PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS - 2009

THE PORT OF LOS ANGELES

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Prepared by:
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THE PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2009

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ACRONYMS AND ABBREVIATIONS

Act	Activity
ARRA	American Reinvestment and Recovery Act
AMP	alternative maritime power
APL	American Presidents Line
APPS	Act to Prevent Pollution from Ships
AQMP	Air Quality Management Plan
APM	A. P. Moeller
AS	actual speed
ATB	articulated tug and barge
BACT	Best Available Control Technology
BNSF	Burlington Northern Santa Fe Railroad
BSFC	brake specific fuel consumption
BTH	Business Transportation and Housing Agency
BTM	body type model (heavy-duty trucks)
BW	breakwater
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CEC	California Energy Commission
CF	control factor
CH_4	methane
CHE	cargo handling equipment
CO	carbon monoxide
CO_2	carbon dioxide
CRC	Coordinating Research Council
D	distance
CTP	Clean Truck Program
DB	dynamic braking
DF	deterioration factor
DMV	Department of Motor Vehicles
DOC	diesel oxidation catalyst
DOE	Department of Energy
DPF	diesel particulate filter
DPM	diesel particulate matter
DR	deterioration rate
DTR	Drayage Truck Registry

DWT	deadweight tonnage
E	emissions
ECA	Emission Control Area
EEIA	Energy and Environmental Analysis
EF	emission factor
EI	emissions inventory
EMD	(GE) Electromotive Division
EPA	U.S. Environmental Protection Agency
FCF	fuel correction factor
g/bhp-hr	grams per brake horsepower-hour
g/day	grams per day
g/kW-hr	grams per kilowatt-hour
g/mi	grams per mile
GHG	greenhouse gas
GM	goods movement
GMP	Goods Movement Plan
GVWR	gross vehicle weight rating
GWP	global warming potential
HC	Hydrocarbons - total
HDDV	heavy-duty diesel vehicle
HDV	heavy-duty vehicle
HFCs	hydrofluorocarbons
HFO	heavy fuel oil
hp	horsepower
hrs	hours
ICTF	Intermodal Container Transfer Facility
IFO	intermediate fuel oil
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ITB	integrated tug and barge
kW	kilowatt
L.A.	Los Angeles
l/cyl	liters per cylinder
LF	load factor
LLA	low load adjustment
Lloyd's	Lloyd's Register of Ships
LNG	liquefied natural gas
LPG	liquefied petroleum gas

LSI	large spark ignited (engine)
M&N	Moffatt & Nichol Engineers
MarEx	Marine Exchange of Southern California
MCR	maximum continuous rating
MDO	marine diesel oil
MGO	marine gas oil
MMGT	million gross tons
MOU	Memorandum of Understanding
mph	miles per hour
MS	maximum speed
MY	model year
N	north
NAAQS	National Ambient Air Quality Standards
nm	nautical miles
NO_x	oxides of nitrogen
N_2O	nitrous oxide
NYK	Nippon Yusen Kaisha
NRE	National Railway Equipment Co.
OBD	on-board diagnostics
OCR	optical character recognition
OGV	ocean-going vessel
PCST	Pacific Cruise Ship Terminals
PFCs	perfluorocarbons
PHL	Pacific Harbor Line
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PMSA	Pacific Merchant Shipping Association
POLB	Port of Long Beach
ppm	parts per million
PZ	precautionary zone
Reefer	refrigerated vessel
RFID	radio frequency identification
RH	relative humidity
RIA	Regulatory Impact Analysis
RO	residual oil
rpm	revolutions per minute
RSD	Regulatory Support Document

RTG	rubber tired gantry crane
S	sulfur
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SF_6	sulfurhexafluoride
SFC	specific fuel consumption
SO_x	oxides of sulfur
SoCAB	South Coast Air Basin
SPBP	San Pedro Bay Ports
SSA	Stevedoring Services of America
TAP	Technology Advancement Program
TWG	Technical Working Group
TEU	twenty-foot equivalent unit
TICTF	Terminal Island Container Transfer Facility
tpd	tons per day
tpy	tons per year
UDDS	Urban Dynamometer Driving Schedule
U.S.	United States
ULSD	ultra low sulfur diesel
UNFCCC	United Nations Framework Connection on Climate Change
UP	Union Pacific Railroad
USCG	U.S Coast Guard
VBP	vessel boarding program
VDEC	verified diesel emission control system
VIN	vehicle identification number
VLCS	very large cargo ship
VMT	vehicle miles of travel
VOCs	volatile organic compounds
VSR	vessel speed reduction
VSRIP	Vessel Speed Reduction Incentive Program
VTS	vessel traffic service
W	west
ZH	zero hour
ZMR	zero mile rate

EXECUTIVE SUMMARY

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 30% of all U.S. containerized trade flows. Although recent economic conditions have caused a near-term reduction in imports and exports, the latest economic forecasts still indicate that the demand for containerized cargo moving through the San Pedro Bay region will increase significantly over the next two decades. The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. Therefore, in November 2006, the San Pedro Bay Ports adopted their landmark, joint Clean Air Action Plan (CAAP) designed to reduce the air health risks and emissions associated with port-related operations, while allowing port development to continue. In order to track CAAP progress, the Port has committed to develop annual air emissions inventories.

The Port released its first activity-based emissions inventory in July 2005, documenting activity levels for the year 2001. In 2007, the Port released the 2005 Inventory of Air Emissions which was the first update since the 2001 inventory and also the first of the annual inventories to follow. In July 2008, the Port released the 2006 Inventory of Air Emissions which was the first emissions inventory report in which the Port included estimates of greenhouse gas (GHG) emissions. In December 2008, the Port released the 2007 Inventory of Air Emissions, and in December 2009, the Port released the 2008 Inventory of Air Emissions.

This study, the 2009 Inventory of Air Emissions, includes emissions estimates based on 2009 activity levels and a comparison with 2005, 2006, 2007 and 2008 emissions estimates to track CAAP progress. As in previous inventories, the following five source categories are included:

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

Exhaust emissions of the following pollutants that can cause local impact have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Hydrocarbons (HC)
- Carbon monoxide (CO)

This study also includes emission estimates of greenhouse gases (GHGs) from port-related tenant operational sources. The following GHGs have been estimated:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Methodology Overview and Geographical Extent

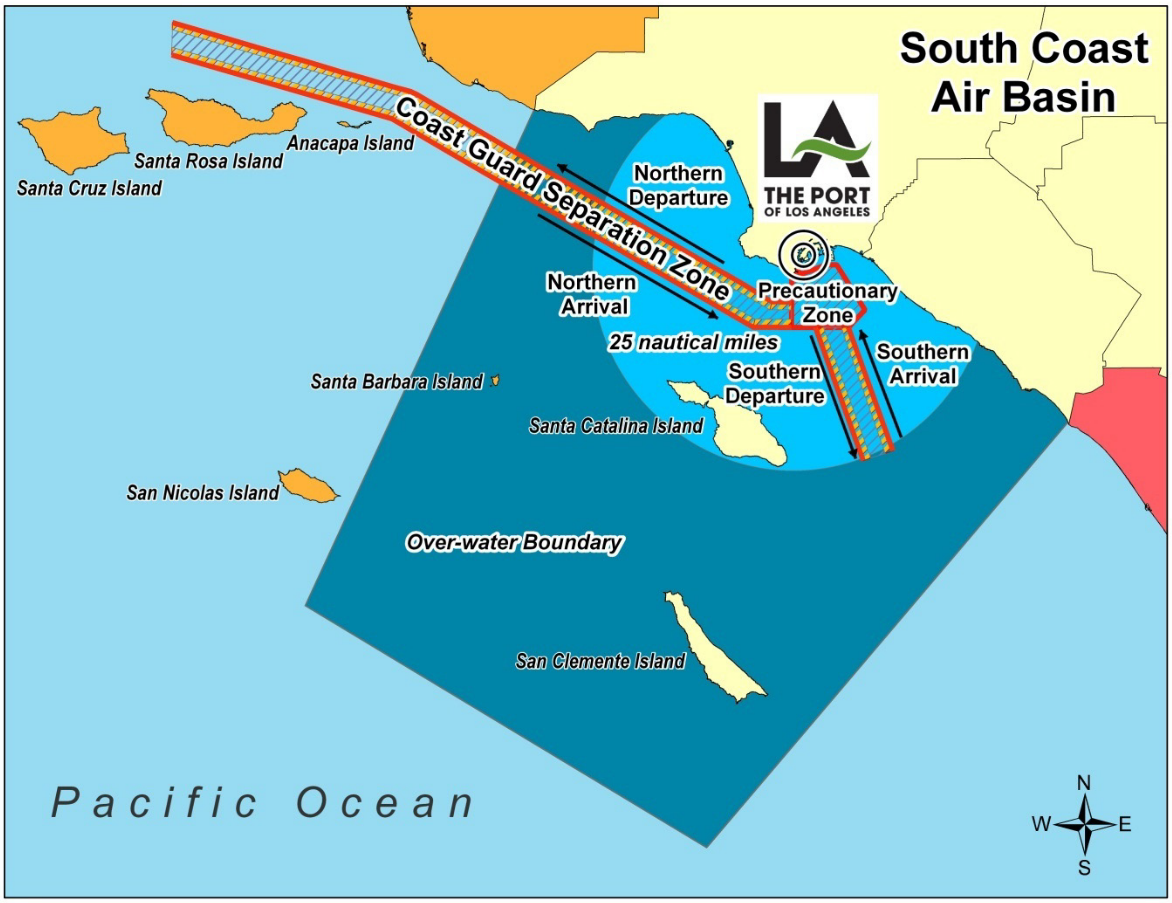
Port tenants and shipping lines play an essential role in the development of an activity-based emissions inventory (EI) by providing the most accurate activity and operational information available. Emissions estimates are developed for each of the various source categories in a manner consistent with the latest estimating methodologies agreed upon by the Port and the participating regulatory agencies. The information gathered, analyzed, and presented in this EI continues to improve the understanding of the nature and magnitude of Port-related emission sources. Development of this inventory was coordinated with the U.S. Environmental Protection Agency - Region 9 (EPA), California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD).

The geographical extent of the inventory is described in Section 1 and in each source category section of the report. The geographical extent of the port-related emissions did not change from previous inventories and includes 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 ES.1 shows the SoCAB boundary.

Figure ES.1: South Coast Air Basin Boundary

Figure ES.2 shows the geographical extent for the ocean-going vessels and harbor craft. The over-water boundary is bounded in the north by the southern Ventura County line at the coast and in the south with the southern Orange County line at the coast.

Figure ES.2: OGV Inventory Geographical Extent



Summary of 2009 Activity

Table ES.1 lists the number of vessel calls and the container cargo throughputs for calendar years 2005 to 2009. In 2009, total TEU throughput at the Port of Los Angeles continued to decline from its peak in 2006 due to recent global economic conditions. The TEU/containership-call efficiency improvements experienced from 2005 to 2008 did not continue in 2009. Despite a 14% decrease in TEUs in 2009, containership calls decreased by only 7%, indicating that on average there were fewer containers unloaded and loaded per vessel call despite the increased use of larger vessels (containerships with TEU capacity of 7,000 or greater). Likely explanations are that containerships were either running less full, calling at more west-coast berths per service, or discharging more cargo at other ports. Compared to 2005, the total TEUs and containership calls decreased by about 10% in 2009 while the TEU/containership-call efficiency remained about the same.

Table ES.1: TEUs and Vessel Call Comparison, %

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2009	2,010	1,355	6,748,995	4,981
2008	2,239	1,459	7,849,985	5,380
2007	2,527	1,573	8,355,038	5,312
2006	2,703	1,627	8,469,853	5,206
2005	2,501	1,481	7,484,625	5,054
Previous Year (2009-2008)	**-10%**	**-7%**	**-14%**	**-7%**
CAAP Progress (2009-2005)	**-20%**	**-9%**	**-10%**	**-1%**

In 2009, there were several significant changes that impacted 2009 port-wide emissions and resulted in lower emissions compared to previous years. The economic slowdown in 2009 with reduced throughput levels was a major factor in emission reductions. However, the rate of emission reductions in 2009 was higher than the change in activity level because of the emission reduction strategies implemented by the Port, tenants, and vessel operators in 2009.

Major highlights of control strategies implemented in 2009 include:

- For ocean-going vessels, the percentage of vessel calls that switched to a cleaner fuel (with lower sulfur content) in main and auxiliary engines was 13% for the first half of 2009 driven by the Port's Fuel Incentive Program. In addition, CARB's marine fuel regulation became effective for the second half of the year requiring cleaner fuel in main and auxiliary engines and auxiliary boilers at berth and within 24 nautical miles (nm) from coast.

- For heavy-duty vehicles, implementation of the Port's Clean Truck Program has resulted in significant turn-over of older trucks to newer and cleaner trucks. The percentage of 2007+ model year trucks increased from about 4% in 2008 to 16% in 2009 (population-weighted basis). The average age of the Port-related truck fleet was 10.9 years in 2009 compared to 12.1 years in 2008. In terms of the calls made by these trucks to terminals, the call-weighted average age in 2009 was 6.9 years as compared to 11.6 years in 2008. This indicates that a large number of newer trucks made proportionally more calls than their older counterparts.

- For the cargo handling equipment and harbor craft categories, implementation of CAAP measures and CARB's regulations along with funding incentives resulted in continued replacement of existing older equipment and vessels (and engines) with cleaner units and lower emissions.

- For locomotives, the fleet-wide emission rates continued to decrease due to the increased introduction of cleaner line haul and switcher locomotives.

Summary of 2009 Emission Estimates

The results for the Port of Los Angeles 2009 Inventory of Air Emissions are presented in this section. Table ES.2 summarizes the 2009 total port-related mobile source emissions of air pollutants in the SoCAB by category.

Table ES.2: 2009 Port-related Emissions by Category, tons per year

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	287	229	244	4,039	2,418	438	208
Harbor craft	56	51	56	1,276	1	390	92
Cargo handling equipment	25	24	24	750	1	712	40
Rail locomotives	28	26	28	940	7	160	51
Heavy-duty vehicles	115	106	115	4,238	5	1,077	208
Total	**511**	**436**	**467**	**11,244**	**2,432**	**2,777**	**599**

DB ID457

The total port-related mobile source GHG emissions in the SoCAB are summarized in Table ES.3 which presents the GHG emissions in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used for criteria pollutants. Throughout the report, GHG emissions are reported in metric tons per year. The CO_2 equivalent values are derived by multiplying the GHG emissions estimates for CO_2, N_2O, and CH_4 by their respective global warming potential (GWP)[1] values and then adding them together.

[1] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, April 2009.

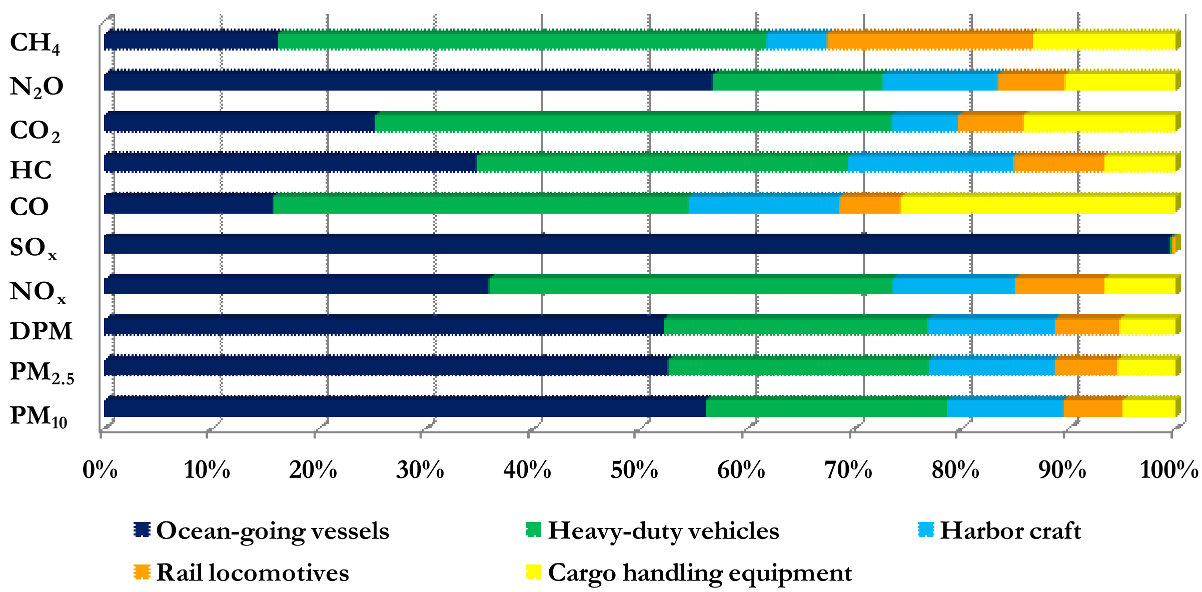
Table ES.3: 2009 Port-related GHG Emissions by Category, metric tons per year

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	232,272	228,105	13	4
Harbor craft	56,562	55,759	3	1
Cargo handling equipment	129,063	128,257	2	3
Rail locomotives	55,629	55,082	1	4
Heavy-duty vehicles	437,120	435,759	4	11
Total	**910,647**	**902,961**	**23**	**23**

DB ID457

Figure ES.3 shows the distribution of the 2009 total port-related emissions for each pollutant and source category. Ocean-going vessels (52%) and heavy-duty trucks (25%) contribute the highest percentage of diesel particulate matter (DPM) emissions among the port-related sources. Over 99% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks (38%) and OGV (36%) account for the majority of NO_x emissions. Heavy-duty trucks (39%) and CHE (26%) account for the majority of CO emissions. Heavy-duty trucks (35%) and OGV (35%) account for the majority of hydrocarbon emissions.

Figure ES.3: 2009 Port-related Emissions by Category, %



In order to put the Port-related emissions into context, the following figures compare the Port's contribution to the total emissions in the SoCAB by major source category. The 2009 SoCAB emissions used for this comparison are based on the 2007 Air Quality Management Plan (AQMP).[2]

In 2009, the Port-related mobile sources contributed to 5% of diesel particulate matter emissions (DPM), 4% of NO_x emissions, and 17% of SO_x emissions in the SoCAB.

Figure ES.4: 2009 DPM Emissions in the South Coast Air Basin, %

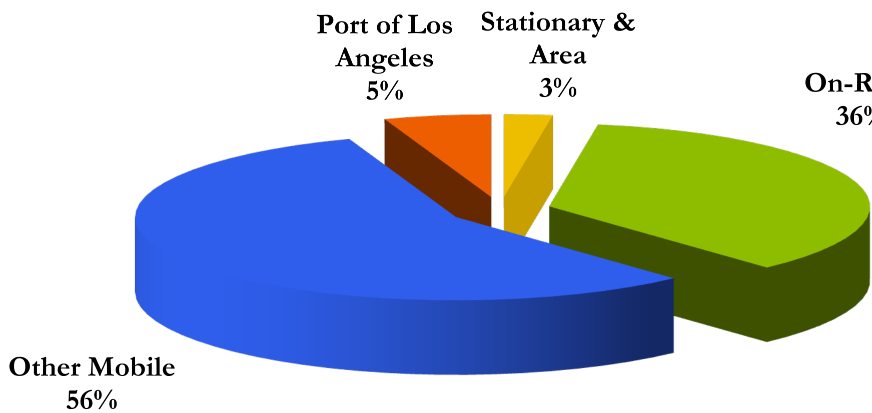
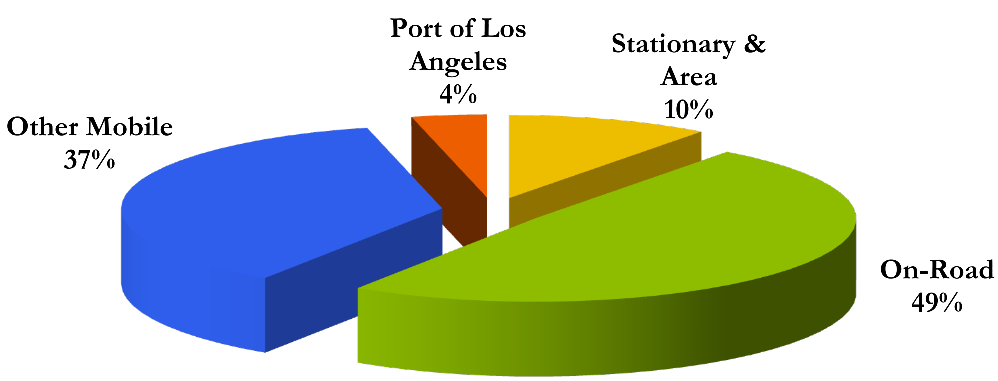


Figure ES.5: 2009 NO_x Emissions in the South Coast Air Basin, %



[2] SCAQMD, *Final 2007 AQMP Appendix III, Base & Future Year Emissions Inventories*, June 2007.

Figure ES.6: 2009 SO_x Emissions in the South Coast Air Basin, %

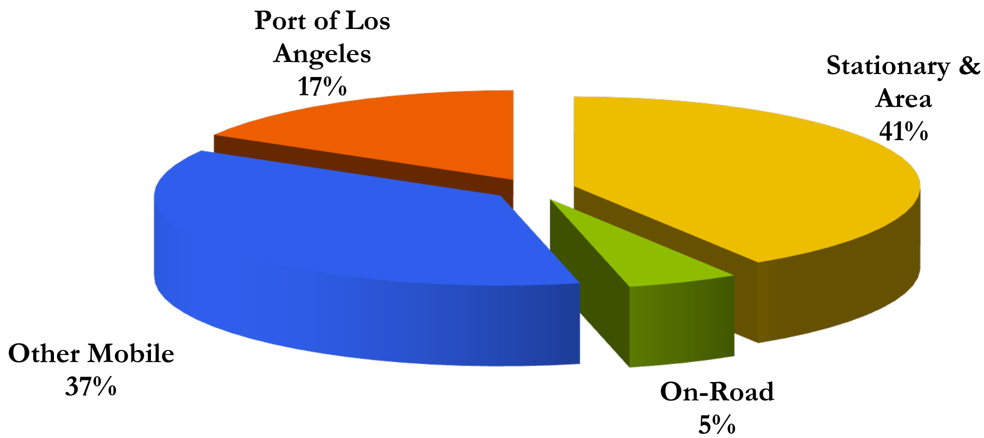


Figure ES.7 provides a comparison of the Port-related mobile source emissions to the total SoCAB emissions from 2005 to 2009. As indicated, the Port's overall contribution to the SoCAB emissions has continued to decrease primarily because of the implementation of control programs.

Figure ES.7: Port's Emissions in the South Coast Air Basin

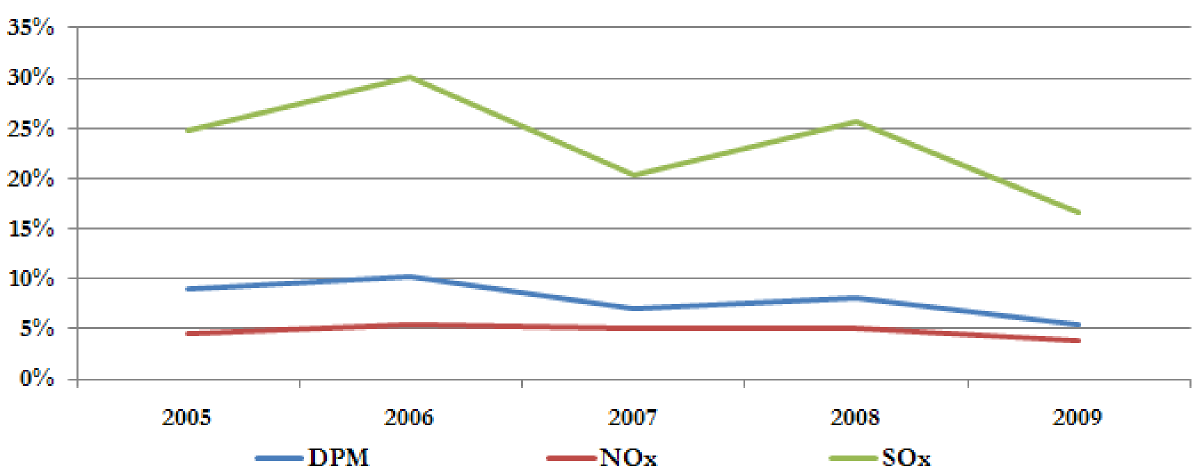


Table ES.4 presents the total net change in emissions for all source categories in 2009 as compared to previous years. The percent change is shown for the previous year (2008) and for the CAAP progress (2005). From 2008 to 2009, there was a 14% decrease in throughput and emissions decreased 37% for DPM, 28% for NO_x, 36% for SO_x, 27% for CO and 26% for HC emissions. From 2005 to 2009, there was a 10% decrease in throughput and emissions decreased 52% for DPM, 33% for NO_x, 56% for SO_x, 32% for CO, and 31% for HC emissions.

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

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	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
Previous Year (2009-2008)	**-37%**	**-37%**	**-37%**	**-28%**	**-36%**	**-27%**	**-26%**
CAAP Progress (2009-2005)	**-52%**	**-52%**	**-52%**	**-33%**	**-56%**	**-32%**	**-31%**

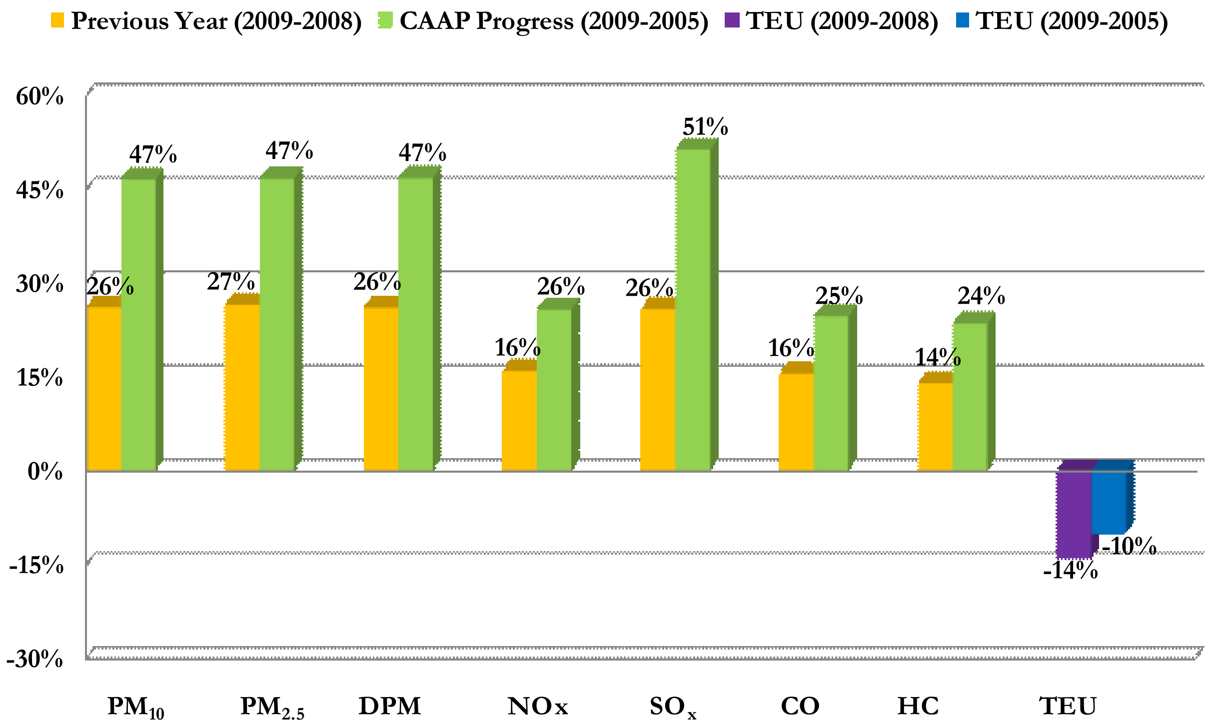
Table ES.5 summarizes the annualized emissions efficiencies (i.e., emissions per container handled) for all five source categories in tons of pollutant per 10,000 TEU moved. In 2009, the overall port efficiency improved for all pollutants as compared to 2008 and 2005. A positive percentage means an increase in emission efficiency in Table ES.5 and Figure ES.8.

Table ES.5: Emissions Efficiency Comparison, tons/10,000 TEU and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.76	0.65	0.69	16.66	3.60	4.11	0.89
2008	1.03	0.88	0.94	19.84	4.87	4.87	1.03
2007	0.93	0.80	0.82	20.40	4.25	4.83	1.05
2006	1.35	1.15	1.23	22.74	7.11	5.50	1.16
2005	1.42	1.21	1.30	22.46	7.42	5.47	1.16
Previous Year (2009-2008)	**26%**	**27%**	**26%**	**16%**	**26%**	**16%**	**14%**
CAAP Progress (2009-2005)	**47%**	**47%**	**47%**	**26%**	**51%**	**25%**	**24%**

Figure ES.8 compares emissions efficiency changes between 2009 and previous years. The purple bar represents TEU change from previous year (-14%) and the blue bar represents TEU change compared to 2005 (-10%). For the 2009-2008 and 2009-2005 comparisons, the emissions efficiencies improved for all pollutants.

Figure ES.8: Emissions Efficiency Comparison, % Change



CAAP Progress

One of the main purposes of the annual inventories is to provide a progress update on achieving the Clean Air Action Plan's San Pedro Bay Standards. These standards consist of the following reduction goals, compared to 2005 published inventories:

- Emission Reduction Standard:
  - By 2014, reduce emissions by 72% for DPM, 22% for NO_x, and 93% for SO_x
  - By 2023, reduce emissions by 77% for DPM, 59% for NO_x, and 92% for SO_x
- Health Risk Reduction Standard: 85% reduction by 2020

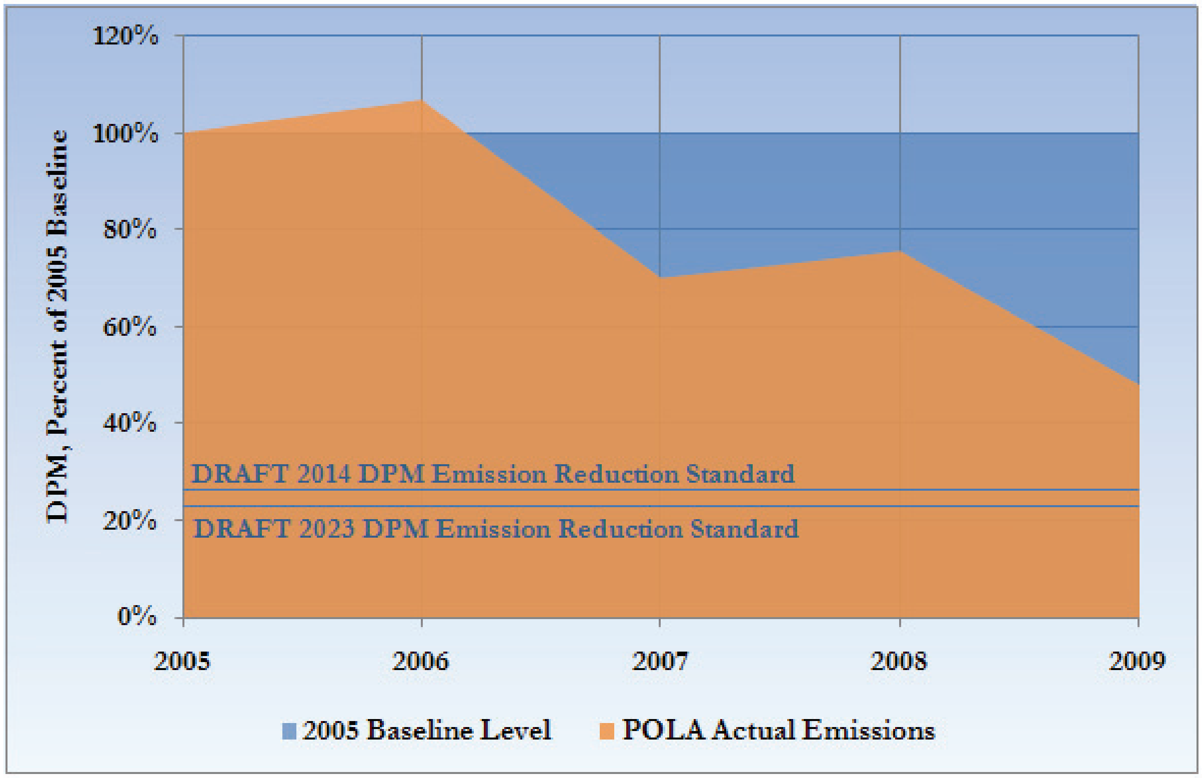
Note: At the time of publication of this document, the standards bulleted above are draft standards that have been released for public review but not formally adopted by the Board of Harbor Commissioners. It is anticipated that the standards will be presented to the Board in 2010 as part of the CAAP Update process currently underway.

Emission Reduction Progress

The Emission Reduction Standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the regional SoCAB attainment dates for the federal $PM_{2.5}$ and ozone ambient air quality standards in the 2007 AQMP. Figures ES.9 through ES.11 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions as well as the draft 2014 and 2023 standards to provide a snapshot of progress to-date towards meeting those standards. In Figure ES.9, DPM emissions reductions are presented as a surrogate to $PM_{2.5}$ reductions since DPM is directly related to $PM_{2.5}$ emissions (equivalent of PM_{10} emissions from diesel-powered sources). In Figure ES.10, NO_x emissions reductions are presented since NO_x is a precursor to the ambient ozone formation and it also contributes to the formation of $PM_{2.5}$. SO_x emissions reductions are presented in Figure ES.11 because of the contribution of SO_x to $PM_{2.5}$ emissions.

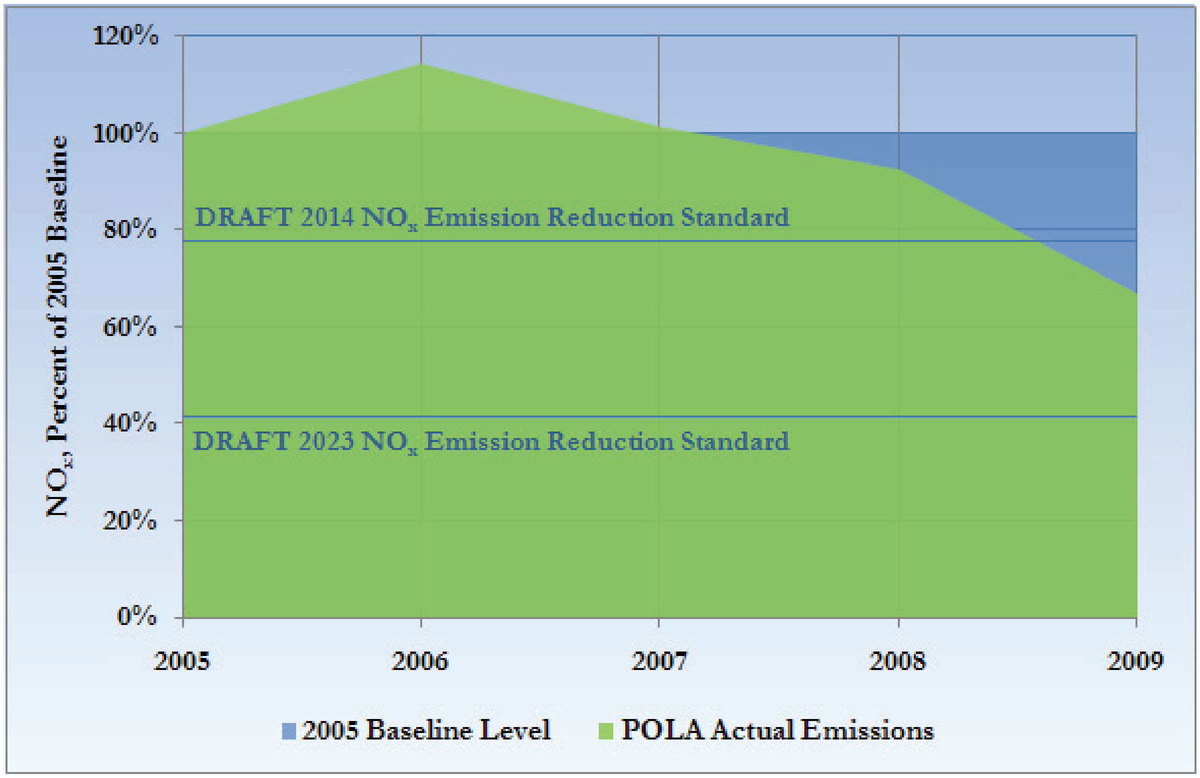
It is important to note that a portion of the current year's emission reductions are attributable to lower cargo throughout. As anticipated cargo volumes increase in the upcoming years, the reduction trend may not continue at the same rate experienced over the last few years. However, continued implementation of several significant emission reduction programs, such as the Port's Clean Truck Program, Vessel Speed Reduction, AMP and CARB's regulatory strategies for port-related sources, is expected to substantially mitigate the impact of resumed cargo growth.

Figure ES.9: DPM Reductions - Progress to Date Compared to 2005



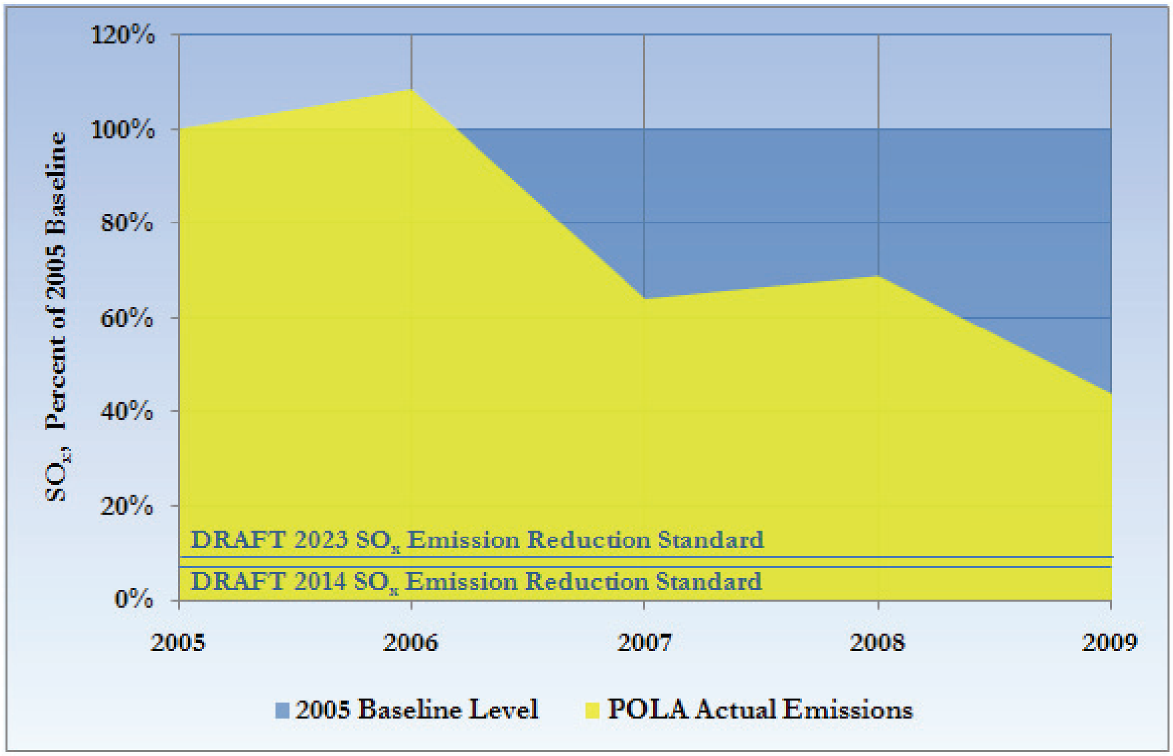
As presented above, by 2009, the Port is over half way towards meeting the 2014 DPM Emission Reduction Standard. With implementation of CAAP measures in 2010 and subsequent years (e.g., vessel speed reduction, shore power), the Port's Clean Truck Program (CTP) and CARB's OGV marine fuel regulation (fully effective in 2010), it is anticipated that the DPM reduction trend will continue in 2010.

Figure ES.10: NO_x Reductions - Progress to Date Compared to 2005



As shown above, the Port is exceeding the 2014 NO_x Emission Reduction Standard in 2009 in part due to lower cargo throughput but also because of the implementation of the emissions control programs. The Port's Clean Truck Program and CAAP measures including the expanded Vessel Speed Reduction (VSR) program, Alternative Maritime Power (AMP) program, and slide valves in OGVs are the primary strategies for reducing NO_x emissions. Implementation of these strategies and CARB's at-berth regulation will significantly help in meeting these standards despite potential increases in throughput.

Figure ES.11: SO_x Reductions - Progress to Date Compared to 2005

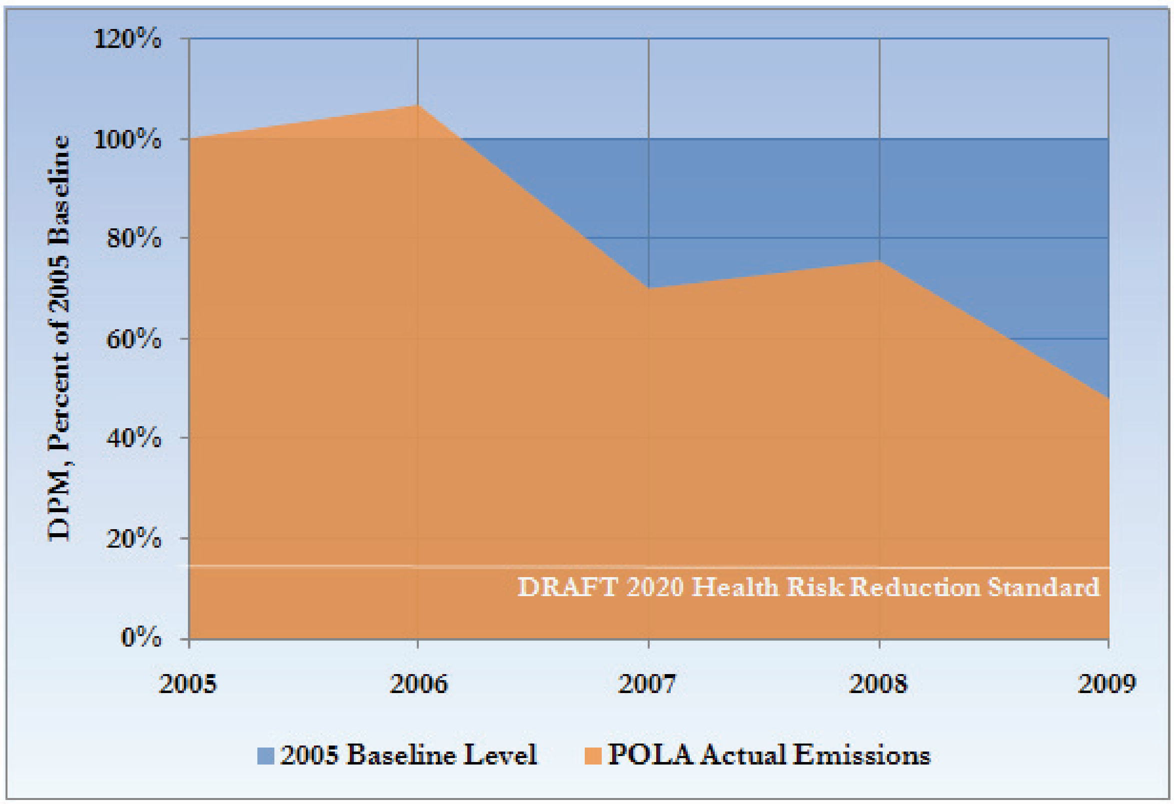


As shown above, by 2009, the Port is over half way towards meeting the SO_x Emission Reduction Standard. Implementation of CAAP measures and CARB's OGV fuel regulation (fully effective in 2010) will result in even higher rates of SO_x reductions in the coming years. The slight erosion of SO_x reductions from 2007 to 2008 was due to the injunction against the previous CARB OGV fuel rule in 2008.

Health Risk Reduction Progress
As described in upcoming CAAP Update, the effectiveness of CAAP's control measures and applicable regulations with respect to the Health Risk Reduction Standard can be tracked by changes in mass emission reductions in DPM from the 2005 baseline. DPM is the predominant contributor to port-related health risk, and the Health Risk Reduction Standard was based on a health risk assessment study that used forecasted reductions in geographically allocated DPM emissions as the key input. Therefore, reductions in DPM mass emissions associated with CAAP measures and applicable regulations are a representative surrogate for health risk reductions.

Progress to-date on health risk reduction is determined by comparing the change in DPM mass emissions to the 2005 baseline. Figure ES.12 presents the progress of achieving the standard to date.

Figure ES.12: Health Risk Reduction Benefits - Progress To Date



As shown above, by 2009 the Port is over half way towards meeting the 2020 Health Risk Reduction Standard. With additional CAAP measures coming on line, CARB's OGV marine fuel regulation, and the continued truck fleet modernization under the Clean Truck Program, it is anticipated that the reduction trend will continue in 2010 and coming years.

SECTION 1 INTRODUCTION

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 30% of all U.S. containerized trade flows. The San Pedro Bay Ports customs district accounts for approximately $300 billion in annual trade. Despite a recent worldwide downturn in shipping, economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will increase significantly over the next two decades. The economic benefits of the Ports are felt throughout the nation.

The ability of the San Pedro Bay Ports to accommodate the projected growth in trade will depend upon the ability of the two ports and their tenants to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. In November 2006, the San Pedro Bay Ports adopted their landmark Clean Air Action Plan (CAAP), designed to reduce health risks and emissions associated with port-related operations while allowing port growth to continue. In order to track CAAP progress, the Port has committed to develop annual inventories of port-related sources starting with the 2005 Inventory of Air Emissions (which served as the CAAP baseline). The detailed annual activity-based inventory, with associated emissions estimates, is a critical and integral component to the success of the CAAP. Activity-based inventories based on detailed data collected on activities that occurred in a specific time period provide the most detailed inventory of air emissions for port-related sources. Activity-based inventories not only provide a greater understanding of the nature and magnitude of emissions, but also help track progress for the many emission reduction strategies that the Port, a landlord port, and its tenants have undertaken.

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives and on-road heavy-duty vehicles and evaluated operations at all Port terminals. The 2001 inventory provided the basis for the CAAP. In 2007, the Port released the 2005 Inventory of Air Emissions which was the first update to the baseline inventory and also the first of the annual inventories to follow. In July and December 2008, the Port released the 2006 and 2007 Inventory of Air Emissions, respectively. In December 2009, the Port released the 2008 Inventory of Air Emissions. These inventory reports are available on the Port's website: *http://www.portoflosangeles.org/environment/studies_reports.asp*

1.1 Goods Movement

International Goods Movement has become a significant contributor to the growth of the southern California economy, and has introduced significant challenges to meeting the National Ambient Air Quality Standards (NAAQS) in the South Coast Air Basin (SoCAB). The Business, Transportation and Housing Agency (BTH) and the California Environmental Protection Agency (Cal/EPA) have jointly adopted a Goods Movement Action Plan (GMP).[3] The GMP is intended to address goods movement related issues such as current and future infrastructure needs, impact on environment, adverse impact mitigation measures to protect public health and community concerns, public safety and security issues, and workforce development opportunities regarding goods movement. As stated in the GMP, "(i)t is the policy of this Administration to improve and expand California's goods movement industry and infrastructure in a manner which will:

- Generate jobs
- Increase mobility and relieve traffic congestion
- Improve air quality and protect public health
- Enhance public and port safety
- Improve California's quality of life"

GMP is focused to address goods movement in California's four major "port-to-border" goods movement corridors:

- Los Angeles-Long Beach/Inland Empire
- Bay Area
- San Diego/Border
- Central Valley

Over decades, these corridors have been major routes for ship to rail, ship to truck, and truck to rail exchanges to move millions of containers per year to their ultimate destinations. As stated in the GMP, "to help develop order of magnitude estimates of how effort should be distributed among the corridors, the agencies compiled a series of indices to compare and contrast key indicators among the corridors. Items included:

- Value by customs district
- Maritime container volume
- Port of Entry tonnage
- Logistics jobs
- Daily vehicle hours of delay
- Mean average annual daily truck volume
- Total emissions per day
- Population

[3] *Goods Movement Action Plan,* 11 January 2007. See: *http://www.arb.ca.gov/gmp/gmp.htm.*

While the relative fractions or contributions of each of these factors vary by corridor, an un-weighted aggregate of the fractions indicate that the Los Angeles/Long Beach-Inland Empire corridor in southern California ranks first by a large margin with about 60 percent of the aggregate shares. The Bay Area, Central Valley, and San Diego corridors represent 19 percent, 13 percent, and 8 percent, respectively. More specific analysis will be necessary to determine the relative allocation of effort among the corridors to achieve simultaneous and continuous improvement."[4]

As a part of the GMP, the California Air Resources Board (CARB) is responsible for developing an emissions reduction plan based on international as well as domestic goods movement related future activities of the four corridors mentioned above. In April of 2006, CARB adopted the *Emissions Reduction Plan for Ports and Goods Movement in California*. The international goods movement category includes emissions from all on-port sources, including:

- All ocean-going vessels up to 24 nautical miles
- All harbor craft up to 24 nautical miles
- All cargo handling equipment
- All on-port trucks operation
- All on-port rail operations
- International goods movement portion of off-port truck operation
- International goods movement portion of off-port rail operation

According to the GMP, the State's five specific goals for addressing the air pollution associated with goods movement are:

1) Reduce total statewide international and domestic goods movement emissions to the greatest extent possible and at least back to 2002 levels by year 2010;
2) Reduce the statewide diesel particulate matter (PM) health risk from international and domestic goods movement 85 percent by year 2020;
3) Reduce oxides of nitrogen (NO_x) emissions from international goods movement in the South Coast 30 percent from projected year 2015 levels, and 50 percent from projected year 2020 levels based on preliminary targets for attaining federal air quality standards;
4) Apply the emission reduction strategies for ports and goods movement statewide to aid all regions in attaining air quality standards; and
5) Make every feasible effort to reduce localized risk in communities adjacent to goods movement facilities as expeditiously as possible.[5]

[4] CARB, Emissions Reduction Plan for Ports and Goods Movement 20 April 2006. (CARB 2006) See: *http://arb.ca.gov/planning/gmerp/gmerp.htm.*
[5] CARB 2006.

In 2007, CARB adopted the State Strategy for California's 2007 State Implementation Plan[6] which included a number of specific control strategies targeting goods movement. These strategies have either been adopted into regulations or are currently under development.

1.2 Container Movements

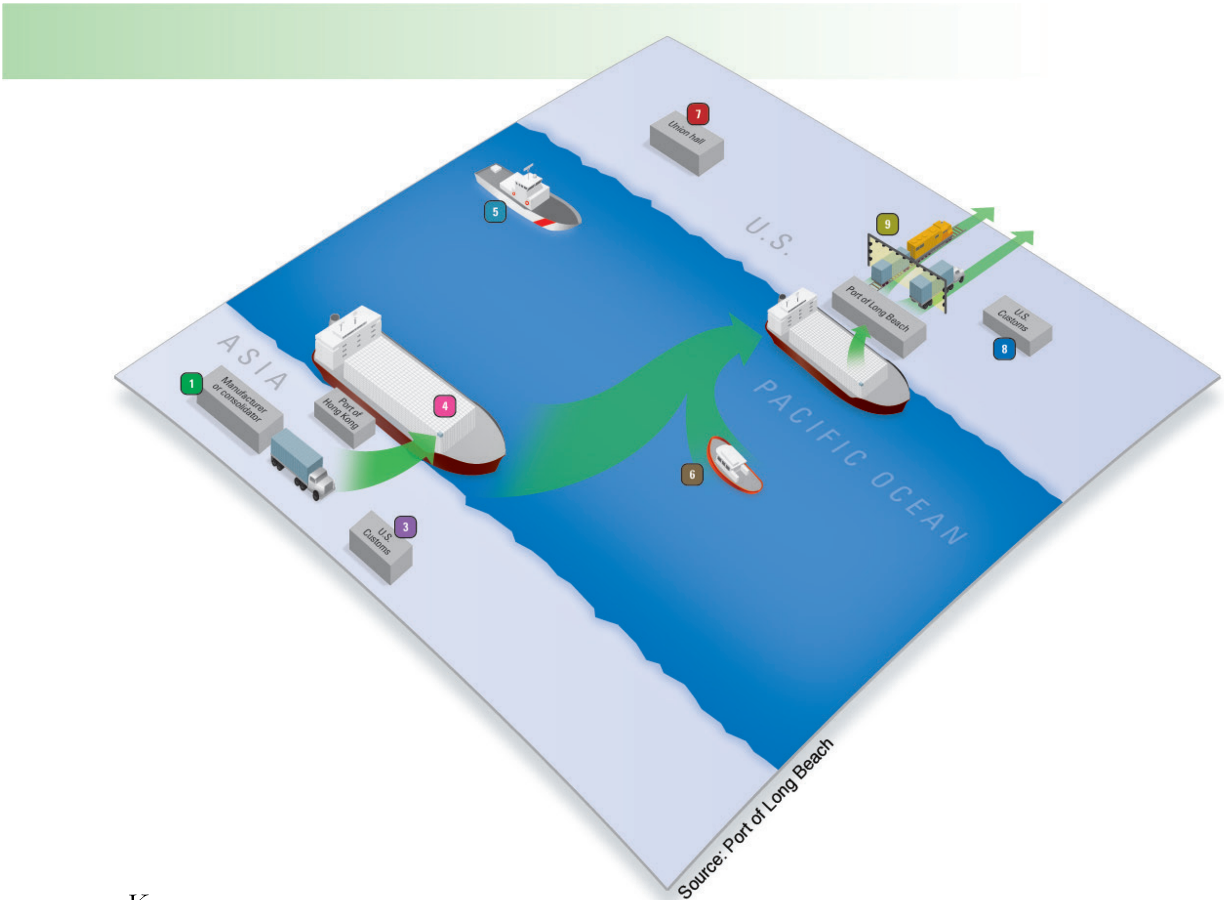
Container terminals and their associated cargo movements are complex intermodal operations that are critical to international trade. Containerized cargo has significantly increased the efficiency and capacity of the transportation system over the prior general cargo/break bulk cargo models (which still exist for non-containerized cargo). Due to the inherent efficiencies of containerized cargo, the types of cargo shipped via containers are increasing yearly. To better understand the operations of the international transportation network associated with ports, this subsection describes overseas container transport, import cargo containers, export cargo containers, and how empty cargo containers are handled.

1.2.1 Overseas Container Transport

Imported cargo generally starts at an overseas manufacturer, supplier, or consolidation facility, where items are boxed and placed inside metal shipping containers. Containers generally come in two common lengths: 20 feet or 1 twenty-foot equivalent (TEU), and 40 feet or two TEUs. Other sizes such as 45-feet and 53-feet are also used. The U.S. buyer may contact an industry professional known as a "freight forwarder," or logistics company, to coordinate landside transportation of the cargo. The container is then transported to a foreign port, assessed for possible security risks, and placed on board a containership, which is specifically designed to carry containerized cargo. Containerships calling at the San Pedro Bay ports range from 2,000 to over 8,000 TEUs per ship. The containerships transport the containerized cargo to the Port, where it is unloaded, and forwarded to local or national destinations. Figure 1.1 presents the steps that are associated with overseas cargo movements.[7]

[6] http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm.
[7] Port of Long Beach, Cargo Movement in Focus, 2006.

Figure 1.1: Overseas Container Transport



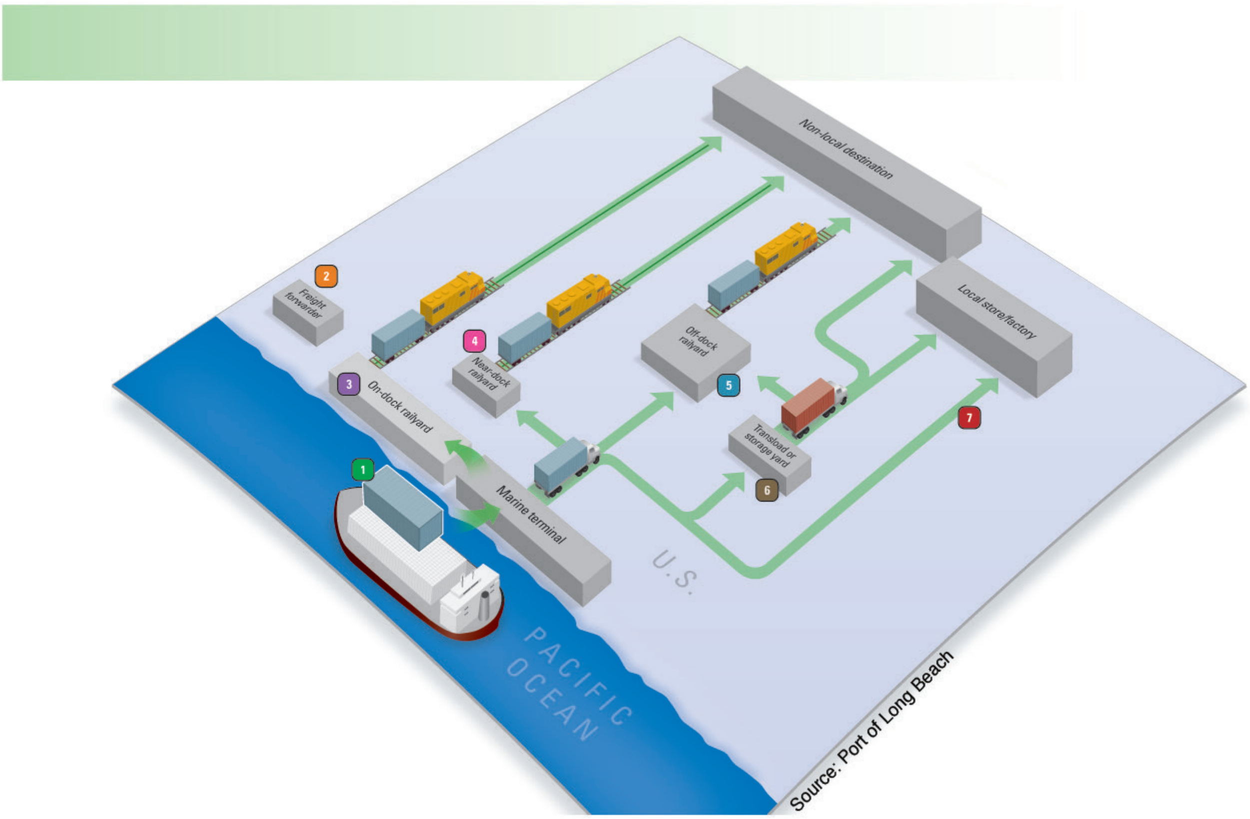
Key:
1) Product ordered
2) Container transported to foreign port (not shown)
3) Security check conducted by U.S. Customs agents based at foreign ports
4) Container loaded onboard containership
5) Coast Guard review conducted for ship, crew, and cargo manifests
6) Containership boarded and docked by a Port pilot
7) Ship unloaded by longshore workers (see Figure 1.2 for details)
8) Security check conducted by U.S. Customs agents
9) Container surveyed for radiation

1.2.2 Import Container Transport

Once the ship arrives at the Port, the imported containers are either transported by train or by truck to their final destination, or to one of several intermediate destinations such as a railyard, warehouse, distribution center, or "transload" facility (a sorting, routing, and short-term storage facility). A container's final destination will determine exactly what path it will take once it leaves the dock. Figure 1.2 presents the steps that are associated with imported container cargo movements.[8]

[8] Port of Long Beach, Cargo Movement in Focus, 2006.

