

The regulation of air pollution from ships: MARPOL Annex VI, Sulphur 2020, particulate emissions and emerging challenges

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MLAANZ 2019

Air emissions from shipping

- Shipping is a very efficient means of transport.
- Traditional fuel, heavy fuel oil (HFO), has a high sulphur content (much higher than car fuel).
- HFO also contains high concentrations of metals and other contaminants.
- Port and coastal communities are most affected.
- Cruise ships often criticised: but ships of all types contribute.



Photo: <https://www.drycargomag.com/imo-sulphur-2020>

Given the looming sulphur cap, today:

- Sulphur and PM emissions from shipping
- The IMO regulation of ship emissions
- The ECAs, and possible future ECAs
- Carriage ban on HFO
- Compliance with the sulphur cap: including scrubbers
- How the sulphur cap interacts with the IMO's GHG strategy
- Australian and NZ position

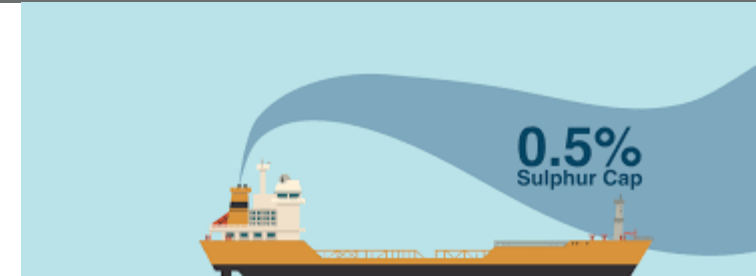


Image: wilhelmsen.com

Gaseous emissions from shipping

Combustion of fossil fuels produce polluting gases including:

- Oxides of nitrogen (NO_x)
- Oxides of sulphur (SO_x)
- Carbon dioxide (CO₂)
- Methane (another GHG)
- Volatile Organic Compounds

Greenhouse gases (CO₂, methane and others) contribute to climate change.

SOx and NOx emissions

NOx and SOx contribute to:

- acid rain
- ocean acidification
- NOx – photochemical smog and ozone

Both have significant adverse health effects on animals/humans.

Obviously very desirable to reduce these emissions: IMO has done a lot of work with that aim in mind.

Focusing on particulate matter (PM) emissions

- Can be anthropogenic (eg from combustion engines) or natural (eg. salt, sand)
- Include Black Carbon, but not limited to BC.

Classified by median aerodynamic diameter, in microns:

- **PM10** (median aerodynamic diameter equals or less than 10 microns) 'coarse PM'
- **PM2.5** equal to or less than 2.5 microns – 'fine PM'
- **PM0.1** equal to or less than 0.1 micron - 'ultrafine PM'

