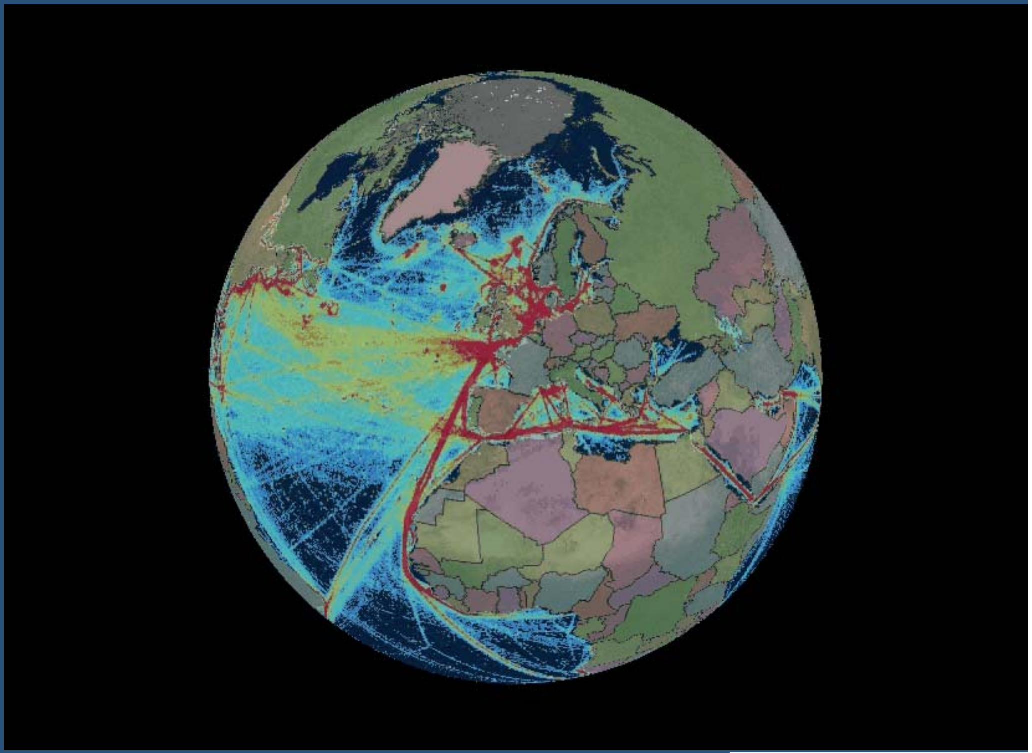
Air pollution and its relations to climate change and sustainable development – Linking immediate needs with long term challenges

Environmental Impacts Of Ocean Shipping In A Freight Context



James Corbett, P.E., Ph.D.

12-14 March 2007

"Saltsjöbaden 3"

Gothenburg, Sweden

Issues posed for workshop

- Emission reduction potential, as well as costs and benefits of emission reductions
- Effective ways to attain emission reductions in the short term (5-10 years) and in the longer term
- Evidence supporting global versus local control

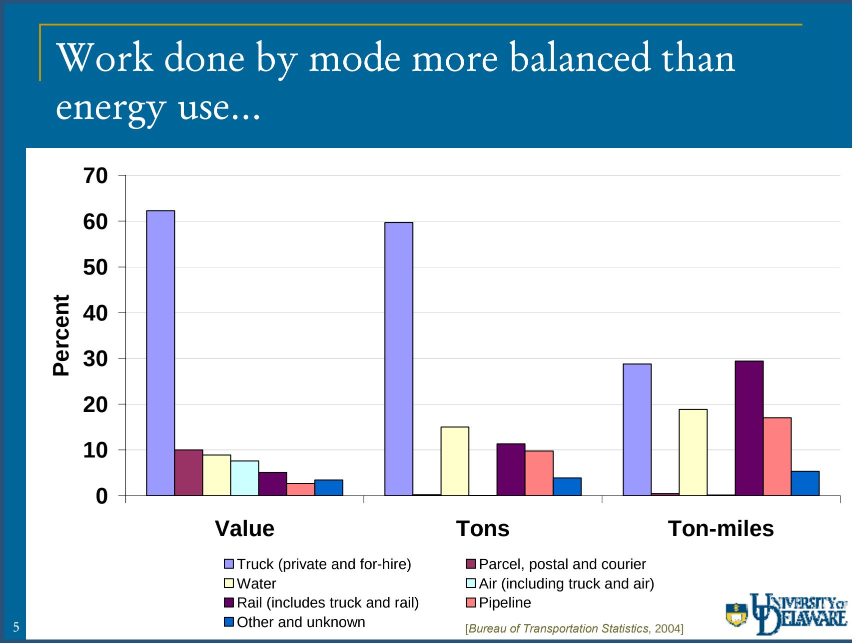
- Could (and should) EU and/or US take initiatives to speed up and strengthen IMO and ICAO action?
- What economic instruments are best suited and promoted to speed up emission abatement?

