Air Emissions From Ships:
A U.S. Perspective on the Challenges and Solutions

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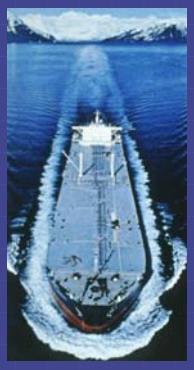
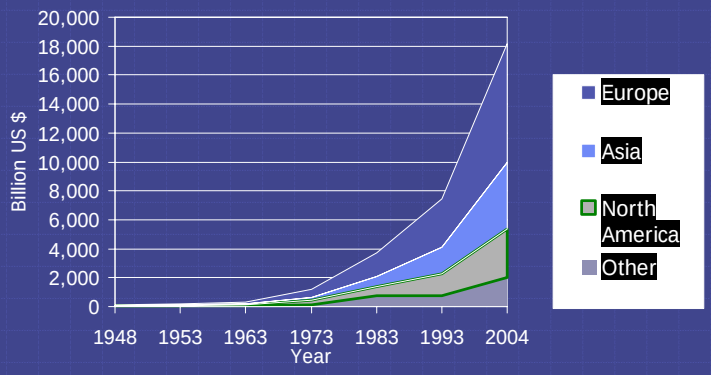
Tokyo - 28 February, 2007

Overview

- The Increasing Significance of Ship Emissions in North America
- U.S. Marine Engine and Fuel Controls
  - Current Requirements
  - Future Standards
- Options to Move Forward at the IMO
  - Recent Proposals to address NOx, PM, and SOx



World Merchandise Trade 1948-2004



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CONTAINERS: Where are they are going?

"China is building close to 100 new container-loading berths over the next few years, each capable of shipping about 250,000 containers a year, most of them to the United States. Meanwhile, five berths are planned for the West Coast of the United States to receive them. Something's got to give."

Steven Pearlstein, "Learn the Lesson of Charleston's Port," The Washington Post, 29 March 2006.

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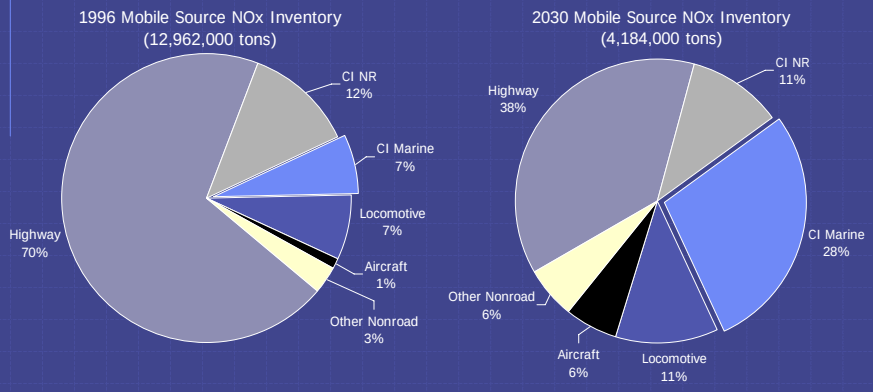
Vessel Emission Impacts in the United States

Vessel NOx Emissions in the U.S.

- Marine diesel engines contribute significantly to air pollution in the United States



48-state inventories; includes Tier 4 Nonroad

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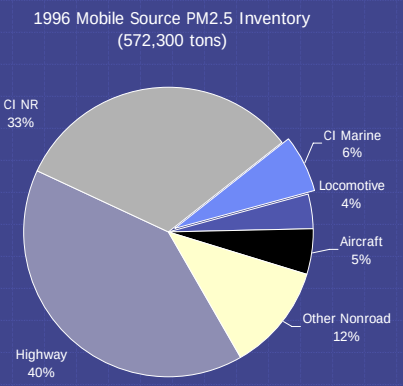
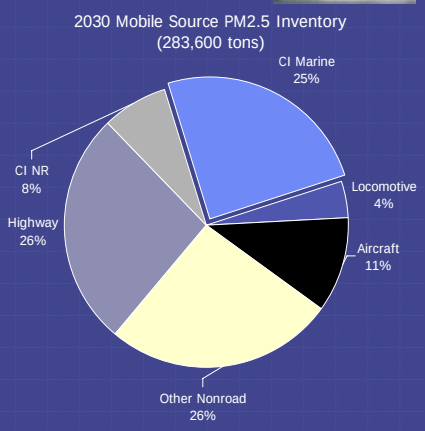
Vessel PM Emissions





