Greenhouse Gas Impacts from Fuel Switching

California Maritime Technical Working Group: Focus on Fuel Switching

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CAL/EPA Headquarters Building
Coastal Hearing Room

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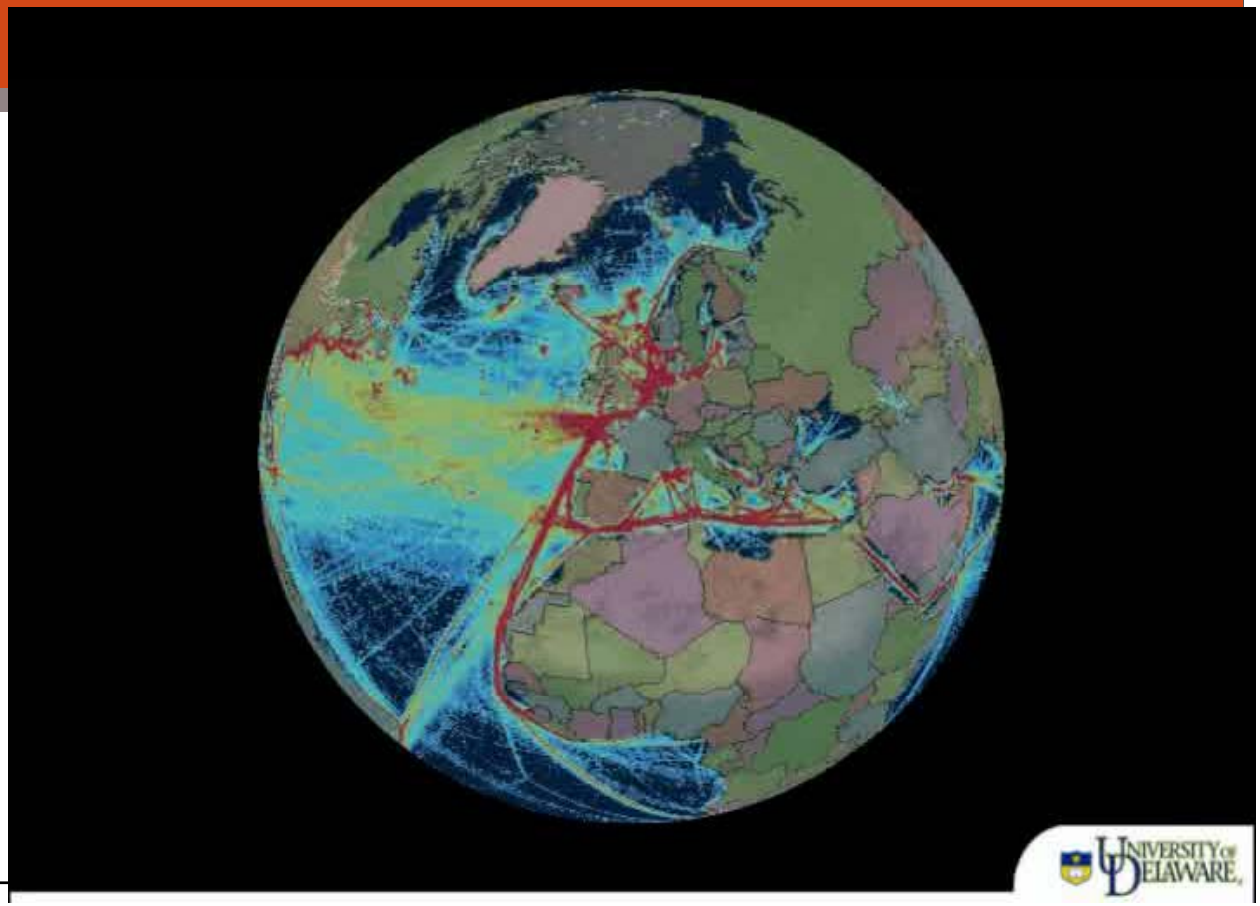

Outline for presentation

- Background: Freight in Context
- Ship emissions inventories and trends
- Assessing impacts and mitigation targets (health, environment, economic)
- Technology-policy options
  - ***Fuel switching***, Abatement technology, Operations

Routes to achieve environmental goals for freight may include combinations of new technologies, alternate fuels, and enabling operational changes

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Background: Freight in Context

The freight system is an important and growing contributor to the economy, transportation energy demand, and environmental impacts.

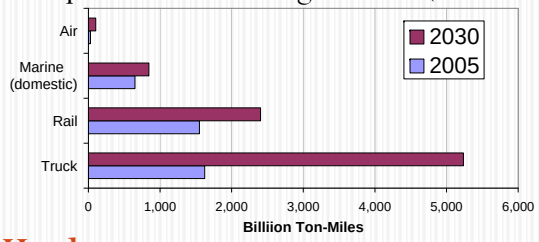
US Context: Freight Overview

Economic Importance

- US spends 6-7% of GPD on freight transport annually
- Value of import/export of goods represents about 25% of GDP (up from 15% in 1990)

Work Performed

- Increases expected over coming decades (EIA 2007):

