferries passengers     | 318,66   | 353,98   | 396,71   | 427,84   |
| UTIs                   | 98,25    | 101,44   | 109,28   | 112,50   |



From these ratios, we can see that dry bulk carriers tend to increase this ratio which is considered for the calls in future scenarios.

The following table and figure show the evolution of calls over the last years as well as the forecast for 2015 and 2020.

| Tipus Vaixell   | 2007 | 2008 | 2009 | 2010 | 2015 | 2020 |
|-----------------|------|------|------|------|------|------|
| CAR-CARRIER     | 689  | 590  | 283  | 468  | 530  | 750  |
| GRANELEROS      | 194  | 190  | 145  | 90   | 120  | 200  |
| PASAJE          | 845  | 885  | 820  | 853  | 930  | 1200 |
| PORTACONTENEDOR | 2399 | 2383 | 2644 | 2480 | 2800 | 3900 |
| CARGA (LO-LO)   | 1150 | 695  | 834  | 771  | 930  | 1300 |
| PETROLEROS      | 19   | 10   | 12   | 11   | 11   | 11   |
| TANQUES         | 951  | 907  | 1064 | 1092 | 1230 | 1480 |
| TRANSBORDADORES | 3496 | 3244 | 2644 | 2589 | 2560 | 2700 |
| RO-RO           | 666  | 605  | 478  | 437  | 460  | 500  |
| FRIGORIFICO     | 50   | 27   | 7    | 36   | 15   | 15   |

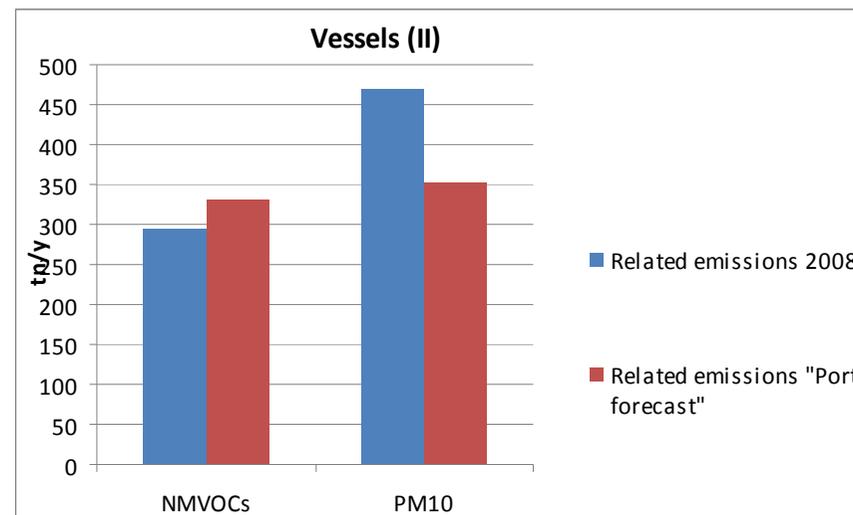
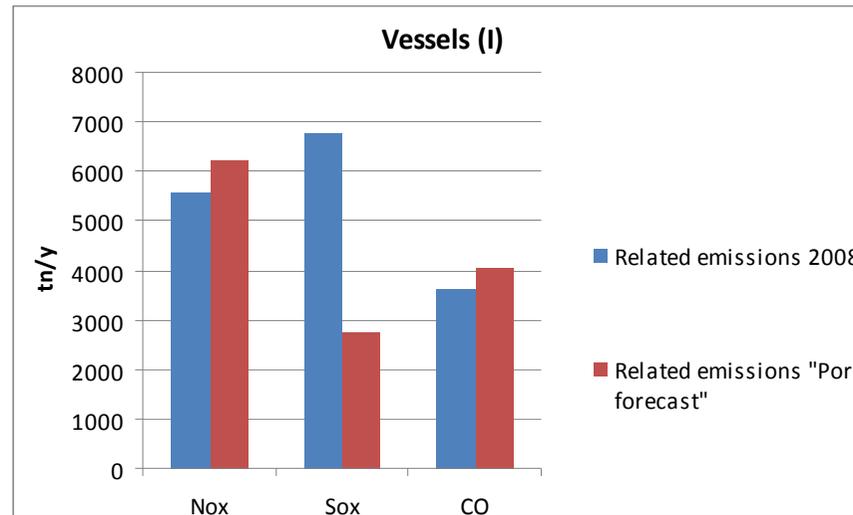


Since we know 2008 emissions by vessel type, emissions can be calculated for the 2015 scenarios. SO<sub>x</sub> and CO emissions are estimated in relation (proportion) to NO<sub>x</sub> emissions. In the case of SO<sub>x</sub>, it is considered a reduction by 97,3% in hotelling phase as a result of EU regulation (2005/33/EC), assuming that in 2008 the fuel sulfur content was 2,7% m/m and from 2010 is 0,10% m/m. PM<sub>10</sub> is also affected by this and it is considered a reduction of 50%.

The following table and figures show and compare the emissions in 2008 and the scenario 2015.

