

Exhaust Emissions from Ship Engines in Australian Waters Including Ports

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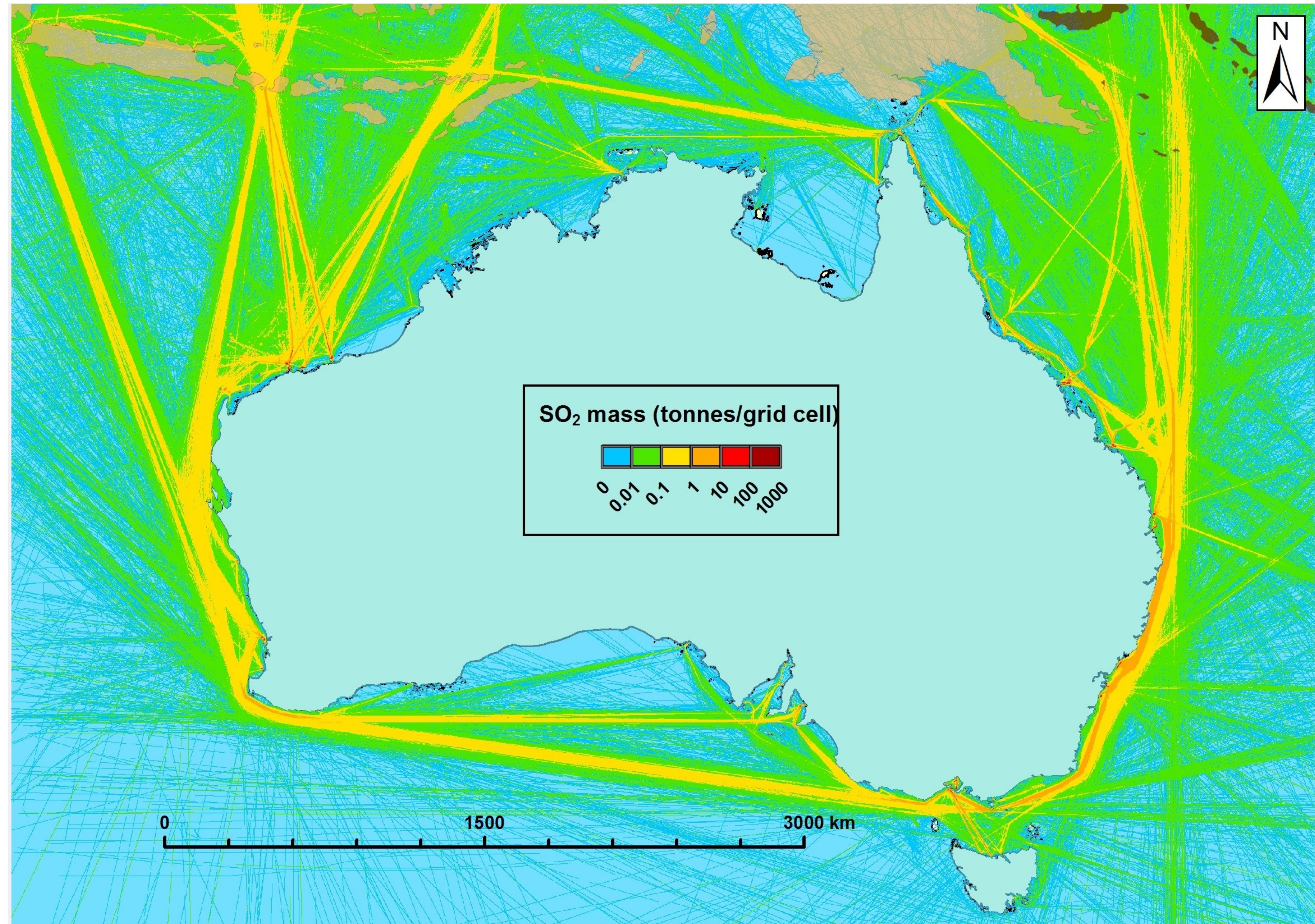
Ship Engine Exhaust Emissions

Overview

- Ships are primarily propelled by large diesel engines
- Smaller diesel engines are used to generate electricity for on-board use
- Auxiliary boilers are used to generate steam for heating tasks when main engines aren't operating
- Almost all fuel used in ocean going vessels is based on the residue from the crude oil refining process - Residual Oil (RO)
- RO has high sulfur content – global average around 2.7% by mass
- SO₂, NO_x and particles in ship engine and boiler exhausts in focus globally
- Southern Hemisphere ship exhaust emissions not well studied

Regulation in Australia

- Shipping is but one of many sources of air pollution
- Terrestrial air emission controls outpacing controls on ship emissions – reducing shipping's contribution to air pollution may be relatively cost effective

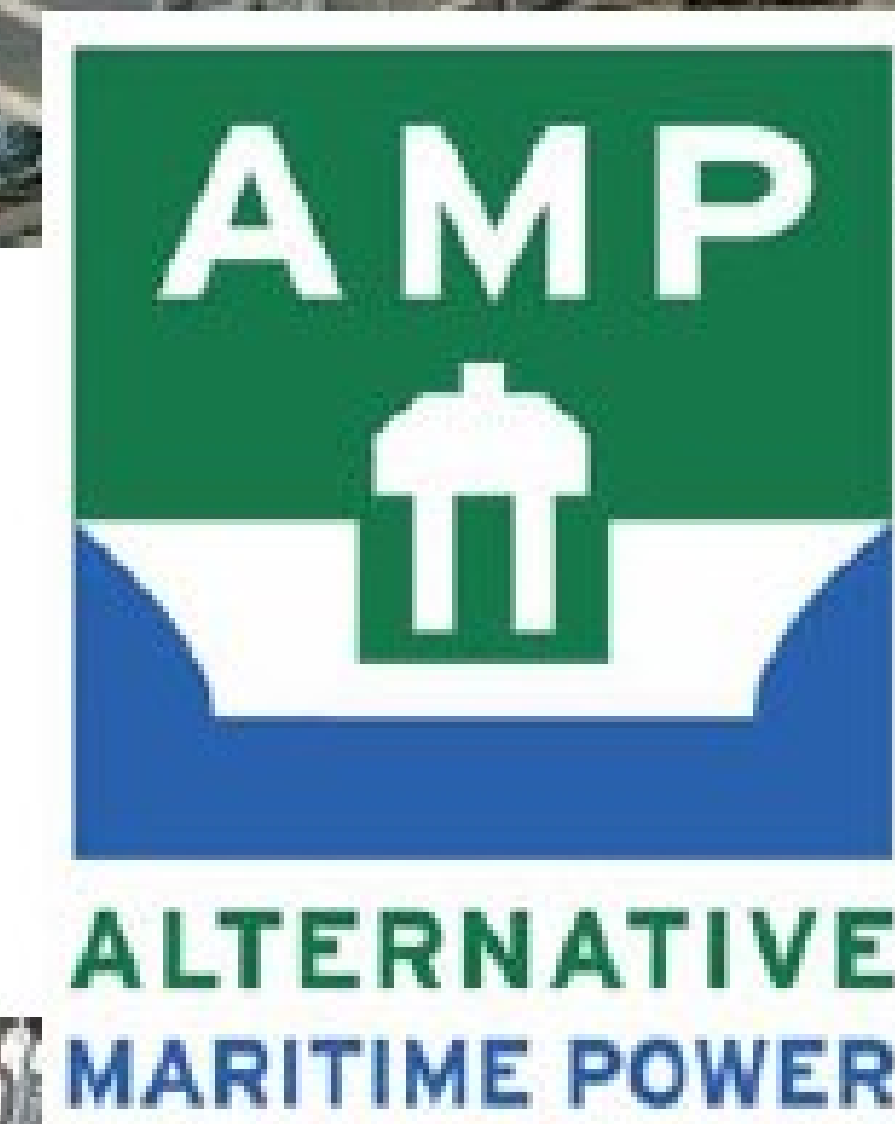
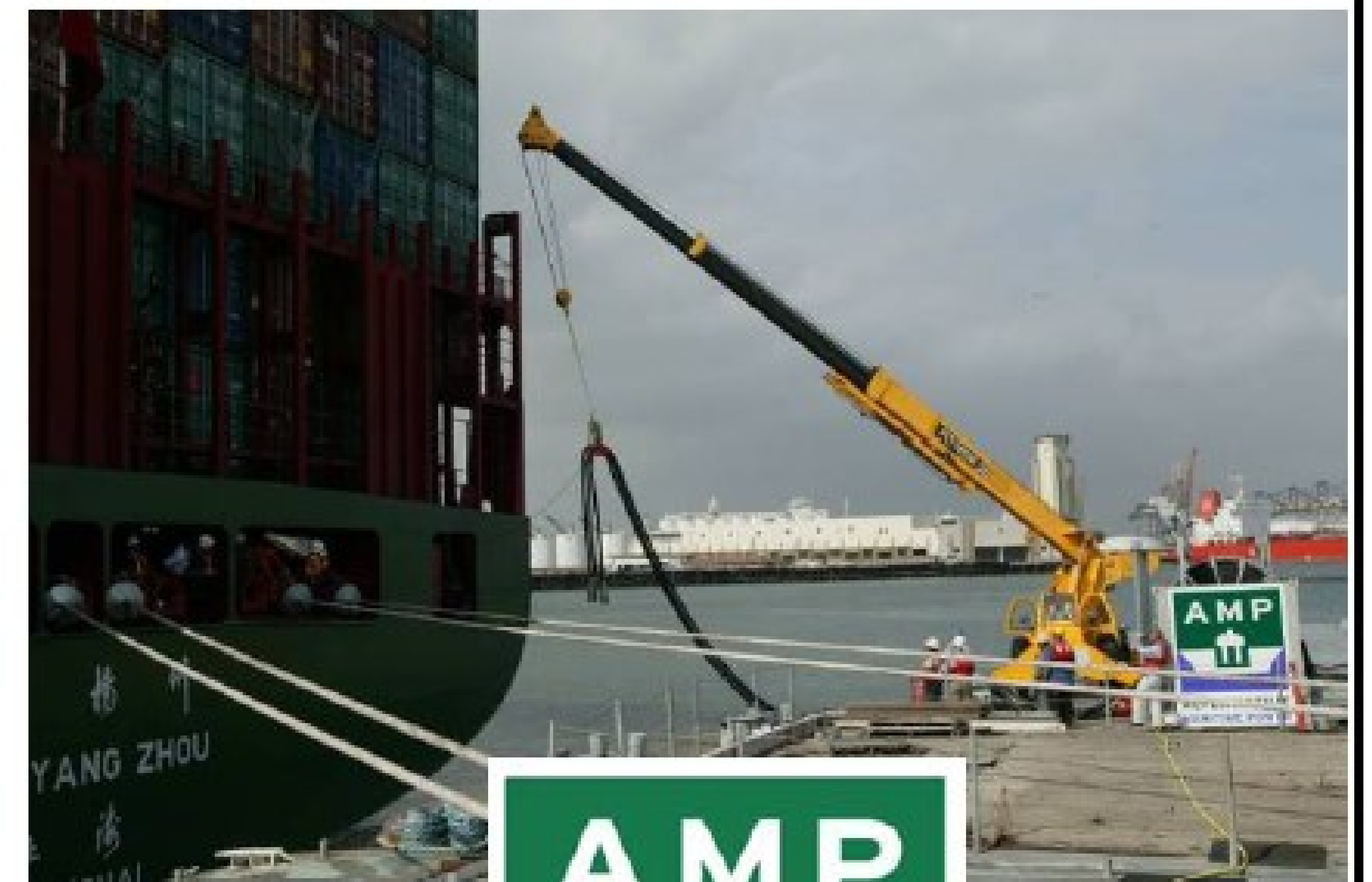