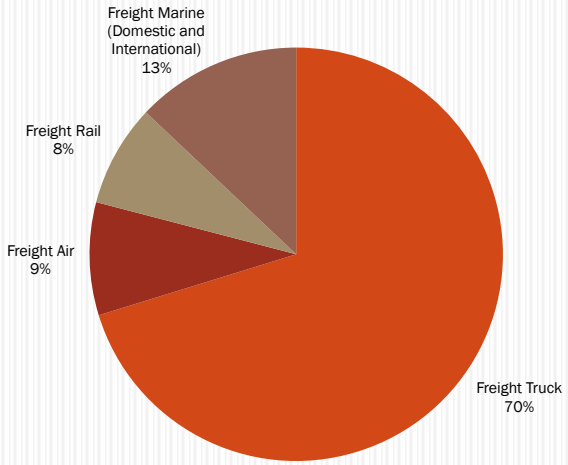


Energy Used

- Represents ~25-30% of total US transportation energy use

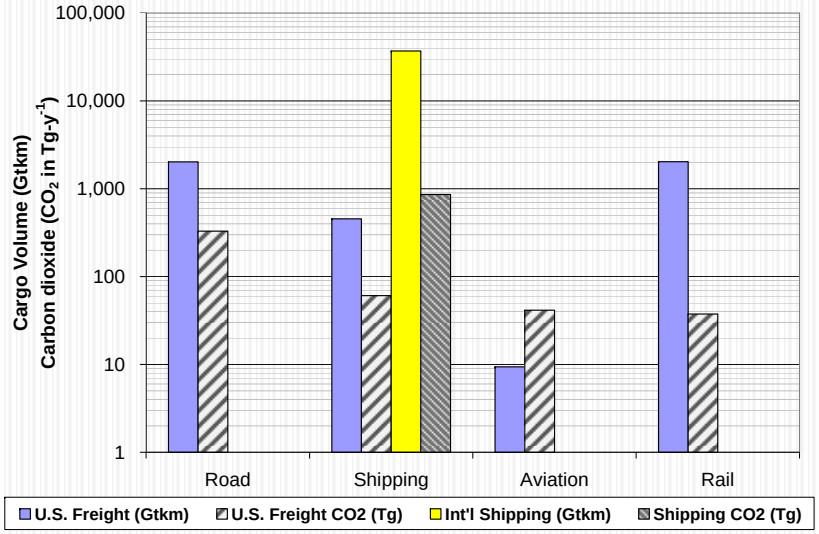
US Context: Environment

- Freight accounts for 470 MMTCO$_2$ annually (7.8% total US CO$_2$ emissions)
- Contributes about50% of NOx emissions and 40% of PM emissions from transportation sources. (EPA)



Proportion of U.S. Carbon Emissions by Freight Type, 2004 (US DOE, 2007)

Background: Cargo Volume and Carbon by Mode

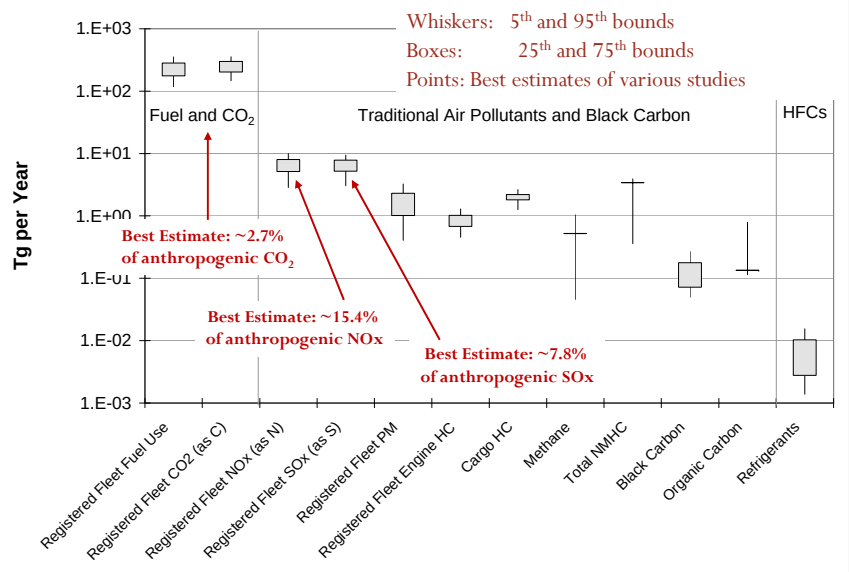


Shipping Inventories & Forecasts

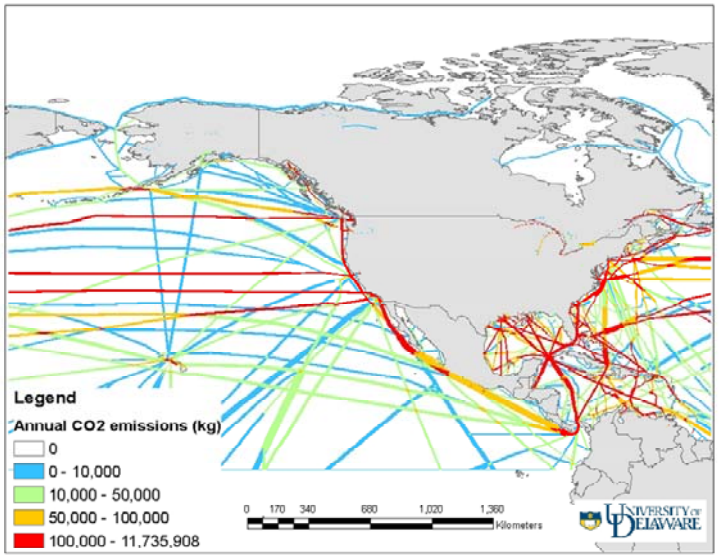
Geospatial shipping activity is an important consideration for policy decision making.

