PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS - 2008

THE PORT OF LOS ANGELES

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Prepared by:
STARCREST CONSULTING GROUP, LLC

THE PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2008 - REVISED

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ACRONYMS AND ABBREVIATIONS

Act	Activity
AAPA	American Association of Port Authorities
ABS	American Bureau of Shipping
AMP	alternative maritime power
ANPRM	Advance Notice of Proposed Rulemaking
APL	American Presidents Line
APM	A. P. Moeller
AS	actual speed
ATB	articulated tug and barge
BACT	Best Available Control Technology
BAEI	Baseline Air Emissions Inventory
BNSF	Burlington Northern Santa Fe Railroad
BTH	Business Transportation and Housing Agency
BW	breakwater
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CF	control factor
CHE	cargo handling equipment
CO	carbon monoxide
CO_2	carbon dioxide
D	distance
DB	dynamic breaking
DF	deterioration factor
DMV	Department of Motor Vehicles
DMVT	daily vehicle miles of travel
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
DPM	diesel particulate matter
DR	deterioration rate
DWT	deadweight tonnage
E	emissions
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/hr	grams per hour
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
HC	Hydrocarbons - total
HDDV	heavy-duty diesel vehicle
HDV	heavy-duty vehicle
HFO	heavy fuel oil
hp	horsepower
hrs	hours
HVAC	heating/ventilation/air conditioning
ICTF	Intermodal Container Transfer Facility
IFO	intermediate fuel oil
IMO	International Maritime Organization
ITB	integrated tug and barge
kW	kilowatt
L.A.	Los Angeles
LAXT	Los Angeles Export Terminal
l/cyl	liters per cylinder
lbs/day	pounds per day
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

MMA	Meyer, Mohaddes Associates, Inc.
MMGT	million gross ton-miles
MOU	Memorandum of Understanding
mph	miles per hour
MS	maximum speed
MTC	Marine Terminals Corporation
MY	model year
N	north
NAAQS	National Ambient Air Quality Standards
nm	nautical miles
NO_x	oxides of nitrogen
N_2O	nitrous oxide
NPRM	Notice of Proposed Rulemaking
NYK	Nippon Yusen Kaisha
OBD	on-board diagnostics
OGV	ocean-going vessel
PCST	Pacific Cruise Ship Terminals
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
RH	relative humidity
RIA	Regulatory Impact Analysis
RO	residual oil
ROG	reactive organic gases
Ro-Ro	roll-on/roll-off vessel
RMG	rail mounted gantry crane
rpm	revolutions per minute
RSD	Regulatory Support Document
RTG	rubber tired gantry crane
RTL	rich text language
S	sulfur
SCAG	Southern California Association of Governments

SCAQMD	South Coast Air Quality Management District
SFC	specific fuel consumption
SO_x	oxides of sulfur
SoCAB	South Coast Air Basin
SPB	San Pedro Bay
SSA	Stevedoring Services of America
SUV	sport utility vehicle
T&M	tampering and mal-maintenance
TEU	twenty-foot equivalent unit
TICTF	Terminal Island Container Transfer Facility
TOG	total organic gases
tpd	tons per day
tpy	tons per year
UDDS	Urban Dynamometer Driving Schedule
U.S.	United States
ULCC	ultra large crude carriers
ULSD	ultra low sulfur diesel
UP	Union Pacific Railroad
USCG	U.S Coast Guard
VBP	vessel boarding program
VLCC	very large crude carrier
VLCS	very large cargo ship
VMT	vehicle miles of travel
VOCs	volatile organic compounds
VSR	vessel speed reduction
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 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 emission estimates for greenhouse gases (GHG). In December 2008, the Port released the 2007 Inventory of Air Emissions.

This study, the 2008 Inventory of Air Emissions, includes emissions estimates based on 2008 activity levels and a comparison with 2005, 2006 and 2007 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 criteria pollutants (pollutants that can cause local impact) have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NOx)
- Oxides of sulfur (SOx)
- Hydrocarbon - total (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 (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)

Methodology Overview and Geographical Extent

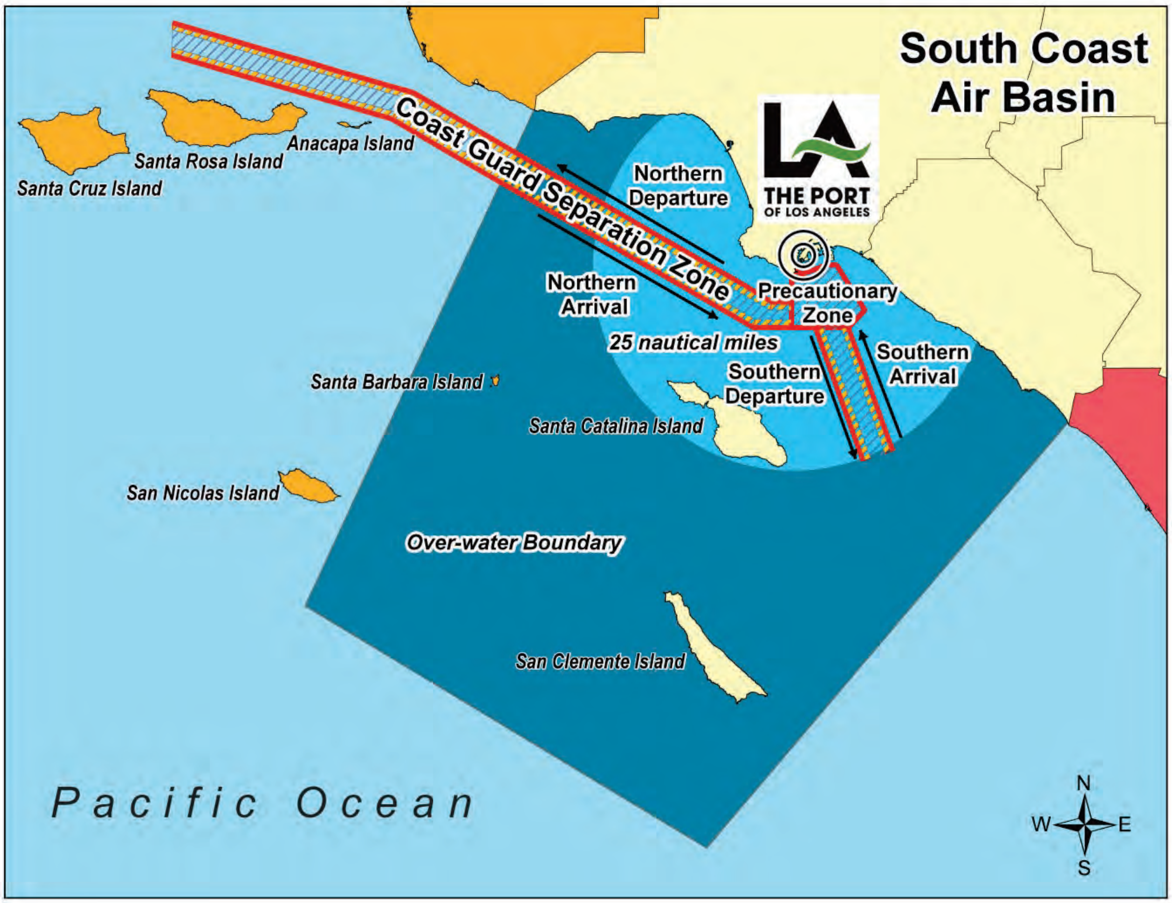
Port tenants and shipping lines play an essential role in the development of an activity-based emissions inventory (EI) by providing the most accurate activity and operational information available. Emissions estimates are developed for each of the various source categories in a manner consistent with 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 2008 Activity

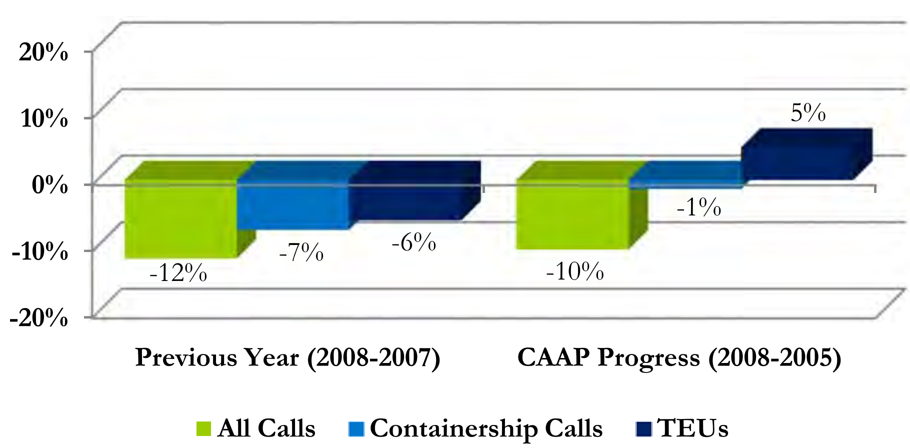
Table ES.1 lists the number of vessel calls and the container cargo throughputs for calendar years 2005 to 2008. The 2008 vessel calls were lower than the previous years, but the average twenty-foot equivalent unit (TEU)/call ratio has continued to increase which shows efficiency improvement (on average, more containerized cargo is moved during each vessel call). In Table ES.1, for a given year the total number of calls (arrivals) and the number of containership calls may be different from previously published reports due to an improved ocean-going vessel (OGV) data processing methodology that more thoroughly associates vessel movements with the port than in previous inventories.

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

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2008	2,239	1,459	7,849,985	5,380
2007	2,537	1,577	8,355,038	5,298
2006	2,701	1,632	8,469,853	5,190
2005	2,500	1,479	7,484,625	5,061
Previous Year (2008-2007)	**-12%**	**-7%**	**-6%**	**2%**
CAAP Progress (2008-2005)	**-10%**	**-1%**	**5%**	**6%**

Figure ES.3 shows the difference for the previous year (2008-2007) and CAAP progress (2008-2005). From 2007 to 2008, there was a 6% decrease in TEU throughput, the number of total calls decreased by 12% and containership calls decreased by 7%. From 2005 to 2008, there was a 5% increase in TEU throughput, the number of total calls decreased by 10% and containership calls decreased by 1%.

Figure ES.3: TEUs and Vessel Call Comparison, %



In 2008, there was one significant change that impacted 2008 port-wide emissions. This change, which affected OGV emissions, was a combination of the initial CARB Fuel Regulation which was in place in 2007, but ended at the end of April 2008, and the Port's Fuel Incentive Program that was launched July 1, 2008 and lasted one year until the new CARB Fuel Regulation went into effect in mid-2009. Fuel switching has a large impact on SO_x emissions for OGV, which has an overall impact on the port-wide SO_x emissions since OGV are the source of 99% of the port-wide SO_x emissions. The following assumptions were made for OGV fuel switching in 2008:

- The percent of vessels that switched to a cleaner fuel for auxiliary engines at berth and within 24 nautical miles (nm) was 100% from January 2008 to the end of April 2008 when the CARB Fuel Regulation[1] was in effect and approximately 14% from July 2008 to December 31, 2008 due to the port's voluntary Fuel Incentive Program. For the months of May and June, 2008, it is assumed that the vessels did not switch fuels and the default intermediate fuel oil (IFO) 2.7% S residual fuel was burned in the auxiliary engines. The percent of fuel switchers for auxiliary engines was significantly lower in 2008 than 2007, therefore auxiliary engine emissions for OGV increased in 2008.

- The percent of vessel calls that switched to a cleaner fuel for main engines during transit was 14% from July 1, 2008 to December 31, 2008 and includes only those companies that voluntarily agreed to the port's Fuel Incentive Program.

[1] Per telephone and email contact with CARB (12 March 09), port's 100% assumed compliance is in agreement with CARB's own emission inventories and as part of Technical Working Group, CARB has reviewed and agreed with dates and compliance rate used for the CARB Fuel Regulation that was in place at beginning of 2008.

Summary of 2008 Emission Estimates

The results for the Port of Los Angeles 2008 Inventory of Air Emissions are presented in this section. Table ES.3 summarizes the 2008 total port-related emissions in the SoCAB by category in tons per year.

Table ES.3: 2008 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	426	341	358	4,798	3,787	485	227
Harbor craft	56	51	56	1,284	1	374	91
Cargo handling equipment	34	32	33	1,169	2	739	47
Rail locomotives	42	38	42	1,366	9	226	74
Heavy-duty vehicles	300	276	300	6,606	5	2,227	398
Total	**857**	**738**	**788**	**15,223**	**3,804**	**4,052**	**837**

DB ID457

The total port-related tenant GHG emissions in the SoCAB are summarized below. The GHG emissions summarized in Table ES.4 are 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)[2] values and then adding them together.

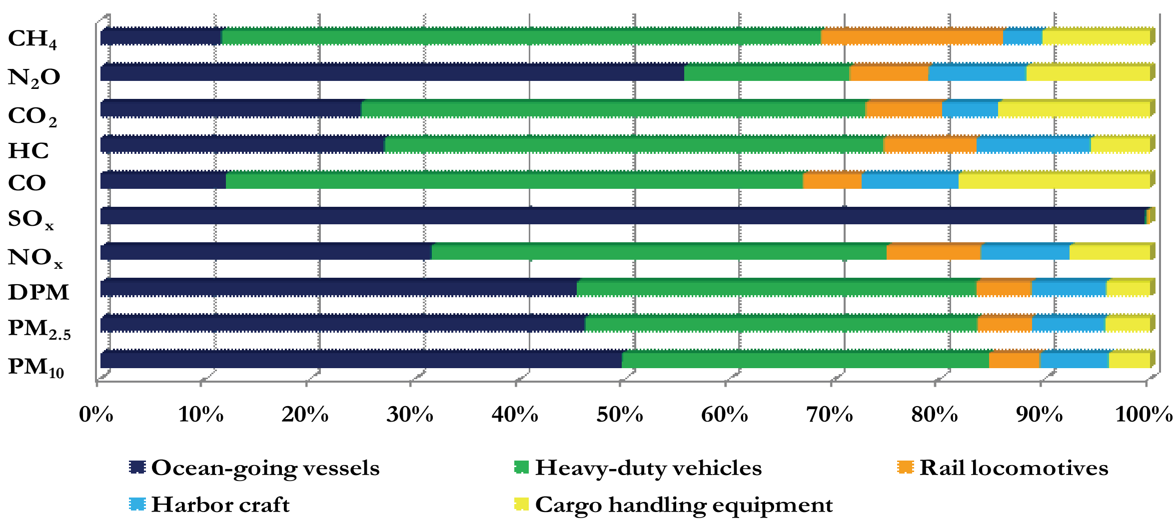
[2] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, 15 April 2008.

Table ES.4: 2008 Port-related GHG Emissions by Category, metric tons per year

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	262,176	257,483	15	4
Harbor craft	55,912	55,119	2	1
Cargo handling equipment	151,180	150,125	3	4
Rail locomotives	76,100	75,347	2	6
Heavy-duty vehicles	499,693	497,963	4	20
Total	**1,045,061**	**1,036,037**	**27**	**36**

Figure ES.4 shows the distribution of the 2008 total port-related emissions for each pollutant and source category. Ocean-going vessels (45 to 50%) and heavy-duty trucks (35 to 38%) contribute the highest percentage of particulate matter emissions among the port-related sources. Over 99% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks (43%) and OGV (32%) account for the majority of NO_x emissions. Heavy-duty trucks (55%) and CHE (18%) account for the majority of CO emissions. Heavy-duty trucks (48%) and OGV (27%) account for the majority of hydrocarbon emissions.

Figure ES.4: 2008 Port-related Emissions by Category, %



In order to put the Port-related emissions into context, the following figures compare the Port's contributions to the other sources in the South Coast Air Basin. The 2008 SoCAB emissions used for this comparison are based on the 2007 Air Quality Management Plan (AQMP).[3]

In the South Coast Air Basin, 9% of diesel particulate matter emissions, 5% of NO_x emissions, and 24% of SO_x emissions are attributed to port-related emissions from the Port of Los Angeles. The Port's percent contribution of DPM and NO_x within the SoCAB remained the same in 2008 as compared to 2007, while SO_x emissions increased by 2% from 2007. When compared to 2005, the port's percent contribution of DPM, NO_x and SO_x emissions within the SoCAB decreased in 2008.

Figure ES.5: 2008 DPM Emissions in the South Coast Air Basin, %

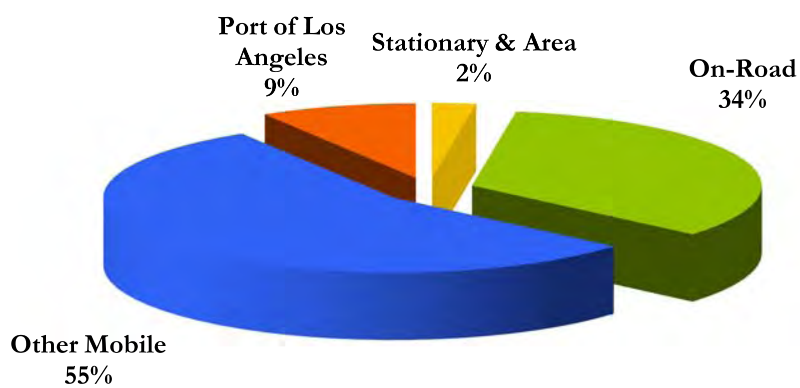
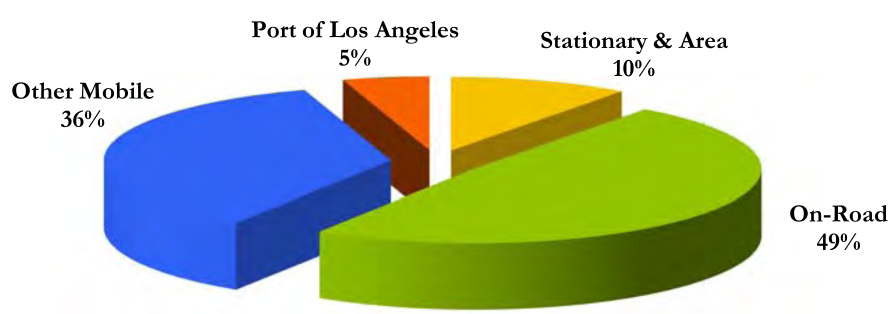


Figure ES.6: 2008 NO_x Emissions in the South Coast Air Basin, %



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

Figure ES.7: 2008 SO_x Emissions in the South Coast Air Basin, %

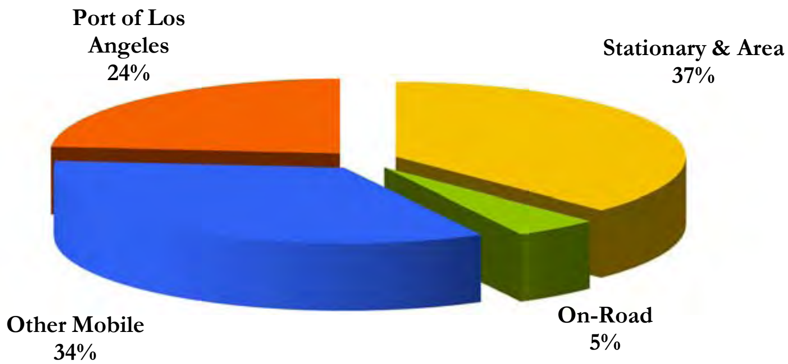


Table ES.5 presents the total net change in emissions for all source categories in 2008 as compared to previous years. The percent change is shown for the previous year (2007) and the CAAP progress (2005).

Table ES.5: Port-wide Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	857	738	788	15,223	3,804	4,052	837
2007	855	744	760	16,553	3,611	4,308	906
2006	1,168	1,000	1,067	18,946	6,072	4,690	1,088
2005	1,059	904	971	16,789	5,585	4,040	957
Previous Year (2008-2007)	**0%**	**-1%**	**4%**	**-8%**	**5%**	**-6%**	**-8%**
CAAP Progress (2008-2005)	**-19%**	**-18%**	**-19%**	**-9%**	**-32%**	**0%**	**-13%**

From 2007 to 2008, NO_x, CO and HC emissions decreased, while DPM and SO_x emissions increased. The SO_x emissions increase is due to the CARB fuel auxiliary engine regulation that was in effect for the entire year in 2007, but it was only in effect for the first four months of 2008, thus the OGV SO_x emissions increased in 2008. In the latter part of 2008, the port had a voluntary Fuel Incentive Program for OGV that partially made up for the ending of the CARB auxiliary engine fuel regulation, but overall SO_x emissions increased slightly over 2007. The DPM emissions increase from 2007 is due in part to the fuel regulation being in force for all of 2007 but only part of 2008 as well as fewer tanker calls in 2008 than in 2007. Many tankers use boilers at higher rates than any other vessel types while at berth, and boilers do not have DPM emissions associated with them. When there are more tankers relative to other vessels (as in 2007) there is comparatively less DPM than PM_{10}. Since the number of tankers was lower in 2008, the DPM increased more than the PM_{10}, resulting in higher overall DPM in 2008 than other years due to less tanker activity. NO_x and HC emissions were reduced due to newer fleet of vessels and equipment which have cleaner and more fuel efficient engines.

From 2005 to 2008, all emissions were reduced despite the 5% increase in throughput, except for CO emissions which remained unchanged. Most of the emission reduction programs reduced particulate matter, thus the 19% PM emission reduction. The diesel engines are currently burning diesel fuel with lower sulfur content than in 2005, including the use of ultra-low sulfur diesel (ULSD) fuel by all source categories except OGV and line haul locomotives. The Port's voluntary Fuel Incentive Program and four months of CARB's Auxiliary Engine Fuel Rule for ocean-going vessels also had a direct impact on the SO_x emissions (32% reduction). NO_x and HC emissions were reduced due to newer fleet of vessels and equipment which have cleaner and more fuel efficient engines.

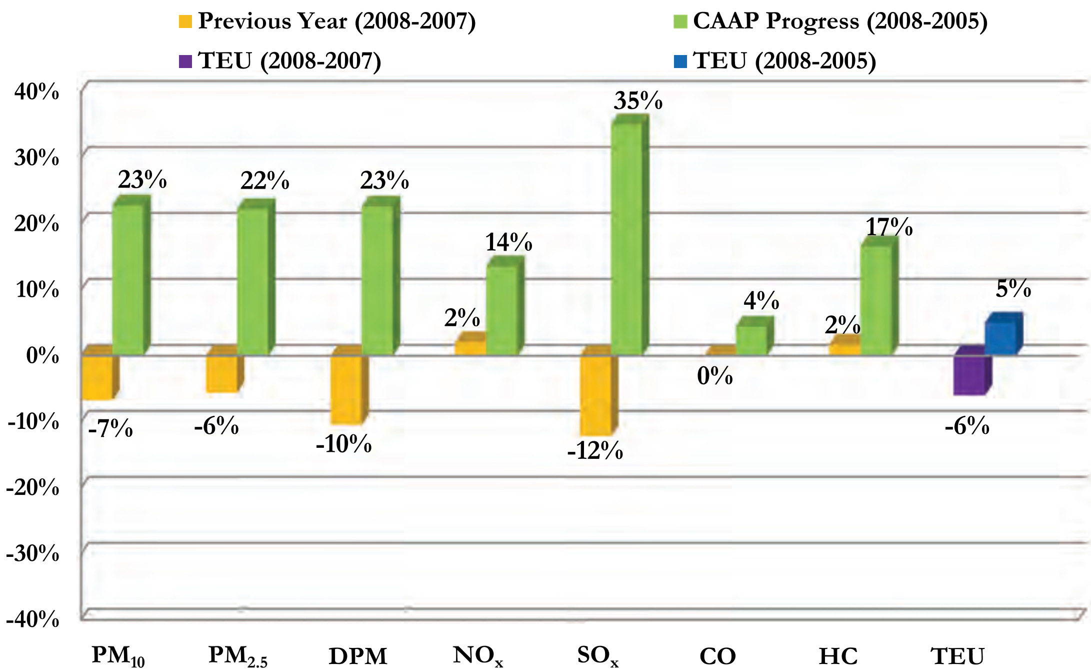
Table ES.6 summarizes the annualized emissions efficiencies (ie, emissions per container handled) of all five source categories in tons of pollutant per 10,000 TEU moved. In 2008, the overall port efficiency improved for all pollutants as compared to 2005. A positive percentage means an increase in emission efficiency in Table ES.6 and Figure ES.8.

Table ES.6: Emissions Efficiency Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	1.09	0.94	1.00	19.39	4.85	5.16	1.07
2007	1.02	0.89	0.91	19.80	4.32	5.15	1.08
2006	1.38	1.18	1.26	22.37	7.17	5.54	1.29
2005	1.41	1.21	1.30	22.43	7.46	5.40	1.28
Previous Year (2008-2007)	**-7%**	**-6%**	**-10%**	**2%**	**-12%**	**0%**	**2%**
CAAP Progress (2008-2005)	**23%**	**22%**	**23%**	**14%**	**35%**	**4%**	**17%**

Figure ES.8 compares emissions efficiency changes between 2008 and previous emission years. The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%). For 2008-2005, emissions efficiencies improved for all pollutants, except for CO which remained the same. For 2008-2007 comparison, emissions efficiencies improved for NO_x, CO and HC.

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:

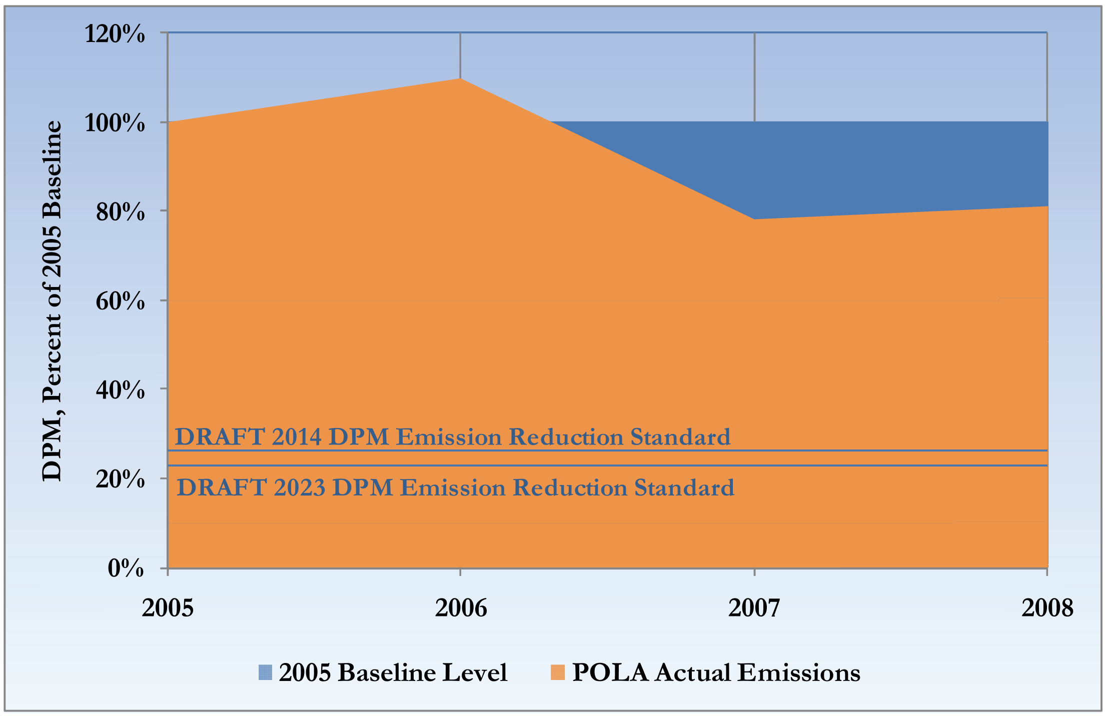
- Emission Reduction Standard:
  - By 2014, reduce emissions by 72% for DPM, 22% for NO_x, and 93% for SO_x
  - By 2023, reduce emissions by 77% for DPM, 59% for NO_x, and 92% for SO_x
- Health Risk Reduction Standard: 85% reduction by 2020

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 early 2010 as part of the CAAP Update process currently underway.

Emissions Reduction Progress

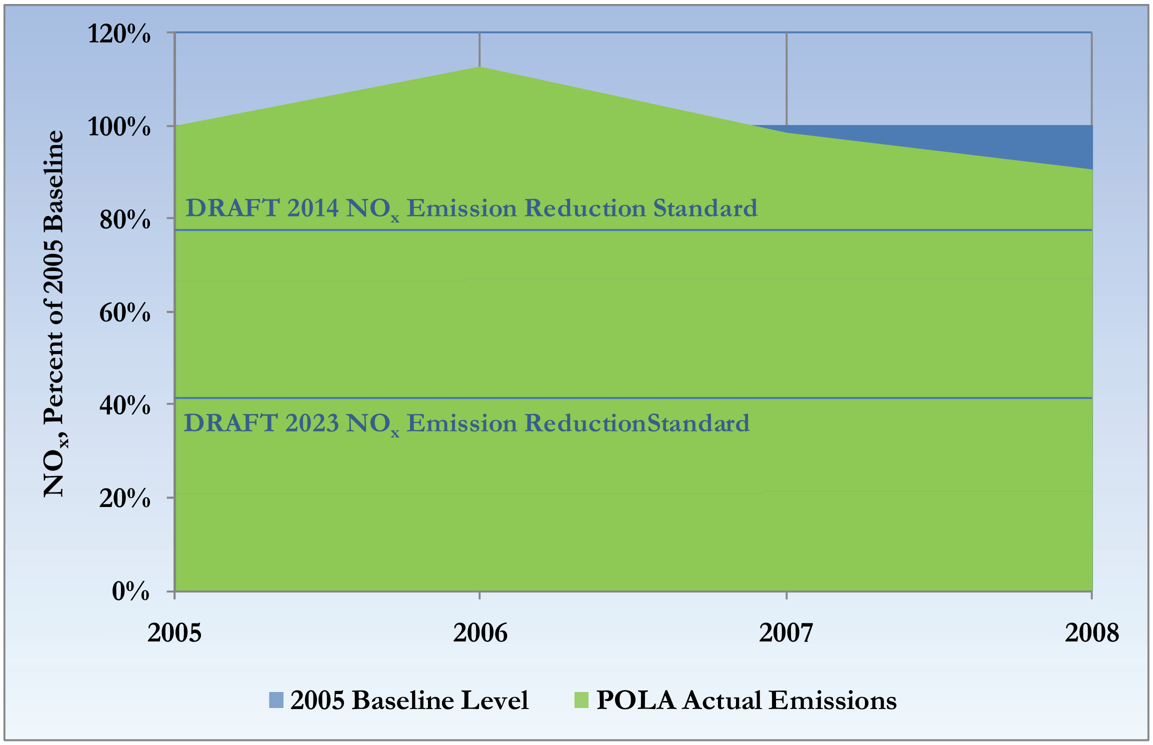
The Emissions Reduction Standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the future compliance dates of the South Coast AQMP. Figures ES.9 through ES.11 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions as well as presenting the draft 2014 and 2023 standards to provide a snapshot of progress to-date towards meeting those standards.

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



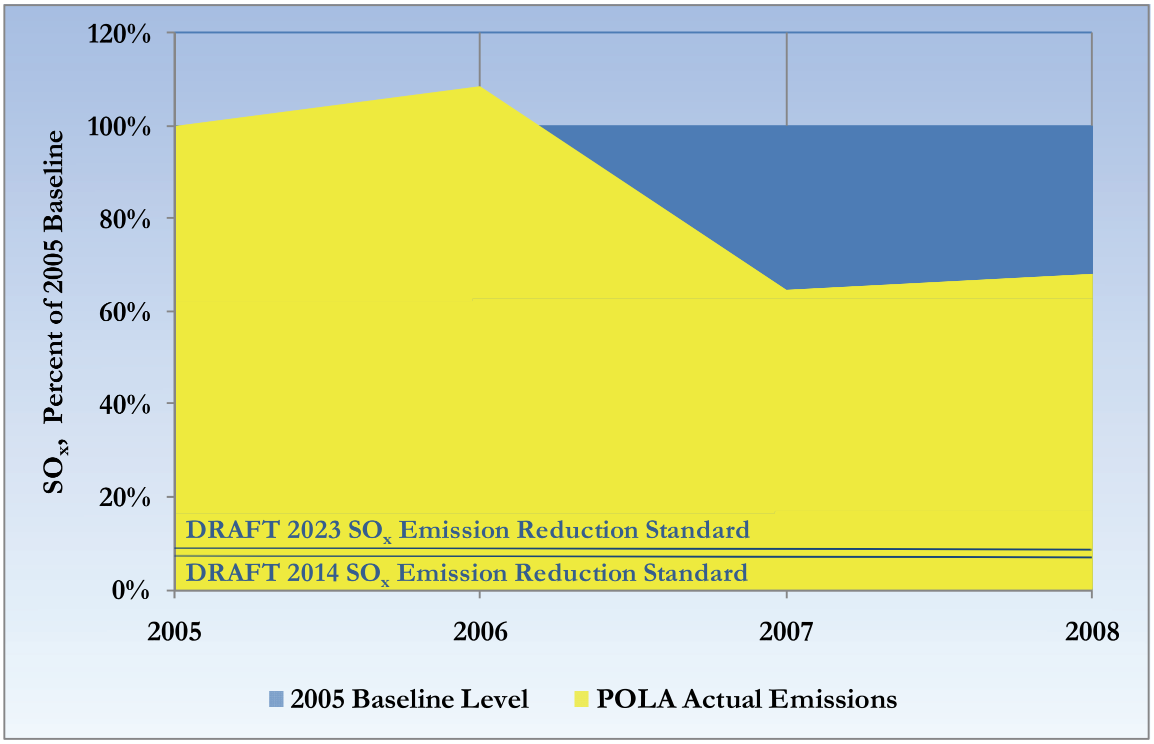
As presented above, by 2008 the port is over a quarter of the way towards meeting the DPM Emission Reduction Standard. With additional CAAP measures coming on-line in the subsequent years, the 2009 SPBP's OGV fuel switch incentive program, CARB's OGV fuel switch regulation implemented in 2009, and the Clean Truck Program (CTP), it is anticipated that the reduction trend 2006 to 2007 will resume in 2009.

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



As shown above, the port is nearly halfway to meeting the 2014 NO_x Emission Reduction Standard in 2008. The SPBP Vessel Speed Reduction (VSR) program, Alternative Maritime Power (AMP), slide valves, and the CTP are the primary strategies for reducing NO_x emissions and meeting the 2014 NO_x standard. Increased participation in VSR out to 40 nm, increased use of AMP (or equivalent technologies) at berth will significantly help in meeting the 2023 standard. Additionally, continued fleet turnover in the CTP will also significantly contribute to NO_x reductions.

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

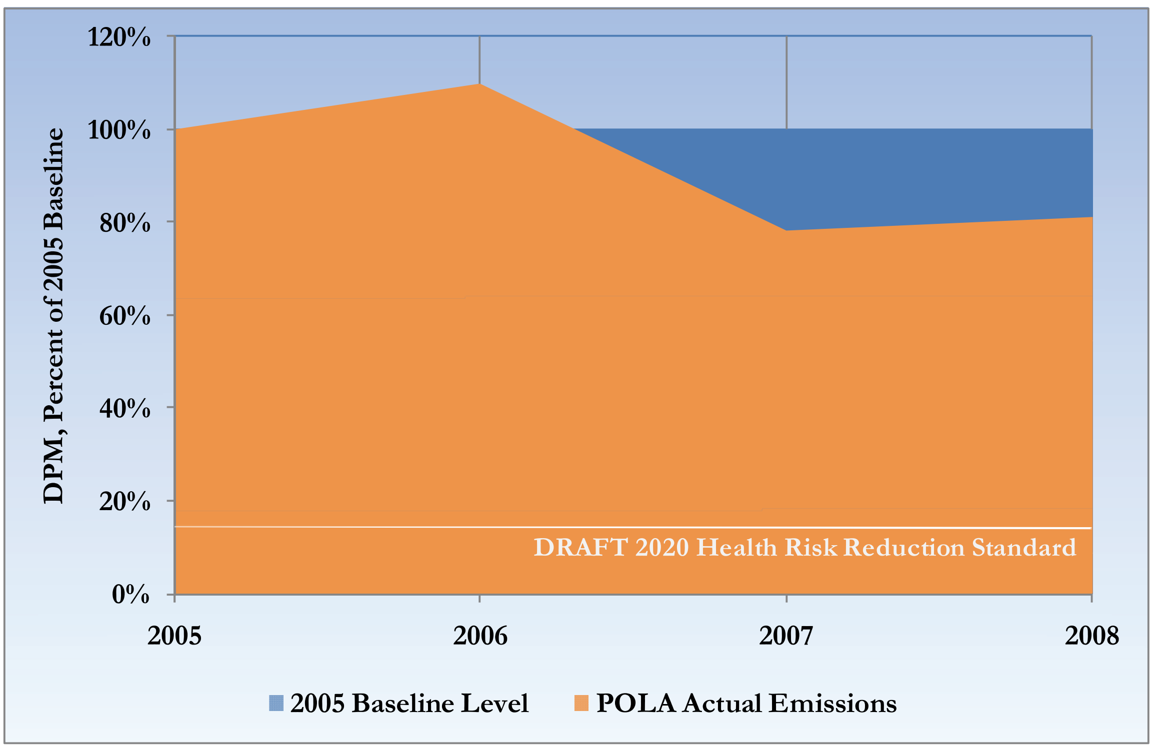


As shown above, by 2008 the port is a third of the way towards meeting the SO_x Emission Reduction Standard. With implementation of additional CAAP measures, the 2009 SPBP's OGV fuel switch incentive program and CARB's OGV fuel regulation implemented in 2009, it is anticipated that the high rate of SO_x reductions will continue 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 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 2008 the port is over a quarter of the way towards meeting the 2020 Health Risk Reduction Standard. With additional CAAP measures coming on line, the 2009 SPBP's OGV fuel switch incentive program, CARB's OGV fuel switch regulation implemented in 2009, and the continued fleet improvements coming from the Clean Truck Program, it is anticipated that the reduction trend 2006 to 2007 will resume in 2009.

