



# **Emissions Inventories at U.S. Ports**

Penelope McDaniel

U.S. Environmental Protection Agency

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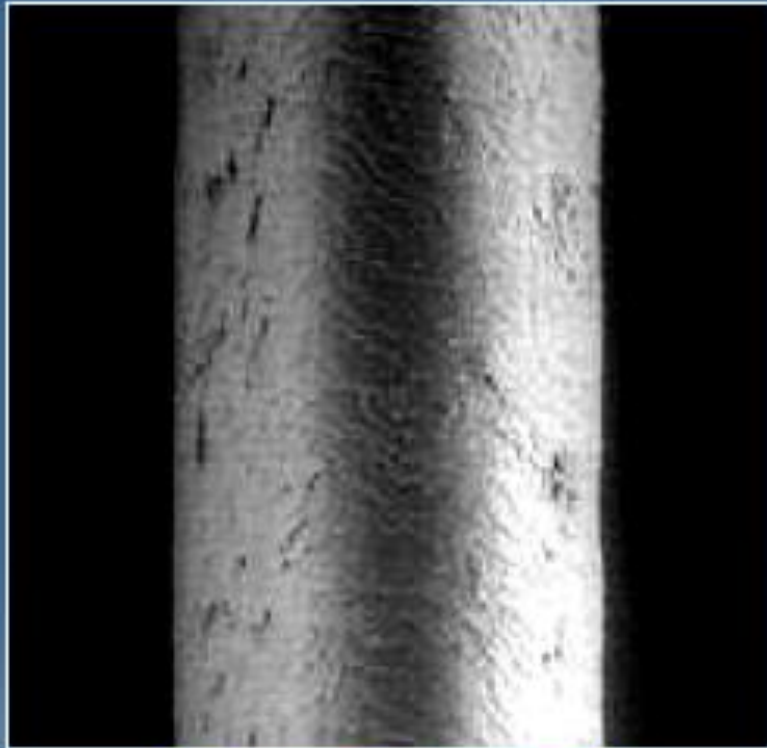


# Presentation Outline

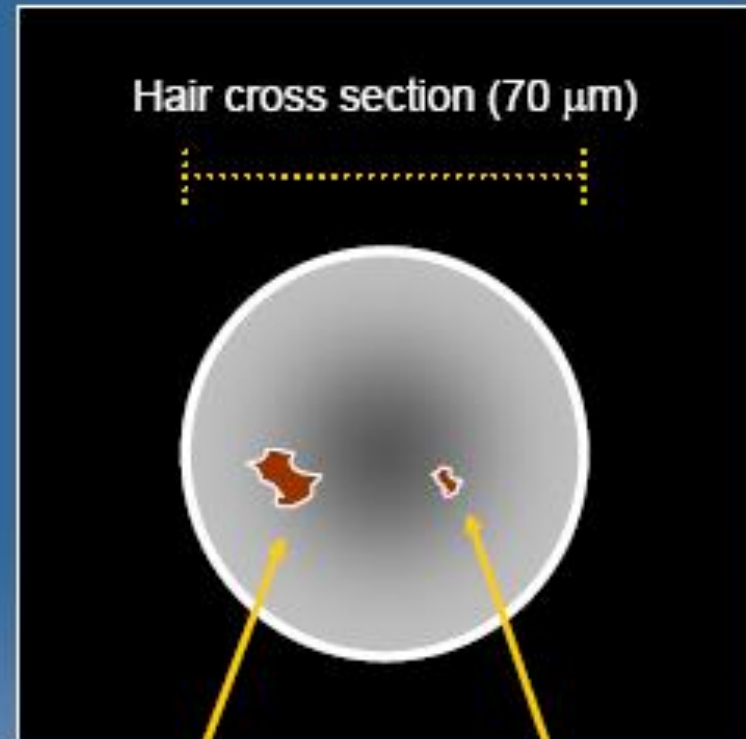
- Introduction
- Impetus: protect human health & the environment
- US EPA air quality regulations overview
  - CAA, mobile sources
- US Port Emission Inventories & Progress