Emissions from ships are likely to grow at a faster rate than GDP and other energy sectors.

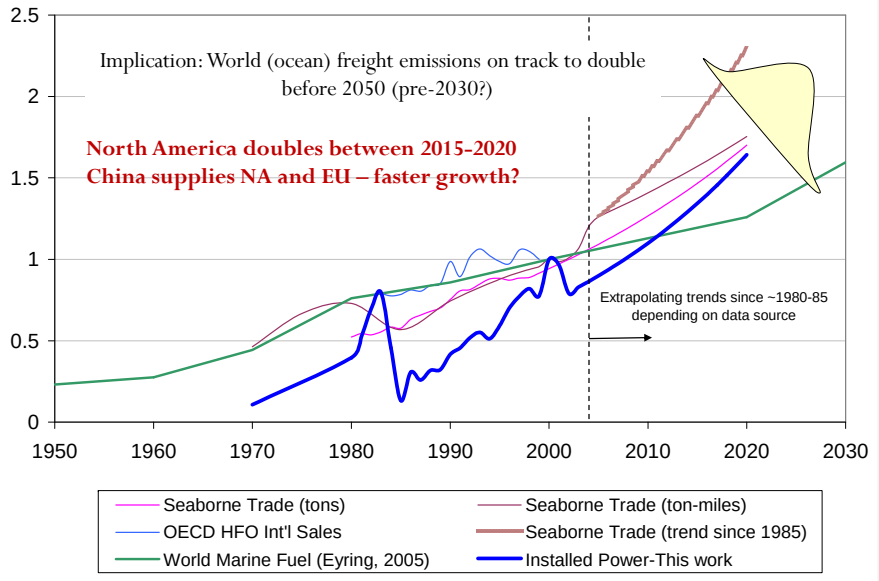
Ship emissions estimates bounded



STEEM: Ship Traffic Energy and Environment Model
Spatial Distribution in Multimodal Context



Building a valid range of world forecasts
... starting with trade and energy

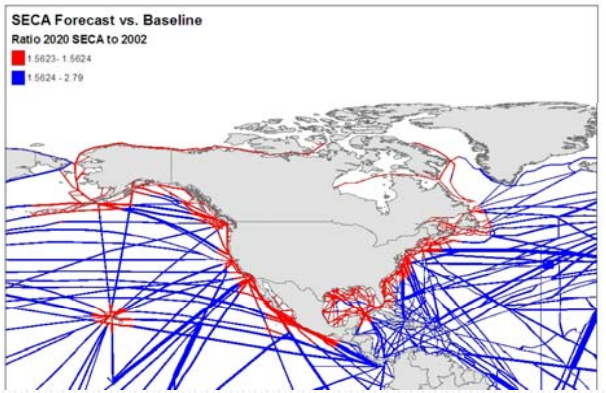


Concept illustration credited to discussions with M. Granger Morgan, Carnegie Mellon University

SECA-compliant increases in emissions?

Hypothetical IMO-compliant SECA (1.5% S) reduces future emissions from BAU

... but not compared to base year



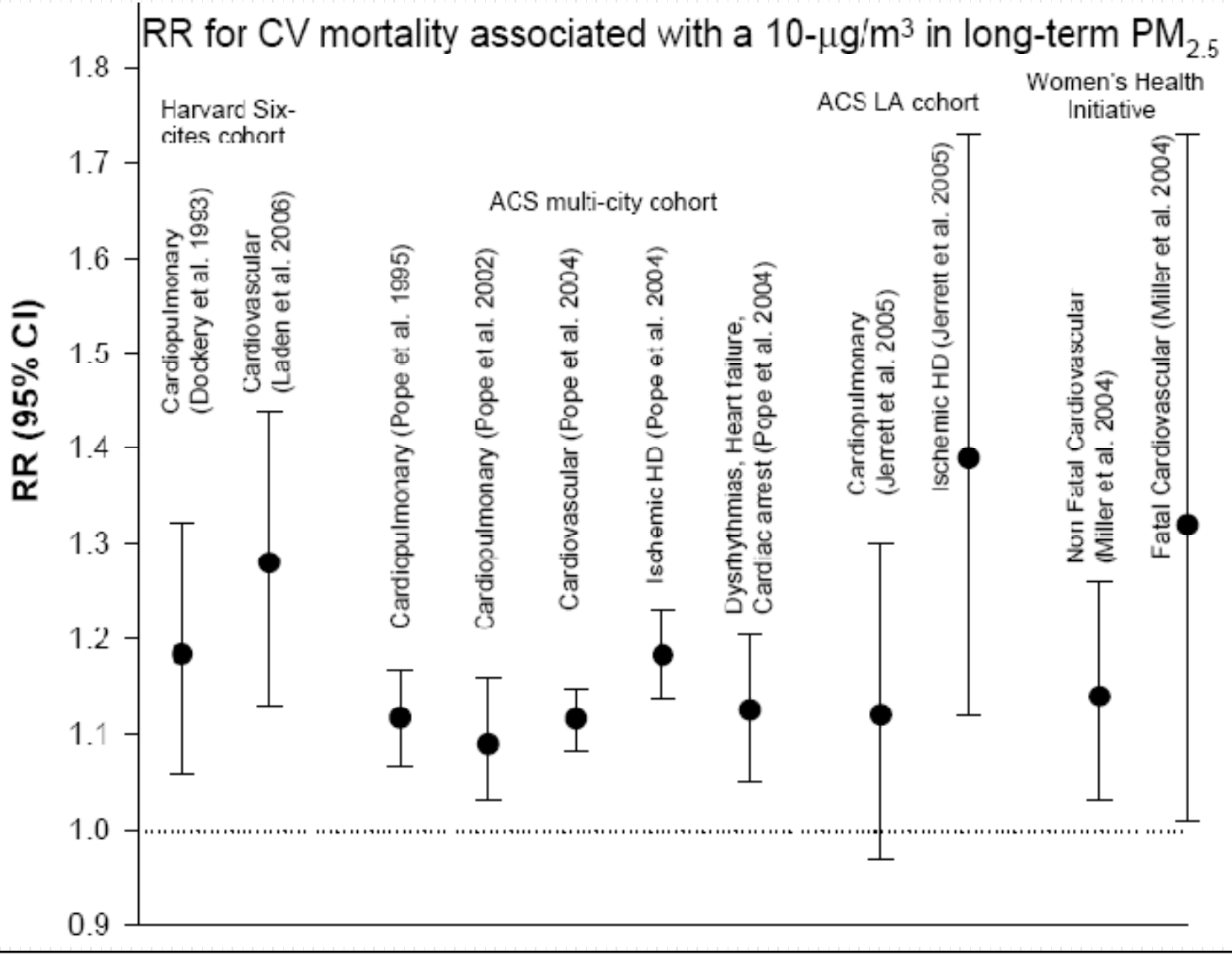
- Reduces 700,000 metric tons from 2020 no-SECA
- Increases by ~2 million Mtons over 2002 base-year

