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REVIEW OF MARPOL ANNEX VI AND THE NOx TECHNICAL CODE

New Global Study Estimating Premature Deaths Caused by Air Pollution from International Shipping

Submitted by the Friends of the Earth International (FOEI)

SUMMARY

Executive summary:	This document describes the first scientific, peer-reviewed, study of global impacts to human health from particulate emissions from ocean-going ships. This document was produced by a coalition of environmental NGOs[1]
Action to be taken:	Paragraph 16
Related documents:	BLG 11/5/5, BLG 11/5/6, BLG 11/INF.3; BLG-WGAP 1/2/11; BLG 10/14/13; MEPC 53/4/1, MEPC 53/4/8; and BLG 12/6/16

Introduction

1 The BLG Sub-Committee agreed at its eleventh session to further consider amendments to the regulations under MARPOL Annex VI. BLG will continue its review of potential international control of air pollution from ships at its twelfth session during February 2008.

2 This document summarizes a recent study estimating premature deaths around the world resulting from particulate matter ("PM") air pollution from international shipping. This study is the first scientific analysis to demonstrate that international shipping emissions have significant global impacts on human health. It was released on the Internet on 5 November 2007 by the American Chemical Society journal *Environmental Science & Technology*. The study will be published in December 2007 in the print version of the journal. It is presently available on the Internet at:

http://pubs.acs.org/cgi-bin/sample.cgi/esthag/asap/pdf/es071686z.pdf[2]

[1] Clean Air Task Force, Friends of the Earth-US, European Environmental Bureau, European Federation for Transport and Environment, North Sea Foundation, Bellona and Swedish NGO Secretariat on Acid Rain.

[2] Corbett, J.J., Winebrake, J.J., Green, E.H., Kasibhatla, P., Eyring, V., and Lauer, A., "Mortality from Ship Emissions: A Global Assessment," *Environmental Sci. Technol,* American Chemical Society published on Web, 11/05/2007 (hereinafter the "Corbett and Winebrake Study").

Supporting material for the study may be found at:

http://pubs3.acs.org/acs/journals/supporting_information.page?in_manuscript=es071686z[3]

3 The study was conducted by an international team of leading researchers, led by Dr. James Corbett of the University of Delaware, and including James Winebrake and Erin Green of the Rochester Institute of Technology, Prasad Kasibhatla of Duke University, and Veronica Eyring and Axel Lauer of DLR-Institute fuer Physik der Atmosphaere (the "Corbett and Winebrake Study" or simply the "Study").

4 The Corbett and Winebrake Study estimated that the ***global death toll in 2002 from PM air pollution emitted by oceangoing ships was approximately 60,000 premature deaths per year.*** And the shipping death toll is estimated to grow by 40% by 2012 along with a continued large increase in global trade and shipping traffic. Europe and Asia are particularly affected – about 1/3 of all shipping deaths occur in Europe, and about ¼ in each of East Asia and South Asia.

5 The Corbett and Winebrake Study provides ample evidence that shipping emissions are severely impacting human health, and must be reduced as soon as possible. This study is consistent with more detailed regional studies that confirm impacts at least as significant as this global study.

Global shipping emissions mortality study

Methodology

6 The Corbett and Winebrake Study used an established methodology similar to that used in other studies to estimate human health impacts from particulate air pollution. Essentially, this approach is to: "(1) determine pollutant emissions from ships; (2) apply atmospheric transportation and chemistry models to estimate the increased (ambient) concentrations due to ships; (3) estimate the increased risk to exposed populations due to these additional concentrations; and (4) calculate additional mortalities due to that increased risk."[4]

7 More specifically:

.1 shipping emissions of PM and PM precursors[5] were based on the two best traffic-based, geospatial, global shipping emissions inventories available;[6]

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[3] Corbett, J.J., Winebrake, J.J., Green, E.H., Kasibhatla, P., Eyring, V., and Lauer, A., "Supporting Material for Mortality from Ship Emissions: A Global Assessment," *Environmental Sci. Technol*, American Chemical Society published on Web, 11/05/2007 (hereinafter the "Supporting Material").

[4] Corbett and Winebrake Study, at p1.

[5] PM is made up of a number of constituents – primarily sulfates, nitrates, black carbon (BC), particulate organic matter (POM), ammonium and a variety of heavy metals. Several cases of the Corbett and Winebrake Study examined BC, POM and sulfates only. Others examined total PM – that is, BC, POM , sulfates, nitrates and ammonium.