PM10.....PM 2.5..... PM 0.1

image modified to show
ultrafine particulate by
Bud Hixson

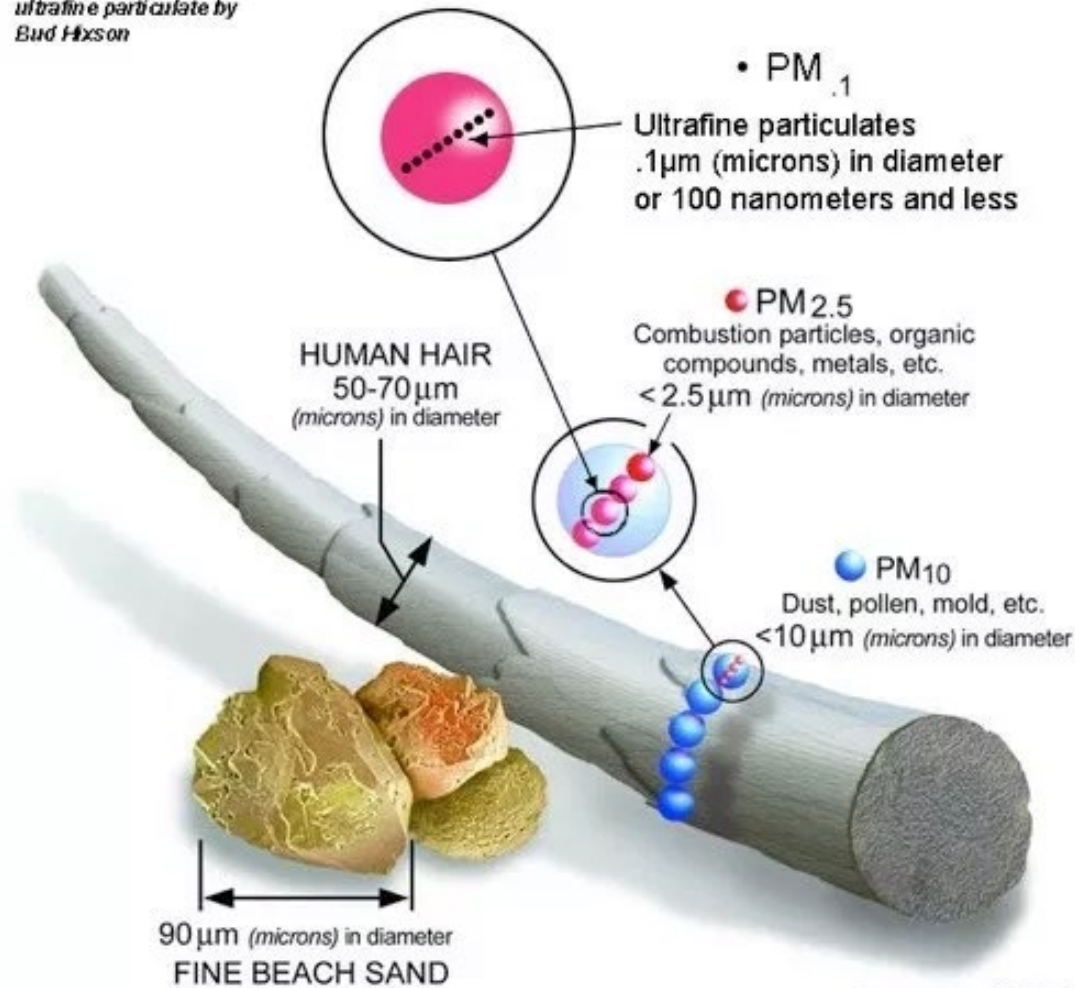


Image courtesy of the U.S. EPA

Ultrafine PM is
400 – 700
times smaller
than a human
hair.

The effect of PM emissions...