48-state inventories; includes Tier 4 Nonroad

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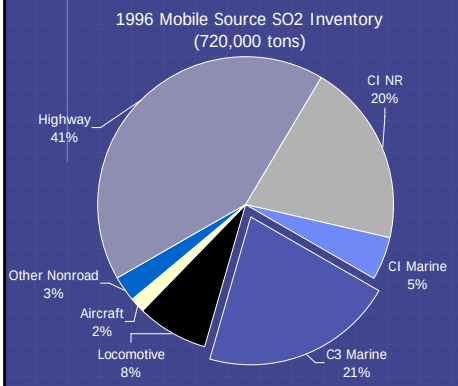
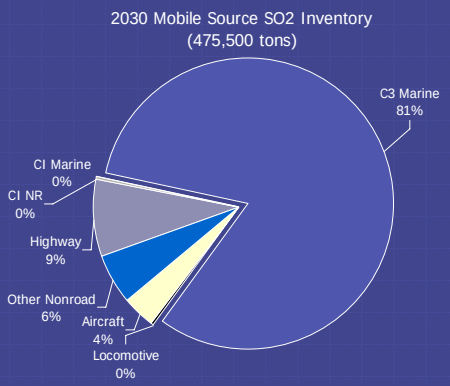
Vessel SOx Emissions

- SOx emissions from marine diesel engines are high due to the sulfur content of residual fuel used in C3 engines





Source: Final Regulatory Analysis: Control of Emissions from Non-road Diesel Engines (EPA420-R-04-007, May 2004; http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf)

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Specific Impacts in Ports

Source: Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (EPA420-R-03-004, Jan 2003; http://www.epa.gov/otaq/regs/nonroad/marine/ci/r03004.pdf)

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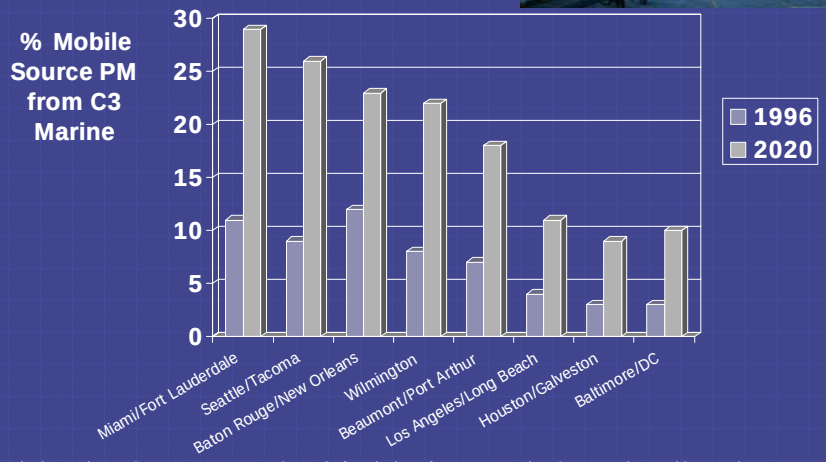
Impacts in Ports



Source: Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (EPA420-R-03-004, Jan 2003; http://www.epa.gov/otaq/regs/nonroad/marine/ci/r03004.pdf)

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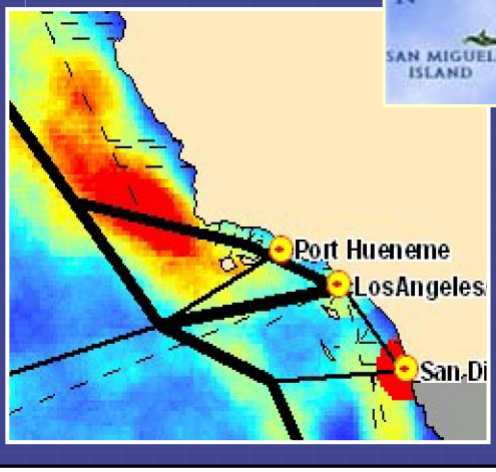
C3 Impacts on Coastal Areas