# Protecting Human Health & the Environment



Human Hair (70  $\mu\text{m}$  diameter)



PM<sub>10</sub> (10 $\mu\text{m}$ )

PM<sub>2.5</sub> (2.5  $\mu\text{m}$ )



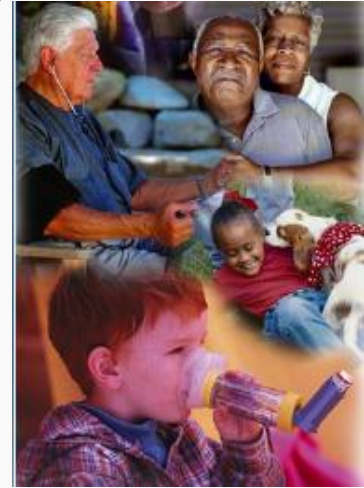
# Protecting Human Health & the Environment

- Exposure to diesel PM may result in both cancer and non-cancer health effects, including premature death
  - US EPA has classified PM<sub>2.5</sub> as a likely human carcinogen
  - Non-cancer health effects may include eye and lung irritation, allergic reactions in the lungs, asthma exacerbation, blood toxicity, immune system dysfunction, and developmental disorders.
- NO<sub>x</sub> adverse health effects in humans: respiratory irritation, immune system suppression, and asthma exacerbation.



# Protecting Human Health & the Environment

- Children, elderly and immune compromised individuals are disproportionately affected by diesel emissions
- Children are especially sensitive because their respiratory systems are still developing, and they have a faster breathing rate
- Degrades air quality, impairs visibility and contributes to climate change





# Summary of Health Effects

POLLUTANT	HEALTH EFFECTS	EXAMPLES OF SOURCES
Particulate Matter (PM <sub>2.5</sub> and PM <sub>10</sub> : less than or equal to 2.5 or 10 microns, respectively)	<ul style="list-style-type: none"> <li>• Hospitalizations for worsened heart diseases</li> <li>• Emergency room visits for asthma</li> <li>• Premature death</li> </ul>	<ul style="list-style-type: none"> <li>• Cars and trucks (especially diesels)</li> <li>• Fireplaces, woodstoves</li> <li>• Windblown dust from roadways, agriculture and construction</li> </ul>
Ozone (O <sub>3</sub> )	<ul style="list-style-type: none"> <li>• Cough, chest tightness</li> <li>• Difficulty taking a deep breath</li> <li>• Worsened asthma symptoms</li> <li>• Lung inflammation</li> </ul>	<ul style="list-style-type: none"> <li>• Precursor sources*: motor vehicles, industrial emissions, and consumer products</li> </ul>
Carbon Monoxide (CO)	<ul style="list-style-type: none"> <li>• Chest pain in heart patients**</li> <li>• Headaches, nausea**</li> <li>• Reduced mental alertness**</li> <li>• Death at very high levels**</li> </ul>	<ul style="list-style-type: none"> <li>• Any source that burns fuel such as cars, trucks, construction and farming equipment, and residential heaters and stoves</li> </ul>
Nitrogen Dioxide (NO <sub>2</sub> )	<ul style="list-style-type: none"> <li>• Increased response to allergens</li> </ul>	<ul style="list-style-type: none"> <li>• See carbon monoxide sources</li> </ul>
Toxic Air Contaminants	<ul style="list-style-type: none"> <li>• Cancer</li> <li>• Chronic eye, lung or skin irritation</li> <li>• Neurological and reproductive disorders</li> </ul>	<ul style="list-style-type: none"> <li>• Cars and trucks (especially diesels)</li> <li>• Industrial sources, such as chrome platers</li> <li>• Neighborhood businesses, such as dry cleaners and service stations</li> <li>• Building materials and products</li> </ul>