**Maritime transport scenarios**

|                        | 2008       |             | 2015        |               | Related emissions 2008 |                |               |               |                | Related emissions "Port forecast" |                |               |               |                |                |
|------------------------|------------|-------------|-------------|---------------|------------------------|----------------|---------------|---------------|----------------|-----------------------------------|----------------|---------------|---------------|----------------|----------------|
|                        | units      | merchandise | calls       | Port forecast | Nox                    | NMVOCs         | PM10          | Sox           | CO             | Nox                               | NMVOCs         | PM10          | Sox           | CO             |                |
|                        |            |             |             |               |                        |                |               |               |                |                                   |                |               |               |                |                |
| cars (units)           | 438.654    |             | 283         | 676.106       | 530                    | 384,07         | 18,66         | 29,62         |                | 719,05                            | 34,94          | 55,45         |               |                |                |
| TEUs                   | 1.797.157  |             | 3478        | 3.253.478     | 3730                   | 2214,89        | 109,76        | 176,69        |                | 2375,37                           | 117,71         | 189,49        |               |                |                |
| cruise passengers      | 2.152.847  |             | 820         | 2.800.000     | 930                    | 684,76         | 29,54         | 50,28         |                | 776,62                            | 33,50          | 57,02         |               |                |                |
| ferries passengers     | 1.048.890  |             | 2644        | 1.233.086     | 2560                   | 718,30         | 36,16         | 60,36         |                | 695,48                            | 35,01          | 58,44         |               |                |                |
| liquid bulk (tn)       | 12.105.080 |             | 1076        | 14.118.000    | 1241                   | 1039,67        | 76,90         | 113,38        |                | 1199,10                           | 88,69          | 130,77        |               |                |                |
| solid bulk (tn)        | 3.506.472  |             | 145         | 4.018.000     | 120                    | 358,75         | 13,84         | 23,75         |                | 296,90                            | 11,45          | 19,66         |               |                |                |
| UTIs                   | 341.173    |             | 485         | 370.447       | 463                    | 202,12         | 9,38          | 15,10         |                | 192,98                            | 8,96           | 14,42         |               |                |                |
| <b>TOTAL EMISSIONS</b> |            |             | <b>8931</b> |               | <b>9574</b>            | <b>5602,56</b> | <b>294,24</b> | <b>469,18</b> | <b>6768,37</b> | <b>3619,12</b>                    | <b>6255,49</b> | <b>330,26</b> | <b>351,92</b> | <b>2753,99</b> | <b>4040,90</b> |



## HARBOR CRAFT

### 1. Tug boats

No change on tug boats fleet is foreseen by 2015 in a way that we can assume that type of boats, fuel and operations will be the same. In that case, only the number of calls varies tug boats operations and related emissions. We do not consider ferries which do not require towage.

Since we know 2008 NOx emissions and the number of vessels calls, we can distribute tug NOx emission through those calls, and then calculate emissions for other number of calls.

This table shows the calculation:

|                   | 2008 calls    | 2015 calls    |
|-------------------|---------------|---------------|
| cars (units)      | 283           | 530           |
| TEUs              | 3478          | 3730          |
| cruise passengers | 820           | 930           |
| liquid bulk (tn)  | 1076          | 1241          |
| solid bulk (tn)   | 145           | 120           |
| UTIs              | 485           | 463           |
| total calls       | 6287          | 7014          |
| <b>NOx</b>        | <b>538,31</b> | <b>600,55</b> |

### 2. Auxiliary means

NOx emissions resulting from auxiliary means working within the port have been estimated considering the overall change of activity at the Port. According to the official forecast, activity would increase around 15%.

|                    | 2008          | Port forecast 2015 |
|--------------------|---------------|--------------------|
| increased activity |               | 15%                |
| <b>NOx</b>         | <b>120,33</b> | <b>138,38</b>      |

## CARGO HANDLING

Cargo handling related emissions are estimated in function of TEUs movements evolution and new terminal equipment. The following table shows TEUs evolution and related emissions. Furthermore, the new containers terminal will be semi-automated which means that an important fraction of machinery will be electrified resulting into a reduction of emissions, which is estimated in 45%.

|            | 2008          | Port forecast 2015 |
|------------|---------------|--------------------|
| TEUs       | 2569549       | 3253478            |
| <b>NOx</b> | <b>121,03</b> | <b>84,28</b>       |
| <b>SO2</b> | <b>19,79</b>  | <b>13,78</b>       |

|    |       |       |
|----|-------|-------|
| CO | 55,50 | 38,65 |
|----|-------|-------|

No other changes are considered regarding the evolution and substitution of machinery, fuel and operations.

### SOLID BULKS

As for solid bulks, reference data is from 2003 as calculated by Generalitat de Catalunya. As explained in previous section, PM10 emissions for 2008 are estimated applying 75% of the measures proposed in 2003. For the scenarios of 2015, solid bulks movement is estimated considering full mitigation measures implementation. The following table shows the estimations:

|                              | 2003          | 2008         | Port forecast 2015 |
|------------------------------|---------------|--------------|--------------------|
| total bulk                   | 3468306       | 3.506.472    | 4018000            |
| related PM10                 | 178,85        | 180,82       | 207,20             |
|                              | no measures   | measures 75% | measures 100%      |
| reduction PM10 with measures |               | 100,85       | 154,08             |
| <b>PM10</b>                  | <b>178,85</b> | <b>79,97</b> | <b>53,12</b>       |

### LAND TRAFFIC: HEAVY DUTY VEHICLES

The trend scenario considers evolution according to the amount of tones expected to be transported by trucks, as well as a reduction by 10% on the emissions factors due to fleet renewal.

The table shows the calculation:

|  | 2008          |            | 2015          |            |
|--|---------------|------------|---------------|------------|
| Tranported tones by road               | 32687121      | tn         | 29931005      | tn         |
| Average load                           | 19,8          | tn/vehicle | 19,8          | tn/vehicle |
| Average distance within Plan area      | 30            | km         | 30            | km         |
| Average distance at port               | 4             | km         | 4             | km         |
| Truck movements                        | 1650865       | movements  | 1511667       | movements  |
| EF Nox                                 | 12,1          | g/km       | 10,89         | g/km       |
| EF PM10                                | 0,52          | g/km       | 0,468         | g/km       |
| <b>Nox emissions wihin port</b>        | <b>79,90</b>  | <b>tn</b>  | <b>65,85</b>  | <b>tn</b>  |
| <b>PM10 emissions within port</b>      | <b>3,43</b>   | <b>tn</b>  | <b>2,83</b>   | <b>tn</b>  |
| <b>Nox emissions within Plan area</b>  | <b>599,26</b> | <b>tn</b>  | <b>493,86</b> | <b>tn</b>  |
| <b>PM10 emissions within Plan area</b> | <b>25,75</b>  | <b>tn</b>  | <b>21,22</b>  | <b>tn</b>  |