Modelled SO₂ emissions from ships around Australia in 2010/11 (total emissions in each 2km x 2km grid cell over 1 year)

L Goldsworthy and B Goldsworthy, Ship Engine Exhaust Emissions and Fuel Consumption in Australian Waters Including Ports, Stage 1, November 2013, University of Tasmania Research Project 2914

Emissions at berth (hotelling)

- Diesel generators make electricity for lighting, air conditioning, control systems, cargo handling, ballast pumping, etc
- Oil fired boilers to heat fuel, cargo, steam for steam driven cargo pumps, hot water
- Often close to urban areas
- Cruise ships have high hotelling loads
- **Fuel switching** – low sulfur fuel at berth, proposals for LNG at berth to also reduce NOx and particles
- **Shore Power**(alternative maritime power, cold ironing) – electricity supplied from land grid
 - shift air pollution emissions away from port
 - possible increase in greenhouse gas emissions
 - shore power doesn't replace boilers so SOx reduction not necessarily as big as for fuel switching
 - need uniform connection standards
 - authorities often assist shippers with cost of conversion
 - Opportunities for local co-generation of shore power – waste heat for local industries



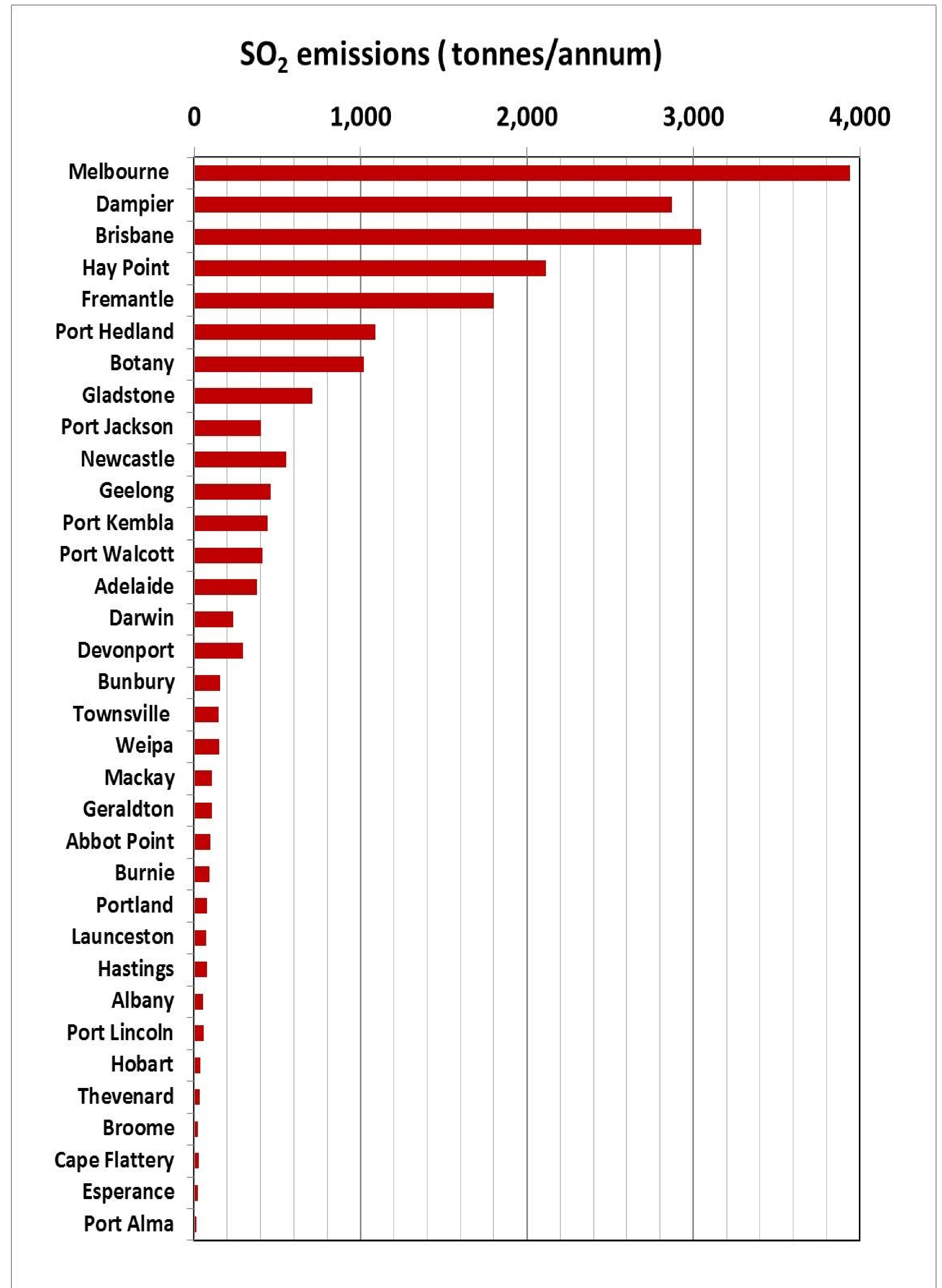
Shore Power

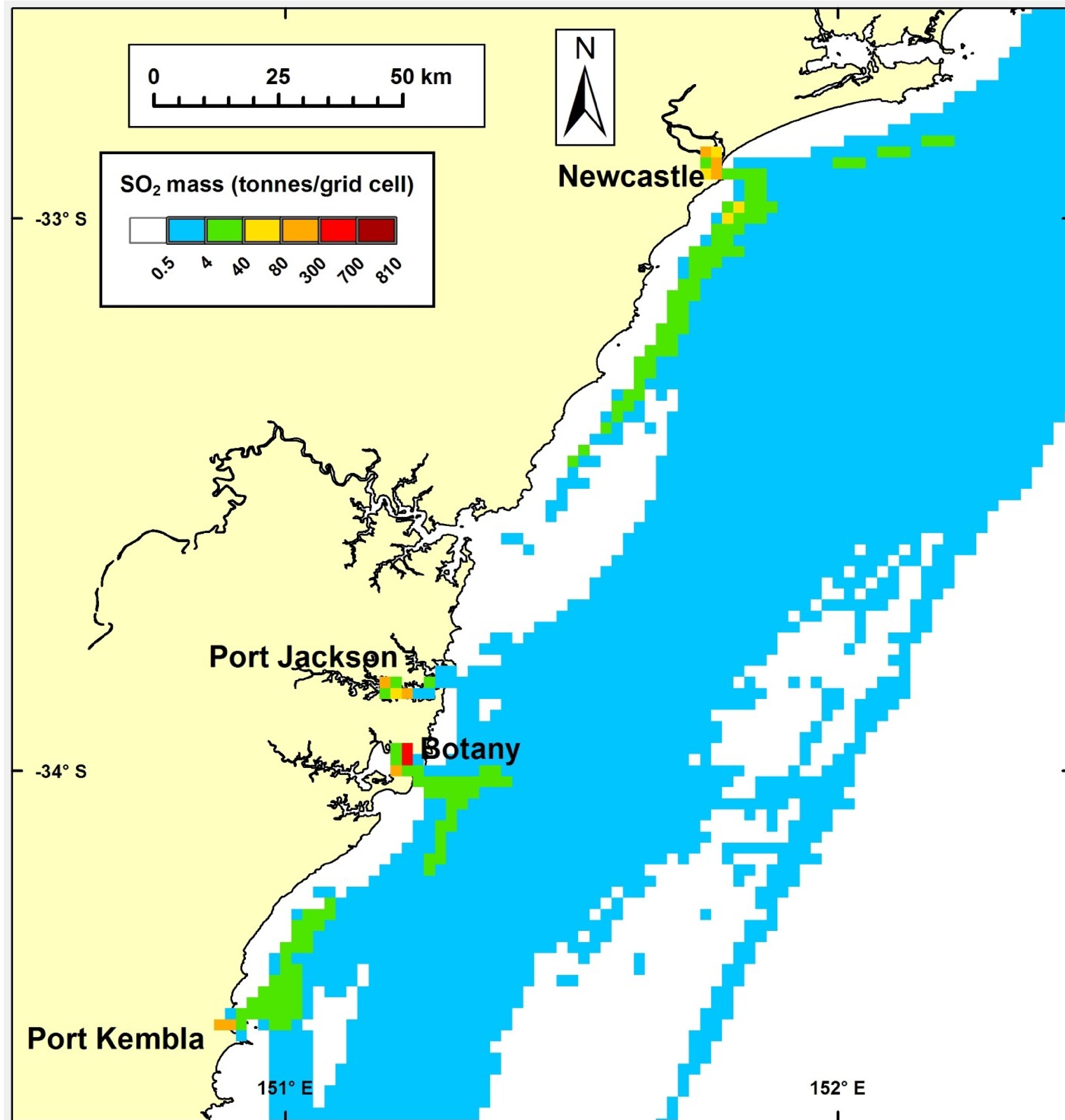
From: Presentation to ENO Transportation November 2008
Geraldine Knatz, Executive Director, Port of Los Angeles

Emissions by Port

Estimates of emissions for 2010/11 for 34 ports

- These 34 ports cover 99% of total Australian cargo throughput
- Includes emissions in all operating modes within port legal boundaries
- Emissions calculated at fine spatial and temporal resolution (Automatic Identification System)
- All ports modelled using a consistent methodology
- Melbourne's total includes the long transit across Port Phillip Bay – some ports (eg Newcastle) have limited transits within their boundaries
- Estimated confidence range about $\pm 30\%$





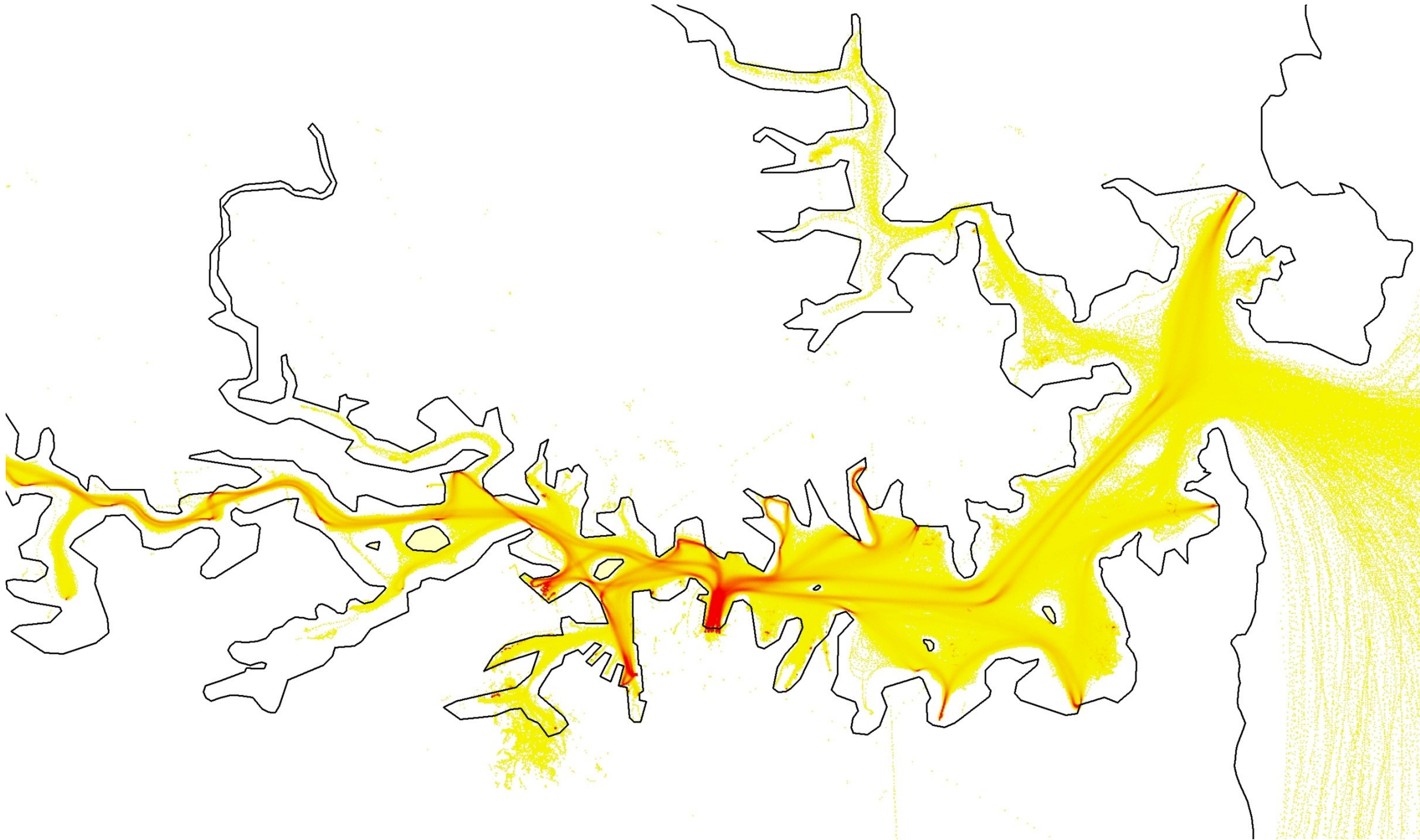
NSW Greater Metropolitan Region

Total ship SO₂ emissions around the NSW Greater Metropolitan Region for 2010/11, at 2km x 2km resolution.

The anchorage areas off the coast for Newcastle, Port Botany and Port Kembla are apparent in green.

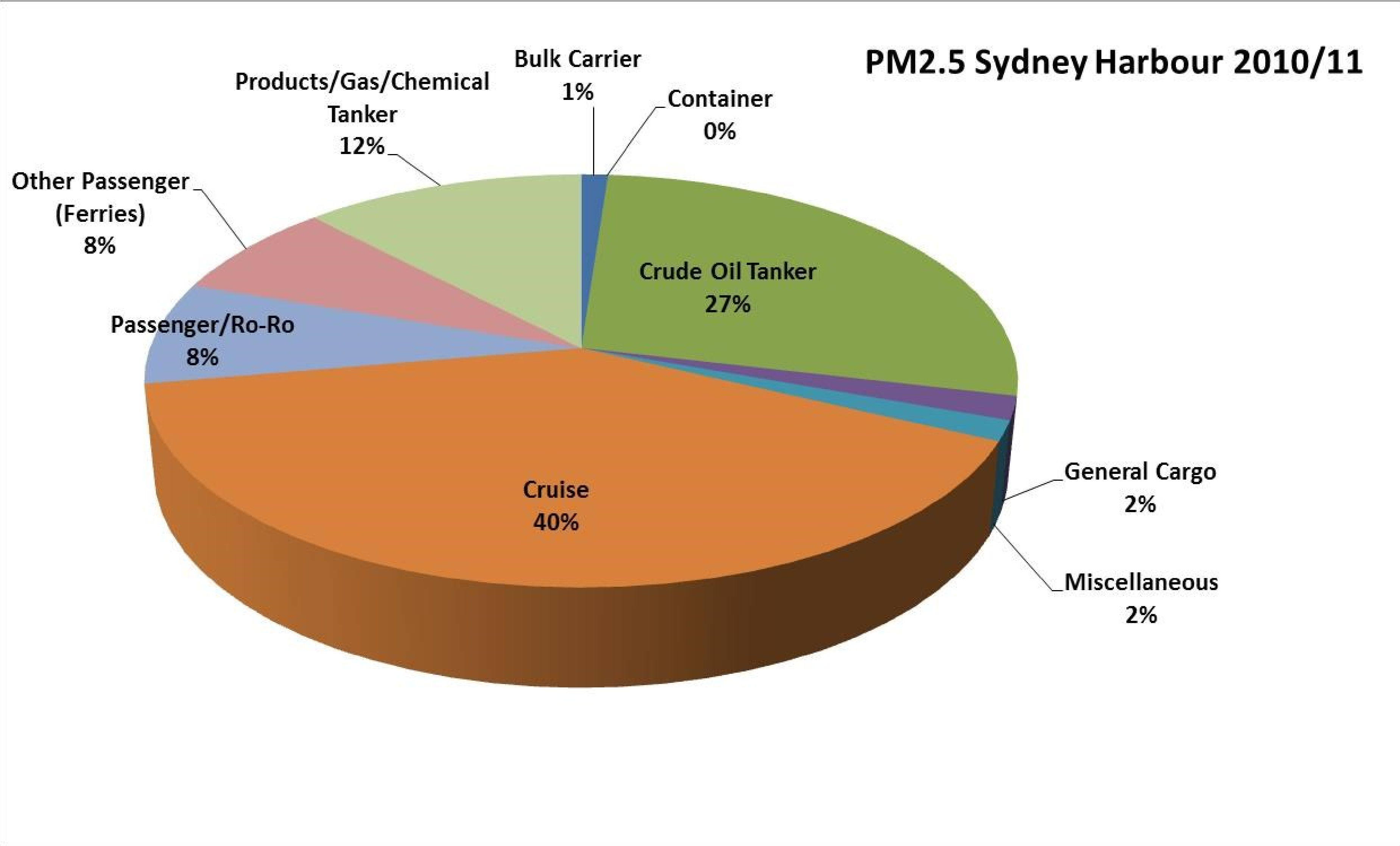
For these ports the anchorage areas lie outside the port boundaries.