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 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 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 inventories of the port-related sources starting with the 2005 Inventory of Air Emissions. 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.[4] 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. In 2007, the Port released the 2005 Inventory of Air Emissions[5] which was the first update to the baseline inventory and also the first of the annual inventories to follow. In July 2008, the Port released the 2006 Inventory of Air Emissions.[6] In December 2008, the Port released the 2007 Inventory of Air Emissions.[7]

[4] *Port of Los Angeles 2001 Baseline Air Emissions Inventory,* 2004.
[5] *Port of Los Angeles Inventory of Air Emissions 2005*, September, 2007.
[6] *Port of Los Angeles Inventory of Air Emissions 2006*, July, 2008.
[7] *http://www.portoflosangeles.org/environment/studies_reports.asp*

1.1 Goods Movement

Goods Movement (GM) has become a key issue associated with both growth of the California economy and the 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).[8] The GMP is intended to address GM 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, it 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

[8] *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."[9]

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 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.[10]

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

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

1.2 Container Movements

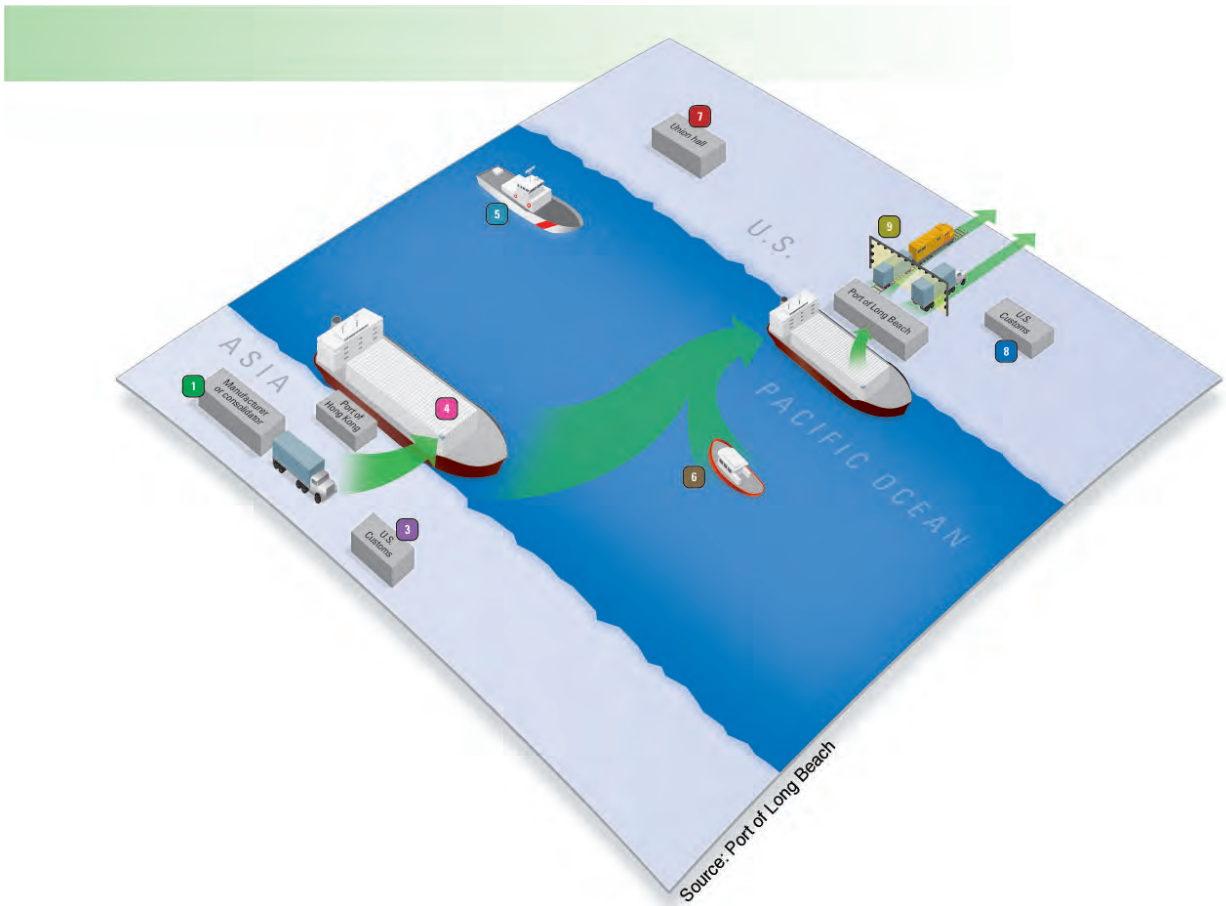
Container terminals and their associated cargo movements are complex intermodal operations that are critical to international trade. Containerized cargo has significantly increased the efficiency and capacity of the transportation system over the prior general cargo/break bulk cargo models (which still 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 sizes 20-foot or 1 twenty-foot equivalent (TEU), or 40-foot or two TEUs. Other sizes such as 45-foot and 53-foot 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 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.[11]

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

Figure 1.1: Overseas Container Transport



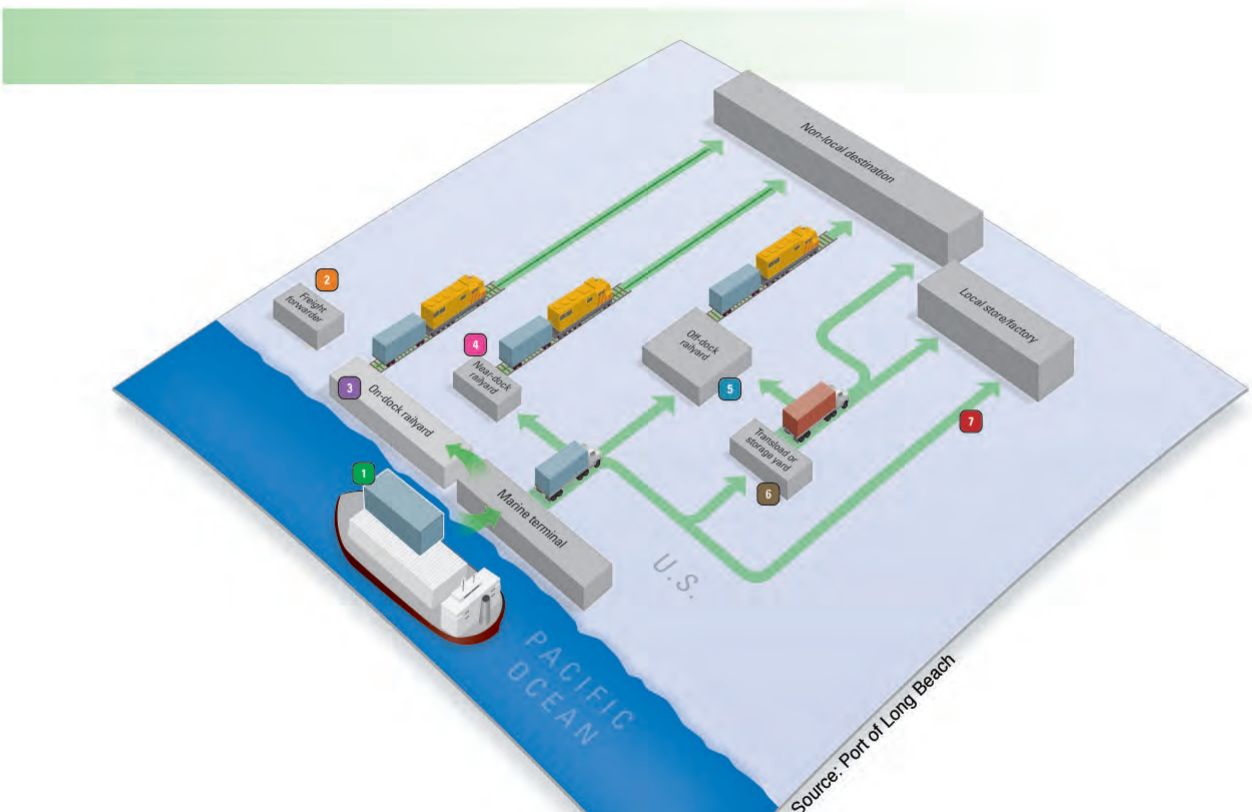
Key:

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.[12]

Figure 1.2: Import Container Transport



Key:

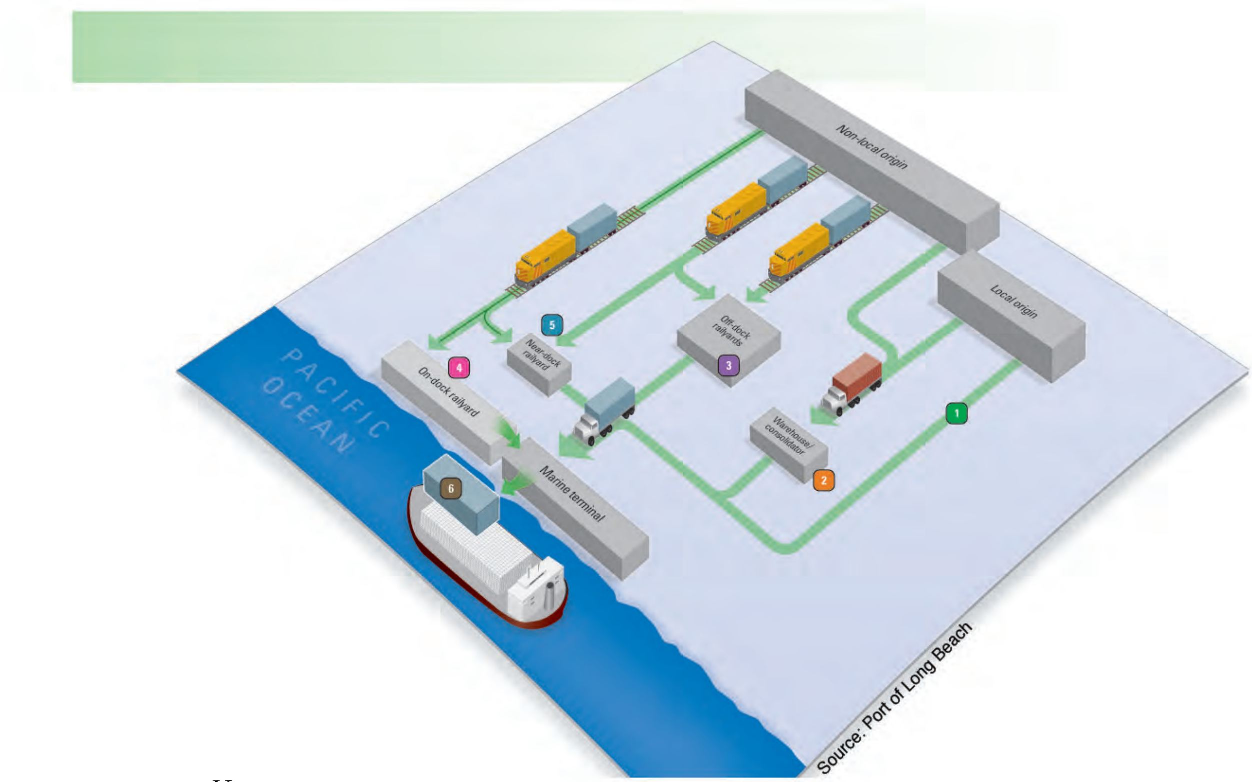
1) The marine terminal operator will arrange for unionized longshore workers to unload the ship. Containers are placed on trucks, rail, or terminal cargo handling equipment for storage on terminal.
2) Trucking company or train operator contacted by freight forwarder or logistics provider to move the 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.

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

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.[13]

Figure 1.3: Export Container Transport



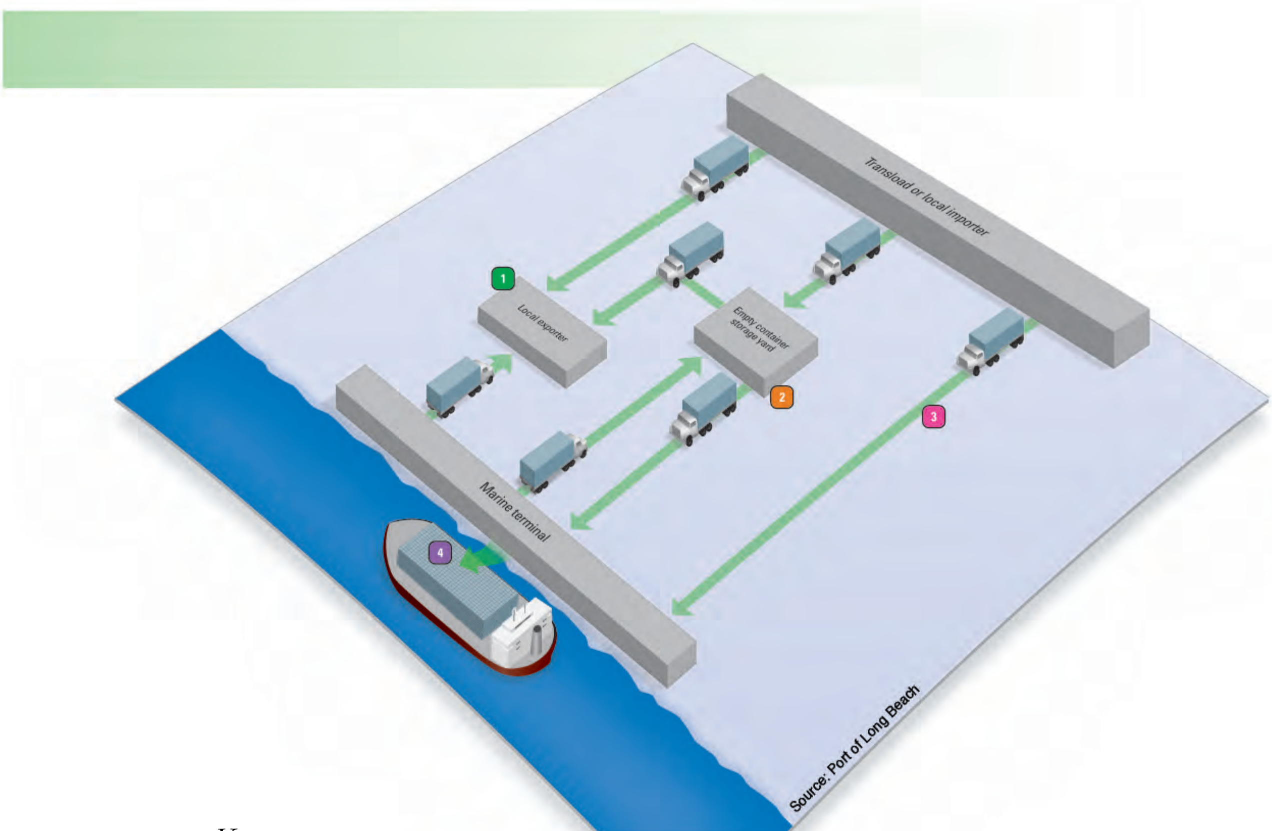
Key:
1) Local origin cargo delivered directly to the marine terminal from the producer, manufacturer, or exporting company.
2) Local or non-local origin cargo delivered to a warehouse/consolidator where the cargo may be temporarily stored with other cargo bound for export. Cargo may also be transferred 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.

[13] 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.[14]

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.

[14] 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 (NOx)
- Oxides of sulfur (SOx)
- Total hydrocarbon (HC)
- Carbon monoxide (CO)
- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)

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.

Total hydrocarbons

Hydrocarbons are organic compounds composed of carbon and hydrogen. 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 formed due to the incomplete fuel combustion and 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.

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 hear contractions, reducing the amount of blood pumped through the body.

Greenhouse gases

Greenhouse gases contribute towards global warming. 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 into increase in global temperature. The first far reaching effort to reduce global warming was established in the form of Kyoto Protocol. Kyoto Protocol is a protocol to the United Nations Framework Connection on Climate Change (UNICCC) with the goal of reducing six GHGs. The six GHGs also referred to as the "six Kyoto gases" are: Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulfur Hexafluoride (SF_6), Hydroflurocarbons (HFCs), and Perflurocarbon (PFCs). Guidance to develop national GHG inventories is provided by 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 for CO_2, CH_4 and N_2O due to cargo handling equipment, harbor crafts, 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 units of carbon equivalents which weight each gas by its global warming potential (GWP) value. To normalize these values in a single greenhouse gas value, the GHG emissions estimates can be multiplied by the following values and then added together resulting in a single greenhouse gas value (CO_2 equivalent). The values are as follows.[15]

- CO2 – 1
- CH4 – 21
- N2O – 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 crafts
- 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.

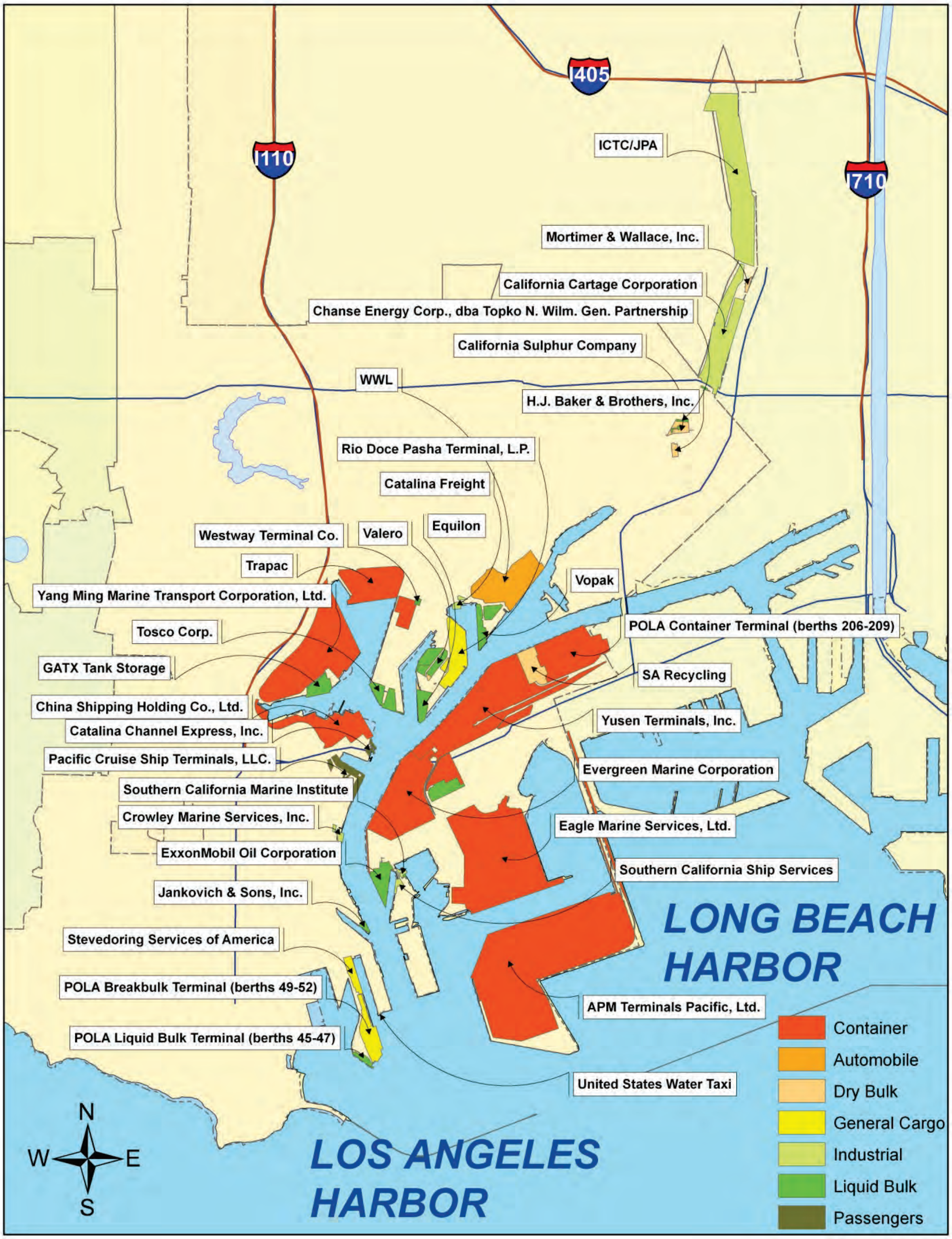
1.3.3 Geographical Extent

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 2008. The geographical scope for cargo handling equipment is the terminals and facilities on which they operate.

[15] *Inventory of Greenhouse Gas and Sinks: 1990-2006,* Annex 3; released by USEPA in April 2008.

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.

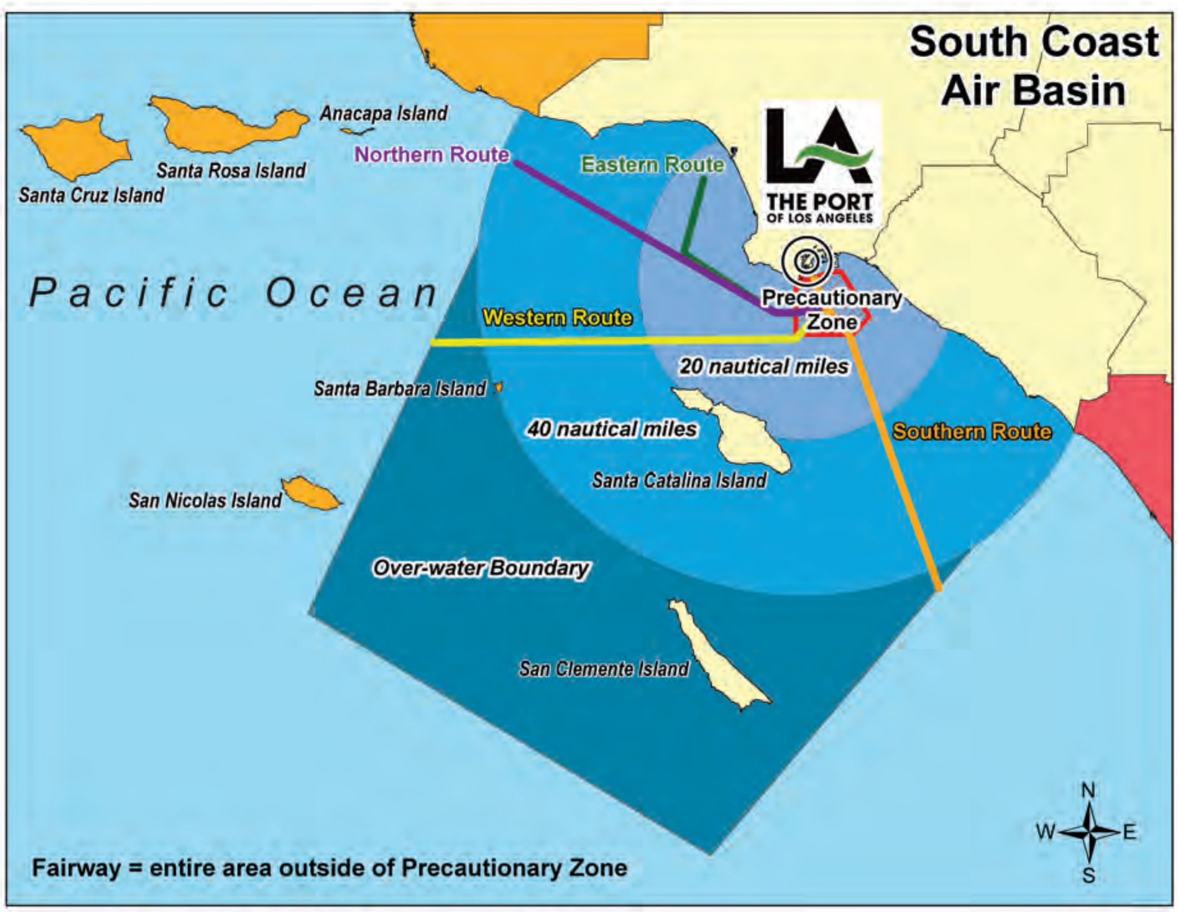
Figure 1.6: South Coast Air Basin Boundary

For marine vessels, OGVs and commercial harbor craft, the geographical extent of the 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) will be 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 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. 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 quantified 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 provide a result of 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. In addition, the emission factors often vary depending on equipment-specific factors such as the model year and the accumulated hours of use, and fuel correction factors may need to be applied.

1.4.1 Ocean-Going Vessels

The basic methodology for estimating emissions from the various types of ocean-going vessels 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 each port visit to adequately characterize the complicated activities of OGVs; (e.g., separate calculations were made for vessel 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 2008 EI include the effects of the following emission reduction measures in place in 2008.

- The vessel speed reduction (VSR) program requiring 12 knots during transiting outside the harbor

- 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 for CARB regulation and/or Port Incentive Fuel Switching Program

- Newer vessels calling at the Port with cleaner and more fuel-efficient engines that meet or exceed standards set by the 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 Port waters were interviewed to update the inventory of harbor craft. The harbor craft are separated into the following categories:

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

CARB emission factors were used in order to be consistent with CARB's latest methodology. Emissions were calculated by multiplying the emission factors by the appropriate measure of activity (such as annual hours of operation) on an engine by engine basis for each vessel included in the inventory.

1.4.3 Cargo Handling Equipment

Cargo handling equipment (CHE) consists of various types of equipment and vehicles that fall within the off-road designation and are used to move cargo within terminals and other off-road areas. 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.

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) and line haul (Burlington Northern Santa Fe, Union Pacific) 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. Therefore, the types of information available for these two types of activity differs for the on-port switching locomotives, information on each locomotive and its activity (e.g., fuel use and throttle notch setting) can be used to

estimate emissions; 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).

1.4.5 Heavy-Duty Vehicles

Heavy-duty on-road vehicles 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.

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 2008 compared with a previous year, then the previous years' emissions were recalculated using the new 2008 methodology and the previous years' activity data to provide a valid basis for comparison. If there were no change in methodology, then the emissions estimated for the prior year's inventory report 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).

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

1.6 Report Organization

This report presents the 2008 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 2008 emissions to previous years' emissions

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: ocean-going vessels (OGVs), on-road heavy-duty vehicles (HDVs), cargo handling equipment (CHE), harbor craft and rail locomotives (RL). 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 Long Beach and Los Angeles adopted the landmark San Pedro Bay Ports Clean Air Action Plan (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 International Maritime Organization (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 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.[16] 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. The NO_x standards are summarized as follow:

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

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 2000 rpm
- 9.8 g/kW-hr if n is equal to or greater than 2000 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 2000 rpm
- 7.7 g/kW-hr if n is equal to or greater than 2000 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 2000 rpm
- 2.0 g/kW-hr if n is equal to or greater than 2000 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.

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.

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,[17] 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.

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

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 United States delegation that participated in negotiations at the International Maritime Organization (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 June 2009, EPA proposed 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 adopted to MARPOL Annex VI. The proposed regulation would establish stricter standards for NO_x, in addition to standards for HC and CO. The proposed Tier 2 NO_x standards for new builds would begin in 2011, and would achieve a 15% reduction from the existing Tier 1 standard. The proposed Tier 3 NO_x standards would begin in 2016 and would reduce NO_x emissions 80% from the Tier 2 standards, while the vessels are operated in specially designated areas. The proposed 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 Emission Control Area.

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, 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 Technology Advancement Program. 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[18]
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 OGV 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.

CAAP Measure- SPBP-OGV1; Vessel Speed Reduction (VSR) Program
In May 2001, a Memorandum of Understanding (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 nautical miles (nm) from Point Fermin. The term of this MOU expired in 2004; however, currently a significant number (roughly 89% in 2008) of the OGVs operating at the Port are abiding 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.

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.

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

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% S 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 ocean-going Vessels, the ports of Long Beach and Los Angeles 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 pays 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 encourages and accelerates 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 U.S. Environmental Protection Agency or California Air Resources Board 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 three nautical miles 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[19]

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 crafts 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 crafts 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 crafts. 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 U.S. 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 begins 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 parts per million (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, carbon monoxide (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.

[19] See: *http://www.arb.ca.gov/regact/2007/chc07/isor.pdf*

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 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 IV engine standards. By the end of 2012, all pre-2007 on-road or pre Tier IV off-road top picks, forklifts, reach stackers, RTGs, and straddle carriers <750 hp must meet at a minimum the EPA 2007 on-road engine standards or Tier IV off-road engine standards. By end of 2014, all CHE with engines >750 hp must meet at a minimum the EPA Tier IV off-road engine standards. Starting 2007 (until equipment is replaced with Tier IV), 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[20]
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

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

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.

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"[21] 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 [Union Pacific (UP) and Burlington Northern Santa Fe (BNSF)] 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-

[21] EPA 2008.

essential idling and install idling reduction devices, identify and expeditiously repair locomotives that smoke excessively and maximize the use of 15 ppm sulfur fuel.

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+ On-Road Heavy Duty Vehicles (HDV), which will ultimately result in 90% reductions in emissions of NO_x and particulate (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 parts per million (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 an ARB approved Level 3 verified diesel emission control strategy (VDECS).

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

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:

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

4. By 1 January 2010 – All 1989-1993 trucks along with un-retrofitted[22] 1994-2003 trucks are banned from port services.

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

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. As of July 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 that 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

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

Highway Safety, Traffic Reduction, Air Quality and Port Security Bond Act of 2006), passed by voters in November 2006, has 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 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 include:

- T-5: Ship electrification at ports (previously adopted as regulation in December 2007)
- T-6: Goods movement efficiency measures

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).

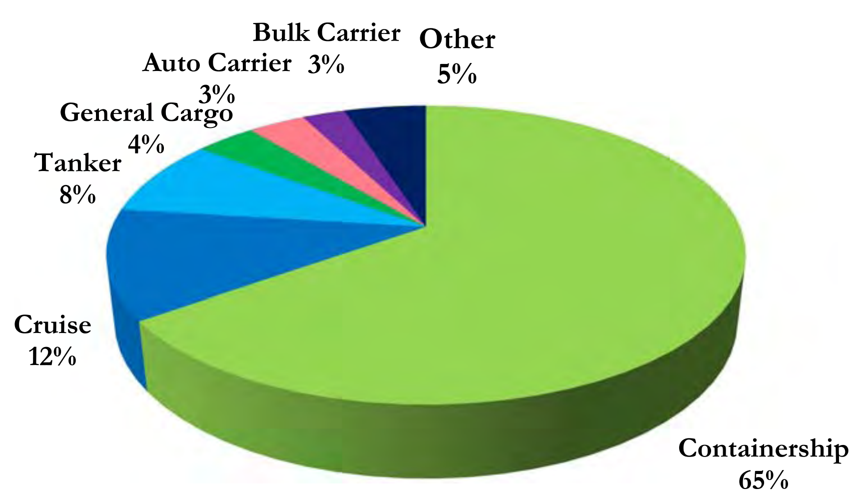
3.1 Source Description

OGVs calling at the Port in 2008 whether inbound from 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, excursion vessels, and other workboats, 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

Based on Marine Exchange of Southern California (MarEx) data, there were 2,239 calls to the port in 2008. Figure 3.1 shows the percentage of inbound calls by vessel type. Containerships (65%) made the majority of the inbound calls; followed by cruise ships (12%); tankers (8%); general cargo (4%); auto carriers (3%), ocean tugs (3%), bulk carriers (3%), and reefer vessels (2%).

Figure 3.1: Distribution of Vessel Types by Inbound Calls

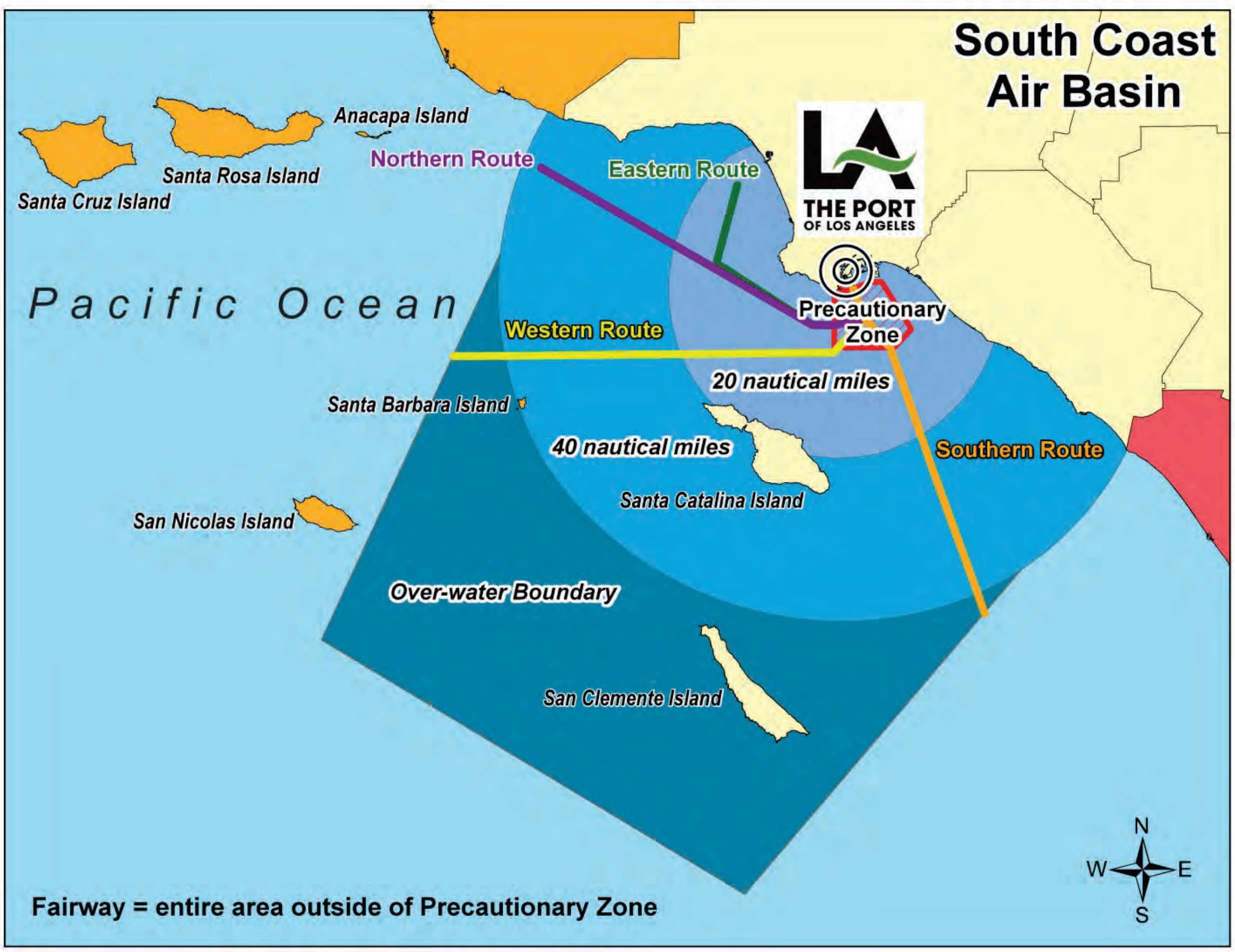


3.2 Geographical Delineation

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



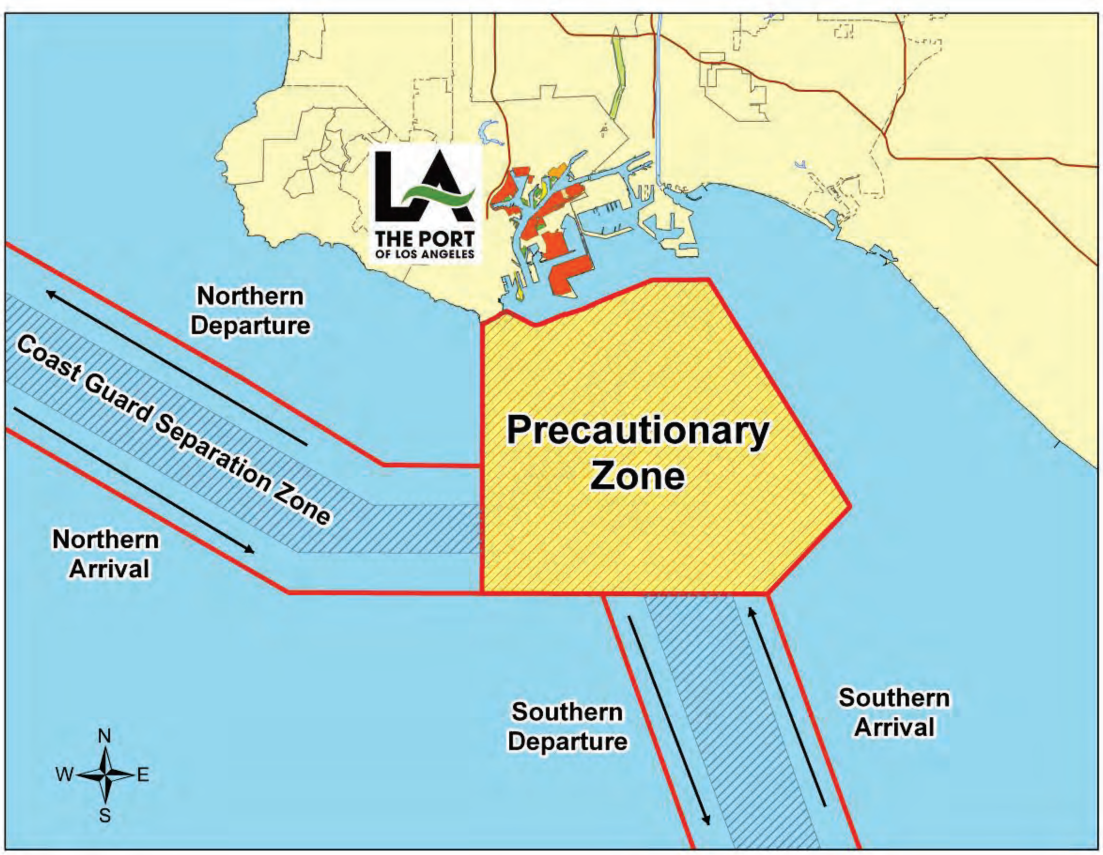
The distances in nautical miles (nm) for the various routes are listed in Table 3.1. The distances shown are from the precautionary zone (PZ) to the basin boundary and from the breakwater (BW) to the PZ. Due to improved GIS measurements, the distances shown are slightly different from those used in previous EI published reports.

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
- Vessel Speed Reduction Program speed data
- Los Angeles Pilot Service
- Lloyd's Register of Ships
- Port VBP 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 speed from the next outer waypoint (i.e., missing speed at 20 nm is given the speed recorded at 25 nm).

For the first few months of 2008, when speeds were not recorded past the 20 nm marker, a different approach is used to fill in missing speeds at the 25 to 40 nm waypoints. The 25 nm to 40 nm speeds data for the latter part of 2008 was 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 were developed for each vessel subtype, and separate factors were developed for vessels that were complying with the VSR speed limit over the 20 nm to 10 nm distance and for vessels that were not complying. The adjustment factors are applied when there are missing MarEx speeds at the 25 to 40 nm waypoints, such as occurred prior to April 2008. 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).

In previous inventories, when there was no speed data past 20 nm, the speed for the waypoints between 25 and 40 nm was assumed to be 94% of Lloyd's speed. The method described above has been used in preparing estimates of previous years' emissions for direct comparison with the 2008 emissions.

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[23] 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 first quarter of 2009. 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, with the exception of ocean tugs.

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.

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

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 April 2009.

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

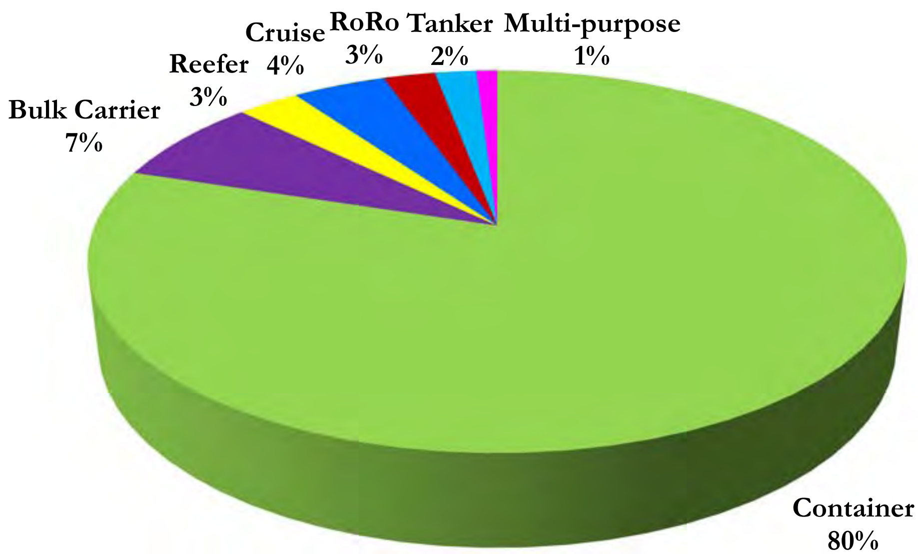


Table 3.2 summarizes the Port of Los Angeles VBP statistics for data collected from 204 vessels and from 36 shipping lines from 2003 to April 2009. Some vessels were boarded more than once (i.e., at berth and during arrival).

Table 3.2: Port of Los Angeles Vessel Boarding Program Statistics

Count	Type
65	Arrivals
166	At berth
55	Departures
1	Shift
287	**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
204	Port of Los Angeles
43	Port of Long Beach
32	Puget Sound
319	Data provided without boarding
598	**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 with Lloyd's and ABS data was 100%, so defaults for main engine power were not required

Auxiliary Engine Data
Due to the fact that auxiliary engine information is usually 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 information. For the 2008 vessels that called at the Port, the auxiliary engine power loads collected from VBP were used for the individual vessels with collected data. The remaining vessels were assigned defaults by vessel type obtained from average auxiliary engine power from Lloyd's and VBP data. See section 3.5.9 for auxiliary engine default discussion.

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 2008. Arrivals and departures do not match because the activity is based on a calendar year.

Table 3.4: Total OGV Movements for 2008

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	79	77	8	164
Bulk	57	55	42	154
Bulk - Heavy Load	2	2	3	7
Container - 1000	176	175	23	374
Container - 2000	96	95	15	206
Container - 3000	142	141	23	306
Container - 4000	368	362	32	762
Container - 5000	341	341	34	716
Container - 6000	199	201	8	408
Container - 7000	99	99	9	207
Container - 8000	30	27	7	64
Container - 9000	8	8	4	20
Cruise	265	264	3	532
General Cargo	81	86	77	244
ITB	74	57	44	175
Reefer	36	34	50	120
Tanker - Aframax	5	6	5	16
Tanker - Chemical	87	81	123	291
Tanker - Handyboat	65	65	94	224
Tanker - Panamax	29	29	48	106
Total	**2,239**	**2,205**	**652**	**5,096**

DB ID451

3.5 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, usually 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:

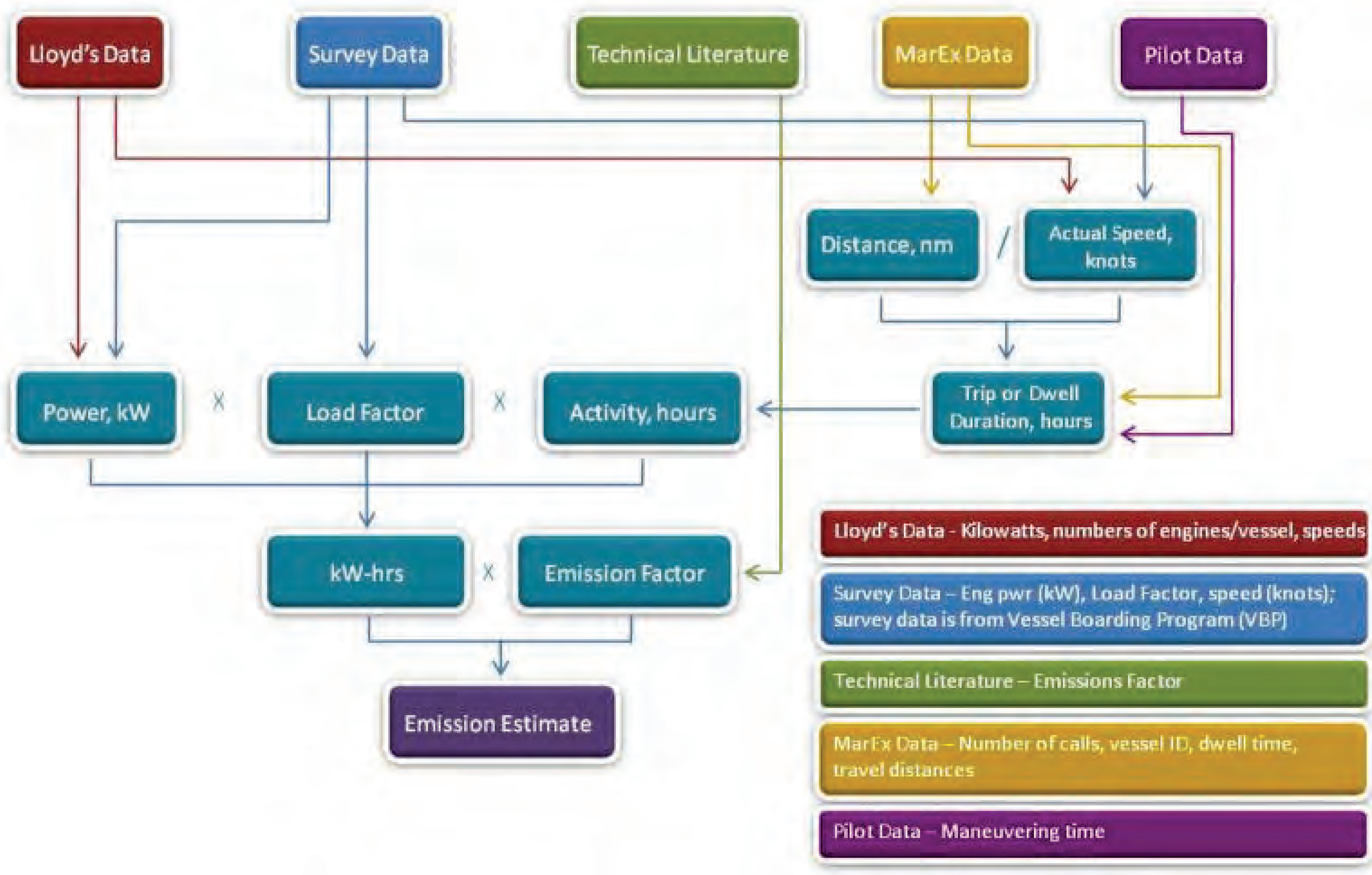
$$Energy = MCR \times LF \times Act \qquad \text{Equation 3.2}$$

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 report 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. The VSR program requests vessels to travel at or below 12 knots when the vessel is within 20 nm of Point Fermin. Vessel speeds are recorded by the Marine Exchange for zones called 10, 15 and 20. And as of April 2008, speeds at 25, 30, 35 and 40 nm are also recorded and provided by MarEx.