## LAND TRAFFIC: LOCOMOTIVES

Rail transport is expected to increase considerably in the coming years reaching a 13,9% quota by 2015. This has been used to estimate the trains' movements. As for emission factors, it has been considered the average for fleet post 1990, from the study *Status and future development of the diesel fleet*.

|  | 2008        |           | 2015         |           |
|--|-------------|-----------|--------------|-----------|
| Number of trains movements               | 1665        | movements | 13618        |           |
| Average time within port                 | 0,25        | h         | 0,25         |           |
| Average time within Plan area            | 0,5         | h         | 0,5          |           |
| Average nominal power output             | 800         | kW        | 800          |           |
| Average load factor                      | 0,5         |           | 0,5          |           |
| Average EF Nox                           | 11,73       | g/kW      | 9,86         |           |
| Average EF PM                            | 0,32        | g/kW      | 0,19         |           |
| <b>Nox emissions within port</b>         | <b>1,95</b> | <b>tn</b> | <b>13,43</b> | <b>tn</b> |
| <b>PM emissions within port</b>          | <b>0,05</b> | <b>tn</b> | <b>0,26</b>  | <b>tn</b> |
| <b>Nox emission induced in Plan area</b> | <b>3,91</b> | <b>tn</b> | <b>26,85</b> | <b>tn</b> |
| <b>PM emissions induced in Plan area</b> | <b>0,11</b> | <b>tn</b> | <b>0,52</b>  | <b>tn</b> |

Beyond the horizon 2015, it is expected that the new container terminal will be fully operational with an enhanced rail system which will be more electrified, and thus emissions will be lowered due to substitution of diesel traction.

## Summary future emissions

The following table shows total port emissions for 2008 and 2015 scenarios. Note that there is a distinction between emissions generated within port, and those induced by the port; this related to the fact of land traffic (trucks and locomotives) which circulates around the port area. For this, it is considered the same area as that of the Air Quality Improvement Plan of the Catalan Government.

\* In red, data which is estimated from NOx emissions

| Aggregated scenarios: emissions within the port  |         |           |                 |                |             |                     |             |                |
|--|---------|-----------|-----------------|----------------|-------------|---------------------|-------------|----------------|
| 2008   |         |           |                 |                |             |                     |             |                |
|  | Vessels | Tug boats | Auxiliary means | Cargo handling | Solid bulks | Heavy-duty vehicles | Locomotives | TOTALS         |
| Nox  | 5602,56 | 538,31    | 120,33          | 121,03         |             | 79,90               | 1,95        | <b>6464,08</b> |
| NMVOCs   | 294,24  | 28,27     | 6,32            |                |             |                     |             | <b>328,83</b>  |
| PM10   | 469,18  | 45,08     | 10,08           |                | 79,97       | 3,43                | 0,05        | <b>607,79</b>  |
| Sox  | 6768,37 | 650,33    | 145,37          | 19,79          |             |                     |             | <b>7583,86</b> |
| CO   | 3619,12 | 347,74    | 77,73           | 55,50          |             |                     |             | <b>4100,09</b> |
| PORT FORECAST 2015                               |         |           |                 |                |             |                     |             |                |
|  | Vessels | Tug boats | Auxiliary means | Cargo handling | Solid bulks | Heavy-duty vehicles | Locomotives | TOTALS         |
| Nox  | 6255,49 | 600,55    | 138,38          | 84,28          |             | 65,85               | 13,43       | <b>7157,98</b> |
| NMVOCs   | 330,26  | 31,71     | 7,31            |                |             |                     |             | <b>369,28</b>  |
| PM10   | 351,92  | 33,79     | 7,78            |                | 53,12       | 2,83                | 0,26        | <b>449,69</b>  |
| Sox  | 2753,99 | 264,39    | 60,92           | 13,78          |             |                     |             | <b>3093,08</b> |
| CO   | 4040,90 | 387,94    | 89,39           | 38,65          |             |                     |             | <b>4556,88</b> |
| Aggregated scenarios: emissions induced the port |         |           |                 |                |             |                     |             |                |
| 2008   |         |           |                 |                |             |                     |             |                |
|  | Vessels | Tug boats | Auxiliary means | Cargo handling | Solid bulks | Heavy-duty vehicles | Locomotives | TOTALS         |
| Nox  | 5602,56 | 538,31    | 120,33          | 121,03         | 0,00        | 599,26              | 3,91        | <b>6985,40</b> |
| NMVOCs   | 294,24  | 28,27     | 6,32            |                |             |                     |             | <b>328,83</b>  |

|      |         |        |        |       |       |       |      |                |
|------|---------|--------|--------|-------|-------|-------|------|----------------|
| PM10 | 469,18  | 45,08  | 10,08  |       | 79,97 | 25,75 | 0,11 | <b>630,17</b>  |
| Sox  | 6768,37 | 650,33 | 145,37 | 19,79 |       |       |      | <b>7583,86</b> |
| CO   | 3619,12 | 347,74 | 77,73  | 55,50 |       |       |      | <b>4100,09</b> |

**PORT FORECAST 2015**

|        | Vessels | Tug boats | Auxiliary means | Cargo handling | Solid bulks | Heavy-duty vehicles | Locomotives | TOTALS         |
|--------|---------|-----------|-----------------|----------------|-------------|---------------------|-------------|----------------|
| Nox    | 6255,49 | 600,55    | 138,38          | 84,28          | 0,00        | 493,86              | 26,85       | <b>7599,42</b> |
| NMVOCs | 330,26  | 31,71     | 7,31            |                |             |                     |             | <b>369,28</b>  |
| PM10   | 351,92  | 33,79     | 7,78            |                | 53,12       | 21,22               | 0,52        | <b>468,35</b>  |
| Sox    | 2753,99 | 264,39    | 60,92           | 13,78          |             |                     |             | <b>3093,08</b> |
| CO     | 4040,90 | 387,94    | 89,39           | 38,65          |             |                     |             | <b>4556,88</b> |

