



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

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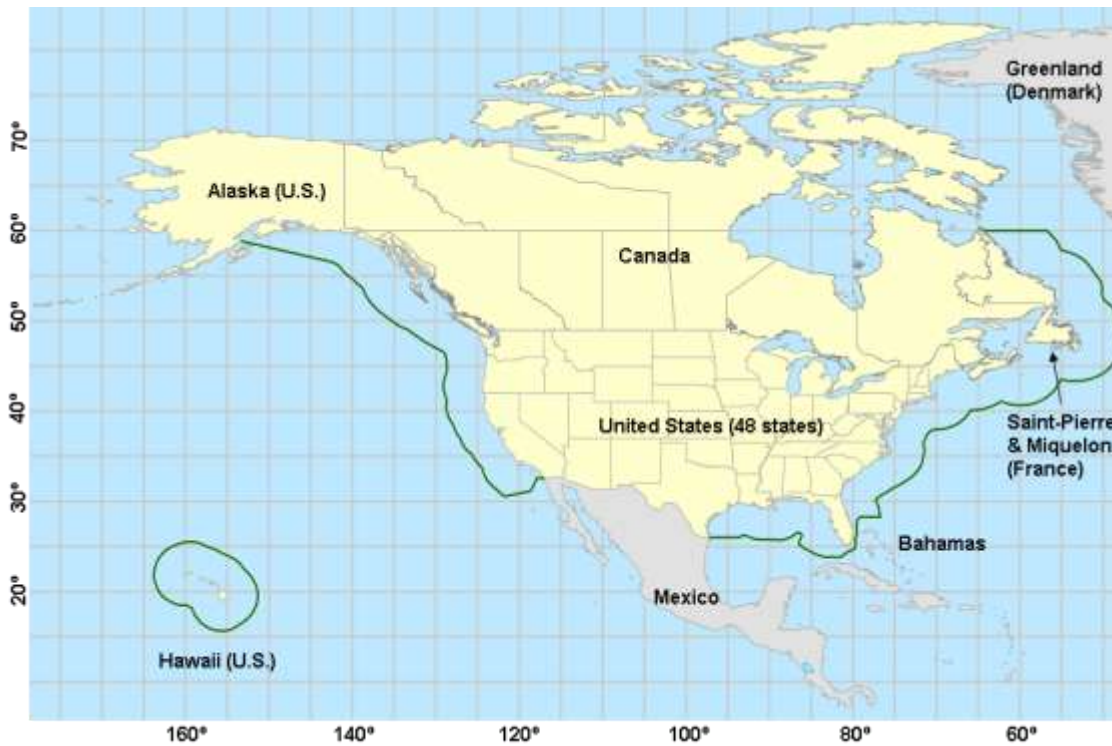
ICF