# US Mechanisms to Reduce Air Pollution

- Laws and Regulations
  - Federal (Congress, US EPA); State and Local; International Treaties
- Voluntary
  - Industry
  - Environmental and public health concerns, social responsibility, economic incentives, competition
- Combined regulatory and voluntary
  - Collaboration between regulators and industry



# Laws & Regulations – Federal Clean Air Act

The Clean Air Act does not specifically regulate marine ports. However:

- Ambient air quality standards:
  - (1) drive Federal, State, and Local regulations, and
  - (2) create incentives for both government and industry to reduce emissions
- Mobile source standards apply to some elements of port activities and help reduce emissions





# Laws & Regulations – Federal Clean Air Act

## Clean Air Act

- 1) US EPA establishes National Ambient Air Quality Standards (NAAQS)
  - “ambient air quality” includes pollution from all sources
- 2) US EPA approves State/local programs that meet Clean Air Act requirements – joint enforcement
- 3) “Stationary sources” regulated differently from “mobile sources”



# Laws & Regulations – Federal Clean Air Act

National Ambient Air Quality Standards (NAAQS):  
Levels of “acceptable” ambient pollutant concentrations

- 1) carbon monoxide (CO)
- 2) sulfur dioxide (SO<sub>2</sub>)
- 3) nitrogen dioxide (NO<sub>2</sub>)
- 4) ozone (O<sub>3</sub>)
- 5) particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), and
- 6) lead (Pb)

- Based on ambient air monitoring data, US EPA designates all areas in the U.S. as “attainment” or “nonattainment”
- Continuous monitoring: designation may change



# US EPA's Mobile Source Regulatory Roadmap

## Tier 2 Light-Duty

final rule 1999  
fully phased in 2009  
Diesels held to same stringent standards as gasoline vehicles



## Heavy-Duty Highway

sales 800,000 / yr  
40B gallons / yr  
final rule 2000  
fully phased in 2010



## Nonroad Diesel

sales over 650,000 / yr  
12B gallons / yr  
final rule 2004  
fully phased in 2015



## Locomotive/Marine

sales 40,000 marine engines,  
1,000 locomotives / yr  
6B gallons / yr  
final rule 2008  
fully phased in 2017



## Ocean Going Vessels

CAA Rule Dec 2009  
IMO MARPOL Annex VI  
ECA Controls  
- Fuel Based 2015  
- SCR Catalyst Based 2016

Note: sales and diesel fuel usage vary year-to-year; these figures are for comparison purposes only



# Federal & California Non-Road Diesel Fuel Standards

## LSD & ULSD Implementation Schedule

**Non-road Diesel Fuel Standards**

Who	Covered Fuel	2006	2007	2008	2009	2010	2011	2012	2013	2014
Large Refiners & Importers	NON-ROAD	500+ ppm	500 ppm	500 ppm	500 ppm	15 ppm	15 ppm	15 ppm	15 ppm	15 ppm
Large Refiners & Importers	LOCOMOTIVE & MARINE	500+ ppm	500 ppm	500 ppm	500 ppm	500 ppm	500 ppm	15 ppm	15 ppm	15 ppm
Small Refiners & Other Exceptions	NON-ROAD, LOCOMOTIVE & MARINE	500+ ppm	500+ ppm	500+ ppm	500+ ppm	500 ppm	500 ppm	500 ppm	500 ppm	15 ppm

**Except in California**, compliance dates for Non-Road, Locomotive and Marine fuels in the years indicated are: June 1 for refiners and importers, August 1 downstream from refineries through fuel terminals, October 1 for retail outlets, and December 1 for in-use.

**In California**, all diesel fuel transitioned to ULSD in 2006. Locomotive and Marine diesel fuels were required to transition to 15 ppm ULSD effective January 1, 2007.