### 1.3 Identification of the future risk activities and vulnerability systems in terms of air quality concentrations

*The model will be run after the completion of this study*

### 1.4 Involvement of stakeholders in the activities relevant with the presence of the port in Barcelona

Stakeholders, their roles and desirable involvement in APICE are explained by risk activity and type of competence/field of action:

#### ACTIVITIES OF SHIPS AND VESSELS

*Legal framework:* IMO is the international responsible for maritime transport legal framework, under the MARPOL Convention. It can intervene in terms of type of vessels engines and fuel. EU can also legislate at this regard. Thus, they should be approached by proposing specific measures and targets by the overall APICE project, not by project site. In Spain, we should furthermore consider:

- General Direction of Environmental Quality and Evaluation within the Ministry of Environment
- The General Direction of the Merchant Navy:
  - o General Sub direction for Safety, Pollution and Maritime Inspection
  - o General Sub direction for Maritime Normative and International Cooperation

*Operations:* The Port Authority of Barcelona (APB) can regulate the vessels access to the port (e.g. speed). It is also responsible for terminals location, maintenance, etc. Therefore any measure regarding vessels movement within the port must be agreed with the APB.

*Users/exploitation:* Ship companies are the main stakeholder. It might be difficult to involve all of them, therefore the European Community Shipowners' Associations (ECSA) could be approached the same way as IMO. It is important to note ECSA's position regarding air quality, for example it has released the study [Analysis of the Consequences of Low Sulphur Fuel Requirements](#).

#### INNER VESSELS FLEET (HARBOR CRAFT)

*Legal framework:* as in previous activity, IMO and EU are responsible for this.

*Operations:* the APB defines how the towage operations must be performed through the conditions established at [Plec de prescripcions particulars del servei portuari bàsic de remolc al Port de Barcelona](#). Mitigation measures will be discussed vis-à-vis the APB so they can be included in this document.

*Users/exploitation:* There are two companies providing towage at the Port of Barcelona: Grupo Rebarsa and Grupo REYSER. Both of them have been already visited and mitigation measures will be presented and discussed with them.

## LAND TRAFFIC: TRUCKS AND LOCOMOTIVES

*Legal framework:* Within Europe railway engines' emissions are regulated by the non-road mobile machinery (NRMM) directives. The legislation currently in force for heavy-duty vehicles is Directive 2005/55/EC (agreed in co-decision) and Directive 2005/78/EC (implementing provisions).

*Operations:* The APB is responsible for planning land traffic within the port. ADIF is responsible for planning the rail system. Both will be approached for optimization of land traffic. It is important to note two initiatives regarding the inner road transport system:

- Strategy to optimize the port terrestrial transport system, signed by Port Authority and Generalitat de Catalunya.
- Collaboration agreement to implement training and sustainable mobility actions, signed by the Logistic Activities Zone, Barcelona-Catalunya Logistic Centre and Royal Automobile Club of Catalonia.

*Users/exploitation:* Truck transport is done by free-lance truck drivers, while rail transport is served by several train companies.

## SOLID BULKS

*Legal framework:* no information

*Operations:* The APB establishes the conditions under which companies can handle solid bulks. This includes actions to reduce air emissions. Therefore APICE project would dialogue on additional prescriptions to be included.

*Users/exploitation:* There is a specific terminal for this purpose with the following companies: Portcemen, Tramer, Ergransa, Bunge, Cargill, Cemex and Sal Costa. These companies will be approached if measures at proposed addressing this source.

## CARGO HANDLING

*Legal framework:* Machinery is regulated by non-road mobile machinery (NRMM) directives (DIRECTIVE 2002/88/EC amends Directive 97/68/EC measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery).

*Operations:* APB establishes the conditions under which companies can handle containers. Therefore APICE project would dialogue on additional prescriptions to be included.

*Users/exploitation:* There are two companies providing the service: TCB and TERCAT. They will be approached in case there are measures addressing this source. They have an environmental quality system including air emissions, and therefore they could include additional targets.

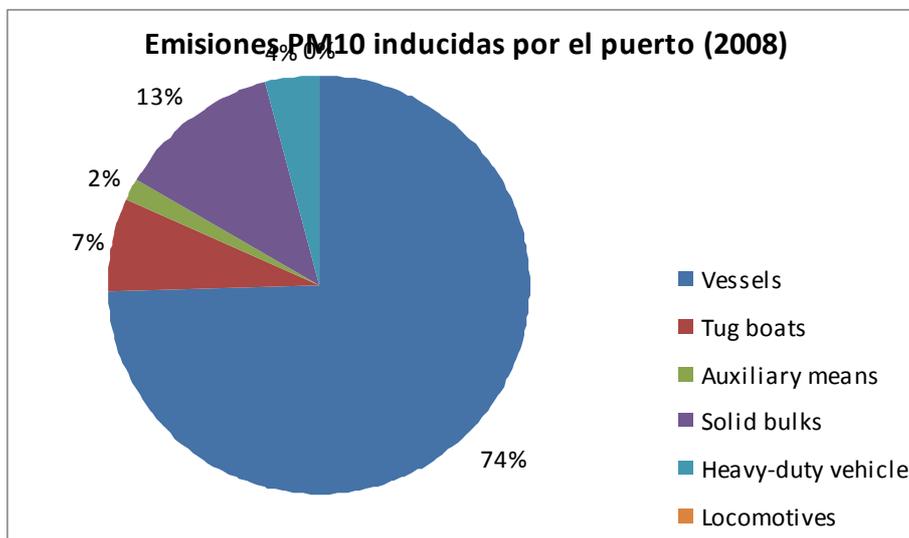
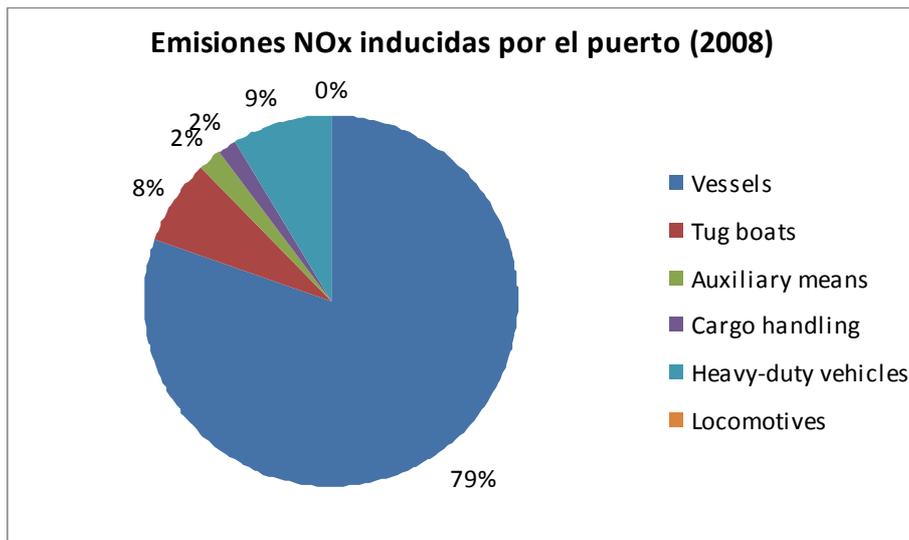
### 1.5 Additional issues

