U.S.-Mexico Fuel Switching Demonstration on Ocean Going Vessels in the Gulf of Mexico and Implications for ECA

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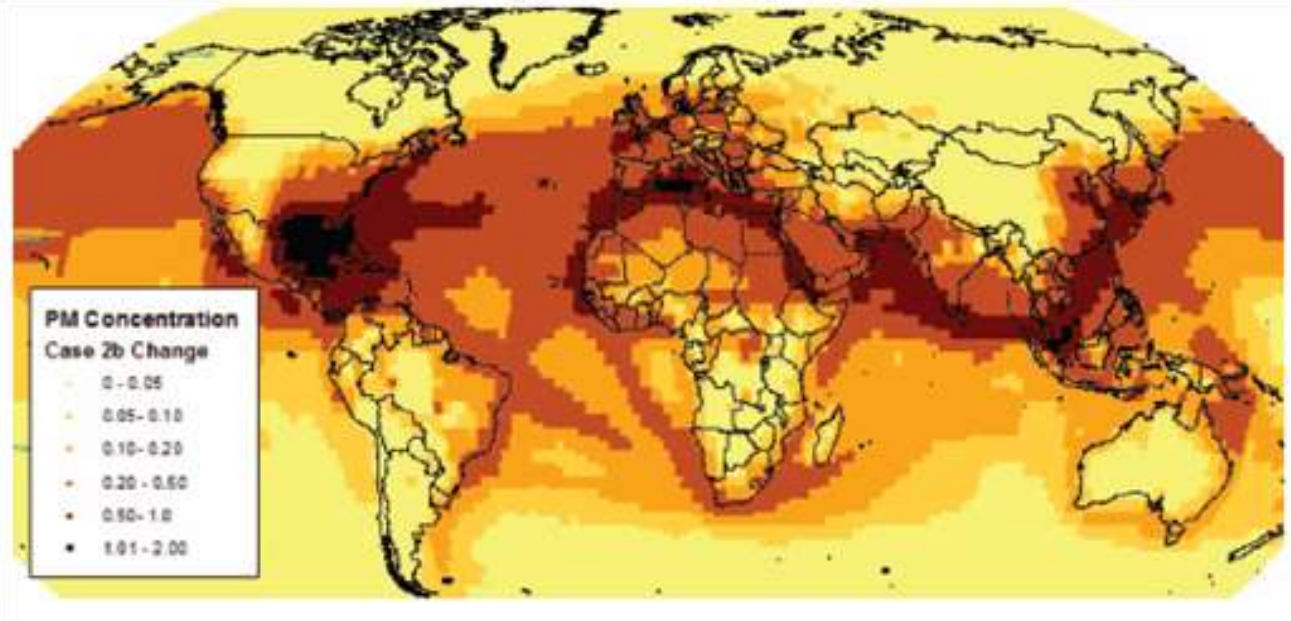
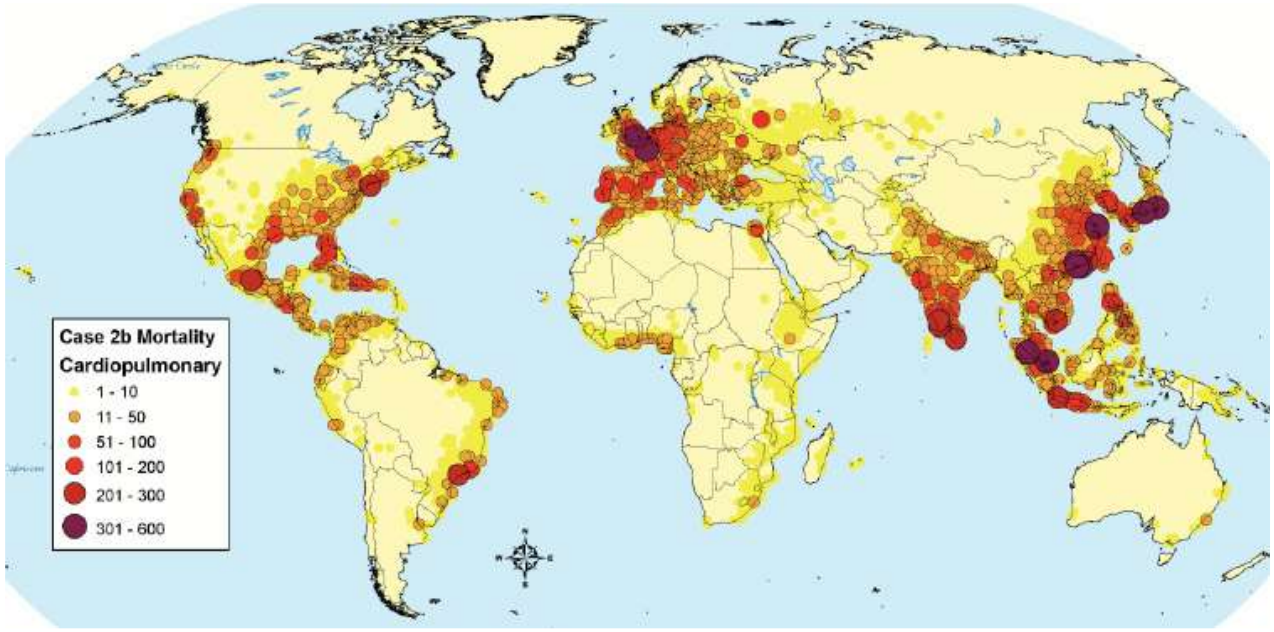
Background

Contribution of shipping to PM2.5 concentrations (in *μ*g/m3)





Worldwide Ship PM-Related Mortality

Source: Corbett, James J., James J. Winebrake, Erin H. Green, Prasad Kasibhatla, Veronika Eyring, Axel Lauer, "Mortality from Ship Emissions: A Global Assessment," *Environmental Science & Technology*, 41(24), December 15, 2007, pp. 8512-8518.