- Santa Barbara example



- Ships accounted for 36% of all area NOx emissions in 1999
- Expected to increase to 61% by 2015

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U.S. Standards

Current Standards

Future Standards under Development

What the Rule Covers--
Marine Diesels

Category 1 Commercial (<5 liter/cylinder)
~15,000/year (about half are aux engines)


workboats


police boats


fishing vessels

~75 hp
~10,000/year

gen sets

sailboats

Category 2 (5 to 30 liter/cyl) <300/year


tugboats


ferries


auxiliary power for ocean-going vessels

Recreational
~15,000/year

cruisers


yachts


Great Lakes freighters

Category 3
(>30 liter/cyl)


ocean-going ships

Covered in separate initiative

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Marine Diesel Engines


Category 1 Commercial


Category 2


Recreational


<37 kW

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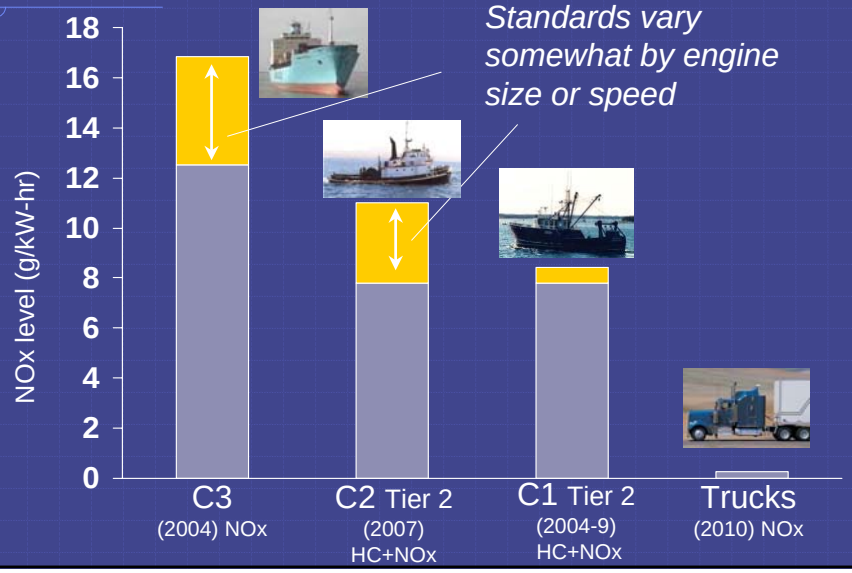
Current Emission Standards



Standards vary somewhat by engine size or speed

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Emission Standards: C1 and C2

- Notice of Proposed Rulemaking
  - Applicable to High and Medium-Speed Marine Diesel Engines
  - Standards to target NOx and PM aftertreatment
    - Follows highway and nonroad programs
    - Up to 90% reduction in PM and 80% in NOx
    - Extensive discussions with engine manufacturers in determining technical feasibility of these standards
  - Interim standard followed by longer-term after-treatment standard

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Emission Standards: C3

- Current MARPOL Annex VI standards currently apply in the United States
- Will soon issue an Advanced Notice outlining consideration of advanced standards for large displacement engines (C3):
- If successful at the IMO, we will simply adopt the IMO standards. If not, we will need to consider application of new standards to foreign-flag vessels entering US ports.

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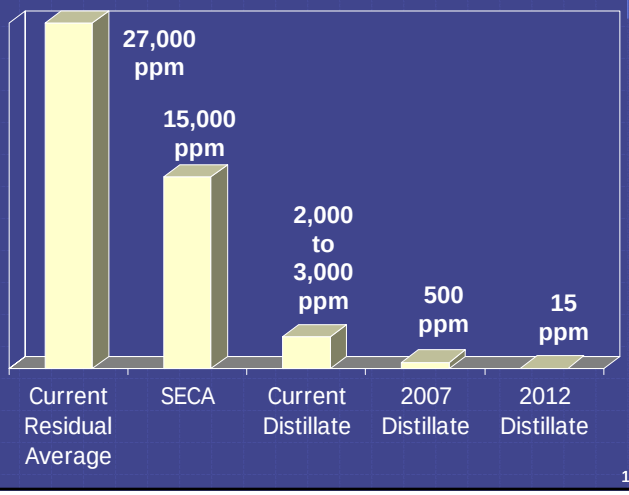
U.S. Marine Fuel Standards

- Federal distillate standards apply to fuel sold in the U.S.A.