Potential Impacts and Mitigation

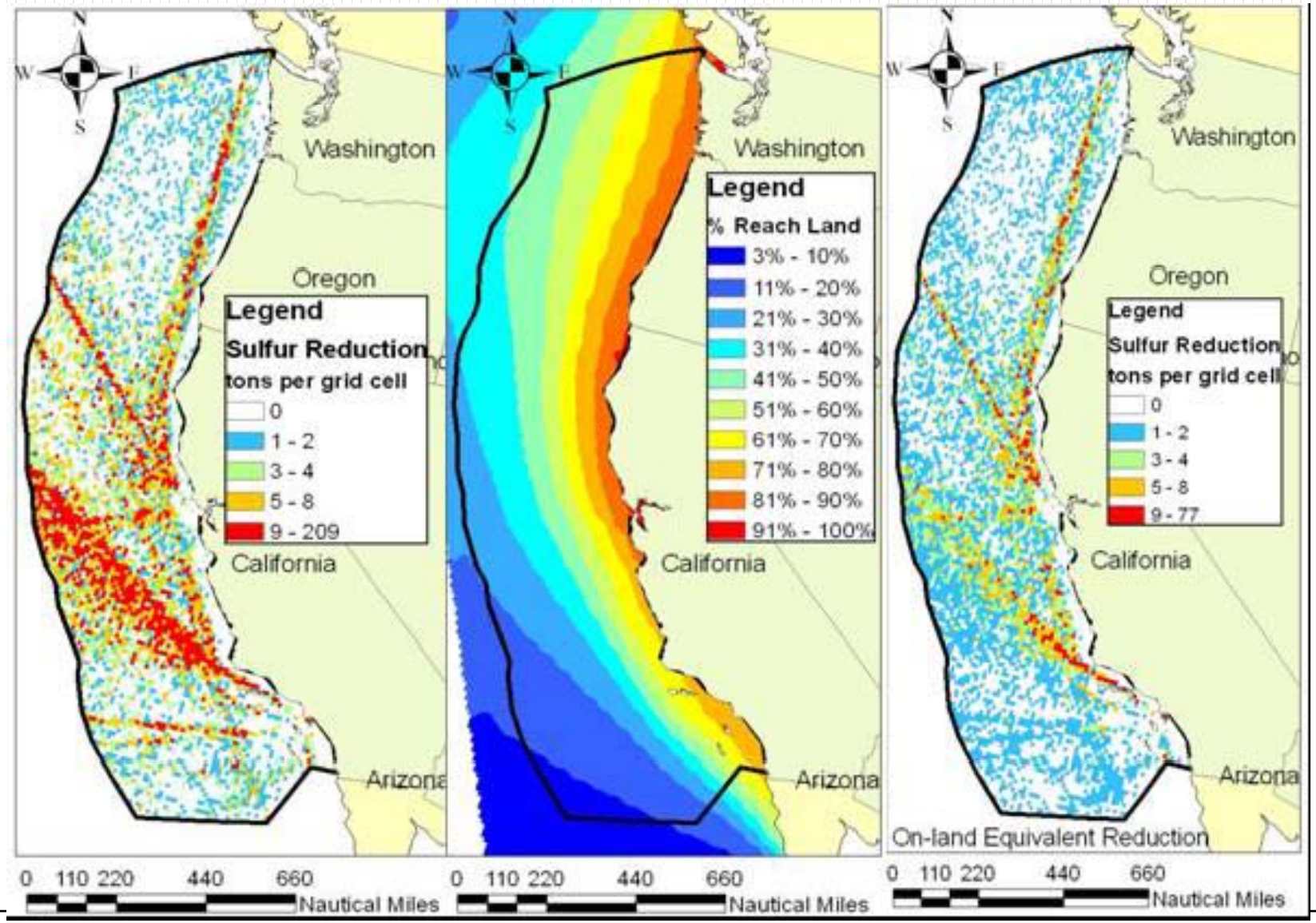
We are just starting to understand the health impacts due to emissions from ships; these analyses can inform policy decisions.