Sydney Harbour

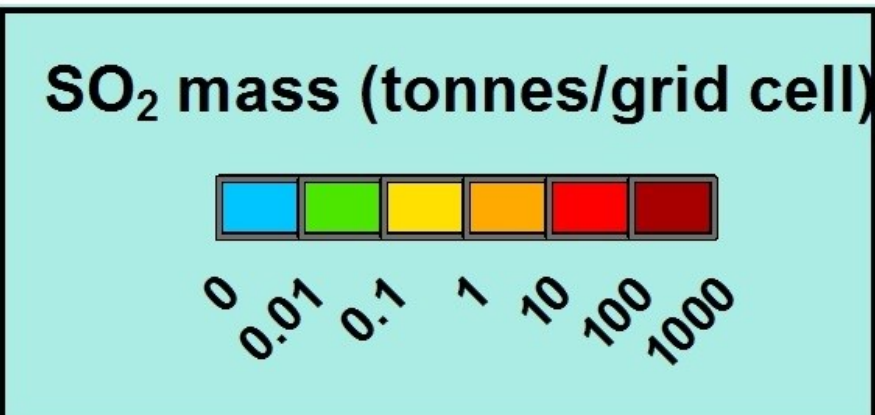


Vessel activity (position reports)
– dominated by ferries

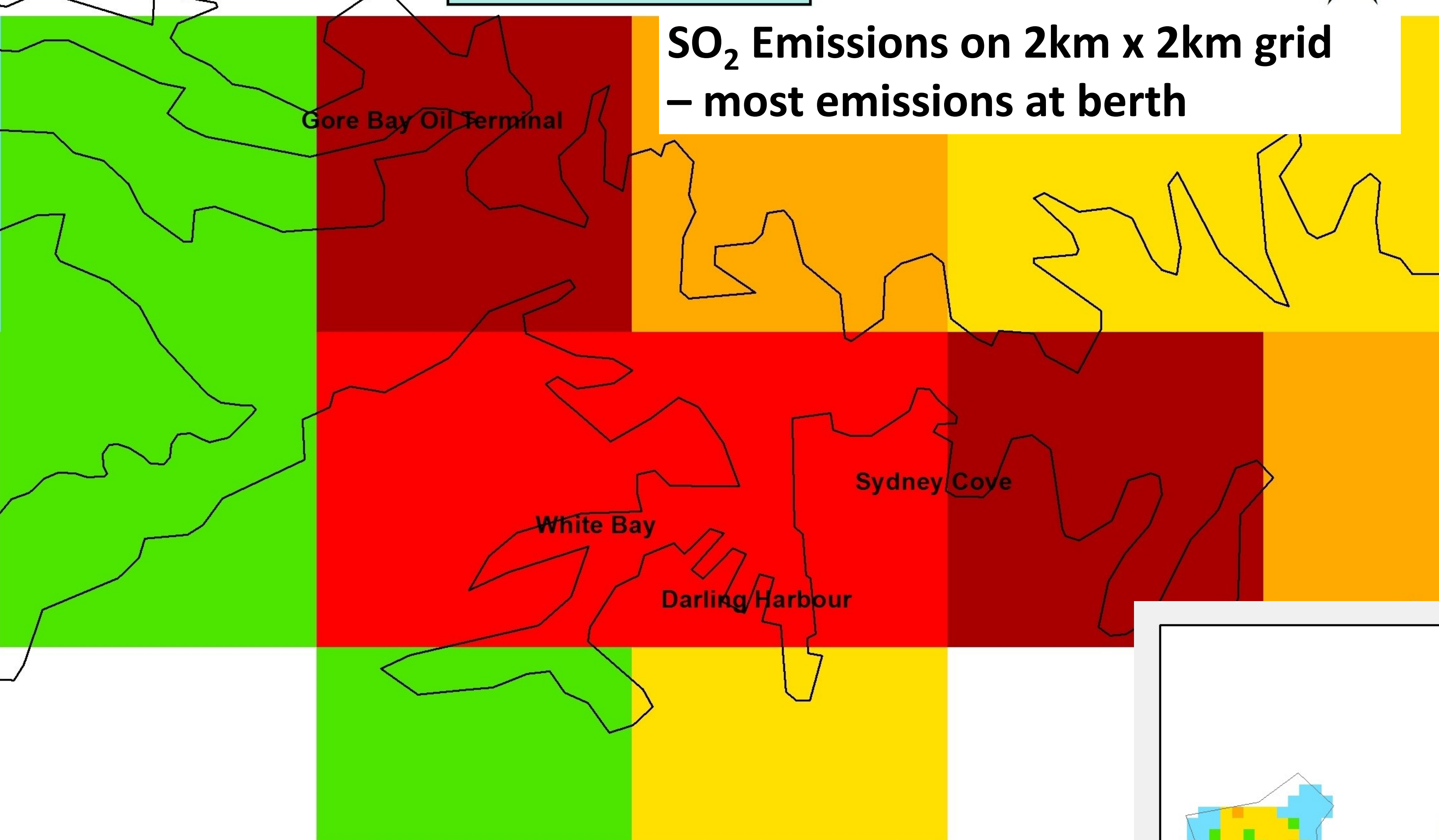
Fine particle emissions (PM2.5)
– dominated by Cruise ships and Tankers