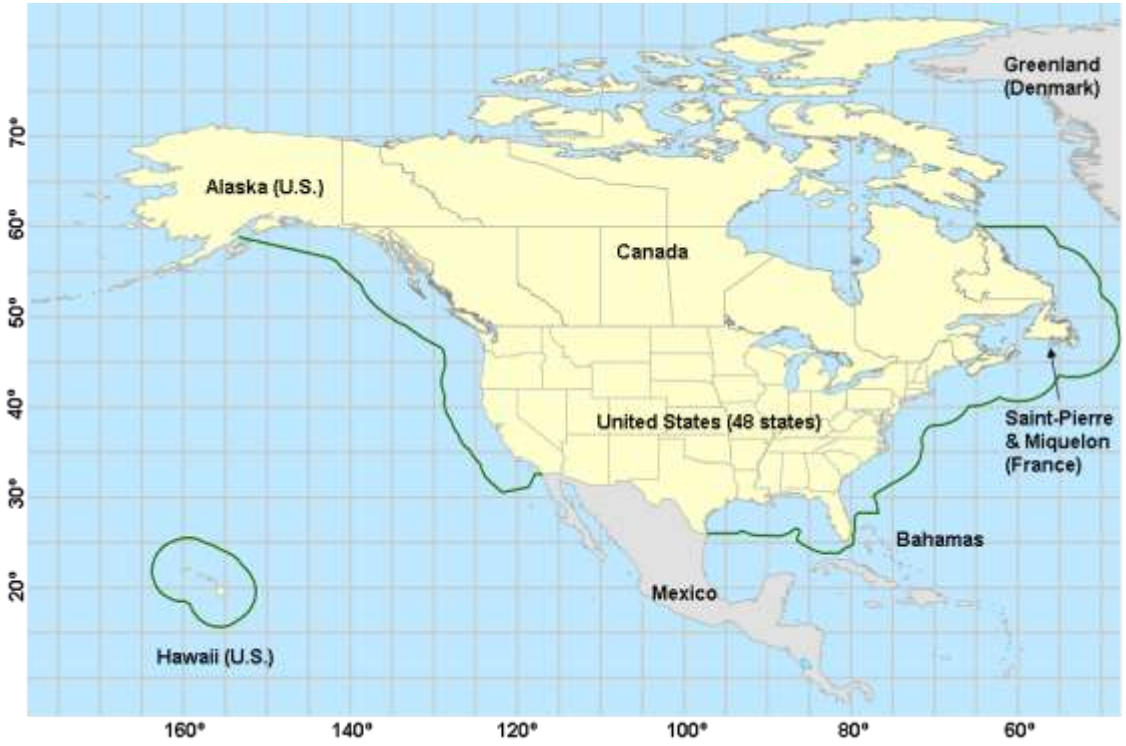
Project Partners

- Port of Houston Authority
- U.S. Maritime Administration
- Mexican Ministry of Environment/PEMEX
- Maersk Line/Hamburg Süd
- ICF, University of California at Riverside, and Battelle

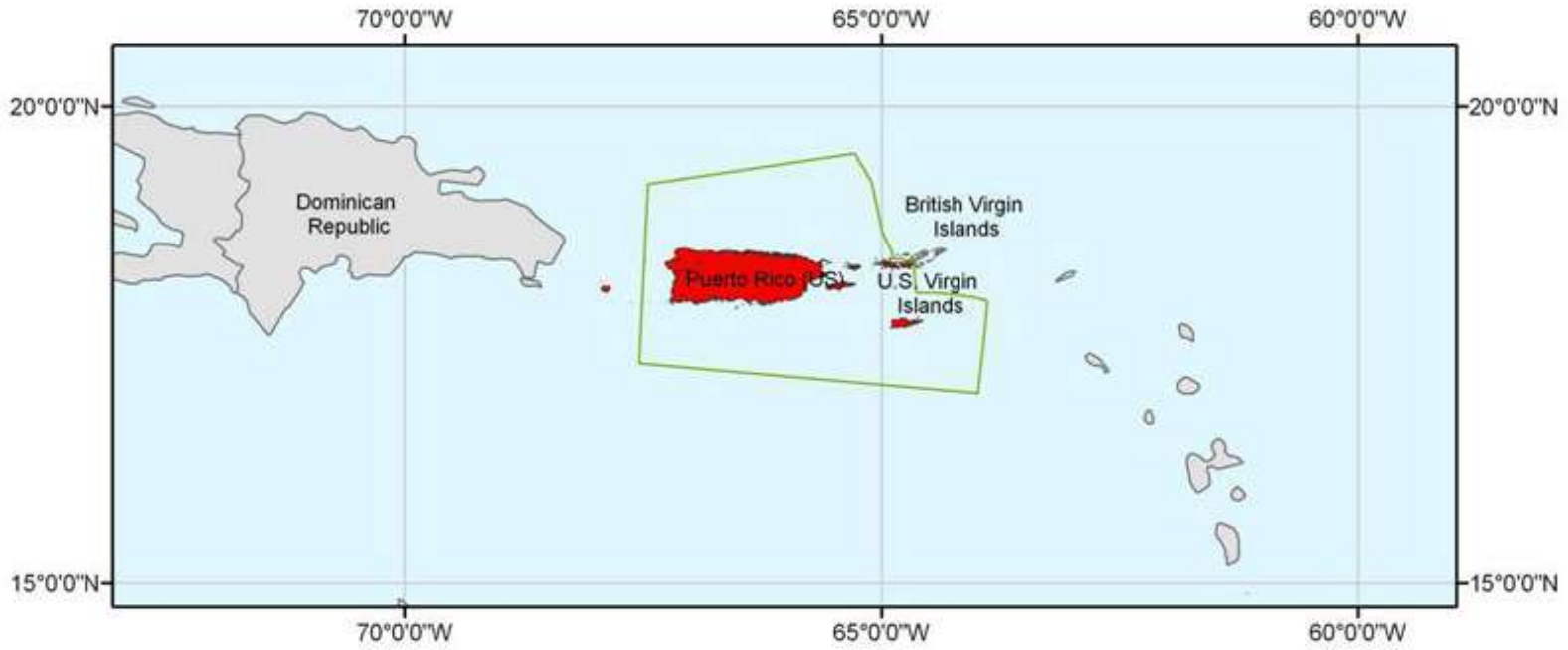
Project Goals

- Demonstrate Switching to Low Sulfur Distillate Fuels in Gulf of Mexico
- Measure Emission Reductions
- Estimate Emission Reductions at Mexican Ports from Fuel Switching
- Estimate Health and Environmental Benefits from Fuel Switching
- Raise Awareness of upcoming Emission Control Area