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

DB ID472

3.5.4 Propulsion Engine Emission Factors

The main engine emission factors used in this study were reported in a 2002 ENTEC study,[24] except for PM emission factors. CARB[25] provided the PM EF for slow and medium speed diesel engines. IVL 2004 study[26] 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 reported in the IVL 2004 study also. Vessels are assumed to operate their main engines on residual oil (RO) which is intermediate fuel oil (IFO 380) or one with similar specifications, with an average sulfur content of 2.7%. This is supported by information collected during the VBP and 2005 CARB survey; exceptions are made for those vessels that use a different fuel other than residual fuel. The two predominant propulsion engine types are:

[24]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).
[25] 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*
[26] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors."* Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency.

- 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

DB ID454

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

DB ID453

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[27] 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.[28]

Equation 3.5 is the EEIA formula used 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

[27] 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.
[28] 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 2.5 (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. The hydrocarbon and CH_4 LLA factors are different from those stated in the previous year's report due to an erroneous HC intercept value previously used.

Table 3.10: Low Load Adjustment Multipliers for Emission Factors[29]

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

DB ID475

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

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

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

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 3.9)

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 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 the vessels that called the Port in 2008 were able to be matched for main engine power using the most current Lloyd's data and VBP information. Therefore, no defaults were used for 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. For medium speed engines built after the year 2000, the 13.0 g/kW-hr NO_X emission factor is used.

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[30]	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

3.5.9 Auxiliary Engine Defaults

Auxiliary engine information is usually not provided to Lloyd's by vessel owners since it is not required by IMO or the classification societies, thus Lloyd's data contains minimal auxiliary engine information. Therefore, auxiliary engine data gathered from the VBP and Lloyd's data on ships making local calls to the port was used to generate profiles or defaults for missing data. Since the defaults are based on the vessels that visit the Port that year, defaults will vary slightly from year to year.

[30] IVL 2004.

Table 3.13 summarizes the auxiliary engine load defaults used for this study by vessel subtype.

Table 3.13: Auxiliary Engine Load Defaults

Vessel Type	Auxiliary Engine Load Defaults (kW)			
	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	369	1,108	616	369
Bulk	283	750	167	283
Bulk - Heavy Load	244	646	144	244
Container - 1000	443	1,051	332	443
Container - 2000	888	1,973	937	888
Container - 3000	692	2,372	593	692
Container - 4000	1,584	2,791	1,282	1,584
Container - 5000	1,156	4,128	991	1,156
Container - 6000	1,544	3,444	1,069	1,544
Container - 7000	1,774	3,958	1,228	1,774
Container - 8000	1,560	3,480	1,080	1,560
Container - 9000	1,560	3,480	1,080	1,560
Cruise	4,663	7,460	4,663	4,663
General Cargo	429	1,137	556	429
ITB	111	293	145	111
Reefer	533	1,599	924	533
Tanker - Aframax	608	837	659	608
Tanker - Chemical	768	1,056	832	768
Tanker - Handyboat	384	528	416	384
Tanker - Panamax	636	874	689	636

DB ID471

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 exhaust for heating purposes and 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 coming on during transit when the lower speeds result in the cooling of main engine exhausts, making the vessels' economizers less effective. The assumption was implemented that auxiliary boilers operate if the main engine power is less than 20% during transit. In the past inventories, boilers were assumed not to be used at all during transit due to higher speeds, which allowed the use of economizers to provide steam and hot water. This change increased boiler emissions somewhat but has not affected a large number of vessel transits.

Table 3.14 and 3.15 shows the emission factors used for the steam boilers based on ENTEC's emission factors for steam boilers (ENTEC 2002).

Table 3.14: 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

Table 3.15: 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

The boiler fuel consumption 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.

$$\textit{Average kW} = ((\textit{daily fuel}/24) \times 1{,}000{,}000)/305 \qquad \text{Equation 3.6}$$

Auxiliary boiler energy defaults in kilowatts used for each vessel type are presented in Table 3.16. 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 boilers will be turned on and the maneuvering defaults are used which are similar to hotelling defaults, except for the tankers. The auxiliary boiler energy defaults were further refined due to additional collected data from VBP and, therefore, are different from the defaults used in previous inventories.

Table 3.16: Auxiliary Boiler Energy Defaults

Vessel Type	Boiler Energy Defaults (kW)			
	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	0	282	282	282
Bulk	0	109	109	109
Bulk - Heavy Load	0	109	109	109
Container - 1000	0	232	232	232
Container - 2000	0	393	393	393
Container - 3000	0	534	534	534
Container - 4000	0	519	519	519
Container - 5000	0	590	590	590
Container - 6000	0	586	586	586
Container - 7000	0	586	586	586
Container - 8000	0	586	586	586
Container - 9000	0	586	586	586
Cruise	0	1,000	1,000	0
General Cargo	0	252	252	252
ITB	0	0	0	0
Reefer	0	464	464	464
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

DB ID47

3.5.11 Fuel Correction Factors

Fuel correction factors are used to adjust the emission rates from the fuel. As discussed earlier, emission factors were given for engines using residual fuel with an average 2.7% sulfur content and marine diesel oil with an average 1.5% sulfur content. Table 3.17 lists the fuel correction factors which are consistent with CARB's fuel correction factors used for their emission estimations methodology for ocean-going vessels.[31] Some of the FCF are slightly different from those used in previous inventory due to the use of CARB's latest FCF.

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

Table 3.17: 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
MGO	0.5%	0.25	0.94	0.18	1.00	1.00	1.00	0.94	1.00
MGO	0.2%	0.19	0.94	0.07	1.00	1.00	1.00	0.94	1.00
MGO	0.1%	0.17	0.94	0.04	1.00	1.00	1.00	0.94	1.00

DB ID455

CARB's marine auxiliary engine fuel regulation that went into effect in 2007 required vessel operators to use MDO or MGO with sulfur content of equal or less than 0.5% sulfur by weight within 24 nm from California. This regulation did not apply to auxiliary boilers. Per the CARB marine auxiliary engine fuel regulation, the cruise ships, which have medium speed diesel-electric engines, burned marine diesel fuel on all their engines within 24 nm from California coast and while at berth, regardless if the engines were used for propulsion or auxiliary load.

For 2008, the vessel operators complied with the regulation from January 2008 to end of April 2008 when the CARB Fuel Regulation was in effect. Thus, this 2008 inventory takes into account 100% of the vessels' auxiliary engines burning marine diesel fuel less than 0.5% sulfur within 24 nm from California coast and while at berth for the first 4 months of the year from January 1, 2008 to April 30, 2008.

Starting July 2008, the port had its own voluntary Fuel Switch Program that involved main engines and auxiliary engines. For those companies that enrolled their vessels in the program, this 2008 inventory assumes that these vessels switched to lower sulfur fuel within 24 nm during port calls made between July 1, 2008 and December 31, 2008.

In summary, the following observations can be made of the fuel switching assumptions used for 2008 inventory in order to calculate emissions for vessels that called the Port in 2008:

- January 2008 – end of April 2008: 100% of vessels' auxiliary engines burned marine diesel fuel (less than 0.5% S).[32]

[32] Per telephone and email contact with CARB (12 March 09), port's 100% assumed compliance is in agreement with CARB's own emission inventories and as part of Technical Working Group, CARB has reviewed and agreed with dates and compliance rate used for the CARB Fuel Regulation that was in place at beginning of 2008.

- May 2008 and June 2008: with a few exceptions, most vessels burned 2.7% S for all their engines. Exceptions for May and June include companies such as Maersk who made a company decision to switch to lower sulfur fuel regardless of whether a regulation or voluntary measure was in place.

- July 2008 – December 2008: those vessels enrolled in port's Fuel Switch Program, main and auxiliary engines burned marine diesel fuel within 24 nm.

The fuel switch assumptions used for the 2008 is a conservative approach as there may have been other companies that switched to lower sulfur fuel during the May-December 2008 time period but the port was not aware of it.

3.5.12 Emission Reduction Technologies

Control factors can also be used for emission reduction technologies that the vessel may have. One such technology for marine main engines is the fuel slide valve. This new type of fuel valve leads to better combustion process, less smoke, and lower fuel consumption which results in reduced overall emissions for NO_x (30% reduction) and PM (25% reduction). Some companies are retrofitting vessels with MAN B&W main engines in their fleet with the fuel slide valve. Since the slide valves are equipped on a vessel by vessel basis, the inventory may not have captured all the vessels that have been retrofitted with slide valves. The newer MAN B&W engines (2004+ model year) have the fuel slide valves. The emission reductions used for the slide valves are based on MAN B&W Diesel A/S emission measurements.

In 2008, fuel slide valves were used by 143 vessels that made almost 467 calls to the Port. This includes the 2004 and newer vessels with MAN B&W engines and the known vessels that retrofitted their main engines with the fuel slide valves.

3.5.13 Improvements to Methodology from Previous Years

Below are some improvements from previous year inventories that have an effect on current emissions and thus may not make apples to apples comparison possible to previously published reports (for apples to apples comparison to other year emissions, see section 9):

- Vessel Type Classification – In previous inventories, the vessel type classification was based on vessel types as reported by the Marine Exchange in the activity source data. The new methodology uses the Lloyd's vessel type classification (based on IMO number) to classify the vessel types and subtypes, which is believed to be a more consistent source of vessel information. In addition, the tanker subtypes were re-assigned so that all tankers, with the exception of chemical tankers, were assigned to the Aframax, Handyboat, Panamax, Suezmax classification. In the past, only tankers that were exclusively crude oil tankers were assigned to these tanker subtypes.

- Vessel Activity – the method for allocating vessel activity and the associated emissions to a port, terminal or berth requires tracing a vessel's movement back a number of steps due to the shifts between ports and anchorages. The 2008 methodology captures all of the ships' movements. Previous inventories assigned associated emissions to a port based on two to three previous movements.

- Calendar Year - In order to evaluate the vessel activity for the entire year, the previous methodology was structured to look two to three weeks into the subsequent year in order to properly allocate the activity of vessels that departed after 31 December of the inventory year. As a result, the data file for a calendar year contained data on activities that occurred in the following year. The new methodology has been designed to limit this activity analysis strictly to the calendar year of study (1 January to 31 December).

- Distances – to reflect more precise GIS measurements, the zone distances for the four major shipping routes were revised up to the geographical extent of the inventory.

- Maneuvering time – average in-harbor maneuvering times were used for each movement, ship type and terminal based on average trip times. In previous inventories, the in-harbor maneuvering time was based on vessel type.

- Maneuvering load – the maneuvering load is calculated on a vessel by vessel basis. In past inventories, it was based on an average load by vessel type.

- Missing speeds - 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. In previous inventories, when there was no speed data past 20 nm, the speed for the waypoints between 25 and 40 nm were assumed to be 94% of the ship's Lloyd's speed. This methodology change has had the greatest impact on emissions of any of the 2008 OGV methodology changes.

- Speeds in Transit Zones - 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. Missing speed measurements are filled in according to established protocols. In the 2007 and previous EIs, each waypoint speed was used as the average speed in the zone between that waypoint and the next one in - e.g., the speed recorded by MarEx at the 20 nm waypoint was allocated to the 15-20 nm zone. Starting with the 2008 EI, the zone speeds have been calculated as the average of the speeds at the adjacent waypoints - e.g., the 15-20 nm zone speed has been calculated as the average of the speeds at the 15 and 20 nm waypoints.

- Slide fuel valves – in 2008 inventory, vessels built in 2004 and newer model year and equipped with MAN B&W propulsion engines are assumed to be equipped with slide valves. In past inventories, the assumption applied to vessels built in 2005 and newer model year MAN B&W propulsion engines.

- Minimum main engine load cap of 2% - the previous EIs calculations did not include a provision for setting a minimum load of 2% for the transiting zones, so, some main engine loads were estimated below 2%.

- Maximum engine load cap - calculated loads above 100% are capped at 100%.

- Low load adjustment factor – the hydrocarbon and CH_4 LLA factor was revised.

- Fuel Switching Hierarchy – a hierarchy was established for the various fuel switching policies (Vessel Operator Fuel Switch Policy, Port Incentive Fuel Switch Program, Vessel Fuel Switch Policy, CARB Fuel Regulation, Default of IFO 2.7% S)

- Implemented 95% reduction for shore power rather than 100% reduction.

- Assumption on Boiler Start-up during Transit - 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, boilers. Because of these lower speeds, it is believed that auxiliary boilers are coming on during transit when the lower speeds result in the cooling of main engine exhausts, making the vessels' economizers less effective. The assumption was implemented that auxiliary boilers operate if the main engine power is less than 20% during transit. In the past inventories, boilers were assumed not to be used at all during transit due to higher speeds, which allowed the use of economizers to provide steam and hot water. This change increased boiler emissions somewhat but has not affected a large number of vessel transits.

- Cruise ships with diesel-electric engines are now assumed to not use their fuel-fired boilers. In past inventories, it was assumed all cruise ships used their boilers.

3.6 Emission Estimates

A summary of the ocean-going vessel emission estimates by vessel type for all pollutants for the year 2008 is presented in Tables 3.18 and 3.19.

Table 3.18: 2008 Ocean-Going Vessel Emissions by Vessel Type, tpy

Vessel Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto Carrier	6.3	5.0	5.7	67.0	51.8	6.1	2.7
Bulk	5.0	4.0	4.5	52.2	45.1	4.7	2.0
Bulk - Heavy Load	0.1	0.1	0.1	2.1	1.8	0.2	0.1
Container - 1000	10.8	8.6	9.4	114.2	97.9	10.8	4.7
Container - 2000	13.9	11.1	9.7	121.5	156.7	10.5	4.5
Container - 3000	27.5	22.0	23.3	268.5	237.4	26.4	12.5
Container - 4000	64.6	51.6	57.0	775.6	496.7	83.9	41.9
Container - 5000	88.3	70.7	76.6	842.4	732.7	97.3	49.2
Container - 6000	51.8	41.4	44.6	551.5	419.2	64.0	32.5
Container - 7000	17.9	14.3	14.3	292.7	155.4	33.1	16.1
Container - 8000	11.4	9.1	9.9	99.2	93.0	12.1	6.3
Container - 9000	3.5	2.8	3.1	28.8	30.7	3.5	1.7
Cruise	63.0	50.4	62.9	1,042.6	467.7	85.2	32.4
General Cargo	13.8	11.1	11.8	141.8	130.9	12.0	4.9
ITB	0.6	0.5	0.6	30.4	1.2	2.7	1.2
Reefer	4.5	3.6	3.3	58.2	45.8	4.9	2.0
Tanker - Aframax	2.2	1.7	0.8	15.5	33.8	1.4	0.6
Tanker - Chemical	21.3	17.1	11.8	162.6	287.9	14.3	6.0
Tanker - Handyboat	11.6	9.2	4.5	76.2	189.4	6.7	2.9
Tanker - Panamax	8.0	6.4	4.1	55.3	112.0	5.2	2.2
Total	**426.0**	**340.8**	**358.0**	**4,798.2**	**3,787.1**	**484.9**	**226.6**

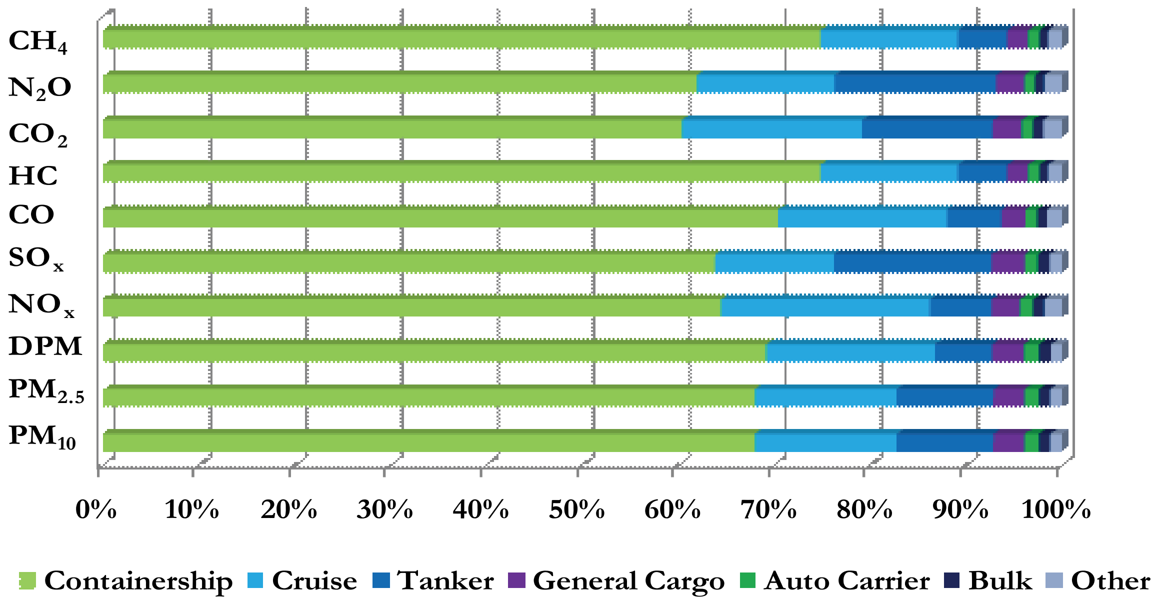
DB ID121

Table 3.19: Summary of 2008 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	3,048.1	2,996.1	0.2	0.0
Bulk	2,620.0	2,576.5	0.1	0.0
Bulk - Heavy Load	159.1	156.1	0.0	0.0
Container - 1000	6,275.9	6,170.0	0.3	0.1
Container - 2000	8,982.5	8,800.9	0.6	0.1
Container - 3000	13,619.3	13,358.4	0.8	0.2
Container - 4000	35,792.2	35,140.6	2.0	0.8
Container - 5000	43,803.2	42,997.0	2.5	0.9
Container - 6000	27,807.9	27,293.0	1.6	0.6
Container - 7000	15,241.6	14,971.5	0.9	0.3
Container - 8000	5,269.1	5,169.1	0.3	0.1
Container - 9000	1,627.9	1,599.1	0.1	0.0
Cruise	49,032.7	48,358.9	2.1	0.6
General Cargo	7,908.8	7,771.1	0.4	0.1
ITB	1,556.8	1,536.0	0.1	0.0
Reefer	3,519.2	3,455.6	0.2	0.0
Tanker - Aframax	2,071.4	2,025.3	0.1	0.0
Tanker - Chemical	16,765.2	16,412.9	1.1	0.1
Tanker - Handyboat	10,720.8	10,477.5	0.8	0.1
Tanker - Panamax	6,354.6	6,218.0	0.4	0.0
Total	**262,176.1**	**257,483.4**	**14.8**	**4.1**

Figure 3.6 shows percentage of emissions by vessel type for each pollutant. Containerships have the highest percentage of the emissions (approximately 60 to 72%) for the vessels, followed by cruise ships (approximately 15 to 20%), tankers (approximately 5 to 20%), general cargo, auto carrier and bulk vessels. The "other" category includes ocean-going tugboats and reefer vessels.

Figure 3.6: 2008 Ocean-Going Vessel Emissions by Vessel Type, %



3.6.1 Emission Estimates by Engine Type

Tables 3.20 and 3.21 present summaries of emission estimates by engine type in tons per year.

Table 3.20: 2008 Ocean-Going Vessel Emissions by Engine Type, tpy

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auxiliary Engine	168.3	134.7	168.3	2,494.9	1,278.0	204.6	74.4
Auxiliary Boiler	65.1	52.1	0.0	171.0	1,343.2	16.3	8.1
Main Engine	192.6	154.0	189.7	2,132.3	1,166.0	264.0	144.1
Total	**426.0**	**340.8**	**358.0**	**4,798.2**	**3,787.1**	**484.9**	**226.6**

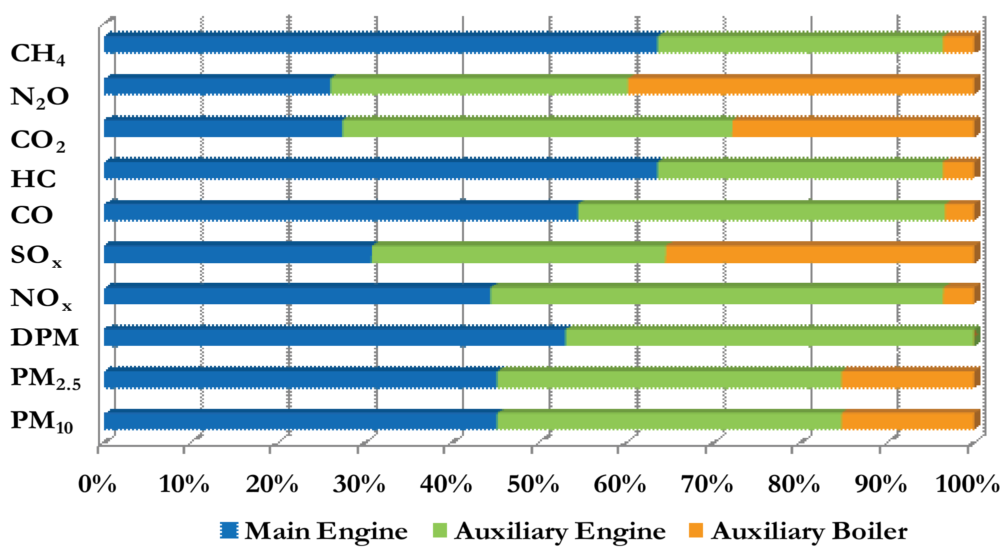
DB ID118

Table 3.21: 2008 Ocean-Going Vessel GHG Emissions by Engine Type, metric tons per year

Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auxiliary Engine	116,837.1	115,236.6	5.1	1.3
Auxiliary Boiler	73,468.1	71,633.6	5.9	0.1
Main Engine	71,865.5	70,613.2	3.9	2.6
Total	**262,176.1**	**257,483.4**	**14.8**	**4.1**

Figure 3.7 shows results in percentages for emission estimates by engine type. The auxiliary boilers generally have lower NO_x emission rates than diesel engines and higher SO_x emission rates than diesel engines which may explain the higher SO_x emissions percentage for auxiliary boilers.

Figure 3.7: 2008 Ocean-Going Vessel Emissions by Engine Type, %



3.6.2 Emission Estimates by Mode

Tables 3.22 and 3.23 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 for emission estimates by mode.

Table 3.22: 2008 Ocean-Going Vessel Emissions by Mode, tpy

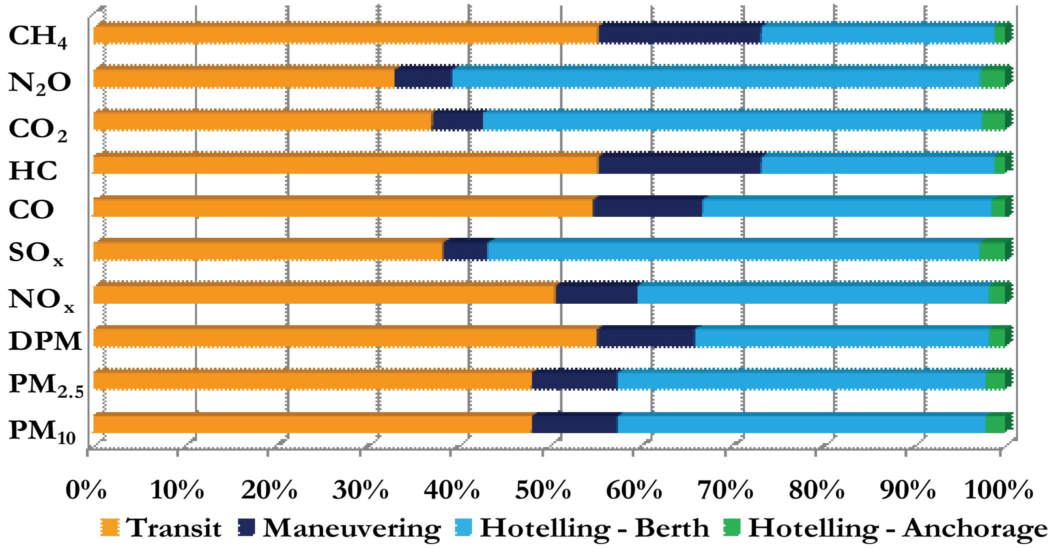
Mode	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Transit	Aux	32.7	26.1	32.7	509.1	245.3	41.5	15.1
Transit	Auxiliary Boiler	4.3	3.4	0.0	11.2	88.2	1.1	0.5
Transit	Main	167.9	134.3	165.1	1,911.2	1,118.9	223.1	109.8
Total Transit		**204.9**	**163.9**	**197.8**	**2,431.6**	**1,452.4**	**265.7**	**125.4**
Maneuvering	Aux	13.9	11.1	13.9	204.9	105.5	16.8	6.1
Maneuvering	Auxiliary Boiler	1.6	1.3	0.0	4.1	32.5	0.4	0.2
Maneuvering	Main	24.7	19.7	24.6	221.1	47.0	40.9	34.3
Total Maneuvering		**40.1**	**32.1**	**38.4**	**430.1**	**185.1**	**58.1**	**40.6**
Hotelling - Berth	Aux	115.3	92.3	115.3	1,700.6	876.1	139.7	50.8
Hotelling - Berth	Auxiliary Boiler	56.7	45.3	0.0	148.7	1,168.6	14.2	7.1
Hotelling - Berth	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Berth		**172.0**	**137.6**	**115.3**	**1,849.3**	**2,044.7**	**153.9**	**57.9**
Hotelling - Anchorage	Aux	6.5	5.2	6.5	80.3	51.1	6.6	2.4
Hotelling - Anchorage	Auxiliary Boiler	2.6	2.1	0.0	6.9	53.9	0.7	0.3
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Anchorage		**9.1**	**7.3**	**6.5**	**87.2**	**105.0**	**7.3**	**2.7**
Total		**426.0**	**340.8**	**358.0**	**4,798.2**	**3,787.1**	**484.9**	**226.6**

DB ID448

Table 3.23: 2008 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	Aux	23,695.2	23,371.2	1.0	0.3
Transit	Auxiliary Boiler	4,826.8	4,706.2	0.4	0.0
Transit	Main	68,639.9	67,516.3	3.5	2.0
Total Transit		**97,161.9**	**95,593.7**	**4.9**	**2.3**
Maneuvering	Aux	9,579.8	9,448.5	0.4	0.1
Maneuvering	Auxiliary Boiler	1,775.8	1,731.5	0.1	0.0
Maneuvering	Main	3,225.6	3,097.0	0.4	0.6
Total Maneuvering		**14,581.2**	**14,277.0**	**0.9**	**0.7**
Hotelling - Berth	Aux	79,782.2	78,689.2	3.5	0.9
Hotelling - Berth	Auxiliary Boiler	63,919.9	62,323.8	5.1	0.1
Hotelling - Berth	Main	0.0	0.0	0.0	0.0
Total Hotelling - Berth		**143,702.1**	**141,012.9**	**8.6**	**1.1**
Hotelling - Anchorage	Aux	3,779.9	3,727.7	0.2	0.0
Hotelling - Anchorage	Auxiliary Boiler	2,945.6	2,872.1	0.2	0.0
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0
Total Hotelling - Anchorage		**6,725.5**	**6,599.8**	**0.4**	**0.0**
Total		**262,176.1**	**257,483.4**	**14.8**	**4.1**

Figure 3.8: 2008 Ocean-Going Vessel Emissions by Mode, %



3.7 Facts and Findings

Information gathered during the data collection process, but not necessarily used for emissions calculations, is summarized in this subsection. Table 3.24 summarizes the number of calls and total TEUs handled by the Port from 2005 to 2008.

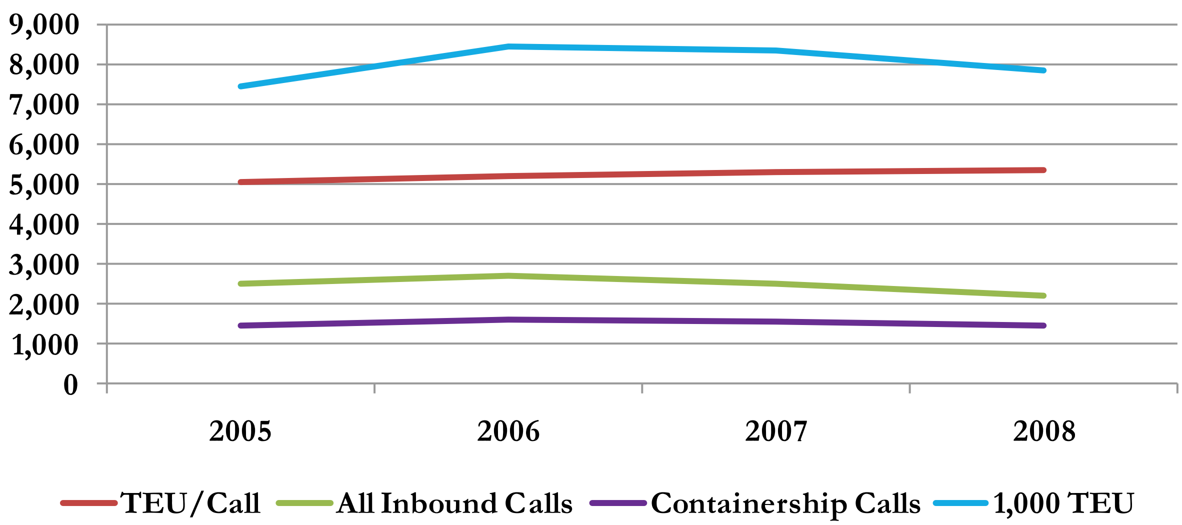
Table 3.24: TEUs and Vessel Call Comparison, 2005-2008

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2008	2,239	1,459	7,849,985	5,380
2007	2,537	1,577	8,355,038	5,298
2006	2,701	1,632	8,469,853	5,190
2005	2,500	1,479	7,484,625	5,061
Previous Year (2008-2007)	**-12%**	**-7%**	**-6%**	**2%**
CAAP Progress (2008-2005)	**-10%**	**-1%**	**5%**	**6%**

DB ID452

Figure 3.9 shows that the vessel calls fluctuate from year to year (two lower lines), but have not increased at the same rate as the TEU throughput (top line). This is due to the increased efficiency at the Port terminals which continue to handle more TEUs per call (second line from the top).

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. Over 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 13% 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 30 "other" flags of registry are included together as "other" category.

Figure 3.10: Flag of Registry, Discrete Vessel

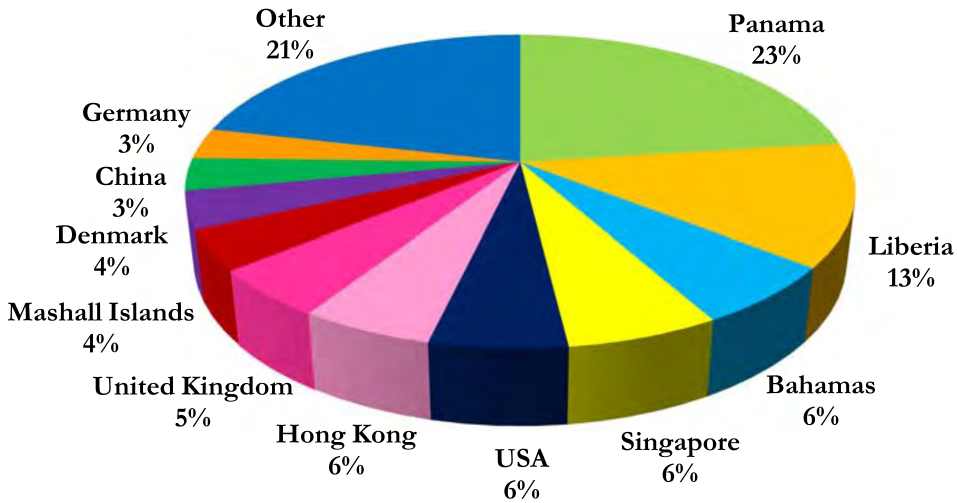
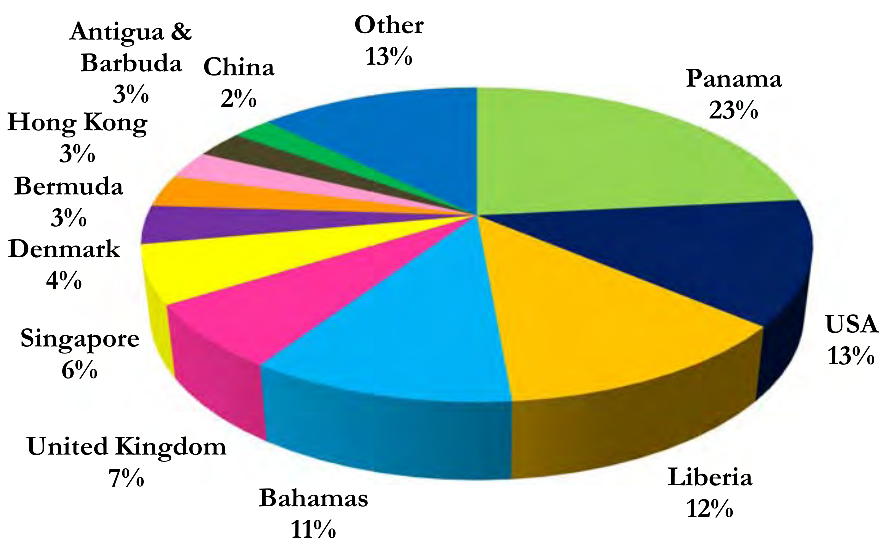


Figure 3.11: Flag of Registry, Vessel Call



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 2008. The other category contains about 125 ports that had less than 2% each.

Figure 3.12: Next (To) Port

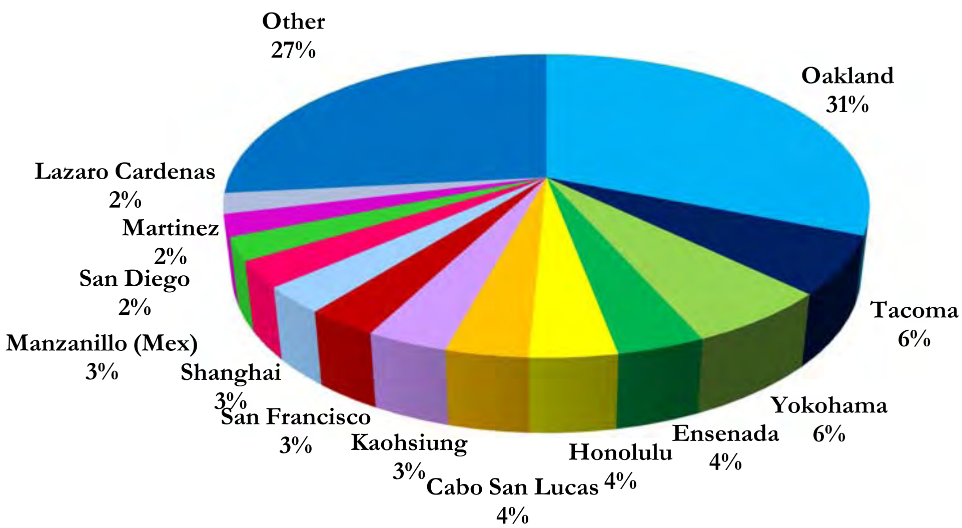
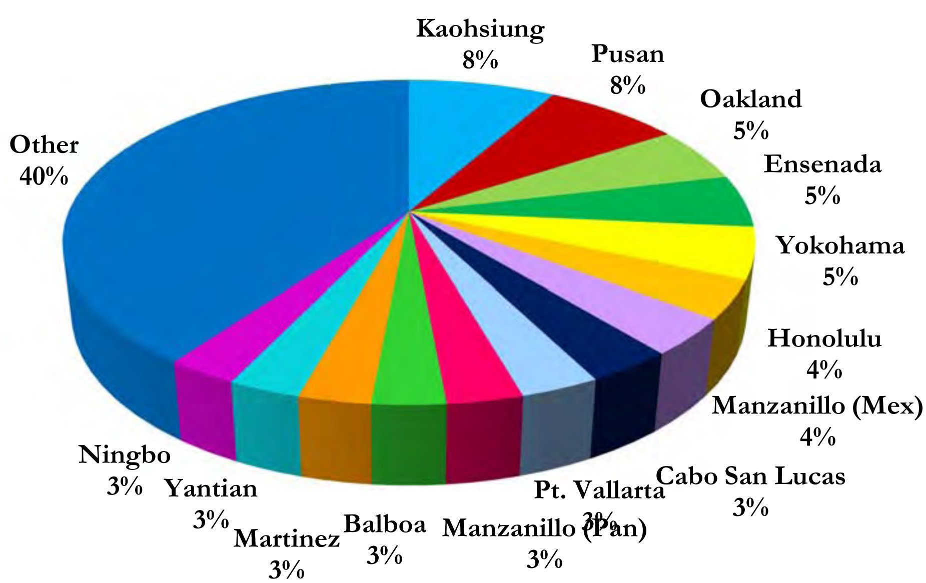


Figure 3.13: Last (From) Port



3.7.3 Vessel Characteristics

Table 3.25 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.

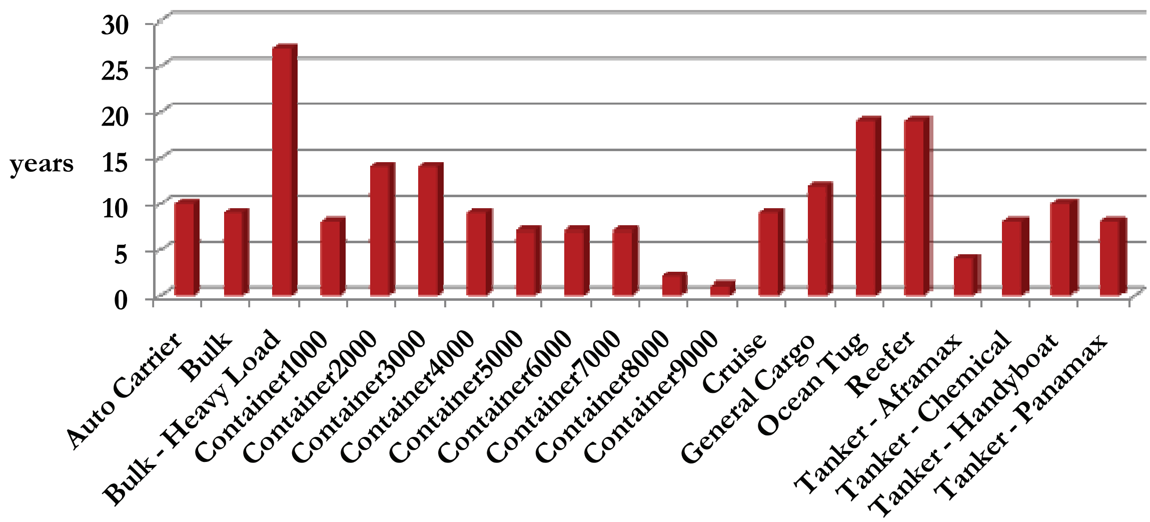
Table 3.25: Vessel Type Characteristics for Vessels that Called the Port in 2008

			Average			
Vessel Type	**Year Built**	**Age (Years)**	**DWT (tons)**	**Max Speed (knots)**	**Main Eng (kW)**	**Aux Eng (kW)**
Auto Carrier	1998	10	22,608	19.3	12,049	3,411
Bulk	1999	9	46,781	14.3	7,993	1,861
Bulk - Heavy Load	1981	27	7,064	13.5	4,489	950
Container - 1000	2000	8	18,900	19.5	12,673	3,472
Container - 2000	1994	14	37,366	20.6	21,031	5,046
Container - 3000	1994	14	46,241	22.4	29,532	4,445
Container - 4000	1999	9	60,060	24.4	43,167	7,689
Container - 5000	2001	7	66,147	25.2	52,235	8,342
Container - 6000	2001	7	82,069	24.9	59,327	12,754
Container - 7000	2001	7	101,587	25.0	57,930	13,203
Container - 8000	2006	2	101,702	25.1	68,370	11,986
Container - 9000	2007	1	108,542	24.8	67,112	na
Cruise	1999	9	7,496	21.3	46,514	11,197
General Cargo	1996	12	42,011	15.1	9,459	2,199
Ocean Tug	1989	19	27,465	15.0	8,271	na
Reefer	1989	19	12,404	19.5	9,860	3,633
Tanker - Aframax	2004	4	105,752	15.0	13,220	2,504
Tanker - Chemical	2000	8	37,207	14.8	8,351	3,017
Tanker - Handyboat	1998	10	45,606	14.8	8,868	2,568
Tanker - Panamax	2000	8	68,221	14.9	11,229	2,714

DB ID460

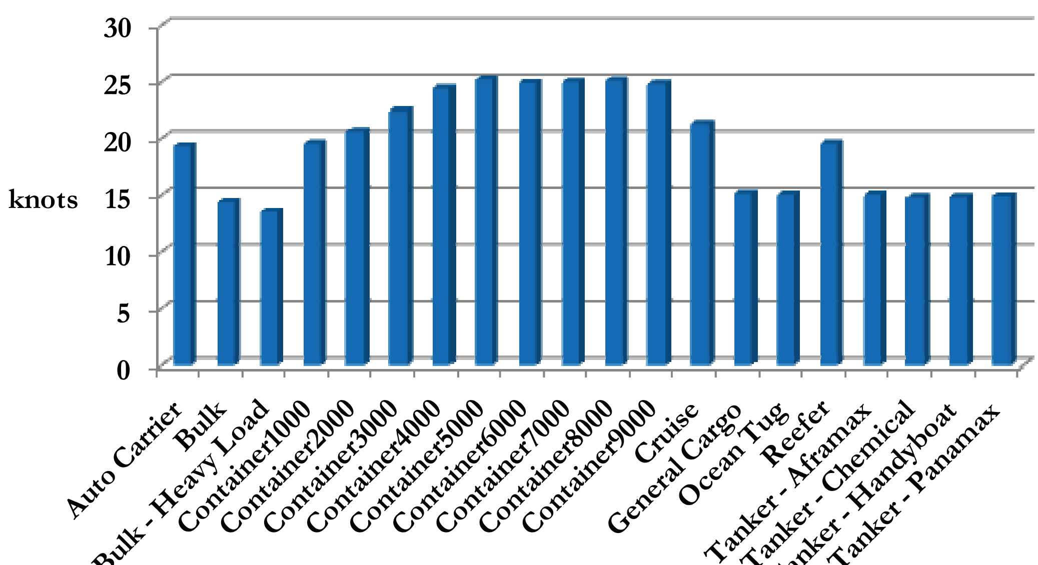
Figures 3.14 through Figure 3.18 show the various vessel type characteristics. The larger containerships (8,000+ TEU) and tankers (Aframax) that called the Port have newer vessels. The bulk heavy-load vessels, reefers, ocean tugs and some of the smaller containerships (2000-3000 TEU) have slightly older vessels.