Regarding future emissions scenarios, we have considered a limited number of factors that will control these emissions, e.g., S content in fuel, goods and passengers movements, land traffic evolution, etc. However, a number of factors have not been applied, especially for

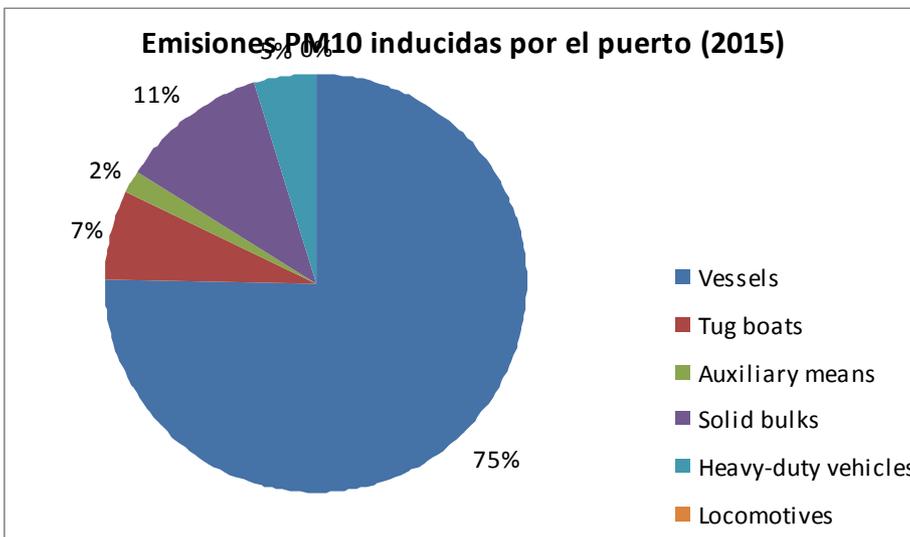
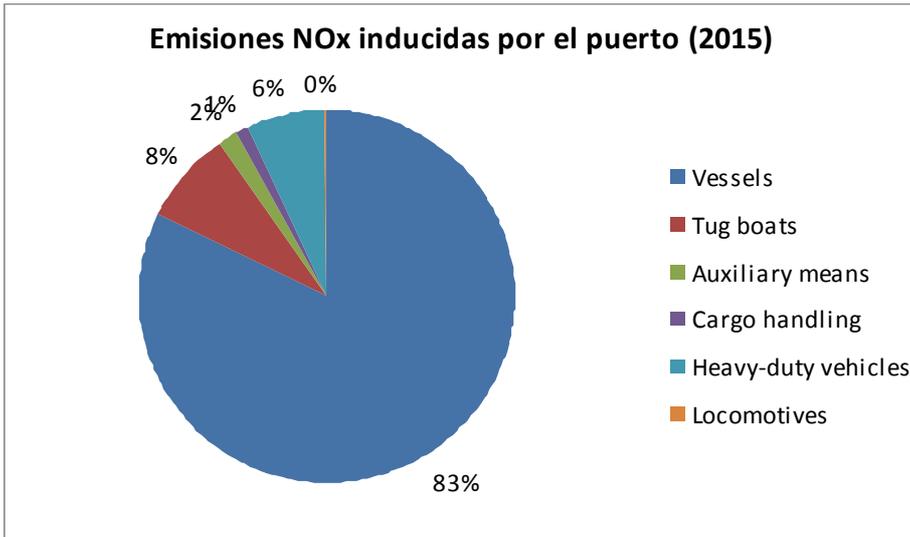
cargo handling, heavy-duty vehicles, and locomotives. Other EU legislation applies to them 91/542/EEC and non-road mobile machinery (NRMM) directives). Notwithstanding, for heavy-duty vehicles and locomotives, lower emission factors have been considered in the future.