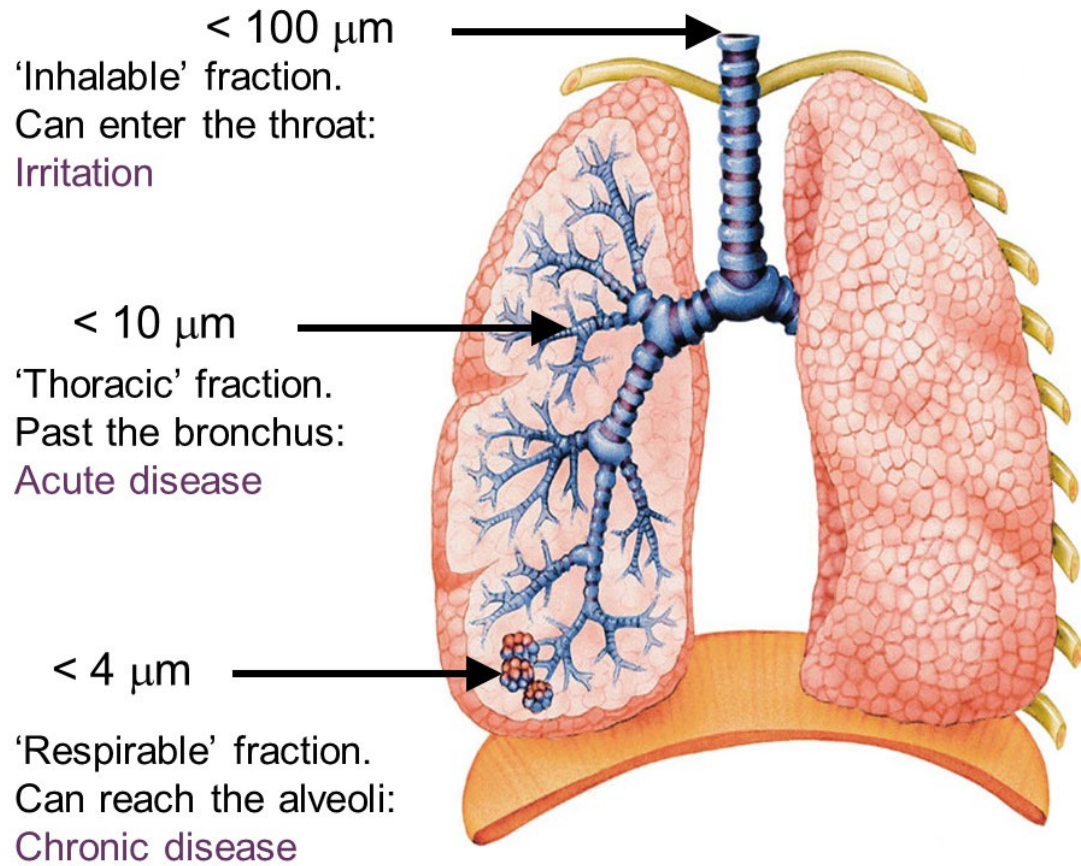


Image: Dr Claire Horwell, Durham University

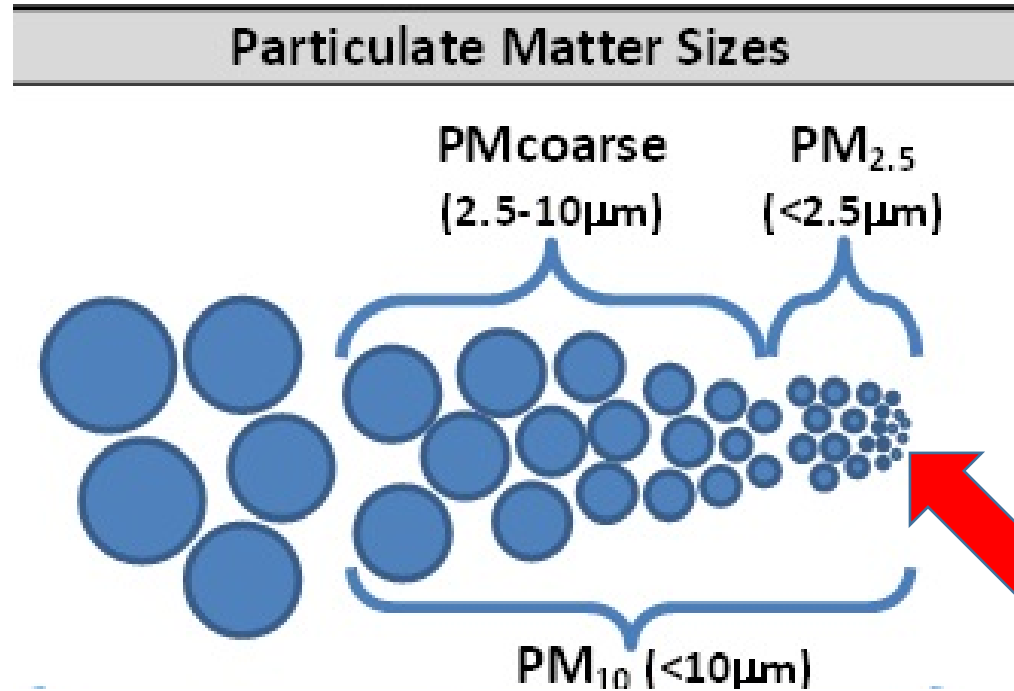


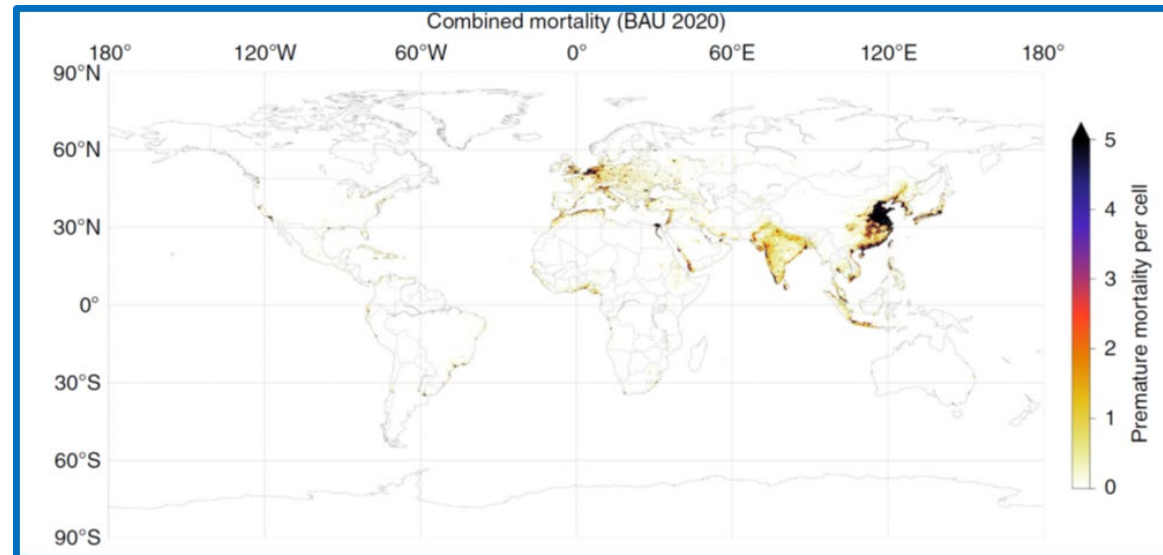
Image: New Hampshire Dept of Environmental Services

PM emissions– what the scientists say

- Shipping PM includes **toxic heavy metals nickel & vanadium**.
- Acute and chronic exposure to HFO cause significant health problems. Acute exposure: exacerbates existing diseases; asthma, stroke, heart conditions
 - Chronic exposure – increases incidences of these diseases as well as lung cancer. Increased mortality rates.
 - **BUT diesel may be no better!**
- Recent studies show associations between PM 2.5 and diabetes, Alzheimer's disease, and impaired cognitive function.
- UK: **levels of air pollution pose greater mortality risk than environmental tobacco smoke OR road traffic accidents.**

Science: pre sulphur cap, ocean shipping:

- emits ~1.5 million tonnes of respirable PM.
- 403,000 premature deaths, generally lung cancer (54,000) and CV (349,000) deaths, attributable to shipping-related fine PM *annually*.
- 14 million cases of childhood asthma per year attributed to shipping



Sofiev et al (2018) 9 Nature Communications 406 DOI: 10.1038/s41467-017-02774-9

Slide data provided by Dr Matt Loxham, University of Southampton

IMO – regulation of ship emissions