[6] These two inventories are the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) and the Automated Mutual-assistance Vessel Rescue system (AMVER) *See*, e.g., Wang, Corbett, Firestone, Environmental Science and Technology (ES&T), in press, 2007.

.2 ambient air PM concentrations were then modeled using the ICOADS- and AMVER-based emissions inventories and two different geospatial global aerosol models;[7] and

.3 premature cardiopulmonary and lung cancer mortality were estimated by applying the ambient PM concentration increases due to shipping to well-accepted concentration-response functions and to population models.

8 One aspect of the study's methodology bears further discussion. The concentration-response (CR) functions used in the Corbett and Winebrake Study were "derived from an American Cancer Society cohort study (Pope 2002) that examined the relationship between PM2.5 and lung cancer and cardiopulmonary mortality in the United States."[8] The Corbett and Winebrake Study used the same basic methodological approach used by the US Environmental Protection Agency in its rulemaking analyses of health impacts from diesel PM emissions. In fact, the CR function derived from Pope 2002 is the same as used by US EPA in recent regulatory proceedings involving both diesel engines and electric generating plants, with the support of the independent Science Advisory Board.[9]

9 The results of the Pope 2002 study are robust, and within the 95th confidence level (the definition of statistically significant) for all-cause mortality, cardiovascular mortality, respiratory mortality and cancer mortality and exposure to PM2.5. Pope 2002 is the largest PM study ever undertaken; it tracked over one million persons for 16 years and 150 metropolitan areas in the US and found that PM2.5 is widely associated with mortality. The Pope ACS studies have been widely evaluated and the results upheld. For example, the earlier findings of the ACS study (Pope 1995) were independently reviewed by the Health Effects Institute (HEI) in 2000 (HEI is jointly funded by industry and US EPA) and its findings were fully reaffirmed. Moreover, a review of the use of the Pope (2002) study for the purposes of EPA's health benefits analyses undertaken by the National Academy of Sciences (NAS) found the results to be conservative, stating: "…the effect estimated from the ACS study might be low for the general population…"[10] The NAS suggests that the Harvard Six Cities Study[11] (with its finding of a higher relative risk) may, in fact, provide a more realistic C-R function for the general population, yet the Corbett and Winebrake Study follows the more conservative EPA approach to estimating mortality. Long-term and short-term medical studies consistently support this link between PM exposure and premature mortality, in addition to a variety of other adverse health effects.[12]

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7 The two global-scale models are the GEOS-Chem and ECHAM5/MESSy1-MADE (or E5/M1-MADE) models. Corbett and Winebrake Study at p2.

8 Corbett and Winebrake Study, at p3. *See also* Supporting Material, at pp3-4.

9 *See*, e.g., US EPA (2004), "Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel; Final Rule," 69 Fed. Reg. 38958, 39136-39 (June 29, 2004); US EPA (2005), "Rule to Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule);[];Final Rule," 70 Fed. Reg. 25162, 25306-08 (May 12, 2005); and US EPA (2007), "Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines less than 30 Liters per Cylinder; Proposed Rule," 72 Fed. Reg. 15938, 16023-30 (April 3, 2007).

10 National Research Council (2002), "Estimating the Public Health Benefits of Proposed Air Pollution Regulations," at p101, National Academies Press (2002).

11 Dockery DW, Pope CA III, Xu X, Spengler JD, Ware JH, Fay ME, Ferris BG Jr., Speizer FE (1993), "An association between air pollution and mortality in six US cities," N Engl J Med 1993;329;1753-1759. See also the "updated 6 cities study": Laden F, Schwartz J, Speizer FE, and Dockery DW (2006), "Reduction in Fine Particulate Pollution and Mortality, Extended Follow-up of the Harvard Six Cities Study," Am J Respir Crit Care Med, vol 173, pp667-672 (2006), available on the Internet at: http://ajrccm.atsjournals.org/cgi/reprint/173/6/667.

12 See, e.g., MEPC 53/4/1, BLG/11/5/27; US EPA (2004) Air Quality Criteria for Particulate Matter (Oct 2004), Vol 1-EPA Report EPA600/P-99/002aF and Vol II-EPA Report EPA600P-99/002bF, available on the Internet at http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

Results

10 The Corbett and Winebrake Study examined six different cases, each comparing modelled PM2.5 concentrations with and without ship emissions. Two cases used the ICOADS-based emissions inventory (one for 2002 and one projected to 2012), the GEOS-Chem model, and partial PM constituents (BC, POM, SO4). Four other cases used the E5/M1-MADE model for 2002 emissions, each using a different combination of emission inventories and PM constituents – that is, ICOADS/partial PM, ICOADS/full PM, AMVER-based emissions inventory/partial PM, and AMVER/full PM.[13] As a result of these different cases, the results of the study are quite robust.