Two general reasons to reduce ship emissions:

1. Ships contribute to problems TODAY
2. Growth in shipping makes problems worse TOMORROW

Freight Transport Mode Linkages:
International trade generates multimodal activity

- Multimodal freight transportation demand consumes about a quarter (~26%) of U.S. transportation energy
  [*Environmental Protection Agency*, 2005a; *Environmental Protection Agency*, 2005b]
  - Dominated by trucking activity (~19%)
  - Domestic waterborne activity (~3%)
  - International Bunkers (~2%)
  - Rail activity (~3%)
- About 52% of NOx in U.S. emitted by freight
- More work for less energy than other mobile sources
- Past as prologue: International freight transportation shows strong growth over the past three decades that will continue over next three decades
  - International freight as a percent of GDP will increase from ~30% currently to 60% by 2030
    [Global Insights, Inc., quoted in *TRB Executive Committee et al.*, 2006]

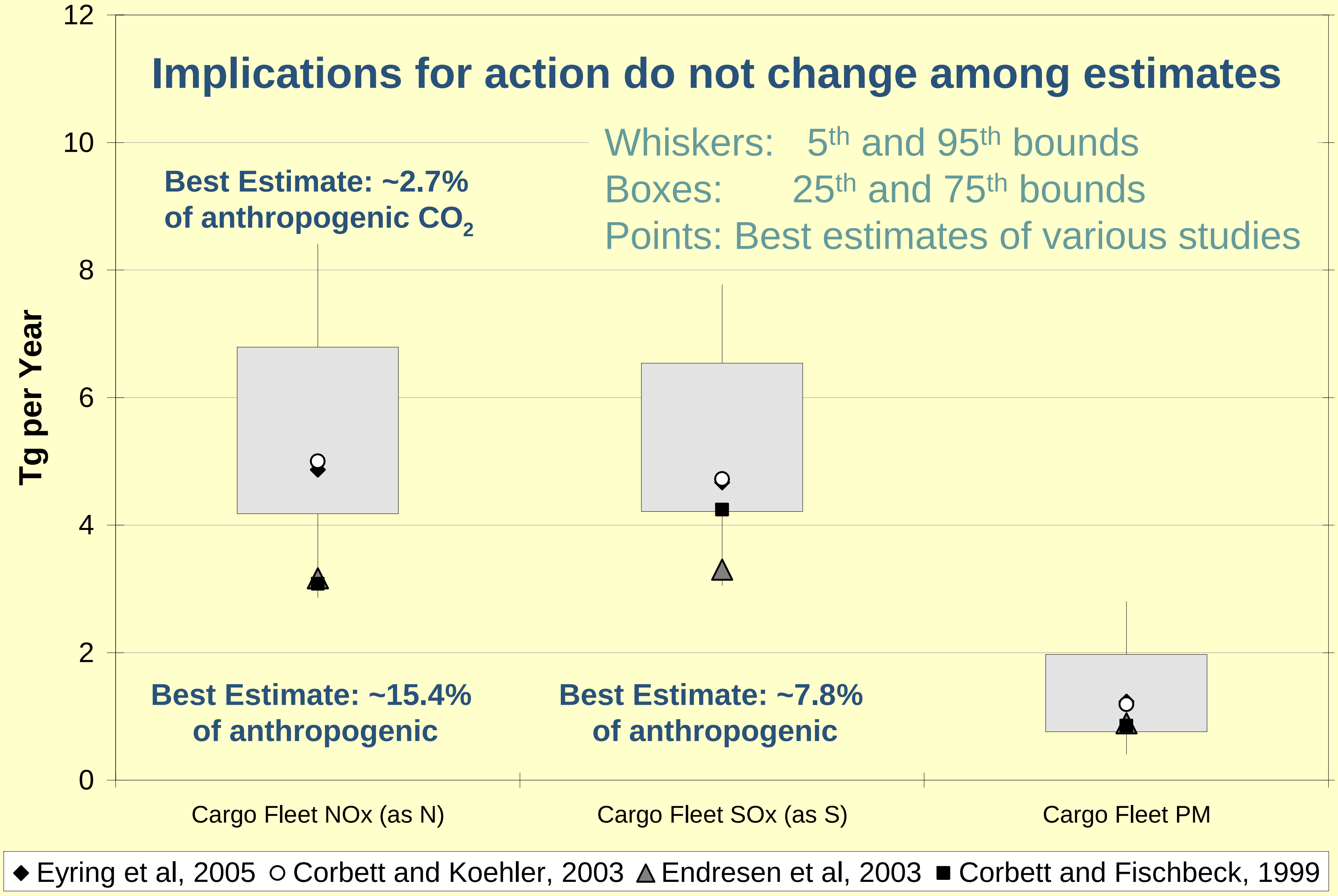


Shipping environmental impacts overview

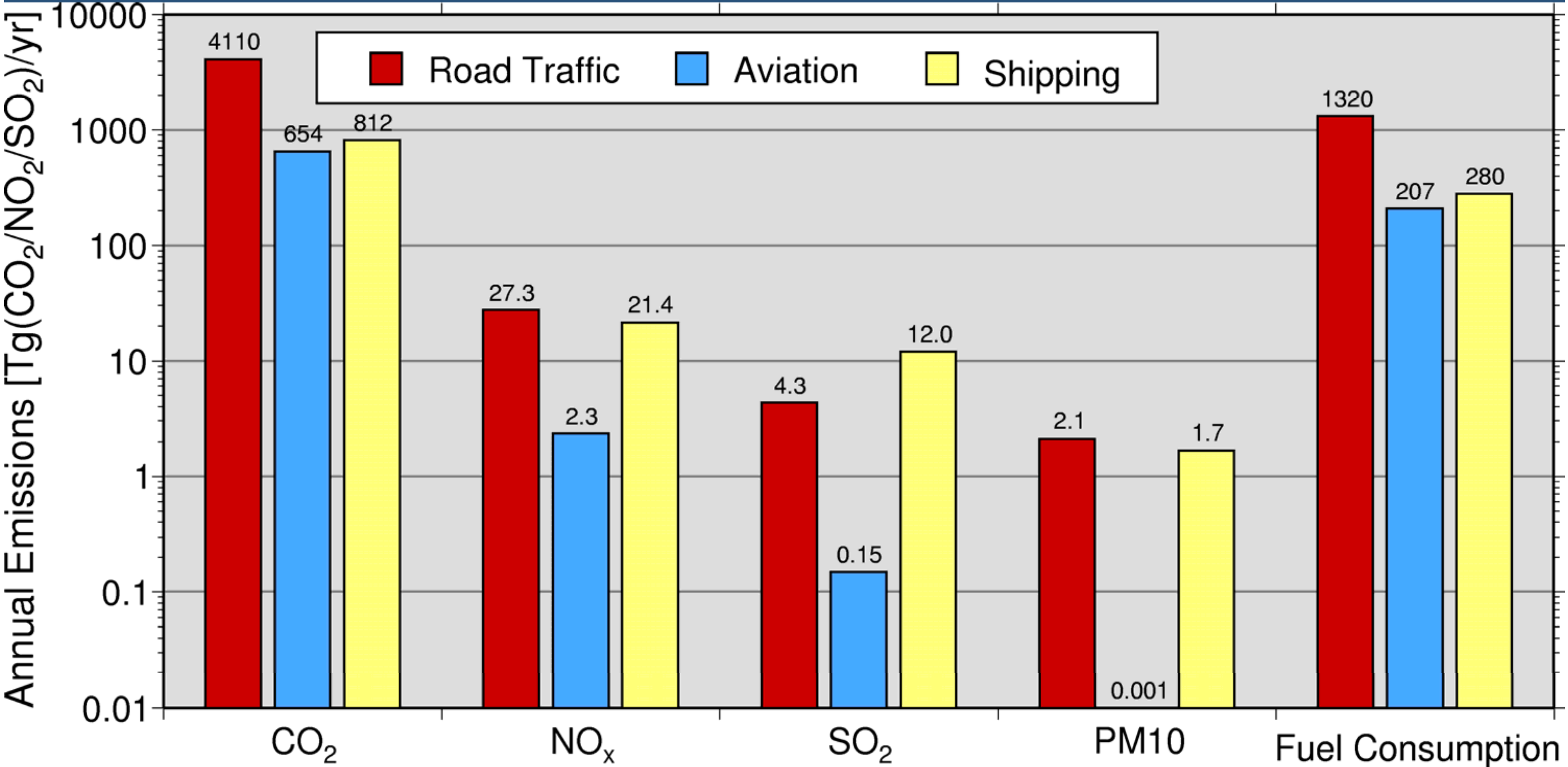
Episodic environmental events	Routine environmental events
Vessel-based	
Oil spills Ocean dumping Sewage discharges Oily wastewater Vessel collisions Ship-strikes with marine life	Engine air emissions Invasive species introductions (ballast water/hull fouling) Hull coating toxics releases Underwater noise
Port-based	
Dredging Port expansion Ship construction, breaking	Stormwater runoff Vessel wake erosion Cargo-handling air emissions

- Could consider security, safety, human factor dimensions within similar contexts