### 1.6 Conclusions for Barcelona

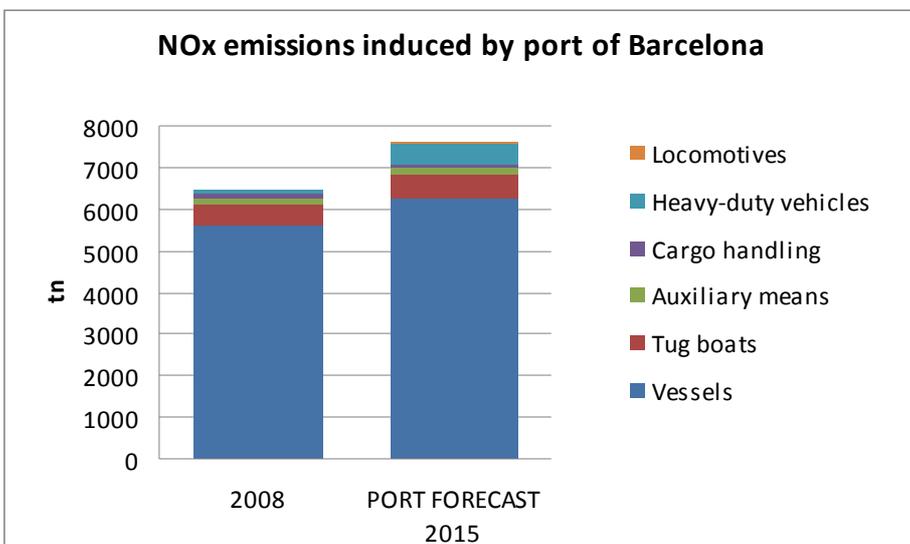
Research and assessment of emissions sources in Port of Barcelona show that main emissions come from maritime traffic during the phases of manoeuvring and hotelling. The following figures show the % of emissions sources for NOx and PM10.

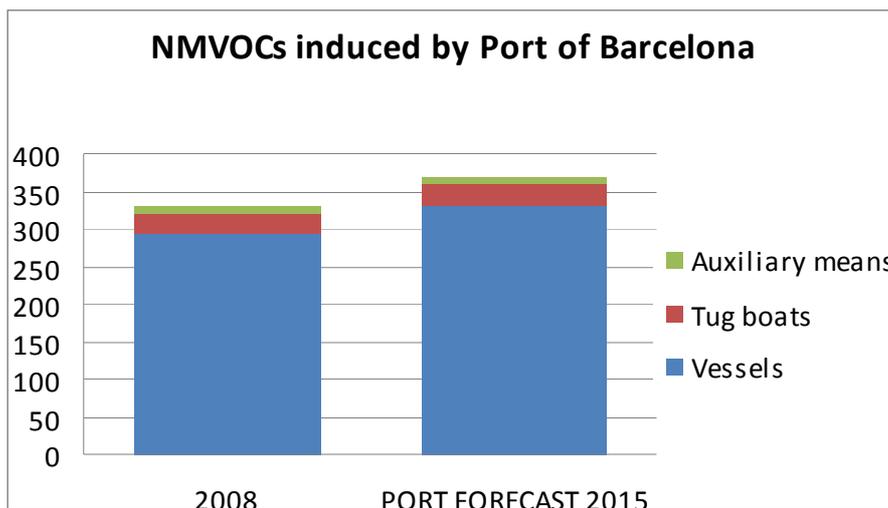
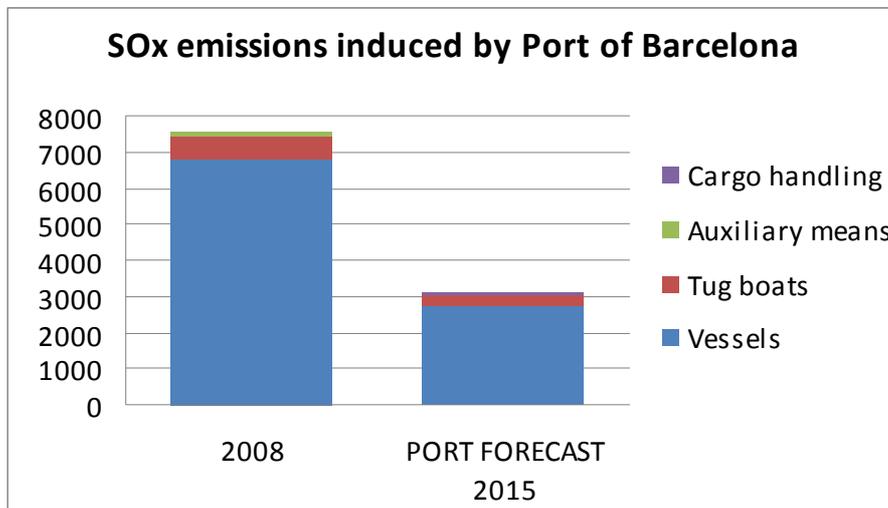
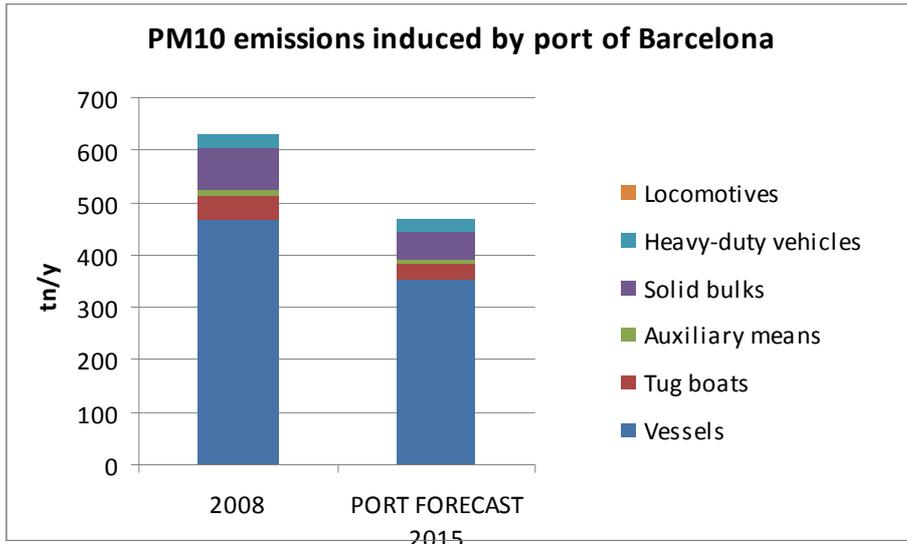


The scenario 2015 shows a similar distribution of these sources, as shown in these figures for the same pollutants.