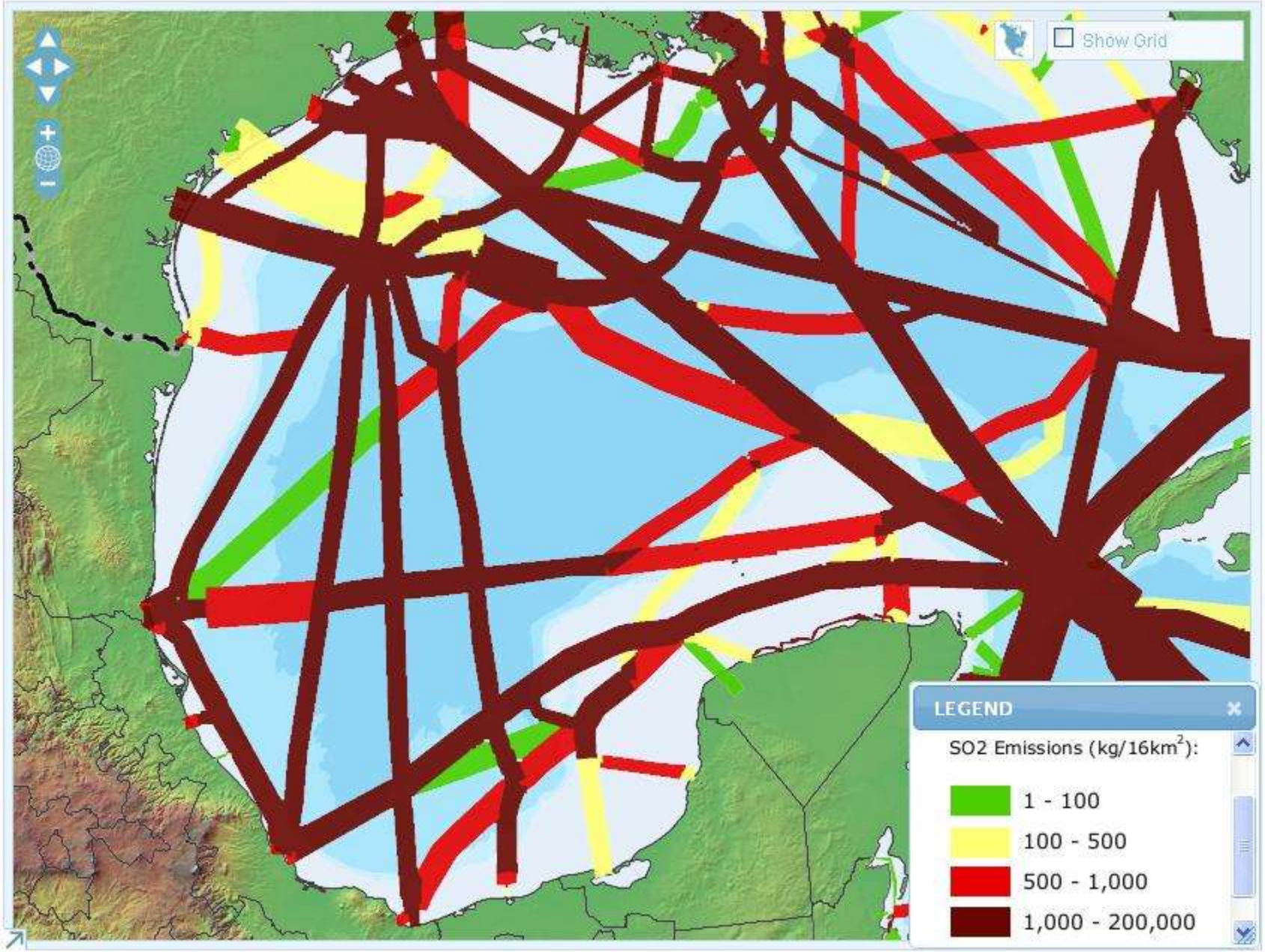
North American Emission Control Area



Caribbean ECA

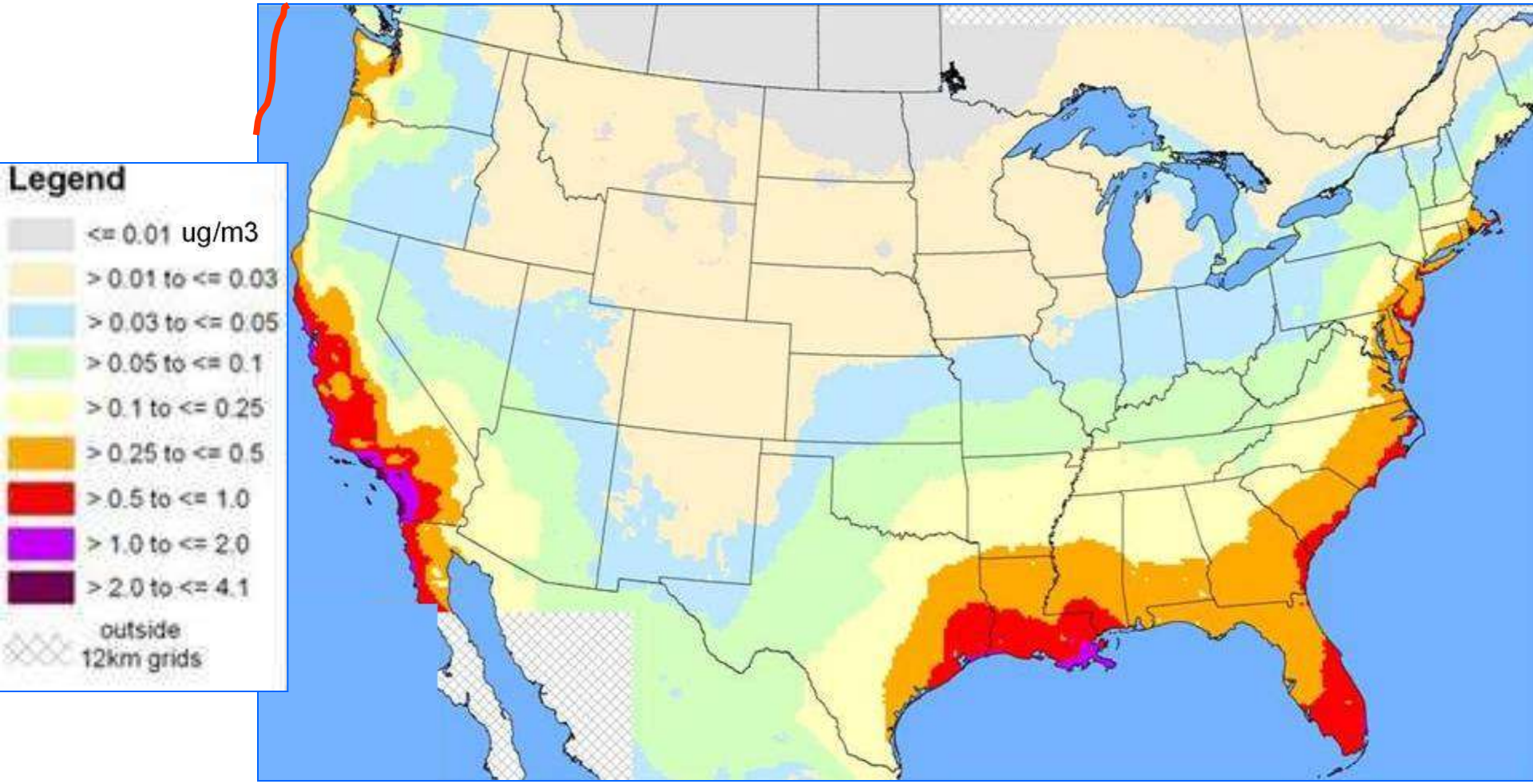


MARINE VESSEL EMISSIONS (CEC 2002*)



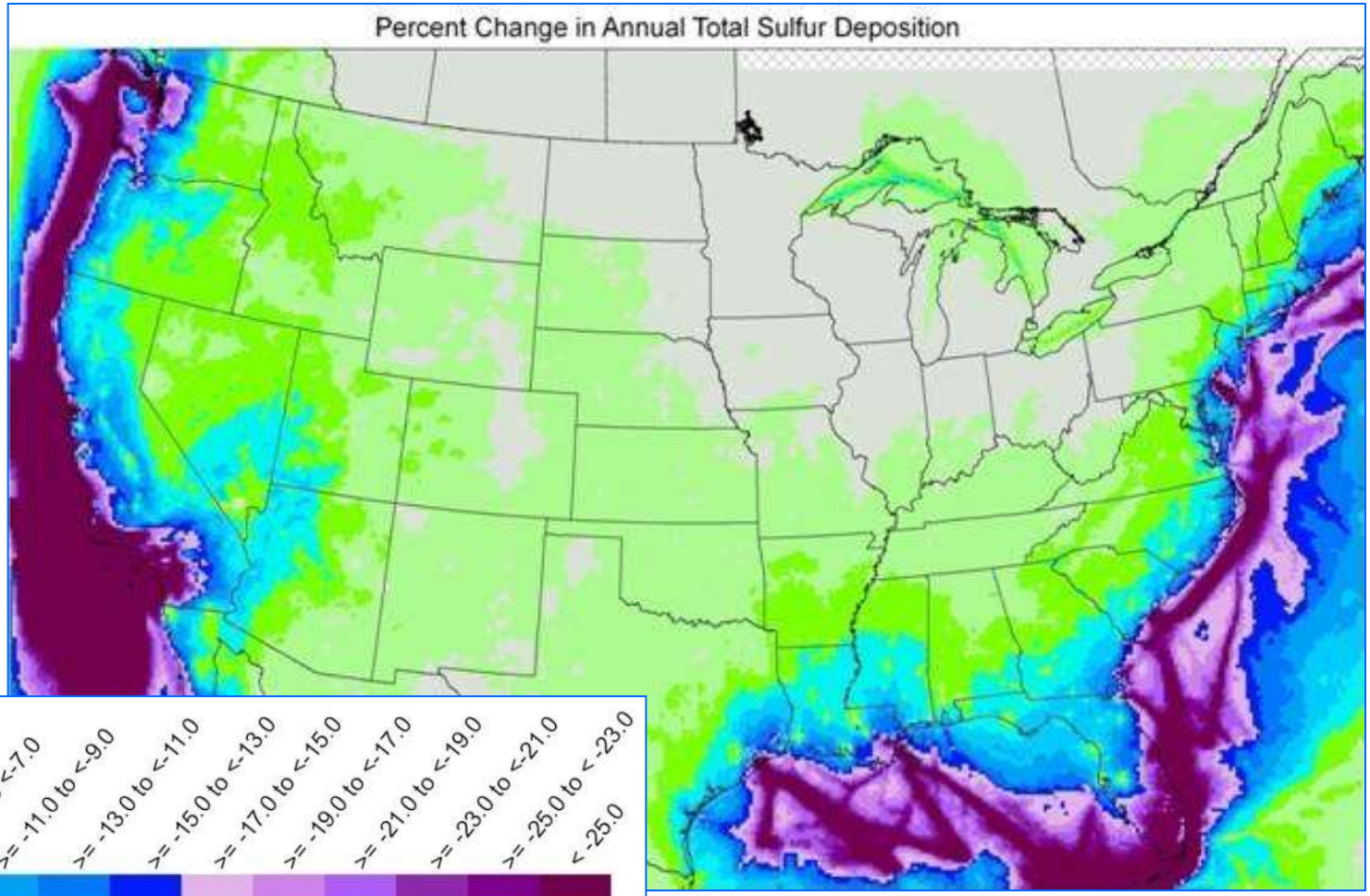
* Source: Wang, C., J.J. Corbett, and J. Firestone. 2007. Modeling energy use and emissions from North American shipping: Application of the ship traffic, energy, and environment model. Environ. Sci. Technol., 41 (9), 3226-323

2020 Potential ECA $PM_{2.5}$ Reductions



2020 Potential Sulfur Deposition Reductions

Improvements in deposition for marine and terrestrial ecosystems



Project Design

- Demonstration of fuel switching on two ocean going vessels of Maersk and Hamburg Süd
  - Fuel switched from high sulfur heavy fuel oil (>3.0% sulfur) to marine gas oil (< 0.1% sulfur)
- Stack emission monitoring
- Modeling – Port emission inventories, air quality, loadings