Figure 3.14: Average Age of Vessels that Called the Port of Los Angeles in 2008, years



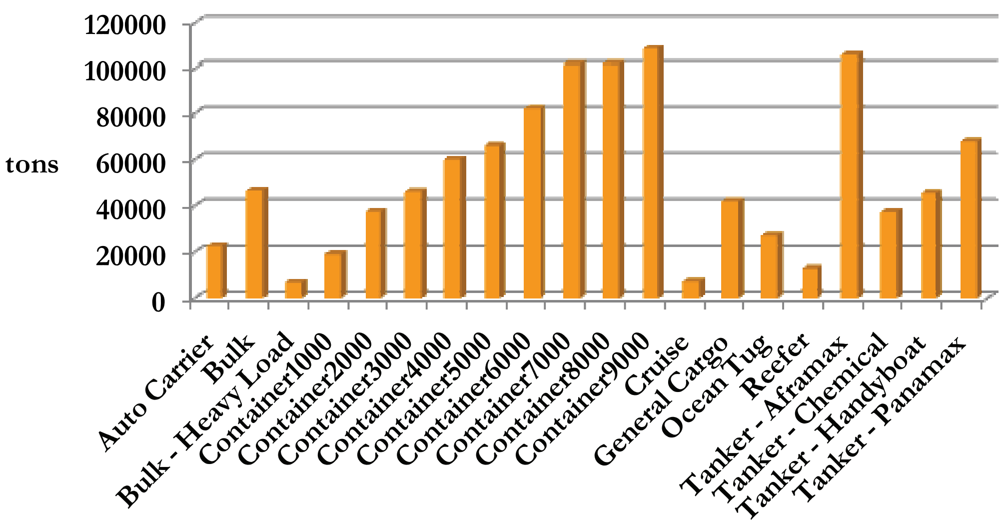
Containerships and cruise ships have the highest maximum rated speeds.

Figure 3.15: Average Maximum Rated Sea Speed of Vessels that Called the Port in 2008, knots



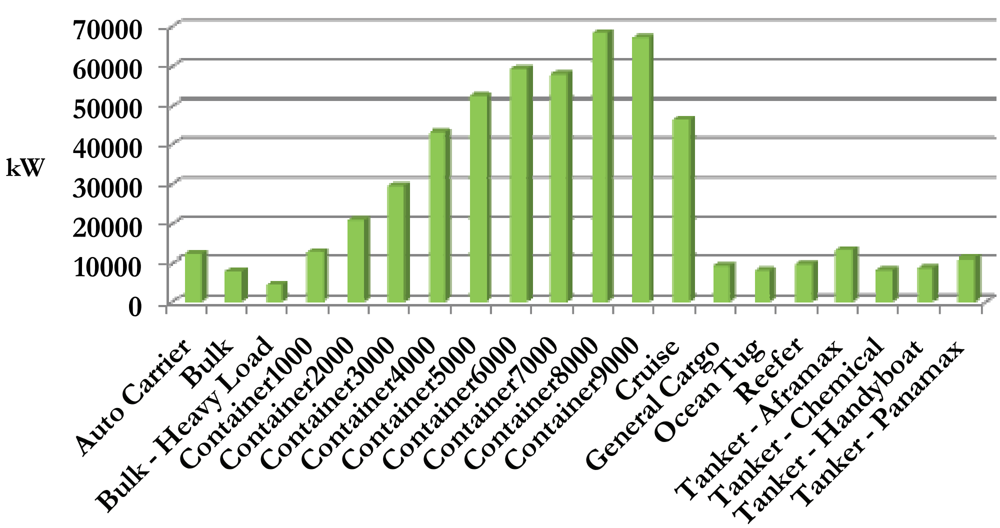
The largest containerships (7000+TEU) and the Aframax tankers have the largest average deadweight tonnage among the various vessel types, while cruise and reefer vessels weigh the least.

Figure 3.16: Average Deadweight of Vessels that Called the Port in 2008, tons



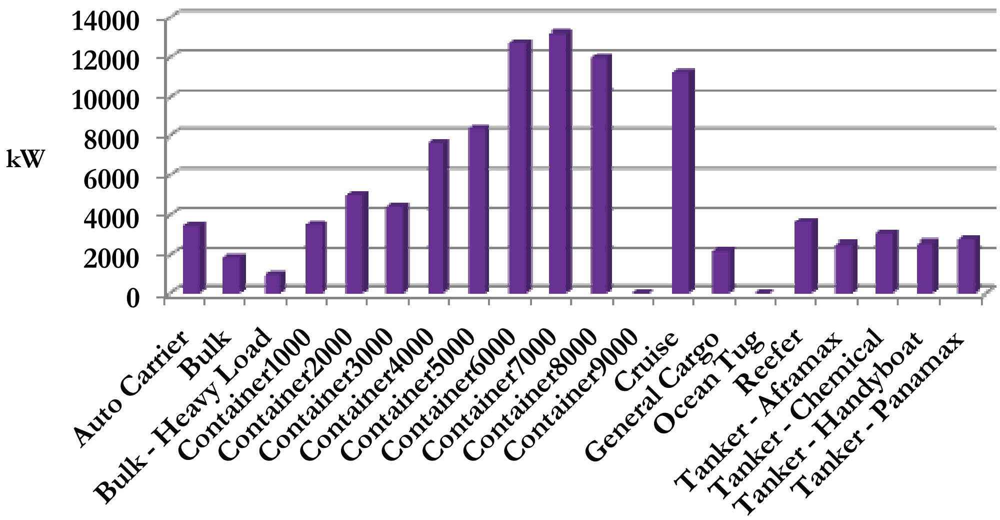
Containerships have the highest main engine total installed power, followed by cruise ships.

Figure 3.17: Average Main Engine Total Installed Power of Vessels that Called the Port in 2008, kilowatts



The 6000+ TEU containerships and cruise ships have the highest auxiliary engine total installed power. The auxiliary engine power for container 9,000 and ocean tugs is not available from Lloyds and therefore not included in the chart below, defaults or vessel boarding information are not included in the vessel characteristics charts.

Figure 3.18: Average Auxiliary Engine Total Installed Power of Vessels that Called the Port in 2008, kilowatts



3.7.4 Hotelling Time at Berth and Anchorage

Tables 3.26 and 3.27 summarize the berth and anchorage hotelling times, respectively.

Table 3.26: Hotelling Times at Berth for Vessels that Called the Port in 2008 by Vessel Type

	Berth Hotelling Time, hours		
Vessel Type	**Min**	**Max**	**Avg**
Auto Carrier	9.4	48.0	21.5
Bulk	11.7	162.0	71.7
Bulk - Heavy Load	163.3	413.9	288.6
Container - 1000	2.7	1,445.7	30.2
Container - 2000	13.4	70.0	40.3
Container - 3000	0.0	119.6	48.9
Container - 4000	9.2	107.8	36.5
Container - 5000	0.0	102.6	55.4
Container - 6000	39.1	95.6	60.6
Container - 7000	40.7	99.0	62.5
Container - 8000	50.7	109.6	85.4
Container - 9000	74.5	108.2	90.4
Cruise	3.3	179.5	13.6
General Cargo	8.1	202.0	59.2
Ocean Tug	14.3	53.8	30.1
Reefer	3.4	292.0	32.2
Tanker - Aframax	30.9	268.2	99.8
Tanker - Chemical	8.1	92.8	34.2
Tanker - Handyboat	13.4	82.8	31.1
Tanker - Panamax	18.6	72.9	42.8

DB ID204

Table 3.27 shows the range and average hotelling times at anchorage with the actual vessel counts for each vessel subtype that visited the anchorages and which the range is based on.

Table 3.27: Hotelling Times at Anchorage by Vessel Type

Vessel Type	Anchorage Hotelling Time, hours Min	Max	Avg	Calls Count
Auto Carrier	1.9	33.8	9.6	9
Bulk	1.8	91.3	27.3	30
Bulk - Heavy Load	2.1	49.9	18.7	2
Container - 1000	1.6	55.3	15.3	13
Container - 2000	1.3	24.1	5.5	10
Container - 3000	2.3	82.1	21.7	9
Container - 4000	1.0	12.0	3.6	27
Container - 5000	1.1	15.2	4.3	17
Container - 6000	2.0	10.4	5.4	8
Container - 7000	0.9	6.9	4.1	9
Container - 8000	1.8	4.3	2.6	7
Container - 9000	2.7	4.8	3.8	3
Cruise	0.0	0.0	0.0	0
General Cargo	1.3	332.0	39.9	28
Ocean Tug	1.1	116.6	18.9	6
Reefer	2.8	25.0	6.9	9
Tanker - Aframax	7.1	108.2	37.7	4
Tanker - Chemical	0.7	313.5	31.3	49
Tanker - Handyboat	1.1	86.5	20.0	28
Tanker - Panamax	1.4	151.2	19.8	23

DB ID449

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 3.28 shows the percentage of repeat vessels. Container vessels, cruise ships and ocean tugs had the highest percentage of frequent callers in 2008. Tankers, reefer vessels, general cargo and bulk vessels are not frequent callers.

Table 3.28: Percentage of Frequent Callers

Vessel Type	Frequent Vessels	Total Vessels	Percent Frequent Vessels
Auto Carrier	3	33	9%
Bulk	1	48	2%
Bulk - Heavy Load	0	3	0%
Container - 1000	12	39	31%
Container - 2000	4	18	22%
Container - 3000	11	28	39%
Container - 4000	14	109	13%
Container - 5000	25	64	39%
Container - 6000	17	32	53%
Container - 7000	5	25	20%
Container - 8000	0	12	0%
Container - 9000	0	3	0%
Cruise	9	28	32%
General Cargo	0	54	0%
ITB	5	6	83%
Reefer	0	18	0%
Tanker - Aframax	0	5	0%
Tanker - Chemical	2	65	3%
Tanker - Handyboat	2	31	6%
Tanker - Panamax	0	26	0%
Total	**110**	**647**	
Average			**17%**

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).

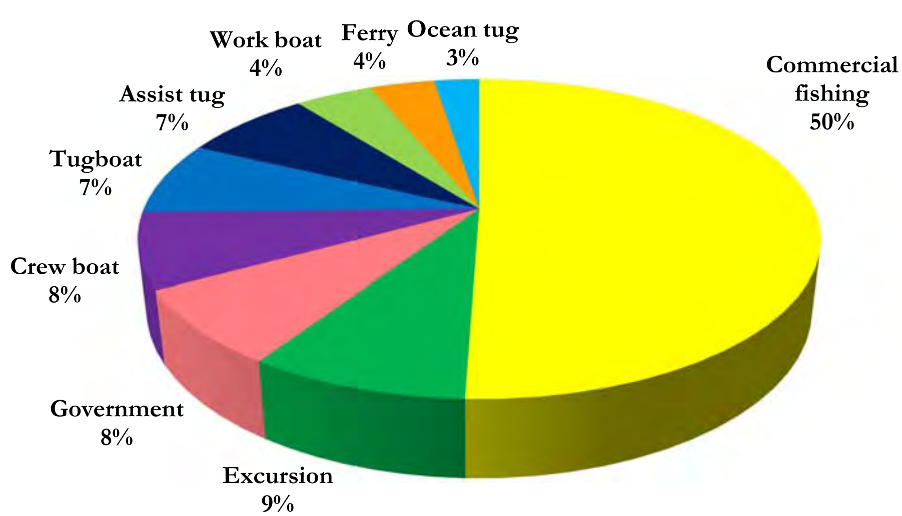
4.1 Source Description

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
- Harbor tugboats
- Ocean tugboats
- Work boats

Recreational vessels are not considered to be commercial harbor craft; therefore their emissions are not included in this study. Figure 4.1 presents the distribution of the 273 commercial harbor craft inventoried for the Port in 2008. Commercial fishing vessels represent 50% of the harbor craft inventoried, followed by the excursion vessels (9%), government vessels (8%), crew boats (8%), harbor tugboats (7%), assist tugs (7%), work boats (4%), ferries (4%), and ocean tugs (3%).

Figure 4.1: Distribution of 2008 Commercial Harbor Craft for Port of Los Angeles

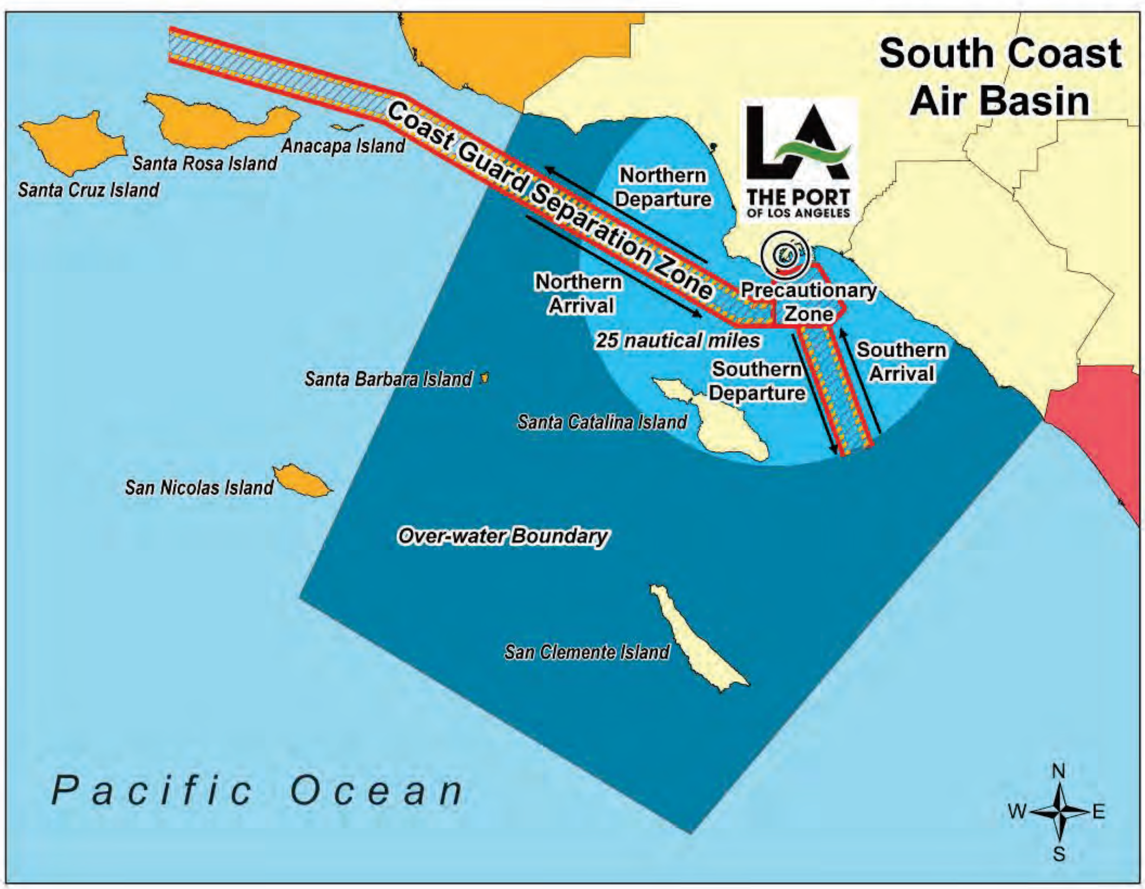


Ocean tugboats included in this section are different from the integrated tug barge (ITB) and articulated tug barge (ATB) included in the ocean-going section of this study. ITB and ATB are seen as a specialized single vessel and are included in the marine exchange data for ocean-going vessels. The ocean tugs 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 separated from harbor tugboats because their engine loads are higher than harbor tugs which tend to idle more in-between jobs.

4.2 Geographical Delineation

The geographical extent of the emissions inventory for harbor craft is the boundary for the SoCAB. Most harbor craft work the majority of the time within the harbor and up to 25 nautical miles from the Port. For those harbor craft that work outside of the harbor and travel to other ports, vessel operators were asked to provide hours up to 50 nautical miles from the Port in order to ensure the SoCAB boundary would be included in the estimated hours.

Figure 4.2: Geographical Extent of Harbor Craft Inventory



4.3 Data and Information Acquisition

To collect data for the harbor craft inventory, the following sources were used:

- Vessel owners and/or operators
- Wharfingers data for commercial fishing vessels at Port-owned berths
- List of repowered vessels in South Coast provided by CARB
- List of Port-funded projects

The operating parameters of interest included the following:

- Vessel type
- Number, type and horsepower (or kilowatts) of main 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
- Engine model year
- Replaced engines
- Emission reduction strategies such as: alternative fuels, retrofits with after-treatment, and shore power

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

Workboats:

- Pacific Tugboat Services
- Jankovich

Crewboats:

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

Assist tugboats and harbor tugs:

- Crowley Marine Services
- Foss Maritime Company
- Millenium Maritime
- Amnav

Harbor and ocean tugs:

- Crowley Petroleum Services
- Sause Brothers Ocean Towing
- Westoil Marine Services
- Peninsula Tugboat Services

4.4 Operational Profiles

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

Tables 4.1 and 4.2 summarize the main and auxiliary engine data, respectively, for each vessel type. The tables below include engine specific information obtained from operators of the vessels included in this inventory. The averages by vessel type in these tables were used as defaults for vessels where the model year, horsepower, or operating activity hour information was missing. The operational hours for some of the vessels that were not at the Port the full year reflect the partial time they worked in the harbor for the 2008 calendar year.

This inventory covers harbor craft that operate in the Port of Los Angeles 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 2008 for the Port of Los Angeles harbor only.

Table 4.1: Propulsion Engine Data by Vessel Category

Harbor Vessel Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Operating Hours Minimum	Annual Operating Hours Maximum	Annual Operating Hours Average
Assist tug	20	40	1967	2008	1995	750	2,540	1,988	0	2,254	1,327
Commercial fishing	138	141	1950	2008	1984	50	940	236	200	4,000	1,599
Crew boat	21	47	1964	2007	1991	210	1,400	394	0	1,847	622
Excursion	24	44	1959	2004	1991	150	530	358	300	3,000	1,525
Ferry	10	22	2001	2008	2004	600	2,300	1,873	600	1,200	1,068
Government	21	31	1963	2006	1998	110	1,800	445	25	1,100	434
Ocean tug	7	14	1985	2007	1999	805	2,000	1,544	80	1,500	476
Tugboat	20	39	1970	2008	1996	200	2,000	809	0	2,477	752
Work boat	12	23	1985	2005	1999	200	800	400	26	3,000	638
Total	**273**	**401**									

DB ID423

Table 4.2: Auxiliary Engine Data by Vessel Category

Harbor Vessel Type	Vessel Count	Engine Count	Model year Minimum	Model year Maximum	Model year Average	Horsepower Minimum	Horsepower Maximum	Horsepower Average	Annual Operating Hours Minimum	Annual Operating Hours Maximum	Annual Operating Hours Average
Assist tug	20	40	1967	2008	1999	115	200	138	0	3,217	1,178
Commercial fishing	138	23	1957	2004	1993	10	195	79	100	4,500	1,635
Crew boat	21	18	1964	2007	1983	11	300	106	0	3,321	797
Excursion	24	26	1966	2003	1990	7	54	39	125	3,000	1,413
Ferry	10	14	2000	2008	2003	18	120	55	300	750	686
Government	21	8	1988	2003	1996	50	400	224	20	200	110
Ocean tug	7	14	1985	2007	1999	60	150	92	50	750	369
Tugboat	20	28	1970	2008	1996	14	95	52	0	2,875	863
Work boat	12	11	1968	2005	1997	20	83	38	0	2,000	727
Total	**273**	**182**									

DB ID422

Table 4.3 summarizes the time spent in harbor (51%), at 25 miles out (35%) and up to the basin boundary (14%) for all harbor craft.

Table 4.3: Allocation of Time Spent by Harbor Craft Type

Harbor Vessel Type	Harbor	Up to 25 Miles	Up to Basin Boundary
Assist tug	99%	1%	0%
Commercial fishing	10%	50%	40%
Crew boat	60%	40%	0%
Excursion	35%	57%	13%
Ferry	38%	60%	2%
Government	97%	3%	0%
Ocean tug	50%	29%	21%
Tugboat	85%	12%	3%
Work boat	55%	45%	0%
Average	**51%**	**35%**	**14%**

DB ID424

Harbor vessel owners and operators were asked to identify replaced engines from their fleet. In addition, lists of replaced engines with funding from the Port, Carl Moyer program and other state-funded programs were reviewed to identify vessels with replaced engines. The following observations can be made of the harbor craft in the 2008 inventory:

- 30 vessels have Tier 2 engines (most engines 2004 and newer)
- 74 vessels have Tier 1 engines (most engines ranging from 2000 to 2003 model year)
- 194 vessels have Tier 0 engines (engines older than 1999)

Note that a vessel may have a combination of engines that meet different standards if all the engines are not replaced at the same time. For example, a vessel may receive funding to replace the auxiliary engines, but not propulsion engines or vice-versa. The following tables show a total of 190 propulsion and auxiliary engines replaced, but the majority of the engines were replaced with Tier 1 engines which were the engines that were available at that time.

Table 4.4 shows that for 2008, 29% (115 engines) of all main engines in harbor craft that operated at the Port had replaced engines. In 2007, the percent of replaced main engines was 27% (114 engines). Most of the engine replacements that account for the 29% occurred between the 2001 and 2005 inventories. Between 2006 and 2008, few engine replacements occurred.

Table 4.4: Count of Replaced Main Engines

Harbor Vessel Type	Engine Count	Propulsion Engines Engines Repowered	Repowered Engines, %
Assist tug	40	0	0%
Commercial fishing	141	20	14%
Crew boat	47	23	49%
Excursion	44	17	39%
Ferry	22	22	100%
Government	31	2	6%
Ocean tug	14	6	43%
Tugboat	39	21	54%
Work boat	23	4	17%
Total	**401**	**115**	**29%**

DB ID199

Figure 4.3 shows the distribution of the 115 replaced main engines by vessel type. Of the total 115 main engines replaced to date, 20 were for commercial fishing representing 17% of all main engines replaced.

Figure 4.3: Distribution of Replaced Main Engines by Vessel Type

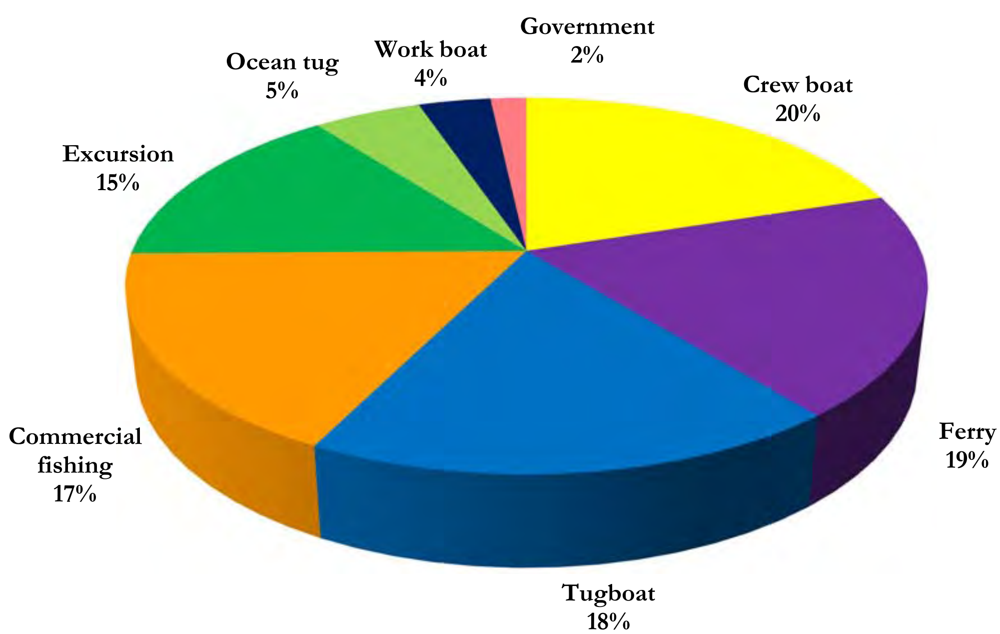


Table 4.5 shows that for 2008, 41% of all auxiliary engines in harbor craft that operated at the Port had replaced engines. There was a decrease in the total count of replaced auxiliary engines from the previous year (76 replaced auxiliary engines in 2007). Similar to the main engines, most engine replacements occurred between the 2001 and 2005 inventories. For some vessel types, there are fewer replaced engines in 2008 than previous year due to the fact that some vessels leave the harbor and different vessels may take their place.

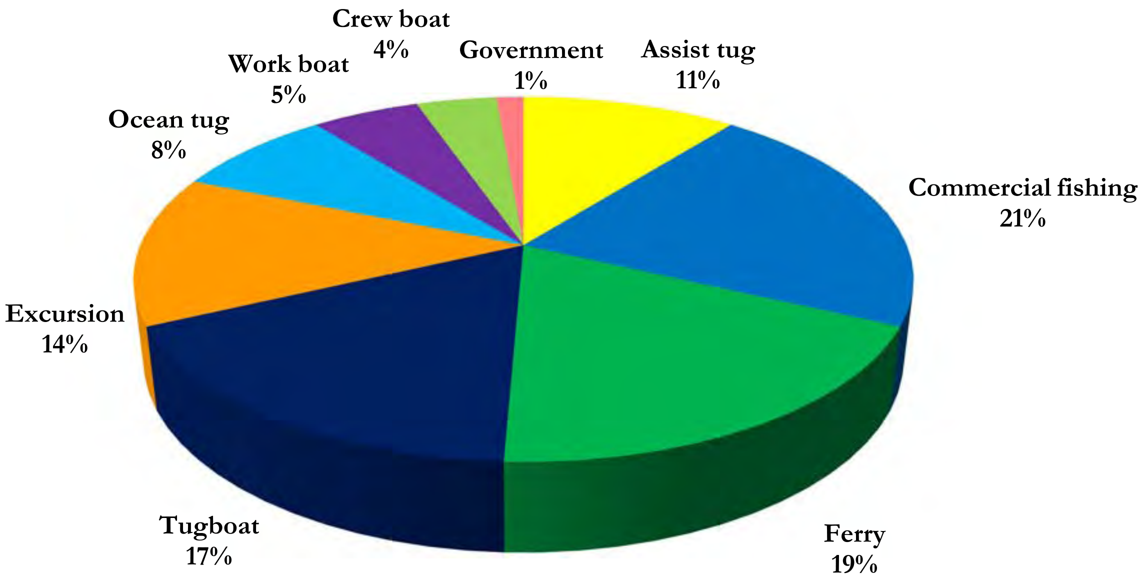
Table 4.5: Count of Replaced Auxiliary Engines

	Auxiliary Engines		
Harbor Vessel Type	**Engine Count**	**Engines Repowered**	**Repowered Engines, %**
Assist tug	40	8	20%
Commercial fishing	23	16	70%
Crew boat	18	3	17%
Excursion	26	10	38%
Ferry	14	14	100%
Government	8	1	13%
Ocean tug	14	6	43%
Tugboat	28	13	46%
Work boat	11	4	36%
Total	**182**	**75**	**41%**

DB ID425

Figure 4.4 shows the distribution of the 75 replaced auxiliary engines by vessel type. Of the total 75 auxiliary engines replaced to date, 16 were for commercial fishing representing 21% of all main engines replaced.

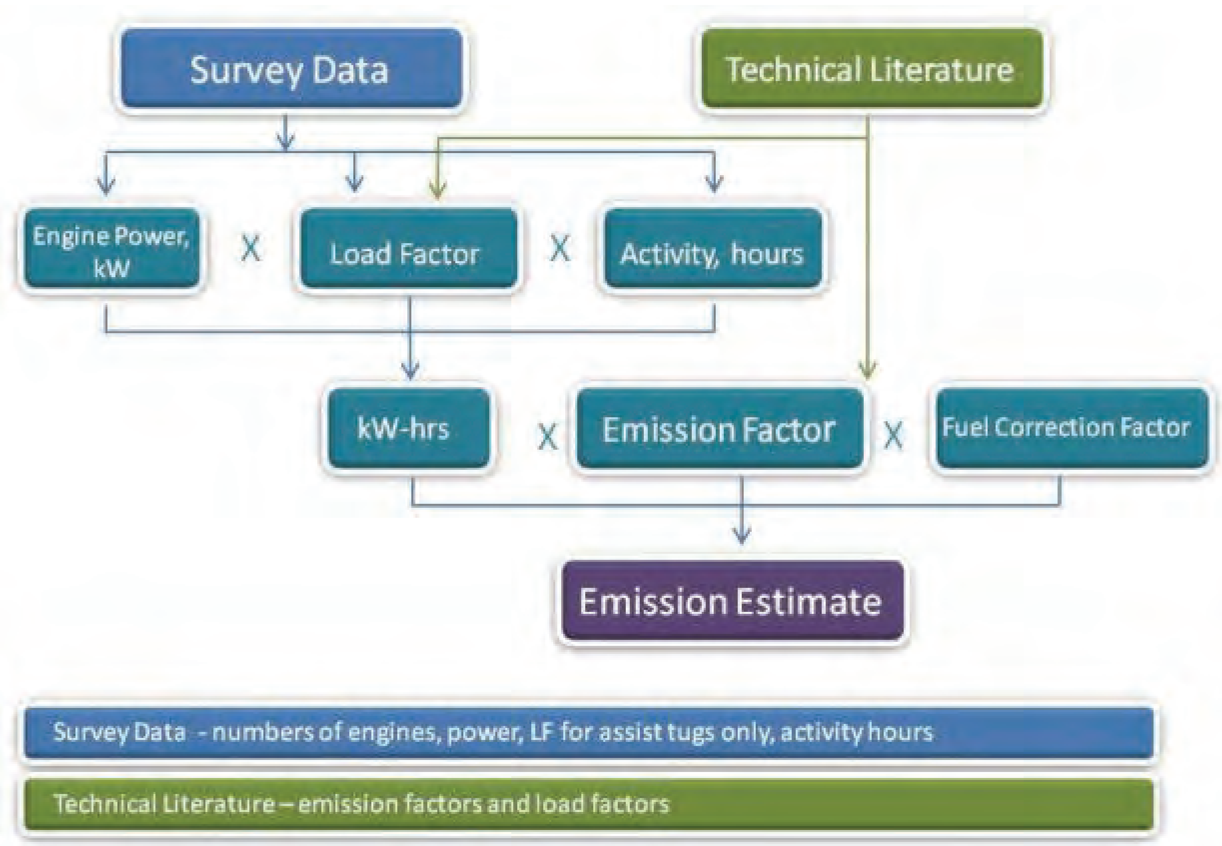
Figure 4.4: Distribution of Replaced Auxiliary Engines by Vessel Type



4.5 Methodology

The emission factors, engine load factors, and emission equations are described in this section. The flow chart in Figure 4.5 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 was required for the emission factors and load factors which are discussed further in this section. Emissions were estimated on a per engine basis, i.e., the main and auxiliary engines for each vessel were estimated for each vessel.

Figure 4.5: Harbor Craft Emission Estimation Flow Chart



4.5.1 Emission Equations

The basic equation used to estimate harbor vessel emissions is:

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

Where:

E = Emission, g/year
HP = Rated horse-power of the engine in kilowatts
Act = Activity, hours/year
LF = Load Factor
EF = Emission Factor, g/kW-hr
FCF = Fuel Correction Factor

The emission factor (EF) is a function of the zero hour (ZH) emission rate for the engine model year in the absence of any malfunction or tampering of engine components that can change emissions, plus a deterioration rate. The deterioration rate reflects the fact that base emissions of engines change as the equipment is used due to wear of various engine parts or reduced efficiency of emission control devices. The emission factor is calculated as:

$$EF = ZH + (DR \times Cumulative\ Hours) \qquad \text{Equation 4.2}$$

Where:

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

The equation for the deterioration rate is:

Equation 4.3

$$DR = (DF \times ZH) / \text{cumulative hours at the end of useful life}$$

Where:

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

Fuel correction factors are applied to correct the emission rates for the fact that over the years, the fuel properties have changed.

4.5.2 Deterioration Factors, Useful Life and Emission Factors

In order to be consistent, the Port's harbor craft emissions calculations methodology is similar to CARB's recent harbor craft emissions calculations methodology.[33] CARB's deterioration factors, useful life, and zero hour emission factors for commercial harbor craft were used, with the exception of greenhouse gas emission factors and SO_x emission factor. The CH_4 emission factor is 2% of the hydrocarbon emission factor. The source for the CO_2, CH_4, and N_2O emission factors is IVL.[34]

The SO_x emissions are calculated using the following mass balance equation:

Equation 4.4

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

Where:

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

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

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

[34] 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	23
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

4.5.3 Fuel Correction Factors

Fuel correction factors are applied to correct the emission rates for the fact that over the years, the fuel properties have changed. 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 California diesel fuel which is different from EPA diesel fuel. Table 4.8 summarizes the fuel correction factors used for harbor craft. The SO_x emission factor is based on EPA's diesel fuel with an average S content in the fuel of 350 ppm.

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 represents the load applied to an engine or the percent of rated engine power that is applied during the engine's normal operation. 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 vessel engine load readings published in the 2001 Port emissions inventory and is not consistent with the 50% engine load used in CARB's latest methodology.[35] In addition, CARB uses 43% engine load for all auxiliary engines as listed in Table 3.8, except for 31% used for the auxiliary engines of tugboats. The Port uses 43% for all auxiliary engines, including the tugboats and assist tugboats. The other vessel type load factors are consistent with CARB's latest methodology.

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

4.5.5 Improvements to Methodology from Previous Years

Below are some improvements from previous year inventories that may have an effect on current emissions and thus may not make apples to apples comparison possible to previous years' published reports (for apples to apples comparison to other year emissions, see section 9).

- Deterioration rates are no longer used for estimating greenhouse gases as in previous inventories due to lack of data sources available on greenhouse deterioration rates. This resulted in significant drop in GHG emission estimates.

- Data collection was improved for missing model year for vessels, thus less defaults were used. In general, for those harbor craft with improved model year data (i.e., commercial fishing vessels), the emissions may have increased from the previous year because the actual model year was older than the default average model year used in the previous inventory. The older the model year, the higher the emission rates and the average cumulative hours, thus higher emissions.

4.6 Emission Estimates

Table 4.10 and 4.11 summarizes the estimated 2008 harbor craft vessels emissions by vessel type and engine type.

Table 4.10: 2008 Commercial Harbor Craft Emissions by Engine Type, tpy

Vessel Type	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Assist Tug	Auxiliary	1.1	1.0	1.1	22.9	0.0	11.6	2.5
	Propulsion	18.1	16.7	18.1	422.4	0.2	114.2	27.8
Assist Tug Total		**19.2**	**17.7**	**19.2**	**445.3**	**0.2**	**125.8**	**30.2**
Commercial Fishing	Auxiliary	0.7	0.7	0.7	11.8	0.0	7.5	1.6
	Propulsion	8.9	8.2	8.9	216.4	0.1	55.1	13.8
Commercial Fishing Total		**9.6**	**8.8**	**9.6**	**228.2**	**0.1**	**62.6**	**15.4**
Crewboat	Auxiliary	0.3	0.3	0.3	6.3	0.0	3.2	0.9
	Propulsion	4.0	3.7	4.0	92.8	0.0	23.0	5.9
Crewboat Total		**4.3**	**4.0**	**4.3**	**99.2**	**0.0**	**26.1**	**6.8**
Excursion	Auxiliary	0.4	0.4	0.4	5.5	0.0	4.3	1.3
	Propulsion	5.8	5.4	5.8	134.2	0.1	36.7	9.0
Excursion Total		**6.3**	**5.8**	**6.3**	**139.7**	**0.1**	**41.0**	**10.3**
Ferry	Auxiliary	0.1	0.1	0.1	1.5	0.0	1.1	0.3
	Propulsion	6.9	6.3	6.9	149.8	0.1	45.3	11.3
Ferry Total		**7.0**	**6.4**	**7.0**	**151.2**	**0.1**	**46.4**	**11.6**
Government	Auxiliary	0.0	0.0	0.0	0.6	0.0	0.2	0.1
	Propulsion	1.4	1.3	1.4	32.2	0.0	9.7	2.3
Government Total		**1.4**	**1.3**	**1.4**	**32.8**	**0.0**	**9.9**	**2.4**
Ocean Tug (Line Haul)	Auxiliary	0.1	0.1	0.1	1.5	0.0	1.0	0.2
	Propulsion	2.8	2.5	2.8	65.5	0.0	22.7	4.9
Ocean Tug		**2.8**	**2.6**	**2.8**	**67.0**	**0.0**	**23.7**	**5.1**
Tugboat	Auxiliary	0.4	0.3	0.4	5.6	0.0	3.1	0.9
	Propulsion	3.8	3.5	3.8	88.1	0.0	26.1	6.2
Tugboat Total		**4.2**	**3.9**	**4.2**	**93.8**	**0.0**	**29.2**	**7.1**
Workboat	Auxiliary	0.1	0.1	0.1	1.6	0.0	1.0	0.3
	Propulsion	1.0	0.9	1.0	25.1	0.0	8.4	1.9
Workboat Total		**1.2**	**1.1**	**1.2**	**26.7**	**0.0**	**9.4**	**2.1**
Harbor craft Total		**56.0**	**51.5**	**56.0**	**1,283.9**	**0.6**	**374.1**	**91.0**

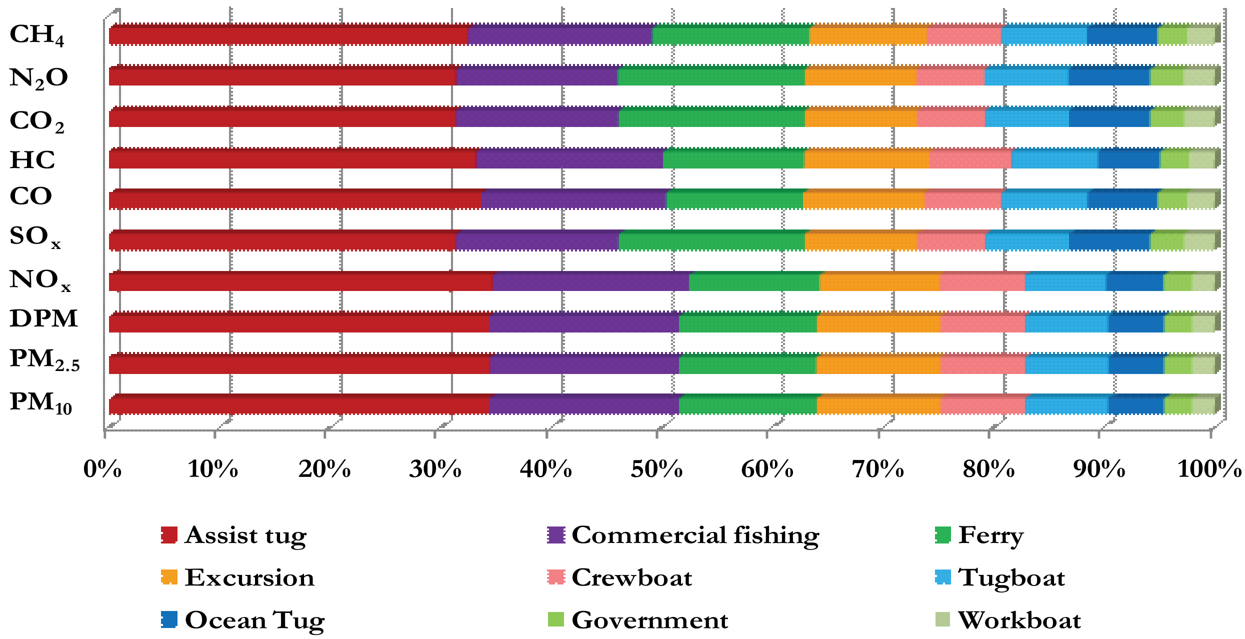
DB ID427

Table 4.11: 2008 Commercial Harbor Craft GHG Emissions by Engine Type, metric tons per year

Vessel Type	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Assist Tug	Auxiliary	1,328.2	1,309.1	0.1	0.0
	Propulsion	16,206.5	15,976.1	0.7	0.4
Assist Tug Total		**17,534.7**	**17,285.2**	**0.8**	**0.4**
Commercial Fishing	Auxiliary	802.9	791.3	0.0	0.0
	Propulsion	7,439.1	7,334.0	0.3	0.2
Commercial Fishing Total		**8,242.0**	**8,125.3**	**0.4**	**0.2**
Crewboat	Auxiliary	309.9	305.4	0.0	0.0
	Propulsion	3,163.0	3,118.0	0.1	0.1
Crewboat Total		**3,472.9**	**3,423.5**	**0.2**	**0.1**
Excursion	Auxiliary	345.2	340.1	0.0	0.0
	Propulsion	5,328.2	5,252.9	0.2	0.1
Excursion Total		**5,673.3**	**5,593.0**	**0.2**	**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	30.4	29.9	0.0	0.0
	Propulsion	1,678.9	1,655.0	0.1	0.0
Government Total		**1,709.2**	**1,685.0**	**0.1**	**0.0**
Ocean Tug (Line Ha	Auxiliary	111.7	110.1	0.0	0.0
	Propulsion	3,991.4	3,934.8	0.2	0.1
Ocean Tug		**4,103.0**	**4,044.9**	**0.2**	**0.1**
Tugboat	Auxiliary	298.3	293.9	0.0	0.0
	Propulsion	3,928.3	3,872.5	0.2	0.1
Tugboat Total		**4,226.6**	**4,166.4**	**0.2**	**0.1**
Workboat	Auxiliary	102.8	101.3	0.0	0.0
	Propulsion	1,458.6	1,437.9	0.1	0.0
Workboat Total		**1,561.4**	**1,539.2**	**0.1**	**0.0**
Harbor craft Total		**55,912.5**	**55,118.5**	**2.5**	**1.3**

Figure 4.6 shows that approximately 34% of the Port's harbor craft emissions are attributed to assist tugs, 17% to commercial fishing, 12% to ferries, 11% to excursion vessels, 8% to tugboats, 8% to crewboats, 5% to ocean tugs, 3% to government vessels, and 2% to workboats.