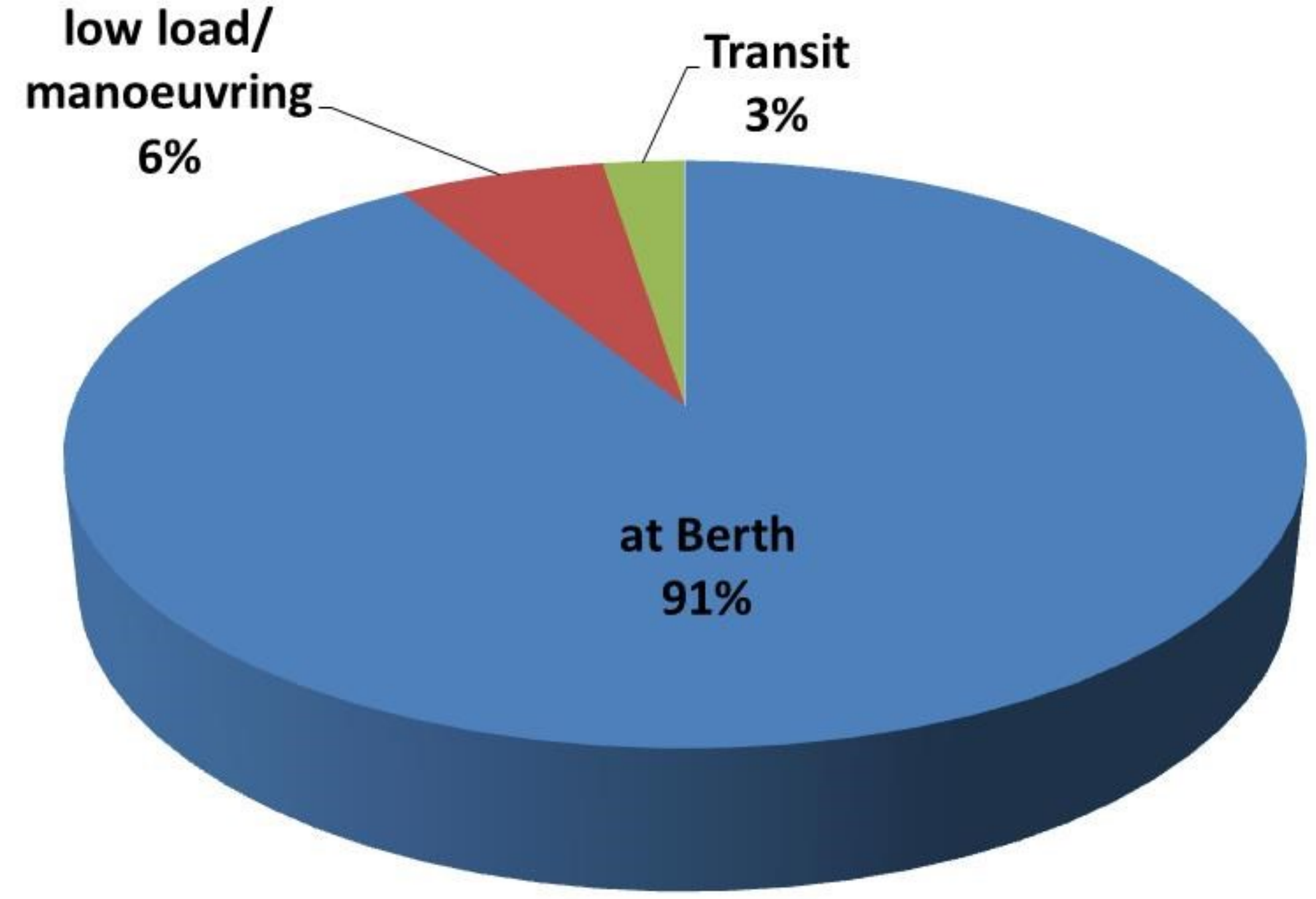
Sydney Harbour



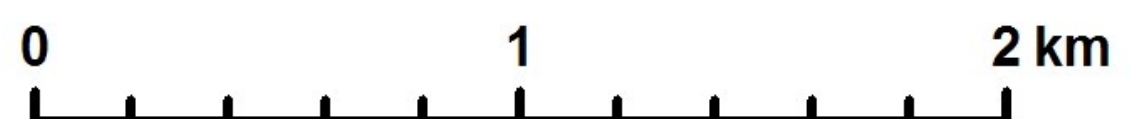
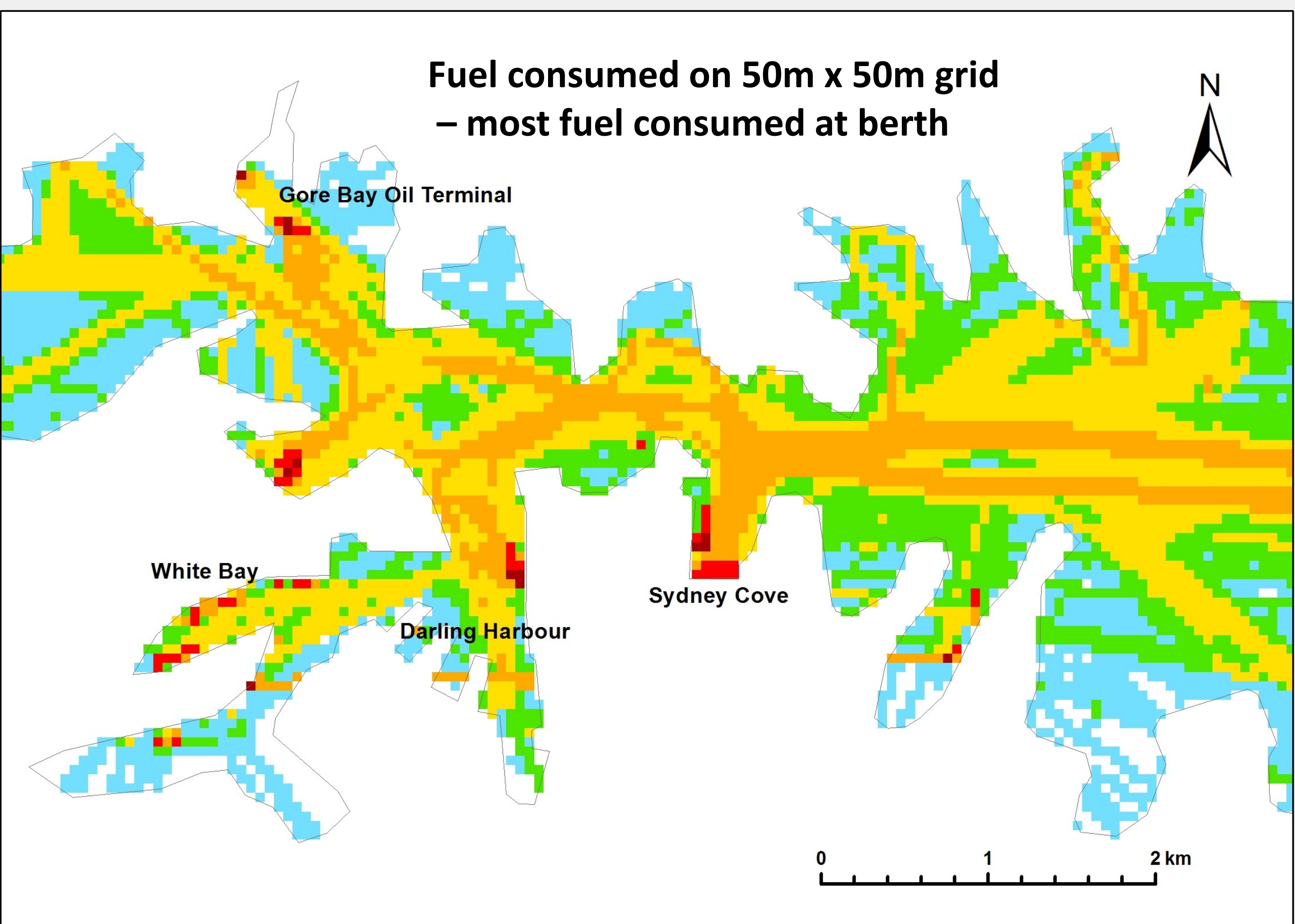
SO₂ Emissions on 2km x 2km grid – most emissions at berth