Maersk Demonstration

- Maersk Roubaix
  - Container Ship – 1118 TEUs
  - 9.7 MW Propulsion Engine
  - Medium Speed Engine
- Switched from Bunker Fuel (3.3% Sulfur) to Distillate Fuel (0.14% Sulfur) 24 nm from shore at Port of Houston and Port of Progreso, Mexico
- Calculated Emission Reductions per call at Progreso
  - 27 kg NOx (7%)
  - 47 kg $PM_{2.5}$ (81%)
  - 479 kg SOx (88%)
  - 2% increase in operating costs

Hamburg Süd Demonstration

- Cap San Lorenzo
  - Container Ship – 3,739 TEUs
  - 28.8 MW Propulsion Engine
  - Slow Speed Engine
- Represents 40% of container ships and 20% of all ships calling on Veracruz and Altamira
- Stack emissions measured in port and at sea at Altamira, Veracruz and Houston

Observed Operational Findings

- No significant issues encountered
- No additional training needed for crew involved in this demonstration
- Cost and Availability of Low Sulfur Fuel
  - Additional cost for fuel switch represents less than 2% of voyage costs
  - Demonstration fuel available in U.S.
- Tank Size
  - Sufficient capacity to carry MGO for demonstration
- Fuel Switching Procedure
  - Boilers must be slowly turned down
  - Switch over took about an hour

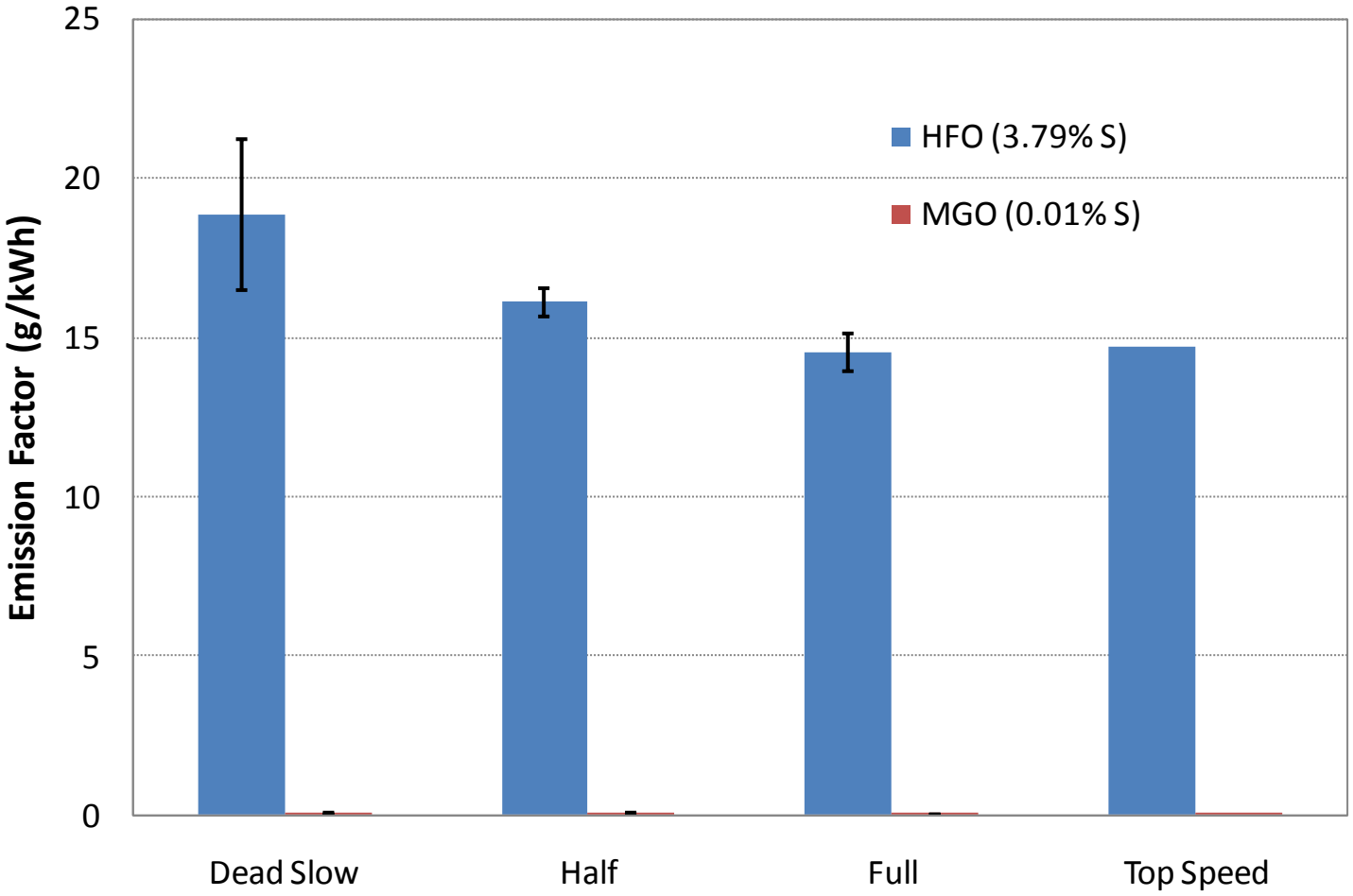
Emission Sampling

- Measurements of in-use stack emissions and their reduction from fuel switching
  - MARPOL NOx Technical Code (NTC) and other protocols
  - Specific engine loads and transient operations, main and auxiliary engines