- UNCLOS obliges parties to protect the marine environment

International Convention for the Prevention of Pollution from Ships 1973 as modified by the 1978 and 1997 Protocols (MARPOL)

- MARPOL 73/78 governs ship based maritime pollution control and prevention. IMO Marine Environment Committee has oversight.
- 1997 Protocol introduced regulation of air emissions via Annex VI. Came into force in 2005. Has fewer ratifications than original Convention.

The original 1997 Protocol Annex VI came into effect 2005

- Introduced the cap on sulphur content of marine fuel 4.5% mass by mass (first in effect 2005).
- Created Emission Control Areas (ECAs), where 1.5% sulphur fuel or equivalent technology to be used.
- Required ships built after 2000 to be designed to reduce NOX emissions.
- Required signatory flag states to issue their ships with an IAPP Certificate proving compliance with Annex VI.

ECAs – current and possible future



www.thormarinetrading.com

Stepping down the sulphur limit in Annex VI

MEPC58 (2008) decided:

- To step down sulphur content over time, to 3.5% then ending at a 0.5% m/m cap effective 1 January 2020 ('2020 sulphur cap');
- A more rapid step down in ECAs, ending at 0.1% m/m cap in 2015;
- Nox controls in ECAs stepped up;
- Permit the use of scrubbers so long as they were at least as effective; and to leave flag states to approve the scrubbers.