Figure 1.2: Import Container Transport



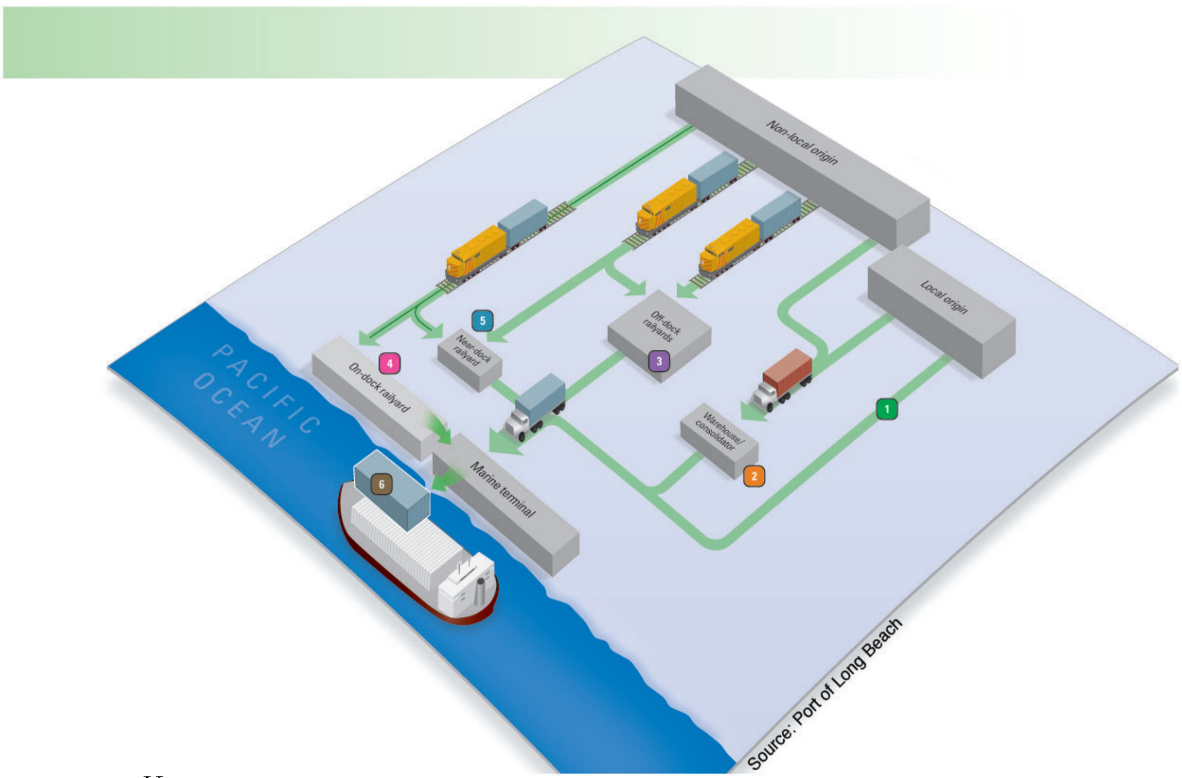
Key:

1) The marine terminal operator will arrange for unionized longshore workers to unload the ship. Containers are placed on trucks, rail, or terminal cargo handling equipment for storage on terminal.
2) Trucking company or train operator contacted by freight forwarder or logistics provider to move the container out of the terminal.
3) Cargo placed directly on rail using "on-dock" rail (as available).
4) Near-dock rail yards are used for terminals without on-dock rail or if additional rail capacity is needed. Trucks are used to "dray" containers from terminals to railyard.
5) Off-dock railyards are used to coordinate rail deliveries to national destinations. Containers are delivered by truck, then sorted and grouped by final destination. These railyards handle Port cargo as well as domestic cargo from other sources.
6) Shipping containers are often moved initially to a "transload" facility where cargo is unloaded, sorted, and repackaged into larger-sized truck trailers. The cargo is then delivered from the facility to regional distribution centers, local stores, or off-dock railyards.

1.2.3 Export Container Transport

Export container cargo is similar to import containers; however, the flow is in the opposite direction. As with imported cargo, exported cargo may require multiple intermediate stops between its producer/manufacturer and the Port. Figure 1.3 presents the steps that are associated with exported container cargo movements.[9]

Figure 1.3: Export Container Transport



Key:

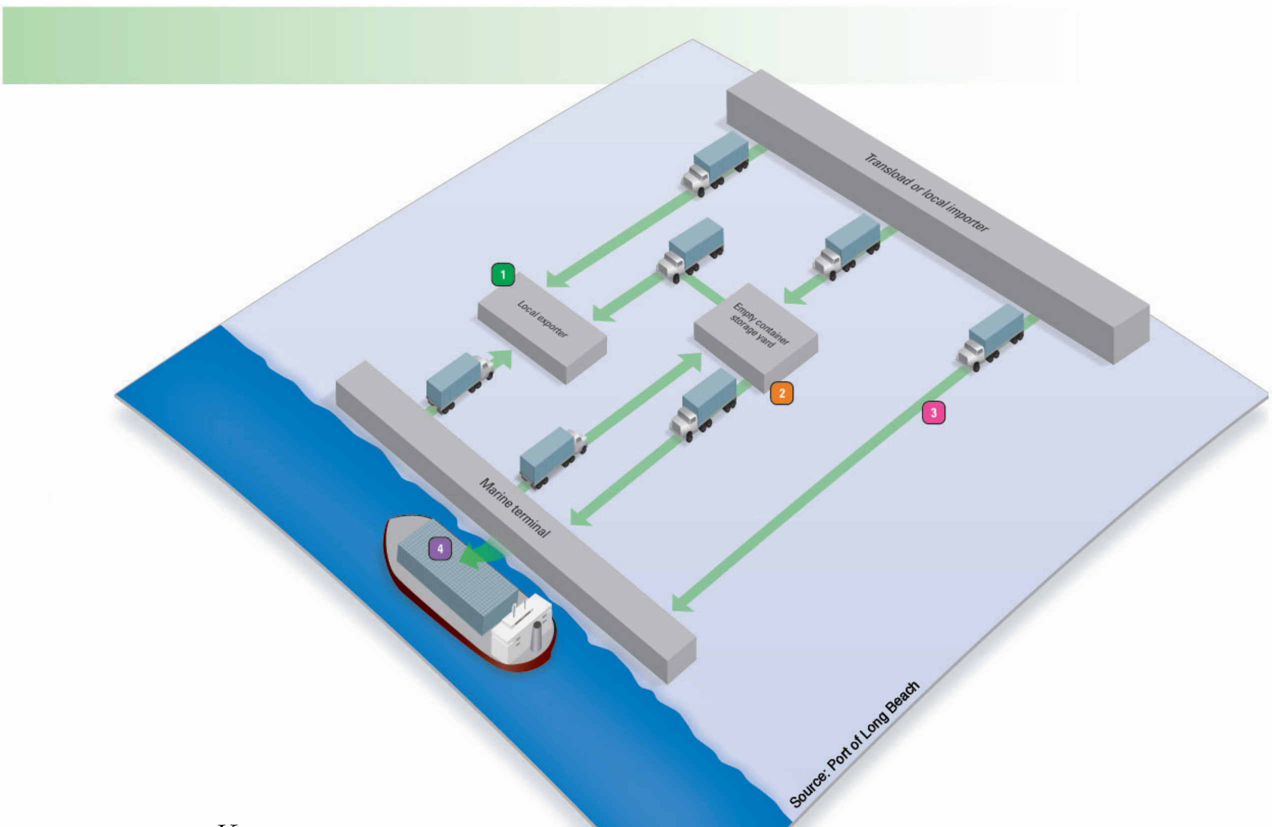
1) Local origin cargo delivered directly to the marine terminal from the producer, manufacturer, or exporting company.
2) Local or non-local origin cargo delivered to a warehouse/consolidator where the cargo may be temporarily stored with other cargo bound for export. Cargo may also be transferred from domestic truck trailers to marine shipping containers.
3) Some non-local origin cargo shipped by rail and delivered to off-dock railyards where the cargo is placed onto truck for final delivery to marine terminals.
4) Some non-local origin cargo shipped by rail directly to the marine terminal where it is loaded onto a ship or stored temporarily for the appropriate ship to arrive.
5) Some non-local origin cargo shipped by rail to near-dock railyards, where the cargo is picked up by truck for a short trip to the marine terminal.
6) Vessel loading of export cargo conducted after the ship has been unloaded of its import cargo.

[9] Port of Long Beach, Cargo Movement in Focus, 2006.

1.2.4 Empty Containers

Since the U.S. imports more goods than it exports, many empties are sent overseas to be reused or are used domestically for other purposes. Typically, about a third of the containers loaded onto a ship at the Port will be filled with cargo, while about two-thirds will be empty. The figure below diagrams the movement of empty containers after the delivery of full, imported containers to local businesses and/or transload facilities. Intermodal containers returning to the local area empty are not depicted; they would enter the system at the marine terminal or empty container storage yard.[10]

Figure 1.4: Empty Container Transport



Key:

1) Empty container delivered to a local exporter to fill. Direct delivery of containers between importers and exporters is encouraged to reduce the number of truck trips a container takes in the South Coast.
2) Empty container delivered to container storage yard from a transload facility or local importer. From the storage yard, containers are moved by truck to the marine terminal for export or to a local exporter to be filled with cargo.
3) Empty container delivered directly from a transload facility or local importer to the marine terminal for export.
4) Empty container loaded onto a containership to be exported and reused overseas.

[10] Port of Long Beach, Cargo Movement in Focus, 2006.

1.3 Scope of Study

The scope of the study is described in terms of the year of activity used as the basis of emissions estimates, the pollutants quantified, the included and excluded source categories and the geographical extent.

1.3.1 Pollutants

Exhaust emissions of the following pollutants have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Particulate matter

Particulate matter refers to tiny, discrete solid or aerosol particles in the air. Dust, dirt, soot, and smoke are considered particulate matter. Vehicle exhaust (cars, trucks, buses, among others) are the predominant source of fine particles. Fine particles are a concern because their very tiny size allows them to travel more deeply into lungs, increasing the potential for health risks.

Diesel particulate matter

Diesel particulate matter is a significant component of PM. Diesel exhaust also includes more than 40 substances that are listed as hazardous pollutants. DPM is considered a surrogate for the effects of both the PM and gaseous component of diesel exhaust. Sources of diesel emissions include diesel-powered trucks, buses, cars (on-road sources); and diesel-powered marine vessels, construction equipment and trains (off-road sources). DPM has been shown to contribute up to 80% of the carcinogenic health risk related to the portion of outdoor pollutants classified as "toxics."

Oxides of nitrogen

Oxides of nitrogen is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Most oxides of nitrogen are colorless and odorless. NO_x forms when fuel is burned at high temperatures, as in a combustion process. Oxides of nitrogen are precursors for ground level ozone formation. Ozone is formed by a reaction involving hydrocarbon and nitrogen oxides in the presence of sunlight. The primary manmade sources of NO_x are motor vehicles, electric utilities and other sources that burn fuels.

Exposure to NO_x has been connected to a range of respiratory diseases and infections. Exposure to ozone can cause difficulty in breathing, lung damage and reduced cardiovascular functions.

Hydrocarbons
Hydrocarbons emissions can be expressed in several ways depending upon measurement techniques and what compounds are included. In general hydrocarbons are a combination of oxygenated (such as alcohols and aldehydes) and non-oxygenated hydrocarbons (such as methane and ethane). Most hydrocarbons serve as fuels for the various sources found at Ports. Some examples of hydrocarbon fuels are the components of gasoline, diesel, and natural gas. Hydrocarbon emissions are found in the engine exhaust due to incomplete fuel combustion and also due to fuel evaporation. A number of hydrocarbons are considered toxics which can cause cancer or other health problems. Hydrocarbons are precursor to ground level ozone formation which leads to smog in the atmosphere. Hydrocarbons estimated in this inventory refer to total hydrocarbons.

Carbon monoxide
Carbon monoxide is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely. Most vehicles are the predominant source of carbon monoxide. CO combines with hemoglobin in red blood cells and decreases the oxygen-carrying capacity of the blood. CO weakens heart contractions, reducing the amount of blood pumped through the body.

Greenhouse gases
Greenhouse gases (GHG) contribute towards global warming and associated climate change. Global warming is a climate regulating phenomenon which occurs when certain gases in the atmosphere (naturally occurring or due to human activities) trap infrared radiation resulting in an increase in average global temperatures. The first far reaching effort to reduce emissions of GHG was established in the form of the Kyoto Protocol. The Kyoto Protocol is a protocol to the United Nations Framework Connection on Climate Change (UNFCCC) with the goal of reducing emissions of six GHGs. The six GHGs, also referred to as the "six Kyoto gases," are: CO_2, CH_4, N_2O, SF_6, HFCs, PFCs. Guidance to develop national GHG inventories is provided by the Intergovernmental Panel on Climate Change (IPCC), the authoritative scientific body on climate change.

CO_2, CH_4, and N_2O are emitted naturally or through human activities such as combustion of fossil fuels and deforestation. SF_6, HFCs and PFCs are synthetically produced for industrial purposes. This emissions inventory report includes estimates of CO_2, CH_4 and N_2O from combustion of fuel in cargo handling equipment, harbor craft, on-road heavy-duty trucks, rail locomotives and vessel operations at and near the Port.

Each GHG differs in its ability to absorb heat in the atmosphere. Sometimes, estimates of greenhouse gas emissions are presented in the unit of carbon dioxide equivalents, which weights each gas by its global warming potential (GWP) value. To normalize these values in a single greenhouse gas value, the GHG emissions estimates are multiplied by the following values and then added together resulting in a single greenhouse gas value (CO_2 equivalent). The values are as follows.[11]

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

In this study, the greenhouse gas emissions are shown in metric tons while the criteria pollutant emissions are shown in short tons.

1.3.2 Emission Sources

The scope includes the following five source categories:

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

Examples of the five sources include the containerships, tankers, and cruise ships that call the Port; the assist tugs and tugboats that assist vessels in the harbor; the cranes and forklifts that may move cargo within the terminals; the railroad locomotives that haul the cargo; and the on-road diesel trucks visiting the terminals that also transport cargo. This inventory does not include stationary sources, as these are included in stationary source permitting programs administered by the South Coast Air Quality Management District (SQAMD).

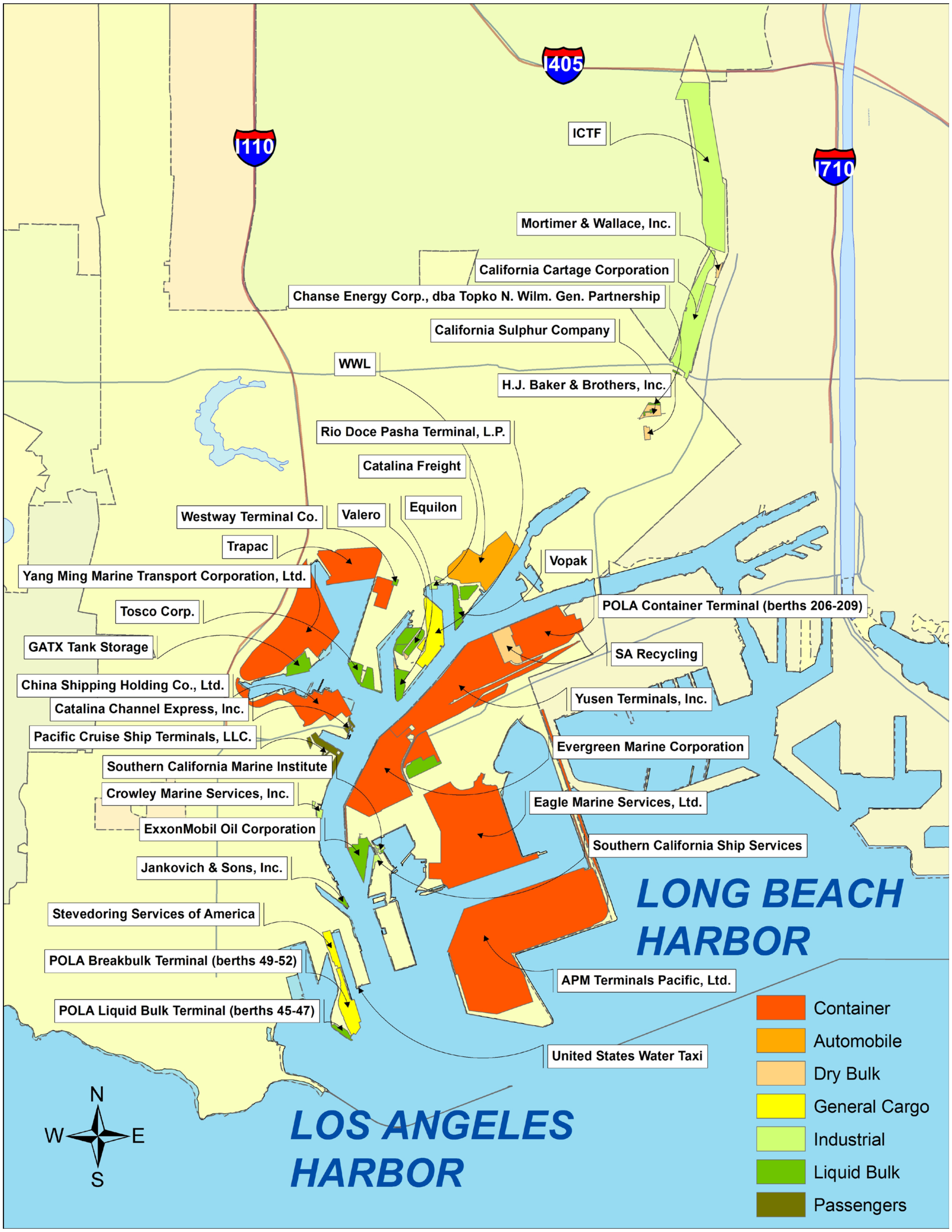
1.3.3 Geographical Extent

The study includes tenant source category emissions that occur on Port-owned land within the Port boundary/district. An overview of the geographical extent is provided below for each of the source categories.

Figure 1.5 shows the land area of active Port terminals in 2009. The geographical scope for cargo handling equipment is the terminals and facilities on which they operate.

[11] *U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007,* April 2009.

Figure 1.5: Port Boundary Area of Study



Emissions from switching and line haul railroad locomotives were estimated for on-dock rail yards, off-dock rail yards, intermodal yards, and the rail lines linking these facilities. For heavy-duty trucks related to the hauling of cargo, emissions from queuing at terminal entry gates, for travel and idling within the terminals, and for queuing at the terminal exit gates have been included. In addition to emissions that occur inside the Port facilities, emissions from locomotives and on-road trucks transporting Port cargo have been estimated for Port-related activity that occurs within the SoCAB boundaries. Emissions are estimated up to first point-of-rest within the SoCAB or up to the basin boundary.

Figure 1.6 shows the SoCAB boundary for rail and HDV in relation to the location of the Port. Since both the Port and the Port of Long Beach are interconnected with intermodal transportation linkages, every effort was made to only account for freight movements originating from or having a destination at the Port.

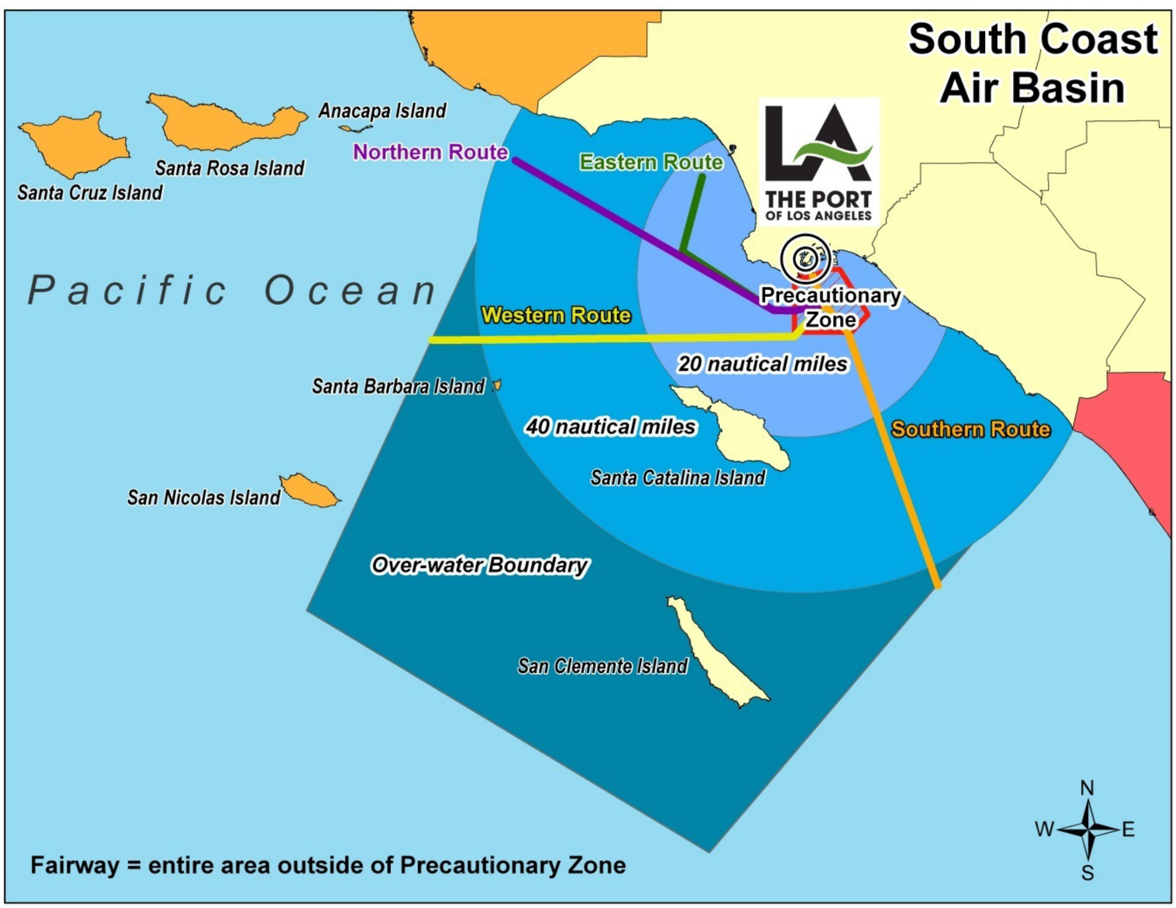
Figure 1.6: South Coast Air Basin Boundary

For marine vessels, OGVs and commercial harbor craft, the geographical extent of the Emissions Inventory (EI) is based on the same boundary that was used in previous marine vessel inventories developed for the SCAQMD and in the 2001 Baseline EI and subsequent inventories. The northern and southern boundary is set by the South Coast county boundary which is continued over the water to the California water boundary to the west. The portion of the study area outside the Port's breakwater is four-sided, and geographically defined by the following coordinates:

- NW corner: 34°02'42.4" north (N) latitude by 118°56'41.2" west (W) longitude
- SW corner: 33°00'00.0" N latitude by 119°30'00.0" W longitude
- SE corner: 32°30'00.0" N latitude by 118°30'00.0" W longitude
- NE corner: 33°23'12.7" N latitude by 117°35'46.4" W longitude

Figure 1.7 shows the geographical extent of the study area for marine vessels (dark blue), the vessel traffic separation zone, and the main arrival and departure vessel flow for the northern and southern separation zones. The precautionary zone (PZ) is further discussed in Section 3.2.

Figure 1.7: OGV Inventory Geographical Extent



1.4 General Methodology

The basic approach to developing an activity-based EI is through data collection efforts with Port tenants, who own, operate and maintain equipment and own or charter vessels. Port tenants and shipping lines play an essential role in the development of an EI by providing the most accurate activity and operational information available. The activity and operational data collected is input into a database for storage. Emissions estimates are developed for each of the various source categories in a manner consistent with the latest methodologies agreed upon by the Port and the participating regulatory agencies. The information gathered, analyzed, and presented in this EI continues to improve the understanding of the nature and magnitude of Port-related emission sources. Specific data collection and analytical approaches unique to each of the five source categories are summarized below along with a summary of the key updates.

In general, emissions estimates are calculated by multiplying units of activity (estimated using the activity and operational information described above) by an emission factor. Emission factors are standard values that express the mass of emissions in terms of a unit of activity. For example, some emission factors are expressed in terms of pounds of emissions (of a particular pollutant) per horsepower-hour. Horsepower-hours are the product of in-use horsepower times hours of operation. Emissions estimates can be calculated, then, by multiplying hours of operation per year (activity data) by in-use horsepower (operational information) by an emission factor (such as pounds per horsepower-hour) to estimate emissions in pounds of emissions per year. The actual calculations are often more complex than this example, because such parameters as in-use horsepower must be estimated as part of the calculations. The emission factors often vary by engine model year, horsepower and age. In addition, correction factors to account for the different type of fuel use (compared to the fuel used to develop the emission factor) and emissions control technology are applied to estimate the in-use emissions.

1.4.1 Ocean-Going Vessels

The basic methodology for estimating emissions from the various types of ocean-going vessels (OGVs) that call on the Port relies on local activity-based data to the greatest extent possible. This includes call records from the Marine Exchange of Southern California, which tracks and records the movement of all OGVs entering or departing San Pedro Bay. In addition, the Port has undertaken a Vessel Boarding Program (VBP) that focuses on gathering specific vessel characteristics and operational data from ships visiting the Port, to gain the most complete and detailed understanding of how the different types of OGVs arrive, depart, and transit San Pedro Bay and the harbor, as well as how they operate while at dock ("hotelling").

Additional ship-specific OGV data was obtained from Lloyd's Register of Ships (Lloyd's), a marine vessel data system that can provide vessel specific data for virtually every OGV in the world fleet. Lloyd's data was also used to develop profiles for parameters that are not known for every ship. The general vessel classifications include the following.

- Automobile carriers
- Bulk carriers
- Containerships
- Cruise ships
- General cargo ships
- Ocean-going tugboats
- Refrigerated vessels
- Roll-on roll-off ships
- Tankers

Emission factors were developed for different types of OGV engines based on review of the literature and discussion/coordination with the regulatory agencies. Emissions were calculated by multiplying the emission factors by vessel-specific activity parameters such as in-use horsepower and hours of operation on a per engine basis. Numerous calculations were made for every ship that visited the Port to adequately characterize the various activities; (e.g., transit, maneuvering, and hotelling activities for propulsion, auxiliary engines and auxiliary boilers). The results of all the calculations were summed to produce the overall emission estimates.

The emission estimates presented in the 2009 EI include the effects of the following emission reduction measures in place in 2009.

- The Vessel Speed Reduction Incentive Program (VSRIP), originally adopted in June 2008 requiring reduced speeds of 12 knots or lower during transiting outside the harbor and within 20 nautical miles (nm) of the Port, was expanded to 40 nm in September 2009

- The use of alternative maritime power (AMP) at China Shipping's Berth 100 and by one NYK vessel calling at Yusen Terminals

- Switching to a lower sulfur fuel near the coast and at berth pursuant to CARB's fuel regulation for ocean-going vessels and Port's Low-Sulfur Fuel Incentive Program

- Newer vessels calling at the Port with cleaner and more fuel-efficient engines that meet or exceed standards set by the International Maritime Organization (IMO)

- New technologies added to vessels that reduce emissions such as fuel slide valves

1.4.2 Harbor Craft

Harbor craft operators whose vessels work within the Port waters were interviewed to update the inventory of harbor craft. Harbor craft are separated into the following categories:

- Assist tugboat
- Tugboats
- Ferries
- Excursion vessels
- Crew boats
- Work boats
- Government vessels
- Commercial fishing vessels

The emission estimation methodology for this category is consistent with CARB's latest methodology. Emissions were calculated by multiplying the emission factors by the appropriate measure of activity (i.e., annual hours of operation) on an engine-by-engine basis for each harbor craft vessel operated at the Port in 2009. Updated activity information for vessels' operating hours and size and model year of propulsion and auxiliary engines were obtained from harbor craft operators.

The 2009 emission estimates for harbor craft reflect the emission benefits associated with replacement of older higher emitting engines with cleaner engines as well as the operation of newer vessels with cleaner engines. The first hybrid tugboat was in operation for the first time in 2009 and is included in the 2009 emission estimates.

1.4.3 Cargo Handling Equipment

Cargo handling equipment (CHE) consists of various types of equipment and vehicles that fall within the off-road equipment designation and are used to move cargo within terminals and other areas within the Ports' boundary. The emission estimation methodology for this category is consistent with CARB's latest CHE emissions estimation methodology. Equipment operators and owners were interviewed and asked to supply updated information such as activity hours, size and model year of all of their CHE used at the Port.

The 2009 emission estimates for cargo handling equipment reflect the emission benefits associated with the implementation of the CAAP measure and CARB's regulation which have resulted in the purchase of cleaner equipment and retrofit of existing equipment with emission control technologies.

1.4.4 Railroad Locomotives

Railroad operations are typically described in terms of two different types of operations, line haul and switching. Line haul operations involve long-distance transportation of a whole (unit) train between the Port and points across the country, whereas switching is the local movement of individual railcars or train segments to prepare them for line haul or to distribute them to destination terminals upon their arrival in port. Different companies conduct switching (Pacific Harbor Line (PHL)) and line haul (Burlington Northern Santa Fe (BNSF) and Union Pacific (UP)) operations within the port. The line haul companies also operate switching locomotives at off-port rail yards. The on-port switching company operates a dedicated fleet of locomotives, while the line haul locomotives that service the Port are part of a nation-wide fleet, meaning that individual locomotives are not assigned specifically to port or South Coast Air Basin service. Since the type of information available for these two types of activities differ, information on each locomotive and its activity (e.g., fuel use) can be used to estimate emissions for the on-port switching locomotives; whereas for the line haul locomotives the information is more general (e.g., in terms of fuel use per ton of cargo and total tons of cargo carried).

The 2009 emission estimates for locomotives reflect the emissions benefits associated with the operation of cleaner locomotives and the implementation of Memorandum of Understanding (MOUs) between Class 1 Railroads, CARB and the U.S. Environmental Protection Agency (EPA).

1.4.5 Heavy-Duty Vehicles

Heavy-duty on-road vehicles (HDVs) transport cargo between the port and off-port locations such as rail yards, warehouses, and distribution centers. To develop emission estimates, truck activities have been evaluated as having two components:

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.

- On-road operations outside the Port boundaries but within the SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

For estimating on-road HDV emissions, activity information was developed by a traffic consultant using the trip generation and travel demand models. For estimating on-terminal HDV emissions, terminal operators were interviewed with regards to on-terminal traffic patterns, including time spent waiting at the entry gate, time and distance on terminal while dropping off and/or picking up cargo, and time spent waiting at exit gates.

Emissions from HDVs were estimated by multiplying the speed-specific emission factor derived from CARB's emission factor model EMFAC 2007 by the distance parameters established for the terminals (on-terminal emissions) or road segments (on-road emissions). On-terminal idling emissions were estimated by multiplying the EMFAC idling emission factor by estimated idling times.

The emissions benefits associated with the implementation of the Port's Clean Truck Program in 2009 are reflected in the 2009 emissions estimates for heavy-duty trucks.

1.5 Methodology Comparison

In order to make a meaningful comparison between annual emission inventories, the same methodology must be used for estimating emissions for each year. If methodological changes had been implemented for a given source category in 2009 compared with a previous year, then the previous years' emissions were recalculated using the new 2009 methodology and the previous years' activity data to provide a valid basis for comparison. If there were no changes in methodology, then the emissions estimated for the prior years' inventory reports were used for the comparison.

Methodology changes have been taken into account for OGVs and HDVs. Further discussion of the methodology changes and the comparison between years is provided in Section 9.

1.6 Report Organization

This report presents the 2009 emissions and the methodologies used for each category in each of the following sections:

- Section 2 discusses regulatory and port measures
- Section 3 discusses ocean-going vessels
- Section 4 discusses harbor craft
- Section 5 discusses cargo handling equipment
- Section 6 discusses locomotives
- Section 7 discusses heavy-duty vehicles
- Section 8 discusses findings and results
- Section 9 compares 2009 emissions to previous years' emissions
- Section 10 presents a discussion of anticipated emissions improvements in 2010

SECTION 2 REGULATORY AND SAN PEDRO BAY PORTS CLEAN AIR ACTION PLAN (CAAP) MEASURES

This section discusses the regulatory and Port measures which address port-related activity. Almost all port-related emissions come from five diesel-fueled source categories: OGVs, HDVs, CHE, harbor craft and rail locomotives. The responsibility for the emissions control of the majority of these sources falls under the jurisdiction of local (South Coast Air Quality Management District, SCAQMD), state (CARB) or federal (U.S. Environmental Protection Agency, EPA) agencies. The Ports of Los Angeles and Long Beach adopted the landmark CAAP in November 2006 to curb port-related air pollution from trucks, ships, locomotives and other equipment by at least 45 percent in five years. A model for seaports around the world, the CAAP is the boldest air quality initiative by any seaport, consisting of wide-reaching measures to significantly reduce air emissions and health risks while allowing for the development of much-needed port efficiency projects. Below is a list of recently adopted and proposed regulatory measures in addition to the CAAP measures that will reduce emissions from the Port over the next five years and beyond.

2.1 Ocean-Going Vessels

Emissions Standard for Marine Propulsion Engines

The IMO adopted limits for NO_x in Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1997. These NO_x limits apply to marine engines over 130 kilowatts (kW) installed on vessels built on or after 2000. The current NO_x standards are from 17.0 grams per kilowatt-hour (g/kW-hr) (for < 130 revolutions per minute [rpm]) to 9.8 g/kW-hr (for $\geq$ 2000 rpm), depending upon the engine speed in rpm. The required number of countries ratified the Annex in May 2004 and it went into force for those countries in May of 2005. Engine manufacturers have been certifying engines to the Annex VI NO_x limits since 2000 as the standards are retroactive in other countries, once Annex VI is ratified. In April 2008, the Marine Environment Protection Committee of the IMO approved a recommendation for new MARPOL Annex VI sulfur limits for fuel and NO_x limits for engines. In October 2008, the IMO adopted these amendments to international requirements under MARPOL Annex VI, which place a global limit on marine fuel sulfur content of 3.5% by 2012, reduced from the current 4.5%, which will be further reduced to 0.5% sulfur by 2020, or 2025 at the latest, pending a technical review in 2018.[12] In Emissions Control Areas (ECAs), sulfur content will be limited to 1.0% in 2010, and further reduced to 0.1% sulfur in 2015 from the current 1.5% limit. In addition, new engine emission rate limits for NO_x for marine diesel engines installed on newly built ships are based on rated engine speed (n) and the year the ship is built.

[12] *http://www.epa.gov/otaq/regs/nonroad/marine/ci/mepc58-5noxsecretariat.pdf*

The NO_x standards are summarized as follows:

NO_x - Tier I; for ships built between January 1, 2000 and December 31, 2010:

- 17.0 g/kW-hr if n is less than 130 rpm
- 45 x n $^{(-0.2)}$ g/kW-hr if n is equal to 130 rpm or less than 2,000 rpm
- 9.8 g/kW-hr if n is equal to or greater than 2,000 rpm

NO_x - Tier II; for ships built starting in January 1, 2011:

- 14.4 g/kW-hr if n is less than 130 rpm
- 44 x n $^{(-0.23)}$ g/kW-hr if n is equal to 130 rpm or less than 2,000 rpm
- 7.7 g/kW-hr if n is equal to or greater than 2,000 rpm

NO_x - Tier III; for ships built starting in January 1, 2016 and operate in ECA area:

- 3.4 g/kW-hr if n is less than 130 rpm
- 9 x n $^{(-0.2)}$ g/kW-hr if n is equal to 130 rpm or less than 2,000 rpm
- 2.0 g/kW-hr if n is equal to or greater than 2,000 rpm
- Tier III NOx standards are based on the use of advanced catalytic after treatment systems

Finally, existing ships built between 1990 and 2000, would be subject to a retrofit requirements of Tier I NO_x standard. On July 21, 2008, President Bush signed into law the Maritime Pollution Protection Act of 2008, ratifying MARPOL Annex VI by the United States, and the requirements became enforceable through the Act to Prevent Pollution from Ships (APPS) in January 2009.

In March 2009, the United States and Canada submitted a proposal to the IMO for the designation of an ECA in which the stringent international emission controls described above would apply to ocean-going ships in waters adjacent to the Pacific coast, Atlantic/Gulf coast, and the eight main Hawaiian Islands. On March 26, 2010, the IMO officially designated waters within 200 miles of North American coasts as an ECA. From the effective date in 2012 until 2015, fuel used by all vessels operating in this area cannot exceed 1.0 percent sulfur (10,000 parts per million (ppm)) which will be further reduced to 0.1 percent (1,000 ppm) beginning in 2015. Also, starting in 2016, NOx after-treatment requirements (Tier III standards) will become applicable in this area.

EPA's Final Regulation – Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters Per Cylinder

On March 14, 2008,[13] the EPA finalized a three part program designed to dramatically reduce emissions from marine diesel engines below 30 liters per cylinder displacement. These include marine propulsion engines used on vessels and marine auxiliary engines. When fully implemented, this rule will cut PM emissions from these engines by as much as 90 percent and NO_x emissions by as much as 80 percent.

The regulations introduce two tiers of standards – Tier 3 and Tier 4 – which apply to both new and remanufactured marine diesel engines, as follows:

- *Newly-built engines:* Tier 3 standards apply to engines used in commercial, recreational and auxiliary power applications (including those below 37 kW that were previously covered by non-road engine standards). The emissions standards for newly-built engines will phase in beginning in 2009. Tier 4 standards apply to engines above 600 kW (800 hp) on commercial vessels based on the application of high-efficiency catalytic after-treatment technology, phasing in beginning in 2014.

- *Remanufactured engines:* The standards apply to commercial marine diesel engines above 600 kW when these engines are remanufactured and will take effect as soon as certified systems are available, as early as 2008.

EPA's Emission Standards for Marine Diesel Engines Above 30 Liters per Cylinder (Category 3 Engines)

EPA is pursuing two parallel, related actions for establishing emission standards for Category 3 marine diesel engines: (1) EPA is a member of the U.S. delegation that participated in negotiations at the IMO with regard to amendments to Annex VI that were adopted in October 2008 including additional NO_x limits for new engines; additional sulfur content limits for marine fuel; methods to reduce PM emissions; NO_x and PM limits for existing engines; and volatile organic compounds (VOCs) limits for tankers. (2) In January 2003, EPA adopted Tier 1 standards for Category 3 marine engines, which went into effect in 2004, establishing NO_x standards based upon internationally negotiated emissions rates and readily available emissions-control technology. In December 2009, EPA finalized emission standards for Category 3 marine diesel engines installed on U.S. flagged vessels as well as marine fuel sulfur limits which are equivalent to the amendments recently adapted to MARPOL Annex VI. The final regulation would establish stricter standards for NO_x, in addition to standards for HC and CO. The final near-term Tier 2 NO_x standards for newly built engines will apply beginning in 2011 and will require more efficient use of current engine technologies, including engine timing, engine cooling, and advanced computer controls. The Tier 2 standards will result in a 15 to 25 percent NOx reduction below the current Tier 1 levels. The final long-term Tier 3 standards for newly built engines will apply beginning in 2016 in ECAs and will require the use of high efficiency emission control technology such as selective catalytic reduction to achieve NOx reductions 80 percent below

[13] *http://wwww.epa.gov/otaq/regs/nonroad/420f08004.htm#wxhaust*

the current levels. These standards are part of EPA's coordinated strategy for addressing emissions from ocean-going vessels which also includes implementation of recent amendments to MARPOL Annex VI and designation of U.S. coasts as an ECA.

CAAP Measure- SPBP-OGV2; Reduction of At-Berth OGV Emissions
This measure requires the use of shore-power for reducing hotelling emissions implemented at all major container and cruise terminals at the Port of Los Angeles within five years. Through the Technology Advancement Program (TAP), this measure also requires demonstration and application of alternative emissions reduction technologies for ships not capable of shore power.

CAAP Measure- SPBP-OGV5; OGV Main &Auxiliary Engine Emissions Improvements
This measure provides for main and auxiliary engine emissions reductions that are validated through the TAP. The goal of this measure is to reduce main and auxiliary engine DPM, NO_x, and SO_x emissions by 90%. The first engine emissions reduction technology identified for this measure is the use of MAN B&W slide valves for main engines. The implementation mechanism for this measure is the terminal lease renewal.

CARB's Regulation to Reduce Emissions from Diesel Auxiliary Engines on Ocean-Going Vessels While at Berth at a California Port[14]
On December 6, 2007, CARB adopted a regulation to reduce emissions from diesel auxiliary engines on OGV while at-berth for container, cruise and refrigerated cargo vessels. The regulation requires that auxiliary diesel engines on OGVs to be shut down (i.e., use shore-power) for specified percentages of fleet's visits and also the fleet's at-berth auxiliary engine power generation to be reduced by the same percentages. As an alternative, vessel operators may employ any combination of clean emissions control technologies to achieve equivalent reductions. Specifically, by 2014, vessel operators relying on shore power are required to shut down their auxiliary engines at-berth for 50 percent of the fleet's vessel visits and also reduce their onboard auxiliary engine power generation by 50 percent. The specified percentages will increase to 70 percent in 2017 and 80 percent in 2020. For vessel operators choosing the emission reduction equivalency alternative, the regulation requires a 10% reduction in OGV hotelling emissions starting in 2010 increasing in stringency to an 80% reduction by 2020.

[14] See: *http://www.arb.ca.gov/regact/2007/shorepwr07/shorepwr07.htm*.

CAAP Measure- SPBP-OGV1; Vessel Speed Reduction (VSR) Program
In May 2001, an MOU between the Port of Los Angeles, the Port of Long Beach, EPA Region 9, CARB, SCAQMD, the Pacific Merchant Shipping Association (PMSA), and the Marine Exchange of Southern California was signed. This MOU called for OGVs to voluntarily reduce speed to 12 knots at a distance of 20 nm from Point Fermin. The term of this MOU expired in 2004; however, a significant number of the OGVs operating at the Port have continued to abide by VSR speeds within 20 nm from Point Fermin.

The CAAP measure requires 90% VSR compliance for OGVs that call on the Port. Reduction in speed demands less power on the main engine, which in turn reduces NO_x emissions and fuel usage.

Vessel Speed Reduction Incentive Program
In June 2008, the Port's Board of Harbor Commissioners adopted a Vessel Speed Reduction Incentive Program (VSRIP) which offered incentives to vessel operators complying with the reduced vessel speed of 12 knots or less within 20 nm of the Port. The incentive provides vessel operators the equivalent of 15 percent of the first day of dockage per vessel visit. Vessel operators achieving 90 percent compliance in a calendar year receive the incentive for 100 percent of their vessel calls in that year. The VSRIP was expanded on September 29, 2009 to 40 nm of the Port. The expanded incentive provides vessel operators the equivalent of 30 percent of the first day of dockage per vessel visit for achieving 90 percent compliance within the 40 nm zone. In 2009, the VSR compliance rate was almost 90% within the 20 nm zone.

CARB's Low Sulfur Fuel for Marine Auxiliary Engines, Main Engines and Auxiliary Boilers
On July 24, 2008, CARB adopted low sulfur fuel requirements for marine main engines, auxiliary engines and auxiliary boilers within 24 nm of the California coastline. The regulation required the use of marine gas oil (MGO) with a sulfur content less than 1.5% by weight or marine diesel oil (MDO) with a sulfur content of equal to, or less than 0.5% by weight. For auxiliary engines, main engines and boilers, the requirements start July 1, 2009. The use of MGO or MDO with a sulfur content of equal to or less than 0.1 % will be required in all engines and boilers by January 1, 2012. The use of low sulfur fuel will reduce emissions of NO_x, DPM and SO_x.

CAAP Measures- SPBP-OGV3 and 4; OGV Main & Auxiliary Engine Fuel Standards
This measure is designed to require the use of lower sulfur distillate fuels in the auxiliary and Main engines of OGVs within 20 nm (and later extending to 40 nm) of Point Fermin and while at berth. Upon lease renewal, this measure requires the use of distillate fuels that have a sulfur content of ≤0.2% MGO. The Ports are focusing these measures to target fuel quality with the goal of synchronizing both the auxiliary and main engine fuels.

Low-Sulfur Vessel Fuel Incentive Program
In order to accelerate the emissions reductions from OGVs, the ports of Los Angeles and Long Beach adopted an incentive program in March 2008 to encourage vessel operators to discontinue the use of highly polluting bunker fuel in favor of cleaner, ≤0.2 percent low sulfur distillate fuel. The program paid eligible shipping lines the difference between the cost of bunker fuel and the more expensive low-sulfur distillate when used in main engines provided that the vessels use low-sulfur distillate fuel in their auxiliary engines while at berth and comply with SPBP-OGV1 (the Vessel Speed Reduction program). This program encouraged and accelerated the use of cleaner fuels in ocean-going vessels prior to the implementation of lease-based low-sulfur fuel agreements and prior to the start of international treaties, and EPA or CARB regulation requiring low sulfur fuel use. This program started July 1, 2008 and ended June 30, 2009, upon the implementation of statewide low sulfur fuel regulation, described above.

CARB's Regulation Related to Ocean-going Ship Onboard Incineration
This regulation was adopted by CARB's board in 2005 and amended in 2006. As of November 2007, it prohibits all cruise ships and ocean-going vessels of 300 registered gross tons or more from conducting on-board incineration within 3 nm of California coast. Enactment of this regulation will reduce toxics air contaminants such as dioxins and toxics metals exposure to the public. It will also reduce PM and hydrocarbon emissions generated during incineration.

2.2 Harbor Craft

EPA's Emission Standards for Harbor Craft Engines
On March 14, 2008, EPA finalized the latest regulation establishing new emission standards for new "Category 1 & 2" diesel engines rated over 50 horsepower (hp) used for propulsion in most harbor craft. The new Tier 3 engine standards phase in starting in 2009. The more stringent Tier 4 engine standards (based on the application of high-efficiency catalytic after treatment technologies) would phase in beginning in 2014 and apply only to commercial marine diesel engines greater than 800 hp. The regulation also includes requirements for remanufacturing commercial marine diesel engines greater than 800 hp.

CARB's Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft[15]
As a part of the Diesel Risk Reduction Plan and Goods Movement Plan, CARB has adopted a regulation in November 2007 that will reduce DPM and NO_x emissions from new and in-use commercial harbor craft operating in Regulated California Waters (i.e., internal waters, ports, and coastal waters within 24 nm of California coastline). Under CARB's definition, commercial harbor craft include tug boats, tow boats, ferries, excursion vessels, work boats, crew boats, and fishing vessels. This regulation requires stringent emission limits from auxiliary and propulsion engines installed in commercial harbor craft.

[15] See: *http://www.arb.ca.gov/regact/2007/chc07/isor.pd.f*

All in-use, newly purchased, or replacement engines must meet EPA's most stringent emission standards per a compliance schedule set by the CARB for in-use engines and from new engines at the time of purchase. In addition, the propulsion engines on all new ferries, with the capacity of more than 75 passengers, acquired after January 1, 2009, will be required to install control technology that represents the best available control technology in addition to an engine that meets the Tier 2 or Tier 3 EPA marine engine standards, as applicable, in effect at the time of vessel acquisition. For harbor craft with home ports in the SCAQMD, the compliance schedule is accelerated by two years (compared to statewide requirements) in order to achieve earlier emission benefits required in SCAQMD. The in-use emission limits only apply to ferries, excursion vessels, tug boats and tow boats. The compliance schedule for in-use engine replacement began in 2009.

CARB's Low Sulfur Fuel Requirement for Harbor Craft
In 2004, CARB adopted a low sulfur fuel requirement for harbor craft. Starting January 1, 2006 (in SoCAB) harbor craft are required to use on-road diesel fuel (e.g., ultra-low sulfur diesel [ULSD]), which has a sulfur content limit of 15 ppm and a lower aromatic hydrocarbon content. The use of lower sulfur and aromatic fuel has resulted in NO_x and DPM reductions. In addition, the use of low sulfur fuel will facilitate retrofitting harbor craft with emissions control devices such as diesel particulate filters (DPFs) that have the potential to reduce PM by additional 85%.

2.3 Cargo Handling Equipment

Emissions Standards for Non-Road Diesel Powered Equipment
The EPA's and CARB's Tier 1, Tier 2, Tier 3, and Tier 4 (interim Tier 4 and final) emissions standards for non-road diesel engines require compliance with progressively more stringent standards for hydrocarbon, CO, DPM, and NO_x. Tier 4 standards for non-road diesel powered equipment complement the 2007+ on-road heavy-duty engine standards which require 90 percent reductions in DPM and NO_x compared to current levels. In order to meet these standards, engine manufacturers will produce new engines with advanced emissions control technologies similar to those already in place for on-road heavy-duty diesel vehicles. These standards for new engines will be phased in starting with smaller engines in 2008 until all but the very largest diesel engines meet NO_x and PM standards in 2015. Currently, the interim Tier 4 standards include a 90% reduction in PM and a 60% reduction in NO_x.

CARB's Cargo Handling Equipment Regulation
In December of 2005 CARB adopted a regulation designed to reduce emissions from CHE such as yard tractors and forklifts starting in 2007. The regulation calls for the replacement or retrofit of existing engines with engines that use Best Available Control Technology (BACT). Beginning January 1, 2007 the regulation requires newly purchased, leased, or rented yard tractors to be equipped with a 2007 or later on-road engine or a Final Tier 4 off-road engine. Newly purchased, leased or rented non-yard tractors must be equipped with a certified on-road or off-road engine meeting the current model year standards in effect at the time the engine is added to the fleet. If the engine is pre-2004, then the highest level

available Verified Diesel Emission Control System (VDEC) must be installed within one year. In-use yard tractors are required to meet either 2007 or later certified on-road engine standards, Final Tier 4 off-road engine standards, or install verified controls that will result in equivalent or fewer DPM and NO_x emissions than a Final Tier 4 off-road engine. In-use non-yard tractors must either install the highest level available VDEC and/or replace to an on-road or off-road engine meeting the current model year standards. For all CHE, compliance dates are phased-in beginning December 31, 2007, based on the age of the engine and number of equipment in each model year group.

CAAP Measures- SPBP-CHE1- Performance Standards for CHE
This measure calls for further CHE improvements at the time of terminal lease renewal. Beginning 2007, all CHE purchases must meet the performance standards of the cleanest available NO_x alternative-fueled engine meeting 0.01 g/bhp-hr PM, available at time of purchase; or cleanest available NO_x diesel-fueled engine meeting 0.01 g/bhp-hr PM, available at time of purchase. If there are no engines available that meet 0.01 g/bhp-hr PM, then must purchase cleanest available engine (either fuel type) and install cleanest VDEC available.

In addition, by the end of 2010, all yard tractors operating at the San Pedro Bay Ports must meet at a minimum the EPA 2007 on-road or Tier 4 engine standards. By the end of 2012, all pre-2007 on-road or pre Tier 4 off-road top picks, forklifts, reach stackers, rubber tired gantry cranes (RTGs), and straddle carriers <750 hp must meet at a minimum the EPA 2007 on-road engine standards or Tier 4 off-road engine standards. By end of 2014, all CHE with engines >750 hp must meet at a minimum the EPA Tier 4 off-road engine standards. Starting 2007 (until equipment is replaced with Tier 4), all CHE with engines >750 hp will be equipped with the cleanest available VDEC verified by CARB.

2.4 Railroad Locomotives

EPA's Emissions Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation[16]
In March 1998, EPA adopted Tier 0 (1973-2001), Tier 1 (2002-2004), and Tier 2 (2005+) emissions standards applicable to newly manufactured and remanufactured railroad locomotives and locomotive engines. These standards require compliance with progressively more stringent standards for emissions of hydrocarbon, CO, NO_x, and DPM. Although the most stringent standard, Tier 2, results in over 40% reduction in NO_x and 60% reduction in DPM compared to Tier 0, full potential of these reductions will not be realized in the next five years because of the long life of diesel locomotive engines.

[16] See: *http://www.epa.gov/otaq/regs/nonroad/420f08004.htm.*

In March 2008, EPA adopted its final regulation – "Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters per Cylinder"[17] When fully implemented, this rule will cut PM emissions from these engines by as much as 90% and NO_x emissions by as much as 80%.

The regulation introduces two tiers of standards – Tier 3 and Tier 4 – which apply to new locomotives as well as standards for remanufactured locomotives, as follows:

- *Newly-Manufactured Locomotives:* The new Tier 3 emission standards will achieve 50 percent reduction in PM beyond the Tier 2 standard and will become effective in 2012. The longer term Tier 4 emission standards which are based on the application of high efficiency catalytic after-treatment technologies for NO_x and PM will become effective in 2015 and will achieve about 80 percent reduction in NO_x and PM compared to Tier 2 standards.

- *Remanufactured Locomotives:* The regulation also establishes emission standards for remanufactured Tier 0, 1, and 2 locomotives which would achieve 50 to 60 percent reduction in PM and 0 to 20 percent reductions in NO_x.

CARB's Low Sulfur Fuel Requirement for Intrastate Locomotives
In 2004, CARB adopted a low sulfur fuel requirement for intrastate locomotives. Intrastate locomotives are defined as those locomotives that operate at least 90 percent of the time within borders of the state, based on hours of operation, miles traveled, or fuel consumption. Mostly applicable to switchers, starting January 1, 2006, statewide, intrastate locomotives are required to use CARB off-road diesel fuel which has a sulfur content limit of 15 ppm sulfur and a lower aromatic content. The use of fuel with lower sulfur and aromatics will result in NO_x and DPM reductions. In addition, use of low sulfur fuel will facilitate retrofitting locomotives with emissions control devices such as DPFs that have potential to reduce DPM by 85%.

Statewide 1998 and 2005 Memorandum of Understanding (MOUs)
In order to accelerate the implementation of Tier 2 engines in the SoCAB, CARB and EPA Region 9 entered into an enforceable MOU in 1998 with two major Class 1 freight railroads in California. This MOU requires UP and BNSF to concentrate introduction of the Tier 2 locomotives in the SoCAB, which will achieve a 65% reduction in NO_x by 2010. In 2005, CARB entered into another MOU with UP and BNSF whereby these two railroads have agreed to phase out non-essential idling and install idling reduction devices, identify and expeditiously repair locomotives that smoke excessively and maximize the use of 15 ppm sulfur fuel.

[17] EPA 2008.

2.5 Heavy-Duty Vehicles

Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles

In 2001, CARB adopted EPA's stringent emission standards for 2007+ HDVs, which will ultimately result in 90% reductions in emissions of NO_x and PM. This regulation will require HDV engine manufacturers to meet a 0.01 g/bhp-hr PM standard starting in 2007, which is 90% lower than the 2004 PM standard of 0.1 g/bhp-hr. The regulation requires a phase-in of a 0.2 g/bhp-hr NO_x standard between 2007 and 2010. By 2010, all engines will be required to meet the 0.2 g/bhp-hr NO_x standard, which represents a greater than 90% reduction compared to the 2004 NO_x standard of 2.4 g/bhp-hr. It is expected that between 2007 and 2010, on average, manufacturers will produce HDV engines meeting the PM standard of 0.01 g/bhp-hr and a NO_x standard of 1.2 g/bhp-hr. This latter standard is referred to as the 2007 interim standard.

Heavy-Duty Vehicle On-Board Diagnostics (OBD) Requirement

In 2005, CARB adopted a comprehensive HDV On-Board Diagnostics (OBD) regulation, which ensures that the increasingly stringent HDV emissions standards being phased in are maintained during each vehicle's useful life. The OBD regulation requires manufacturers to install a system in HDVs to monitor virtually every emissions related component of the vehicle. The OBD regulation will be phased in beginning with the 2010 model years with full implementation required by 2016.

Ultra-Low Sulfur Diesel (ULSD) Fuel Requirement

In 2003, CARB adopted a regulation requiring that diesel fuel produced or offered for sale in California for use in any on-road or non-road vehicular diesel engine (with the exception of locomotive and marine diesel engines) contain no more than 15 ppm of sulfur (S) by weight, beginning June of 2006, statewide. This ULSD fuel is needed in order for retrofit technologies, such as diesel particulate filters, to work successfully.

CARB's Regulation for Reducing Emissions from On-Road Heavy-Duty Diesel Trucks Dedicated to Goods Movement at California Ports

As a part of CARB's emissions reduction plan for ports and goods movement in California, in December of 2007, CARB adopted a regulation designed to modernize the drayage truck fleet in use at California's ports. This objective is to be achieved in two phases:

1. By December 31, 2009, all pre-1994 model year (MY) engines are to be retired or replaced with 1994 and newer MY engines. Furthermore, all drayage trucks with 1994 – 2003 MY engines will be required to achieve an 85 percent PM emission reduction through the use of a CARB approved Level 3 VDECS.

2. By December 31, 2013, all trucks operating at California ports must comply with the 2007+ on-road heavy-duty truck engine standards.

CARB's Truck and Bus Regulation

In December 2008, CARB adopted a regulation that places requirements on in-use HDVs operating throughout the state. Under the regulation, existing HDVs are required to be replaced with HDVs meeting the latest NOx and PM Best Available Control Technology (BACT). By January 1, 2021, all MY 2007 trucks are required to meet NOx and PM BACT (i.e. 2010+ EPA Engine Standards). MY 2008 and MY 2009 must be replaced with 2010+ engines by January 1, 2022 and January 1, 2023 respectively.

CARB's Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation

In December 2008, CARB adopted a new regulation to reduce greenhouse gas emissions by improving the fuel efficiency of heavy-duty tractors that pull 53-foot or longer box-type trailers through improvements in tractor and trailer aerodynamics and the use of low rolling resistance tires. All pre-2011 MY tractors that pull affected trailers are required to use SmartWay verified low rolling resistance tires, beginning January 1, 2012. Pre-2011 MY 53-foot or longer-type box trailers are required to be SmartWay certified or retrofitted with SmartWay verified technologies by December 31, 2012 with the exception of 2003-2008 MY refrigerated-van trailers equipped with 2003 or later transport refrigeration units which will have a compliance phase-in between 2017 and 2019. Drayage tractors and trailers that operate within a 100 mile radius of a port or intermodal rail yard are exempt from this regulation.

CAAP Measures- SPBP-HDV1- Performance Standards for On-Road Heavy-Duty Vehicles; Clean Truck Program

Per the stated goals of the CAAP, the Ports of Los Angeles and Long Beach approved the Clean Truck Program (CTP) which progressively bans older trucks from operating at the two ports. The ban is implemented in three phases as follows:

1. By 1 October 2008 – All pre-1989 trucks are banned from port services.

2. By 1 January 2010 – All 1989-1993 trucks along with un-retrofitted[18] 1994-2003 trucks are banned from port services.

3. By 1 January 2012 – All trucks that do not meet 2007and later on-road heavy duty engine standards are banned from port services.

[18] CTP retrofit requirements include ARB Level 3 reduction for PM plus 25% NOx reduction.

2.6 Non-Regulatory Programs

The recently adopted CARB regulations, the anticipated CARB rulemakings, and the measures in the CAAP will provide a vital and complementary combination of measures that support the overall effort to meet both the State and San Pedro Bay Ports air quality improvement goals.

Non-regulatory grant funding programs are also helping to significantly reduce emissions from sources including those associated with ports. In 2009, the port submitted several grant applications to EPA, California Energy Commission (CEC) and Department of Energy (DOE) for American Reinvestment and Recovery Act (ARRA) funding. In 2009, the Port has received almost $2 million in funding to replace, repower, and/or retrofit 27 pieces of equipment, including harbor craft, currently in operation at the port. The emission reductions achieved will improve air quality and health in the surrounding area.

Another example of these types of programs is the Carl Moyer Program. This program is a CARB-administered grant program implemented in partnership with local air districts to fund the replacement of older, higher emitting engines or to cover the incremental cost of purchasing cleaner-than-required engines and vehicles. Under this program, owners/operators of mobile emissions sources can apply for incremental funding to reduce emissions. The program also includes a fleet modernization component. All emissions source categories at the ports have been successful in obtaining Carl Moyer funding. It is important to note that only emission reductions that are surplus to regulatory requirements are eligible for Carl Moyer funding. As regulations are developed which require retrofit or replacement of specific equipment and/or vehicles, those projects will no longer be eligible for funding. In addition to the Carl Moyer Program, Proposition 1B (the Highway Safety, Traffic Reduction, Air Quality and Port Security Bond Act of 2006), passed by voters in November 2006, authorized $1 billion in bond funding over 4 years for incentives to reduce diesel emissions associated with goods movement. Under this Program, the CARB will work in partnerships with local public agencies (i.e., air quality management districts and ports) to identify and fund qualified projects. Local agencies would request funding from the CARB to provide financial incentives to owners of equipment used in goods movement in order to upgrade to cleaner technologies. In August of 2008, the ports received $98 million from this program which is leveraged by $145 million from the ports to help truckers who frequently service the ports to modernize their existing trucks.

2.7 Greenhouse Gases

Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006, establishes a first-in-the world comprehensive program requiring the CARB to develop regulatory and market mechanisms that will ultimately reduce GHG emissions to 1990 levels by the year 2020 and reduce emissions to 80 percent below 1990 levels by 2050. Mandatory caps will begin in 2012 for significant sources and ratchet down to meet the 2020 goals. In the interim, CARB will begin to measure the GHG emissions of industries determined to be significant sources of GHG emissions.

On October 25, 2007, CARB approved several emission reduction strategies to reduce GHG emissions as "early action measures." Early action measures pertaining to goods movement activities for ships, port drayage trucks, cargo handling equipment and transport refrigeration units included:

- Green Ports (Ship Electrification)
- SmartWay Truck Efficiency
- Tire Inflation Program
- Anti-idling Enforcement
- Refrigerant Tracking, Reporting, and Recovery Program
- Low Carbon Fuel Standard

In December 2007, CARB approved the 2020 statewide GHG emission limit of 427 million metric tons of carbon dioxide equivalent (MMT CO2E). Also in December 2007, CARB adopted a regulation requiring the largest industrial sources to report and verify their GHG emissions. In December 2008, CARB adopted the Climate Change Scoping Plan to achieve the reductions in GHG emissions mandated in AB 32. The AB 32 Scoping Plan contains the main strategies California will use to reduce the GHGs that cause climate change. Several of these measures are targeted at goods movement, including ports and are expected to achieve a combined 3.7 million metric tons of carbon dioxide equivalent. Proposed measures in the Scoping Plan affecting goods movement which have been fully or partially adopted as regulations include:

- T-5: Ship electrification at ports (previously adopted as regulation in December 2007)
- T-6: Goods movement efficiency measures (Port Drayage Trucks regulation adopted in December 2007; other measures under development)
- T-7: Heavy-Duty Vehicle GHG Emission Reduction (adopted December 2008)

In addition, the following Scoping Plan's specific measures are planned for adoption in the next few years with potential impacts on Port-related sources:[19]

- Transport Refrigeration Units Cold Storage Prohibition and Energy Efficiency
- Refrigerant Recovery from Decommissioned Refrigerated Shipping Containers
- Medium and Heavy-Duty Vehicle Hybridization
- Cargo Handling Equipment – Anti-Idling, Hybrid, Electrification
- Commercial Harbor Craft Maintenance and Design efficiency
- Goods Movement System-Wide Efficiency Improvements
- Vessel Speed Reduction
- Clean Ships

[19] *http://www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf*

SECTION 3 OCEAN-GOING VESSELS

This section presents emissions estimates for the ocean-going vessels source category, including source description (3.1), geographical delineation (3.2), data and information acquisition (3.3), operational profiles (3.4), emissions estimation methodology (3.5), and the emission estimates (3.6).