## US Port Emissions Inventories

- Used to establish air quality “baseline” for port operations
- May also play roles in measuring emission reduction program success
- Frequency of updates varies, depending on data needs, funding and staffing



# San Pedro Bay Ports Clean Air Action Plan Objectives

## 1. San Pedro Bay Specific Objectives

- Reduce public health risk from toxic air contaminants associated with port-related mobile sources to acceptable levels.
- Reduce criteria pollutant emissions to the levels that will assure that port related sources decrease their "fair share" of regional emissions.
- Prevent port-related violations of the state and federal air quality standards.

## 2. Project Specific Objectives

- Projects must meet a residential cancer risk threshold.
- Projects that exceed thresholds for criteria pollutants must implement the maximum available controls and feasible mitigations for any emissions increases.

## 3. Source Specific Objectives

- A series of performance goals for each of the five sectors.



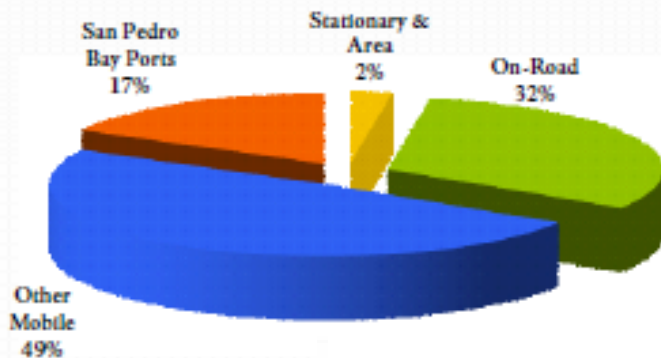
# San Pedro Bay Ports Clean Air Action Plan Emission Reduction Initiatives

- Heavy-duty truck control measures
- OGV control measures
- Cargo handling equipment control measures
- Rail locomotive control measures
- Construction activities BMPs
- Technology Advancement Program
- Zero Emission Container Movement
- Operational efficiency improvement initiatives
- Continual improvement in EI