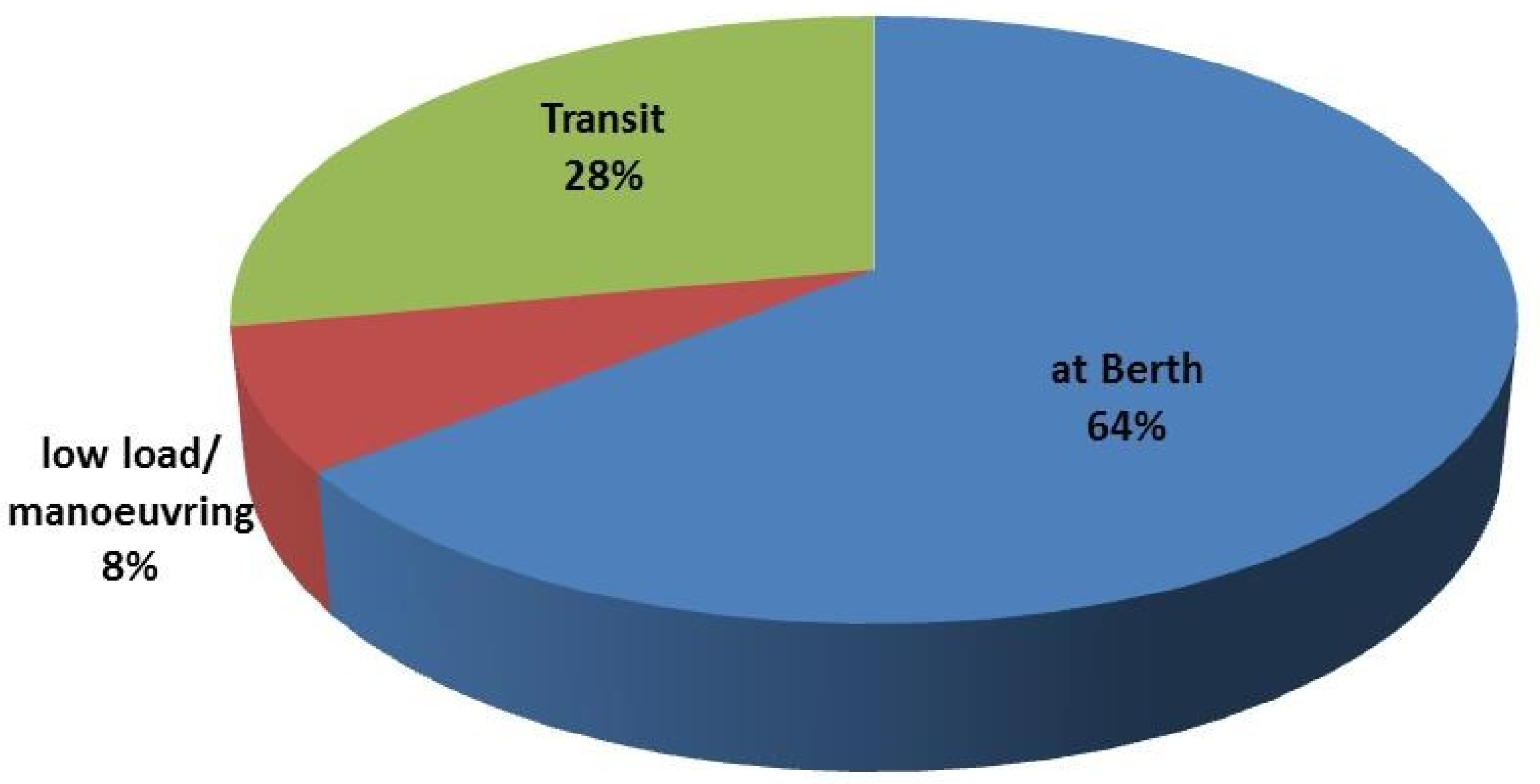
SO₂ Sydney Harbour 2010/11



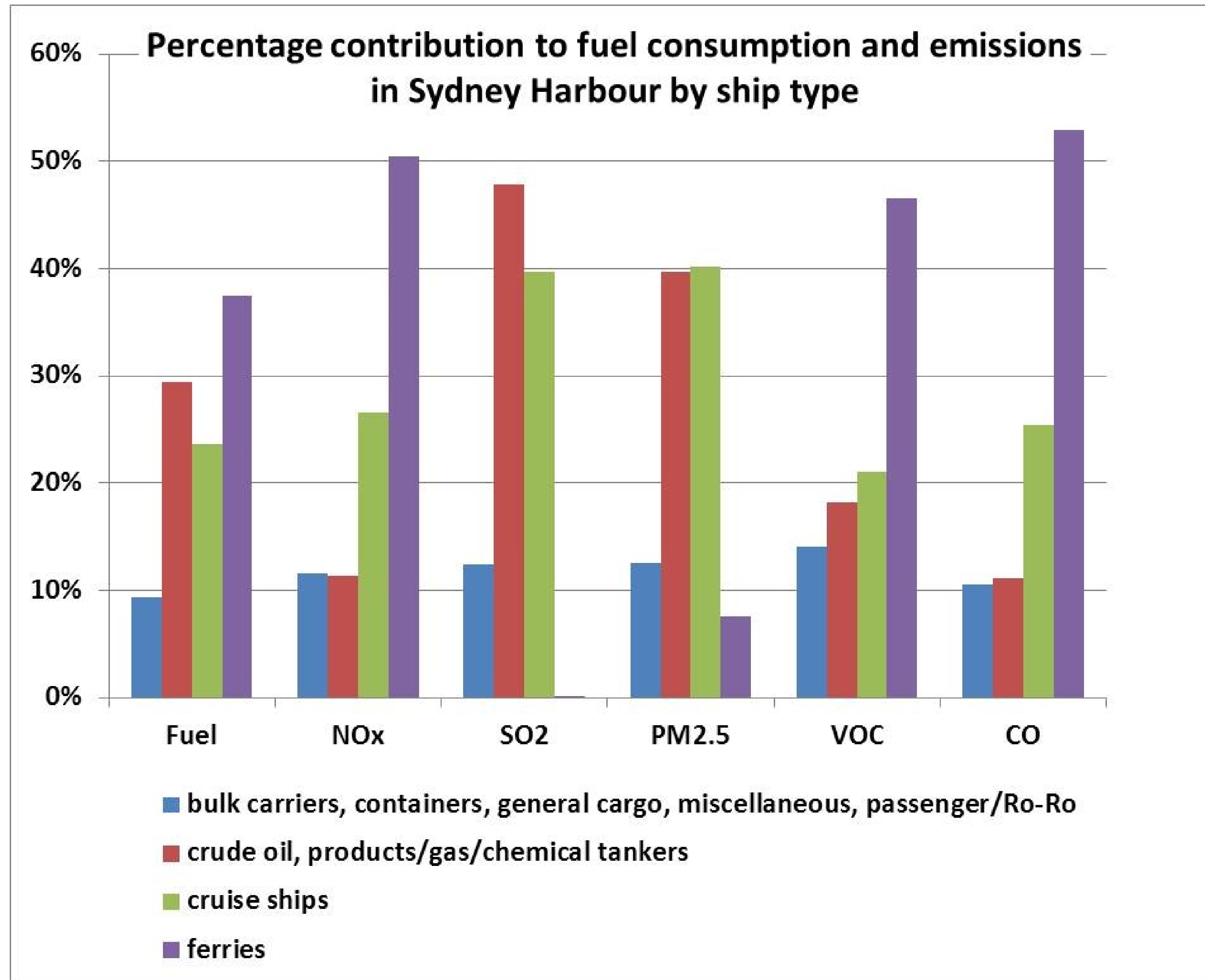
Fuel consumed on 50m x 50m grid – most fuel consumed at berth



Fuel Consumption Sydney Harbour 2010/11

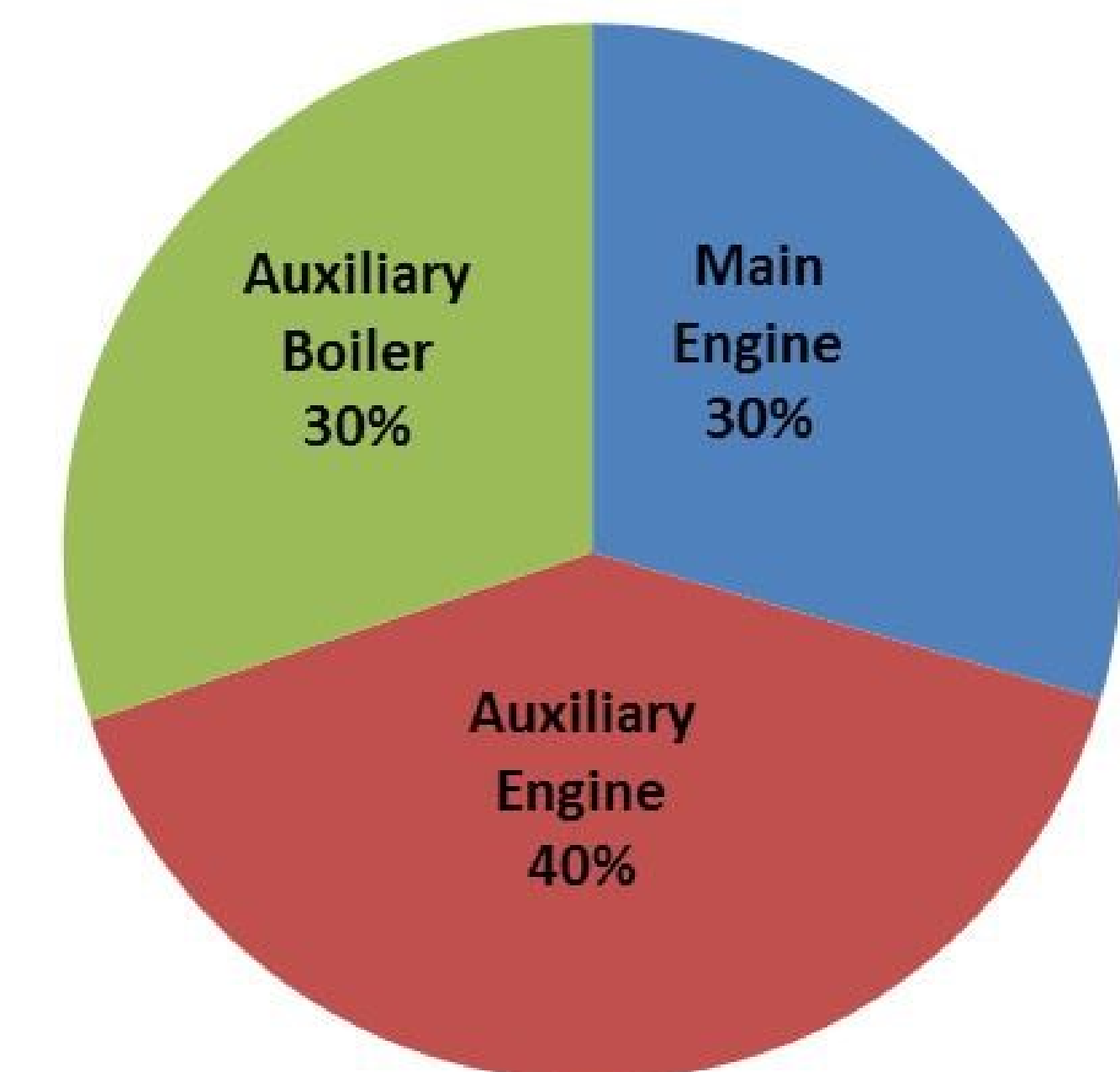


Sydney Harbour Fuel Consumption and Emissions by Ship Type



- Ferries produce little SO₂ and PM_{2.5} because they operate on Ultra Low Sulfur Diesel (ULSD)
- Ferries' percentage contribution of NO_x, VOC and CO high because other vessel types consume some of their fuel in boilers which produce less NO_x, VOC and CO per tonne of fuel compared with diesel engines