11 The global results of the Study may be summarized as follows:

.1 cases analysing partial PM constituents (omitting nitrate and ammonium) – best estimates were 19,000 to 40,000 premature deaths in 2002;
.2 cases analysing complete PM constituents – best estimates were 62,000 to 64,000 premature deaths in 2002;
.3 annual mortalities are expected to increase by 40% by 2020 due to expected growth in shipping activity; and
.4 the range of 2002 mortality from shipping represents about 3% to 8% of all deaths from global outdoor fine PM pollution, estimated at between 740,000 and 880,000 a year.

12 The Study also modelled shipping ambient air impacts and premature mortality for five different regions of the world – North America; Europe and the Mediterranean; East Asia; South Asia; and East South America. While the global total is nearly the same, impacts vary by region when alternate global inventories are selected. Highlights of the regional modelling are:

.1 the European/Mediterranean region is a major impact region of global shipping deaths – between 27% and 42% of global shipping impacts;
.2 East Asia and South Asia were also heavily impacted, each representing about one-quarter of the global impact; and
.3 about one-tenth of global shipping deaths occurred in the North American region.

13 The following table sets forth in greater detail the results of the Study for the two cases that examined all PM constituents (sulfates, nitrates, POM, BC and ammonium).

[13] Corbett and Winebrake Study, at pp5-6.

Annual Mortality Attributable to Ship PM2.5 Emissions by Region and by Cases Examining All PM Constituents

Region	Case 1c **ICOADS/ E5/M1-MADE/ Full PM**	Case 2b **AMVER/ E5/M1-MADE/ Full PM**
North America	**5,110** (1,850 – 8360)	**8,810** (3,200 – 14,410)
Europe/Mediterranean	**26,170** (9,170 – 43,650)	**16,530** (6,010 – 27,010)
East Asia	**19,870** (7,220 – 32,470)	**15,280** (5,560 – 24,980)
South Asia	**9,950** (3,610 – 16,280)	**16,280** (5,910 – 26,600)
East South America	**790** (290 – 1,290)	**1,760** (640 – 2,870)
Global Total	**64,180** (23,320 – 104,920)	**61, 840** (22,470 – 101,100)

Policy implications

14 Some IMO observers have questioned the need for additional SOx and other emission reductions from ships, claiming that the environmental impact of these emissions have not been adequately established.[14] This need has now been made absolutely clear. The Corbett and Winebrake Study clearly establishes that ocean-going ship emissions of PM and its precursors, including NOx and SOx, produce substantial impacts to human health – in fact, the most substantial impact of all – death. In fact, the study underestimates the human health impacts, since further analysis to estimate illnesses and medical costs would be additional to these mortality estimates. The Study makes a clear and convincing case that substantial reductions in shipping emissions are needed as soon as possible.

15 Moreover, the societal costs of shipping emissions are huge – and easily substantial enough to support the efforts necessary to reduce shipping emissions. Many benefits of reduced emissions cannot be quantified in monetary terms. However, a variety of efforts have been made in recent years to quantify some of the benefits of air pollution reduction. For example, in order to evaluate the benefits of its regulatory programs, the US EPA has quantified a number of benefits from reduced particulate emissions in the US. Using EPA's figure for the value of a statistical life, the **annual cost** to society of the 60,000 or so annual deaths found by the Corbett and Winebrake Study to be caused by shipping is over **$300 billion a year**.[15] This dwarfs the estimated costs of reducing shipping emissions. To repeat, many health impacts from shipping emissions were not estimated by the Corbett and Winebrake Study, such as non-fatal heart attacks, lung disease, exacerbated asthma, hospital visits and lost work days, as well as a variety

[14] *See*, e.g., WGAP 1/2/13, BLG 11/5/9.

[15] *See*, e.g., US EPA (2004), "Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel; Final Rule," 69 Fed. Reg. 38958 (June 29, 2004); and US EPA (2004), "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines," Chapter 9 at Table 9-7, p9-33, EPA Doc. No. EPA420-R-04-007 (May 2004).

of environmental impacts. The benefits of reducing shipping emissions clearly and vastly outweigh the costs of those reductions.

Action requested of the Sub-Committee

16 The Sub-Committee is invited to consider the above information and to recommend to the MEPC stringent limitations for air emissions from ships in the amended MARPOL Annex VI.

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