

# New ship emissions inventory for the Mediterranean Sea

## *Recent study sheds new light on earlier work*

In order to provide an up-to-date ship emission inventory for the Mediterranean Sea, a study (further referred to as the 'CONCAWE study') was recently completed for CONCAWE by the environmental and engineering consultancy Entec UK Ltd. Entec have been involved in a number of previous such studies and, in their own view, the CONCAWE study has resulted in a more robust inventory for the Mediterranean than was the case in their earlier work. A previous study carried out for DG Environment jointly by Entec, IIASA and the Norwegian Meteorological Institute and published in October 2006<sup>1</sup> (further referred to as the 'DG-ENV study') currently serves as a basis for input into the Integrated Assessment Modelling (using the IIASA GAINS model). This in turn, provides policy guidance for the revision of the National Emission Ceiling Directive (NECD). This article explores the key differences between the DG-ENV and CONCAWE studies.

### **Key features of the CONCAWE study**

A key objective was to provide a more accurate, detailed and complete inventory than had hitherto been the case. The input data and methodology were specifically reviewed to achieve this. The key new elements were:

- Use of the 2005 vessel movements and characteristics data provided by Lloyds Marine Intelligence Unit (LMIU). This latest ship movement database includes some significant improvements over the 2000 LMIU database used by Entec in their previous studies, e.g. more accurate vessel arrival and departure times, and vessel-specific engine power data for main and auxiliary engines. In addition a full year of ship movements data was obtained from Lloyds rather than the 'four months' of data used in previous work.

- Manual addition of approximately 100,000 passenger vessel movements (mainly Greek port callings) using detailed company timetables. This was done to overcome the limitations of the LMIU database where multiple port calls within a single day are not recorded.
- Improved routing algorithms for individual point-to-point journeys based on the enhanced information in the latest LMIU database.
- Use of a much finer 'near shore' grid resolution (10x10 km) than the EMEP 50x50 gridding used in previous studies. A key reason for using finer resolution gridding near shore was to enable emissions within 'territorial waters' (12 nautical miles) to be determined accurately.
- Improved methodology for determining the time a ship spends in port based on the more detailed arrival/departure time data included in the latest LMIU database.
- Use of a more robust methodology for determining the relative percentages of gas oil and heavy fuel oil in the total fuel consumed, resulting in figures essentially in-line with studies carried out by the Beicip-Franlab consultancy for the EU Commission in 2002 and 2003<sup>2</sup>. In line with European legislation, the gas oil sulphur level was set at 0.2% for 2005 and 0.1% for 2010 and beyond.

### **Emission intensity map**

To provide an overall perspective on the spatial distribution of emissions, the resulting emission intensity map (i.e. tonnes of SO<sub>2</sub> emissions/km<sup>2</sup>) for the survey year of 2005 is shown in Figure 1. The high activity within coastal areas of the Mediterranean is readily

<sup>1</sup> *Interim report, Analysis of Policy Measures to Reduce Ship Emissions in the Context of the Revision of the National Emission Ceilings Directive, Janusz Cofala et al., October 2006.*

<sup>2</sup> *Advice on the costs to fuel producers and price premia likely to result from a reduction in the level of sulphur in marine fuels marketed in the EU (April 2002). Advice on marine fuels (October 2003). Contract EN.C1/SER/2001/0063*

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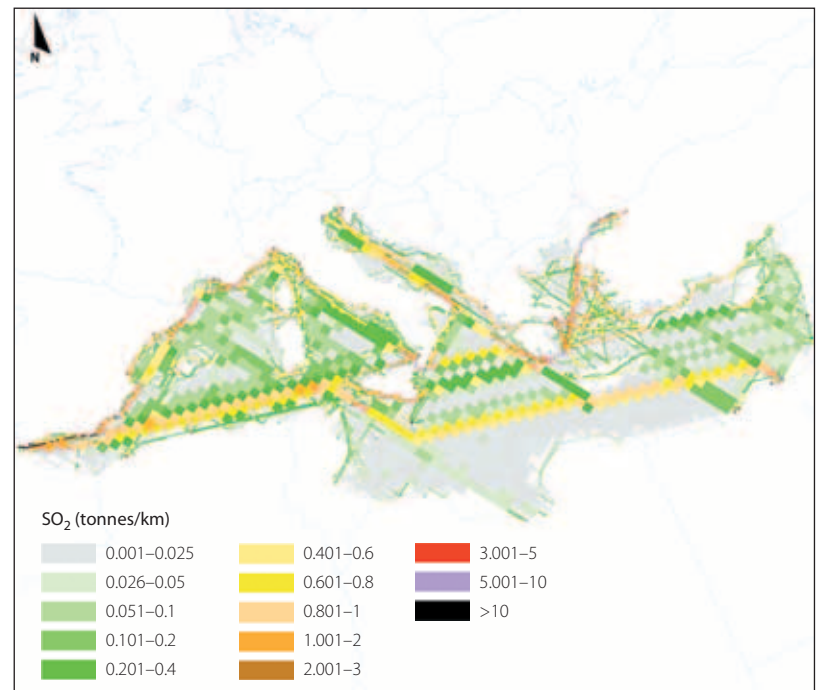
seen in the finer near-shore grids. Also visible is the impact of the large number of 'transit' ships sailing between Suez and Gibraltar.