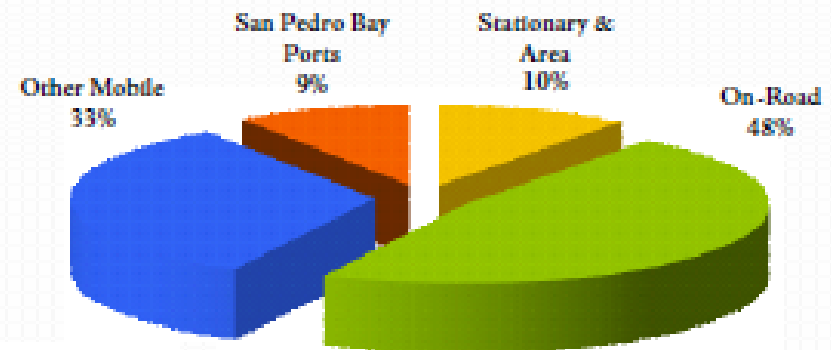


# 2008 San Pedro Bay Ports – Contribution to SoCAB Emissions

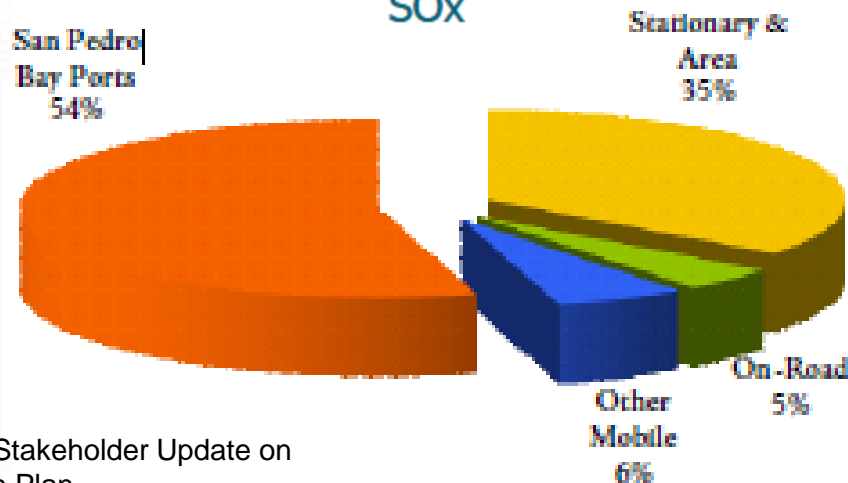
## DPM



## NOx



## SOx







## Port of Los Angeles

- Activity based emissions inventory
- 2001 inventory published July 2005
- 2003 inventory published 2007, first of annual updates
- 2006 inventory published 2008, first to include greenhouse gas emissions estimates
- 2008 inventory released December 2009



## Port of Los Angeles: Inventory Source Categories

- Ocean-going vessels
- Harbor craft
- Cargo handling equipment
- Railroad locomotives
- Heavy-duty vehicles



## Port of Los Angeles: Pollutant Emissions Estimated

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO<sub>x</sub>)
- Oxides of sulfur (SO<sub>x</sub>)
- Hydrocarbons (HC)
- Carbon monoxide (CO)



## Port of Los Angeles: Greenhouse Gas Emissions Estimated

- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous oxide (N<sub>2</sub>O)



## Port of Los Angeles: Geographical Extent

- emissions from all source categories within the harbor district;
- emissions from rail locomotives and on-road trucks transporting cargo to or from the Port up to the cargo's first point of rest within the South Coast Air Basin (SoCAB) or up to the basin boundary, whichever comes first; and
- emissions from commercial marine vessels within the harbor and up to the study area boundary.

Figure E3.2: OGV Inventory Geographical Extent





# Port of Los Angeles: Emission Inventory Results

**Table ES.4: Port-wide Emissions Comparison, tons per year and % Change**

EI Year	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	NO <sub>x</sub>	SO <sub>x</sub>	CO	HC
2009	511	436	467	11,244	2,432	2,777	599
2008	805	690	736	15,577	3,822	3,826	811
2007	777	673	682	17,052	3,553	4,036	875
2006	1,140	975	1,040	19,262	6,026	4,658	981
2005	1,062	908	974	16,812	5,552	4,093	870
<b>Previous Year (2009-2008)</b>	<b>-37%</b>	<b>-37%</b>	<b>-37%</b>	<b>-28%</b>	<b>-36%</b>	<b>-27%</b>	<b>-26%</b>
<b>CAAP Progress (2009-2005)</b>	<b>-52%</b>	<b>-52%</b>	<b>-52%</b>	<b>-33%</b>	<b>-56%</b>	<b>-32%</b>	<b>-31%</b>



## Port of Long Beach

- Activity based emissions inventory
- 2002 baseline inventory published 2005
- Inventories published for 2005, 2006, 2007, 2008
- 2006 inventory published June 2008, first to include greenhouse gas emissions estimates
- 2009 inventory released June 2010





## Port of Long Beach: Inventory Source Categories

- Ocean-going vessels
- Harbor craft
- Cargo handling equipment
- Railroad locomotives
- Heavy-duty vehicles



## Port of Long Beach: Pollutant Emissions Estimated

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO<sub>x</sub>)
- Oxides of sulfur (SO<sub>x</sub>)
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous oxide (N<sub>2</sub>O)



## Port of Long Beach: Geographical Extent

- emissions from all source categories within the harbor district;
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- emissions from commercial marine vessels within the harbor and up to the study area boundary.