Northeast Diesel Collaborative

Ports Work Group

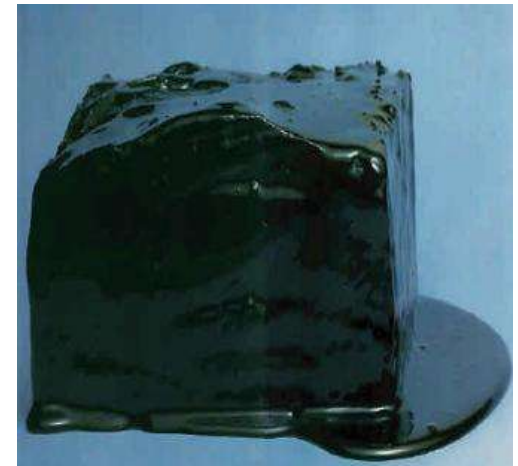
March 16, 2011

North American Emission Control Area

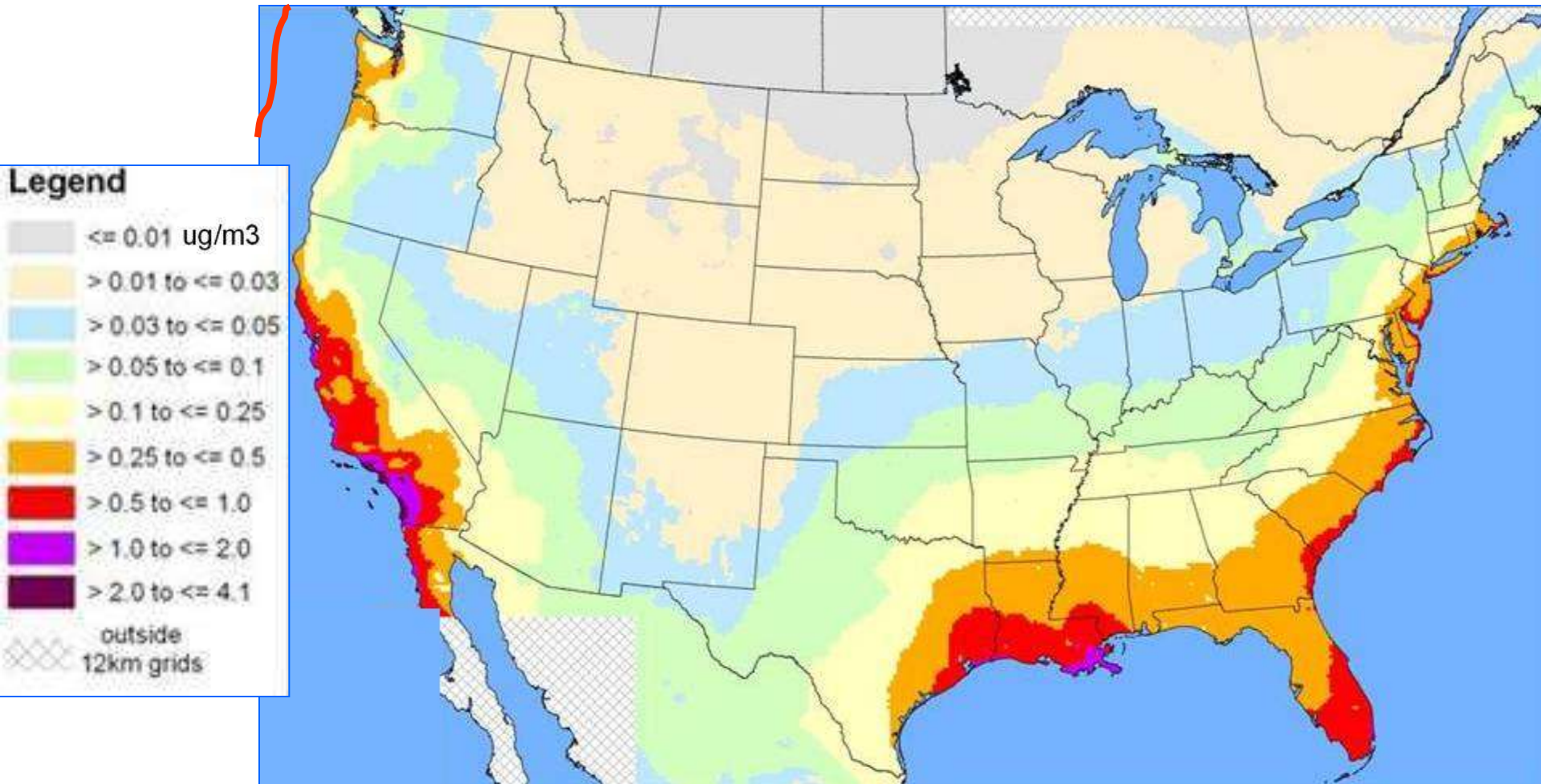


MARPOL Annex VI Emission Control Area

- ECA NOx Controls
 - Tier 3 NOx 80% reduction new vessels (2016)
- ECA PM and SOx Controls
 - 1.00% Fuel Sulfur (2010-2014)
 - By 2012 in NA ECA
 - 0.10% Fuel Sulfur 2015+
 - Up to 96% reduction in SOx
 - ~85% reduction in PM

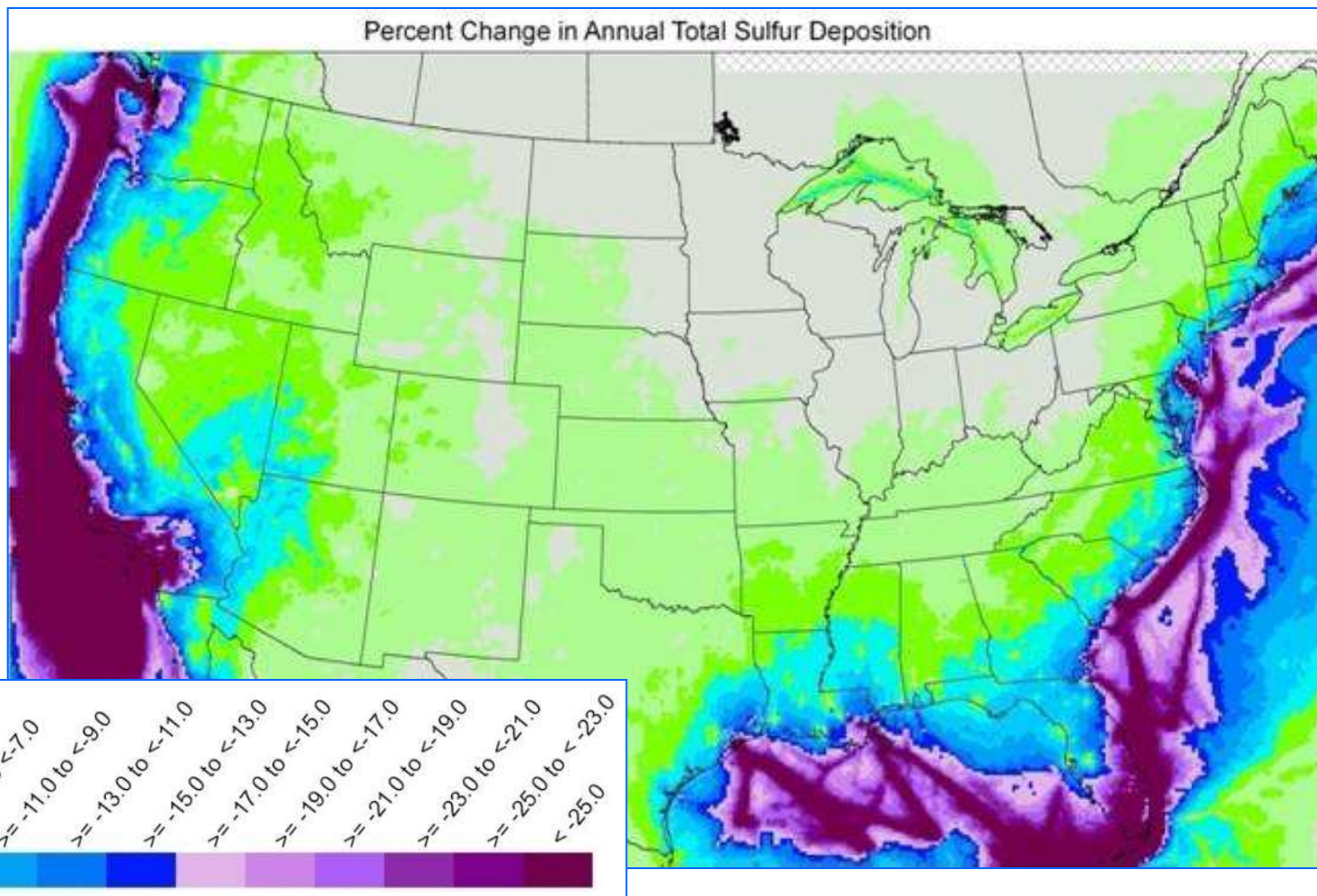


2020 Potential ECA PM_{2.5} Reductions



2020 Potential Sulfur Deposition Reductions

Improvements
in deposition
for marine and
terrestrial
ecosystems



Project Partners

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

Project Goals

- Demonstrate Switching to Low Sulfur Distillate Fuels on an Ocean Going Vessel sailing between Houston and Mexico
- Measure Emission Reductions
- Estimate Emission Reductions at Mexican Ports from Fuel Switching
- Estimate Health and Environmental Benefits from Fuel Switching
- Raise Awareness

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
- Outreach to stakeholders -- Video, workshops

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 NO_x (7%)
 - 47 kg PM_{2.5} (81%)
 - 479 kg SO_x (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 training needed
- 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