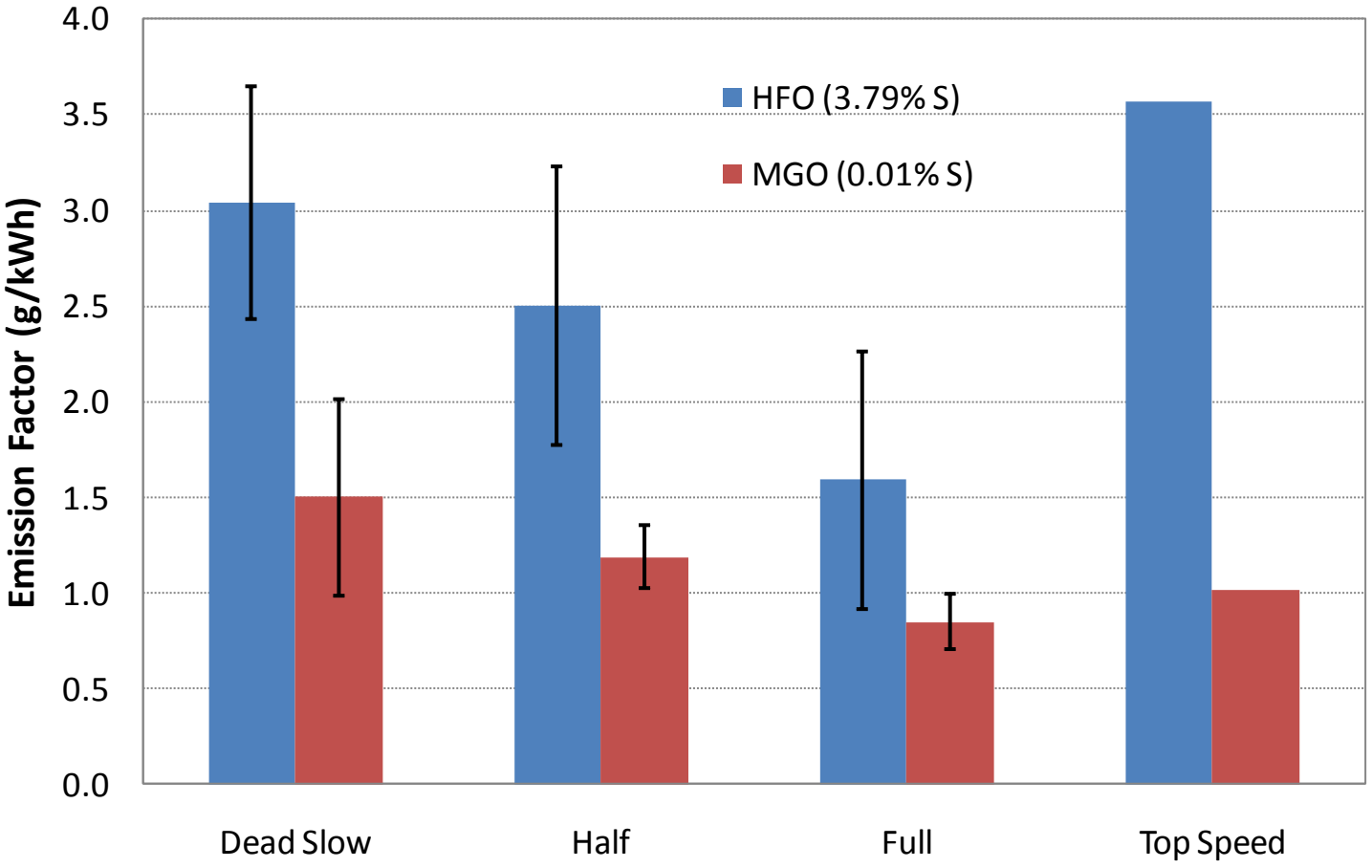
Pollutants measured

- NOx, CO, CO_2 continuously
- PM continuously and speciated PM (EC, OC) with discrete filter samples
- Measure SO_2 and calculate SOx from fuel measurements