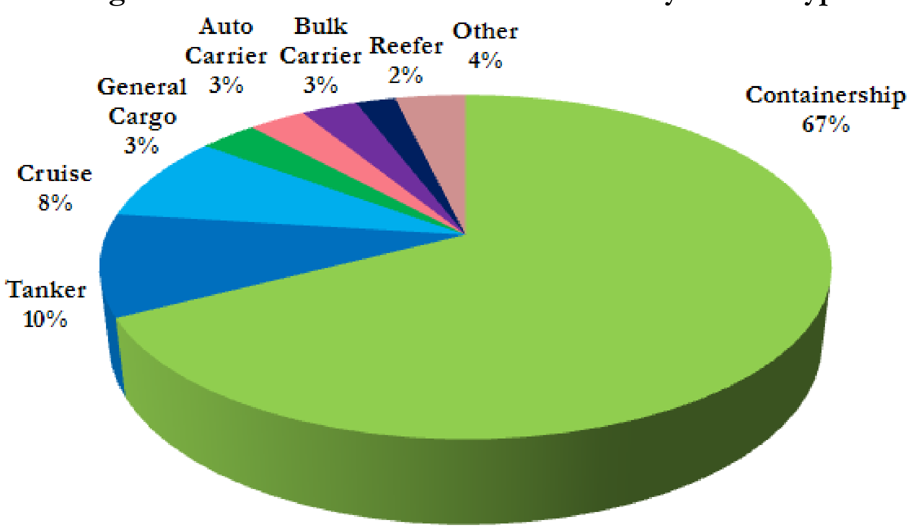
3.1 Source Description

OGVs calling at the Port in 2009 whether inbound from (or outbound to) the open ocean or transiting from neighboring POLB are included. OGVs calling only at POLB or bypassing both ports without physically stopping at a Port dock have not been included. Harbor craft, including tugboats, ferries, excursion vessels, work and crew boats and commercial fishing vessels are discussed in Section 4. Ocean-going vessels are categorized by the following main vessel types for purposes of this EI:

- Auto carrier
- Bulk carrier
- Containership
- Passenger cruise vessel
- General cargo
- Ocean-going tugboat
- Refrigerated vessel (Reefer)
- Tanker
- Miscellaneous

Based on Marine Exchange of Southern California (MarEx) data, there were 2,010 inbound vessel calls to the port in 2009. Figure 3.1 shows the percentage of inbound calls by vessel type. Containerships (67%) made the majority of the inbound calls; followed by tankers (10%); cruise ships (8%); general cargo (3%); auto carriers (3%); bulk carriers (3%); reefer vessels (2%); and other vessels including ocean tugs and miscellaneous vessels (4%).

Figure 3.1: Distribution of Inbound Calls by Vessel Type

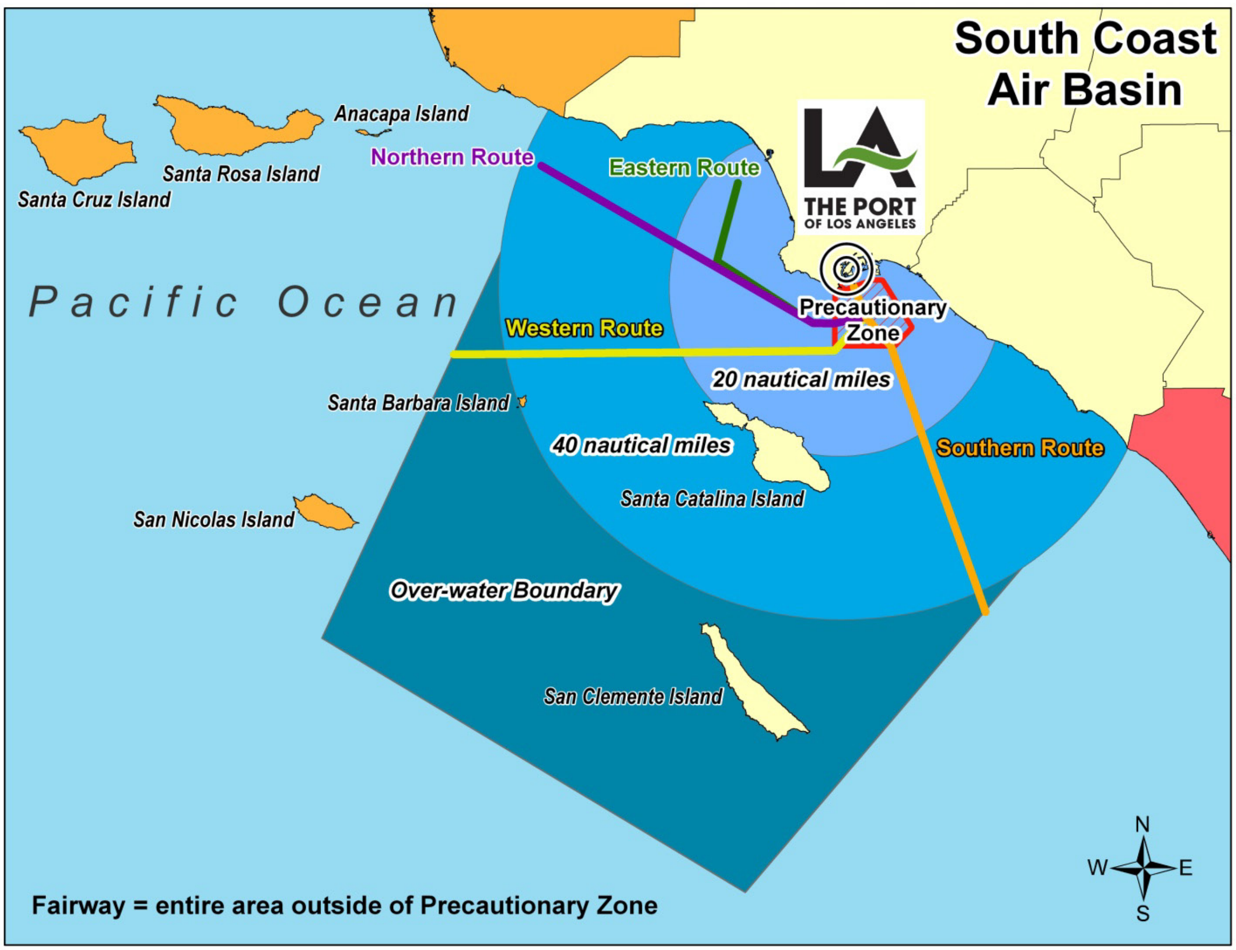


3.2 Geographical Delineation

The geographical extent of the emissions inventory for commercial marine vessels is the boundary for SoCAB. Figure 3.2 shows this portion of the study area as well as the major shipping routes. The Marine Exchange of Southern California (MarEx) ship routes were used along with their estimates of travel distances offshore from Point Fermin. These trip segments were organized into four routes (each comprised of both inbound and outbound traffic) reflecting north, east (El Segundo), west, and south routes.

- North: The predominant trade route for OGVs in terms of ship calls, involving coastwise trade to the U.S. continental ports and the Far East (Great Circle Route).
- South: The second most traveled direction for ship calls, serving not only Mexico and other ports but also traffic through the Panama Canal.
- West: Mainly involved with travel to Hawaii and some trips to the Channel Islands.
- East: This is a short trip between the Port and El Segundo petrochemical complex.

Figure 3.2: Geographical Extent and Major Shipping Routes



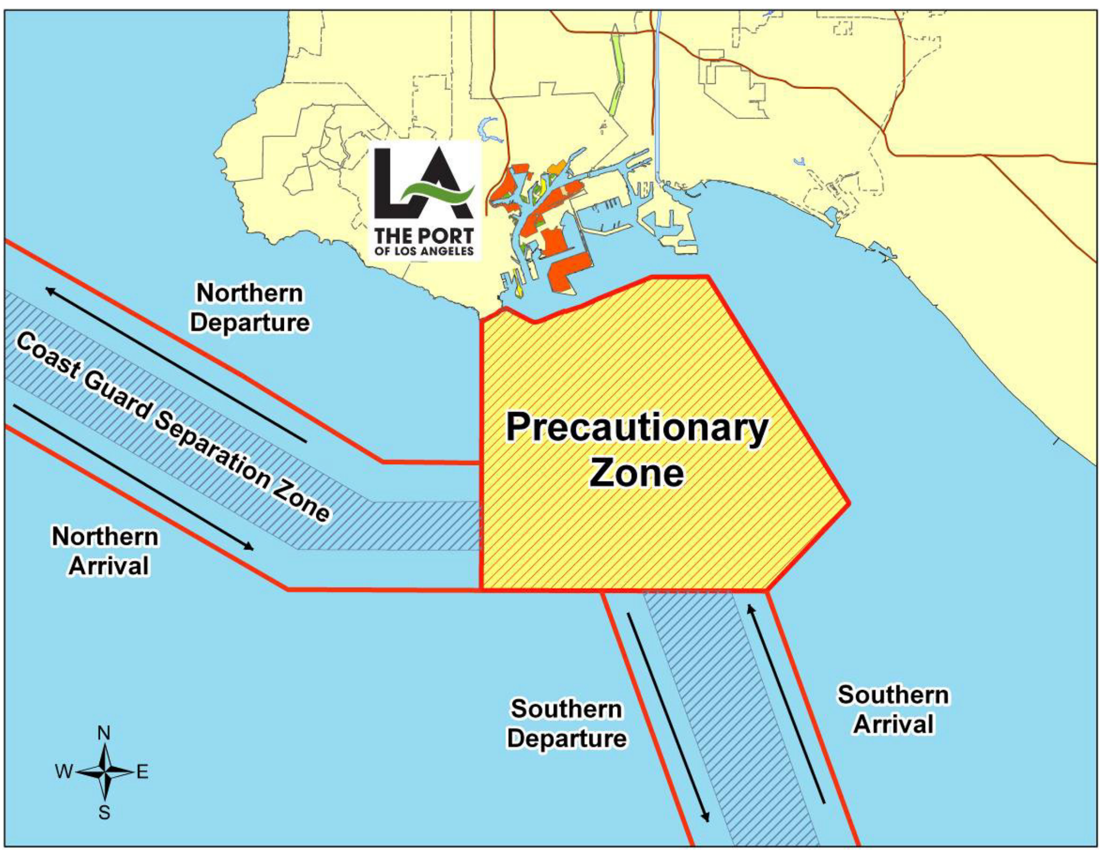
The distances in nautical miles (nm) for the various routes are listed in Table 3.1. The distances shown are from the Precautionary Zone (PZ) to the basin boundary and from the breakwater (BW) to the PZ.

Table 3.1: Route Distances, nm

Route	PZ to Boundary Distance, nm		BW to PZ Distance, nm	
	Inbound	Outbound	Inbound	Outbound
North	43.3	42.4	8.6	7.6
East	25.7	25.7	7.6	7.6
South	31.3	32.5	8.5	7.4
West	40.0	40.0	8.6	8.6

Figure 3.3 shows the precautionary zone which is a designated area where ships are preparing to enter or exit a port. In this zone the Los Angeles pilots are picked up or dropped off. The harbor is located within the breakwater and is characterized by the slowest vessel speeds.

Figure 3.3: Precautionary Zone



3.3 Data and Information Acquisition

Various sources of data and operational knowledge about the Port's marine activities were used to compile the data necessary to prepare emission estimates. These sources included:

- Marine Exchange of Southern California
- VSR Program speed data
- Los Angeles Pilot Service
- Lloyd's Register of Ships
- Port VBP data
- Terminals (shore power data)
- Nautical charts and maps

Each data source is detailed in the following subsections.

3.3.1 Marine Exchange of Southern California

MarEx operates the Vessel Traffic Service (VTS) in cooperation with the U.S. Coast Guard (USCG), the Ports of Los Angeles and Long Beach, and the State of California. The VTS was established in 1994 to provide traffic safety, traffic monitoring and security functions for the two ports, and is the first private/public VTS partnership in the country that is funded by industry. MarEx requires ships to report their activities to the VTS upon arrival and departure and tracks ship route taken.

The MarEx data that was evaluated in developing the emission estimates includes vessel names, arrival and departure dates and times, transit speeds and directions, berth of destination, and other information. This data source was the primary basis for establishing:

- Calculated hotelling time
- Distribution of arrival and departure travel directions by route
- Number of ship calls
- Names of vessels
- Vessel origination and destination

3.3.2 Vessel Speed Reduction Program Data

MarEx monitors OGV speeds over the four routes into and out of the Port as part of a VSR program that was started in May 2001. Speeds are recorded on each route at a series of waypoints that are located on arcs emanating from Point Fermin, at the following nautical mile distances: 10, 15, 20, 25, 30, 35, and 40. The measured speeds from the 10 nm waypoint outside the precautionary zone to the 40 nm waypoint are used in estimating emissions, so the full effect of the VSR program is reflected in the OGV emission estimates. The measurement of speeds from 25 nm to 40 nm began in April 2008; prior to then, only speeds up to the 20 nm waypoint were measured. The speed in the precautionary zone is not monitored by MarEx (see section 3.5.3 for assigned PZ speeds by vessel type); however, Coast Guard regulation limits speed within the PZ to 12 knots.

In preparing the MarEx speed data for use in estimating emissions, the data is first reviewed for blanks, zeros, and values that are likely not accurate, such as recorded speeds over 40 knots. These missing speeds or inaccurate values are marked as blanks and are filled in using the methodology based on available speeds from other waypoints.

In the 2007 and earlier inventories, when speeds were not monitored past the 20 nm marker, the speeds for the waypoints between 25 and 40 nm were assumed to be 94% of Lloyd's speed. For the 2008 EI, when the Marine Exchange expanded speed monitoring to include the area out to 40 nm, a different approach was phased in to fill in missing speeds for the 25 to 40 nm waypoints, and this approach has also been used to estimate 2009 emissions. In this approach, the 25 nm to 40 nm speed data is used to develop adjustment factors that correlate average speeds at the 25, 30, 35, and 40 nm waypoints with the maximum speed value reported by Lloyd's for each vessel. Adjustment factors are developed for each vessel subtype, and separate factors are developed for vessel trips that complied with the VSR speed limit over the 20 nm to 10 nm distance and for vessel trips that did not comply. The adjustment factors are applied to a vessel's Lloyd's speed when there are missing MarEx speeds at the 25 to 40 nm waypoints. They are applied on a trip-by-trip basis by first determining whether a vessel complied with the VSR limit over the 20 nm to 10 nm distance, then by multiplying the vessel's Lloyd's speed by the appropriate adjustment factor (i.e., based on the waypoint that is missing a speed, the vessel subtype, and whether the vessel was compliant or noncompliant in the 20-10 nm zones on that trip). The method described here has also been used in preparing estimates of previous years' emissions for direct comparison with the 2009 emissions (see Section 9).

Once all speeds are filled in for each waypoint, the speeds for each segment are calculated by averaging the two waypoint speeds at each end of the zone (i.e., the speed for the 20 nm zone equals (speed at 15 + speed at 20)/2). This method for estimating average speeds for the zone or leg of transit is consistent with the propulsion engine activity methodology for calculating load and time (see section 3.5.3).

3.3.3 Los Angeles Pilot Service

The Los Angeles Pilot Service maintains an automated database which documents the time when the pilot took control of the ship's bridge and when the pilot relinquished control back to the ship's officers. The date and time data was used to estimate transit time profiles for maneuvering from berth to precautionary zone for the following movements:

- Inbound from sea
- Outbound to sea
- Anchorage shifts
- Other shifts (e.g., inter-port and intra-port shifts)

Average in-harbor maneuvering times were used for each movement, ship type and terminal based on average trip times.

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3.3.4 Lloyd's Register of Ships

Lloyd's[20] is considered to be the leading resource for obtaining ship characteristics such as tonnage, speed, engine power plant configuration, age, and other parameters. The company is known as a classification society for the purpose of insuring many of the vessels on an international basis; for the vessels classified by Lloyd's the data are quite complete, however, for other ships using a different insurance certification authority, the data are less complete and/or accurate. Lloyd's was used for obtaining information such as main and auxiliary engine power and vessel speed ratings because it is the best available source of such information. The survey results from the Port of Los Angeles VBP suggest that the current Lloyd's data are fairly accurate for propulsion horsepower and vessel speed.

The company Fairplay has the rights to Lloyd's ship data and sells the software containing information on commercial marine vessels, which include ocean-going vessels. Lloyd's data used in this report was obtained in January 2010. The worldwide fleet of OGVs was assembled in a common database and a query was completed to match with the MarEx vessel data. There was a 100% match between the Lloyd's data and MarEx data for all vessels, with the exception of ocean tugs.

[20] Lloyd's – Fairplay, Ltd., *Lloyd's Register of Ships*. See: *http://www.lr.org/code/home.htm.*

3.3.5 Vessel Boarding Program Survey Data

The best source of local activity data and ship parameters is from the individuals who own and/or operate the vessels. The VBP provided for an in-depth survey of OGVs during which Starcrest consultants boarded the ship and interviewed the ship's executive and engineering staff, which usually included the Captain and Chief Engineer.

Building on previous boardings conducted by the Port of Los Angeles, Port of Long Beach and Starcrest, this inventory includes the information from previous boardings, new data received from companies and new boardings conducted since the last inventory. Figure 3.4 presents the percent of vessels by vessel type for the vessels boarded at the Port of Los Angeles between 2003 and October 2009.

Figure 3.4: Percent by Vessel Type of Vessels Boarded in 2003-2009

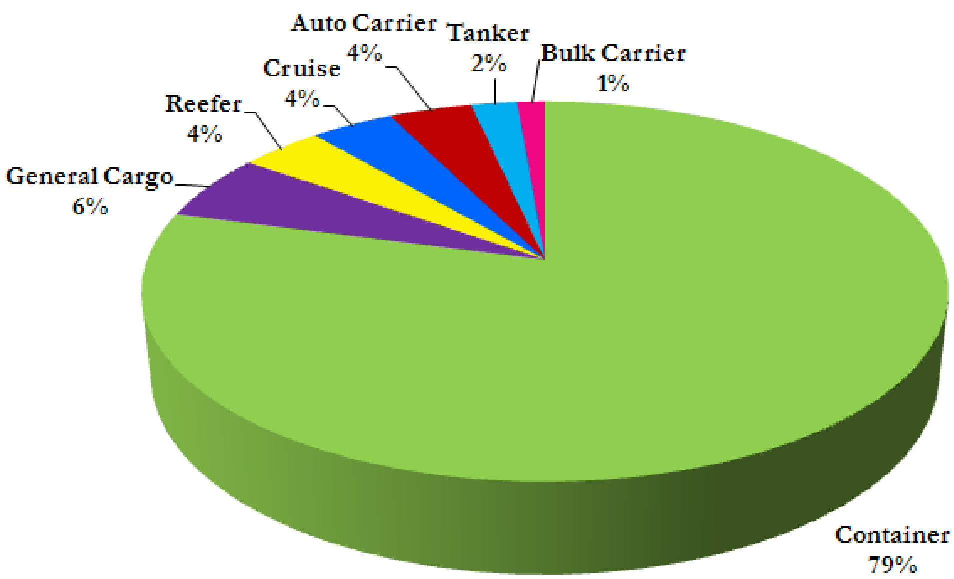

Table 3.2 summarizes the Port of Los Angeles VBP statistics for data collected from 231 vessels and from 45 shipping lines from 2003 to October 2009. Some vessels were boarded more than once (i.e., at berth and during arrival).

Table 3.2: Port of Los Angeles Vessel Boarding Program Statistics

Count	Type
69	Arrivals
200	At berth
67	Departures
2	Shift
338	**Boardings**

Table 3.3 summarizes the statistics for the various data collected from other ports or provided by shipping lines without boarding the vessel.

Table 3.3: Vessel Boarding Program Statistics

Number of Vessels	Program
231	Port of Los Angeles
43	Port of Long Beach
32	Puget Sound
8	Port of Houston Authority
565	Data provided without boarding
879	**Vessels Total**

The following VBP survey data was used specifically for emission estimation methodology in this study:

- Main engine power
- Auxiliary engine power
- Auxiliary engine load
- Boiler fuel consumption
- Vessels that switched fuels
- Emission reduction technologies such as slide valves

The specific values used for emission estimation methodology are discussed in Section 3.5. Other data collected and findings are summarized in Section 3.7. For main engine data, the match between Lloyd's and MarEx data was 100% except for ocean tugs, so defaults for main engine power were only used for ocean tugs.

Auxiliary Engine Load Data

Due to the fact that auxiliary engine load information is not provided to Lloyd's by vessel owners since it is not required by IMO or the classification societies, Lloyd's contains minimal auxiliary engine installed power information. For the 2009 vessels that called at the Port, the following hierarchy was used for the auxiliary engine power loads:

- ✓ VBP Ships - latest reported load for the boarded vessel by IMO number by mode
- ✓ VBP Sister Ships - latest reported load based on the boarded vessel by IMO number by mode
- ✓ Port Defaults - average loads (auxiliary engine power x load factor) by vessel class, by mode

Based on the above hierarchy, if a vessel was boarded as part of the VBP and auxiliary engine loads by mode were collected, then the latest of those loads based on the latest boarding of the vessel were used directly. If a sister vessel (i.e., vessel with identical characteristics) was identified as part of the VBP survey or based on information from the shipping line, then the latest boarded vessel's auxiliary engine loads by mode were used for the sister ship. Finally, if a vessel was not boarded and didn't have a sister ship that was identified, or if there were data gaps in the VBP data, then defaults by vessel class by mode were used. See section 3.5.9 for auxiliary engine load defaults discussion.

3.3.6 Vessels' Shore Power Data

Under the Port's shore power program called Alternative Maritime Power (AMP™), a number of vessels are using shore side electrical power at berth instead of running their diesel-powered auxiliary engines. Information regarding the number of vessel calls and corresponding berths that utilized shore power for hotelling operations were obtained by contacting terminal operators. In 2009, shore power was used for 59 container vessel calls at the China Shipping terminal and by one NYK vessel at the YTI terminal representing about 3% of all vessel calls. For a comparison of shore power calls with prior years, refer to Section 9.

3.4 Operational Profiles

Vessel activity is defined as the number of ship trips by trip type and segment. Trip segments are used for the at-sea portion of the ship trip between the open ocean and the precautionary zone. These trips are then processed so as to define time in mode and geographical segment. The purpose of this step is to estimate power demand for that mode of operation and multiply it by the amount of time spent in that particular mode, which estimates available energy expressed as power times unit of time (e.g., kilowatt-hours, kW-hrs). A vessel-by-vessel analysis was conducted. The only need for average power or time-in-mode was for vessels that lacked data for those fields. Vessel activity was drawn from three sources:

- MarEx trip tables which define arrivals, departures, and shifts
- MarEx speed tables which define speeds for the VSR Program at 10, 15, 20, 25, 30, 35, and 40 nautical miles
- Average transit times for harbor maneuvering

Hotelling

Hotelling time is calculated by subtracting departure time from arrival time while at berth or anchorage. Ship movements are tracked by MarEx as to:

- Arrivals (inbound trip)
- Departures (outbound trip)
- Shifts (inter-port, intra-port, and anchorage shifts)
- Total movements (sum of all the above)

Arrivals

For this study, arrivals include inbound trips from the sea to a berth and inbound trips from the sea to an anchorage. An inbound trip from the sea to an anchorage is assigned to the port if the next port of call is a berth at the port.

Departures

For this study, departures include outbound trips from a berth or anchorage to the sea.

Shifts

While many vessels make only one arrival and departure at a time, some vessels make multiple stops within a port. To assist with preparation of the marine emissions inventory, all shifts were grouped together, since they do not have an "at-sea" component as with arrivals and departures. When a vessel shifts from one berth to another or from an anchorage to a berth, the emissions associated with that shift (transit emissions from/to berth) are allocated to the "to berth" or "arriving berth."

There are three broad categories of shifts:

- Intra-port shifts – movements within a port from one berth to another.
- Inter-port shifts – movements between adjacent ports. This is a common occurrence in co-located ports such as Los Angeles and Long Beach.
- Anchorage shifts – movements between a terminal and anchorage. For example, a vessel receives a partial load, goes to anchorage, and then returns to the terminal to complete loading.

Table 3.4 presents the arrivals, departures, shifts and total movements for vessels at the Port in 2009. Arrivals and departures do not match because the activity is based on a calendar year.

Table 3.4: Total OGV Movements for 2009

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	61	63	16	140
Bulk	53	50	47	150
Bulk - Heavy Load	3	3	5	11
Bulk Wood Chips	4	4	6	14
Container - 1000	115	115	10	240
Container - 2000	165	167	22	354
Container - 3000	89	89	5	183
Container - 4000	295	299	18	612
Container - 5000	359	368	27	754
Container - 6000	138	174	40	352
Container - 7000	106	106	12	224
Container - 8000	78	77	7	162
Container - 9000	10	10	5	25
Cruise	163	162	1	326
General Cargo	61	56	62	179
Ocean Tug	73	69	55	197
Miscellaneous	2	2	0	4
Reefer	42	39	40	121
Tanker - Aframax	1	1	1	3
Tanker - Chemical	92	97	180	369
Tanker - Handyboat	60	57	88	205
Tanker - Panamax	40	36	89	165
Total	**2,010**	**2,044**	**736**	**4,790**

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3.5 Emission Estimation Methodology

Emissions are estimated as a function of vessel power demand (energy expressed in kW-hrs) multiplied by an emission factor, where the emission factor is expressed in terms of grams per kilowatt-hour (g/kW-hr). Emission factors and emission factor adjustments for low propulsion engine load are then applied to the various activity data. The process for estimating emissions from propulsion engines is illustrated as a process flow diagram in Figure 3.5.

Equations 3.1 and 3.2 report the basic equations used in estimating emissions.

$$E = Energy \times EF \times FCF \times CF \qquad \text{Equation 3.1}$$

Where:

E = Emissions from the engine(s)
Energy = Energy demand, in kW-hrs, calculated using Equation 3.2 below as the energy output of the engine (or engines) over the period of time
EF = Emission factor, expressed in terms of g/kW-hr
FCF = Fuel correction factor
CF = Control factor(s) for emission reduction technologies

The 'Energy' term of the equation is where most of the location-specific information is used. Energy is calculated using Equation 3.2:

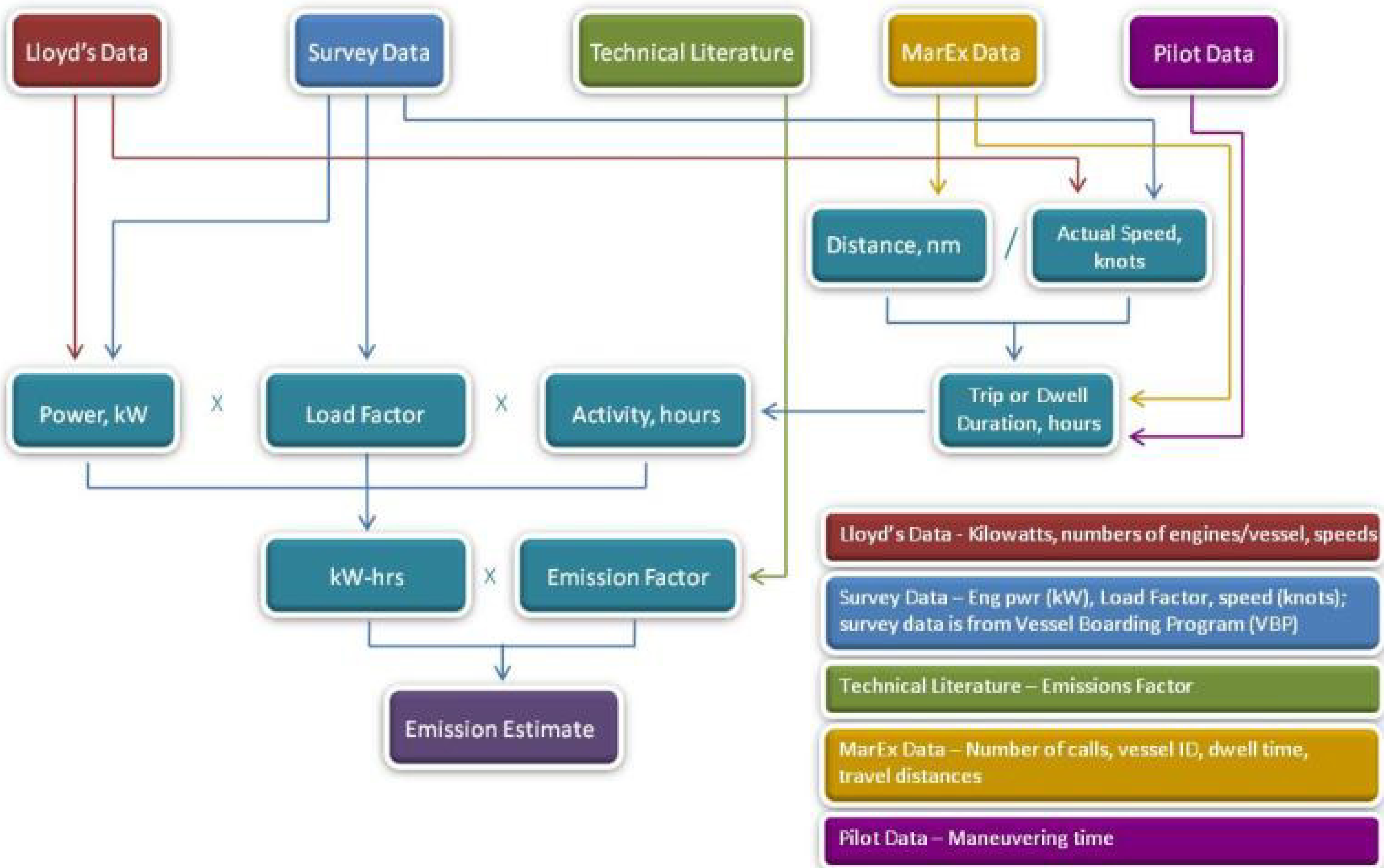
$$Energy = MCR \times LF \times Act \qquad \text{Equation 3.2}$$

Where:

MCR = maximum continuous rated engine power, kW
LF = load factor (unitless)
Act = activity, hours

The emissions estimation methodology section discusses methodology used for propulsion engines (subsections 3.5.1 to 3.5.7), auxiliary engines (subsections 3.5.8 and 3.5.9) and auxiliary boilers (subsections 3.5.10). Propulsion engines are also referred to as main engines. Incinerators are not included in the emissions estimates because incinerators are not used within the study area. Interviews with the vessel operators and marine industry indicate that vessels do not use their incinerators while at berth or near coastal waters.

Figure 3.5: Propulsion Engine Emission Estimation Flow Diagram



3.5.1 Propulsion Engine Maximum Continuous Rated Power

MCR power is defined as the manufacturer's tested engine power; for this study, it is assumed that the Lloyd's 'Power' value is the best surrogate for MCR power. The international specification is to report MCR in kilowatts, and it is related to the highest power available from a ship engine during average cargo and sea conditions. However, operating a vessel at 100% of its MCR power is very costly from a fuel consumption and engine maintenance perspective, so most operators limit their maximum power to about 83% of MCR.

3.5.2 Propulsion Engine Load Factor

Load factor is the ratio of an engine's power output at a given speed to the engine's MCR power. Propulsion engine load factor is estimated using the Propeller Law, which says that propulsion engine load varies with the cube of vessel speed. Therefore, propulsion engine load at a given speed is estimated by taking the cube of that speed divided by the vessel's maximum speed, as illustrated by the following equation.

$$LF = (AS / MS)^3 \qquad \text{Equation 3.3}$$

Where:

LF = load factor, percent
AS = actual speed, knots
MS = maximum speed, knots

For a few instances, the calculated load factor using the actual speed data recorded and provided by MarEx, has exceeded the 83% MCR. This may be due to vessels traveling faster than the maximum rated speed due to wind conditions or currents. For the purpose of estimating emissions, the load factor has been capped to 1.0 so that there are no calculated propulsion engine load factors greater than 100% (i.e., calculated load factors above 1.0 are assigned a load factor of 1.0).

3.5.3 Propulsion Engine Activity

Activity is measured in hours of operation. The transit time in precautionary zone and the fairway, from outside the PZ to the edge of the geographical boundary, is estimated using equation 3.4 which divides the segment distance traveled by ship speed.

$$Act = D/AS \qquad \text{Equation 3.4}$$

Where:

Act = activity, hours
D = distance, nautical miles
AS = actual ship speed, knots

Actual speeds provided by MarEx (discussed in section 3.3.2) are used for estimating the fairway transit time. Vessel speeds are recorded by the Marine Exchange at 10, 15, 20, 25, 30, 35 and 40 nm. The Port's Vessel Speed Reduction Incentive Program (VSRIP) requires reduced speeds of 12 knots or slower during transiting outside the harbor and within 40 nm of the Port.

The PZ uses assigned speeds based on VBP data, as found in Table 3.5.

Table 3.5: Precautionary Zone Speed, knots

Vessel Type	Class	Speed
Auto Carrier	Fast	11.0
Bulk	Slow	9.0
Containership	Fast	11.0
Cruise	Fast	11.0
General Cargo	Slow	9.0
Miscellaneous	Slow	9.0
Ocean tug	Slow	9.0
Reefer	Slow	9.0
RoRo	Slow	9.0
Tanker	Slow	9.0

3.5.4 Propulsion Engine Emission Factors

The main engine emission factors used in this study were reported in a 2002 ENTEC study,[21] except for PM emission factors. CARB[22] provided the PM EF for slow and medium speed diesel engines. IVL 2004 study[23] was the source for the PM EF for gas turbine and steamship vessels. The greenhouse gas emission factors for CO_2, CH_4 and N_2O were also reported in the IVL 2004 study. These emissions factors are based on residual oil (RO) which is intermediate fuel oil (IFO 380) or one with similar specifications, with an average sulfur content of 2.7%.

[21] ENTEC, *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community, Final Report*, July 2002. Prepared for the European Commission.(ENTEC 2002).

[22] CARB, *A Critical Review of Ocean-Going Vessel Particulate Matter Emission Factors*, 9 Nov 07. See: *www.arb.ca.gov/msei/offroad/pubs/ocean_going_vessels_pm_emfac.pdf*

[23] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors."* Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency.

The two predominant propulsion engine types are:

- Slow speed diesel engines, having maximum engine speeds less than 130 rpm
- Medium speed diesel engines, having maximum engine speeds over 130 rpm (and typically greater than 400 rpm).

Table 3.6 and 3.7 list the emission factors for propulsion power using residual fuel.

Table 3.6: Emission Factors for OGV Propulsion Power using Residual Oil, g/kW-hr

Engine	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Slow speed diesel	≤ 1999	1.5	1.2	1.5	18.1	10.5	1.4	0.6
Medium speed diesel	≤ 1999	1.5	1.2	1.5	14.0	11.5	1.1	0.5
Slow speed diesel	2000 +	1.5	1.2	1.5	17.0	10.5	1.4	0.6
Medium speed diesel	2000 +	1.5	1.2	1.5	13.0	11.5	1.1	0.5
Gas turbine	all	0.05	0.04	0.0	6.1	16.5	0.2	0.1
Steamship	all	0.8	0.6	0.0	2.1	16.5	0.2	0.1

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Table 3.7: GHG Emission Factors for OGV Propulsion Power using Residual Oil, g/kW-hr

Engine	Model Year	CO_2	N_2O	CH_4
Slow speed diesel	≤ 1999	620	0.031	0.012
Medium speed diesel	≤ 1999	683	0.031	0.010
Slow speed diesel	2000 +	620	0.031	0.012
Medium speed diesel	2000 +	683	0.031	0.010
Gas turbine	all	970	0.08	0.002
Steamship	all	970	0.08	0.002

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3.5.5 Propulsion Engines Low Load Emission Factors

In general terms, diesel-cycle engines are not as efficient when operated at low loads. An EPA study[24] prepared by Energy and Environmental Analysis, Inc. (EEIA) established a formula for calculating emission factors for low engine load conditions such as those encountered during harbor maneuvering and when traveling slowly at sea such as in the reduced speed zone. While mass emissions (e.g., pounds per hour) tend to go down as vessel speeds and engine loads decrease, the emission factors (e.g., g/kW-hr) increase. This is based on observations that compression-cycle combustion engines are less efficient at low loads.

The following equations describe the low-load effect where emission rates can increase, based on a limited set of data from Lloyd's Maritime Program and the U.S. Coast Guard. The low load effect was described in a study conducted for the EPA by ENVIRON.[25] Equation 3.5 is the equation developed by EEIA to generate emission factors for the range of load factors from 2% to 20% for each pollutant:

Equation 3.5

$$y = a\,(\text{fractional load})^{-x} + b$$

Where:

y = emissions in g/kW-hr
a = coefficient
b = intercept
x = exponent (negative)
fractional load = derived by the Propeller Law (see equation 3.3)

Table 3.8 provides the variables for equation 3.5. These variables are slightly different than those listed in previous inventory reports due to modifications made to rounding. These modified variables reflect 4 decimal places of precision.

Table 3.8: Low-Load Emission Factor Regression Equation Variables as Modified

Pollutant	Exponent	Intercept (b)	Coefficient (a)
PM	1.5	0.2551	0.0059
NO_x	1.5	10.4496	0.1255
CO	1.0	0.1458	0.8378
HC	1.5	0.3859	0.0667

DB ID476

[24] EEIA for Sierra Research, for EPA, *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data,* February 2000. Sierra Research work assignment No. 1-10. EPA420-R-002.
[25]EPA, *Commercial Marine Inventory Development,* July 2002. EPA 420-R-02-019.

Table 3.9 provides the emission factors based on Equation 3.5 and variables in Table 3.8 at 2% to 20% loads.

Table 3.9: EEIA Emission Factors, g/kW-hr

Load	PM	NO_x	CO	HC
2%	2.34	54.82	42.04	23.97
3%	1.39	34.60	28.07	13.22
4%	0.99	26.14	21.09	8.72
5%	0.78	21.67	16.90	6.35
6%	0.66	18.99	14.11	4.92
7%	0.57	17.23	12.11	3.99
8%	0.52	16.00	10.62	3.33
9%	0.47	15.10	9.45	2.86
10%	0.44	14.42	8.52	2.50
11%	0.42	13.89	7.76	2.21
12%	0.40	13.47	7.13	1.99
13%	0.38	13.13	6.59	1.81
14%	0.37	12.85	6.13	1.66
15%	0.36	12.61	5.73	1.53
16%	0.35	12.41	5.38	1.43
17%	0.34	12.24	5.07	1.34
18%	0.33	12.09	4.80	1.26
19%	0.33	11.96	4.56	1.19
20%	0.32	11.85	4.33	1.13

The low load adjustment (LLA) multipliers that are applied to the propulsion engine g/kW-hr emission factors are then determined by dividing each of the EEIA emission factors by the emission factor at 20% load using Equation 3.5. This results in positive numbers greater than one, since emissions increase as load is decreased. At 20% load, the value is exactly 1.0 since it is divided into itself.

Equation 3.6

LLA (at _% load) = y (at _% load) / y (at 20% load)

Where:

LLA = Low load adjustment multiplier
y = emission factors in g/kW-hr from equation 3.5 (See Table 3.9)

Table 3.10 lists the resulting low-load adjustment factors for diesel propulsion engines. Adjustments to N_2O and CH_4 emission factors are made on the basis of the NO_x and HC low load adjustments, respectively. The LLA is not applied at engine loads greater than 20%. For main engine loads below 20 percent, the LLA increases so as to reflect increased emissions (on a g/kW-hr basis) due to engine inefficiency. Low load emission factors are not applied to steamships or ships having gas turbines because the EPA study only observed a rise in emissions from diesel engines.

Table 3.10: Low Load Adjustment Multipliers for Emission Factors[26]

Load	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
2%	7.29	4.63	1.00	9.68	21.18	1.00	4.63	21.18
3%	4.33	2.92	1.00	6.46	11.68	1.00	2.92	11.68
4%	3.09	2.21	1.00	4.86	7.71	1.00	2.21	7.71
5%	2.44	1.83	1.00	3.89	5.61	1.00	1.83	5.61
6%	2.04	1.60	1.00	3.25	4.35	1.00	1.60	4.35
7%	1.79	1.45	1.00	2.79	3.52	1.00	1.45	3.52
8%	1.61	1.35	1.00	2.45	2.95	1.00	1.35	2.95
9%	1.48	1.27	1.00	2.18	2.52	1.00	1.27	2.52
10%	1.38	1.22	1.00	1.96	2.18	1.00	1.22	2.18
11%	1.30	1.17	1.00	1.79	1.96	1.00	1.17	1.96
12%	1.24	1.14	1.00	1.64	1.76	1.00	1.14	1.76
13%	1.19	1.11	1.00	1.52	1.60	1.00	1.11	1.60
14%	1.15	1.08	1.00	1.41	1.47	1.00	1.08	1.47
15%	1.11	1.06	1.00	1.32	1.36	1.00	1.06	1.36
16%	1.08	1.05	1.00	1.24	1.26	1.00	1.05	1.26
17%	1.06	1.03	1.00	1.17	1.18	1.00	1.03	1.18
18%	1.04	1.02	1.00	1.11	1.11	1.00	1.02	1.11
19%	1.02	1.01	1.00	1.05	1.05	1.00	1.01	1.05
20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[26] The LLA multipliers for N_2O and CH_4 are based on NO_x and HC, respectively.

The LLA multipliers are applied to the at-sea emission factors for diesel propulsion engines only. The low load emission factor is calculated for each pollutant using Equation 3.7. In keeping with the port's emission estimating practice of assuming a minimum main engine load of 2%, the table of LLA factors does not include values for 1% load.

Equation 3.7

$$EF = Base\ EF \times LLA$$

Where:

EF = Resulting emission factor
Base EF = Emission factor for diesel propulsion engines (see Tables 3.6 and 3.7)
LLA = Low load adjustment multiplier (see Table 3.10)

3.5.6 Propulsion Engine Harbor Maneuvering Loads

Main engine loads within a harbor tend to be very light, especially on in-bound trips when the main engines are turned off for periods of time as the vessels are being maneuvered to their berths. During docking, when the ship is being positioned against the wharf, the assist tugboats do most of the work and the main engines are off. Main engine maneuvering loads are estimated using the Propeller Law, with the over-riding assumption that the lowest average engine load is 2%.

Harbor transit speeds within the breakwater were profiled from VBP information as follows:

- Inbound fast ships (auto, container, cruise ships) at 7 knots
- Inbound slow ships (any other vessel type) at 5 knots
- Outbound traffic for all vessels at 8 knots

The departure speed, and hence the departure load, is typically higher than on arrival because on departure the engine power is used to accelerate the vessel away from the berth, while on arrival the vessel usually travels slower and spends some time with the main engine off.

3.5.7 Propulsion Engine Defaults

All vessels that called the Port in 2009 were able to be matched for main engine power using the most current Lloyd's data and VBP information, except for ocean tugs. Therefore, defaults were only used for ocean tugs' main engine power.

3.5.8 Auxiliary Engine Emission Factors

The ENTEC auxiliary engine emission factors used in this study are presented in Table 3.11.

Table 3.11: Emission Factors for Auxiliary Engines using Residual Oil, g/kW-hr

Engine	MY	PM_{10}	$PM_{2.5}$	DPM	NO_X	SO_x	CO[27]	HC
Medium speed	≤ 1999	1.5	1.2	1.5	14.7	12.3	1.1	0.4
Medium speed	2000+	1.5	1.2	1.5	13.0	12.3	1.1	0.4

DB ID456

Table 3.12: GHG Emission Factors for Auxiliary Engines using Residual Oil, g/kW-hr

Engine	MY	CO_2	N_2O	CH_4
Medium speed	all	683	0.031	0.008

DB ID456

3.5.9 Auxiliary Engine Load Defaults

Lloyd's database contains limited auxiliary engine's installed power information because IMO or the classification societies do not require vessel owners to provide this information. Therefore, auxiliary engine load data for each vessel follows the hierarchy described in section 3.3.5 (i.e., VBP, sister ships, Port defaults). Defaults for auxiliary engine loads were developed based on the vessel class averages of the installed auxiliary engine power (call-weighted averages by vessel class using Lloyds and VBP data for vessels calls in 2009) multiplied by load factors by vessel class by mode, which were derived from historical VBP data. Since the defaults are based on the vessels that visit the Port that year, defaults will vary slightly from year to year.

[27] IVL 2004.

Table 3.13 summarizes the auxiliary engine load defaults used for this study by vessel subtype. For diesel electric cruise ships, house load defaults are listed in Table 3.14. Diesel electric tankers did not call the port in 2009.

Table 3.13: Auxiliary Engine Load Defaults

Vessel Type	Auxiliary Engine Load Defaults (kW)			
	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	440	1,321	734	440
Bulk	234	620	138	234
Bulk - Heavy Load	330	873	194	330
Bulk - Wood Chips	234	619	138	234
Container - 1000	446	1,058	334	446
Container - 2000	904	2,008	954	904
Container - 3000	649	2,225	556	649
Container - 4000	1,428	2,516	1,156	1,428
Container - 5000	1,123	4,012	963	1,123
Container - 6000	1,370	3,057	949	1,370
Container - 7000	1,694	3,778	1,173	1,694
Container - 8000	1,592	3,551	1,102	1,592
Container - 9000	1,498	3,341	1,037	1,498
Cruise	5,453	8,724	5,453	5,453
General Cargo	457	1,209	591	457
Ocean Tug	88	233	114	88
Miscellaneous	234	619	138	234
Reefer	444	1,331	769	444
Tanker - Aframax	864	1,188	936	864
Tanker - Chemical	726	998	786	726
Tanker - Handyboat	671	922	727	671
Tanker - Panamax	602	828	652	602

Table 3.14: Diesel Electric Cruise Ship Auxiliary Engine Load Defaults

Vessel Type	Passenger Count	Auxiliary Engine Load Defaults (kW) Sea	Maneuvering	Berth Hotelling
Cruise, Diesel Electric	0-1,500	3,500	3,500	3,000
Cruise, Diesel Electric	1,500-2,000	7,000	7,000	6,500
Cruise, Diesel Electric	2,000-3,000	10,500	10,500	9,500
Cruise, Diesel Electric	3,000-3,500	11,000	11,000	10,000
Cruise, Diesel Electric	3,500-4,000	11,500	11,500	10,500
Cruise, Diesel Electric	4,000+	12,000	12,000	11,000

3.5.10 Auxiliary Boilers

In addition to the auxiliary engines that are used to generate electricity for on-board uses, most OGVs have one or more boilers used for fuel heating and for producing hot water. Boilers are typically not used during transit at sea since many vessels are equipped with an exhaust gas recovery system or "economizer" that uses heat of the main engine exhaust for heating fuel or water. Therefore, the boilers are not needed when the main engines are used. Vessel speeds have been reduced in recent years due to increased compliance with the VSR program extending to 20 nm, and some vessels voluntarily comply out to 40 nm. Because of these lower speeds, it is believed that auxiliary boilers are used during transit when the lower speeds result in the cooling of main engine exhausts, making the vessels' economizers less effective. As such, it is assumed that auxiliary boilers operate when the main engine power load is less than 20% during maneuvering and transit.

Tables 3.15 and 3.16 show the emission factors used for the steam boilers based on ENTEC's report (ENTEC 2002).

Table 3.15: Emission Factors for OGV Auxiliary Boilers using Residual Oil, g/kW-hr

Engine	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Steam boilers	0.8	0.6	0.0	2.1	16.5	0.2	0.1

DB ID880

Table 3.16: GHG Emission Factors for OGV Auxiliary Boilers using Residual Oil, g/kW-hr

Engine	CO_2	N_2O	CH_4
Steam boilers	970	0.08	0.002

DB ID880

The boiler fuel consumption data collected from vessels during the VBP was converted to equivalent kilowatts using Specific Fuel Consumption (SFC) factors found in the ENTEC report. The average SFC value for using residual fuel is 305 grams of fuel per kW-hour. Using the following equation, the average kW for auxiliary boilers was calculated.

Average kW = ((daily fuel/24) x 1,000,000)/305 Equation 3.8

Auxiliary boiler energy defaults in kilowatts used for each vessel type are presented in Table 3.17. The cruise ships and tankers (except for diesel electric tankers and cruise ships) have much higher auxiliary boiler usage rates than the other vessel types. Cruise ships have higher boiler usage due to the number of passengers and need for hot water. Tankers provide steam for steam-powered liquid pumps, inert gas in fuel tanks, and to heat fuel for pumping. Ocean tugboats do not have boilers; therefore their boiler energy default is zero. As mentioned earlier, boilers are not typically used at sea during normal transit; therefore the boiler energy default at sea is zero (if main engine load is greater than 20%). If the main engine load is less than or equal to 20%, the maneuvering boiler load defaults shown in the table are used which are similar to hotelling defaults, except for the tankers. The auxiliary boiler load defaults are based on the latest available VBP data, and therefore, are different from the defaults used in previous inventories.

Table 3.17: Auxiliary Boiler Load Defaults

Vessel Type	Boiler Load Defaults (kW)			
	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	0	246	246	246
Bulk	0	137	137	137
Bulk - Heavy Load	0	137	137	137
Bulk - Wood Chips	0	137	137	137
Container - 1000	0	228	228	228
Container - 2000	0	348	348	348
Container - 3000	0	497	497	497
Container - 4000	0	530	530	530
Container - 5000	0	629	629	629
Container - 6000	0	578	578	578
Container - 7000	0	497	497	497
Container - 8000	0	440	440	440
Container - 9000	0	440	440	440
Cruise	0	1,393	1,393	0
General Cargo	0	137	137	137
Ocean Tug	0	0	0	0
Miscellaneous	0	137	137	137
Reefer	0	212	212	212
Tanker - Aframax	0	371	2,500	371
Tanker - Chemical	0	371	2,500	371
Tanker - Handyboat	0	371	2,500	371
Tanker - Panamax	0	371	2,500	371

3.5.11 Fuel Correction Factors

Fuel correction factors are used when the actual fuel used is different than the fuel used to develop the emission factors. As discussed earlier, main, auxiliary and auxiliary boiler emission factors are based on residual fuel with an average 2.7% sulfur content or marine diesel oil with an average 1.5% sulfur content. Table 3.18 lists the fuel correction factors for fuels with different sulfur content. These fuel correction factors are consistent with CARB's emission estimations methodology for ocean-going vessels.[28]

Table 3.18: Fuel Correction Factors

Actual Fuel	Sulfur Content	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
HFO	1.5%	0.82	1.00	0.56	1.00	1.00	1.00	1.00	1.00
MDO	1.5%	0.47	0.90	0.56	1.00	1.00	1.00	0.90	1.00
MDO/MGO	0.5%	0.25	0.94	0.18	1.00	1.00	1.00	0.94	1.00
MDO/MGO	0.2%	0.19	0.94	0.07	1.00	1.00	1.00	0.94	1.00
MDO/MGO	0.1%	0.17	0.94	0.04	1.00	1.00	1.00	0.94	1.00

Beginning July 1, 2009, CARB's marine auxiliary engine fuel regulation (adopted in July 2008) required vessel operators to use MGO with a sulfur content less than 1.5% by weight or MDO with a sulfur content equal to or less than 0.5% by weight within 24 nm from California coast (and while at berth) in their diesel powered main, auxiliary and auxiliary boilers. For the period of July 1, 2009 to December 31, 2009, a 100% compliance is assumed with CARB's regulation (and confirmed by CARB). During this period, an average 0.5% sulfur fuel content is assumed for both main and auxiliary engines and auxiliary boilers.

From January 1, 2009 to June 30, 2009, the Port continued to implement its Low Sulfur Fuel Incentive Program which provided incentives to vessel operators switching to low-sulfur marine fuel (i.e., fuel with sulfur content of 0.2% or less) in their auxiliary engines (while at berth) and main engines within at least 20 nm and up to 40 nm of Port Fermin and also complying with the Port's VSR program. For vessels that participated in the Low Sulfur Fuel Incentive Program in 2009, the emissions benefits due to the use of lower sulfur fuel are reflected during this period.

The fuel switches accounted for in the Port's program for the first half of 2009 represents a conservative approach as there may have been other companies that switched to lower sulfur fuel during this period that the Port was not aware of.

[28] See *http://www.arb.ca.gov/regact/2008/fuelogv08/fuelogv08.htm;* Appendix D, Tables II-6 to II-8.

3.5.12 Control Factors for Emission Reduction Technologies

Control factors are used to take into account the emissions benefits associated with emission reduction technologies installed on vessels. One such technology for marine main engines is the fuel slide valve. This new type of fuel valve leads to a better combustion process, less smoke, and lower fuel consumption, which results in reduced overall emissions for NO_x (30% reduction) and PM (25% reduction). The newer MAN B&W engines (2004+ model year vessels) are equipped with the fuel slide valves. Some companies are also retrofitting their vessels equipped with MAN B&W main engines with slide valves. Since information on slide valve retrofits has primarily been collected through VBP surveys, the inventory may not have captured all the vessels that have been retrofitted with slide valves. The emission reduction estimates for the slide valves are based on MAN B&W Diesel A/S emission measurements. In order to obtain the latest information on the applicability and control effectiveness of slide valves, the representative from MAN B&W in Denmark was recently contacted. Based on the recent communication with MAN B&W and preliminary information provided, for the 2009 inventory, the current emission reduction benefits (i.e., 30% NOx and 25% PM reductions) are applied to 2004 and newer vessels equipped with MAN B&W engines as well as to existing engines known to be retrofitted with slide valves. The ports will continue to work with MAN B&W and the Technical Working Group (TWG) to refine the emission benefits for slide valves used in new engines and as retrofits for future EIs to ensure that the latest available information is used. In 2009, slide valves were used in 27% of all vessel calls.

In addition, shore side electrical power was used for 59 vessel calls representing about 3% of all vessel calls. At-berth reduction of 95% in all pollutants for auxiliary engines emissions is assumed for ships that used shore side electrical power. This reduction estimate accounts for the time necessary to connect and disconnect the electrical power and start-up the auxiliary engines.

3.5.13 Improvements to Methodology from Previous Years

There were no changes to the ocean going vessels emission calculation methodology in this inventory compared to the 2008 methodology. For comparison of 2009 emissions to previous years' emissions, refer to Section 9.

3.5.14 Future Improvements to Methodology

For the 2010 EI, improvements to the methodology will be considered in at least two areas: 1) engine modification technologies incorporated in new engines as standard practice and installed as retrofits in existing vessels. The ports will work with engine manufacturers and shipping companies, and through the TWG process, to further refine the emissions benefits associated with slide valves (new engines and retrofits) as well as other technologies being implemented; 2) in an effort to continue to improve the auxiliary engine loads by vessel mode, a new approach will be considered, in consultation with TWG, based on VBP reported auxiliary loads (actual power of the engine used), by vessel class and by mode instead of using the average installed auxiliary engine power adjusted by applying load factor by vessel class and mode. Under the new approach, default loads for auxiliary engines by operating mode will be based on the average of loads for each vessel subclass recorded for vessels boarded. Load Factors will no longer be used as installed power, as this is not a scalable variable by vessel owner and class, which may result in potential over/under estimates of auxiliary engine load. Information from CARB surveys, if available, will also be used for filling any data gaps.

3.6 Emission Estimates

A summary of the ocean-going vessel emission estimates by vessel type for all pollutants for the year 2009 is presented in Tables 3.19 and 3.20.

Table 3.19: 2009 Ocean-Going Vessel Emissions by Vessel Type, tons per year

Vessel Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto Carrier	3.9	3.2	3.6	62.4	31.3	5.9	2.5
Bulk	3.2	2.6	2.9	45.9	28.7	4.1	1.8
Bulk - Heavy Load	0.3	0.2	0.3	4.4	2.9	0.4	0.1
Bulk - Wood Chips	0.2	0.1	0.1	3.8	1.4	0.3	0.1
Container - 1000	4.0	3.2	3.5	65.1	31.8	6.3	2.9
Container - 2000	14.7	11.8	11.2	207.9	149.2	19.7	8.5
Container - 3000	11.4	9.1	9.9	157.5	90.5	16.3	7.8
Container - 4000	33.3	26.6	29.7	522.5	246.0	59.9	29.8
Container - 5000	67.9	54.3	59.5	833.7	534.4	99.6	50.8
Container - 6000	32.0	25.6	28.4	413.2	237.4	52.8	27.9
Container - 7000	16.3	13.1	14.1	309.8	117.6	36.6	17.9
Container - 8000	11.3	9.0	10.3	213.8	77.1	28.1	14.4
Container - 9000	1.0	0.8	0.9	29.2	5.7	3.5	1.8
Cruise	35.6	28.5	35.6	617.8	253.0	54.2	21.2
General Cargo	5.8	4.7	5.4	84.0	47.5	7.2	2.9
Ocean Tug	0.9	0.7	0.9	30.0	5.4	2.7	1.2
Miscellaneous	0.0	0.0	0.0	1.1	0.3	0.1	0.0
Reefer	4.5	3.6	4.1	53.6	38.0	4.4	1.9
Tanker - Aframax	0.3	0.2	0.2	1.8	3.7	0.2	0.1
Tanker - Chemical	21.0	16.8	12.8	197.6	262.8	18.4	7.6
Tanker - Handyboat	10.3	8.2	5.8	98.5	139.6	8.6	3.6
Tanker - Panamax	8.7	6.9	4.7	85.6	113.9	8.5	3.6
Total	**286.6**	**229.3**	**243.8**	**4,039.0**	**2,418.3**	**437.8**	**208.4**

DB ID692

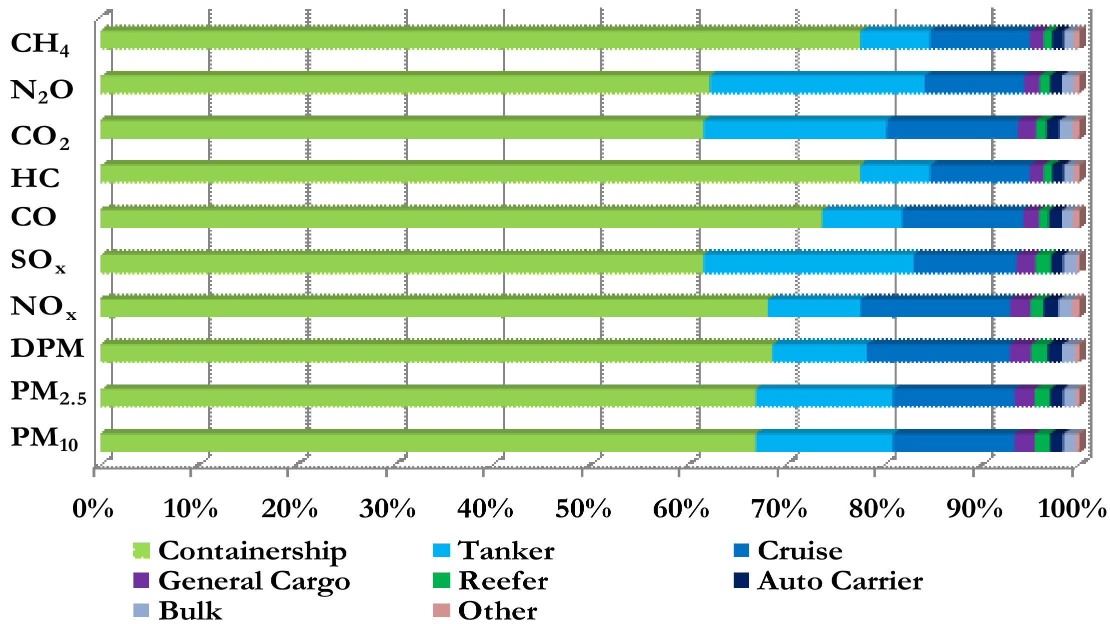
Table 3.20: Summary of 2009 Ocean-Going Vessel GHG Emissions by Vessel Type, metric tons per year

Vessel Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auto Carrier	3,120.1	3,068.2	0.2	0.0
Bulk	2,510.8	2,468.3	0.1	0.0
Bulk - Heavy Load	255.8	251.3	0.0	0.0
Bulk - Wood Chips	233.5	229.3	0.0	0.0
Container - 1000	3,295.6	3,239.0	0.2	0.1
Container - 2000	13,358.4	13,114.0	0.8	0.2
Container - 3000	7,742.6	7,597.3	0.5	0.1
Container - 4000	24,472.0	24,033.8	1.4	0.5
Container - 5000	43,944.9	43,131.6	2.6	0.9
Container - 6000	21,516.6	21,116.6	1.3	0.5
Container - 7000	15,906.1	15,624.5	0.9	0.3
Container - 8000	11,502.4	11,300.6	0.6	0.3
Container - 9000	1,417.8	1,391.8	0.1	0.0
Cruise	31,008.9	30,587.1	1.3	0.4
General Cargo	4,209.1	4,142.3	0.2	0.1
Ocean Tug	1,539.3	1,518.7	0.1	0.0
Miscellaneous	69.6	68.5	0.0	0.0
Reefer	2,592.2	2,548.7	0.1	0.0
Tanker - Aframax	199.1	195.0	0.0	0.0
Tanker - Chemical	21,549.5	21,108.8	1.4	0.1
Tanker - Handyboat	11,054.9	10,821.3	0.7	0.1
Tanker - Panamax	10,773.3	10,548.1	0.7	0.1
Total	**232,272.5**	**228,104.8**	**13.2**	**3.8**

DB ID692

Figure 3.6 shows percentage of emissions by vessel type for each pollutant. Containerships contributed the highest percentage of the emissions (approximately 62 to 78%), followed by cruise ships (approximately 10 to 15%), tankers (approximately 7 to 22%), general cargo, auto carrier, reefers, and bulk vessels. The "other" category includes ocean-going tugboats and miscellaneous vessels.