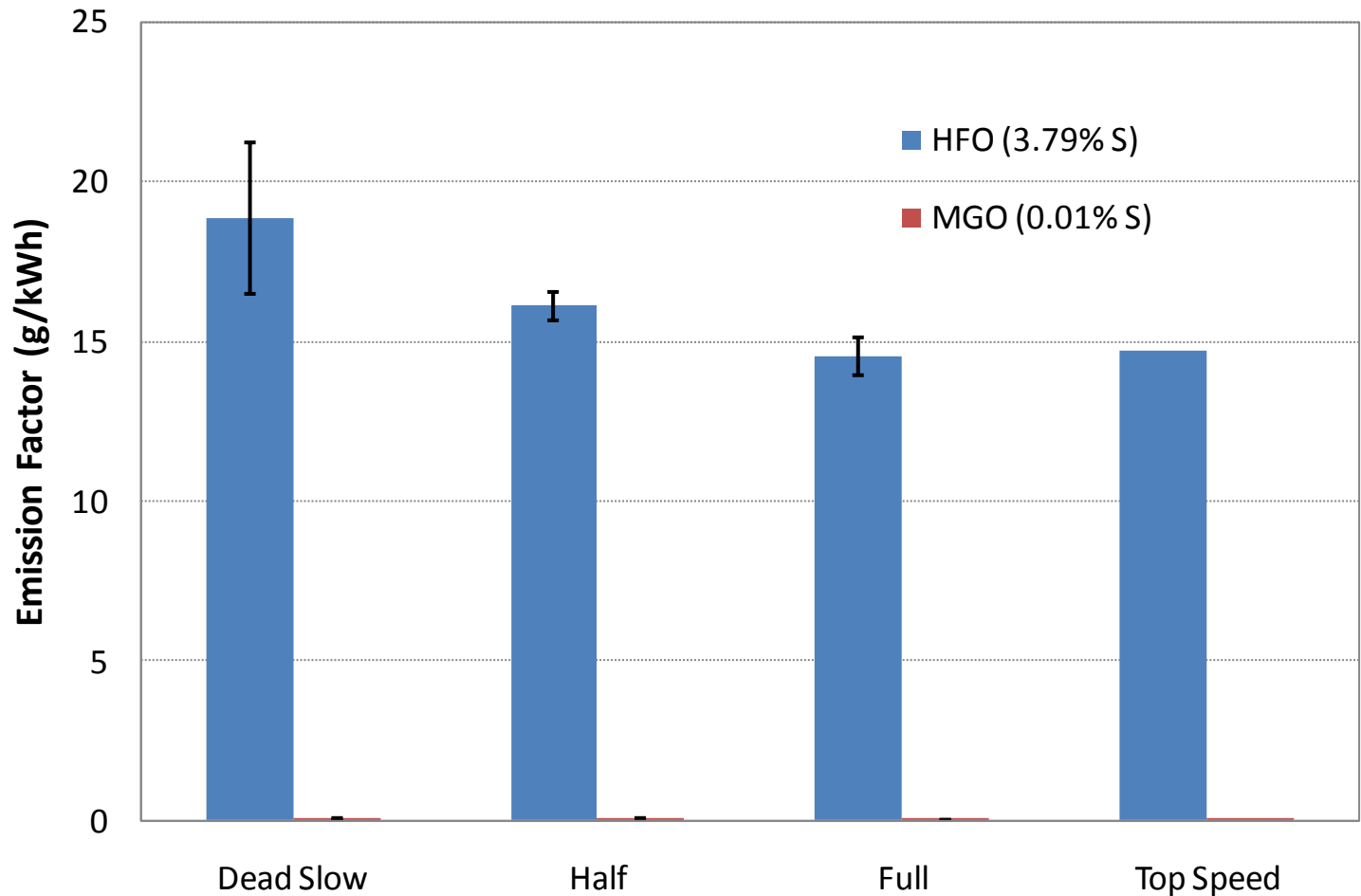
- Measurements of in-use stack emissions and their reduction from fuel switching
 - MARPOL NO_x Technical Code (NTC) and other protocols
 - Specific engine loads and transient operations, main and auxiliary engines