Propulsion Engine Results – SO2

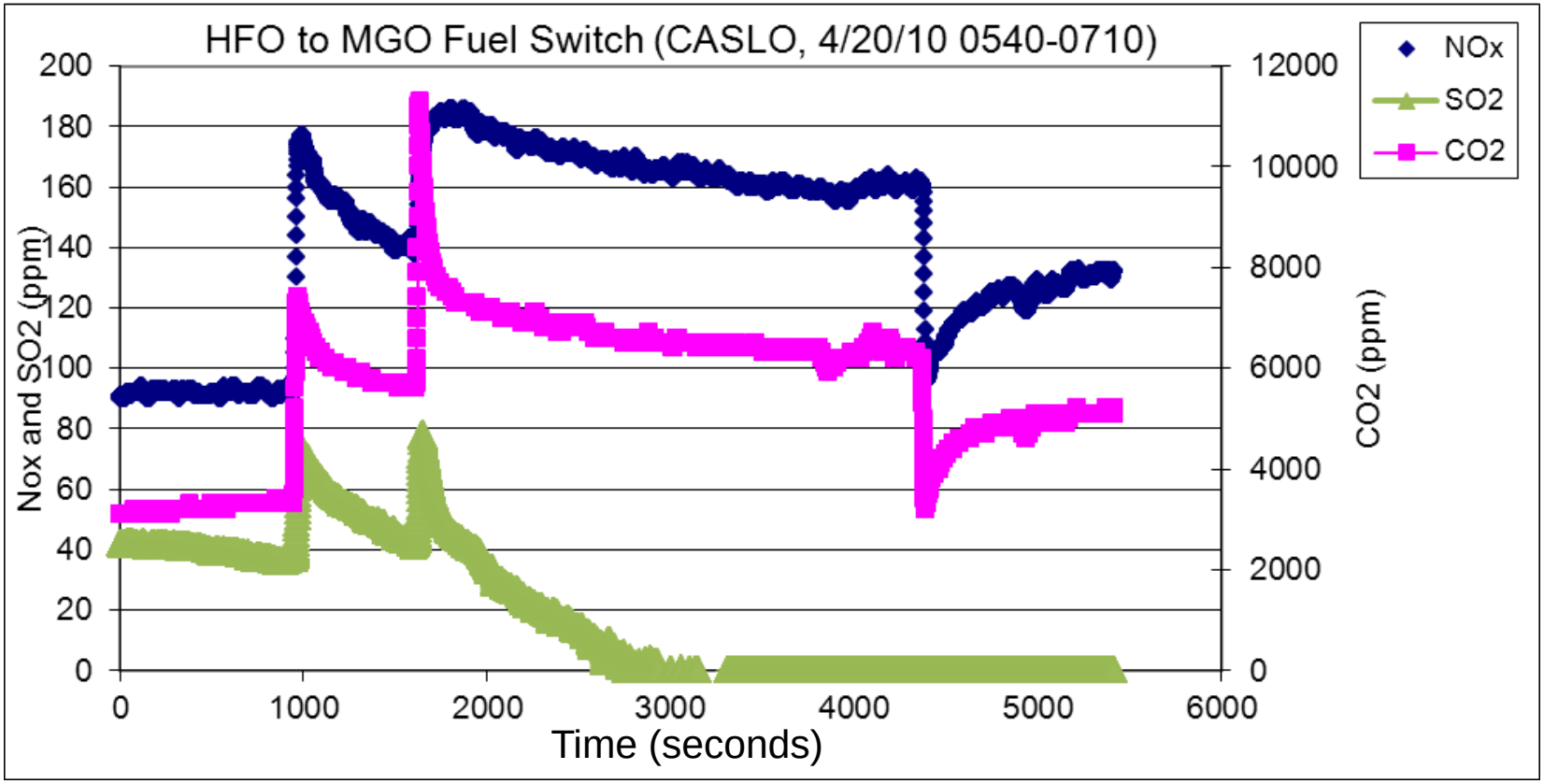


Propulsion Engine Results – $PM_{2.5}$



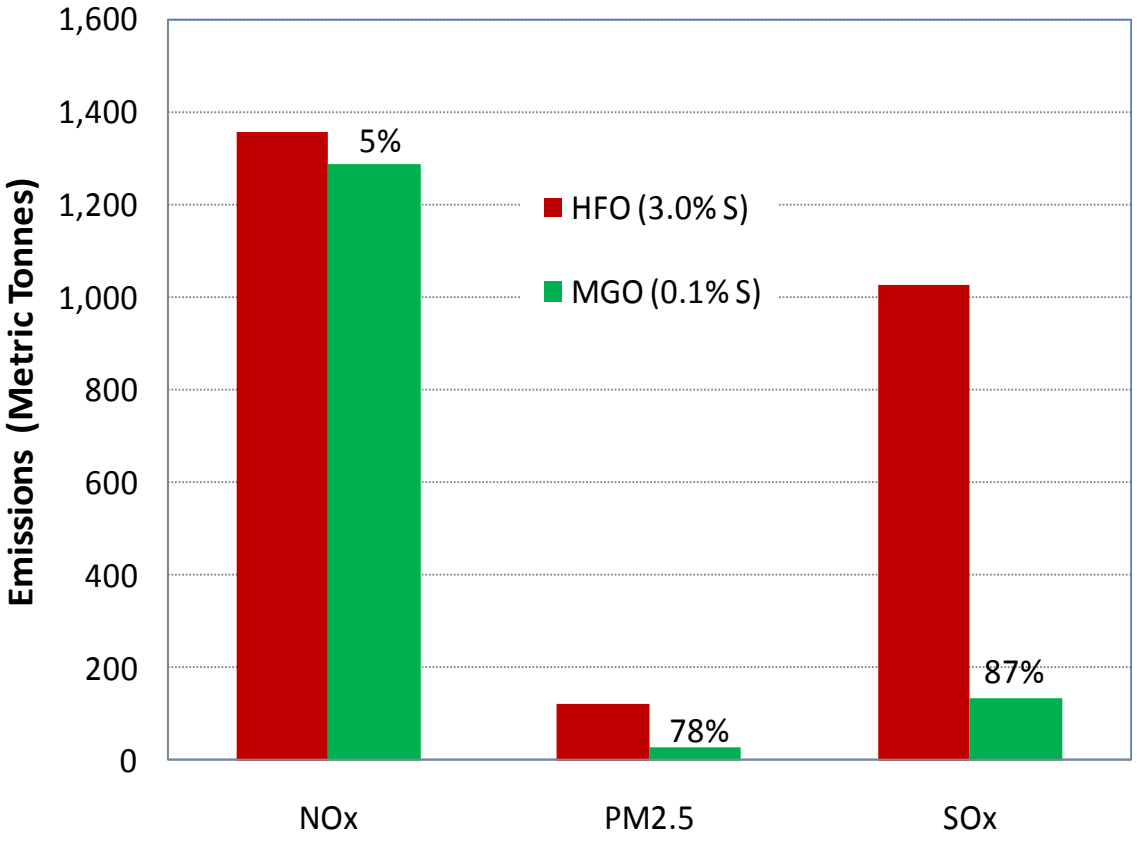
Fuel Switching Emissions

HFO -> MGO



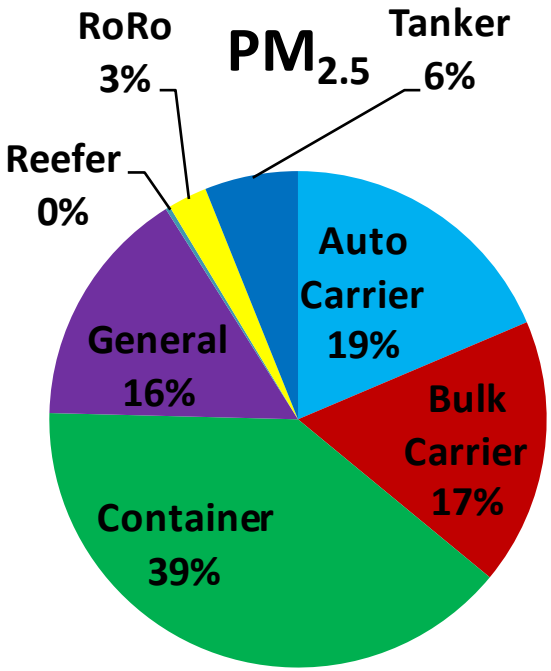
Reductions from Fuel Switching in Port of Veracruz