Regulation 14 – ‘Sulphur and PM’

MEPC58 (2008) also resolved to ‘include’ PM in Regulation 14 but:

- set no target for PM reduction: sulphur a *proxy* for PM (namely, reduction of SO leads to reduction of PM)
- Scrubbers only had to reduce *sulphur*: no explicit requirement for scrubbers to efficiently remove PM.

MEPC60 (2011)

Decided that ship efficiency measures would be introduced from 2013:

- EEDI index applicable to new builds of main types of ships
- SEEMP for all ships
- EEDI becomes increasingly strict; aim is to reduce fossil fuel consumption.

Ban on carriage of non compliant fuel for use on board a ship

In 2018, MEPC introduced a ban on the carriage of non compliant fuel oil for use on board the ship unless on board a ship installed with approved scrubber.

- **Effective 1 March 2020**

Amended Regulation 14.1 reads:

14.1 The sulphur content of fuel oil used or carried for use on board a ship shall not exceed 0.50% m/m. (Underlining added)

- Intended to make it easier to enforce compliance.

The 2020 sulphur cap and the early movers:

Some regions have their own rules for fuel use: eg

- California
- EU
- China (in force 1 Jan 2019; now thinking about introducing 0.1% cap)

Others have restrictions that apply only to cruise ships:

Alaska, Sydney.

How will shipowners comply with the new sulphur limit?

- Low sulphur fossil fuels: blends, LNG.
- 'dual fuel' engines
- Stick with HFO but use scrubbers:
 - Open loop
 - Closed loop
 - Hybrid

R&D happening into alternative fuels/sources: biofuels, hydrogen fuel cells, electric/battery

Emerging issue #1 Compliance and Enforcement

- Annex VI imposes obligations on flag state, port state, ship and bunker suppliers: Regulations 14 and 18.
- Certification, Documentation, inspection, prosecution.
- Ship documentation and records
- FONAR REPORT
- Port States are to ensure compliance: but penalties are determined by domestic law.



Sniffer drone: Danish Maritime Authority

Compliance and Enforcement (cont)

- How many ships will be inspected?
- Will the penalties be a sufficient deterrent?
- Will some operators 'play the odds'? (carriage ban helps though)
- A port that does not/cannot inspect at a high rate may become notorious as a 'port of convenience' – leading to commercial distortion
- How will the carriage ban work?
- What will happen in countries that are not a party to Annex VI: or choose not to enforce in their waters?

emerging issue #2: Scrubbers

- *Flag states* get to 'approve' scrubbers (using IMO guidelines)
- Most scrubbers installed are 'open loop' scrubbers: cheaper, easier to run than closed loop.
- SO_x discharge not a problem: rather, is **heavy metals and other contaminants...** are we just moving these toxins from air to sea (affecting the environment, and marine animals...)?
- Some *port states* have imposed ban on 'open loop' scrubbers operating in their waters. Eg Singapore, Fujairah, Belgium, Germany, parts of China. Ships will have to switch to low sulphur fuel.
- IMO has work underway to consider/standardise rules on scrubber washwater.

Emerging issue #3 – PM, especially ultrafine

- Recent scientific studies on ship fuel and particulates:
Low sulphur HFO may actually produce *more* ultrafine particles in some conditions

Hulda Winnes et al, 'On-board measurements of particle emissions from marine engines using fuels with different sulphur content' (2016) 230(1) *Journal of Engineering for the Maritime Environment* 45.

Engines using high sulphur fuel with scrubbers AND particulate filters will likely be less harmful for human health

Sapcariu SC et al., Metabolic Profiling as Well as Stable Isotope Assisted Metabolic and Proteomic Analysis of RAW 264.7 Macrophages Exposed to Ship Engine Aerosol Emissions: Different Effects of Heavy Fuel Oil and Refined Diesel Fuel (2016) 11(6) PLoS ONE <https://doi.org/10.1371/journal.pone.0157964>.

So is it sufficient to manage PM by proxy?