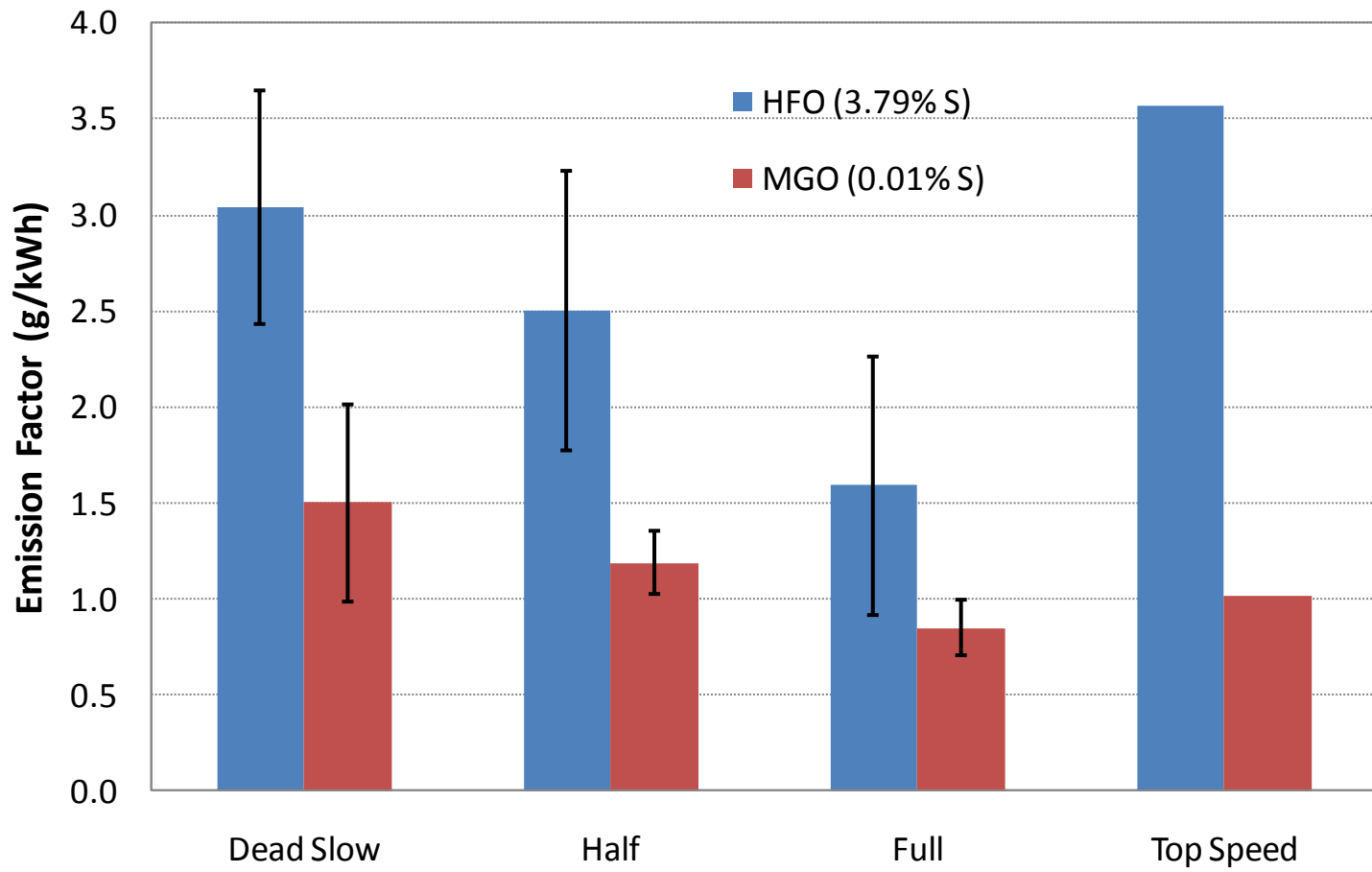
Pollutants measured

- NO_x, CO, CO₂ continuously
- PM continuously and speciated PM (EC, OC) with discrete filter samples
- Measure SO₂ and calculate SO_x from fuel measurements