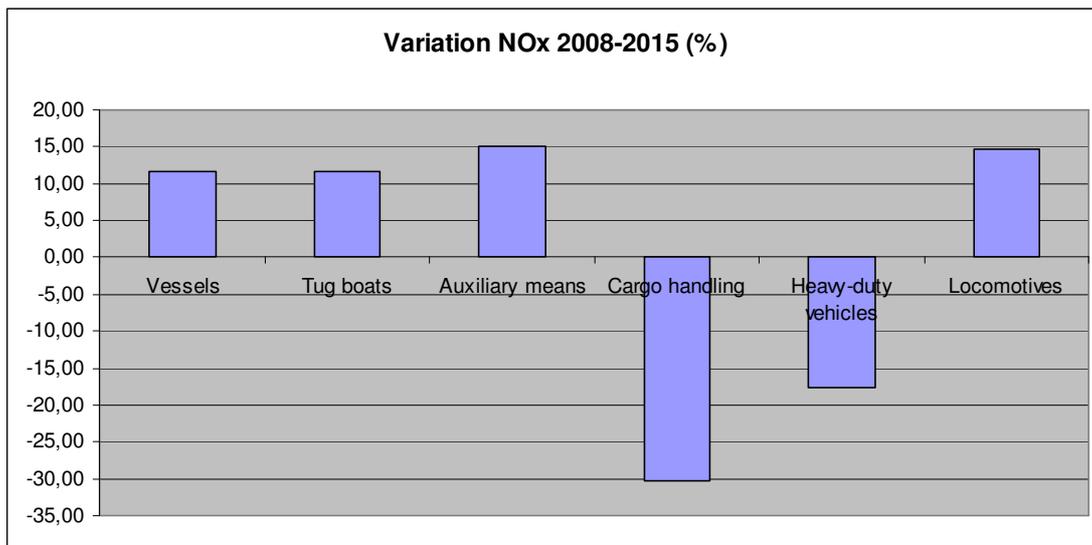
As for total emissions and variation between 2008 and 2015, emissions increase for all pollutants except for Sox and PM10, as shown in these figures.



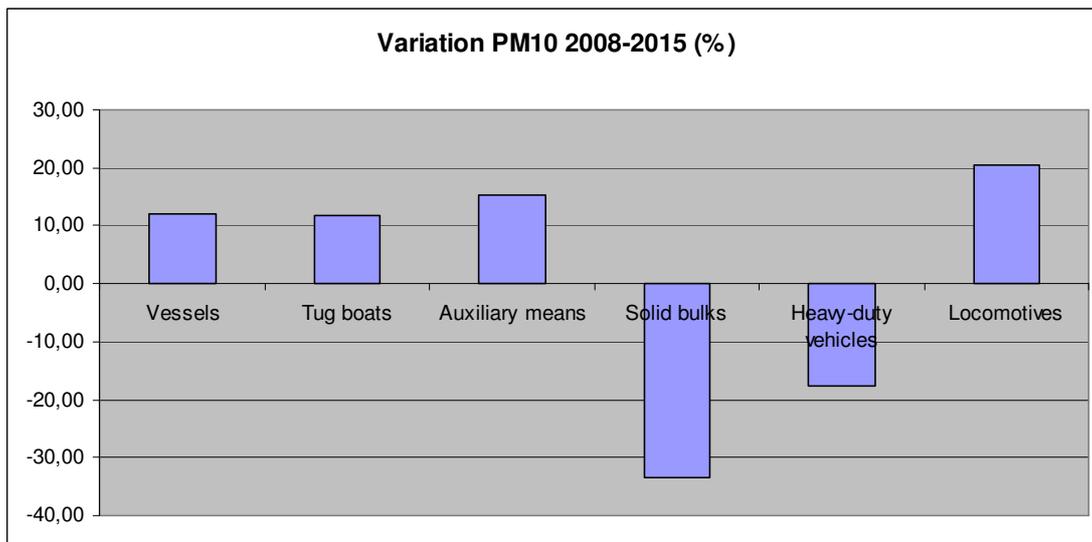


In order to have a better insight of the emissions evolution, it is convenient to look at each emission source and each pollutant.

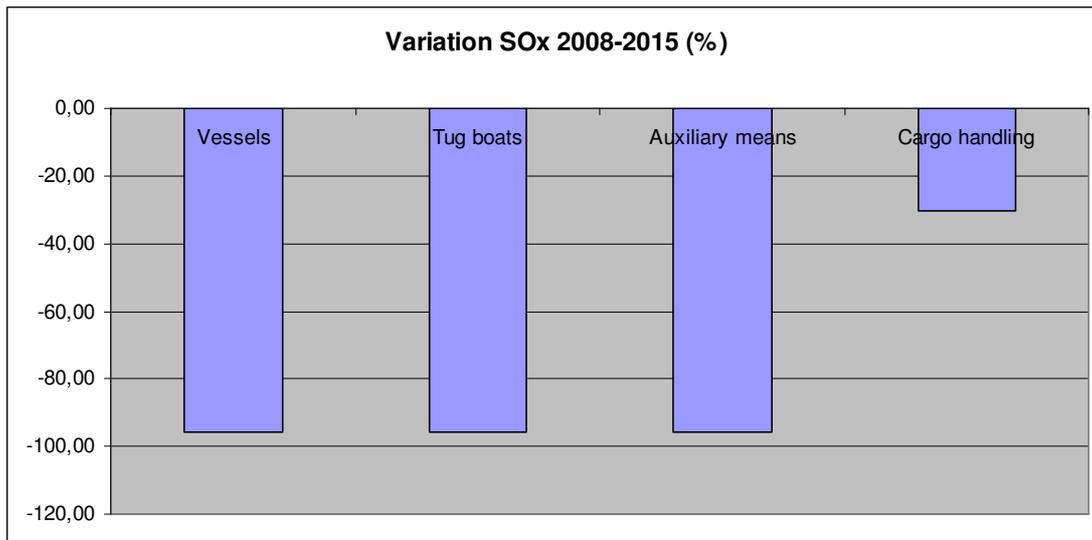
NOx variations are shown in the figure below. Emissions increase in all maritime sources due to a greater activity. However, in the case of cargo handling machinery, it is reduced due to automatization of the new terminal. In the case of land traffic, heavy-duty vehicles decreases while locomotives increase, due to increased transfer to rail freight transport.