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California Requirements

- Emission standard applicable to auxiliary engines and diesel-electric engines on vessels entering California ports.
  - effective 24 miles from port
- Further requirements under consideration
  - Expansion of existing rule to all propulsion engines
  - Shore-side power

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Annex VI of MARPOL: Status in U.S.

- U.S. Senate gave advice and consent to U.S. ratification last April.
- Congress currently considering the draft implementing legislation.
- Expect passage this year.

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North American SECA

- Exploring feasibility of SECA designation for North American Coastal Areas
- Studies underway include:
  - Fate & transport of emissions
  - Offshore traffic patterns & density
  - Environmental & human health impacts
  - Global fuels market analysis
- Collaborative effort: States, Canada, Mexico

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Current IMO Negotiations

What Are the Principal Challenges?

- Reduction of PM and SOx emissions
  - PM major contributor to human health problems
  - Sulfates contribute to acid deposition
  - High sulfur content of residual fuel leads to high levels of sulphur and particulate matter
- Reduction of NOx emissions without significant fuel penalty and CO2 increases

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NOx -What Can the Technology Do?

- In-engine improvements can yield 10-25% improvement over the current IMO limits.
- Water-based technologies can achieve approx 50% reduction, but exact fuel penalties from 2-5%.
- Selective catalytic reduction (SCR) can achieve 85-95% reductions with little or no fuel penalty depending upon design.

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Is Advanced After-Treatment Feasible?

- SCR Systems in use today on over 100 marine vessels
  - Can be designed to operate on high-sulphur HFO, but low-sulphur fuels enable greater efficiencies at lower load and smaller, less-expensive designs
  - Can operate with heavy fuel oil at 30-100% load
  - Need lower sulphur fuel oil to operate at low loads
- Trans-oceanic operation would be expensive due to urea demands, but operation on a geographical basis makes sense.

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PM and Sulphur

- Engine technology modifications have very limited potential for reducing PM and sulphur
- Significant reductions will require either:
  - 1) clean fuel, or
  - 2) exhaust gas cleaning technology.
- Various proposals on the table at IMO

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Current Proposals Before the IMO

- 1) Lower sulphur limits applicable in SECAs
- 2) Complete changeover to distillate fuels
- 3) Global sulphur limits reduced, but use open to both distillate and residual fuels.

- Numerous arguments concerning each of these approaches:
  - Timeframes necessary for ensuring adequate supplies of distillate fuels, cost, and CO2 implications;
  - Operational constraints associated with carrying multiple fuels, fuel switching, ...

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Fuel Switching: Is it a Problem?

- Many have argued in recent years that fuel switching is a safety problem.
- Past experience for decades as well as current experience suggest that the challenge is very manageable.
- MAERSK reports no problems.
- Many would prefer a 2 fuel regime over more complicated options.

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U.S. Proposal

- Require a NOx reduction of approx. 20% from existing large displacement engines:
  - Apply to pre-2000 engines
  - Phase-in over multiple years
  - Achieve through change to slide valves and change in injector design
- Establish PM and sulphur performance standards
  - applicable in defined geographic areas
  - effective in 2011
  - may be met through use of distillate fuel or scrubbers

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U.S. Proposal (Continued)

- New builds in 2011 to meet a 15-25% reduction in NOx through in-engine design changes.
- New built large-displacement engines (>30 l/cyl) in 2016 to meet an 80% reduction in NOx:
  - Standard applies only in geographic areas (x miles from shore as defined for the PM standard)
  - On/off after-treatment technology used only when inside these defined coastal areas
  - Ship operates in mid-ocean with residual fuel and by-passes after-treatment system

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Advantages of Proposal

- Performance based approach allowing ship owner to decide what mechanism to comply.
- Limits pressure on overall demand for distillate fuels.
- Allows lower-cost operation in mid-ocean while achieving very significant reductions.
- Offers a long-term solution that will give the industry regulatory stability.

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Summary

- Negotiations to continue in April followed by sessions in July, November, and March 2008.
- Incremental improvement will lead to further local and regional actions.
- The essential challenge lies in securing agreement on deep reductions that will provide long-term stability.

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Questions:

www.epa.gov/otaq/marine.htm

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