SO_2 emissions from ships in Europe

Can restrictions in the Mediterranean and the Atlantic be environmentally justified?

In response to concerns over the contribution of international shipping to air pollution, during the 1990s, the International Maritime Organization of the United Nations developed an annex to the MARPOL Convention covering air pollution from ships (Annex VI). This Annex incorporates the concept of SO_x Emission Control Areas or SECAs. Under its provisions, when ships operate in, or pass through such areas, they are required to use a fuel with a sulphur content of 1.5% m/m or less. Outside SECAs the sulphur content is limited to 4.5% m/m. For a sea area to be designated as a SECA, an application has to be made to the IMO, including a detailed environmental and cost-effectiveness justification in accordance with specific criteria laid down in Annex VI. To date the Baltic and North Seas are designated SECAs but the requirements will not be binding until Annex VI, signed by parties to the MARPOL Convention in September 1999, has been ratified.

In January this year, as a follow-up to their acidification strategy and in preparation for their planned revision to the sulphur-in-liquid-fuels Directive (SLFD), the Environment Directorate of the European Commission (DG Environment) launched their 'Community Strategy on Air Pollution from Seagoing Ships'. In support of this strategy, consultants engaged by DG Environment will study the implications for the EU of entry into force of SECA status of the Baltic and North Seas. In addition, they will examine the implications of extending the SECA requirements to further sea areas, e.g. the Atlantic approaches to Europe and the Mediterranean. They will also assess the implications of lower sulphur requirements than those contained in Annex VI for SECAs, e.g. 1% m/m.

CONCAWE believes that any measure to limit ship emissions must include a thorough assessment of the environmental justification and cost-effectiveness. This applies to any extension of restrictions on SO_2 emissions from ships beyond the North and Baltic Seas. This is in line with the requirements of Annex VI to MARPOL and would ensure consistency between this strategy and the development of the National Emission Ceilings Directive (NECD), a major building block in the Commission's strategy to combat acidification in the EU. To 'share the burden' between Member States and arrive at individual national emission ceilings Integrated Assessment Modelling techniques were used with a view to minimizing the overall cost to the EU to attain its environmental targets. In this article we use the extensive data sources used by DG Environment in the development of the NECD to explore the possible environmental justification of restrictions of SO_2 emissions in the Mediterranean and the Atlantic approaches.

In examining this question we need to clear up a potential misunderstanding. If we are developing a cost-effective strategy to deliver defined environmental targets (as for the NECD), then focusing on emissions *per se* is not appropriate. What we need to understand is the relationship between emission sources and their contribution to environmental loads. If a given emission source does not contribute to the exceedance of any environmental target, then it is environmentally benign. Any expenditure towards controlling such a source would be a waste of societal resources, at least on environmental grounds.

Figure 1 shows the SO_2 emissions from EU/EEA countries, a selection of accession countries and the four sea areas which border the EU. These data are forecasts for 2010 and reflect the obligations under either the NECD or the UN-ECE[1] Gothenburg Protocol but not the implications of the entry into force of Annex VI to the IMO MARPOL convention.

[1] *United Nations Economic Council for Europe*

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Figure 1, taken in isolation, would suggest that the Mediterranean and Atlantic are important sources to control in a '2010 EU'. Indeed the emissions from these two areas are much higher than those from the Baltic and North Seas which have already been accepted as SECAs by the IMO.

The relevance of these numbers must, however, be considered in the context of their environmental impact. Figure 2 shows the result of some of the Integrated Assessment Modelling carried out in connection with the NECD[2]. The percentage of ecosystems that are still expected to exceed their acid critical loads by 2010 is shown for each EMEP[3] grid square (assuming already agreed emission reduction measures are implemented). A blank denotes no exceedance.

Separate work of the Norwegian Meteorological Institute (NMI)[4], also under the UN-ECE EMEP programme, provides extensive data on the contribution of a given country or sea area to deposition in each of the EMEP grids. We have utilized the NMI database to illustrate the importance of the difference between an 'emission' focus and a 'deposition' focus. This allows the all important determination of what percentage of a given emission source deposits on the EU 'exceedance grid squares' i.e. the 'non-blank' EU squares in Figure 2.

The results of this analysis are plotted as Figure 3, providing a very different perspective from Figure 1. Although SO_2 emissions from ships in the Mediterranean and Atlantic are the second and third highest emission sources in a '2010 Europe', less than 1% and 4% respectively of these emissions deposit on the EU 'exceedance squares'.

This is very different to the situation for the North and Baltic Seas. These areas deposit some 30% of their emissions on to the exceedance squares. To achieve a 1-kilotonne reduction in sulphur deposition over the 'exceedance grid squares' would require SO_2 emissions reductions of 200 kt from ships in the Mediterranean, 50 kt SO_2 for the Atlantic and only 6 kt for the North or Baltic Seas. As a result, any cost-effectiveness justification valid for the North and Baltic Seas is not applicable to the Mediterranean or Atlantic since, assuming similar unit costs, the costs to achieve the same environmental benefit are at least an order of magnitude higher.