Figure 4.6: Harbor Craft Emission 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 of 25 hp or greater using diesel, gasoline, or alternative fuels. Due to the diversity of cargo, there is a wide range of equipment types. The majority of the equipment can be classified into one of the following equipment types:

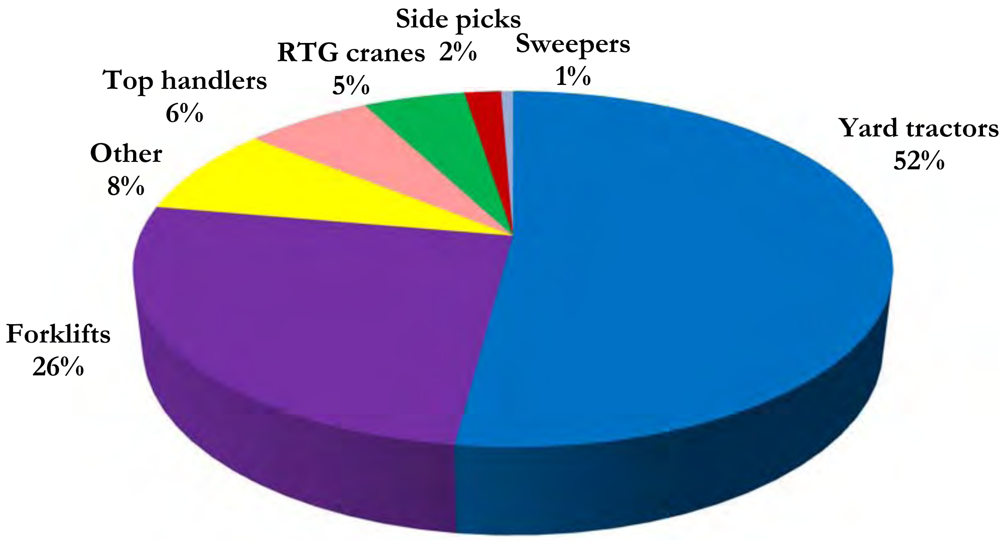
- Forklift
- Rubber tired gantry (RTG) crane
- Side pick
- Sweeper
- Top handler
- Yard tractor
- Other

The "Other" category contains the following:

- Bulldozer
- Dump truck
- Excavator
- Fuel truck
- Loader
- Man lift
- Rail pusher
- Roller
- Skid steer loader
- Trucks (propane, utility, water, vacuum)

Figure 5.1 presents the distribution of the 2,141 pieces of equipment inventoried at the Port for 2008. Out of all CHE inventoried at Port facilities, 52% were yard tractors, 26% were forklifts, six percent were top handlers, five percent were RTG cranes, two percent were side picks, 1% were sweepers, and eight percent were other equipment.

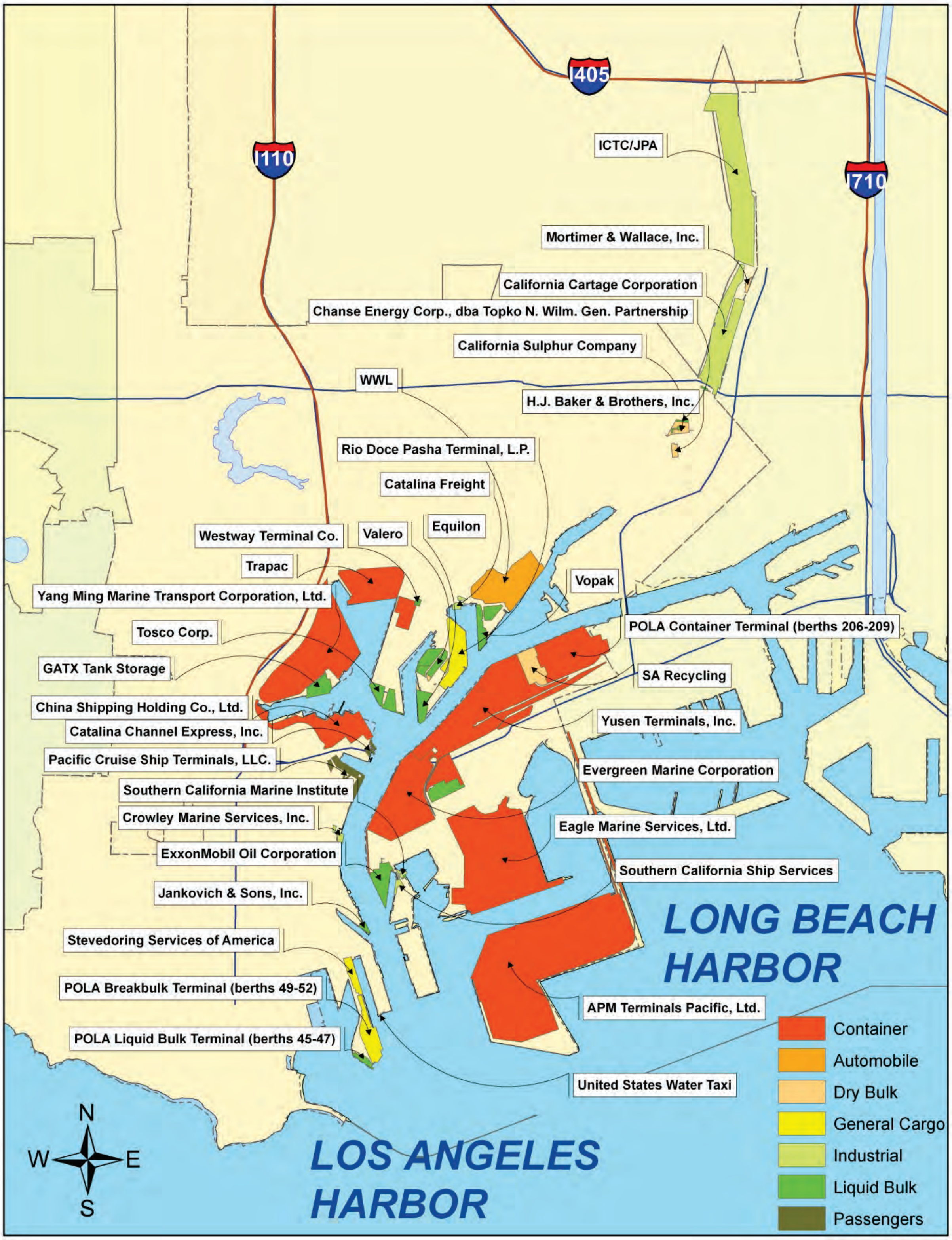
Figure 5.1: Distribution of 2008 Port CHE by Equipment Type



5.2 Geographical Delineation

The CHE EI consist of equipment from following terminals: container; dry bulk; break bulk; liquid bulk; auto; cruise ship; and equipment from Union Pacific (UP) Intermodal Container Transfer Facility (ICTF) and smaller facilities located within Port boundaries. Figure 5.2 presents a map illustrating the geographical delineation for CHE.

Figure 5.2: CHE EI Geographical Boundaries



Following is the list of the terminals, by 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 (Trapac) Terminal
- Berths 212-225: Yusen Container Terminal
- 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 49-53, 87-89, 153-155 and 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 70-71: Westway
- Berths 118-119: Kinder Morgan
- General Petroleum
- Berths 187-191: Vopak
- Berths 167-169: Equillon/Shell Oil
- Berths 238-240: ExxonMobil
- Berths 148-151: ConocoPhillips
- Ultramar/Valero

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

Passenger Terminals:
- 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

The terminal's maintenance and/or CHE operating staff were contacted either in person or by telephone to obtain information on the CHE specific to their terminal's operation for calendar year 2008. Information collected for each piece of equipment is listed below:

- Equipment type
- Equipment identification number
- Equipment make and model
- Engine make and model
- Rated horsepower
- Model year
- Type of fuel used (diesel, ULSD, gasoline or propane)
- Alternative fuel used, start date (examples include emulsified fuel, O_2 fuel)
- Fuel consumption
- Annual hours of operation (some terminal operators use hour meters)
- Diesel Oxidation Catalyst (DOC) installed and date installed
- On-road engine installed
- Any other emissions control devices installed

5.4 Operational Profiles

Table 5.1 summarizes the data collected in 2008. The table includes equipment count, horsepower, model year, and annual operating hours for each equipment type. The table does not include the count or characteristics of auxiliary engines (20 kW) for 30 RTG. The main engines for these RTGs are included in the table.

Table 5.1: CHE Characteristics for All Terminals, 2008

Equipment	Count	Power (horsepower) Min	Max	Average	Model Year Min	Max	Average	Annual Operating Hours Min	Max	Average
Crane	11	130	750	261	1965	2004	1987	257	3,141	912
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf crane	69	na	na	na	na	na	na	na	na	na
Excavator	6	428	428	428	1996	2004	2000	1,000	5,358	2,398
Forklift	551	40	330	101	1968	2008	1998	1	3,730	953
Loader	12	96	430	304	1984	2006	1996	100	4,595	1,493
Man Lift	20	48	87	76	1989	2007	1999	50	1,136	447
Rail Pusher	3	130	200	170	1993	2004	1999	1	354	132
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	111	180	685	535	1983	2007	2002	4	3,786	1,794
Side pick	40	136	330	196	1990	2008	2001	1	3,244	1,295
Skid steer loader	9	30	94	54	1994	2004	2001	10	1,443	687
Sweeper	13	35	205	108	1995	2006	2001	5	1,251	398
Top handler	138	174	350	288	1979	2008	2001	1	5,000	1,898
Truck	25	36	493	197	1979	2008	2003	1	2,000	908
Yard tractor	1,114	170	270	212	1995	2008	2004	1	6,714	1,769
Total count	**2,141**									

DB ID228

Table 5.2 shows the percentage of container terminal CHE (70%) as compared to the total Port CHE.

Table 5.2: 2008 Percentage of Container Terminal CHE as Compared to Total CHE

Equipment	Total Count	Container Terminal Count	Percent
Forklift	551	96	17%
RTG crane	111	101	91%
Side pick	40	37	93%
Top handler	138	133	96%
Yard tractor	1,114	1,012	91%
Sweeper	13	8	62%
Other	174	105	60%
Total	**2,141**	**1,492**	**70%**

DB ID233

The equipment characteristics for the CHE found at the Port's container terminals are summarized in Table 5.3. The table does not include the count or characteristics of auxiliary engines (20 kW) for 30 RTG. The main engines for these RTGs are included in the table.

Table 5.3: CHE Characteristics for Container Terminals, 2008

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	69	na	na	na	na	na	na	na	na	na
Forklift	96	45	275	140	1986	2008	2002	1	3,730	586
Man Lift	8	80	87	84	1995	2006	2000	100	876	297
Rail Pusher	2	180	200	190	1993	2000	1997	1	42	22
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	101	180	685	523	1983	2007	2003	4	3,555	1,707
Side pick	37	152	330	200	1990	2008	2001	1	3,244	1,372
Sweeper	8	100	205	142	1995	2006	2002	5	834	340
Top handler	133	250	335	288	1987	2008	2001	1	5,000	1,945
Truck	7	235	250	244	2001	2008	2006	200	2,000	718
Yard tractor	1,012	170	270	215	1996	2008	2004	1	6,714	1,692
Total count	**1,492**									

DB ID229

Table 5.4 shows the equipment characteristics of break-bulk terminal equipment.

Table 5.4: CHE Characteristics for Break-Bulk Terminals, 2008

Break Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Crane	5	150	750	336	1965	1995	1979	257	3,141	1,103
Excavator	6	428	428	428	1996	2004	2000	1,000	5,358	2,398
Forklift	113	40	330	152	1979	2008	1995	1	2,508	620
Loader	7	200	430	374	1984	2001	1997	281	4,595	2,105
Man lift	8	60	80	74	1996	2002	1999	68	1,136	626
Rail pusher	1	130	130	130	2004	2004	2004	354	354	354
Side pick	2	152	152	152	2000	2000	2000	67	94	81
Skid steer loader	5	30	45	42	2002	2004	2003	1,026	1,443	1,209
Sweeper	4	35	96	67	1996	2004	2000	156	1,251	607
Top handler	3	174	250	225	1979	1990	1986	200	297	259
Truck	6	210	493	399	1979	2007	1998	1	909	215
Yard tractor	19	177	215	188	2000	2008	2003	1	5,785	1,386
Total count	**179**									

DB ID231

Table 5.5 shows the equipment characteristics of dry bulk terminal equipment.

Table 5.5: CHE Characteristics for Dry Bulk Terminal Equipment, 2008

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 several facilities within the Port boundary that were included in this inventory that did not fit into the container, dry bulk and break bulk terminal categories listed above. These other facilities/tenants include smaller facilities and UP ICTF.

Table 5.6: CHE Characteristics for Other Terminals, 2008

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	297	48	155	74	1987	2008	1998	0	1,458	1,234
Loader	3	96	310	239	1989	2006	1995	100	500	367
Man lift	4	48	80	63	1989	2007	1997	50	617	254
RTG crane	10	250	350	300	1988	2006	1998	575	3,786	2,764
Side Pick	1	136	136	136	1992	1992	1992	875	875	875
Skid steer loader	4	54	94	69	1994	2001	1999	10	96	35
Sweeper	1	37	37	37	1999	1999	1999	25	25	25
Top handler	2	350	350	350	1988	1995	1992	695	1,768	1,232
Truck	10	36	36	36	2007	2007	2007	1051	1974	1564
Yard tractor	79	173	250	183	1995	2005	2003	100	4,751	2,842
Total count	**417**									

DB ID232

There are 47 additional equipment in the inventory that belong to auto terminal (8 forklifts), cruise terminal (33 forklifts and 2 trucks) and liquid bulk (4 forklifts).

The 2008 inventory includes 444 pieces of equipment installed with diesel oxidation catalysts (DOC), and 601 yard tractors equipped with certified on-road engines. All terminals used ULSD fuel for the 1,621 pieces of diesel equipment. Emulsified fuel was not used in 2008 due to supplier unavailability. Diesel particulate filters (DPF) which are a level 3-verified technology were installed in 76 yard tractors in 2008. The number of DOC decreased substantially from previous year (589) mainly due to equipment turnover.

Table 5.7 is a summary of the emission reduction technologies used on the equipment. It should be noted that some of these technologies may be used in combination with one another. For example, equipment using ULSD may also be equipped with on-road engines, DOCs or DPFs.

Table 5.7: Summary of 2008 CHE Emission Reduction Technologies

Equipment	DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel
2008									
Forklifts	3	4	0	177	177	2%	2%	0%	100%
RTG cranes	10	0	0	111	111	9%	0%	0%	100%
Side handlers	11	0	0	40	40	28%	0%	0%	100%
Top handlers	50	0	0	138	138	36%	0%	0%	100%
Yard tractors	370	592	76	1,059	1,059	35%	56%	7%	100%
Sweepers	0	1	0	11	11	0%	9%	0%	100%
Other	0	4	0	85	85	0%	5%	0%	100%
Total	**444**	**601**	**76**	**1,621**	**1,621**	**27%**	**37%**	**5%**	**100%**

DB ID234

Twenty four percent of equipment inventoried was not equipped with a diesel engine; a total of 420 pieces of equipment were powered with propane engines, and 11 were powered with gasoline engines as listed on Table 5.8.

Table 5.8: 2008 Count of Engine Types

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2008					
Forklifts	1	0	365	8	177
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	111
Side handlers	0	0	0	0	40
Top handlers	0	0	0	0	138
Yard tractors	0	0	55	0	1,059
Sweepers	0	0	0	2	11
Other	19	0	0	1	85
Total	**89**	**0**	**420**	**11**	**1,621**

DB ID235

The inventory does not include smaller electric equipment that may be at terminals. However, it does include a total of 89 of the following electric equipment:

- 69 electric wharf cranes
- 12 electric cranes
- 7 electric pallet jacks
- 1 electric forklift

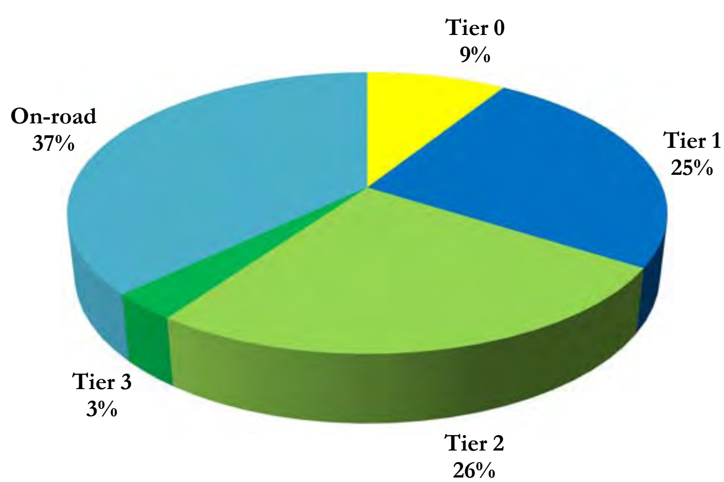
Table 5.9 summarizes the distribution of off-road diesel equipment by the engine standards which are based on model year and horsepower range. In addition, the count of diesel equipment with on-road engines is included. On-road engine standards are cleaner than Tier 3 off-road engine standards. With the Port CAAP and CARB CHE rule, the on-road engines count (602 in 2008) has increased significantly for the off-road equipment at the port. In previous inventory the on-road engine count (281 in 2007) was included mainly with the Tier 3 count.

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

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3	On-road Engine	Total
Yard tractors	14	239	214	0	592	1,059
Forklifts	61	69	34	9	4	177
Top handlers	24	30	62	22	0	138
Other	28	27	11	15	4	85
RTG cranes	8	23	77	3	0	111
Side handlers	7	15	16	2	0	40
Sweepers	3	3	4	0	1	11
Total	**145**	**406**	**418**	**51**	**601**	**1,621**
Percent	**9%**	**25%**	**26%**	**3%**	**37%**	

Figure 5.3 shows the percent of diesel equipment by engine standards and those with on-road engines.

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



5.5 Methodology

The methodology used to estimate the CHE emissions is consistent with CARB's latest methodology. The basic equation used to estimate CHE emissions in tons is as follows.

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

Where:

E = emissions, tons
Pop = population of equipment
EF = emission factor, grams of pollutant per horsepower-hour (g/hp-hr)
HP = rated horsepower for the equipment
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower)
Act = equipment activity, hours of use
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 or use of alternative fuels not originally included in the emissions factors

The emission factor is a function of the zero hour emission rate for the equipment model year (g/hp-hr) in the absence of any malfunction or tampering of engine components that can change emissions, plus a deterioration rate. The deterioration rate reflects the fact that base emissions of engines change as the equipment is used due to wear of various engine parts or reduced efficiency of emission control devices. The emission factor is calculated as:

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

Where:

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

5.5.1 Emission Factors

The zero hour emission rates used are consistent with the OFFROAD model. The ZH emission rates are a function of fuel, 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. The OFFROAD ZH emission factors 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
- LNG engine emission factors are based on recent testing of LNG yard tractors[36]

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

5.5.2 Load Factor, Useful Life, and Deterioration Rates

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 horsepower. It accounts for the fact that in their normal operations, engines are not used at their maximum horsepower rating. Equipment specific load factors used in 2008 are different than those used in previous EIs. In addition to the yard tractor load factor of 39% which has been used since the 2006 EI report, a load factor of 20% is used for RTG cranes. The 20% RTG load factor is based on a 2008-2009 study conducted by both ports in consultation with CARB. The 39% yard tractor load factor is based on a 2006 study conducted by ports in consultation with CARB.

[36] Dr. Wayne Miller, University of California, Riverside, *A Study of Emissions from Yard Tractors Using Diesel and LNG Fuel,* July, 2007.

Table 5.10 lists the equipment type, the useful life and load factor used, respectively.

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
Aerial lift, truck, other with off-road engine	16	0.51
Truck, other with on-road engine	16	0.51
Sweeper	16	0.68
Loader, backhoe	16	0.55
Yard tractor with off-road engine	12	0.39
Yard tractor with on-road engine	12	0.39

Table 5.11 lists the deterioration factors by horsepower group.

Table 5.11: Deterioration Factors by Horsepower Group

Horsepower Group	PM	NO_x	CO	HC
50	31%	6%	41%	51%
120	44%	14%	16%	28%
175	44%	14%	16%	28%
250	44%	14%	16%	28%
500	67%	21%	25%	44%

DB ID445

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 5.12 shows the emission reduction percentages provided by CARB for the various technologies used by the Port equipment. The control factor is 1 minus the emission reduction in decimal; for example, a 70% reduction has a control factor of 0.3.

Table 5.12: CHE Emission Reductions 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%

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)[37]
- DPF: CARB verified technology[38]
- Vycon: CARB verified technology[39]

Table 5.13 lists the fuel correction factors for ULSD fuel. The SO_x emission factor is based on EPA's diesel fuel with an average S content in the fuel of 350 ppm.

Table 5.13: Fuel Correction Factors

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	0.72	1	0.93	0.72
1996 and newer	0.80	0.95	0.043	1	0.72	1	0.95	0.72

DB ID444

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

5.5.4 Improvements to Methodology from Previous Years

Below are some improvements from previous year inventories that may have an effect on current emissions and thus may not make apples to apples comparison possible to previous years' published reports (for apples to apples comparison to 2005 emissions, see section 9).

- Deterioration rates are no longer used for estimating greenhouse gases as in previous inventories due to lack of data sources available on greenhouse deterioration rates. This change has resulted in significant drop in GHG emissions.
- RTG load factor changed from default 43% to 20% based on port study.

5.6 Emission Estimates

CHE emissions estimates are broken down by terminal type and equipment type. A summary of the CHE emission in tons per year by terminal type for 2008 is presented in Tables 5.14 and 5.15.

Table 5.14: 2008 CHE Emissions by Terminal Type, tpy

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	1.5	0.1
Break-Bulk	4.0	3.7	3.9	118.2	0.1	65.0	8.3
Container	24.9	23.3	24.6	876.6	1.5	308.0	22.5
Cruise	0.3	0.2	0.2	8.6	0.0	17.4	1.6
Dry Bulk	0.5	0.5	0.5	10.2	0.0	3.8	0.8
Liquid	0.0	0.0	0.0	1.0	0.0	1.1	0.1
Other	4.1	3.9	3.7	153.9	0.1	342.6	14.0
Total	**33.9**	**31.7**	**33.0**	**1,168.7**	**1.7**	**739.5**	**47.4**

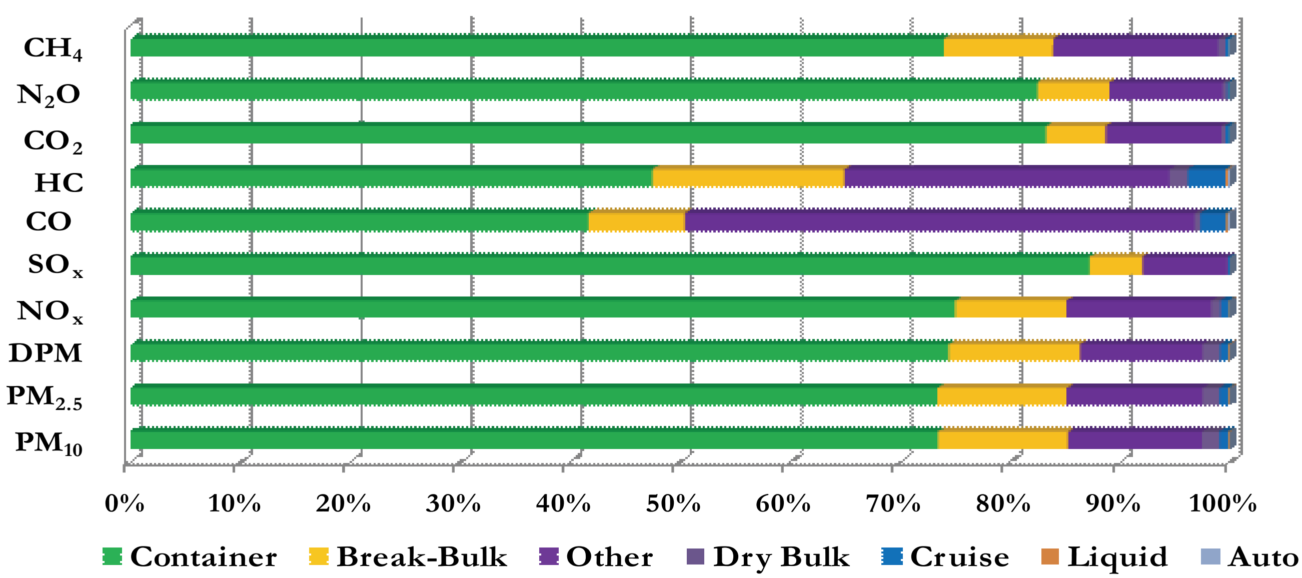
DB ID450

Table 5.15: 2008 CHE GHG Emissions by Terminal Type, metric tons per year

Terminal Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auto	17.1	16.9	0.0	0.0
Break-Bulk	8,239.7	8,168.0	0.2	0.4
Container	125,851.6	124,987.8	2.6	2.7
Cruise	519.5	517.4	0.0	0.0
Dry Bulk	569.2	564.2	0.0	0.0
Liquid	58.9	58.6	0.0	0.0
Other	15,923.7	15,811.6	0.3	0.5
Total	**151,179.8**	**150,124.5**	**3.2**	**3.7**

Figure 5.4 presents the percentage of cargo handling equipment emissions by terminal type. Roughly 70% of the Port's CHE PM emissions, 75% of the NO_x emissions, 85% of the SO_x emissions, 40% of the CO, 47% of the hydrocarbon emissions, 82% of the CO_2 and N_2O emissions, and 75% of the CH_4 emissions are attributed to the container terminals. Break-bulk terminals and other type of facilities account for the remainder of the emissions. The facilities with propane forklifts and equipment with alternative fuels have higher CO and hydrocarbon emissions.

Figure 5.4: 2008 CHE Emissions by Terminal Type, %



Tables 5.16 and 5.17 present the emissions by equipment type.

Table 5.16: 2008 CHE Emissions by Equipment Type, tpy

Port Equipment	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Crane	Diesel	1.1	1.0	1.1	21.0	0.0	8.6	1.5
Excavator	Diesel	0.6	0.5	0.6	22.7	0.0	4.0	0.9
Forklift	Diesel	2.1	1.9	2.1	39.1	0.0	16.1	2.8
Forklift	Gasoline	0.0	0.0	0.0	7.5	0.0	20.7	1.8
Forklift	Propane	0.6	0.6	0.0	52.4	0.0	323.2	11.3
Loader	Diesel	0.9	0.8	0.9	29.0	0.0	5.6	1.4
Man Lift	Diesel	0.2	0.2	0.2	2.7	0.0	1.4	0.3
Rail Pusher	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0
Rub-trd Gantry Crane	Diesel	2.7	2.5	2.7	95.0	0.1	23.5	2.70
Side pick	Diesel	1.1	1.1	1.1	35.8	0.0	8.5	1.4
Skid Steer Loader	Diesel	0.1	0.1	0.1	0.9	0.0	0.7	0.2
Sweeper	Diesel	0.1	0.1	0.1	1.5	0.0	0.8	0.1
Sweeper	Gasoline	0.0	0.0	0.0	0.9	0.0	4.6	0.1
Top handler	Diesel	6.8	6.4	6.8	237.7	0.3	46.9	7.4
Truck	Diesel	0.5	0.4	0.5	8.9	0.0	3.9	0.5
Truck	Gasoline	0.0	0.0	0.0	1.1	0.0	2.1	0.2
Yard tractor	Diesel	16.9	15.8	16.9	594.7	1.1	161.5	11.6
Yard tractor	Propane	0.3	0.3	0.0	17.6	0.0	107.3	3.1
Total		**33.9**	**31.7**	**33.0**	**1,168.7**	**1.7**	**739.5**	**47.4**

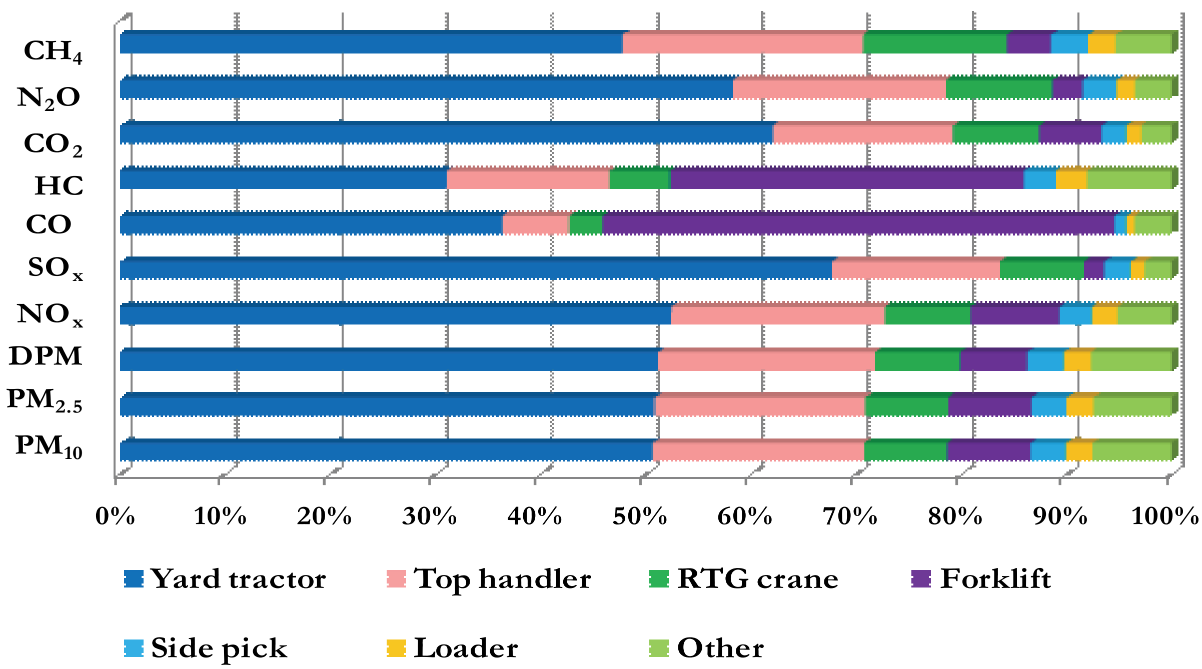
DB ID237

Table 5.17: 2008 CHE GHG Emissions by Equipment Type, metric tons per year

Port Equipment	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Crane	Diesel	937.2	928.5	0.0	0.0
Excavator	Diesel	1,996.3	1,979.2	0.0	0.1
Forklift	Diesel	2,959.4	2,930.8	0.1	0.1
Forklift	Gasoline	312.2	309.5	0.0	0.0
Forklift	Propane	5,685.5	5,685.5	0.0	0.0
Loader	Diesel	2,159.1	2,140.4	0.1	0.1
Man Lift	Diesel	197.2	195.2	0.0	0.0
Rail Pusher	Diesel	16.0	15.9	0.0	0.0
Rub-trd Gantry Crane	Diesel	12,379.9	12,270.5	0.3	0.5
Side pick	Diesel	3,550.5	3,516.1	0.1	0.1
Skid Steer Loader	Diesel	85.4	84.4	0.0	0.0
Sweeper	Diesel	153.7	152.4	0.0	0.0
Sweeper	Gasoline	132.4	131.1	0.0	0.0
Top handler	Diesel	25,964.5	25,748.7	0.6	0.8
Truck	Diesel	797.8	791.4	0.0	0.0
Truck	Gasoline	58.9	58.4	0.0	0.0
Yard tractor	Diesel	90,724.8	90,117.6	1.8	1.8
Yard tractor	Propane	3,068.9	3,068.9	0.0	0.0
Total		**151,179.8**	**150,124.5**	**3.2**	**3.7**

Figure 5.5 presents the percentage of cargo handling equipment emissions by equipment type. Yard tractors attribute for roughly 50% of the CHE PM and NO_x emissions, 68% of the SO_x emissions, 36% of the CO emissions, 30% of the hydrocarbon emissions, 62% of the CO_2 emissions, 58% of N_2O emissions and 48% of the CH_4 emissions. Top handlers, RTG cranes, forklifts, side picks and loaders follow in emissions. In the figure, "other" equipment includes excavator, man lift, rail pusher, skid steer loader, sweeper, and truck.

Figure 5.5: 2008 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., whereas "inbound" rail freight is destined for shipment out of the Port by vessel. 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."

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 have historically been older line haul locomotives that have been converted to switch duty as newer line haul locomotives with more horsepower have been added to the nation's line haul fleet. The older switching locomotives used at the Port, however, have been replaced by new, low-emitting locomotives as part of an agreement among the Ports of Los Angeles and Long Beach and the Pacific Harbor Line (PHL), owners/operators of the switchers. The 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 Port is served by three railway companies:

- Burlington Northern and 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.

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

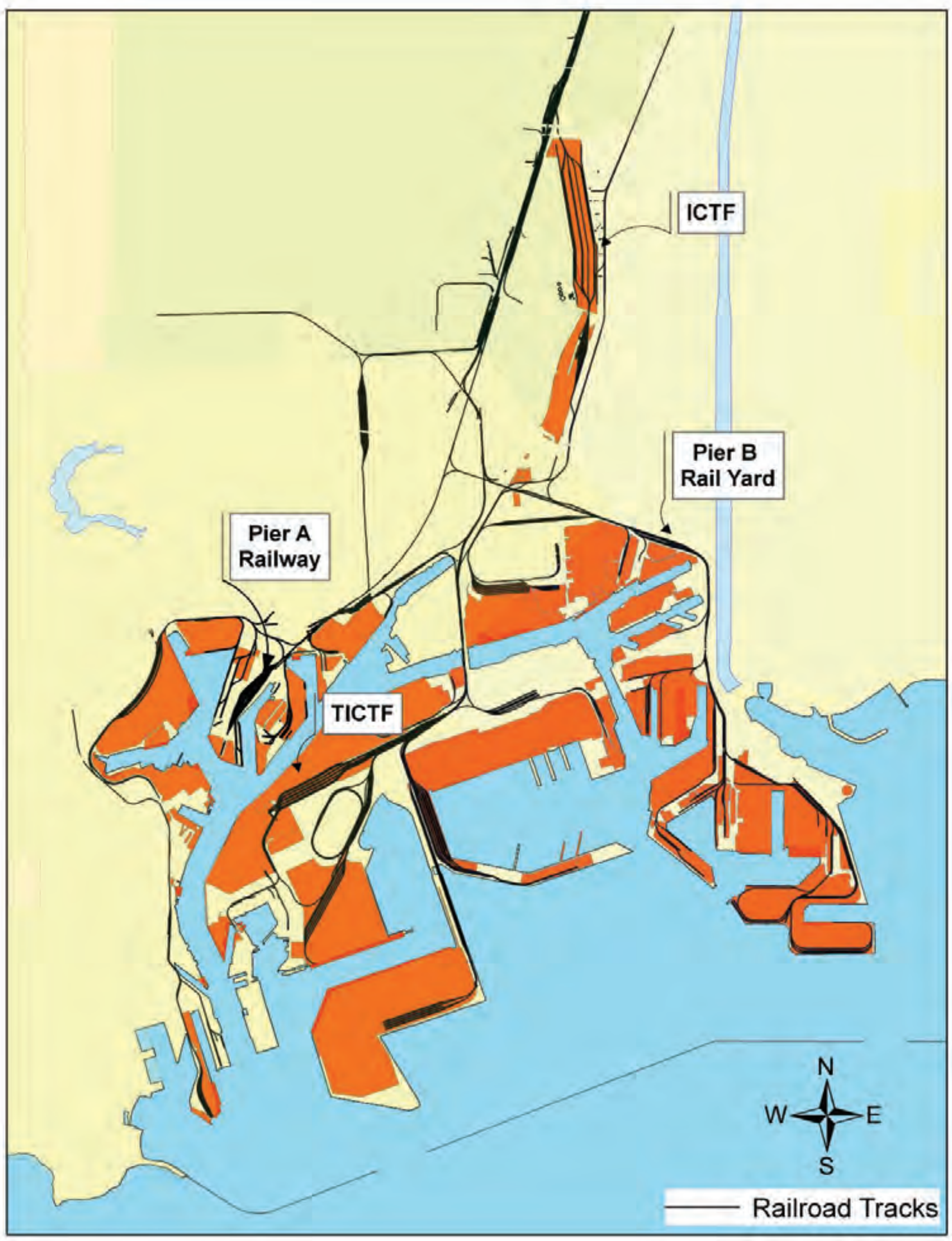


Figure 6.4: Air Basin Major Intermodal Rail Routes

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 locomotive fleet, including their new locomotives that have been placed into service as well as the old locomotives that have been phased out (but were used to a limited extent in the early part of the year), and a record of the fuel used per month in each of its locomotives. PHL has previously provided data in the form of files downloaded from their older locomotives' electronic event recorders. This allowed the emission estimates to be "tailored" to the average duty cycle of PHL locomotives, which was slightly different from the average switching duty cycle published by EPA. This information has not been used with the new locomotives because their average duty cycle is likely to be different from that of the older locomotives. Instead, emission factors representative of the "default" EPA duty cycle have been used for the new locomotives.

The line haul railway company operating the Intermodal Container Transfer Facility (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. As stated previously, 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 is 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, using flat cars that have remained on site after the off-loading of inbound containers or those brought in by one of the railroads. Alternatively, containers can be 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 to build an entire train.

Within the Port, complete trains can be built at the terminals servicing Yang Ming and American Presidents Line (APL). In addition, the Terminal Island Container Transfer Facility (TICTF) is shared by Nippon Yusen Kaisha (NYK) and Evergreen as a location 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 hauled by truck (drayed) to off-port locations operated by the line haul railroads. The containers are loaded onto railcars at these locations.

Alameda Corridor

The Alameda Corridor is a 20-mile rail line running between the San Pedro Bay area and downtown Los Angeles 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

Inbound Trains

In-bound trains that carry cargo (or empty containers) that are all destined for the same terminal are delivered directly to the terminal by the Class 1 railroad 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 is bound for multiple terminals with 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.

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 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 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 a typical mobile source means that the engine's speed is dictated by 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.

The characteristics of BNSF line haul locomotives operating within the Port were estimated from a sampling of BNSF locomotives that called on the Port area in 2001 updated with information provided in 2007. The sample of locomotives, primarily the 6-axle General Electric (GE) C44-9W (also known as Dash 9's), has an average of 4,256 horsepower. The 2007 data confirmed that the Dash 9 is still the predominant BNSF locomotive calling at the Port.