Figure 3.6: 2009 Ocean-Going Vessel Emissions by Vessel Type, %



3.6.1 Emission Estimates by Engine Type

Tables 3.21 and 3.22 present summaries of emission estimates by engine type in tons per year.

Table 3.21: 2009 Ocean-Going Vessel Emissions by Engine Type, tons per year

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Main Engine	126.8	101.4	124.4	1,909.0	734.8	254.9	139.8
Auxiliary Engine	119.4	95.5	119.4	1,968.8	889.3	167.1	60.8
Auxiliary Boiler	40.5	32.4	0.0	161.2	794.2	15.8	7.9
Total	**286.6**	**229.3**	**243.8**	**4,039.0**	**2,418.3**	**437.8**	**208.4**

DB ID692

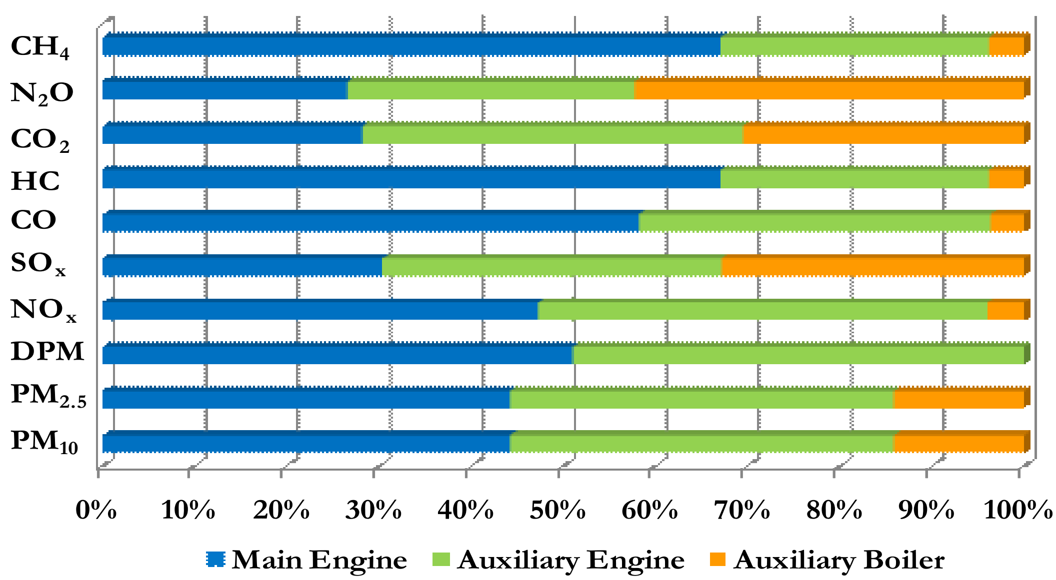
Table 3.22: 2009 Ocean-Going Vessel GHG Emissions by Engine Type, metric tons per year

Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Main Engine	65,574.9	64,435.7	3.5	2.5
Auxiliary Engine	95,425.7	94,127.4	4.1	1.1
Auxiliary Boiler	71,271.8	69,541.7	5.6	0.1
Total	**232,272.5**	**228,104.8**	**13.2**	**3.8**

DB ID692

Figure 3.7 shows percentages of emissions by engine type for each pollutant. The majority of OGV emissions are associated with main and auxiliary diesel engines while auxiliary boilers contribute significantly to SO_x emissions with a smaller contribution to other pollutants. The auxiliary boilers emission rates are lower for NO_x than diesel engines and higher for SO_x than diesel engines.

Figure 3.7: 2009 Ocean-Going Vessel Emissions by Engine Type, %



3.6.2 Emission Estimates by Mode

Tables 3.23 and 3.24 present summaries of emission estimates by the various modes in tons per year. For each mode, the engine type emissions are also listed. Hotelling at terminal berth and at anchorage are listed separately. Transit and harbor maneuvering emissions include both berth and anchorage calls. Figure 3.8 shows results in percentages of emissions by mode.

Table 3.23: 2009 Ocean-Going Vessel Emissions by Mode, tons per year

Mode	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Transit	Main	111.2	89.0	108.9	1,693.9	707.9	212.6	105.0
Transit	Aux	23.2	18.5	23.2	358.5	174.4	30.5	11.1
Transit	Auxiliary Boiler	2.9	2.3	0.0	11.0	57.5	1.1	0.5
Total Transit		**137.3**	**109.8**	**132.1**	**2,063.4**	**939.8**	**244.2**	**116.7**
Maneuvering	Main	15.6	12.5	15.5	215.1	26.9	42.3	34.7
Maneuvering	Aux	10.1	8.1	10.1	166.3	75.5	14.1	5.1
Maneuvering	Auxiliary Boiler	1.0	0.8	0.0	3.9	18.9	0.4	0.2
Total Maneuvering		**26.7**	**21.3**	**25.6**	**385.2**	**121.3**	**56.8**	**40.1**
Hotelling - Berth	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hotelling - Berth	Aux	75.8	60.6	75.8	1,302.3	559.2	110.6	40.2
Hotelling - Berth	Auxiliary Boiler	33.8	27.0	0.0	135.9	662.2	13.3	6.7
Total Hotelling - Berth		**109.6**	**87.7**	**75.8**	**1,438.2**	**1,221.5**	**123.9**	**46.9**
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hotelling - Anchorage	Aux	10.3	8.2	10.3	141.7	80.1	11.8	4.3
Hotelling - Anchorage	Auxiliary Boiler	2.8	2.2	0.0	10.4	55.5	1.0	0.5
Total Hotelling - Anchorage		**13.1**	**10.5**	**10.3**	**152.2**	**135.7**	**12.9**	**4.8**
Total		**286.6**	**229.3**	**243.8**	**4,039.0**	**2,418.3**	**437.8**	**208.4**

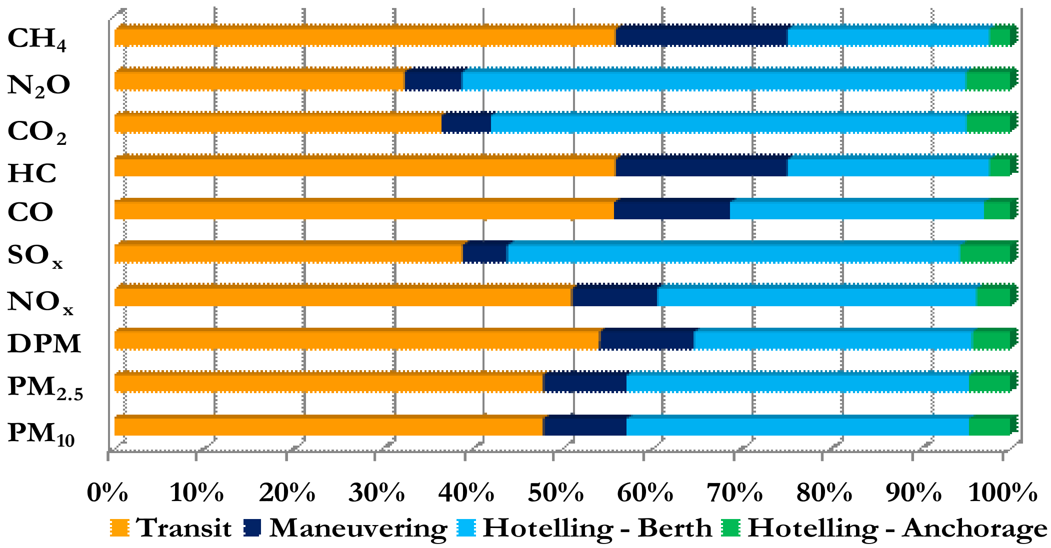
DB ID694

Table 3.24: 2009 Ocean-Going Vessel Greenhouse Gas Emissions by Mode, metric tons per year

Mode	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Transit	Main	62,423.5	61,410.1	3.1	1.9
Transit	Aux	17,431.9	17,194.1	0.8	0.2
Transit	Auxiliary Boiler	4,843.8	4,725.9	0.4	0.0
Total Transit		**84,699.2**	**83,330.1**	**4.3**	**2.1**
Maneuvering	Main	3,151.5	3,025.6	0.4	0.6
Maneuvering	Aux	8,074.7	7,964.9	0.3	0.1
Maneuvering	Auxiliary Boiler	1,704.9	1,663.5	0.1	0.0
Total Maneuvering		**12,931.0**	**12,653.9**	**0.8**	**0.7**
Hotelling - Berth	Main	0.0	0.0	0.0	0.0
Hotelling - Berth	Aux	63,158.5	62,300.6	2.7	0.7
Hotelling - Berth	Auxiliary Boiler	60,127.6	58,668.8	4.7	0.1
Total Hotelling - Berth		**123,286.1**	**120,969.4**	**7.4**	**0.9**
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0
Hotelling - Anchorage	Aux	6,760.6	6,667.9	0.3	0.1
Hotelling - Anchorage	Auxiliary Boiler	4,595.5	4,483.6	0.4	0.0
Total Hotelling - Anchorage		**11,356.1**	**11,151.4**	**0.7**	**0.1**
Total		**232,272.5**	**228,104.8**	**13.2**	**3.8**

DB ID694

Figure 3.8: 2009 Ocean-Going Vessel Emissions by Mode, %



3.7 Facts and Findings

Table 3.25 summarizes the number of calls and total TEUs handled by the Port as well as the average TEUs/call from 2005 to 2009.

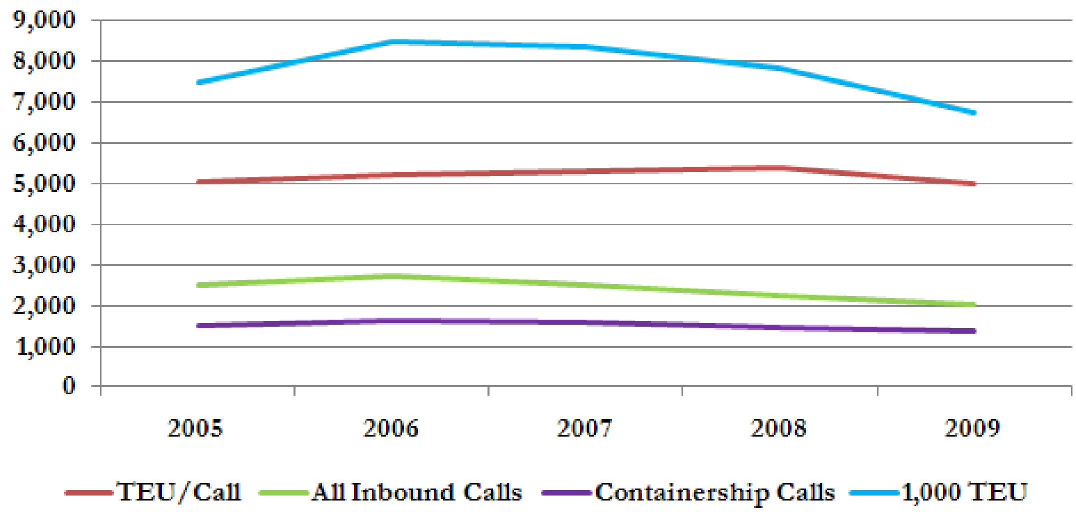
Table 3.25: TEUs and Vessel Call Comparison, 2005-2009

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2009	2,010	1,355	6,748,995	4,981
2008	2,239	1,459	7,849,985	5,380
2007	2,527	1,573	8,355,038	5,312
2006	2,703	1,627	8,469,853	5,206
2005	2,501	1,481	7,484,625	5,054
Previous Year (2009-2008)	**-10%**	**-7%**	**-14%**	**-7%**
CAAP Progress (2009-2005)	**-20%**	**-9%**	**-10%**	**-1%**

DB ID452

Figure 3.9 presents the trends in the total TEUs, vessel calls and TEU/call for 2005 to 2009. As shown, the number of TEUs has decreased over the last three years reflective of recent global economic conditions. The corresponding number of vessel calls has also decreased because of lower cargo throughput as well as transition to larger container vessels. The TEU/container call efficiency decreased in 2009 compared to efficiency improvements experienced from 2005 to 2008. In 2009, despite a 14% decrease in TEUs, the container calls decreased by only 7%, indicating that on average, there were fewer containers unloaded and loaded per call despite the increased use of larger vessels.

Figure 3.9: Vessel Call and TEU Trend



3.7.1 Flags of Convenience
Most OGVs are foreign flagged ships, whereas harbor vessels are almost exclusively domestic. Approximately 94% of the OGVs that visited the Port of Los Angeles were registered outside the U.S. Although only 6% of the individual OGVs are registered in the U.S., they comprised 14% of all calls. This is most likely because the U.S. flagged OGVs make shorter, more frequent stops along the west coast. Figures 3.10 and 3.11 show the breakdown of the ships' registered country (i.e., flag of registry) for discrete vessels and by the number of calls, respectively. Approximately 25 "other" flags of registry are included together as "other" category.

Figure 3.10: 2009 Flag of Registry, Discrete Vessels

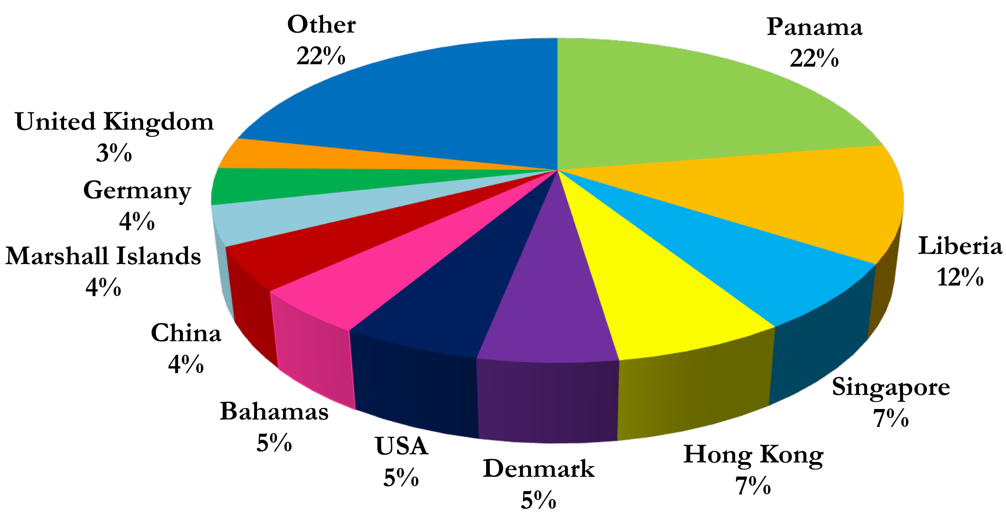
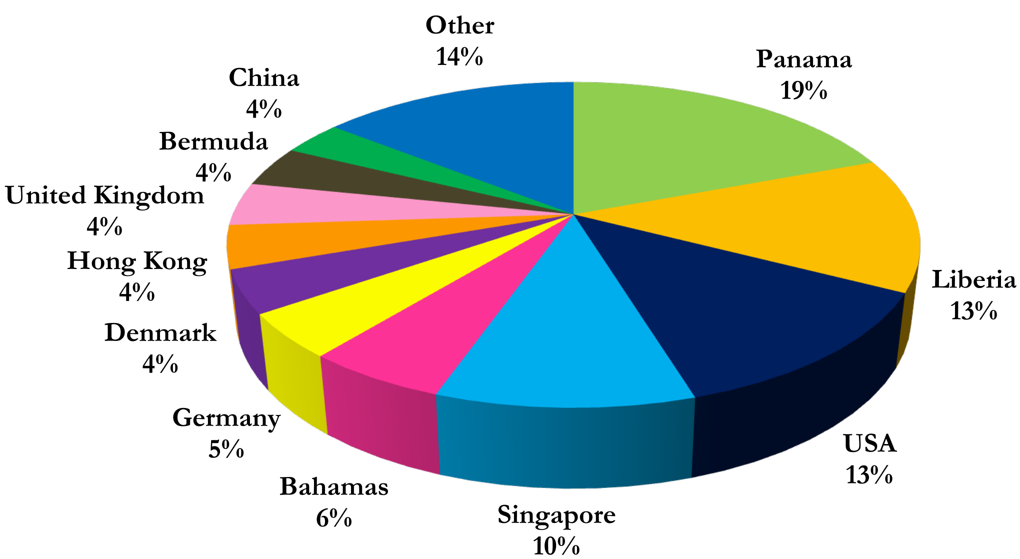


Figure 3.11: 2009 Flag of Registry, Vessel Calls



3.7.2 Next and Last Port of Call

Figures 3.12 and 3.13 summarize the next (to) port and last (from) port, respectively, for vessels that called in 2009. The other category contains about 130 ports that had less than 2% each.

Figure 3.12: 2009 Next (To) Port

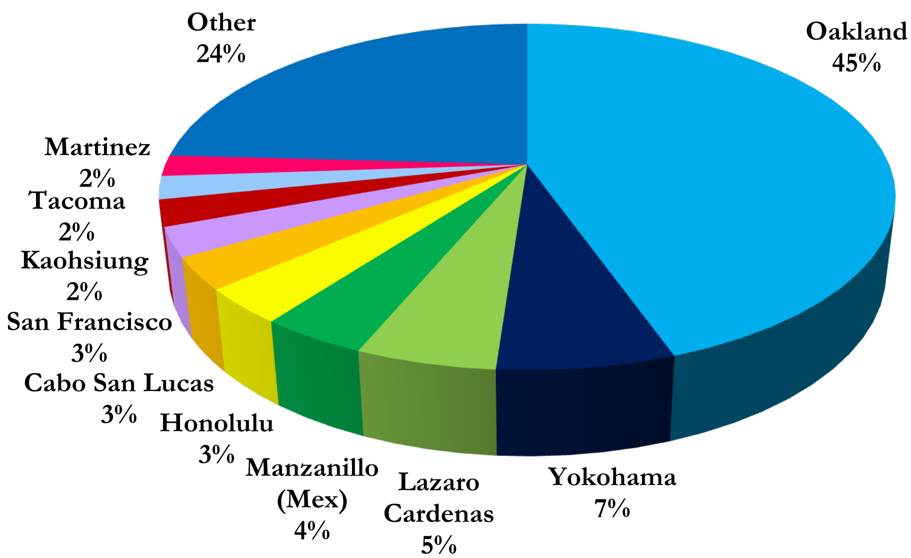
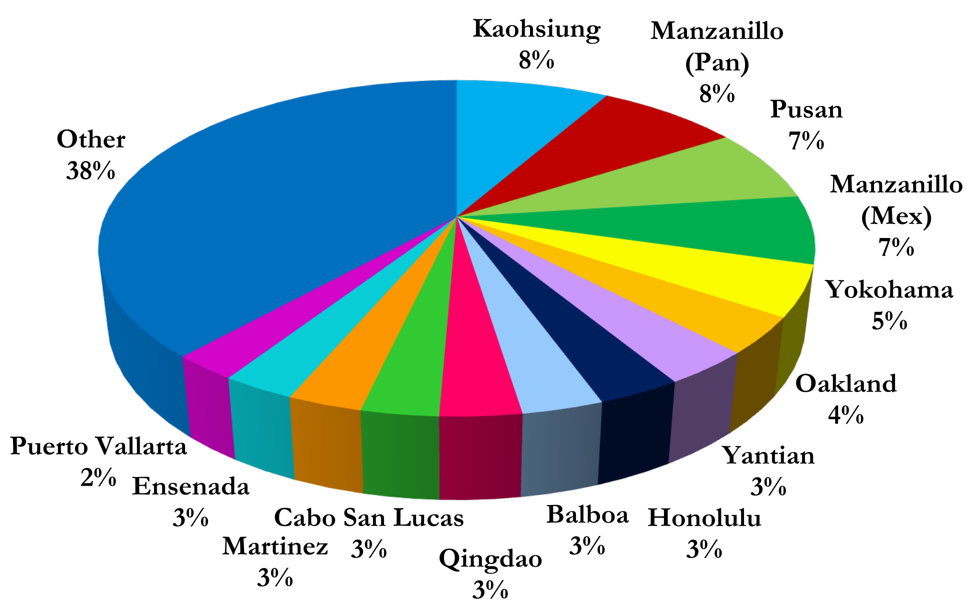


Figure 3.13: 2009 Last (From) Port



3.7.3 Vessel Characteristics

Table 3.26 summarizes the vessel and engine characteristics by vessel type. The year built, deadweight (Dwt), speed, and main engine power are based on the specific vessels that called at the Port. Due to the large number of containerships and tankers that call at the Port and their variety, the vessels were divided by vessel types.

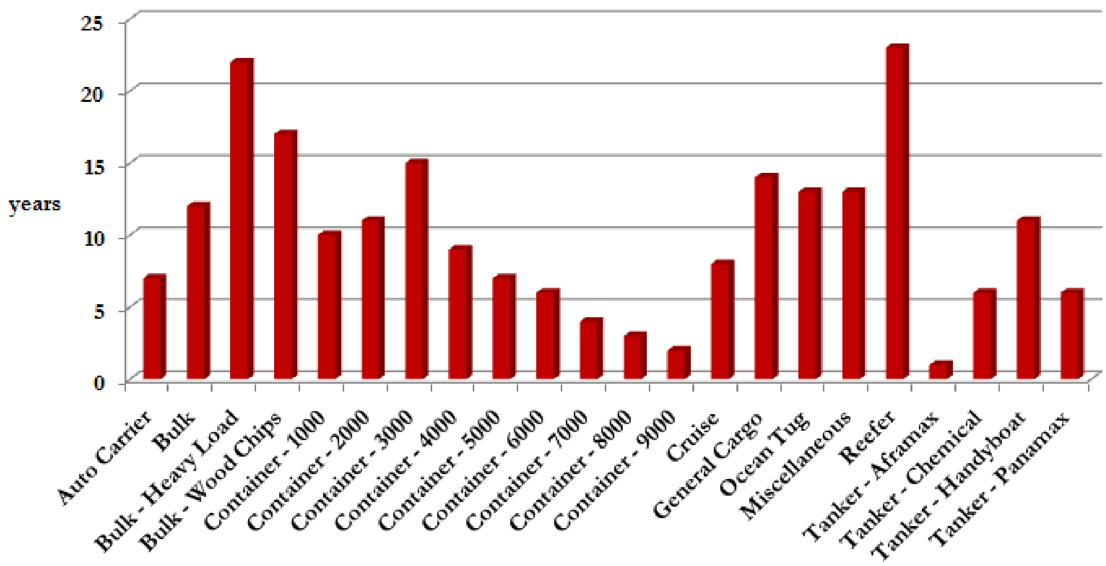
Table 3.26: Vessel Type Characteristics for Vessels that Called the Port in 2009

Vessel Type	Year Built	Age (Years)	Average DWT (tons)	Max Speed (knots)	Main Eng (kW)	Aux Eng (kW)
Auto Carrier	2003	7	16,719	19.8	13,000	3,317
Bulk	1997	12	45,376	14.5	7,847	1,804
Bulk - Heavy Load	1987	22	22,880	16.0	9,348	1,940
Bulk - Wood Chips	1992	17	38,296	14.5	6,056	1,842
Container - 1000	1999	10	20,666	19.6	13,263	3,254
Container - 2000	1998	11	37,734	21.3	22,454	4,928
Container - 3000	1994	15	47,656	23.1	32,943	4,640
Container - 4000	2000	9	60,481	24.1	40,961	7,376
Container - 5000	2002	7	66,828	25.1	51,270	8,447
Container - 6000	2003	6	80,301	25.1	60,151	12,476
Container - 7000	2005	4	92,920	25.0	61,182	12,897
Container - 8000	2006	3	100,376	25.0	68,017	11,985
Container - 9000	2007	2	NA	25.7	68,639	11,665
Cruise	2001	8	6,933	21.4	48,525	10,531
General Cargo	1995	14	42,255	15.1	9,059	2,299
Ocean Tug	1997	13	27,465	NA	7,594	NA
Miscellaneous	1997	13	NA	14.4	11,540	NA
Reefer	1986	23	11,684	19.7	9,680	3,401
Tanker - Aframax	2008	1	NA	NA	15,820	NA
Tanker - Chemical	2003	6	37,930	14.7	8,696	2,901
Tanker - Handyboat	1998	11	45,197	14.8	8,928	2,690
Tanker - Panamax	2003	6	68,110	15.0	11,585	2,687

DB ID695

Figures 3.14 through Figure 3.17 show the various vessel type characteristics. The larger containerships (8,000 and 9,000+ TEU) and tankers (Aframax) that called the Port were newer vessels. The reefers, bulk heavy-load vessels and bulk wood chip vessels were generally older vessels.

Figure 3.14: Average Age of Vessels that Called the Port in 2009, years



As shown in Figure 3.15, containerships and cruise ships have the highest maximum rated speeds.

Figure 3.15: Average Maximum Rated Sea Speed of Vessels that Called the Port in 2009, knots

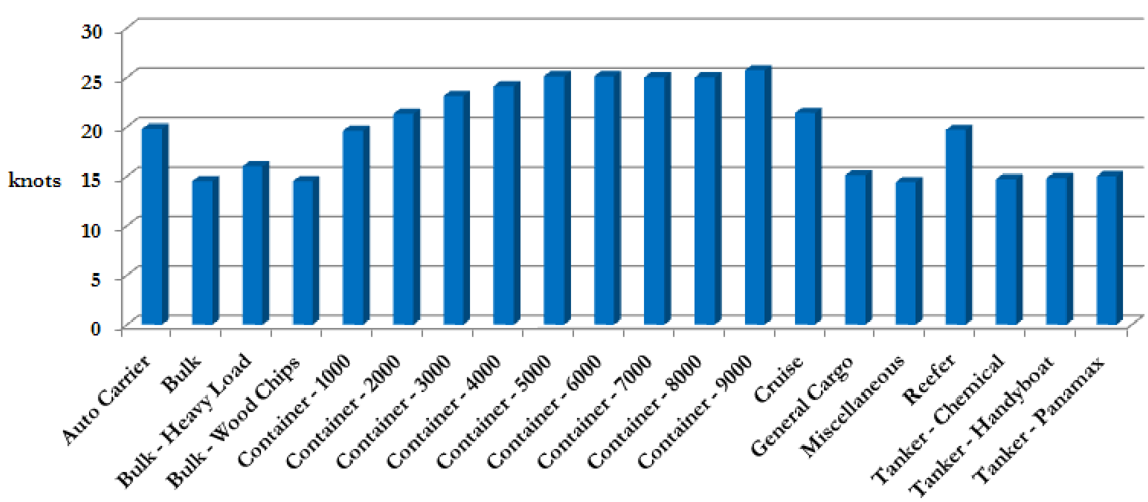
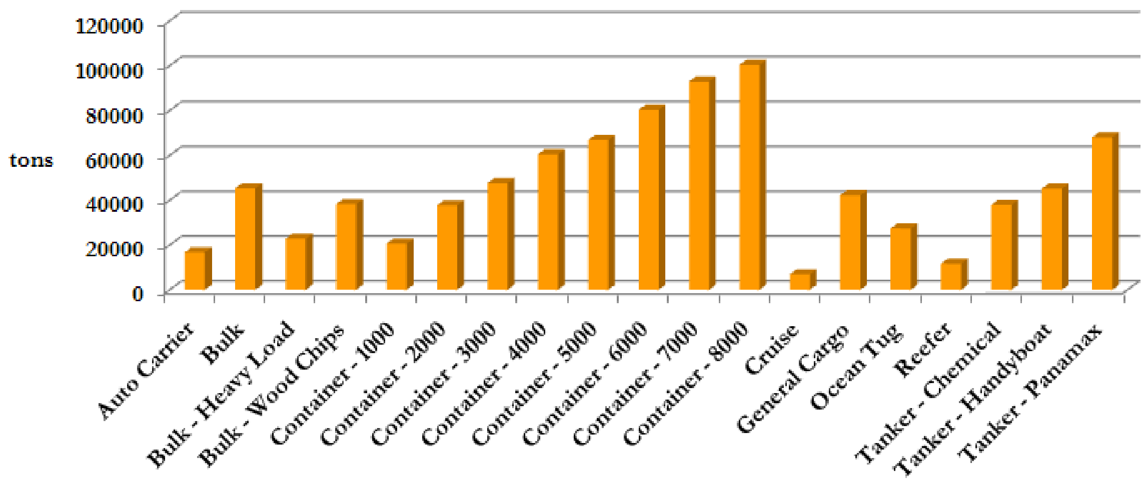


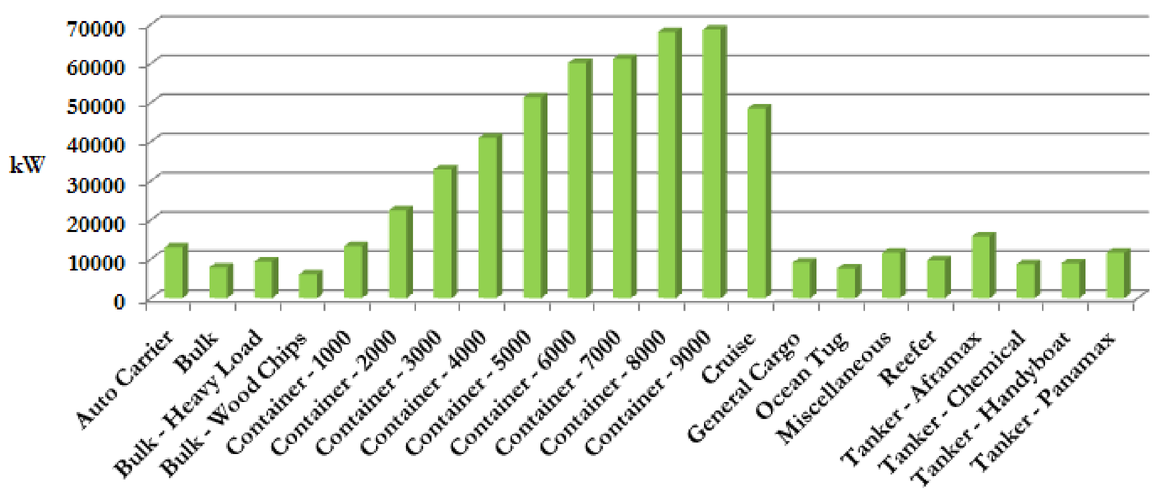
Figure 3.16 shows the average deadweight of all vessel calls by vessel type. The largest containerships (8000+TEU) have the largest average deadweight tonnage among the various vessel types, while cruise and reefer vessels weigh the least.

Figure 3.16: Average Deadweight of Vessels that Called the Port in 2009, tons



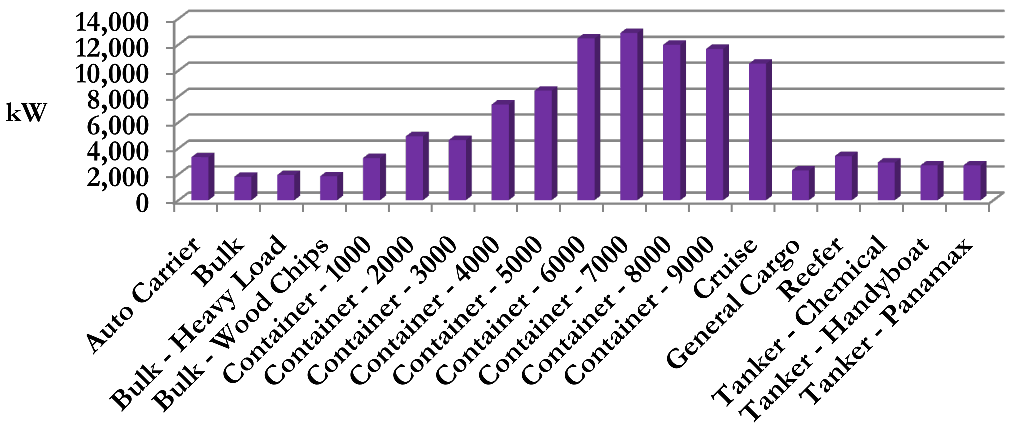
As shown in Figure 3.17, containerships have the highest main engine total installed power, followed by cruise ships.

Figure 3.17: Average Main Engine Total Installed Power of Vessels that Called the Port in 2009, kilowatts



Containerships and cruise ships have the highest auxiliary engine total installed power, as shown in Figure 3.18.

Figure 3.18: Average Auxiliary Engine Total Installed Power of Vessels that Called the Port in 2009, kilowatts



3.7.4 Hotelling Time at Berth and Anchorage

Tables 3.27 and 3.28 summarize the berth and anchorage hotelling times, respectively.

Table 3.27: Hotelling Times at Berth for Vessels that Called the Port in 2009 by Vessel Type

	Berth Hotelling Time, hours		
Vessel Type	Min	Max	Avg
Auto Carrier	5.5	49.0	24.6
Bulk	17.6	146.1	66.6
Bulk - Heavy Load	25.8	203.1	90.5
Bulk - Wood Chips	44.1	200.8	104.2
Container - 1000	7.5	56.9	19.0
Container - 2000	11.6	97.4	32.7
Container - 3000	24.3	77.0	47.8
Container - 4000	0.0	88.4	29.3
Container - 5000	10.7	111.1	51.6
Container - 6000	9.7	123.2	56.4
Container - 7000	36.9	111.1	68.9
Container - 8000	36.6	113.6	83.8
Container - 9000	48.8	87.3	69.9
Cruise	5.0	64.6	12.6
General Cargo	12.2	107.0	41.9
Ocean Tug	9.3	142.9	29.4
Miscellaneous	49.4	50.4	49.9
Reefer	5.2	103.8	31.1
Tanker - Aframax	51.1	51.1	51.1
Tanker - Chemical	8.3	102.9	35.7
Tanker - Handyboat	9.3	81.5	31.7
Tanker - Panamax	16.2	116.7	46.1

DB ID705

Table 3.28 shows the range and average of hotelling times at anchorage with the actual vessel counts for each vessel subtype that visited the anchorages.

Table 3.28: Hotelling Times at Anchorage by Vessel Type in 2009

Vessel Type	Anchorage Hotelling Time, hours Min	Max	Avg	Calls Count
Auto Carrier	1.3	308.4	49.4	8
Bulk	1.6	136.6	32.7	32
Bulk - Heavy Load	17.5	169.2	61.9	2
Bulk - Wood Chips	0.2	67.6	30.5	3
Container - 1000	0.8	27.5	11.7	4
Container - 2000	0.6	352.4	28.4	12
Container - 3000	2.3	14.2	8.0	3
Container - 4000	2.2	22.6	6.5	11
Container - 5000	1.3	28.5	9.9	11
Container - 6000	3.0	8.0	5.4	3
Container - 7000	1.3	5.2	2.5	12
Container - 8000	1.5	7.3	3.5	6
Container - 9000	2.4	13.6	6.7	3
Cruise	92.0	92.0	92.0	1
General Cargo	2.3	183.4	42.9	26
Ocean Tug	2.2	109.9	28.7	8
Miscellaneous	0.0	0.0	0.0	0
Reefer	3.1	12.8	7.6	7
Tanker - Aframax	4.0	4.0	4.0	1
Tanker - Chemical	1.1	308.4	37.5	62
Tanker - Handyboat	0.4	195.0	34.0	25
Tanker - Panamax	2.7	143.1	27.3	32

DB ID705

3.7.5 Frequent Callers

For purpose of this discussion, a frequent caller is a vessel that made six or more calls in one year. The vessels that made a call to a berth at the Port were included, while the vessels that only went to anchorage were not. Table 3.29 shows the percentage of repeat vessels. Container vessels, cruise ships and ocean tugs had the highest percentage of frequent callers in 2009. Tankers, reefer vessels, general cargo and bulk vessels are not frequent callers.

Table 3.29: Percentage of Frequent Callers in 2009

Vessel Type	Frequent Vessels	Total Vessels	Percent Frequent Vessels
Auto Carrier	4	26	15%
Bulk	0	50	0%
Bulk - Heavy Load	0	3	0%
Bulk - Wood Chips	0	4	0%
Container - 1000	9	21	43%
Container - 2000	14	24	58%
Container - 3000	5	20	25%
Container - 4000	5	96	5%
Container - 5000	21	76	28%
Container - 6000	14	31	45%
Container - 7000	5	37	14%
Container - 8000	2	23	9%
Container - 9000	0	3	0%
Cruise	5	26	19%
General Cargo	0	46	0%
Ocean Tug	4	8	50%
Miscellaneous	0	2	0%
Reefer	1	23	4%
Tanker - Aframax	0	1	0%
Tanker - Chemical	1	76	1%
Tanker - Handyboat	2	26	8%
Tanker - Panamax	0	36	0%
Total	**92**	**658**	
Average			**14%**

DB ID706

SECTION 4 HARBOR CRAFT

This section presents emissions estimates for the commercial harbor craft source category, including source description (4.1), geographical delineation (4.2), data and information acquisition (4.3), operational profiles (4.4), emissions estimation methodology (4.5), and the emission estimates (4.6).

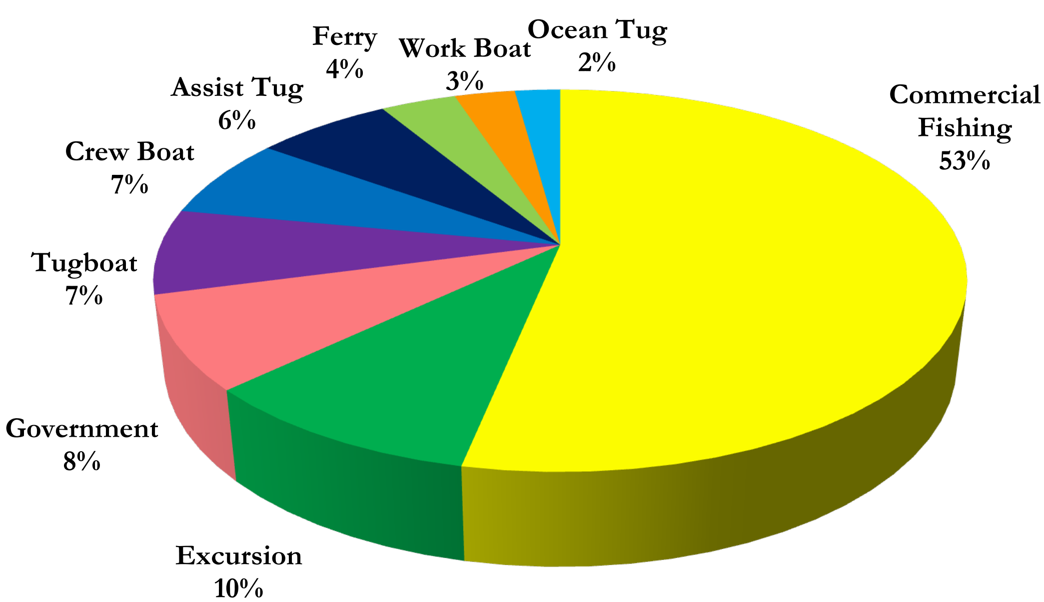
4.1 Source Description

Harbor craft are commercial vessels that spend the majority of their time within or near the Port and harbor. The harbor craft emissions inventory consists of the following vessel types:

- Assist tugboats
- Commercial fishing vessels
- Crew boats
- Ferry vessels
- Excursion vessels
- Government vessels
- Tugboats
- Ocean tugboats
- Work boats

Recreational vessels are not considered to be commercial harbor craft; therefore their emissions are not included in this inventory. Figure 4.1 presents the distribution of the 278 commercial harbor craft inventoried for the Port in 2009. Commercial fishing vessels represent 53% of the harbor craft inventoried, followed by the excursion vessels (10%), government vessels (8%), tugboats (7%), crew boats (7%), assist tugs (6%), ferries (4%), work boats (3%), and ocean tugs (2%).

Figure 4.1: Distribution of 2009 Commercial Harbor Craft by Vessel Type

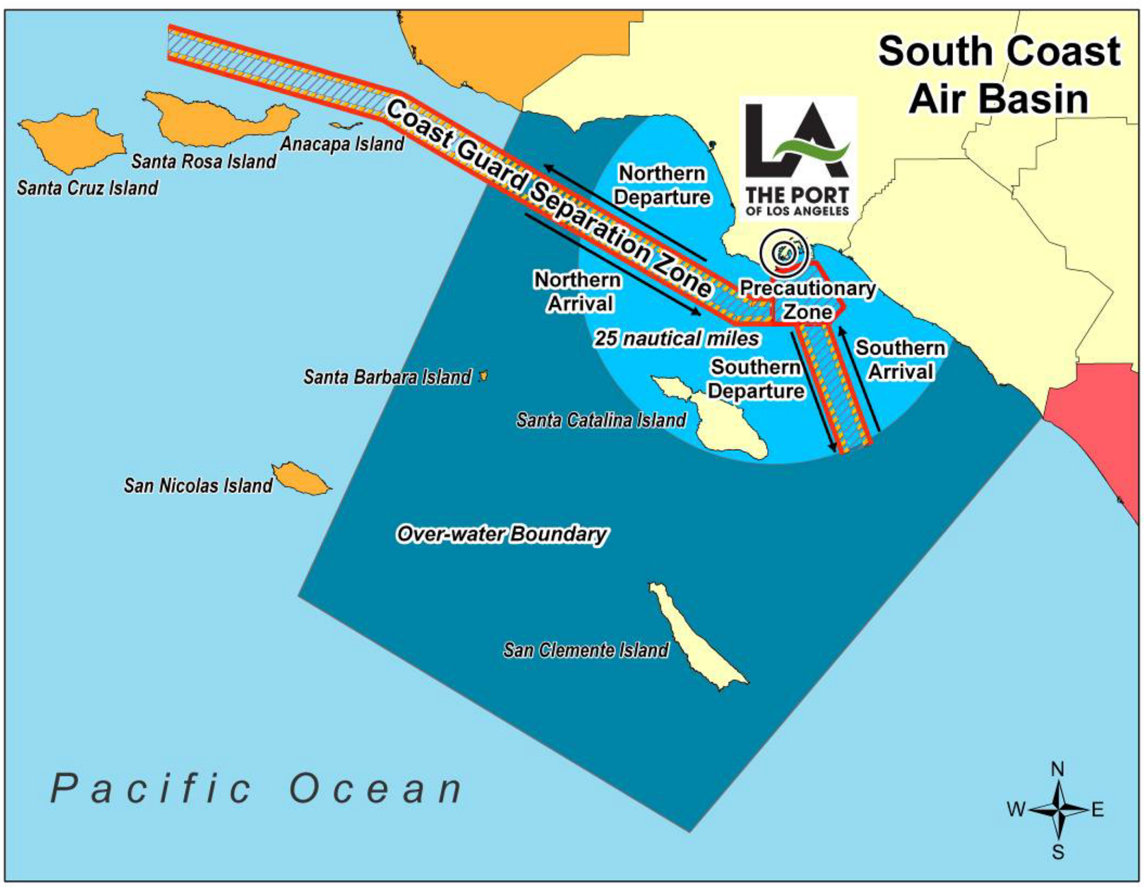


Ocean tugboats included in this section are different from the integrated tug barge (ITB) and articulated tug barge (ATB) included in the ocean-going section of this report. ITB and ATB are seen as a specialized single vessel and are included in the marine exchange data for ocean-going vessels. The ocean tugboats in this section are not rigidly connected to the barge and are typically not home-ported here, but may make frequent calls with barges. They are different from harbor tugboats because their engine loads are higher than harbor tugboats which tend to idle more in-between jobs. Tugboats are typically home-ported in San Pedro Bay harbor and primarily operate within the harbor area, but can also operate outside the harbor based on the work assignments.

4.2 Geographical Delineation

The geographical extent of the emissions inventory for harbor craft is the boundary for the SoCAB as shown in Figure 4.2 (in dark blue). Most harbor craft operate the majority of the time within the harbor and up to 25 nm from the Port. For those harbor craft that operate outside of the harbor and travel to other ports, vessel operators were asked to provide the estimated percent of operation up to 50 nm from the Port in order to capture the emissions within the SoCAB boundary.

Figure 4.2: Geographical Extent of Harbor Craft Inventory



4.3 Data and Information Acquisition

The following sources were used to collect data for the harbor craft inventory:

- Vessel owners and/or operators
- Port Wharfingers data for commercial fishing vessels at Port-owned berths

The operating parameters of interest included the following:

- Vessel type
- Number, type and horsepower (or kilowatts) of main propulsion engine(s)
- Number, type and horsepower (or kilowatts) of auxiliary engines
- Activity hours
- Annual fuel consumption
- Qualitative information regarding how the vessels are used in service
- Main and auxiliary engine model year
- Repowered (replaced) engines
- Emission reduction strategies, if any (e.g., shore power, retrofits with after-treatment technologies)

The following companies were contacted to collect information on their fleet:

Excursion vessels:

- L.A. Harbor Sportfishing
- 22nd St. Partners, Sportfishing
- Los Angeles Harbor Cruise
- Spirit Cruises
- Fiesta Harbor Cruises
- Seahawk Sportfishing

Commercial fishing vessels:

- Berth 73 and Fish Harbor, Port-owned marinas

Ferry vessels:

- Catalina Channel Express
- Seaway Co. of Catalina

Government Vessels:

- L.A. Fire Department
- L.A. Police Department
- Harbor Department
- Port of Los Angeles Pilots

Work boats:
- Pacific Tugboat Services
- Jankovich

Crew boats:
- U.S. Water Taxi
- American Marine Corp.
- Southern California Ship Services

Assist tugboats and harbor tugs:
- Crowley Marine Services
- Foss Maritime Company
- Millennium Maritime
- Amnav

Harbor and ocean tugs:
- Crowley Petroleum Services
- Sause Brothers Ocean Towing
- Westoil Marine Services

It should be noted that engine specific information for individual commercial fishing vessels is not readily available due to difficulty in contacting the commercial fishing vessel operators. The Port's data from the Wharfinger Department was used to identify the commercial fishing vessels that berthed at the Port-owned marinas and to determine the total number of vessels compared to prior years. The engine power and activity hours for these vessels were primarily based on CARB's commercial harbor vessel survey results, with limited information available from some vessel operators. In 2009, data collection was improved for commercial fishing vessels with missing model years by individually looking up the vessels in the USCG vessel database.

4.4 Operational Profiles

Commercial harbor craft companies were identified and contacted to obtain the operating parameters for their vessels.

Tables 4.1 and 4.2 summarize the main and auxiliary engine data, respectively, for each vessel type. The averages by vessel type were used as defaults for vessels for which the model year, horsepower, or operating hours information was missing. The operational hours for some of the vessels that were not at the Port for the entire year reflect the partial time that they operated in the 2009 calendar year.

This emissions inventory covers harbor craft that operate in the Port of Los Angeles harbor most of the time. There are a number of companies that operate harbor craft in both the Ports of Los Angeles and Long Beach harbors. The activity hours for the vessels that are common to both ports reflect work performed during 2009 for the Port of Los Angeles harbor only.

Table 4.1: 2009 Summary of Propulsion Engine Data by Vessel Category

			Propulsion Engines								
Harbor	Vessel	Engine	Model year			Horsepower			Annual Operating Hours		
Vessel Type	Count	Count	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Assist tug	18	36	1967	2008	1995	750	2,400	1,934	600	2,415	1,438
Commercial fishing	148	152	1950	2008	1984	50	940	237	200	1,500	1,464
Crew boat	19	43	1964	2007	1994	180	1,400	442	250	1,672	955
Excursion	27	50	1959	2004	1991	150	530	358	0	3,000	1,483
Ferry	10	22	2001	2008	2004	600	2,300	1,873	600	1,200	1,068
Government	22	35	1963	2009	1999	68	1,800	439	17	1,727	491
Ocean tug	6	12	1985	2007	2001	805	2,000	1,477	200	1,500	542
Tugboat	20	40	1980	2009	2001	200	1,500	702	0	2,827	692
Work boat	8	15	1979	2009	1996	210	800	490	0	3,825	1,478
Total	**278**	**405**									

DB ID423

Table 4.2: 2009 Summary of Auxiliary Engine Data by Vessel Category

			Auxiliary Engines								
Harbor	Vessel	Engine	Model year			Horsepower			Annual Operating Hours		
Vessel Type	Count	Count	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Assist tug	18	36	1967	2008	1998	115	425	149	172	3,025	1,605
Commercial fishing	148	23	1957	2004	1993	10	195	79	100	1,500	1,179
Crew boat	19	17	1964	2007	1983	11	133	60	300	2,040	863
Excursion	27	26	1966	2003	1993	7	54	39	0	3,000	1,385
Ferry	10	14	2000	2008	2003	18	120	55	300	750	686
Government	22	9	2003	2007	2004	50	400	204	20	500	156
Ocean tug	6	12	1985	2007	2001	60	150	90	200	750	417
Tugboat	20	28	1970	2009	2000	14	101	50	0	2,875	623
Work boat	8	13	1968	2005	1989	27	101	68	0	2,000	824
Total	**278**	**178**									

DB ID422

Table 4.3 summarizes the time spent in harbor (50%), at 25 nautical miles out (35%) and up to the basin boundary (15%) for all harbor craft.

Table 4.3: Allocation of Operating Time Spent by Vessel Type

Harbor Vessel Type	Harbor	Up to 25 Miles	Up to Basin Boundary
Assist tug	100%	0%	0%
Commercial fishing	10%	50%	40%
Crew boat	55%	45%	0%
Excursion	36%	56%	8%
Ferry	38%	60%	2%
Government	95%	5%	0%
Ocean tug	50%	25%	25%
Tugboat	81%	15%	4%
Work boat	71%	29%	0%
Average	**50%**	**35%**	**15%**

DB ID424

Harbor vessel owners and operators were requested to identify the replaced engines in their fleet (i.e., repowered with cleaner engines). Table 4.4 shows the number of replaced (repowered) harbor craft main engines by vessel type. As shown, in 2009, 30% of all main harbor craft engines (122 engines) that operated at the Port were replaced with cleaner engines. Most of these engine replacements occurred between 2001 and 2005.

Table 4.4: Replaced Harbor Craft Main Engines by Vessel Type

	Propulsion Engines		
Harbor Vessel Type	Engine Count	Engines Repowered	Repowered Engines, %
Assist tug	36	0	0%
Commercial fishing	152	21	14%
Crew boat	43	26	60%
Excursion	50	17	34%
Ferry	22	22	100%
Government	35	0	0%
Ocean tug	12	6	50%
Tugboat	40	25	63%
Work boat	15	5	33%
Total	**405**	**122**	**30%**

DB ID199

Figure 4.3 shows the distribution of the 122 replaced main engines by vessel type. The majority of main engine replacements were in crew boats and tugboats followed by ferries, commercial fishing vessels, excursion vessels, and other harbor craft categories.

Figure 4.3: Distribution of Replaced Main Engines by Vessel Type

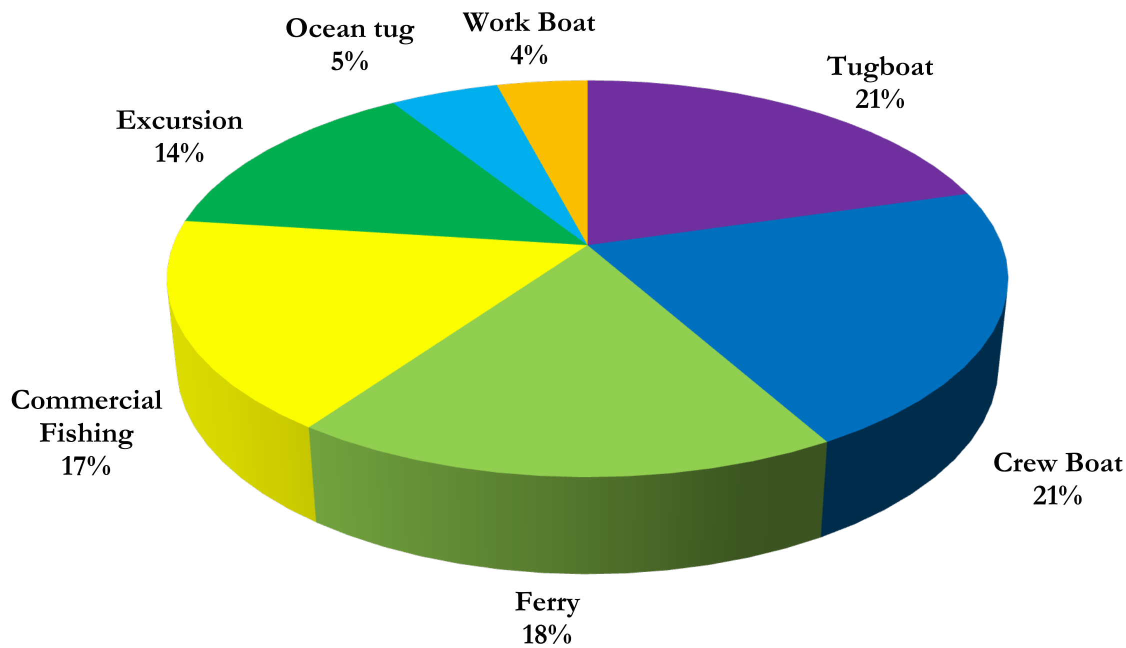


Table 4.5 shows the number of replaced (repowered) harbor craft auxiliary engines by vessel type. As shown, in 2009, 44% of all auxiliary harbor craft engines (78 engines) that operated at the Port have been replaced with cleaner engines. Similar to the main engines, most engine replacements occurred between the 2001 and 2005 time period.

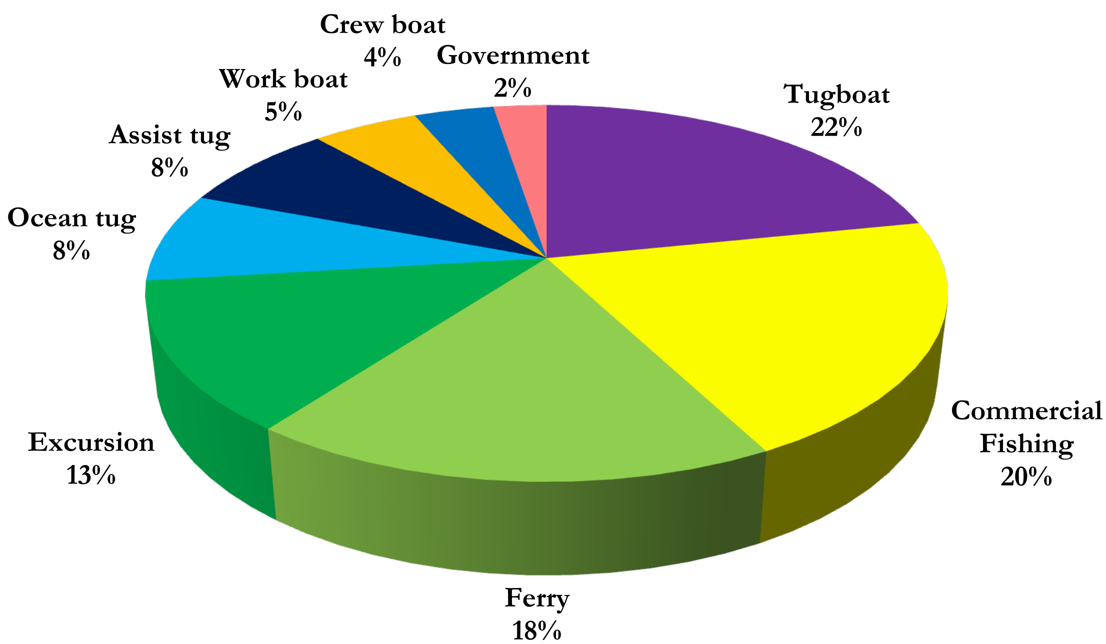
Table 4.5: Replaced Harbor Craft Auxiliary Engines by Vessel Type

	Auxiliary Engines		
Harbor Vessel Type	**Engine Count**	**Engines Repowered**	**Repowered Engines, %**
Assist tug	36	6	17%
Commercial fishing	23	16	70%
Crew boat	17	3	18%
Excursion	26	10	38%
Ferry	14	14	100%
Government	9	2	22%
Ocean tug	12	6	50%
Tugboat	28	17	61%
Work boat	13	4	31%
Total	**178**	**78**	**44%**

DB ID425

Figure 4.4 shows the distribution of the 78 replaced auxiliary engines by vessel type. The majority of auxiliary engine replacements were in tugboats, commercial fishing vessels and ferries followed by excursion vessels, assist and ocean tugs, and other harbor craft categories.

Figure 4.4: Distribution of Replaced Auxiliary Engines by Vessel Type

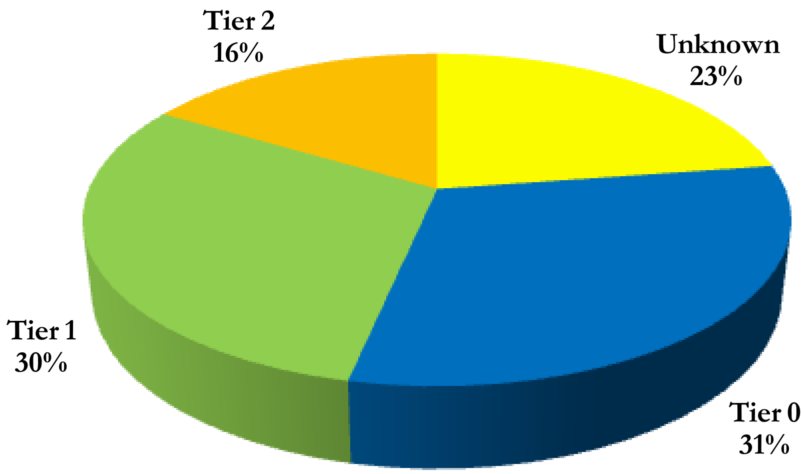


The harbor craft engines (propulsion and auxiliary) for all vessels operated at the Port were categorized by EPA's Tier 0, Tier 1 and Tier 2 engine standards for vessels with known engine model year and horsepower, or were classified as "unknown" for vessels for which the engine model year or horsepower information was not available, as follows:

- Tier 0 are 1999 and older model year engines
- Tier 1 engines' model year ranges from 2000 to 2003 (less than or equal to 750 hp engines) and from 2000 to 2006 (greater than 750 hp engines)
- Tier 2 engines' model years are 2004+ (less than or equal to 750 hp engines) and 2007+ (greater than 750 hp engines)
- Unknown refers to engines with missing model year, horsepower or both

Figure 4.5 provides the distribution of harbor craft propulsion and auxiliary engines by EPA's engine standards.