Figure E3.2: OGV Inventory Geographical Extent





# Port of Long Beach: Emission Inventory Results

Table ES.6: Port-wide Emissions Comparison, tpy and % Change

EI Year	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	NO <sub>x</sub>	SO <sub>x</sub>	CO	HC
2005	1,085	915	977	15,588	6,740	3,215	779
2009	543	453	471	10,129	3,661	1,819	483
Change (tpy)	-542	-462	-507	-5,459	-3,079	-1,396	-295
Change (%)	-50%	-51%	-52%	-35%	-46%	-43%	-38%



# Proposed San Pedro Bay Ports Emission Reduction Standards

- By 2014, reduce emissions by:
  - 72% DPM
  - 22% NO<sub>x</sub>
  - 93% SO<sub>x</sub>
- By 2023, reduce emissions by:
  - 77% DPM
  - 59% NO<sub>x</sub>
  - 93% SO<sub>x</sub>



# San Pedro Bay Ports Zero Emission Container Movement Systems (ZECMS)

- Short-term goal
  - determine if ZECMS are feasible for the ports and if so, demonstrate innovative technologies that can be utilized for more efficient and greener movement of cargo
- Long-term goal
  - to be able to handle anticipated cargo throughput growth with pollution-free technologies and strategies



# Northwest Ports Clean Air Strategy

- Port of Seattle, Port of Tacoma, Port of Metro Vancouver

## Objectives:

- Reduce maritime and port-related air quality impacts on human health, the environment, and the economy
- Reduce contribution to climate change through co-benefits associated with reducing air quality impacts
- Help the airshed continue to meet air quality emissions regulations and goals





# Puget Sound Maritime Emissions Inventory

- Identifies and quantifies pollutants emitted from maritime-related diesel equipment operating within the greater Puget Sound region.
- Baseline inventory covers 2005 emissions
- Update now underway for 2011 emissions



# Puget Sound Maritime Emissions Inventory

- Ocean-going vessels
- Harbor vessels
- Cargo handling equipment
- Rail
- Heavy-duty vehicles
- Fleet vehicles (passenger cars & trucks)



# Puget Sound Maritime Emissions Inventory: Emissions Estimated

- Carbon monoxide (CO)
- Oxides of nitrogen (NO<sub>x</sub>)
- Oxides of sulfur (SO<sub>2</sub>)
- Volatile organic compounds (VOC)
- Particulate matter (PM)
- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>), and
- Nitrous oxide (N<sub>2</sub>O)
- Diesel particulate matter (DPM)