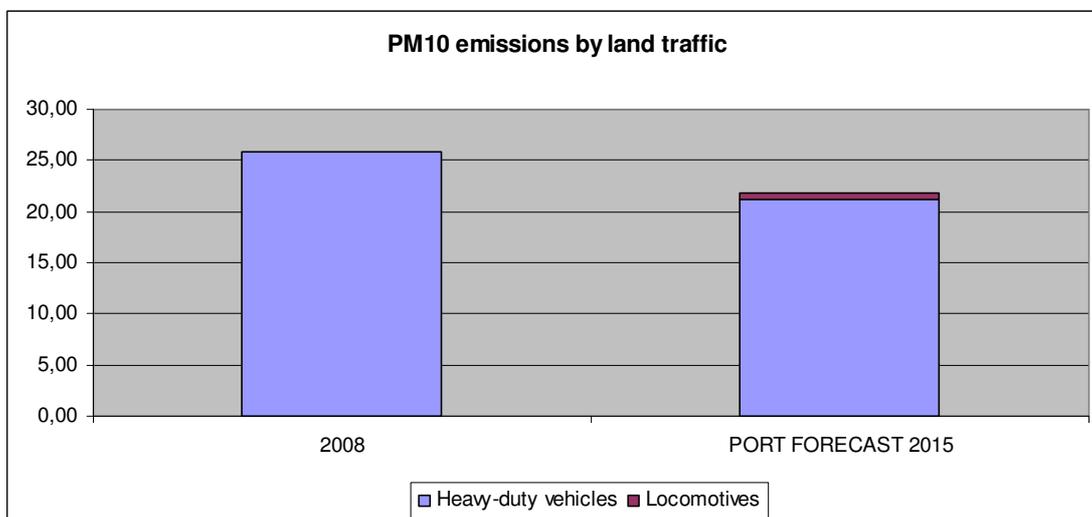
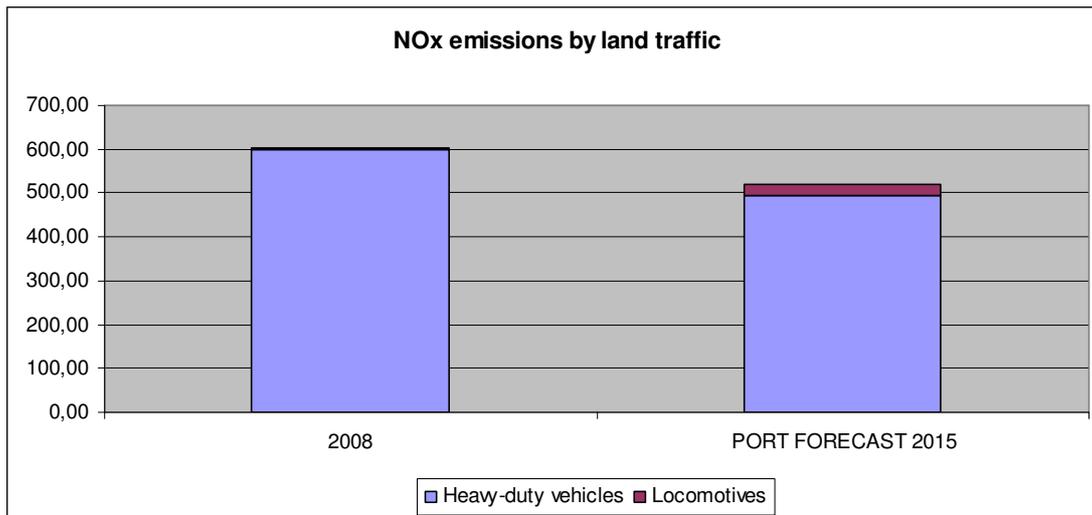
As for PM10, the situation is very similar for the same reasons. Cargo handling is not considered here. In the case of solid bulks, emissions are lowered due to further mitigation measures implementation. The following figure shows these variations.



Regarding SOx emissions, all sources are reduced similarly due to the reduction of S maritime fuel content as well as the automatization of containers terminal.



Finally, it is important to focus on how the ratio rail/road freight transport has an effect on air emissions. Although land traffic is expected to increase due to greater port activity, emissions as a result of land traffic diminish due to greater proportion transported by rail. In the case of NOx, emissions are reduced by 13,67% while for PM10, by 15,93%. The following figures show this evolution.



To conclude, it has been shown that air emissions caused by vessels in manoeuvring and hotelling phases are the main source of air pollution at the port. Although SOx have started to be drastically cut due to new IMO legislation in force, NOx emissions and PM10 emissions are expected to increase. The reduction of these pollutants must be seen in a longer perspective than 2015 since this would be achieved through new engines and fuels that will not be legally required in the short term. The same applies for tug boats and auxiliary means.

In the case of cargo handling machinery, the semi-automatisation of new TERCAT terminal will have important effects on improving air quality. However, it might be considered to introduce some measures in TCB terminal.

Solid bulks handling have been improved over the last years and mitigation measures have been included. It will be further investigated whether additional measures could be proposed.

The Port Authority has a strong willingness on transferring more traffic land to locomotives, and important efforts are being devoted from the point of view of infrastructures, operations and marketing. Although land traffic emissions will likely diminish, additional measures, mainly technical, could have an improved effect on air quality.

This research will allow the team to model air emissions to study pollutants concentrations, especially in the light of future scenarios. An additional 2015 scenario will be proposed which will include mitigation measures proposed by APICE project, as part of the Common Transnational Strategy and Local Adaptation Plan. These activities will follow to this study, based on the insight gained and further research on air emissions abatement strategies.