Figure 4.5: Distribution of Harbor Craft Engines by Engine Standards, %

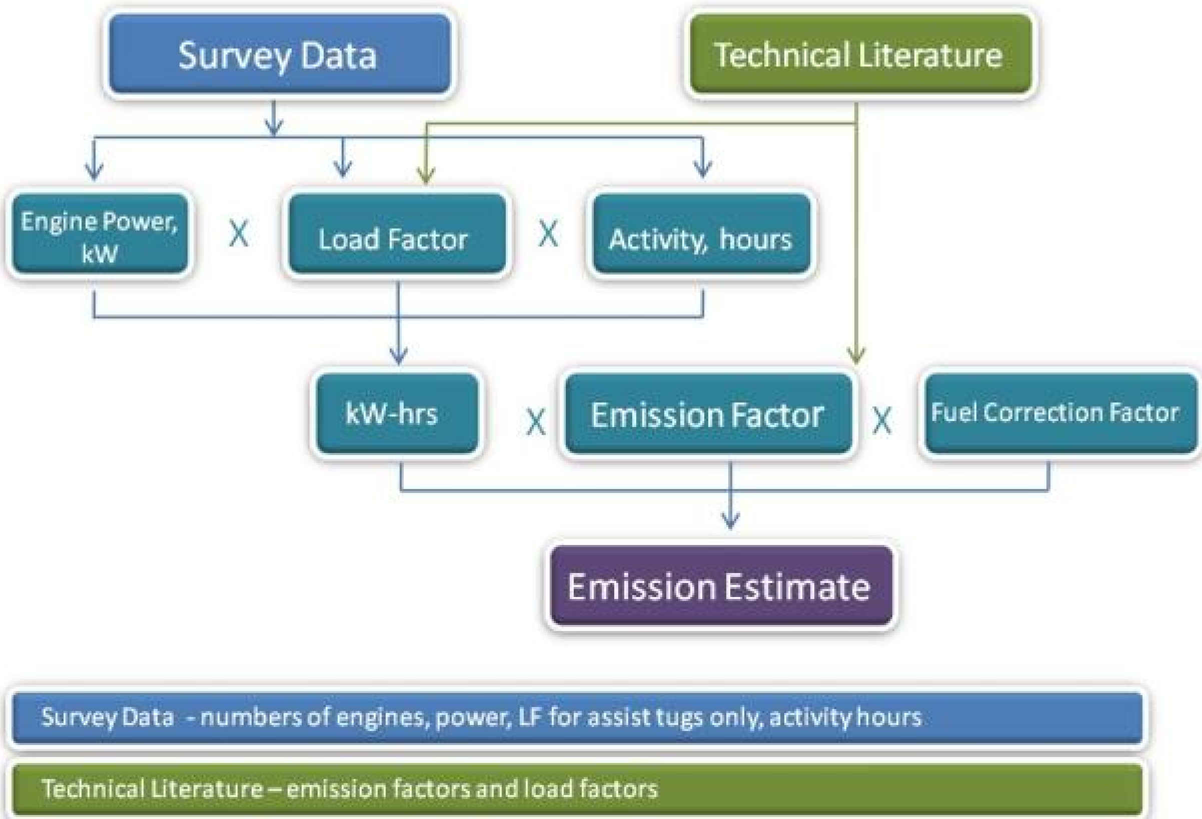


4.5 Emissions Estimation Methodology

The emissions calculation parameters, methodologies and equations are described in this section. The flow chart in Figure 4.6 graphically breaks down the steps taken to estimate the harbor vessel emissions. Survey data mainly includes the data collected from vessel owners for each main and auxiliary engine. Technical literature from CARB and other references for the emission calculation methodology and the required parameters are further discussed in this section. Emissions were estimated on a per engine basis, i.e., the main and auxiliary engines were estimated for each vessel. In order to ensure consistency, the Port's harbor craft emissions calculations methodology is primarily based on CARB's latest harbor craft emissions calculations methodology with the exceptions noted in this section.[29]

[29] Appendix B: Emissions Estimation Methodology for Commercial Harbor Craft Operating in California. See *http://www.arb.ca.gov/regact/2007chc07/chc07.htm*

Figure 4.6: Harbor Craft Emission Estimation Flow Chart



4.5.1 Emissions Calculation Equations

The basic equation used to estimate harbor craft emissions for each engine is:

$$E = Power \times Act \times LF \times EF \times FCF \qquad \text{Equation 4.1}$$

Where:

E = emissions, tons/year
Power = rated power of the engine in horsepower or kilowatts
Act = activity, hours/year
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower)
EF = emission factor, grams of pollutant per unit of work (g/hp-hr or kW/hp-hr)
FCF = fuel correction factor to reflect changes in fuel properties that have occurred over time

The engine's emission factor (EF) is a function of the zero hour (ZH) emission rate, deterioration rate and cumulative hours. The deterioration rate reflects the fact that the engine's base emissions (ZH emission rates) change as the equipment is used, due to wear of various engine parts or reduced efficiency of emission control devices. The cumulative hours reflects the engine's total operating hours. The emission factor is calculated as:

EF = ZH + (DR x Cumulative Hours) Equation 4.2

Where:

ZH = emission rate for a given engine size category and model year when the engine is new and there is no component malfunctioning
DR = deterioration rate (rate of change of emissions as a function of equipment age)
Cumulative hours = total number of hours the engine has been in use and calculated as annual operating hours times age of the engine

The equation for the deterioration rate is:

Equation 4.3

DR = (DF x ZH) / cumulative hours at the end of useful life

Where:

DR = deterioration rate
DF = deterioration factor, percent increase in emissions at the end of the useful life (expressed as %)
ZH = emission rate for a given engine size category and model year when the engine is new and there is no component malfunctioning
Cumulative hours at the end of useful life = annual operating hours times useful life in years

4.5.2 Emission Factors, Deterioration Factors and Useful Life

Zero hour emission factors, deterioration factors, and useful life for commercial harbor craft were based on CARB's latest methodology, with the exception of greenhouse gas emission factors. Since the greenhouse gas emission factors for this category are evolving, the greenhouse gas emission factors are determined based on a paper published by IVL[30] which is the same source used to determine greenhouse gas emission factors for ocean going vessels. The CH_4 emission factor is 2% of the hydrocarbon emission factor per the IVL study.

The SO_x emission factor is calculated using the following mass balance equation included in the CARB's methodology:

Equation 4.4

$$SO_x \text{ (gms/hp-hr)} = (\text{S content in } X/1{,}000{,}000) \times (2\ SO_2/\text{g S}) \times BSFC$$

Where:

X = S content in parts per million (ppm)
BSFC = Brake Specific Fuel Consumption (184 g/bhp-hr per CARB's methodology mentioned above)

Tables 4.6 and 4.7 provide the deterioration factors and useful life for harbor craft engines, respectively.

Table 4.6: Engine Deterioration Factors for Harbor Craft Diesel Engines

HP Range	PM	NOx	CO	HC
25-50	0.31	0.06	0.41	0.51
51-250	0.44	0.14	0.16	0.28
>251	0.67	0.21	0.25	0.44

DB ID702

[30] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors."* Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency.

Table 4.7: Useful Life by Vessel Type and Engine Type, years

Harbor Vessel Type	Auxiliary Engines	Main Engines
Assist tug	23	21
Commercial fishing	15	21
Crew boat	22	22
Excursion	20	20
Ferry	20	20
Government	25	19
Ocean tug	25	26
Tugboat	23	21
Work boat	23	17

DB ID703

4.5.3 Fuel Correction Factors

Fuel correction factors are applied to adjust the emission rates for changes in fuel properties. For this inventory, fuel correction factors were used to take into account the use of ULSD used by all harbor craft. Fuel correction factors used for NO_X, HC, and PM take into account the properties of California diesel fuel which is different from EPA diesel fuel. Table 4.8 summarizes the fuel correction factors used for harbor craft. The FCF for SO_x reflects the change from diesel fuel with an average sulfur content of 350 ppm to ULSD (15 ppm). Due to the lack of any additional information, it was assumed that fuel correction factor for NO_x is also applicable to N_2O emissions and fuel correction factor for HC is also applicable to CH_4 emissions.

Table 4.8: Fuel Correction Factors for ULSD

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.72	0.93	0.043	1.00	0.72	1.00	0.93	0.72
1996 and newer	0.80	0.95	0.043	1.00	0.72	1.00	0.95	0.72

DB ID446

4.5.4 Load Factors

Engine load factor is used in emissions calculations to reflect the fact that, on average, engines are not used at their maximum power rating. Table 4.9 summarizes the average engine load factors that were used in this inventory for the various harbor vessel types for their propulsion and auxiliary engines.

Table 4.9: Load Factors

Harbor Vessel Type	Auxiliary Engines	Main Engines
Assist tug	0.43	0.31
Commercial fishing	0.43	0.27
Crew boat	0.43	0.45
Excursion	0.43	0.42
Ferry	0.43	0.42
Government	0.43	0.51
Ocean tug	0.43	0.68
Tugboat	0.43	0.31
Work boat	0.43	0.45

DB ID426

The 31% engine load factor for assist tugboats is based on actual vessels' main engine load readings published in the Port's 2001 emissions inventory and is not consistent with the 50% engine load used in CARB's latest methodology.[31] In addition, CARB uses 43% engine load for all auxiliary engines as listed in Table 4.9, except for the auxiliary engines of tugboats for which CARB's load factor is 31%. The Port uses 43% for all auxiliary engines, including the tugboats and assist tugboats. The main engine load factors for other vessel types are consistent with CARB's latest methodology.

4.5.5 Improvements to Methodology from Previous Year

There were no changes to the harbor craft emission calculation methodology in this inventory compared to the 2008 methodology. For comparison of 2009 emissions to previous years' emissions, refer to Section 9.

[31] CARB, *Emissions Estimation Methodology for Commercial Harbor Craft Operating in California*, Appendix B.

4.5.6 Future Improvements to Methodology

Harbor craft emissions are estimated for three operating zones: within the harbor, within 25 nautical miles of the Port and up to the Basin boundary. The vessel operators are typically contacted at the beginning of the year and are requested to provide the estimated percent of their operation within these zones associated with port-related activities for the preceding calendar year. However, operators for some vessels (e.g., crew boats, work boats, excursion) may have difficulty in making these estimates if such information is not tracked during the year. In order for a more accurate allocation of emissions within these zones, for the next EI, the operators will be contacted earlier during the year requesting them to track and estimate their operating time within these zones (e.g., based on their work assignments throughput the year, fuel consumption records, etc.).

4.6 Emission Estimates

Tables 4.10 and 4.11 summarize the estimated 2009 harbor craft emissions by vessel type and engine type.

Table 4.10: 2009 Commercial Harbor Craft Emissions by Vessel and Engine Type, tons per year

Vessel Type	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Assist Tug	Auxiliary	1.4	1.3	1.4	30.0	0.0	15.7	3.2
	Propulsion	16.3	15.0	16.3	387.4	0.2	113.4	25.7
Assist Tug Total		**17.7**	**16.3**	**17.7**	**417.4**	**0.2**	**129.1**	**28.9**
Commercial Fishing	Auxiliary	0.5	0.5	0.5	7.7	0.0	4.6	1.1
	Propulsion	9.2	8.4	9.2	214.5	0.1	55.6	14.3
Commercial Fishing Total		**9.7**	**8.9**	**9.7**	**222.1**	**0.1**	**60.2**	**15.4**
Crew boat	Auxiliary	0.3	0.3	0.3	5.0	0.0	2.5	0.7
	Propulsion	5.2	4.8	5.2	119.8	0.1	32.3	8.0
Crew boat Total		**5.4**	**5.0**	**5.4**	**124.9**	**0.1**	**34.8**	**8.8**
Excursion	Auxiliary	0.4	0.4	0.4	5.1	0.0	4.0	1.2
	Propulsion	6.5	6.0	6.5	150.3	0.1	40.6	10.0
Excursion Total		**6.9**	**6.4**	**6.9**	**155.4**	**0.1**	**44.6**	**11.2**
Ferry	Auxiliary	0.1	0.1	0.1	1.5	0.0	1.1	0.3
	Propulsion	7.0	6.5	7.0	151.3	0.1	45.8	11.5
Ferry Total		**7.2**	**6.6**	**7.2**	**152.7**	**0.1**	**46.9**	**11.8**
Government	Auxiliary	0.0	0.0	0.0	0.5	0.0	0.3	0.1
	Propulsion	1.4	1.3	1.4	32.6	0.0	11.9	2.6
Government Total		**1.4**	**1.3**	**1.4**	**33.1**	**0.0**	**12.2**	**2.6**
Ocean Tug	Auxiliary	0.1	0.1	0.1	1.4	0.0	1.0	0.2
	Propulsion	2.7	2.5	2.7	62.6	0.0	22.0	4.8
Ocean Tug		**2.8**	**2.5**	**2.8**	**64.1**	**0.0**	**23.0**	**5.0**
Tugboat	Auxiliary	0.1	0.1	0.1	2.6	0.0	1.6	0.5
	Propulsion	1.6	1.5	1.6	41.1	0.0	18.7	3.4
Tugboat Total		**1.7**	**1.6**	**1.7**	**43.7**	**0.0**	**20.3**	**4.0**
Work boat	Auxiliary	0.2	0.2	0.2	3.4	0.0	1.7	0.5
	Propulsion	2.5	2.3	2.5	59.4	0.0	17.7	4.3
Work boat Total		**2.8**	**2.5**	**2.8**	**62.8**	**0.0**	**19.4**	**4.7**
Harbor craft Total		**55.6**	**51.1**	**55.6**	**1,276.1**	**0.6**	**390.5**	**92.3**

DB ID427

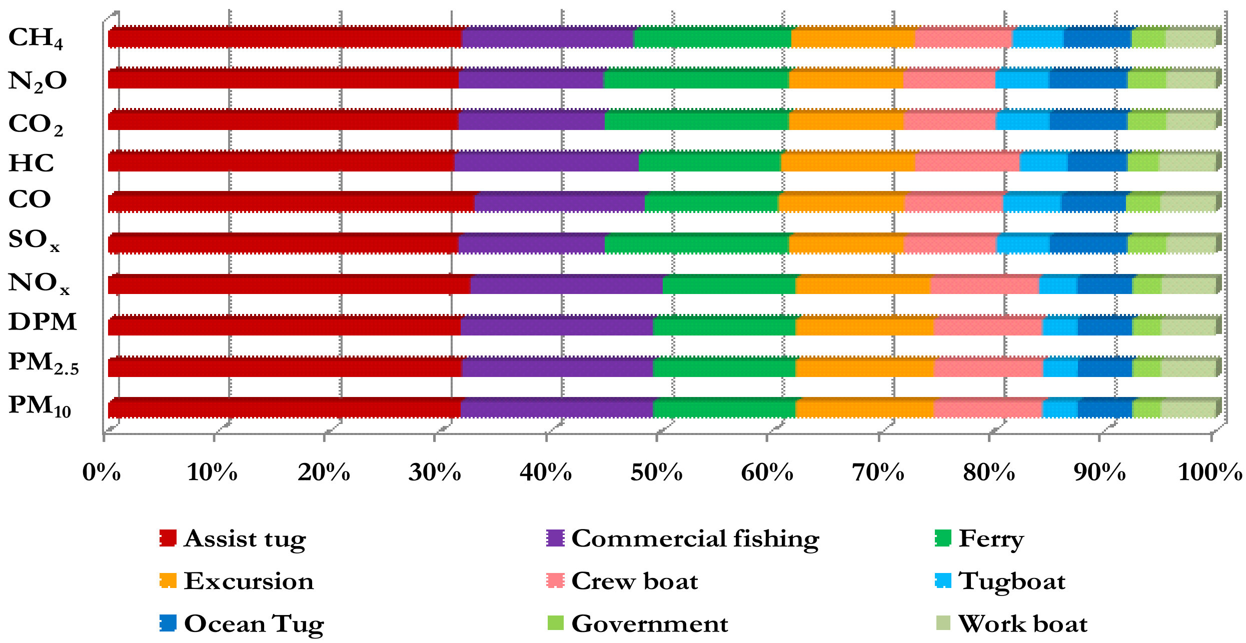
Table 4.11: 2009 Commercial Harbor Craft GHG Emissions by Vessel and Engine Type, metric tons per year

Vessel Type	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Assist Tug	Auxiliary	1,805.1	1,779.3	0.1	0.1
	Propulsion	16,077.9	15,849.5	0.7	0.4
Assist Tug Total		**17,883.1**	**17,628.8**	**0.8**	**0.4**
Commercial Fishing	Auxiliary	463.8	457.1	0.0	0.0
	Propulsion	7,020.3	6,921.1	0.3	0.2
Commercial Fishing Total		**7,484.1**	**7,378.2**	**0.3**	**0.2**
Crew boat	Auxiliary	198.5	195.6	0.0	0.0
	Propulsion	4,519.0	4,454.9	0.2	0.1
Crew boat Total		**4,717.5**	**4,650.5**	**0.2**	**0.1**
Excursion	Auxiliary	316.3	311.6	0.0	0.0
	Propulsion	5,569.4	5,490.8	0.2	0.1
Excursion Total		**5,885.7**	**5,802.4**	**0.3**	**0.1**
Ferry	Auxiliary	99.2	97.8	0.0	0.0
	Propulsion	9,290.1	9,158.3	0.4	0.2
Ferry Total		**9,389.3**	**9,256.1**	**0.4**	**0.2**
Government	Auxiliary	35.9	35.4	0.0	0.0
	Propulsion	1,954.9	1,927.2	0.1	0.0
Government Total		**1,990.9**	**1,962.6**	**0.1**	**0.0**
Ocean Tug	Auxiliary	108.0	106.5	0.0	0.0
	Propulsion	3,885.9	3,830.8	0.2	0.1
Ocean Tug		**3,993.9**	**3,937.2**	**0.2**	**0.1**
Tugboat	Auxiliary	151.8	149.6	0.0	0.0
	Propulsion	2,538.3	2,502.3	0.1	0.1
Tugboat Total		**2,690.1**	**2,651.9**	**0.1**	**0.1**
Work boat	Auxiliary	157.5	155.2	0.0	0.0
	Propulsion	2,369.8	2,336.3	0.1	0.1
Work boat Total		**2,527.3**	**2,491.5**	**0.1**	**0.1**
Harbor craft Total		**56,562.0**	**55,759.3**	**2.5**	**1.3**

DB ID427

Figure 4.7 shows that approximately 32% of the Port's harbor craft emissions are attributed to assist tugs, 17% to commercial fishing, 13% to ferries, 12% to excursion vessels, 10% to crew boats, 5% to work boats, 5% to ocean tugs, 3% to tugboats, and 3% to government vessels.

Figure 4.7: 2009 Harbor Craft Emissions Distribution



SECTION 5 CARGO HANDLING EQUIPMENT

This section presents emissions estimates for the cargo handling equipment source category, including source description (5.1), geographical delineation (5.2), data and information acquisition (5.3), operational profiles (5.4), emissions estimation methodology (5.5), and the emission estimates (5.6).

5.1 Source Description

Cargo handling equipment includes equipment used to move cargo (containers, general cargo, and bulk cargo) to and from marine vessels, railcars, and on-road trucks. The equipment typically operates at marine terminals or at rail yards and not on public roadways or lands. This inventory includes cargo handling equipment with 25 hp or greater engines using diesel, gasoline, or alternative fuels. Due to the diversity of cargo handled by the ports terminals, there is a wide range of equipment types. The majority of non-electric cargo handling equipment can be classified into one of the following equipment types:

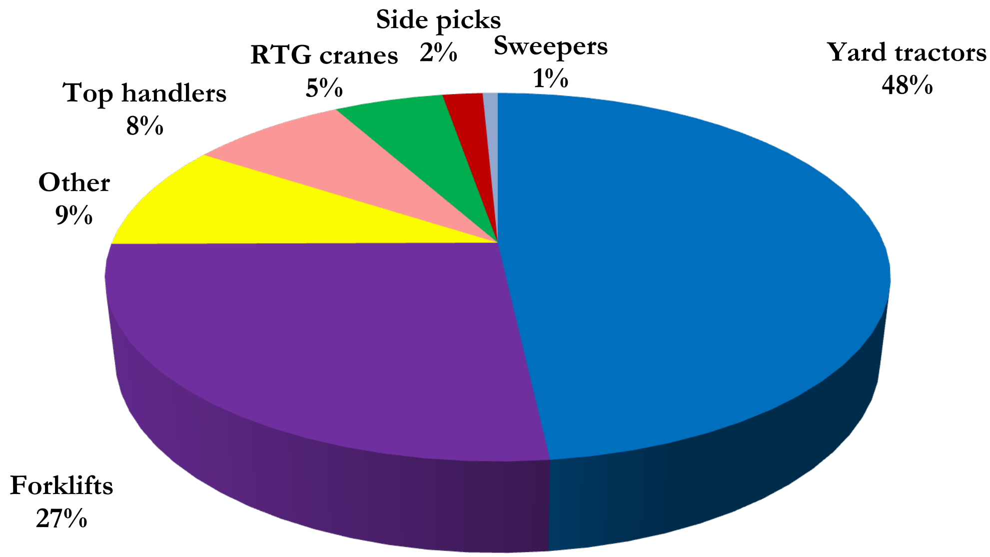
- Forklift
- Rubber tired gantry (RTG) crane
- Side pick
- Sweeper
- Top handler
- Yard tractor
- Other

The "Other" category contains the following equipment types:

- Bulldozer
- Crane
- Excavator
- Loader
- Man lift
- Miscellaneous (cone vehicles)
- Rail pusher
- Skid steer loader
- Trucks (fuel, utility, water, vacuum)

Figure 5.1 presents the distribution of the 2,000 pieces of equipment inventoried at the Port for calendar year 2009. Out of the total cargo handling equipment inventoried at the Port terminals and facilities, 48% were yard tractors, 27% were forklifts, 8% were top handlers, 5% percent were RTG cranes, 2% were side picks, 1% were sweepers, and 9% were other equipment (including electric-powered equipment).

Figure 5.1: Distribution of 2009 Cargo Handling Equipment by Equipment Type



5.2 Geographical Delineation

Figure 5.2 presents the geographical delineation for cargo handling equipment and covers equipment from container, dry bulk, break bulk, liquid bulk, auto, and cruise terminals as well as equipment from UP Intermodal Container Transfer Facility (ICTF) and smaller facilities located within Port boundaries and covered under port's jurisdiction.

Figure 5.2: Geographical Boundaries for Cargo Handling Equipment

Following is the list of the terminals, by major cargo type, included in the inventory:

Container Terminals:
- Berth 100: West Basin Container Terminal (China Shipping)
- Berths 121-131: West Basin Container Terminal (Yang Ming)
- Berths 136-139: Trans Pacific Container Terminal (Trapac)
- Berths 212-225: Yusen Container Terminal (YTI)
- Berths 226-236: Seaside Terminal (Evergreen)
- Berths 302-305: APL Terminal (Global Gateway South)
- Berths 401-406: APM Terminals (Pier 400)

Break-Bulk Terminals:
- Berths 174-181: Pasha Stevedoring Terminals
- Berths 54-55: Stevedore Services of America (SSA)
- Berths 153-155: Crescent Warehouse Company
- Berths 210-211: SA Recycling

Dry Bulk Terminals:
- California Sulfur
- LA Grain
- Berths 165-166: U.S. Borax

Liquid Terminals:
- Berths 118-119: Kinder Morgan
- Berths 187-191: Vopak
- Berths 167-169: Equillon/Shell Oil
- Berths 238-240: ExxonMobil
- Berths 148-151: ConocoPhillips
- Berths 163-164: Ultramar/Valero

Auto Terminal:
- Berths 195-199: WWL Vehicle Services Americas (formerly DAS)

Cruise Terminal:
- Berths 91-93: Pacific Cruise Ship Terminals (PCST)

Other Facilities:

- Al Larson
- Union Pacific Intermodal Containers Transfer Facility (ICTF)
- California Cartage
- Southern California (SoCal) Ship Services
- San Pedro Forklifts
- Three Rivers Trucking
- California Multimodal

5.3 Data and Information Acquisition

For each terminal or facility, the maintenance and/or cargo handling equipment operating staff were contacted either in person, by e-mail or by telephone to obtain information on the equipment specific to their terminal's or facility's operation for calendar year 2009. Information requested is listed below:

- Equipment type
- Equipment identification number
- Equipment make and model
- Engine make and model
- Rated horsepower (or kilowatts)
- Equipment and engine model year
- Type of fuel used (ULSD, gasoline, propane, or other)
- Alternative fuel used
- Annual hours of operation (some terminal operators use hour meters)
- Emission control technologies installed (e.g., Diesel Oxidation Catalyst, Diesel Particulate Filter) and date installed
- On-road engine installed
- New equipment purchased; Equipment retired or removed from service

5.4 Operational Profiles

Table 5.1 summarizes the cargo handling equipment data collected from all terminals and facilities in 2009. The table includes the count of all equipment as well as the range and the average of horsepower, model year, and annual operating hours by equipment type for equipment with known operating parameters. For the equipment with missing model year, horsepower, or operating hours, the averages by equipment and fuel type are used. The table does not include the count or characteristics of small auxiliary engines (20 kW) for 30 RTGs because the count column is equipment count, not engine count. The main engines for these RTGs are reflected in the table. Emissions for both main and auxiliary engines are included in the inventory. For the electric-powered equipment shown in the table, "na" denotes "not applicable" for engine size, model year and operating hours.

Table 5.1: 2009 CHE Characteristics for All Terminals

		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	**Count**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Bulldozer	1	165	165	165	1993	1993	1993	386	386	386
Crane	11	130	750	261	1965	2004	1987	165	2,407	740
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf crane	73	na	na	na	na	na	na	na	na	na
Excavator	10	371	428	401	1998	2008	2004	31	3,072	1,775
Forklift	538	35	350	105	1979	2009	1998	0	2,726	848
Loader	13	52	430	288	1984	2009	1999	16	3,879	1,113
Man Lift	23	48	87	75	1989	2007	2000	0	728	216
Miscellaneous	6	37	37	37	2008	2008	2008	1,365	3,105	1,957
Rail Pusher	3	130	200	170	1993	2004	1999	6	651	226
RMG cranes, electric	10	na	na	na	na	na	na	na	na	na
RTG crane	108	250	685	543	1995	2009	2004	0	3,979	1,155
Side pick	40	136	330	208	1992	2009	2002	9	3,996	1,055
Skid steer loader	12	30	94	58	1994	2007	2003	2	877	252
Sweeper	15	35	260	128	1995	2008	2002	0	918	293
Top handler	154	174	375	290	1979	2008	2003	0	3,655	1,534
Truck	14	97	525	319	1995	2009	2004	73	2,950	1,303
Yard tractor	962	170	270	215	1995	2008	2006	0	5,390	1,699
Total count	**2,000**									

DB ID228

Table 5.2 presents the percentage of cargo handling equipment at container terminals (69%) as compared to the total Port equipment.

Table 5.2: 2009 Container Terminal CHE Compared to Total CHE

Equipment	Total Count	Container Terminal Count	Percent
Forklift	538	115	21%
RTG crane	108	98	91%
Side pick	40	37	93%
Top handler	154	149	97%
Yard tractor	962	868	90%
Sweeper	15	9	60%
Other	183	106	58%
Total	**2,000**	**1,382**	**69%**

DB ID233

The equipment characteristics for the Port's seven container terminals are summarized in Table 5.3. It should be noted that the auxiliary engines (20 kW) for 30 RTGs are not shown in the table but the main engines for these RTGs are included; however, emissions for both main and auxiliary engines are included in the inventory.

Table 5.3: 2009 CHE Characteristics for Container Terminals

Container Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf cranes	73	na	na	na	na	na	na	na	na	na
Forklift	114	45	330	133	1985	2009	2000	0	2,726	363
Forklift, electric	1	na	na	na	na	na	na	na	na	na
Man Lift	7	80	87	84	1995	2006	2001	0	238	88
Rail Pusher	2	180	200	190	1993	2000	1997	6	20	13
RMG cranes, electric	10	na	na	na	na	na	na	na	na	na
RTG crane	98	350	685	570	1999	2007	2003	0	3,755	1,069
Side pick	37	152	330	213	1995	2009	2003	9	3,996	1,115
Sweeper	9	100	240	154	1995	2008	2002	0	712	250
Top handler	149	250	335	290	1987	2008	2003	0	3,655	1,558
Truck	7	235	250	244	2001	2008	2006	73	1,837	845
Yard tractor	868	170	270	217	2000	2008	2006	0	5,390	1,684
Total count	**1,382**									

DB ID229

Table 5.4 presents the cargo handling equipment characteristics of the Port's four break-bulk terminals.

Table 5.4: 2009 CHE Characteristics for Break-Bulk Terminals

Break Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	1	165	165	165	1993	1993	1993	386	386	386
Crane	5	150	750	336	1965	1995	1979	165	2,407	724
Excavator	10	371	428	401	1998	2008	2004	31	3,072	1,775
Forklift	130	35	350	150	1979	2009	1997	0	2,250	495
Forklift, electric	1	na	na	na	na	na	na	na	na	na
Loader	8	52	430	339	1984	2008	1999	429	3,879	1,503
Man lift	8	60	80	74	1996	2002	1999	0	728	300
Man Lift, electric	4	na	na	na	na	na	na	na	na	na
Rail pusher	1	130	130	130	2004	2004	2004	651	651	651
Side pick	2	152	152	152	2000	2000	2000	33	36	35
Skid steer loader	8	30	70	53	2002	2007	2004	2	877	364
Sweeper	5	35	260	105	1996	2008	2002	19	918	428
Top handler	4	174	375	262	1979	2004	1991	56	242	166
Truck	6	210	525	445	1995	2009	2004	422	2,950	1,993
Yard tractor	23	177	215	191	2000	2008	2004	0	688	278
Total count	**216**									

DB ID231

Table 5.5 presents the cargo handling equipment characteristics of the Port's three dry bulk terminals.

Table 5.5: 2009 CHE Characteristics for Dry Bulk Terminals

Dry Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Loader	2	110	200	155	1995	1995	1995	1,040	1,040	1,040
Yard tractor	4	250	250	250	1995	1995	1995	2,080	2,080	2,080
Total count	**6**									

DB ID230

There were also 39 pieces of cargo handling equipment operated at the Port's cruise, auto and liquid bulk terminals including 8 forklifts at the auto terminal, 26 forklifts and 1 truck at the cruise terminal and 4 forklifts at the liquid bulk terminals. In addition to these other terminals, there are also several other facilities within the Port boundary which were included in this inventory but did not fit into the typical terminal categories listed above. These other facilities/tenants include smaller facilities and UP's ICTF. Table 5.6 presents the cargo handling equipment characteristics of these other facilities.

Table 5.6: 2009 CHE Characteristics for Other Facilities

Other Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	**Count**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Crane	6	130	244	198	1987	2004	1993	600	847	754
Forklift	254	48	155	76	1987	2008	1997	65	1,500	1,233
Loader	3	96	310	239	1989	2006	1995	16	321	122
Man lift	4	48	80	63	1989	2007	1997	15	456	188
Miscellaneous	6	37	37	37	2008	2008	2008	1,365	3,105	1,957
RTG crane	10	300	350	310	1995	2009	2000	113	3,979	2,134
Side Pick	1	136	136	136	1992	1992	1992	875	875	875
Skid steer loader	4	54	94	69	1994	2001	1999	3	96	28
Sweeper	1	37	37	37	1999	1999	1999	8	8	8
Top handler	1	325	325	325	2006	2006	2006	2,114	2,114	2,114
Yard tractor	67	173	250	189	1995	2005	2003	100	3,802	2,149
Total count	**357**									

DB ID232

The 2009 CHE inventory includes 303 pieces of equipment with diesel oxidation catalysts (DOC), 19 retrofitted with level-3 verified DPFs, and 670 yard tractors equipped with certified on-road engines. All terminals used ULSD fuel for all the 1,491 pieces of diesel equipment.

Table 5.7 is a summary of the emission reduction technologies utilized in cargo handling equipment. It should be noted that some of these technologies may be used in combination with one another. For example, some on-road yard tractors may be equipped with DOCs.

Table 5.7: Summary of 2009 CHE Emission Reduction Technologies

Equipment	DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel	Emulsified Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel
Forklifts	3	4	1	185	0	185	2%	2%	1%	100%
RTG cranes	10	0	0	108	0	108	9%	0%	0%	100%
Side handlers	9	0	0	40	0	40	23%	0%	0%	100%
Top handlers	52	0	0	154	0	154	34%	0%	0%	100%
Yard tractors	229	661	18	902	0	902	25%	73%	2%	100%
Sweepers	0	1	0	13	0	13	0%	8%	0%	100%
Other	0	4	0	89	0	89	0%	4%	0%	100%
Total	**303**	**670**	**19**	**1,491**	**0**	**1,491**	**20%**	**45%**	**1%**	**100%**

DB ID234

Twenty five percent of equipment inventoried were not equipped with diesel engines but were powered by propane or gasoline engines or electric motors. Specifically, a total of 397 pieces of equipment were powered with propane engines, 10 were powered with gasoline engines, 5 were LNG-powered, and 97 were electric-powered, as listed on Table 5.8.

Table 5.8: 2009 Count of CHE Engine Types

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
Forklifts	3	0	342	8	185	538
Wharf gantry cranes	73	0	0	0	0	73
RTG cranes	0	0	0	0	108	108
Side handlers	0	0	0	0	40	40
Top handlers	0	0	0	0	154	154
Yard tractors	0	5	55	0	902	962
Sweepers	0	0	0	2	13	15
Other	21	0	0	0	89	110
Total	**97**	**5**	**397**	**10**	**1,491**	**2,000**

DB ID235

The inventory does not include smaller electric equipment that may be operating at the terminals but includes the following electric equipment:

- 73 electric wharf cranes
- 10 electric cranes
- 7 electric pallet jacks
- 3 electric forklifts
- 4 electric man lifts

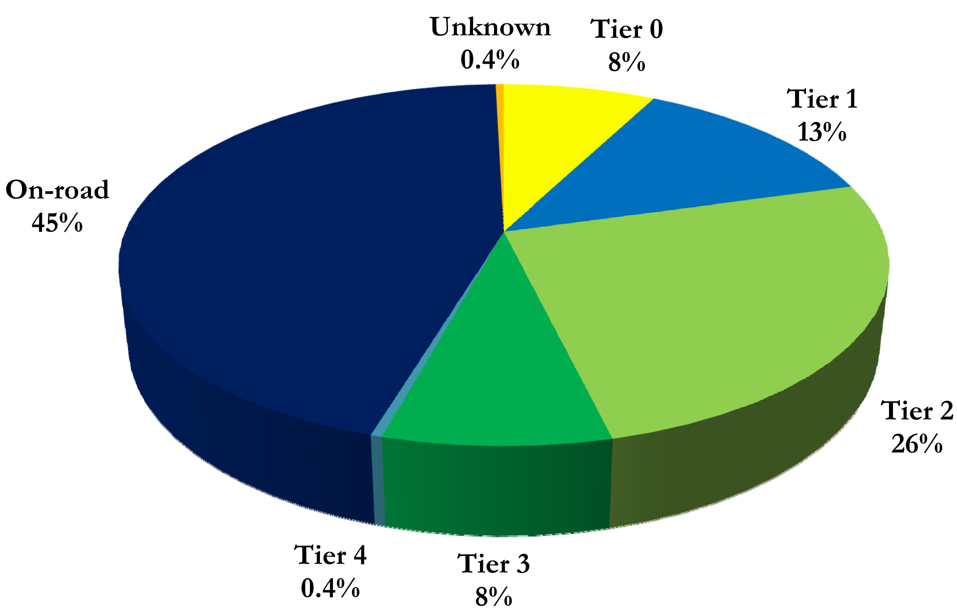
Table 5.9 summarizes the distribution of diesel cargo handling equipment equipped with off-road engines by off-road diesel engine standards (Tier 0, 1, 2, and 3) and those equipped with on-road diesel engines. On-road diesel engine standards are lower than Tier 3 off-road diesel engine standards. As shown in Table 5.9, with the implementation of the Port's CAAP measure for CHE and CARB's In-Use CHE regulation, the cargo handling equipment with cleaner on-road engines continue to represent a significant portion of all diesel-powered equipment at the Port. The Unknown Tier column shown in the table represents equipment with unknown horsepower or model year information (which provides the basis for Tier level classifications). Figure 5.3 presents the distribution of diesel equipment by off-road and on-road engine standards.

Table 5.9: 2009 Count of Diesel Equipment by Type and Engine Standards

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	On-road Engine	Unknown Tier	Total Diesel
Yard tractors	8	29	197	7	0	661	0	902
Forklifts	56	68	36	16	0	4	5	185
Top handlers	16	30	56	52	0	0	0	154
Other	22	28	16	13	6	4	0	89
RTG cranes	4	23	60	21	0	0	0	108
Side handlers	5	13	13	9	0	0	0	40
Sweepers	3	3	3	2	0	1	1	13
Total	**114**	**194**	**381**	**120**	**6**	**670**	**6**	**1,491**
Percent	**8%**	**13%**	**26%**	**8%**	**0.4%**	**45%**	**0.4%**	

DB ID878

Figure 5.3: Distribution of Diesel Equipment by Engine Standards, %



5.5 Methodology

The methodology used to estimate the cargo handling equipment emissions is consistent with CARB's latest methodology. The basic equation used to estimate emissions for each piece of equipment is as follows.

$$E = Power \times Act \times LF \times EF \times FCF \times CF \qquad \text{Equation 5.1}$$

Where:

E = emissions, tons/year
Power = rated power of the engine in horsepower or kilowatts
Act = equipment activity, hours/year
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower)
EF = emission factor, grams of pollutant per unit of work (g/hp-hr or kW/hp-hr)
FCF = fuel correction factor to reflect changes in fuel properties that have occurred over time
CF = control factor to reflect changes in emissions due to installation of emission reduction technologies not originally included in the emissions factors

The engine's emission factor is a function of the zero hour emission rate, deterioration rate, and cumulative hours. The deterioration rate reflects the fact that the engine's base emissions (zero hour emission rates) change as the equipment is used, due to wear of various engine parts or reduced efficiency of emission control devices. The cumulative hours reflects the equipment's total operating hours. The emission factor is calculated as:

$$EF = ZH + (DR \times Cumulative\ Hours) \qquad \text{Equation 5.2}$$

Where:

ZH = emission rate for a given engine size category and model year when the engine is new and there is no component malfunctioning
DR = deterioration rate (rate of change of emissions as a function of equipment usage)
Cumulative hours = number of hours the equipment has been in use and calculated as annual operating hours times age of the equipment

The equation for the deterioration rate is:

Equation 5.3

DR = (DF x ZH) / cumulative hours at the end of useful life

Where:

DR = deterioration rate (expressed as $g/hp\text{-}hr^2$)
DF = deterioration factor, percent increase in emissions for a new engine at the end of the useful life (expressed as %)
ZH = emission rate for a given horsepower category and model year when the engine is new and there is no component malfunctioning
Cumulative hours at the end of useful life = annual operating hours times useful life in years

5.5.1 Emission Factors

The zero hour (ZH) emission rates for cargo handling equipment used in this inventory were provided by CARB and are consistent with the OFFROAD model. The ZH emission rates are a function of fuel type, model year and horsepower group as defined in the OFFROAD model.

ZH emission rates vary by engine horsepower and model year to reflect the fact that depending upon the size of the engines, different engine technologies and emission standards are applicable. ZH emission factors (provided by CARB) by horsepower and engine year were used for:

- Diesel engines certified to off-road diesel engine emission standards
- Diesel engines certified to on-road diesel emission standards
- Gasoline and LPG engines certified to large spark ignited engine (LSI) emission standards

5.5.2 Load Factor, Useful Life, Deterioration Rates and Fuel Correction Factors

Load factor is defined as the ratio of average load experienced by the equipment during normal operation as compared to full load at maximum rated power. It accounts for the fact that in their normal operations, engines are not used at their maximum power rating. Equipment specific load factors used in 2009 are the same as those used in 2008 EI. Load factors for cargo handling equipment are primarily based on CARB's methodology except for RTG cranes and yard tractors which were updated based on joint studies conducted by the Ports of Los Angeles and Long Beach in consultation with CARB. Specifically, the yard tractor load factor[32] of 39% has been used since the 2006 EI report, and the 20% load factor for RTG cranes[33] has been used since the 2008 EI report.

Table 5.10 lists the useful life and load factor by equipment type.

Table 5.10: CHE Useful Life and Load Factors

Port Equipment	Useful Life	Load Factor
RTG crane	24	0.20
Crane	24	0.43
Excavator	16	0.57
Forklift	16	0.3
Top handler, side pick, reach stacker	16	0.59
Man lift, truck, other with off-road engine	16	0.51
Truck, other with on-road engine	16	0.51
Sweeper	16	0.68
Loader	16	0.55
Yard tractor with off-road engine	12	0.39
Yard tractor with on-road engine	12	0.39

DB ID459

32 San Pedro Bay Ports Yard Tractor Load Factor Study Addendum, December 2008.
33 Rubber Tired Gantry Crane Load Factor Study, November 2009.

Table 5.11 lists the deterioration factors for cargo handling equipment by horsepower group. There are no deterioration factors for GHGs.

Table 5.11: Deterioration Factors by Horsepower Group

Horsepower Group	PM	NO_x	CO	HC
0 to 50	31%	6%	41%	51%
51 to 120	44%	14%	16%	28%
121 to 175	44%	14%	16%	28%
176 to 250	44%	14%	16%	28%
250 +	67%	21%	25%	44%

DB ID445

Table 5.12 lists the fuel correction factors for ULSD fuel.[34] The base emission factors are based on the diesel fuel in use at the time the factors were developed and are adjusted by the following fuel correction factors to reflect the characteristics of ULSD. The FCF for SOx reflects the change from diesel fuel with a sulfur content of 140 ppm to ULSD (15 ppm).

Table 5.12: Fuel Correction Factors for ULSD

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.720	0.930	0.110	1	0.720	1	0.930	0.720
1996 and newer	0.800	0.948	0.110	1	0.720	1	0.948	0.720

DB ID444

[34] *http://www.arb.ca.gov/msei/offroad/techmemo/arb_offroad_fuels.pdf*

Table 5.13 shows the fuel correction factors for gasoline engines. LNG and propane engines have no FCF.

Table 5.13: Fuel Correction Factors for Gasoline

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1997 and older	1	0.867	1	0.795	0.850	1	0.867	0.850
1998 and newer	1	1	1	1	1	1	1	1

5.5.3 Control Factors

Control factors were used to reflect the change in emissions due to the use of various emissions reduction technologies. Table 5.14 shows the emission reduction percentages provided by CARB for the various technologies used by the Port equipment. The control factor is applied to the baseline emissions to estimate the remaining emissions and is 1 minus the emission reduction in decimal; for example, a 70% reduction has a control factor of 0.3.

Table 5.14: CHE Emission Reduction Percentages

Technology	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
DOC	30%	30%	30%	0%	na	70%	70%	na	0%	70%
DPF	85%	85%	85%	0%	na	0%	0%	na	0%	0%
Vycon's REGEN	25%	25%	25%	30%	15%	0%	0%	15%	30%	0%
BlueCAT	0%	0%	0%	85%	na	0%	85%	na	0%	0%

DB ID474

CARB's sources for the emission reductions are as follows:

- DOC: CEC Report (Air Quality Implications of Backup Generators in California Volume Two: Emission Measurements From Controlled and Uncontrolled Backup Generators)[35]
- DPF: CARB verified technology[36]
- Vycon: CARB verified technology[37]
- Nett BlueCAT 300: CARB verified technology for off-road large spark-ignition (LSI) equipment[38]

[35] See *http://www.enenrgy.ca.gov/pier/final_project_reports/CEC-500-2005-049.html*
[36] *http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm*
[37] *http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm*
[38] *http://www.ar.ca.gov/msprog/offroad/orspark/verdev.htm*

5.5.4 Improvements to Methodology from Previous Year

There were no changes to the emission calculation methodology this year compared to the 2008 methodology. For comparison of 2009 emissions to previous years' emissions, refer to Section 9.

5.5.5 Future Improvements to Methodology

The emission factors for yard tractors equipped with on-road engines for this inventory were provided by CARB based on CARB's yard tractor emissions testing study, in which yard tractors equipped with MY 2004 on-road and off-road engines were tested on the same duty cycle. However, during the development of the 2009 CHE emissions inventory, it was recognized that the emission reductions obtained through CARB's testing may not represent the reductions that would be achieved with some newer model year trucks (i.e., 2007+ model years) because of the differences in the timing of new standards for on-road and off-road engines. Accordingly, the emissions for on-road yard tractors for some of the newer model years may be overestimated. For the next EI, the emission factors used for on-road yard tractors will be evaluated in more detail to ensure that they accurately represent the applicable standards and the yard tractors' off-road duty cycle application.

5.6 Emission Estimates

Tables 5.15 and 5.16 provide a summary of cargo handling equipment emissions by terminal type.

Table 5.15: 2009 CHE Emissions by Terminal Type, tons per year

Terminal Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto	0.0	0.0	0.0	0.2	0.0	1.3	0.1
Break-Bulk	3.4	3.2	3.3	98.9	0.1	73.4	8.4
Container	18.6	17.3	18.3	528.4	1.3	310.4	15.6
Cruise	0.1	0.1	0.0	4.5	0.0	14.6	1.2
Dry Bulk	0.4	0.4	0.4	9.2	0.0	3.5	0.7
Liquid	0.0	0.0	0.0	1.0	0.0	1.5	0.2
Other	2.7	2.6	2.3	107.9	0.1	306.9	13.8
Total	**25.2**	**23.6**	**24.4**	**750.1**	**1.5**	**711.6**	**40.0**

DB ID237

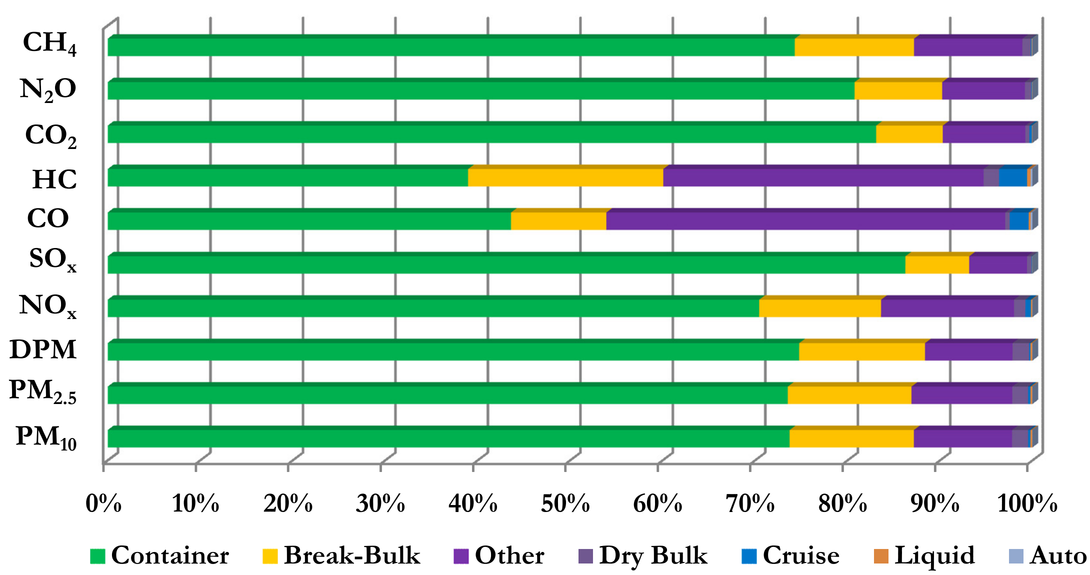
Table 5.16: 2009 CHE GHG Emissions by Terminal Type, metric tons per year

Terminal Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auto	15.0	14.8	0.0	0.0
Break-Bulk	9,305.3	9,226.7	0.2	0.4
Container	107,243.2	106,595.9	1.9	2.3
Cruise	348.2	347.7	0.0	0.0
Dry Bulk	564.1	558.4	0.0	0.0
Liquid	58.2	57.9	0.0	0.0
Other	11,529.4	11,455.4	0.2	0.4
Total	**129,063.4**	**128,256.7**	**2.4**	**3.1**

DB ID237

Figure 5.4 presents the percentage of cargo handling equipment emissions by terminal type. Container terminals account for roughly 74% of the Port's cargo handling equipment PM emissions, 70% of the NO_x emissions, 86% of the SO_x emissions, 44% of the CO, 39% of the HC emissions, 83% of the CO_2 emissions, 79% of the N_2O emissions, and 74% of the CH_4 emissions are attributed to the container terminals. Break-bulk terminals and other terminals and facilities account for the remainder of the emissions.

Figure 5.4: 2009 CHE Emissions by Terminal Type, %



Tables 5.17 and 5.18 present the emissions by cargo handling equipment type and engine type.

Table 5.17: 2009 CHE Emissions by Equipment and Engine Type, tons per year

Port Equipment	Engine	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Bulldozer	Diesel	0.0	0.0	0.0	0.3	0.0	0.1	0.0
Crane	Diesel	0.8	0.8	0.8	16.3	0.0	6.7	1.2
Excavator	Diesel	0.5	0.5	0.5	17.5	0.0	4.3	0.7
Forklift	Diesel	1.4	1.3	1.4	26.3	0.0	11.4	1.8
Forklift	Gasoline	0.0	0.0	0.0	7.5	0.0	21.0	1.9
Forklift	Propane	0.5	0.5	0.0	45.6	0.0	321.3	14.0
Loader	Diesel	0.6	0.6	0.6	21.4	0.0	4.2	1.0
Man Lift	Diesel	0.1	0.1	0.1	1.4	0.0	0.8	0.2
Miscellaneous	Diesel	0.0	0.1	0.1	1.1	0.0	0.7	0.0
Rail Pusher	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0
Rub-trd Gantry Crane	Diesel	1.7	1.6	1.7	61.0	0.1	15.2	1.8
Side pick	Diesel	0.7	0.7	0.7	26.7	0.0	5.3	0.8
Skid Steer Loader	Diesel	0.0	0.0	0.0	0.6	0.0	0.4	0.0
Sweeper	Diesel	0.1	0.1	0.1	1.3	0.0	0.7	0.1
Sweeper	Gasoline	0.0	0.0	0.0	1.1	0.0	5.0	0.2
Top handler	Diesel	5.0	4.6	5.0	178.9	0.3	36.7	4.6
Truck	Diesel	0.5	0.5	0.5	13.4	0.0	4.8	0.5
Yard tractor	Diesel	12.7	11.8	12.7	307.5	1.0	152.9	6.9
Yard tractor	LNG	0.0	0.0	0.0	0.6	0.0	0.0	0.5
Yard tractor	Propane	0.3	0.3	0.0	21.2	0.0	119.9	3.9
Total		**25.2**	**23.6**	**24.4**	**750.1**	**1.5**	**711.6**	**40.0**

DB ID237

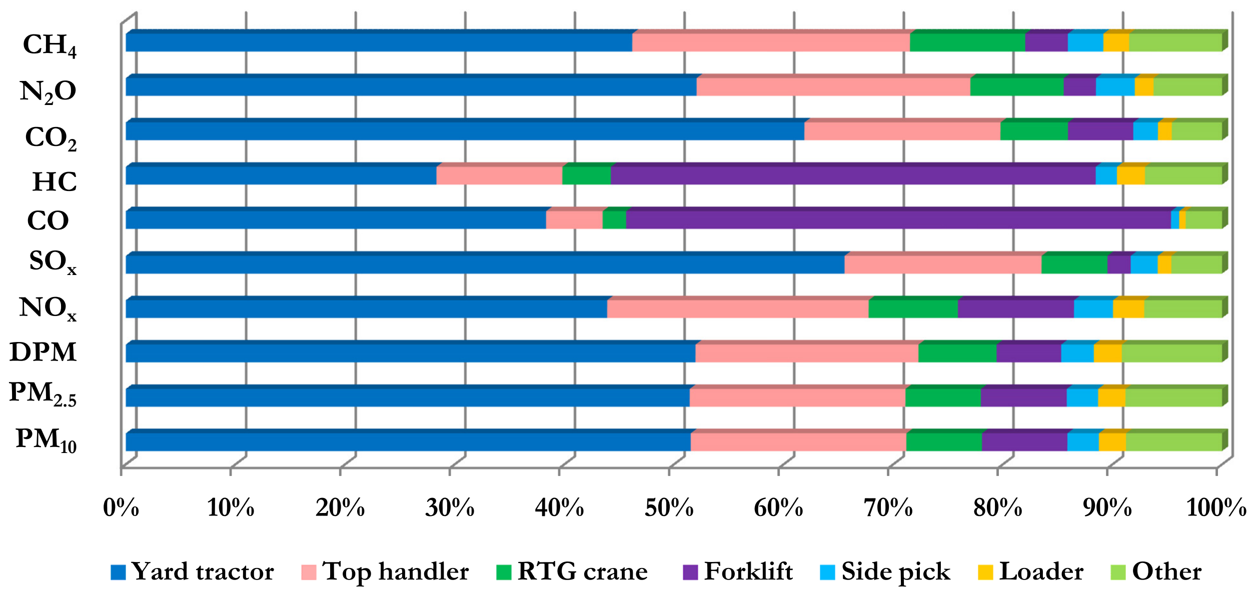
Table 5.18: 2009 CHE GHG Emissions by Equipment and Engine Type, metric tons per year

Port Equipment	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Bulldozer	Diesel	20.0	19.8	0.0	0.0
Crane	Diesel	734.0	727.2	0.0	0.0
Excavator	Diesel	2,267.7	2,248.3	0.1	0.1
Forklift	Diesel	2,231.6	2,209.9	0.1	0.1
Forklift	Gasoline	307.9	305.3	0.0	0.0
Forklift	Propane	5,125.7	5,125.7	0.0	0.0
Loader	Diesel	1,633.1	1,618.9	0.0	0.1
Man Lift	Diesel	106.6	105.5	0.0	0.0
Miscellaneous	Diesel	124.9	123.5	0.0	0.0
Rail Pusher	Diesel	26.1	25.8	0.0	0.0
Rub-trd Gantry Crane	Diesel	7,968.5	7,898.5	0.2	0.3
Side pick	Diesel	2,912.0	2,883.6	0.1	0.1
Skid Steer Loader	Diesel	57.9	57.3	0.0	0.0
Sweeper	Diesel	133.6	132.3	0.0	0.0
Sweeper	Gasoline	137.2	135.9	0.0	0.0
Top handler	Diesel	23,142.4	22,940.7	0.6	0.8
Truck	Diesel	2,329.3	2,309.9	0.1	0.1
Yard tractor	Diesel	76,537.2	76,121.0	1.2	1.4
Yard tractor	LNG	0.0	0.0	0.0	0.0
Yard tractor	Propane	3,267.8	3,267.8	0.0	0.0
Total		**129,063.4**	**128,256.7**	**2.4**	**3.1**

DB ID237

Figure 5.5 presents the percentage of cargo handling equipment emissions by equipment type. Yard tractors contribute to roughly 52% of the cargo handling equipment PM emissions, 44% of the NO_x emissions, 66% of the SO_x emissions, 38% of the CO emissions, 28% of the HC emissions, 62% of the CO_2 emissions, 52% of N_2O emissions and 46% of the CH_4 emissions. Top handlers, forklifts, RTG cranes, side picks and loaders follow in emissions. "Other" equipment refers to bulldozer, crane, excavator, man lift, rail pusher, skid steer loader, sweeper, off-road truck, and miscellaneous equipment.

Figure 5.5: 2009 CHE Emissions by Equipment Type, %



SECTION 6 RAILROAD LOCOMOTIVES

This section presents emissions estimates for the railroad locomotive source category, including source description (6.1), geographical delineation (6.2), data and information acquisition (6.3), operational profiles (6.4), emissions estimation methodology (6.5), and the emission estimates (6.6).

6.1 Source Description

Railroad operations are typically described in terms of two different types of operation, line haul and switching. Line haul refers to the movement of cargo over long distances (e.g., cross-country) and occurs within the Port as the initiation or termination of a line haul trip, as cargo is either picked up for transport to destinations across the country or is dropped off for shipment overseas. Switching refers to short movements of rail cars, such as in the assembling and disassembling of trains at various locations in and around the Port, sorting of the cars of inbound cargo trains into contiguous "fragments" for subsequent delivery to terminals, and the short distance hauling of rail cargo within the Port. It is important to recognize that "outbound" rail freight is cargo that has arrived on vessels and is being shipped to locations across the U.S. (also known as eastbound cargo), whereas "inbound" rail freight is destined for shipment out of the Port by vessel (also known as westbound cargo). This is contrary to the usual port terminology of cargo off-loaded from vessels referred to as "inbound" and that loaded onto vessels as "outbound."

The Port is served by three railway companies:

- Burlington Northern Santa Fe (BNSF)
- Union Pacific (UP)
- Pacific Harbor Line (PHL)

These railroads primarily transport intermodal (containerized) freight, with lesser amounts of dry bulk, liquid bulk, and car-load (box car) freight. PHL performs most of the switching operations within the Port, while BNSF and UP provide line haul service to and from the Port and also operate switching services at their off-port locations. The two railroads that provide line haul service to the Port are termed Class 1 railroads, based on their relative size and revenues.

Locomotives used for line haul operations are typically large, powerful engines of 3,000 to 4,000 hp or more, while switch engines are smaller, typically having 1,200 to 3,000 hp engines. Figures 6.1 and 6.2 illustrate typical line haul and switching locomotives, respectively, in use at the Port. The locomotives used in switching service at the Port by PHL, and reportedly at the near-Port railyard operated by UP, are new, low-emitting locomotives specifically designed for switching duty. PHL's previous fleet of older locomotives has been replaced as part of an agreement among the Ports of Los Angeles and

Long Beach and PHL. UP has reported that they operate similar low-emission locomotives at their local near-port railyard as part of an agreement between the railroad and CARB. PHL's replacement locomotives were added to the PHL fleet starting in 2007, and by the early part of 2008 all of the older locomotives had been permanently removed from service. The new locomotives made up the entire PHL fleet in 2009.

Figure 6.1: Typical Line Haul Locomotive

Figure 6.2: New PHL Switching Locomotive

6.2 Geographical Delineation

Figure 6.3 illustrates the rail track system serving both ports, and Figure 6.4 presents a broader view of the major rail routes in the air basin that are used to move port-related intermodal cargo. The specific activities included in this emissions inventory are movements of cargo within Port boundaries, or directly to or from port-owned properties (such as terminals and on-port rail yards). Rail movements of cargo that occur solely outside the port, such as switching at off-port rail yards, and movements that do not either initiate or end at a Port property (such as east-bound line hauls that initiate in central Los Angeles intermodal yards) are not included.

Figure 6.3: Port Area Rail Lines

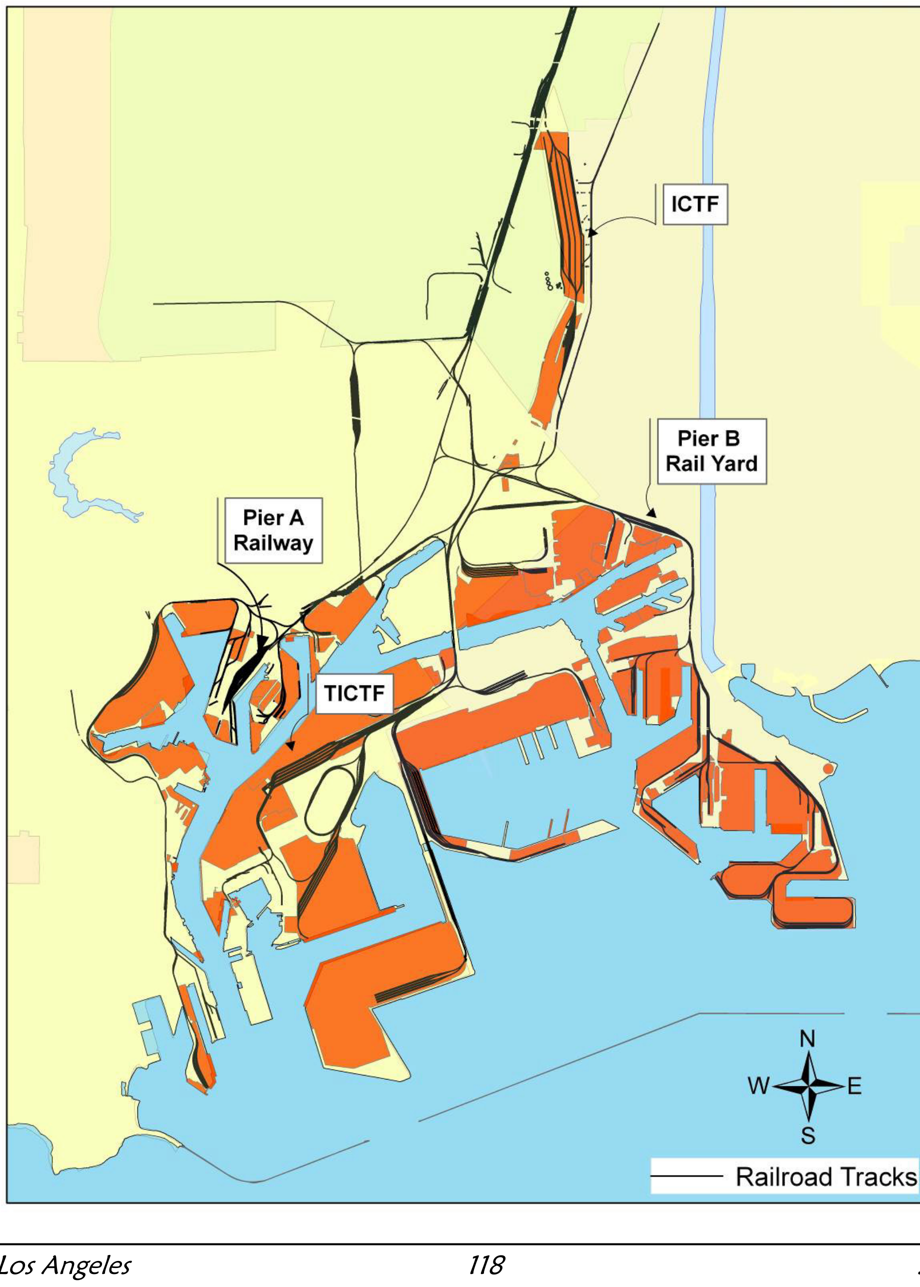


Figure 6.4: Air Basin Major Intermodal Rail Routes

6.3 Data and Information Acquisition

The locomotive section of the EI presents an estimate of emissions associated with Port-related activities of the locomotives operating within the Port and outside the Port to the boundary of the SoCAB. Information regarding these operations has been obtained from:

- Previous emissions studies
- Port cargo statistics
- Input from railroad operators

PHL provided a description of their new locomotive fleet, and a record of the fuel used per month in each of its locomotives. The UP railway company operating the ICTF, which is on Port property and operates as a joint powers authority of the Port of Los Angeles and POLB, also provided information on their switch engines, including representative fuel usage. In addition, railroad personnel were interviewed for an overview of their operations in the area. In addition, certain information related to line haul locomotive fleets has been obtained from railroad companies' Internet websites. Additionally, terminal operators and Port departments have provided information on Port rail operations that provides an additional level of understanding of overall line haul rail operations.

Throughput information provided by the railroad companies to the ports was used to estimate on-Port and off-Port rail activity. It should be noted that data collection is particularly difficult with respect to estimating rail emissions associated with Port activities. As a result, the rail data for locomotive operations associated with Port activities as presented in this study continues to be somewhat less refined and specific than the data for other emission source categories. The Port continues to work with the railroads to further enhance the accuracy of the port activity data on which the rail emissions inventory is based.

6.4 Operational Profiles

6.4.1 Rail System

The rail system is described below in terms of the activities that are undertaken by locomotive operators. Specifically, descriptions are provided for the assembly of outbound trains, the disassembly of inbound trains, and the performance of switching operations, as well as a detailed listing of the activities of line haul and switching operations.