### Current inventory and emission forecasts: comparison with the DG-ENV study

The results of both studies are shown in Table 1. Beyond establishing the inventory for the base year, both studies also included forecasts for 2010 and 2020. The CONCAWE study estimates SO<sub>2</sub> and NO<sub>x</sub> emissions in 2005 at respectively 67% and 80% of the DG-ENV study numbers for 2000. The much decreased SO<sub>2</sub> emissions figure is due to the improved methodology used in the CONCAWE study for attributing gas oil or heavy fuel oil to individual ships, the overall effect of which is to increase the proportion of gas oil in the total ship fuel pool. This of course reduces the total SO<sub>2</sub> emissions for a given total fuel consumption. The SO<sub>2</sub> emissions are lower in 2010 than in 2005 because of the entry into force of the requirements for all EU ferries to comply with a maximum fuel sulphur content of 1.5% and for all ships in EU ports to utilise marine gas oil (0.1%S) while alongside. The reduction in SO<sub>2</sub> emissions resulting from these requirements more than offsets the growth in ship movements between 2005 and 2010.

It must also be noted that, as a result of the finer near-shore gridding, the CONCAWE study found that a higher fraction of the emissions occurs in the 12-mile territorial

**Figure 1 Base case 2005 SO<sub>2</sub> inventory**



water zones than evidenced in previous inventories. The recent work attributes about 30% of emissions to the 12-mile zones, compared to an average of about 20% for all EU seas reported by IIASA in their October 2006 and March 2007 reports.

The growth rate assumptions of 2.5% per annum for cargo vessels and 3.9% for passenger vessels used in the DG-ENV study were also used in the CONCAWE study. The emissions implied by these growth rates in a 2010

**Figure 1**

*The map shows the level of SO<sub>2</sub> emissions per square kilometre for the base year of 2005. The high activity within coastal areas is readily seen in the finer near-shore grids, and the impact of the large number of 'transit' ships sailing between Suez and Gibraltar can also be observed.*

**Table 1 Emissions in the Mediterranean: 2006 DG-ENV study vs. CONCAWE Study**

(Figures in kt/a)	SO <sub>2</sub>			NO <sub>x</sub>		
	DG ENV	CONCAWE	Ratio	DG ENV	CONCAWE	Ratio
Reference year	2000	2005	%	2000	2005	%
Mediterranean total 2000/05	1278	862	67%	1818	1448	80%
Mediterranean total 2010	1602 <sup>b</sup>	840	52%	2383 <sup>a</sup>	1461	61%
Mediterranean total 2020	2082 <sup>c</sup>	1088	52%	3095 <sup>b</sup>	1771	57%

<sup>a</sup> Addendum to CONCAWE—Ship Emission Inventory—Mediterranean Sea, February 2007, Entec Limited; Entitled: *Ship Emissions in the Mediterranean Sea—Approach to CONCAWE Ship Emissions Study, with Comparisons against Entec's Earlier Work for the European Commission.*

<sup>b</sup> Data used by IIASA for IAM RAINS modelling in the CAFE programme.

<sup>c</sup> Cost-optimised reductions of air pollutants emissions in EU Member States to meet the environmental targets of the Thematic Strategy on Air Pollution-NEC Scenario Analysis Report Nr 3 Part 1, Table 3.2. IIASA March 2007 (Derived from October 2006 Entec Study).

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and 2020 time horizon (current horizon years for the NECD and the Thematic Strategy on Air Pollution respectively) are also given in the table.

Over the past several years, Entec have been contracted by DG-ENV for a number of shipping-related studies. In their view, 'Port callings are likely to be the most appropriate overall proxy for the growth in movements (compared to the total number of movements that would include port callings plus vessels passing through the Mediterranean Sea without calling)<sup>3</sup>. According to the CONCAWE study there were 249,819 port callings in 2005 within the Mediterranean Sea. The 2006 DG-ENV study indicated a number of 239,308 in 2000. Lloyds have confirmed that the underlying method of reporting and including port calls into the database has not changed between 2000 and 2005, which indicates that ship activity within the Mediterranean Sea has only grown by some 4% over this period, i.e. somewhat less than 1% annually. This is very different from the growth rate assumptions of 2.5% for cargo vessels and 3.9% for passenger vessels used in the DG-ENV study.

This very different perspective on growth has a profound influence on the 'emissions multiplier' used to generate 2010 and 2020 'uncontrolled' baseline emissions for use in IIASA Integrated Assessment Modelling (IAM). Over a ten-year period (2010 horizon) growth rates of 2.5% for cargo vessels and 3.9% for passenger vessels result in multipliers of 1.28 and 1.47 respectively. With a 1% growth rate, over the same period the multiplier would drop to 1.11. The emissions of SO<sub>2</sub> and NO<sub>x</sub> in Table 1 reflect these multipliers together with the changes in legislative requirements over the period and the penetration rate of new vessels meeting the NO<sub>x</sub> emission limits required by IMO.

Based on the new CONCAWE study, projected 2020 emissions for both SO<sub>2</sub> and NO<sub>x</sub> would be almost halved compared to those currently used by IIASA in their IAM assessment work associated with the NECD review. Aside from the essential issue of cost-effectiveness, this large reduction has important implications for the potential contribution that Mediterranean ship emissions can make to delivering further improvements in human health or the environment at the 2020 horizon and therefore for related policies. CONCAWE believes it is essential that this more up-to-date and accurate data set for the Mediterranean Sea be taken into account in the NECD review work. Although the CONCAWE study was confined to the Mediterranean Sea, it would also be prudent to test the robustness of Entec's earlier work on other European Sea areas against the latest (2005) Lloyds database by suitably designed sensitivity scenarios.

<sup>3</sup> *Addendum to CONCAWE—Ship Emission Inventory—Mediterranean Sea, February 2007, Entec Limited; Entitled: Ship Emissions in the Mediterranean Sea—Approach to CONCAWE Ship Emissions Study, with Comparisons against Entec's Earlier Work for the European Commission.*