Propulsion Engine Results – SO₂

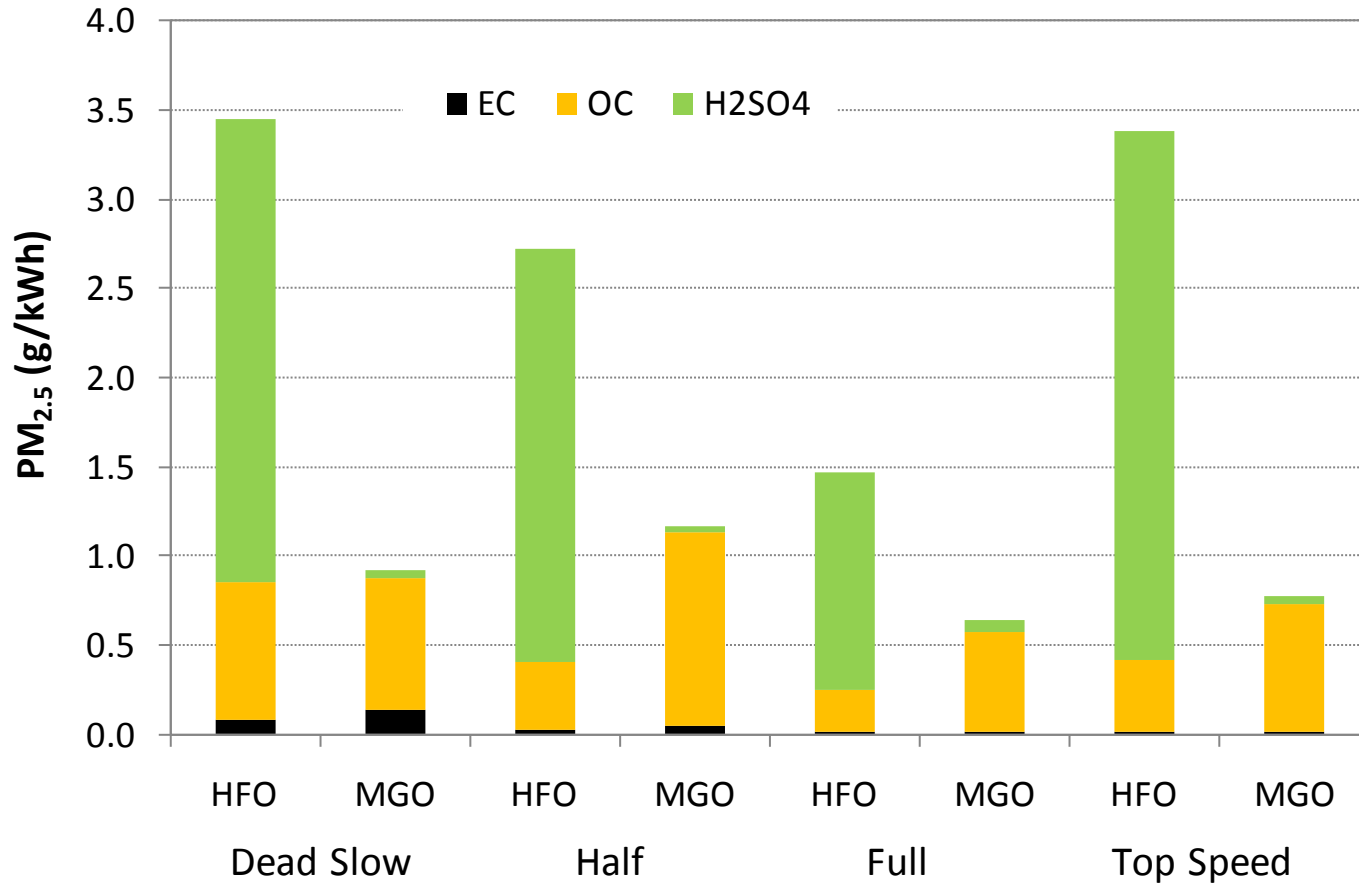


Propulsion Engine Results – PM_{2.5}



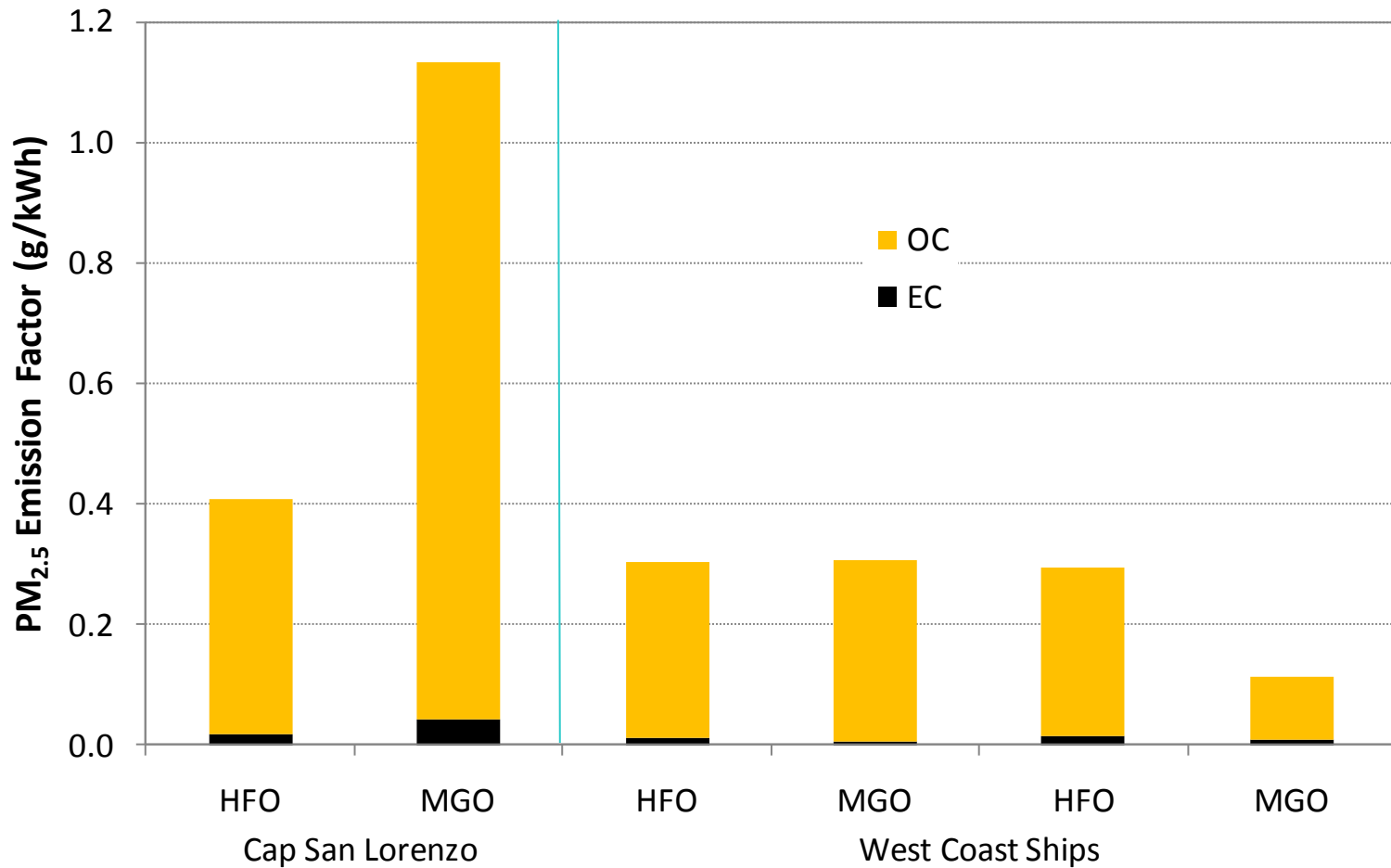
Propulsion Engine Results

Particulate Composition



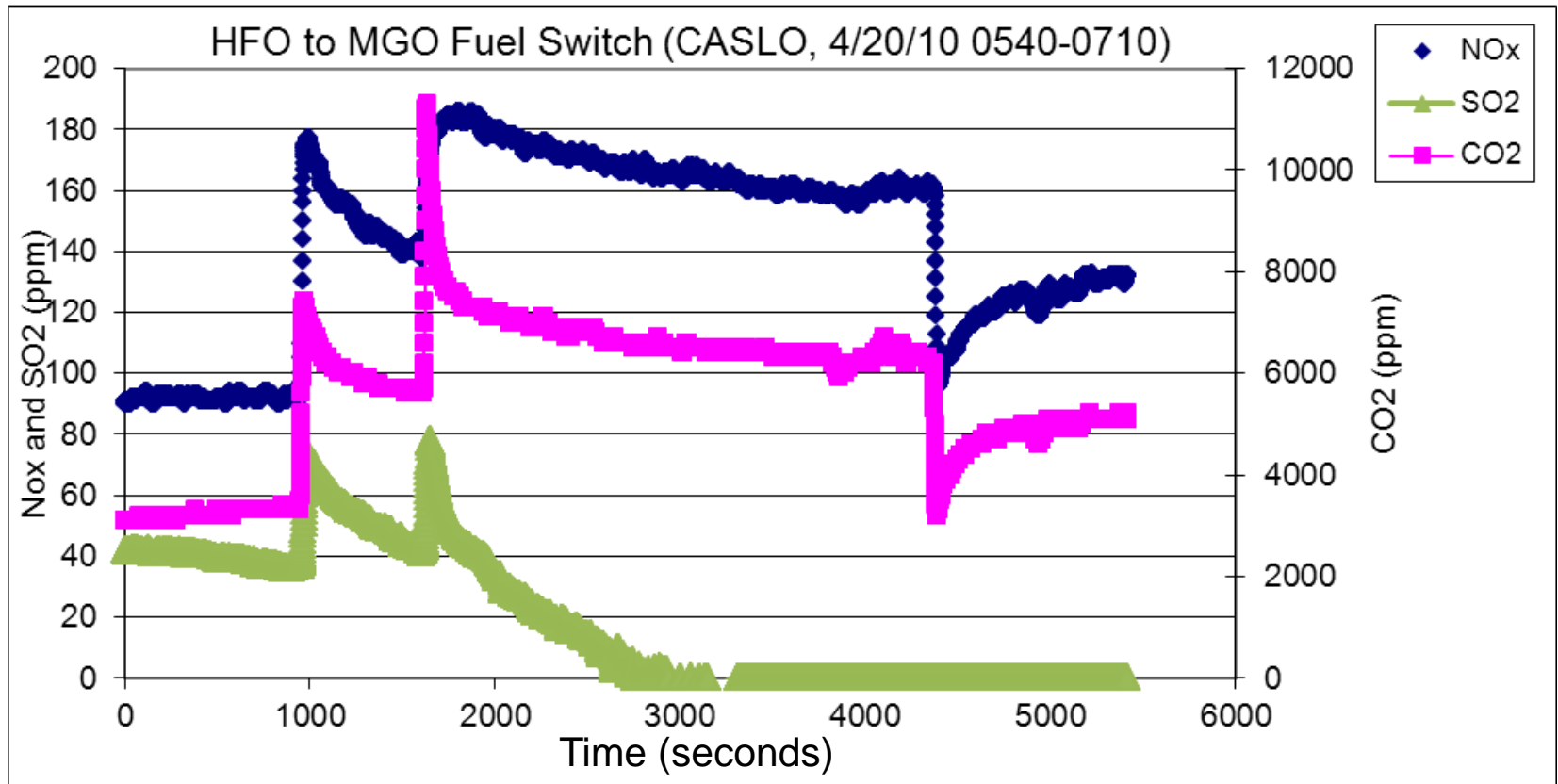