Outbound Trains

The assembly of outbound trains occurs in one of three ways. Container terminals with sufficient track space build trains on-terminal in on-dock railyards, using flat cars that have either remained on site after the off-loading of inbound containers or have been brought in by one of the railroads. Alternatively, some containers are trucked (drayed) to an off-terminal transfer facility where the containers are transferred from truck chassis to railcars. A third option is for the terminal to store individual railcars (e.g., tank cars, bulk cars, container cars) or build a partial train on-terminal, to be collected later by a railroad (typically PHL) and moved to a rail yard with sufficient track space to build an entire train.

Within the Port, complete trains can be built at the terminals servicing the West Basin Container Terminal, the APL terminal, and the APM terminal. In addition, the Terminal Island Container Transfer Facility (TICTF) is shared by NYK and Evergreen as a facility to build trains. Trains are also built outside of the Port at the Watson Yard, the Dolores Yard, and the Manuel Yard, and at locations within the POLB. If containers to be transported by rail are not loaded onto railcars at the Port, they are typically drayed to off-port locations operated by the line haul railroads, as noted above.

Inbound Trains
In-bound trains carrying cargo (or empty containers) that are all destined for the same terminal are delivered directly to the terminal by the Class 1 railroads if the receiving terminal has the track space to accommodate all of the cars at one time (e.g., the TICTF on Terminal Island). Trains carrying cargo that are bound for multiple terminals within one or both Ports are staged by the Class 1 railroads at several locations, where they are broken up, typically by PHL, and delivered to their destination terminals. Inbound trains are also delivered to off-Port locations such as the Watson Yard, the ICTF operated by UP, the Dolores Yard, and the Manuel Yard. Of these locations, only the ICTF is included in the emission estimates presented in this emissions inventory, because of its status as a joint powers authority of the Port of Los Angeles and the Port of Long Beach.

Alameda Corridor
The Alameda Corridor is a 20-mile rail line running between the San Pedro Bay area and downtown Los Angeles that is used by intermodal and other trains servicing the San Pedro Bay Ports and other customers in the area. Running largely below grade, the Alameda Corridor provides a more direct route between downtown Los Angeles and the Port than the routes that had previously been used, shortening the travel distance and eliminating many at-grade crossings (reducing traffic congestion). Figure 6.5 illustrates the route of the Alameda Corridor and the routes it has replaced.

Figure 6.5: Alameda Corridor

Switching
Switching locomotives deliver and pick up railcars transporting containers, liquid and dry bulk materials, and general cargo to and from terminals at the Port. Switching operations take place around the clock, seven days per week, although weekend activity is generally lower than weekday or weeknight activity.

PHL is the primary switching railroad at the Port. PHL operations are organized into scheduled shifts, each shift being dispatched to do specified tasks in shift-specific areas. Other shifts move empty or laden container flat cars to and from container terminals. Much of the work involves rearranging the order of railcars in a train to organize cars bound for the same destinations (inbound or outbound) into contiguous segments of the train, and to ensure proper train dynamics. Train dynamics can include, for example, locating railcars carrying hazardous materials the appropriate minimum distance from the locomotives, and properly distributing the train's weight. Although there is a defined schedule of shifts that perform the same basic tasks, there is little consistency or predictability to the work performed during a given shift or at a particular time.

Specific Rail Activities
Locomotive activities of the Class 1 railway companies consist of:

- Delivering inbound trains (and/or empty railcars) to terminals or to the nearby rail yards, using line haul locomotives.
- Picking up trains from the terminals or nearby rail yards and transporting them to destinations across the country, using line haul locomotives.
- Breaking up inbound trains and sorting rail cars into contiguous fragments, and delivering the fragments to terminals, using PHL switch locomotives.

Locomotive switching activities consist of:

- Breaking up inbound trains and sorting railcars into contiguous fragments, and delivering the fragments to terminals.
- Delivering empty container flat cars to terminals.
- Delivering rail cars to non-container facilities, and removing previously delivered rail cars. (For example, delivering full tank cars to a terminal that ships product and removing empties, or delivering empty tank cars to a terminal that receives product and removing full ones.)
- Rearranging full and empty railcars to facilitate loading by a terminal.
- Picking up outbound containers in less than full train configuration and transporting them to a yard for assembly into full trains – to be transported out of the Port by one of the line haul railroads.

6.4.2 Locomotives and Trains

Locomotives operate differently from other types of mobile sources with respect to how they transmit power from engine to wheels. While most mobile sources use a physical coupling such as a transmission to transfer power from the engine to the wheels, a locomotive's engine turns a generator or alternator powering an electric motor that, in turn, powers the locomotive's wheels. The physical connection of the engine, transmission, and wheels of a typical mobile source means that the engine's speed varies with the vehicle's speed through a fixed set of gear ratios, resulting in the highly transient operating conditions (particularly engine speed and load) that characterize mobile source operations. In contrast, the locomotive's engine and drive system operate more independently, such that the engine can be operated at a particular speed without respect to the speed of the locomotive itself. This allows operation under more steady-state load and speed conditions, and as a result locomotives have been designed to operate in a series of discrete throttle settings called notches, ranging from notch positions one through eight, plus an idle position.

Many locomotives also have a feature known as dynamic braking, in which the electric drive engine operates as a generator to help slow the locomotive, with the resistance-generated power being dissipated as heat. While the engine is not generating motive power under dynamic braking, it is generating power to run cooling fans, so this operating condition is somewhat different from idling. Switch engines typically do not utilize dynamic braking.

Line Haul Locomotives
Line haul locomotives are operated in the Port by BNSF and UP. Because the function of line haul locomotives is to transport freight to and from destinations across the country, there is no readily identifiable "fleet" of line haul locomotives that call on the Port other than the Class 1 railroads' nation-wide fleets.

While each railroad operates a variety of different models of locomotive, a typical BNSF line haul locomotive is the General Electric (GE) C44-9W (also known as the Dash 9), and the newer ES44 series. Among the UP locomotives calling at the Port are six-axle, Electromotive Division (EMD) SD70s as well as GE ES44 series locomotives. Line haul locomotives typically have six axles and 4,000 to 4,400 horsepower. Both UP and BNSF are party to a Memorandum of Understanding with CARB that comes into force in 2010 and by which the railroads have agreed to meet specified fleet-wide average emission rates from their line haul and switching locomotives operating in the SoCAB. As part of achieving these fleet average emission rates, the railroads may divert a higher percentage of their new, Tier 2 locomotives to the SoCAB and to the Ports, reducing their Port-related emissions.

Line haul locomotives are typically operated in groups of two to five units, with three or four units being most common, depending on the power requirements of the specific train being pulled and the horsepower capacities of available locomotives. Thus, two higher-horsepower locomotives may be able to pull a train that would take three units with lower power outputs. Locomotives operated in sets are connected such that every engine in the set can be operated in unison by an engineer in one of the locomotives.

Switching Locomotives
Most switching within the Port is conducted by PHL. Early in 2006, an agreement was concluded among PHL, the Port, and the Port of Long Beach whereby the two ports helped fund the replacement of PHL's locomotives with new locomotives meeting Tier 2 locomotive emission standards. The locomotives purchased under this agreement were delivered during 2007 and 2008, so early in 2008 the last of the pre-Tier 2 locomotives were retired as the new locomotives were placed into service. PHL's fleet in 2009 consisted of 16 new Tier 2 locomotives, and 6 additional new locomotives that are powered by a set of three relatively small diesel engines and generators rather than one large engine (known as multi-engine genset switchers). These multi-genset units emit less than Tier 2 emission levels of most pollutants.

The Class 1 railroads also operate switch engines in and around the Port, primarily at their switching yards outside of the Port.

Train Configuration
Container trains are the most common type of train operating at the Port. While equipment configurations vary, these trains typically consist of up to 25 or more double-stack railcars, each railcar consisting of five platforms capable of carrying up to four TEUs of containerized cargo (e.g., most platforms can carry up to two 40-foot containers). With this configuration, the capacity of a train is 500 TEUs or about 278 containers at an average ratio of 1.8 TEU/container. As a practical matter, not all platforms carry four TEUs because not all platforms are double stacked with two 40-foot containers; the current capacity or "density" is estimated to be approximately 95% (meaning, for example, a 25-car train would carry 500 TEUs x 95% = 475 TEUs).

In developing off-port line haul locomotive emission estimates, the following assumptions were made regarding the typical make-up of trains traveling the Alameda Corridor and beyond: 26 double-stack railcars, 95% density, for a capacity of 494 TEUs or 274 containers (average). These assumptions are generally consistent with information developed for the No Net Increase Task Force's evaluation of 2005 Alameda Corridor locomotive activities.[39] Average train capacity assumptions for on-port emission estimates are lower based on reported container throughput and weekly/annual train information provided by Port terminals. It is assumed that the length and/or capacity of trains are adjusted in the off-port rail yards prior to or after interstate travel to or from the Port, so the number of trains entering and leaving the Port is higher than the number of trains traveling the Alameda Corridor.

6.5 Methodology

The following section provides a description of the methods used to estimate emissions from switching and line haul locomotives operating within the Port and in the South Coast Air Basin.

Emissions have been estimated using the information provided by the railroads and the terminals, and from published information sources such as the EPA's "Emission Factors for Locomotives"[40] and their Regulatory Support Document (RSD),[41] both published as background to EPA's locomotive rule-making processes. For on-Port switching operations, the fuel use information provided by the switching companies has been used along with EPA and manufacturer information on emission rates. Off-Port switching emissions have been estimated using 2005 fuel use data previously provided by the railroad company operating the ICTF, scaled to the increase in facility throughput between 2005 and 2009. For the limited line haul operations in the Port (arrivals and departures), emission estimates

39 Personal communication, Art Goodwin, Alameda Corridor Transportation Authority, with Starcrest Consulting Group, LLC, February 2005.
40 EPA-420-F-09-025, Office of Transportation and Air Quality, April 2009
41 EPA Office of Mobile Sources, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised.

have been based on schedule and throughput information provided by the railroads and terminal operators and on EPA operational and emission factors. Off-Port line haul emissions have been estimated using cargo movement information provided by the line haul railroads, and weight and distance information first developed for the 2005 emissions inventory. A detailed explanation of emission calculation methods is presented below.

Different calculation methods were required for the different types of locomotive activity because different types of information were used for different activities. However, an attempt has been made to standardize the activity measures used as the basis of calculations in order to develop consistent methodologies and results.

6.5.1 Switching Emissions

Emissions from PHL's on-port switching operations have been based on the horsepower-hours of work represented by their reported locomotive fuel use, and emission factors from the EPA documents cited above and from information published by the locomotive manufacturers. The calculations estimate horsepower-hours for each locomotive from fuel consumption in gallons per year and combine the horsepower-hour estimates with emission factors in terms of mass of emissions per horsepower-hour. Fuel usage is converted to horsepower-hours using an average value of 15.2 horsepower-hour per gallon of fuel (from EPA, 2009):

Equation 6.1

$$\textit{gallons/year} \times \textit{horsepower-hour/gallon} = \textit{horsepower-hours/year}$$

The calculation of emissions from horsepower-hours uses the following equation.

$$E = \frac{\textit{hp-hrs} \times EF}{(453.59\ g/lb \times 2{,}000\ lb/ton)}$$

Equation 6.2

Where:

E = emissions, tons per year
hp-hrs = annual work, horsepower-hours
EF = emission factor, grams pollutant per horsepower-hour

EPA in-use emission factors for Tier 2 locomotives were used for the 16 Tier 2 locomotives, and manufacturer's published emission rates have been used for the 6 genset switchers. The genset locomotives each operate with three diesel engines originally certified to EPA Tier 3 nonroad engine standards. Emission rates published by the locomotives' manufacturer, National Railway Equipment Co. (NRE) have been used instead of the Tier 3 nonroad standards because differences in duty cycle between nonroad and locomotive operation make the nonroad standards less appropriate.

The EPA and NRE emission factors cover particulate, NO_x, CO, and HC emissions. SO_2 emission factors have been developed to reflect the use of 15 ppm ULSD using a mass balance approach. The mass balance approach assumes that the sulfur (S) in the fuel is converted to SO_2 and emitted during the combustion process. While the mass balance approach calculates SO_2 specifically, it is used as a reasonable approximation of SO_x. The following example shows the calculation of the SO_x emission factor.

Equation 6.3

$$\frac{15 \text{ g S}}{1{,}000{,}000 \text{ g fuel}} \times \frac{3{,}200 \text{ g fuel}}{\text{gal fuel}} \times \frac{2 \text{ g } SO_2}{\text{g S}} \times \frac{\text{gal fuel}}{15.2 \text{ hp-hr}} = 0.006 \text{ g } SO_2/\text{hp-hr}$$

In this calculation, 15 ppm S is written as 15 lbs S per million lbs of fuel. The value of 15.2 hp-hr/gallon of fuel is the average BSFC noted in EPA's technical literature on locomotive emission factors (EPA, 2009). Two grams of SO_2 is emitted for each gram of sulfur in the fuel because the atomic weight of sulfur is 32 while the molecular weight of SO_2 is 64, meaning that the mass of SO_2 is two times that of sulfur.

Greenhouse gas emission factors from EPA references[42] were used to estimate emissions of greenhouse gases CO_2, CH_4, and N_2O from locomotives. Additionally, all particulate emissions are assumed to be PM_{10} and DPM, and $PM_{2.5}$ emissions have been estimated as 92% of PM_{10} emissions to be consistent with CARB's $PM_{2.5}$ ratio used for offroad diesel equipment. Emission factors for the Tier 2 and genset switching locomotives, including those used for the off-port switching activity, are listed in Tables 6.1 and 6.2. The BSFC figure noted above is different from that used in the previous emissions inventories (based on recently released 2009 EPA document cited above) so the updated switching emission factors are different from those used in previous years. The emission factors for PM, NOx, and HC emissions from Tier 2 switching locomotives are also different from the previous inventories because of a change in the published EPA estimates.

Table 6.1: Switching Emission Factors, g/hp-hr

Fuel or Locomotive Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Tier 2 Locomotives	0.19	0.17	0.19	7.30	0.006	1.83	0.51
Genset Locomotives	0.05	0.05	0.05	3.37	0.006	1.51	0.04

[42] CO_2 - Table A-39, page A-59, Annex 2 of the report entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007* April 2009; CH_4 and N_2O - Table A-92, page A-121 in Annex 3 of the same report.

Table 6.2: GHG Switching Emission Factors, g/hp-hr

Fuel or Locomotive Type	CO_2	N_2O	CH_4
Tier 2 Locomotives	670	0.017	0.050
Genset Locomotives	670	0.017	0.050

The activity measure used in the switching emission estimates is total horsepower-hours of activity, derived from the locomotive-specific fuel use data provided by PHL for the on-port switching, and an estimate of off-port switching fuel use derived from information provided earlier by the railroad operating the off-dock rail yard that is located on Port property. For the off-dock rail yard, the reported 2005 fuel usage was multiplied by the ratio of 2009 to 2005 container throughput reported by the railroad using the assumption that switching activity varies linearly with container throughput.

As an example of how fuel usage was used to estimate total hp-hrs, a total of 10,000 gallons of fuel per year would be multiplied by the fuel use factor of 15.2 hp-hr per gallon (hp-hr/gal) to produce an estimate of 152,000 hp-hrs. This would be multiplied by the g/hp-hr emission factors to estimate the mass of emissions over the year.

PHL operates within both the Port of Los Angeles and the Port of Long Beach. While some of the shifts are focused on activities in only one of the ports, other shifts may work in either or both ports depending upon the day's needs for switching services. Therefore, it is not possible to clearly designate which shifts operate solely within the Port of Los Angeles so a method was required for apportioning emissions between the two ports. To do this, the previous baseline emissions inventory evaluated the work shifts as to whether they are likely to work in either port exclusively or in both ports, resulting in a split of 69% of activity within the Port of Los Angeles and 31% within the Port of Long Beach, which has been maintained for the current inventory. The difference between the two ports' allocations is so great in part because PHL's main yard is within the Port of Los Angeles, so almost all work shifts involve at least some activity within the Port of Los Angeles.

Rail cargo from both the Port of Los Angeles and the Port of Long Beach is handled at the off-dock ICTF, and the complexities of the rail system are such that apportionment of activity (and emissions) between the two ports is difficult. The previous baseline emissions inventories used an allocation of 55% Port of Los Angeles and 45% Port of Long Beach – this allocation has been maintained for the current inventories because it still seems a reasonable assumption, given that the Port of Los Angeles' overall TEU throughput represented about 55% of the two ports' combined throughput in 2009.

Regardless of apportionment, the sum of the two ports' emissions represents all of the estimated switching emissions from locomotives operated at the ICTF.

6.5.2 Line Haul Locomotive Emissions

Emissions from line haul locomotives operating in the Port have been estimated on an activity basis, i.e., estimates of the number and characteristics of locomotives that arrive and depart with cargo. The information used in developing these estimates has been obtained from the Port and Port terminals.

The number of locomotive trips in the Port has been estimated by evaluating cargo movements, percentage of cargo transported by rail, and typical number of locomotives per train, using a methodology similar to that used for the 2001 baseline emissions inventory. Emission factors for most pollutants have been taken from EPA's recent documentation representing EPA's projected 2009 nationwide fleet of line haul locomotives, as shown in Table 6.3. The emission factors are presented in terms of grams per horsepower-hour (g/hp-hr), converted from the gram-per-gallon factors listed in the EPA documentation using the line haul BSFC of 20.8 hp-hr/gal.

The SO_x emission factor has been estimated from assumed fuel sulfur content values using a mass balance equation similar to the switching locomotives calculation. For line haul locomotives, which enter and leave California to pick up and deliver transcontinental rail cargo and typically refuel while in the SoCAB, the calculations are based on the use of 50% ULSD fuel from SoCAB refueling and 50% higher sulfur (350 ppm) fuel from out-of-state sources. Table 6.4 lists the greenhouse gas emission factors derived from the EPA reference.[43]

Table 6.3: Emission Factors for Line Haul Locomotives, g/hp-hr

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
EF, g/bhp-hr	0.24	0.22	0.24	7.93	0.06	1.28	0.42

The same information sources for greenhouse gases were used for line haul locomotives as for switching locomotives, described above. Table 6.4 lists the greenhouse gas emission factors.

[43] CO_2 - Table A-39, page A-59, Annex 2 of the report entitled: *2009 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007,* April 2009; CH_4 and N_2O - Table A-92, page A-121 in Annex 3 of the same report.

Table 6.4: GHG Emission Factors for Line Haul Locomotives, g/hp-hr

	CO_2	N_2O	CH_4
EF, g/bhp-hr	487	0.013	0.040

On-Port Line Haul Emissions

On-port line haul locomotive activity has been estimated through an evaluation of the amount of cargo reported by the terminals to be transported by rail and their reported average or typical number of trains per week or per year. These numbers have been combined with assumptions regarding the number of locomotives, on average, that are involved with on-port line haul railroad moves, and the average duration of incoming and outgoing port trips, in the same approach taken for the previous emissions inventories. The number of trains per year, locomotives per train, and on-port hours per train were multiplied together to calculate total locomotive hours per year. This activity information is summarized in Table 6.5. While most of the rail cargo, and the basis for these estimates, center on container traffic, the local switching railroad has reported that they prepare an average of one train per day of cargo other than containers for transport out of the San Pedro Bay Ports area. It has been assumed that a similar number of trains are inbound, and that the total number has an even split between both ports. Therefore, the number of trains per year includes an average of one non-container train every other day in each direction (for an annual total of 365 additional trains for each port).

Table 6.5: On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Totals
Number of trains/year	2,425	2,762	5,187
Number of locomotives/train	3	3	NA
Hours on Port/trip	1.0	2.5	NA
Locomotive hours/year	7,275	20,715	27,990

DB ID487

The average load factor for a typical line haul locomotive calling on the Port has been estimated by multiplying the percentage of full power in each throttle notch setting by the average percentage of line haul locomotive operating time in that setting, as summarized in Table 6.6. Both of these sets of percentages are EPA averages listed in the RSD documentation. This average load factor is probably overestimated because the throttle notch distribution is representative of nation-wide operation; including time traveling uphill when the higher notch positions are most often used. However, detailed throttle notch information has not been made available to enable the development of an average on-port load factor.

Table 6.6: Estimated Average Load Factor

Notch	% of Full Power in Notch	% of Operating Time in Notch	% Full Power x % Time
DB	2.1%	12.5%	0.003
Idle	0.4%	38.0%	0.002
1	5.0%	6.5%	0.003
2	11.4%	6.5%	0.007
3	23.5%	5.2%	0.012
4	34.3%	4.4%	0.015
5	48.1%	3.8%	0.018
6	64.3%	3.9%	0.025
7	86.6%	3.0%	0.026
8	102.5%	16.2%	0.166
Average line haul locomotive load factor:			**28%**

DB ID489

The estimated number of locomotive hours for the Port was multiplied by an average locomotive horsepower and the average load factor discussed above to estimate the total number of horsepower-hours for the year:

Equation 6.4

27,990 locomotive hours/year x 4,000 horsepower/locomotive x 0.28

= 31.3 million horsepower-hours (rounded)

Emission estimates for on-port line haul locomotive activity were calculated by multiplying this estimate of horsepower-hours by the emission factors listed in Tables 6.3 and 6.4 in terms of g/hp-hr.

Out-of-Port Line Haul Emissions

Line haul locomotive activity between the Port and the air basin boundary has been estimated through an evaluation of the amount of Port cargo transported by rail and of average or typical train characteristics such as number of containers and number of gross tons per train. In this way, estimates have been prepared of gross tonnage and fuel usage, similar to the methodology used for the previous Port emissions inventories.

The four components to locomotive activity that were estimated to develop the off-port emission estimates are the number of trains, the average weight of each train, the distances traveled within the South Coast Air Basin, and the amount of fuel used per ton-mile of train activity. Using the average train capacities discussed above (average 274 containers per train) and the two San Pedro Bay Ports' 2009 intermodal throughputs, the average number of port-related trains was estimated to be 21 to 22 per day through the Alameda Corridor[44] including non-container trains discussed above. The gross weight (including locomotives, railcars, and freight) of a typical train was estimated to be 6,344 tons, using the assumptions in Table 6.7. The distance assumptions are 21 miles for the Alameda Corridor and 84 miles between the north end of the Alameda Corridor and the Air Basin boundary. The latter distance is a weighted average of the east and south routes taken by UP trains and the east route taken by most BNSF trains, weighted by the approximate percentage distribution of freight reported by the railroads for the 2008/2009 time period, as shown in Table 6.8. Gross ton-miles were calculated by multiplying together the number of trains, the gross weight per train, and the miles traveled, as summarized in Table 6.9. This table also shows the estimated total fuel usage, estimated by multiplying the gross tons by the average fuel consumption for the two line haul railroads in 2009. This average was derived from information reported by the railroads to the U.S. Surface Transportation Board in an annual report known as the "R-1."[45] Among the details in this report are the total gallons of diesel fuel used in freight service and the total freight moved in thousand gross ton-miles. The total fuel reported by both railroads was divided by the total gross ton-miles to derive the average factor of 1.040 gallons of fuel per thousand gross ton-miles. The 2008 annual reports are the latest available so these reported values have been used as the basis of the 2009 fuel consumption factor. Also listed in Table 6.9, is the estimated total out-of-port horsepower-hours, calculated by multiplying the fuel use by the fuel use conversion factor of 20.8 hp-hr/gal.

Table 6.7: Assumptions for Gross Weight of Trains

Train Component	**Approximate Weight lbs**	**Weight tons (short)**	**Number per train**	**Weight tons (short)**
Locomotive	420,000	210	4	840
Railcar (per double-stack platform)	40,000	20	130	2,600
Container		10.6	274	2,904
Total weight per train, gross tons				**6,344**

44 Overall Alameda Corridor traffic for 2009 was an average of 36 per day. This includes non-port-related traffic; See: *www.acta.org/PDF/CorridorTrainCounts.pdf.*

45 *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2008* (Union Pacific Railroad) and *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2008* (BNSF Railway). Available at http://www.stb.dot.gov/econdata.nsf/FinancialData?OpenView

Table 6.8: Train Travel Distance Assumptions

	Miles	Approximate Percentage of Freight, 08/09	Miles x %
UP - LA east	84	15%	13
UP - LA south	91	28%	25
BNSF - LA east	82	56%	46
Weighted average distance			**84**

Table 6.9: Gross Ton-Mile, Fuel Use, and Horsepower-hour Estimate

	Distance miles	Trains per year	MMGT per year	MMGT-miles per year
Alameda Corridor	21	4,696	30	630
Central LA to Air Basin Boundary	84	4,696	30	2,520
Million gross ton-miles				**3,150**
Estimated gallons of fuel (millions)				**3.28**
Estimated million horsepower-hours				**68.3**

Emission estimates for out-of-port line haul locomotive activity were calculated by multiplying this estimate of overall horsepower-hours by the emission factors in terms of g/hp-hr.

6.5.3 Improvements to Methodology from Previous Years

While the locomotive emissions calculation methodology is essentially the same as that used for the 2008 methodology, one improvement is for switching locomotives, for which EPA's new brake specific fuel consumption (15.2 bhp-hr/gal) was used for converting EPA's emissions factors from g/gal to g/bhp-hr. Previously, the same conversion factor was used for both line haul and switcher locomotives. EPA's new documentation also allowed an updating of the fleet average emission factors for line haul locomotives and for Tier 2 switching locomotives. Section 9 includes the comparison to previous years' emissions.

6.5.4 Future Improvements to Methodology

The Ports of Los Angeles and Long Beach have been in discussions with both UP and BNSF over the last year in order to improve the existing emissions calculation methodology based on more specific operating parameters for trains serving the ports. These parameters include, but are not limited to, specific train characteristics (e.g., number of locomotives, number of TEUs per train), fleet composition by Tier level (for assigning a more accurate fleet-based emission factor for locomotives serving the ports) and fuel consumption factor (gallons of fuel per gross ton-mile). These improvements are anticipated to be incorporated into the 2010 EI.

6.6 Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented below in Tables 6.10 and 6.11. These emissions include operations within the Port and Port-related emissions outside the Port out to the boundary of the South Coast Air Basin.

Table 6.10: Port-Related Locomotive Operations Estimated Emissions, tons per year

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Switching	1.9	1.7	1.9	75.0	0.1	19.7	5.0
Line Haul	26.2	24.0	26.2	865.3	6.6	139.8	45.9
Total	**28.1**	**25.7**	**28.1**	**940.3**	**6.6**	**159.6**	**50.9**

DB ID696

Table 6.11: GHG Port-Related Locomotive Operations Estimated Emissions, metric tons per year

	CO_2 Equivalent	CO_2	N_2O	CH_4
Switching	6,776.5	6,713.1	0.2	0.5
Line Haul	48,852.1	48,368.4	1.3	4.0
Total	**55,628.5**	**55,081.5**	**1.5**	**4.5**

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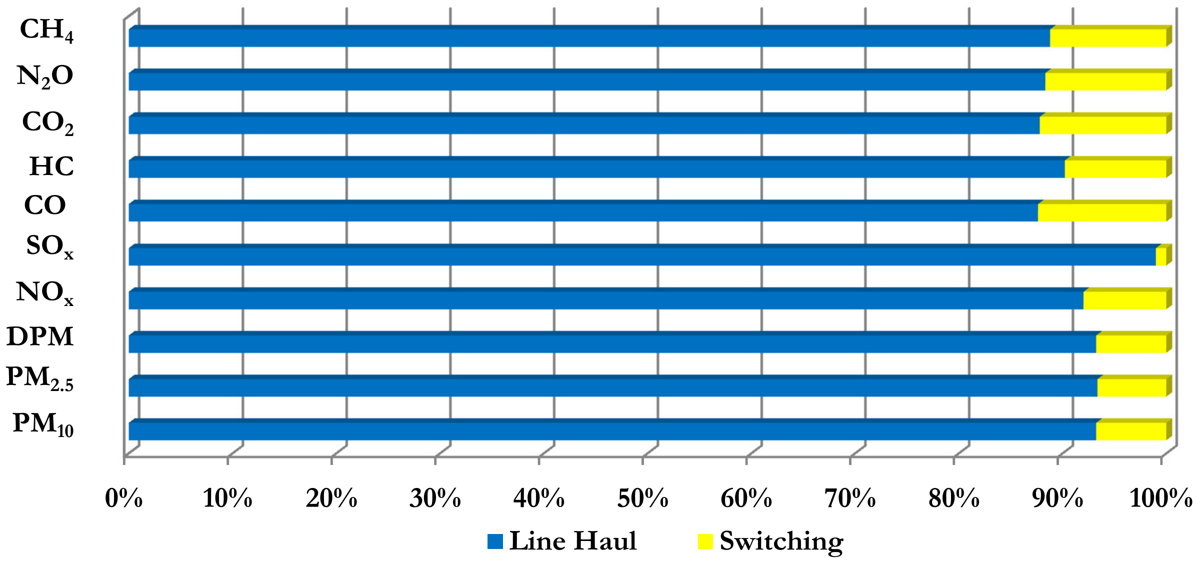
Figure 6.6 depicts the distribution of emissions with line haul emissions accounting for roughly 87% to 99% of the total locomotive emissions.

Figure 6.6: Distribution of Locomotive Emissions by Category, %



SECTION 7 HEAVY-DUTY VEHICLES

This section presents emissions estimates for the heavy-duty vehicles source category, including source description (7.1), geographical delineation (7.2), data and information acquisition (7.3), operational profiles (7.4), emissions estimation methodology (7.5), and the emission estimates (7.6).

7.1 Source Description

Trucks are used extensively to move cargo, particularly containerized cargo, to and from the terminals that serve as the bridge between land and sea transportation. Trucks deliver cargo to local and national destinations, and they also transfer containers between terminals and off-port railcar loading facilities, an activity known as draying. In the course of their daily operations, trucks are driven onto and through the terminals, where they deliver and/or pick up cargo. They are also driven on the public roads within the Port boundaries, and on the public roads outside the Port.

This report deals exclusively with diesel-fueled HDVs, as there were few gasoline-fueled or alternatively-fueled counterparts in use in 2009. Alternatively fueled trucks, primarily those fueled by LNG, made up approximately 3% of the truck fleet serving Port terminals and made approximately 5% of the terminal calls in 2009, based on fuel type information in the Port's Clean Trucks Program's Drayage Truck Registry. Use of this new registry of Port-related truck data, including the fuel type information, will be incorporated into the 2010 inventory when LNG trucks may make up a larger percentage of Port truck calls. For this 2009 inventory, the small percentage of alternatively-fueled trucks (which do not emit diesel particulate matter) are included in the emission calculations as if they were diesel trucks; therefore, diesel particulate matter may be slightly overestimated in this inventory.

The most common configuration of HDV is the articulated tractor-trailer (truck and semi-trailer) having five axles, including the trailer axles. The most common type of trailer in the study area is the container trailer, built to accommodate standard-sized cargo containers. Additional trailer types include tankers, boxes, and flatbeds. A tractor traveling without an attached trailer is called a "bobtail" (no trailer load). A tractor pulling an unloaded container trailer chassis is known simply as a "chassis." These vehicles are all classified as heavy HDVs regardless of their actual weight because the classification is based on gross vehicle weight rating (GVWR), which is a rating of the vehicle's total carrying capacity. Therefore, the emission estimates do not distinguish among the different configurations.

As examples of typical HDVs, Figure 7.1 shows a container truck transporting a container in a terminal, and Figure 7.2 shows a bobtail. The equipment images shown in the figures are not photographs of actual pieces of equipment used at the surveyed terminals but are for illustrative purposes only.

Figure 7.1: Truck with Container

Figure 7.2: Bobtail Truck

7.2 Geographical Delineation

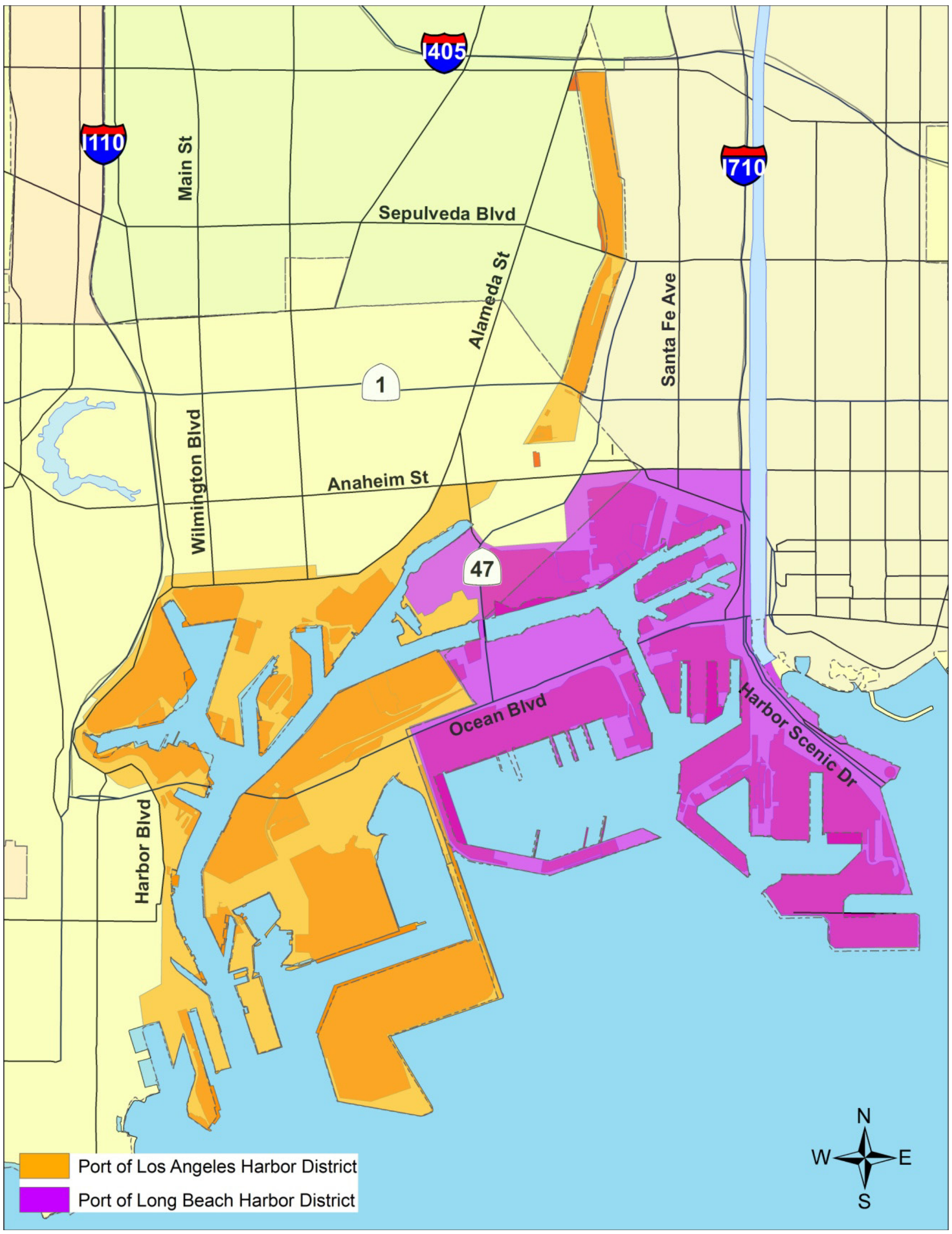
To develop emission estimates, truck activities have been evaluated as having two components:

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.

- On-road operations, consisting of travel on public roads outside the Port boundaries but within the SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

Figure 7.3 shows the roadways in and around the Port that the HDVs use in daily operations. The figure presents the scope of a traffic study that evaluated traffic patterns in both the Port of Los Angeles and the Port of Long Beach. That traffic study and its use in developing the HDV emission estimates presented in this report are discussed in more detail in the following subsections.

Figure 7.3: Port and Near-Port Roadways



7.3 Data and Information Acquisition

Data for the HDV emission estimates came from two basic sources: terminal interviews and computer modeling of on-road HDV traffic volumes, distances, and speeds. These information sources are discussed below.

7.3.1 On-Terminal

The Port and their consultant collected information regarding on-terminal truck activity during in-person and telephone interviews with terminal personnel. This information included their gate operating schedules, on-terminal speeds, time and distance traveled on terminal while dropping off and/or picking up loads, and time spent idling at the entry and exit gates. Most terminals were able to provide estimates of these activity parameters, although few keep detailed records of information such as gate wait times and on-terminal turn-around time. However, the reported values appear to be reasonable and have been used in estimating on-terminal emissions, except as noted in the following text.

7.3.2 On-Road

The Port retained a consultant (Iteris, Inc.) to develop estimates of on-road truck activity inside and outside the Port. To do this, the consultant used trip generation and travel demand models they have used in previous Port transportation studies[46] to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections.

The trip generation model was derived from a computer model designed to forecast truck volumes that was developed by Moffatt & Nichol Engineers (M&N), who were team members on the *2001 Port Transportation Study*. The Port's consultant developed and validated the trip generation model using terminal gate traffic count data. They reported in their traffic study report that the model validation confirmed that the model was able to predict truck movements to within two to ten percent of actual truck counts for all the container terminals combined, and to within 15 percent or better for the majority of individual terminals (MMA 2001). These were considered to be excellent validation results considering the variability of operating conditions and actual gate counts on any given day. The main input to the trip generation model for this study consisted of the average daily container throughput in 2009.

[46] Meyer, Mohaddes Associates, Inc., *Ports of Long Beach/Los Angeles Transportation Study*, June 2001(MMA 2001) and Meyer, Mohaddes Associates, Inc., *Port of Los Angeles Baseline Transportation Study, (*April 2004).

The results of the trip generation model were used by Iteris, Inc. as input to a regional travel demand model used for transportation planning by the Southern California Association of Governments (SCAG), the federally designated Metropolitan Planning Organization for the SoCAB area. Iteris incorporated port-specific truck travel information from the trip generation model, as well as the results of an origin/destination survey of approximately 3,300 Port-area truck drivers, into the travel demand model to predict truck travel patterns and estimate the number of trucks traveling over roadways in the region. The intent was to model Port-related trucks on their way from the Port until they make their first stop, whether for delivery of a container to a customer or to a transloading facility, or to the boundary of the South Coast Air Basin. Transloading is the process of unloading freight from its overseas shipping container and re-packing it for overland shipment to its destination.

The travel demand model produces estimates of the number of trucks and their average speed in each direction over defined roadway segments, along with the length of each roadway segment. A brief example illustrating the data is provided in Table 7.1. The number of trucks and the distances were multiplied for each segment and summed to produce estimates of vehicle miles of travel (VMT). In addition, a VMT-weighted average speed was calculated that takes into account how many miles were driven at each speed; these VMT and speed estimates were used with the speed-specific EMFAC emission factors (discussed below) to estimate on-road driving emissions.

Table 7.1: On-Road HDV Activity Modeling Results – Example

Distance (miles)	Volume Dir 1 (# trucks)	Volume Dir 2 (# trucks)	Speed Dir 1 (mph)	Speed Dir 2 (mph)
0.71	4	2	50	48
0.12	19	12	33	32
0.36	1	3	35	35
0.01	4	5	40	40
0.55	1	2	62	60
1.87	1	3	62	60
0.45	12	9	47	46
0.26	12	10	26	25

7.4 Operational Profiles

Based on the data and information collected, activity profiles were developed for on-terminal and on-road truck traffic, as described below.

7.4.1 On-Terminal

Table 7.2 illustrates the range and average of reported characteristics of on-terminal truck activities at Port container terminals. The total number of trips was based on information provided by the terminals.

Table 7.2: Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Idling Gate In (hours)	Unload/ Load (hours)	Idling Gate Out (hours)
Maximum	15	1.5	na	0.17	0.39	0.15
Minimum	10	0.9	na	0.00	0.15	0.00
Average	13	1.3	na	0.09	0.27	0.04
Total			**3,465,623**			

Table 7.3 shows the same summary data for the terminals and facilities other than container terminals. The total number of trips was based on information provided by the terminals.

Table 7.3: Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Idling Gate In (hours)	Unload/ Load (hours)	Idling Gate Out (hours)
Maximum	20	1.3	na	0.10	0.37	0.10
Minimum	2	0.0	na	0.00	0.00	0.00
Average	8	0.5	na	0.04	0.10	0.02
Total			**1,376,929**			

Table 7.4 provides more detail on the on-terminal operating parameters, listing total estimated miles traveled and hour of idling on-terminal and waiting at entry gates. Terminals are listed by type.

Table 7.4: Estimated VMT and Idling Hours by Terminal

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	622,022	103,670
Container	1,483,641	375,856
Container	470,361	245,633
Container	432,013	177,125
Container	922,989	258,437
Container	737,829	221,349
Other	188,369	27,531
Other	284,700	41,610
Other	67,600	8,320
Other	400	200
Dry Bulk	1,250	375
Break Bulk	525	788
Auto	1,463	995
Liquid	70	140
Break Bulk	29,089	6,545
Liquid	18	0
Dry Bulk	13,520	1,976
Break Bulk	6,286	4,275
Other	520	910
Other	0	480
Other	10,200	1,360
Other	782,762	352,243
Liquid	5,550	555
Total	**6,061,176**	**1,830,371**

7.4.2 On-Road

Figure 7.4 provides a regional map of area roadways. The daily traffic estimates are based on average week-day activity during an average month. They have been annualized for the emission estimates presented in this inventory on the basis of 300 days of terminal operation per year.

Figure 7.4: Regional Map

7.5 Methodology

This section discusses how the emission estimates were developed based on the data collected from terminals or developed by traffic modeling. Figure 7.5 illustrates this process in a flow diagram format for the two components of the HDV evaluation previously discussed (on-terminal and on-road components). It is important to note that the speed-specific grams-per-mile emission rates estimated by CARB's EMFAC 2007 model were used in support of this analysis. However, because EMFAC does not directly report the gram per hour emission rates associated with idle engine operation, CARB's published idle emission rates, rather than the modeled output, were used for gate and on-terminal idling periods.

The general form of the equation for estimating the emissions inventory for a fleet of on-road vehicles is:

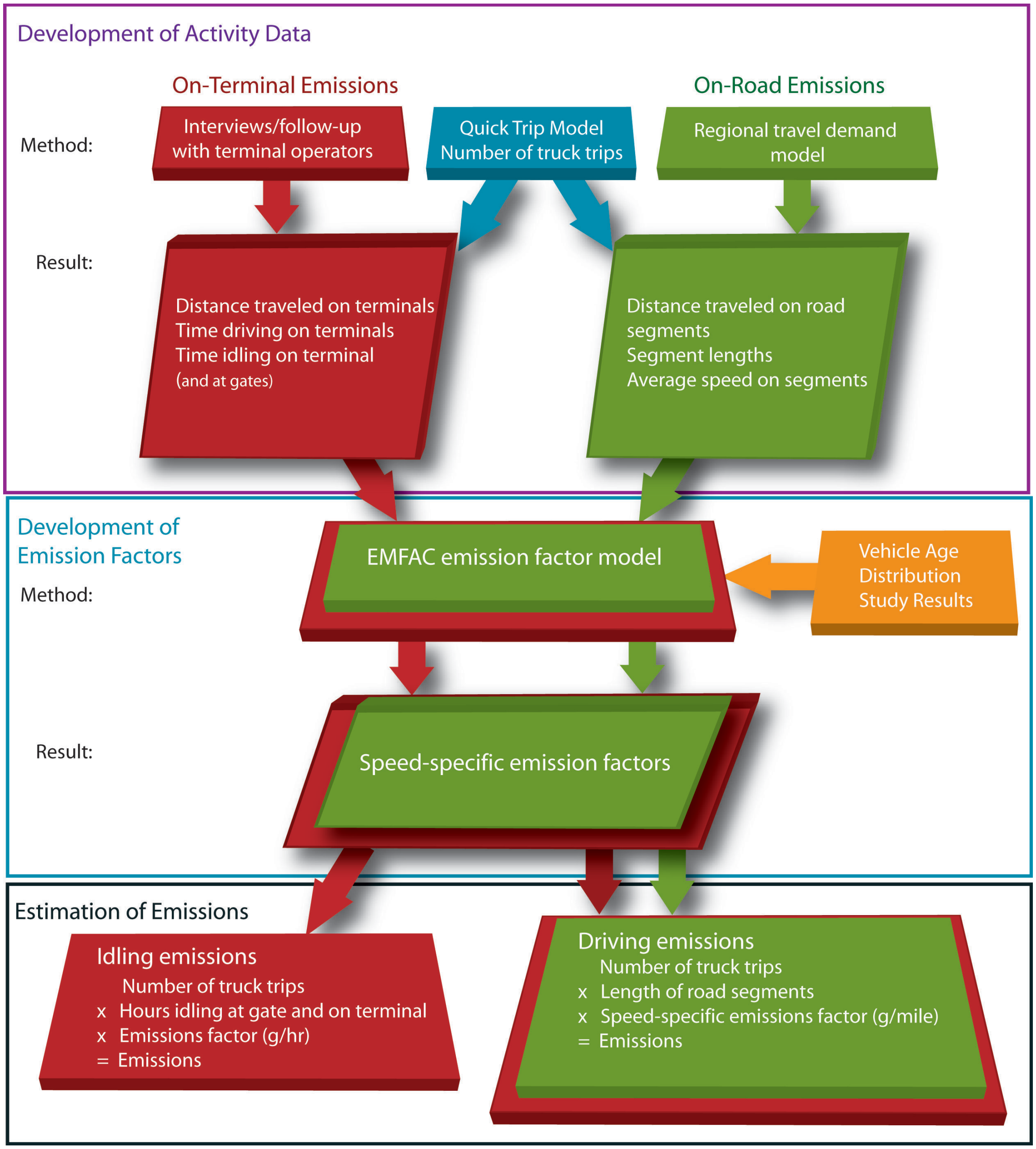
Equation 7.1

Emissions = Population x Basic Emission Rate x Activity x Correction Factors

Where:

Population = number of vehicles of a particular model year in the fleet
Basic Emission Rate = amount of pollutants emitted per unit of activity for vehicles of that model year
Activity = the average number of miles driven per truck, hours of idle operation
Correction Factors = adjustment to Basic Emission Rate for specific assumptions of activity and/or atmospheric conditions

Figure 7.5: HDV Emission Estimating Process



The basic emission rate is modeled as a straight line (over time) with a "zero mile rate" (ZMR) or intercept representing the emissions of the vehicle when new (well maintained and un-tampered), plus a "deterioration rate" (DR) or slope representing the gradual increase in the emission rate over time or as a function of use (mileage). For heavy-duty diesel trucks the deterioration rate is expressed as grams per mile traveled per 10,000 accumulated miles.

Equation 7.2

Basic Emission Rate = ZMR + (DR x Cumulative Mileage /10,000)

In estimating the emissions from heavy-duty trucks, two types of activity can be considered: running emissions that occur when the engine is running with the vehicle moving at a given speed, and idle emissions that occur when the engine is running but the vehicle is at rest. Running emissions are expressed in grams per mile, while idle emissions are expressed in grams per hour. The emission factors (g/mi or g/hr) are multiplied by the activity estimates, VMT or hours of idle operation, to derive a gram per day (g/day) or gram per year inventory (converted in this report to tons per year).

7.5.1 The EMFAC Model

The CARB has developed a computer model to calculate the emissions inventories of various vehicle classes in the California fleet. EMFAC 2007, the latest official version of the model, has been approved by the EPA for use in California and this model, with noted exceptions, was used to estimate the emissions from heavy-heavy-duty diesel trucks that called on the Port's terminals in 2009.

Although the EMFAC model produces ton-per-day estimates of emissions by vehicle class and model year, it is generally a macro-scale model that is inappropriate for directly estimating inventories at a sub-county level. In order to calculate the inventory of emissions for Port-related heavy-duty trucks, by-model-year emission factors from EMFAC were coupled with Port-specific truck model year distribution and VMT estimates.

7.5.2 Basic Emission Rates

The basic emission rates of heavy-duty diesel trucks included in EMFAC are derived from tests of vehicles randomly selected from the in-use fleet. Because CARB has imposed progressively more stringent standards for the allowable emissions from trucks over many years, different model years of trucks have been certified to specific standards and, therefore, are assumed to emit at different rates. Table 7.5 lists the basic emission rates used by EMFAC to develop the model year-specific emission factors.

Table 7.5: Emission Factors in EMFAC 2007 (ZMR in g/mi – DR in g/mi/10,000mi)

Model Years	HC		CO		NO_x		PM		CO_2	
	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR	ZMR	DR
Pre-87	1.20	0.027	7.71	0.176	23.0	0.019	1.73	0.028	2237	0.00
1987-90	0.94	0.032	6.06	0.209	22.7	0.026	1.88	0.025	2237	0.00
1991-93	0.62	0.021	2.64	0.090	19.6	0.039	0.78	0.014	2237	0.00
1994-97	0.46	0.024	1.95	0.103	19.3	0.046	0.51	0.011	2237	0.00
1998-02	0.47	0.024	1.99	0.103	18.9	0.053	0.56	0.010	2237	0.00
2003-06	0.30	0.011	0.87	0.031	12.5	0.052	0.35	0.005	2237	0.00
2007-09	0.26	0.008	0.74	0.022	6.84	0.047	0.035	0.001	2237	0.00

CARB has included an update to the idle emissions rates for heavy-duty diesel trucks; their "low idle" emission rates were used in developing the emissions inventory for the Port. These factors are presented in Table 7.6.

Table 7.6: Idle Emission Rates in EMFAC 2007 (g/hr)

Model Years	HC	CO	NO_x	PM	CO_2
Pre-1987	25.9	28.4	45.7	4.76	4,640
1987-90	15.2	23.4	70.2	2.38	4,640
1991-93	12.1	21.5	78.4	1.78	4,640
1994-97	9.68	19.8	85.3	1.33	4,640
1998-02	7.26	17.8	92.1	0.92	4,640
2003-06	5.97	16.6	95.5	0.72	4,640
2007-09	5.97	16.5	95.5	0.072	4,640

A more in-depth explanation of CARB's heavy-duty diesel inventory estimation methodology can be found in their document "*Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors*"[47] 3 April 2006.

EMFAC does not provide estimates of SO_x or N_2O emissions, so for these pollutants, gram-per-mile emission factors were developed using a mass balance approach for SO_x and a gram-per-gallon emission factor from CARB for N_2O.

The following equation is used to derive the SO_x emission factor.

Equation 7.3

$$SO_x \text{ emissions (g/mile)} = \frac{(X \text{ g S}/1{,}000{,}000 \text{ g fuel}) \times (3{,}220 \text{ g/gallon}) \times (2 \text{ g } SO_x/\text{g S})}{(5.29 \text{ miles/gallon})}$$

The emission calculations are based on 15 ppm ULSD diesel fuel. The weight of a gallon of diesel fuel is assumed to be 7.1 pounds or 3,220 grams (7.1 lbs x 453.59 g/lb). Based on the EMFAC model, the 2009 fleet average fuel economy of the heavy-heavy duty diesel fleet has been calculated to be 5.29 miles per gallon.

The N_2O emission factor was calculated using the following equation:

Equation 7.4

$$N_2O \text{ emissions (g/mile)} = \frac{(X \text{ g } N_2O/\text{gallon})}{(5.29 \text{ miles/gallon})}$$

7.5.3 Mileage Accrual Rates/Cumulative Mileage

Since no data were available to estimate the actual mileage of each truck visiting the Port, the mileage accrual rates used by EMFAC were not changed. The mileage accrual rates are the estimates of the miles traveled each year by vehicles of a specific age and type of vehicle. When vehicles are new, the mileage accrual rates are assumed to be at their highest. The miles per year tend to decline as the truck ages.

[47] See: *http://www.arb.ca.gov/msei/supportdocs.html#onroad.*(CARB 2006)

CARB has also modified the mileage accrual rates used in EMFAC as discussed in their document entitled "*Redistribution of Heavy-Heavy Duty Diesel Truck Vehicle Miles Traveled in California*" 13 September 2006.[48] The mileage accrual rates included in the EMFAC 2007 update and used in this analysis are shown in Table 7.7.

Table 7.7: Mileage Accrual Rates Heavy-Heavy Duty Diesel Trucks in EMFAC 2007 (mi/yr)

Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year	Truck Age (years)	Miles/Year
1	80,705	13	43,854	25	16,662
2	85,152	14	39,965	26	15,164
3	86,460	15	36,504	27	13,653
4	85,386	16	33,452	28	12,136
5	82,571	17	30,772	29	10,629
6	78,547	18	28,417	30	9,159
7	73,755	19	26,335	31	7,759
8	68,546	20	24,469	32	6,467
9	36,199	21	22,764	33	5,324
10	57,926	22	21,171	34	4,369
11	52,881	23	19,645	35	3,363
12	48,169	24	18,150	36+	3,363

The cumulative mileage of a vehicle is assumed to be the sum of its mileage accrual rates. That is, for a three-year-old truck, for example, the average odometer reading would be assumed to be 252,317 miles, or 80,705 + 85,152 + 86,386. In turn, the cumulative mileage is used to assess the level of deterioration to be added to the basic emission rate (see above).

In keeping with our example of a three-year-old truck in 2009 (MY 2007), the basic emission rate for NO_x would be calculated by the model as follows:

Equation 7.5

6.84 g/mi (ZMR) + 0.047 g/mi/10K miles (DR) x 252,317 miles (Cumulative Mileage) = 8.03 g/mi

[48] See: *http://www.arb.ca.gov/msei/supportdocs.html#onroad*

7.5.4 Correction Factors

As stated earlier, correction factors are used to adjust the basic emission rates to reflect vehicle specific activity such as speed and type and quality of fuel burned, and specific ambient conditions such as temperature and relative humidity (RH). In order to better reflect the emissions of the Port truck fleet, the basic emission rates were adjusted for both fuel and speed.

Fuel correction factors are applied to adjust for differences in the fuel used during certification or in-use testing, and the fuel used in routine operation. According to CARB's memo in which the EMFAC 2007 heavy-duty diesel emission rates are discussed, the reported emission factors represent pre-clean diesel rates. CARB diesel has a lower sulfur and aromatic hydrocarbon content compared to pre-clean diesel. According to CARB's memo entitled "*On-Road Emissions Inventory Fuel Correction Factors,*" 26 July 2005, a 28 percent reduction in HC, seven percent reduction in NO_x and a 25 percent reduction in PM should be applied to the basic emission rates to reflect the benefits of CARB diesel. The fuel correction factors are applied as multiplicative modifiers to the basic emission rates. That is, a 25 percent reduction would yield a correction factor of 0.75. Table 7.8 lists the diesel fuel correction factors.

Table 7.8: CARB Diesel Fuel Correction Factors

Pollutant	Fuel Correction Factor
HC	0.72
CO	1.0
NO_x	0.93
PM	0.75

Speed is used as a surrogate for the work of the engine or load and emissions tend to increase or decrease as load increases or decreases. The basic emission rates are derived from testing vehicles over a reference cycle with a single average speed of about 20 miles per hour (the Urban Dynamometer Driving Schedule or UDDS). Speed correction factors adjust the basic emission rates for cycles or trips of differing speeds.

As running emissions are expressed in terms of grams per mile, the speed correction factors tend to be higher at the extremes of speed. At high speeds, the vehicle's engine has to work harder to overcome wind resistance and emissions tend to increase as a consequence. At low speeds, the vehicle has to overcome inertia and rolling resistance. Although emissions tend to be lower at lower speeds, as the speed approaches zero the grams/mile ratio increases. The result is a generally a "U" shaped curve describing the impact of speed on emissions.

In the current version of EMFAC, at least two pollutant specific speed correction factors are needed to properly characterize the emissions of the heavy-duty truck fleet. The equation and coefficients used to derive the speed correction factors included in EMFAC 2007 are described in CARB documentation.[49]

Equation 7.6

$$\textit{Speed Correction Factor} = A + (B \times Speed) + (C \times Speed^2)$$

Table 7.9 lists the speed correction factor coefficients.

Table 7.9: CARB Speed Correction Factor Coefficients

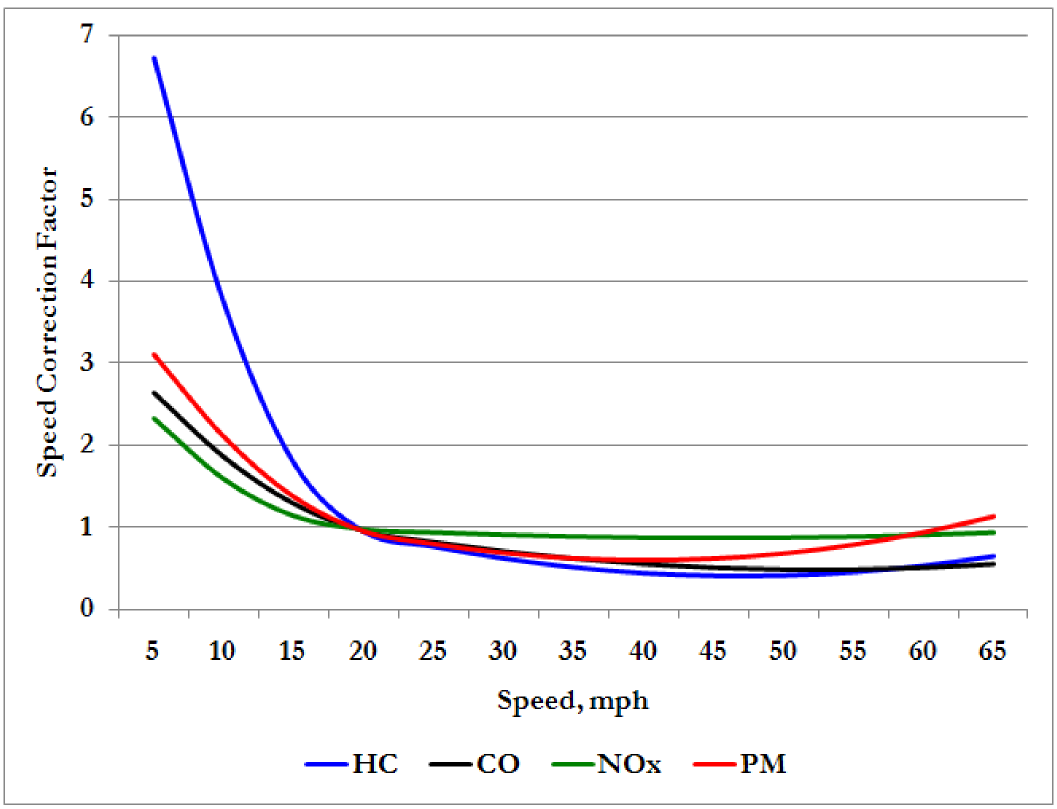
Pollutant	Model Year Group	Speed Range	A	B	C
HC	Pre-1991	5.00 - 18.8	7.1195	-0.4789	0.008159
		18.8 - 65.0	1.6373	-0.04189	0.0003884
	1991-2002	5.00 - 18.8	11.614	-0.9929	0.02278
		18.8 - 65.0	2.3019	-0.08712	0.0009773
	2003+	5.00 - 18.8	10.219	-0.8937	0.02146
		18.8 - 65.0	1.6053	-0.03799	0.0002985
CO	Pre-1991	5.00 - 65.0	1.6531	-0.04198	0.0003352
	1991-2002	5.00 - 18.8	3.0388	-0.1511	0.002267
		18.8 - 65.0	1.8753	-0.05664	0.0005141
	2003+	5.00 - 18.8	6.2796	-0.5021	0.01177
		18.8 - 65.0	1.3272	-0.02463	0.000336
NO_x	Pre-1991	5.00 - 18.8	2.2973	-0.1173	0.002571
		18.8 - 65.0	1.3969	-0.02658	0.0002725
	1991-2002	5.00 - 18.8	3.7668	-0.2862	0.007394
		18.8 - 65.0	1.0771	-0.005981	0.00009271
	2003+	5.00 - 18.8	2.7362	-0.148	0.002958
		18.8 - 65.0	1.5116	-0.03357	0.0003118
PM	Pre-1991	5.00 - 18.8	2.6039	-0.1266	0.002198
		18.8 - 65.0	1.4902	-0.03121	0.0002733
	1991-2002	5.00 - 18.8	5.7807	-0.4032	0.007918
		18.8 - 65.0	2.2766	-0.08661	0.0009948
	2003+	5.00 - 18.8	1.4086	-0.02313	0.00007449
		18.8 - 65.0	1.4881	-0.0408	0.0007894

[49] Amendment to EMFAC Modeling Change Technical Memo, *Revision of Heavy Heavy-duty Diesel Truck Emission factors and Speed Correction Factors*, 20 October 2006.

The EMFAC model uses these speed correction factors to derive the speed specific emission factors for each pollutant at 5 mile-per-hour increments for use in this analysis. The model does this by deriving the model year and pollutant specific speed correction factors and then weighting each factor by the population of trucks in each model year group. Figure 7.6 illustrates the differences in fleet weighted speed correction factors with speed, for each pollutant.

The output from the model is a table of emission estimates by model year and speed. This output is processed to develop a set of model year-weighted composite emission factors, for speeds from 5 to 65 mph, reflecting the model year distribution of the trucks calling at Port terminals over the year. The model year distribution and development of the composite emission factors are discussed in the following two subsections.

Figure 7.6: Fleet Weighted Speed Correction Factors



7.5.5 Model Year Distribution

Because vehicle emissions vary according to the vehicle's model year and age, the activity level of trucks in each model year is an important part of developing emission estimates. As a routine component of the annual emissions inventory updates, optical character recognition (OCR) license plate data were collected from container terminal operators in order to determine the distribution of model years (count of vehicles and number of terminal calls by model year) of trucks calling upon the Port. Most terminals collect this information as part of their terminal operating routine, and those that do collect the information provide the records, consisting primarily of license plate numbers with date/time stamps, to the Port.