Cohort Studies – CV Mortality

Pope and Dockery, JAWMA, 2006



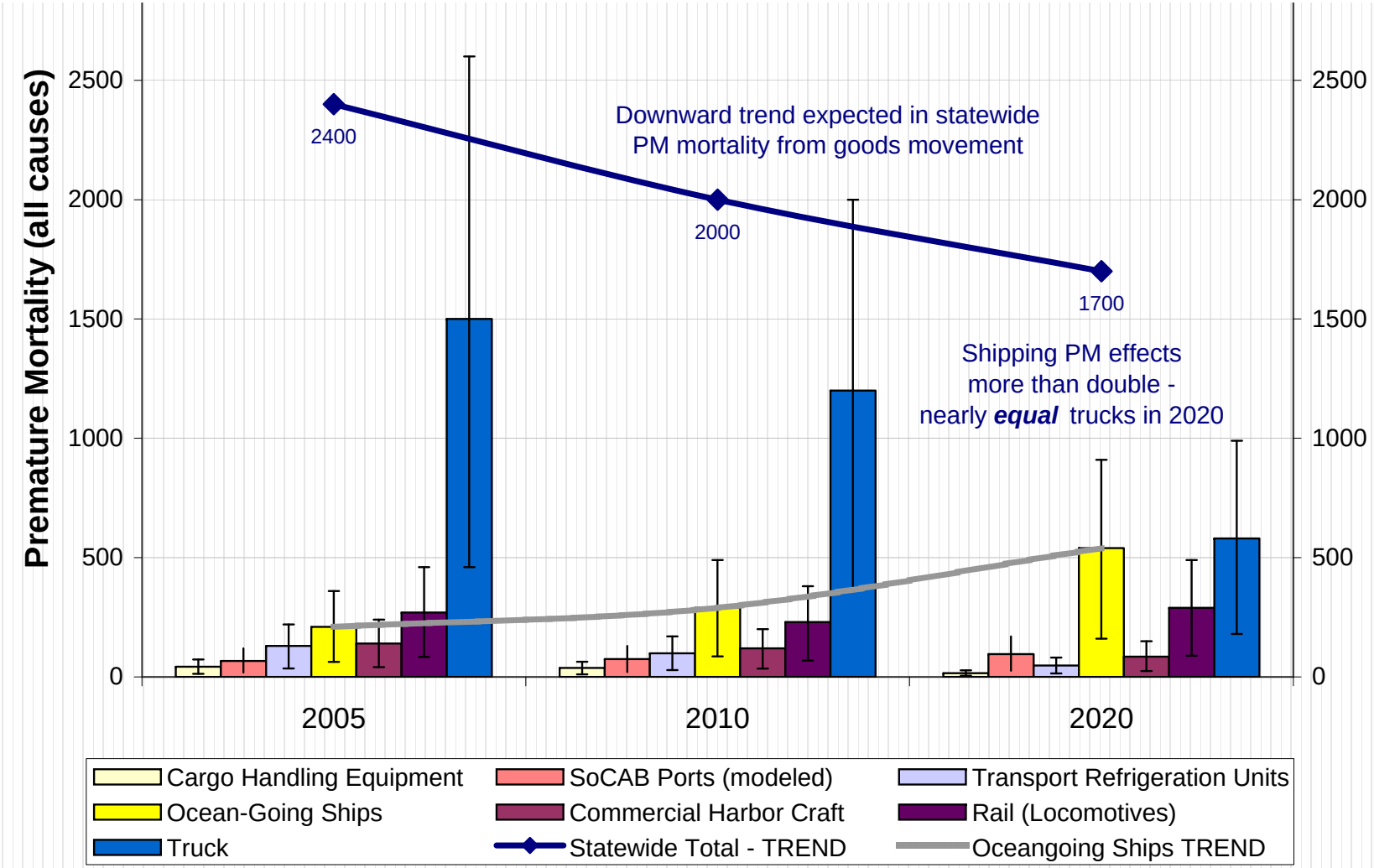
Estimating exposure is in progress



Premature mortality from goods movement

ARB, Quantification of Health Impacts…of air pollution from Goods Movement, 2006

California sees ***significant*** and ***increasing*** ship impacts
– without considering sulfate PM yet, and only considering 24 nm from shore



Approaches to setting ship targets

1. DO SOMETHING: Reduce emissions to improve performance, irrespective of growth.

2. HOLD THE LINE: Reduce emissions to hold current exposure (impacts?) constant at some base year, offsetting trade-driven growth in emissions.

3. MITIGATE CURRENT IMPACTS: Reduce emissions by X amount, maintaining emissions (impacts?) reductions from some base year, despite growth in trade.