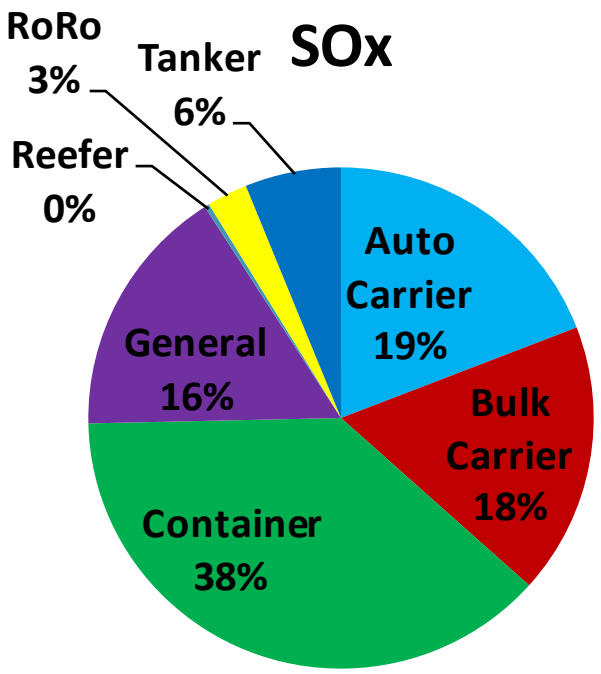
With 24 nm Boundary



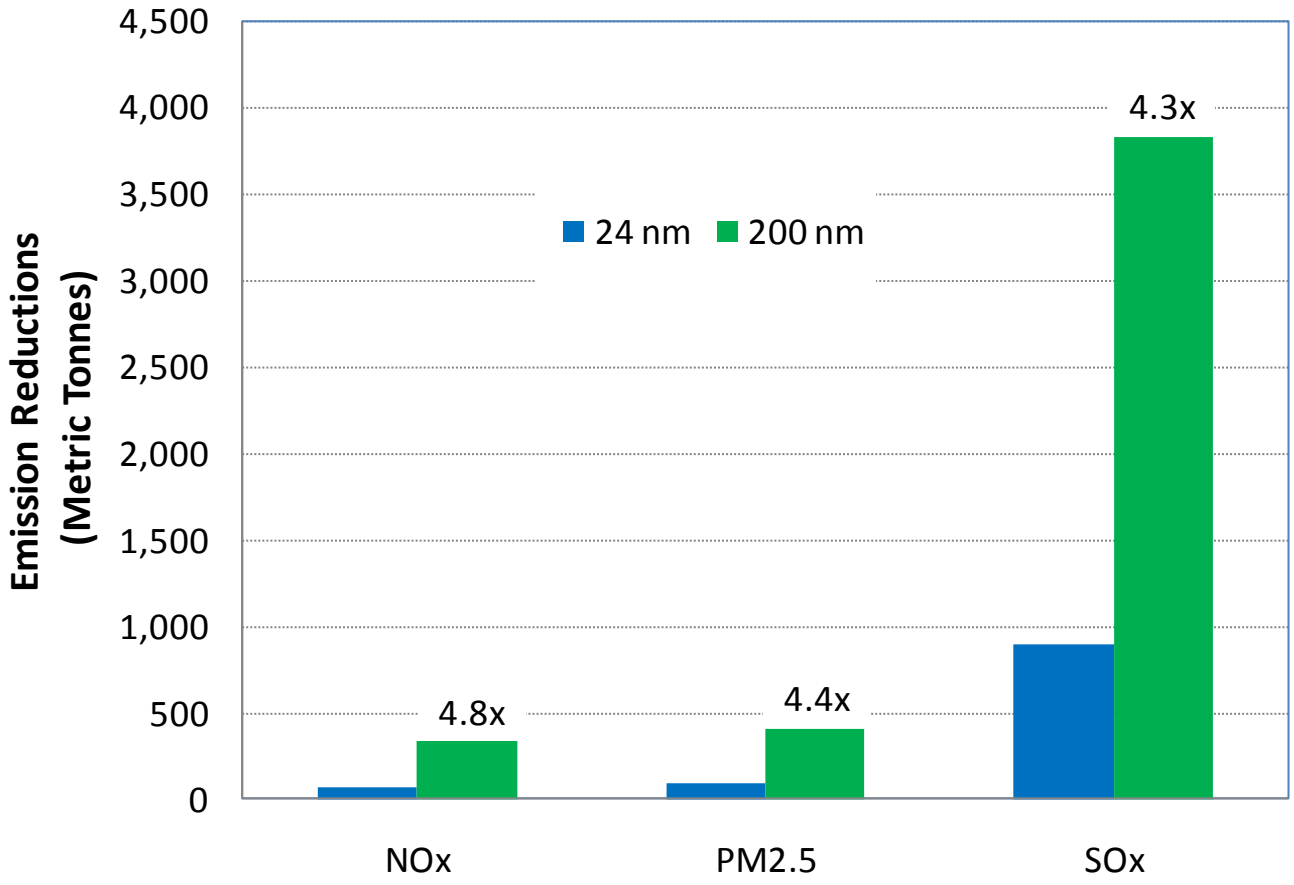
Emission Inventory based on 2005 activity data

Veracruz Emissions by Ship Type





Effect of Fuel Switching Zone Size for Port of Veracruz



Dispersion Modeling

Estimated Annual Total Deposition of SO_2 to Reefs in Veracruz

Reef		Units	HFO	MGO	Difference	Percent Reduction
Reef Area 1	Area	m^2	283,474,477			
	Total Annual SO_2 Flux	g/m^2	0.19	0.01	0.18	
	Total Annual Deposition	kg	53,000	1,900	52,000	96%
Reef Area 2	Area	m^2	57,673,276			
	Total Annual SO_2 Flux	g/m^2	0.0093	0.00081	0.008	
	Total Annual Deposition	kg	540	47	490	91%
Total	**Total Annual SO_2 Deposition**	**kg**	**54,000**	**2,000**	**52,000**	**96%**

Raising Awareness

- Meetings and Workshops
  - Mexico City
  - Veracruz
  - U.S. Gulf States
- Aquarium Kiosk - Video
- Press Releases
- Web site
- Final Report

www.epa.gov/international/fuelswitch.html

Summary

- Fuel switching can significant reduce PM and SOx emissions
- Fuel switching within 24 nm reduces annual emissions of PM by 78% and SOx by 87% at the Port of Veracruz
- Deposition of SOx on sensitive reefs around Veracruz reduced by 52 Metric Tonnes per year (96%)
- Final Report available at http://www.epa.gov/international/fuelswitch.html

Outcomes

- Awareness of North American ECA and implications for Mexico
- Initiating technical studies needed to determine impacts of an ECA on Mexican public health and environment, if Mexico were to adopt an ECA