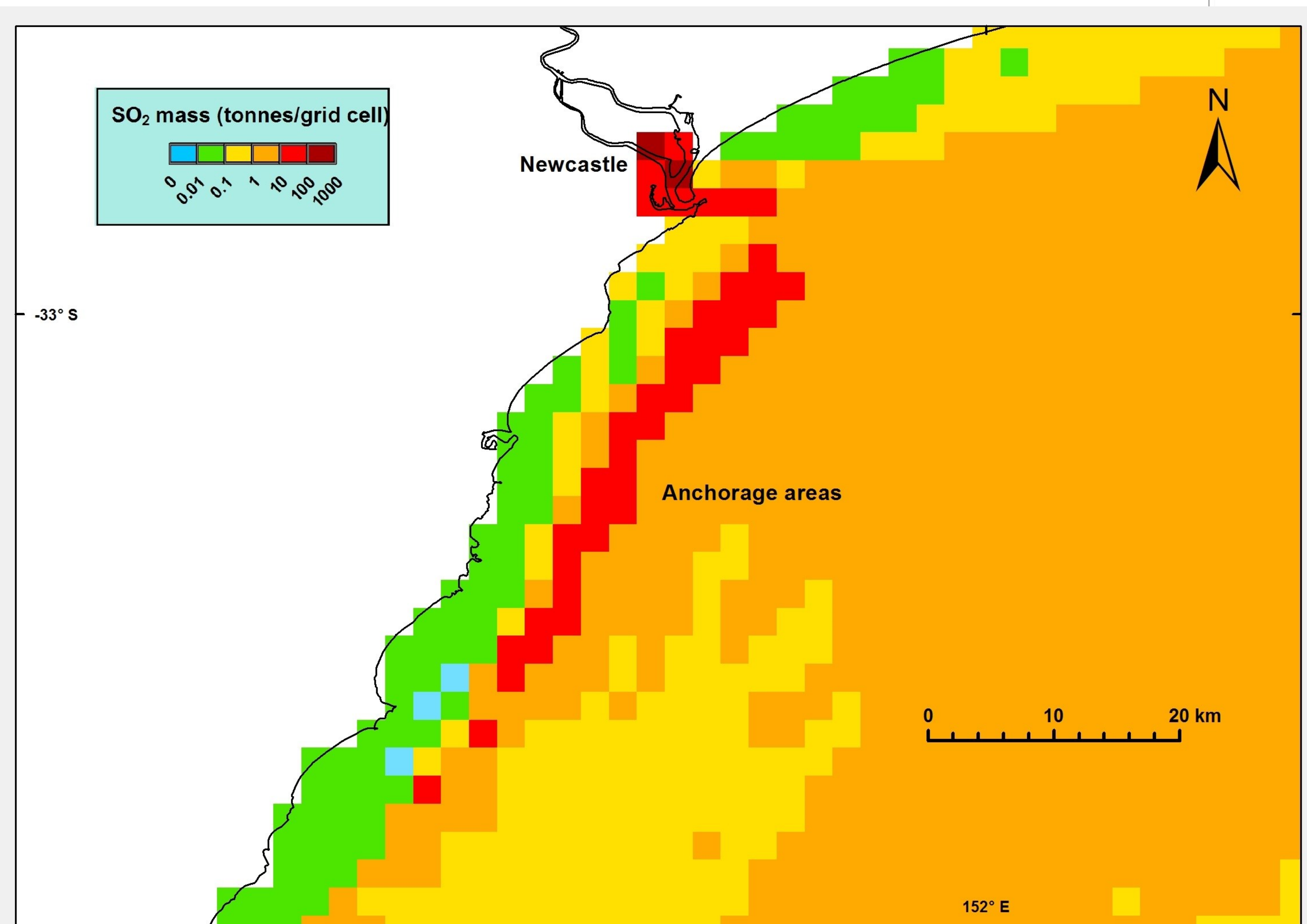
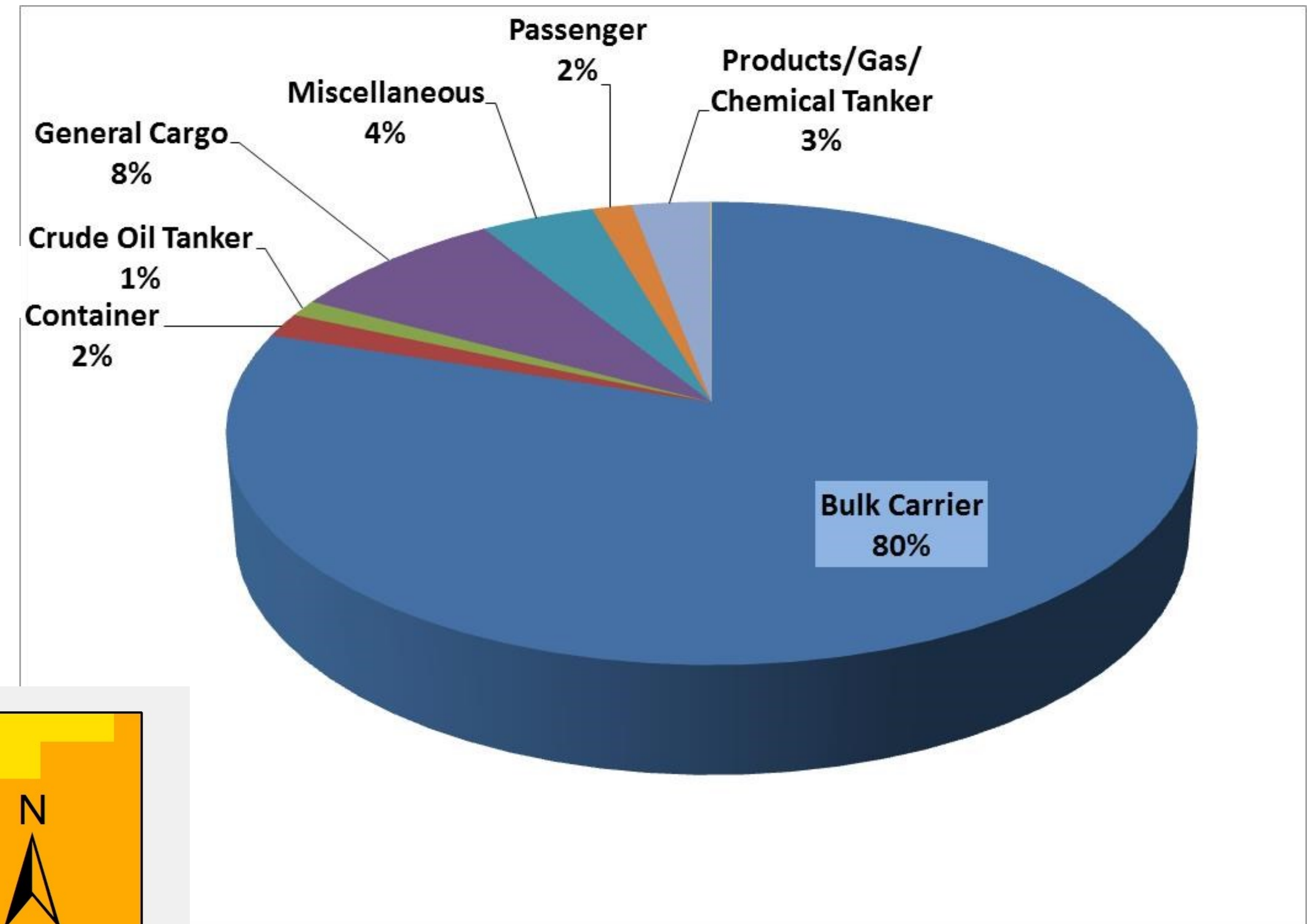
Fuel Consumption in Sydney Harbour by Machinery Type



Newcastle

Emissions dominated by Bulk Carriers

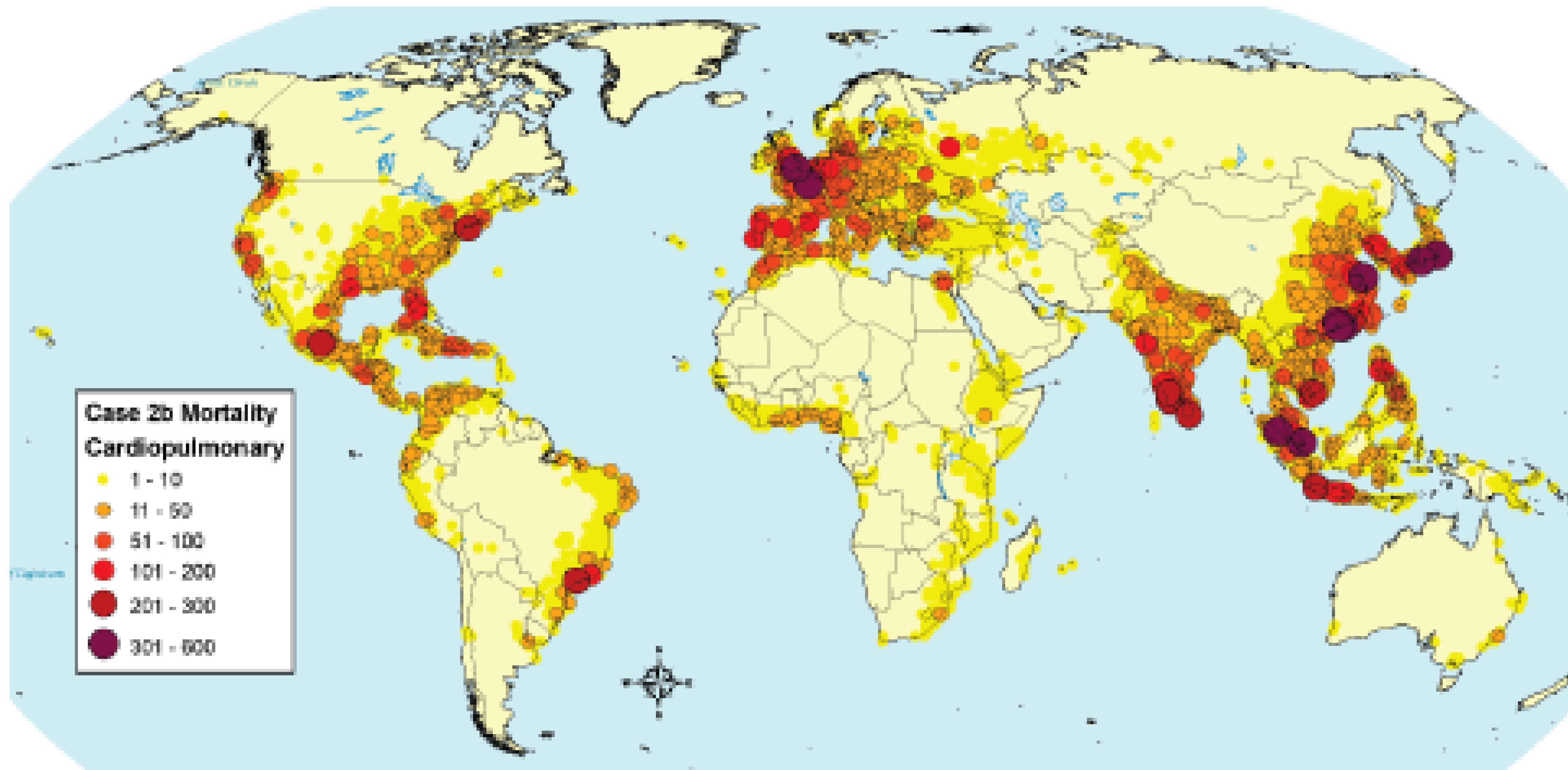
Fine particle (PM2.5) emissions 2010/11



SO₂ Emissions 2010/11 on a 2km x 2km grid

Emissions in anchorage and harbour entry areas approximately 2 x in-harbour emissions