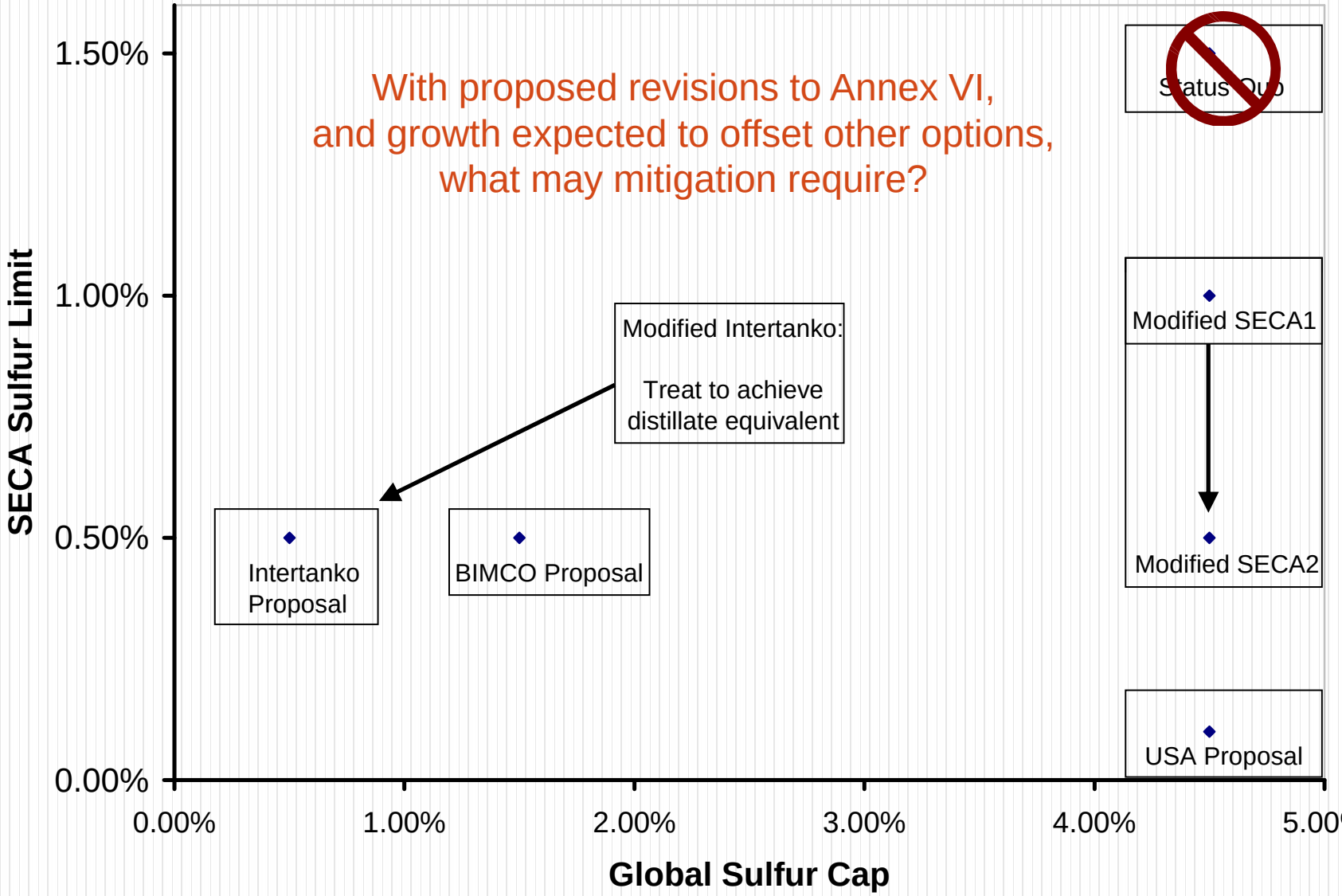
Choice of action targets driven by evidence of impacts, benefits

Choice of strategies influenced by economics, technology

Mitigation Options

Fuel switching remains a viable option for reducing emissions and is included in a number of international proposals; total fuel cycle emissions analysis is needed to consider tradeoffs between GHGs and other pollutants.