Ships can comply with MARPOL 'Sulphur & PM' regulation without much focus on PM.

More scientific studies are focussing on the disproportionate harmfulness of the smaller PM; and considering different outputs of low sulphur fuel v HFO in different conditions

MARPOL Annex VI and guidelines have little to say about PM: whether measuring, monitoring or reducing it.

MARPOL Regulation 14 in Australia

Party to MARPOL, Annex VI, so will enforce 0.5% limit from 2020:

Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth) needs updating but expected to be done in time.

Only additional restriction: cruise ships berthed in Sydney Harbour must use 0.1% sulphur content fuel, scrubbers or shore power: (AMSA Marine Notice 21/2016)

Should we be considering scrubber washwater restrictions in our territorial waters, or perhaps around national marine parks (incl GBR PSSA? Ningaloo?)

Should we require use of 0.1% sulphur fuel in our waters (as China is considering), or in our ports, like EU?

MARPOL Annex VI in New Zealand

- Currently not a party to MARPOL Annex VI; but [being considered by Minister of Transport](#)
- Cruise lines' undertaking....
- Scrubber use in fjords?
- Marten (2016) 30 ANZ Mar LJ 90

Scott Hammond/Stuff.co.nz



The 'other' big emission focus for IMO: greenhouse gas emissions?

In April 2018 MEPC72 adopted the *Initial IMO Strategy on reduction of GHG emissions from ships*. This contains 'levels of ambition': (inter alia)

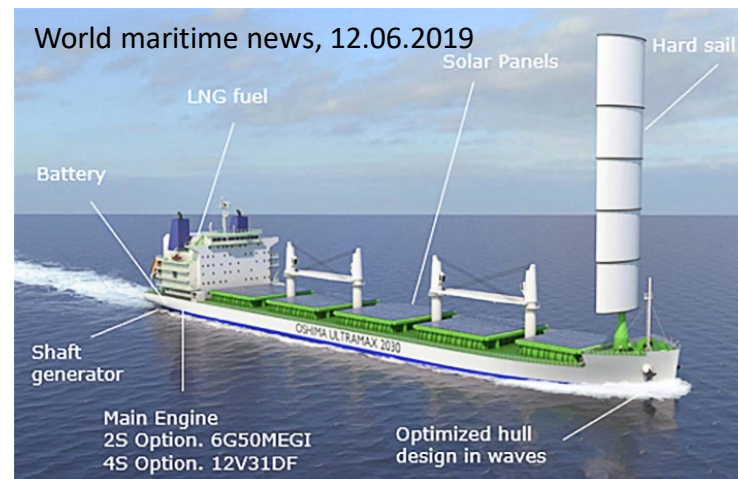
- aiming for a reduction in **CO₂ emissions** per transport work, at an average across international shipping, by at least **40% by 2030**, pursuing efforts towards 70% by 2050, compared to 2008; and
- to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 **whilst pursuing efforts towards phasing them out.**

MEPC.304 (72): <http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-%28MEPC%29/Documents/MEPC.304%2872%29.pdf>

Does the sulphur cap assist is to meet the GHG emission target?

No. Sulphur cap will not directly reduce GHG emissions. (In fact, the cap may have a *detrimental* effect on climate change.)

But reducing GHG will improve air emissions, because it involves less reliance on fossil fuels. This is necessary as efficiency measures alone will be outrun by increases in world trade.



MS Roald
Admunsen,
Hurtigruten.
Photo:
cruisemapper.co
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In conclusion:

- 2020 Sulphur cap will lead to reduction in SO_x and PM emissions - but evidence suggests that lower sulphur fuels produce more of the harmful ultrafine PM (which appear to be more toxic).
- The standard scrubbers are not all that good at removing PM. Currently no requirement to use scrubbers with good level of PM reduction – should there be?
- Dealing with PM ‘by proxy’ with sulphur has glossed over the problem
- Growing imperative to reduce reliance on fossil fuels: not only for climate change but to minimise these harmful pollutants.

Kate Lewins & Matthew Loxham, 'PM by Proxy? Regulation of sulphur and PM emissions from shipping' (2020) LMCLQ (forthcoming)



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