Emissions + Atmospheric Transport + Public Health Modelling



Cardiopulmonary mortality attributable to ship particle emissions worldwide according to Corbett et al, *Mortality from Ship Emissions: A Global Assessment*, Environ. Sci. Technol. 2007, 41, 8512–8518

Case 2b world fleet including auxiliary engines, all PM constituents (particulate organic matter, sulfates, black carbon)

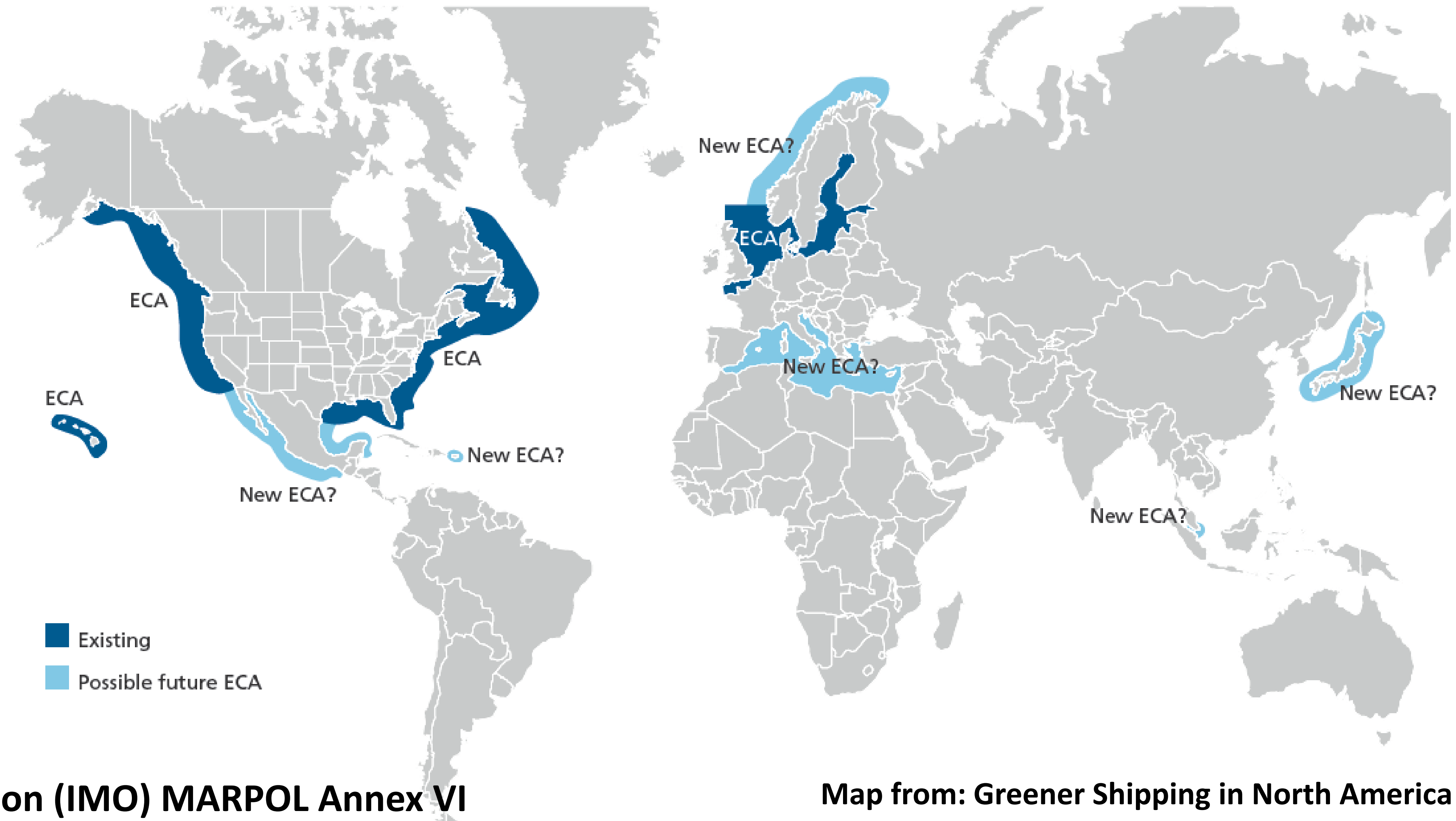
USA/Canada – new IMO Emission Control Area (ECA) covering the Pacific coast, the Atlantic/Gulf coast and the eight main Hawaiian Islands, 200 nautical miles:

“...expected to yield significant health and welfare benefits, in 2020 annually preventing between 5,500 and 14,000 premature deaths, 3,800 emergency room visits, and 4,900,000 cases of acute respiratory symptoms...monetized health benefits in the US in 2020 are projected to range from \$47 billion to \$110 billion...”

EPA-420-F-10-015, March 2010

IMO Emission Control Areas (ECAs) and EU Sulfur Regulations

Reducing fuel sulfur significantly reduces emissions of fine particles



International Maritime Organisation (IMO) MARPOL Annex VI

- Affects main propulsion engines, auxiliary engines and auxiliary boilers
- 2010 ECA fuel sulfur 1.0%
- 2012 global fuel sulfur 3.5%
- 2015 ECA fuel sulfur 0.1% or equivalent result using exhaust scrubbers
- 2016 ECA Tier3 NOx for new engines (IMO Tier 1 less 80%)
- 2020 global fuel sulfur 0.5% - if refineries can produce it, might be deferred to 2025

Map from: Greener Shipping in North America
DNV February 2011

North American ECA effective from 2012

Central American ECA now approved, effective from 2014

European Union Ports

- 2010 fuel sulfur 0.1% while at berth in European Union - affects auxiliary engines and auxiliary boilers

Ship Emissions Mitigation Measures in Place around the World

- **low sulfur fuel at berth** (auxiliary engines, auxiliary boilers) - EU approach, Hong Kong?
- **low sulfur fuel near the coast** (main engines, auxiliary engines, auxiliary boilers) – IMO ECA approach
- **differentiate port fees** according to fuel sulfur or NO_x emissions at berth
 - fuel sulfur rebate (Vancouver) , direct charge (Gothenburg)
 - Swedish ports differentiated fees according to NO_x emissions, assistance to frequent users for fitting control equipment
- **Norwegian NO_x tax and NO_x levy for domestic shipping**
 - includes assistance with capital cost of abatement equipment
- **Shore power** (Cold Ironing)
 - some ports mandating the use of shore power where facilities are provided by the ports
 - capital grants to frequent users to assist in the installation
- **Voluntary use of low sulfur fuel**
 - Fair Winds Charter - shipping lines voluntarily using fuel of sulfur content 0.5% or less in Hong Kong Port – mandatory from 2015?
 - Maersk will voluntarily use low sulfur fuel in New Zealand ports
- **Vessel Speed Reduction (VSR)**
 - Reduction of vessel speed near coast reduces fuel consumption and emissions near population centres– fuel cost savings

Issues with Emissions Mitigation Measures

- Is the impact of ship emissions in Australia significant enough to warrant implementation of controls?
- Cost and availability of low sulfur fuel
- Potential for technical problems at fuel changeover – fuel pump seizure, boiler safety
- Costs of modifying fuel systems
- Cost of shore power for ports and shipowners – enough frequent visitors in Australia?
- If individual ports act alone, shippers may move ports, especially container trade
- Mode shifting to less greenhouse friendly transport such as road?
- Capital costs of emissions control equipment – who pays?



Concluding Remarks

Need studies of impacts of ship emissions on human health in specific Australian locations

– atmospheric dispersion and health modelling based on accurate inventories

Thank You

SYDNEY HARBOUR

SYDNEY HARBOUR PRECINCTS AND TENANTS

- A Overseas Passenger Terminal (see p8)
- B Wharf 5 Barangaroo Cruise Passenger Terminal (see p7)
- C Moores Wharf – Sydney Ports Corporation Marine Operations
- D Gypsum Resources Australia (see p10)
- E Sugar Australia (see p10)
- F Cement Australia (see p11)
- G Glebe Island – Sydney Ports Corporation Marine Services
- H Bailey's Marine Fuels (see p12)
- I Sydney Ports Corporation – Corporate Office
- J Gore Bay Terminal (see p13)
- K Blackwattle Bay (see p13)
- L Future Cruise Passenger Terminal at Wharf 5 White Bay (under construction)

① Berth numbers