Revisions to IMO Annex VI – Proposed Options

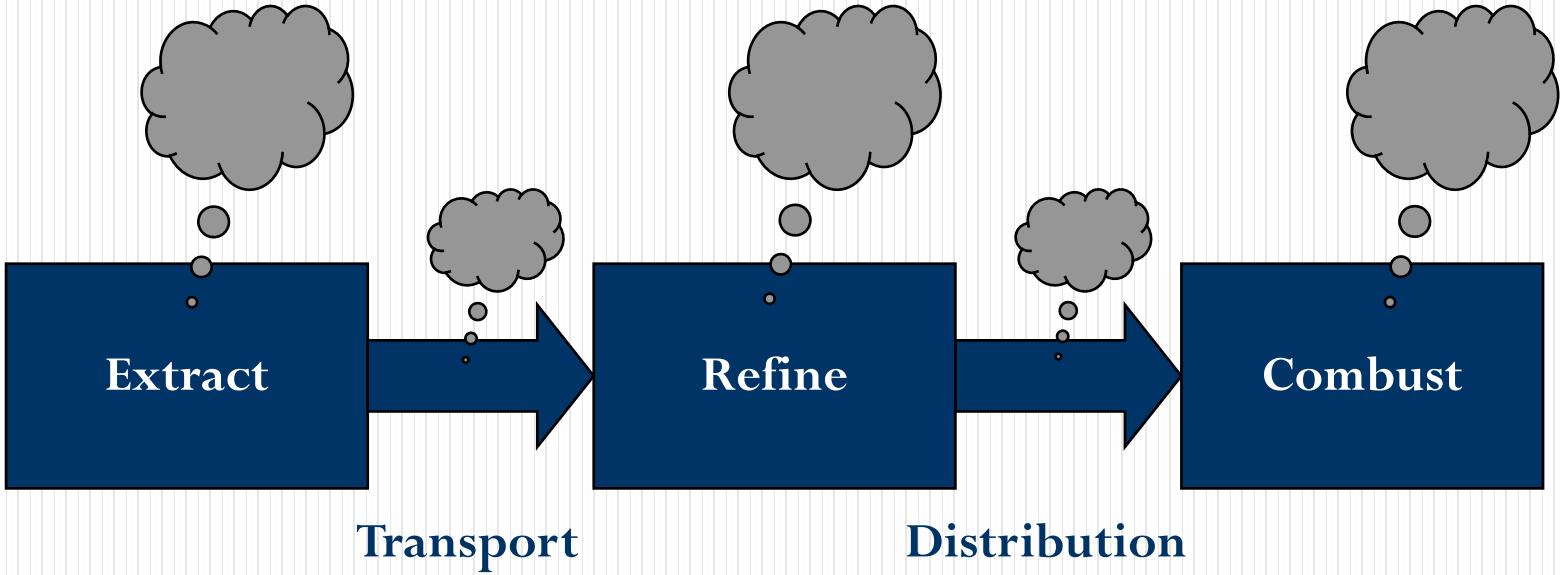


TEAMS

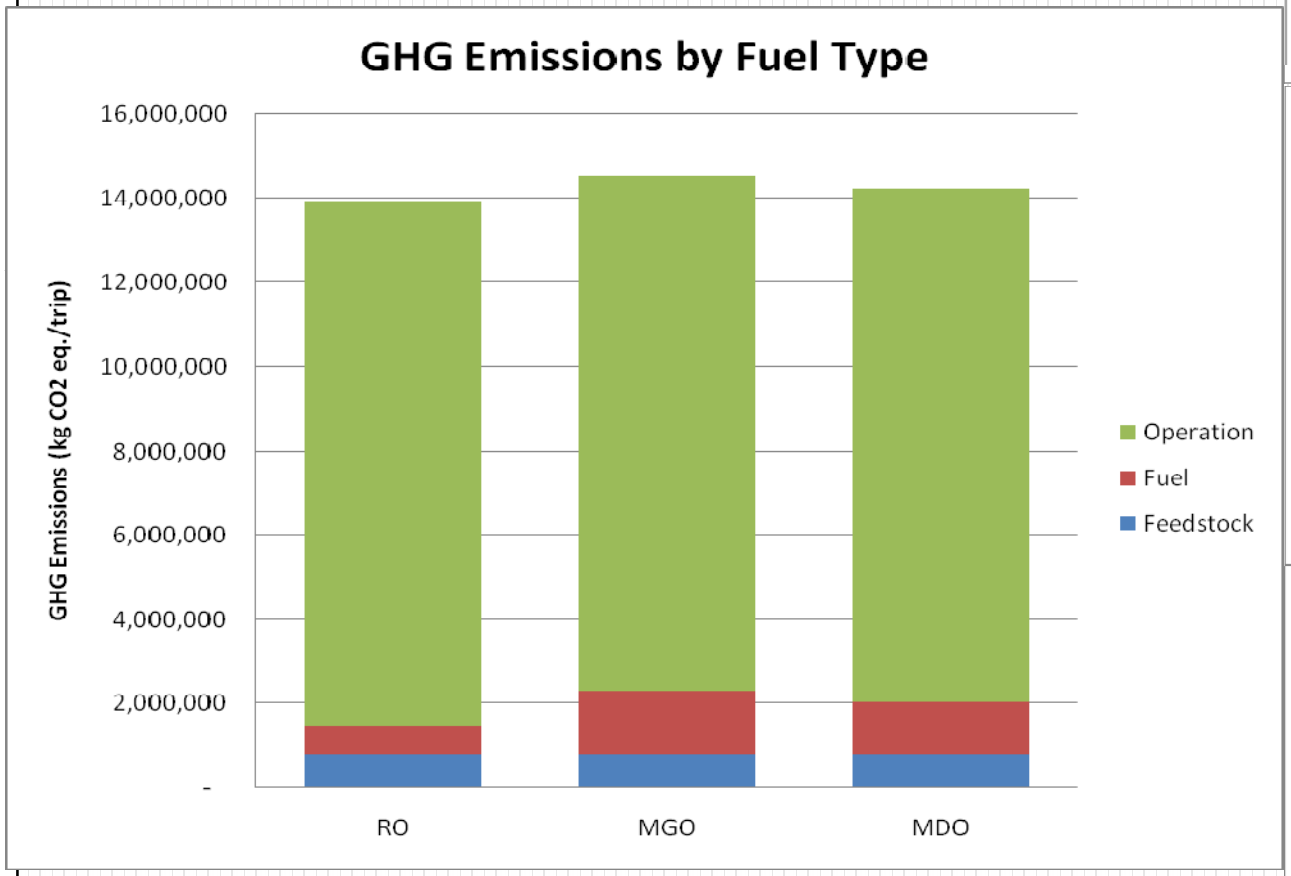
- Total Energy and Emissions Analysis for Marine Systems (TEAMS) Model
- Emerged from:
  - Increasing interest in alternative fuels for ships
  - Need to understand emissions tradeoffs between GHG emissions and other pollutants
  - Improve landside v. waterside transportation analyses