Figure O.1: Georgia Basin/Puget Sound Airshed





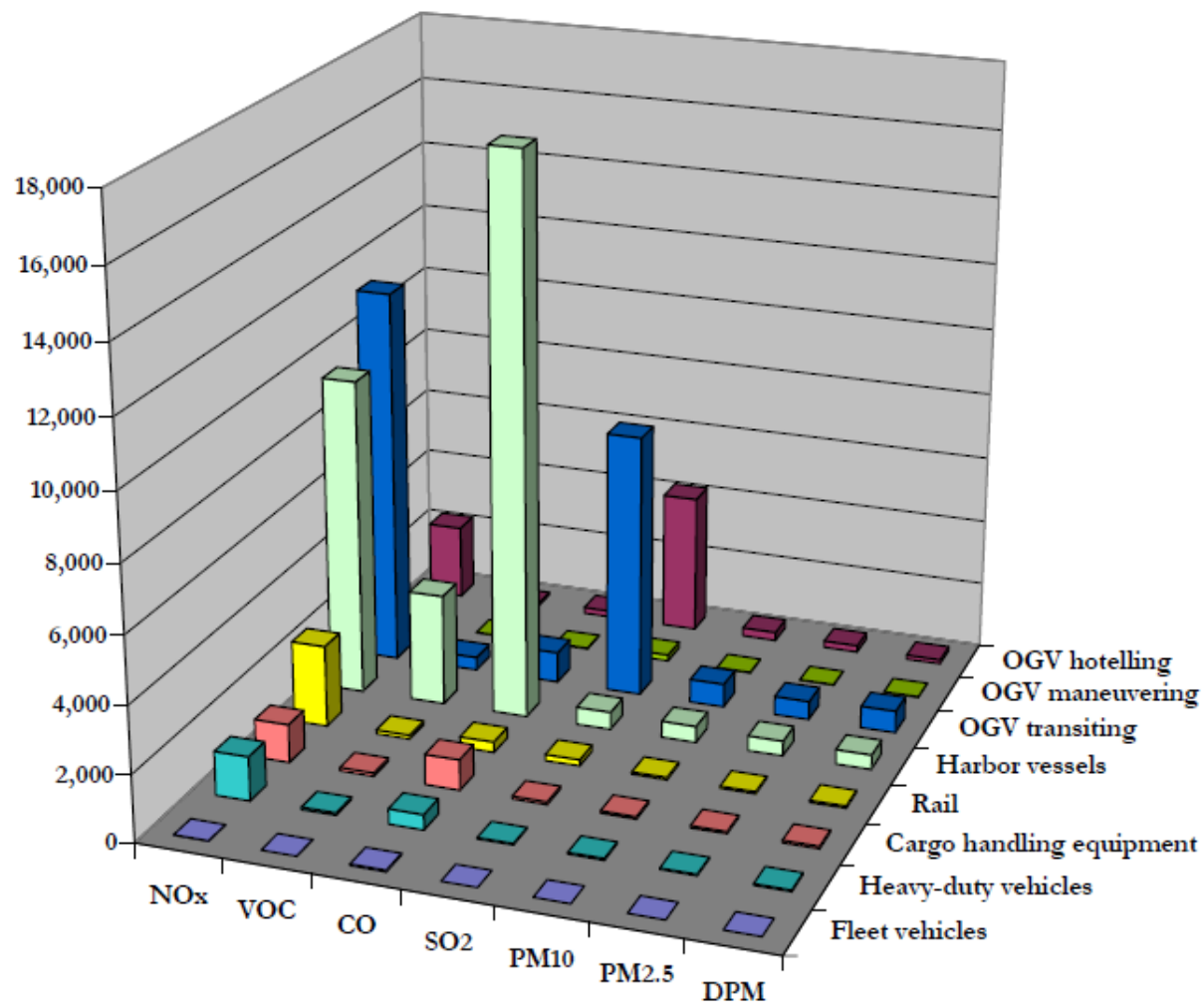
# Puget Sound Maritime Emissions Inventory: Results

Table ES.3: Puget Sound 2005 Maritime Air Emissions Inventory Summary, tpy

Source Category	NO <sub>x</sub>	VOC	CO	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	Greenhouse Gases, CO <sub>2</sub> eq
Ocean-going vessels:								
Hotelling	2,259	74	191	4,229	262	209	131	274,421
Maneuvering	313	24	33	191	22	17	21	12,481
Transiting	11,390	399	932	7,953	709	566	663	496,844
Harbor vessels	9,555	3,363	16,854	529	495	456	445	689,649
Rail, off-terminal	1,285	57	166	96	35	32	32	59,854
Rail, on-terminal	1,180	67	154	93	35	32	35	48,135
Cargo handling equipment	1,155	103	918	80	74	72	74	111,592
Heavy-duty vehicles, off-terminal	1,120	58	307	35	45	39	39	156,242
Heavy-duty vehicles, on-terminal	203	18	148	4	4	4	4	17,845
Fleet vehicles	10	5	50	0	0	0	0	3,365
<b>Total</b>	<b>28,469</b>	<b>4,167</b>	<b>19,752</b>	<b>13,211</b>	<b>1,682</b>	<b>1,427</b>	<b>1,444</b>	<b>1,870,429</b>



Figure ES.2: Puget Sound 2005 Maritime Air Emissions Inventory Summary, tpy





# Puget Sound Maritime Clean Air Strategy Result Examples

- OGVs switch to low sulfur fuel while hotelling
- All CHE used at the ports now use ULSD fuels or equivalent
- All Port of Seattle dray trucks, Port Metro Vancouver trucks, 94% of dray truck at Port of Tacoma now comply with 1994 PM emission standards



# Port Authority of New York and New Jersey

## New Jersey:

- Port Newark
- Elizabeth Port Authority Marine Terminal
- Auto Marine Terminal (Bayonne/Jersey City).