SO_2 emissions from ships (2010 NECD case* for EU/EEA countries, a selection of accession countries, and the four sea areas bordering the EU)

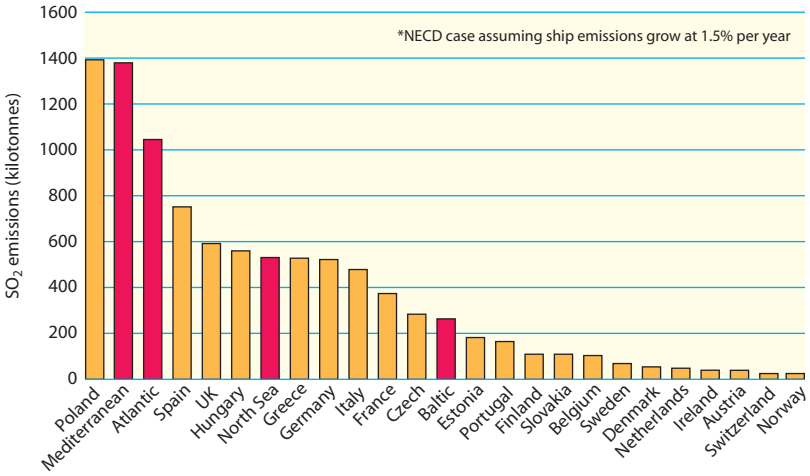

Figure 1
SO_2 emissions from the Mediterranean and Atlantic are much higher than those from the Baltic and North Sea which are already designated control areas, but …

Percentage ecosystems exceeding critical load, 2010[2]

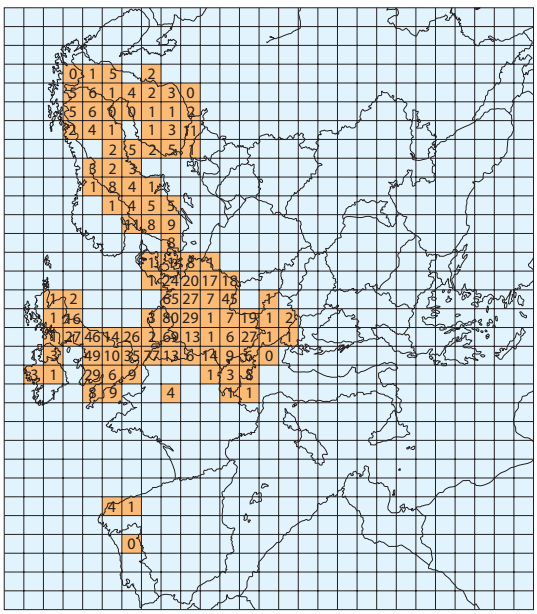

Figure 2
… virtually all critical load exceedances are in northern Europe.

[2] *IIASA 7th Interim Report for the NECD*
[3] *UN-ECE EMEP programme:*
[4] *EMEP 1998 deposition data by individual country or sea area from Norwegian Meteorological Institute web site adjusted for NECD emissions ceilings in 2010*

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Ratio of total sulphur deposition* on all EU exceedance grids to emissions from a given country or sea area from ships

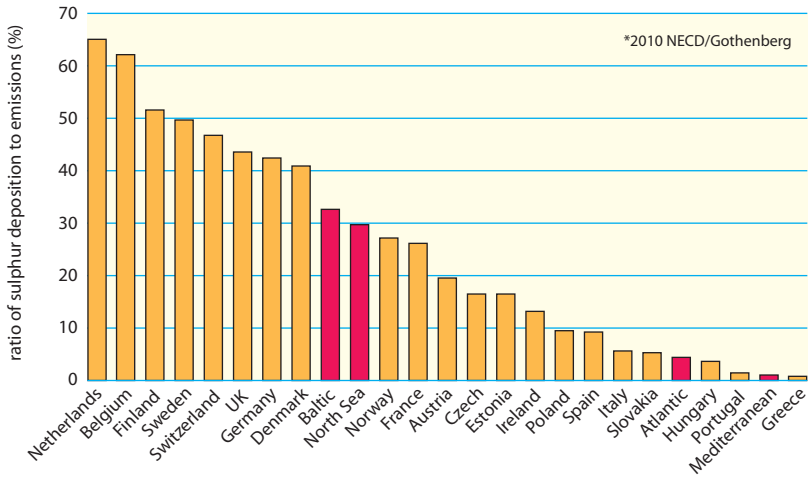

Figure 3
Less than 4% and 1% of the SO_2 emissions from the Atlantic and Mediterranean respectively deposit on EU exceedance squares (see also Figure 2).