Basic specifications of UP locomotives were obtained from the railroad's Internet website.[40] The UP website lists approximately 6,500 line haul locomotives in the company's nation-wide fleet, with an average power rating of 3,655 horsepower. Most of the locomotives are six-axle units, the remainder being four-axle units. Six-axle locomotives are generally more powerful than four-axle locomotives. Most of the UP locomotives calling on the Port are six-axle, 4,000-horsepower Electromotive Division (EMD) SD70s.

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. A total of 30 locomotives were used at some point during the year, including 8 of the older locomotives, 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 a multi-genset switcher). These multi-genset units emit most pollutants at less than Tier 2 emission levels.

[40] *See: http://www.uprr.com.*

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 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 approximately 90% (meaning, for example, a 25-car train would carry 500 TEUs x 90% = 450 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: 24 double-stack railcars, 90% density, for a capacity of 432 TEUs or 240 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.[41] Consistent with 2007, the estimated number of railcars per train has been maintained at 24, higher than the 23 assumed for the 2006 emissions inventory, based on the Alameda Corridor Transportation Authority's report that there were fewer trains running on the Corridor but there were more containers per train.[42] 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.

[41] Personal communication, Art Goodwin, Alameda Corridor Transportation Authority, with Starcrest Consulting Group, LLC, February 2005.
[42] http://www.acta.org/corridor_performance_train_counts.htm, "Number of Trains Running on the Alameda Corridor"

Emissions have been estimated using the information provided by the railroads and the terminals, and from published information sources such as the EPA's Regulatory Support Document (RSD) published as background to EPA's locomotive rule-making process.[43] 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 2008. For the limited line haul operations in the Port (arrivals and departures), emission estimates 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 developed for the 2005 emissions inventory. A detailed explanation of emission calculation methods is presented below.

Different calculation methods were required 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, throttle notch frequencies for their older locomotives, 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 0.048 gallons per horsepower-hour (from EPA, 1998):

$$\frac{\text{gallons/year}}{\text{gallons/horsepower-hour}} = \text{horsepower-hours/year} \qquad \text{Equation 6.1}$$

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

$$E = \frac{\text{hp-hrs} \times EF}{(453.59 \text{ g/lb} \times 2{,}000 \text{ lb/ton})} \qquad \text{Equation 6.2}$$

Where:

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

[43] EPA Office of Mobile Sources, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised.

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, because the PHL throttle notch data is not specific to those locomotives, which may have a different average duty cycle from the older units. 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.

Previous inventories of Port emissions have detailed the methods used to estimate emissions from PHL's pre-Tier 2 fleet of locomotives. While these methods have been used to estimate the 2008 emissions from those locomotives, they are not described in the current document because these locomotives accounted for only 3% of PHL's operations in terms of fuel consumption over the year because they were phased out in the early part of the year.

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 for throttle notch position 1.

Equation 6.3

$$\frac{15 \text{ g S}}{1{,}000{,}000 \text{ g fuel}} \times \frac{3{,}200 \text{ g fuel}}{\text{gal fuel}} \times \frac{0.048 \text{ gal fuel}}{\text{hp-hr}} \times \frac{2 \text{ g } SO_2}{\text{g S}} = 0.005 \text{ g } SO_2/\text{hp-hr}$$

In this calculation, 15 ppm S is written as 15 lbs S per million lbs of fuel. The value of 0.048 gals fuel/hp-hr is the average brake-specific fuel consumption derived from EPA's technical literature on locomotive emission factors. Two grams of SO_2 is emitted for each gram of sulfur in the fuel because the atomic weight of sulfur is 32 while that of SO_2 is 64, meaning that the molecular weight of SO_2 is double that of a molecule of sulfur.

Greenhouse gas emission factors from EPA references[44] were used to estimate emissions of greenhouse gases CO_2, CH_4, and N_2O from all locomotives. Additionally, all particulate emissions are assumed to be PM_{10} and DPM; $PM_{2.5}$ 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 all switching locomotives, including those used for the off-port switching activity, are listed in Tables 6.1 and 6.2.

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
PHL Pre-Tier 2 Fleet	0.38	0.35	0.38	17.6	0.005	1.83	0.87
Off-Port Switchers	0.44	0.40	0.44	17.40	0.005	1.83	1.01
Tier 2 Locomotives	0.21	0.19	0.21	7.30	0.005	1.83	0.52
Genset Locomotives	0.05	0.05	0.05	3.37	0.005	1.51	0.04

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

Fuel or Locomotive Type	CO_2	N_2O	CH_4
PHL Pre-Tier 2 Fleet	487	0.013	0.040
Off-Port Switchers	487	0.013	0.040
Tier 2 Locomotives	487	0.013	0.040
Genset Locomotives	487	0.013	0.040

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 2008 to 2005 container throughput reported by the railroad (1-[586,415/600,615]) or a decrease of 2.4%, using the assumption that switching activity varies linearly with container throughput.

[44] CO_2 - Table A-38, page A-37, Annex 2 of the report entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* April 2008; CH_4 and N_2O - Table A 90, page A-115 in Annex 3 of the same report.

As an example of how fuel use was used to estimate total hp-hrs, a total of 10,000 gallons of fuel per year would be divided by the fuel use factor of 0.048 gallons per hp-hr (gal/hp-hr) to produce an estimate of 208,333 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. The result was a split of 69% of activity within the Port of Los Angeles and 31% within the Port of Long Beach. 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 are 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 2008. 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 have been taken from EPA's RSD documentation representing EPA's projected 2008 nationwide fleet of line haul locomotives, as shown in Tables 6.3 and 6.4. The emission factors are presented in terms of grams per horsepower-hour (g/hp-hr) as listed in the RSD documentation.

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 from the EPA reference.[45]

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	0.25	0.23	0.25	8.13	0.06	1.28	0.43

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, similar to the approach taken for the 2001 baseline emissions inventory. 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 centers 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 366 additional trains for each port).

[45] CO_2 - Table A-38, page A-37, Annex 2 of the report entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* April 2008; CH_4 and N_2O - Table A 90, page A-115 in Annex 3 of the same report.

Table 6.5: On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Totals
Number of trains/year	4,008	5,219	9,227
Number of locomotives/train	3	3	NA
Hours on Port/trip	1.0	2.5	NA
Locomotive hours/year	12,024	39,143	51,167

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 a location-specific average 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%**

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

51,167 locomotive hours/year x 4,000 horsepower/locomotive x 0.28

= 57.3 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 240 containers per train) and the two San Pedro Bay Ports' 2008 intermodal throughputs, the average number of port-related trains was estimated to be 30 per day through the Alameda Corridor[46] including non-container trains discussed above. The gross weight (including locomotives, railcars, and freight) of a typical train was estimated to be 5,784 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 an average of the east and south routes taken by UP trains and the east route taken by most BNSF trains, weighted by the percentage distribution of freight reported in the 2001 baseline emissions inventory, as shown in Table 6.8 (information from 2001 was used because information from both railroads was not available for the 2008 inventory period). 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 2007. This average was derived from information reported by the railroads to the U.S. Surface Transportation Board in an annual report known as the

[46] Overall Alameda Corridor traffic for 2008 was an average of 44 per day. This includes non-port-related traffic; See: *www.acta.org/PDF/CorridorTrainCounts.pdf.*

"R-1."[47] 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 1.077 gallons of fuel per thousand gross ton-miles. The 2007 annual reports are the latest available so these reported values have been used as the basis of the 2008 fuel consumption factor. Also listed in Table 6.9, is the estimated total out-of-port horsepower-hours, calculated by dividing the fuel use by the fuel use factor of 0.048 gal/hp-hr.

Table 6.7: Assumptions for Gross Weight of Trains

Train Component	**Approx. 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	120	2,400
Container		10.6	240	2,544
Total weight per train, gross tons				**5,784**

Table 6.8: Train Travel Distance Assumptions

	Miles	**% of freight, 2001**	**Miles x %**
UP - LA east	84	36%	30
UP - LA south	91	10%	9
BNSF - LA east	82	54%	44
Weighted average distance			**84**

[47] *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2007* (Union Pacific Railroad) and *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2007* (BNSF Railway). Available at http://www.stb.dot.gov/econdata.nsf/FinancialData?OpenView

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	6,067	35	735
Central LA to Air Basin Boundary	84	6,067	35	2,940
Million gross ton-miles				**3,675**
Estimated gallons of fuel (millions)				**4.0**
Estimated million horsepower-hours				**82.5**

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

EPA's new emission factors for line haul locomotives are an improvement from previous year inventories. Section 9 includes the comparison to previous years' emissions.

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, tpy

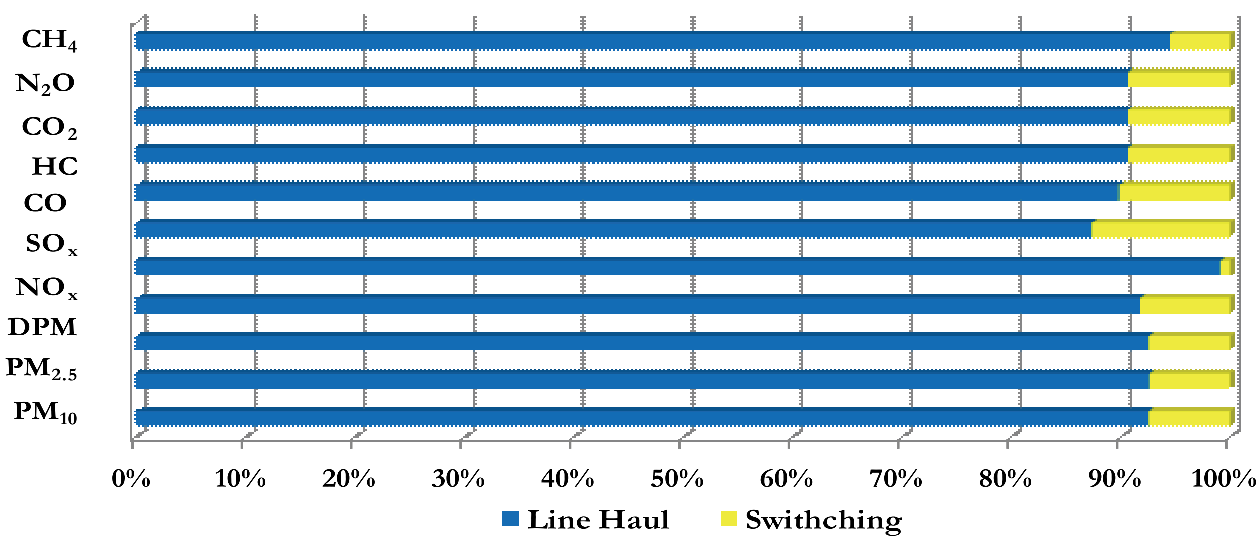
	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Switching	3.1	2.8	3.1	112.2	0.1	28.5	7.5
Line Haul	38.6	35.5	38.6	1,254.3	9.3	197.5	66.3
Total	**41.7**	**38.3**	**41.7**	**1,366.5**	**9.3**	**226.0**	**73.8**

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

	CO_2 Equivalent	CO_2	N_2O	CH_4
Switching	7,113.8	7,043.3	0.2	0.6
Line Haul	68,986.4	68,303.4	1.8	5.6
Total	**76,100.2**	**75,346.7**	**2.0**	**6.2**

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 2008. 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

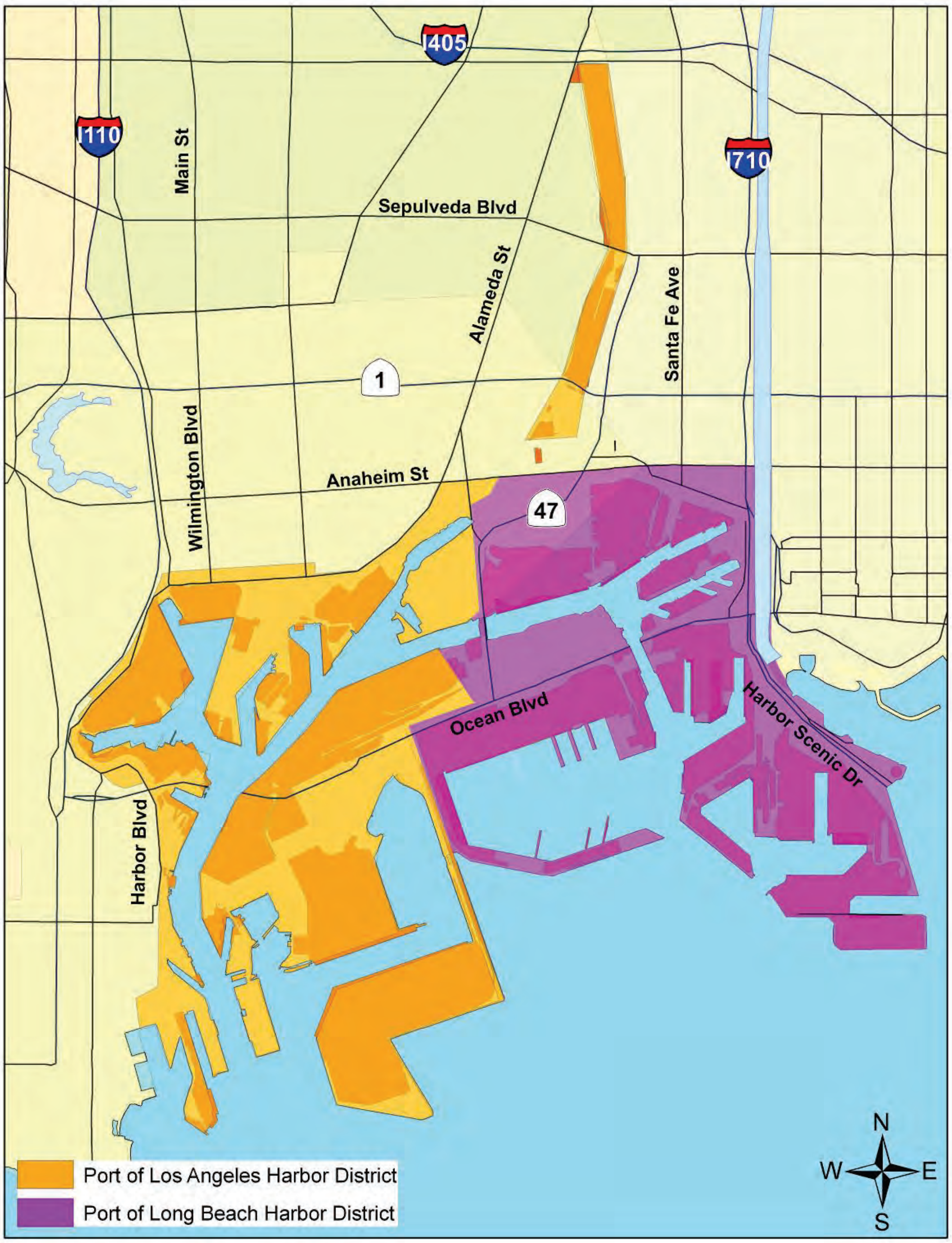
To develop emission estimates, truck activities have been evaluated as having two components:

- 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 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 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) 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[48] 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 2008.

[48] 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 as input to a Port-area travel demand model also developed by Iteris. This model was based on the regional 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 Port-area travel demand model.

The travel demand model produced terminal-specific estimates of truck traffic volumes and speeds over defined Port roadway segments. A brief example is provided in Table 7.1. The traffic volumes and distances were combined to produce estimates of vehicle miles of travel (VMT), which in turn were used with the speed-specific EMFAC emission factors (discussed below) to estimate on-Port on-road driving emissions associated with each container terminal. The same model was used to produce estimates of Port-related truck traffic traveling through the POLB, such as toward the 710 Freeway across Terminal Island.

The roadway volumes of truck traffic outside the Port area were estimated by Iteris using a regional analysis that modeled Port-related trucks bi-directionally on highways and major thoroughfares within the greater Los Angeles area until the trucks leave the highways and enter city streets. 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 reach 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.

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

Roadway Segment	From	To	Direction	Bobtails	Chassis	Con-tainers	Dist. miles	Speed mph
Anaheim St	Anaheim Wy	9th Street	East Bound	313	62	366	0.65	40
Santa Fe	Canal	Santa Fe	East Bound	71	-	57	0.18	20
Canal	Harbor	Canal	East Bound	95	13	131	0.21	29
Henry Ford	SR-47 SB Off Ramp	Henry Ford	East Bound	96	46	301	0.69	40

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)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	15	1.5	na	0.17	0.37	0.10
Minimum	10	0.9	na	0.00	0.08	0.00
Average	13	1.2	na	0.10	0.26	0.03
Total			**4,004,100**			

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)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	20	1.3	na	0.10	0.45	0.10
Minimum	2	0.0	na	0.00	0.00	0.00
Average	8	0.5	na	0.04	0.12	0.03
Total			**1,663,004**			

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 was used.

This subsection describes the specific methodology used to develop the emission estimates for HDVs in the locations described above. The general form of the equation for estimating the emissions inventory for a fleet of on-road vehicles is:

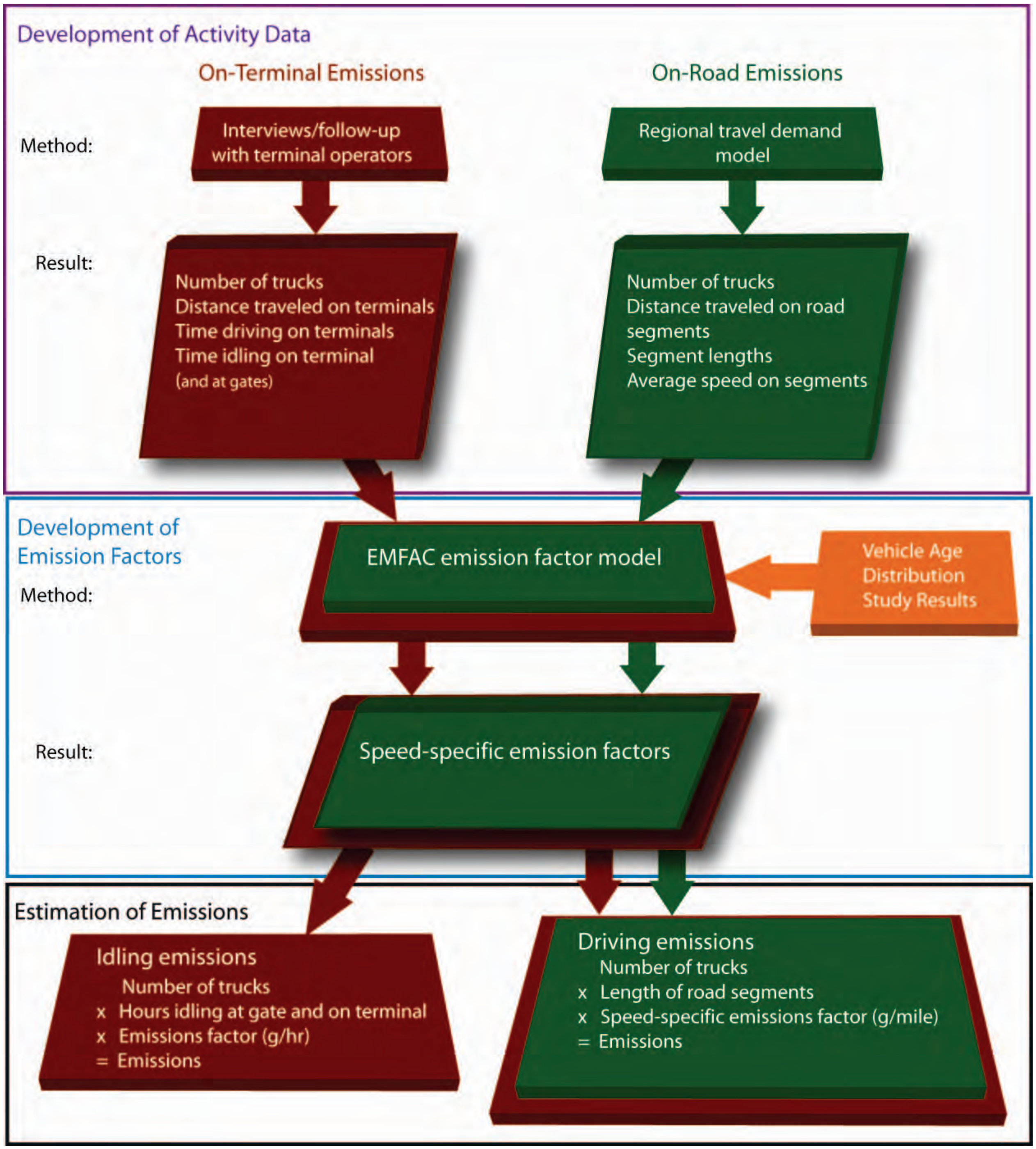
Equation 7.1

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

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, or gallons of fuel consumed
Correction Factor = 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 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.

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 of heavy-heavy-duty diesel trucks that call on the Port.

Although the EMFAC model produces ton per day estimates of emissions by vehicle class, it is generally a macro-scale model that is inappropriate for estimating inventories at a sub-county level. In order to calculate the inventory of emissions for Port-related heavy-duty trucks, the emission factors and correction factors from EMFAC were coupled with Port specific truck activity 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 7.4 lists the emission factors used to estimate the emission of trucks visiting the Port.

Table 7.4: 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	0.26	0.008

CARB has included an update to the idle emissions rates for heavy-duty diesel trucks and their "low idle" emission rates were used in developing the emissions inventory for the Port. These factors are presented in Table 7.5.

Table 7.5: 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*"[49] 3 April 2006.

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

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

Equation 7.3

$$SO_x \text{ emissions (g/mile)} = \frac{(X \text{ g S}/1{,}000{,}000 \text{ g fuel}) \times (3{,}311.21 \text{ g/gallon}) \times (2 \text{ g } SO_x/\text{g S})}{(5.56 \text{ miles/gallon}) \times (453.59 \text{ g/lb} \times 2{,}000 \text{ lbs/ton})}$$

The emission calculations are based on 15 ppm ULSD diesel fuel. The weight of a gallon of diesel fuel is assumed to be 7.3 pounds or 3,311.21 grams (7.3 lbs x 453.59 g/lb). Based on the EMFAC model, the fleet average fuel economy of the heavy-heavy duty diesel fleet is assumed to be 5.56 miles per gallon.

The N_2O emission factor was calculated using the following equation:

Equation 7.4

$$N_2O \text{ emissions (g/mile)} = \frac{(X \text{ g } N_2O/\text{gallon})}{(5.56 \text{ miles/gallon})}$$

7.5.3 Age Distribution

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 age distribution (count of vehicles by model year) of trucks calling upon the Port. Close to 5,000,000 OCR readings were collected from nine different terminals during the period spanning January 1 through December 31, 2008. "OUTGATE" records, those identifying vehicles exiting the terminals, were eliminated from the analysis in order to minimize double counting. The OCR data were further cleaned by eliminating any occurrences of identical plate readings within ten minutes of each other. Approximately 3,000,000 OCR readings were used in the final analysis.

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

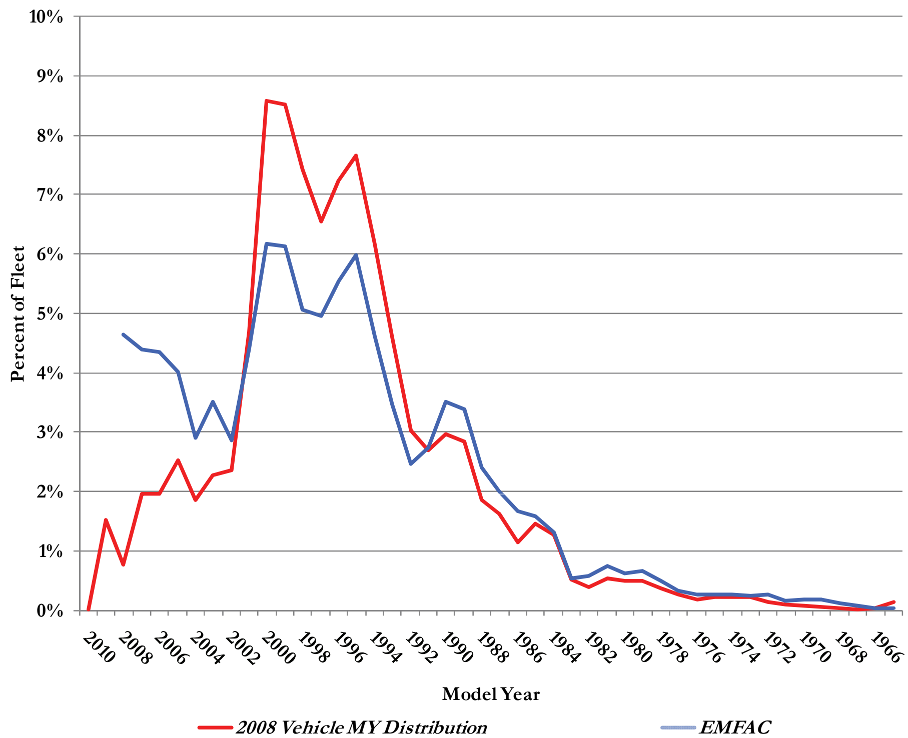
The 5,000,000 records were screened to remove special characters, state suffixes (i.e., CA, NV, etc.), character strings that were obviously not license plate numbers (i.e. "NO OCR", "-----"), and records that were less than six digits in length. Registration information was sought for the subset of just over 212,000 cleaned, unique license plate readings from the California Department of Motor Vehicles (DMV).

The majority of the records submitted to the DMV were returned without matching registration information. However, approximately 75,000 records were returned with vehicle identification numbers (VINs), vehicle model year information, and/or information on the registered owner of the vehicle. The matching DMV files also included a body type model (BTM) field and this information was used to distinguish trucks from other types of vehicles captured by the OCR systems. Only those vehicles designated with a BTM of DS (diesel tractor truck), TB (tilt cab tractor), TL (tilt tandem tractor), TM (tandem axel tractor), TRAC and TRACTOR (tractors) were included in the final analysis. Some 50,154 unique trucks were identified through this process with a model year range from pre-1965 to 2010.

The 50,154 unique trucks were then matched against the 3,000,000 original OCR readings in order to determine the number trips per truck taken by model year (the trip distribution), with each OCR reading considered as a separate trip. The results show that the overwhelming majority of trips (>80%) were attributable to the 1994 and newer trucks.

The distribution of the truck population by age is presented in Figure 7.6 below. The average age of the Port-related fleet was determined to be 12.1 years, which is similar to the EMFAC estimate of heavy-duty diesel trucks in operation within the SoCAB of 11.6 years.

Figure 7.6: Population Distribution of the Heavy-Duty Truck Fleets



EMFAC carries an estimate of 45 model years of population within each calendar year ranging from the newest, for which the model year is the same as the current calendar year, to the oldest where the model year is the current calendar year minus 45. Therefore, EMFAC does not allow the model year to be greater than the current calendar year. For purposes of this analysis, 2009 model year trucks that were in the sample of license plates provided by the terminals were assumed to have the same activity as 2008 model year trucks.

7.5.4 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 from EMFAC were used. 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.

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.[50] The mileage accrual rates included in the EMFAC 2007 update and used in this analysis are shown in Table 7.6.

Table 7.6: 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, the basic emission rate for NO_x would be calculated as follows:

Equation 7.5

6.84 g/mi (ZMR) + 0.047 g/mi/10K miles (DR) x 252,317 miles (Cumulative Mileage) = 7.22 g/mi

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

A population weighted basic emission rate for each pollutant was derived performing the calculation above for each model year; the results were then weighted by the population fraction in each model year. These fleet weighted emission rates are presented in Table 7.7. These weighted basic emission rates are summary numbers prior to the model's application of speed, fuel, and other correction factors as discussed below. The speed-specific population-weighted emission factors used in developing the Port's HDV emission estimates are presented below in Tables 7.10 and 7.11.

Table 7.7: Heavy Heavy-Duty Diesel Truck Fleet Weighted Emission Rates

Pollutant	Emission Rate (g/mile)
HC	2.46
CO	12.18
NO_x	21.89
PM	1.90

7.5.5 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. 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 distance approaches zero the grams/mile ratio increases. The result is a generally "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 needed to derive the speed correction factors included in EMFAC 2007 are described in CARB documentation.[51]

Equation 7.6

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

Table 7.10 lists the speed correction factor coefficients.

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

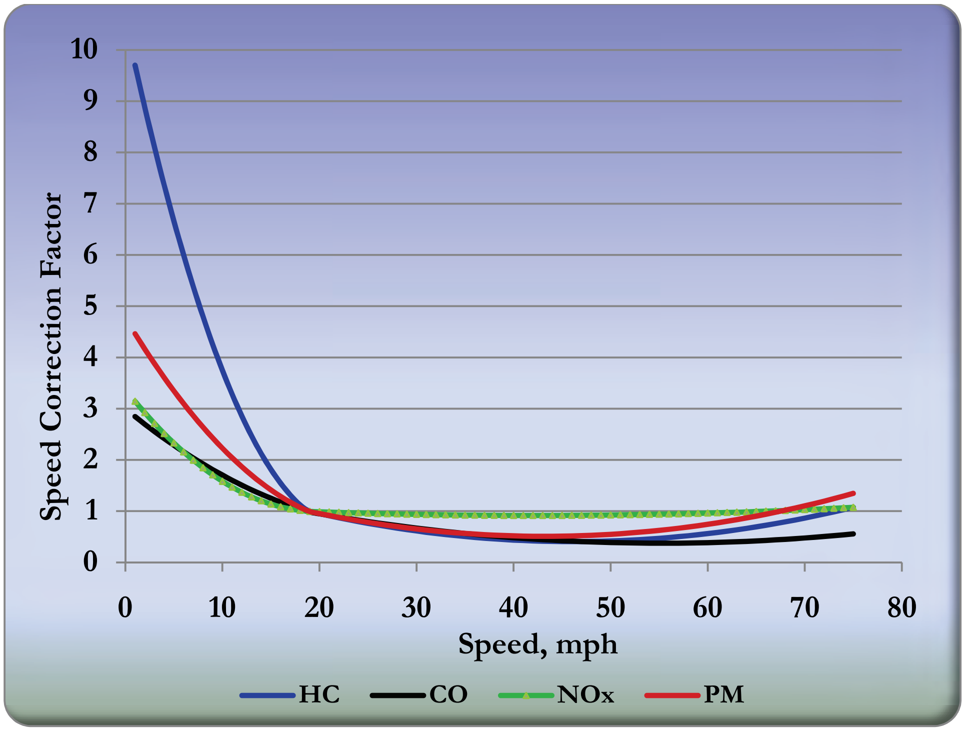
Table 7.9: CARB Speed Correction Factor Coefficients

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

These speed correction factors were used to derive speed specific emission factors for each pollutant at 5 mile per hour increments for use in this analysis. This was accomplished by deriving the model year and pollutant specific speed correction factors and then weighting each factor by the population of Port trucks in each model year group. Figure 7.6 shows the fleet weighted speed correction factors for each pollutant.

The speeds used in the on-road emission calculations were estimated by the travel demand modeling discussed previously. The on-terminal speeds are those reported as average on-terminal speeds by the respective terminal operators.

Figure 7.7: Fleet Weighted Speed Correction Factors



7.5.6 Speed-Specific Emission Factors

The speed-specific emission factors for heavy-heavy duty diesel trucks used in the emissions inventory estimate were obtained from CARB's EMFAC 2007 model. The program was run for the SoCAB for the 2008 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 reweighted to reflect the distribution of trucks by age within the port truck fleet. A single set of pollutant specific gram per hour idle emission rates were 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)[52] 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 used to estimate emissions. The units are in grams per mile, except for the idle emission factor (0 mph) which is in grams/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	1.525	1.403	1.525	83.331	0.042	19.983	10.554	gm/hr
1-5	4.997	4.597	4.997	52.648	0.017	30.076	14.834	gm/mi
6-10	4.160	3.827	4.160	43.338	0.017	26.646	11.378	gm/mi
11-15	2.777	2.555	2.777	29.791	0.017	20.668	6.042	gm/mi
16-20	1.824	1.678	1.824	23.136	0.017	15.918	2.790	gm/mi
21-25	1.443	1.328	1.443	21.922	0.017	13.034	1.955	gm/mi
26-30	1.217	1.120	1.217	21.393	0.017	10.917	1.578	gm/mi
31-35	1.046	0.962	1.046	21.012	0.017	9.129	1.290	gm/mi
36-40	0.930	0.856	0.930	20.771	0.017	7.670	1.091	gm/mi
41-45	0.870	0.800	0.870	20.703	0.017	6.540	0.981	gm/mi
46-50	0.865	0.796	0.865	20.805	0.017	5.738	0.960	gm/mi
51-55	0.915	0.842	0.915	21.061	0.017	5.265	1.027	gm/mi
56-60	1.021	0.939	1.021	21.507	0.017	5.121	1.183	gm/mi
61-65	1.182	1.087	1.182	22.162	0.017	5.306	1.428	gm/mi
66-70	1.398	1.286	1.398	23.008	0.017	5.820	1.762	gm/mi

[52] 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	4,640	0.037	0.183	gm/hr
1-5	3,845	0.015	0.866	gm/mi
6-10	3,491	0.015	0.670	gm/mi
11-15	2,866	0.015	0.355	gm/mi
16-20	2,352	0.015	0.164	gm/mi
21-25	2,110	0.015	0.115	gm/mi
26-30	1,980	0.015	0.093	gm/mi
31-35	1,873	0.015	0.076	gm/mi
36-40	1,788	0.015	0.064	gm/mi
41-45	1,724	0.015	0.058	gm/mi
46-50	1,683	0.015	0.057	gm/mi
51-55	1,663	0.015	0.060	gm/mi
56-60	1,666	0.015	0.070	gm/mi
61-65	1,691	0.015	0.084	gm/mi
66-70	1,738	0.015	0.104	gm/mi

7.5.7 Improvements to Methodology from Previous Years

Below are some improvements from previous year inventories that may have an effect on current emissions and thus may not make apples to apples comparison to previous years' published emissions possible (see section 9 for comparison):

- In 2005, the emission factor for the HDV N_2O was estimated using an equation based on a correlation between N_2O and NO_x. Starting with the 2007 inventory, the EF was changed to reflect information released by CARB which correlates the N_2O EF with fuel consumption. This new correlation produces lower EFs and therefore, lower emission estimates than the previous method.

7.6 Emission Estimates

On-terminal and on-road emissions have been estimated by terminal and are summed to represent Port-wide emissions. 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-Port on-road emissions were estimated on a terminal-specific basis for the container terminals, using the travel demand modeling results discussed above, which estimated how many trucks from each container terminal traveled along each section of road within the port. The off-Port on-road emissions were estimated for Port trucks in general (not terminal-specific) in a similar manner to the on-Port estimates, 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. In most cases, emissions have been allocated to the non-container terminals using a ratio approach based on the number of trucks visiting each non-container terminal relative to the total number of container terminal truck calls. This approach was used because the in-Port travel demand model does not include terminal-specific estimates for Port terminals other than container terminals. The ratio approach assumes that the trucks servicing non-container terminals have the same general activity patterns as trucks servicing the container terminals, in terms of speed and mileage within the Port and in the region. There are five non-container terminal businesses located on Port property to the north of the main Port area whose trucks primarily serve on-Port terminals and make round trips between the business and the Port. Facility-specific estimates have been developed for these businesses, using facility-specific information related to the number of round trips made per day.

Idling emissions were estimated separately for the on-terminal estimates, since the on-road traffic modeling analysis reported only volumes, distances, and average speeds, which were used to estimate VMT. 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. Since annual activity was used for the on-terminal analysis, emissions have been calculated as tons per year, with idling and transit activities estimated separately. Table 7.12 summarizes the two modes of on-terminal operation by terminal.

Table 7.12: On-Terminal VMT and Idling Hours by Terminal Type

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	580,350	313,389
Container	1,753,425	444,201
Container	521,505	92,712
Container	509,550	208,916
Container	822,375	230,265
Container	926,325	247,020
Other	188,369	27,531
Other	284,700	41,610
Other	67,600	8,320
Other	1,266	633
Dry Bulk	1,250	375
Break Bulk	700	1,050
Auto	1,625	1,105
Liquid	70	140
Break Bulk	54,990	24,196
Liquid	18	0
Dry Bulk	15,600	2,280
Break Bulk	25,145	16,093
Other	2,080	3,640
Other	60	480
Other	10,200	1,360
Other	931,860	419,337
Liquid	6,697	12,948
Total	**6,705,760**	**2,097,600**

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Tables 7.13 and 7.14 summarize emissions from HDVs associated with all Port terminals.

Table 7.13: Summary of HDV Emissions, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	6,705,760	28	26	28	453	0	214	84
On-Road	267,558,106	272	250	272	6,154	5	2,013	314
Total	**274,263,866**	**300**	**276**	**300**	**6,606**	**5**	**2,227**	**398**

Table 7.14: Summary of HDV GHG Emissions, metric tons per year

Activity Location	VMT	CO_2 Equivalent	CO_2	N_2O	CH_4
On-Terminal	6,705,760	30,570	30,440	0	4
On-Road	267,558,106	469,122	467,523	4	17
Total	**274,263,866**	**499,693**	**497,963**	**4**	**20**

Tables 7.15 and 7.16 show emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 7.15: Summary of HDV Emissions Associated with Container Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	5,113,530	21	20	21	339	0	164	64
On-Road	241,780,198	246	226	246	5,561	5	1,820	284
Total	**246,893,728**	**267**	**246**	**267**	**5,900**	**5**	**1,984**	**348**

Table 7.16: 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	5,113,530	23,200	23,101	0	3
On-Road	241,780,198	423,976	422,531	4	15
Total	**246,893,728**	**447,176**	**445,632**	**4**	**18**

Tables 7.17 and 7.18 show emissions associated with other Port terminals and facilities separately.

Table 7.17: Summary of HDV Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	1,592,230	6	6	6	113	0	51	20
On-Road	25,777,907	26	24	26	593	1	193	30
Total	**27,370,137**	**33**	**30**	**33**	**706**	**1**	**244**	**50**

Table 7.18: 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	1,592,230	7,370	7,339	0	1
On-Road	25,777,907	45,146	44,992	0	2
Total	**27,370,137**	**52,516**	**52,331**	**0**	**2**

SECTION 8 SUMMARY OF 2008 EMISSION RESULTS

The emission results for the Port of Los Angeles 2008 Inventory of Air Emissions are presented in this section. Tables 8.1 and 8.2 summarize the 2008 total Port-related emissions in the South Coast Air Basin by category.

Table 8.1: 2008 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	426	341	358	4,798	3,787	485	227
Harbor craft	56	51	56	1,284	1	374	91
Cargo handling equipment	34	32	33	1,169	2	739	47
Rail locomotives	42	38	42	1,366	9	226	74
Heavy-duty vehicles	300	276	300	6,606	5	2,227	398
Total	**857**	**738**	**788**	**15,223**	**3,804**	**4,052**	**837**

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 global warming potential (GWP)[53] values (1 for CO_2, 310 for N_2O, 21 for CH_4) and then adding them together.

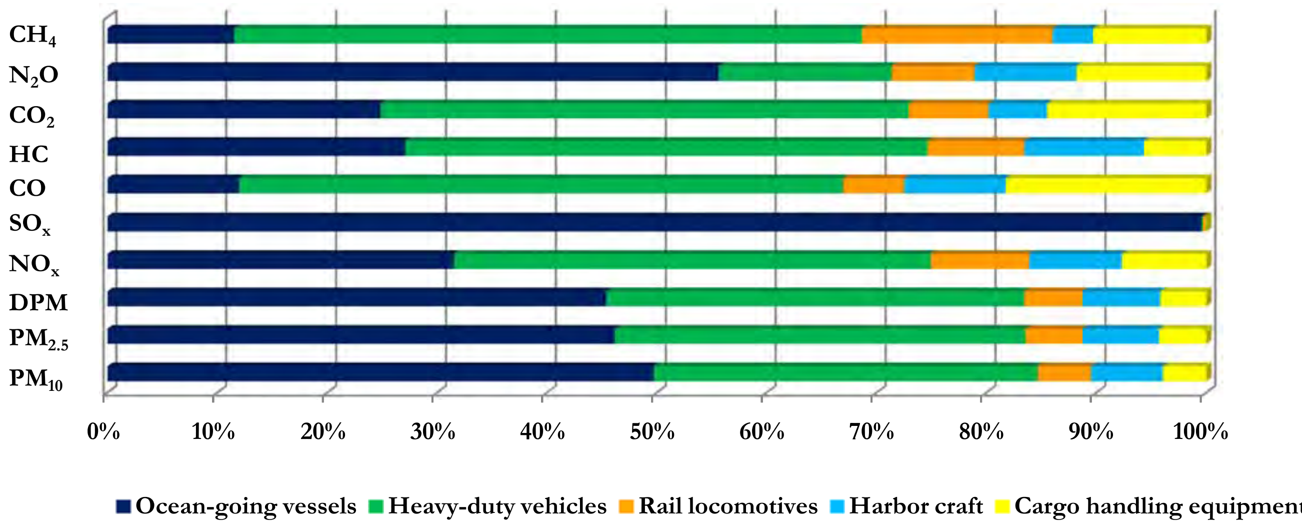
Table 8.2: 2008 Port-related GHG Emissions by Category, metric tons per year

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	262,176	257,483	15	4
Harbor craft	55,912	55,119	2	1
Cargo handling equipment	151,180	150,125	3	4
Rail locomotives	76,100	75,347	2	6
Heavy-duty vehicles	499,693	497,963	4	20
Total	**1,045,061**	**1,036,037**	**27**	**36**

[53] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, 15 April 2008.