## New York:

- Howland Hook Marine Terminal (Staten Island)
- Brooklyn Port Authority Marine Terminal



Figure 1: Port Authority of New York and New Jersey Seaport Facilities Map





# Clean Air Strategy for the Port of New York & New Jersey

- Reduce maritime-related air quality impacts on human health and the environment from criteria air pollutants, especially those that come from diesel particulate emissions
- Reduce maritime-related contribution to greenhouse gas emissions associated with climate change
- Contribute to the effort to bring the airshed into air quality attainment



# Port Authority of New York and New Jersey

- 2006 baseline inventory published November 2008
- Previous partial inventories:
  - ocean-going vessels/harbor craft (2000)
  - on-dock railroad locomotives (2002)
  - heavy-duty diesel vehicles (on-road trucks, 2005)
  - cargo handling equipment (2002 and 2004).



# Port Authority of New York and New Jersey: Emissions Estimated

- Oxides of nitrogen (NO<sub>x</sub>)
- Carbon monoxide (CO)
- Particulate matter less than 10 microns in diameter (PM<sub>10</sub>)
- Particulate matter less than 2.5 microns in diameter (PM<sub>2.5</sub>)
- Volatile organic compounds (VOCs)
- Sulfur dioxide (SO<sub>2</sub>)
  
- Carbon dioxide (CO<sub>2</sub>)
- Nitrous oxide (N<sub>2</sub>O)
- Methane (CH<sub>4</sub>)



# Port Authority of New York and New Jersey: Geographical Extent

17 counties across the states of New Jersey  
and New York coincident with the New  
York/Northern New Jersey/Long Island Non-  
Attainment Area (NYNJLINA)



# Contributions of port emissions to total NYNJLINA (2006 baseline)

**Table 1: Total Criteria Emission Summary by Source Category, %**

NYNJLINA Source Category	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	VOC	CO	SO <sub>2</sub>
PANYNJ Maritime Emissions	2%	< 1%	1%	< 1%	< 1%	2%
Stationary and Area Emissions	31%	93%	75%	2%	56%	84%
Other Mobile Emissions	23%	4%	16%	34%	17%	11%
On-Road Mobile Emission	44%	3%	8%	64%	27%	3%
Total NYNJLINA Emissions, tons per year	445,285	178,451	42,441	522,245	2,840,374	170,044



# Port Authority of New York and New Jersey: Inventory Results

**Table ES.1: Criteria Pollutant Emission Summary by Source Category, tpy - 2006**

Source Category	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	VOC	CO	SO <sub>2</sub>
Cargo Handling Equipment	1,402	93	86	124	465	219
Heavy-Duty Diesel Vehicles	1,935	59	54	87	564	26
Railroad Locomotives	286	10	9	20	44	32
Ocean-Going Vessels	3,691	348	279	165	319	3,270
Harbor Craft	486	26	24	18	41	50
<b>Total PANYNJ Emissions</b>	<b>7,800</b>	<b>537</b>	<b>452</b>	<b>413</b>	<b>1,434</b>	<b>3,597</b>
<b>NYNJLINA Emissions</b>	<b>445,285</b>	<b>178,451</b>	<b>42,441</b>	<b>522,245</b>	<b>2,840,374</b>	<b>170,044</b>
<b>PANYNJ Percentage</b>	<b>1.8%</b>	<b>0.3%</b>	<b>1.1%</b>	<b>0.1%</b>	<b>0.05%</b>	<b>2.1%</b>