Comparison to other ships

Half Speed



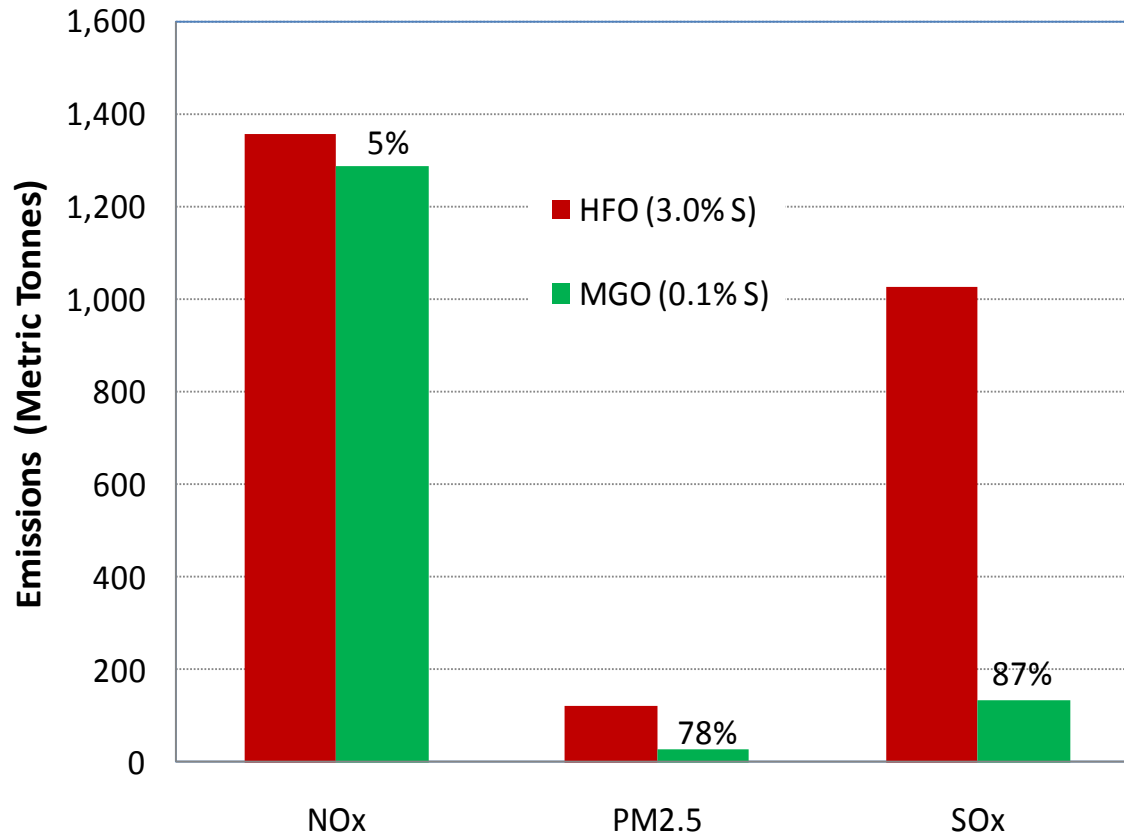
Fuel Switching Emissions

HFO -> MGO



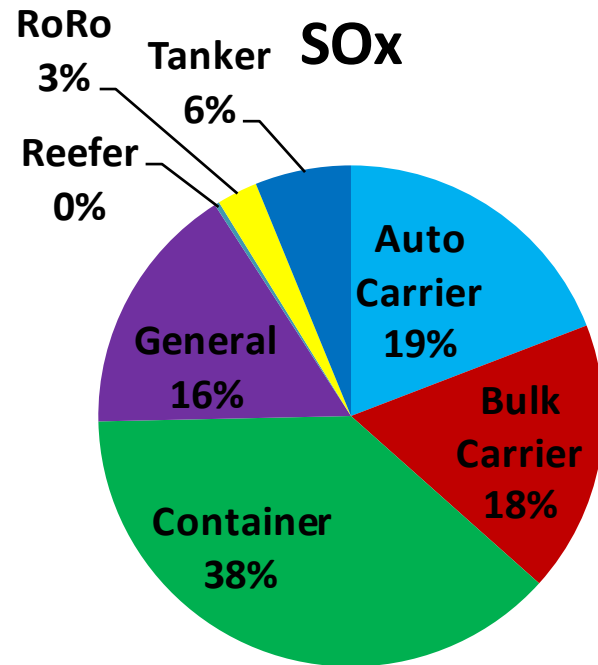
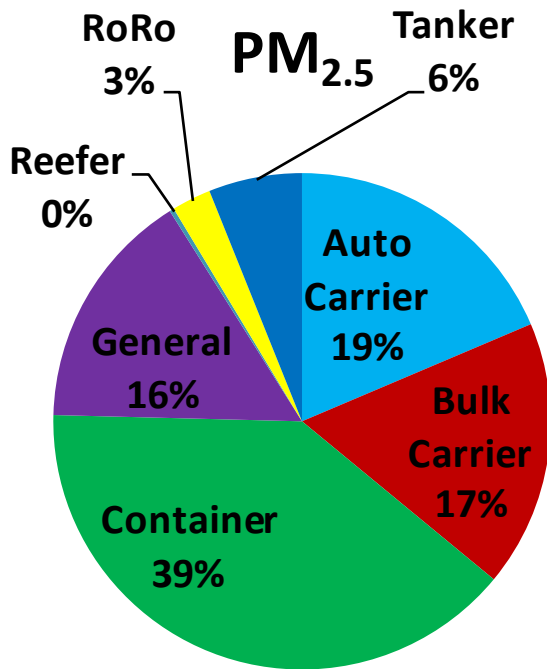
Reductions from Fuel Switching in the Port of Veracruz