Ship emissions estimates bounded



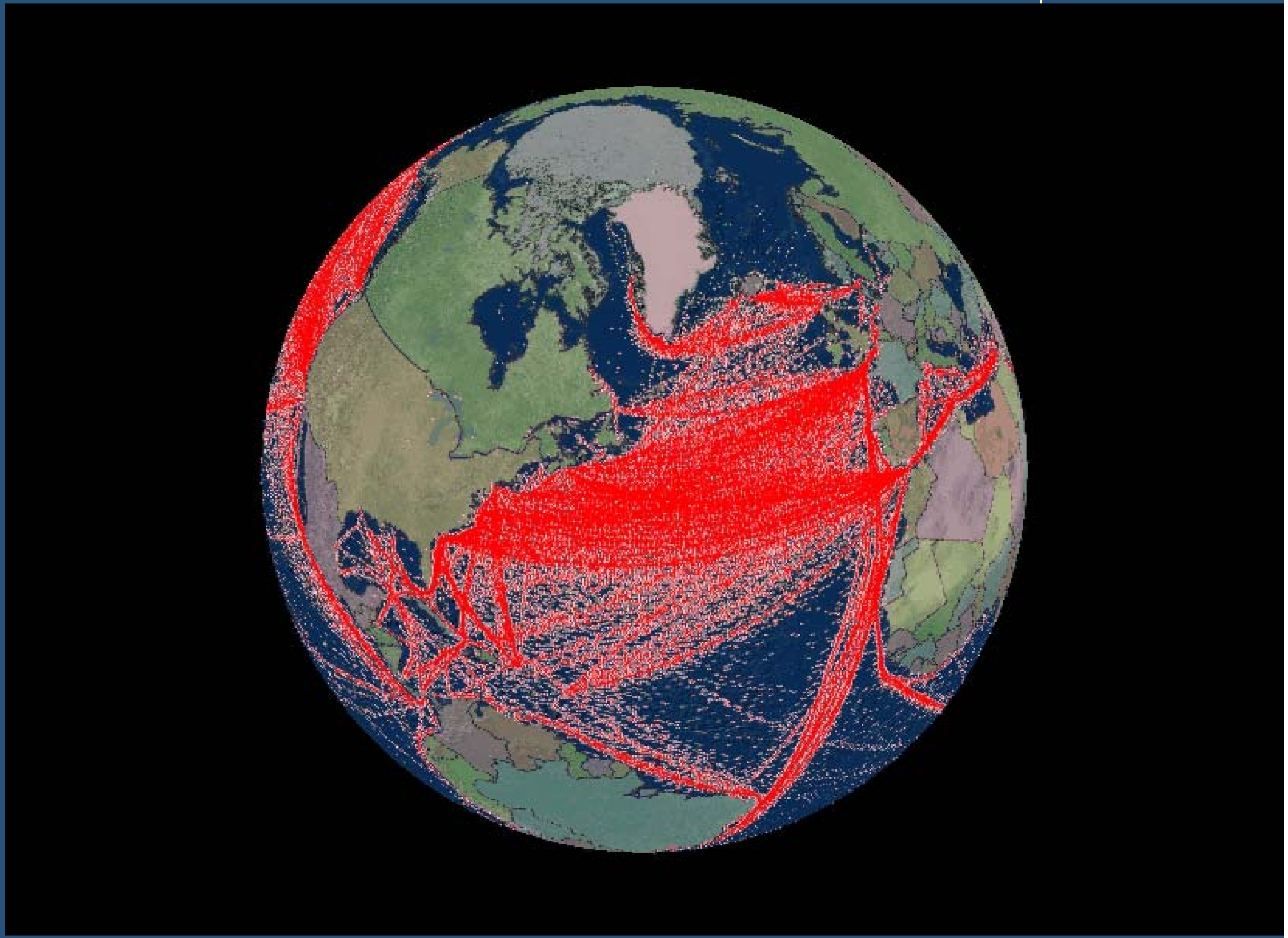
Comparison with other modes



From Eyring et al., Part 1, *JGR*, 2005

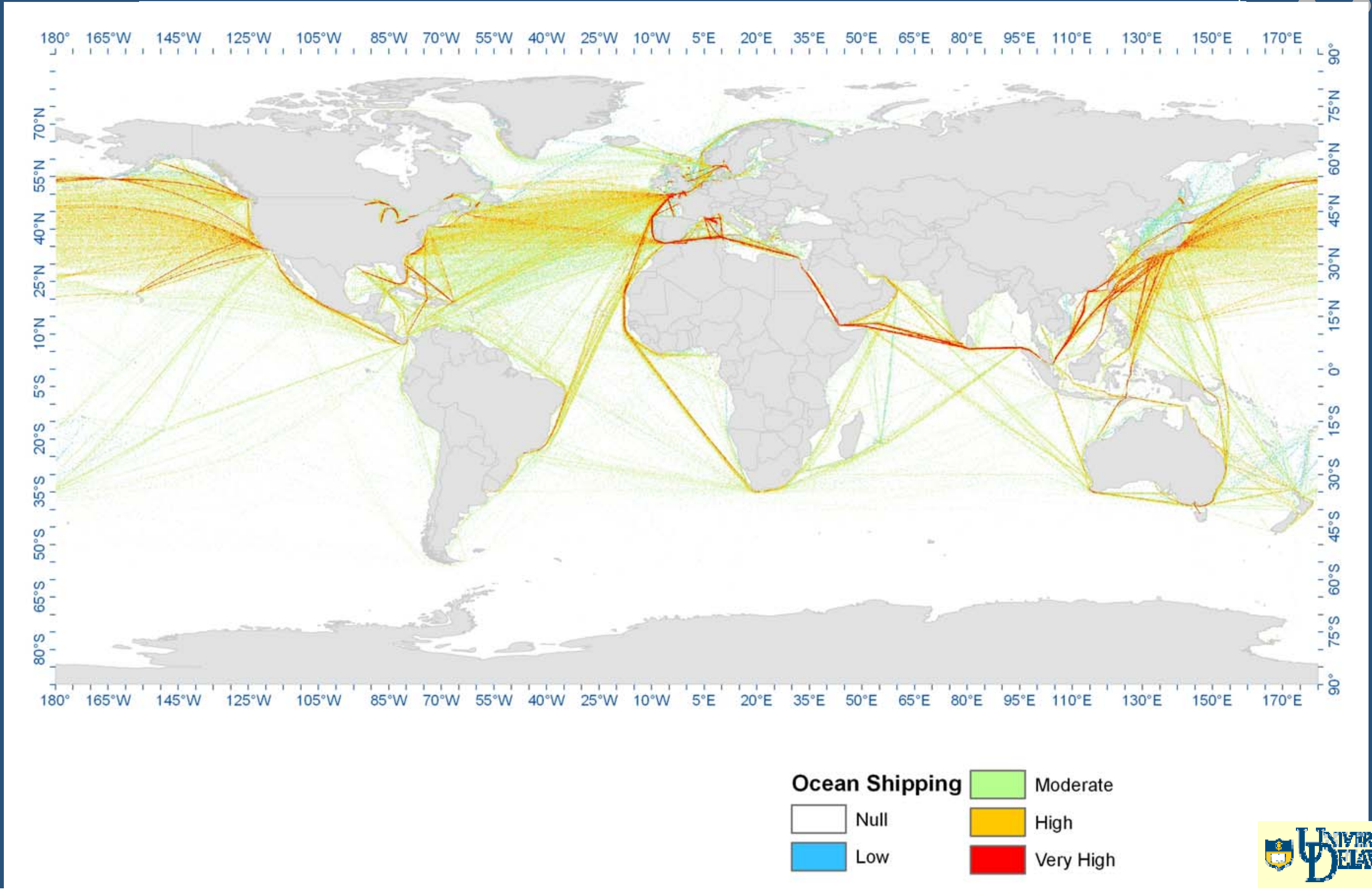
Ship traffic differs by vessel type

- Containership
- Tanker
- Bulk Carrier
- General Cargo
- Refrigerated Cargo
- Ro-Ro
- Passenger



Trade driven by commodity demand & resource supply

Trade import patterns are clear …
… connected to domestic freight system



Forecasting Summary

- Power-based trends used for forecasting
  - First-order indicator of proportional change in emissions, adjusted for control measures
- Forecasts are primarily extrapolations of BAU that can be bounded and/or adjusted
  - North American trends validated by comparison with other modal trends and ship trade-energy models, at multiple scales

- *Ship emissions growth rates are faster than GDP*
- *Future emissions with IMO-compliant SECA will be greater than base year emissions in 2002.*