Figure 8.1 shows the distribution of the 2008 total port-related emissions for each pollutant and source category. Ocean-going vessels (45 to 50%) and heavy-duty trucks (35 to 38%) contribute the highest percentage of particulate matter emissions among the port-related sources. Over 99% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks (43%) and OGV (32%) account for the majority of NO_x emissions. Heavy-duty trucks (55%) and CHE (18%) account for the majority of CO emissions. Heavy-duty trucks (48%) and OGV (27%) account for the majority of hydrocarbon emissions

Figure 8.1: 2008 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 DPM emissions were 248 tons per year for 2008; these emissions constituted 69% of the OGV emissions (source category), 31% of the total Port-related emissions in the inventory, and 3% of all emissions in the SoCAB (based on emissions reported in the latest Air Quality Management Plan). For the OGV source category, the table shows that the category's 358 tons constituted 45% of overall Port DPM emissions and 4% of SoCAB DPM emissions. The bottom of the table highlighted in grey shows that the Port's total DPM emissions constituted approximately 9% of the SoCAB DPM emissions reported in the Air Quality Management Plan. The other two tables similarly present NO_x and SO_x emissions.

Table 8.3: 2008 DPM Emissions Percentage Comparison, tpy and %

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	6	2%	1%	0%
OGV	Bulk vessel	5	1%	1%	0%
OGV	Containership	248	69%	31%	3%
OGV	Cruise	63	18%	8%	1%
OGV	General cargo	12	3%	1%	0%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Reefer	3	1%	0%	0%
OGV	Tanker	21	6%	3%	0%
OGV	**Subtotal**	**358**	**100%**	**45%**	**4%**
Harbor Craft	Assist tug	19	34%	2%	0%
Harbor Craft	Harbor tug	4	7%	1%	0%
Harbor Craft	Commercial fishing	10	17%	1%	0%
Harbor Craft	Ferry	7	12%	1%	0%
Harbor Craft	Line haul tug	3	5%	0%	0%
Harbor Craft	Government	1	3%	0%	0%
Harbor Craft	Excursion	6	11%	1%	0%
Harbor Craft	Crewboat	4	8%	1%	0%
Harbor Craft	Work boat	1	2%	0%	0%
Harbor Craft	**Subtotal**	**56**	**100%**	**7%**	**1%**
CHE	RTG crane	3	8%	0%	0%
CHE	Forklift	2	6%	0%	0%
CHE	Top handler, side pick	8	24%	1%	0%
CHE	Other	3	10%	0%	0%
CHE	Yard tractor	17	51%	2%	0%
CHE	**Subtotal**	**33**	**100%**	**4%**	**0%**
Rail	Switching	3	7%	0%	0%
Rail	Line haul	39	93%	5%	0%
Rail	**Subtotal**	**42**	**100%**	**5%**	**0%**
HDV	On-Terminal	28	9%	4%	0%
HDV	On-Road	272	91%	34%	3%
HDV	**Subtotal**	**300**	**100%**	**38%**	**3%**
Port	**Total**	**788**		**100%**	**9%**
SoCAB AQMP	**Total**	**9,014**			

Table 8.4: 2008 NO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	NO_x Emissions	Percent NO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	67	1%	0%	0%
OGV	Bulk vessel	54	1%	0%	0%
OGV	Containership	3,094	64%	20%	1%
OGV	Cruise	1,043	22%	7%	0%
OGV	General cargo	142	3%	1%	0%
OGV	Ocean tugboat	30	1%	0%	0%
OGV	Reefer	58	1%	0%	0%
OGV	Tanker	310	6%	2%	0%
OGV	**Subtotal**	**4,798**	**100%**	**32%**	**2%**
Harbor Craft	Assist tug	445	35%	3%	0%
Harbor Craft	Harbor tug	94	7%	1%	0%
Harbor Craft	Commercial fishing	228	18%	1%	0%
Harbor Craft	Ferry	151	12%	1%	0%
Harbor Craft	Line haul tug	67	5%	0%	0%
Harbor Craft	Government	33	3%	0%	0%
Harbor Craft	Excursion	140	11%	1%	0%
Harbor Craft	Crewboat	99	8%	1%	0%
Harbor Craft	Work boat	27	2%	0%	0%
Harbor Craft	**Subtotal**	**1,284**	**100%**	**8%**	**0%**
CHE	RTG crane	95	8%	1%	0%
CHE	Forklift	99	8%	1%	0%
CHE	Top handler, side pick	274	23%	2%	0%
CHE	Other	89	8%	1%	0%
CHE	Yard tractor	612	52%	4%	0%
CHE	**Subtotal**	**1,169**	**100%**	**8%**	**0%**
Rail	Switching	112	8%	1%	0%
Rail	Line haul	1,254	92%	8%	0%
Rail	**Subtotal**	**1,366**	**100%**	**9%**	**0%**
HDV	On-Terminal	453	7%	3%	0%
HDV	On-Road	6,154	93%	40%	2%
HDV	**Subtotal**	**6,606**	**100%**	**43%**	**2%**
Port	**Total**	**15,224**		**100%**	**5%**
SoCAB AQMP	**Total**	**311,603**			

Table 8.5: 2008 SO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	SO_x Emissions	Percent SO_x Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	52	1%	1%	0%
OGV	Bulk vessel	47	1%	1%	0%
OGV	Containership	2,420	64%	64%	15%
OGV	Cruise	468	12%	12%	3%
OGV	General cargo	131	3%	3%	1%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Reefer	46	1%	1%	0%
OGV	Tanker	623	16%	16%	4%
OGV	**Subtotal**	**3,787**	**100%**	**100%**	**23%**
Harbor Craft	Assist tug	0.2	31%	0%	0%
Harbor Craft	Harbor tug	0.0	8%	0%	0%
Harbor Craft	Commercial fishing	0.1	15%	0%	0%
Harbor Craft	Ferry	0.1	17%	0%	0%
Harbor Craft	Line haul tug	0.0	7%	0%	0%
Harbor Craft	Government	0.0	3%	0%	0%
Harbor Craft	Excursion	0.1	10%	0%	0%
Harbor Craft	Crewboat	0.0	6%	0%	0%
Harbor Craft	Work boat	0.0	3%	0%	0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0%**
CHE	RTG crane	0	8%	0%	0%
CHE	Forklift	0	2%	0%	0%
CHE	Top handler, side pick	0	18%	0%	0%
CHE	Other	0	4%	0%	0%
CHE	Yard tractor	1	67%	0%	0%
CHE	**Subtotal**	**2**	**100%**	**0%**	**0%**
Rail	Switching	0	1%	0%	0%
Rail	Line haul	9	99%	0%	0%
Rail	**Subtotal**	**9**	**100%**	**0%**	**0%**
HDV	On-Terminal	0	2%	0%	0%
HDV	On-Road	5	98%	0%	0%
HDV	**Subtotal**	**5**	**100%**	**0%**	**0%**
Port	**Total**	**3,804**		**100%**	**24%**
SoCAB AQMP	**Total**	**16,151**			

In order to put the Port-related emissions into context, the following figures and tables compare the Port's contributions to the other sources in the South Coast Air Basin. The 2008 SoCAB emissions are based on 2007 AQMP Appendix III.[54]

Figure 8.2: 2008 DPM Emissions in the South Coast Air Basin, %

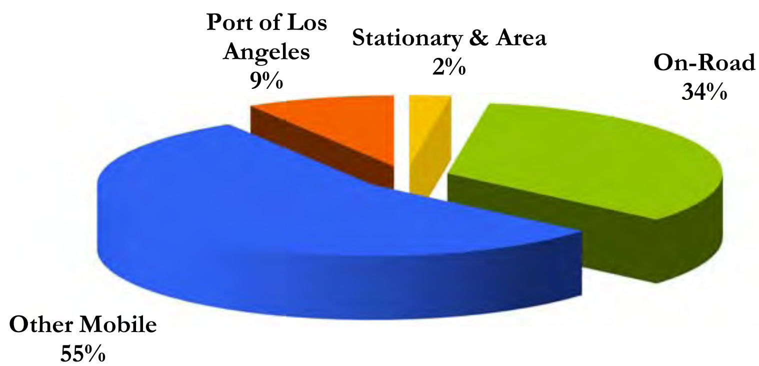


Figure 8.3: 2008 NO_x Emissions in the South Coast Air Basin, %

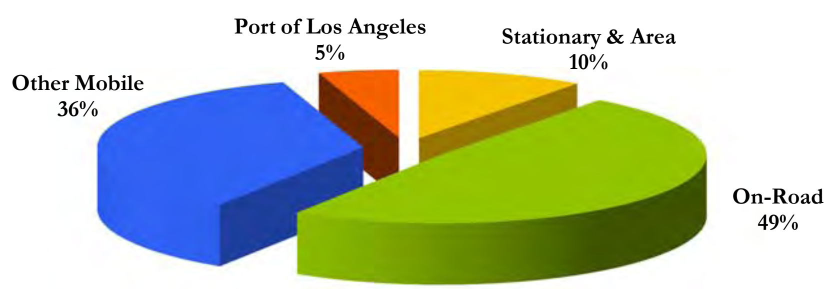
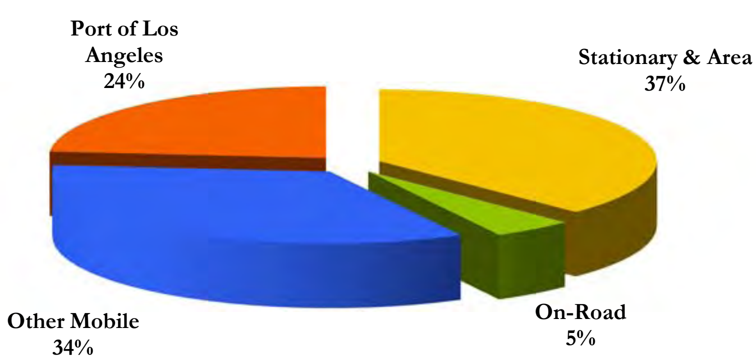


Figure 8.4: 2008 SO_x Emissions in the South Coast Air Basin, %



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

SECTION 9 COMPARISON OF 2008 AND PREVIOUS YEARS' FINDINGS AND EMISSION ESTIMATES

This section compares emissions during the 2008, 2007, 2006 and 2005 calendar years, overall and for each emission source category. Emission source categories are addressed in separate subsections, each containing the emissions comparisons in table and chart format, explaining how the emissions were estimated and comparing findings for the source category.

The tables and charts in this section summarize the percent change for the previous year (2008-2007) and the CAAP Progress (2008-2005) using the current methodology for emissions comparison. Calendar year 2005 is considered the baseline year for CAAP since it is prior to the implementation of the CAAP control measures.

9.1 2008 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 for 2008 vs. previous 2007 Inventory of Air Emissions
The following list provides an overview of any changes in methodology for the five source categories. Table 9.1 lists the changes by source category, a qualitative impact on total emissions for that source category, and pollutants and engine type affected, if applicable. A "low" impact to emissions is less than 15% change, while "medium" impact is 15% to 30% change in emissions.

OGV

- The methodology used in 2008 to estimate ocean-going vessel emissions differs in several respects from the methodology used in the 2007 Inventory of Air Emissions. Thus, emissions were re-estimated for previous years using the current methodology. Section 9.1.1 describes the changes in the OGV methodology in detail, and presents the source category comparisons across years.

Harbor Craft

- The methodology used in 2008 to estimate harbor craft emissions differs in some respect from the methodology used in the 2007 Inventory of Air Emissions, so emissions have been re-estimated for the previous years using the current methodology. Section 9.1.2 describes the changes in the harbor craft methodology in detail, and presents the source category comparisons across years.

CHE

- The methodology used in 2008 to estimate cargo handling equipment emissions differs in some respects from the methodology used in the 2007 Inventory of Air Emissions, so emissions have been re-estimated for the previous years using the current methodology. Section 9.1.3 describes the changes in the CHE methodology in detail, and presents the source category comparisons across years.

Rail

- The methodology used in 2008 to estimate rail emissions differs from the methodology used in the 2007 Inventory of Air Emissions due to updated EPA emission factors for line-haul locomotives. Section 9.1.4 presents the source category comparisons across years.

HDV

- The methodology used in 2008 to estimate HDV emissions is the same as the methodology used in the 2007 Inventory of Air Emissions. Section 9.1.5 presents the source category comparisons across years.

Table 9.1: 2008 Changes in Methodology by Source Category

Source Category	Item	Impact on Emissions	Increase/ Decrease	Pollutants Impacted	Engine Type Impacted
OGV	Modified Vessel Type Classification	Low	Varies	All	All
OGV	Improved Vessel Activity Allocation to Port	Low	Increase	All	All
OGV	Limited Activity Data to Calendar Year (no carryover)	Low	Decrease	All	All
OGV	Updated Zone Distances	Low	Increase	All	All
OGV	Changed Maneuvering Time Assumptions from Vessel Type to Berth Location	Low	Varies	All	All
OGV	Calculated Maneuvering Load on a Vessel by Vessel Basis instead of Averages	Low	Varies	All	All
OGV	Changed assumption of missing speeds	Medium	Decrease	All	Propulsion
OGV	Averaged and allocated speeds for segments	Low	Decrease	All	Propulsion
OGV	Changed Assumption on Introduction of Slide Valves from 2005 to 2004 MY	Low	Decrease	PM, NO_x	Propulsion
OGV	Minimum Main Engine Load of 2%	Low	Increase	All	Propulsion
OGV	Maximum Main Engine Load Cap of 100%	Low	Decrease	All	Propulsion
OGV	Corrected Low Load Adjustment Factors	Low	Decrease	HC, CH_4	Propulsion
OGV	Standardized Fuel Switching Hierarchy	Low	Varies	PM, NO_x, SO_x, N_2O	Prop and Aux
OGV	Changed Operator Query from Marex to Lloyds for Fuel Switching	Low	Increase	PM, NO_x, SO_x, N_2O	Prop and Aux
OGV	Implemented 95% Reduction for Shore Power rather than 100% Reduction	Low	Increase	All	Auxiliary
OGV	Made Assumption that Boilers are On when main engine load $\leq$20%	Low	Increase	All	Boilers
OGV	Implemented Assumption that D/E cruise ships do not use their fuel-fired boilers	Low	Decrease	All	Boilers
Harbor Craft	Removed deterioration rates for GHG	Medium	Decrease	CO_2, N_2O, CH_4	Prop and Aux
Harbor Craft	Model Year data collection	Low	Increase	All	Prop and Aux
CHE	Updated RTG Load factor	Medium	Decrease	All	na
CHE	Removed deterioration rates for GHG	Medium	Decrease	CO_2, N_2O, CH_4	na
HDV	Corrected Minor Calculation Errors	Low	Decrease	All	na

Port-wide Overview of Activity and Emissions Changes

Table 9.2 and Figure 9.1 illustrate the number of vessel calls and the container cargo throughputs. The 2008 vessel calls were lower than the previous years, but the average TEU/call ratio has continued to increase which shows efficiency improvement (on average, more containerized cargo is moved during each vessel call). In Table 9.2, for a given year the total number of calls (arrivals) and the number of containership calls may be different from previously published reports due to an improved OGV data processing methodology that more thoroughly associates vessel movements with the port than in previous inventories.

Table 9.2: TEUs and Vessel Call Comparison, %

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2008	2,239	1,459	7,849,985	5,380
2007	2,537	1,577	8,355,038	5,298
2006	2,701	1,632	8,469,853	5,190
2005	2,500	1,479	7,484,625	5,061
Previous Year (2008-2007)	**-12%**	**-7%**	**-6%**	**2%**
CAAP Progress (2008-2005)	**-10%**	**-1%**	**5%**	**6%**

Figure 9.1: TEUs and Vessel Call Comparison, %

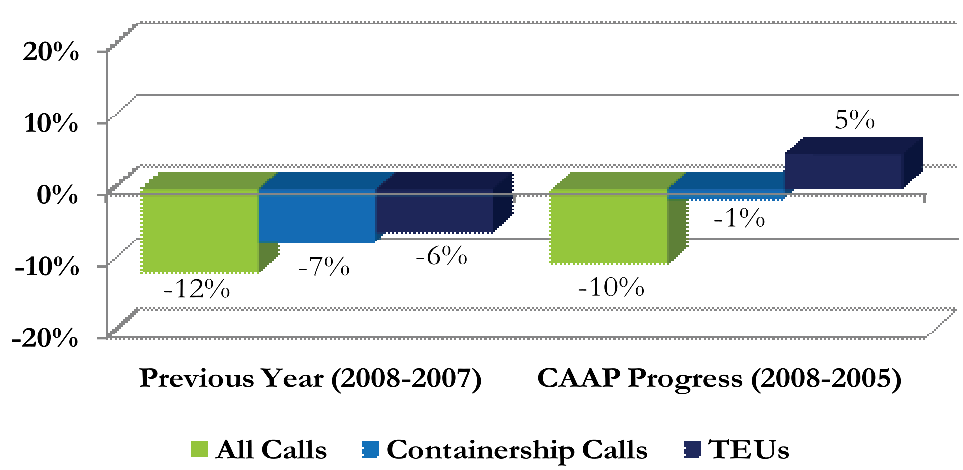


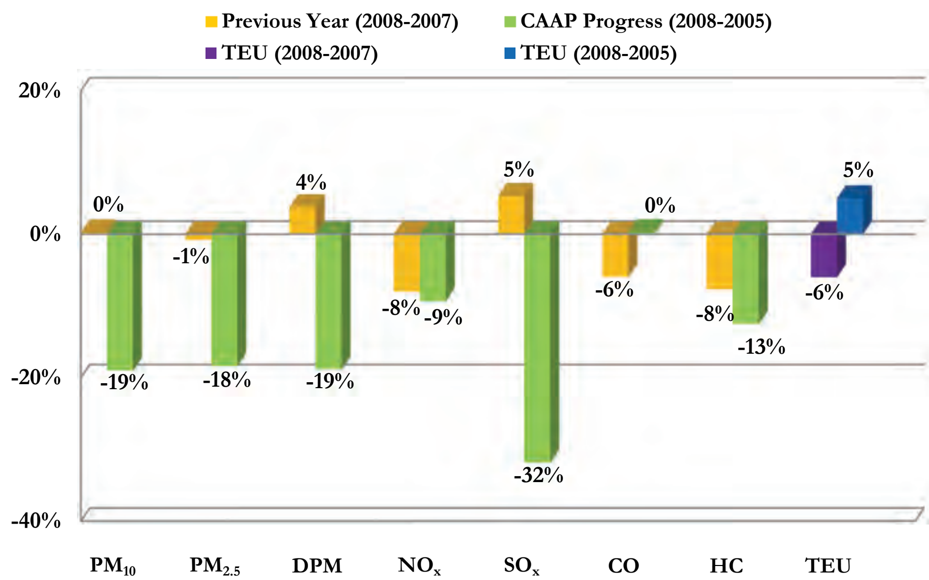
Table 9.3 presents the total net change in emissions for all source categories in 2008 as compared to previous years. From 2007 to 2008, there was a 6% decrease in throughput and emissions decreased 8% for NO_x and 6% for CO emissions. Emissions increased for DPM and SO_x emissions. The SO_x emissions increase is due to the CARB fuel auxiliary engine regulation that was in effect for the entire year in 2007, but was only in effect for the first four months of 2008, thus the OGV SO_x emissions increased 5% in 2008. The DPM emissions increase from 2007 is due in part to the fuel regulation being in force for all of 2007 but only part of 2008 as well as fewer tanker calls in 2008 than in 2007. Many tankers use boilers at higher rates than any other vessel types while at berth, and boilers do not have DPM emissions associated with them. When there are more tankers relative to other vessels (as in 2007) there is comparatively less DPM than PM_{10}. Since the number of tankers was lower in 2008, the DPM increased more than the PM_{10}, resulting in higher overall DPM in 2008 than other years due to less tanker activity. NO_x and HC emissions were reduced by 8% due to newer fleet of vessels and equipment which have cleaner and more fuel efficient engines.

Table 9.3: Port-wide Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	857	738	788	15,223	3,804	4,052	837
2007	855	744	760	16,553	3,611	4,308	906
2006	1,168	1,000	1,067	18,946	6,072	4,690	1,088
2005	1,059	904	971	16,789	5,585	4,040	957
Previous Year (2008-2007)	**0%**	**-1%**	**4%**	**-8%**	**5%**	**-6%**	**-8%**
CAAP Progress (2008-2005)	**-19%**	**-18%**	**-19%**	**-9%**	**-32%**	**0%**	**-13%**

Figure 9.2 shows the percent change in port-wide emissions since the previous year and CAAP progress. From 2005 to 2008, emissions were reduced despite the 5% increase in throughput, except for CO emissions which remained unchanged. Most of the emission reduction programs reduced particulate matter, thus the 19% PM emission reduction. The diesel engines are currently burning diesel fuel with lower sulfur content than in 2005, including the use of ultra-low sulfur diesel (ULSD) fuel by all source categories except OGV and line haul locomotives. The Port's voluntary Fuel Incentive Program and three months of CARB's Auxiliary Engine Fuel Rule for ocean-going vessels also had a direct impact on the SO_x emissions (32% reduction). NO_x and HC emissions were reduced due to newer fleet of vessels and equipment which have cleaner and more fuel efficient engines.

Figure 9.2: Port-wide Emissions Comparison, % Change



Figures 9.3 through 9.5 show how the percent emissions for DPM, NO_x and SO_x have changed throughout the years for ocean-going vessels, heavy-duty vehicles, harbor craft, rail locomotives, and cargo handling equipment.

Figure 9.3 shows that OGVs contributed about 45% of the DPM emissions in 2008 as compared to 36% in 2007. This is due to the CARB Fuel Regulation that was in place for the entire year in 2007 and reduced PM and SO_x emissions for OGV that year. In 2008, the CARB Fuel Regulation was only in place for the first 4 months of the year.

Figure 9.3: DPM Emissions Comparison, % Change

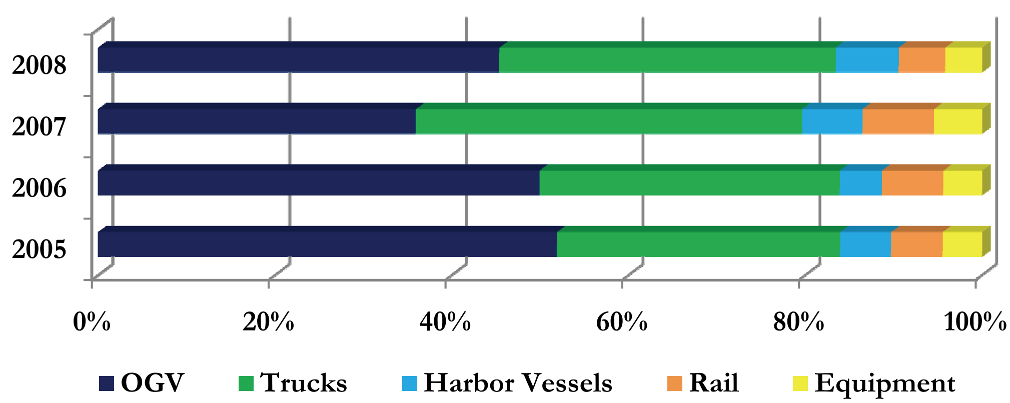


Figure 9.4 shows that the contribution by each source category has remained fairly constant throughout the years for NO_x emissions. Rail contributed less in 2008 due to a newer fleet as compared to previous years.

Figure 9.4: NO_x Emissions Comparison, % Change

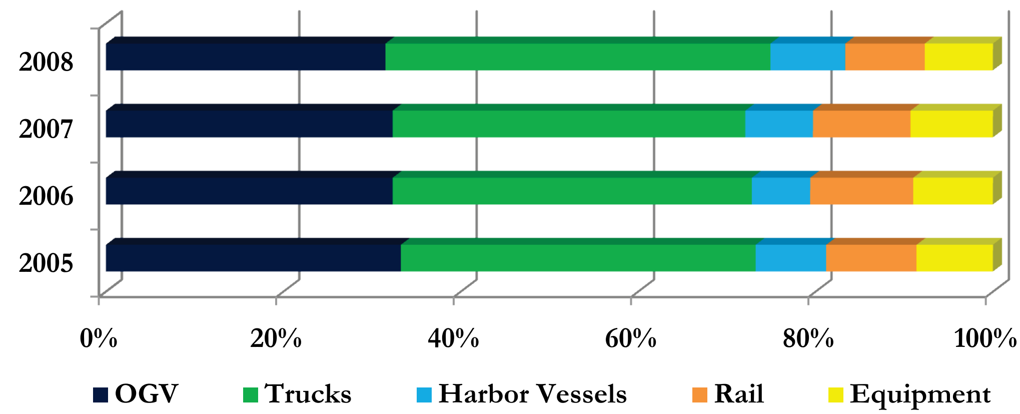


Figure 9.5 shows that through the years, OGVs are by far the largest contributors to SO_x emissions at the port (97% to over 99%). In 2008, OGVs contributed over 99% of the SO_x port-related emissions. This is due to the fact that SOx emissions are directly affected by the type of fuel burned by engines. OGVs burn residual fuel with an average 2.7% S content and when they switch to a lower sulfur fuel it usually is to a marine distillate (0.1 to 0.5% S). The other source categories, with the exception of rail, have switched completely to using ULSD at varying years.

Figure 9.5: SO_x Emissions Comparison, % Change

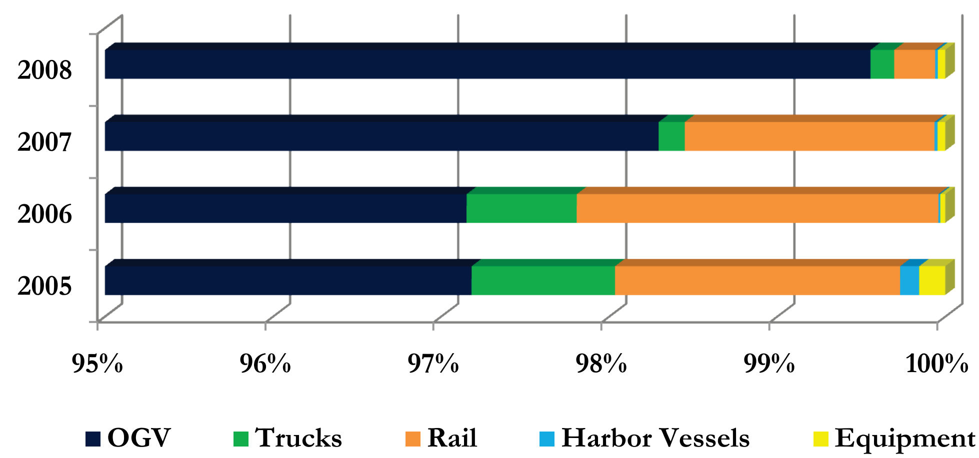


Table 9.4 compares the port-wide greenhouse gas emissions to the previous year.

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

Year	CO_2 Equivalent	CO_2	N_2O	CH_4
2008	1,045,061	1,036,037	27	36
2007	1,127,348	1,113,998	40	39
2006	1,275,928	1,242,776	104	42
2005	1,085,689	1,056,875	91	36
Previous Year (2008-2007)	**-7%**	**-7%**	**-34%**	**-9%**
CAAP Progress (2008-2005)	**-4%**	**-2%**	**-71%**	**-1%**

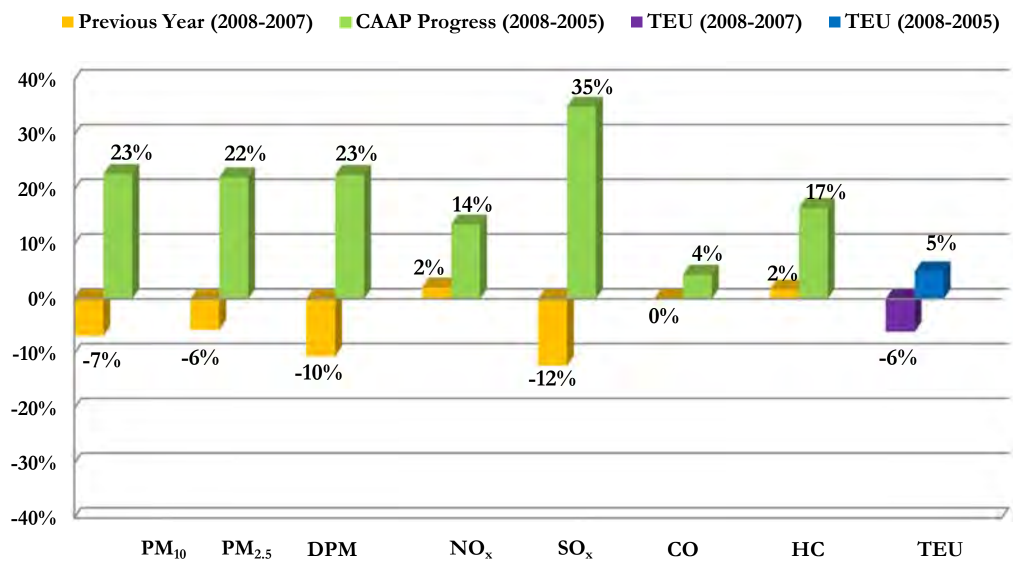
Table 9.5 and Figure 9.6 compare emissions efficiency changes for the various years which show that emissions per TEU continue to improve over the years. A positive percent for the emissions efficiency comparison means an improvement in efficiency. In 2008, the overall port efficiency improved for all pollutants as compared to 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
2008	1.09	0.94	1.00	19.39	4.85	5.16	1.07
2007	1.02	0.89	0.91	19.80	4.32	5.15	1.08
2006	1.38	1.18	1.26	22.37	7.17	5.54	1.29
2005	1.41	1.21	1.30	22.43	7.46	5.40	1.28
Previous Year (2008-2007)	**-7%**	**-6%**	**-10%**	**2%**	**-12%**	**0%**	**2%**
CAAP Progress (2008-2005)	**23%**	**22%**	**23%**	**14%**	**35%**	**4%**	**17%**

The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%).

Figure 9.6: Port-wide Changes in Emissions Efficiency, % Change



9.1.1 Ocean-going Vessels

The 008 methodology to estimate OGV emissions changed from previous years; therefore 2005 to 2007 activity was re-estimated using latest OGV methodology. The changes include:

- Vessel Type Classification – In previous inventories, the vessel type classification was based on vessel types as reported by the Marine Exchange in the activity source data. The new methodology uses the Lloyd's vessel type classification (based on IMO number) to classify the vessel types and subtypes, which is believed to be a more consistent source of vessel information. In addition, the tanker subtypes were re-assigned so that all tankers, with the exception of chemical tankers, were assigned to the Aframax, Handyboat, Panamax, Suezmax classification. In the past, only tankers that were exclusively crude oil tankers were assigned to these tanker subtypes.

- Vessel Activity – the method for allocating vessel activity and the associated emissions to a port, terminal or berth requires tracing a vessel's movement back a number of steps due to the shifts between ports and anchorages. The 2008 methodology captures all of the ships' movements. Previous inventories assigned associated emissions to a port based on two to three previous movements.

- Calendar Year - In order to evaluate the vessel activity for the entire year, the previous methodology was structured to look two to three weeks into the subsequent year in order to properly allocate the activity of vessels that departed after 31 December of the inventory year. As a result, the data file for a calendar year contained data on activities that occurred in the following year. The new methodology has been designed to limit this activity analysis strictly to the calendar year of study (1 January to 31 December).

- Distances – to reflect more precise GIS measurements, the zone distances for the four major shipping routes were revised up to the geographical extent of the inventory.

- Maneuvering time – average in-harbor maneuvering times to/from each terminal based on average trip times associated with those terminals is used for 2008 EI. In previous inventories, the in-harbor maneuvering time was based on averages by vessel type.

- Maneuvering load – the maneuvering load is calculated on a vessel by vessel basis. In past inventories, it was based on an average load by vessel type.

- Missing speeds - 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. In previous inventories, when there was no speed data past 20 nm, the speed for the waypoints between 25 and 40 nm were assumed to be 94% of the ship's Lloyd's speed. This methodology change has had the greatest impact on emissions of any of the 2008 OGV methodology changes.

- Speeds in Transit Zones - 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. Missing speed measurements are filled in according to established protocols. In the 2007 and previous EIs, each waypoint speed was used as the average speed in the zone between that waypoint and the next one in - e.g., the speed recorded by MarEx at the 20 nm waypoint was allocated to the 15-20 nm zone. Starting with the 2008 EI, the zone speeds have been calculated as the average of the speeds at the adjacent waypoints - e.g., the 15-20 nm zone speed has been calculated as the average of the speeds at the 15 and 20 nm waypoints.

- Slide fuel valves – in the 2008 inventory, vessels built in 2004 and newer model year and equipped with MAN B&W propulsion engines are assumed to be equipped with slide valves. In past inventories, the assumption applied to vessels built in 2005 and newer model year MAN B&W propulsion engines.

- Minimum main engine load floor of 2% - the previous EIs calculations did not include a provision for setting a minimum load of 2% for the transiting zones, so, some main engine loads were estimated below 2%.

- Maximum engine load cap - calculated loads above 100% are capped at 100%.

- Low load adjustment factor – the hydrocarbon and CH_4 LLA factor was revised.

- Fuel Switching Hierarchy – a hierarchy was established for the various fuel switching policies (Vessel Operator Fuel Switch Policy, Port Incentive Fuel Switch Program, Vessel Fuel Switch Policy, CARB Fuel Regulation, Default of IFO 2.7% S)

- Implemented 95% reduction for shore power rather than 100% reduction.

- Assumption on Boiler Start-up during Transit - 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, boilers. Because of these lower speeds, it is believed that auxiliary boilers are coming on during transit when the lower speeds result in the cooling of main engine exhausts, making the vessels' economizers less effective. The assumption was implemented that auxiliary boilers operate if the main engine power is less than 20% during transit. In the past inventories, boilers were assumed not to be used at all during transit due to higher speeds, which allowed the use of economizers to provide steam and hot water. This change increased boiler emissions somewhat but has not affected a large number of vessel transits.

- Cruise ships with diesel-electric engines are now assumed to not use their fuel-fired boilers. In past inventories, it was assumed all cruise ships used their boilers.

The various emission reduction strategies for ocean-going vessels are listed in Table 9.6 by percent of all calls.

Table 9.6: OGV Emission Reduction Strategies, % of All Calls

Year	Slide Valve	IMO Compliant	Percent (%) of All Calls Shore Power	Fuel Switch Aux Eng[a]	Fuel Switch Main Eng[b]	VSR
2008	21%	51%	2%	see note	see note	89%
2007	15%	45%	3%	100%	26%	84%
2006	7%	44%	2%	39%	10%	74%
2005	4%	30%	1%	27%	3%	64%
2001	0%	0%	0%	0%	0%	58%

Note (a): For 2008 calendar year, the percentage varied throughout the year. The percent of vessels that switched to a cleaner fuel for auxiliary engines at berth and within 24 nm is 100% from January 2008 to end of April 2008 when the CARB Fuel Regulation was in effect and approximately 14% from July 2008 to December 31, 2008 for the port's voluntary Fuel Incentive Program. For the months of May and June 2008, it is assumed that the vessels did not switch fuels and the default IFO 2.7% S residual fuel was burned in the auxiliary engines.

Note (b): For main engine fuel switch, for most fleets, it was assumed that no main engine fuel switching occurred during January 2008 to end of June 2008. The exception is vessels owned by Maersk whose policy was to switch the main engines to cleaner fuel during transit near the coast of California. For July 2008 to December 2008, 14% of the vessel calls switched their main engines to cleaner fuels based on the Fuel Incentive Program statistics.

Table 9.7 compares the overall engine activity (in terms of kW-hrs). The values do not match previous inventories due to new OGV methodology used that has a bearing on engine load and thus affects the engine kilowatts used to calculate engine activity.

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
2008	356,613,828	110,549,958	172,215,300	73,848,570
2007	429,235,209	119,653,479	204,582,604	104,999,127
2006	470,330,055	134,822,204	226,502,353	109,005,498
2005	420,670,866	128,371,245	197,033,267	95,266,354
Previous Year (2008-2007)	**-17%**	**-8%**	**-16%**	**-30%**
CAAP Progress (2008-2005)	**-15%**	**-14%**	**-13%**	**-22%**

Table 9.8 shows the emissions estimate comparisons for calendar year 2008, 2007, 2006, and 2005 for OGV in tons per year and as a percent change, respectively. The methodology used in 2008 to estimate OGV emissions changed from what was used in previous EI reports, thus all the OGV emissions are different from what was published previously.

Table 9.8: OGV Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	426	341	358	4,798	3,787	485	227
2007	367	294	273	5,352	3,548	533	244
2006	632	505	533	6,126	5,898	573	256
2005	591	472	504	5,583	5,425	507	226
Previous Year (2008-2007)	**16%**	**16%**	**31%**	**-10%**	**7%**	**-9%**	**-7%**
CAAP Progress (2008-2005)	**-28%**	**-28%**	**-29%**	**-14%**	**-30%**	**-4%**	**0%**

Despite the 6% decrease in TEU throughput from 2007 and the reduced engine activity, PM and SO_x emissions increased from 2007 to 2008 because not as many vessels switched fuel in 2008. The CARB Fuel Regulation was only in place for 4 months in 2008 as compared to a full year in 2007. NO_x, CO and HC emissions were reduced in 2008. Comparing 2008 to 2005, emissions were reduced for all criteria pollutants, except HC emissions which remained approximately the same. PM, NO_x and SO_x emission reductions are due to fuel switching, slide valves, newer vessels and improved VSR compliance in 2008.

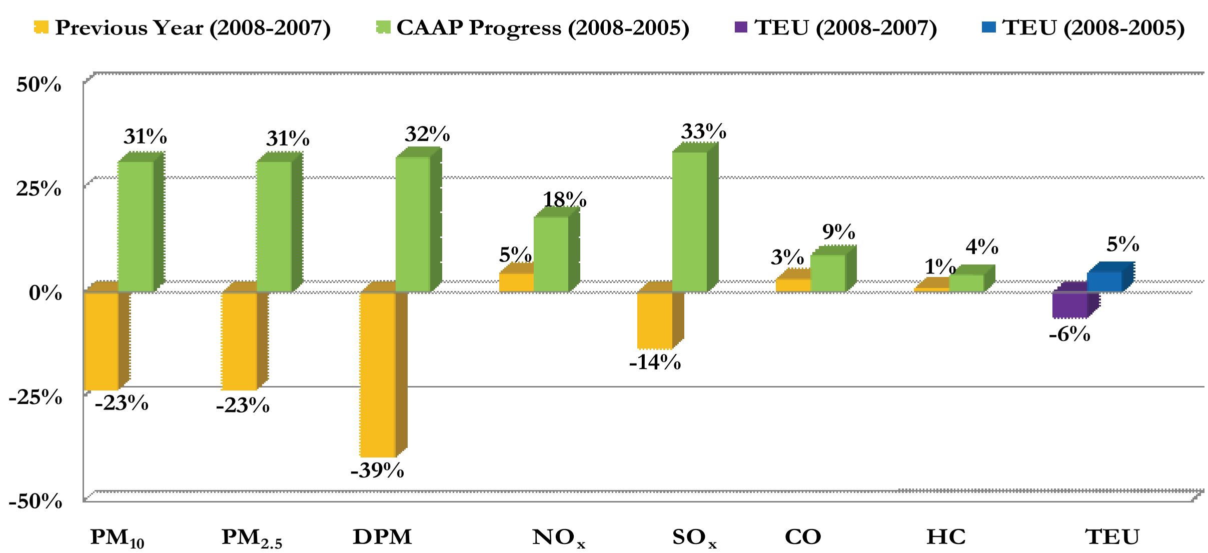
Table 9.9 and Figure 9.7 show the emissions efficiency changes for 2008-2007 and 2008-2005. A positive percent for the emissions efficiency comparison means an improvement in efficiency. These data illustrate that, with the exception of PM and SO_x, emission efficiency improved for NO_x, CO and HC for previous year comparison (2008-2007). For 2008-2005, emission efficiency improved for all pollutants, illustrating the effect of CAAP, regulatory action, and other overall efficiency improvements.

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
2008	0.54	0.43	0.46	6.11	4.82	0.62	0.29
2007	0.44	0.35	0.33	6.41	4.25	0.64	0.29
2006	0.74	0.60	0.63	7.22	6.95	0.68	0.30
2005	0.79	0.63	0.67	7.46	7.25	0.68	0.30
Previous Year (2008-2007)	**-23%**	**-23%**	**-39%**	**5%**	**-14%**	**3%**	**1%**
CAAP Progress (2008-2005)	**31%**	**31%**	**32%**	**18%**	**33%**	**9%**	**4%**

The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%).

Figure 9.7: OGV Emissions Efficiency Comparison, %



9.1.2 Harbor Craft

The 2008 methodology to estimate harbor craft emissions differs in some respects from that used in developing previous years' inventories; therefore, emissions from 2005 to 2007 were re-estimated using the revised methodology and the past years' activity data. The changes from previous inventories include:

- GHG deterioration rates - In the initial development of the GHG emission estimates, the calculations were developed to use the deterioration rates for analogous criteria pollutants. That is, emissions of methane were modeled to increase as hydrocarbons increased and emissions of nitrous oxide were modeled to increase as emission of oxides of nitrogen increased. However, the decision was made for the 2008 inventory to remove the deterioration factors for those two gases because there are currently no substantiating data sources available on greenhouse gas deterioration rates. The change resulted in reduced emission estimates because the estimates were no longer increased in proportion to higher cumulative hours (i.e., older equipment is assumed to emit at the same rate as newer equipment).