With 24 nm Boundary

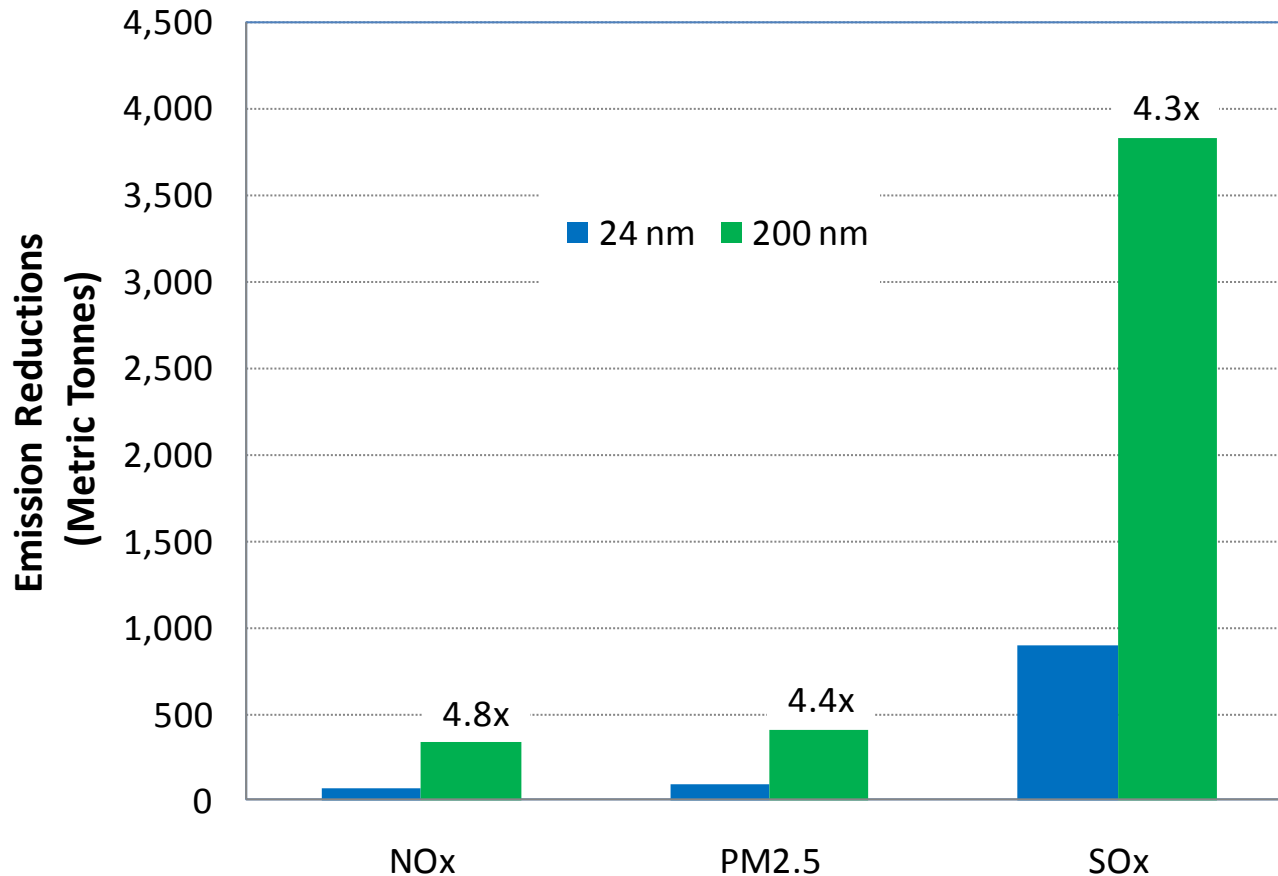


Emission Inventory based on 2005 activity data

Veracruz Emissions by Ship Type



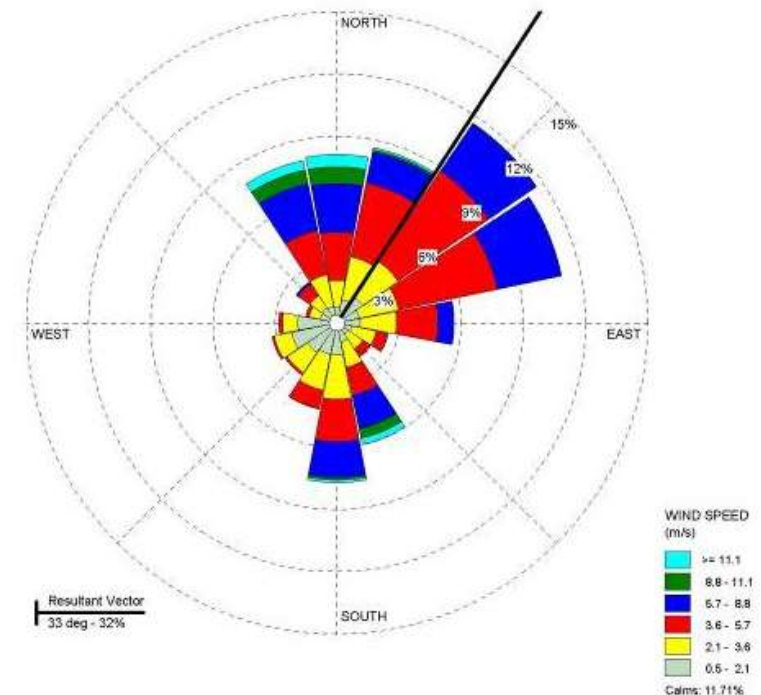
Effect of Fuel Switching Zone Size for Port of Veracruz