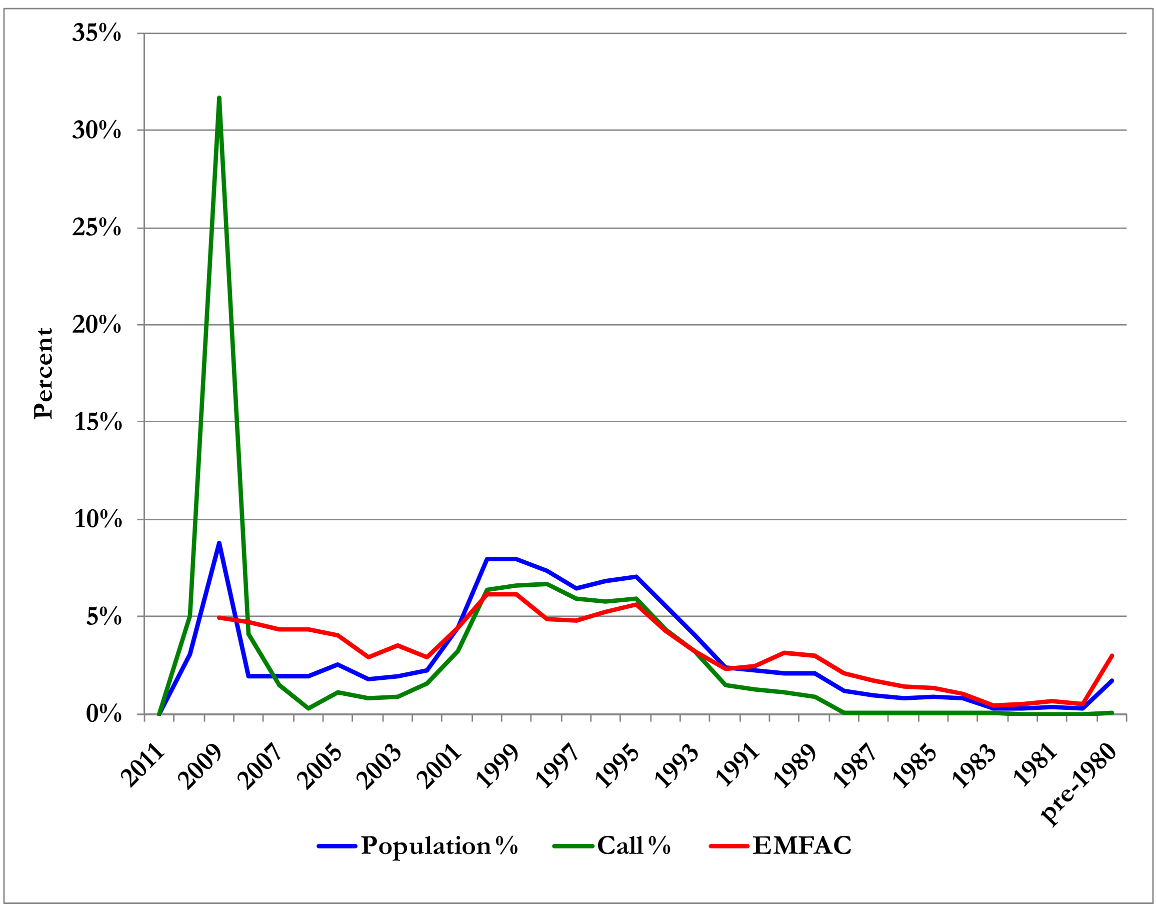
Approximately 4.78 million OCR readings were collected from nine different terminals of the Port of Los Angeles and the Port of Long Beach during the period spanning January 1 through December 31, 2009. These readings were processed to eliminate records that identify vehicles exiting the terminals, to minimize double counting of trips. The records were also screened to remove special characters, state suffixes (i.e., CA, NV, etc.), character strings that were obviously not license plate numbers (e.g., "NO OCR", "-----", etc.), and records that were less than six digits in length. This process left approximately 174,000 unique license plate numbers for which registration information was sought from the California Department of Motor Vehicles (DMV).

The DMV returned a total of approximately 205,000 records; many of these were "no match" returns, meaning the number that was submitted was not a valid license plate number format and/or did not match any numbers in the DMV's database. Removing these invalid records left approximately 52,000 records with vehicle identification numbers (VINs) and vehicle model year information. The matching DMV files also include a body type model (BTM) field, which was used to distinguish trucks from other types of vehicles captured by the OCR systems. Vehicles designated with a BTM of DS (diesel tractor truck), TB (tilt cab tractor), TL (tilt tandem tractor), TM (tandem axle tractor), TRAC and TRACTOR (tractors) were included in the analysis. This process identified approximately 37,500 unique license plate numbers belonging to trucks. When these were matched back to the OCR call records, a total of 32,511 unique trucks were identified, with a model year range from 1950 to a single 2011 model year truck. The difference between the 37,500 unique truck license plate numbers and the 32,511 confirmed matches is due to the DMV returning multiple license plate numbers of trucks based on their VIN. That is, if a truck's VIN was associated with more than one license plate number (e.g., because of change of ownership), then more than one license plate number was returned. This did not cause duplication because only license plate numbers present in the original OCR data (reflecting actual Port terminal visits) were kept for the analysis.

The valid truck license plate numbers were then matched against the original OCR readings and further cleaned by eliminating occurrences of identical plate readings within ten minutes of each other, which are likely to be duplicate readings related to the same entry event. This matching process resulted in 3.28 million terminal calls matched to a known license plate number and truck model year. These matched calls were used to develop a call-weighted model year distribution, the percentage of terminal calls made up by each model year. The results show that the overwhelming majority of calls (over 90%) were attributable to 1994 model year and newer trucks.

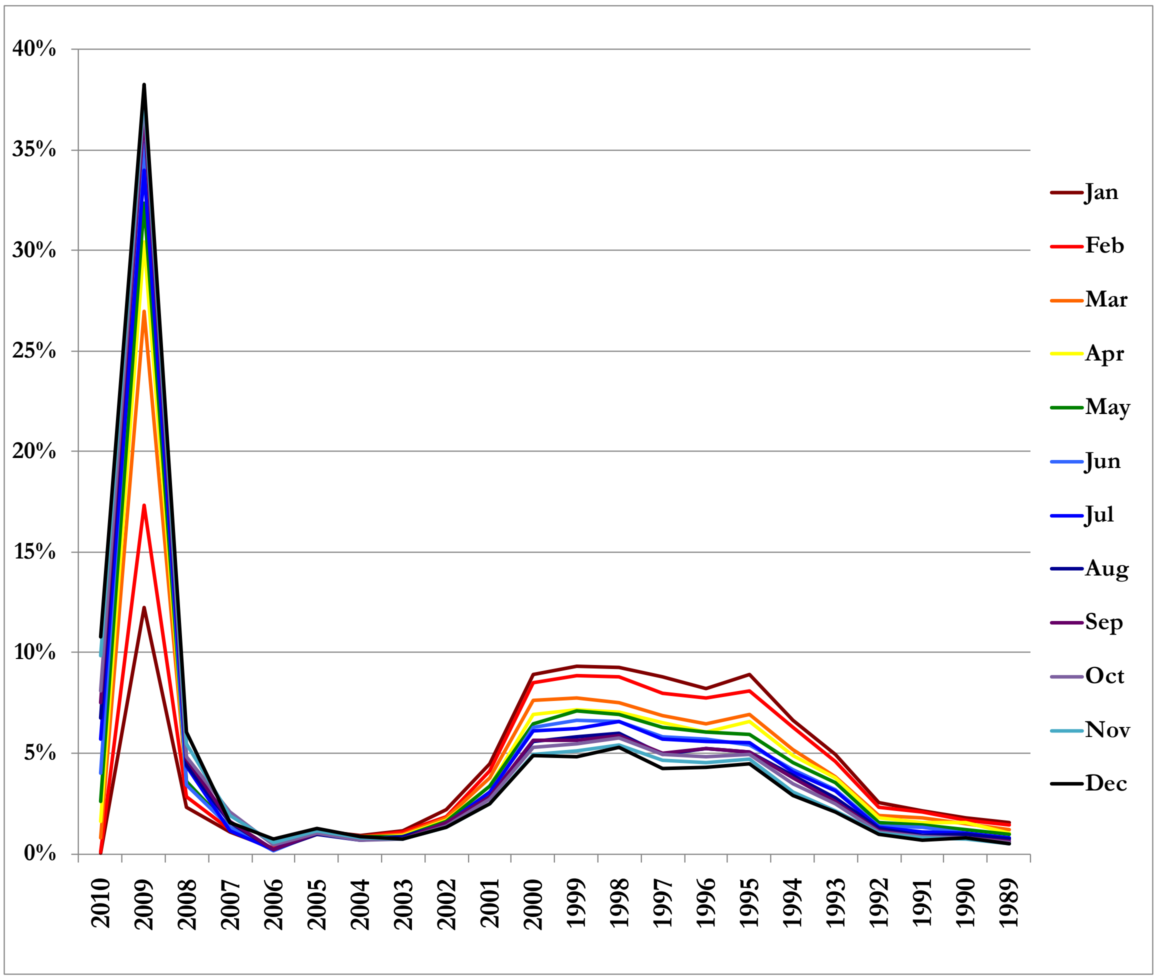
The distribution of truck model years by population and by calls is presented in Figure 7.7 below, in comparison to the default distribution contained in the EMFAC model. The 2009 call-weighted average age of the Port-related fleet, which was used to develop the composite emission factors, is 6.9 years. The population weighted average age of the Port-related fleet was determined to be 10.9 years, which is slightly newer than the EMFAC estimate of heavy-duty diesel trucks in operation within the SoCAB of 11.6 years.

Figure 7.7: Distribution of the Heavy-Duty Truck Fleets



The prominent spike to the left of the call-weighted distribution is composed of model year 2009 vehicles, which became the predominant model year truck over the course of 2009. To illustrate this, Figure 7.8 presents the distribution of calls by model year in each month. This figure clearly shows the decrease in calls of older model year trucks and the increase in calls of model year 2009 trucks over the course of the year.

Figure 7.8: Monthly Call Distribution by Model Year



<u>7.5.6 Speed-Specific Emission Factors</u>

As noted above, speed-specific emission factors for heavy-heavy duty diesel trucks were obtained from CARB's EMFAC 2007 model. The program was run for the SoCAB for the 2009 calendar year assuming annual average atmospheric conditions, and the output option was selected to provide model year specific emission rates by pollutant at five mile-per-hour intervals of speed (5 mph to 70 mph).

The ton-per-day outputs were converted to gram-per-mile emission rates by converting tons to grams and then dividing the resulting grams by the speed specific daily VMT. The model year and speed specific gram-per-mile emission rates were then weighted to reflect the distribution of trucks by age within the fleet of trucks calling at Port terminals, using the call-weighted distribution discussed in the previous subsection. A single set of pollutant specific gram-per-hour idle emission rates was derived in a similar manner.

Because emissions of N_2O and SO_x are estimated on a per-gallon basis, the average fuel economy of the heavy-heavy duty diesel fleet was obtained from EMFAC and the number of gallons of fuel consumed by operating mode was estimated by dividing the mode specific VMT by the average fuel economy. A fuel consumption rate of 0.4 gallons of diesel per hour was derived through an analysis of tests performed by the Coordinating Research Council (CRC)[50] and was used to estimate N_2O and SO_x emissions at idle. Tables 7.10 and 7.11 summarize the speed-specific emission factors developed as described above and used to estimate emissions. The units are in grams per mile, except for the idle emission factors (0 mph) which are in grams per hour.

Table 7.10: Speed-Specific Emission Factors, grams/mile

Speed Range (mph)	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	Units
0 (Idle)	1.249	1.149	1.249	86.106	0.042	19.270	9.494	g/hr
1 - 5	4.351	4.003	4.351	48.667	0.018	26.949	13.494	g/mile
6 - 10	3.589	3.302	3.589	39.992	0.018	23.677	10.308	g/mile
11 - 15	2.362	2.173	2.362	27.378	0.018	18.049	5.409	g/mile
16 - 20	1.519	1.397	1.519	21.172	0.018	13.653	2.472	g/mile
21 - 25	1.185	1.090	1.185	20.051	0.018	11.108	1.731	g/mile
26 - 30	0.988	0.909	0.988	19.569	0.018	9.289	1.387	g/mile
31 - 35	0.841	0.774	0.841	19.221	0.018	7.759	1.125	g/mile
36 - 40	0.745	0.685	0.745	19.000	0.018	6.518	0.945	g/mile
41 - 45	0.698	0.642	0.698	18.935	0.018	5.566	0.847	g/mile
46 - 50	0.701	0.645	0.701	19.023	0.018	4.903	0.832	g/mile
51 - 55	0.754	0.694	0.754	19.251	0.018	4.530	0.899	g/mile
56 - 60	0.858	0.789	0.858	19.649	0.018	4.446	1.048	g/mile
61 - 65	1.011	0.930	1.011	20.238	0.018	4.650	1.279	g/mile
66 - 70	1.214	1.117	1.214	20.999	0.018	5.144	1.593	g/mile

[50] CRC, E55-59, *http://www.crcao.com/*

Table 7.11: Speed-Specific GHG Emission Factors, grams/mile

Speed Range (mph)	CO_2	N_2O	CH_4	Units
0 (Idle)	4,640	0.037	0.183	g/hr
1 - 5	3,842	0.015	0.785	g/mile
6 - 10	3,489	0.015	0.606	g/mile
11 - 15	2,865	0.015	0.318	g/mile
16 - 20	2,351	0.015	0.145	g/mile
21 - 25	2,109	0.015	0.102	g/mile
26 - 30	1,979	0.015	0.082	g/mile
31 - 35	1,872	0.015	0.066	g/mile
36 - 40	1,786	0.015	0.056	g/mile
41 - 45	1,723	0.015	0.050	g/mile
46 - 50	1,682	0.015	0.049	g/mile
51 - 55	1,662	0.015	0.053	g/mile
56 - 60	1,665	0.015	0.062	g/mile
61 - 65	1,690	0.015	0.075	g/mile
66 - 70	1,737	0.015	0.094	g/mile

7.5.7 Improvements to Methodology from Previous Years

The following improvements to the emissions calculation methodology were made in this inventory compared to 2008 EI methodology. For comparison of 2009 emissions to previous years' emissions, refer to Section 9.

- A newly available data source was evaluated to validate the model year distribution derived from the OCR data. As part of the San Pedro Bay Ports' clean truck programs, the container terminals have been collecting truck entry data using radio frequency identification (RFID) technology. This data is collected and correlated with truck-specific information contained in the Drayage Truck Registry (DTR) that has also been established as part of the truck programs. The model year information contained in the DTR data has been compared with model year information developed from the OCR and DMV data previously described in this section. The comparison between the OCR and RFID data sets revealed a similar spike in 2009 model year trucks and a lower population of older trucks. Evaluation of the RFID/DTR data is continuing with respect to a comparison of trip frequencies by model year as well as the population comparison.

- The weighting of model years in the development of the composite emission factors was changed from population-based to call-based to better reflect the significant change in the distribution of truck model years, and their activity patterns. For the previous inventories, the population percentages of each model year were used to develop the composites because there was not a significant difference between the percentages of trucks and calls by model year, and the corresponding differences between mileage by model year were assumed similarly not to be significant (and mileage is the underlying basis of the activity estimates).

  In contrast, the 2009 population-based and call-based model year distributions are very different, with 2009 model year trucks making up approximately 9% of the truck population but conducting almost 32% of terminal calls. This level of activity by the newest trucks is better represented by a call-weighted distribution since this method reflects the increased presence of 2009 model year trucks in Port truck traffic.

  The reasons for the significant presence of new trucks in the terminal calls are the progressive bans under the CTP[51], the second of which went into effect January 1, 2010, and more importantly, the container fee that went into effect in February 2009, which created a disincentive to move cargo with pre-2007 trucks.

7.5.8 Future Improvements to Methodology

The RFID/DTR data may prove to be a valuable supplement to the OCR/DMV data in evaluating the model year distribution of future Port-related fleets. While incomplete for 2009 because the RFID monitoring commenced in February of that year, the data will cover all six container terminals of the Port of Los Angeles rather than the five that operate OCR systems, and may provide a more complete record of truck entries. Also, a new methodology will be developed to better represent emissions for LNG trucks in the 2010 EI.

7.6 Emission Estimates

The estimates of 2009 HDV emissions are presented in this section. As discussed above, on-terminal emissions are based on terminal-specific information such as number of trucks passing through the terminal and the distance they travel on-terminal, and the Port-wide totals are the sum of the terminal-specific estimates. The on-road emissions have been estimated for Port trucks using travel demand model results to estimate how many trucks travel along defined roadways in the SoCAB on the way to their first cargo drop-off point. The on-terminal estimates include the sum of driving and idling emissions calculated separately. The on-road estimates include idling emissions as a normal part of the driving

[51] *http://www.portoflosangeles.org/Tariff/SEC20.pdf*

cycle. This is a valid approach because the average speeds include estimates of normal traffic idling times and the emission factors are designed to take this into account.

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Tables 7.12 and 7.13 summarize emissions from HDVs associated with all Port terminals.

Table 7.12: Summary of HDV Emissions, tons per year

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	6,061,176	14	13	14	358	0	128	51
On-Road	233,791,284	101	93	101	3,880	5	949	157
Total	**239,852,460**	**115**	**106**	**115**	**4,238**	**5**	**1,077**	**208**

Table 7.13: Summary of HDV GHG Emissions, metric tons per year

Activity Location	VMT	CO_2 Equivalent	CO_2	N_2O	CH_4
On-Terminal	6,061,176	27,356	27,260	0	2
On-Road	233,791,284	409,765	408,499	4	8
Total	**239,852,460**	**437,120**	**435,759**	**4**	**11**

Tables 7.14 and 7.15 show emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 7.14: Summary of HDV Emissions Associated with Container Terminals, tons per year

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	4,668,854	11	10	11	272	0	99	39
On-Road	215,001,111	93	86	93	3,570	4	875	145
Total	**219,669,965**	**104**	**96**	**104**	**3,842**	**5**	**973**	**184**

Table 7.15: Summary of HDV GHG Emissions Associated with Container Terminals, metric tons per year

Activity Location	VMT	CO_2 Equivalent	CO_2	N_2O	CH_4
On-Terminal	4,668,854	21,058	20,985	0	2
On-Road	215,001,111	376,993	375,828	3	8
Total	**219,669,965**	**398,051**	**396,813**	**3**	**9**

Tables 7.16 and 7.17 show emissions associated with other Port terminals and facilities separately.

Table 7.16: Summary of HDV Emissions Associated with Other Port Terminals, tons per year

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	1,392,322	3	3	3	86	0	29	12
On-Road	18,790,173	8	7	8	310	0	75	12
Total	**20,182,494**	**11**	**10**	**11**	**396**	**0**	**104**	**24**

Table 7.17: Summary of HDV GHG Emissions Associated with Other Port Terminals, metric tons per year

Activity Location	VMT	CO_2 Equivalent	CO_2	N_2O	CH_4
On-Terminal	1,392,322	6,297	6,275	0	1
On-Road	18,790,173	32,772	32,671	0	1
Total	**20,182,494**	**39,070**	**38,946**	**0**	**1**

SECTION 8 SUMMARY OF 2009 EMISSION RESULTS

The emission results for the Port of Los Angeles 2009 Inventory of Air Emissions are presented in this section. Tables 8.1 and 8.2 summarize the 2009 total Port-related emissions in the South Coast Air Basin by category.

Table 8.1: 2009 Port-related Emissions by Category, tons per year

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	287	229	244	4,039	2,418	438	208
Harbor craft	56	51	56	1,276	1	390	92
Cargo handling equipment	25	24	24	750	1	712	40
Rail locomotives	28	26	28	940	7	160	51
Heavy-duty vehicles	115	106	115	4,238	5	1,077	208
Total	**511**	**436**	**467**	**11,244**	**2,432**	**2,777**	**599**

DB ID457

The greenhouse gas emissions summarized in Table 8.2 are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used throughout the report for criteria pollutants. The CO_2 equivalent values are derived by multiplying the GHG emissions estimates by their respective GWP[52] values (1 for CO_2, 310 for N_2O, 21 for CH_4) and then adding them together.

Table 8.2: 2009 Port-related GHG Emissions by Category, metric tons per year

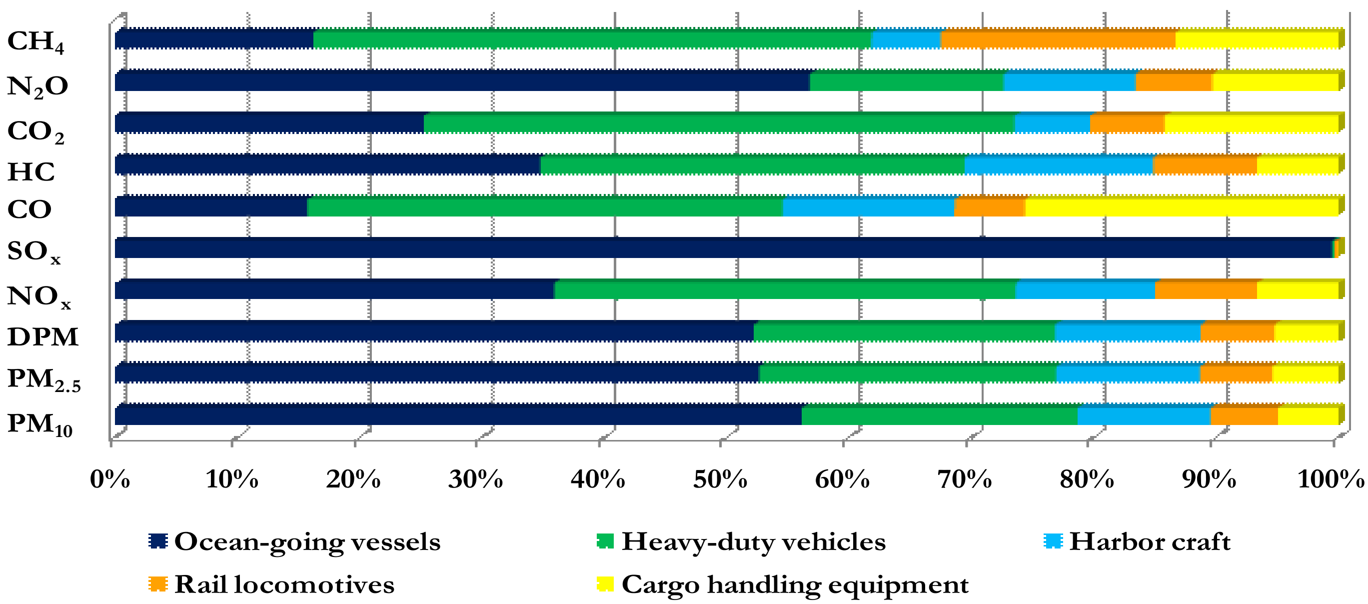
Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	232,272	228,105	13	4
Harbor craft	56,562	55,759	3	1
Cargo handling equipment	129,063	128,257	2	3
Rail locomotives	55,629	55,082	1	4
Heavy-duty vehicles	437,120	435,759	4	11
Total	**910,647**	**902,961**	**23**	**23**

DB ID457

[52] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, April 2009.

Figure 8.1 shows the distribution of the 2009 total port-related emissions for each pollutant and source category. Ocean-going vessels (52%) and heavy-duty trucks (25%) contribute the highest percentage of DPM emissions among the port-related sources. Over 99% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks (38%) and OGV (36%) account for the majority of NO_x emissions. Heavy-duty trucks (39%) and CHE (26%) account for the majority of CO emissions. Heavy-duty trucks (35%) and OGV (35%) account for the majority of hydrocarbon emissions.

Figure 8.1: 2009 Port-related Emissions by Category, %



Tables 8.3 through 8.5 present DPM, NO_x and SO_x emissions by source category and subcategory in the context of port-wide and air basin-wide emissions. For example, Table 8.3 shows that containership's DPM emissions were 167 tons per year in 2009, representing 69% of the total OGV emissions (source category), 36% of the total Port-related emissions, and 2% of all emissions in the SoCAB (based on emissions reported in the latest Air Quality Management Plan). In 2009, the OGV source category contributed 244 tons of DPM representing 52% of the Port's overall DPM emissions and 3% of SoCAB DPM emissions. The bottom of the table highlighted in grey shows that the Port's total DPM emissions constituted approximately 5% of the SoCAB DPM emissions. The other two tables similarly present NO_x and SO_x emissions.

Table 8.3: 2009 DPM Emissions by Category and Percent Contribution, tons per year and %

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	4	1%	1%	0%
OGV	Bulk vessel	3	1%	1%	0%
OGV	Containership	167	69%	36%	2%
OGV	Cruise	36	15%	8%	0%
OGV	General cargo	5	2%	1%	0%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Miscellaneous	0	0%	0%	0%
OGV	Reefer	4	2%	1%	0%
OGV	Tanker	23	10%	5%	0%
OGV	**Subtotal**	**244**	**100%**	**52%**	**3%**
Harbor Craft	Assist tug	18	32%	4%	0%
Harbor Craft	Harbor tug	2	3%	0%	0%
Harbor Craft	Commercial fishing	10	17%	2%	0%
Harbor Craft	Ferry	7	13%	2%	0%
Harbor Craft	Ocean tugboat	3	5%	1%	0%
Harbor Craft	Government	1	3%	0%	0%
Harbor Craft	Excursion	7	12%	1%	0%
Harbor Craft	Crewboat	5	10%	1%	0%
Harbor Craft	Work boat	3	5%	1%	0%
Harbor Craft	**Subtotal**	**56**	**100%**	**12%**	**1%**
CHE	RTG crane	2	7%	0%	0%
CHE	Forklift	1	6%	0%	0%
CHE	Top handler, side pick	6	23%	1%	0%
CHE	Other	3	12%	1%	0%
CHE	Yard tractor	13	52%	3%	0%
CHE	**Subtotal**	**24**	**100%**	**5%**	**0%**
Rail	Switching	2	7%	0%	0%
Rail	Line haul	26	93%	6%	0%
Rail	**Subtotal**	**28**	**100%**	**6%**	**0%**
HDV	On-Terminal	14	12%	3%	0%
HDV	On-Road	101	88%	22%	1%
HDV	**Subtotal**	**115**	**100%**	**25%**	**1%**
Port	**Total**	**467**		**100%**	**5%**
SoCAB AQMP	**Total**	**8,636**			

Table 8.4: 2009 NO_x Emissions by Category and Percent Contribution, tons per year and %

Category	Subcategory	NO_x Emissions	Percent NO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	62	2%	1%	0%
OGV	Bulk vessel	54	1%	0%	0%
OGV	Containership	2,753	68%	24%	1%
OGV	Cruise	618	15%	5%	0%
OGV	General cargo	84	2%	1%	0%
OGV	Ocean tugboat	30	1%	0%	0%
OGV	Miscellaneous	1	0%	0%	0%
OGV	Reefer	54	1%	0%	0%
OGV	Tanker	383	9%	3%	0%
OGV	**Subtotal**	**4,039**	**100%**	**36%**	**1%**
Harbor Craft	Assist tug	417	33%	4%	0%
Harbor Craft	Harbor tug	44	3%	0%	0%
Harbor Craft	Commercial fishing	222	17%	2%	0%
Harbor Craft	Ferry	153	12%	1%	0%
Harbor Craft	Ocean tugboat	64	5%	1%	0%
Harbor Craft	Government	33	3%	0%	0%
Harbor Craft	Excursion	155	12%	1%	0%
Harbor Craft	Crewboat	125	10%	1%	0%
Harbor Craft	Work boat	63	5%	1%	0%
Harbor Craft	**Subtotal**	**1,276**	**100%**	**11%**	**0%**
CHE	RTG crane	61	8%	1%	0%
CHE	Forklift	79	11%	1%	0%
CHE	Top handler, side pick	206	27%	2%	0%
CHE	Other	75	10%	1%	0%
CHE	Yard tractor	329	44%	3%	0%
CHE	**Subtotal**	**750**	**100%**	**7%**	**0%**
Rail	Switching	75	8%	1%	0%
Rail	Line haul	865	92%	8%	0%
Rail	**Subtotal**	**940**	**100%**	**8%**	**0%**
HDV	On-Terminal	358	8%	3%	0%
HDV	On-Road	3,880	92%	35%	1%
HDV	**Subtotal**	**4,238**	**100%**	**38%**	**1%**
Port	**Total**	**11,244**		**100%**	**4%**
SoCAB AQMP	**Total**	**297,176**			

Table 8.5: 2009 SO_x Emissions by Category and Percent Contribution, tons per year and %

Category	Subcategory	SO_x Emissions	Percent SO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	31	1%	1%	0%
OGV	Bulk vessel	33	1%	1%	0%
OGV	Containership	1,490	62%	61%	10%
OGV	Cruise	253	10%	10%	2%
OGV	General cargo	47	2%	2%	0%
OGV	Ocean tugboat	5	0%	0%	0%
OGV	Miscellaneous	0	0%	0%	0%
OGV	Reefer	38	2%	2%	0%
OGV	Tanker	520	22%	21%	4%
OGV	**Subtotal**	**2,418**	**100%**	**99%**	**17%**
Harbor Craft	Assist tug	0.2	32%	0%	0%
Harbor Craft	Harbor tug	0.0	5%	0%	0%
Harbor Craft	Commercial fishing	0.1	13%	0%	0%
Harbor Craft	Ferry	0.1	17%	0%	0%
Harbor Craft	Ocean tugboat	0.0	7%	0%	0%
Harbor Craft	Government	0.0	4%	0%	0%
Harbor Craft	Excursion	0.1	10%	0%	0%
Harbor Craft	Crewboat	0.1	8%	0%	0%
Harbor Craft	Work boat	0.0	4%	0%	0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0%**
CHE	RTG crane	0	6%	0%	0%
CHE	Forklift	0	2%	0%	0%
CHE	Top handler, side pick	0	20%	0%	0%
CHE	Other	0	6%	0%	0%
CHE	Yard tractor	1	66%	0%	0%
CHE	**Subtotal**	**1**	**100%**	**0%**	**0%**
Rail	Switching	0	1%	0%	0%
Rail	Line haul	7	99%	0%	0%
Rail	**Subtotal**	**7**	**100%**	**0%**	**0%**
HDV	On-Terminal	0	3%	0%	0%
HDV	On-Road	5	97%	0%	0%
HDV	**Subtotal**	**5**	**100%**	**0%**	**0%**
Port	**Total**	**2,432**		**100%**	**17%**
SoCAB AQMP	**Total**	**14,615**			

In order to put the Port-related emissions into context, the following figures and tables compare the Port's contributions to the total emissions in the South Coast Air Basin by major emission source category. The 2009 SoCAB emissions are based on 2007 AQMP Appendix III.[53]

Figure 8.2: 2009 DPM Emissions in the South Coast Air Basin, %

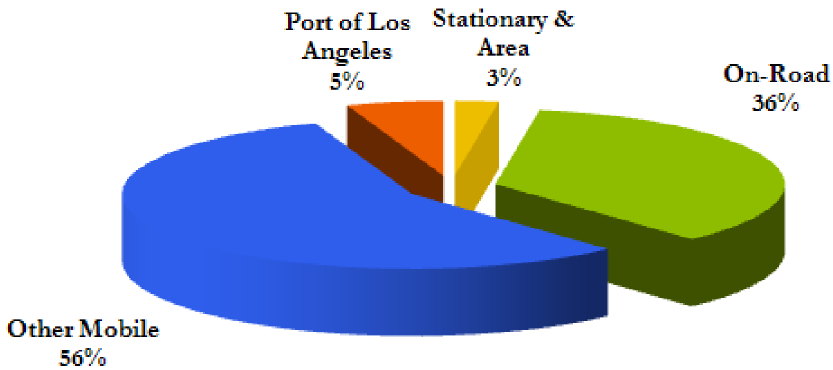


Figure 8.3: 2009 NO_x Emissions in the South Coast Air Basin, %

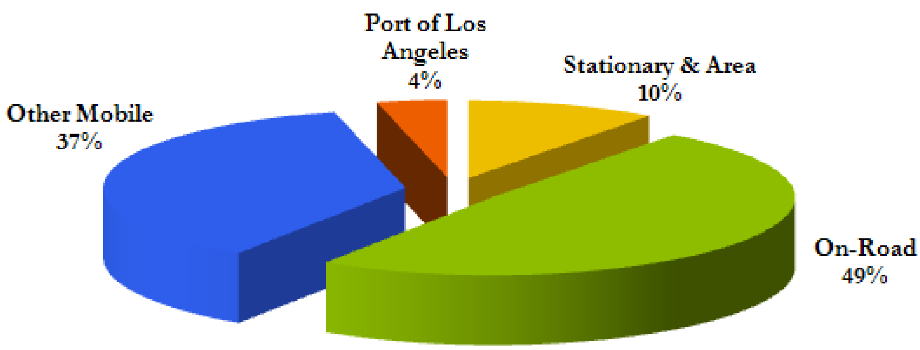
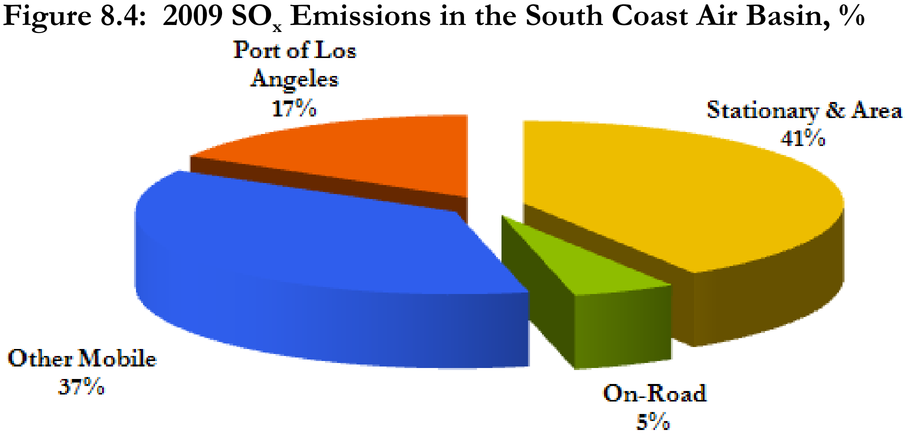


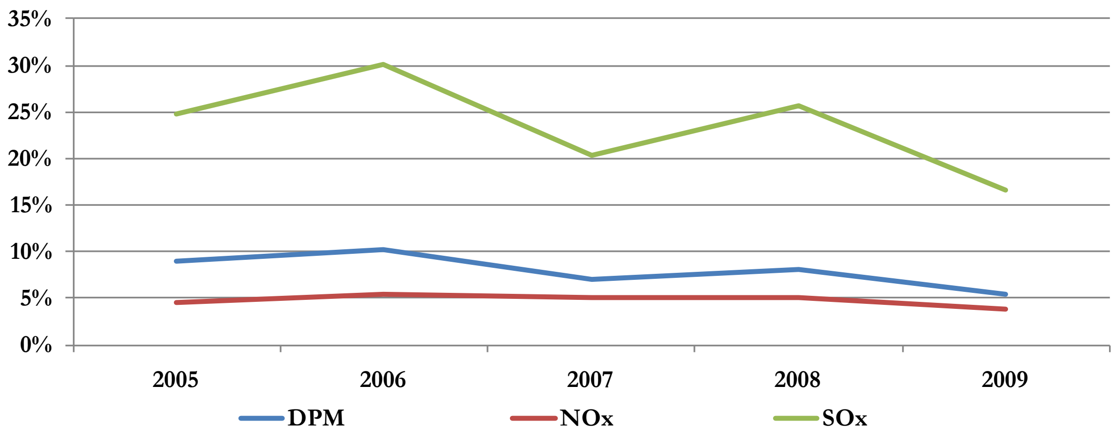
Figure 8.4: 2009 SO_x Emissions in the South Coast Air Basin, %



[53] SCAQMD, *Final 2007 AQMP Appendix III, Base & Future Year Emissions Inventories*, June 2007.

Figure 8.5 provides a comparison of the Port-related mobile source emissions to the total SoCAB emissions from 2005 to 2009. As indicated, the Port's overall contribution to the SoCAB emissions has continued to decrease because of the implementation of control programs.

Figure 8.5: Port's Emissions in the South Coast Air Basin



SECTION 9 COMPARISON OF 2009 AND PREVIOUS YEARS' FINDINGS AND EMISSION ESTIMATES

This section compares emissions during the 2009, 2008, 2007, 2006 and 2005 calendar years, overall and for each emission source category. Emission source categories are addressed in separate subsections, containing the emissions comparisons in table and chart formats, which explain the findings and differences in emissions.

The tables and charts in this section also summarize the percent change from the previous year (2009-2008) and for the CAAP Progress (2009-2005) using the current methodology for emissions comparison. Calendar year 2005 is considered the baseline year for CAAP from which CAAP progress is tracked.

9.1 2009 Comparisons

In preparing the comparisons, the first step was to account for changes in methodology between the current year and any of the previous years. To provide a valid basis for comparison, if methodological changes were implemented for a source category, then the previous years' emissions were recalculated using the new methodology and the previous years' activity data. If there were no changes in methodology, then the emissions estimated for the prior years' inventories were used for the comparison. Because of the Port's process of continual review and improvement of the inventories, the previous years' emissions presented in this comparison may not exactly match those published in the inventory report for the prior year(s).

Methodological differences between 2009 and 2008 Inventory of Air Emissions
The methodologies used for developing the 2009 inventory were the same as those used for the 2008 inventory for ocean-going vessels, harbor craft, cargo handling equipment, and heavy-duty trucks. For rail, the methodology used in 2009 to estimate emissions differs from the methodology used in 2008 due to the updated emission factors for switcher locomotives (based on EPA's new brake specific fuel consumption factor for switcher locomotives). Sections 9.1.1 through 9.1.5 present the source category comparisons across years (2005 to 2009).

Port-wide Overview of Activity and Emissions Changes

Table 9.1 presents the number of vessel calls and the container cargo throughputs for calendar years 2005 to 2009. In 2009, total TEU throughput at the Port of Los Angeles continued to decline from its peak in 2006 due to recent global economic conditions. The TEU/containership-call efficiency improvements experienced from 2005 to 2008 did not continue in 2009. Despite a 14% decrease in TEUs, the containership calls decreased by only 7%, indicating that on average there were fewer containers unloaded and loaded per vessel call despite the increased use of larger vessels (containerships with TEU capacity of 7,000 TEUs and greater). Likely explanations are that containerships were either running less full, were calling at more west-coast berths per service, or were discharging more cargo at other ports. Compared to 2005, the number of TEUs and containership calls decreased by about 10% in 2009 while the TEU/containership-call efficiency remained about the same.

Table 9.1: TEUs and Vessel Call Comparison, %

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2009	2,010	1,355	6,748,995	4,981
2008	2,239	1,459	7,849,985	5,380
2007	2,527	1,573	8,355,038	5,312
2006	2,703	1,627	8,469,853	5,206
2005	2,501	1,481	7,484,625	5,054
Previous Year (2009-2008)	**-10%**	**-7%**	**-14%**	**-7%**
CAAP Progress (2009-2005)	**-20%**	**-9%**	**-10%**	**-1%**

Table 9.2 provides a comparison of OGV container vessel calls from 2005 to 2009 highlighting the general trend toward larger vessels.

Table 9.2: OGV Container Vessel Calls Count by Container Vessel Category

Category	2009 Arrivals	2008 Arrivals	2007 Arrivals	2006 Arrivals	2005 Arrivals	2009-2008	2009-2007	2009-2006	2009-2005
Container - 1000	115	176	237	218	202	-35%	-51%	-47%	-43%
Container - 2000	165	96	104	149	184	72%	59%	11%	-10%
Container - 3000	89	142	127	201	296	-37%	-30%	-56%	-70%
Container - 4000	295	368	537	515	398	-20%	-45%	-43%	-26%
Container - 5000	359	341	328	289	215	5%	9%	24%	67%
Container - 6000	138	199	160	181	131	-31%	-14%	-24%	5%
Container - 7000	106	99	80	78	52	7%	33%	36%	104%
Container - 8000	78	30	4	1	0	160%	1850%	7700%	NA
Container - 9000	10	8	0	0	0	25%	NA	NA	NA

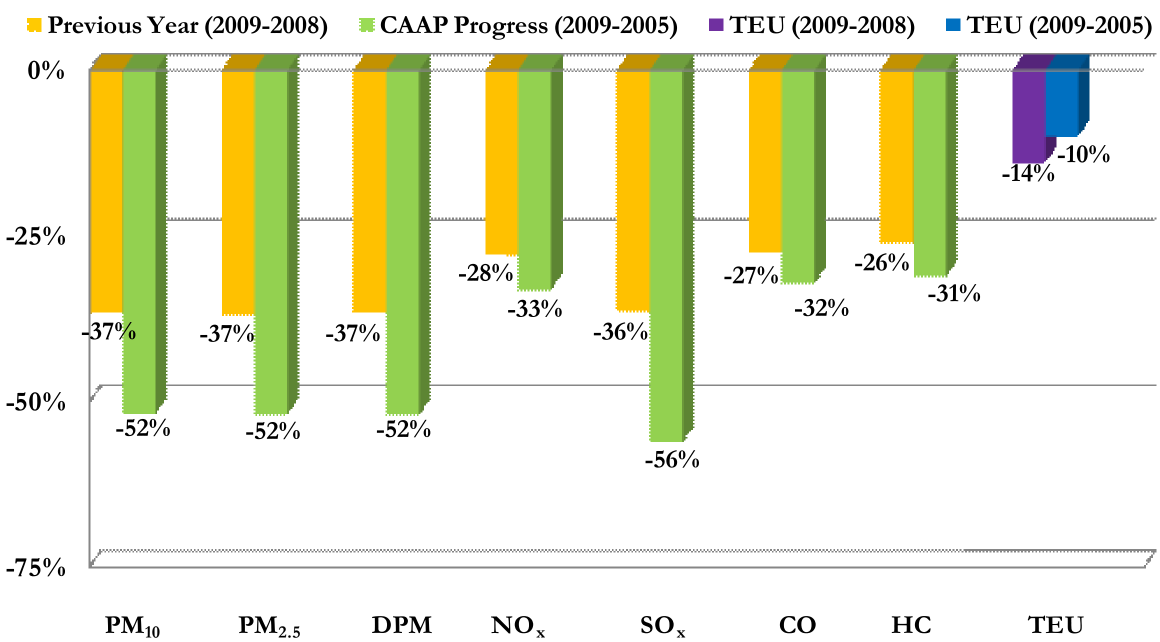
Table 9.3 presents the total net change in emissions from all source categories in 2009 as compared to previous years. From 2008 to 2009, there was a 14% decrease in throughput and emissions decreased 37% for DPM, 28% for NO_x, 36% for SO_x, 27% for CO and 26% for HC emissions. For 2005 to 2009, there was a 10% decrease in throughput and emissions decreased 52% for DPM, 33% for NO_x, 56% for SO_x, 32% for CO, and 31% for HC emissions.

Table 9.3: Port-wide Emissions Comparison, tons per year and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	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
Previous Year (2009-2008)	**-37%**	**-37%**	**-37%**	**-28%**	**-36%**	**-27%**	**-26%**
CAAP Progress (2009-2005)	**-52%**	**-52%**	**-52%**	**-33%**	**-56%**	**-32%**	**-31%**

Figure 9.1 shows the percent change in port-wide emissions since the previous year and CAAP progress.

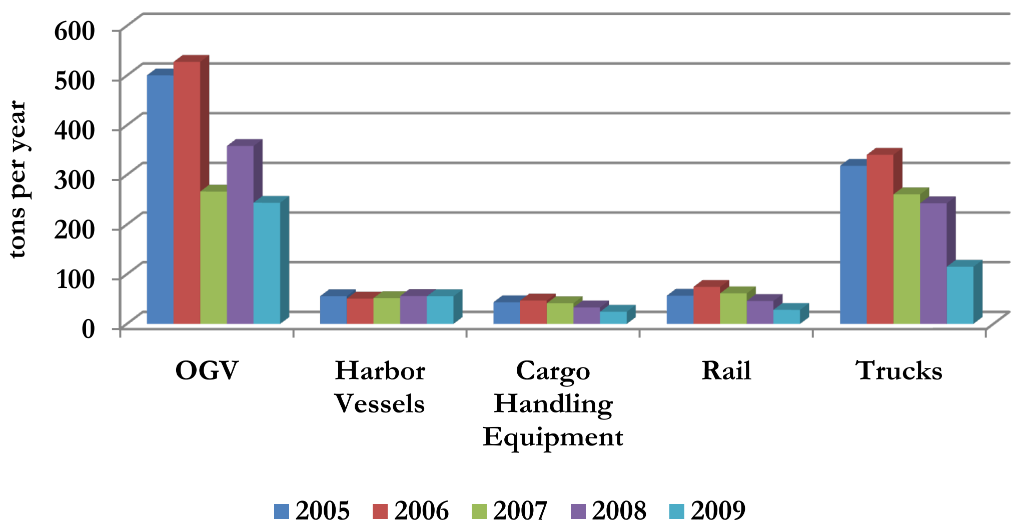
Figure 9.1: Port-wide Emissions Comparison, % Change



Figures 9.2 through 9.4 show the change over the years in DPM, NO_x and SO_x emissions contributions for ocean-going vessels, heavy-duty vehicles, harbor craft, rail locomotives, and cargo handling equipment categories. As indicated, emissions for all categories have decreased over the years primarily due to the implementation of the Port's programs as well as lower throughput levels in recent years because of global economic conditions and regulations impacting these categories.

As shown in Figure 9.2, OGVs and HDVs contribute to the majority of DPM emissions. DPM emissions for all categories have been reduced from 2005 to 2009 except for harbor craft which has remained relatively the same mainly because of activity level. The increase in OGV DPM emissions in 2008 was due to the injunction against the CARB's previous OGV auxiliary engine fuel regulation which was in place for the entire year in 2007.

Figure 9.2: DPM Emissions Comparison by Category, tons per year



As shown in Figure 9.3, HDVs followed by OGVs dominate the NO_x emissions followed by rail, cargo handling equipment and harbor craft. NO_x emissions also show a downward trend over the last several years.

Figure 9.3: NO_x Emissions Comparison by Category, tons per year

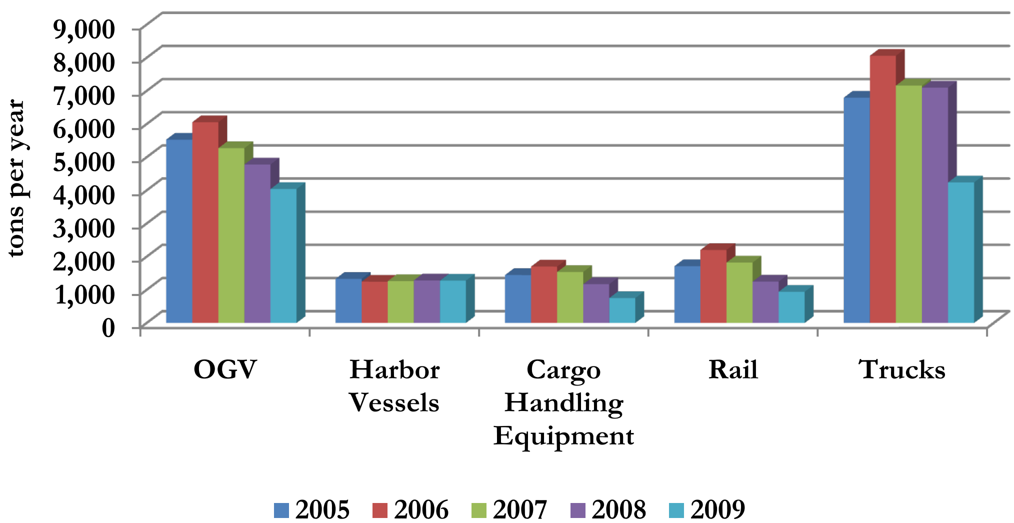


Figure 9.4 shows that OGVs are by far the largest contributors to SO_x emissions at the port (97% to over 99%) because of the slower penetration of cleaner (lower sulfur) fuels in OGVs compared to other source categories. SO_x emissions are directly affected by the type of fuel burned by engines. OGVs burn residual fuel with an average 2.7% sulfur content or marine distillate fuel (0.1 to 0.5% sulfur on average). The other source categories, with the exception of rail, have completely switched to using ULSD (15 ppm).

Figure 9.4: SO_x Emissions Comparison by Category, tons per year

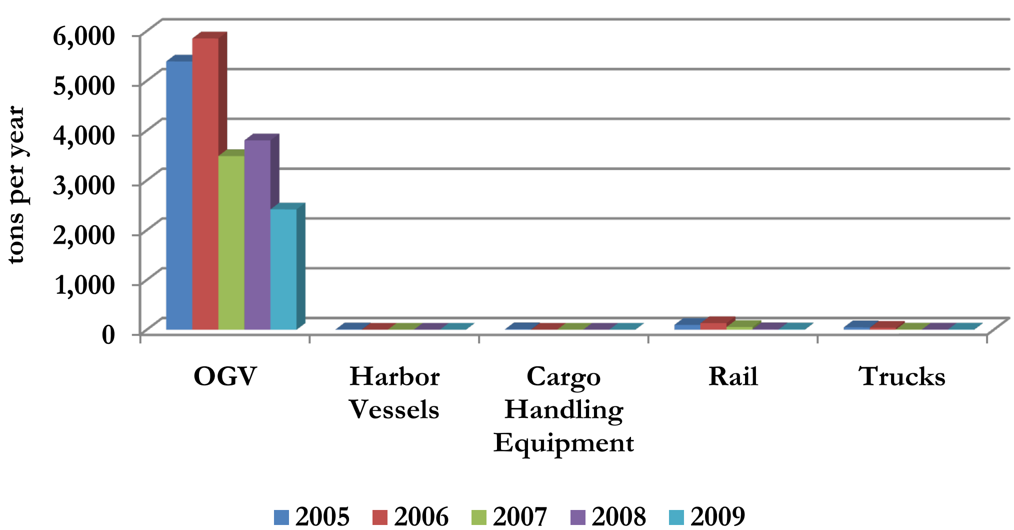


Table 9.4 compares the 2009 port-wide GHG emissions to the previous years. GHG emissions have continued to decrease over the years mainly due to lower activity.

Table 9.4: Port-wide GHG Emissions Comparison, metric tons per year

Year	CO_2 Equivalent	CO_2	N_2O	CH_4
2009	910,647	902,961	23	23
2008	1,047,251	1,038,239	27	35
2007	1,127,501	1,114,193	40	37
2006	1,276,634	1,243,487	104	42
2005	1,086,574	1,057,749	90	37
Previous Year (2009-2008)	**-13%**	**-13%**	**-13%**	**-33%**
CAAP Progress (2009-2005)	**-16%**	**-15%**	**-74%**	**-37%**

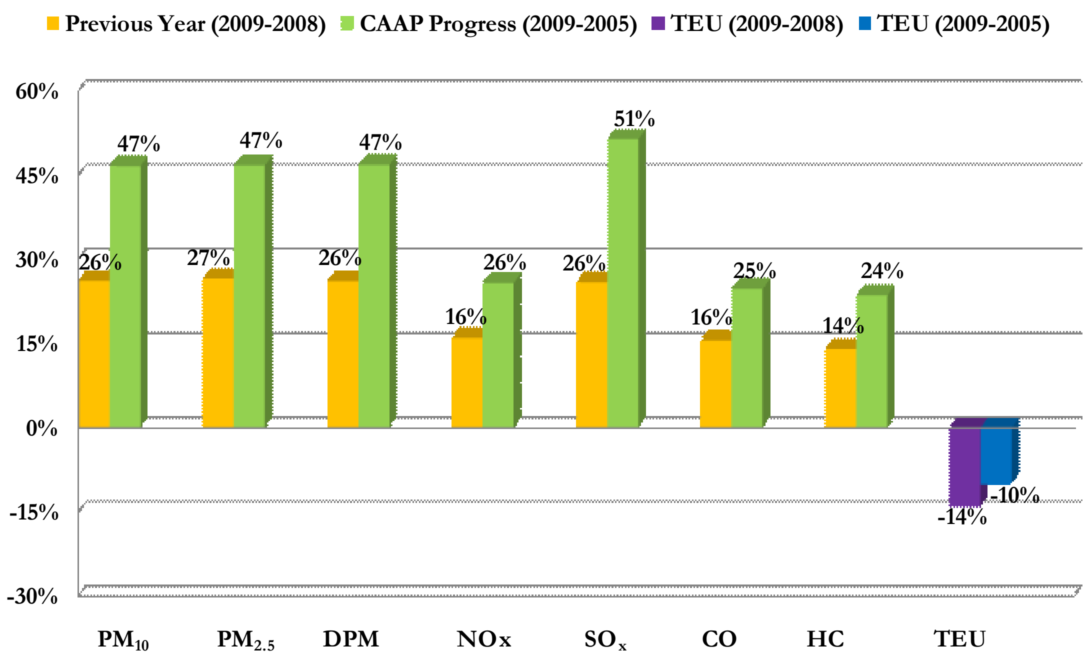
Table 9.5 and Figure 9.5 compare emissions efficiency changes from 2005 to 2009 which show that emissions per 10,000 TEU continue to improve over the years. A positive percent for the emissions efficiency comparison means an improvement in efficiency. In 2009, the overall port efficiency improved for all pollutants as compared to 2008 and 2005.

Table 9.5: Port-wide Emissions Efficiency, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.76	0.65	0.69	16.66	3.60	4.11	0.89
2008	1.03	0.88	0.94	19.84	4.87	4.87	1.03
2007	0.93	0.80	0.82	20.40	4.25	4.83	1.05
2006	1.35	1.15	1.23	22.74	7.11	5.50	1.16
2005	1.42	1.21	1.30	22.46	7.42	5.47	1.16
Previous Year (2009-2008)	**26%**	**27%**	**26%**	**16%**	**26%**	**16%**	**14%**
CAAP Progress (2009-2005)	**47%**	**47%**	**47%**	**26%**	**51%**	**25%**	**24%**

The purple bar represents TEU change from previous year (-14%) and the blue bar represents TEU change when compared to 2005 (-10%).

Figure 9.5: Port-wide Changes in Emissions Efficiency, % Change



9.1.1 Ocean-Going Vessels

The methodology used in 2009 to estimate ocean-going vessel emissions is the same as the methodology used in the 2008 Inventory of Air Emissions.

The various emission reduction strategies for ocean-going vessels are listed in Table 9.6 by percent of all calls from 2005 to 2009. Table 9.6 presents the following emission reductions strategies: 1) Slide Valve refers to the slide valve technology which is standard in newer MAN B&W main engines (2004+ model year vessels) and can also be retrofitted into existing engines. The percentage of calls with slide valves shown in Table 9.6 covers both new vessels and known retrofits; 2) IMO Compliant refers to calls by vessels meeting or exceeding IMO's Tier I standard (2000 and newer model years); 3) Shore Power refers to vessel calls using shore power at berth (instead of running their diesel-powered auxiliary engines); 4) Fuel Switch for auxiliary and main engines refers to vessel calls switching to lower sulfur fuel as a result of the Port's Fuel Incentive Program, CARB's marine fuel regulation, or the shipping company's corporate policy (e.g. Maersk) and 5) VSR refers to the vessel calls reducing their transit speed to 12 knots within 20 nm of the Port.

Table 9.6: OGV Emission Reduction Strategies, % of All Calls

Year	Slide Valve	IMO Compliant	Shore Power	Fuel Switch Main Eng	Fuel Switch Aux Eng	VSR
	Percent (%) of All Calls					
2009	27%	60%	3%	78%	78%	87%
2008	23%	48%	2%	38%	63%	86%
2007	22%	48%	3%	24%	100%	82%
2006	17%	46%	2%	13%	33%	71%
2005	11%	34%	2%	7%	27%	63%

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In 2009, the percentage of the main engines, auxiliary engines and auxiliary boilers that switched to lower sulfur marine fuel varied throughout the year with the implementation of CARB's marine fuel regulation and the Port's Fuel Incentive Program. A compliance rate of 100% is assumed for CARB's marine fuel regulation requiring the use of lower sulfur fuel (0.5% sulfur) in main and auxiliary engines and auxiliary boilers which became effective on July 1, 2009. The percent of vessel calls in 2009 switching to cleaner fuels (0.2% sulfur) under the Port's Fuel Incentive Program (in place for the first six months of 2009) in auxiliary engines at berth and main engines within 20 nm (or 40 nm) from the Port was approximately 13%. The only exception applied to the above assumption was for Maersk's corporate policy, based on the use of a maximum of 0.2% sulfur in main and auxiliary engines along the California coast, which was used to calculate Maersk's emissions for the entire year.

Also shown in Table 9.6, there were fuel switches in 2005, 2006, 2007, and 2008 which were associated with vessel operators' voluntary actions, CARB auxiliary engine fuel regulation, and the Port's Fuel Incentive Program.

Table 9.7 presents the overall engine activity (in terms of kW-hrs) from 2005 to 2009. Compared to 2009, the total engine activity decreased by 12% from 2008 and 24% from 2005.

Table 9.7: OGV Power Comparison, kW-hr

Year	Total All Engines Total kW-hr	Main Eng Total kW-hr	Aux Eng Total kW-hr	Boiler Total kW-hr
2009	313,840,018	100,057,594	142,089,943	71,692,482
2008	354,790,197	108,703,490	172,147,895	73,938,812
2007	422,022,283	113,935,708	204,507,495	103,579,080
2006	464,306,949	130,038,183	226,460,062	107,808,704
2005	415,321,809	124,527,173	196,943,790	93,850,846
Previous Year (2009-2008)	**-12%**	**-8%**	**-17%**	**-3%**
CAAP Progress (2009-2005)	**-24%**	**-20%**	**-28%**	**-24%**

Table 9.8 compares the OGV emissions for calendar years 2009, 2008, 2007, 2006, and 2005 in tons per year and as a percent change in 2009 compared to 2008 and 2005. The emissions for previous years are different from those in previously published reports because of changes in methodologies.

Table 9.8: OGV Emissions Comparison, tons per year and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	287	229	244	4,039	2,418	438	208
2008	426	341	358	4,780	3,805	484	224
2007	360	288	266	5,272	3,490	528	240
2006	626	501	527	6,056	5,852	569	253
2005	587	469	500	5,530	5,391	504	223
Previous Year (2009-2008)	**-33%**	**-33%**	**-32%**	**-16%**	**-36%**	**-10%**	**-7%**
CAAP Progress (2009-2005)	**-51%**	**-51%**	**-51%**	**-27%**	**-55%**	**-13%**	**-7%**

OGV emissions decreased for all pollutants in 2009 compared to 2008 and 2005. Reductions in OGV emissions are attributed to the decreased activity levels as well as the implementation of the Port's Vessel Speed Reduction and Low Sulfur Fuel Incentive Programs, increased use of shore power for vessels at berth, CARB's marine fuel regulation which became effective in the second half of 2009, and an increase in number of calls made by IMO compliant and slide valve equipped vessels.

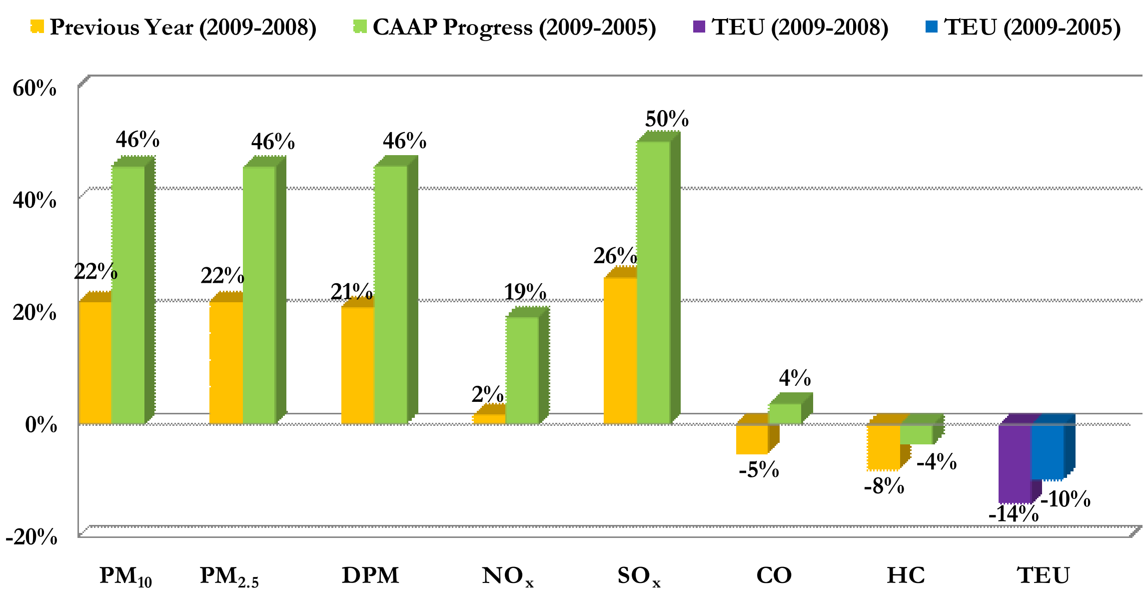
Table 9.9 and Figure 9.6 show the emissions efficiency changes for 2009-2008 and 2009-2005. A positive percent for the emissions efficiency comparison means an improvement in efficiency. As indicated, emission efficiency improved for all pollutants in 2009 compared to 2008 except for CO and HC which decreased slightly. For 2009-2005, emission efficiency also improved for all pollutants, except for HC.