- CO_2 correction - With the lack of a credible deterioration rate for CO_2 emissions, a factor of one (1) was coded into the deterioration rate field of the calculation database table in the understanding that the calculations used the factor in a multiplicative manner (i.e., multiplying the base emission rate by 1 would not change the base rate). However, the calculation called for adding the deterioration rate to the base emission rate so the base rates were inadvertently increased. As with the other greenhouse gases, the deterioration rate for CO_2 was subsequently set to zero. In removing the estimates of deterioration for these pollutants, the greenhouse gases emissions inventory (CO_2 equivalent) was reduced by approximately 28% for the harbor craft source category and 2% for the overall port-wide inventory.

- Engine model year records – The engine model year (1950 to 1997) for approximately 60 commercial fishing vessels was recorded in the 2008 activity import file. In the previous studies, the model years for these vessels were not known and therefore were given a default based on the port's overall model year average (1994 to 1996) for that year. This data collection improvement led to increased emissions in 2008 when compared to the previous years even though the total activity decreased.

Table 9.10 summarizes the number of harbor craft inventoried for 2005 to 2008. Overall, the total vessel count decreased 3% from 2007 to 2008 and increased 7% between 2005/2006 and 2008.

Table 9.10: Harbor Craft Count Comparison

Harbor Vessel Type	2008 Count	2007 Count	2006 Count	2005 Count
Assist tug	20	16	16	16
Commercial fishing	138	140	121	156
Crew boat	21	22	19	14
Excursion	24	24	24	24
Ferry	10	9	9	9
Government	21	27	26	26
Ocean tug	7	7	7	7
Tugboat	20	23	20	19
Work boat	12	15	15	14
Total	**273**	**283**	**257**	**285**

Table 9.11 summarizes the percent distribution of engines based on engine standards.

Table 9.11: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2
2008	57%	26%	17%
2007	64%	27%	9%
2006	61%	29%	10%
2005	64%	30%	7%

For this comparison, the following model years fall into the Tier 0, Tier 1 and Tier 2:

- Tier 0 are engines older than 1999
- Tier 1 engines' model year ranges from 2000 to 2003
- Tier 2 engines' model year are 2004+

Prior to 2005, many engines were replaced as a result of the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor. In 2005, 64% of the engines were Tier 0 engines; 30% had Tier 1 engines and 7% had Tier 2 engines. In 2006, the percentage of Tier 0 engines was reduced to 61% and the Tier 2 percentage increased to 10%. In 2007, the percentage of Tier 0 engines increased back to 64%, while the percentage of Tier 1 and 2 engines decreased to 27% and 9%, respectively. In 2008, there were less Tier 0 engines (57%) and more Tier 2 engines (17%) which shows that some vessels were repowered and that new vessels were added to the fleet.

Table 9.12 compares the engines (main and auxiliary engines combined) by vessel type and Tier for 2005 to 2008. Although many vessels have 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 the vessel to be out of service which is lost revenue for the harbor craft owners.

Table 9.12: Harbor Craft Engine Standards Comparison by Vessel Type

Harbor Vessel Type	2008 Tier 0	2008 Tier 1	2008 Tier 2	2008 Total	2007 Tier 0	2007 Tier 1	2007 Tier 2	2007 Total	2006 Tier 0	2006 Tier 1	2006 Tier 2	2006 Total	2005 Tier 0	2005 Tier 1	2005 Tier 2	2005 Total
Assist tug	36	16	28	80	32	20	12	64	31	20	12	63	35	24	4	63
Commercial fishing	127	30	7	164	130	32	6	168	108	34	6	148	149	42	6	197
Crew boat	39	18	8	65	42	18	9	69	30	18	9	57	14	18	9	41
Excursion	43	25	2	70	45	23	2	70	45	23	2	70	45	23	2	70
Ferry	0	20	16	36	4	18	10	32	4	18	10	32	8	14	10	32
Government	24	13	2	39	36	12	0	48	34	12	0	46	34	12	0	46
Ocean tug	8	8	12	28	20	8	0	28	20	8	0	28	20	8	0	28
Tugboat	28	19	20	67	40	22	14	76	32	21	14	67	32	23	8	63
Work boat	26	5	3	34	35	7	0	42	35	7	0	42	31	7	0	38
Total Engines	**331**	**154**	**98**	**583**	**384**	**160**	**53**	**597**	**339**	**161**	**53**	**553**	**368**	**171**	**39**	**578**

As can be seen in Table 9.13, there was a 4% decrease in vessel count in 2008 from 2007. The activity (as measured by horsepower-hours) decreased 3% in 2008 from previous year. The activity hours does not necessarily change at same rate as the vessel count.

Table 9.13: Harbor Craft Engine Comparison

Year	Vessel Count	Engine Count	Total HP-hr
2008	273	583	114,055,589
2007	283	597	117,501,429
2006	257	553	115,940,879
2005	285	578	115,692,693
Previous Year (2008-2007)	**-4%**	**-2%**	**-3%**
CAAP Progress (2008-2005)	**-4%**	**1%**	**-1%**

There was an operational improvement that led to increased emissions in 2008 when compared to the previous years even though the total activity decreased. The engine model year (1950 to 1997) for approximately 60 commercial fishing vessels was recorded in the 2008 activity import file. In the previous studies, the model years for these vessels were not known and therefore were given a default based on the port's overall model year average (1994 to 1996) for that year. Table 9.14 compares the average cumulative hour by vessel type and shows the impact the data improvement had on the cumulative hours for commercial fishing vessels in 2008 as compared to previous years.

Table 9.14: Average Cumulative Hour Comparison by Vessel Type

	2008	**2007**	**2006**	**2005**
Assist tug	14,845	12,258	14,738	11,965
Commercial fishing	30,495	15,428	13,168	14,906
Crew boat	12,848	11,688	8,119	7,946
Excursion	23,001	19,336	17,428	15,261
Ferry	5,313	4,353	4,494	4,772
Government	4,443	3,686	3,809	3,625
Ocean tug	2,593	3,135	3,643	4,239
Tugboat	7,839	8,187	8,728	11,449
Work boat	3,065	3,934	2,430	2,324

Because there was a change in the methodology, the previous years' activity was re-estimated using 2008 methodology. Table 9.15 shows the emissions estimate comparisons for calendar year 2005 to 2008 for harbor craft.

Table 9.15: Harbor Craft Emission Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
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	52	56	1,336	6	369	89
Previous Year (2008-2007)	**8%**	**8%**	**8%**	**2%**	**-3%**	**9%**	**9%**
CAAP Progress (2008-2005)	**0%**	**0%**	**0%**	**-4%**	**-90%**	**1%**	**3%**

Although overall vessel count and activity is slightly down in 2008 as compared to 2007, emissions increased for all pollutants except for SO_x emissions. The increase in emissions is due to the model year data collection improvement for commercial fishing vessels which increased cumulative hours and thus emissions in 2008. The reduction is SO_x emissions is due to the use of ULSD fuel by all harbor craft.

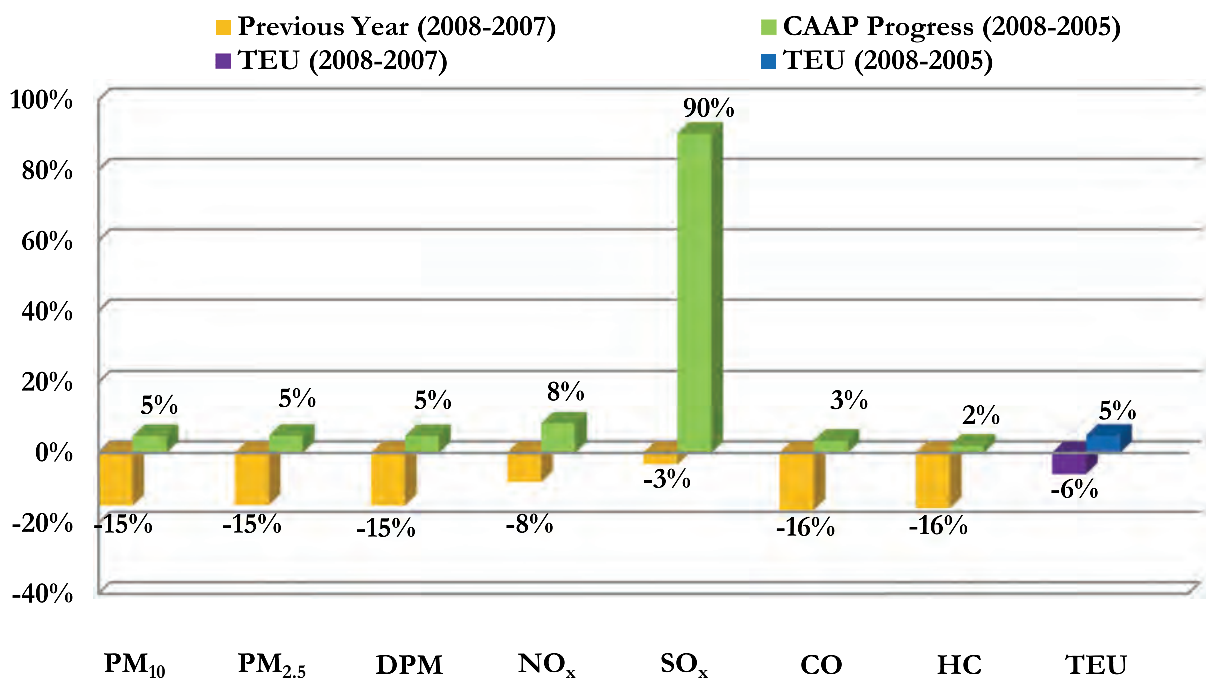
Table 9.16 shows the emissions efficiency changes. It should be noted that the total emissions for harbor craft were used for the efficiency comparison, which includes emissions from harbor craft (e.g. commercial fishing vessels) that are not relevant to container throughput. A positive percent for the emissions efficiency comparison means an improvement in efficiency. For 2008-2005, emission efficiency improved for all pollutants.

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
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 (2008-2007)	**-15%**	**-15%**	**-15%**	**-8%**	**-3%**	**-16%**	**-16%**
CAAP Progress (2008-2005)	**5%**	**5%**	**5%**	**8%**	**90%**	**3%**	**2%**

Figure 9.8 shows the emissions efficiency comparison for previous year and CAAP progress for harbor vessels. The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%).

Figure 9.8: Harbor Craft Emissions Efficiency Comparison, %



9.1.3 Cargo Handling Equipment

The 2008 methodology to estimate cargo handling emissions changed from previous years; therefore 2005 to 2007 emissions were re-estimated using latest methodology. Some changes from previous inventories include:

- The load factor for RTG cranes changed from 0.43 to 0.20.

- GHG deterioration rates - In the initial development of the GHG emission estimates, the calculations were developed to use the deterioration rates for analogous criteria pollutants. That is, emissions of methane were modeled to increase as hydrocarbons increased and emissions of nitrous oxide were modeled to increase as emission of oxides of nitrogen increased. However, the decision was made for the 2008 inventory to remove the deterioration factors for those two gases because there are currently no substantiating data sources available on greenhouse gas deterioration rates. The change resulted in reduced emission estimates because the estimates were no longer increased in proportion to higher cumulative hours (i.e., older equipment is assumed to emit at the same rate as newer equipment).

- CO_2 correction - With the lack of a credible deterioration rate for CO_2 emissions, a factor of one (1) was coded into the deterioration rate field of the calculation database table in the understanding that the calculations used the factor in a multiplicative manner (i.e., multiplying the base emission rate by 1 would not change the base rate). However, the calculation called for adding the deterioration rate to the base emission rate so the base rates were inadvertently increased. As with the other greenhouse gases, the deterioration rate for CO_2 was subsequently set to zero. In removing the estimates of deterioration for these pollutants, the greenhouse gases emissions inventory (CO_2 equivalent) was reduced by approximately 26% for the CHE source category and 5% for the overall port-wide inventory.

Table 9.17 shows a 29% decrease (2008-2007) and 12% decrease (2008-2005) in equipment activity (measured as a product of horsepower, annual activity and load factor) despite an increase in total number of equipment. The increase in equipment count is due to the tenants buying new equipment to comply with the CARB CHE rule. The decrease in activity is possibly due to equipment not used as much due to a decrease in throughput in 2008 and the new equipment may not have been used if it arrived at end of the calendar year.

Table 9.17: CHE Count and Activity Comparison

	Total Population	Total Hp-hr-LF
2008	2,141	213,113,489
2007	2,014	298,475,254
2006	1,926	318,299,748
2005	1,702	241,366,009
Previous Year (2008-2007)	**6%**	**-29%**
CAAP Progress (2008-2005)	**26%**	**-12%**

Table 9.18 summarizes the various engine power types for CHE, which include electric, liquefied natural gas (LNG), propane, gasoline, and diesel.

Table 9.18: CHE Engine Power Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
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	1,059	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**	**1,376**	**1,782**

Table 9.19 summarizes the various emissions controls for diesel powered CHE by equipment counts and by percent total diesel equipment (found in the total equipment count column). With this table there are several items to note:

- Emission controls can be used in combination with each other, therefore they cannot be added across to come up with total equipment count (control equipment counts are greater than total equipment counts).

- Emulsified fuel has not been used since 2006 due to supplier unavailability.

- With the Port CAAP and CARB CHE rule in place, the on-road engines count has increased significantly for the off-road equipment at the port (602 in 2008 vs. 281 in 2007).

- Mainly due to turnover, the diesel oxidation catalysts count continues to decrease as older equipment with DOCs are replaced with newer equipment that do not require the use of DOCs.

- ULSD was used in 2006, 2007, and 2008 by all diesel equipment.

Table 9.19: CHE Diesel Power Equipment Emissions Control Matrix

Equipment	DOC Installed	On-Road Engines	DPF Installed	USLD Fuel	Emulsified Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	USLD Fuel	Emulsified Fuel
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	1,059	0	1,059	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**	**1,376**	**43%**	**12%**	**0%**	**51%**	**16%**

The cargo handling equipment emission estimating methodology used in 2008 is similar to that used in previous years, with the exception for the RTG crane load factor change (20% in 2008 vs. 43% in previous years). Thus, the previous year emissions were re-estimated using the 2008 methodology. Table 9.20 shows the emissions estimate comparisons for calendar year 2008, 2007, 2006, and 2005 for cargo handling equipment in tons per year and as a percent change. The emissions for all pollutants decreased for the previous year comparison (2008-2007) and the CAAP progress (2008-2005). ULSD has been used by all diesel equipment since the beginning of 2006. Emission reductions are due to decreased activity, newer equipment with cleaner engines, increase in on-road engine count, and use of ULSD.

Table 9.20: CHE Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	34	32	33	1,169	2	739	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 (2008-2007)	**-21%**	**-20%**	**-20%**	**-24%**	**-2%**	**-17%**	**-37%**
CAAP Progress (2008-2005)	**-24%**	**-23%**	**-24%**	**-19%**	**-81%**	**0%**	**-37%**

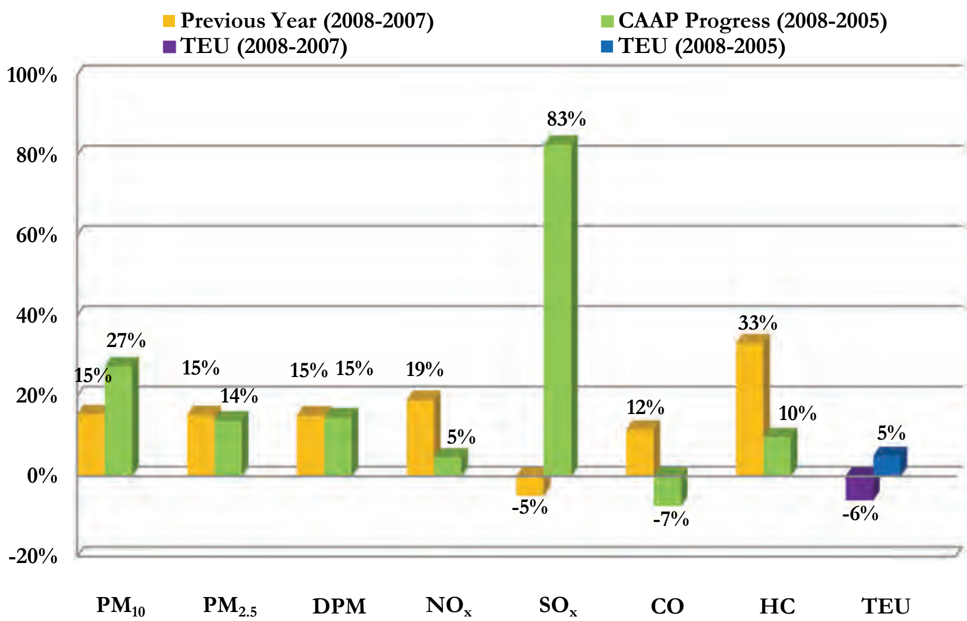
Table 9.21 shows the emissions efficiency changes. From 2007 to 2008, there was a 6% decrease in TEU throughput, and a 12% to 33% improvement in efficiency, except for SO_x. From 2005 to 2008, there was a 5% increase in TEU throughput, but emissions efficiency improved 5% to 83% for pollutants, with the exception of CO. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.21: CHE Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
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 (2008-2007)	**15%**	**15%**	**15%**	**19%**	**-5%**	**12%**	**33%**
CAAP Progress (2008-2005)	**27%**	**14%**	**15%**	**5%**	**83%**	**-7%**	**10%**

Figure 9.9 shows the emissions efficiency comparison for previous year and CAAP progress for CHE. The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%).

Figure 9.9: CHE Emissions Efficiency Comparison, %



9.1.4 Rail Locomotives

The methodology used in 2008 to estimate rail emissions differs from what was used in the 2007 Inventory of Air Emissions due to updated EPA line-haul locomotive emission factors. Tables 9.22 show the various throughput comparisons for rail locomotives for 2005, 2006 2007 and 2008.

Table 9.22: TEU Throughput Comparison

	2008	2007	2006	2005
Total Port Throughput	7,849,985	8,355,039	8,469,853	7,484,624
Total On-Dock Rail	1,983,589	2,098,398	2,466,759	1,891,198
% On-Dock	25%	25%	29%	25%
Near-Dock Rail	542,434	643,919	653,321	555,694
% Near-Dock	7%	8%	8%	7%
Off-Dock Rail	819,503	838,077	858,960	868,416

The methodology used in 2008 to estimate rail locomotive emissions changed due to the updated EPA emission factors; therefore rail activity was re-estimated using latest emission factors for the comparison. Table 9.23 shows the emissions estimate for calendar year 2008, 2007, 2006 and 2005 for locomotive engines in tons per year and as a percent change. The decrease in emissions for rail in 2008 is due to:

- Lower activity in 2008
- Use of newer and cleaner switcher locomotives
- Use of lower sulfur in 2008. Switcher locomotives used ULSD in 2008. For line-haul locomotives, it is assumed that half the fuel burned is from out of state (350 ppm Sulfur fuel content), and the other half uses in-state ULSD fuel.

Table 9.23: Rail Emission Comparison, tpy and %

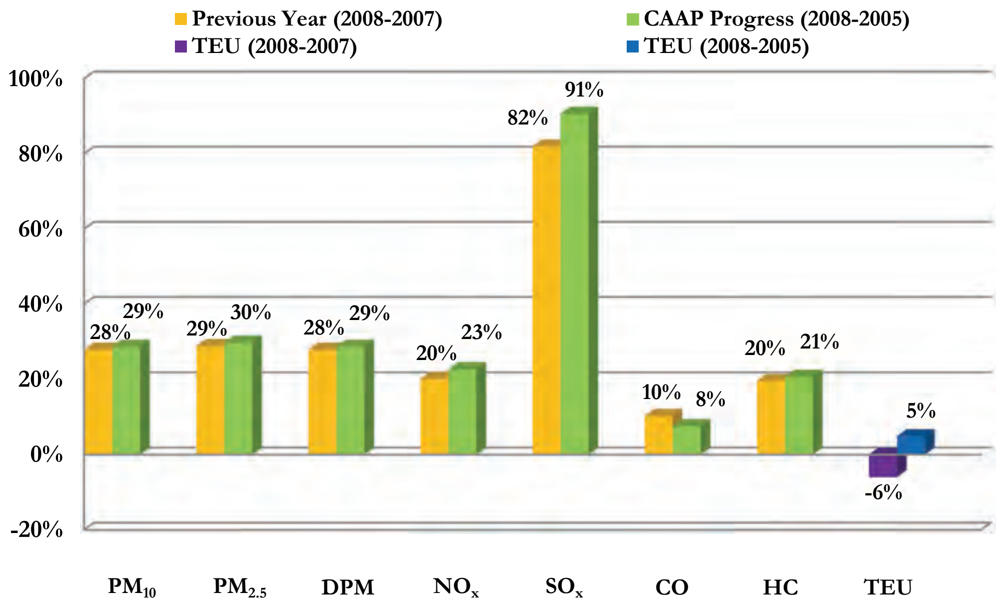
EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	42	38	42	1,366	9	226	74
2007	61	57	61	1,821	55	268	98
2006	74	69	74	2,202	131	320	119
2005	56	52	56	1,685	95	233	89
Previous Year (2008-2007)	**-32%**	**-33%**	**-32%**	**-25%**	**-83%**	**-16%**	**-24%**
CAAP Progress (2008-2005)	**-25%**	**-26%**	**-25%**	**-19%**	**-90%**	**-3%**	**-17%**

Table 9.24 and Figure 9.10 show the emissions efficiency changes. A positive percent for the emissions efficiency comparison means an improvement in efficiency. For both the previous year comparison (2008-2007) and CAAP progress (2008-2005), emission efficiency has improved for all pollutants.

Table 9.24: Rail Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	0.05	0.05	0.05	1.74	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	0.07	0.07	0.07	2.25	0.13	0.31	0.12
Previous Year (2008-2007)	**28%**	**29%**	**28%**	**20%**	**82%**	**10%**	**20%**
CAAP Progress (2008-2005)	**29%**	**30%**	**29%**	**23%**	**91%**	**8%**	**21%**

Figure 9.10: Rail Emissions Efficiency Comparison, %



9.1.5 Heavy-Duty Vehicles

The methodology used in 2008 to estimate HDV emissions is the same methodology as used in the 2007 Inventory of Air Emissions. Due to the Port's process of continually reviewing and improving the inventory process, the previous years' emissions presented below are not identical to those published in the 2007 inventory report. Calculation improvements have resulted in revised prior year emission estimates that are compatible with the 2008 estimates.

The average on-terminal total idling time at container terminals has continued to improve. Table 9.25 shows the decrease in total port-wide idling time which is due to three main factors:

- The terminals modernized their gate system with optical character recognition (OCR) and added several queuing lines at the in and out gates which increased the efficiency at the gates and thus reduced 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 Long Beach and Los Angeles, 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 9.25: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2008	2,097,600
2007	2,334,568
2006	2,962,463
2005	3,017,252
Previous Year (2008-2007)	**-10%**
CAAP Progress (2008-2005)	**-30%**

Table 9.26 summarizes the average age of the port-related fleet and it shows that the average age of trucks stayed the same as 2007. The Clean Trucks Program was launched October 2008 which requires the progressive ban of pre-2007 trucks between 2008 and 2012. In the next few years, the average age of the port-related fleet should become younger which will translate into lower emissions.

Table 9.26: Port-related Fleet Weighted Average Age

Year	Weighted Average Age
2008	12.1
2007	12.2
2006	11.4
2005	11.2

Table 9.27 summarizes the emission changes. The previous years' emissions do not match exactly the emissions published in the 2007 inventory report due to the Port's process of continual review and improvement of the inventories.

Table 9.27: HDV Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	300	276	300	6,606	5	2,227	398
2007	332	305	332	6,580	6	2,274	406
2006	362	333	362	7,672	40	2,518	543
2005	311	286	311	6,715	48	2,185	478
Previous Year (2008-2007)	**-10%**	**-10%**	**-10%**	**0%**	**-6%**	**-2%**	**-2%**
CAAP Progress (2008-2005)	**-4%**	**-4%**	**-4%**	**-2%**	**-89%**	**2%**	**-17%**

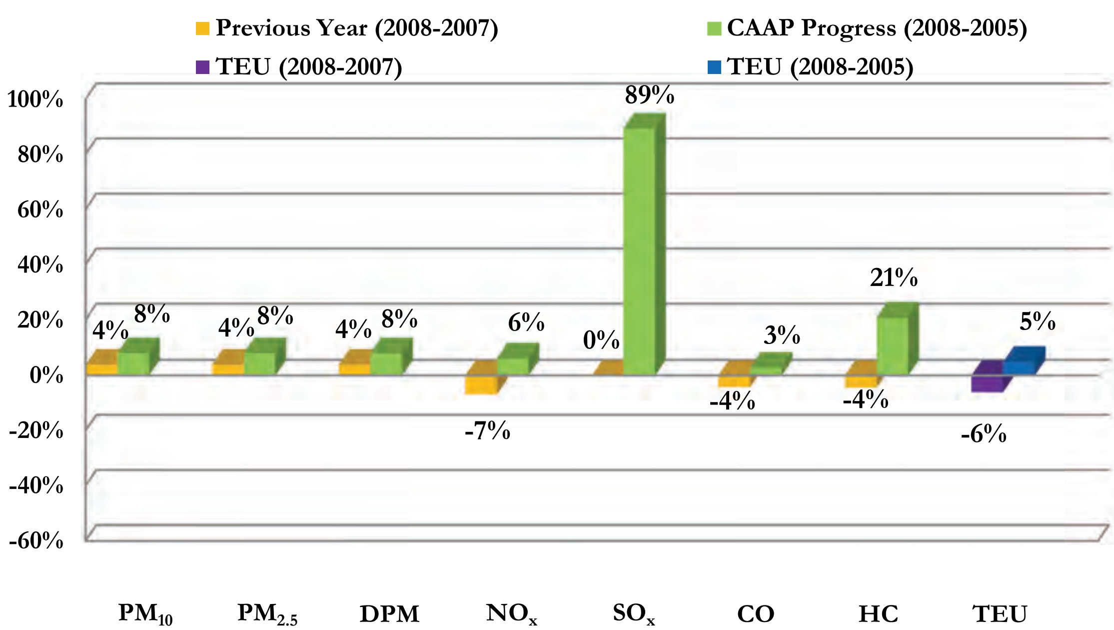
Table 9.28 and Figure 9.11 show the emissions efficiency changes. A positive percent for the emissions efficiency comparison means an improvement in efficiency. Comparing 2008 to CAAP progress (2008-2005), emission efficiency has improved for all pollutants. Comparing 2008 to 2007, PM emission efficiency improved, while the SO_x emissions efficiency stayed the same.

Table 9.28: HDV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2008	0.38	0.35	0.38	8.42	0.01	2.84	0.51
2007	0.40	0.37	0.40	7.88	0.01	2.72	0.49
2006	0.43	0.39	0.43	9.06	0.05	2.97	0.64
2005	0.42	0.38	0.42	8.97	0.06	2.92	0.64
Previous Year (2008-2007)	**4%**	**4%**	**4%**	**-7%**	**0%**	**-4%**	**-4%**
CAAP Progress (2008-2005)	**8%**	**8%**	**8%**	**6%**	**89%**	**3%**	**21%**

The purple bar represents TEU change from previous year (-6%) and the blue bar represents TEU change when compared to 2005 (5%).

Figure 9.11: 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 early 2010 as part of the CAAP Update process currently underway.

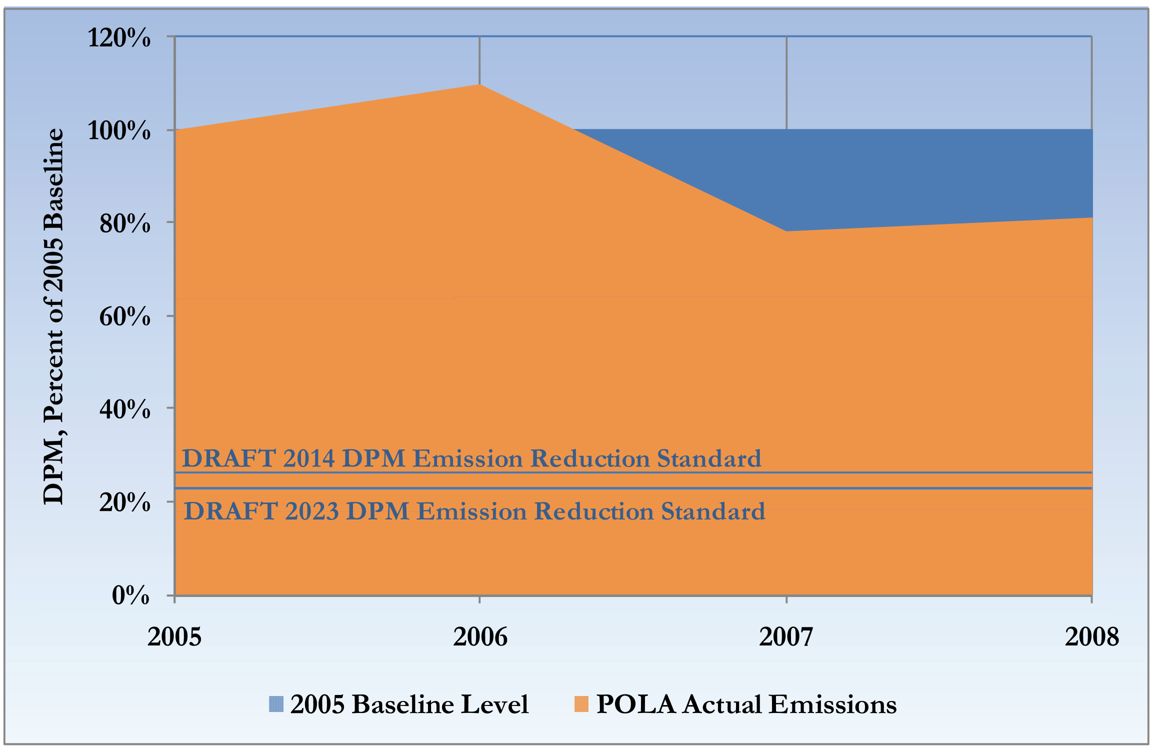
Emissions Reduction Progress

The Emissions Reduction Standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the future compliance dates of the South Coast AQMP. Tables 9.29 to 9.31 show the standardized estimates of emissions by source category for calendar years 2005 through 2008, using current year methodology. Figures 9.12 through 9.14 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions as well as presenting the draft 2014 and 2023 standards to provide a snapshot of progress to-date towards meeting those standards.

Table 9.29: DPM Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008
OGV	504	533	273	358
HC	56	51	52	56
CHE	44	47	41	33
Rail	57	74	61	42
HDV	311	362	332	300
Total	**971**	**1,067**	**760**	**788**
% Cumulative Change		**10%**	**-22%**	**-19%**

Figure 9.12: DPM Reductions - Progress to Date Compared to 2005

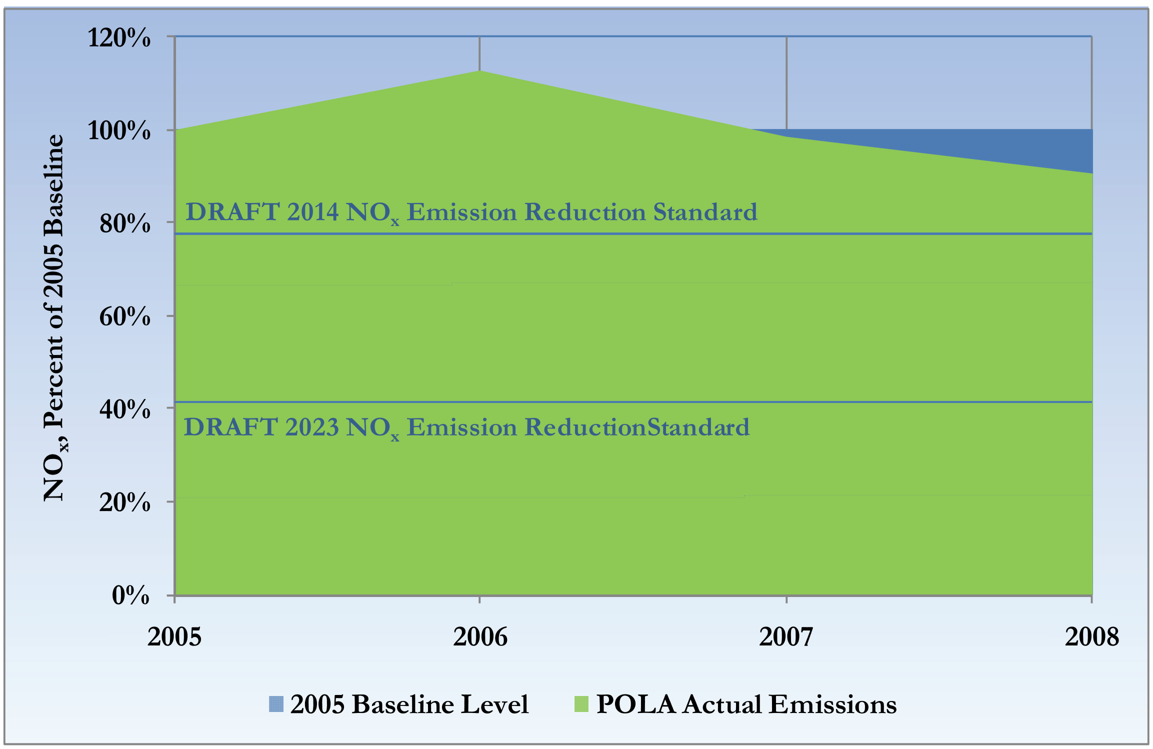


As presented above, by 2008 the port is over a quarter of the way towards meeting the DPM Emission Reduction Standard. With additional CAAP measures coming on-line in the subsequent years, the 2009 SPBP's OGV fuel switch incentive program, CARB's OGV fuel switch regulation implemented in 2009, and the Clean Truck Program (CTP), it is anticipated that the reduction trend 2006 to 2007 will resume in 2009.

Table 9.30: NO_x Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008
OGV	5,583	6,126	5,352	4,798
HC	1,336	1,245	1,263	1,284
CHE	1,444	1,700	1,537	1,169
Rail	1,712	2,202	1,821	1,366
HDV	6,715	7,672	6,580	6,606
Total	**16,789**	**18,946**	**16,553**	**15,224**
% Cumulative Change		**13%**	**-1%**	**-9%**

Figure 9.13: NO_x Reductions - Progress to Date Compared to 2005

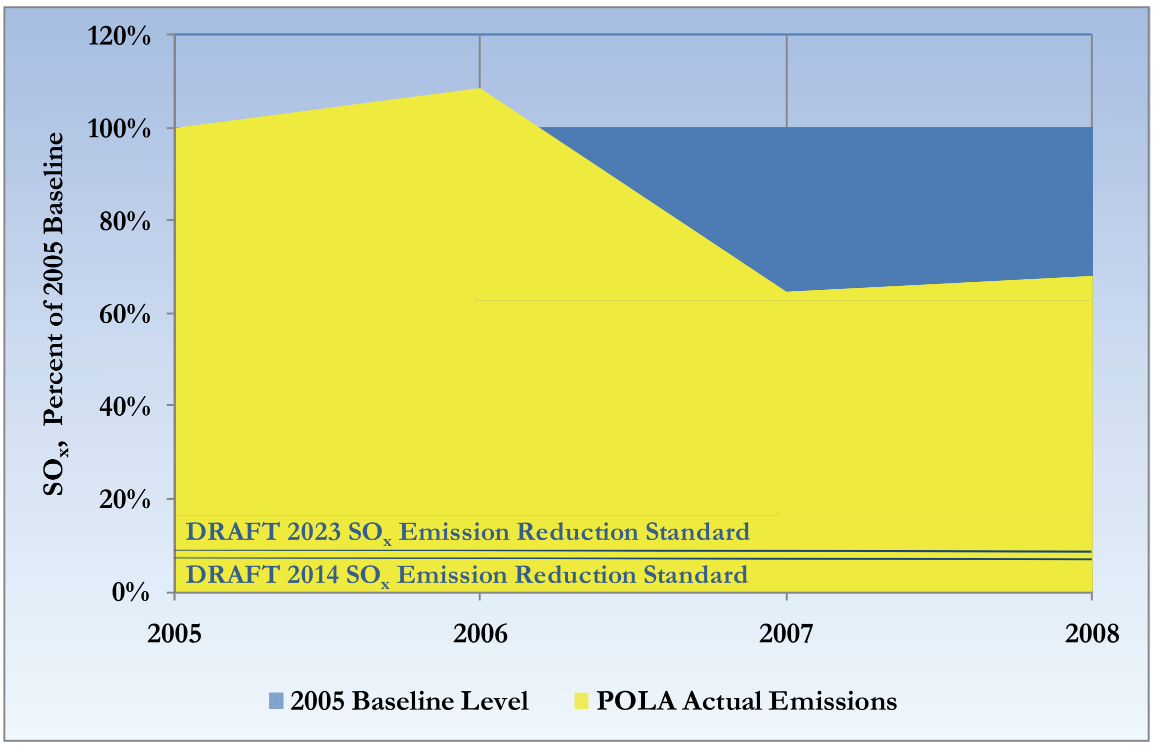


As shown above, the port is nearly halfway to meeting the 2014 NO_x Emission Reduction Standard in 2008. The SPBP Vessel Speed Reduction (VSR) program, Alternative Maritime Power (AMP), slide valves, and the CTP are the primary strategies for reducing NO_x emissions and meeting the 2014 NO_x standard. Increased participation in VSR out to 40 nm, increased use of AMP (or equivalent technologies) at berth will significantly help in meeting the 2023 standard. Additionally, continued fleet turnover in the CTP will also significantly contribute to NO_x reductions.

Table 9.31: SO_x Emissions by Calendar Year and Source Category, tpy

Category	2005	2006	2007	2008
OGV	5,425	5,898	3,548	3,787
HC	6	1	1	1
CHE	9	2	2	2
Rail	97	131	55	9
HDV	48	40	6	5
Total	**5,585**	**6,072**	**3,611**	**3,804**
% Cumulative Change		**9%**	**-35%**	**-32%**

Figure 9.14: SO_x Reductions - Progress to Date Compared to 2005



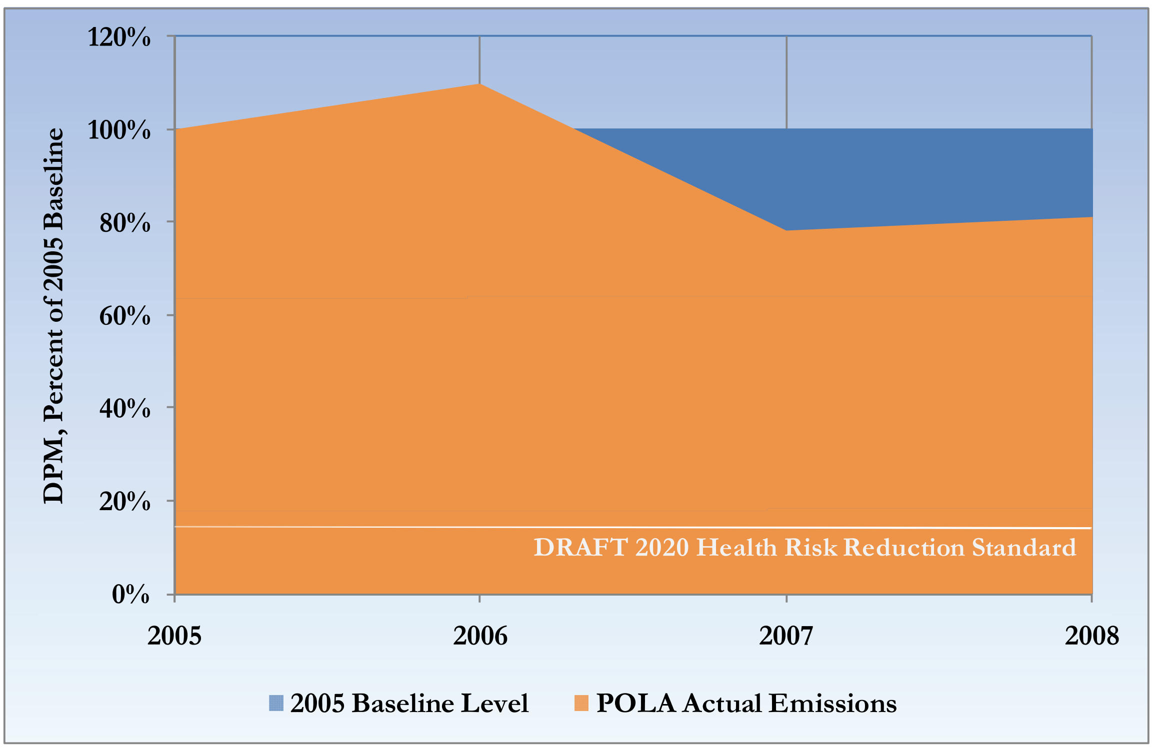
As shown above, by 2008 the port is a third of the way towards meeting the SO_x Emission Reduction Standard. With implementation of additional CAAP measures, the 2009 SPBP's OGV fuel switch incentive program and CARB's OGV fuel regulation implemented in 2009, it is anticipated that the high rate of SO_x reductions will continue 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 9.15 presents the progress of achieving the standard to date.

Figure 9.15: Health Risk Reduction Benefits - Progress To Date



As shown above, by 2008 the port is over a quarter of the way towards meeting the 2020 Health Risk Reduction Standard. With additional CAAP measures coming on line, the 2009 SPBP's OGV fuel switch incentive program, CARB's OGV fuel switch regulation implemented in 2009, and the continued fleet improvements coming from the Clean Truck Program, it is anticipated that the reduction trend 2006 to 2007 will resume in 2009.