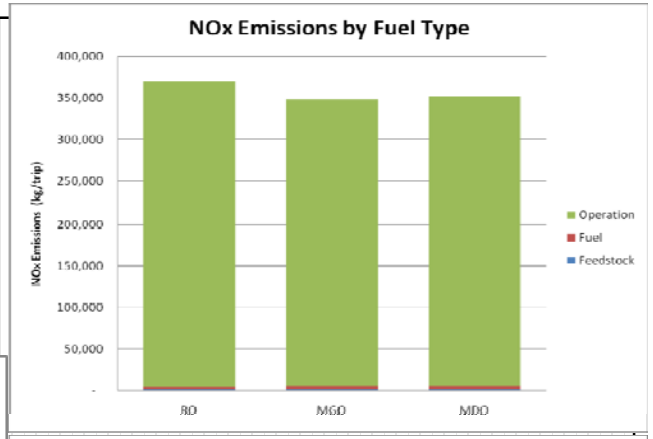
Well-to-Hull Analysis (W2H)

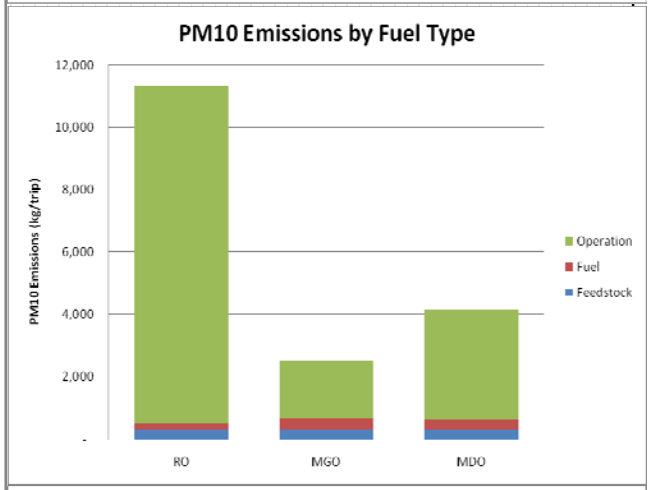
W2H Analysis accounts for energy consumption and emissions along the entire fuel cycle of a given fuel

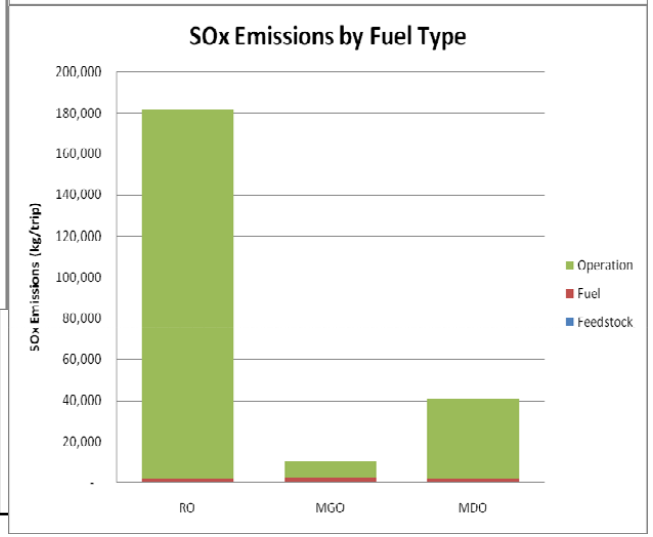


Total Fuel Cycle Comparisons









Winebrake, J.J., J.J. Corbett, and P.E. Meyer, A Total Fuel Life-Cycle Analysis Of Energy And Emissions From Marine Vessels, Paper No. 07-0817, in *Transportation Research Board 86th Annual Meeting*, Transportation Research Board, Washington, DC, 2007

Is CO_2 trade-off the key issue?

- Many concerned about increases in GHG emissions due to production of fuels that reduce other pollutants
- Tradeoffs exist among different pollutant types
- Cost of action v. no-action may focus on false choice
  - Health-based benefits of action may have high ***value:cost*** ratios
  - Current marginal costs of removing criteria pollutants appear lower than estimated benefits
  - Current trading price to offset a ton of CO_2 implies lower marginal cost to reduce CO_2 than to reduce pollutants

Environmental Control Technology Choices

- Environmental control technologies
  - Pre-combustion: e.g., water emulsions
  - In-engine: e.g., humidification
  - Post-combustion: e.g., SCR, scrubbers, PM controls

Only technology (and cost) combos get multiple pollutants

Nearly all carry CO_2 penalties of 1-3% or more for retrofits

- Alternative marine fuels and energy systems

Could double fuel price (freight rate ↑), and may require phase in

Also may carry CO_2 penalties in total fuel cycle

- Operational (behavior) changes

Possible in short term, possible multimodal logistics effects

Achieves reductions in CO_2 and all pollutants (win-win)

Assess key tradeoffs (cost, performance, reductions) among available options

(Marine) Freight Transport insights

- Technology will involve fleet retrofits and new-builds
- Economics influence (but don't exclude) role of alternative fuels
- 0.5% SECA *or lower* may be justified in large regions
  - Health effects work ongoing, but SOx control benefits appear greater than control costs
  - Reducing SOx and NOx will modify climate assessments
    - Most abatements increases CO_2; reduced emissions change ozone and indirect aerosol forcing
- Market incentives promising at several scales
- Operational logistics changes may involve all modes

A modern fleet of ships does not so much make use of the sea as exploit a highway. -- Joseph Conrad, The Mirror of the Sea, Ch. 22, 1906

Questions and Discussion

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