When it comes to comparing reductions in emissions from ships in the Mediterranean and Atlantic areas to further reductions in land-based sources, the situation is even clearer. Each of the eight countries which lie to the left of the Baltic Sea in Figure 3 (NL, B, SF, S, CH, UK, D, DK) deposit more than 40% of their 'post NECD/Gothenburg' level emissions on the 'exceedance squares'. This means that a 1-kilotonne reduction in sulphur deposition over the 'exceedance squares' would require a reduction of only 5 kt SO_2.

The cost of a move to 1.5% sulphur bunkers has recently been estimated by consultants to DG Environment to range from 850–1400 EUR/t of SO_2[5]. This is significantly higher than the cost of 450 EUR/t used in the original submission by the EU for recognition of the North Sea as a SECA[6]. However, even if the lower figure of 450 were used, it means that the 1-kilotonne reduction in deposition discussed above would cost some 900,000 EUR/a for ships in the Mediterranean and 220,000 EUR/a for ships in the Atlantic.

To compare these costs to the alternative of further land-based controls in, say, the UK and Germany, we need to access the SO_2 cost curve data used in the Integrated Assessment Modelling for the NECD[7]. At NECD ceilings, the next measures in both countries cost about 1500 EUR/t SO_2, increasing to about 5000 EUR/t toward the higher end of the cost curves. Even using this higher figure, the cost of a 1-kilotonne reduction in deposition achieved through land-based measures in those countries would be only 25 kEUR/year. This is because a much larger proportion of land-based emissions deposits on areas in the vicinity of the emission source and represents a difference of more than an order of magnitude in the cost effectiveness!

This analysis clearly demonstrates that the designation of the Mediterranean and Atlantic Seas as SECAs would not be justified on either environmental or cost grounds. However, it is worth noting that the costs for a similar 1-kilotonne reduction in deposition resulting from emissions from the North or Baltic Seas is some 30,000 kEUR/a, which is comparable to the cost of further land-based controls in Germany and the UK.

Before concluding this article it is worth focusing briefly on other environmental concerns that might drive a requirement for further SO_2 emission reductions. There might firstly be concerns over compliance with the EU first Daughter Directive which sets air quality standards for SO_2. In the case of SO_2 emissions from ships, this is likely to affect operations in some EU ports. CONCAWE has previously studied the contribution of ship emissions to local air quality in the vicinity of EU ports[8]. This indicated that, in large ports like Rotterdam and Antwerp, ship emissions contributed significantly to overall levels of SO_2. However in medium to small ports and for operation outside ports, the contribution was low. These findings indicate that any requirement for low sulphur fuels in-port would need to be based on a case-by-case assessment requiring local action by the port authorities.

[5] *Study on the Economic, Legal, Environmental and Practical Implications of a European Union System to Reduce Ship emissions of SO_x and NO_x, BMT Study 3623, August 2000*
[6] *IIASA Data*
[7] *IIASA RAINS Model SO_2 Cost Curves for Germany and UK*
[8] *CONCAWE Report 2/94*

A further emerging environmental concern associated with SO_2 emissions is the role they play in the formation of secondary particulates. Although the importance of sulphate particulates as a health concern has yet to be confirmed, they do represent a significant contribution to overall levels of fine particulates[9]. Does this mean that reduction of SO_2 emissions from ships in the Mediterranean and the Atlantic may yet be environmentally justified? This question should perhaps best be addressed within the Commission's new 'Clean Air For Europe' programme (CAFE) where all contributions to particulates will be examined. However, the EMEP data used above to demonstrate the lack of justification, from an acidification point of view, for action on ships in these areas, does provide an early insight into the likely answer to this question.

For example, about 25% of the SO_2 emissions from Greece deposit on Greece itself, whereas only 2% of SO_2 emissions from ships in the Mediterranean do so. The NECD ceiling for Greece implies a marginal cost of some 200 EUR/t SO_2. Therefore, the cost of achieving a 1 t/a reduction in secondary particulates derived from SO_2 emissions from ships in the Mediterranean would be more than an order magnitude higher than further land-based SO_2 controls in Greece. This indicates that if concerns over secondary particulates from SO_2 emissions are confirmed and their control becomes a target within CAFE, then the priority should be for significant further reduction measures on southern-European land-based sources rather than reductions in emission from ships in the Mediterranean or the Atlantic.

According to the substantial data underpinning the NECD, we can conclude that the extension of SECAs beyond the North and Baltic Seas is clearly not justified on either environmental or cost-effectiveness grounds.

Available data indicate that the extension of SECAs beyond the North and Baltic Seas is clearly not justified on either environmental or cost-effectiveness grounds

[9] *An Initial Framework to Assess the Control of Fine Particulates in Europe, IIASA, April 2000*