Table 9.9: OGV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.42	0.34	0.36	5.98	3.58	0.65	0.31
2008	0.54	0.43	0.46	6.09	4.85	0.62	0.29
2007	0.43	0.35	0.32	6.31	4.18	0.63	0.29
2006	0.74	0.59	0.62	7.15	6.91	0.67	0.30
2005	0.78	0.63	0.67	7.39	7.20	0.67	0.30
Previous Year (2009-2008)	**22%**	**22%**	**21%**	**2%**	**26%**	**-5%**	**-8%**
CAAP Progress (2009-2005)	**46%**	**46%**	**46%**	**19%**	**50%**	**4%**	**-4%**

The purple bar represents the TEU change from the previous year (-14%) and the blue bar represents the TEU change when compared to 2005 (-10%).

Figure 9.6: OGV Emissions Efficiency Comparison, %



9.1.2 Harbor Craft

The methodology used in 2009 to estimate harbor craft emissions is the same as the methodology used in the 2008 Inventory of Air Emissions.

Table 9.10 summarizes the number of harbor craft inventoried from 2005 to 2009. Overall, the total vessel count increased by about 2% from 2008 to 2009 and decreased by 3% between 2005 and 2009, highlighting the variability in harbor craft operations from year to year.

Table 9.10: Harbor Craft Count Comparison

Harbor Vessel Type	2009 Count	2008 Count	2007 Count	2006 Count	2005 Count
Assist tug	18	20	16	16	16
Commercial fishing	148	138	140	121	156
Crew boat	19	21	22	19	14
Excursion	27	24	24	24	24
Ferry	10	10	9	9	9
Government	22	21	27	26	26
Ocean tug	6	7	7	7	7
Tugboat	20	20	23	20	19
Work boat	8	12	15	15	14
Total	**278**	**273**	**283**	**257**	**285**

Table 9.11 summarizes the percent distribution of engines based on EPA's engine standards from 2005 to 2009. As expected, the percentage of Tier 2 engines has continued to increase over the years based on the introduction of newer vessels with newer engines into the fleet and replacements of existing higher-emitting engines with cleaner engines.

Table 9.11: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2	Unknown
2009	31%	30%	16%	23%
2008	36%	30%	13%	22%
2007	18%	30%	5%	47%
2006	17%	32%	6%	45%
2005	15%	32%	4%	49%

For this comparison, the harbor craft engines were categorized by EPA's Tier 0, Tier 1 and Tier 2 engine standards for vessels with known engine model year and horsepower, or were classified as "unknown" for vessels for which the engine model year or horsepower information was not available, as follows:

- Tier 0 are 1999 and older model year engines
- Tier 1 engines' model year ranges from 2000 to 2003 (less than or equal to 750 hp engines) and from 2000 to 2006 (greater than 750 hp engines)
- Tier 2 engines' model years are 2004+ (less than or equal to 750 hp engines) and 2007+ (greater than 750 hp engines)
- Unknown refers to engines with missing model year, horsepower or both

The majority of engine replacements occurred prior to 2005 under the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor, replacing Tier 0 engines with Tier 1 or 2 engines. The percentage of Tier 0 engines shown in Table 9.11 is not likely representative of the actual number of Tier 0 engines in the harbor area because of the significant number of vessels with unknown model year or horsepower information, most of which are expected to have Tier 0 engines (e.g., for fishing vessels, which very limited information was available).

Table 9.12 compares the number of engines (main and auxiliary engines combined) by vessel type and Tier level for 2005 to 2009. Although a number of vessels have already been repowered, there are still many Tier 0 engines at the Port. This is due to the high cost of replacing engines and the time it requires for the vessel to be out of service resulting in lost revenue for the harbor craft owners. As shown in Table 9.12, fishing vessels account for a vast majority of vessels with unknown engine model years and horsepower, most of which are expected to be older vessels and equipped with Tier 0 engines.

Table 9.12: Harbor Craft Engine Standards Comparison by Vessel Type

Vessel Type	2009 Tier 0	2009 Tier 1	2009 Tier 2	2009 Unknown	2009 Total	2008 Tier 0	2008 Tier 1	2008 Tier 2	2008 Unknown	2008 Total
Assist Tug	30	16	22	4	72	32	24	20	4	80
Commercial Fishing	50	32	4	89	175	59	31	4	70	164
CrewBoat	31	16	13	0	60	39	18	8	0	65
Excursion	26	25	2	23	76	26	25	2	17	70
Ferry	0	32	4	0	36	0	32	4	0	36
Government	10	21	9	4	44	10	11	4	14	39
Ocean Tug	4	12	8	0	24	8	12	8	0	28
Tugboat	13	17	28	10	68	27	19	20	1	67
WorkBoat	15	5	6	2	28	6	5	3	20	34
Total	**179**	**176**	**96**	**132**	**583**	**207**	**177**	**73**	**126**	**583**
% of Total	**31%**	**30%**	**16%**	**23%**	**100%**	**36%**	**30%**	**13%**	**22%**	**100%**

Vessel Type	2007 Tier 0	2007 Tier 1	2007 Tier 2	2007 Unknown	2007 Total	2006 Tier 0	2006 Tier 1	2006 Tier 2	2006 Unknown	2006 Total
Assist Tug	20	24	4	16	64	20	24	4	15	63
Commercial Fishing	0	33	3	130	166	0	35	3	110	148
CrewBoat	30	18	9	12	69	17	18	9	13	57
Excursion	12	25	2	31	70	14	23	2	31	70
Ferry	2	28	0	2	32	2	28	0	2	32
Government	9	12	0	27	48	11	12	0	23	46
Ocean Tug	16	8	0	4	28	16	8	0	4	28
Tugboat	14	24	12	26	76	10	25	12	20	67
WorkBoat	5	5	2	30	42	5	5	2	30	42
Total	**108**	**177**	**32**	**278**	**595**	**95**	**178**	**32**	**248**	**553**
% of Total	**18%**	**30%**	**5%**	**47%**	**100%**	**17%**	**32%**	**6%**	**45%**	**100%**

Vessel Type	2005 Tier 0	2005 Tier 1	2005 Tier 2	2005 Unknown	2005 Total
Assist Tug	20	26	2	15	63
Commercial Fishing	0	43	3	151	197
CrewBoat	11	18	9	3	41
Excursion	14	23	2	31	70
Ferry	4	24	0	4	32
Government	11	12	0	23	46
Ocean Tug	16	8	0	4	28
Tugboat	12	25	6	20	63
WorkBoat	1	7	0	30	38
Total	**89**	**186**	**22**	**281**	**578**
% of Total	**15%**	**32%**	**4%**	**49%**	**100%**

As shown in Table 9.13, there was a 2% increase in vessel count. However, there is no change in overall engine count in 2009 compared to 2008. The activity level for harbor craft (measured as a product of the rated engine size in kW, annual operating hours and load factors) increased by 2% in 2009 compared to the previous year and decreased slightly compared to 2005. The slight increase in the overall activity level is partially due to the activity data provided (in 2009 but not in 2008) for some crew boats and work boats which may have included their entire operating domain (including services to oil facilities) beyond port-related activities.

Table 9.13: Harbor Craft Comparison

Year	Vessel Count	Engine Count	Total kW-hr-lf
2009	278	583	85,340,167
2008	273	583	83,832,177
2007	281	597	86,102,396
2006	256	553	84,911,739
2005	255	578	86,193,466
Previous Year (2009-2008)	**2%**	**0%**	**2%**
CAAP Progress (2009-2005)	**9%**	**1%**	**-1%**

Table 9.14 shows the harbor craft activity comparison by vessel type for calendar years 2005 to 2009. While several vessel types experienced a decrease in activity from 2008 to 2009, work boats, crew boats, excursion vessels and government vessels had more noticeable increases in activity levels in 2009.

Table 9.14: Harbor Craft Activity Comparison by Type

Vessel Type	2009 Total kW-hr-lf	2008 Total kW-hr-lf	2007 Total kW-hr-lf	2006 Total kW-hr-lf	2005 Total kW-hr-lf
Assist Tug	26,981,055	26,455,256	28,199,475	29,326,156	25,216,358
Commercial Fishing	11,292,471	12,435,917	12,561,312	11,129,915	14,100,514
CrewBoat	7,117,574	5,239,643	5,405,789	4,771,333	2,894,600
Excursion	8,880,701	8,032,825	11,478,645	11,478,645	11,478,645
Ferry	14,166,552	14,166,552	13,127,241	13,127,241	13,127,241
Government	3,003,841	2,578,877	2,930,317	2,997,617	2,997,617
Ocean Tug	6,025,998	6,190,690	2,899,793	2,899,793	3,148,265
Tugboat	4,058,737	6,376,719	7,608,589	7,289,805	11,374,109
WorkBoat	3,813,237	2,355,698	1,891,234	1,891,234	1,856,117
Total	**85,340,167**	**83,832,177**	**86,102,396**	**84,911,739**	**86,193,466**

Table 9.15 shows the emissions comparisons for calendar years 2005 to 2009 for harbor craft.

Table 9.15: Harbor Craft Emission Comparison, tons per year and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	56	51	56	1,276	1	390	92
2008	56	51	56	1,284	1	374	91
2007	52	48	52	1,263	1	343	84
2006	51	47	51	1,245	1	339	82
2005	56	51	56	1,332	6	367	88
Previous Year (2009-2008)	**-1%**	**-1%**	**-1%**	**-1%**	**1%**	**4%**	**1%**
CAAP Progress (2009-2005)	**0%**	**0%**	**0%**	**-4%**	**-90%**	**6%**	**5%**

Although the overall vessel count and activity increased by about 2% in 2009 as compared to 2008, emissions decreased for PM and NO_x due to the introduction of newer vessels and engine replacements with cleaner engines. The slight increase in HC and CO is more directly related to change in activity level with lesser impact from introduction of cleaner engines that do not have lower CO and HC standards reflecting the composition of vessels and engines model years. Increase in SOx is attributed to increase in activity and the use of ULSD fuel in 2008 and 2009.

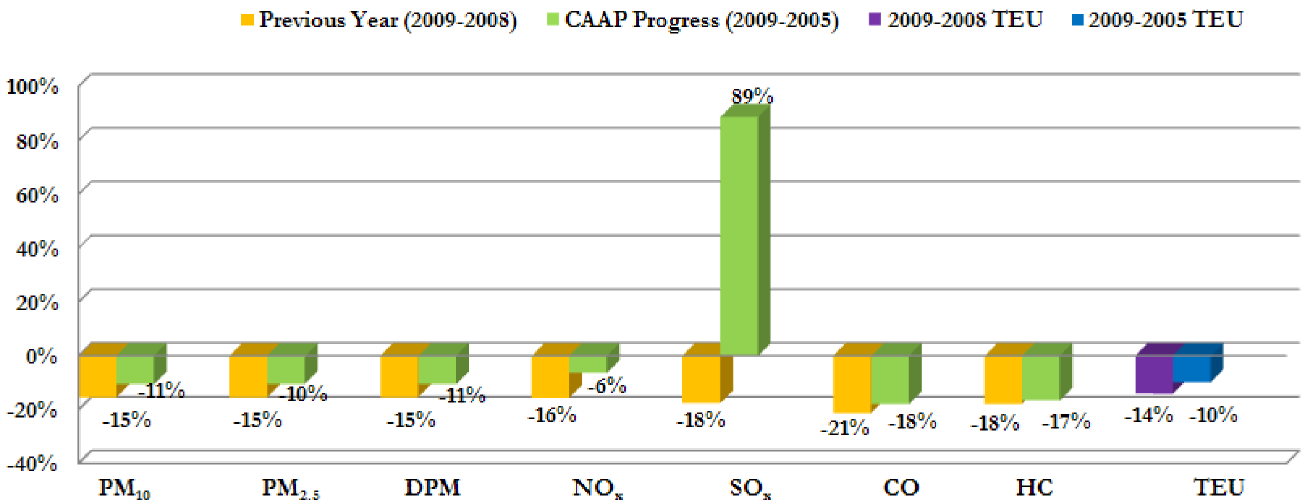
Table 9.16 shows the emissions efficiency changes from 2005 to 2009. It should be noted that the total harbor craft emissions were used for this efficiency comparison although emissions from several harbor craft types (e.g. commercial fishing vessels) are not dependent on container throughput. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.16: Harbor Craft Emissions Efficiency Comparison, tons/10,000 TEU & %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.08	0.08	0.08	1.89	0.00	0.58	0.14
2008	0.07	0.07	0.07	1.64	0.00	0.48	0.12
2007	0.06	0.06	0.06	1.51	0.00	0.41	0.10
2006	0.06	0.06	0.06	1.47	0.00	0.40	0.10
2005	0.07	0.07	0.07	1.78	0.01	0.49	0.12
Previous Year (2009-2008)	**-15%**	**-15%**	**-15%**	**-16%**	**-18%**	**-21%**	**-18%**
CAAP Progress (2009-2005)	**-11%**	**-10%**	**-11%**	**-6%**	**89%**	**-18%**	**-17%**

Figure 9.7 shows the emissions efficiency comparisons between 2009 and 2008 and between 2009 and 2005 for CAAP progress for harbor vessels. The purple bar represents the TEU change from the previous year (-14%) and the blue bar represents the TEU change when compared to 2005 (-10%).

Figure 9.7: Harbor Craft Emissions Efficiency Comparison, %



9.1.3 Cargo Handling Equipment

The 2009 methodology to estimate cargo handling emissions is the same as the methodology used in the 2008 Inventory of Air Emissions.

Table 9.17 shows a 7% decrease in the number of cargo handling equipment and a 14% decrease in the overall activity level (measured as a product of the rated engine size in kW, annual operating hours and load factors) in 2009 compared to 2008. The decrease in population and overall activity is attributed to the slowdown in the economy and the resulting handling of less cargo as well as retirement of older equipment in compliance with CARB's CHE regulation and the Port's CAAP measure. From 2005 to 2009, there was a 12% increase in population and 31% decrease in activity level.

Table 9.17: CHE Count and Activity Comparison

	Total Population	kW-hr-lf
2009	2,000	166,351,503
2008	2,141	194,741,187
2007	2,014	205,802,047
2006	1,995	223,652,392
2005	1,782	243,218,670
Previous Year (2009-2008)	**-7%**	**-14%**
CAAP Progress (2009-2005)	**12%**	**-31%**

Table 9.18 summarizes the various engine and power types for CHE, including electric, liquefied natural gas (LNG), diesel, propane, and gasoline.

Table 9.18: CHE Engine Type Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
2009						
Forklifts	3	0	342	8	185	538
Wharf gantry cranes	73	0	0	0	0	73
RTG cranes	0	0	0	0	108	108
Side handlers	0	0	0	0	40	40
Top handlers	0	0	0	0	154	154
Yard tractors	0	5	55	0	902	962
Sweepers	0	0	0	2	13	15
Other	21	0	0	0	89	110
Total	**97**	**5**	**397**	**10**	**1,491**	**2,000**
2008						
Forklifts	1	0	365	8	177	551
Wharf gantry cranes	69	0	0	0	0	69
RTG cranes	0	0	0	0	111	111
Side handlers	0	0	0	0	40	40
Top handlers	0	0	0	0	138	138
Yard tractors	0	0	55	0	1059	1,114
Sweepers	0	0	0	2	11	13
Other	19	0	0	1	85	105
Total	**89**	**0**	**420**	**11**	**1,621**	**2,141**
2007						
Forklifts	1	0	350	8	175	534
Wharf gantry cranes	69	0	0	0	0	69
RTG cranes	0	0	0	0	107	107
Side handlers	0	0	0	0	43	43
Top handlers	0	0	0	0	138	138
Yard tractors	0	2	58	0	947	1,007
Sweepers	0	0	0	2	9	11
Other	19	0	0	1	85	105
Total	**89**	**2**	**408**	**11**	**1,504**	**2,014**
2006						
Forklifts	0	0	355	8	191	554
Wharf gantry cranes	69	0	0	0	0	69
RTG cranes	0	0	0	0	103	103
Side handlers	0	0	0	0	43	43
Top handlers	0	0	0	0	134	134
Yard tractors	0	2	58	0	897	957
Sweepers	0	0	0	2	10	12
Other	19	0	0	0	104	123
Total	**88**	**2**	**413**	**10**	**1,482**	**1,995**
2005						
Forklifts	0	0	263	8	151	422
Wharf gantry cranes	67	0	0	0	0	67
RTG cranes	0	0	0	0	98	98
Side handlers	0	0	0	0	41	41
Top handlers	0	0	0	0	127	127
Yard tractors	0	0	53	0	848	901
Sweepers	0	0	0	3	8	11
Other	12	0	0	0	103	115
Total	**79**	**0**	**316**	**11**	**1376**	**1,782**

Table 9.19 summarizes the number and percent of diesel powered CHE with various emission controls by equipment type from 2005 to 2009. The emission controls for CHE include: DOCs, DPFs, on-road engines (CHE equipped with on-road engines instead of off-road engines), LNG, use of ULSD with a maximum sulfur content of 15 ppm, and Emulsified Fuel. Several items to note include:

- Since emission controls can be used in combination with each other, the number of equipment with controls (shown in Table 9.18) cannot be added across to come up with total equipment count (counts of equipment with controls are greater than total equipment counts).

- With implementation of the Port's CAAP measure for CHE and CARB's CHE regulation, the number of cargo handling equipment equipped with on-road engines has continued to increase over the years (e.g., 601 in 2008 to 670 in 2009).

- Mainly due to turnover, the DOCs and DPFs counts have continued to decrease as older equipment with DOCs and DPFs were replaced with newer equipment that did not require the use of DOCs or were already equipped with DPFs.

- Emulsified fuel has not been used since 2006 due to supplier unavailability

- ULSD was used in 2006, 2007, 2008, and 2009 by all diesel equipment.

Table 9.19: CHE Diesel Equipment Emissions Control Matrix

Equipment	DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel	Emulsified Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel	Emulsified Fuel
2009											
Forklifts	3	4	1	185	0	185	2%	2%	1%	100%	0%
RTG cranes	10	0	0	108	0	108	9%	0%	0%	100%	0%
Side handlers	9	0	0	40	0	40	23%	0%	0%	100%	0%
Top handlers	52	0	0	154	0	154	34%	0%	0%	100%	0%
Yard tractors	229	661	18	902	0	902	25%	73%	2%	100%	0%
Sweepers	0	1	0	13	0	13	0%	8%	0%	100%	0%
Other	0	4	0	89	0	89	0%	4%	0%	100%	0%
Total	**303**	**670**	**19**	**1,491**	**0**	**1,491**	**20%**	**45%**	**1%**	**100%**	**0%**
2008											
Forklifts	3	4	0	177	0	177	2%	2%	0%	100%	0%
RTG cranes	10	0	0	111	0	111	9%	0%	0%	100%	0%
Side handlers	11	0	0	40	0	40	28%	0%	0%	100%	0%
Top handlers	50	0	0	138	0	138	36%	0%	0%	100%	0%
Yard tractors	370	592	76	1059	0	1059	35%	56%	7%	100%	0%
Sweepers	0	1	0	11	0	11	0%	9%	0%	100%	0%
Other	0	4	0	85	0	85	0%	5%	0%	100%	0%
Total	**444**	**601**	**76**	**1,621**	**0**	**1,621**	**27%**	**37%**	**5%**	**100%**	**0%**
2007											
Forklifts	4	4	0	175	0	175	2%	2%	0%	100%	0%
RTG cranes	10	0	0	107	0	107	9%	0%	0%	100%	0%
Side handlers	13	0	0	43	0	43	30%	0%	0%	100%	0%
Top handlers	54	0	0	138	0	138	39%	0%	0%	100%	0%
Yard tractors	508	273	58	947	0	947	54%	29%	6%	100%	0%
Sweepers	0	1	0	9	0	9	0%	11%	0%	100%	0%
Other	0	3	0	85	0	85	0%	4%	0%	100%	0%
Total	**589**	**281**	**58**	**1,504**	**0**	**1,504**	**39%**	**19%**	**4%**	**100%**	**0%**
2006											
Forklifts	4	4	0	191	15	191	2%	2%	0%	100%	8%
RTG cranes	10	0	0	103	28	103	10%	0%	0%	100%	27%
Side handlers	13	0	0	43	10	43	30%	0%	0%	100%	23%
Top handlers	54	0	0	134	42	134	40%	0%	0%	100%	31%
Yard tractors	531	216	0	897	128	897	59%	24%	0%	100%	14%
Sweepers	0	1	0	10	0	10	0%	10%	0%	100%	0%
Other	0	5	0	104	0	104	0%	5%	0%	100%	0%
Total	**612**	**226**	**0**	**1,482**	**223**	**1,482**	**41%**	**15%**	**0%**	**100%**	**15%**
2005											
Forklifts	3	0	0	27	15	151	2%	0%	0%	18%	10%
RTG cranes	0	0	0	36	28	98	0%	0%	0%	37%	29%
Side handlers	14	0	0	16	10	41	34%	0%	0%	39%	24%
Top handlers	48	0	0	79	36	127	38%	0%	0%	62%	28%
Yard tractors	520	164	0	483	129	848	61%	19%	0%	57%	15%
Sweepers	0	0	0	0	0	8	0%	0%	0%	0%	0%
Other	0	1	0	65	0	103	0%	1%	0%	63%	0%
Total	**585**	**165**	**0**	**706**	**218**	**1376**	**43%**	**12%**	**0%**	**51%**	**16%**

Table 9.20 compares the total number of cargo handling equipment with off-road diesel engines (meeting Tier 0, 1, 2, 3 and 4 off-road diesel engine standards) and those equipped with on-road diesel engines from 2005 to 2009. Since classification of engine standards is based on the engine's model year and horsepower, equipment with unknown horsepower or model year information are listed separately under the Unknown Tier column in this table. As indicated, over the last five years, implementation of the CAAP's CHE measure and CARB's CHE regulation have resulted in a steady increase in the number of newer and cleaner equipment (i.e., primarily Tier 2 and Tier 3 with a few Tier 4) replacing the older and higher-emitting equipment (Tier 0 and Tier 1). In addition, the number of equipment with on-road engines which are even cleaner than Tier 3 off-road engines have significantly increased since 2005.

Table 9.20: CHE Diesel Engine Tier Comparison

EI Year	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	On-road Engine	Unknown Tier	Total Diesel
2009	114	194	381	120	6	670	6	1,491
2008	135	422	401	57	0	601	5	1,621
2007	202	578	387	36	0	293	8	1,504
2006	227	599	398	29	0	225	4	1,482
2005	256	582	360	0	0	165	13	1,376
Previous Year (2009-2008)	**-16%**	**-54%**	**-5%**	**111%**	**100%**	**11%**	**20%**	**-8%**
CAAP Progress (2009-2005)	**-55%**	**-67%**	**6%**	**100%**	**100%**	**306%**	**-54%**	**8%**

The cargo handling equipment emission estimating methodology used in 2009 was the same as the methodology used in 2008. However, methodological improvements have been made since the 2001 inventory for cargo handling equipment (e.g., load factors for yard tractors and RTG cranes were updated in 2006 and 2008 inventories based on joint ports studies in consultation with CARB to develop more representative and port-specific load factors). Therefore, the previous years' emissions were re-estimated using the 2009 methodology.

Table 9.21 shows the emissions comparisons for calendar years 2009, 2008, 2007, 2006, and 2005 for cargo handling equipment in tons per year and as a percent change for 2009 compared to 2008 and 2005 (CAAP progress). As shown, the emissions for all pollutants have decreased over the years. Compared to 2008, the 2009 emissions have experienced a significant drop due to reduced container throughput levels in 2009 and implementation of the Port's CHE measure and CARB's CHE regulation resulting in the introduction of newer equipment with cleaner engines and the installation of emission controls.

Table 9.21: CHE Emissions Comparison, tons per year and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	25	24	24	750	1	712	40
2008	34	32	33	1,169	2	740	47
2007	43	40	41	1,537	2	891	76
2006	48	45	47	1,700	2	939	87
2005	45	41	44	1,444	9	742	75
Previous Year (2009-2008)	**-26%**	**-26%**	**-26%**	**-36%**	**-15%**	**-4%**	**-16%**
CAAP Progress (2009-2005)	**-43%**	**-43%**	**-44%**	**-48%**	**-84%**	**-4%**	**-47%**

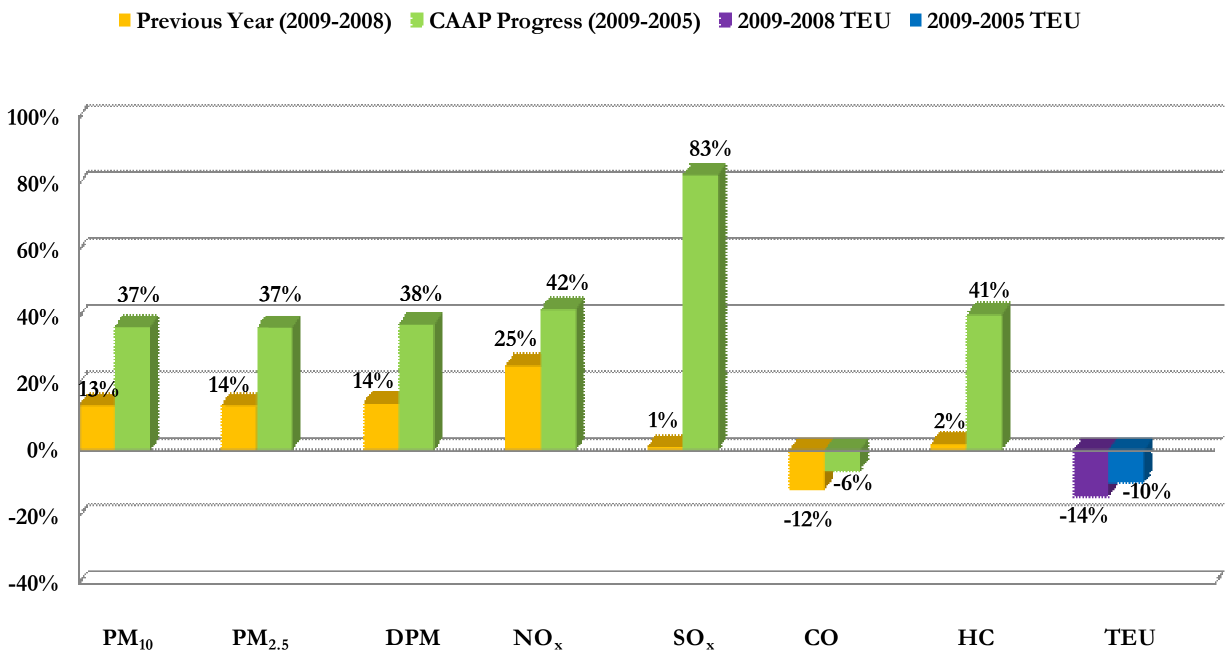
Table 9.22 shows the emissions efficiency changes over the last five years. From 2008 to 2009, there was a 14% decrease in TEU throughput, and a 1% to 25% improvement in efficiency, except for CO. From 2005 to 2009, there was a 10% decrease in TEU throughput, but emissions efficiency improved by 37% to 83% for all pollutants, with the exception of CO. The change in CO emissions efficiency is related to the slower rate of reduction in CO engine standards and emissions compared to other pollutants and the composition of equipment types and model years. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.22: CHE Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.04	0.03	0.04	1.11	0.00	1.05	0.06
2008	0.04	0.04	0.04	1.49	0.00	0.94	0.06
2007	0.05	0.05	0.05	1.84	0.00	1.07	0.09
2006	0.06	0.05	0.06	2.01	0.00	1.11	0.10
2005	0.06	0.06	0.06	1.93	0.01	0.99	0.10
Previous Year (2009-2008)	**13%**	**14%**	**14%**	**25%**	**1%**	**-12%**	**2%**
CAAP Progress (2009-2005)	**37%**	**37%**	**38%**	**42%**	**83%**	**-6%**	**41%**

Figure 9.8 shows the CHE emissions efficiency comparisons between 2009 and 2008 and between 2009 and 2005 for the CAAP progress. The purple bar represents the TEU change from the previous year (-14%) and the blue bar represents the TEU change when compared to 2005 (-10%).

Figure 9.8: CHE Emissions Efficiency Comparison, %



9.1.4 Rail Locomotives

The methodology used in 2009 to estimate rail emissions is the same as the methodology used in the 2008 Inventory of Air Emissions except for the use of updated EPA's switcher locomotive emission factors.

Table 9.23 shows the throughput comparisons for rail locomotives for 2005, 2006, 2007, 2008, and 2009. Compared to 2008, there was a 14% decrease in total TEU throughput and a 13% decrease in on-dock TEUs in 2009. The percentage of on-dock TEU remained constant between both 2008 and 2009, and 2005 and 2009.

Table 9.23: TEU Throughput Comparison

Throughput	2005	2006	2007	2008	2009
Total TEU Throughput	7,484,615	8,469,980	8,355,038	7,849,985	6,748,995
On-dock lifts	1,022,269	1,333,383	1,134,269	1,075,237	939,477
On-dock TEUs*	1,840,084	2,400,089	2,041,684	1,935,427	1,691,059
% On-Dock	25%	28%	24%	25%	25%

* At an average 1.8 TEU/container

The methodology used in 2009 to estimate rail locomotive emissions changed due to the updated EPA emission factors for switcher locomotives; therefore rail emissions were re-estimated using latest emission factors for comparison with prior years. Table 9.24 shows the locomotive emissions estimate for calendar year 2009, 2008, 2007, 2006 and 2005 (using 2009 methodology) in tons per year and as a percent change. The decrease in emissions for rail in 2009 is primarily due to lower activity in 2009, rail efficiency improvements, and turn over to cleaner locomotives.

Table 9.24: Rail Emission Comparison, tons per year and %

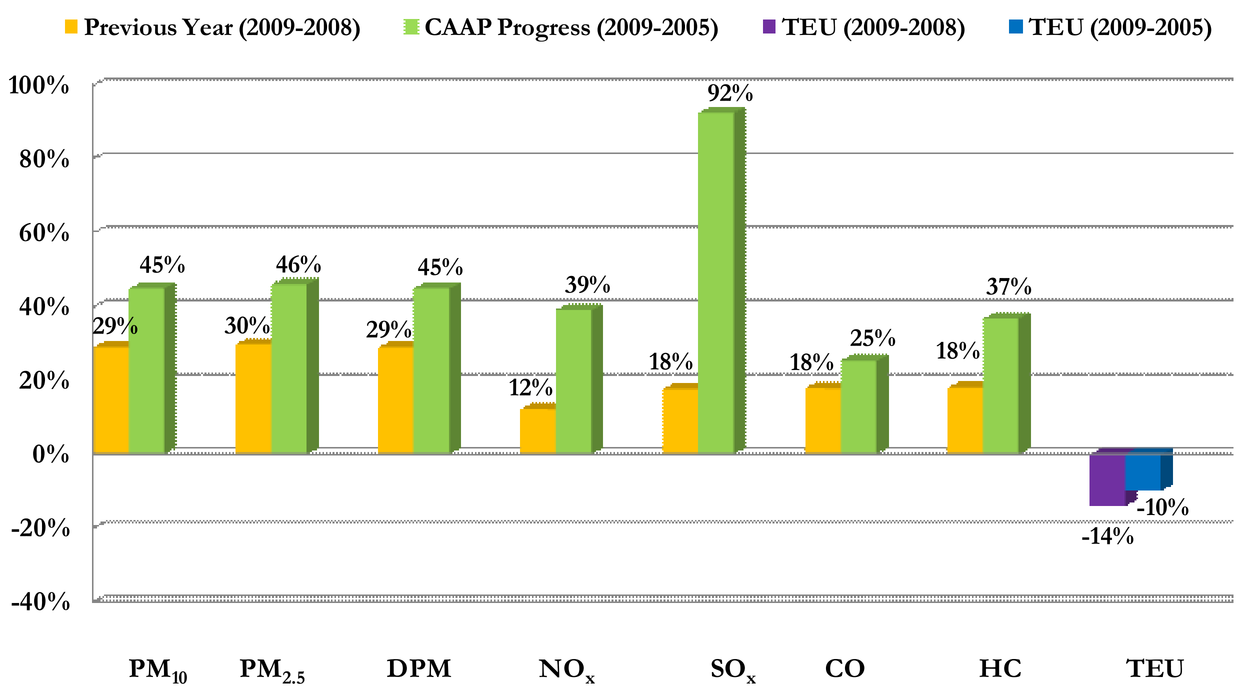
EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	28	26	28	940	7	160	51
2008	46	43	46	1,246	9	226	72
2007	61	57	61	1,821	55	268	98
2006	74	69	74	2,202	132	320	119
2005	57	53	57	1,712	98	237	89
Previous Year (2009-2008)	**-39%**	**-40%**	**-39%**	**-25%**	**-29%**	**-29%**	**-30%**
CAAP Progress (2009-2005)	**-50%**	**-51%**	**-50%**	**-45%**	**-93%**	**-33%**	**-43%**

Table 9.25 and Figure 9.9 show the emissions efficiency changes from 2005 to 2009. A positive percent for the emissions efficiency comparison means an improvement in efficiency. For both the previous year comparison (2009-2008) and CAAP progress (2009-2005), emission efficiencies have improved for all pollutants.

Table 9.25: Rail Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.04	0.04	0.04	1.39	0.01	0.24	0.08
2008	0.06	0.05	0.06	1.59	0.01	0.29	0.09
2007	0.07	0.07	0.07	2.18	0.07	0.32	0.12
2006	0.09	0.08	0.09	2.60	0.16	0.38	0.14
2005	0.08	0.07	0.08	2.29	0.13	0.32	0.12
Previous Year (2009-2008)	**29%**	**30%**	**29%**	**12%**	**18%**	**18%**	**18%**
CAAP Progress (2009-2005)	**45%**	**46%**	**45%**	**39%**	**92%**	**25%**	**37%**

Figure 9.9: Rail Emissions Efficiency Comparison, %



9.1.5 Heavy-Duty Vehicles

The methodology used in 2009 to estimate HDV emissions is the same methodology as used in the 2008 Inventory of Air Emissions, with the exception of using call-weighted model year distribution instead of population weighted distribution. Please refer to section 7.5.7 for discussion of this improvement to methodology.

Emissions from the HDV source category have continued to improve, due largely to the following factors affecting the number of truck visits, newer trucks, and average idling times.

- Reduced number of truck terminal visits in 2009 due to the economic downturn.

- Younger fleet of trucks in 2009 due to the Port's CTP launched October 2008 which includes a progressive ban of older trucks between 2008 and 2012.

- The terminals continued to optimize their gate systems with OCR and the addition of RFID readers to identify and help check in trucks complying with the CTP ban provisions, which also helped reduce idling time.

- Assembly Bill 2650 (known as the Lowenthal Bill), introduced in 2004, required that each marine terminal in California operate in a manner that does not cause the engines on trucks to idle or queue for more than 30 minutes while waiting to enter the gate into the marine terminal.

- Since July 2005, all marine terminals, at the Ports of Los Angeles and Long Beach, offer off-peak shifts on nights and weekends. As part of the program, a Traffic Mitigation Fee is required for cargo movement through the ports during peak daytime hours.

Table 9.26 shows the continuous improvement in total port-wide idling time.

Table 9.26: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2009	1,830,371
2008	2,097,600
2007	2,334,568
2006	2,962,463
2005	3,017,252
Previous Year (2009-2008)	**-13%**
CAAP Progress (2009-2005)	**-39%**

Table 9.27 summarizes the average age of the port-related fleet from 2005 to 2009. Compared to 2008, the average age of trucks visiting the Port has decreased from an average 12.1 to 10.9 years (population-weighted) and 6.9 years (call-weighted) due to the Port's Clean Truck Program which was launched in October 2008 requiring the progressive ban of pre-2007 trucks between 2008 and 2012.

Table 9.27: Port-related Fleet Weighted Average Age

Year	Population-Weighted Average Age (years)	Call-Weighted Average Age (years)
2009	10.9	6.9
2008	12.1	11.6
2007	12.2	12.4
2006	11.4	11.3
2005	11.2	11.2

Table 9.28 summarizes the HDV emissions from 2005 to 2009 and the percent change in 2009 compared to 2008 and 2005. As shown, the HDV emissions in 2009 have decreased for all pollutants due to the implementation of the Clean Truck Program, reduced on-terminal idling and reduced cargo throughput.

Table 9.28: HDV Emissions Comparison, tons per year and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	115	106	115	4,238	5	1,077	208
2008	243	223	243	7,098	5	2,003	376
2007	261	240	261	7,160	6	2,007	378
2006	340	313	340	8,059	40	2,490	439
2005	318	293	318	6,795	48	2,242	395
Previous Year (2009-2008)	**-53%**	**-53%**	**-53%**	**-40%**	**-8%**	**-46%**	**-45%**
CAAP Progress (2009-2005)	**-64%**	**-64%**	**-64%**	**-38%**	**-90%**	**-52%**	**-47%**

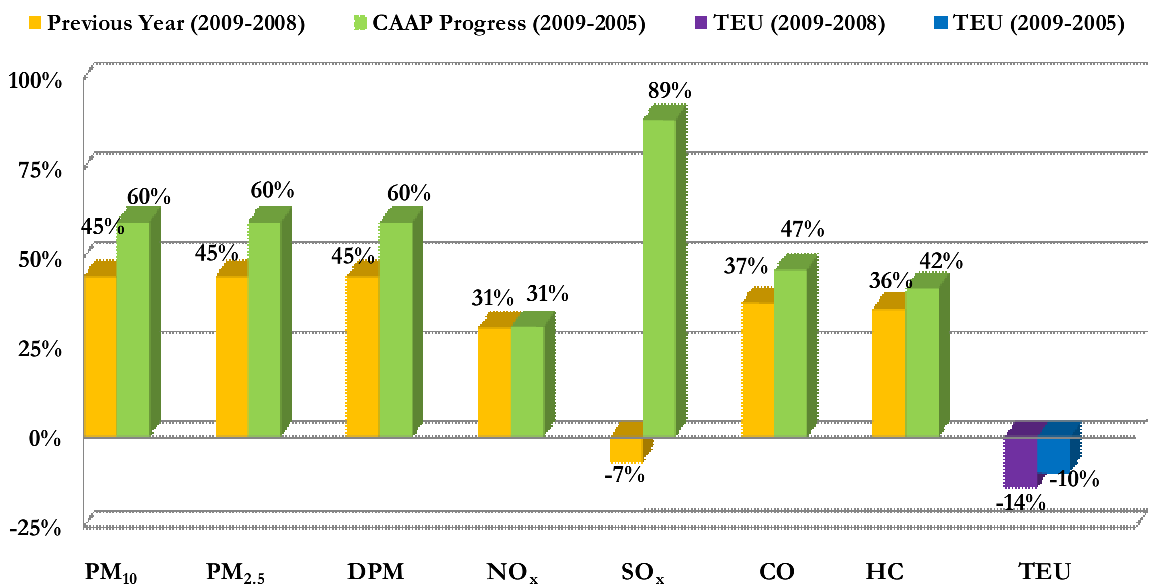
Table 9.29 and Figure 9.10 show the emissions efficiency changes. A positive percent for the emissions efficiency comparison means an improvement in efficiency. Comparing 2009 to 2005 for CAAP progress, emission efficiency has improved for all pollutants. Comparing 2009 to 2008, emission efficiency has improved for all pollutants, except for a slight decrease in SO_x emissions efficiency caused by a decrease in the miles-per-gallon figure underlying the 2009 emissions modeling run.

Table 9.29: HDV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2009	0.17	0.16	0.17	6.28	0.01	1.60	0.31
2008	0.31	0.28	0.31	9.04	0.01	2.55	0.48
2007	0.31	0.29	0.31	8.57	0.01	2.40	0.45
2006	0.40	0.37	0.40	9.51	0.05	2.94	0.52
2005	0.43	0.39	0.43	9.08	0.06	3.00	0.53
Previous Year (2009-2008)	**45%**	**45%**	**45%**	**31%**	**-7%**	**37%**	**36%**
CAAP Progress (2009-2005)	**60%**	**60%**	**60%**	**31%**	**89%**	**47%**	**42%**

The purple bar represents the TEU change from the previous year (-14%) and the blue bar represents the TEU change when compared to 2005 (-10%).

Figure 9.10: HDV Emissions Efficiency Comparison, %



9.2 CAAP Progress

One of the main purposes of the annual inventories is to provide a progress update on achieving the Clean Air Action Plan's San Pedro Bay Standards. These standards consist of the following reduction goals, compared to 2005 published inventories:

- Emission Reduction Standard:
  - By 2014, reduce emissions by 72% for DPM, 22% for NO_x, and 93% for SO_x
  - By 2023, reduce emissions by 77% for DPM, 59% for NO_x, and 92% for SO_x
- Health Risk Reduction Standard: 85% reduction by 2020

Note: At the time of publication of this document, the standards bulleted above are draft standards that have been released for public review but not formally adopted by the Board of Harbor Commissioners. It is anticipated that the standards will be presented to the Board in 2010 as part of the CAAP Update process currently underway.

Emissions Reduction Progress

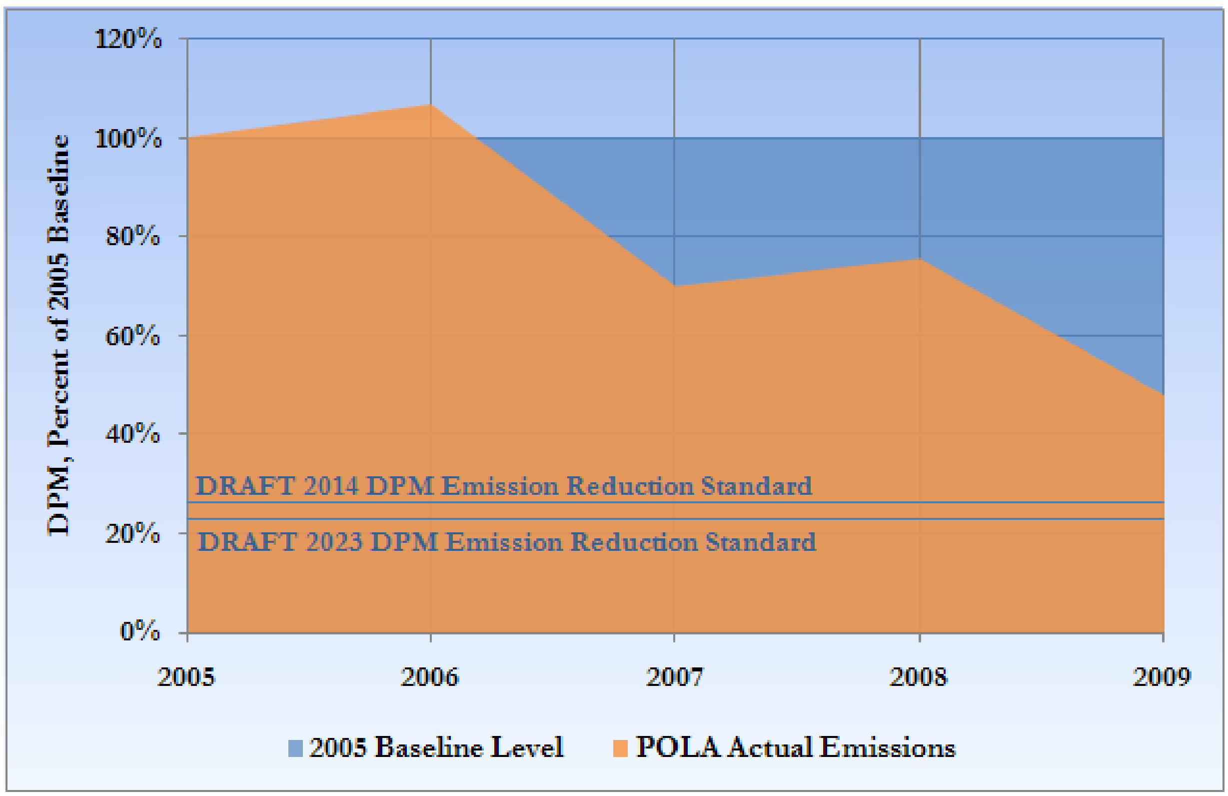
The Emissions Reduction Standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the regional SoCAB attainment dates for the federal $PM_{2.5}$ and ozone ambient air quality standards in the 2007 AQMP. Tables 9.30 to 9.32 show the standardized estimates of emissions by source category for calendar years 2005 through 2009, using current year methodology. Figures 9.11 through 9.13 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions as well as present the draft 2014 and 2023 standards to provide a snapshot of progress to-date towards meeting those standards. In Figure 9.11, DPM emissions reductions are presented as a surrogate to $PM_{2.5}$ reductions since DPM is directly related to $PM_{2.5}$ emissions (equivalent of PM_{10} emissions from diesel-powered sources). In Figure 9.12, NO_x emissions reductions are presented since NO_x is a precursor to the ambient ozone formation and it also contributes to the formation of PM2.5. SO_x emissions reductions are presented in Figure 9.13 because of the contribution of SO_x to $PM_{2.5}$ emissions.

It is important to note that a portion of the current year's emission reductions are attributable to lower cargo throughout. As anticipated cargo volumes increase in the upcoming years, the reduction trend may not continue at the same rate experienced over the last few years. However, continued implementation of several significant emission reduction programs, such as the Port's Clean Truck Program, Vessel Speed Reduction, AMP and CARB's regulatory strategies for port-related sources, is expected to substantially mitigate the impact of resumed cargo growth.

Table 9.30: DPM Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008	2009
OGV	500	527	266	358	244
HC	56	51	52	56	56
CHE	44	47	41	33	24
Rail	57	74	61	46	28
HDV	318	340	261	243	115
Total	**974**	**1,040**	**682**	**736**	**467**
% Cumulative Change		**7%**	**-30%**	**-24%**	**-52%**

Figure 9.11: DPM Reductions - Progress to Date Compared to 2005

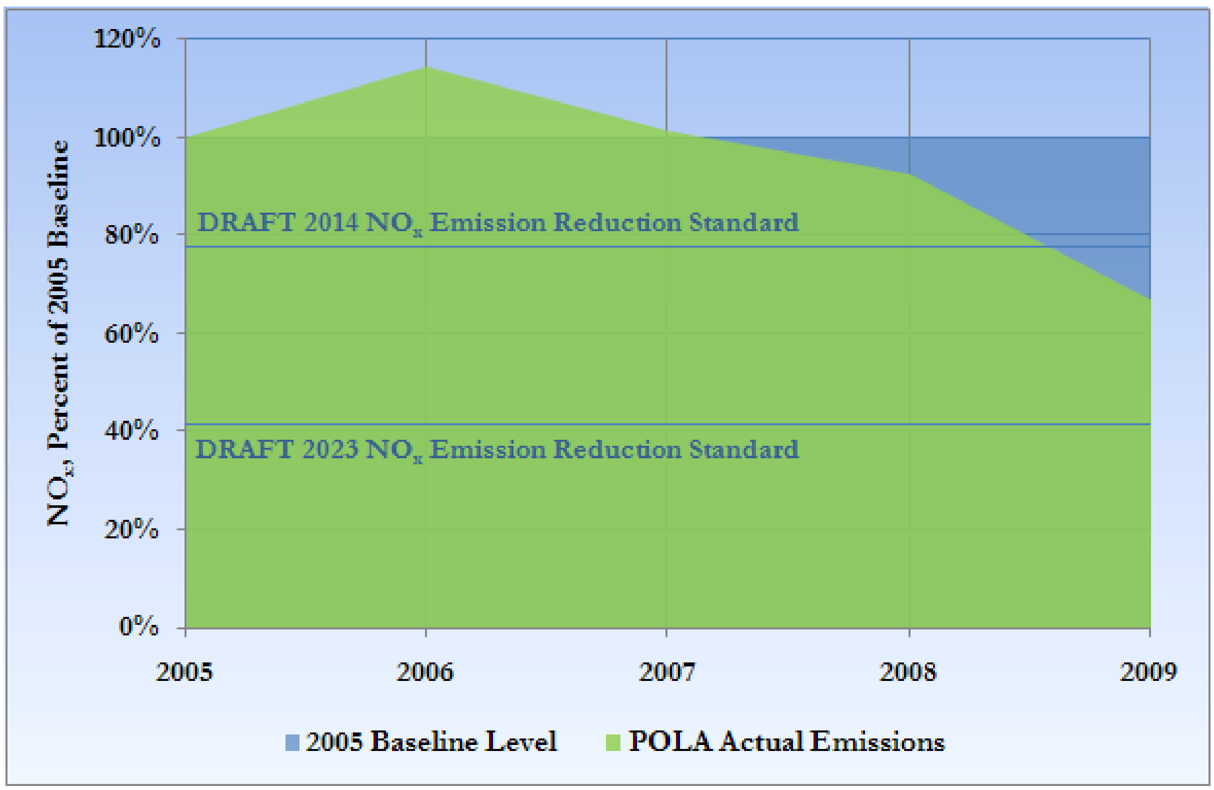


As presented above, by 2009, the Port is over half way towards meeting the DPM Emission Reduction Standard. With implementation of CAAP measures in 2010 and subsequent years (e.g., vessel speed reduction, shore power), the Port's Clean Truck Program and CARB's OGV marine fuel regulation (fully effective in 2010), it is anticipated that the DPM reduction trend will continue in 2010.

Table 9.31: NO_x Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008	2009
OGV	5,530	6,056	5,272	4,780	4,039
HC	1,332	1,245	1,263	1,284	1,276
CHE	1,444	1,700	1,537	1,169	750
Rail	1,712	2,202	1,821	1,246	940
HDV	6,795	8,059	7,160	7,098	4,238
Total	**16,812**	**19,262**	**17,052**	**15,577**	**11,244**
% Cumulative Change		**15%**	**1%**	**-7%**	**-33%**

Figure 9.12: NO_x Reductions - Progress to Date Compared to 2005

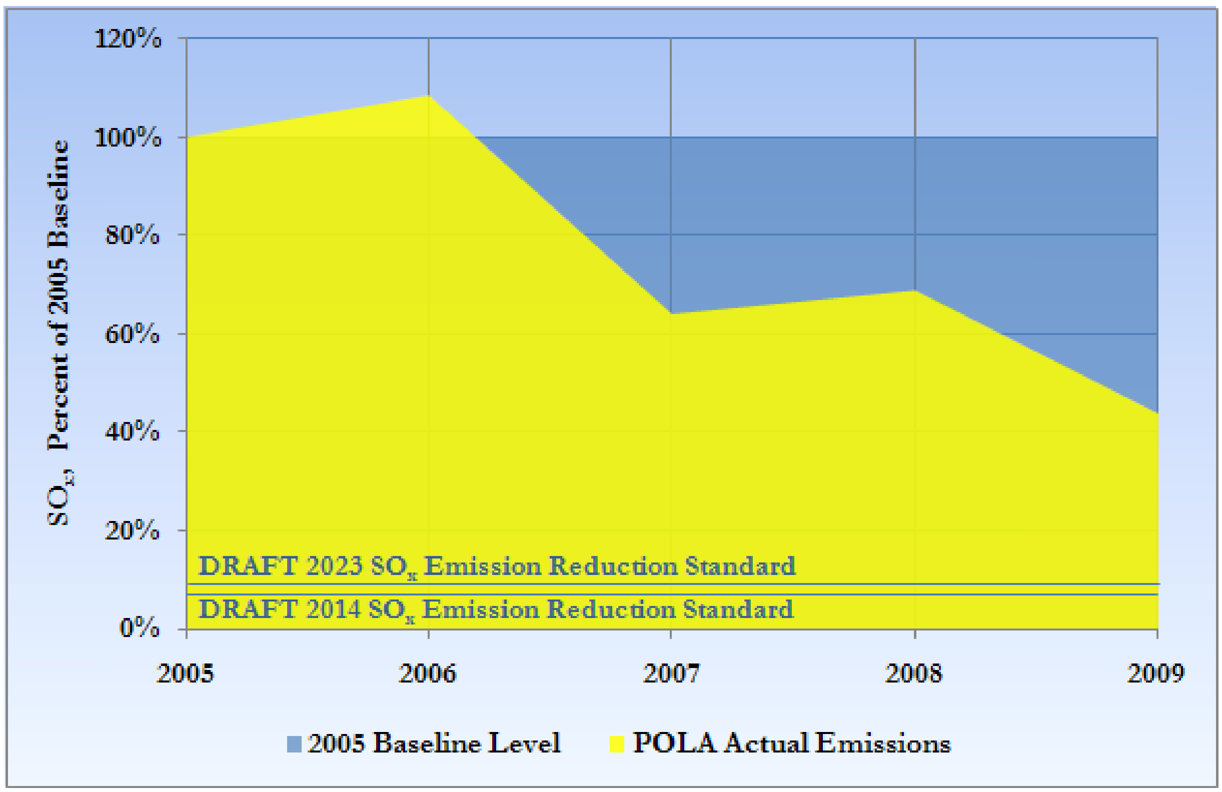


As shown above, the Port is exceeding the 2014 NO_x Emission Reduction Standard in 2009 in part due to lower cargo throughput but also because of the implementation of the control programs. The Port's Clean Truck Program and CAAP measures including the expanded VSR program, AMP program, and slide valves in OGVs are the primary strategies for reducing NO_x emissions. Implementation of these strategies and CARB's at-berth regulation will significantly help in meeting these standards despite potential increases in throughput.

Table 9.32: SO_x Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008	2009
OGV	5,391	5,852	3,490	3,805	2,418
HC	6	1	1	1	1
CHE	9	2	2	2	1
Rail	98	132	55	9	7
HDV	48	40	6	5	5
Total	**5,552**	**6,026**	**3,553**	**3,822**	**2,432**
% Cumulative Change		**9%**	**-36%**	**-31%**	**-56%**

Figure 9.13: SO_x Reductions - Progress to Date Compared to 2005



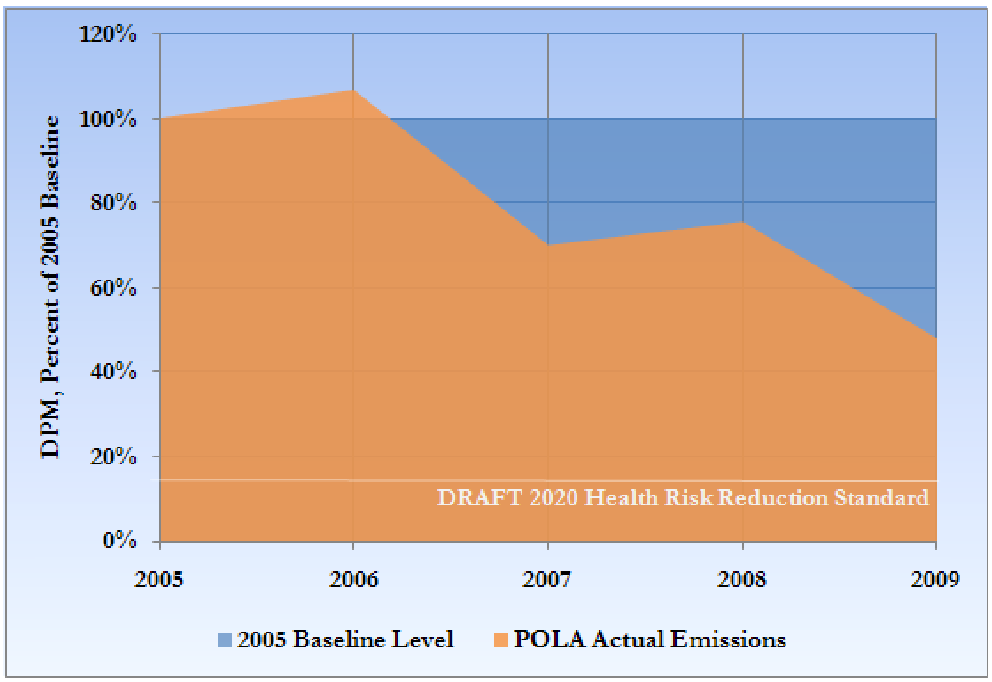
As shown above, by 2009, the Port is over half way towards meeting the SO_x Emission Reduction Standard. Implementation of CAAP measures and CARB's OGV fuel regulation (fully effective in 2010) will result in even higher rates of SO_x reductions in the coming years. The slight erosion of SO_x reductions from 2007 and 2008 was due to the injunction against the previous CARB OGV fuel rule in 2008.

Health Risk Reduction Progress

As described in Section 2 of the upcoming CAAP Update, the effectiveness of CAAP's control measures and applicable regulations with respect to the Health Risk Reduction Standard can be tracked by changes in mass emission reductions in DPM from the 2005 baseline. DPM is the predominant contributor to port-related health risk, and the Health Risk Reduction Standard was based on a health risk assessment study that used forecasted reductions in geographically allocated DPM emissions as the key input. Therefore, reductions in DPM mass emissions associated with CAAP measures and applicable regulations are a representative surrogate for health risk reductions.

Progress to-date on health risk reduction is determined by comparing the change in DPM mass emissions to the 2005 baseline. Figure 9.14 presents the progress of achieving the standard to date.

Figure 9.14: Health Risk Reduction Benefits - Progress To Date



As shown above, by 2009 the Port is over half way towards meeting the 2020 Health Risk Reduction Standard. With additional CAAP measures coming on line, CARB's OGV marine fuel regulation, and the continued fleet improvements coming from the Clean Truck Program, it is anticipated that the reduction trend will continue in 2010 and coming years.

SECTION 10 LOOKING FORWARD TO 2010 EI

As presented in this 2009 EI report, the Port-related mobile source emissions have continued to decrease over the last several years in part due to the reduced cargo throughput (reflective of global economic conditions) as well as the implementation of the CAAP and regulatory programs affecting these sources. For 2010, the trend in TEU throughput is expected to reverse and show an increase compared to 2009 as evidenced from the TEU throughput levels in the first quarter of 2010. Although the anticipated increase in throughput level in 2010 may offset some of the emissions reductions seen in 2009, the implementation of the CAAP measures and regulatory programs will continue to provide emissions benefits in 2010 and later years.

The following is a brief description of the anticipated impacts of control programs and measures in 2010 for each category, which will result in further reduction of emissions from these port-related sources:

OGV

In 2010, continued implementation of the CAAP measures including the increased use of shore power for vessels at-berth and the expansion of the Port's vessel speed reduction program to 40 nm will result in significant emission benefits. In addition, CARB's marine fuel regulation requiring the use of lower sulfur fuel (0.5% sulfur) in main and auxiliary engines and auxiliary boilers within 24 nm of the California coastline, which became effective on July 1, 2009 will be in full effect in 2010 resulting in substantial reductions in DPM and SO_x emissions and to a smaller extent in NO_x emissions. In addition, the trend toward newer vessels complying with new IMO standards and incorporating emission reduction technologies (e.g., slide valves) is expected in 2010 to continue offering additional emission benefits.

Harbor Craft

Under CARB's regulation for commercial harbor craft, in-use, newly purchased, or replacement engines in ferries, excursion vessels, tug boats and tow boats must meet EPA's most stringent emission standards per a compliance schedule set by CARB for in-use engines and from new engines at the time of purchase. For harbor craft with home ports in the SoCAB, the compliance schedule for in-use engine replacements begins in 2010 with the oldest model year engines (1979 and earlier). In addition, depending on the availability of state and federal incentive funding in 2010, existing older engines could be replaced with newer engines in advance of CARB's regulation for affected engines or in vessels not subject to CARB' regulation (e.g., crew boats, work boats).

CHE

In 2010, implementation of the CAAP measure for CHE and CARB's in-use CHE regulation will result in continued emissions benefits due to the replacement of existing older equipment with newer and cleaner equipment powered by on-road engines or Tier 3 off-road engines. In addition, successful demonstration of electric-powered CHEs (e.g., RTGs, yard tractors) is expected to result in increased use of these units and additional emission reductions.

Rail

The 1998 MOU among the Class 1 railroads (UP and BNSF), CARB, and EPA requires the accelerated introduction of cleaner locomotives in SoCAB. Specifically, the MOU requires BNSF and UP to achieve fleet-wide average emission rates meeting EPA's Tier 2 emission standards for their locomotives operating in SoCAB by 2010. The averaging provisions included in the MOU, which allow the railroads to average line haul and switching emissions to achieve the Tier 2 average, mean that the line haul locomotives may not average Tier 2 emission levels. However, additional reductions from line haul locomotives and off-port switcher locomotives are anticipated from implementation of the MOU in 2010.

HDV

Under the Port's CTP, following the first phase of the progressive ban of older trucks operating at the Port (banning pre-1989 trucks from port service) in October 2008, the second phase of the CTP will be implemented in 2010. Specifically, as of January 1, 2010, all 1989-1993 model year trucks as well as the non-retrofitted 1994-2003 model year trucks (i.e., not achieving CARB Level 3 PM reduction plus 25% NOx reduction) will behave been banned from port service. Implementation of the CTP has already resulted in significant emissions reductions due to early turn-over of older trucks with newer trucks which will continue in 2010 under phase 2 of the CTP. The Port will continue the efforts to increase the population of alternatively-fueled trucks serving the Port.

The 2010 EI will reflect the Port's actual throughput level in 2010 and the net emissions benefits associated with these programs and strategies. In addition, consistent with the Port's EI development process, the latest available emission factors and methods as well as methodological improvements will be incorporated in the 2010 EI.