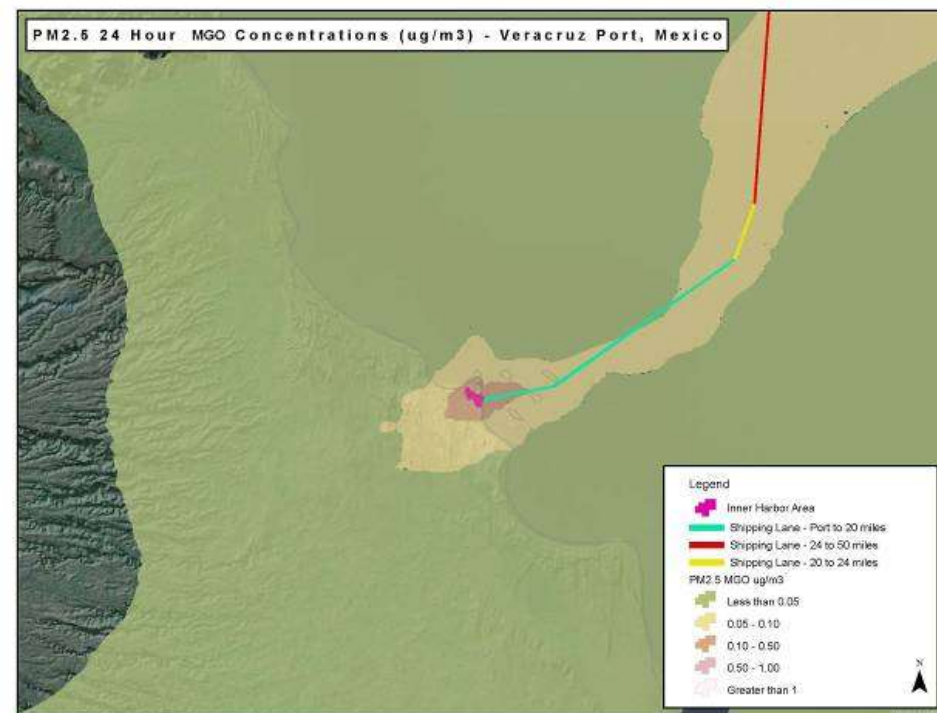
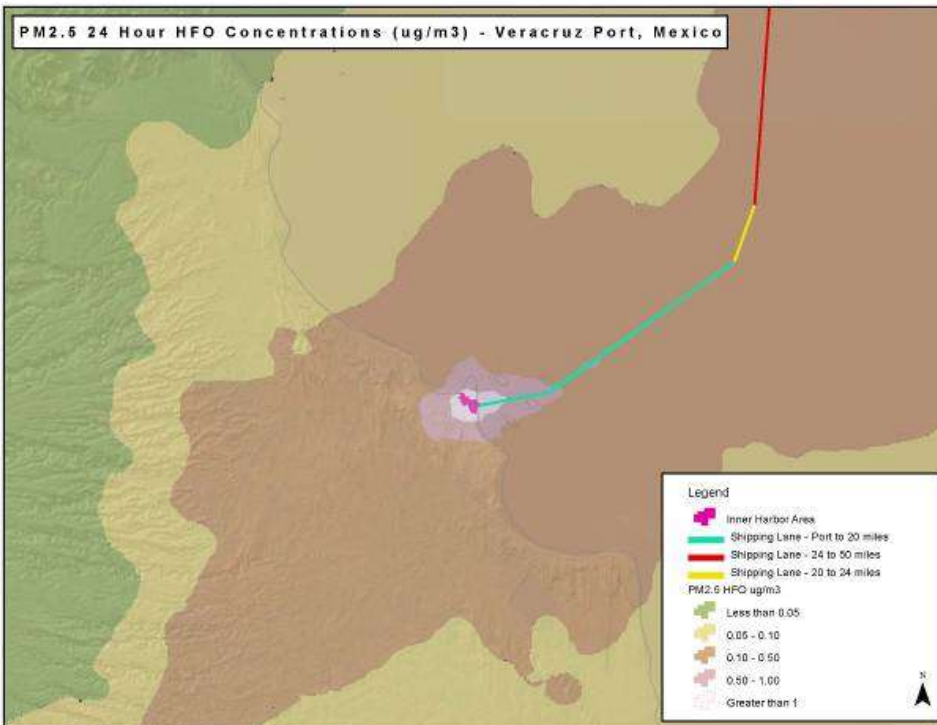
Dispersion Modeling

Model and Data

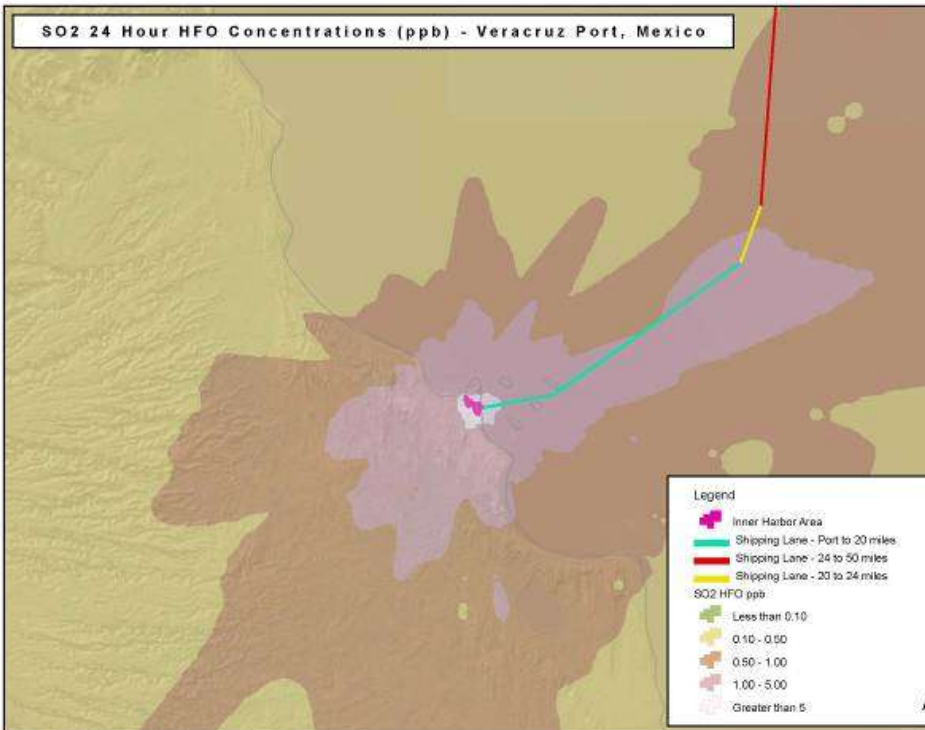
- AERMOD -- deposition of $PM_{2.5}$ and SO_2
- All ships switching fuels within 24 nm of Veracruz
- On-shore wind from NE



24 Hour Concentrations – PM_{2.5}



24 Hour Concentrations – SO₂



Dispersion Modeling

Estimated Annual Total Deposition of SO₂ 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 SO₂ 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 reduces PM emissions by up to 80 percent and SOx emissions by up to 97 percent
- Fuel switching within 24 nm reduces annual emissions of PM by 78% and SOx by 87% at the Port of Veracruz
- Concentrations of PM and SOx emissions around Veracruz reduced by 7x and 24x respectively
- Deposition of SOx on sensitive reefs around Veracruz reduced by 52 Metric Tonnes per year (96%)
- Continued interest in Mexico on this issue
- Final Report available at <http://www.epa.gov/international/fuelswitch.html>