Critical freight forecasting questions

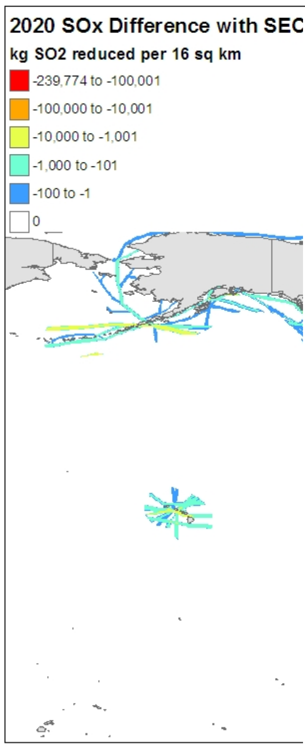
- Baseline Conditions: Current energy, activity patterns?
- Rates of Change: Forecast trend in needed energy?
- Patterns of Change: Where will freight growth occur?

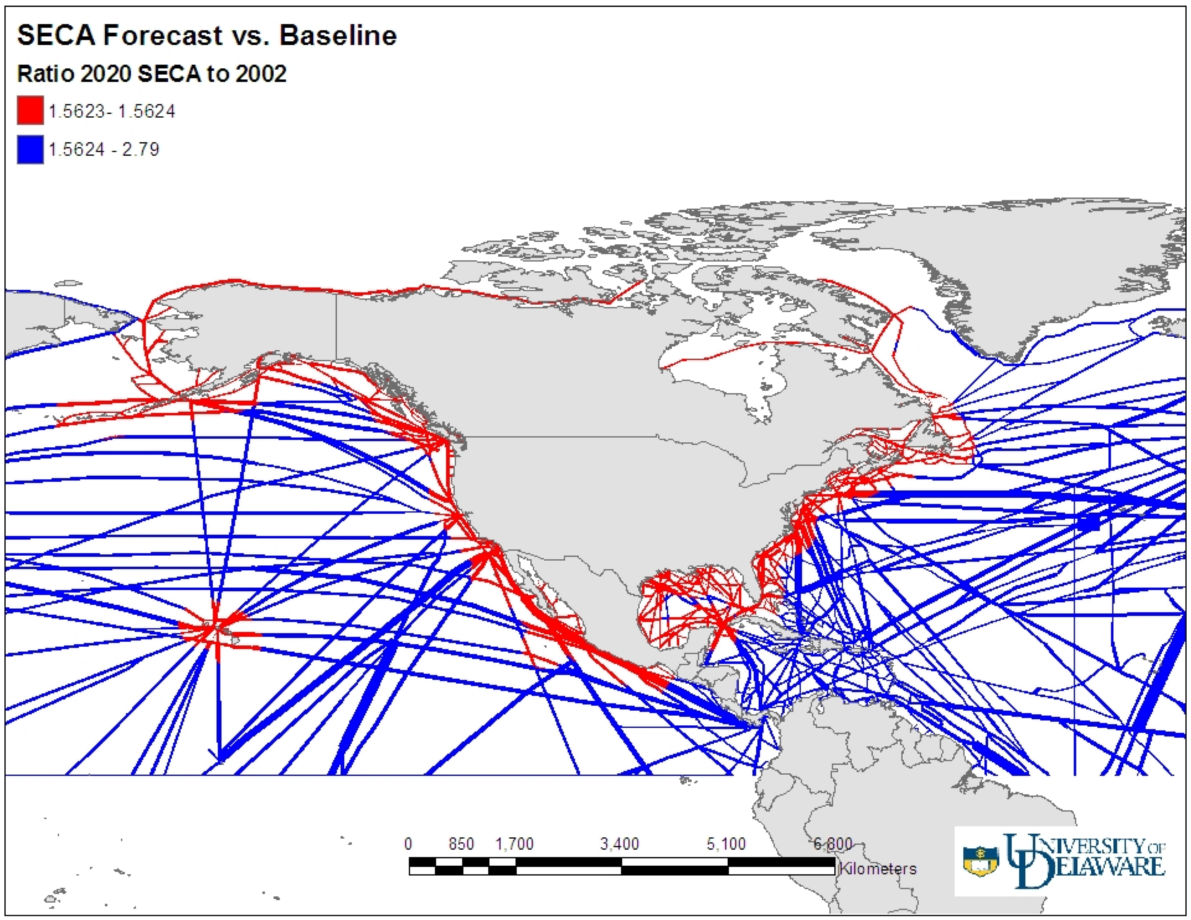
- Each involves uncertainty and bounding
  - May be validated with some independence
- Emerging convergence on current baseline
  - Improving spatial allocation of better estimates
- Continuing work on future usage and location
  - Modal analyses need integration and coupling

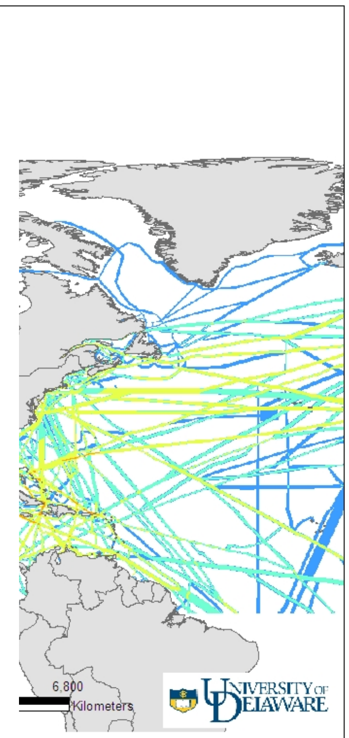
North American Results:

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

… but not compared to base year

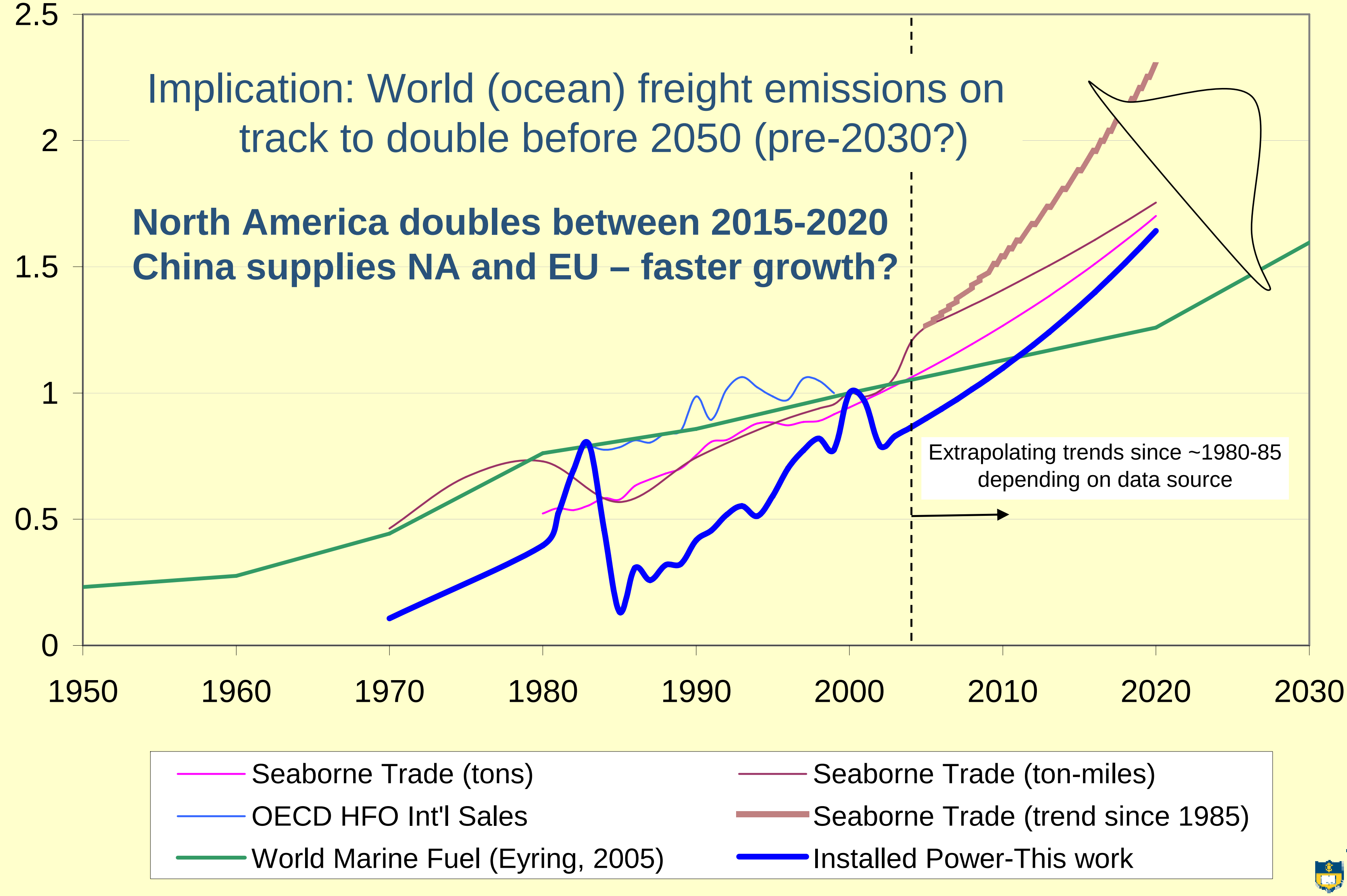






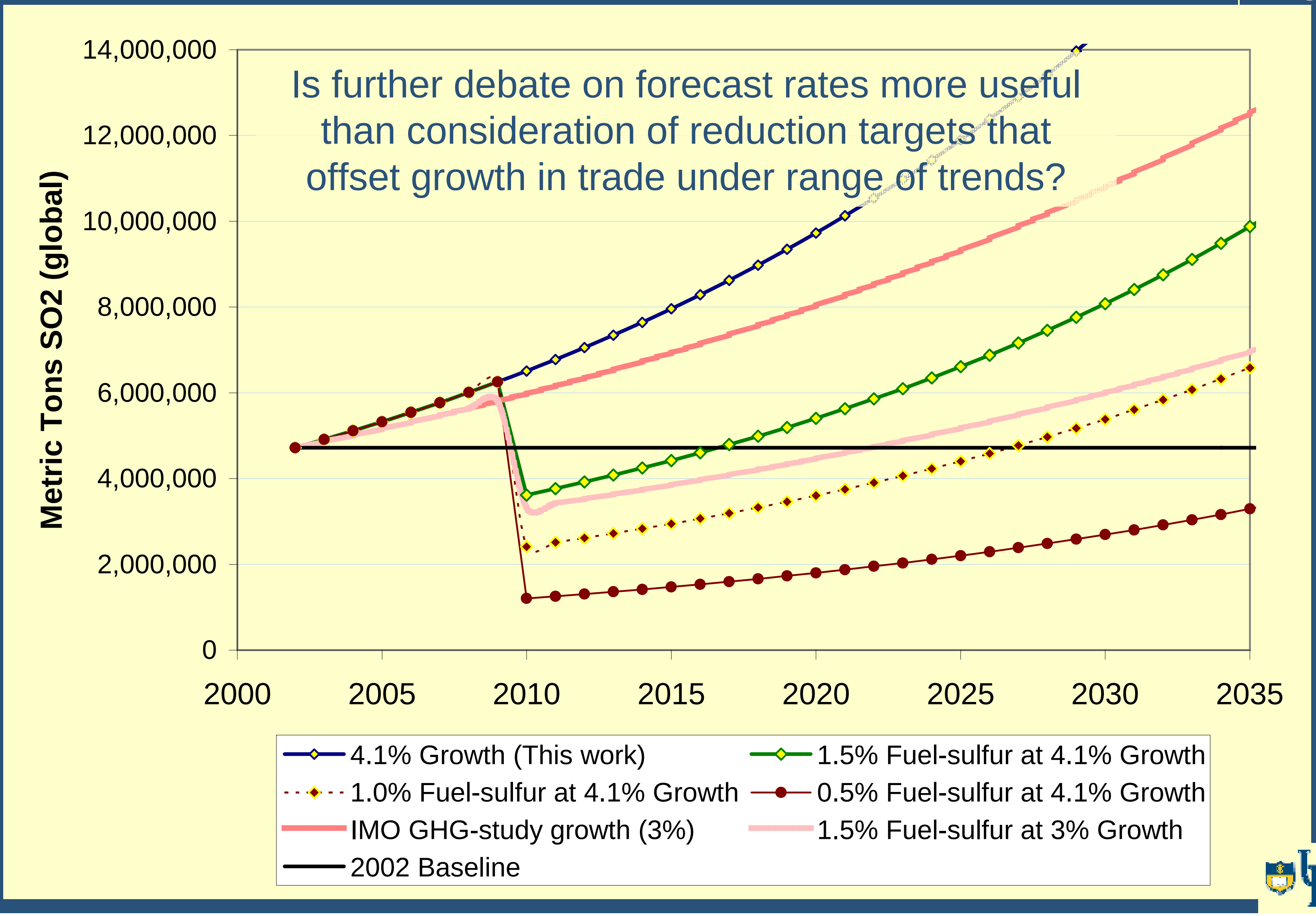
- Red… ion
  tons … se-year

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



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

Bounding insights to transform policy debate, focus dialogue



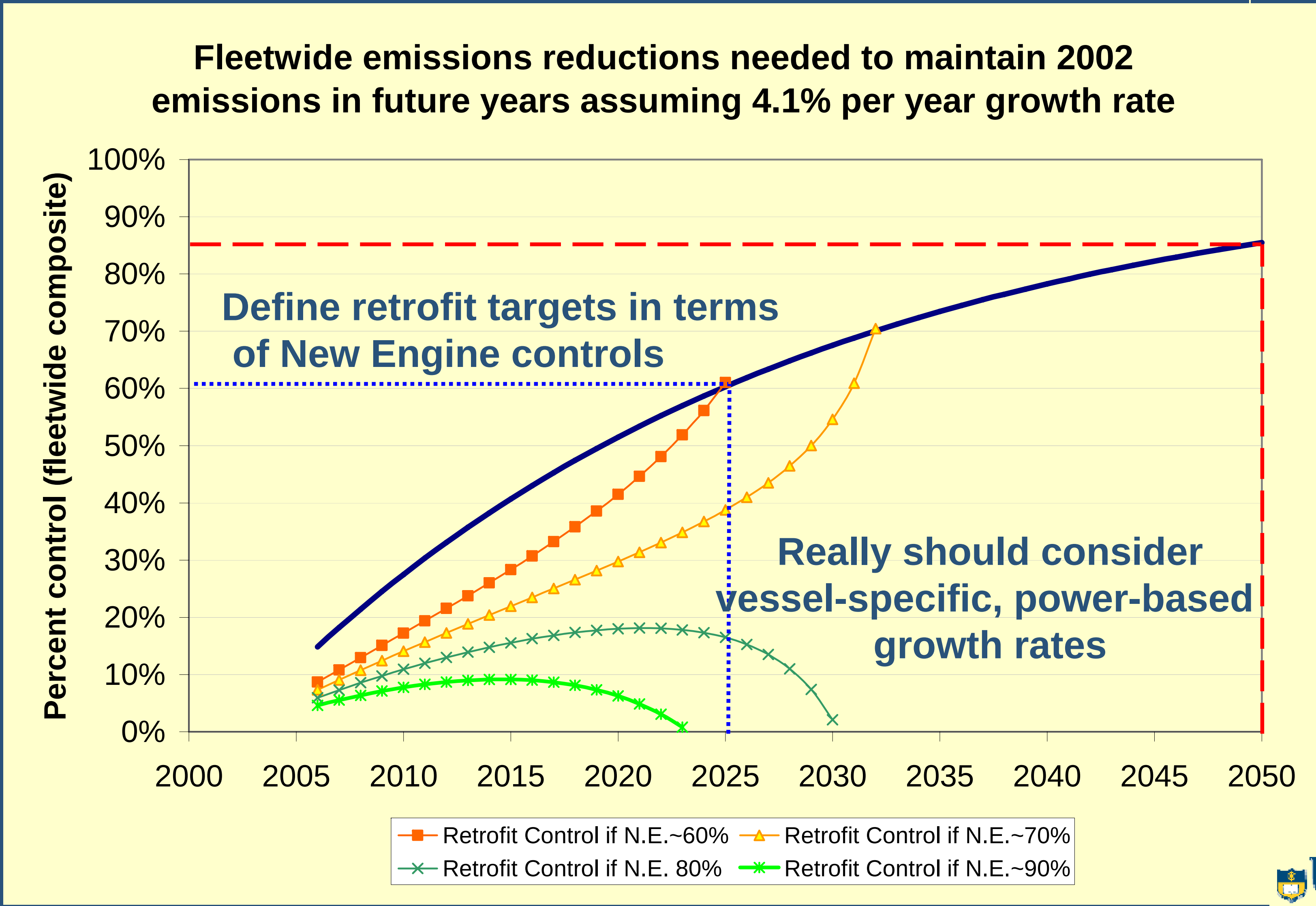
Approaches to setting ship targets

1. Reduce emissions to improve performance, irrespective of growth.

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

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

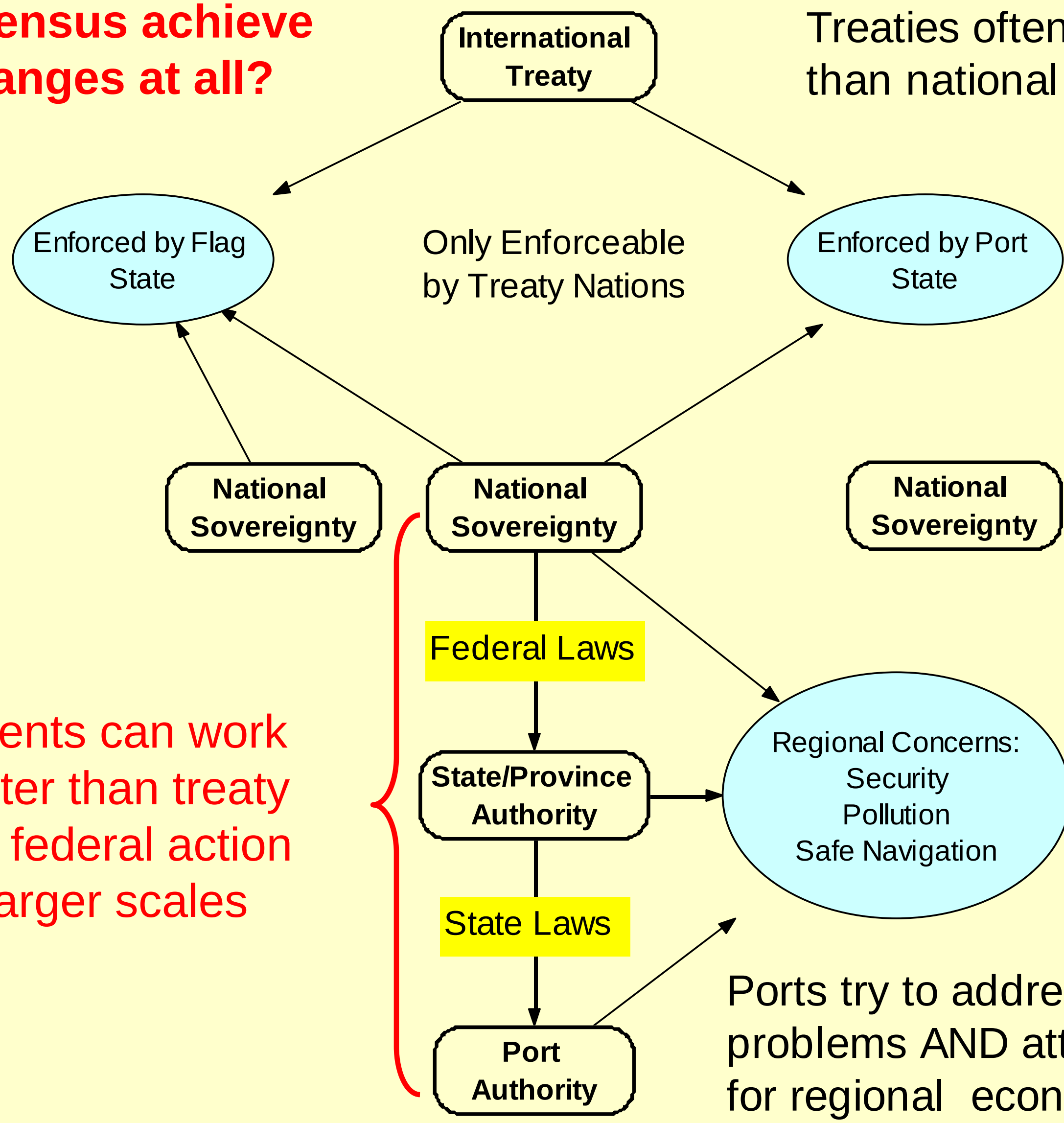
One approach:
Use growth to define control targets



Jurisdictional constraints

Can treaty consensus achieve these target ranges at all?

Treaties often are weaker than national laws



Some nations don't participate, even though their ships sail globally

Economic instruments can work at these levels faster than treaty or multinational or federal action - if compatible at larger scales

Ports try to address policy problems AND attract cargoes for regional economy

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Menu of options to be matched with strategies and fleet

- 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 CO2 penalties of 1-3% for retrofits

- Alternative marine fuels and energy systems

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

- Operational (behavior) changes

  Possible in short term, possible multimodal logistics effects

  Achieves reductions in CO2 and all pollutants (win-win)

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Mitigation insights

- Technology will involve fleet retrofits and new-builds
- Economics determines role of alternative fuels
- 0.5% SECA *or lower* may be justified in large regions
  - 2020 with SECA (1.5% sulfur) reduces 2020 without control more than 700 thousand metric tons
  - 2020 with IMO-compliant SECA increases by 2 million metric tons 2002 base-year emissions
  - Health effects work ongoing, but SOx control benefits appear greater than control costs
- Market incentives promising at several scales
- Decades required to completely achieve change

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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

Courtesy: National Maritime Museum, Britain

Discussion welcome

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